



SUB-COMMITTEE ON STANDARDS OF
TRAINING AND WATCHKEEPING
32nd session
Agenda item 3

STW 32/INF.2
20 October 2000
ENGLISH ONLY

VALIDATION OF MODEL TRAINING COURSES

Note by the Secretariat

SUMMARY

<i>Executive summary:</i>	This document provides the text of draft model courses to be validated by the Sub-Committee
<i>Action to be taken:</i>	Paragraph 2
<i>Related documents:</i>	STW 32/3/1

1 Attached hereto at annex is the text of the following model courses:

- .1 On-board assessment;
- .2 Training of trainers; and
- .3 GMDSS second class radio electronics officer.

Action requested by the Sub-Committee

2 The Sub-Committee is invited to consider the above information and decide as appropriate.

Model Course No: 1.30

On-board Assessment

On-board Assessment

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Model Course No: 1.30

Introduction

■ Purpose of the model courses

The purpose of the IMO model courses is to assist training providers and their teaching staff in organizing and introducing new training courses, or in enhancing, updating or supplementing existing training material where the quality and effectiveness of the training courses may thereby be improved.

It is not the intention of the model course programme to present instructors with a rigid “teaching package” which they are expected to “follow blindly”. Nor is it the intention to substitute the instructor’s presence with audiovisual or programmed material. As in all training endeavours, the knowledge, skills and dedication of the instructors are the key components in the transfer of knowledge and skills to those being trained through IMO model course material.

Because educational systems and the cultural backgrounds of trainees in maritime subjects vary considerably from country to country, the model course material has been designed to identify the basic entry requirements and trainee target group for each course in universally applicable terms, and to specify clearly the technical content and levels of knowledge and skill necessary to meet the technical intent of IMO conventions and related recommendations.

■ Use of the model course

To use the model course the instructor should review the course plan and detailed syllabus, taking into account the information provided under the entry standards specified in the course framework. The actual level of knowledge and skills and the prior technical education of the trainees should be kept in mind during this review, and any areas within the detailed syllabus which may cause difficulties because of differences between the actual trainee entry level and that assumed by the course designer should be identified. To compensate for such differences, the instructor is expected to delete from the course, or reduce the emphasis on, items dealing with knowledge or skills already attained by the trainees. The instructor should also identify any academic knowledge, skills or technical training which they may not have acquired.

By analyzing the detailed syllabus and the academic knowledge required to allow training in the technical area to proceed, the instructor can design an appropriate pre-entry course or, alternatively, insert the elements of academic knowledge required to support the technical training elements concerned at appropriate points within the technical course.

Adjustment of the course objectives, scope and content may be necessary if within the respective maritime industry the trainees completing the course are to undertake duties which differ from the course objectives specified in the model course.

Within the course plan the course designers have indicated their assessment of the time which should be allotted to each area of learning. However, it must be appreciated that these allocations are arbitrary and assume that the trainees have fully met all entry requirements of the course. The instructor should therefore review these assessments and may need to re-allocate the time required to achieve each specific learning objective or training outcome.

■ Lesson plans

Having adjusted the course content to suit the trainee intake and any revision of the course objectives, the instructor should draw up lesson plans based on the detailed syllabus. The detailed syllabus contains specific references to the textbooks or teaching material proposed to be used in the course. An example of a lesson plan is included in Part D: Instructor's Manual on page 55. Where no adjustment has been found necessary in the learning objectives of the detailed syllabus, the lesson plans may simply consist of the detailed syllabus with keywords or other reminders added to assist the instructor in making his presentation of the material.

■ Presentation

The presentation of concepts and methodologies must be repeated in various ways until the instructor is satisfied that the trainee has attained each specific learning objective or training outcome. The syllabus is laid out in learning objective format and each objective specifies *what the trainee must be able to do* as the learning outcome.

■ Evaluation or assessment of trainee progress

No specific guidance on the assessment of trainees has been included since that forms the subject matter of a large part of this course. The progress of trainees can be judged from the

outcome of the various activities undertaken by them, which will indicate if further explanation or clarification of any topic is needed. An overall evaluation of the course will be afforded by the final activity, for which the trainees are divided into two groups, each of which examines the other.

■ Implementation

For the course to run smoothly and to be effective, considerable attention must be paid to the availability and use of:

- ☐ properly qualified instructors;
- ☐ support staff;
- ☐ rooms and other spaces;
- ☐ equipment;
- ☐ textbooks, technical papers; and
- ☐ other reference material.

Thorough preparation is the key to successful implementation of the course. IMO has produced a booklet entitled “Guidance on the implementation of IMO model courses”, which deals with this aspect in greater detail. A copy of the booklet is included as an attachment to this course.

■ Training and the STCW 1995 Convention

The standards of competence that have to be met by seafarers are defined in Part A of the STCW Code in the Standards of Training, Certification and Watchkeeping for Seafarers Convention, as amended in 1995. This IMO model course has designed to support the implementation of the revisions. It addresses the requirements of Regulation I/6 and Section A-VI/6 of the STCW Code.

Part A provides the framework for the course with the aims and objectives and notes on the suggested teaching facilities and equipment. A list of useful teaching aids, IMO references and textbooks is also included.

Part B provides an outline of lectures, demonstrations and exercises for the course. A suggested timetable is included but from the teaching and learning point of view, it is more important that the trainee achieves the minimum standard of competence defined in the STCW Code than that a strict timetable is followed. Depending on their experience and ability, some students will naturally take longer to become proficient in some topics than in others. Also included in this section are guidance notes and additional explanations.

A separate IMO model course addresses Assessment of Competence. This course explains the use of various methods for demonstrating competence and criteria for evaluating competence as tabulated in the STCW Code.

Part C gives the Detailed Teaching Syllabus. This is based on the theoretical and practical knowledge specified in the STCW Code. It is written as a series of learning objectives, in other words what the trainee is expected to be able to do as a result of the teaching and training. Each of the objectives is expanded to define a required performance of knowledge, understanding and proficiency. IMO references, textbook references and suggested teaching aids are included to assist the teacher in designing lessons.

Part D gives guidance notes and additional explanations.

■ Responsibilities of Administrations

Administrations should ensure that training courses delivered by training providers are such as to ensure those completing training do meet the requirements of STCW Regulation I/6.2.

Part A

Course Framework

■ Scope

Aims

This course is primarily intended for senior officers responsible for conducting onboard assessment of other officers and ratings under their charge. It should therefore be included in the curriculum of courses preparing candidates for certification as masters, chief mates, chief engineers and second engineers.

The course is of limited duration and therefore cannot be considered as providing comprehensive assessor training, which would take much longer. However, the course does include the many principles of developing and implementing a shipboard assessment system.

In the introductory part, the course reviews IMO model courses, their purpose and usage.

In subsequent parts, the course deals with development of a competence-based assessment system, identifying and selecting performance objectives, and determining performance measures and standards.

The main part of the course deals with the techniques of conducting the assessment and developing a performance improvement plan.

The 'learning style' of the course is rather participative, About 45% of the course time is allocated to exercises. It is recommended these exercises be performed in groups of 4 to 5 participants.

■ Objectives

Participants successfully completing the training course on shipboard assessment should be capable of undertaking all of the responsibilities expected of assessors within their field of expertise. They will be familiar with the concepts generally taken into account when developing an suitable assessment package for a particular type of ship.

To provide knowledge and skills for trainees to administer, supervise and monitor training and assessment of seafarer competence in accordance with the provisions of Section A-I/6 of the STCW Code.

A trainee successfully completing the course will be able to:

- .1 apply the international provisions concerning the training, assessment, officers and ratings of merchant vessels;
- .2 apply the implementation of these provisions under national law;
- .4 determine appropriate assessment methodologies; and
- .5 organize, administer and conduct assessments.

■ Entry standards

Persons to be trained to conduct assessments for certificates of competency issued under international instruments dealing with certification of persons to be employed aboard ship should hold a certificate of competency no lower than the certificate or qualification which is to be issued by or on behalf of the Administration in the discipline concerned and have appropriate experience and a thorough knowledge of both the theoretical and the practical aspects of all subjects involved.

In the case of those who are to conduct assessments for issue of certificates as master, chief engineer, deck or engineering officer, such experience should preferably include service as master or as chief engineer, as appropriate. A refresher course in the theoretical aspects of the discipline concerned may be necessary for those persons whose recent experience has been mostly of a practical nature. Similarly, a refresher course in the practical aspects of the discipline concerned may be necessary for those persons whose recent experience has been mostly of a theoretical nature. Other qualifications may be recognized as equivalent in the case of those persons who are to conduct assessments in academic or specialized subjects.

Fluency in both the spoken and written language in which the assessment will be conducted is essential.

■ Course certificate

On completion of the course – if assessment which indicates the participants' usefulness as prospective assessors can be made a document may be issued certifying that the holder has successfully the training course on shipboard assessment. If, on the other hand, assessment is not for that purpose, then a certificate of attendance would suffice.

■ Course intake limitations

The intake of students should be approximately 16 to 20 to allow about 4 or 5 in each group. This will allow each participant to benefit from the participative emphasis of the course.

■ Staff requirements

The conduct of the course will require a minimum of two experienced instructors, who should have an adequate background and knowledge of competence-based assessment. At least one, who would normally be the course leader, should be competent in the field of assessor and assessor development.

The instructors should be capable of operating the kind of audio-visual equipment which could be expected to be available.

It would be a benefit if at least one of the instructors had previously participated in the course.

Participants may seek answers to local problems and opinions on a wide range of issues which affect them. While such matters may not be included in the planned course it would be of considerable advantage if the instructors had a sufficiently wide experience to handle such matters.

■ Teaching facilities and equipment

A classroom, four smaller rooms for suitable group work and a work room for instructors must be provided. The classroom must be equipped with an overhead projector and screen, desks, tables, chairs, white-boards or blackboards and writing materials or flip-over board and writing materials, etc. The ambience should be one which will encourage everyone to participate in active discussions. For the most part the arrangement should be that all participants can face each other, i.e. facing inwards in a rectangle or similar configuration. A video camera, etc. would be an asset but is not essential.

The group rooms should be provided with a table and chairs, giving ample work space for approximately four to six participants and an observer.

For the purpose of conducting an interactive simulation exercise a telephone or intercom communications should be established between group rooms and a room in which the instructors can be based.

■ Teaching aids (A)

A1 Instructor manual (Part D of the course)

A2 Videos:

V1 IMO - Safer Shipping and Cleaner Oceans (IMO Sales No 202)

V2 Setting a New Course: An Introduction to the Revised STCW Convention (Code No.538)

V3 Onboard Training by Design (Code No. 489)

V4 STCW and Flag State Implementation (Code No. 629)

V5 Onboard Training and Assessment - STCW '95 (Code No. 651)

Available from: Videotel Marine International Limited
84 Newman Street
London W1P 3LD, UK
Tel: +44 (0)20 7299 1800
Fax: +44 (0)20 7299 1818
E-mail: mail@videotelmail.com
URL: www.videotel.co.uk

Audio-visual examples listed above may be substituted by other similar audio-visual material at the discretion of the training provider and administration.

■ Bibliography (B)

- B1 Fletcher, Shirley, *Competence-Based Assessment Techniques* 2nd ed (London, Kogan Page, 1997) (ISBN 0 7494 2197 5)
- B2 Fletcher, Shirley, *Designing Competence-Based Training* 2nd ed (London, Kogan Page, 1997) (ISBN 0 7494 2196 7)
- B3 Holder, L A, *Training and Assessment on Board*, 2nd ed (London, Witherby & Co Ltd, 1997) (ISBN 1 85609 123 6)
- B4 Brown, Sally *et al*, *500 Tips on Assessment* (London, Kogan Page, 1996) (ISBN 0 7494 1941 5)
- B5 The Nautical Institute, *Maritime Education and Training* (London, The Nautical Institute, 1997) (ISBN 1 87 00 77 415)
- B6 International Shipping Federation, *On Board Training Record Book for Deck Cadets* 2nd ed (London, International Shipping Federation, 1996)
- B7 International Shipping Federation, *On Board Training Record Book for Engineer Cadets* 2nd ed (London, International Shipping Federation, 1997)
- B8 International Shipping Federation, *The revised STCW Convention: A guide for the shipping industry on the 1995 amendments to the IMO International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (London, International Shipping Federation, 1995)
- B9 International Shipping Federation, *ISF Personal Training and Service Record Book* (London, International Shipping Federation, 1998)
- B10 R.J. Kibler, L.L. Barker and D.T. Miles, *Behavioral Objectives and Instruction*. (Boston, Allyn and Bacon Inc.,1970) (Out of print)
- B11 R.F. Mager, *Measuring Instructional Intent (or Got a Match?)*. (Belmont, California, Lear Siegler, Inc./Fearon Publishers,1973) (ISBN 0-8224-4462-3)
- B12 R.F. Mager, *Preparing Instructional Objectives* (revised 2nd ed) (Belmont, California, Pitman Learning Inc., 1997) (ISBN 18796-18036)
- B13 E . Raeng, *Assessing Seafarers' Competence*. (FAME/MARTA, Manila, 1999. Tel: +632 635 4820; Fax: +632 638 7961)

Secondhand copies of out of print books may be available from the Warsash Nautical Bookshop, 6 Dibles Road, Warsash, Southampton SO31 9HZ, UK. Tel: +44 1489 572 384
Fax: +44 1489 885 756 E-mail: orders@nauticalbooks.co.uk URL: www.nauticalbooks.co.uk

■ IMO references (R)

- R1 STCW 95. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995 (STCW 1995), 1998 edition (IMO Sales No. 938)
- R2 STCW 95 Amendment 1 (1997). (IMO Sales No 945)
- R3 STCW-F 95: International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel, 1995. (IMO Sales No 915)
- R4 STCW 95: IMO workshop material on implementation of the revised STCW Convention. (London, IMO, 1997) (IMO Sales No 972)
- R5 MSC/Circ. 853 Guidance on Shipboard Assessments of Proficiency
- R6 IMO What it is, What it does, How it works

Computer-based programs (C)

- C1 VIDEOTEL MARINE INTERNATIONAL LTD, *SETS (Seafarers' Evaluation and Training System)*. (Windows 3.1 or later). London, Videotel Marine International
- C2 DET NORSKE VERITAS, *Seaskill*. (Windows 95). Oslo, DNV
- C3 SEAGULL AS, *Assessor Training*, (PO Box 1062, N-3194 Horten, Norway. Tel: +47 330 47 930. Fax: +47 330 46 279)

Internet websites (W)

- W1 **DNV — STCW 95 Training and Qualification Support**<http://www.dnv.com/stcw/Rev1/>
- W2 **USCG STCW Home Page**<http://www.uscg.mil/STCW/index.htm>
- W3 **USCG Exam Question Bank**<http://www.uscg.mil/hq/g-m/marpers/examques/index.htm>
- W4 **USCG NVICs published in the 90s**<http://www.uscg.mil/hq/g-m/nvic/index90.htm>
- W5 **ILO Sectoral Activities: Shipping**<http://www.ilo.org/public/english/100secto/sectors/mariti.htm>
- W6 **ILO Database of International Labour Standards**<http://ilolex.ilo.ch:1567/public/english/50normes/infleg/iloeng/index.htm>
- W7 **PC Maritime Ltd**<http://www.pcmaritime.co.uk/comm/index.htm?/comm/products.htm>
- W8 **Poseidon Simulation AS — Radar Simulator**<http://www.poseidon.no/Radar.htm>
- W9 **MARINTEK — Information Technology**<http://www.marintek.sintef.no/mt23doc/mitd/programme/b2-98m.html>
- W10 **IMO -STCW 95 Bibliography (information sheet No. 23)**<http://www.imo.org>

Details of distributors of IMO publications that maintain a permanent stock of all IMO publications may be found on the IMO web site at <http://www.imo.org>

Part B

Course Outline and Timetable

Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and , finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees handouts contribute to the learning process.

Course Outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

Subject Area	Hours	
	Lectures	Activity
1 Course Introduction	1.0	
2 Process Overview	1.0	
3 IMO and its Contribution to Training	1.0	
4 Purpose of the Course	0.5	
5 Development of Shipboard Assessment System	1.5	
6 Development of Competence-based Assessment	1.0	1.0
7 The On-board Assessment	0.5	1.0
8 Identify Performance Objectives	0.5	2.0
9 Select Performance Objectives for On-board Assessment	1.0	1.0
10 Determine Performance Measures and Standards	1.0	2.0
11 Prepare assessment Package	2.0	
12 The Assessment Process 12.1 Preparation for the Assessment 12.2 Conduct Pre-assessment Briefing 12.3 Observe candidate's performance and record the results 12.4 Evaluate the process and determine the assessment 12.5 Assessment debrief	5.0	6.0
13 Develop Performance Improvement Plan	1.0	1.0
Subtotals	17.0	14.0

TOTAL 31

Note: Teaching staff should note that outlines are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

Course Timetable

Period/Day	1st Day		2nd Day		3rd Day		4 th Day		5th Day	
1st Period (1.5 hours)	1	Course Introduction	6	Development of competence - based assessment (continued)	9	Select performance objectives for shipboard assessment (continued)	12	The assessment process (continued)	12	The assessment process (continued)
	2	Process Overview			10	Determine performance measures and standards				
2nd Period (1.5 hours)	3	IMO and its contribution to training	7	The on-board assessment	10	Determine performance measures and standards (continued)	12	The assessment process (continued)	12	The assessment process (continued)
LUNCH BREAK										
3rd Period (1.5 hours)	4	Purpose of the Course	8	Identify performance objectives	11	Prepare assessment package (continued)	12	The assessment process (continued)	12	The assessment process (continued)
	5	Development of Shipboard assessment system							12	Develop performance improvement plan
4th Period (1.5 hours)	6	Development of competence-based assessment	9	Select performance objectives for shipboard assessment	11	Prepare assessment package	12	The assessment process (continued)	13	Develop performance improvement plan (continued)
					12	The assessment process				

Teaching staff should note that the hours for lectures and exercises are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for teaching.

Part C

Detailed Teaching Syllabus

The detailed teaching syllabus has been written in learning-objective format in which the objective describes what the trainee must do to demonstrate that knowledge has been transferred.

All objectives are understood to be prefixed by the words, "The expected learning outcome is that the trainee will be able to ...".

In order to assist the instructor, references are shown against the learning objectives to indicate those parts of the instructor manual and other references that the instructor may find useful in preparing and presenting course material.

The abbreviations used are:

- *Ann.:* *annex*
- *Art.:* *article*
- *App.:* *appendix*
- *Ch.:* *chapter*
- *Fig.:* *figure*
- *Para.:* *paragraph*
- *Pt.:* *part*
- *Reg.:* *regulation*
- *Sect.:* *section*
- *Ta.:* *table*

The following are examples of the use of references:

The following are examples of the use of references:

"R1 Reg. II/3" refers to Regulation II/3 of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as amended in 1995;

"A1" refers to the Instructor Manual in Part D.

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
1. Course Introduction (1 hour) .1 explains the scope and objectives of the course .2 explains the relationship of this course with other IMO model courses .3 explains that use is made during the course of individual and group activities to develop skills in preparing assessment material .4 explains the need to supplement what is learnt during the course with practical experience in developing assessment material and conducting assessments .5 states that Part D not only contains material necessary to the course, arranged according to subject areas, but is also intended to serve as a reference manual	R1 Sect. A-I/6 R4	B8 B13	A1 Sect.1
2. Process Overview (1 hour) .1 states that the process must ensure that candidates meet all minimum national and international requirements .2 states that the process must test knowledge, understanding and skills actually used in the position concerned .3 states that assessments must be properly administered .4 states that the process must apply the same minimum standard at all locations and at all times until standards are changed .5 states that the process should allow candidates to appeal against decisions of the assessor .6 states that the process must be secure as to actual assessment content .7 states that the process must ensure that approved assessment remain up-to-date and valid .8 states that the assessment process must comply with quality standards as stipulated in Regulation I/8 of STCW 95	R1 Sect. A-I/8	B5 Sect IV.	A1 Sect.2
3. IMO and Its Contribution to Training (1 hour) .1 explains the reasons for the establishment of the International Maritime Organization .2 explains the purpose of IMO	R6		A1 Sect.3 V1 W10

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
.3 describes briefly the structure of IMO .4 explains how ship standards are maintained .5 describes IMO's involvement with the establishment of standards of training and assessment for seafarers .6 explains the purpose of IMO's model courses .7 outlines the range of subjects covered by model courses .8 explains the 1995 amendments to the STCW Convention .9 states that the training and assessment of seafarers as required is stipulated in Regulation I/6 and Regulation I/14		B5 Ch.21 B8 W10	V2
4. Purpose of the Course (0.5 hour)			A1 Sect.4
.1 determines personal objectives for this course .2 determines the competences required to be assessed		B5 Ch.2	
5. Development of Shipboard Assessment System (1.5 hours)		B4, B13	A1 Sect.5
.1 explains what is meant by: — education — training — a learning system — performance — assessment .2 explains the purpose of assessment .3 explains the methods of assessment .4 describes situations where training and assessment should be of benefit .5 explains the difference between symptoms and causes when applied to performance at work .6 describes the effect of learning on the person .7 explains five areas in which training can improve performance .8 determines a required job performance - given relevant information .9 identifies training needs from given information or observation		B5 Ch.24	V3 V4 V3

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
.15 selects suitable assessment methods for specified subject areas .16 describes the role of the assessor in the various assessment methods .17 generates documented procedures for conducting assessments			Activity
7. The On-board Assessment (1.5 hours)	R5	B5 Ch.28	A1 Sect.7
.1 defines shipboard assessment .2 defines performance objective .3 defines performance measure .4 defines performance standard .5 lists the issues to take into account when preparing .6 states that shipboard assessment should be carried out in accordance with Regulation I/6 of STCW Convention and Section A-I/6 of the STCW Code .7 lists the stages in developing shipboard assessment .8 designs a feedback form for monitoring the process	R1 Reg. I/6 Sect. A-I/6		Activity
8. Identify Performance Objectives (2.5 hours)	R5	B10	A1 Sect.8
.1 states that identifying performance objectives involves the following three sub-steps: .1 determines the critical performance objectives by considering the consequences of performance failure with respect to: — personal injury and loss of life; — environmental damage and pollution; and — economic costs. .2 reviews available resources to identify performance objectives, including — STCW tables of standards of competence; — approved Training Record Books; — ship's operating procedures; — international, national and local regulations; — company instructions and procedures; — technical equipment and technical equipment manuals;	R1 R2 R3	B6 B7	

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
— task analysis; and — subject matter expert advice. .3 ensures that performance outcomes are tied to STCW competences .2 performs a task analysis .3 writes detailed learning outcomes that demonstrate			Activity Activity
9. Select Performance Objectives for On-board Assessment (2 hours)	R1 Sect. A-I/6	B10 B11, B12	A1 Sect.9
.1 discusses that the performance objectives for on-board assessment should be selected by reviewing the following four general factors: .1 the safety implications of conducting the assessment .2 the current shipboard operating conditions, including: — environmental conditions; — location; — equipment status; — workload; and — personnel schedules. .3 the ability to establish adequate controls over shipboard operations throughout the assessment period. .4 the candidates' current skill level, taking into account: — prior training; and — experience. .2 generates a series of tasks to assist in shipboard	R5		Activity
10. Determine Performance Measures and Standards (2 hours)	R5		A1 Sect.10
.1 discusses that the determination of performance measures and standards involve the following three sub-activities: .1 selecting the methods of measuring the steps or components of the practical test, which may include:			

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
— observation of whether or not a step was completed; — recording a value from an indicator or gauge (such as a compass); or — monitoring performance with respect to an established metric (such as time to complete a step). .2 identifying the standard corresponding to each step or component. .3 determining how the overall performance objective is met (i.e., what critical factors must be applied). .2 designs an assessment specification and scoring .3 critically reviews methods and outcomes of an evaluation of competence			Activity
11. Prepare Assessment Package (2 hours)	R5		Activity A1 Sect.11
.1 states that in developing an assessment package, the following may be necessary: — student workbook, including reference material for the candidate; — guide to assessment; — instructions for the assessor and candidate; — checklists; — worksheets; — work forms; — record of observed performance; — summary form .2 states that a scheme must be provided to determine whether the summarized performance constitutes competent performance.			
12 The Assessment Process (11 hours)	R5		A1 Sect.12
.1 state that the steps involved in conducting assessment should include: — the preparation for the assessment — conducting a pre-assessment briefing with the candidate — observing the candidate's performance and recording the results			V5

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
— evaluating the process and determining the assessment outcome — conducting an assessment debrief. 12.1 Preparation for the assessment (2 hours) .1 state that preparation for the assessment involves .1 Gathering of materials — identify appropriate materials for items to be assessed — procure the necessary materials .2 Preparing the staging area — ensure a safe working environment — stand-by appropriate safety appliances — ascertain the need for appropriate attire .3 Preparing and arranging equipment — identify equipment to be used — ensure equipment are in good working condition — ascertain that assessment can be conducted without disrupting normal function of ship .4 Conducting any necessary safety checks — ensure that there are adequate controls to avoid problems — determine the standard safety check list for items to be assessed — take account of the weather condition during period of assessment — obtain permit to carry out assessment from master or responsible officer .5 Informing affected personnel — inform candidate and other affected personnel in advance — clarify that assessment will not interfere with shipboard routine operations — notify affected watchkeeper — confirm that candidate is ready for the assessment .2 makes preparation for an assessment on board 12.2 Conduct pre-assessment briefing (3 hours)			Activity

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
.1 states that a pre-assessment briefing with the candidate should be conducted, which should address the following: .1 The scope (what and how much) — items to be assessed — the competences being assessed — the framework for assessment — the purpose of the assessment .2 Procedures (rules) — guidelines on the competences to be assessed — circumstances that may require the assessment to be postponed — the time-frame — parameter of permissible activities — guidelines for appeal .3 Standards (goal to be met) — the acceptable level of knowledge, understanding and proficiency, as per the STCW competence tables — any other criteria, including for safety .4 Outcome and consequences of the assessment — the form or manner by which the outcome will be made known to candidate — the need to agree on the candidate's strength and weaknesses — the expected consequences of the outcome, (for example, the need for the candidate to be re-assessed or send for further training) — the documents involved in recording the outcome (for example, the Training and Assessment Record Book) .2 conducts a pre-assessment briefing 12.3 Observe the candidate's performance and record the results (3 hours) .1 states that throughout the assessment, the following should be noted: .1 Avoiding coaching — refrain from giving guidance/hints/tips to candidate — ensure performance is candidate's own effort		B6, B7 B9	V2 Activity

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
.2 Remaining objective — keep within the scope and guidelines of assessment — avoid personal opinions that are subjective — take account of conditions beyond control of candidate which may affect his/her performance — exercise impartiality — be specific and clear in instructions — direct observation on candidate's performances rather than on candidate himself/herself — refrain from candidate's influences (such as arguments/pleading) .3 Maintaining positive control of the situation — keep out unwarranted interference — maintain a conducive environment for assessment — ensure timely intervention when potentially hazardous situation arises — stick to allocated time-frame — apply fair and firm stand in determining outcomes .4 Ensuring realistic assessment conditions and providing appropriate information — create scenarios as realistic as possible when actual conditions not present e.g responding to emergencies etc. — disseminate relevant information to ensure that candidate is not at a disadvantage .5 Avoiding unnecessary interference — allow candidate to complete the task uninterrupted — abide by the time frame for each task to prevent disruption on subsequent tasks .6 Maintaining records in accordance with the assessment guidelines — record the assessment in the approved Training and Assessment Record Book — record the assessment in the candidate's company training record book where appropriate .2 observes and assesses a "candidate's" performance		B6 B7	Activity

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
12.4 Evaluate the process and determine the .1 states that upon observing the performances, the process should be evaluated and the assessment outcome should be determined, covering the following steps: .1 recording performance for each individual .2 applying the evaluation instructions as stipulated in STCW 95 Competence Table, paying attention to the required criteria for evaluating competence .3 determining the outcomes and immediately 12.5 Assessment debrief (2 hours) .1 states that an assessment debrief should be conducted with the candidate as soon as possible, adhering to the following guidelines: .1 Focus on positive outcomes first — outline candidate's satisfactory performances — avoid making statements/comments that will demoralize the candidate .2 Identify areas needing improvement — make references to areas where performances were not up to expectation, based on factual observation — discuss ways in which candidate can improve on the performances in order to satisfy the competence requirement .3 Specify the assessment results — inform candidate on the assessment result (i.e. whether he/she has PASS or FAIL) .4 Close with a recommendation .1 recommend necessary actions for the candidate to take for improvement, including: — more exposure to a particular task — further or refresher training — source of materials to gain knowledge — need for closer supervision or coaching — if appropriate, specify minimum period before the next assessment of the failed task .2 conducts a post-assessment debriefing			Activity

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
13. Develop Performance Improvement Plan (2 hours) .1 explains the purpose of developing the performance improvement plan .2 states that it is necessary to determine the need for such a plan for each candidate .3 states that the plan is not required if the following three conditions are met: — the assessment was conducted according to agenda/schedule — the assessment appeared fair and valid — the candidate passed without any areas for improvement being identified .4 states that it is necessary to allocate some time to review and analyze the assessment process and outcome, taking into consideration: — the candidate's results — how the results compare with prior assessment results — the extent to which the assessment accurately reflected realistic shipboard operations .5 states that if any of the three conditions identified in 13.3 is not met, a preliminary improvement plan must be prepared, which may address: — areas of additional training for the candidate — changes in shipboard procedure and tasks — changes in ship equipment — changes in the assessment process .6 states the need to communicate (face to face) with the candidate and/or ship master/company designated person/management representative the contents of the performance improvement plan .7 recognises that there may be a need to revise the plan before finalizing it .8 states that the documents with the recommendations must be written and signed.	R5		A1 Sect.13

Part D : Instructor Manual

Introduction

This course comprises lectures, discussions and a series of demonstrations with full involvement by the participants of how various assessment techniques could be applied to the conduct of competence based assessment onboard ship. This involves:

- Short presentations of assessment techniques, with explanations of practical implications.
- Applications of competence based assessment techniques by the course instructors and by the participants.
- Discussions.
- Participants' workshops, with task-solving and interactive exercises.

The instructor manual provides guidance on the material that is to be presented during the course. It is arranged under the thirteen main subject areas identified in Part B, the course outline and detailed syllabus.

While the course manual as well as the teaching aids facilitate the planning and conduct of the course, the instructors may need to prepare their own inputs on an ad hoc basis. This requirement follows from the fact that circumstances, particularly the composition of the group of trainees, will be different each time the course is conducted. The input, therefore, must be adapted according to the particular conditions prevailing for each course in order to achieve both the general objectives and the detailed learning objectives of each session.

It is important to recognize that since this course is for the training of assessors, it should be itself a model of good practice. Trainees should be allowed to observe good preparation, exercises and group-work practice. There will be many opportunities for the instructor to employ the course itself as a vehicle to discuss the relevance and implications of certain learning objectives.

The main purpose of using learning objectives is to define clearly what the trainee should be able to do in a specified area of knowledge or skill upon completion of the course. In some instances, considerable work will be necessary; in others, the time required might be minimal. This is governed not only by the difficulty of the subject but also by the abilities and experience of the trainees.

The course outline and provisional timetable provide guidance on the time allocation for the course material. Every effort has been made to ensure the reliability of the time allocations. However, because of differences in the backgrounds, abilities, interests and personalities of the trainees comprising each class or group, the time actually taken for each subject area will vary even if the same instructional team is used. This is especially true in respect of time allocated to practical activities. Where group activities are involved, group dynamics will vary significantly as the compositions of the groups are changed during the course, to prevent the members of a group repeatedly relying on the same person to lead their discussions. The detailed teaching syllabus must be carefully studied and appropriate lesson plans or lecture notes compiled. An example of a lesson plan is set out on page 59. Each lecture should commence with a statement of the objectives it is intended to achieve. At the end of each lecture, the trainees should be guided in further reading and any activity they should undertake. Questions arising from such readings and activities must be given priority at an appropriate time.

The learning objectives of every session should be made known, and their achievement

discussed with the participants at frequent intervals. Monitoring the achievement of objectives and taking remedial action are an important part of managing any learning process.

As far as possible, sessions should be presented within a context which is familiar to participants and use should be made of practical examples. They should be well illustrated and make full use of the teaching aids and the exercises presented in this manual. Included are exercises that will raise the participants' awareness of the scope and value of the course. It should be noted that alternative exercises may be developed by the instructor, based upon other IMO model courses.

The presentation of the various subject areas should be done in such a way that all those taking part in the course are involved in an interactive manner during the lecturing and tutorial process. Lecturers should encourage questions from the trainees and encourage other trainees to offer their opinions on the questions raised.

The lecturing should aim at conveying as much practical information as possible to the participants, in order to develop their knowledge of and their skills in the tasks they will be expected to carry out.

The course contains a series of exercises, some of which are linked. The output of exercises cover learning objectives of that particular subject area. The exercises in Section 12 of the course is an examination of the application of the knowledge and skills acquired during the course.

The teaching methods of dictation and student note-taking should not be used. Handouts for additional study may be prepared and distributed to enhance the learning outcome.

Further background material to the development of the programme is contained in the materials listed in Part A.

Guidance Notes

1) Course Introduction (1 hour)

The purpose is to introduce the course as a part of the overall IMO training strategy to improve the training and certification standards of seafarers. The target group of trainees for this course are those persons who will conduct in-service assessment of competence of seafarers on board, intended to be used in qualifying for certification under the STCW Convention. Reference should be made to Section A-I/6 of STCW 95.

The trainees should be advised that, during the course, the lectures will be supplemented by individual and group activities involving such matters as competence-based assessment techniques.

While

the present course aims at familiarizing participants with the various methods that may be used to assess the competency of trainees on board ship, it is essential that practical experience is gained under the supervision of an experienced shipboard assessor.

However, the problems encountered in assessing the competency of seafarers are similar whatever discipline is involved, and whether the assessment is carried out ashore or on board.

2) Process Overview (1 hour)

This is intended to introduce the participants to the competence-based assessment process, outlining briefly the various components of the total system. It is not intended to deal with any of the matters in depth; however, it is important at this stage of the course that questions arising from the presentation are dealt with in a substantive way so as to start generating a good rapport between the class and the instructor, and between the members of the class.

Stress that the assessment process must comply with quality standards as stipulated in Regulation I/8 of STCW 95.

Introduction

While a number of differing processes may be employed to satisfy the requirements of the revised STCW Convention, all must ensure that candidates for certificates of competency to be issued under that Convention meet all requirements of national and international laws. The requirements laid down in the STCW Convention specify minimum age, medical fitness, experience and standards of competence.

International law

Requirements of international law are contained in conventions and protocols; these may be bilateral in certain instances but in the main they are multilateral treaties between States.

States become Parties to these conventions and protocols by ratifying them or by accepting them. In so doing they bind themselves to comply with all requirements of such conventions and to take all steps that may be necessary to give full effect to them.

National legislation

International law is given effect by the States concerned incorporating all necessary measures into their national law, rules, regulations, administrative orders and instructions.

It is therefore essential to a process of training, examination and certification that the national legislation provides all necessary authority to ensure that certificates are only issued to those who are properly qualified and further prohibits ships from sailing without the requisite complement of certificated personnel.

Examples of national laws which typically provide the necessary legal framework covering the documentation, training, examination and certification of merchant marine personnel may be consulted on application to any maritime administration.

Competency

The objective of requiring merchant marine personnel to hold appropriate certificates is to ensure that they are competent to safely carry out all tasks associated with the functions they fill on board ship.

Competency is defined as the ability to do a task adequately, and in the case of seafarers the range of tasks which may be involved is considerable.

Before anyone can evaluate the competency of a seafarer we must know as precisely as possible exactly what we are evaluating. In most countries the syllabuses for the examination of seafarers for certificates of competency have in the past been drawn up simply on the basis of experience, through listing a series of topics, without a great deal of attention being necessarily expended on defining the precise level of knowledge, the degree of skill and the type of behaviour which should be required of candidates to ensure that they will safely and efficiently perform the duties that they will be called upon to undertake.

Job analysis

A modern approach to training is first to carry out a job analysis, so as to clearly identify the specific tasks involved. The areas and levels of knowledge and the types and degrees of skill necessary to perform each task competently are then identified.

The STCW Convention

The revised STCW Convention introduced the concept of “competence” for various functions at each level of certification as the basis for certification. The knowledge, understanding and proficiency required for each competence are specified. The 1978 Convention did not specify the required knowledge in detail.

The new STCW Code addresses this shortcoming by establishing, for the first time, uniform standards in particular maritime skills. The revised Convention contains specific criteria detailing the standards of knowledge, understanding and proficiency to be achieved in each element of competence, for example:

STCW Code, Chapter III

Section A-III/3: Mandatory minimum requirements for certification of chief engineer officers and second engineer officers on ships powered by main propulsion machinery of between 750 kW and 3,000 kW propulsion power

Standard of competence

- Every candidate for certification as chief engineer officer and second engineer officer of seagoing ships powered by main propulsion machinery of between 750 kW and 3,000 kW power shall be required to demonstrate ability to undertake, at management level, the tasks, duties and responsibilities listed in column 1 of table A-III/2.
- The minimum knowledge, understanding and proficiency required for certification is listed in column 2 of table A-III/2. This incorporates, expands and extends in depth the subjects listed in column 2 of table A-III/1 for officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room.
- Bearing in mind that a second engineer officer shall be in a position to assume the responsibilities of the chief engineer officer at any time, assessment in these subjects shall be designed to test the candidate's ability to assimilate all available information that affects the safe operation of the ship's machinery and the protection of the marine environment.
- The level of knowledge of the subjects listed in column 2 of table A-III/2 may be lowered but shall be sufficient to enable the candidate to serve in the capacity of chief engineer officer or second engineer officer at the range of propulsion power specified in this section.
- Training and experience to achieve the necessary level of theoretical knowledge, understanding and proficiency shall take into account the relevant requirements of this part and the guidance given in part B of this Code.
- The Administration may omit knowledge requirements for types of propulsion machinery other than those machinery installations for which the certificate to be awarded shall be valid. A certificate awarded on such a basis shall not be valid for any category of machinery installation which has been omitted until the engineer officer proves to be competent in these items. Any such limitation shall be stated on the certificate and in the endorsement.
- Every candidate for certification shall be required to provide evidence of having achieved the required standard of competence in accordance with the methods for demonstrating competence and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-III/2.

Near-coastal voyages

- The level of knowledge, understanding and proficiency required under the different sections listed in column 2 of table A-III/2 and the requirements of paragraphs 2.1.1 and 2.1.2 of regulation III/3 may be varied for officers of ships engaged on near-coastal voyages, as considered necessary, bearing in mind the effect on the safety of all ships which may be operating in the same waters. Any such limitation shall be stated on the certificate and in the endorsement.

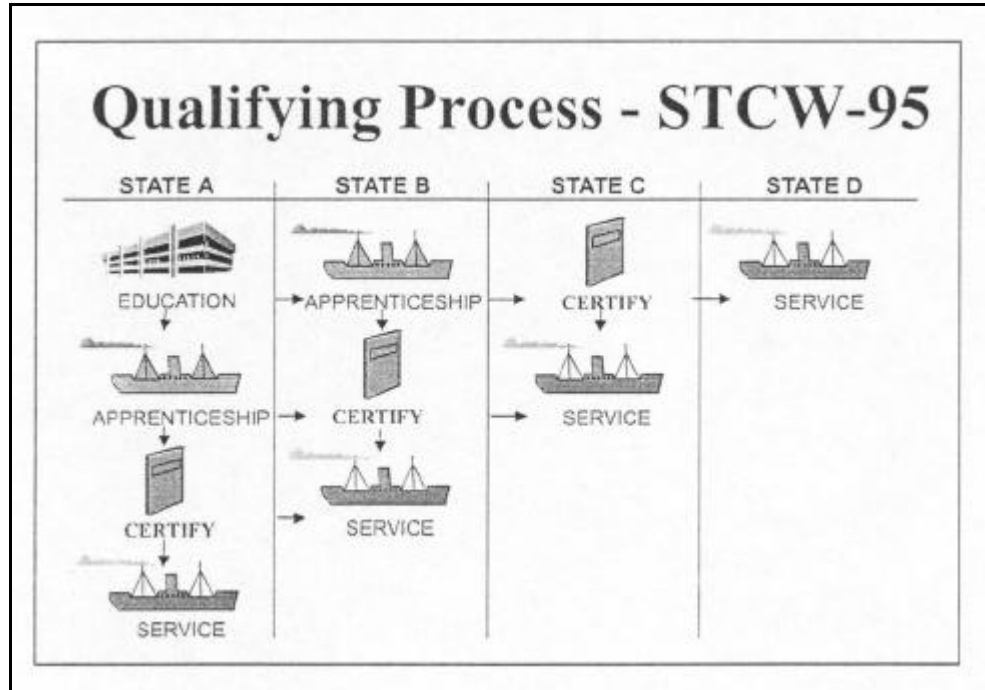
It should also be observed that the revised STCW Convention does not prescribe minimum levels of manning. It deals solely with the qualifications of shipboard personnel. International provisions for manning are contained in IMO Assembly resolution A.890(21), Principles of Safe Manning. The resolution was presented to the IMO Assembly in 1999 and supercedes Resolution A.481(XII).

Training and assessment

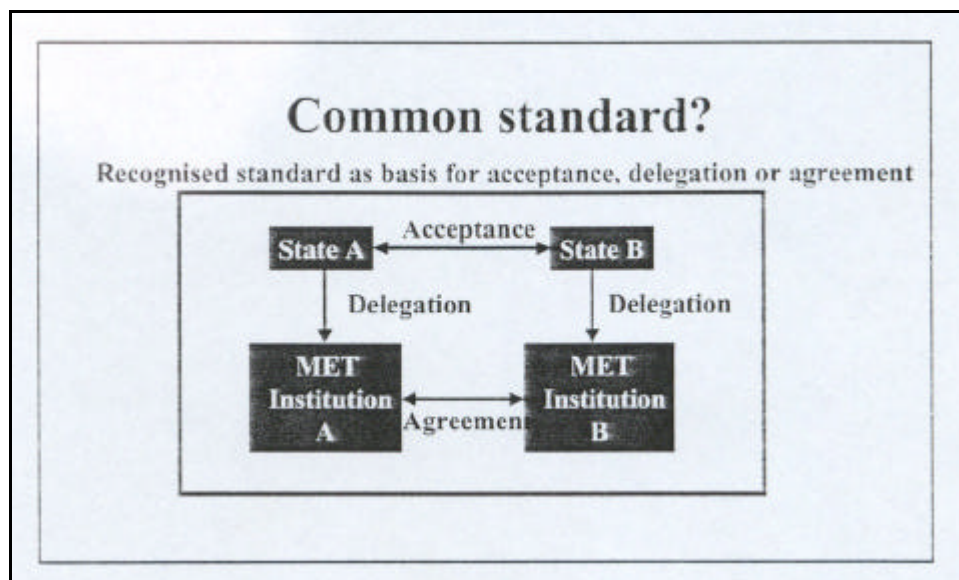
Under the revised STCW Convention regulation I/6 and section A-I/6, all training and assessment of seafarers is required to be administered, supervised and monitored. Moreover, the trainers and assessors have to be appropriately qualified. Further, regulation I/8 and section A-I/8 require quality standards to be applied to all training and assessment activities.

Qualification Process

The revised STCW Convention gives a range of possibilities with regards to the qualification process. In theory, a seafarer may complete his education in State A, do his sea service and/or participate in in-service training in State B, get his certificate from State C, and serve aboard a ship in State D. Such a qualification process will only work if the different states involved are confident that the education and training systems in other states are compliant.



There is a need for a common standard to make the qualification process work in accordance with the STCW-95 intentions. Such a recognised standard may serve as a basis for acceptance from other States with regards to the maritime educational and training system as such. The standard could also facilitate delegation of responsibility to the individual MET institution. Moreover, agreements on co-operation may be facilitated.



3) IMO and Its Contribution to Training (1 hour)

A short talk on the IMO, and IMO's role in education and training, should be given.

Video V1 provides a useful introduction to the role and achievements of the IMO, and V2, B5 Chapter 21 and B8 all give a summary of the amendments in STCW 95.

The purpose here is to introduce the course as an essential part of the overall IMO strategy to improve maritime training and certification standards for seafarers.

The following IMO Model Courses are designed to address the competences specified in the STCW Convention. Each of these courses calls for the assessment of competence in one way or another. The criteria to be used in evaluating competence are specified in the STCW Code. This is covered at a later stage in this course.

List of IMO Model Courses for which Assessment is an Essential Part

- 1 Officer in Charge of a Navigation Watch
- 2 Master and Chief Mate
- 3 Officer in Charge of an Engineering Watch
- 4 Chief Engineering Officer and Second Engineering Officer
- 5 Navigation at the Operational Level: Radar Navigation, Radar Plotting, and ARPA
- 6 Navigation at the Management Level: Radar, ARPA, Bridge Teamwork and SAR
- 7 Proficiency in Fire Prevention and Fire Fighting
- 8 Proficiency in Advanced Fire Fighting
- 9 Proficiency in Personal Survival Techniques
- 10 Proficiency in Survival Craft and Rescue Boats other than Fast Rescue Boats
- 11 Proficiency in Fast Rescue Boats
- 12 Proficiency in Personal Safety and Social Responsibilities
- 13 Tanker Familiarization
- 14 Specialized Training for Oil Tankers
- 15 Specialized Training for Chemical Tankers
- 16 Specialized Training for Liquefied Gas Tankers
- 17 Proficiency in Elementary First Aid
- 18 Proficiency in Medical First Aid
- 19 Proficiency in Medical Care
- 20 Crowd Management, Familiarization and Safety Training for Personnel Providing Services to Passengers in Passenger Spaces
- 21 Crisis Management and Human Behaviour Training; and Passenger Safety, Cargo Safety and Hull Integrity Training

It must be emphasized that whilst many Administrations also examine candidates for certificates valid in fishing vessels and for certificates valid in internal waters as well as for certificates for the operation of radiocommunication equipment, the present course mainly concentrates on the certification of masters, mates and engineer officers.

However, whatever discipline is involved, the problems encountered in assessing the competency of seafarers are similar.

The course can be readily adapted to the training of assessors in any discipline by substituting material specific to the discipline concerned in the various activities undertaken during the course.

In this section should stressed that IMO courses cover a wide range of subjects from the support level to the management level; some are technical and some purely administrative. They include a wide variety of topics for both seagoing and shore-based personnel.

The briefing should further emphasize that the 1995 amendments to the STCW Convention require a minimum standard of competence in the task to be performed. For this reason the training and assessment of seafarers is required in compliance with Regulation I/6 of STCW 95.

Thus, even when confronted with the task of implementing competence-based assessment on board the ship, the assessor must approach the task with considerable flexibility in order to succeed within the particular circumstances. The structure and contents of this course are designed with the above firmly in mind.

4) Purpose of this Course (0.5 hour)

This section of the course aims at familiarising the trainee with the basic structure of certification embodied in the 1995 STCW Convention and emphasising competence-based assessment onboard ship.

The objective is to allow trainees to gain an insight into the practical training value of sea service performed in various types of ships and during various types of voyages. This, however, is realistic and should help to produce the desired outcome of this course. An appreciation of the knowledge and skills which are required of shipboard assessors should include:

- Training Awareness
- Substantive Knowledge
- Assessment Skills
- Managerial Skills
- Attitudes

The output of the exercises and group activities later in the course should be a "catalogue" or list of problems of implementation of shipboard assessment and of the skills which the participants find they must acquire, i.e. their own training needs. These should be seen as the personal objectives of individual participants. Subsequently, the instructor should demonstrate the plan for the current course, and point out how it corresponds to the needs derived from the exercises. Reference should be made to the variety of competences required as stipulated in STCW 95.

5) Development of Shipboard Assessment System (1.5 hour)

An introductory briefing should contain a description of the "learning style" of the course, by emphasizing its "participative" and "interactive" nature. In this connection, the extensive use of group work and exercises should be introduced, together with a summary of work management in groups, keeping in mind that both group work and interactive training are dealt with in detail later.

First, it is important to distinguish "education" from "training". Education usually means the preparation for careers and for life in general, which involves learning concepts, principles, problem-solving methods etc., whereas training rather means the preparation for a specific job or set of tasks. The content of a training course is therefore more specialized than an educational programme. Some training courses contain supportive elements which many would describe as educational. This often applies to long courses.

The basic premise is that training involves **LEARNING** which is designed to change the **PERFORMANCE** of **PEOPLE** doing **JOB**S.

The four capitalized words in the definition - learning, performance, people, jobs - embrace quite a lot about training. The relationship between the terms becomes even more involved.

Training courses are often said to be aimed at skill development, implying that they are not knowledge-based. However, training often requires the learning of knowledge.

It is worthwhile to take each component of the definition of training and examine it more thoroughly, beginning with the last word in the definition - **JOB**S. By doing this it is possible to emphasize the importance of the job to the design of learning. Further, as will be seen later, the trainer should begin the process of planning a training programme with some ideas and information about the work which has to be done.

Jobs

Jobs are made up of a number of specific tasks that people do. The number of tasks, their complexity and difficulty, and the relationship between them vary widely from job to job. The knowledge, skills and attitudes required for job performance also vary. Also there is often a range of acceptable differences in the way individuals do the same job. Nevertheless, there is usually a core of tasks and skills which are the same for a given type of job. If training is to improve job performance, the job itself must be fully understood.

People

When dealing with adults doing jobs, one must take account of the fact that the trainee brings to the training situation existing knowledge, skills and attitudes regarding that job, as well as ways of learning. This necessitates paying attention not only to the aims of training, but also to the aims - and existing skills, knowledge and attitudes of the **LEARNER**.

Performance

The performance of people doing jobs means how well they carry out the tasks that make up their job.

When job performance is judged and found to be below standard, training may change job performance. This approach to training is based on the need to change job performance, not on the other often used reasons for training, such as informing, motivating or rewarding. Generally, there is a need to change job performance when:

- the employee does not know how to do all or part of his/her current job
- the employee is given new tasks requiring new knowledge, skills or attitudes
- the employee is given an entirely new job requiring new knowledge, skills or attitudes.

Each of these may require a different training policy or strategy, or they may require no training at all, as we will see in later sessions.

Generally, training is needed when discrepancies exist between what an employee is expected to do and what he/she actually does, and only then if these discrepancies can be reduced through learning. It is important to recognize the difference between the symptoms, e.g. poor performance and the causes.

Learning

The word "learning" generally refers to a change of some kind in the learner. Such changes are often classified as:

Psycho-motor - physical and manipulative skills such as those required to operate equipment, a machine or an instrument.

Cognitive - the ability to recall learned materials, and the development of thinking skills.

Affective - attitudes, values and interests.

Testing

Testing is a procedure used to measure a sample of behaviour in order to discover how well a student performs, usually in comparison with others, or compared with identified performance criteria. In this context it is important that the test, in whatever form it is being used, yields consistent results by being valid, reliable and practical. Whilst we can only take a sample of a person's knowledge or comprehension about a topic in this way, testing methods do provide a more reliable estimate of performance than most other observational techniques; unsystematic or irregular observation being too unreliable.

With measurement, we are concerned with getting a statement of performance, i.e. how much?, against some established scale or rule, usually expressed in a quantitative form although it may be non-numerical. During this process information and data is being gathered but it must be systematic, valid and reliable.

Assessment

Assessment can be considered as placing an interpretation on measurement information and is usually concerned with assigning a score, mark, grade or ranking. Assessment procedures (e.g. norm-referenced assessment, criterion-referenced assessment and goal-based assessment) may be used to make judgements and decisions about students, lecturers, courses, resources or curricula. Judgements about the value of such data are properly the role of evaluation. Evaluation depends upon both measurement and assessment and is concerned with the assignment of worth or merit to particular performances, behaviours, or processes.

Purpose of assessment

Students are assessed with a view to finding out the extent of their knowledge, understanding and skill, and how well they have learned. In general there are several recognised main purposes for assessment, namely motivating students, grading for advancement (further studies, career, etc.), standards setting and providing feedback to students and teachers. Their impact on the assessment process can be varied however and the lecturer setting the assignment, test or examination must be clear about the objectives of such assessment if it is to achieve its purpose.

Assessment is only one inter-linked part of the teaching process model (objectives, syllabus and assessment) and may be permitted to dominate it if care is not exercised. It is a fact of life that if marks are not an outcome in some form or other, students will not be motivated to put in their best effort. If practical work is not assessed or does not contribute to assessment, then students will ignore it. The lecturer faces the challenge of selecting and creating the most effective and relevant assessment method.

Methods of assessment

In considering the methods to be used, it is worth bearing in mind some of the factors which can contribute to a student's score:

- General level of intelligence.
- Knowledge, skills and ability in the tested area.

- Ability to understand instructions.
- Skill and experience in sitting for examinations and in answering the type of questions used.
- "Luck" in choosing questions and guessing answers.
- Student health, fatigue, motivation, stress, memory fluctuation.
- Combining of examination results.
- Unreliability of marking.

The chance or uncertainty element in the above can be reduced by:

- Keeping instructions clear and simple.
- Avoiding difficult vocabulary or irrelevant special knowledge.
- Providing students with pre-assessment experience and adequate motivation.
- Controlling assessment conditions.

Video V4 and the booklet that accompanies the video provide useful explanations and illustrations of what assessment under STCW 95 means in practice. V3 covers only on board training.

6) Development of Competence-based Assessment (2 hours)

Up to the present time, most certificate of competency examinations conducted ashore have tested *knowledge* rather than *skills*. Both knowledge and skills are needed and it is on board ship that real competence must be demonstrated.

Knowledge-based assessments are usually in the form of written or oral examinations.

Skill-based assessments are usually in the form of observation of the candidate's practical knowledge.

Competence-based assessment incorporates the assessment of:-

- skills to specified standards
- relevant knowledge and understanding
- ability to use skills and apply knowledge and understanding to the performance of relevant task

Assessment is about the collection of evidence. All forms of assessment can be included in this description - from everyday activities to the most complex statistical system.

The choice of assessment methods for a particular task should take into consideration factors that may influence it such as:-

- assessment objectives
- qualifications of candidates
- the comparative effectiveness of different assessment methods
- constraints of time
- availability of facilities
- cost

-- hazards

The purpose of assessment within a programme of learning is to collect sufficient evidence to demonstrate that trainees have learned at least the required minimum percentage of the syllabus. If the programme of learning is also linked to an award system, a further purpose may be the achievement of formal recognition that learning has been acquired. This usually takes the form of a certificate or diploma.

In a competence-based assessment system, the purpose of assessment is to collect sufficient evidence that individuals can perform or behave to the specified standards in a specific role. If this assessment is also linked to an award system, a further purpose is formal recognition of successful performance.

These facts were recognised when the STCW Convention was revised. The revised Convention aims to ensure that seafarers in the future will be fully competent. It is necessary to ensure that formal assessments are properly organised, carried out and recorded. It will be necessary to ensure that the evidence gathered is acceptable to national authorities responsible for issuing certificates of competency.

It should also be remembered that there are specified requirements for continued professional competence and revalidation of certificates, and refresher and updating training.

The Assessment Process

A process is a "series of actions or events", or a "sequence of operations". We could say that all forms of assessment involve the following sequence of operations:

- defining requirements or objectives of assessment;
- collecting evidence;
- matching evidence to requirements or objectives;
- making judgements based on this matching activity.

In order to operate a competence-based approach we need assessors. These are people who are competent within the area being assessed and have received training on how to support and assess others. Assessors need to use the standards to check for competence. To do this they will use a variety of methods but will always use the standards.

A 'competence standard' contains details of what needs to be demonstrated (performance criteria), in what circumstances or conditions it must be completed (range statements) and what knowledge is required to be able to do it effectively (underpinning knowledge, skills and attitudes).

Performance criteria are the key to the competence-based approach as they contain the details of what must actually be done to complete the task.

Range statements are also important as they give the variables, circumstance or conditions under which competence must be demonstrated.

Range statements have to be written to be as comprehensive as possible. In some cases this can cause problems for trainees. For example, the range statement for -

Respond to the malfunction of vessel's systems affecting navigation
may say:

Provide a navigational response to emergencies to the vessel for :

- the vessel dragging anchor during your watch;

- failure of navigational equipment, such as gyro compass, GPS and echo sounder;
- loss of power to electronic navigational equipment; and
- sudden failure of steering gear.

In a well run and well maintained vessel many months may pass without a need to respond to a failure or malfunction of the engines or navigational equipment. Nevertheless, it is important to know what to do; what procedures and what actions to take when things do go wrong or should an emergency arise.

In this case it is entirely possible that some candidates will not have experienced failure of the steering gear, what does the assessor do?

What is needed is that individuals should produce real evidence of those areas where they do have experience. The assessor will then need to be satisfied, by questioning and discussion, that the candidate understands how to transfer the skills to those parts of the range for which direct evidence cannot be produced. They may have participated in drills or, if not, they should certainly be familiar with the procedures on board for such events.

The underpinning knowledge, skills and attitude requirement is important because it ensures a full understanding of the task.

Competence-Based Assessment

You may notice some key differences in the competence-based assessment approach:

- focus on "outcomes";
- individualized assessment;
- no percentage rating;
- no comparison with other individuals' results;
- all standards (requirements) must be met;
- on-going process (leads to further development and assessment);
- only "competent" or "not yet competent" judgements made.

As we have already noted, the purpose of competence-based assessment is:

To collect sufficient evidence to demonstrate that individuals can perform or behave to the specified standards in a specified role.

We can add to this definition by clarifying that in competence-based assessment we are referring to work roles and therefore to standards of occupational competence. Occupational competence reflects performance at work. Our definition of the purpose of competence-based assessment will therefore look like this:

To collect sufficient evidence of workplace performance to demonstrate that individuals can perform or behave to the specified standards required within a specified occupational role.

This differs drastically from traditional forms of occupational assessment in which evidence collected relates to what has been learned. In competence-based assessment, our key concern is actual performance. Our focus is therefore, on what individuals can do rather than what individuals know.

This outlines the key purpose of competence-based assessment. The issue of "perform" vs "behave" in the definition above will depend on whether we have set vocational outcomes or behavioural outcomes as the basis of our competence system.

Practical Implications of Competence-Based Assessment

The introduction of competence-based assessment at national, organizational or departmental level has wide implications for managers, for trainers, and for those being assessed.

Unlike traditional forms of occupation-related assessment, competence-based assessment can be, and should be, undertaken in the workplace, and should be individualized.

Who Assesses?

The first question then is if assessment is to be undertaken in the workplace, who are the assessors?

The most obvious choice is the person who has the necessary knowledge and competence in the particular task to be assessed. This arrangement raises a number of questions:

Do shipboard officers have time to undertake formal assessment?

What if the officers or assessor doesn't like or has a poor relationship with the person being assessed?

What skills will assessors need?

The Assessor's Role

It is the assessor's role to help the candidate show competence in the area being assessed. The important thing about assessment is that it is about someone's ability to complete a task competently and not just a test of knowledge. But what is competence? Competence is the blend of skills, knowledge, values and attitudes required to consistently perform a task to an agreed standard.

The assessor must give the candidate the opportunity to demonstrate the ability to perform a specific task to the required standard. This demonstration will be by a variety of methods ranging from observation of the candidate performing a task, through to the candidate producing written evidence to support his/her competence.

If the candidate can prove he/she can perform the task consistently and correctly, then he or she is competent. If this cannot be proved, the candidate must be given guidance and support until assessment can take place again.

The best way to keep all of the assessments together is in a portfolio of evidence. It is very likely that the majority of candidates will be putting together a portfolio of evidence for the first time and will need a fair amount of help at the beginning of the process.

Feedback from assessors who have worked through the assessment process indicates that there are a number of logical steps which need to be taken to make sure the process moves along smoothly.

Skills of an Assessor

Anyone wishing to become an assessor will need to develop some particular skills. The points listed below cover the key skills that an assessor needs.

The assessor must:

1. Be competent in the area being assessed. This does not mean ‘must hold the certificate themselves’ but all assessors must have sufficient knowledge and skill in the area being assessed. How else will they be able to accurately judge others’ competence?
2. Be comfortable with the whole approach to assessing and the use of a competence-based approach. This includes the paperwork, the vocabulary and the ethos of the scheme.
3. Know how to relate the standards to examples that others can understand and identify.
4. Identify appropriate and sufficient evidence for each standard. The evidence should also be attributable to the individual.
5. Conduct direct observations of performance in an unobtrusive way and give constructive feedback to candidates.
6. Decide whether the evidence presented meets the standard. Does it match the range statements and performance criteria?
7. Identify the gaps where evidence is needed and give guidance about types of evidence to gather, or give training and support as required.
8. Give constructive feedback to people being assessed (including saying ‘no’ if necessary).
9. Be able to write an objective record of the assessment meeting.
10. Meet other assessors regularly to ensure a common approach. This includes being able to explain and agree assessments with other assessors and, if necessary, justify them.
11. Liaise closely with others to follow the progress of individuals being assessed without breaking any confidentiality.

In the United Kingdom assessment for vocational qualifications (commonly known as VQs) is a very formal process based on collecting observation evidence of a candidate’s performance. Most VQs have a very rigid way of working and are very specific about the type of evidence required for each element.

While it is important that all of the performance criteria, range and knowledge parts are completed, there are no requirements for large volumes of evidence to be produced. What is important is showing that the candidate is competent.

What about Quality?

The second implication concerns the movement of assessment to a local rather than a central basis:

- How can quality of assessment be assured if it is undertaken locally by shipboard officers?
- Who trains assessors?
- Who ensures that quality of assessment is maintained?
- Who pays for this?

The IMO competence-based assessment system is introduced for certification of seafarers as per the STCW 95 Convention.

We also need to consider what other purposes competence-based assessment can be put to within shipboard organization, and what resources we will need.

What about training?

Last but not least is the issue of linking competence-based assessment to training. As the assessment system operates on a continuous - rather than one-off- basis, and is operated within the workplace environment, training needs are identified at individual level. Questions here include:

- What systems do we need to ensure that identified training needs are communicated to those who can take relevant action?
- In what way do we need to reorganize our training resources to provide training which meets those needs?

For maritime training institutions and for shipping companies, the issues of resourcing, reorganization and administration are paramount.

Qualifications of Trainers and Assessors

All ships' officers are normally expected to play their part in training junior officers, cadets and crew members, passing on their knowledge and experience in their own specialist disciplines. They are also expected to evaluate the performance of trainees and provide evidence to be used as part of the certification process.

Those who are appointed with a specific and formal training or assessment role will need to pay attention to the more detailed provisions of the Standards of Training, Certification and Watchkeeping (STCW) Convention as follows. The mandatory part of the STCW Code Section A-I/6 paragraph 3 requires that, *"each party shall ensure that instructors, supervisors and assessors are appropriately qualified for the particular types and levels of training or assessment of competence of seafarers either on board or ashore, as required under the convention..."*. Part B of the code contains further guidance to assist in interpreting the requirements.

The STCW Code defines in-service training requirements. The main provisions affecting ships' officers (from Section A-I/6 paragraph 4 and 5) are as follows:

- 1) Any person conducting in-service training of a seafarer ... on board ... which is intended to be used in qualifying for certification under the Convention shall:
 - a. Have an appreciation of the training programme and an understanding of the specific training objectives for the particular type of training being conducted
 - b. Be qualified in the task for which training is being conducted: and ..
- 2) Any person responsible for the supervision of in-service training of a seafarer intended to be used in qualifying for certification under the Convention shall have a full understanding of the training programme and the specific objectives for each type of training being conducted.
- 3) Any person conducting in-service assessment of competence of a seafarer ... on board ... which is intended to be used in qualifying for certification under the Convention shall:
 - a. Have an appropriate level of knowledge and understanding of the competence to be assessed;
 - b. Be qualified in the task for which assessment is being made:
 - c. Have received appropriate guidance in assessment methods and practice;
 - d. Have gained practical assessment experience.

Don't be put off by the jargon. It is not a new system. It is formalising a system which we have used for years, in which the real judges of competence are the senior staff who are responsible for the development of their juniors.

Trainees are expected to be familiar with the ISM Code (see R7), thus there is no in-depth coverage of the ISM Code in this course. If this is not the case some time will need to be devoted to this topic. Reference B3 Ch.5 and B5 Ch. 27 provide practical advice and guidance.

Activity 6.17 — Generates documented procedures for conducting assessment (1 hour)

The purpose of this activity is to allow trainees to gain an insight into the process of maintaining control in the conduct of competence-based assessments.

The important consideration is to have procedures that are practical and controls that are readily verifiable.

It is best to have the activity performed in groups composed of trainees from training / examining bodies and members of Administrations, if possible. This will encourage sharing of viewpoints to get the most of practicality in implementation and the control mechanism.

7) The On-board Assessment (1.5 hours)

Definitions

Shipboard Assessment is a process by which shipboard performance is observed, measured and compared to standards of performance in order to determine a mariner's proficiency.

A *performance objective* is performance, representing an aspect of a mariner's skill or knowledge that is necessary for successful completion of a shipboard task.

A *performance measure* is an observable action, or indication of an action, that is recordable.

A *performance standard* is an established minimum level or boundary of performance based on relevant assessment criteria.

Formal Assessment for (STCW) Certificates of Competency

Shipboard assessment should be carried out in accordance with Regulation I/6 of STCW Convention and Section A-I/6 of the STCW Code. If a seafarer's Certificate of Competency is to be issued by a national administration which has already established an approved training and assessment system which meets the requirements of STCW, then the shipboard training, shipboard assessments and record keeping should be in accordance with that national scheme.

The STCW Convention states, that every candidate for certification as officer in charge of a navigational watch of ships of 500 gross tonnage or more ... whose seagoing service forms part of a training programme approved as meeting the requirements ... shall follow an approved programme of on board training which:

- ensures that during the required period of seagoing service the candidate receives systematic practical training and experience in the tasks, duties and responsibilities of an officer in charge of a navigational watch ...
- is closely supervised and monitored by qualified officers aboard the ships in which the seagoing service is performed; and

-- is adequately documented in a training record book or similar document

On board training requirements are also specified for candidates for certification as officer in charge of an engineering watch or as designated duty officer in a periodically unmanned engine-room of ships powered by main propulsion machinery of 750 kW or more.

The assessment process can be viewed as a series of six sequential steps. The first four steps involve the development of assessment procedures and the assessment package and should be conducted by shore based personnel as part of the approved training program in which the training record book is to be used. A qualified individual aboard a ship should conduct the assessment. The individual who conducted the assessment should prepare the performance improvement plan. The six steps are listed below:

1. Identify performance objectives
2. Identify performance objectives for shipboard assessment
3. Determine performance measures and standards
4. Prepare assessment package
5. Conduct assessment
6. Develop a performance improvement plan

Activity 7.8 — Designs a feedback form for monitoring the process (1 hour)

The aim of this exercise is to help trainees design feedback forms that collect relevant information to improve their quality system. Trainees should be advised that the feedback forms must (a) provide for sufficient space for effective information, but at the same time are not too lengthy, (b) take account of various category of seafarers, from ratings to masters and chief engineers, and (c) relate only to quality issues.

After the activity, one or a number of the forms can be selected for presentation by filling them up arbitrarily and then seeking comments from the trainees on their effectiveness for the forms' intended purpose.

8) Identify Performance Objectives (2.5 hours)

The main aim is to identify the performances, or non-performances, which lead to dire consequences if not properly carried out. Candidates should be briefed on the resource materials available to identify these performances. It should be pointed out that, all too often failure to perform or omission to perform certain critical step(s) in a given task results in unfavourable events leading to material/environmental/human sufferings. This will make the assessment more meaningful as it underscores the importance of ensuring that candidates acquire the competences required.

Activity 8.2 — Performs a task analysis (1 hour)

The objective of this activity is to show how a specific function of a ship's officer may be defined in terms of the tasks which must be carried out in order to perform that function satisfactorily, and upon which general training objectives may be based.

This exercise may best be carried out by dividing the class into small groups. Group sizes should be limited to a maximum of 4.

For this activity, until action 2 of activity 8.3 that follows, it is prudent to avoid giving the trainees the opportunity to refer to the table of competency standards, on fire prevention and fire fighting, in the STCW Code. Differences in the analysis between groups will serve to show that the scope of training schemes will always be, to some extent, subjective and to emphasize the need to involve representatives of the industry, including practicing seafarers, in the validation of such analyses. It therefore highlights the value of having the standards in STCW Code to serve as common reference points for consistency of standards internationally.

Learning objectives¹

Learning objectives serve as guides for both trainers and assessors. With clearly defined outcomes, it is easier to produce better training and better evaluation.

Instructional or learning objectives are intended outcomes towards which trainees progress; they are the end results stated in terms of *change of behaviour*. In constructing learning objectives we are always concerned with the products of training rather than the process by which this is intended to be achieved, ie it is trainee oriented, rather than assessor oriented.

Take an example concerned with lifting blocks and tackle, equally applicable on deck and in the engine room. In addition to *knowledge* of parts of the blocks and different types of blocks a trainee must have *skills* and *ability* which may be defined as follows:

- Skills in using blocks and tackles safely

- Skill in reeving tackles

- Ability to select the correct tackle for the job

These are the learning outcomes that the assessor looks for.

Stating learning objectives as Learning Outcomes

The list of objectives should be detailed enough to convey clearly the intent of the training and instruction. This may be best achieved in two steps; first by stating the general objective: second by listing under each general objective a sample of the specific types of behaviour that trainees are expected to demonstrate. This is important if a specified standard is to be met.

For example, in general terms:

- Trainees should understand principle “XXXX” (the general objective)

Specific learning objectives:

- Describe principle “XXXX” in his/her own words

- Identify examples of principle “XXXX”

- List the differences between principle “XXXX” and “YYYY”

¹Trainers wishing to study this matter in more depth may find IMO Model Course 6.09 *Training Course for Instructors* of value.

Explain the relationship between principle “XXXX” and principle “YYYY” and “ZZZZ”.

Note:

- the general learning objective is a verb (understands)
- it is not necessary to be repeat and state ‘Trainees should’ every time
- the general learning objective is a verb (understands)
- each specific objective begins with a verb which is observable in some by an assessor

Example:

Controlling the operation of the ship and care for persons on board at the operational level

Maintain the Sea-worthiness of the Ship

Demonstrates a knowledge and understanding of stability, trim and stress tables, diagrams and stress-calculating equipment

Trim

- defines ‘trim’ as the difference between the draught aft and the draught forward
- states that trim may be changed by moving masses already on board forward or aft, or by adding or removing masses at a position forward of or abaft the centre of flotation
- defines ‘centre of flotation’ as the point about which the ship trims
- states that the centre of flotation is situated at the centre of area of the waterplane, which may be forward of or abaft amidships
- uses hydrostatic data to find the position of the centre of flotation for various draughts
- uses hydrostatic curves or deadweight scale to find the MCT 1cm for various draughts
- given the value of MCT 1cm, masses moved and the distances moved forward or aft, calculates the change in trim

This is what is meant by stating the specific learning outcomes in behavioural terms. It is terms like these which make precisely clear what the trainees will have to do in order to demonstrate their understanding.

Activity 8.3 — Writes detailed learning outcomes that demonstrate competence (1 hour)

The objective of this activity is to provide an insight into how detailed learning outcomes can be written to describe what a trainee should know and should be able to do to meet general training objectives and also to act as the basis for the construction of test items.

The same groups as for the previous activity should be asked to put into learning objectives the required knowledge and skills identified by them in the previous activity. They should be instructed to include in the objectives any constraints or performance standards which they consider relevant. The suitability of the objectives for use in drawing up tests should form part of the discussion during the presentation.

Instructors should ensure that specific learning objectives are presented using ‘acceptable’ verbs and actions, not verbs such as ‘understands’, ‘knows’, ‘appreciates’, ‘realises’, ‘believes’ etc. Each outcome should indicate exactly how the trainee would demonstrate that the skill or knowledge has been achieved.

So from the exercise the trainees will learn that the procedure for preparing and writing learning objectives (outcomes) include the following steps:

- identifying the general objectives by analysing the purposes and content of topic area
- stating each general objective in broad enough terms so that it embraces many specific behavioural outcomes
- defining each general objective by listing a representative sample of the behavioural outcomes desired.

The general objectives must be realistic to the time allowed for the assessment and for the facilities and training aids available.

Thus learning outcomes provide the necessary foundation for establishing criteria for assessment and evaluation.

9) Select Performance Objectives for On-board Assessment (2 hours)

On-the-job assessment is undoubtably a better option than off-the-job assessment. It provides actual conditions of work where the competences are needed, thus injecting realism. However, not all performances can be appropriately assessed on board the ship.

There are competences that seafarers need to attain prior to being assigned any shipboard duties, and these have to be assessed. For example, they need to receive basic safety training.

There are also constraints, such as the safety implications and the prevailing shipboard operating conditions, which make assessment on board a less suitable alternative for some performances.

The selection of the performance objectives for each individual candidate for shipboard assessment will therefore be based on three criteria. These are the candidate's current skill level, safety considerations, and whether adequate controls can be established for the assessment period.

Activity 9.2 — Generates a series of tasks to assist in shipboard assessment (1 hour)

The objective of this activity is to allow trainees gain experience in defining the tasks for a specific competence such that assessment of the competence can be effectively and realistically carried out. The course may use other competence for the activity, as much depends on the profile of the trainees. Attachment 1, provides two samples of tasks that are generated and defined to assess competences specified in Table A-II/1 and III/1 of STCW Code. These are competences required by officers in charge of a navigating watch on ships of 500 gross tonnage or more, and officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room.

The activity can be carried out in small groups of trainees, each group comprising trainees from the same discipline.

10) Determine Performance Measures and Standards (3 hours)

In the lecture the instructors should emphasize that the assessor must first establish the performance standards for the performances to be assessed, taking into consideration the function level of the competence required. Both performance criteria and assessment criteria should be clearly and explicitly identified, and be conveyed to the candidate.

Methods of measuring the performances should be selected based on objectivity in obtaining the measurement. These may include observation which is verifiable, recording of values from instruments, and time-clocking. The intention is to minimise the use of subjective judgements, so that the assessment outcome can be approached with discreet evidence.

Activity 10.2 — Designs an assessment specification and scoring scheme for a practical test (1 hour)

The objective of this activity is to provide trainees with practice in constructing test specifications and scoring schemes for oral and practical examinations which will ensure reliable testing of a candidate's skills and knowledge and produce a consistent treatment of candidates.

The examples given in Attachment 1, provide the tests objectives, performance measures and performance standards of tasks associated with various competences required in the STCW Code. In particular, Example 4 shows how a particular task, on demonstration of the use of breathing apparatus, in Activity 14.8, would be assessed. The other examples in Attachment 1 are similarly drawn up to assess their respective competences. The instructor can re-design Activity 14.8 to reflect the competences to suit the needs of the course trainees.

Activity 10.3 — Critically reviews methods and outcomes of an evaluation of competence (1 hour)

The purpose of the activity is to gain insight into the effectiveness of different methods and various range of assessments. A particular method may well be suitable and proper for use when assessing one particular competence but not for another.

The activity can be individually carried out or in small groups of trainees from the same discipline. Presentation and comments from class should be encouraged to share opinions.

11) Prepare Assessment Package (2 hours)

There are several components of an assessment package. The three necessary components are (1) the student workbook, including reference material for the candidate; (2) a guide that includes detailed instructions for conducting the assessment, and additional components such as various aids for recording observed performance (checklists, worksheets, work forms) and a summary form of documented results; (3) a scheme to ascertain the compliance or non-compliance of competence performance by the candidate

The assessment package covers the assessment process that is eventually filed for record-keeping. It may be used as evidence, for recalling of facts to formulate training and development plans, as well as for compiling statistics to serve some other purpose.

The instructor should also emphasize that, since the process of assessment is through a quality standard system, subject to verification to ensure validity, reliability and consistency of results, record-keeping is necessary.

12) The Assessment Process (11 hours)

The steps involved in conducting assessment should include:

- the preparation for the assessment
- conducting a pre-assessment briefing with the candidate
- observing the candidate's performance and recording the results
- evaluating the process and determining the assessment outcome
- conducting an assessment debrief.

Preparation for the Assessment

The preparation for the assessment involves the following steps:

1. Gathering of materials
2. Preparing the staging area
3. Preparing and arranging equipment
4. Conducting any necessary safety checks
5. Informing affected personnel

1) Gathering of Materials

To ensure that shipboard assessments are successfully carried out, identifying and gathering of relevant materials for items to be assessed are essential, eg. plans, checklists, manuals, nautical publications, charts, consumables, etc.

If necessary materials are not available, then these have to be procured before any assessment can be carried out.

2) Preparing the Staging Area

The staging area where the assessment is to be carried out has to be thoroughly checked and inspected to ensure a safe working environment. An accident occurring during a shipboard assessment is the last thing that we want! It is important to ensure that the location of the staging area will not hinder the normal operation and functioning of the ship. Appropriate life saving and safety appliances should be readily available if there is any risk of injury during the assessment. Trainee should ascertain the need for appropriate attire, eg. safety shoes, helmet, gloves, goggles, safety belt, etc. and the assessor should ensure that these are used

3) Preparing and Arranging Equipment

The equipment that is used for the assessment has to be identified and checked to ensure that it is in good working condition. Malfunctioning equipment can be hazardous to both trainee and assessor. It is also important to ascertain that the equipment being used for the assessment will not cause disruption to the normal function and operation of the ship.

4) Conducting Any Necessary Safety Checks

Pre-assessment safety checks are essential to ensure that there are adequate control to avoid problems and potential hazards. Contingency plans should be available so that the assessor could regain control if any problem arises during the assessment. Determine the standard safety check list for the item to be assessed and go through the check list thoroughly. For assessment in emergency drills such as boat drill or man-overboard drill, the weather condition during the assessment has to be taken into consideration. Adverse weather condition can make above-mentioned drills hazardous and extreme care has to be exercised. When the assessment involves dangerous operations such as entry into a confined space, a

permit to carry out the assessment should be obtained from the master or responsible officer and ensure that the safety check list for entry into a confined space is carefully followed.

5) Informing Affected Personnel

The trainee and other personnel, eg. watchkeepers and department heads, affected by the assessment must be informed in advance of the date and staging area the assessment is going to be conducted. In addition a brief description of the competence to be assessed should also be given. Clarify with the affected personnel that the assessment will not interfere with the normal operation of the ship. It is also important to confirm with the trainee that he/she is ready for the assessment.

Conduct Pre-assessment Briefing

A pre-assessment briefing with the candidate should be conducted and should address the following:

1. The scope (what and how much)
2. Procedures (rules)
3. Standards (goal to be met)
4. Outcome and consequences of the assessment

1) The Scope (What and How Much)

Before the assessment the trainee must be briefed on the items to be assessed. The competence being assessed should also be discussed. Lay out the framework for the assessment in detail so that the trainee is fully aware of what and how much is expected of him in this assessment. The purpose of the assessment should also be explained to the trainee.

2) Procedures (Rules)

Guidelines on the competence to be assessed should be provided to the trainee. Any circumstances that may require the assessment to be postponed should be clearly stated before the assessment is started. Trainee must be thoroughly briefed on the safety precautions or safe working practices that are essential for the successful completion of the assessment. The time-frame and parameter of permissible activities must be clearly spelled out to the trainee before the commencement of any assessment. Guidelines for appeal must be available in case the assessment outcome is not in favour of the trainee.

3) Standards (Goal to be Met)

The trainee must be made fully aware of the fact that the acceptable level of knowledge, understanding and proficiency, as per the STCW 95 competence tables must be met.

4) Outcome and Consequences of the Assessment

Brief the trainee on the form or manner by which the outcome of the assessment will be made known to him/her and also the need to agree on the trainee's strengths and weaknesses after the assessment. The expected consequences of the outcome of an assessment must be made known to the trainee, eg. if the outcome is unfavourable (not yet competent) then the candidate can expect to be re-assessed or sent for further training. The results of the assessment will be entered in the trainee's Training and Assessment Record Book and also the Company's own Training Record Book.

Observe the Candidate Performance and Record the Results

The assessment should be conducted in an environment such that the candidate should be able to perform the required task independently. Coaching and assisting the candidate in whatever manner should be avoided.

Assessors should ensure that the task assessed should be kept within the scope and guidelines of the assessment.

It is important that assessors should exercise impartiality towards candidate, taking into consideration factors/conditions beyond the candidate's control that may affect his performance.

Observations of the assessment proceedings should be kept strictly to the candidate's performance not to the candidate himself.

Strict discipline should be maintained throughout the assessment proceedings.

Any unwarranted interference that may disrupt the smooth flow of the assessment proceedings should be prevented.

Safety of the candidate should be of utmost importance. If at any time a potentially hazardous situation is deemed to exist, the assessor should be in a position to intervene.

As in any form of assessment, the allocated time should be adhere to. Fairness and firmness in determining the outcome of the assessment should be observed.

It should be noted that before the commencement of the assessment the candidate should not feel that he is deprive of some relevant information, such as criteria of assessment, time to complete the task etc.

Where appropriate and applicable, the assessment should be conducted in a realistic situation, but if this is not achievable then certain scenarios should be created to assimilate the real situation; e.g. responding to emergencies, etc.

Candidate should be allowed to complete the task uninterrupted, but bearing in mind that the time allocated for each task to be performed/assessed must be abide by to prevent disruption on subsequent tasks.

Upon completion of the assessment, the evidence of the performance should be noted and be recorded in the candidate's Record Book.

Evaluate the Process and Determine the Assessment Outcome

During the assessment, assessors should take note of the relevant/required steps in the performance of the task. These should be based on the STCW 95 Competence Tables where the required criteria for evaluating competence is stipulated.

Any mistakes made by the candidate should be noted, so that they may be raised during the debrief.

The outcome of the assessment should be determine as soon as possible and the results documented.

Assessment Debrief

As previously mentioned, it is important that the assessment debrief is conducted as soon as possible while the task performed is still fresh in the candidate's memory. It may then be much easier for him to have a better understanding of the correct procedures/methods to be employed in the performance of the task.

Candidate should be credited for satisfactory performances achieved.

Avoid making statements/comments that may demoralise the candidate for mistakes made during the assessment

Candidates are to be told of the areas where improvement is needed based on the earlier observations.

Discuss ways in which candidate can improve on the performances in order to satisfy the competence requirement.

Encourage candidate to ask relevant questions for further improvements.

Assure candidate that any doubts he may have will be clarified as soon as possible or before the next assessment.

Candidates are to be informed of the assessment result without hesitation. Do not withheld the result for longer than necessary.

Always make it a point to close the assessment proceedings with any useful recommendations for the candidate's improvement. These may include but not limited to:-

- more exposure to a particular task
- further or refresher training
- source of materials to gain knowledge
- need for closer supervision or coaching
- if appropriate, specify minimum period before the next assessment of the task in which the candidate is not yet competent.

Depending on the profiles of the course trainees, more emphasis may be required for this section of the course. If the majority of trainees are serving navigation and engineering officers, or are those directly involved in the actual assessment on board, allocating more time to the assessment process is prudent.

Samples of the necessary items in the package should be on hand for reference and guidance.

The remaining sections of this Part deals with the conduct of the assessment. As mentioned, emphasis and time allocated depend on the make-up of the trainees. The course can select the activities laid out, to include all of them for exercise in full participation or go through some of them to achieve familiarization.

Activity 12.1.2 — Makes preparation for an assessment on board (1 hour)

The activity allows the trainees to experience the steps involved in preparing for a shipboard assessment. The underlying objective is to give them an insight into any constraints or difficulties that may arise, because of the many inter-linked steps, in the actual implementation of an onboard assessment. Ideally, such an insight would encourage them to anticipate problems and get them to make sure that onboard assessments are well-planned ahead. Only then can the assessments be properly administered and be effective.

The activity can be carried out individually or the class grouped in small number of trainees. During the presentation, each individual or group should be advised to voice any concerns, whether real or anticipated.

Activity 12.2.2 — Conducts a pre-assessment briefing (1 hour)

This activity is a natural follow-on of activity 12.1.2. The objective is to allow trainees the experience in conducting a pre-assessment briefing by role-playing the part of the assessor.

At the same time, trainees are also assuming the part of the candidates and would gain insight into their feelings. Trainees who role-play as candidates should be encouraged to feedback to the “assessors” if they think that they are being put in an uncomfortable situation or are under pressure. The implication is that the assessment will be conducted under unfair conditions and behavior of “candidates” is not true to life.

Activity 12.3.2 — Observes and assesses a “candidate’s” performance (3 hours)

This activity is a follow-on of activity 12.2.2. The objective is to allow trainees the experience in conducting a pre-assessment briefing by role-playing the part of the assessor.

At the same time, trainees are also assuming the part of the candidates and would gain insight into their feelings. Trainees who role-play as candidates should be encouraged to feedback to the “assessors” if they think that they are being put in an uncomfortable situation or are under pressure. The implication is that the assessment will be conducted under unfair conditions and behavior of “candidates” is not true to life.

Activity 12.5.2 — Conducts a post-assessment debriefing (1 hour)

This activity is a follow-up of activity 12.3.2. The objective is to allow trainees the experience in conducting a post-assessment briefing by role-playing the part of the assessor.

At the same time, trainees are also assuming the part of the candidates and would gain insight into their feelings. Trainees who role-play as candidates should be encouraged to feedback to the “assessors” if they think that they are being put in an uncomfortable situation or are under pressure. The implication is that the assessment will be conducted under unfair conditions and behavior of “candidates” is not true to life.

13. Developing Performance Improvement Plan (2 hours)

The purpose of the performance improvement plan is to address areas for improvement in both the assessment process and the candidate’s performance. Without it the system is not complete, as there may be deficiencies either in the manner of conducting the assessment which will be carried forward to the next assessment, or the assessed candidate would continue to be incompetent.

The performance improvement plan may require changes in the ship’s system or the assessment process itself, apart from the recommendations made to the candidate for further training. The plan can therefore only be effective if all aspects of the shipboard assessment system is reviewed.

List of Activities

- 6.17 Generates documented procedures for conducting assessment
- 7.8 Designs a feedback form for monitoring the process
- 8.2 Performs a task analysis
- 8.3 Writes detailed learning outcomes to demonstrate competence
- 9.2 Generates a series of tasks that assist in shipboard assessment
- 10.2 Designs an assessment specification and scoring scheme for a practical test
- 10.3 Critically reviews methods and outcomes of an evaluation of competence
- 12.1.2 Makes preparation for an assessment on board
- 12.2.2 Conducts a pre-assessment briefing
- 12.3.2 Observes and assesses a “candidate’s” performance
- 12.5.2 Conducts a post-assessment debriefing

EXAMPLE OF A LESSON PLAN					
Main element Specific learning objective (in teaching sequence, with memory keys)	COURSE: TRAINING AREA:	LESSON NUMBER: 3		DURATION: 90 minutes	
		References	A/V aids	Instructor guidelines	Time (mins)
5 Development of shipboard assessment system 1. Set scene and explain basic definitions: — education: different systems in different countries elicit from trainees — education is 'about things' — whereas training is 'how to' — mention relationship of learning system to performance of people doing jobs — assessment as a measure 2. Purpose of assessment — methods — intelligence - how important? — knowledge, skills and ability — experience — trainee entry standards — course programme and syllabus — minimum performance standards of trainees for issue of certificate or document attesting success 3. Methods of assessment — depends on facilities and available equipment — tests — observation — objectivity	Teaching Method <i>Lecture</i> Questioning	B5 Ch. 24	V3	A1 - Part 5	16
					4
					4
					3

Appendix A

Activity for Section 6

Activity 6.17 — Generates documented procedures for conducting assessment (1 hour)

Objective	To provide practice in writing procedures for the conduct of competence-based assessments, in order to maintain control and consistency of the process that leads to the issue of certificates of competency.
Situation	1. Regulation I/8 of STCW, 1995, requires that, among other things, all training and assessment of competence activities carried out by non-governmental organizations or entities under its authority are continuously monitored through a quality standards system. 2. A national maritime training institution is set up to conduct training and assessment leading to certificates of competency, and is currently making preparations for the required assessments. 3. You are either a member of the Administration or staff member of the training institution or ship's officer involved in the development of the quality standards manual.
Action	Draft procedures for staff of the training institution to conducting the assessments, in the college and on-board including any necessary written examinations. The procedures should be common for both navigating officers and engineering officers. Explain your procedures to the class and comment on other presentations.

Activity for Section 7

Activity 7.8 — Designs a feedback form for monitoring the process (1 hour)

Objective	To gain an insight to the construction and format of well-designed feedback forms to be used in conjunction with the assessment process, and which form part of the quality assurance monitoring arrangements.
Situation	Similar to activity 6.17 above. In addition, candidates for the assessments could include foreign nationals who may have to leave the country soon after the assessment.
Action	1. Design a feedback form for use by candidates being assessed for issue of <i>either</i> certificates of competency <i>or</i> documents attesting to completion of basic safety training. 2. Design a feedback form (other than result of assessment outcome) for use by assessors.

Activities for Section 8**Activity 8.2 — Performs a task analysis (1 hour)**

Objective To define a specific competence of a ship's officer in terms of the tasks which must be carried out in order to perform that function satisfactorily.

Function Fire prevention and fire fighting.

Action For the above competence, draw up a list of the various tasks which the officer concerned must undertake in its performance. Using your list, produce a statement of general training objectives to cover the tasks you have identified and be prepared to present these objectives to the class.

Activity 8.3 — Writes detailed learning outcomes that demonstrate competence (1 hour)

Objective To gain an insight into how to express the knowledge and skill requirements for a given task in detailed learning objectives which describe how a trainee will demonstrate attainment of the requisite learning.

- Action**
1. Write a set of detailed learning objectives to cover the required knowledge and skills specified in activity 8.2. Include in the objectives any constraints or performance standards which you consider necessary. Where achievement of an objective requires the use of information which trainees are not expected to memorize, the provision of such information should be stated in the objective.
 2. Be prepared to comment on the adequacy of the learning objectives presented for defining the requisite knowledge and skills and on their suitability as the basis for assessment.
 3. Compare the learning objectives with the criteria for evaluating competence specified in Table A-VI/1-2 of STCW Code, and identify any mismatch.

Activity for Section 9**Activity 9.2 — Generates a series of tasks to assist in shipboard assessment (1 hour)**

Objective To gain insight in defining specific competence in terms of the tasks which must be performed in order to effectively evaluate the competence.

- Situation**
1. A function of navigation at the management level requires competence in maneuvering and handling a ship in all conditions. Among other things, this includes having knowledge, understanding and proficiency in (i) maneuvering and handling the ship when approaching pilot stations and embarking or disembarking pilots, with due regard to weather, tide, headreach and stopping distances, and (ii) dry-docking, both with and without damage.
 2. A function of maintenance and repair of the main propulsion machinery of 3,000 kW power, at management level, requires competence in organizing safe maintenance and repair procedures and ensuring safe working

practices. Besides the knowledge, understanding and proficiency in organizing and carrying out the procedures and practices safely, it is also necessary to demonstrate theoretical knowledge in marine engineering practice.

Action Generate a checklist of tasks which the candidate is expected to perform either in situation (1) for a chief mate being assessed in the competence required by a master, or in situation (2) for a second engineering officer being assessed in the competence required by a chief engineering officer. The checklist would include to define equipment, controls, procedures, forms, publications and communication systems used on board. It is to ensure that shipboard assessment is conducted effectively and that items are assessed in a consistent manner.

Activities for Section 10

Activity 10.2 — Designs an assessment specification and scoring scheme for a practical test (1 hour)

Objective To provide practice in drawing up a test specification and scoring scheme for a practical examination to produce a comprehensive and consistent test of candidates' skills.

Situation Trainees are required to satisfy the Administration that they possess the ability to carry out the following practical operations, which are taken from the syllabus of a fire prevention and fire fighting course.

Fire-fighting Drill and Rescue Exercise (To be conducted under truly realistic training conditions)

Small fires

3. demonstrates the correct use of various types of portable fire extinguishers, suitable, respectively, for the following types of fire:
 - materials such as wood
 - oil
 - fat
 - plastics
 - propane
 - electrical
4. demonstrates how to extinguish fires by using a hose with water jet and spray nozzles and with a foam applicator

Extensive fires

1. demonstrates the extinguishing of extensive fires of various types, including an oil fire, using, as appropriate:
 - water (jet, spray and fog application)
 - foams, including aqueous-film-forming foam (AFFF)
 - powder or other suitable chemical agent
 - CO₂
2. using a lifeline, but without breathing apparatus, demonstrates entering and passing through a compartment into which high-expansion foam has been injected

Drills in smoke-filled spaces

1. demonstrates how to check and use the following breathing apparatus:
 - smoke helmet type with air pump and hose
 - self-contained or compressed-air breathing apparatus (CABA)
2. demonstrates entering a small room using CABA when the room is filled with non-toxic artificial smoke
3. demonstrates how to search for persons (using dummies) to effect rescue in a smoke-filled space while wearing breathing apparatus
4. takes part in team exercises, communicating with other team members, while wearing CABA in a smoke-filled space
 - demonstrates the use of various types of portable fire extinguishers on fires in a smoke-filled enclosed space while wearing CABA
 - demonstrates extinguishing an extensive fire when wearing CABA in smoke-filled enclosed spaces, including an accommodation room, or a simulated engine-room with fire and heavy smoke, and using, as appropriate:
 - water fog
 - water (jet or spray)
 - foam
 - powder

Action Draw up a test specification and scoring scheme for a practical test of the objectives in the syllabus above to be used by the instructors of the fire-fighting school in their assessment of candidates. Your test should take account of the time required and the fact that up to sixteen candidates may need to be examined in groups of four persons at a time.

Activity 10.3 — Critically reviews methods and outcomes of an evaluation of competence (1 hour)

Objective To illustrate and gain insight in determining the effectiveness of the various methods and range in evaluating competence.

- Situation**
1. A deck cadet officer and an engineering cadet officer are serving seetime on board a chemical tanker of 5,000 Gross Tonnage with a 3,500 kW propulsion power. Both of them are undergoing courses in a maritime training institution in their respective discipline, which include a 12-month cadetship onboard.
 2. The chief mate and second engineer on board the tanker are holding the relevant certificates of competency for their duties and responsibilities and both have attended shipboard assessment courses organized by their company. All other officers have not yet attended any shipboard assessment course.
 3. The company superintendent has requested the master of the chemical tanker to provide as much shipboard assessment to the cadets as is possible, while they are sailing with the tanker.

- The master replies officially to the superintendent that the chief mate and second engineer have tested the cadets as follows :

Deck cadet

Item assessed	Duration of assessment	Method of assessment	Outcome of assessment	Remarks
Fixing vessel's position	15 minutes	Questioning	Found competent after some prompting	Needs further guidance
Determining and correcting errors in magnetic and gyro-compass	35 minutes	Actual performance with vessel's equipment	Competent	
Maintaining a safe navigation watch	Over a 3-month period	Second mate's observation	Competent	Correctly follows instructions of second mate
Characteristics of chemicals	1 hour	Written test	Score 65% of marks	Test paper set and administered by second mate
Fire fighting	1 hour	Observation	Competent	Observed during fire drills. (No fire was simulated.)

Engineer cadet

Item assessed	Duration of assessment	Method of assessment	Outcome of assessment	Remarks
Welding technology	1 hour	Questioning	Competent	Assessors include third engineer and fitter
Overhauling auxiliary cooling water pump	4 hours	Actual performance on board	Not yet competent	Argue with third engineer over tools.
Watchkeeping duties	Over a 3-month period	Chief engineer's observation	Competent	Chief engineer kept watch with the engine cadet twice in the entire period.
Safe working practices	1 hour	Multiple-choice test	Competent	Test paper set by second engineer
Cargo operation	2 hours	Written and oral tests	Competent	Tests set by third mate

Action Critically comment on the above methods and range in evaluating the competence of either the deck cadet or engine cadet in performing the tasks indicated. Prepare for comments in class).

Activities for Section 12

Activity 12.1.2 — Makes preparation for an assessment on board (1 hour)

Objective To gain insight into the steps involved in making preparation for an assessment on board.

- Situation**
1. The general cargo ship of 3,750 gross tonnage, with a periodically unmanned engine-room, trades between Japan and Australia.
 2. Since joining the ship, more than 8 months ago, both the second mate and the third engineer have expressed desire to go for their respective higher grade of certificate of competency. They have received the required training, are being continuously assessed on board and found competent in a number of areas. With about 1 month remaining before due for leave, they ask to be assessed further in the other areas of competence.

— Their current qualification and experience are given below.

Second Mate

Grade of certificate of competency held : Officer in charge of a navigational watch of ships of 1,600 Gross Registered Tons or more.

Certificate assessing for: Chief mate of ships of 3,000 Gross Tonnage or more.

Sea-going service:

Ship Type	Gross Tons	Trading area	Capacity in which served	From			To		
				d	m	y	d	m	y
Cargo	1800	coastal	3 rd mate	15	8	95	2	2	96
Cargo	1800	coastal	2 nd mate	10	5	96	25	11	96
Tanker	2400	coastal	2 nd mate	14	12	96	3	4	97
Cargo	5100	ocean	2 nd mate	26	4	97	31	5	97
Cargo	4100	ocean	2 nd mate	28	6	97	15	10	97

Third Engineer

Grade of certificate of competency held: Engineer officer in charge of a watch of motor ships of 750 kW propulsion power or more.

Certificate assessing for: Second engineer officer of motor ships of between 750 and 3000 kW propulsion power (unrestricted).

Sea-going service:

Ship type	Propulsion power (kW)	Trading area	Capacity in which served	Service m	d	Remarks
Cargo	2500	ocean	4th E.O. in charge of a watch	5	9	
Fishing vessel	1000	coastal	engineer in charge of machinery and engines	6	6	
Action	1.	Determine the next higher grade of certificate of competency applicable to the second mate or third engineer. State any other requirements, apart from the required assessment, that either one should meet prior to the award of the higher certificate.				
	2.	For the higher grade determined, choose one competence from the relevant table of competency in the STCW Code. Prepare a schedule for the assessment, which should include all the items mentioned in sub-part 12.1 of the course. A nil entry or any specific conditions should be defined in the schedule, where appropriate.				

Be prepared to present and comment your schedule to the class.

Activity 12.2.2 — Conducts a pre-assessment briefing (1 hour)

Objective To gain experience in conducting a pre-assessment briefing.

Action Using the schedule prepared in activity 12.1.2, take turns to assume the role of the assessor and brief one course trainee who would role-play as the candidate. Switch roles when briefing is completed. Comment on each other's role as assessor.

Activity 12.3.2 — Observes and assesses a “candidate’s” performance (3 hours)

Objective To gain experience conducting an assessment

Action Using the schedule prepared in activity 12.1.2, take turns to assume the role of the assessor and brief one course trainee who would role-play as the candidate. Switch roles when briefing is completed. Comment on each other's role as assessor.

Activity 12.5.2 — Conducts a post-assessment debriefing (1 hour)

Objective To gain experience in conducting a post-assessment debriefing.

Action Using the schedule prepared in activity 12.1.2, take turns to assume the role of the assessor and brief one course trainee who would role-play as the candidate. Switch roles when briefing is completed. Comment on each other's role as assessor.

Attachment 1

Examples of Competence-Based Assessment for Seafarers

1 The following pages provide examples of STCW competency with test objectives, performance measures, and performance standards. The examples are for hypothetical assessments of shipboard tasks associated with various functions and competences. The respective areas of knowledge, understanding and proficiency are identified in the appropriate standards of competence of the STCW Code.

2 The first example (Example 1) for a task associated with “steering control systems”, is extracted from MSC/Circ 853. It gives an explanation on the tabulation of the Competence / Performance Objectives / Performance Measures / Performance Standards.

3 The other five examples (Examples 2 - 6), are derived in a likewise manner based on assumptions appropriate for the respective tasks.

4 The first step in the process is to generate the tasks for the specific competence to be assessed. Pages 6 to 23 provide two samples of the tasks generated for the various competences required in STCW Code.

Sample A is for competence specified in Table A-II/1 of the STCW Code and Sample B is for competence specified in Table A-III/1 of the STCW Code.

These are meant for the mandatory minimum requirements for certification of officers in charge of (a) a navigational watch on ships of 500 gross tonnage or more, and (b) an engineering watch in a manned engine-room or as designated duty engineers in a periodically unmanned engine-room.

5 The next step is to expand on the tasks, define the performance measures and then, the performance standards for each of the tasks. As mentioned in paragraph 3 above, pages 24 to 38 provide the examples of these in tabulated form. The usefulness of developing these type of tabulation is that they can serve as checklists for conducting practical tests or for conducting assessments on board.

6 Pages 37 and 38 are two examples of the format that can be used to design and develop Training Record Books. The “Tasks” and “Criteria For Satisfactory Performance” are similarly generated and defined as above.

7 The instructor should use the samples/examples appropriately throughout the course. In particular, the samples/examples are suitable for Sections 6, 8, 9, 10 and 12 of the course.

The instructor should note that the examples and samples are for illustrative purposes only.

EXAMPLE 1

1 This example is for a task associated with “steering control systems,” an area of knowledge, understanding and proficiency identified in the standard of competence for officer in charge of a navigational watch (Table A-II/1 in the STCW Code). A candidate for certification as officer in charge of a navigational watch will normally be trained and assessed in steering ability during the period of required seagoing service when watchkeeping duties are being performed pursuant to paragraph 2.3 of STCW regulation II/1.

In the table below, the STCW competence comes directly from the *Competence* column of STCW Table A-II/4. The performance objectives are derived from a consideration of the *Knowledge, Understanding and Proficiency* column of Table A-II/4. The performance measures and performance standards are derived from an analysis and elaboration of the *Criteria for Evaluating Competence* column of Table A-II/4.

2 This example assumes that the candidate understands:

- .1 the general mechanics of steering, including relationship of the propeller to the rudder, and between the wheel turn, rudder position and ship's heading;
- .2 standard commands, standard responses, and essential terminology, in English;
- .3 the principle of momentum and how it must be taken into account when steering;
- .4 the significance of steerage way and losing steerage way;
- .5 the effects on steering from outside forces such as weather, wind and sea state;
- .6 the relationship of speed to steering (slower speed, increased helm; sea speed, minimum helm);
- .7 operational differences between magnetic and gyro compasses;
- .8 use of the automatic pilot, and response of wheel when autopilot is engaged; and use of non-follow-up switch;
- .9 steering with master and pilot on the bridge (understands master/pilot roles, communicates clearly with pilot; requests repetition of helm orders when not understood);
- .10 standard emergency procedures, including execution of the Williamson turn;
- .11 steering during narrow channel transits, including dredged channels in open water, with emphasis on relationship of vessel speed to rudder applied; use of ranges (to mark centre/right of channel; steer forward range to correct); effects of squat and bottom suction (minimized rudder response); effects of bank suction and sheer (correct rudder response to steer; possible necessity to steer in direction of another vessel to keep to channel); effects of bow suction/cushion (correct rudder response

to meeting situation); turn rate (hearing gyro gearing; relationship of staff and buoy; turn rate indicator); steering failure (communicate immediately with watch officer as in "Helm not responding" and procedures to follow including non-follow-up switch); and

- .12 proper procedures for relieving the watch, with emphasis on visual environment (need to allow 15-20 minutes for sight adjustment; use of red goggles); night orders (understands effect on watch; watch transit assessment/voyage plan); status of steering mode and engines (understands hand or autopilot mode and requirements of both; understands use of port and starboard steering engines; and communicates with watch officer as to responsibilities in each mode); completion of evolution (understands not to relieve during turn, crossing or meeting situations without permission of watch officer); duties of relieving helms person (gyro course steered, magnetic course checked, rudder angle/helm carried; effect of leeway and current); proper relief communicated to watch officer (communicates course to steer, and magnetic course, steering mode, engine, helm response).

On-board assessment of competence in steering should be based on the following table:

STCW Competence	Performance Objectives	Performance Measures	Performance Standards
<i>Steer the ship and comply with helm orders also in the English language</i>	<i>Demonstrate knowledge of magnetic and gyro-compass operations</i> <i>Demonstrate ability to steer and follow helm orders</i>	<i>Report current course by reference to magnetic and gyro-compass when required</i> <i>Proper protocol is followed when demonstrating ability in a full range of standards during 30 minutes of helm time at sea speed</i>	<i>Response to questions regarding present course are correct, prompt and clear</i> <i>Helm orders are repeated exactly, and watch officer is notified when order has been followed and completed</i>
		<i>Proper response to —</i> 1. “port / starboard” rudder 2. steering by LCD display 3. use of rudder angle indicator, “port / starboard” 10, 20, etc 4. “shift rudder” 5. “hard a port / starboard” 6. “ease rudder - port / starboard more” 7. “meet her” 8. “nothing to starboard or port of...”	1. directional distinction 2. degrees increase to starboard decrease to port 3. appropriate rudder response 4. appropriate rudder response 5. 35 degrees 6. appropriate rudder response 7. ability to slow, but not stop vessel swing 8. appropriate rudder response

STCW Competence	Performance Objectives	Performance Measures	Performance Standards
		<i>Practical helmsmanship —</i> 1. rudder angle indicator - no course given 2. meet ordered course - course given 3. steady course on range or landmark 4. checking magnetic 5. ability to hold ordered course over time 6. turn / rate awareness	1. call out passing each 10 degrees 2. check swing within 5 / 10 degrees of course to steer (CTS); apply necessary counter rudder; correct to CTS accordingly 3. range correctly identified + / - 2 degrees; able to use forward range as guide 4. at each course change, and every 15 minutes 5. + / - 3 degrees on compass, minimal rudder use, 5 - 10 degrees of rudder angle and then steady up; deviations are promptly reported to the watch officer 6. hear gyro compass, use buoy / staff; use rate of turn indicator; rudder is taken off before the new course is reached in time to control momentum
	<i>Demonstrate ability to change-over from automatic pilot to hand steering and vice versa</i>	<i>Execute orders to change-over</i>	<i>Change-overs are executed properly and OOW is notified when each change-over is completed</i>

Sample A: Defining the tasks for competence in Table A-II/1 of STCW Code

Function 1: Navigation at the operational level

Competence 1: Plan and conduct a passage and determine position

Task 1. Plan a passage

1.1 Consult nautical charts and publications.

The information obtained from navigational publications is relevant, interpreted correctly and properly applied. All potential navigational hazards are accurately identified.

1.2 Select charts of adequate scale.

The charts selected are the largest scale suitable for the area of navigation and charts are corrected in accordance with the latest information available.

1.3 Set courses.

The courses are suitably set in respect of the ship's size, draft and manoeuvrability, and set with sufficient distance off shallow waters, banks and other dangers to navigation. Due consideration is given to current, ice, prevailing meteorological conditions and routing and traffic separation schemes.

1.4 Calculate Estimated Time of Arrival (ETA).

The total distance is correctly calculated and ETA given within acceptable time limits.

Task 2. Conduct a passage and determine position

2.1 Determine and apply compass error for courses and compass bearings.

Errors in magnetic and gyro compasses are determined and correctly applied to courses and bearings.

2.2 Recognize conspicuous objects and other terrestrial aids to navigation in daylight and at night.

The information obtained from navigational charts and publications is relevant, interpreted correctly and properly applied. All potential navigational hazards are accurately identified.

2.3 Establish position by terrestrial observations i.e. lighthouses, buoys and beacons.

The position is determined within the limits of acceptable instruments stem errors.

2.4 Establish position by use of electronic navigational equipment.

The position is determined within the limits of acceptable instrument/system errors.

2.5 Determine ship's position by dead reckoning.

The position is determined within acceptable limits.

2.6 Operate electronic position fixing and navigational equipment.

Performance checks and tests to navigation systems comply with manufacturer's recommendations and good navigational practice.

2.7 Use celestial bodies to determine the ship's position.

The fix is within acceptable accuracy, due regard taken to possible errors of the position lines and the meteorological conditions.

2.8 Steer the ship and comply with helm orders in the English language.

A steady course is steered within acceptable limits having regard to the area of navigation and prevailing sea state. Alteration of course are smooth and controlled. Communications are clear and concise at all times and orders are acknowledged in a seaman-like manner.

2.9 Operate the steering control systems. Know the operational procedures and change-over from manual to automatic control and vice-versa. Adjust the controls for optimum performance.

The selection of mode of steering is the most suitable for the prevailing weather, sea and traffic conditions and intended manoeuvres.

- 2.10 Able to use and interpret information obtained from shipborne meteorological instruments.

Measurements and observations of weather conditions are accurate.

- 2.11 Able to apply the meteorological information available.

Meteorological information is correctly interpreted and applied.

Competence 2: Maintain a safe navigational watch

Task 3: Maintain a safe navigational watch

- 3.1 On preparing for sea, check ship's draught, and check that the necessary equipment on the bridge is operational and proper sailing information is available.

All navigational and communication equipment is operational and all appropriate charts, tidal and weather information is available.

- 3.2 On leaving or entering port notify the master/engine control room as appropriate.

The master/engine control room is notified as appropriate.

- 3.3 Assist in carrying out the master's/pilot's order/directions.

Master's/pilot's instructions are verified and essential information recorded and relevant information given to those concerned.

- 3.4 Monitor the course, speed and position.

Ship's safety is constantly monitored and the candidate shows to be particularly vigilant and on the alert in confined waters.

- 3.5 Display/sound correct lights, flags, shapes and sound signals.

Correct lights, flags, shapes and sound signals are displayed/sounded.

- 3.6 Properly monitor the pilot's safety when boarding and disembarking.

The pilot's safety is ensured when boarding and disembarking.

- 3.7 On leaving or entering port notify the crew as appropriate.

The crew is available for handling moorings/anchors when needed.

- 3.8 At the commencement of the watch ascertain ship's position, course and speed and appraise the traffic situation and any danger to the ship.

All checks are promptly and correctly carried out. A clear statement is given that the situation is under full control when the watch is formally taken over.

- 3.9 Keep a proper lookout by sight and hearing.

Sound signals, lights and other objects are properly detected and their appropriate bearing in degrees or points is reported to the officer of the watch.

- 3.10 Fix the ship's position regularly, assess risks of collision and/or grounding and take appropriate actions.

Apply properly the International Regulations for Preventing Collisions at Sea.

- 3.11 Check the reliability of the information obtained from primary method of position fixing at appropriate intervals.

The reliability of the information obtained from the primary method of position fixing is checked at appropriate intervals.

- 3.12 Adjust the ship's course and speed to the traffic, the waters and the meteorological condition.

The speed and mode of steering is suitable for the prevailing conditions.

- 3.13 Monitor and control navigational instruments and record relevant activities and incidents.

Compasses are regularly checked and errors are correctly applied. All movements and activities related to the navigation of the ship are properly recorded.

Competence 3: Use radar and ARPA to maintain safety of navigation

Task 4: Use radar and ARPA

- 4.1 Carry out operational checks and adjust the equipment to proper performance.
The equipment is functioning properly and in accordance with the manufacturers specifications.
- 4.2 Able to operate and to interpret and analyze information obtained from radar and ARPA, as applicable.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.
- 4.3 Interpret and analyze factors affecting performance and accuracy.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.
- 4.4 Set up and maintain displays.
The displays are properly set up and maintained.
- 4.5 Detect and be aware of the possibility of misinterpretation of information, false echoes, sea returns, etc.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.
- 4.6 Interpret and analyze information obtained from racons and SARTs.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.
- 4.7 Detect and calculate range and bearing, and speed of other ships, time and distance of closest approach of crossing, meeting and overtaking ships.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions. The course and speed of other ships, as well as time and distance of assumed closest approach to other ships, are ascertained with sufficient accuracy to take appropriate actions.
- 4.8 Identify critical echoes, detect course and speed changes of other ships, take into account the effect of changes in own ship's course or speed or both.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.
- 4.9 Apply the International Regulations for Preventing Collisions at Sea.
Action taken to avoid close encounter or collision with other vessels is in accordance with the International Regulations for Preventing Collisions at Sea.
- 4.10 Use plotting techniques and relative and true motion concepts.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.
- 4.11 Use parallel indexing techniques.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.
- 4.12 Interpret and analyze information related to system performance and accuracy, tracking capabilities and limitations, and processing delays.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions. The course and speed of other ships as well as time and distance of assumed closest approach to other ships are ascertained with sufficient accuracy to take appropriate actions.
- 4.13 Use operational warnings and Systems tests.
The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.

4.14 Use of the target acquisition and its limitations.

The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions.

4.15 Use true and relative vectors, graphic representation of target information and danger areas.

The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions. The course and speed of other ships as well as time and distance of assumed closest approach to other ships are ascertained with sufficient accuracy to take appropriate actions.

4.16 Derive and analyze information, critical echoes, exclusion areas and trial manoeuvres.

The information obtained from the equipment is correctly interpreted and applied with due regards to the limitations of the equipment and prevailing circumstances and conditions. The course and speed of other ships as well as time and distance of closest approach to other ships are ascertained with sufficient accuracy to take appropriate actions.

4.17 Take appropriate action to avoid accidents.

Action taken to avoid a close encounter or collision with other vessels is in accordance with the International Regulations for Preventing Collisions at Sea. Decisions to amend course and/or speed are both timely and in accordance with accepted navigation practice. Adjustments made to the ship's course and speed maintain safety of navigation. Manoeuvring signals are made at the appropriate time and are in accordance with the International Regulations for Preventing Collisions at Sea.

Competence 4: Respond to emergencies

Task 5: Respond to emergencies

5.1 During relevant drills demonstrate ability to take precautions for the protection and safety of passengers and crew in emergency situations.

The type and scale of the emergency is promptly identified. Initial actions are in accordance with contingency plans and are appropriate to the urgency of the situation and nature of the emergency.

5.2 During relevant drills demonstrate ability to take initial actions following a collision or grounding, initial damage assessment and control.

The type and scale of the emergency is promptly identified. Initial actions and, if appropriate, manoeuvring of the ship are in accordance with contingency plans and are appropriate to the urgency of the situation and nature of the emergency.

5.3 During relevant drills demonstrate ability to act correctly when rescuing persons from the sea, assisting a ship in distress, responding to emergencies which arise in port.

The type and scale of the emergency is promptly identified. Initial actions and, if appropriate, manoeuvring of the ship are in accordance with contingency plans and are appropriate to the urgency of the situation and nature of the emergency.

Competence 5: Respond to a distress signal at sea

Task 6: Respond to a distress signal at sea

6.1 During relevant drills establish the position of a unit in distress in relation to own position.

The distress or emergency signal is immediately recognized. The positions are correctly plotted in suitable charts.

6.2 During relevant drills make a preliminary assessment of the situation and inform the master.

Contingency plans and instructions in standing orders are implemented and complied with.

Competence 6: Use the IMO Standard Marine Navigational Vocabulary as replaced by the IMO Standard Marine Communication Phrases and use English in written and oral form

Task 7: Use the IMO Standard Marine Communication Phrases and write and speak English

7.1 Use IMO Standard Marine Communication Phrases.

Navigation and Safety communication is satisfactorily conducted with persons unable to understand the officer's national language.

7.2 Understand Meteorological and Marine Safety messages.

The messages relevant to the safety of the ship are correctly interpreted or drafted.

7.3 Fill in standard English nautical reports and forms.

All reports and forms relevant to the duties of an officer in charge of a navigational watch are correctly fulfilled.

7.4 Communicate with other ships and coast stations.

Communications are clear and understood.

7.5 Perform the officer's duties also with multi-lingual crew.

Communications are clear and understood.

Competence 7: Transmit and receive information by visual signalling

Task 8: Transmit and receive visual signals

8.1 Transmit and receive Morse signals by light.

Communication within the operator's area of responsibility are consistently successful.

8.2 Use the International Code of Signals to interpret messages given by flags and pendants.

Communication within the operator's area of responsibility are consistently successful.

Competence 8: Manoeuvre the ship

Task 9: Manoeuvre the ship

9.1 Use available information as to the ship's turning circles and stopping distances when manoeuvring taking into account the effects of deadweight, draught, trim, speed and under-keel clearance on turning circles and stopping distances.

The information is adequately used during normal situations while taking note of draught and trim. Safe operating limits of ship propulsion, steering and power systems are not exceeded in normal manoeuvres. Adjustments made to the ship's course and speed maintain safety of navigation.

9.2 Use available information as to the ship's turning circles and stopping distances when manoeuvring taking into account the effects of wind and current on ship handling.

The information is adequately used during normal situations while taking due regards to wind and current. Safe operating limits of ship propulsion, steering and power systems are not exceeded in normal manoeuvres. Adjustments made to the ship's course and speed maintain safety of navigation.

9.3 Use available information as to the ship's turning circles and stopping distances when manoeuvring taking into account the effects of squat, shallow water and similar effects.

The information is adequately used during normal situations while taking due regards to squat, shallow water and similar effects. Safe operating limits of ship propulsion, steering and power systems are not exceeded in normal manoeuvres. Adjustments made to the ship's course and speed maintain safety of navigation.

9.4 Demonstrate proper mooring procedures.

Moorings are made fast or taken on board as ordered. Ship is safely moored without undue delay.

9.5 Demonstrate proper anchoring procedures.

Anchors are lowered/heaved and secured as ordered. Ship is safely anchored without undue delay.

9.6 Manoeuvre to rescue a man overboard.

The actions taken are as generally recommended and the turning manoeuvre brings the ship into its wake.

Function 2: Cargo handling and stowage at the operational level

Competence 1: Monitor loading, stowage, securing and unloading of cargoes and their care during the voyage

Task 1: Monitor loading of cargoes

1.1_ Supervise the preparation of holds and deep tanks for loading.

Precautions are taken before entering holds or confined spaces to ensure safe atmosphere. The holds and deep tanks are in good order and condition, sufficiently cleaned and adequately dunned for the new cargo. Any heating arrangement is functioning. The bilges are dry and there is free drainage to the suctions.

1.2 Supervise the operation of the ship's cargo gear.

The gear is safely operated and the safe working load never exceeded. Damaged or worn out ropes, wires or parts of the gear are detected and replaced.

1.3 Supervise the loading. Take into account the effect of cargo including heavy lifts on the seaworthiness and stability of the ship.

The cargo is loaded in accordance with the cargo plan while maintaining proper trim and stability at all times. Dangerous goods are detected and handled in accordance with international regulations and recognized standards and codes of safe practice. Any incidents or accidents during loading are reported immediately and proper actions taken.

Task 2: Stowage and securing cargoes

2.1 Ensure a solid stow and securing of all cargoes in packaged form.

Cargoes liable to slide during rolling or pitching are adequately stowed and secured to avoid damage to ship and cargo. Special attention is paid to dangerous goods, heavy loads and vehicles.

2.2 Ensure separation between bulk cargoes or packaged goods if required.

The cargoes are not mixed or contaminated and all cargoes are delivered at the due port.

2.3 Supervise that adequate precautions are taken to ensure ventilation and facilitate inspections during the voyage.

The ventilation is sufficient to avoid sweat from cargo and ship and harmful gases are let out.

2.4 Stowage and securing of dangerous, hazardous and harmful cargoes and their effect on the safety of life and of the ship.

The handling of dangerous, hazardous and harmful cargoes complies with international regulations and recognized standards and codes of safe practice.

Task 3: Taking care of cargoes during voyage

3.1 Inspect the cargo at regular intervals.

Routine inspections are carried out, taking into account the condition of the cargo and the weather.

3.2 Record all inspections and the conditions found.

The results of the inspections are properly recorded and any need for actions reported immediately.

3.3 Take actions to avoid damage to the ship or cargo.

Correct actions are taken to adjust ventilation, temperature or to carry out any other operation to avoid damage to ship or cargo.

Task 4: Taking care of cargoes during voyages

4.1 Inspect hatch gear and cargoes before and during discharging.

Any damage is immediately reported and properly recorded. Appropriate action are taken to avoid accidents or further damage.

4.2 Ensure that all cargoes are discharged in good condition.

Cargo operations are carried out in accordance with the cargo plan or other documents and established safety rules/regulations, equipment operating instructions and shipboard limitations. Improper handling of gear or cargo is immediately stopped or reported.

4.3 Ensure satisfactory trim, stability, hogging and sagging at all times.

Factors influencing the safety of the ship are constantly monitored and kept within stated acceptable limits.

4.4 Identify and damage to ship or cargo after discharging and establish possible causes.

Any damage is detected, immediately reported and causes established or suggested depending on the circumstances.

Function 3: Controlling the operation of the ship and care for persons on board at the operational level

Competence 1: Ensure compliance with pollution prevention requirements

Task 1: Take actions to prevent pollution

1.1 Ensure that procedures are agreed and observed and all scuppers are blocked before bunkering.

The operations are fully observed, all scuppers are blocked and pipes and hoses inspected before bunkering takes place.

1.2 During relevant drills initiate immediate investigation to detect the source of pollution.

All available resources are utilized to detect the source and the master or appropriate authorities are informed.

1.3 During relevant drills stop or prevent leakage's and spills of harmful liquids and solid substances.

The situation is thoroughly assessed and the actions taken are effectively organized and exercised with due consideration for the extent of the pollution.

1.4 Have all tanks and compartments sounded if any damage is suspected.

The soundings are readily available and the results immediately reported to the master.

1.5 Carry out bilge, ballast and bunkering operations.

All operations are carried out in accordance with MARPOL and due regard paid to Shipboard Oil Pollution Emergency Plan (SOPEP).

Competence 2: Maintain seaworthiness of the ship

Task 2: Monitor stowage and securing of cargoes

2.1 Inspect hull and hull openings, compartments, hatch covers, equipment and complement and take action if any defects are detected.

The inspection is properly carried out, due regards paid to the prevailing circumstances and areas where defects are most likely to occur. Any defect is immediately reported and recorded and the suggested or executed action adequate for the situation.

- 2.2 Ensure that all loose objects are securely fastened to avoid damage.
Inspection is carried out at regular intervals and more frequently in heavy weather or if other incidents occur. Heavy or otherwise dangerous objects are given the highest priority and good seamanship exercised.
- 2.3 Arrange for regular control measures to ensure watertight integrity.
Peaks, bilges, tanks and other compartments are sounded regularly, the results recorded and any irregularities reported and examined further.
- 2.4 Calculate stability, trim and stresses using stability trim, and stress tables, diagrams and stress calculating equipment.
Ensure that stability conditions comply with the IMO intact stability criteria under all conditions of loading.
- 2.5 During relevant drills take actions to ensure and maintain the watertight integrity of the ship.
Actions to ensure and maintain the watertight integrity of the ship are in accordance with accepted practice.

Competence 3: Prevent, control and fight fires on board

Task 3: Prevent fires on board

- 3.1 Operate fire and smoke detecting equipment.
The equipment is tested and operated in accordance with manufacturer's manuals and ship-specific instructions.
- 3.2 Ensure that all persons on watch are able to detect and correct hazardous situations and actions and keep the ship clean and tidy.
Watch personnel make regular inspections in areas exposed to ignition. Easily inflammable material is put in safe places and the watch demonstrate an attitude of alertness and readiness to respond to fires.
- 3.3 Make the watch locate and use fire-fighting appliances and emergency escape routes and sound alarm.
Every person on watch can use portable or otherwise adequate fire-extinguishers for small fires, demonstrate ability to find emergency escape routes and raise the alarm.

Task 4: Fight fires on board

- 4.1 Locate fire-stations and demonstrate proper use of fixed installations and other fire-fighting appliances and agents.
All stations are located and the most suitable one selected in the event of a fire. Proper equipment and extinguishing agents selected for the various materials on fire.
- 4.2 Locate and use fire protective equipment (fireman's outfit, including breathing apparatus).
The equipment is quickly donned and used in a way that no accidents are likely to occur.
- 4.3 Demonstrate ability to act in accordance with the fire-fighting plan during fire-drills.
During debriefing after an exercise or a real fire extinguishing action the reasons for each action taken, including the priority in which they were taken, are explained and accepted as the most appropriate.
- 4.4 During relevant drills carry out rescue operations wearing breathing apparatus.
The breathing apparatus is tested and used in accordance with manufacturers manual and the rescue operation is successful.

Competence 4: Operate life saving appliances

Task 5: Operate life saving appliances

5.1 Organize abandon ship drills.

On sounding the alarm all persons meet at the designated life-boat station wearing life jackets or immersion suits and carry out their duties on request.

5.2 Demonstrate the ability to organize and supervise the launching, handling and recovery of life boat.

Correct orders for embarkation, launching, immediately clearing the ship's side, safely handling the boat under motor, oars or sail as appropriate, and safe boat recovery.

5.3 Demonstrate the ability to organize and supervise the launching or throwing overboard a liferaft, and manoeuvre it clear of ship's side.

The duties for the persons designated for the task are clearly allocated and orders efficiently executed.

5.4 Demonstrate proper use of radio lifesaving appliances, satellite, EPIRBs and SARTs.

Equipment is operated in accordance with manufacturer's instruction.

5.5 Ensure that all survival craft launching equipment on board is functioning.

Equipment is maintained in accordance with manufacturer's instructions and regulatory requirements.

5.6 Ensure rations on board survival craft are adequate.

Food and water are sufficient for the survival craft designated complement.

5.7 Ensure that equipment on board survival craft is adequate.

Equipment such as pyrotechnics, signalling equipment, all meet regulatory requirements.

Competence 5: Apply medical first aid on board

Task 6: Apply medical first aid on board

6.1 During relevant drills stop excessive bleeding, ensure breathing and put injured persons in proper position.

The actions demonstrated are in compliance with accepted recommendations given in international medical first aid guidance.

6.2 During relevant drills detect signs of shock and heat stroke and act accordingly.

The treatment recommended or given is adequate. Ability to request Radio Medico for advice is demonstrated.

6.3 During relevant drills treat burns, scalds, fractures and hypothermia.

Recommended guidelines for proper actions are explained and the basic principles for avoiding hypothermia are demonstrated.

6.4 During relevant drills, locate and access shipboard medicine and equipment.

Ability to access the medical cabinet in a timely way.

Competence 6: Monitor compliance with legislation requirements

Task 7: Monitor compliance with legislation

7.1 State where laws, Rules regulations concerning ship operation and pollution prevention are available.

The statement given is correct and includes relevant bodies or organizations which may be contacted to attain special information or guidance which is not easily accessible.

7.2 Use legislation to ascertain due approach to solve questions encountered during on board operations.

Legislative requirements relating to safety of life at sea and protection of the marine environment are correctly identified.

Sample B - Defining the tasks for competence in Table A-III/1 of STCW Code

Function 1: Marine engineering at the operational level

Competence 1: Use of appropriate tool for fabrication and repair operations typically performed on ships

- 1.1 Reorganize characteristics and limitations of materials used in construction and repair onboard
Identification of important parameters for fabrication of ship related components is appropriate.
- 1.2 Select and use special tools for work on specific machinery and equipment i.e. pumps, purifiers, reducers
Correct hand and machine tools, tools are chosen and used in accordance with instructions, manuals and good workmanship.
- 1.3 Select and use appropriate material
The selected material is suitable for the part(s) to be fabricated or repaired.
- 1.4 Use machine tools and equipment for fabrication and repair
Use of equipment and machine tools is appropriate and safe and fabrication is to designated tolerances.

Competence 2: Use of hand tools and measuring equipment for dismantling, maintenance, repair and assembly of shipboard plant and equipment

- 2.1 Select and use hand tools for dismantling, inspecting, repairing and reassembling equipment
Hand tools are properly selected and used for adjustments and calibrations and for dismantling and re-assembling of machinery and equipment
- 2.2 Select and use general and special measuring equipment
The selected measuring instruments used for adjustments, calibrations, repair and maintenance of machinery and equipment are relevant for the task, correct measures are taken and checked for compliance with stated tolerances
- 2.3 Locate and use relevant manuals and interpret drawings, diagrams, sketches and instructions
The instructions, drawings and diagrams relevant for the job are quickly identified and properly used.

Competence 3: Use of hand tools, electrical and electronic measuring and test equipment for fault finding, maintenance and repair operations

- 3.1 Locate and interpret relevant manuals
The selected manuals, drawings and diagrams are appropriate and quickly located
- 3.2 Select and test measuring equipment
Selection of test and measuring equipment is appropriate
- 3.3 Use and interpret test and measuring equipment reading
Use of test and measuring equipment is appropriate and interpretation of results is accurate
- 3.4 Evaluate the necessity for taking corrective action with or without assistance
Selection of proper equipment and procedures for the conduct of repair and maintenance is in accordance with manuals and good practices
- 3.5 Repair faults and correct malfunctions
The situation is assessed correctly and the action taken acceptable. Commissioning and performance testing of equipment and systems brought back into service after repair is in accordance with manual and good practices

Competence 4: Maintain a safe engineering watch

- 4.1 List or orally explain the reasons an officer in charge of the engineering watch shall not hand over the watch to the relieving officer
Explanation is consistent with requirements in section A-VIII/2, paragraph 56, of the STCW Code
- 4.2 Explain the starting orders and special instructions of the chief engineer officer relating to the operation of the ships systems and machinery
Explanation is satisfactory to the assessor
- 4.3 Explain the nature of all work being performed on machinery and systems, the personnel involved, and potential hazards
Explanation is satisfactory to the assessor
- 4.4 Determine the level and, where applicable, the condition of water or residues in bilge, ballast tanks, slop tanks, reserve tanks, fresh water tanks, sewage tanks and any special requirements for use or disposal of the contents thereof
Explanation is consistent with requirements in section A-VIII/2, paragraph 56, of the STCW Code
- 4.5 Determine the condition and level of fuel in the reserve tanks, settling tank, day tank, and other fuel storage facilities
Determination are correct
- 4.6 Determine any special requirements relating to sewage system disposals and the acceptable alternative for such disposals for the duration of the voyage
Ability to correctly explain acceptable alternatives for sewage system disposals
- 4.7 Determine the condition and mode of operation of the various main and auxiliary systems, including the electrical power distribution system
Determinations are correct
- 4.8 Determine, where applicable, the condition of monitoring and control console equipment, and which equipment is being operated manually
Determination are correct
- 4.9 Describe potential adverse conditions that could result from bad weather, ice, contaminated water, or shallow water
Descriptions are complete and accurate
- 4.10 Determine, where applicable, the condition and mode of operation of automatic boiler controls such as flame safeguard control system, limit control system, combustion control system, fuel supply control system, and other equipment related to the operation of steam boilers and explain the function of each
Correct determination and satisfactory explanation
- 4.11 Determine any special modes of operation dictated by equipment failure or adverse ships conditions and describe how various how various equipment failures or adverse ship condition could potentially dictate special modes of operation
Correct determination and satisfactory explanation
- 4.17 Identify all escape routes from the machinery spaces
All escape routes are properly identified
- 4.18 Describe the various engine-room alarm systems and distinguish between the various alarms, especially the fire-extinguishing media alarm
Description is accurate
- 4.19 Operate the propulsion equipment in response to needs for changes in direction or speed
Capability for operation is satisfactory

- 4.20 Determine and describe all preventive maintenance, damage control, or repair operations to be performed during the engineering watch. Describe how all machinery to be worked on is isolated, bypassed, or adjusted. Record all work carried out on the watch
Determinations are complete; descriptions are satisfactory; and work performed is properly recorded
- 4.21 Inspect the machinery in the charge of the officer in charge of the engineering watch. Describe the condition of all such machinery
Condition is accurately described
- 4.22 Make rounds of the machinery and steering-gear spaces for the purpose of observing and reporting equipment malfunctions or breakdowns and performing under direction routine adjustments, required upkeep, and other necessary tasks. Describe potential malfunctions and breakdowns
Performance and description are satisfactory and accurate
- 4.23 Describe actions that would be necessary in case of damage resulting from equipment breakdown, fire, flooding, rupture, collision, grounding, or other causes in order to contain the effects
Descriptions are satisfactory
- 4.24 Record all events related to the main and auxiliary machinery which have occurred during the engineering watch
Records are suitable
- 4.25 Describe special watchkeeper precautions to be taken under adverse conditions in rough seas, restricted visibility, coastal and congested waters, and at anchor
Descriptions are satisfactory
- 4.26 Describe the procedures for taking over the engineering watch in port
Description includes the requirements of section A-VIII/2, part 4-2, of the STCW Code
- 4.27 Describe the procedures for performing the engineering watch in port
Description includes the requirements of section A-VIII/2, part 4-4, of the STCW Code

Competence 5: Use of English in written and oral form

- 5.1 Use engineering publications operational manuals and fault finding instructions written in English
The publications and manuals relevant to the engineering duties are correctly interpreted
- 5.2 Fill in standard engineering reports and forms in English
All reports and forms relevant to the engineering duties are correctly filled
- 5.3 Communicate with members of the watch, in a multilingual crew, in safety related duties
All orders and information related to Watchkeeping duties are correctly understood and acted upon those concerned

Competence 6: Operate main and auxiliary machinery and associated control systems

- 6.1 Prepare main machinery for departure
All checks and actions are carried out in accordance with laid down instructions and all auxiliary and control systems are functioning properly. All relevant checks and actions are recorded
- 6.2 Prepare and test the steering gear for departure
All checks and actions are carried out in accordance with laid down instructions and all control systems are functioning properly. All relevant checks and actions are recorded
- 6.3 Prepare auxiliary machinery for operation
All checks and actions are carried out in accordance with laid down instructions and all auxiliary and control systems are functioning properly. All relevant checks and actions are recorded

- 6.4 Operate steam boilers, including combustion control and burner management systems
The equipment is operated in accordance with instructions and good practice. All instruments are monitored, necessary adjustments made and required actions taken on and properly recorded
- 6.5 Check steam boiler water level
Water level is checked in accordance with instruction manual and good practice and necessary action is taken when water level is abnormal
- 6.6 Locate common faults in machinery and plants, in engine room boiler room and steering gear room and take action necessary to prevent damage
The causes of machinery malfunctions are promptly identified and action is taken to ensure the overall safety of the ship and the plant having regard to the prevailing circumstances and conditions

Competence 7: Operate pumping systems and associated control systems

- 7.1 Operate bilge and ballast pumping systems
The operations are carried out in accordance with established rules and procedures. The marine environment is in no way polluted by improper operation or negligence
- 7.2 Operate fuel pumping systems
The operations are carried out in accordance with established rules and procedures. The marine environment is in no way polluted by improper operation or negligence
- 7.3 Operate cargo pumping systems (liquid cargo ship)
The operations are carried out in accordance with established rules and procedures. The marine environment is in no way polluted by improper operation or negligence
- 7.4 Perform routine pumping operations
Operations are planned and carried out in accordance with established rules and procedures to ensure safety of operations and avoid pollution of the marine environment

Function 2: Electrical, electronic and control engineering at the operational level

Competence 1: Operate alternators, generators and control systems

- 1.1_ Locate and use relevant manuals, drawings, diagrams and instructions
The instructions and manuals relevant for safe and efficient operations are quickly identified and properly used
- 1.2 Prepare for starting, coupling (connecting) and change over alternators or generators
Operations are planned in accordance with established procedures and instructions
- 1.3 Start, couple and change over alternators or generators
The operations are carried out as planned and all machinery and equipment are functioning satisfactorily
- 1.4 Location of common faults and action to prevent damage
The causes of malfunction are promptly identified and actions are designed to ensure the overall safety of the ship and the plant having regard to the prevailing circumstances and conditions
- 1.5 Identify ship's electrical distribution system
Diagrammatic sketch from generator to final breaker panels, including circuit breakers trips, transformers, fuses, supply voltages, shore connections and emergency switchboard connection
- 1.6 Locate all electronic control equipment as found in ship's spaces
The list include control function description manufacture, power supply operating voltage
- 1.7 Identify all ship's electronic monitoring equipment
List should include function, location manufacture, power supply and operating voltage

- 1.8 Describe main engine throttle control system
Sketch should include block diagram of major components and explanation of operation including alternate means of controlling throttle
- 1.9 Describe electronic steering gear control system
Sketch should include block diagram of major components and explanation of operation including alternate means of controlling steering
- 1.10 Describe ships internal communication system
Sketch should include block diagram of major components and explanation of operation

Function 3: Maintenance and repair at the operational level

Competence 1: Maintain marine engineering systems, including control systems

- 1.1 a) Locate and use relevant manuals and interpret drawings, sketches and instructions
The instructions and drawings relevant for the job are quickly identified and properly used.
b) Carry out routine testing and maintenance / repair to plant and equipment
Items include mechanical, pneumatic, hydraulic, electrical and electronic systems. Submit report of results
- 1.2 Select and use special tools for work on machinery and equipment
Correct tools are chosen and used without causing any damage to machinery or equipment
- 1.3 Use machine tools and equipment for fabrication and repair
The selected material is suitable for the parts to be fabricated and the work is carried out within the designed tolerances.
- 1.4 Ensure safety for all persons working on plant or equipment
Isolation, dismantling and re-assembly of plant and equipment is in accordance with accepted practices and procedures to ensure safety or operations.
- 1.5 Undertake the following maintenance and repair to the main engine
- 1.5.1 Use turning gear, place notices, record and take all safety precautions
Take all safety precautions and display notice that turning gear is engaged. Obtain bridge clearance before turning engine.
- 1.5.2 Carry out a crank case inspection and make a written report
Work is carried out with manufacturers recommendations or acceptable practices.
- 1.5.3 Take crankshaft deflection
Work is carried out with readings manufacturers recommendation or acceptable practices.
- 1.5.4 Inspect, check condition, wear and clearances, overhaul and test:
1. fuel injection valves
 2. air start valves
 3. relief valves
 4. exhaust valves
 5. fuel pumps
- Work is carried out according to the instructions of the manufacturer's manual and the necessary safety criteria.*
- 1.5.5 Replace and/or overhaul the following components, checking and adjusting clearances where appropriate:
1. large bore or trunk pistons
 2. cylinder heads

3. turbochargers
4. top end bearings
5. bottom end bearings
6. main bearing
7. piston-rod scraper rings
8. cross head guides
9. tie bolts
10. holding down bolts and chocks

Work is carried out according to the instructions of the manufacturers manual and the necessary safety criteria. The clearances are correctly adjusted.

1.6 Undertake the following maintenance and repair to the auxiliary boiler.

1.6.1 Take a boiler out of service. Isolate. Blow a boiler down. Open up a boiler

Task is carried out in accordance with the manufacturer's instructions and accepted practices. Necessary safety criteria are taken care of.

1.6.2 Examine a boiler, reporting on its conditions:

1. internally
2. externally

Task is carried out in accordance with the manufacturer's instructions and accepted practices. Necessary safety criteria are taken care of.

1.6.3 Inspect water gauge fittings and check that passages, cocks and valves are clear

Task is carried out in accordance with the manufacturer's instructions and accepted practices. Necessary safety criteria are taken care of.

1.6.4 Open up and inspect:

1. safety valves
2. feed check valves

Task is carried out in accordance with the manufacturer's instructions and accepted practices. Necessary safety criteria are taken care of.

1.7 Undertake the following maintenance and repair to deck machinery and survival equipment

1.7.1 Carry out routine maintenance on:

1. anchor windlass
2. cargo winches
3. cargo cranes
4. mooring winches
5. capstans
6. survival craft and launching gear
7. hatch covers

The work is carried out in accordance with the instructions of the manufacturer's manual and necessary safety precautions

1.7.2 Steering gear:

1. make routine check and test on system during voyage
2. check level of hydraulic fluid and purge air from the system as appropriate

Perform in accordance with manufacturer's recommendations. Follow manufacturer's recommendations or acceptable engineering practice.

Function 4: Controlling the operation of the ship and care for persons on board at the operational level

Competence 1: Ensure compliance with pollution-prevention requirements

- 1.1_ Ensure that procedures are agreed and observed and all scuppers are blocked before bunkering
The operations are fully observed, all scuppers are blocked and pipes and hoses inspected before bunkering takes place.
- 1.2 During relevant drills initiate immediate investigation to detect the source of pollution
All available resources are utilized to detect the source and the master or appropriate authorities are informed
- 1.3 During relevant drills stop or prevent leakage and spills of harmful liquids and solids substances
The situation is thoroughly assessed and the actions taken are well organized and exercised with due consideration taken to the extent of the pollution
- 1.4 Have all tanks and compartments sounded if any damage suspected
The soundings are readily available and the results immediately reported is to the master
- 1.5 Carry out bilge, ballast and bunkering operations
All operations are carried out in accordance with MARPOL and due regard paid to Shipboard Oil Pollution Emergency Plan (SOPEP)

Competence 2: Maintain seaworthiness of the ship

- 2.1 Inspect hull and hull openings, compartments, hatch covers, equipment and complement and take action if any defects are detected
The inspection is properly carried out, due regards paid to the prevailing circumstances and areas where defects are most likely to occur. Any defect is immediately reported and recorded and the suggested or executed action adequate for the situation
- 2.2 Ensure that all loose objects are securely fastened to avoid damage
Inspection is carried out at regular intervals and more frequently in heavy weather or if other incidents occur. Heavy or otherwise dangerous objects are given the highest priority and good seamanship exercised.
- 2.3 Arrange for regular control measures to ensure watertight integrity
Peaks, bilge, tanks and other compartments are sounded regularly, the results recorded and any irregularities reported and examined further.
- 2.4 Calculate stability, trim and stresses using stability trim, and stress tables, diagrams and stress calculating equipment
Ensure that stability conditions comply with the IMO intact stability criteria under all conditions of loading.
- 2.5 During relevant drills take actions to ensure and maintain the watertight integrity of the ship
Actions to ensure and maintain the watertight integrity of the ship are in accordance with accepted practice.

Competence 3: Prevent, control and fight fires on board

Fire prevention -

- 3.1 Operate fire and smoke detecting equipment
The equipment is tested and operated in accordance with manufacturer's manuals and ship-specific instructions.

- 3.2 Ensure that all persons on watch are able to detect and correct hazardous situations and actions and keep the ship clean and tidy
Watch personnel make regular inspections in areas exposed to ignition. Easily inflammable material is put in safe places and the watch demonstrate an attitude of alertness and readiness to respond to fires.
- 3.3 Make the watch locate and use fire-fighting appliances and emergency escape routes and sound alarm
Every person on watch can use portable or otherwise adequate fire-extinguishers for small fires, demonstrate ability to find emergency escape routes and raise the alarm

Control and fight fires -

- 4.1 Locate fire-stations and demonstrate proper use of fixed installations and other fire-fighting appliances and agents
All stations are located and the most suitable one in the event of a fire. Proper equipment and extinguishing agents selected for the various materials on fire.
- 4.2 Locate and use fire-protective equipment (fireman's outfit, including, breathing apparatus)
The equipment is quickly donned and used in a way that no accidents are likely to occur.
- 4.3 Demonstrate ability to act in accordance with the fire-fighting plan during fire-drills
During debriefing after an exercise or a real fire extinguishing action the reasons for each action taken, including the priority in which they were taken, are explained and accepted as the most appropriate.
- 4.4 During relevant drills carry out rescue operations wearing breathing apparatus
The breathing apparatus is tested and used in accordance with manufacturers manual and the operation is successful.

Competence 4: Operate life-saving appliances

- 5.1 Organize abandon ship drills
On sounding the alarm all persons meet at the designated life-boat station wearing life jackets or immersion suits and carry out their duties on request.
- 5.2 Demonstrate the ability to organize and supervise the launching, handling and recovery of life boat
Correct orders for embarkation, launching, immediately clearing the ship's side, safely handling the boat under motor, oars or sail as appropriate, and safe boat recovery.
- 5.3 Demonstrate the ability to organize and supervise the launching or throwing overboard a liferaft, and manoeuvre it clear of ship's side
The duties for the persons designated for the raft are clearly allocated and orders efficiently executed
- 5.4 Demonstrate proper use of radio life-saving appliances, satellite EPIRBs and SARTs
Equipment is operated in accordance with manufacturer's, instruction.
- 5.5 Ensure that all survival craft launching equipment on board is functioning
Equipment is maintained in accordance with manufacturer's instructions and regulatory requirements.
- 5.6 Ensure rations on board survival craft are adequate
Food and water are sufficient for the survival craft designated complements.
- 5.7 Ensure that equipment on board survival craft is adequate
Equipment such as pyrotechnics, signalling equipment, all meet regulatory requirements.

Competence 5: Apply medical first aid on board

- 6.1 During relevant drills stop excessive bleeding, ensure breathing and put casualties in proper position
The actions demonstrated are in compliance with accepted recommendations given in international medical first aid guidance.
- 6.2 During relevant drills detect sign of shock and heat stroke and act accordingly
The treatment recommended or given is adequate. Ability to request Radio Medico for advice is demonstrated.
- 6.3 During relevant drills treat burns, scalds, fractures and hypothermia
Recommended guidelines for proper actions are explained and the basic principles for avoiding hypothermia are demonstrated.
- 6.4 During relevant drills, locate and access shipboard medicine and equipment
Ability to access the medical cabinet in a timely way.

Competence 6: Monitor compliance with legislation requirements

- 7.1 State where laws, rules and regulations concerning ship operation and pollution prevention are available
The statement given is correct and includes relevant bodies or organizations which may be contacted to attain special information or guidance which is not easily accessible
- 7.2 Use legislation to ascertain due approach to solve questions encountered during onboard operations
Legislative requirements relating to safety of life at sea and protection of the marine environment are correctly identified.

Example 2 - Start diesel generator for putting on load-sharing

FUNCTION	Electrical. Electronic and Control Engineering at the Operational Level.
COMPETENCE	Operate alternators, generators and control systems.

STCW Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
<i>Operate alternators, generators and control systems</i>	<i>Prepares diesel generator for starting and connecting to the busbars</i>	<i>Carries out essential checks and prepares generators for connecting to busbars</i>	<i>Operations are planned and carried out in accordance with established rules and procedures to ensure safety</i>
		<i>Pre-start inspection — diesel engine and alternator:</i> 1. Inspects alternator for loose cable connections, 2. Inspects coupling between diesel engine and alternator 3. Inspect engine to ensure nothing fouls the moving parts 4. Checks gauges for correct indication 5. Checks lub. oil level in: i) turbocharger ii) governor iii) rocker arm tank iv) sump	1. Checks and removes items that fouls the rotating parts. 2. Fasteners are secured. 3. Checks and removes items that obstruct moving parts. 4. Ability to ascertain gauges are in working order. 5. Appropriately tops up level if necessary.

STCW Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
		<i>Inspection — Auxiliary sea water cooling system:</i> 1. Inspects auxiliary cooling pump and piping for leakages. 2. Checks and opens required valves to: i) lub. oil cooler ii) fresh water cooler iii) charge air cooler 3. Inspects controller for auxiliary cooling pump motor.	1. Checks and rectifies leaks, if any. 2. Correct valves are open for cooling systems. 3. Knows how to change position of controller.
		<i>Prepares diesel engine for start-up:</i>	
		1. Opens required valves for: i) fresh water cooling ii) lub. oil system 2. Using turning bar, crank engine with indicator cocks open. 3. Blows through and close indicator cocks. 4. Opens required valves in fuel oil system. 5. Checks generator air circuit breaker 6. Checks and switches starting control to local position. 7. Starts engine.	1. Correct valves are opened. 2. At least 2 cranks. Checks for leakages from indicator cocks. 3. Executes blow through appropriately. 4. Correct valves are opened. 5. Checks and ascertains circuit breaker in open position 6. Switches from remote if required. 7. Releases starter as soon as engine "fires"

STCW Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
		8. On running engine, checks i) for leakages ii) readings on gauges iii) abnormal sounds.	8. Parameter readings are normal. No abnormal noise.
		<i>Paralleling alternators:</i> 1. Allows engine to warm up. 2. Adjust voltage. 3. Turns on synchroscope and observes direction and speed of rotation. Adjusts as required. 4. Closes incoming generator breaker to stop synchroscope at 11 o'clock 5. Switches off synchroscope. 6. Divides the load evenly between the two generators.	1. Allows engine to run up to correct speed. Checks and reports that all parameter readings are normal. 2. 440 V 3. Able to adjust synchroscope to slow speed and in clockwise direction. 4. Closing of circuit breaker is planned and properly executed. 5. Switches off the synchroscope after operation. 6. Manipulates governor switches to achieve equal loading.

Example 3 - Checking water level in steam boiler

FUNCTION	Marine engineering at the operational level
COMPETENCE	Operate main and auxiliary machinery and associated systems

STCW Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
<i>Operate Main and Auxiliary Machinery and Associated Control Systems</i>	<i>Demonstrate methods of checking water level in steam boilers</i>	<i>Carry out the correct sequence of blowing the gauge glass</i>	<i>Operations are planned and carried out in accordance with established rules and procedures to ensure safety of operations</i>
	Demonstrate procedure of blowing water gauge glass.	Proper sequence of blowing the gauge glass is demonstrated as in a routine operation of an auxiliary boiler.	Gauge glass blowing is carried out in accordance with accepted practice and procedure to ensure safety. Explanation is given before or after executing each step.
		<i>Observes the precautions before blowing gauge glass:</i> Checks: i) water level in glass, ii) protective glass plates in iii) no personnel at vicinity	Checks and ensures the following: 1. water level is about half glass ii) protective glass plates iii) no personnel present at
		<i>Carries out the following procedure:</i> 1. Closes the steam and water cocks 2. Opens the drain cock to clear content in glass 3. Opens the steam cock to blow; clear strong sound through the drain.	1. Executes closing of steam cock. 2. Drain cock is opened. Draining of content is noted. 3. Steam cock is correctly opened. Ability to explain the indications of a clear passage.

STCW Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
		4. Closes the steam cock 5. Opens the water cock to blow water line; close the water cock. 6. Closes the drain cock. 7. Opens the water cock. 8. Opens the steam cock, water level drops to the level appropriate to what is inside the boiler.	4. Executes closing of steam cock. 5. Correctly opens the water cock. Able to explain the indications of a clear water passage. 6. Appropriately closes the drain cock. 7. The water cock is fully opened. Observes water filling up the glass. 8. Steam cock is fully opened. Level should be between one-quarter to three-quarters of glass.

Example 4 - Using self-contained breathing apparatus

SPECIFICATION of MINIMUM STANDARD	TABLE A-VI/1-2:
COMPETENCE	Fight Prevention and Fire Fighting

As part of required Competence	Respective Performance Objectives/Tasks	Performance Measures	Performance Standards
<i>Fight and extinguish fires</i>	<i>Fire-fighting equipment and its location on board</i> ----- <i>Use of breathing apparatus for fighting fires and effecting rescues *</i> <i>* Taken from item .8 under "Knowledge, understanding and proficiency" of STCW Code Table A-VI/1-2</i>	<i>Locates and identifies types of breathing apparatus and all equipment necessary for fighting fires and effecting rescues</i> <i>Inspects, dons and uses the breathing apparatus in fire fighting and rescue drills under truly realistic training conditions</i>	<i>Correctly locates and identifies breathing apparatus and equipment used for fighting fires and effecting rescue operations</i> <i>Procedures and techniques comply with accepted practices</i>
		<i>Inspection —</i> 1. Identifies breathing apparatus for intended purpose 2. Identifies the main components of the breathing apparatus 3. Checks air capacity and estimates duration for use	1. Breathing apparatus identified is appropriate for intended purpose 2. Correctly identifies the following components and their functions: a) cylinder b) face mask c) features of face mask d) harness and straps e) warning whistle f) pressure gauge g) positive pressure feature 3. Air capacity and usage duration correctly calculated

STCW Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
		<i>Donning and Testing —</i> 1. Dons the breathing apparatus 2. Performs the following tests on the breathing apparatus: a) gauge and capacity of air supply b) low pressure audible alarm c) face mask - under positive pressure and not leaking	1. The breathing apparatus is donned in accordance with the manufacturer's instruction 2. The tests are carried out in accordance with the manufacturer's instruction and any unsatisfactory outcome arising from the tests is reported. For example, the incorrect setting of the low pressure alarm should be reported immediately
		<i>Preparation for assigned task—</i> 1. Establishes means of communication 2. Understands the emergency signals agreed with team members and with other teams 3. Identifies all other equipment required for the intended task(s) 4. Takes instructions	<i>(Performance standards for this section are to be set in conjunction with Performance Standards of other Competence)</i> 1. Shows awareness and understanding in the means of communication established with other members of the team, and with other team(s) 2. Shows ability to apply or act on any agreed emergency signals 3. Is able to list other equipment necessary for the task(s) at hand and report any items not available 4. Show understanding in the instructions issued

STCW Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
		<i>Using the breathing apparatus—</i> 1. Uses the breathing apparatus for the assigned task(s), including fighting fire in smoke-filled enclosed spaces	1. The breathing apparatus is used in accordance with the manufacturer's instruction, taking into account: a) the behaviour and action of the trainee the task(s) b) safety considerations on the part of the trainee c) the ability of the trainee in coping with the environment in which the breathing apparatus is used

Example 5 - Operation of survival craft engine, understanding its associated accessories and use of fire extinguisher provided

SPECIFICATION of MINIMUM STANDARD	TABLE A-VI/2-1:
COMPETENCE	Survival Craft and Rescue Boats other than fast rescue boats

As part of required Competence	Respective Performance Objectives/Tasks	Performance Measures	Performance Standards
<i>Operate a survival craft engine</i>	<i>Methods of starting and operating a survival craft engine and its accessories together with the use of the fire extinguisher provided</i>	<i>Demonstrates ability to start and operate an inboard engine fitted in an open or enclosed lifeboat</i> ----- <i>Demonstrates understanding of the functions of the accessories associated with the survival craft engine</i> <i>Demonstrates ability to use the fire extinguisher provided</i>	<i>Propulsion is available and maintained as required for manoeuvring</i> ----- <i>Knowledge of the accessories assists in ensuring availability and maintenance of propulsion</i> <i>Able to extinguish oil fire using a similar type of fire extinguisher</i>
		<i>Starting the survival craft engine —</i> 1. Checks levels of fuel and lubricating oil 2. Checks that gear lever is in neutral 3. Prepares the engine for starting	1. Correctly checks the levels and reports any abnormalities 2. Shifts the gear levers to "Ahead", "Astern" and "Neutral" positions before engaging it to "Neutral" 3. Controls are set in accordance with the manufacturer's instruction, and the fuel system primed as necessary

As part of required Competence	Respective Performance Objectives/Tasks	Performance Measures	Performance Standards
		4. Starts engine and adjusts throttle 5. Performs the following checks and tests, if applicable: a) oil pressure b) water cooling c) "Ahead" and "Astern" propulsion 6. Stops engine	4. Engine is started in accordance with manufacturer's instruction, and fuel throttle adjusted as desired. (In the event that engine cannot be started, the ability to perform simple trouble-shooting must be shown) 5. Shows ability to carry out the applicable checks and tests with minimum delay 6. Engine is stopped in accordance with procedures laid out, if any, including: a) shutting off fuel b) engaging gear to "Neutral"
		<i>Understanding the functions of the accessories —</i> 1. Explains the function of cooling system and the cooling medium used 2. Explains the use of anti-freeze protection for fresh water cooling system, if appropriate	1. Shows an understanding of the cooling system 2. Shows an understanding in the use of anti-freeze and the circumstances for its use

As part of required Competence	Respective Performance Objectives/Tasks	Performance Measures	Performance Standards
		3. Explains the requirements and limitation, if any, of starting the engine out of the water 4. Knowledge on the source of power to start the engine	3. Shows knowledge in the requirements / limitation, including as a minimum: a) the capability of the engine of operating for not less than 5 minutes after starting from cold with the lifeboat out of the water b) any limitation(s) specified by the manufacturer 4. Able to identify the source(s) of power and any recharging mechanism
		<i>Using the fire extinguisher provided —</i> 1. Uses the fire extinguisher provided in the boat	1. Shows ability in using of the fire extinguisher to put out oil fire. (The ability may be demonstrated in Fire Prevention and Fire Fighting training extinguishers are used to assess competence)

Example 6 - Complying with pollution-prevention requirements onboard tankers

SPECIFICATION of MINIMUM STANDARD	TABLE A-II/1 — FUNCTION: Controlling the operation of the <i>tanker</i> and care for person on board at the operational level
COMPETENCE	Ensure compliance with pollution-prevention requirements

Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
Ensure compliance with pollution-prevention requirements	Prevention of pollution of the marine environment and anti-pollution procedures	Demonstrates competence during approved in-service and / or approved training ship experience	Procedures for monitoring shipboard operations and ensuring compliance with MARPOL requirements are fully observed
	Knowledge of the precautions to be taken to prevent pollution of the marine environment	<i>Pollution Prevention —</i> 1. Demonstrates awareness of causes of marine pollution 2. Demonstrates knowledge of methods and procedures to prevent marine pollution 3. Demonstrates a basic working knowledge of IMO requirements on safety and environmental -protection	1. The main sources and causes of marine pollution are correctly identified 2. The various methods and procedures in preventing marine pollution are correctly identified during the following operations: a) loading b) unloading c) cargo transferring d) tank cleaning / e) bunkering f) pumping out bilges 3. The relevant IMO requirements necessary to ensure compliance are identified

Competence	Performance Objectives/Tasks	Performance Measures	Performance Standards
	<i>Anti-pollution procedures and all associated equipment</i>	<i>Response —</i> 1. Demonstrates awareness of the measures to be taken in the event of spillage 2. Demonstrates ability to abide by the Shipboard Oil Pollution Emergency Plan (SOPEP) 3. Understands the requirements of the ship/shore safety and pollution - prevention checklists 4. Demonstrates onboard use of equipment to protect the environment	1. The measures to be taken in the event of spillage are correctly identified, including the need to: a) immediately report appropriate officials b) promptly notify shore-based personnel c) promptly implement shipboard spill-containment procedures 2. Able to clearly explain the concept and contents of the Shipboard Oil Pollution Emergency Plan and where necessary, execute the procedures therein 3. Able to effectively complete the requirements in the checklists, or at least ensure its completeness 4. Environmental protection equipment carried on board are used for practice or in actual operation, in accordance with the manufacturer's instructions.

Function: Navigation at the operational level

Competence: Plan and conduct a passage and determine position(STCW Code, Table A-II/1)

No.	TASKS: Plan a passage	CRITERIA FOR SATISFACTORY PERFORMANCE	Ship Ref. No.	Assignment completed					
				Date	Confirmed by qualified instructor	Date	by qualified assessor	Type of Assessment	Remarks
1.1	Consult nautical publications	The information obtained from navigational publications is relevant, interpreted correctly and properly applied. All potential navigational							
1.2	Select charts of adequate scale	The charts selected are the largest scale suitable for the area of navigation and charts are corrected in accordance							
1.3	Set courses	The courses are suitably set in respect of the ship's size, draft and manoeuvrability, and set with sufficient distance off shallow waters, banks and other dangers to navigation. Due consideration is given to current, ice, prevailing meteorological conditions and							
1.4	Calculate Estimated Time of Arrival (ETA)	The total distance is correctly calculated and ETA given within acceptable time limits.							

Function: Marine Engineering at operational level**Competence: Use of appropriate tool for fabrication and repair operations typically performed on ships(STCW Code, Table A-III/1)**

No.	TASKS	CRITERIA FOR SATISFACTORY PERFORMANCE	Ship Ref. No.	Assignment completed					
				Date	Confirmed by qualified instructor	Date	Confirmed by qualified assessor	Type of Assessment	Remarks
1.1	Recognize characteristics and limitations of materials used in construction and repair onboard	Identification of important parameters for fabrication of ship related components is appropriate.							
1.2	Select and use special tools for work on specific machinery and equipment i. e. pumps, purifiers, reducers	Correct hand and machine tools, tools are chosen and used in accordance with instructions, manuals and good workmanship.							
1.3	Select and use appropriate material	The selected material is suitable for the part(s) to be fabricated or repaired.							
1.4	Use machine tools and equipment for fabrication and repair	Use of equipment and machine tools is appropriate and safe and fabrication is to designated tolerances.							

DRAFT

IMO Model Course
Training for Instructors

Training for Instructors

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Friday, 10 November 2000

Model Course No: 3.12

Introduction

- Purpose of the model courses

The purpose of the IMO model courses is to assist training providers and their teaching staff in organizing and introducing new training courses, or in enhancing, updating or supplementing existing training material where the quality and effectiveness of the training courses may thereby be improved.

It is not the intention of the model course programme to present instructors with a rigid “teaching package”, which they are expected to “follow blindly”. Nor is it the intention to substitute the instructor’s presence with audiovisual or programmed material. As in all training endeavours, the knowledge, skills and dedication of the instructors are the key components in the transfer of knowledge and skills to those being trained through IMO model course material.

Because educational systems and the cultural backgrounds of trainees in maritime subjects vary considerably from country to country, the model course material has been designed to identify the basic entry requirements and trainee target group for each course in universally applicable terms, and to specify clearly the technical content and levels of knowledge and skill necessary to meet the technical intent of IMO conventions and related recommendations.

- Use of the model course

To use this model course the instructor should review the course plan and detailed syllabus, taking into account the information provided under the entry standards specified in the course framework. The actual level of knowledge and skills and the prior technical education of the trainees should be kept in mind during this review, and any areas within the detailed syllabus which may cause difficulties because of differences between the actual trainee entry level and that assumed by the course designer should be identified. To compensate for such differences, the instructor is expected to delete from the course, or reduce the emphasis on, items dealing with knowledge or skills already attained by the trainees. The instructor should also identify any academic knowledge, skills or technical training which they may not have acquired.

By analysing the detailed syllabus and the academic knowledge required to allow training to proceed, the instructor can design an appropriate pre-entry course, or, alternatively, insert the elements of academic knowledge required to support the technical training elements concerned at appropriate points within the course.

Adjustment of the course objectives, scope and content may be necessary if, within the respective maritime industry, the trainees completing the course are to undertake duties which differ from the course objectives specified in the model course.

Within the course plan the course designers have indicated their assessment of the time which should be allotted to each area of learning. However, it must be appreciated that these allocations are arbitrary and assume that the trainees have fully met all entry requirements of the course. The instructor should therefore review these assessments and may need to re-allocate the time required to achieve each specific learning objective or training outcome.

- Lesson plans

Having adjusted the course content to suit the trainee intake and any revision of the course objectives, the instructor should draw up lesson plans based on the detailed syllabus. The detailed syllabus contains specific references to the textbooks or teaching material proposed to be used in the course. Where no adjustment has been found necessary in the learning objectives of the detailed syllabus, the lesson plans may simply consist of the detailed syllabus with keywords or other reminders added to assist the instructor in making his presentation of the material.

- Presentation

The presentation of concepts and methodologies must be repeated in various ways until the instructor is satisfied that the trainee has attained each specific learning objective or training outcome. The syllabus is laid out in learning objective format and each objective specifies *what the trainee must be able to do* as the learning outcome.

- Evaluation or assessment of trainee progress

No specific guidance on the assessment of trainees has been included since that forms the subject matter of a large part of this course. The progress of trainees can be judged from the

outcome of the various activities undertaken by them, which will indicate if further explanation or clarification of any topic is needed. An overall evaluation of the course will be afforded by the final activity, for which the trainees are divided into two groups, each of which examines the other.

- Implementation

For the course to run smoothly and to be effective, considerable attention must be paid to the availability and use of:

- ☐ properly qualified instructors;
- ☐ support staff;
- ☐ rooms and other spaces;
- ☐ equipment;
- ☐ textbooks, technical papers; and
- ☐ other reference material.

Thorough preparation is the key to successful implementation of the course. IMO has produced a booklet entitled “Guidance on the implementation of IMO model courses”, which deals with this aspect in greater detail. A copy of the booklet is included as an attachment to this course.

- Training and the STCW 1995 Convention

The standards of competence that have to be met by seafarers are defined in Part A of the STCW Code in the Standards of Training, Certification and Watchkeeping for Seafarers Convention, as amended in 1995. This IMO model course has designed to support the implementation of the revisions. It addresses the requirements of Regulation I/6 and Section A-VI/6 of the STCW Code.

Part A provides the framework for the course with the aims and objectives and notes on the suggested teaching facilities and equipment. A list of useful teaching aids, IMO references and textbooks is also included.

Part B provides an outline of lectures, demonstrations and exercises for the course. A suggested timetable is included but from the teaching and learning point of view, it is more important that the trainee achieves competence in the required skills than that a strict timetable

is followed. Depending on their experience and ability, some students will naturally take longer to become proficient in some topics than in others. Also included in this section are guidance notes and additional explanations.

A separate IMO model course addresses Assessment of Competence. This course explains the use of various methods for demonstrating competence and criteria for evaluating competence as tabulated in the STCW Code.

Part C gives the Detailed Teaching Syllabus. This is based on the theoretical and practical knowledge required. It is written as a series of learning objectives, in other words what the trainee is expected to be able to do as a result of the teaching and training. Each of the objectives is expanded to define a required performance of knowledge, understanding and proficiency. IMO references, textbook references and suggested teaching aids are included to assist the teacher in designing lessons and exercises.

Part D gives guidance notes and additional explanations.

- Responsibilities of Administrations

Administrations should ensure that training courses delivered by training providers are such as to ensure those completing training do meet the requirements of STCW Regulation I/6.2.

Part A: Course framework

Aims

This course is designed to facilitate the delivery of training in the competence standards required by the IMO Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995 (STCW 95). It will also provide a sound basis for the delivery of other training programmes.

Since the course is relatively short it cannot provide a full course of teacher training. However, it should provide a useful introduction for those with limited teaching experience. For those who have been teaching for some time the course may introduce some new approaches or serve as a reminder of techniques that have been forgotten.

Objectives

The objectives of the course include the planning and preparation of effective teaching and instruction; the selection of appropriate methods of instruction and teaching materials; and the evaluation of the teaching and learning process.

Entry standards

Those wishing to deliver training in the competence standards required by the STCW 95 Convention and other courses for seafarers should already have the necessary technical knowledge. This course assumes that the trainee instructors are appropriately qualified in the technical aspects of their subjects¹. It would be useful if at least some of a group of trainee instructors had experience in training.

Course certificate

If the course includes an appropriate assessment of the trainee instructor's ability to act as an instructor a certificate or document may be issued to indicate that the holder has successfully completed a course of training for instructors. If on the other hand formal assessment is not used, then a certificate of attendance is appropriate.

Course intake limitations

The size of the group should be neither too large nor too small. A maximum number of participants would be 20, this would allow about four in each group for groupwork. A suggested minimum number would be ten; otherwise it is difficult to promote discussion in the group.

Staff requirement

Ideally the course should have two experienced instructors, who should have background knowledge of the marine industry and some experience in maritime education and training. At least one member of staff should have undergone teacher training.

Teaching facilities and equipment

A suitable classroom is required with desks or tables and chairs. It should be possible to move the furniture around so that different arrangements of the room can be demonstrated. In

¹ See STCW 1995, Regulation I/6
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addition, extra rooms will be needed when the class is split into groups. Each group should have a separate space in which to work.

The main room should be provided with a whiteboard or blackboard and writing materials, a flip-over board with writing materials and an overhead projector. Electrical outlets should be available so that the equipment can be positioned safely

Group rooms should be provided with a table and chairs and some form of board and writing materials.

A video camera is not an essential requirement for the course, but if a video camera is available it can be a useful aid.

Teaching Aids

- A1 The Instructor Manual (Part D of this course)
- A2 Video cassette player and/or film projector
- A3 An item of new technology.
This could be of any format, for example an educational package available on floppy disc or CD-ROM or a MS PowerPoint presentation.
- A4 An overhead projector with pens and acetates
- A5 A video camera, or CCTV (optional)

Videos

- V1 Tale of two trainers (Code No. 197)
- V2 Understanding English On Board Ship Part 1 (Code No. 525)
- V3 STCW and flag state implementation (Code No. 629)
- V4 The Culture Gap (Code No. 539)

Available from: Videotel Marine International Limited
84 Newman Street
London W1P 3LD, UK
Tel: +44 (0)20 7299 1800
Fax: +44 (0)20 7299 1818
E-mail: mail@videotelmail.com
URL: www.videotel.co.uk

Audio-visual examples listed above may be substituted by other similar audio-visual material at the discretion of the training provider and administration.

IMO References (R)

- R1 The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995 (STCW 1995) (IMO Sales No. 938).
- R2 STCW 95: IMO workshop material on implementation of the revised STCW Convention (IMO Sales No 972)
- R3 IMO model course No. 1.07 Radar Navigation, Radar Plotting and Use of ARPA at Operational Level (IMO Sales No T-107)
- R4 IMO model course No. 1.08 Radar, ARPA, Bridge Teamwork and Search and Rescue at the Management Level (IMO Sales No T-108)

Publications (P)

- P1 *On Board Training Record Book for Deck Cadets*. 3rd edition (London, International Shipping Federation, 2000)
- P2 *On Board Training Record for Engineer Cadets*. 2nd edition (London, International Shipping Federation, 1997)
- P3 *The Revised STCW Convention*, 1st edition (London, International Shipping Federation, 1995)
- P4 *Maritime Education and Training: A Practical Guide*. The Nautical Institute, London, 1997

Recommended reading

Fletcher, S *Designing Competence-based Training*, Kogan Page, 1997

Gibbs, G. Habeshaw, S. and Habeshaw, T *53 Interesting Things to do in your Lectures*, Technical and Educational Services Ltd, 1992

Gower R., Phillips D., Walters S. *Teaching Practice Handbook*. Heinemann, 1983

Reece, I and Walker, S. *A Practical Guide to the Overhead Projector and Other Visual Aids*, Business Education Publishers, 1995

Scrivener J. *Learning Teaching*. Macmillan Heinemann, 1994

Urr P. *A Course in Language Teaching*. Cambridge University Press, 1996

Secondhand copies of out of print books may be available from the Warsash Nautical Bookshop, 6 Dibles Road, Warsash, Southampton SO31 9HZ, UK. Tel: +44 1489 572 384 Fax: +44 1489 885 756 E-mail: orders@nauticalbooks.co.uk

Internet websites (W)

- W1 **DNV — STCW 95 Training and Qualification Support**
<http://www.dnv.com/stcw/Rev1/>
- W2 **USCG STCW Home Page**
<http://www.uscg.mil/STCW/index.htm>
- W3 **USCG Exam Question Bank**
<http://www.uscg.mil/hq/g-m/marpers/examques/index.htm>
- W4 **USCG NVICs published in the 90s**
<http://www.uscg.mil/hq/g-m/nvic/index90.htm>
- W5 **ILO Sectoral Activities: Shipping**
<http://www.ilo.org/public/english/100secto/sectors/mariti.htm>
- W6 **ILO Database of International Labour Standards**
<http://ilolex.ilo.ch:1567/public/english/50normes/infleg/iloeng/index.htm>
- W7 **PC Maritime Ltd**
<http://www.pcmaritime.co.uk/comm/index.htm?/comm/products.htm>
- W8 **Poseidon Simulation AS — Radar Simulator**
<http://www.poseidon.no/Radar.htm>
- W9 **MARINTEK — Information Technology**
<http://www.marintek.sintef.no/mt23doc/mitd/programme/b2-98m.html>
- W10 **IMO -STCW 95 Bibliography (information sheet No. 23)**
<http://www.imo.org>

Details of distributors of IMO publications that maintain a permanent stock of all IMO publications may be found on the IMO web site at <http://www.imo.org>

Part B: Course Outline and Timetable

Course Outline

The table, which follows, lists the areas of knowledge, understanding and proficiency, together with the estimated total hours that are required. These timings are suggestions only and should be adapted to suit individual groups of trainees depending upon their knowledge and experience, the availability of equipment and resources.

Implementation

Instructors are advised to familiarise themselves with the instructor manual in part D of this model course, prior to implementing this syllabus.

The manual provides suggestions for ways to implement the material included in the syllabus.

Subject: Instruction of competence-based training courses

Competence: Teach a competence-based course effectively using appropriate methods and teaching aids

Subject area	Hours	
	Lecture	Activity
1. Describe how training activities may change in the new regime 1.1 Describe the training requirements under STCW 1995 Convention 1.2 Describe how the quality of marine education and training is controlled	2	-
2. Plan an effective teaching environment 2.1 Plan the learning process 2.2 Demonstrate a knowledge of the factors which affect student learning	5	4
3. Use a range of teaching methods effectively 3.1 Demonstrate a range of teaching methods appropriate to trainees needs	6	10
4. Use appropriate training aids 4.1 Demonstrate a range of teaching aids 4.2 Select appropriate training aids	3	9
5. Produce a relevant plan 5.1 Identify outcomes for a lesson 5.2 Recognise factors to consider when planning a lesson	3	6
6. Evaluate teaching and learning 6.1 Analyse uses of assessment correctly 6.2 Identify measures of performance correctly 6.3 Select correct assessment methods	2	4
7. Design a course of study 7.1 Identify the factors to be considered when designing a learning programme 7.2 Deliver a new course of study	3	3
Totals	24	36

Note: Teaching staff should note that outlines are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

The lecture and practical hours are for guidance only.

Course Timetable

Period/Day	Day 1	Day 2	Day 3	Day 4	Day 5
1st Period (1.5 hours)	1. Describe how training activities may change in the new regime	2. Plan an effective teaching environment (continued)	3. Use a range of teaching methods effectively (continued)	3. Use a range of teaching methods effectively (continued)	3. Use a range of teaching methods effectively (continued)
2nd Period (1.5 hours)	1. Describe how training activities may change in the new regime (continued) 2. Plan an effective teaching environment	2. Plan an effective teaching environment (continued)	3. Use a range of teaching methods effectively (continued)	3. Use a range of teaching methods effectively (continued)	3. Use a range of teaching methods effectively (continued)
MEAL BREAK					
3rd Period (1.5 hours)	2. Plan an effective teaching environment (continued)	2. Plan an effective teaching environment (continued)	3. Use a range of teaching methods effectively (continued)	3. Use a range of teaching methods effectively (continued)	4. Use appropriate training aids
4th Period (1.5 hours)	2. Plan an effective teaching environment (continued)	2. Plan an effective teaching environment (continued) 3. Use a range of teaching methods effectively	3. Use a range of teaching methods effectively (continued)	3. Use a range of teaching methods effectively (continued)	4. Use appropriate training aids (continued)

Teaching staff should note that the hours for lectures and exercises are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

Course Timetable

Period/Day	Day 6	Day 7	Day 8	Day 9	Day 10
1st Period (1.5 hours)	4. Use appropriate training aids (continued)	4. Use appropriate training aids (continued)	5. Produce a relevant plan (continued)	6. Evaluate teaching and learning	7.Design a course of study
2nd Period (1.5 hours)	4. Use appropriate training aids (continued)	4. Use appropriate training aids (continued)	5. Produce a relevant plan (continued)	6. Evaluate teaching and learning (continued)	7.Design a course of study (continued)
MEAL BREAK					
3rd Period (1.5 hours)	4. Use appropriate training aids (continued)	5. Produce a relevant plan	5. Produce a relevant plan (continued)	6. Evaluate teaching and learning (continued)	7. Design a course of study (continued)
4th Period (1.5 hours)	4. Use appropriate training aids (continued)	5. Produce a relevant plan (continued)	5. Produce a relevant plan (continued)	6. Evaluate teaching and learning (continued)	7.Design a course of study (continued)

Teaching staff should note that the hours for lectures and exercises are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

Part C: Detailed Teaching Syllabus

Introduction

The teaching syllabus shows the required performance expected of the trainees. The detailed teaching syllabus is presented here as a series of learning objectives. These objectives describe what a trainee must do to demonstrate the specific knowledge or skill.

All outcomes are understood to be prefixed by the words, “The expected training outcome is that the trainee is able to ...” .

References are also shown to IMO publications, teaching aids and textbooks that instructors may wish to use in preparing and presenting the course.

The material listed in the course framework has been used to structure the detailed teaching syllabus, in particular,

Teaching aids (indicated by A)
IMO References (indicated by R)
Publications (indicated by P)

will provide information to instructors.

In order to assist the instructor, references are shown against the learning objectives to indicate those parts of the instructor manual and other references that the instructor may find useful in preparing and presenting course material.

The abbreviations used are:

? <i>Ann.:</i>	<i>annex</i>
? <i>Art.:</i>	<i>article</i>
? <i>App.:</i>	<i>appendix</i>
? <i>Ch.:</i>	<i>chapter</i>
? <i>Para.:</i>	<i>paragraph</i>
? <i>Pt:</i>	<i>part</i>
? <i>Reg.:</i>	<i>regulation</i>
? <i>Sect.:</i>	<i>section</i>
? <i>Ta.:</i>	<i>table</i>

The following are examples of the use of references:

“R1 Reg. II/3” refers to Regulation II/3 of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as amended in 1995;

“A1” refers to the Instructor Manual in Part D.

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
1 Describe how training activities may change in the new regime Required performance: 1.1 Describe the training requirements under STCW 1995 Convention .1 state that training must be supervised and monitored in accordance with the STCW Code .2 state that those responsible for training and assessment must be appropriately qualified Required performance: 1.2 Describe how the quality of marine education and training is controlled .1 state that a training provider shall have a quality policy and quality standards .2 state that control measures include performance monitoring .3 state that an audit aims to identify measures to improve training delivered .4 state that an independent evaluation of the quality standard system is required every 5 years .5 state that the quality standards system is documented in a quality manual which may be consulted .6 state that the quality manual includes: -- a policy regarding quality and the means of implementing it -- the organisation structure -- responsibilities -- procedures for teaching, training etc -- processes -- resources for quality management .7 describe a technique to help ensure the quality of teaching is maintained	R1, R2	P3 W1-W10, P4 Ch.19, 21	A1, V3
2 Plan an effective teaching environment Required performance: 2.1 Plan the learning process	R1	P4 Sect I	A1, V1

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
.1 list the requirements for the effective planning of a course .2 identify the factors which affect teaching .3 list the qualities required by a instructor .4 organise the environment to assist learning Required performance: 2.2 Demonstrate a knowledge of the factors that affect student learning .1 identify the factors which influence student motivation .2 discuss individual learning needs within a group .3 demonstrate effective use of communication skills .4 adjust teaching practice for cultural differences 3 Use a range of teaching methods effectively Required performance: 3.1 Demonstrate a range of teaching methods appropriate to trainees needs .1 deliver teaching sessions using a variety of teaching styles .2 manage and lead group learning .3 relate styles to size of group 4 Use appropriate training aids Required performance: 4.1 Demonstrate a range of teaching aids .1 identify the reasons for using learning aids .2 use boards properly .3 produce effective handouts .4 design useful OHP transparencies .5 use the OHP effectively .6 evaluate the use of learning aids in different contexts			V4 A1, A5, V2 P4 Sect.II A1, A2, A3, A4

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
.7 lists sources of teaching aids and information including the Internet Required performance: 4.2 Select appropriate training aids .1 justify choice of learning aids for different teaching situations 5 Produce a relevant lesson plan Required performance: 5.1 Recognise outcomes for a lesson .1 identify the trainees likely knowledge and competence at the start of the lesson .2 identify the trainees desired knowledge and competence at the end of the lesson .3 identify the outcomes to be taught in the lesson Required performance: 5.2 Recognise factors to consider when planning a lesson .1 identify the main planning considerations .2 produce a structured lesson plan 6 Evaluate teaching and learning Required performance: 6.1 Analyse uses of assessment correctly .1 analyse strengths and weaknesses of learners .2 assess student learning .3 plan assessment into overall lesson design Required performance: 6.2 Identify measures of performance correctly .1 encourage feedback	R1	P1, P2 P4. Ch.4 P4 Sect.IV	A1, A5 A1, A5

Knowledge, understanding and proficiency	IMO Reference	Textbooks, Bibliography	Teaching Aids
.2 use feedback to aid self evaluation Required performance: 6.3 Select correct assessment methods .1 identify the criteria for assessing competence .2 use methods effectively 7 Design a course of study Required performance: 7.1 Recognise the factors to be considered when designing a learning programme .1 relate outcomes to identified competence .2 identify outcomes for a specified programme .3 design a learning programme to suit the needs of the learners		P4 Ch.5	

Part D: Instructor Manual

General

Since this course is designed to train instructors it is important that it is a model of good practice. This manual reflects the opinions of the course designers on teaching methodology. The topics chosen are those that the members of the course team consider being most important. Although this guidance should be useful at first, the instructor should develop his ideas and refine and develop the course considering practical experience.

As with any course, good preparation and planning are essential if the course is to be well presented and run.

Lectures and methods of delivery.

Although one of the aims of the course is to introduce trainee instructors to a variety of teaching methods some subjects will require an introduction and there should be some provision for classroom lectures. As far as possible these lectures should reflect the best aspects of the formal lecture. Audio visual aids should be used to enhance the presentation.

The course has a number of practical exercises and training sessions. Trainee instructors may be reluctant to participate in some of these exercises at the start of the course. They should be encouraged to join in the sessions and to try the alternative methods.

Guidance Notes: General

Suggested Timetable

This timetable is based upon two daily sessions of three hours duration. Each session should include a short break, and there should be a longer break between the two sessions.

DAY 1	Introduction to the course The effective instructor	Informal practical session
DAY 2	The trainee instructor & communication	Planning the learning process
DAY 3	Teaching aids: boards & charts	Teaching methods: lectures
DAY 4	Teaching aids: the OHP	Informal practical teaching
DAY 5	Teaching aids: handouts	Teaching methods: case study
DAY 6	Informal practical teaching	Teaching methods: role-play & simulation
DAY 7	Teaching methods: groups & games	Teaching aids: audio-visual material
DAY 8	Preparation for practical teaching	Practical teaching
DAY 9	Practical teaching	Using evaluation and feedback
DAY 10	New course design	Evaluation

[To be revised and re-set]

Guidance notes for individual sessions

Session 1: Introduction to the Course

What I hear, I forget
What I see, I remember
What I do, I understand
 Confucius, 451 B.C.

This little motto from many years ago is as relevant today as it was then. Practical exercises are the most effective way to teach and learn practical skills.

An instructor at a training college or academy or other training provider is an important person. The instructor is important to the students or trainees who come to learn, to develop their potential and their career ambitions. The instructor is important to the organisation as it is he that permits it to fulfil its mission and obligations.

The STCW Convention requires that administrations ensure that teaching and training is conducted within the framework of a quality standards system. This is to ensure the quality of the education and training delivered meets the standards required and that there is a proper means by which mistakes can be recognised, improvements made, and responsibilities assigned. It is a framework for managing the work and output of the training provider. The material in the Instructor Manual covers these aspects.

The trainee should be given a copy of the course timetable, including the topics to be covered in each session and the time allocated to each subject. The teacher trainer should try and introduce the trainee instructors to the idea that they are part of a group. There are several techniques available for this, such as the examples given in the Compendium.

The purpose of the course should then be described. The introductory briefing should stress to the trainee instructors that the methods of teaching and preparation covered in this course can be applied to any course of training. It should also emphasise that the trainee instructors will be required to participate in the practical aspects of the course and to contribute to discussions.

The instructor should establish what the trainee instructors expect to gain from attending the course.

Trainees should be asked to prepare a short talk on any subject of their choice lasting 5 - 10 minutes.

Session 2: Practical

This is an informal session. Trainee instructors should be asked to deliver the short talk prepared in Session 1 on the subject of their choice lasting for 5 - 10 minutes. The talks could be delivered to the whole group or the class could be subdivided into smaller groups to allow time for every participant to deliver a talk. The teacher trainer should discuss the talk with the trainee instructor.

Session 3: Communication

This session is concerned with the role of the trainee instructor and the role of the trainer.

The trainee instructors should establish how they see their role and how their future students may see the role of the trainer. A list of the competences of a trainer should be established.

The effect of seating arrangements and non-verbal communication should be explored. This could include practical exercises such as physically re-arranging the furniture in the room to investigate the effects on communications.

Session 4: Planning the learning process

This session deals with planning the learning process. A short formal introduction could be used, followed by student practical work in planning. The video V1 gives a graphical illustration of the prepared trainer and the unprepared trainer. It provides a useful link between the earlier session and this one.

It is the intention that in this session the trainee instructors should review sample STCW Competency Tables and the way in which these can be used to produce a suitable scheme of work. This is probably best done by the teacher trainer using an IMO model course as an example and then using another section of the STCW Competency Tables for some practical work with the trainee instructors.

Reference should be made to the Tables of Competencies in the STCW Code. Table A-II/1 "Specification of minimum standard of competence for officers in charge of a navigational watch on ships of 500 gross tonnage or more" and Table A-III/1 "Specification of minimum standard of competency for officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room" would be useful.

The trainee instructors should assess the knowledge and skills that an instructor would need to deliver competence-based training and review the kind of planning that would be necessary

The format of IMO Model Courses should also be covered. For preference some examples of IMO Model Courses should be available for trainee instructors to review

Session 5: Teaching aids, theory and practice

This session investigates the use of question and answer techniques with a view to the trainee instructors using these techniques as a background for their work with teaching aids.

This session is part theory and part practical. It should cover the advantages and disadvantages of using boards and flip charts. It should also look at the basic techniques that an instructor uses for board and flip-chart work. This should be followed by a short practical session in small groups with trainee instructors making use of boards or flip charts.

Session 6: Lectures

The formal lecture should be discussed, since it is probably the most used of all the teaching methods. Trainee instructors should look at some possible lesson plans for formal lectures. They should then do some practical work in the preparation of a 10 minute introduction to a formal lecture using an OHP, board or flip-chart.

Session 7: Use of the OHP

This session is part theory and part practical. It should cover the advantages and disadvantages of using overhead projectors. It should also cover techniques that an instructor would use for making OHP slides and lecturing using the OHP. This should be followed by a short practical session in small groups with trainee instructors making OHP slides to use to deliver a short lesson in Session 8 based upon the format of a formal lecture.

Session 8: Presentation

This is a practical session in which the trainee instructors will deliver their introductions. The length of the introduction may need adjusted according to the class size. If necessary the class may be broken into smaller groups so that there is a reasonable time for each trainee instructor.

The format and delivery of each introduction should be discussed. The trainee instructors could be asked to provide written comments for discussion if this proved to be a better approach for a particular group. The discussion session will need to be carefully controlled.

Session 9: Handouts

There should be some theoretical input on the design of handout material. Most lectures involve some type of handout material and there are several different styles. Trainee instructors should then design samples of different styles of handouts. The compendium contains some examples for reference.

Session 10: Case studies

Initially the session should look at the pros and cons of using case studies. Sample case studies should be provided, these should be of different complexity. The trainee instructors should assess the way in which case studies could be used in their own teaching.

As an alternative some case studies of training can be reviewed in order to emphasise the necessity for planning and organisation in good teaching practice.

Trainees could be asked to write a short case study to illustrate a key point.

Session 11: Teaching practice

Trainee instructors will present a short piece of teaching. For this they should either use a handout or a small case study which they have prepared.

Session 12: Teaching methods, role-play and simulation

This is a session where the trainee instructors will look at the use of role-play and simulation. The IMO model courses in Radar Navigation, Radar Plotting and Use of ARPA at Operational Level or Radar, ARPA, Bridge Teamwork and Search and Rescue at the Management Level (Ref R3, R4) make useful material to study. If these are available the trainee instructors can review these courses in terms of the roles which trainees on these courses would take and the benefits which would result.

If these courses are not available a small simulation role-play could be used to show the benefits of using this teaching method.

Session 13: Teaching methods, groupwork and games

The session should begin with an initial theoretical look at the benefits of groupwork and the organisation of group work in the classroom.

This should be followed by a look at the use of games for teaching purposes. A simple game could be played to illustrate the method.

A practical session on the use of groups should follow. The teacher trainer could ask the trainee instructors to adopt roles. This would allow discussion to take place regarding the way the groups had operated.

Session 14: Audio-visual aids

Some suitable audio-visual material should be provided for the trainee instructors to review. A list of possible commercial videos is provided, but any suitable material will do. The trainee instructors should decide which key points the material makes and make up some suitable questions for trainee instructors to answer after viewing the material. If sufficient material is available the whole class could be broken into groups. Each group would then view the audio-visual material using the appropriate checklist.

Session 15: Preparation and planning

'If you don't know where you are going, any road will take you there'. Such a thought will not apply to our participants. By this stage of the course the crucial role of planning and preparation should be clear in the minds of all participants.

In this session the trainee instructors should make their own preparations for practical teaching.

Sessions 16 and 17: Teaching practice

This is an extensive practical teaching session. Each trainee instructor should be asked to deliver a longer session of teaching, using appropriate methods and teaching aids. Time will be required for discussions after each presentation. This is an opportunity for the teacher trainer to evaluate the performance of the trainee instructors.

Session 18: Evaluation and feedback

Evaluation and assessment can be powerful teaching aids. In this session the teacher trainer should introduce the trainee instructors to the wider concepts of evaluation as part of the teaching process. Some time can then be spent by the trainee instructors in producing materials suitable for obtaining feedback.

Self-evaluation is an important aspect of an instructors work, particularly for less experienced instructors. The session will examine the ways in which an instructor can evaluate teaching. The trainee instructors should spend some time in preparing to evaluate their own teaching when they return to their centres.

Session 19: New course design

This session is a brief look at how a new course can be put together based upon the STCW Tables. Trainee instructors could be asked to prepare an outline of a suitable course of study.

Session 20: Evaluation

This is a plenary session to carry out a review of the course.

Compendium to the Instructor Manual

Session 1: Introduction to the Course

Breaking the ice

The trainee instructors are likely to be nervous and apprehensive about the course. The teacher trainer should make every effort to put them at ease. There are a number of possible ways of “breaking the ice”.

The simplest way is to ask the trainee instructors to introduce themselves with their name, background etc. A more interesting alternative which involves greater interaction between participants is to ask each participant to interview their neighbour, concentrating their questions in two or three specific areas: job title, work experience, training, family and hobbies or non-work interests, favourite things etc. The interview should take no more than five minutes after which ask each participant (in turn, or at random) to make a short presentation describing his neighbour to the group. To encourage concentration and to tax the memory a little the interviewer should not make any notes

For a less threatening alternative, ask trainees to complete simple questionnaires anonymously and the results can be discussed by the group. Questions used may include such things as:

Where do the trainee instructors teach?
 With which subjects are they involved?
 Why are they attending this particular course?
 What do they expect to gain from the course?

A little quiz involving ‘true or false’ is also a good ice breaker. Ask each participant to write down three things about themselves. Two should be true and one false.

For example, I like watching movies; I was born in Madras and I love English food!

Now choose at random and ask participants to say the three things. Invite the group to say which one they think is untrue. Use every opportunity to get participants to enlarge on the true or false statements and encourage humour to relieve the initial tension in the group and help participants get to know one another.

Training requirements under STCW 1995

The STCW Convention is one of the most important conventions governing the training and qualification seafarers employed to crew ships, and has direct impact on the seafarers themselves as well as maritime instructors and teachers. It requires that administrations ensure that teaching and training is conducted within the framework of a quality standards system. Depending how familiar participants are with the implementation of the Convention requirements video V3 provides a useful general summary of the topic.

To introduce why this course was developed, the new regulatory requirements for training and assessment and quality standards some time during the first session needs to be spent covering these aspects. This will put the purpose of the course into the context of the STCW 1995 Convention. Whilst these requirements may have always been best practise, and as such

adopted by some training colleges and academies, they are now a basic requirement that needs to be met in order to deliver training to the standard of STCW 1995. Reference R2 contains explanations and definitions of some of the Convention terminology.

Control of quality

All training that is required by the revised STCW Convention must be monitored as part of a quality standards system (QSS), see Regulation I/8 paragraph 1.1.

A quality standards system is a system that provides for, and ensures that, the most practicable standards for seafarers' competence are met. QSS activities would include widely differing activities like:

- a. Approval of training courses
- b. Assessment of competence
- c. Certification, endorsement and revalidation
- d. Approval of trainers and assessors

Regulation I/8 of the revised STCW Convention refers to the application of quality standards systems to all activities concerning training and assessment. Therefore, training providers: maritime training centres, simulator training centres and administrations which carry out any training and assessment activity must establish a quality standards system for the activity.

Lecturers should note the specific requirements in the STCW Code, Regulation I/8 Quality standards paragraph 1, 2 and 3; and in Section A-I/8 Quality standards paragraphs 1, 2, 3 and 4. Note that this includes reference to the qualifications and experience of instructors.

All Parties have to ensure that all activities which give effect to Convention requirements are *continuously monitored* through a quality standards system, whether they are carried out by other entities under its authority or carried out within a Government ministry, department or organization (again see Regulation I/8).

The essential steps to take to ensure the good quality of an operation are to:

- .1 establish clear policies and standards governing staff quality and the conduct of the activities;
- .2 adopt realistic and properly funded implementation and control measures which give practical effect to these policies and standards in order to allow the objectives to be achieved;
- .3 develop and introduce procedures which allow the performance and results of these activities to be monitored and checked to ensure that the objectives (i.e. the Convention requirements) are being achieved; and
- .4 ensure that staff participate fully in the development and establishment of the system and are kept fully informed at all times.

Quality standards system

Quality standards systems are already widely applied in the business world and increasing use is being made of them by academic institutions.

The mentioned standards consist of five parts:

- a. The two first parts cover the certification requirements and the so-called “*quality assurance*” principles. These elements of quality are requirements which will be found in any quality management system.
- b. Another part of the standard covers *development activities*, i.e., development of courses, simulator exercises and curriculum plans. This should be performed in a structured way. Specific verification activities shall ensure that all courses and plans fulfil regulatory requirements.
- c. The standards also cover the *operational* part of any training activity. This could be identifying instructor and trainer needs. Necessary equipment required for any specific training shall be identified, including maintenance requirements.
- d. The final part of the standards focus on the “*result phase*” of any training. This will include examination criteria to be specified and how this is to be carried out. Procedures for issuing diploma or documents of evidence must be identified. A system for ensuring that all mandatory elements are covered through tests and exams during the education must be established.

Section B-I/8 Guidance regarding quality standards paragraphs 1 to 8 inclusive provide essential guidance and although not repeated here should be referenced by the lecturer.

Maintaining quality standards

Provision has also to be made for external evaluation of the quality standards and the activities they cover to be carried out at intervals of not more than five years. National academic standards organizations or committees may have already developed quality standards that are well suited for application to maritime academy activities.

Session 2: Practical

This informal practical session is introduced early in the course so that the trainee instructors have the opportunity of speaking to the group informally. This initial talk should concentrate on such things as audibility, clarity and speech together with non-verbal communication. It is not too early to introduce the basic point that a successful presentation need time spent in planning and preparation.

There are many traps that speakers, whether teachers, lecturers, instructors or others that are required to present in public may fall. To help participants to avoid these traps discuss the following points.

- Look at the class, don't keep your eyes on your notes
- Never read anything except quotations
- Show enthusiasm: if the teacher is not, why should the students be
- Pause often – silence seems much longer for you than for the audience/students
- Exaggerate body movements and verbal emphasis
- Use humour, but be careful. Different nationalities and different cultures have very different senses of humour: what is amusing to one can be offensive to another.

Session 3: Communication

During this session there are some important aspects of the teaching and learning process which the teacher trainer should emphasise to the trainee instructors.

- Different approaches are needed for teaching adults from those traditionally used for teaching children. Research shows that adults prefer to be treated as adults. Adults have experience that may be useful to the whole group. This means that the instructor's role is different, but it is just as important.

When teaching a competence based course to adult trainees an instructor should try to

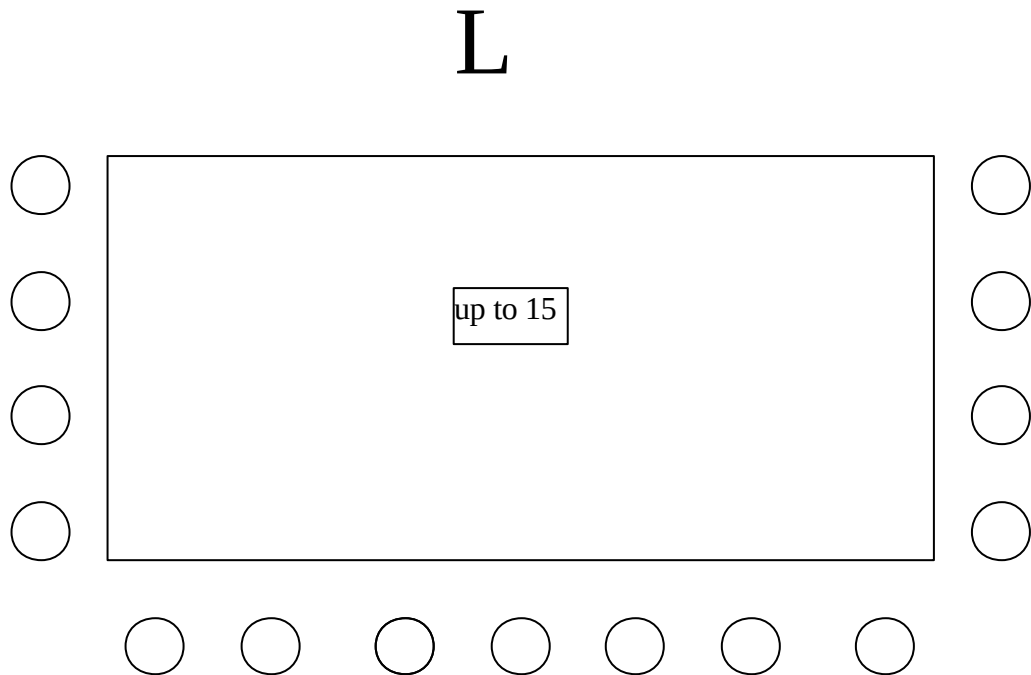
- help them to decide how they learn best
- use methods which make learning as active as possible
- encourage them to participate as much as possible
- help them to take responsibility for their own learning
- encourage them to think about what they have learned

Seating arrangements

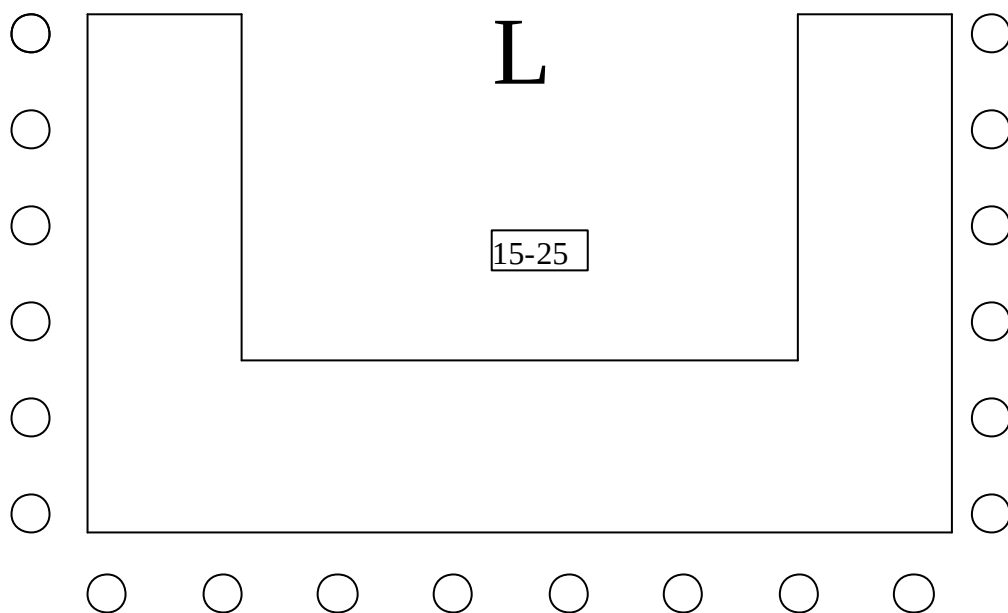
Seating arrangements can have an important influence on communications in the classroom. Different room layouts are appropriate for different sizes of groups. There are four commonly used classroom arrangements.

The trainee instructors should be encouraged to alter the seating in the room and to take note of the physical factors that influence the teaching and learning process. This would include such factors as how well they can hear, how well they can see the board and so on. Some typical seating plans are shown on the following pages.

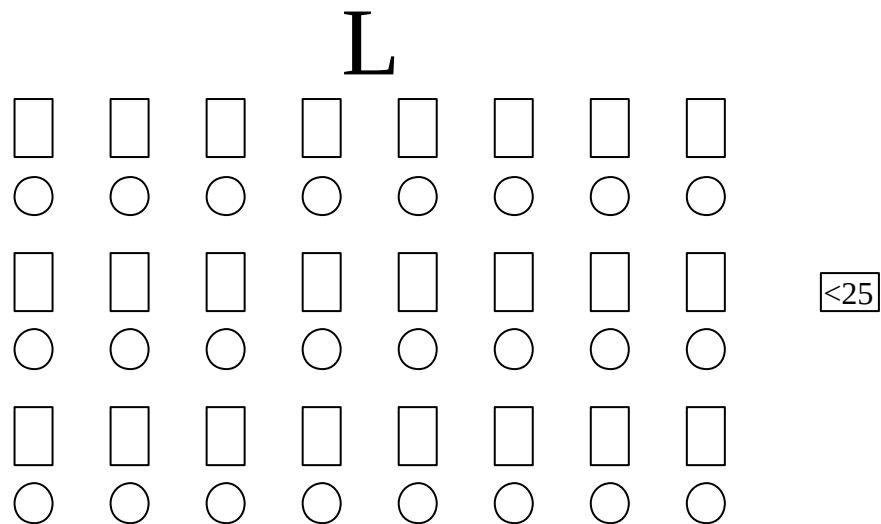
(1) Table



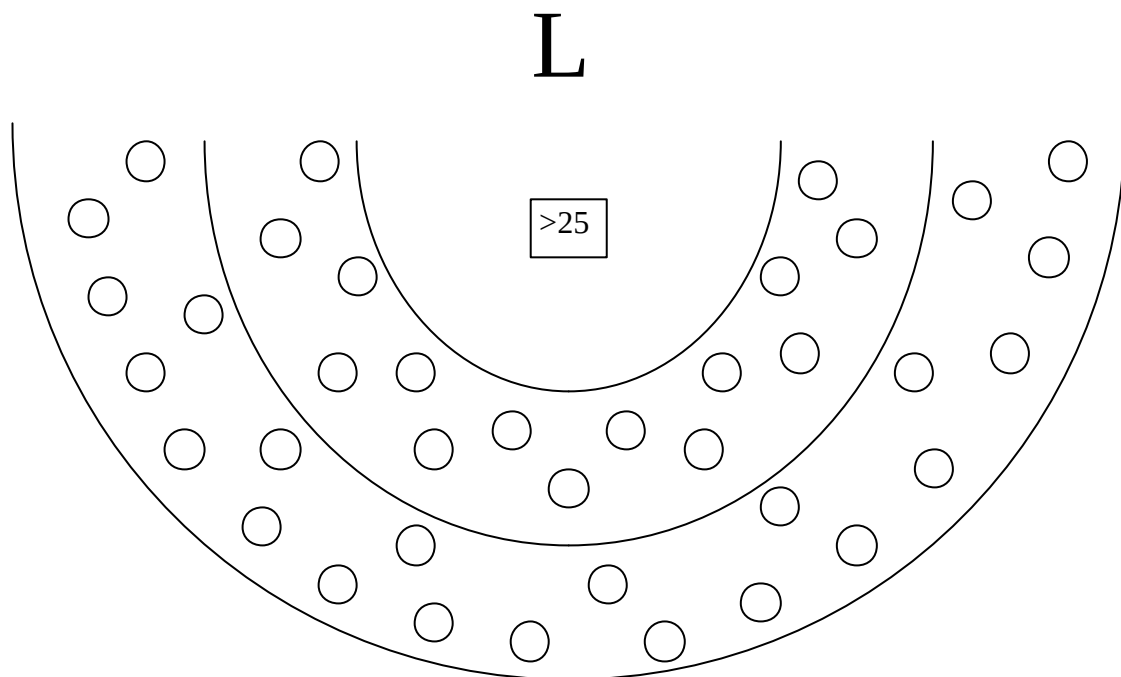
(2) U-shape



(3) Traditional School



(4) Lecture Theatre



Verbal and non-verbal communication

Instructors should always be aware that their “body language” sends messages to their trainees. The way in which an instructor stands or sits can indicate confidence. An instructor should not move about all the time, as this gives the impression that the instructor is unsettled. The teacher trainer should emphasise these points by illustrating the effects of sitting while teaching, moving restlessly, etc. The trainee instructors should be persuaded that for most formal teaching situations the instructor should stand.

Facial expressions may also have an influence. It can often be difficult for an instructor to control facial expressions, but it is often important to try. The facial expression of trainees can indicate whether or not they are following a lesson well. The body language of trainees can also provide an instructor with a useful guide to how the lesson is progressing. For example, trainees who are constantly moving, sighing or yawning are bored.

The trainee instructors should discuss the effect upon trainees of the instructor's appearance. They should be encouraged to conclude that dress has an effect and that since an instructor may be judged by appearance an appropriate mode of dress is important. Some organisations have their own rules about an instructor's dress.

The trainee instructors should consider communication within the classroom and the problems that can occur with spoken and written words. Spoken communication can be difficult. The words that an instructor chooses can be too difficult. Jargon words and technical words should be introduced with careful explanation of their meanings. This is particularly a problem where words are used in everyday speech, but have very exact meanings in technical work.

Remember the KISS principle: **Keep It Simple, Stupid**

Any form of written work, particularly handout material should be checked for readability as well as spelling. Most word processing packages have a grammar option that will indicate the reading ease of a piece of work.

Session 4: Planning the learning process

Planning: Aims and objectives

Trainees' capabilities at the start of the course



Learning



Trainees' capabilities at the end of the course

Good planning is essential for all teachers, especially for those new to the work. The best starting point is to decide exactly what it is that the learner is to learn.

The aim of a course is usually a very general or vague statement such as “to promote an appreciation of the main features of STCW 95”. A statement of this type is of limited use since it is difficult to understand the exact content of the course.

For practical purposes the aim is broken down into smaller parts. In older style courses the lecturer was given a list of topic headings. For example, Welding processes: common faults, visual examination of welded work, methods of corrosion control. With this type of syllabus the instructor often had to refer to old examination papers or tests to find out the depth to which the topic was to be studied.

The new style functional approach recognises that there is a difference between knowing something and being able to do something. The functional approach of STCW '95 aims to integrate knowledge, understanding and proficiency. The syllabus is defined in terms of standards of competence. STCW '95 defines “standards of competence” as . . .

“The level of proficiency to be achieved for the proper performance of the functions on board ship in accordance with internationally agreed criteria . . . incorporating prescribed standards of levels of knowledge, understanding and demonstrating skill”.

This competence based syllabus

- places emphasis on what a trainee will be expected to do
- is related to realistic practices
- focuses on outcomes instead of the learning process
- is concerned with the demonstration of skills to a specified level of competence
- includes the ability to transfer knowledge and skills to new situations
- is concerned with ensuring consistency of achievement
- is concerned with international recognition and transferability

Competence can be used to identify mental skills as well as practical skills. For example STCW '95 Table A-III/1 provides the specification of minimum standard of competence for officers in charge of an engineering watch in a manned engine- room or designated duty engineers in a periodically unmanned engine-room.

Table A – III/1

Specification of minimum standard of competence for officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room.

Function: marine engineering at the operational level

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for Demonstrating competence	Criteria for evaluating competence
Use appropriate tools for fabrication and repair operations typically performed on ships	Characteristics and limitations of materials used in construction and repair of ships and equipment. Characteristics and limitations of processes used for fabrication and repair. Properties and parameters considered in the fabrication and repair of systems and components Application of safe working practices in the workshop environment	Assessment evidence obtained from one or more of the following: .1 approved workshop skills training .2 approved practical experience and tests	Identification of important parameters for fabrication of typical ship related components is appropriate Selection of material is appropriate Fabrication is to designated tolerances Use of equipment and machine tools is appropriate and safe.
Use hand tools and measuring equipment for dismantling maintenance, repair and re-assembly of shipboard plant and equipment.	Design characteristics and selection of materials in construction equipment. Interpretation of machinery drawings and handbooks Operational characteristics of equipment and systems.	Assessment of evidence obtained from one or more of the following: .1 approved workshop skills training .2 approved practical experience and tests	Safety procedures followed are appropriate Selection of tools and spare gear is appropriate Dismantling, inspecting, repairing and reassembling equipment is in accordance with manuals and good practice Re-commissioning and performance testing is in accordance with manuals and good practice

In this table Column 1 states the competence -

“Use appropriate tools for fabrication and repair operations typically performed on ships”.

This is broken down into smaller items in Column 2 that lists the knowledge, understanding and proficiency.

- *Characteristics and limitations of materials used in construction and repair of ships' equipment.*
- *Characteristics and limitations of processes used for fabrication and repair.*
- *Properties and parameters considered in the fabrication and repair of systems and components*
- *Application of safe working practices in the workshop environment.*

The knowledge is still included, but there is more emphasis on the type of tasks, which a seafarer should be able to perform satisfactorily. The table then goes on to give guidelines on assessment. Column 3 gives details of the methods for demonstrating competence and Column 4 gives details of the criteria for evaluating competence.

The tables of competence do not prescribe any particular teaching method. Each class of trainees is different. Each teaching situation is different. The instructor needs to use knowledge of a particular class group and the local environment to determine what works best for the trainee. Instructors need to have knowledge of the methods that are available to decide which is the best technique for a particular set of circumstances. However, with a syllabus of this type the instructor should be considering methods in which the trainee will participate rather than methods where the trainee is passive.

Practical exercise

Identify which of the following tasks are related to practical skills and which are related to mental skills. All of the tasks are taken from the On Board Training Record Book for Engineering cadets, ref P2.

1. Draw a schematic arrangement of the main engine system, using blocks to indicate the main components.
2. Prepare and test the steering gear and telegraphs for a sea passage.
3. Check starting compressor and prepare starting air system
4. Apply feedwater treatment and perform routine tests on boiler water.
5. Explain the effect of varying the temperature of circulating water
6. Start main engine from local and remote positions.

The scheme of work

Once the objectives have been identified they have to be put into an order for teaching. The teacher trainer should emphasise to the trainee instructors that it is important to remember that a syllabus is not necessarily written in the order in which subjects should be taught and the Competency tables in the STCW Code may not be written in the best teaching order. Similarly,

many new instructors look for a textbook and use that as a teaching order, but a textbook may not provide the best scheme of work.

One technique is to write the names of the topics on to small cards and then try to put the cards into a sensible teaching order. The teacher trainer should ask the trainee instructors to try this with a section of work taken from the STCW Competency Tables. Often more than one sequence will be possible. There are many factors that can be used when trying to establish a good teaching order; some examples are:

- difficulty of topic: easy topics first
- chronological order
- normal/abnormal
- most relevant first
- theory/practical work
- availability of resources
- demands of other subjects
- safety
- textbook
- syllabus
- experience

Planning should always begin with a consideration of the trainees and their level of knowledge and understanding. The trainees are the people for whom the course is being designed.

The trainee instructors should be encouraged to think about the trainees and such factors as their age, educational background, employment and interests.

The teacher trainer should encourage the trainee instructors to think about the subject. Is their knowledge up to date? What experience do they have of the subject? What facilities are available?

Using a small section from one a table chosen from STCW Competency Tables the trainee instructors should consider the length of course that they would consider to be appropriate and the equipment that they would need.

A final scheme of work should be based upon the content, the length of the course, the teaching and learning methods and any assessment that is used

Planning is more complicated when there are links between subjects or when courses overlap. For example, if a class were to study “taking moments about the keel” it would be beneficial if they had previously studied moments and some ship construction or general ship knowledge.

A properly designed scheme of work can save time since work does not have to be done twice.

A sample scheme of work

1.	Operate ARPA and navigation controls	2 hours
2.	Perform basic radar plotting	6 hours
3.1	Apply COLREGS in open waters	6 hours
3.2	Control navigation in controlled water	10 hours
3.3	Control navigation in/near traffic separation schemes	6 hours
3.4	Manage a bridge team	2 hours
4	Plan and co-ordinate search and rescue	6 hours

Source: IMO Model Course No 1.08 Radar, ARPA, Bridge Teamwork and Search and Rescue, Management Level

Session 5: Teaching aids, theory and practice

Question and answer

Asking questions is a very powerful method of teaching. The trainee instructors should be introduced to this method and its benefits. It forces trainees to participate in the lesson and promotes thinking and understanding. The trainee instructors will need to think about the type of question that they would ask. The words used in the questions are very important. Some questions can be answered in a single word such as yes or no. These are called closed questions. Simple closed questions can be useful at the beginning of a lesson as the whole class know the answer and can respond with confidence. For more complicated topics closed questions are not as useful as open questions. Open questions require the trainees to shape an answer in their own words. The answer will be one or more sentences long. This requires a deeper understanding.

Questions can be used to provide a framework for a lesson. If questions are used in this way they must be carefully controlled. In this situation the instructor should know the answer to the question before it is asked. Probable wrong answers and strategies to deal with them should also be considered.

The trainee instructors should be given some questions and asked if they are open or closed.

Exercise

Consider which of the following questions would be most useful for testing a trainee's knowledge.

1. What is meant by the abbreviation VLCC?
2. What is SOLAS?
3. What is meant by the term "pitch" when discussing a propeller?
4. What is the difference between a rope and a line?
5. How does a four-stroke engine work?
6. What is inert gas for?
7. At what temperature should bananas be transported?
8. Why is crude oil washing carried out?

9. How often should a ship be surveyed in a dry dock?
10. What are the benefits of an immersion suit?
11. What does it mean if a VHF message begins with the word 'Mayday'?
12. How does a refrigerator work?

When using questions, the trainee instructor must decide how to control the class. All of the class may try and speak at once and nothing is achieved. The question may be put to the class as a whole or the question may be put to an individual. Some trainees may be more willing than others to answer the questions may. The trainee instructor must try and get as much response from all the trainees as possible so the questions should be spread around the class. Questions should be clear and asked in language that the trainees can understand. Simple questions should be asked before complicated ones. The answers should be treated tactfully. A correct answer should be praised. If an answer is partly correct, the correct elements should be praised before the incorrect elements are addressed. It is important to find the reason behind an incorrect answer. No one should be made to look or feel stupid as this may affect his or her willingness to participate. Sometimes asking in a different way, breaking the question into smaller sections or offering simple clues may help.

When a trainee asks a question the instructor will not always know the answer. In this situation the instructor should respond by advising the trainee where to find the answer or offering to find the information. There is no point in providing incorrect information.

The following advantages and disadvantages of questions should be stressed to the trainee instructors:

Advantages

- trainees are involved
- the instructor gains feedback
- problems can be identified at an early stage
- trainee maintain their concentration
- questions can be organised to develop key points

Disadvantages

- careful planning is required
- some trainees may not respond
- some answers given by trainees can be difficult to deal with

Learning aids and resources

The teacher trainer should discuss the importance of learning aids with the trainee instructors. The teacher trainer should begin by stressing some basic ideas such as those outlined in the next paragraph.

When an instructor stands in front of a class talking, the main sense that the learners are using is their hearing. Research suggests that sight is a very important sense for learning and using sight and sound together improves memory and understanding. Some aids require a great deal of preparation and expensive equipment. It is important to decide how and where learning aids will be used. It is possible to become so interested in making and using learning aids that the

instructor forgets the main purpose of the lesson. Good learning aids are a useful way of making topics more interesting. The main factors to be considered will be the trainees, the teaching methods, the type of learning and any practical considerations.

The most commonly used aids are boards and flipcharts, so these are the first aids that the trainee instructors should consider. Boards of various types are available to most instructors. The types include chalkboards, whiteboards, magnetic boards and flipcharts. The teacher trainer should begin to introduce the trainee instructors to the principles of board work by asking them to make a list of the advantages and the disadvantages of boards.

This should be followed by a review of the different types of boards and flipcharts that are available.

Chalkboards: The main problem with chalkboards is the dust. For black or green chalkboards the best colour to use is not white, but yellow. Chalkboards tend to be roller or fixed. The advantage of the roller type is that it allows more space and it is possible to write and draw at a comfortable height. The difficulty is that work can disappear from the learners' view as the board is rotated.

Whiteboards: These are used in a similar way to chalkboards. The white background looks more modern and there is less dust. It is important to use the correct type of pen or the ink is very difficult to remove. Experienced teacher trainers often try a small test patch.

Magnetic boards: these are less common than chalkboards and whiteboards. They are usually used when the teacher trainer wishes to show movement. Shaped magnets can be used or card pictures attached to magnets. They can be moved around the board or re-arranged easily.

Any steel surface can also be used as a magnet board.

Flipcharts: These are essentially large pieces of paper placed on a stand. Diagrams can be prepared before hand that can help with neatness.

The trainee instructors should be asked to produce a checklist for the use of boards and flipcharts in the classroom. This should include most of the following:

- Ensure all of the learners can see the board clearly - check this yourself
- Remove any old work from the board before you start
- Keep any writing or diagrams simple and clear
- Make sure that any writing is large enough to read
- Items can be emphasised by using colour, underlining, using capital letters
- A little colour adds emphasis but too much becomes messy and confusing
- Do not use abbreviations or symbols if these can be avoided
- Do not write words vertically or at odd angles
- Use a template if a frequently drawn diagram has to be accurate

- Do not try and talk to the class while facing the board

Session 6: Lectures

Planning a lesson

Trainee instructors should be introduced to the principles of lesson planning. Careful planning cannot guarantee that a lesson will be a success, but a lack of planning usually produces failure so lesson planning is an essential part of teaching.

Key points to cover include:

- Every lesson should have three sections, a beginning, a middle and an ending.

In the beginning or introduction the trainee instructor should cover some of the following:

- A personal introduction
- A review of the previous lesson (if there was one)
- A rough evaluation of the existing knowledge of the trainees
- An overview of the lesson
- An explanation of why the topic is studied
- A description of how the lesson will be conducted
- A statement of the end product of the lesson

This activity provides a framework for the lecture. It sends a series of signals to the group and sets the scene for the lesson.

At the end of the lesson the trainee instructor should review and summarise the main conclusions of the lesson. The summary reinforces the key points of the lesson and draws the lesson together. There are several ways of summarising, the main points can be put onto an OHP, oral or written questioning can be used or a handout of the main points can be distributed. Trainees can be invited to ask questions, but at the end of the session they are often reluctant to ask questions that might extend the lesson. One important aspect of this part of the lesson is that it gives the trainee instructor the chance to get some feedback from the trainees.

The trainee instructor should try some of the following

- Review the key points on the board or using an OHP
- Recap the main points
- Ask trainees to review the key points from their notes
- Ask the trainees questions
- Suggest further reading

The central part of the lesson may be delivered in a variety of ways depending upon which method(s) are chosen. See the sessions on teaching methods for further information.

A lesson plan should include

- Class details
- Subject (topic)
- Length of lesson
- Expected knowledge and understanding at the beginning of the lesson
- Objectives of the lesson
- Time for each element of the lesson
- Trainee instructor activity
- Teaching method(s)
- Teaching aids
- Assessment

Sample lesson plan 1: A sample lesson plan for a lesson involving numerical work.

Title	
Class	
Time	
Starting knowledge	
Objectives	

Content	Instructor	Trainee	Teaching Aids	Time Allocation
Introduction	Asking questions Stating objectives	Answering Listening	OHP	10 minutes
New ideas developed	Exposition	Listening	Handout	10 minutes
Tutorial	Assisting with individual tutorial work	Individual tutorial work	Handout	30 minutes
Conclusion and review	Questioning Summarising	Answering	OHP/Chalkboard	10 minutes

Skeleton lesson plan 2: Based upon a traditional lecture format with increased trainee participation.

Title	
Class	
Time	
Starting knowledge	
Objectives	

Content	Instructor	Trainee	Teaching Aids	Time Allocation
Introduction	Asking questions Stating objectives	Answering Listening	OHP	10 minutes
Main point	Exposition	Listening	OHP/Chalkboard	15 minutes
Review of main point	Asking questions Summarising	Answering Listening	OHP/Chalkboard	5 minutes
Second point	Exposition	Listening	OHP/Chalkboard	5 minutes
Review of main & secondary points	Asking questions Summarising	Answering Listening	OHP/Chalkboard	10 minutes
Trainee questions	Answering	Asking questions		10 minutes
Conclusion and review	Summarising	Listening		5 minutes

Skeleton lesson plan 3

Title	
Class	
Time	
Starting knowledge	
Objectives	

Content	Instructor	Trainee	Teaching Aids	Time Allocation
Introduction	Asking questions Stating objectives	Answering Listening	OHP	10 minutes
Main point	Exposition	Listening	OHP	10 minutes
Buzz group activity based on main point & introductory second point	Monitoring groups	Discussing, thinking	Handout	10 minutes
Second point	Exposition	Listening	OHP	10 minutes
Student task	Monitoring	Discussing, thinking, writing	Handout	10 minutes
Revision	Questioning Summarising	Answering	OHP of planned questions	10 minutes

Sample plan for a practical lesson: Personal survival techniques

Title	Personal survival techniques: practical work
Class	Pre-sea trainees
Time	2 Hours 30 min
Starting knowledge	Theoretical knowledge gained during theory classes
Objectives	To allow the trainees to gain the practical skills necessary to survive at sea Ref. STCW 95 Table
Equipment	Swimming pool, liferaft, lifejackets

Activity	Instructor	Trainees	Time
Introduction Transferring & securing liferaft Liferaft launch	Exposition Questioning Observing, commenting	Listening Answering Observing, launching liferaft	10 min
Revision of methods of boarding liferaft "dry" Group enter pool to float/swim Group put on lifejackets while in water & assess problems with moving Group investigate the ability of the lifejacket to self right, try swimming as normal & on their backs	Questioning Observing, Commenting Observing, commenting	Answering Floating, swimming Moving, wearing lifejacket. Swimming	10 min
Demonstrations, followed by trainees trying Best position to conserve heat in water Forming circle to aid visibility/ morale Towing an unconscious person	Demonstrating Observing commenting	Observing, listening Moving, swimming, towing	20 min
Layout & actions on boarding liferaft	Questioning, observing, commenting	Answering, boarding liferaft	5 min
Jumping into water from a height	Demonstrating, observing, commenting	Jumping, observing, listening	5 min
Jumping from poolside board, Actions on entering cold water, boarding raft via ramp	Demonstrating, observing, commenting	Jumping, observing, listening	15 min

Jumping from poolside board, Actions on entering cold water, boarding raft via other access point using ladder	Demonstrating, observing, commenting	Jumping, observing, listening	15 min
Assistance using quoit & line Recovery of unconscious person	Demonstrating, observing, commenting	Assisting fellow trainee to board using quoit & line Recovering unconscious person	20 min
Righting upturned liferaft	Demonstrating, observing, commenting	Performing correct action to "right" liferaft	35 min
Mock abandon ship using high board	Demonstrating, observing, commenting	Abandoning ship via high board, calling correct actions, securing raft, manoeuvring raft with paddles.	10 min
Conclusion	Questioning, summarising	Answering, listening	5 min

Session 7: Use of the OHP

This session focuses on the overhead projector (OHP). Overhead projectors have been in use for many years and they remain popular. The teacher trainer should point out the most common problems and point out to the trainee instructors that:

- It is always advisable to check that the OHP is working before a training session and to make sure that the image is in focus.
- Ideally the screen should be at an angle to avoid the “keystone effect”, where the image is wider at the top than the bottom.
- If a whiteboard is used as an OHP screen, there can be problems with reflections.
- Trainees need time to look at the images before they are removed
- A small pointer on top of the OHP works better than a pointer on the screen
- The instructor must not stand between the projector and the screen

The teacher trainer should demonstrate overlay and reveal techniques. Overlays are used to present complex ideas. The basic transparency is mounted on a cardboard frame and the overlays are then positioned. The basic transparency is shown and then the overlays are added. The overlays are usually hinged at the side with tape.

A reveal technique is where part of the transparency is initially shown and then additional sections are revealed. The simplest way of doing this is to put a piece of paper on top of the transparency and then slide the paper down revealing more parts of the OHP.

The trainee instructors should evaluate the OHP as an educational aid, in the context of their own teaching.

Evaluation of the OHP

- once transparencies are made they last a long time
- the instructor can face the trainees to observe their reactions
- an OHP is reasonably reliable
- transparencies can be made to suit the exact requirements of the lesson
- an OHP can be noisy
- the fan can cause problems due to heat or the draught produced

The rest of the session should be practical and concentrate on the designing and making of some OHP slides.

Guidelines for transparencies

Materials

Good quality lettering can be achieved using stencils or a dry letter system. One good way of achieving neat lettering is to word process or type the original hard copy and then photocopy onto a transparency. Any freehand lettering should be as neat as possible.

A wide variety of coloured pens are available. Larger areas can be coloured using colour film.

Layout

- Each transparency should only cover a single topic
- Each transparency should have a heading
- Transparencies should be simple and uncluttered
- Avoid writing at the edge of the transparency - put the main idea at the centre
- Use a mixture of upper and lower case
- Do not use too many words - key words are better than sentences (Five or six lines of writing).

Some lecturers like to use an overhead projector with a continuous roll of acetate instead of a board. The lecturer can either prepare standard frames before the lecture and simply roll the acetate on to the next topic when required. This can allow more work to be prepared in advance than is possible on a roller type of chalkboard.

Session 8: Presentation

Session 8 is a practical session. If a video camera or closed circuit television (CCTV) is available the session can be recorded in order to assist feedback to the trainees.

Session 9: Handouts

On many courses time is short and so there is insufficient time available for trainees to copy information from a board or OHP. Class time can be supplemented by using handouts, and in any case is better spent on practical work. Useful handouts require some time for preparation and can be expensive so an instructor must decide whether they will be effective. Handouts must be helpful to the trainee or there is no point in using them.

Some handouts simply provide information and other handouts form an integral part of the lesson. The first type of handout would include such things as a list of mathematical formulae, a weather map or the outline of an experiment. The second type of handout would require the trainee instructor to contribute something. For example, spaces can be left for the trainee to answer questions during or after the lesson.

Before a handout is used key points have to be considered. The trainee instructors should assess the following:

- Why is the handout needed?
- When is the handout going to be given out?
- What type of handout should be used?
- Will the trainees understand the purpose of the handout?
- Will the handout be used to assess the trainees?

Some sample handouts follow for review.

The trainee instructors should develop a suitable handout for their next teaching session.

Handout: Example 1 (Extract)

GMDSS: GENERAL REGULATIONS

1 TESTING

Transmitter Testing

When testing or adjusting a transmitter, to reduce interference to other stations, the operator should not, where possible, use a priority frequency (e.g. use an inter-ship working frequency), and should monitor the frequency before use.

Other guidelines are; use low power, use an artificial antenna, ensure that a test call does not exceed 10 seconds, and include station ID in each call.

Statutory Tests

These must be conducted at the stated regular intervals, with the result recorded in the GMDSS Radio Log. Some of the main checks/tests are as follows.

Daily: internal (non-radiating) DSC tests; battery on/off load voltage check; check that printers have adequate paper supply.

Weekly: external (to shore station) MF DSC test calls; check of the reserve power supply, when it is not a battery (e.g. motor generator).

Monthly: EPIRB/SART internal test and check for security and damage to devices and mountings; battery maintenance including s.g. cell check, condition of connectors, etc.; check of the condition of antennae systems; survival craft portable VHF test (not using ch.16).

2 STATION IDENTIFICATION

RT ID is usually ship's name and/or alphanumeric callsign, the first two characters of which identify nationality. Examples of callsigns; GPK, PCH33 for CRSs, GVSU, 9KLM, MXCN3 for ships.

Terrestrial telex (Selcal) ID is a number of 4 digits (CRS) or 5 digits (ship). On establishing a telex link, stations exchange answerbacks. For example 32445 GHPE X is a ship station answerback, with Selcal number and callsign. All ship answerbacks end in X. An example of a CRS answerback is 3220 AUTO G, indicating that Portishead Radio autotelex facility has been accessed. CRS answer-backs end in a nationality-identifying group of 1-2 letters.

DSC uses 9 digit Maritime Mobile Service Identification (MMSI) numbers. Those commencing with 00 are CRSs, those with 0 group calls. The first three numbers, or the first three after 00 or 0, identify nationality. This part of the ID is known as the MID, although this abbreviation is used in Sailor equipment for the MMSI.

Inmarsat Mobile Numbers (IMN) are 7 digit (Sat-A) or 9 digit (all other) numbers, with the first digit identifying the system, thus; 1 = Sat-A 3 = Sat-B 4 = Sat-C 6 = Sat-M

3 CONTROL OF WORKING

Control during distress working is the responsibility of the station in distress, or of another ship or a CRS, as circumstances dictate. In Sea Areas A1/A2 the appropriate shore station would be expected to assume control shortly after the initial distress sequence. In Sea Areas A3/A4 a ship in the vicinity may be designated in charge of on-scene communications by the MRCC for the area.

In routine communications the controlling station determines frequencies/times for the exchange of traffic. In ship-shore working, the CRS controls. In intership working the ship, which has been called controls. A ship, which causes interference to other ship-shore working, must cease transmission at the first request of a CRS.

The Order of Priority is used to decide the order in which traffic on hand is to be dealt with, as shown below. Types 1-3 are often referred to as priority, or SOLAS, communications

1. distress,
2. urgency,
3. safety,
4. direction-finding,
5. SAR aircraft,
6. ship's business, ship-shore OBS weather reports,
7. UN traffic,
8. priority government traffic,
9. service traffic relating to the working of the radio system,
10. all other communications.

Handout: example 2**Use of Pesticides in Ships**

1	Introduction	
2	Prevention of infestation	
3	Chemical control of infestation	
4	Control of rodent pests	
5	Regulations for use of pesticides	
6	Safety precautions-General	
	Annex 1- Pesticides suitable for shipboard use	
	Annex 2 "TLVs" for vapours in air	
	Annex 3- Fumigation warning sign	
	Annex 4 - IMDG code class 9 schedule for "CTUs" etc.	
	Annex 5 - Model checklist for intransit fumigation	

Session 10: Case studies

This session deals with the use of a case study as a teaching method.

In this approach learning takes place by discussion of the various aspects of a situation or problem. This could be real or imaginary. A case study needs to be well organised if it is to be used effectively. A case study is often used to assess why something went wrong. Marine accidents can provide an extensive source of useful case studies.

The general technique to be introduced to the trainee instructors is that the background theoretical knowledge should be introduced and key aspects should be highlighted. The information provided for the case study should be read through and any points that the trainees raise should be clarified. The situation should be assessed from more than one viewpoint to illustrate different aspects of the case study.

Some sample case studies are included.

If the case study is being used as a group activity a good atmosphere for discussion must be developed. Trainees must be made to feel confident that they can express their opinions freely. The management of the discussion of the case study is not easy and requires practice. The session should end with a summary of the key points. The trainee instructors should be asked to develop a list of the advantages and disadvantages of this method. For example:

Advantages

- relevant, real situations can be used
- develops problem solving skills
- encourages trainee instructors to think about situations

Disadvantages

- the case study should have a clear purpose
- case studies can sometimes seem false
- a case study needs to be properly structured

SAMPLE TEACHING CASE STUDY 1

A young instructor was asked to conduct a one-hour lesson on oily-water separators to a group of ten Engineer Officers. The instructor was nervous because they were all older and more experienced than he was. He wrote a set of objectives to cover basic principles of operation and a set of procedures for carrying out maintenance.

Both the principles of operation and the maintenance procedures were put onto a series of OHP slides. The instructor wanted the entire group to practice the maintenance procedures during the hour.

The instructor arrived at the class of ten trainees. The lesson began with the instructor showing the OHP of the principles of operation. He then lectured on the maintenance procedures. He suddenly realised that he had run ten minutes over time and called an end to the lesson.

SAMPLE TEACHING CASE STUDY 2

An instructor was scheduled to teach a class for one hour in a room that he knew was equipped with a chalkboard and an OHP. The topic was the properties of oil cargoes. The trainees were all experienced officers. The instructor planned to undertake a short introduction to the lesson using question and answer techniques. This was to last approximately ten minutes.

The main part of the lesson was to be a case study that was suitable for experienced officers. He estimated that 12 trainees would make up the class and he intended to divide the class into three groups of four students. The case study was to last for 40 minutes. The concluding part of the lesson was to draw the information together using a series of elaborate OHP slides.

When the instructor arrived to take the class he discovered that instead of 12 experienced officers the class consisted of 20 trainees who had not been to sea. The instructor decided to carry on with the prepared lesson.

The instructor began by using the introduction that he had prepared. The trainees were unable to answer the questions. The instructor stuck to his list of prepared questions. The instructor became frustrated with the class and was rude to two trainees who could not answer. The instructor then found that one trainee could answer many of the questions and so asked this trainee all the remaining questions. This took 20 minutes instead of the 10 minutes that he planned.

The instructor then divided the class into three large groups and handed out the case study. There were not sufficient copies of the case study for the number of trainees. The instructor gave no advice on how to use the case study and told the trainees to read the case study “quickly”.

It soon became clear that the trainees did not fully understand the case study. So the instructor stopped the case study after 20 minutes to undertake the concluding part of the lesson. The instructor went to use the OHP having moved the trainees so that they could all see the screen. When the instructor switched on the OHP he found that it did not work.

The instructor then began to use the chalkboard to summarise the key points. Many of the key points were too difficult for the trainees to understand. The instructor quickly went through the key points and ended the lesson 10 minutes early.

SAMPLE TEACHING CASE STUDY 3

A lecturer was conducting a lesson on cargo oil calculations to a group of trainees. Some of the trainees had served on oil tankers and some had not.

The lecturer began by saying, "Today we're going to look at oil calculations. We're converting True Observed Volume to tonnes". He then produced this OHP slide of a worked example.

Density at 15°C = 997.4 TOV = 4480m ³ Free water = 20m ³ VCF = 0.9982 WCF = 0.9463		
TOV		4480
Free water		-20
GOV		4460
VCF	x	0.9982
GSV		4452
WCF	x	0.9463
TONNES		4213

The lecturer said, "I'll leave this on so you can see how they are done".

He then asked the class to work on a sheet of tutorial examples. This produced a mixed response. Some trainees began to do the calculations, but others just sat and looked confused. The instructor told them just to copy the calculation from the OHP slide and that would make things clear.

SAMPLE CASE STUDY 1

The vessel *IMO Star*, a 35,000 DWT tanker was on passage when her destination was changed to a different port. Her chart portfolio did not include all the charts required for navigation to the new port. One of the officers attached a piece of plain paper to the bottom of a chart that the vessel had and used this as an extension of the chart. Since the real chart was not available reference was made to the port entry guide and a course was plotted towards the pilot station. The position of the pilot station was on the plain paper.

The master contacted the vessel's agent requesting charts for the area, but he did not say why he required the charts. The vessel continued on, with positions being plotted regularly. The last position plotted was on the plain paper. At the time the last position was plotted the watch was changed. The second officer took over the watch, the master was present on the bridge. A lookout/helmsman was also on watch. The weather was partly cloudy, with moderate visibility and occasional heavy showers. Both radars were operating, one radar was equipped with ARPA.

One hour later, during a heavy rain shower, a radar echo was detected fine on the starboard bow. It was assumed to be a small vessel and the second officer altered course to keep clear. After steaming a further mile a light was seen on the same bearing as the radar echo. A further alteration of course was made, but the vessel ran aground. It was then found that the echo had in fact been a light beacon. This beacon was clearly marked on the correct chart.

This case study could be used to illustrate the following points:

- All appropriate charts should be carried
- Sailing directions should be consulted when planning a passage
- Owners should keep records of the charts carried on vessels
- Masters should never assume a destination port will not be changed
- If charts are ordered by fax, telex, etc. the reasons for demanding them should be given
- The largest scale chart should be used
- No Master should take his ship into an area for which he has no chart of a suitable scale
- Stationary targets should be checked against charted objects
- If the Master is unsure if a vessel is in safe water he should proceed with extreme caution

SAMPLE CASE STUDY 2

While the vessel was at anchor an accident occurred when an engine room rating was working alone in the engine room on single ladder. The top rung of the ladder had been placed against a vertical corner of some trunking. The ladder was fitted with rubber feet. The ladder slipped or the rating lost his balance. The rating fell about two metres onto the deck plates.

This case study could be used to illustrate the following points:

- After the accident the rubber feet were found to have oil on them.
- A ladder must be properly secured
- A safety harness is recommended
- The risks were increased by the ship's movement, wet or oily surfaces, working alone

SAMPLE CASE STUDY 3

A 1,000 GT coaster was secured alongside a quay. An approved gangway was available on board but the master had given instructions for it not to be rigged. The master signed off and went home leaving the chief mate in charge.

The mate did not change or countermand the master's instructions. Some time later the mate was returning to the ship and found the main deck level with the quay and about 1.5m off. The mate tried to step from the quay onto the main deck but slipped and fell between the vessel and the quay.

This case study could be used to illustrate the following points:

- Even a narrow gap between the vessel and the quay can cause an accident if no gangway is fitted
- The master should have used the gangway which was available
- The master should make sure safe access is maintained at all times

Session 11: Teaching practice

This is another practical teaching session.

In teaching much depends on motivation: if the instructor shows that he or she is actively interested in the trainees as individuals, trainees will respond well, contributing to a good rapport and a productive learning atmosphere. If student motivation is a problem, it may be helpful to explain the rationale behind the activities and to emphasise that for learning to take place, individuals need to be prepared to work with and support each other.

Successful teaching is based on the instructor understanding and responding to trainees' needs which means that he or she must take an interest in the group as individuals. Ongoing needs' analysis can help the instructor decide the best focus of the teaching

Classroom management

Input is the term used to describe new information that teachers select and present to students. Learning is not a linear process, however. Not only does every student need frequent of new concepts, he also needs regular revision in order to retain previous information.

The format of lessons should be varied according to the level and learning needs of the class, meaning that input can be introduced at any stage.

Session 12: Teaching methods, role-play and simulation

Role-play

When using role-play trainees have to act the part of the person in a given situation. It can be a role that the trainees will need to perform themselves, or it could be the role of someone with whom the trainee instructor will have to deal. It is a useful method of making trainees appreciate the pressure and influences be involved in a role. If a realistic setting is available this adds to the authenticity of the role-play.

When preparing for a role-play session each trainee should be given a card describing his or her role. Trainees who are not playing a part should be given guidelines on what aspects of the role-play to observe. Before the session begins the trainee instructor needs to introduce the situation and explain why the role is being undertaken. A role-play needs to be monitored very carefully by the trainee instructor. If problems develop the trainee instructor may have to intervene. The trainee instructor should have some alternative plans available to cope with the situation in case a role-play does not work. Once the session has ended the role-play should be analysed and the trainees questioned about their role. This allows key points to be summarised and any questions to be resolved.

The advantages of a role-play are that:

- there is a high level of trainee participation
- it can be very realistic
- it allows trainees to experience a role in a safe environment

The disadvantages of role-play are that:

- some trainees do not like participating
- a role-play can take a long time
- a role-play needs careful preparation
- it needs skilful management

Simulation

Simulation of a real situation is used in situations where it is not possible or desirable to undertake training in real conditions. Ship handling simulators allow trainees to try manoeuvres without putting their vessel at risk. It allows trainees to experience a variety of situations in a short period of time. The initial situation is described to the trainees and then the exercise runs in real time. Trainees are observed during the simulation and then the exercise is reviewed at the end of the exercise. An example of this technique is shown in reference R3.

Advantages

- can be used for dangerous situations

- trainees must participate
- exercises can be repeated

Disadvantages

- cost
- can be time consuming
- supervision can be difficult

Simulation provides an ideal method for trainees to gain experience of dangerous or unusual situations while receiving advice.

Session 13: Teaching methods, groupwork and games

Managing group work

Managing group work can be tricky and teachers may, understandably, feel threatened by the prospect of 'losing control' of their class. However, students will not learn to develop competence if they are not permitted a degree of freedom in the classroom. Teenage and adult learners tend to respond well when they are given responsibility for directing their own work and group work can bring a dynamic appeal to the classroom. There are many factors to consider when managing groups: giving instructions; arranging groups; monitoring work in progress; dealing with different levels; and handling feedback and correction.

Each of these factors will be expanded on in the sections that follow.

Giving instructions

This is crucial to group work: teachers who are not familiar with organising interactive tasks may underestimate the challenge of making sure that instructions are both clear and understood. It can be very demoralising for everyone if group work fails. It is worthwhile taking a few moments to check that everyone knows what the task involves rather than students wasting time wondering what to do. This checklist of tips will help teachers ensure that their instructions are understood:

- Be clear about the aims and the timing of each stage of group tasks. During planning, break down the activity into logical steps and prepare a simple instruction for each step. Prior to the lesson, test the instructions by reading them aloud: if the wording is ambiguous, change it.
- Make sure that the language used for giving instructions is not above the students' language level: use short, simple sentences.
- Give oral instructions *before* dividing the class into groups: students cannot concentrate on listening if they are moving around or speaking to their partners.
- Before starting the activity, check that students understand by asking individuals
- Do a sample answer in front of the class to demonstrate what is required.
- For complex tasks or with elementary groups, demonstrate the activity in front of the class with one of the more able students.
- For longer tasks or with large groups, write reminders on the board so that the students do not have to keep asking what to do.

Arranging groups can be done in different ways, depending on the layout of the class and the furniture. If left to form their own groups, it is likely that the students will gravitate towards the

same people every time. Encourage students to mix by choosing different techniques for grouping, for example by allocating a number between one and four to each student then grouping them by number. If it is inconvenient to move the classroom furniture, have the students move their chairs into groups instead or, if writing is not required, ask them to stand up and move into groups. Limit the size of groups as it is difficult for more than ten people to contribute at once

Monitoring work in progress

While students are working, it is important to monitor their work discreetly, without interfering. At this stage, teacher talking time should be minimal. The teacher should move quietly around the room or sit behind each group in turn, listening to students' discussions, taking notes of points that need to be covered and checking that all students are interacting. Although students may at first be distracted by the teacher's presence, they will soon become familiar with the procedure and will realise that they should not ask for help unless absolutely necessary during these activities. If the task involves more than one stage, the teacher should make sure that the groups keep to the time allocated for each task.

Dealing with different levels

There is inevitably a range of ability in every class so the student-centred teacher should be aware of the different levels and be prepared to make arrangements that cater for all needs. From time to time, students should work in mixed ability groups as this reflects 'real life' working conditions and gives less able students the opportunity to learn from the stronger members of the group. However, students who are confident in their abilities often tend to dominate weaker students so it is often more advisable to group students by ability. In the event that groups with a higher level of ability finish before weaker students, the stronger students will need supplementary activities to keep them focussed while others finish the task, for example:

- students check their answers together and then with members of another group;
- students swap their written work with a partner, checking each other's work (this could be a general check or a specific check directed by the teacher); and
- the teacher provides a follow-on task which builds on the original activity.

Groups of weak students also need to be monitored. They may become discouraged if they perceive that other students are constantly waiting for them or feel pressurised by not having the time they need to complete an activity. If this is a problem, it may be necessary to adapt tasks for the lower levels. In this case, prepare variations of the task at two different levels with appropriate instructions for each task. Alternatively, keep the instructions the same but grade the material so that weak students have easier tasks to do.

Most of these techniques can also apply to pair work as much as group work. There are two types of pair work: open pairs and closed pairs. Open pair work is when the whole class listens while two students demonstrate a model or give answers, for example. Selecting students from different parts of the room for open pair work makes students more likely to pay attention in the class. Closed pair work is when every student is allocated a partner and the whole class works together at the same time. Pair work is generally easier and faster to set up than group work and can be used for virtually any type of practice. Often all it requires is for one student to turn to a partner. Trying out various combinations of pairs will prevent the predictability of always working with the same partner. Students can turn round and work with the person sitting behind them; move and work with someone at the opposite side of the room; or can be allocated a partner by the instructor.

Feedback and correcting group work

Feedback takes place when the teacher (and possibly the students) comments on students' work. Feedback is usually carried out at the end of an activity and is especially important after the production stage when students have been working independently of the teacher. Regular follow-up of production tasks will get students into the habit of reflecting on their work and will help make them aware of their own errors. However, it is very important to use feedback time positively so that students do not feel continually criticised for their efforts. Give students a sense of their own progress by giving praise for good work by reminding them of what they have learned.

Group Discussion (Buzz groups)

In this method the trainees are divided into groups of 4 to 6. The trainees are given a short time to discuss a topic or problem. The groups then report back to the whole class.

Each group must have clear guidelines on the topic and the time that is available. They should be given clear information on the type of report, which the group will give to the whole class. This report could include the use of an OHP or a flipchart. Each group can be asked to choose their own leader or the instructor may appoint one.

Advantages

- allows trainees to express their ideas
- gives a change of activity in a large group
- can be used to obtain feedback in a large lecture

Disadvantages

- can be difficult to organise
- can be time consuming

Games

This teaching method can get trainees actively involved since there is an element of competition. If the game is played in teams the trainees will have to work together and co-operate. The game need not be very complicated. Simple games are often more useful. Even a quiz can be very effective.

Guidelines for using games

- The game should have rules that are clear and simple.
- The game should have been tried and tested before it is used with trainees.
- The instructor should introduce the game and explain the rules.

- The instructor should only offer help when it is essential.
- At the end of the lesson the instructor should summarise any key points.

A simple game can be tried as part of this session. The trainee instructors can be asked to assess the advantages and disadvantages of using a game.

Advantages of games

- they can be fun
- the instructor can get information about the trainees' understanding
- the instructor can observe the trainees
- they can provide an informal lesson

Disadvantages of games

- some games do not work
- commercially available games may not be suitable or too costly
- the method requires a great deal of classroom control

Games can be simple. For example "Bingo" and "crosswords" can be used.

Example 1: Bingo

A series of small cards can be made using pictures of buoys, vessels' day signals and lights or International Code of Signals flags. More than one picture of the same item can be made. The trainee instructors choose five or six cards each. Trainees then listen as the instructor reads out the names of the buoys, etc. in a random order. A trainee recognising the name of a chosen card turns over the card. On turning over the last card the trainee shouts "*bingo*". The winner is the first person to shout.

This game can be adapted for many simple knowledge applications.

Example 2: Crosswords

Simple crosswords can be made. There are some simple software applications that can help. These can be very effective in promoting the memorising of simple definitions.

Session 14: Audio-visual aids

In general it is better to use pre-recorded material rather than "off air" programmes. The actual programme content may not match the advertised programme and so watching the programme may be a waste of time.

Film is less convenient than video- cassette because the whole of the film must be shown. It is not necessary to use the whole of an audio or video-cassette. There is little point in trainees watching for one hour to see five minutes of useful material. The instructor needs to watch the video to decide which part or parts to use. Trainees should be told what to watch out for before the material is shown and questions can be used to reinforce any points that are being developed. The audio-visual material can be repeated if necessary to make things clear. A handout can be prepared for use in conjunction with the audio-visual materials.

Slides can be useful. They do not have to be expensive. Reasonable priced commercial slides are readily available for some subjects. Most seafarers have pictures that they have taken and these can cheaply be made into slides. Slides taken during a field trip can be useful when discussing the trip with the trainee instructors.

It is possible to use slides together with an audiocassette to produce a "slide - tape" instructional package. To hold the interest of trainees, whose expectations of visual images is high with what they see from television and films, the quality of production needs to be very good.

Information technology has become cheaper in the recent years. Various presentation packages are available. The trainee instructor needs to assess how useful an individual package will be for the trainees and whether it represents an effective use of the trainee instructors' time. To do this the trainee instructor must try and use the package in the way in which a trainee would use it.

Models

Models can be helpful in allowing trainees to gain a better picture of a process. Some models can be very elaborate and very expensive. Models can be simple and home made. A simple model of a derrick can be made to illustrate the operation.

Choosing a visual aid

Factors to consider

- room layout and design
- teaching method
- trainees
- trainee instructor's preference

Session 15: Preparation and planning

Preparing for practical teaching

Sessions 16 & 17: Teaching Practice

These sessions offer the opportunity for extended practical teaching. These sessions provide the best opportunity for assessment of the trainees.

Session 18: Evaluation and feedback

Evaluation of trainees as part of the learning process

Evaluation and assessment are undertaken in order to issue a qualification. However, evaluation and assessment can also be used informally. Informal evaluation is sometimes referred to as “formative”. Formative evaluation is not used to put trainees into a rank order. The purpose of this type of evaluation is to aid teaching and learning. There are many reasons for the use of informal evaluation during a course.

Trainees can be evaluated to

- ensure they have the knowledge and skills to begin a course
- reinforce learning
- test understanding
- maintain standards
- predict future performance
- provide motivation
- provide feedback to trainees
- provide feedback to the instructor

One of the most important aspects of this type of evaluation is that it allows trainees to monitor their own progress. If this type of evaluation is used its purpose must be made clear to the trainees. There are three key aspects to using formative evaluation.

1. It should be informal or rather the feedback should be given informally. A simple mark will not be sufficient, the trainees should be told how the work could be improved. This type of marking of written work can be time consuming, but it is very valuable to the trainees.
2. The feedback should be prompt. The trainees should be given their results and associated comments as quickly as possible after the evaluation. The feedback has less meaning if there is a long delay. The trainee cannot begin to improve until the feedback is given.

3. The feedback must motivate the trainee. Formative evaluation is informal and so should be less stressful to the trainee than a formal assessment. The way in which feedback is given is very important. Suggestions should be given on how to improve rather than condemning the work. The best technique is to comment on any good aspects of the evaluation and then to explain why things are incorrect. A balance is needed between drawing the trainee's attention to incorrect answers and being so critical the trainee instructor is de-motivated.

The evaluations that are used to help teaching and learning are called formative evaluations. The main types of formative evaluations are

- practical tests
- essays
- projects
- assignments
- question and answer sessions
- selection tests e.g. multiple choice, true/false
- short answer tests

Multiple choice questions

These can be effective and can be used to assess quite complex topics. Once written they are quick and easy to mark. They can be very difficult to write. Once the correct answer is written, providing believable wrong answers can be difficult. They should also be checked to ensure that the position of the correct answer on the list of possible answers is not always the same.

True/false

These are not particularly useful. Trainees have a 50% chance of getting them right without even reading the questions.

Matching

This technique is most useful for assessing lower level knowledge and skills. They are used for identifying associations between things.

Short answers

These are best used to test recall of information or for small calculations.

Essays

Essays can either be structured or extended. They allow trainees greater freedom than the other questions. They are more difficult to mark. The marking can also be very subjective.

The trainee instructors should spend time writing some evaluation and assessment questions on a suitable topic chosen from the STCW Competence tables..

Evaluation of teaching effectiveness

At the end of a lesson an instructor should always think about the effectiveness of the teaching. A systematic approach is needed if the trainee instructor is to gain useful information. There are several aspects of the lesson to consider.

- The subject

An instructor must have “mastery” of the subject material. This means that the instructor must know and understand the subject material thoroughly. The instructor should consider whether or not further research is required before teaching another lesson on that topic. Trainees will often raise questions on aspects of a topic that the instructor has not previously considered. By thinking about topics raised by the trainees the instructor’s knowledge will improve.

- The preparation

Thorough preparation should have been made for the lesson. An honest review of such items as whether the needs of the trainees were correctly identified, the appropriateness of the teaching method and the quality of the lesson plan should be made.

- The presentation

The instructor should review how well the teaching method was implemented and the effectiveness of the teaching aids.

- Classroom communications and relationships

Evaluation of this aspect of teaching should cover such things as how well the trainees participated in the lesson and the “climate” in the classroom. This would include the appropriateness of the language and the role of non-verbal communications.

- Assessment

If assessment was part of the lesson the trainee instructor should consider the purpose of the assessment and whether the assessment was satisfactory.

One of the most helpful things that a new instructor can do is to keep a diary of lessons taught. This records what has happened during the lessons. There are many different styles of diary. One simple style uses headings and then comments about the lesson are made under each heading. The instructor can also try and grade each aspect of the lesson. This can be done by

awarding a mark out of ten or by using a grading scheme such as poor, fair, good or excellent. Self-evaluation can be difficult. It means admitting that there are problems or that things could be better. It is much easier to ignore and find excuses when another person makes an evaluation. It is possible to say that the other person has poor judgement, they are too old or too young, that they only like to see certain teaching methods in use, etc. However, with self-evaluation this type of excuse is not valid. If self-evaluation is not carried out in an honest way the only person being deceived is the instructor. It is very unlikely that any instructors could honestly grade themselves as excellent in every aspect of a lesson.

It is possible to obtain feedback from other sources, but each possible source will have advantages and disadvantages. The trainees who are taking the lesson are perhaps the most obvious people to ask for feedback. If an instructor is delivering several lessons the trainees should be able to make useful comments. However, trainees must feel that they can speak freely.

If trainees feel that if they offer any criticism or adverse comments they will be punished in some way, the feedback will be of limited value. This is particularly likely to be a problem with young trainees if the instructor is also the assessor. Even if trainees are asked to complete questionnaires anonymously they may feel that their handwriting may be recognised.

Fellow instructors could be asked for comments. This is sometimes called "peer review". Instructors are usually busy people so it can be difficult to organise. The observing instructor will need to attend a teaching session. In addition time will need to be put aside before the lesson for a discussion of the lesson's aims, the needs of the trainees, etc. After the lesson there will need to be time for a review. An instructor could produce a checklist and ask the observing instructor to complete it during the lesson. This is useful when an instructor wants an opinion of some particular aspect of the lesson. One problem with obtaining feedback from a fellow instructor is that they make unfair comparisons between their teaching practices and those they observe. An outside observer in the room can also effect the climate in the classroom. Trainees may be less willing to talk when another person is present.

Managers can also be asked for feedback. The problems are similar to those met with using a fellow instructor. Problems can be more serious if the manager has no experience of acting as an instructor.

Session 19: New course design

This session involves the use of the STCW competence tables in order to try and design a new course. The following factors must be identified

- Aim(s) of the course
- Expected entry knowledge of the trainees
- Competences
- Order in which the topics should be taught
- Time allocation for the whole course

- Time allocation for individual topics and assessments
- Teaching and learning methods
- Resources required (including textbooks)
- Assessment methods

Session 20: Evaluation

Plenary

Alternatives

If considered more appropriate some other teaching methods could also be considered in place of those suggested. Possible methods could include the following

Team Teaching

Team teaching is a teaching approach used where two or more instructors co-operate in the delivery of a course. This could include all the aspects of a course such as the planning, presentation, evaluation and evaluation. The term is generally used where instructors share the presentation of a course to a large group of trainees. The method is most often used in a situation where each instructor has special expertise and is responsible for a section of the course. For example a course might be delivered by a deck officer teaching some sections and an engineer officer teaching others.

This type of approach requires careful planning in order that topics are not duplicated. There must be no gaps left that would make the course disjointed. The course should flow from one lesson to the next.

Advantages

- each instructor works in an area of expertise
- each instructor needs to prepare fewer lessons
- cost

Disadvantages

- large rooms are needed
- vulnerable to communication problems
- can be muddled

A well co-ordinated programme where team teaching is used can be very successful. Tutorial support is usually required for the method to be effective.

Tutorial

This method can be used on a one to one basis or with small groups. The method is generally used to provide additional support for trainees undertaking a course of study. Trainees are

required to complete a small task. Sometimes the trainees are asked to complete the task before the tutorial and the instructor looks at the work with the trainee instructors. Alternatively the trainees carry out the task during the tutorial. The instructor monitors the trainees and provides help where it is needed. The instructor's time should be divided fairly amongst the trainees so that no trainee is left requiring help for a long period. Some trainees will ask for assistance without trying to complete the task themselves and others will be reluctant to ask for help when they need it.

Advantages

- individual attention
- support
- helps to evaluate the teaching

Disadvantages

- cost
- trainees may not like the individual attention.

This is a very commonly used method. Most courses will have some tutorials.

Demonstrations practical work/workshops/laboratory work

These situations provide trainees with a chance to develop practical skills. Theory should be linked to the practical skill and the situation should be as realistic as possible.

A session often begins with a demonstration. This teaching method is most often used when teaching a practical skill. The skill is demonstrated and then the trainees practice the skill. When preparing for the demonstration the instructor should check that all the equipment is working and then practice the demonstration to find out how long it will take.

It is essential that all the trainees can see the demonstration that is taking place. When presenting the demonstration the instructor should explain clearly why the skill is needed. Any equipment that is used should be explained to the trainees, including the use of any technical terms. Any safety requirements should be stressed to the trainees. It is sometimes difficult to perform the demonstration slowly. Once the instructor has performed the demonstration a trainee can be asked to perform the task. The instructor can then provide a commentary explaining what the trainee is doing and stressing the key points of the skill.

If a demonstration is not used the session should still have a clear introduction. The instructor should check that all the equipment that is required is ready and available. The equipment must be in proper working order.

Trainees should be provided with clear instructions. A worksheet or task sheet should be provided for the trainees giving full details of the skill. If the practical work is to be assessed an evaluation sheet should also be prepared. This should identify the tasks to be assessed and the key points.

In practical sessions safety is very important. For this reason practical work classes are usually smaller than theoretical classes or additional staff are used. The trainees should be carefully

supervised and left to work at their own pace as far as practicable. The instructor should correct any faults as they arise. It provides a useful situation for less formal feedback from trainees.

Advantages

- can reinforce or introduce theory
- trainees can have individual attention
- trainees work at their own pace
- trainees gain practical skills

Disadvantages

- needs careful control of safety
- cost
- some trainees view practical work as boring
- time

Seminars

The seminar method is a method where an individual trainee or group of trainees carries out research into a topic and then presents the results to the others. A discussion or questions usually follow this. The student has to be given the seminar topic in sufficient time so that the trainee instructor can research the topic properly and prepare the presentation.

Advantages

- Trainees are involved in finding the information
- trainees are given responsibility
- trainees have the opportunity to join in discussions
- trainees are required to think about the best method of presenting the information

Disadvantages

- trainees may be reluctant to participate
- trainees may not respect other trainees
- poor presentations can be difficult for other trainees to understand
- trainees may criticise others too severely
- trainees may be reluctant to criticise others

Seminar work can be difficult to assess since there are three separate elements: the research, the presentation and the answering of questions.

Project

Trainees choose a topic or are given a topic by the instructor. Trainees can work individually or as part of a group. The trainees carry out research on the project and then report back. The report can be a written report or a verbal report.

Care must be taken when setting the project. It must be appropriate to the level of the course and the trainees should be able to complete the project in a reasonable time.

Advantages

- trainees are motivated
- a project can be cross-curricular
- a project improves personal study skills

Disadvantages

- can be difficult to manage
- requires appropriate resources
- time consuming

Project work tends to be used in higher level courses. It is often used for evaluation purposes as an alternative to formal examinations.

MODEL
COURSE
X.XX

SECOND – CLASS
RADIOELECTRONIC
CERTIFICATE FOR THE
GLOBAL MARITIME
DISTRESS AND SAFETY
SYSTEM

Course+Compendium

(DRAFT)

Model Course X.XX

SECOND – CLASS RADIOELECTRONIC
CERTIFICATE FOR THE GLOBAL
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INTRODUCTION

Purpose of the model courses

The purpose of the IMO model courses is to assist maritime training institutes and their teaching staff in organizing and introducing new training courses, or in enhancing, updating or supplementing existing training material where the quality and effectiveness of the training courses may thereby be improved.

It is not the intention of the model course programme to present instructors with a rigid "teaching package" which they are expected to "follow blindly". Nor is it the intention to substitute audio-visual or "programmed" material for the instructor's presence. As in all training endeavours, the knowledge, skills and dedication of the instructor are the key components in the transfer of knowledge and skills to those being trained through IMO model course material.

Because educational systems and the cultural backgrounds of trainees in maritime subjects vary considerably from country to country, the model course material has been designed to identify the basic entry requirements and trainee target group for each course in universally applicable terms, and to specify clearly the technical content and levels of knowledge and skill necessary to meet the technical intent of IMO conventions and related recommendations.

Use of the model course

To use the model course the instructor should review the course plan and detailed syllabus, taking into account the information provided under the entry standards specified in the course framework. The actual level of knowledge and skills and the prior technical education of the trainees should be kept in mind during this review, and any areas within the detailed syllabus which may cause difficulties because of differences between the actual trainee entry level and that assumed by the course designer should be identified. To compensate for such differences, the instructor is expected to delete from the course, or reduce the emphasis on, items dealing with knowledge or skills already attained by the trainees. He should also identify any academic knowledge, skills or technical training which they may not have acquired.

By analysing the detailed syllabus and the academic knowledge required to allow training in the technical area to proceed, the instructor can design an appropriate pre-entry course or, alternatively, insert the elements of academic knowledge required to support the technical training elements concerned at appropriate points within the technical course.

Adjustment of the course objectives, scope and content may also be necessary if in your maritime industry the trainees completing the course are to undertake duties which differ from the course objectives specified in the model course.

Within the course plan the course designers have indicated their assessment of the time which should be allotted to each learning area. However, it must be appreciated

that these allocations are arbitrary and assume that the trainees have fully met all entry requirements of the course. The instructor should therefore review these assessments and may need to re-allocate the time required to achieve each specific learning objective.

Lesson plans

Having adjusted the course content to suit the trainee intake and any revision of the course objectives, the instructor should draw up lesson plans based on the detailed syllabus. The detailed syllabus contains specific references to the textbooks or teaching material proposed to be used in the course. Where no adjustment has been found necessary in the learning objectives of the detailed syllabus, the lesson plans may simply consist of the detailed syllabus with keywords or other reminders added to assist the instructor in making his presentation of the material.

Presentation

The presentation of concepts and methodologies must be repeated in various ways until the instructor is satisfied that the trainee has attained each specific learning objective. The syllabus is laid out in learning-objective format and each objective specifies what the trainee must be able to do as the learning outcome.

Implementation

For the course to run smoothly and to be effective, considerable attention must be paid to the availability and use of:

- ☐ properly qualified instructors;
- ☐ support staff;
- ☐ rooms and other spaces;
- ☐ equipment;
- ☐ textbooks, technical papers; and
- ☐ other reference material.

Thorough preparation is the key to successful implementation of the course. IMO has produced a booklet entitled "Guidance on the implementation of IMO model courses", which deals with this aspect in greater detail. A copy of this booklet is included as an attachment to this course.

Part A

Course Framework

The main purpose of the Course is to give trainees theoretical knowledge and practical skills sufficient to perform functions of a second-class radioelectronic. The Model Course provides only the basic IMO standards of knowledge and skills for second-class radioelectronics, taking into account various educational systems and cultural background of trainees.

The Model Course is based on the Model Course 1.25, recommended by IMO, “General Operator’s Certificate for the Global Maritime Distress and Safety System”, as regards training organization, teaching aids and technical facilities. As the competence level of second-class radioelectronics involves higher requirements concerning trouble shooting, maintenance and repair of GMDSS equipment, the course comprises specific sections providing this kind of training.

Standard Requirements

On successful completion of the course and assessments, a document may be issued certifying that the holder has successfully completed a course of training which meets or exceeds the level of knowledge and competence specified in IMO STCW Code sections A-IV/2, B-IV/2, 15-28, and Article S47 of the Radio Regulations second-class radioelectronic.

In compliance with the above documents second-class radioelectronic

should have knowledge of:

- General principles and basic factors necessary for safe and efficient use of all the subsystems and equipment required in the GMDSS;
- The use, operation and service areas of the GMDSS subsystems, including navigational and meteorological warning systems and selection of appropriate communication circuits;
- The SOLAS Convention and Radio Regulations particularly related to distress radiocommunications, prevention of unauthorized transmission and harmful interference;
- Other documents related to public communication and distress and safety communication;
- International Code of Signals and IMO Standard Marine Communication Phrases;
- Principles of electricity and the theory of radio and electronics sufficient to meet requirements GMDSS equipment maintenance;
- The GMDSS radio equipment, including radiotelephone receivers and transmitters, digital selective calling equipment (DSC), narrow-band- direct-printing telegraph equipment (NBDP), ship earth stations (SES), emergency

position indicating radiobeacons (EPIRB), radio equipment for survival craft, power supplies, marine antenna systems, and other equipment used for radionavigation, with particular reference to maintaining the equipment in service;

- Factors that affect reliability, availability, maintenance and repair procedures;
- microprocessors and fault diagnosis in systems using microprocessors;
- control systems in the GMDSS radio equipment including testing and analysis;
- computer software for the GMDSS radio equipment and methods of correcting faults caused by loss of software control of the equipment;

should have practical skills in:

- communication procedures and discipline to prevent harmful interference in the GMDSS subsystems;
- selection of optimum frequencies for communications;
- radiocommunications watchkeeping relevant to all GMDSS subsystems, exchange of radiocommunication traffic, particularly concerning distress, urgency and safety procedures and radio records;
- use of the international phonetic alphabet;
- monitoring a distress frequency while simultaneously monitoring or working on at least one other frequency;
- radio medical systems and procedures.

should be able to perform:

- correct and efficient operation of all GMDSS subsystems and equipment under normal propagation conditions and under typical interference conditions;
- safe operation of all the GMDSS communication equipment and ancillary equipment, including safety precautions;
- adequate and accurate keyboard work for the satisfactory exchange of communications;
- operational techniques for receiver and transmitter adjustment for the appropriate mode of operation, including digital selective calling and direct-printing telegraphy;
- use of radio life-saving appliances and emergency position indicating radio beacons;
- basic maintenance procedures, both preventive and corrective, for all the GMDSS communication equipment and radionavigation equipment;
- reading and understanding of pictorial, logic and module interconnection diagrams;
- use and care of those tools and test instruments necessary to carry out at-sea electronic maintenance at the level of unit or module replacement;
- tracing and correction of conditions contributing to the fault occurring to board/module level;
- methods of alleviating electrical and electromagnetic interference such as bonding, shielding and bypassing;
- antenna adjustment, re-alignment and maintenance, as appropriate;
- replacement of parts with due regard to observance of manual soldering techniques and occupational safety rules.

References

- IMO resolutions relating to the Global Maritime Distress and Safety System (GMDSS)
- Radio Regulations, 1999

For the development of the Module course the following documents have been used:

- STCW Code Section B-IV/2, 15-28
- CEPT Project Team Examination Syllabus for the Marine Mobile Satellite, London, 1993.
- Model Course Second Class Radio Electronics Certificate for GMDSS (IMO Res. A/703 (17), Draft Gdynia Marine Academy, Poland, 1996.

Performance Requirements

Candidates for the second-class radioelectric certificate should perform typical functions provided for by IMO requirements.

Performance requirements on completion of the course

	Functions	Requirements
1.	Duties of second-class radioelectronics prior to ship's departure	Knowledge of operations and procedures regarding preparation of communication and navigational equipment for sea service. To be able to perform these functions.
2.	Duties of second-class radioelectronics relating to establishing communication in case of distress, urgency and safety and public correspondence exchange	Knowledge of communication procedures of GMDSS subsystems according to SOLAS and Radio Regulations, selection of modes and lines of radio communication technically and economically effective taking into account radio wave propagation.
3.	Duties of second-class radioelectronics relating to environment protection	Knowledge of regulations regarding environment protection and personal safety reduction and elimination of hazardous influence of radio equipment on the environment and crew. To prevent radio interferences and unauthorized transmissions.
4.	Duties of second-class radioelectronics relating to PC computers and PC computer based equipment maintenance	Practical knowledge necessary for configuration of PC based radio and navigational equipment, use of PC as terminal, PC maintenance and troubleshooting.
5.	Duties of second-class radioelectronics relating to maintenance of communication and navigational equipment.	Practical knowledge necessary for communication and navigational equipment testing, using safe methods; knowledge methods of failure location

		in microprocessor based equipment.
6.	Duties of second-class radioelectronics in case failure of operational communication and navigational equipment.	Practical knowledge of shipborne communication and navigational equipment configuration for duplication purposes, repairs to the level of modular unit; ability to notify a shore service.
7.	Duties of second-class radioelectronics relating to communication and navigational equipment repairs	Practical knowledge necessary for effecting repairs in case of faults in communication and navigational equipment, using the means available on board and, if necessary replacing modular units; ability to analyze electric circuits for trouble shooting purposes; ability to effect all repairs in full compliance with safe working practices.
8.	Duties of second-class radioelectronics relating to endurance of communication during search and rescue operations	Practical knowledge of appropriate procedures in accordance with the Radio Regulations, SOLAS, International aeronautical and maritime search and rescue manual.
9.	To use oral and written English necessary for second-class radio electronics	Practical knowledge of the English language necessary for understanding of technical documents and communication; ability to use SEASPEAK, IMO Standard Marine Communication Phrases, phonetic alphabet.

Entry level

The teaching syllabus and the programme of second-class radioelectronic require that the candidates should have B.Sc. in electronics.

To undertake the course the candidates should know and be able to use:

- basic signal conversions in electronic systems;
- time and frequency signals;
- fundamentals of information and coding theory;
- circuit theory of electronic devices: principles of operation and basic features of - typical analog, analog-digital and digital electronic devices;
- methods and means of measuring signal parameters and technical characteristics of electronic devices;
- principles of operation of communication, facsimile and television systems;
- fundamentals of electronic equipment maintenance including methods and means of diagnostics;
- methods for meeting the requirements of environment and labor protection, rules of accident prevention and fire safety during electronic equipment maintenance;
- methods of mounting and dismounting of electronic equipment elements;
- English for electronics.

PART B

Organization

Staff requirements

All training and instruction should be given by personnel properly qualified in the subject matter.

Instructors in charge of practical training in radiocommunication procedures should be in possession of a valid General Operator's Certificate. In addition to having considerable experience in maritime radio-communications, including the GMDSS, all instructors should have a good general knowledge of ships, maritime safety and search and rescue matters.

Instructors providing practical training in maintenance should possess qualification and valid second-class radioelectronic certificate as well as practical experience in in-service maintenance of shipborne communication and electronic navigational equipment.

Course intake limitations

Practical training should be undertaken in small groups of not more than 8 trainees, depending on the available equipment.

The use of simulators to supplement training on real equipment may allow greater numbers to be accommodated without sacrificing training standards. However, the course co-ordinator will have to ensure that the timetable arrangements provide sufficient access to real GMDSS equipment. Note also the arrangements needed for examination and assessment listed under column 3 of table A-IV/2 of the STCW Code.

Practical training in the GMDSS and electronic navigational equipment maintenance should ensure use of real shipborne equipment.

Examination

Personnel authorized to evaluate competence of trainees during examination should have appropriate qualification, experience in use of shipborne equipment and be familiar with the training programme and technical aids used by the training institution. The examination should be supervised by an independent, objective examiner.

On all theoretical subjects, the examination should be conducted as a combination of written, oral and/or PC-based tests.

On all practical subjects, the examination should include a combination of oral tests and practical demonstrations with use of GMDSS simulator and shipborne communication and electronic navigational equipment.

A part of the written and oral tests should be conducted in English in order to ensure that the student, as a minimum, is able to:

- read and understand written distress and safety messages received via NBDP and Inmarsat-A/-B/-C;
- compose written distress and safety messages for transmission via NBDP and Inmarsat-A/-B/-C;
- conduct distress traffic and participate actively in SAR communications via radiotelephony;
- read and understand the information given in all relevant service documents, including relevant parts of the technical documentation;
- carry out all relevant and necessary general radiocommunications using radiotelephony, NBDP and DSC;

and

- exchange written messages with shore companies engaged in repair of shipborne equipment.

Teaching Facilities and Equipment

Minimum recommended set of equipment:

- network PC based simulator or any other simulator meeting requirements of STCW relating to GMDSS simulators – every trainee should have a separate working station;
- a set of shipborne GMDSS equipment for Sea area A3 including at least VHF radio station with DSC, MF/HF radio station with DSC and radio telex equipment, ship earth station (SES) Inmarsat-C with EGC receiver, NAVTEX receiver – one set for 4 trainees;
- GPS receiver – one for maximum 4 trainees;
- SES Inmarsat A or B;
- dummy COSPAS-SARSAT EPIRB with hydrostatic release mechanism;
- dummy SART;
- portable VHF radios with charging device;
- set of reserve source of energy with automatic charging device;
- RADAR and ARPA laboratory;
- navigational aids laboratory;
- PC laboratory;
- analogue and digital circuits laboratory.

Development of skills and testing competence as regards trouble shooting and repairs for the GMDSS equipment to the level of replaceable module/unit requires use of life equipment and a set of measuring equipment, including at least multimeter, oscillograph, signal generator, frequencymeter as well as a set of electronic and radio navigation aids.

Use of concrete equipment as examples in the Model Course Compendium is called for by methodological considerations and does not reflect any preferences.

Classroom facilities should include a blackboard, whiteboard or flip-chart and an overhead projector. When audio-visual material such as videos, slides, tape-recordings, etc. are used, the appropriate equipment should be available.

Manuals and documents:

The list of manuals and normative documents (international and national) should meet the requirements of the General Operator's Certificate for the GMDSS Model Course (1.25), which should be supplemented with:

- the training programme;
- a set of technical documentation for the shipborne GMDSS equipment;
- manuals and text books necessary for studying the sections.

Teaching aids (A)

GOC Model Course 1.25 Compendium

PC programs, including documentation, for simulation of:

1. Inmarsat-A/B operation
2. Inmarsat-C operation
3. Narrow-Band Direct Printing (NBDP)
4. Digital Selective Calling (DSC)
5. Radiotelephony operation
6. EBIRBs and SART operation

- A3. User manuals for all installed GMDSS equipment
- A4. ITU Map of Coast Stations Open to Public Correspondence
- A5. Radio Log-book
- A6. Demonstration equipment (SARTs, EPIRBs)
- A7. Live GMDSS radio equipment
- A8. Technical Manuals for GMDSS equipment

IMO/ICAO References (R)

- R1. IMO GMDSS Handbook

- R2. IMO and ICAO International Aeronautical and Maritime Search-and Rescue Manual
- R3. IMO Standard Marine Communication Phrases
- R4. IMO Master Plan of shore based facilities for the GMDSS
- R5. IMO STCW Code
- R6. IMO Resolution A.814(19)
- R7. International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended
- R8. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995 (STCW Convention) and Seafarer's Training, Certification and Watchkeeping Code (STCW Code)
- R9. Performance standards for shipborne Radiocommunications and Navigational Equipment

Textbooks (T)

- T1. ITU Manual for Use by the Maritime Mobile and Maritime Mobile-Satellite Service
- T2. ITU List:
 - 1. ITU List of Coast Stations
 - 2. ITU List of Radiodetermination and Special Service Stations
 - 3. ITU List of Call Signs and Numerical Identities
 - 4. ITU List of Ship Stations
- T.3 Other textbooks:
 - 1. Inmarsat Maritime Communications Handbook
 - 2. Design and installation guidelines for Inmarsat-A, -B, -C & -E
 - 3. Inmarsat-E User Manual
 - 4. Inmarsat SafetyNET User's Handbook
 - 5. Admiralty List of radio signals, volume 5 (GMDSS)
 - 6. Semiconductor Reference Guide. Tandy Corporation, USA, 1992

Bibliography of other publications used in the course (B)

- B1. P.C. Smith and J.J. Seaton, GMDSS for Navigators. (Rushden, Butter-Worth-Heineman, 1994) (ISBN-0-7506-2177-X)

- B3. G.D.Lees, Handbook for Marine Radio Communication. 2nd edn. (London, Lloyd's of London Press, 1996) (ISBN 1-85978-041-5)
- B4. Eiden C., Fiebelmann H., Cramer M. PC-Hardware. Verlags GmbH, 1995.
- B5. Ibrahim K.F. Electronic System @ Techniques. Longman Scientific&Technical, London 1987
- B6. Lenk J.D. Handbook of Practical Electronic Cuircuits – Prentice-Hall, Inc., Englewood Cliffs. 1982.
- B7. Red E.T. Arbeitsbuch fur den HF-Techniker. Franzis – Verlag GmbH Munchen, 1986
- B8. Upgrade Guide, Stan Miastkowski, PC World, 2000
- B9. Upgrading and repairing of PCs, Scott Mueller, QUE, 1999
- B10. Inside the Windows 95 File Sysytem, Stan Mitchell, O”Reilly &Associates, 1997
- B11. Data and Computer Communications, 5/e, William Stallings, Prentice Hall, 1997
- B12. Introduction to Networking, Barry Nance, QUE, 1994
- B13. Encyclopaedia. Hardware Ibm PC M. Guk, “PETER”, 2000
- B14. Е.Л. Смирнов и др. Технические средства судовождения. Том 1. Теория - Санкт-Петербург: Элмор, 1996. 550 с.
- B15. Е.Л. Смирнов и др. Технические средства судовождения. Том 2. Конструкция и эксплуатация - Санкт-Петербург: Элмор, 2000. 556 с. (ISBN 5-7399-0073-5)
- B16. Hardware of PC, O. Kolesnichenko, I. Shishigin, St.Psb., 1999

Note It is expected that the national institution implementing the course will insert references to national requirements and regulations as necessary

Part C

Course Outline

The programme of the Model Course is in full accordance with IMO Resolution A.703 (17). The Model Course is arranged in the form of separate sections in a logic and methodological sequence.

The total quantity of class hours –584, including: theoretical training –263 hrs., practical training and simulation – 321 hrs.

?	Section	Hours		
		Total	Theoretical	Practical
1	FUNDAMENTALS OF RADIO SYSTEMS	42	42	---
2	RADIO COMMUNICATION EQUIPMENT	56	36	20
3	MICROPROCESSORS	31	17	14
4	PC SOFTWARE AND HARDWARE	58	22	36
5	ELECTRONIC NAVIGATIONAL AIDS	39	21	18
6	SHIPBORNE RADAR. ARPA.	64	24	40
7	RADIONAVIGATION SYSTEMS.	58	23	35
8	REGULATIONS AND COMMUNICATION PROCEDURES	134	54	80
9	TECHNICAL MAINTENANCE OF SHIPBORNE GMDSS EQUIPMENT	102	15	87
10	THE ENGLISH LANGUAGE (optional)			
Total:		584	263	321

Notes:

1. It is assumed that the trainees having B.Sc. in electronics, are familiar with microprocessors fundamentals and PC software and hardware. Trainees should have the level of knowledge in this field in accordance with the entry Standards. In this case sections 3 and 4 are optional. Use of PC software and hardware is covered by section 9.
2. Section 10 contains requirements regarding the English language knowledge. The number of class hours and the training syllabus should be determined by maritime training institutions.
3. Sections 1...4 only give a brief outline of the programme, as these general technical issues are well covered by appropriate text-books and manuals. Sections 5...9 related to special training of second-class radioelectronics, give a more detailed description of the course on the basis of technical instructions for various kinds of the GMDSS equipment.

4. Section 8 is based on IMO Model Course 1.25 “General operator’s certificate for the Global Marine Distress and Safety Systems”. Amendments to IMO 1.25 Model Course resulted from the fact that this is not a separate course but only an integral part of the 2d Class Radioelectronics training.

References to IMO Resolution A.703 (17)

IMO Resolution A,703 (17) item	Sections
1 General	Physical fitness certificate
1.1	The entire Model Course
1.2	
2. Theoretical	
2.1	1,2,6,7
2.2	8
2.3	1,2
2.4	1,2,8,9
2.5.	9
2.6	3,4,9
2.7	9
2.8	9
3 Regulations and documents	8
4 Watch-keeping	8
5 Practical training	5,6,7,8,9
6 Miscellaneous	8,9,10

Detailed teaching syllabus

The detailed teaching syllabus has been written in learning-objective format in which the objective describes what the trainee must do to demonstrate his/her competence.

All objectives are understood to be prefixed by the words, "The expected learning outcome is that the trainee..."

Learning Objectives	IMO Reference	Textbooks, Bibliography
I. FUNDAMENTALS OF RADIO SYSTEMS (42 hour)		
1. Radio engineering systems-definitions, purpose, classification. Basic signal conversion in radio engineering systems. Basic features of communication systems in telephony, telex and data communication.	R1	T1, B5, B6
2. Terminal equipment-purpose and basic features information theory elements and coding-Code code (ITA-2, ASC II code); terminal basic characteristics-code ,transmission speed, synchronization, transmission method.	R1, R9	T1, B5, B6
3. Signals in radio engineering systems signal classification; signal spectrum; continuous signal transmission by digital method;	R1, R9	T1, B5, B6,

4. Modulation purpose, modulation types: amplitude modulation, angle modulation; binary signal modulation-manipulation; SSB signals; Classification of emission; Features of receiving and detecting phase-modulated oscillations by means of frequency modulator and frequency detector.	R1, R9	T1, B1, B5, B6
5. Noise stability codes-principles of construction and basic features. Noise stability codes used in GMDSS equipment, check parity codes, 3/4 code, cyclic codes BCH with error detection and correction, codes in DSC systems, convolutional codes.	R1, R9	B1, B5, B6
6. Algorithm of improved error protection: Modes ARQ, FEC-col, FEC-sel.	R1, R9	
7. Antennas and radio wave propagation: antennas: purpose and principles of operation; radio wave propagation, features of radio wave propagation in various bands.	R1,R9	B1
8. Electronic compatibility of radio electronic aids.	R1, R9	B1
9. Measuring methods and means of signal parameters and radio electronic device characteristics	R1, R9	B5, B6
II. RADIO COMMUNICATION EQUIPMENT (56 hour)		
1. The requirements to the GMDSS equipment configuration and its technical characteristics	R1,R9	B5, B6
2. VHF radio installations with DSC	R1, R9	B1, B5, B6, A8
3. MF/HF radio installations with DSC and NBDP	R1, R9	B1, B5, B6, A8
4. SES INMARSAT-C	R1, R9	B1, B5, B6, A8
5. Specialized computers and interfaces	R1, R9	B1, B5, B6, A8
6. SART	R1, R9	B1, B5, B6, A8
7. EPIRB	R1, R9	B1, B5, B6, A8
8. NAVTEX receivers	R1, R9	B1, B5, B6, A8
9. GMDSS equipment power supply	R1, R9	B1, B5, B6, A8
III. MICROPROCESSORS (31 hour)		
1.Tasks of control MP system	R1, R9	B1, B4
2.Microcomputer architecture	R1, R9	B4, B5, B9
3.Interrupts, interrupt request lines	R1, R9	B4, B5, B9
4.Direct memory access	R1, R9	B4, B5, B9
5.Input/output ports	R1, R9	B4, B9
6.ROM BIOS	R1, R9	B4, B9

7.Buses: data bus; address bus; control bus	R1, R9	B4, B9
8.Kinds of buses(MCA,PCI,USB,IEEE1394)	R1, R9	B4, B9
9.Sequential and parallel data transmission	R1, R9	B4, B5, B9
IV. PC SOFTWARE AND HARDWARE (58 hour)		
PC hardware Video subsystem Peripheral devices System unit	R1, R9	B4, B5, B9, B10
2. PC operational systems OS MS DOS OS MS Windows, multitasking, file systems Software installation	R1, R9	B4, B5, B9, B10
3. System software Disk diagnostic & maintenance tools File compressing Antivirus software	R1, R9	B4, B5, B9, B10
4. Local and Computing networks Local network conception Network software Worldwide network Internet	R1, R9	B8, B9, B10, B11
5. PC maintenance Error diagnostics Installation, replacement and connection of modules.	R1, R9	B8, B9, B10, B11
V. ELECTRONIC NAVIGATIONAL AIDS (39 hour)		
1. Basic concept of navigation Basic points, lines and planes used for position fixing at sea Coordinate system (frame) Units of distance and speed in navigation	R1, R2, R9	B14, B15
2. Magnetic compasses Magnetic compasses with magnetized needle sensor Magnetic flux-gate compasses (induction compasses) Digital magnetic compasses Classification of the magnetic compasses Magnetic compass maintenance	R1, R2, R9	B14, B15
3. Gyrocompasses and gyrocompass and attitude reference system Basic properties with of gyroes with 2 and 3 degrees freedom Gyrocompasses Gyrocompass and attitude reference systems Gyrocompass maintenance and repair	R1, R2, R9	B14, B15
4. Rate of turn indicators Theory of rate of turn indicator Functional configuration of the rate gyro	R1, R2, R9	B14, B15

General information about rate gyro maintenance		
5. Auto pilots. Conventional autopilots The selection of optimum parameter value of conventional autopilot Adaptive autopilots	R1, R2, R9	B14, B15
6. Logs Electromagnetic logs Sonar logs Radio Doppler logs Sonar correlation logs General information about log maintenance	R1, R2, R9	B14, B15
7. Depth measuring systems (navigational echo-sounders) Echo-sounder operation principles Echo-sounder main parameters Echo-sounder main errors General information about echo-sounder maintenance	R1, R2, R9	B14, B15
VI. SHIPBORNE RADAR. ARPA. (90 hour)		
1. Shipborne radar: Navigational radar functions Radio location pulse principle General radar structure scheme Range and direction measurement principle in navigational radar Radar picture formation on radar display Main operational characteristics of shipboard radar Main technical characteristics of shipborne radar: Radar transmitter technical characteristics Radar receiver technical characteristics Antenna technical characteristics Interfering factors Shipborne radar construction Antenna and wave-guide track Transmitter Receiver Indicator	R1, R2, R9	B1
2. Automatic radar plotting aid, auto tracking aid and electronic plotting aids: ARPA, ATA and EPA functions Operation and data information principles Manoeuvre planning and play principle Main operation and technical characteristics Information processing and presentation	R1, R2, R9	B1
3. Automatic Identification Systems (AIS) AIS function, operation principles Transmitted data, modes, provided data	R1, R2, R9	B1
4. Voyage Data Recorder (VDRs), Information system function, operation principle	R1, R2, R9	
5. Electronic chart navigation information systems	R1, R2,	

(ECDIS): ECDIS operation principles: Provided information, tasks, information correction, coupling with information sensors, operation tests	R9	
6. Navigational complexes Operation principle, complement and joint information processing, operation tests	R1, R2, R9	B1
7. Technical operation of shipborne radars, ATA, EPA, ARPA, ECDIS, AIS, navigational complexes Main stages of operation Main features of operation	R1, R2, R9	B1
VII. RADIONAVIGATION SYSTEMS. (58 hour)		
1. Radionavigation systems (RNS): Classification, structure and purpose Prospects of use	R1, R2, R9	B1
2. Pulse, phase and combined radionavigation systems: Structure and purpose of RNS; Principle of position-fixing; General configurations of receivers	R1, R2, R9	B1
3. Satellite RNS: Satellite COSPAS SARSAT system: Structure and purpose of systems segments, principle of position-fixing, radio-beacons GPS, GLONASS and GPS-based systems GPS: Principle of position-fixing, system structure, information transmitted. Receivers: Classification, accuracy; GLONASS: Structure of the system, receivers, accuracy of position-fixing; Combined use of the system	R1, R2, R9	B1
4. Differential sub systems: Principle of differential method, control segment, information transmitted, receivers	R1, R2, R9	B1
5. Wide Area Differential systems Structure, information transmitted, accuracy of position-fixing	R1, R2, R9	B1
6. Maintenance and repairs of shipborne radionavigation systems receivers	R1, R2, R9	B1

VIII. REGULATIONS AND COMMUNICATION PROCEDURES (134 hour)		
1. Principles and basic features of maritime mobile service. Principles and basic features of maritime mobile – satellite service. GMDSS	R1- R9	A1 – A7
3. GMDSS Communication Systems. Purpose and use of Digital Selective Calling. General principles of Narrow Band Direct Printing (NBDP). INMARSAT System. Shipborne radio equipment Radiotelephony	R1- R9	A1 –A7
4. GMDSS Alerting Systems Emergency Position-Indicating Radio Beacons (EPIRB) Search and Rescue Radar Transponders (SART) Maritime Safety Information Service	R1- R9	A1 –A7
5. GMDSS Distress and Safety Communication Procedures SAR Operations Organization Distress and Safety procedures Distress Frequencies protection	R1- R9	A1 –A7
6. Miscellaneous skills Spoken and written English Language for emergency communication. Compulsory documents and publications of ship station Public correspondence procedures	R1- R9	A1 –A7
7. Assessment and discussion		
IX. TECHNICAL MAINTENANCE OF SHIPBORNE GMDSS EQUIPMENT (40 hour)		
1. Maintenance Occupational safety for ship GMDSS equipment operation. Maintenance of reserve power supply sources. Maintenance of antenna systems. Maintenance of EPIRBs. Software servicing. Maintenance of Matrix printers.	R1, R9	T1 –T6, B3, B7, A8
2. Localizing failures. General principles of localization of failures in ship radiocommunication equipment. Localization of failures in ship radiostations without built-in diagnostic systems. Localization of failures in ship radiostations with built-in diagnostic systems. Localization of failures in ship satellite	R1, R9	T1 –T3, B3, B7, A8

communication radiostations.		
3. Repairs Replacement of electronic schemes components. Replacement of blocks and modules. Elimination of failures connected with software. Assembling cables in high-frequency joints.	R1, R9	T1 –T3, B3, B7, A8
4. Record-keeping.	R1, R9	T1 –T3, B3, B7
X. THE ENGLISH LANGUAGE (optional)		

Part D

Evaluation

Introduction

The effectiveness of any evaluation depends on the accuracy of the description of what is to be measured.

The learning objectives that are used in the detailed teaching syllabus will provide a sound base for the construction of suitable tests for evaluating trainee progress.

Method of evaluation

The methods chosen to carry out an evaluation will depend upon what the trainee is expected to achieve in terms of knowing, comprehending and applying the course content.

The methods used can range from a simple question-and-answer discussion with the trainees (either individually or as a group) to prepared tests requiring the selection of correct or best responses from given alternatives, the correct matching of given items, the supply of short answers or the supply of more extensive written responses to prepared questions.

Where the course content is aimed at the acquisition of practical skills, the test would involve a practical demonstration by the trainee making use of appropriate equipment, tools, etc. in accordance with the Performance requirements.

The responses demanded may therefore consist of:

- the recall of facts or information, by viva-voce or objective tests
- the practical demonstration of an attained skill
- the oral or written description of procedures or activities
- the identification and use of data from sketches, drawings, maps, charts, etc.
- carrying out calculations to solve numerical problems the writing of an essay or report.
- Practical demonstration of trouble shooting and repair to the level of replaceable module (unit)

Validity

The evaluation must be based on clearly defined objectives, and it must truly represent what is to be measured. There must be a reasonable balance between the subject topics involved and also in the testing of trainees' KNOWLEDGE, COMPREHENSION and APPLICATION of concepts.

The time allocated for the trainee to provide a response is very important. Each question or task must be properly tested and validated before it is used to ensure that the test will provide a fair and valid evaluation.

Reliability

To be reliable, an evaluation procedure should produce reasonably consistent results no matter which set of papers or version of the test is used.

Subjective testing

Traditional methods of evaluation require the trainee to demonstrate what has been learned by stating or writing formal answers to questions.

Such evaluation is subjective in that it invariably depends upon the judgement of the evaluator. Different evaluators can produce quite different scores when marking the same paper or evaluating oral answers.

Objective testing

A variety of objective tests have been developed over the years. Their common feature is that the evaluation does not require a judgement by the evaluator. The response is either right or wrong.

One type of objective test involves supplying an answer, generally a single word, to complete the missing portion of a sentence. Another involves supplying a short answer of two or three words to a question. Such tests are known as 'completion tests' and 'short answer tests'

Another form of objective testing consists of selective response test in which the correct, or best, response must be selected from given alternatives. Such tests may consist of 'matching tests', in which contained in two separate lists must be matched, or they may be the true/false type or of the multiple-choice type.

The most flexible form of objective test is the multiple-choice test in which presents the trainee with a problem and a list of alternative solutions, from which he must select the most appropriate.

Distracters

The incorrect alternatives in multiple-choice questions are called 'distracters', because their purpose is to distract the uninformed trainee from the correct response.

The options "none of the above" or "all of the above" are used in some tests. These can be helpful, but should be used sparingly.

Distracters should distract the uninformed, but they should not take the form of 'trick' questions that could mislead the knowledgeable trainee (for example, do not insert "not" into a correct response to make it a distracter).

Guess factor

The 'guess factor' with four alternative responses in a multiple-choice test would be 25%. The pass mark chosen for all selective-response questions should take this into account.

Scoring

In simple scoring of objective tests one mark may be allotted to each correct response and zero for a wrong or nil response.

A more sophisticated scoring technique entails awarding one mark for a correct response, zero for a nil response and minus one for an incorrect response. Where a multiple-choice test involves four alternatives, this means that a totally uninformed guess involves a 25% chance of gaining one mark and a 75% chance of losing one mark.

Scores can be weighted to reflect the relative importance of questions, or of sections of an evaluation.

Part E

Compendium

Glossary of terms

AC	Alternating current
ADC	Analog-Digital Converter
AFA	Audio Frequency Amplifier
AFC	Amplitude Frequency characteristics
AGC	Automatic Gain Control, used to vary the radio Receiver to keep the signal at a usable level
AIS	Automatic Identification System
ALU	Arithmetic and Logic Unit
AM	Amplitude Modulation
ARPA	Automatic radar Plotting Aids
ARQ	Automatic request for repeat. The error-correction process used in store-and-forward messaging, by which a receiver checks for errors in received data packets and requests the sending end to re-transmit those packets.
ASCII	American Standard Code for Information Interchange. A standard alphanumeric character set, based on 7-bit codes.
AT	Autotrack
ATA	Autotracking Aid
BCH code	Bose-Chaudhuri-Hocquenghem code
BIOS	Basic Input Output System
CO	Crystal Oscillator

COSPAS-SARSAT	A satellite-based distress beacon locating system
CMOS	Complimentary Metal Oxide Semiconductor
CP	Central Processor
CPA	Closest point of Approach
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DAC	Digital-Analog Converter
DC	Direct Current
DGPS	Differential Global Positioning System based on GPS satellite, with accuracy enhanced by the use of transmission of differential corrections from suitably located shore-based radiobeacons
DMA	Direct Memory Access
DNC	Domain Name System
DRAM	Dinamic Random Access Memory
DSC	Digital Selective Calling
DTE	Data Terminal Equipment
DTG	Dynamically Tuned Gyroscope
ECDIS	Electronic Chart Navigation Information System
ECP	Enhanced Parallel Port
EBL	Electronic Bearing Line
EEPROM	Electrically Erasable Programmable Read-Only Memory
EGNOS	European Geostationary Navigation Overlay System
ELT	Electronic Typewriter

EPA	Electronic Plotting Aid
EPIRB	Emergency Position-Indicating Beacon
EPP	Enhanced Parallel Port
ERT	Electro-Ray Tube
FAT	File Allocation Interface
FM	Frequency Modulation
FEC	Forward Error Correction
FSK	Frequency Shift Keying
FTP	File Transfer Protocol
GARS	Gyrocompass and Attitude Reference System
GDI	Graphic Device Interface
GLONASS	The Global Navigation Satellite System - provide three-dimensional positioning, velocity and time measuring information, available for civilian use and recognized by IMO, using satellite of the Russian federation
GMDSS	The Global Maritime Distress and safety System
GPS	Global Positioning System - provide three-dimensional positioning, velocity and time measuring information, available for civilian use and recognized by IMO, using satellite of the United States
HDD	Hard Disk Drive
HDOP	Horizontal Delution of Precision
HF	High Frequency
HFA	High Frequency Amplifier
HTML	Hyper Text Mackup Locator
HTTP	Hyper Text Transfer Protocol
IC	Integrated Circuit

ISO	International Standard Organization
IHO	The International Hydrographic Organization
IMO	The International Maritime Organization
INMARSAT	The International Mobile Satellite Organization
IRC	Internet Relay Chart
IRQ	Interrupt Request
ISA	Industry Standard Architecture
ITA2	International Telegraph Alphabet 2
ITU	The International Telecommunication Union
LAN	Local Area Network
LCD	Liquid-Crystal Display
LF	Low Frequency
LFA	Low Frequency Amplifier
LPF	Low Pass Filter
LUT	Local User Terminal
MAC	Media Access Control
MCA	MicroCannel Architecture
MCC	Mission Control Center
MDRAM	Multibank DRAM
MF	Medium Frequency
MMSI	Maritime Mobile Service Identity number
MP	Micpoprocessor
MPS	Micporocessor System
MTBF	Mean Time between Failure
MTSAS	Multi Functional Transport Augmentation System

MSK	Minimum Frequency Modulation
MTTR	Mean Time to Repair
NAVTEX	The low-frequency system developed by IMO for the broadcast and automatic reception of MSI by means of direct-printing telegraphy
NBDP	Narrow-Band Direct Printing
OA	Operational Amplifier
OS	Operational System
OSI	Open System Interconnection
PC	Personal Computer
PCI	Peripheral Component Interconnect
PDOP	Position Delution of Precision
PFC	Phase Frequency Characteristic
PM	Phase Modulation
POST	Power On Self-Test
PROM	Programmable Read-Only Memory
PS	Power Supply
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
RAM	Random Access Memory
RAMDAC	RAM Digital-to-Analog Connector
RCC	Rescue Co-ordination Centre
RFA	Radio Frequency Amplifier
RLE	Run Length Encoding
RNS	Radionavigation system
RO	Reference Oscillator

ROM	Read Only Memory
ROT	Rate of Turn
RTCM	Radio Technical Commission for Maritime Service
SA	Selective Availability
SART	Search and Rescue Transponder
SES	Ship Earth Station. An Inmarsat terminal carried on board a ship
SPOC	Search and Rescue Point of Contact
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995
TCA	Time of Closest Approach
TCPA	Predicted time to CPA
UART	Universal Asynchron Receiver/Transmitter
UHF	Ultra High Frequency
UPS	Uninterruptible Power Supply
URL	Uniform Resource Locator
USB	Universal Serial Bus
VCO	Voltage Controlled Oscillator
VDOP	Vertical Delution of Precision
VDR	Voyage Data Recorder
VHF	Very High Frequency
VFAT	Virtual FAT
VRAM	Video Random Access Memory
WAAS	Wide Area Augmentation System
WAIS	Wide Area Information Server
WWW	World Wide Web

SECTION 1

FUNDAMENTALS OF RADIO SYSTEMS

The purpose of the module “Fundamentals of radio systems” is to give the trainees the basic knowledge sufficient for acquiring the following modules. The trainees should have clear understanding of the operation principles of radio systems used in Merchant Marine essential for communication and navigational equipment maintenance including troubleshooting at the module exchange level.

The entry standards:

The candidates should have knowledge of:

- basic principles of analog ,analog-discrete and digital circuit theory;
- methods of typical electronic device construction in analog and digital integrated circuits;
- measuring methods and means of electronic device features.

After completion of this course the trainees should have knowledge of:

- basic signal conversion in radio engineering systems;
- principles of coding, basic characteristics of codes used in GMDSS equipment;
- construction and operation principles of various radio communication systems;
- purpose of the typical radio engineering devices;
- time and frequency signal characteristics;
- modulated signal spectrum in different modes of emission;-
- features of radio wave propagation in different bands;
- fundamentals of electromagnetic compatibility;
- radio measurement technique.

Outline

	Learning objective	Hours		
		Total	Theoretical	Practical
1.	Radio engineering systems-definitions, purpose, classification. Basic signal conversion in radio engineering systems. Basic features of communication systems in telephony, telex and data communication.	3	3	-
2.	Terminal equipment-purpose and basic features - information theory elements and coding-Bode code (ITA-2, ASC II code); - terminal basic characteristics-code ,transmission speed, synchronization, transmission method.	4	4	-
3.	Signals in radio engineering systems - signal classification; - signal spectrum; - continuous signal transmission by digital method;	5	5	-
4.	Modulation - purpose, modulation types: amplitude modulation, angle modulation; - binary signal modulation-manipulation;	8	8	-

	- SSB signals; - Emission class characteristics used in Marine Mobile Service; - features of receiving and detecting phase-modulated oscillations by means of frequency modulator and frequency detector.			
5.	Noise stability codes-principles of construction and basic features. Noise stability codes used in GMDSS equipment, check parity codes, weight code 3:4, cyclic codes BCH with error detection and correction, codes in DSC systems, convolutional codes.	4	4	-
6.	Algorithm of improved error protection: Modes ARQ, FEC-col, FEC-sel.	4	4	-
7.	Antennas and radio wave propagation: - antennas: purpose and principles of operation; - radio wave propagation, features of radio wave propagation in various bands.	6	6	-
8.	Electronic compatibility of radio electronic aids.	4	4	-
9.	Measuring methods and means of signal parameters and radio electronic device characteristics	4	4	-
	Total:	42	42	-

Concept

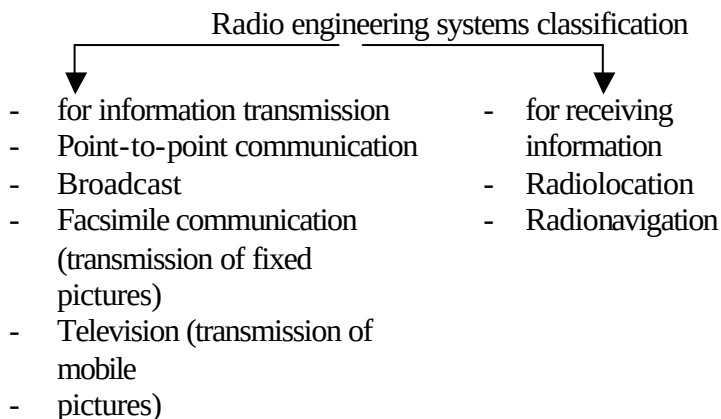
Radio engineering is the sphere of engineering using electromagnetic fields (radio waves) for transmission (radio communication) or obtaining (radiolocation, radio navigation) information. Radio waves propagate in space at the light speed $C=300000\text{km/sec}$. Mathematically, radio waves are described by harmonic oscillations $s(t)=A\cdot\cos(2\pi ft+\varphi)$ where A – amplitude, f – frequency, φ - initial phase. The basic feature of a radio wave is frequency f . The frequency unit is 1Hz-one cycle of oscillation per second. For the measurement of radio frequencies multiple units are used: $1\text{kHz}=1000\text{Hz}$; $1\text{MHz}=1000\text{kHz}$. If you know frequency f , you can estimate a period $T=1/f$. If you know a period T , you can estimate wavelength: $\lambda=c\cdot T$. The wavelength is measured in meters or in multiple/partial units-kilometers, decimeters, etc.

Information is the knowledge of the world surrounding us. Material carrier of the information is communication (speech, text, image). For message transmission signals-processes are used propagating in space and time (light, electrical signals). For forming and receiving signals special technical aids – communication systems are used

Radio engineering systems .Definition, purpose, classification

Electro communication systems are the most useful in which electrical signals (changing current or voltage) are used for information transmission. For communication with mobile objects radio waves – electromagnetic oscillations with

frequencies $3 \cdot 10^3 \dots 3 \cdot 10^{12}$ Hz, capable to propagate in space- are used. Combination of technical aids in which radio waves are used for transmitting and receiving the information is called radio-engineering systems.



Basic signal conversions in radio engineering systems

Let's consider the basic signal conversion in radio engineering systems for information transmission taking radio communication system as an example. Radio communication is information interchange by means of electromagnetic waves. The block diagram of the communication system is shown in figure 1.1. Information source (operator) interacts with the communication system by means of input device (transmitting terminal T_t). The input device converts information (speech, text, image) into electrical signals which spectrum is within low frequencies. Input device depends on the type of the transmitting information: for speech transmission- microphone, for text transmission – transmitting part of telegraph direct printing equipment or personal computer printer, while transmitting images “the picture” is produced as the final number of separate elements of various brightness and color which are converted into sequence of electrical signals by means of special image scanning system. When transmitting fixed images (charts) transmitting facsimile equipment is used, transmitting moving images- transmitting television tubes. For increasing voltage of these signals audio frequency amplifiers are utilized (AFA). The transmission of these signals is accomplished on physical communication lines- connecting wires. The example of these electro communication systems is city telephone network, communication system between separate computer components (processor with a printer and display), between several computers in the same building (on the ship)-local computer network. Information transmission to mobile objects (ships, aircraft) is accomplished by means of electromagnetic waves, propagating in geostationary space. Electromagnetic wave transmission at greater distances is possible only on high frequencies (radio frequencies). These high frequency harmonic oscillations called carriers are generated by special radio frequency oscillator.

When it is necessary that carrier oscillations contained transmitted information low frequency (LF) signals should be superimposed over high frequency (HF) carrier- this process is called modulation and produced by modulator. The modulation concept is to change one of the parameters of carrier oscillations according to the law of control signal. Amplitude, frequency and phase modulation are used

For increasing the range of radio communication systems modulated signals are amplified by radio frequency amplifier (RFA). These units are placed in radio transmitter- device for forming modulated radio signals.

Modulated oscillations from the radio transmitter output are fed to the transmitting antenna in which electrical signals are converted into electromagnetic fields (radio waves). Radio waves propagate in geostationary space.

Medium of radio waves propagation forms communication channel.

For signal reception it is necessary to effect procedures opposite to conversions in radio transmitter- reception of electromagnetic waves and their conversion into radio signals by antennas, amplification of these signals by amplifier, separation of LF signal by demodulator (detector), LF amplification by audio frequency amplifier. For prevention the presence of signals from other stations at the receiver input there is selective device at its input performing frequency signal assignment on the selected carrier. These conversions are accomplished in a radio receiver. (The shown block diagram is direct amplification receiver that is not used in GMDSS equipment due to unsatisfactory features. In GMDSS superheterodyne radio receiving devices are used – detailed information will be given in module 2). For the information susceptibility by the information receiver (operator) an output device is used (receiving terminal) that converts electrical signal into information apprehended by the operator (sound, printed signals).The output device depends on the type of information. For speech reception a loudspeaker is used, for text reception- telegraph directing equipment, printer or display of personal computer, for image reception- receiving telegraph apparatus (fixed images) or receiving television tube (moving images). For functioning these devices are connected to the source of electrical energy – power supply (PS).

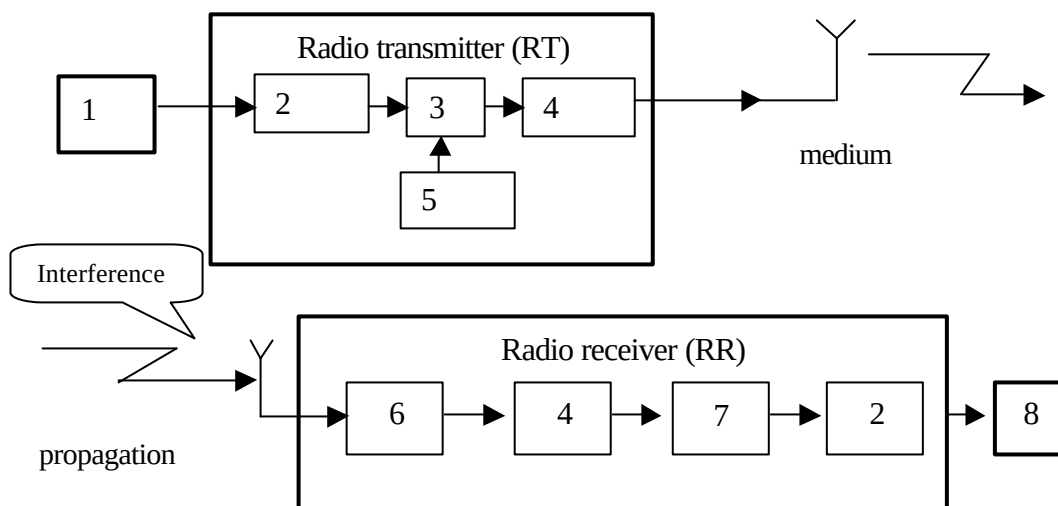


Fig 1.1. The block diagram of the radio communication system

Symbols:

1. transmission terminals
2. audio frequency amplifier
3. modulator
4. radio frequency amplifier
5. radio frequency oscillator
6. selective device
7. demodulator
8. receiving terminal

This radio communication system allows to transmit information in one direction – from a transmitter to a receiver. For information interchange in both directions it is necessary to add the second equipment kit to the system. In this case a radio transmitter and radio receiver are designed in a single combined installation that is able to work in transmission and reception modes. This installation is called a radio station (radio installation). In the radio station modulator and demodulator are designed as a single unit that is called modem. Similarly, T_x and T_{rx} are designed as a single unit that is called Data Terminal Equipment (DTE) or terminal. Thus, it is possible to change the direction of information transmission alternatively and accomplish the transmission and reception on a single carrier (single channel) in turns. This mode is called simplex communication. When there is a communication line with two channels it is possible to transmit information simultaneously in both directions (if the terminal equipment is able to accomplish two-way information interchange. These two-way transmitting systems are called duplex.

Features of communication systems in telephone, telegraph and data communication modes.

The basic feature of the information transmitting system is communication quality that is defined by the correspondence of the received message to the transmitted one.

The communication quality depends on the type of information. When transmitting continuous signal (telephony) communication quality is characterized by signal-to-noise ratio ensuring speech readability. When transmitting discrete information (telegraphy and data communication) the quality is evaluated by the error factor k_0 – ratio of the mutilated character number to the total number of the transmitted characters. The existing direct printing systems (telegraphy) in HF- range ensure the character transmission with the average value $k_0 = 0.05$. To improve the accuracy of the transmitting information in modern communication systems various error-correction devices are used. For example, when using the error – correction direct printing equipment (modes ARQ, FEC) on decametric channels error factor is reduced up to 0.001...0.0001.

Data Terminal Equipment

In a radio station input-output devices are combined in a single unit that is called DTE or terminal, e.g. keyboard-printing device.

Elements of information theory and coding

In terminals information symbols are converted into electrical signals receiving at a given period of time one of several permitted values. For example, for transmission

of Russian alphabet characters it is necessary to have 33 different signals, for transmission of English text-26, for figure transmission – 10 signals. For simplicity of realization and compatibility of information transmitting systems capable to transmit various messages the number of permitted signal values is equal to 2 and they are marked by symbols 1 and 0. Symbol 1 corresponds to high level of voltage with the length t_0 , symbol 0 – low level of voltage with the same length. These signals are called binary. To indicate the alphabet characters by combination 1 and 0 special signals are used by means of which every alphabet character is indicated by the binary number or code. Coding and decoding are performed in a terminal.

A code is called a table in which each alphabet character is given the combination of binary elements- code combinations. There are homogeneous and non-homogeneous codes. The example of non-homogeneous code is Morse code – alphabet characters have different length and the often-used characters have short code combinations – dots that are seldom used – longer combinations –dashes. This code structure saves time during the transmission and has musical color that facilitates oral information reception, but is not convenient during reception. In the existing automatic receiving and recording devices of discrete information (direct printing equipment, PC printers) homogeneous codes are used in which every code combination contains the same number of elements. This number of elements n is called the length of combination. The minimum length of code combination $k_{\min}$ is calculated if

$$k_{\min} = \log_2 N, \text{ where } N - \text{the number of characters transmitted by the code.}$$

The feature of the terminal speed of response is the technical velocity V that is measured by a signal number transmitted per second and measured by Bauds:

$$V = 1/t_0, \text{ Baud}$$

Every element of the code combination (1 or 0) contains particular number of information equal to 1bit, the speed of data transmission is measured in bit/sec. During technical realization of discrete (digital) information transmission two different signals correspond to code elements 1 and 0, e.g. voltage pulse with the length of t_0 seconds and pause with the same length. For example, when $t_0 = 20$ msec $B = 50$ bit/sec. It is obvious, that during the information transmission B is equal to V .

Code Bode (ITA-2)

At present International Telegraph Network has been put into operation for transmitting alphanumeric messages (telex). Narrow Band Direct Printing Telegraph Equipment (NBDP) is used as terminal devices of the information input-output in telegraph networks. In Direct Printing Telegraph Equipment code Bode is used that is called International telegraph code N 2 (ITA). Code Bode is a 5 –element code, i.e. can present 32 characters. For enhancing code capability special combinations are used that are termed alphabetical registers (Latin and Russian letters - in telegraph terminal (TT) adjusted for messages in Russian) and a numeric register. As a result, the same code combination is used for forming the characters of Russian and Latin alphabets or figures depending on the selected register. When transmitting information by means of TT it is necessary to select the appropriate register.

Code ASC II

American Standard Code for information Interchange (ASC II) is used in modern personal computers (PC). It consists of 7 information elements. As information interchange in PC is performed by byte (1 byte= 8 bits), the remaining bit can be

used for various service purpose – or error detection in the received byte by checking if it is even and for increasing the number of characters. 7 information elements (bit) present 128 combinations that allow to code small and capital alpha-numeric characters, as well as some additional graphic and control symbols. Within the code there can be national variants, thus special symbols can be selected that are used in this or that region.

Basic features of the terminals

- Code (ITA-2) –in Direct Printing Telegraph Equipment, ASC II - in PC (in shipboard equipment PC is used as a terminal that works in telex and data communication modes).
- Transmission speed is measured in Bauds or bit/sec. Speed 50 or 100 Bauds is used for direct printing on HF radio channels. In VHF range or on satellite channels higher speed of 1200 Bauds or more is used.
- Transmission type. Data communication can be carried out either in parallel (from keyboard in PC microprocessor through the special interface - Centronics) or in series (from PC to radio link through interface RS232-422).

The specific feature of the parallel input- output equipment is one or several registers termed data ports. Detailed information is given in module 4.

Signals in radio engineering systems

Depending on the type of the transmitted information electrical signals are described either by continuous time functions (telephony- analog signals) or discrete functions (telegraphy and data communication-digital signals). Analog signals in time domain are characterized by a dynamic range-value domain within which a signal is changed. Digital signals are characterized by levels corresponding to 1 or 0 or the length, i.e. transmission speed. (see unit 2).

Signal spectrums

- For the signal transmission by means of harmonic electromagnetic waves it is convenient to analyze signals in frequency domain. The connection between presentation of signals in time and frequency domains is estimated by Fourier transformation.

$$X(2\pi f=w) = \int_{-\infty}^{\infty} S(t) \cdot e^{j2\pi ft} dt, S(t) = [1/(2\pi)] \cdot \int_{-\infty}^{\infty} X(w) \cdot e^{j\omega t} dw$$

- The function $X(f)$ is called a signal spectrum $S(t)$. The physical meaning of spectrum is to define the total combination of harmonic components (with the given amplitudes and frequencies) forming the given signal shape in time domain. In general, signal spectrum is infinite, i.e. for obtaining the given signal shape it is necessary to have a great number of harmonics, however harmonic amplitudes drop with the frequency increase. This permits to limit the real spectrum by some frequency band sufficient to ensure signal reproduction with the frequency accuracy. The given power level outside this band is usually taken as selection criteria of the occupied frequency band (e.g. 1% from the total signal power).

Fig. 1.2. shows rectangular signal characteristics in time and frequency domain. It is evident that for rather accurate reproduction of the pulse shape three harmonic components of the basic frequency $1/t_0$ are enough. The real frequency band of the rectangular pulse with the length t_0 is defined by the ratio. For example, in the frequency band $(0 \dots 1/t_0)$ there is 90% of the signal energy and in the band $(0 \dots 2/t_0)$ – 95%. The frequency band occupied by the signal depends on its length – with the reduction of the length, i.e. increase of the transmission speed, frequency band increases. In the decametric marine radiocommunication the frequency band assigned to direct printing communication is 300Hz that corresponds to transmission speeds 50 or 100 Bauds.

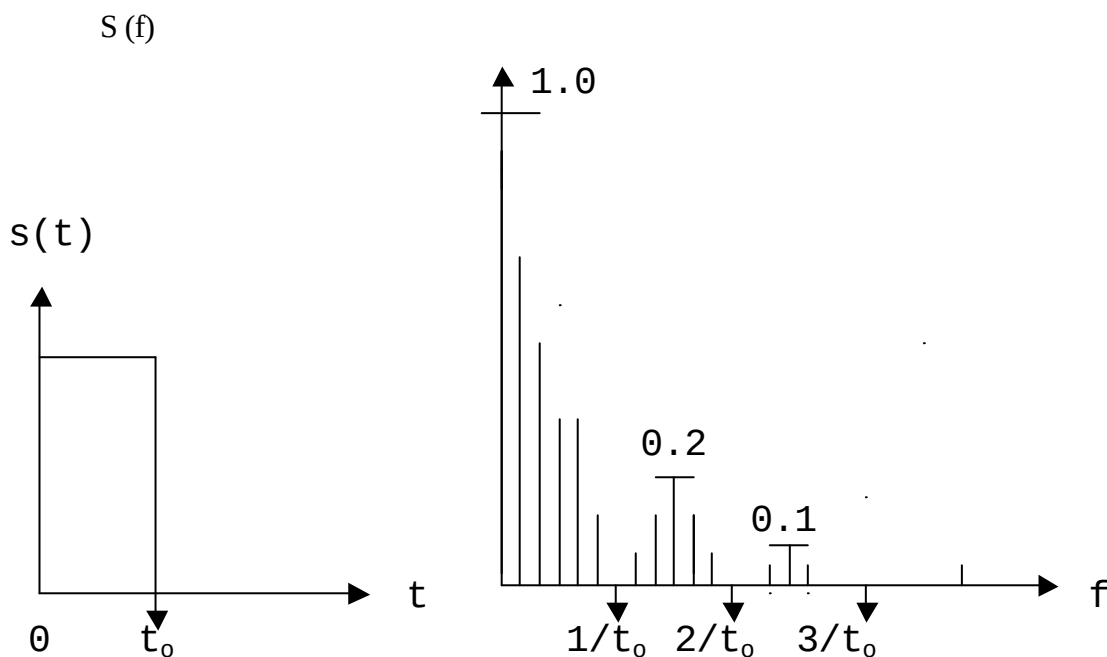


Fig. 1.2. Time and frequency presentation of a rectangular pulse.

- The audible signal spectrum received by a man contains harmonic components from 16 Hz to 20000Hz, however, frequency component level at the lower and upper parts of frequency domain is extremely small compared to the frequency amplitudes in the middle of the frequency range. So, without the influence to the speech readability the frequency range of the speech signals in the telephone network is limited by band 300-3400Hz (in the USA –300-3300Hz).
- In marine radio communication according to Radio Regulations requirements the upper frequency of the telephone signal does not to exceed 3000Hz in HF range.

Transmission of the continuous signals by the digital method- digital telephony

For the transmission of a continuous signal $s(t)$ by the digital method it is necessary to carry out two operations: discretization of the continuous signal by time and quantization by level. The purpose of the first operation is to replace continuous signal by the transmission of the signal value at the equal time periods $t_i, t_{i+1} \dots$ with the interval $T=1/(2F_{\max})$ where $F_{\max}$ – the maximum frequency of the signal spectrum $s(t)$. The level quantization is to divide the range of the signal change (from $A_{\max}$ to 0) into N levels with quantization step $A_{\max}/(N+1)$. The true signal values at the counting moment are replaced by the nearest permitted signal level and for the

regeneration of signal values at the receiving site it is enough to transmit the level number. For transmitting any of N signal levels by the binary homogeneous code the length of the code combination is $n = \log_2 N$. The length of the binary signal transmission t_0 is defined by the ratio $t_0 = 1/(2F_{\max}n)$. For example, for digital transmission of telephone signal $F_{\max} = 4000\text{Hz}$ and $N = 256$ ($n=8$) that corresponds to the transmission speed 64 kbit/sec.

Modulation

Purpose of modulation

Signal spectrums generated by the terminals (microphones, direct printing telegraph equipment, computers) are on low frequencies. The main energy of digital signals appears on “zero” frequency, i.e. constant signal component, so these signals are often termed direct current signals. The low frequency current freely propagates in the conductors (physical wires), but the radiation and reception of the electromagnetic waves on these frequencies are impossible. For the signal transmission at greater distances by means of electromagnetic waves it is necessary to transfer the spectrum of LF signals to the high frequency domain (radio frequency). The spectrum transfer is called modulation that is carried out by a modulator.

Types of modulation

The aim of modulation is that one of the HF harmonic parameters (it is called carrier oscillation and frequency- carrier frequency) is changed according to the law of LF (control) signal containing transmitting information. In accordance with the harmonic oscillation parameters there are amplitude, frequency and phase modulations.

Amplitude modulation

During the amplitude modulation (AM) the amplitude of HF carrier oscillation is changed according to the law of a control signal. Let us consider the simplest case of AM when the control signal is also a harmonic oscillation ($S_0 \cdot \cos 2\pi F_0 t$ – one tone modulation)

AM oscillation is presented as:

$$U_{AM} = (A_0 + S_0 \cdot \cos 2\pi F_0 t) \cdot \cos 2\pi f_0 t =$$

$$A_0 \cdot [\cos 2\pi f_0 t + 0.5M \cdot \cos 2\pi(f_0 + F_0)t + 0.5M \cdot \cos 2\pi(f_0 - F_0)t]$$

Fig. 1.3. shows the control signal spectrums – harmonic signal with the frequency F_0 and amplitude S (fig. A), carrier oscillation – harmonic signal with the frequency f_0 and amplitude A_0 (fig. b) and modulated oscillation (fig. c). It is seen from the figures that the base LF signal (with the frequency F_0) as a result of modulation is transferred to the radio frequency domain (f_0). Modulated oscillation spectrum contains the carrier (f_0) and two sideband frequencies – upper with $(f_0 + F_0)$ and lower with the frequency $(f_0 - F_0)$. The ratio $M = S_0 / A_0$ is termed AM factor, $0 \leq M \leq 1$.

Signal spectrum at voice –frequency AM

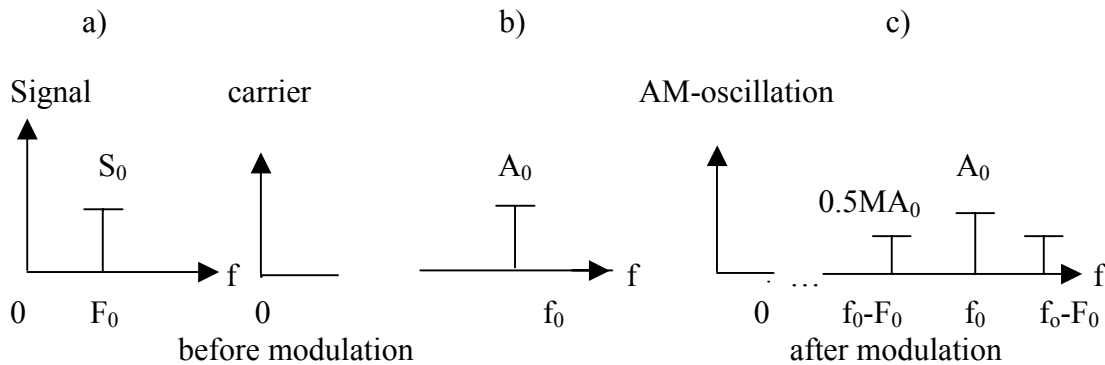


Fig. 1.3. Signal spectrums during one tone AM

In general, when the control signal spectrum occupies frequency band from 1 - $F_{\min}$ up to 2 - $F_{\max}$ (fig. 1.4, a), sidebands appear in the AM signal spectrum – the lower one with band from 3 - $(f_0 - F_{\max})$ to 4 - $(f_0 - F_{\min})$ and the upper with the band from 6 - $(f_0 + F_{\min})$ to 7 - $(f_0 + F_{\max})$, 5 - f_0 (fig.1.4,b).

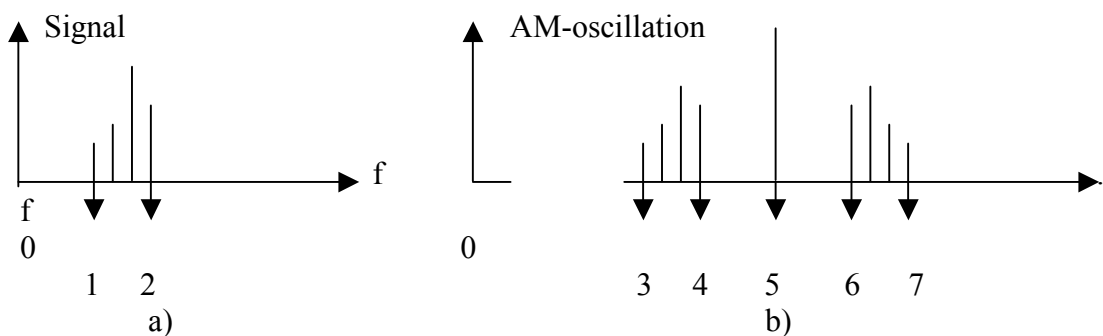


Fig. 1.4. AM signal spectrum in the general case.

The frequency spectrum occupied by the modulated signal is near the carrier frequency f_0 and occupies the band $2 F_{\max}$. Every sideband contains information about the control signal.

Angle modulation

During frequency modulation (FM) according to the law of the control signal carrier oscillation frequency is changed at about the average value f_0 . Frequency-modulated oscillation during one tone modulation is presented as:

- $U_{fm} = A_0 \cos(2\pi f_0 t + k \cdot S \cdot \cos 2\pi F_0 t)$. Maximum frequency deviation $f_d = k \cdot S$ from f_0 is termed frequency deviation. The value $M_f = f_d / F_0$ is termed FM index. Value M is usually selected more than 1.
- During phase modulation (PM) according to the law of the control signal the carrier oscillation phase is similarly changed. As the phase and frequency are interconnected (frequency is derived from the phase and the phase is an integral from the frequency), these types of modulation have the common meaning –

angle modulation. Signal spectrums during FM and PM have more complicated composition than during AM, however, the main spectrum phenomena- carrier frequency and sidebands-remain.

The spectrum width of FM oscillation is $F_{fm} = 2M_f * \Delta F_{max}$, where ΔF_{max} is a frequency band occupied by the control signal.

Thus, FM oscillation spectrum is wider than AM oscillation spectrum. Frequency modulation is used in ultra high frequency (UHF) range, so that the relative spectrum width was not extremely large.

Frequency modulation has the high frequency stability compared to AM. The reason of this is that noise at the input of the receiving device causes random amplitude change, i.e. distorts information parameter. During FM the noise influence on the signal amplitude can be eliminated putting it through the amplitude filter – amplitude limiter that does not cause the distortion of the information parameter- frequency.

For the low frequency regeneration at the receiving device reverse conversion – demodulation (detection) is carried out by amplitude, frequency or phase detectors.

Binary signal modulation – manipulation

- While transmitting the coded information control signals are presented as the sequence of rectangular pulses and pauses (or opposite polarity pulses). In this case the modulated parameter of the carrier oscillation takes one of two fixed values; this type of modulation is termed manipulation. Similarly to modulation there are amplitude, frequency or phase manipulations. In AM systems harmonic carrier amplitude varies depending on 0 or 1 at the modulator input. For example, binary 1 can correspond to the assigned carrier amplitude, binary 0 corresponds to zero amplitude – the absence of the amplitude, i.e. pause. These signals are called signals with the passive pause. While receiving a signal with a passive pause there is a problem to distinguish oscillation amplitudes on receipt, as during propagation signals reduce and their level can be equal to the noise level. Amplitude modulation is said to have the low noise stability, i.e. high probability of the erroneous registration of binary signals.

In frequency manipulation systems there is carrier change according to the incoming digital signal. For example, the lower frequency corresponds to binary 1 in comparison with the carrier frequency, the higher carrier frequency corresponds to binary 0.

- Frequency forming is carried out by the carrier frequency shift “up” and “down” for some value. These signals are called orthogonal in mathematics. Frequency manipulation has higher noise stability compared to the amplitude, as during frequency manipulation the signal amplitude is not essential for the receiver.

In phase manipulation systems the phase shift of the harmonic oscillations is changed depending on the incoming binary signal. For the better distinction of phase-manipulated signals the phase shift between signals s_1 and s_0 is selected to be the highest, i.e. equal to π . In these case $s_1 = -s_0$. These signals are called opposite.

Manipulated signal spectrums according to their structure do not differ from modulated oscillation spectrums – they contain the carrier frequency and two sidebands. For information interchange between personal computers by means of telephone networks modems are used, though in telephone networks VHF signals are transmitted. As it has been mentioned above, the main signal energy appears at “zero” frequency at the computer output, i.e. constant component, and the telephone

network selects signals starting from frequency 300Hz. Modulators are used for the transfer of the direct current signal energy to the voice frequency domain 300...3400Hz. For example, in the frequency modulation mode the modem modulator in the transmission mode converts signals corresponding to 1 and 0 into harmonic oscillations with frequency 1270 Hz and 1070Hz respectively with the same length. For simultaneous signal reception frequencies 2225Hz and 2025 Hz are used. The direct current signals come to the computer outputs and are formed in modem demodulators.

Single- sideband signals

Analysis of AM signal spectrum shows (fig. 1.3.) that the information of the transmitted signal is in every sideband. Carrier with the frequency f is known at the transmitting site (transmitter frequency tuning) and carries no information about the transmitted signal. Calculations show that even at the maximum value of the modulation factor $M=1$, the power of the AM signal sideband component does not exceed 25% from the carrier power. For improving energy characteristics the carrier frequency voltage is suppressed or eliminated. These SSB signals are called signals with single-sideband (SSB). The calculations show that the use of SSB signals gives power effect 4...8 times greater.

It is necessary to note that transmitters and receivers of SSB signals have a more complicated structure. To simplify the transmitter circuits SSB signals with the partially suppressed carrier are used.

For emission modes see IMO Model Course 1.25

Features of obtaining and detecting PM oscillations by means of the frequency modulator and frequency detector.

In modern communication systems phase modulation possessing the greatest noise stability is used, e.g. in GMDSS VHF equipment). PH oscillations are obtained by the frequency modulator. For these purpose before modulation the signal is differentiated and then fed to the frequency modulator, as a result there are PM signals. Differentiation is called pre-correction and is realized by means of high-pass filter or derivation circuits. In speech spectrum the level of a HF component (2000-3000Hz) is lower than the level of a MF component. Thus, the signal-to-noise ratio at the receiver output is reduced on the upper frequencies. By means of HF filter for increasing the noise stability the level of the upper frequencies is artificially raised. For the unification of the correction circuit characteristics AF characteristic of the HF filter must have the speed of increase 6dB per octave (the octave – frequency change twice) in FM band. At the receiving site the feedback correction circuit is connected after the frequency detector – integrated circuits (low frequency filters) possessing the amplitude-frequency characteristic symmetric to feature of high-pass filter in a transmitter.

Noise stability codes – principles of construction and basic features

- Codes for discrete information transmission (ASCII) are not able to detect automatically errors due to the noise.

- To eliminate the errors in modern communication systems noise stability codes are used capable to detect and correct errors. For the error correction redundancy is added to the code to increase the length of the code combination; testing codes are added to the information elements that are formed according to the definite rules.

At the receiving site the received code combination is processed to check the selected rule. The violation of the code forming rule informs of the error in the code combination.

Noise stability codes used in GMDSS

In GMDSS equipment various noise stability codes are used that differ by the complex structure and the number of the detected / corrected errors.

Check parity codes

If we add one testing element to the basic combination of ASCII code so that the number of “units” in the code combination was even, the obtained code will be able to detect single errors automatically (by means of the analysis of the received code combination). These codes with check parity are used for data interchange between the computers.

Weight code 3:4

In marine radio communication in Telex system redundancy code is used for the error detection containing 7 elements, in every combination there are three 1 or four 0. From 128 combinations 35 have the feature of weight 3:4, 32 combinations are used for transformation of ITA-2 code that is used in DPTE, the remaining 3 combinations are service used for the algorithm realization.

Bose- Chaudhuri- Hocquenghem (BCH) cyclic codes

Cyclic codes are formed by multiplication of the base code combination by some binary number (it is called forming or generating polynomial). As a result the obtained code combination will contain redundant elements the number of which is defined by the forming polynomial. Cyclic codes are written down as (n,k) , where k is the number of the information elements in a code combination, $(n-k)$ – the number of the testing elements. On reception the received combination is divided to the forming polynomial. When dividing with no remainders the received combination is considered to have no errors. If there is a remainder the received code sequence is considered to have an error.

For the error correction in a binary code it is necessary to determine the position of the erroneous element and invert the incorrectly received element. For determining the position of the erroneous element special generating polynomial is selected and the position of the wrongly received element is determined by the remainder type (in a binary system). For example, if the remainder from the division is 0, then there is no error. If the remainder is 11, then there was an error in the third position $((11)_2 = (3)_{10})$.

Error correction code is used in EPIRBs for determining the position of the object in distress.

Noise stability signal coding of DSC in GMDSS equipment

In DSC system for error detection a special redundancy code is used consisting of 10 elements. The first 7 elements are informational forming messages, the last 3 elements are testing. The testing elements are figures in a binary system equal to the number of “zero” in the information part (from 0 to 7).

Convolutional codes

The convolutional code is a result of adding the testing element r after every information element k (fig. 1.5.):

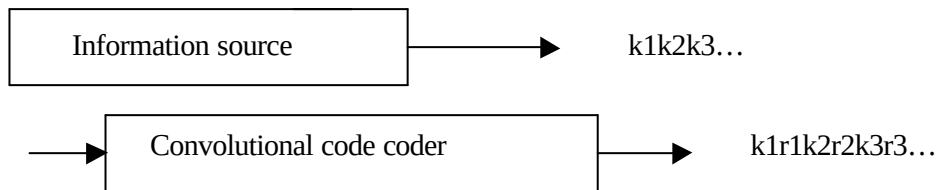


Fig. 1.5. Convolutional code coder

On receipt as a result of information and testing elements analysis a decoder is able to detect error and determine the position of the erroneous element, i.e. to correct error.

In Inmarsat-C equipment the convolutional code is used with the following features:

- ?? modulation speed-1200Bauds;
- ?? data transmission speed- 600bit/sec;
- ?? $k=2:1$, i.e. every information element k has one testing element r .

Error protection algorithm

Error correction codes are able to improve the error protection of the received information by means of the automatic correction of erroneously received code elements. However, technical realization of these systems is rather complicated (e.g. in EPIRBs cyclic code with the forming polynomial of length 21 is used.) Error correction codes are more simple according to the technical realization. They can detect errors in code combinations. For receiving correct information special procedures – algorithms are used. Error protection algorithms used in Marine Mobile Service in the direct printing telegraph mode are described below.

Algorithms with the decision feedback (ARQ)

For error detection the redundancy weight code 3:4 is used. The algorithms concept is to transmit information in packets – for 3 characters. The received code combinations transmitted on the forward channel are checked as to the errors (by means of the redundancy code 3:4). When detecting an error they are eliminated (“erased”) and a request is sent to repeat the transmission. On correct reception the receiving station makes a request to transmit the next data packet. Request signals are transmitted on the backward channel. These systems are termed the systems with the decision feedback; this mode of data transmission is indicated by the abbreviation ARQ (Automatic Repetition Request).

Algorithm of direct printing telegraph information transmission from TT 1 to TT 2 in ARQ mode.

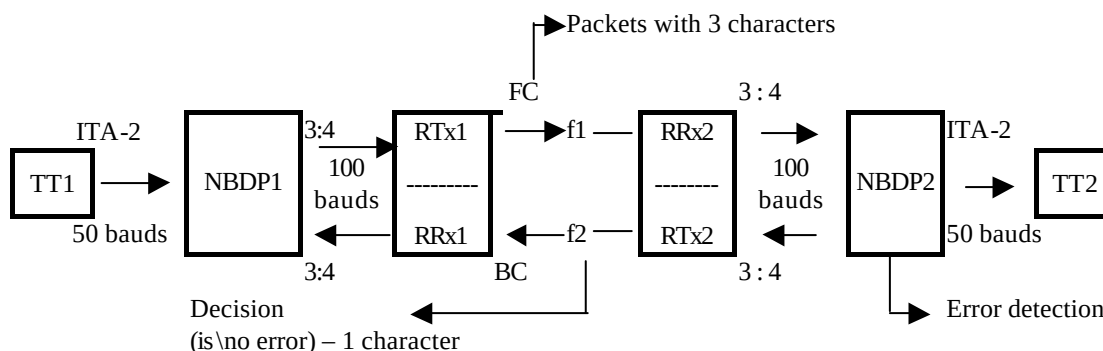


Fig. 1.6. Data transmission algorithm in ARQ mode.

Algorithm without a backward channel- Forward Error Correction (FEC)

ARQ mode provides point-to-point communication. When transmitting information in Broadcast mode the backward channel mode is impossible. While transmitting information in Broadcast mode the mode without a backward channel is used, error protection is provided by duplication – twice repetition of every character. Error detection code 3:4 is also used. On correct reception of one of the copies (or both) the received character is typed, when detecting an error symbol “*” is used in both copies instead of the received character. This mode is called FEC. In this mode data reception by many subscribers is possible.

Algorithm of direct printing telegraph data transmission in FEC mode

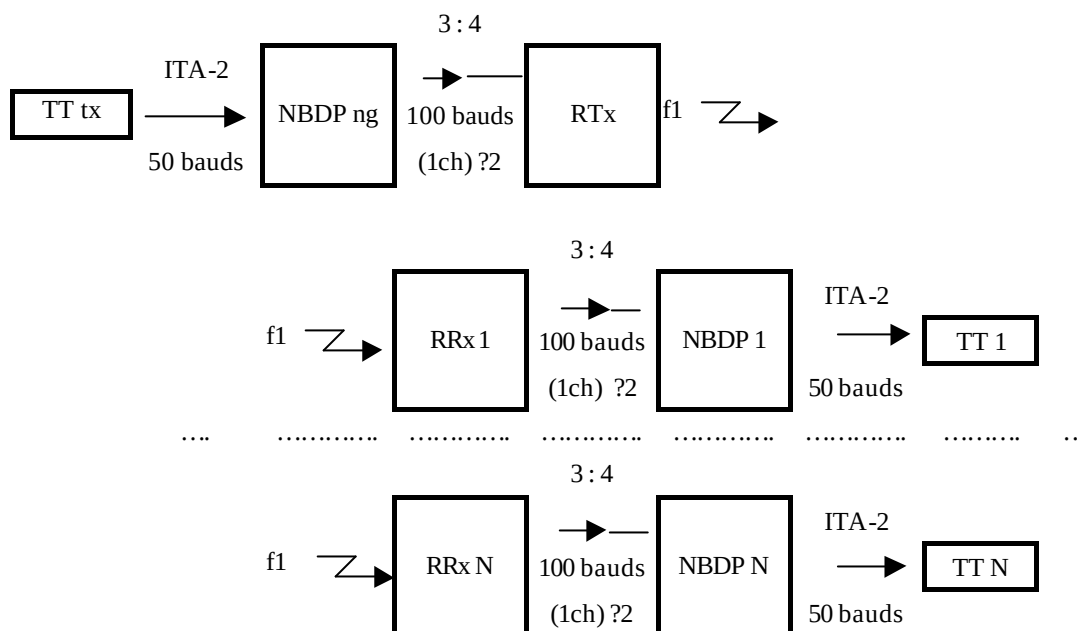


Fig. 1.7. Algorithm of data transmission in FEC mode.

There is FEC-col – broadcast mode (the same mode is used in NAVTEX equipment for navigational and meteo – information) and FEC-sel – data transmission to one

subscriber without a backward channel. In FEC-sel mode the inversion of code elements 3:4 occurs resulting in code 4:3. As in the mode of code 4:3 only two equipment sets are adjusted, communication is established only between two subscribers.

The call of subscribers in the mode of ARQ and FEC-sel is accomplished by means of selective call individual for every subscriber, in FEC-col – broadcast mode – general call to all subscribers.

Antennas. Radio wave propagation

Antennas – purpose, principles of operation

The transmitting antennas are devices for conversion HF currents (voltages) into electromagnetic field, the receiving antennas perform back conversion. Antennas are connected with the receivers and transmitters by means of feeders – lines for transmission radio frequency signal energy from the radio transmitter to the antenna or from the antenna to the radio receiver. Antenna can be regarded as an open tank circuit. In the conventional circuit electrical energy is concentrated between the condenser plates, and the magnetic energy is between the coil windings. To “release” the electrical field it is necessary to move the condenser plates back. To preserve the capacity it is necessary to increase the size of the plates. The outside magnetic field is similarly produced. Within some limits the tank circuit is changed to two wires (leads). Thus, antennas are circuits with distributed parameters in which inductance and capacity are distributed along the conductor, the length of which is compared to the length of electrical signal wave. To produce electromagnetic waves it is necessary to feed the signal to the break between the wires, which are called a vibrator. The vibrator radiates maximum energy in resonance, i.e. when the conductor length is half the wavelength. This antenna is called a half-wave vibrator.

If the vibrator is placed in a variable electromagnetic field, there will be current and voltage oscillations under the field influence, i.e. a vibrator acts as a receiving antenna.

The maximum value of the current amplitude appears when the length of the arriving wave is equal to the double length of a vibrator. The maximum current value appears in the middle of the vibrator, so a feeder (wire) for current transmission to the receiver should be connected to the break in the middle of the vibrator (this vibrator is termed dipole- fig. 1.8.)

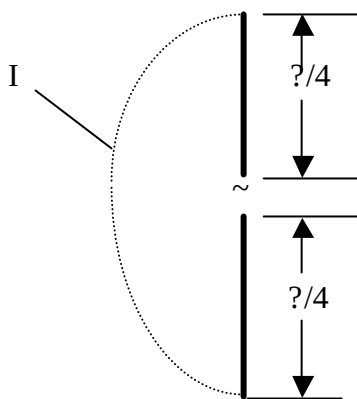


Fig. 1.8. The dipole.

Antennas radiate or receive electromagnetic waves in various directions differently. The feature of the antenna directivity is called the dependence of radiation power on the direction at the same distance from the antenna. The diagram of this dependence is termed the directivity diagram; the numeric value is directivity gain. Fig. 1.9. shows the directivity diagram of a half-wave vibrator for the plane in which it is placed (a), and in the plane perpendicular to its axis (b). In the first case there are two maximums of radiation (reception) in the direction perpendicular to the vibrator axis, in the second case the vibrator radiates steadily in all directions.

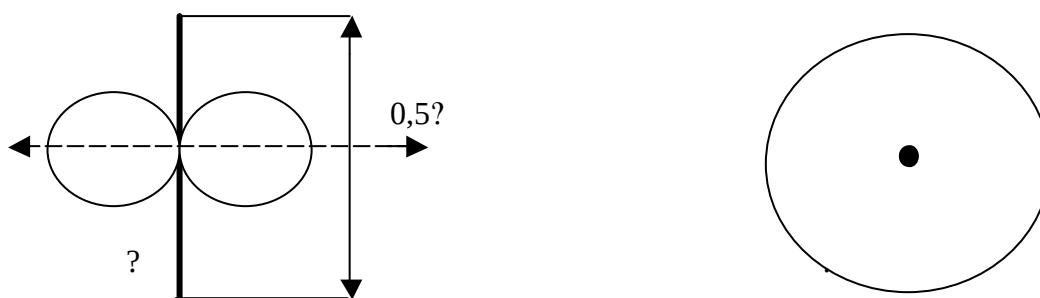


Fig. 1.9. Directivity diagram of a half-wave vibrator.

The dipole directivity diagram shown in the figure is located far from the earth's surface (at the distance greater than the wave length), i.e. in free space. The conductive earth 'surface changes the process in the antenna and its directivity diagram.

The influence of the earth's surface can be taken into consideration by means of antenna mirror image. Let's consider the vertical post of length 1 touching the earth's surface with its one end. the resonance wave length of this asymmetrical dipole is equal to the vibrator length 4 times greater (fig. 1.10.). If the vibrator length is less than a quarter wave length, the part of the horizontal lead is connected to the top end to increase the "electrical "length of the antenna, this produces additional capacity (inverted L – and T-type antennas)

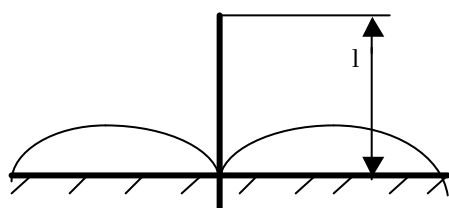


Fig. 1.10. Directivity diagram of the asymmetrical dipole.

While changing the radiation wave length for tuning the antenna in resonance the antenna tuning unit is used – tank circuit with variable parameters. Antenna tuner unit is connected at the output of the radio-transmitting device for power increase transmitted to the antenna. In modern radio transmitters the tuner unit adjustment is performed automatically.

For reducing the dimensions of the antenna loop and magnet antennas are used, which react on the magnetic component of the electromagnetic field. The loop antenna is a flat coil of a rectangular or round shape which windings are wound on a hard frame. The magnetic antenna is a coil with a ferrite core. These antennas are

low-directivity antennas – directivity diagram of loop antennas is the same as the dipole diagram placed along the loop axis, the magnet antenna has a zero diagram along the antenna axis. These antennas are less sensitive than L-type antennas. In VHF range for increasing the distance directional antennas are used. For example, the antenna of “wave channel” type has the directivity diagram as a narrow semi-directional loop. This directivity diagram is achieved by adding a reflector to a dipole (before a vibrator) and directors (up to 8 – before a vibrator) – see fig. 1.11.

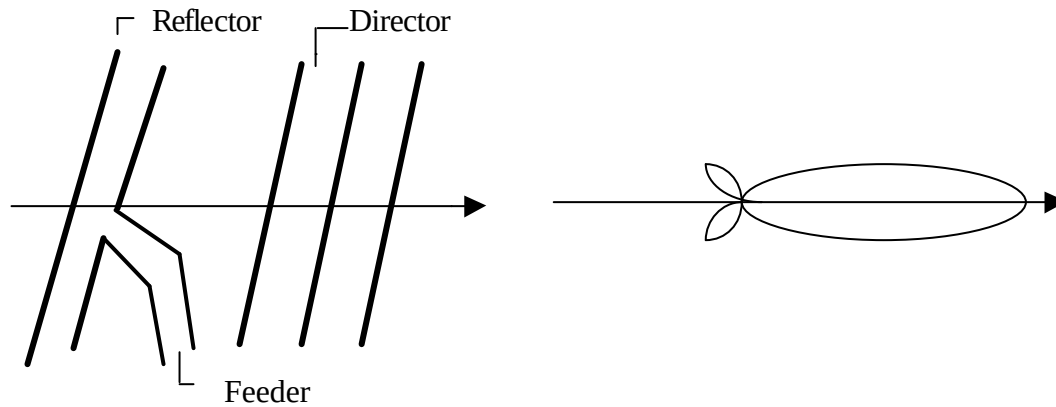


Fig. 1.11. Antenna of “wave channel” type.

In radiolocation (centimeter and millimeter wave band) box horn and slot antennas are used. For the electromagnetic energy transmission special lines – wave guides are used in these bands.

Radio wave propagation

Basic features of radio waves

Radio waves are variable coupled electrical and magnetic fields. The electromagnetic field is described by Maxwell equation who proved the hypothesis that the variable electric field excites a variable magnetic field in the surrounding space and vice versa. The basic features of the electromagnetic field:

- In homogeneous space radio waves propagate straight, the velocity of propagation is 300,000km/sec.
- Wave propagation in the conductive medium (ground, water, ionized gas) is accompanied by the energy absorption
- If the waves from the same source arrive at the receiving point by different ways, integration of these waves –interference occurs.
- While encountering the obstructions the waves are able to go round them – the process is termed diffraction. Diffraction reduces with the wavelength reduction.

In the vicinity of the earth 's surface radio waves do not propagate as in the free space, as the medium (earth's surface – atmosphere) is non-homogeneous.

The upper part of the atmosphere containing free carriers of the electrical charges appearing due to the sun influence is termed the ionosphere.

Ion and electron concentration at different heights is different; there are several layers with the increased ion concentration:

The lower D-layer at the height of 60 ...90km with the concentration up to $10^9/\text{m}^3$. The D-layer is formed in the daytime, at night the D-layer disappears.

The E-layer at the height of 120km with the concentration up to $10^{10}/\text{m}^3$;

The F-layer at the height of 180...400km with the concentration up to $10^{11}/\text{m}^3$.

The charge concentration depends on the season (in summer is more than in winter) and on the time of the day (in the daytime is more than at night). With the increase of the sun activity and space radiation great changes of ionization (ionospheric storms) occur.

During radio wave propagation between the earth's surface and ionosphere there is loss of the energy due to the interconnection of the electromagnetic field with the free charge carriers. Propagation conditions depend on the wavelength (frequency).

During the radio wave propagation it is necessary to analyze the radio waves propagating along the earth's surface (surface or ground) and the radio waves penetrating into the ionosphere and reflecting from it (ionospheric or sky) separately.

The more the losses due to the partial penetration into the ground, the less the wavelength, i.e. the larger the frequency.

The more the losses, the larger the wavelength, i.e. the less the frequency.

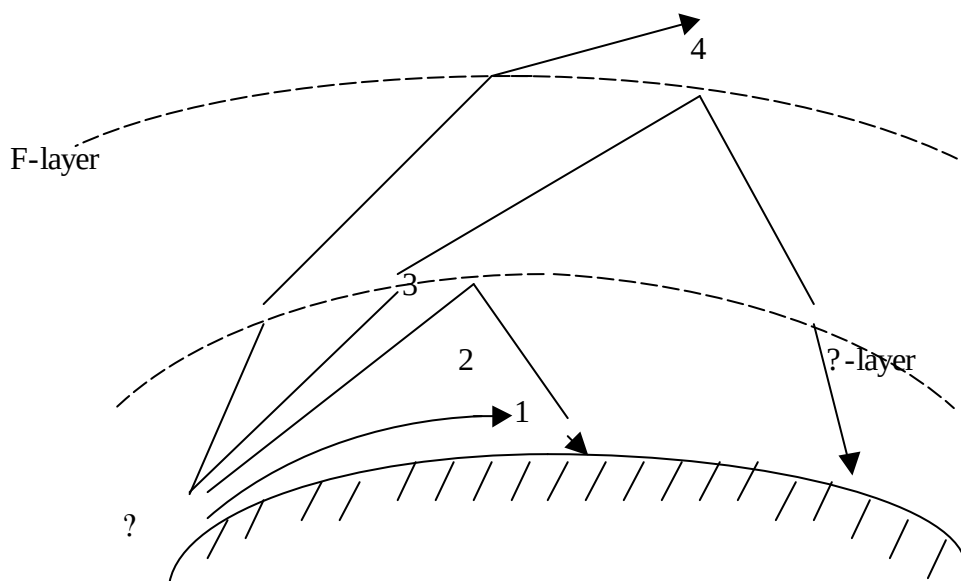
While penetrating into the ionosphere layers the radio waves reflect from them, the possibility of penetration depending on the degree of ionospheric ionization, frequency and wave angle on incidence.

The maximum frequency which can be reflected from the ionospheric layer at the vertical drop to its boundary is termed a critical frequency and defined by $f_{cr} = 9\sqrt{N}$, where N-the concentration of free charges.

Features of radio wave propagation in different ranges

Depending on the propagation conditions radio waves are divided into the ranges:

range		Wavelength	frequency	
Super long waves	(SLW)	>10000m	<30kHz	VLF
Long waves	(LW)	10000...1000m	30...300kHz	LF
Medium waves	(MW)	1000...100m	300...3000kHz	MF
Short waves	(SW)	100...10m	3...30MHz	HF
Ultra short waves	(USW)	<10m	>30MHz	VHF
Metric		10...1m 100...10cm	30...300MHz	
Decimetric		10...1cm	300...3000MHz	
Centimetric		10...1mm	3...30GHz	
Millimetric			30...300GHz	



1- surface beam, 2-sky beam having reflected from the E-layer, 3 – sky wave having reflected from the F-layer, 4 – sky wave with the frequency higher than critical.

Fig. 1.12. Surface and sky waves.

In marine radio communication super long waves are not used.

The long (kilometric) waves propagate between the lower part of the ionosphere and the earth's surface with small losses, they are characterized by the propagation uniformity. The long waves are used for communication with the ships anywhere in the World ocean (at long distances up to 20,000km), however, due to the large dimensions of the antennas and high power of the transmitters they are used for one-way communication "shore-to-ship (timing reference signals, navigational aids).

The medium (hectometric) waves propagate both as a surface beam which is greatly absorbed in the ground, and as a sky beam which appears only at night and in the daytime due to the considerable ion concentration is absorbed by the ionosphere. Good communication at any time of the day is accomplished by the surface wave and consists of hundreds of kilometers, at night due to the interference of the ground and surface waves at large distances there are fadings. The medium wave range is used in broadcasting, marine radio communication related to distress and safety traffic (2182kHz is an international distress frequency in telephony) for transmitting navigational messages.

The short (decametric) waves also propagate by means of the surface and ionospheric beams. The surface beam energy quickly fades due to the losses in the earth's surface and consists of tens of kilometers. The sky beam is absorbed in the D- and E-layers and is reflected from the F-layer. For reducing the losses of the sky beam it is necessary to select the maximum useful frequencies, however, the critical frequency being able to reflect from the F-layer depends on the charge particle concentration. So, in the daytime with the maximum concentration of the F-layer radio waves with the length of 10-25m are used and at night- 35m and more. The short waves are characterized by the dependence of the propagation conditions on the time of the day, season, geographical position of the communication lines (e.g. radio wave fadings during propagation in the W-E direction is higher than in the N-S

direction). Propagation is influenced by different ionospheric disturbances (ionospheric storms etc.) Owing to the multiple propagation of the short waves signals at the receiving point are defined by the sum of the received copies. As the signal copies have different phases, during the integration there are strong fadings-random changes of the signal level at the receiving point.

The next feature of the short waves is “ zones of silence” – zones which are located between the range of operation of the surface wave and the distance at which the reflected ionospheric wave appears.

According to the above the short wave communication is unstable and depends on rightly selected wavelength, the value of which is very difficult to calculate beforehand. The short wave advantage is to communicate with any point of the globe using low-powered transmitters (hundreds of watts).

The ultra high waves propagate only as a surface beam, a sky wave penetrates into the ionosphere and does not reflect from it even at the maximum charge particle concentration. The surface wave has almost no diffraction, i.e. the range of communication is defined by the limits of the line-in-sight and depends on the height of the antenna installation. If the height of the transmitting and receiving antennas is equal to h_1 , m and h_2 , m respectively, then the communication range $D = 3,6(\sqrt{h_1} + \sqrt{h_2})$, km and is tens of kilometers. The main advantage of VHF – communication is a good communication not depending on the atmosphere condition, absence of atmospheric disturbances, low power of the transmitters (watts), capability of simultaneous operation of a considerable number of radio stations without mutual interference. It is used at short range (coasting navigation, communication in the road and in the port). Television systems also work in this range.

For increasing the range of VHF-communication radio relay lines are used – a number of towers are set at the line-of-sight distance with the receivers and transmitters which relay signals. For communication with the mobile objects (ships) satellites are used as a relay. For example, INMARSAT system is used for communication with the ships. INMARSAT system consists of 4 satellites covering the globe (except the Polar regions), coast earth stations and ship earth stations.

Electromagnetic compatibility of radio electronic devices

The increase of the number of simultaneously operating radio-engineering devices causes considerable mutual interferences. The possibility of simultaneous operation of the radio-engineering devices without reducing the operation quality is termed electromagnetic compatibility. Electromagnetic compatibility of the radio electronic devices ensures the economical and effective use of the radio frequency resource (radio frequency spectrum).

This problem has become very important in recent years due to the continuously increasing number of radio transmitting devices. Electromagnetic compatibility is achieved by means of the measures providing the minimum level of mutual interference during the radio equipment operation. The first measure is to improve the technical characteristics of the equipment. The second one is to define the rules and regulations ensuring the effective use of the radio-engineering systems without mutual interference. Special attention is paid to the adequate use of the radio frequency spectrum. Requirements to the radio-engineering systems and the rules of

their use are given in the international and national standard documents regarding the use of radio frequency spectrum issued by ITU. The ITU issues Radio Regulations giving the standard requirements of using the radio-engineering systems. National standards are published by the State Committee on radio frequencies and the State Committee on standards. The requirements of using shipboard radio equipment are shown in standard documents (branch standards, guiding rules and regulations).

Methods and devices for measuring signal parameters and radio electronic device characteristics

One of the most important requirements to the radio electronic equipment functioning is to know the technical conditions. For this purpose it is necessary to ensure the diagnostics of radio electronic devices. The aim of the diagnostics is to check the compliance of the technical characteristics with the necessary standards.

The technical condition of the radio electronic systems is characterized by a number of signal parameters formed by this system and radio electronic device features. To estimate the quantitative values of signal parameters and the device features special measuring devices are used. Radio electronic measuring is characterized by the following features:

- a great number of physical values, parameters and characteristics which are necessary to measure;
- broad limits of measured values;
- wide frequency range of the measured values (from direct current to hundreds of GHz).

The above features require a great range of radio measuring devices. In addition to the well-known measuring devices such as voltmeter, frequency meter, signal oscillators, oscilloscopes, special devices can be used – modulation meters, nonlinear distortion meters, noise level meters, spectrum analyzers, error factor meters and others. For using these measuring devices (correct connection, data interpretation etc.) it is necessary to use manuals, other standard references.

Some parameters and characteristics (voltage, frequency, power etc.) are measured when the equipment is switched on. In this case while measuring it is essential to observe accident protection rules.

Modern communication and navigational systems have the built-in equipment for checking the operation and diagnostic systems.

The use of these testing systems is given in the manuals. Detailed information is given in Module 9 of this Module course.

SECTION 2

RADIO COMMUNICATION EQUIPMENT

The purpose of this section is to give the basic knowledge of the existing GMDSS equipment sufficient for the individual analysis of the similar equipment block-diagrams essential for at sea maintenance; including troubleshooting and repair at the unit (module) exchange level.

Entry standard:

The candidates should have knowledge of:

- the principles of operation, characteristics and parameters of the modern electronic equipment element base;
- electrical circuits and the purpose of the circuit elements: voltage rectifier and regulator, radio frequency amplifiers, audio frequency amplifiers, auto generators, converters and frequency multipliers, modulators, multiplexer and demultiplexers;
- the fundamentals of the digital circuit theory: electrical parameters and the construction of the basic logic elements, block-diagrams of digital devices (triggers, registers, counters, decoders, code converters, analog-digital and digital-analog converters);
- the principle of operation of the microprocessor system elements, programmed devices of input-output, programmed logic integrated circuits;
- the principles of the microprocessor construction, principle of operation of the signal processing devices based on microprocessors and digital devices.

After completion of the course the trainees should have knowledge of:

- the technical and performance standards of the GMDSS shipboard equipment;
- the purpose, the construction and functioning principles of the shipboard radio engineering devices in GMDSS;
- the block-diagrams of the GMDSS radio equipment;

Outline

	Learning objectives	Hours		
		Total	Theoretical	Practical
1	The requirements to the GMDSS equipment configuration and its technical characteristics	4	4	-
2	VHF radio installations with DSC	10	6	4
3	MF/HF radio installations with DSC and NBDP	16	10	6
4	SES INMARSAT-C	12	8	4
5	Specialized computers and interfaces	6	4	2
6	SART	1	0.5	0.5
7	EPIRB	2	1	1
8	NAVTEX receivers	1	0.5	0.5
9	GMDSS equipment power supply	4	2	2
Total		56	36	20

2.1. The requirements to the BASIC TECHNICAL CHARACTERISTICS OF GMDSS shipboard radio equipment.

The requirements to the minimum number of the GMDSS equipment for all ships comply with SOLAS Convention. The minimum number of the equipment depends on the Sea area of a ship and is given in SOLAS Convention, Chapter IV, and Regulations 7-11

The technical characteristics of the GMDSS equipment are determined by the requirements of Radio Regulations, ITU-R Recommendations, IMO Resolutions and national requirements.

The minimum requirements to the basic technical characteristics are given in table 2.1.

Table 2.1. Technical characteristics of the main GMDSS shipboard equipment.

Parameter		MF/HF	VHF	INMARSAT-C
Frequency range (MHz):		1.605-27.5	156.025-162.025	1530-1545; 1626.5-1646.5
Frequency tolerance		10 Hz	10×10^{-6}	2×10^{-7}
The number of channels (min)		6+6+6*	70, 16, 6, 13 + one working	Determine by the system
Warm-up period (min)		1	1	...
Tuning speed (sec)		15	5	...
Emission modes		J3E, H3E, F1B (J2B)	G3E, G2B	G1D
Transmitter output power (W)	Min Max	60 400 (MF)	6 25	12 dB/W
Communication channel width, kHz		3 (J3E), 0.5 (F1B)	Not more than 10	5
Receiver sensitivity (mV) with signal-to-noise ratio 20 dB		6	2 (DSC-1)	
Error probability (DSC and NBDP) with signal-to-noise ratio 12 dB		10^{-2}	10^{-2}	
Receiver output power (mW)	At the loudspeaker At the handset	2000 1	Is not exactly specified	
Transmission speed (Baud)		100	1200	1200

* 6 frequencies for radiotelephony: 2182; 4125; 6215; 82991; 12290 and 16462;

6 frequencies for NBDP: 2174.5; 4177.5; 6268; 8376.5; 12520 and 16420;

6 frequencies for DSC: 2187.5; 4207.5; 6312; 8414.5; 12577 and 16804.5 kHz.

The technical characteristics of the specific equipment manufactured at present by various firms, as a rule, exceed the minimum requirements.

2.2. VHF radio installations with DSC

The performance standards to the VHF shipboard radio installations providing radiotelephone communication and digital selective call are given in IMO Resolution A.803.

The basic technical characteristics of some existing GMDSS radio installations are shown in table 2.2.

Table 2.2. Comparative characteristics of VHF radio installations.

	RT2048	STR 8400	JHS-32A
Frequency range, MHz	154.400 – 163.750	153.900 – 163.100	155.000 – 163.500
Frequency tolerance	10×10^{-6} (5×10^{-6})	10×10^{-6}	10×10^{-6}
The number of channels ITU /USA	54	54	57
Private channels (+weather channels)	10 (40)	16	99
Channel spacing, kHz	25/12.5	25/12.5	25/10

Communication mode	Simplex and semi-duplex		Simplex and duplex
Antenna impedance	50 Ohm		
Output power max (min), W	25(1)		23-25(1)
Maximum frequency deviation	±5 kHz		
Sensitivity (S/N=12dB), μV	0.25	0.3	±2
Distortions	<5%	<3%	< 10%
AF output power, W	6	4	2
Pre-emphasis	6 dB/octave		
Power supply, V	13.2		100-240, 50/60 Hz; 24 (21.6-31.2) DC
Current consumption, A:			
Reception	0.1		0.15
Transmission on 25 W	5		5.5
Dimensions, mm	252x139x160	192x60x27	290x240x145
Weight, kg	3.3 (without DSC)	1.25 (without DSC)	About 11 kg
Operating temperature	From -10 to +55°C	From -20 to +55°C	From -15 to +55°C

At the beginning of GMDSS introduction into VHF radio installations, the existing VHF telephone communication stations, added with the DSC devices, were used. At present VHF radio stations and DSC modem are combined together.

The block-diagrams of VHF radio installations manufactured by various firms are similar, in general, and described below taking RT2048, STR8400 and JHS-32A as examples.

VHF radio station capable of voice communication.

VHF radio station capable of voice communication (RT2048 for example) consists of the synthesizer unit, the transceiver (Rx/Tx Unit), interface unit, selcall unit and the keyboard placed in the keyboard unit (Fig. 2.1.). By means of the jumper the station can be switched to the programming mode in which the national channels can be adjusted and assign the priority channel etc.

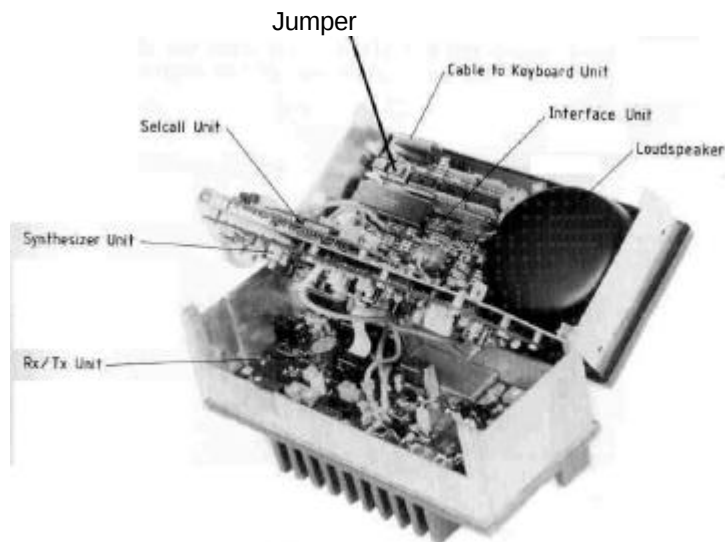


Fig. 2.1. Example of VHF radio station configuration

For feeding the radio station from AC mains a separate power unit is used. The radio station operates with an asymmetric antenna.

The block-diagram is given in Fig. 2.2.

THE RECEIVING PATH. In the receiving mode the antenna is connected to the input of the receiver RFA (Rx-am) by one contact pair of the antenna relay. The second contact pair supplies +8V to the Rx lead by which the receiving path stages obtain power. In the input circuits and RFA load there are varicaps that are fed by the voltage from a synthesizer. This voltage adjusts the input circuit filters and RFA load while changing channels.

The amplified RF signal is fed to the first mixer where the local oscillator frequency f_{LO1} also comes from the synthesizer changing from 139.1 to 148.45 MHz with step 12.5 kHz (depending on the selected channel¹). The frequency difference (1 st IF) is assigned by the filter adjusted to 15.3 MHz is amplified and fed to the second mixer integrated into ICs with the amplifier-limiter and frequency detector.

The second IF is assigned by the external filter adjusted to 450 kHz from the combination frequency spectrum formed in the second mixer from the first IF and frequency f_{LO2} obtained from the reference oscillator².

At the frequency detector output there is a distorted AF signal as it detects FM signals received in this range for communication. Distortions are eliminated by means of a corrector network. The corrector networks of AF pre-amplification and noise suppression are in the interface unit (Fig. 2.3.). After passing these networks (6 dB/octave deemphasis filter) AF is fed to the telephone output (TO) and AFPA placed on the transceiver board.

¹ On channel 16 (156.8 MHz) $f_{LO1}=156.8-15.3=141.5$ MHz
and on channel 6 (156.3 MHz) $f_{LO1}=156.3-15.3=141.0$ MHz

² $f_{IF2}=15.300-14.850=0.450$ MHz

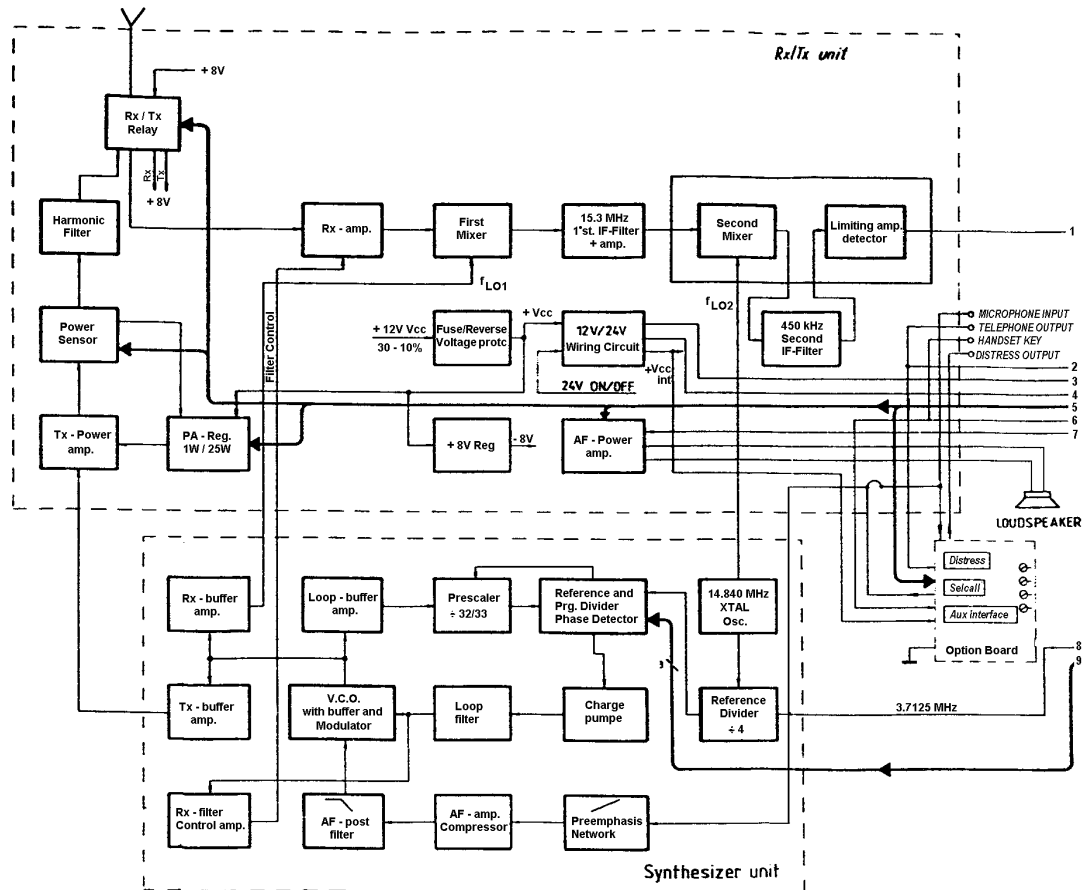


Fig. 2.2. Block-diagram of the transceiver and synthesizer

THE TRANSMISSION PATH. In RT2048 radio station transmitter an indirect method of phase modulation is used. AF voltage is fed to preemphasis network from the microphone or tone output of DSC modem (1300 and 2100 Hz). The preemphasis network consists of the frequency depending voltage divider providing the increase of the audio spectrum upper frequencies (6 dB/oct). After the compressor amplifier and LPF the audio signal is passed to a varicap integrated into a voltage-controlled oscillator (VCO) generating the transmitting frequency of a selected channel. AF compression is necessary for limiting the emitted frequency band. The maximum change of the varicap capacity will not only depend on the modulating voltage amplitude U_F , which is evident, but on its frequency F (due to the corrector network). Thus, the varicap capacity and frequency deviation will be directly proportional to the modulating signal frequency and amplitude ($\propto F \cdot U_F$), that is the reason of phase modulation.

After the amplification in a buffer amplifier the modulated oscillations are fed to the two-stage power amplifier on one microcircuit. The collector power supply of the preamplifier can be changed. The output power is also changed. The output power is varied by the microprocessor command and, in case of the antenna circuit failure detected by the power sensor, connected to PA output.

For efficiency increase the output stage transistors operate with the collector current cut-off and produce a great number of harmonics. For their filtering the harmonic filter realized as a seven order Chebyshev filter is used.

The filtered PM oscillations are passed through the antenna relay contacts to the antenna. The relay obtains power supply by pressing TO handset keys and switches the antenna from the receiver input to the transmitter output. Simultaneously the other contact pair switches the collector power supply voltage +8V from the receiving path stages to the low powered transmission path stages (Tx lead).

The *SYNTHESIZER*. The synthesizer generates the frequency of local oscillators 1 and 2 (LO_1 and LO_2) for the receiving path, the clock frequency for the microprocessor and carrier that is modulated in it. The frequency spacing with step 12.5 kHz is formed from the reference oscillator frequency 14.850 kHz in the synthesizer based on a phased-locked loop system (PLL). The reference oscillator provides the frequency stability (0.001%) by means of the crystal resonator without the additional means of temperature stabilization. After the four-multiple division the reference frequency 3712.5 kHz is fed to the PLL ring, to the reference divider and microprocessor clock input.

The reference divider, programmable divider and phase detector are realized in one microcircuit. The division ratio is equal to 297, so frequency 12.5 kHz ($14850:4:297$) is passed to one input of the phase detector – which comparison frequency determines a step of the synthesizer frequency spacing. The VCO frequency divided by N is fed to the other PD input.

The common division ratio of the programmable divider and prescaler $\div 32/33$ N is set by the microprocessor command and depends on the selected channel. For example, for channel 6 (156.3 MHz) $N=12504$, if the prescaler divides the passed frequency 24 times by 33 and 366 times by 32 ($12504=24 \times 33 + 366 \times 32$). The programmable divider changes the prescaler division ratio from 32 to 33. The mismatched signal from a phase detector after the amplification and filtration is fed to the VCO varicap for the mismatching compensation.

AUDIO FREQUENCY PATH. From the frequency detector output AF voltage is passed to the squelch filter and AF mute circuit located in the interface board (Fig. 2.3.). After passing the active HPF squelch circuits with frequency 45 kHz and amplifier the noise voltage increased to 6-8 dB is fed to the Squelch detector comparison circuit.

The noise level can be adjusted by the potentiometer */SQ control/* placed on the front panel. The comparator is based on the operational amplifier, the reference voltage 0.6V is fed to its direct input and the noise rectifier voltage is fed to the inversion input. When the noise voltage exceeds the reference one there is a signal at the comparator output passing to the microprocessor, which sends a command to the switching off circuit. The audio signal passes the corrector network (-6 dB/oct) providing the correct reception of PM signal in the frequency detector is amplified and fed to TO, volume regulator and selective call unit (if any) or DSC decoder.

From the volume regulator on the front panel the audio signal is passed to the AFPA located in the transceiver unit. The audio signal from the microprocessor can be fed to AFPA through the same lead.

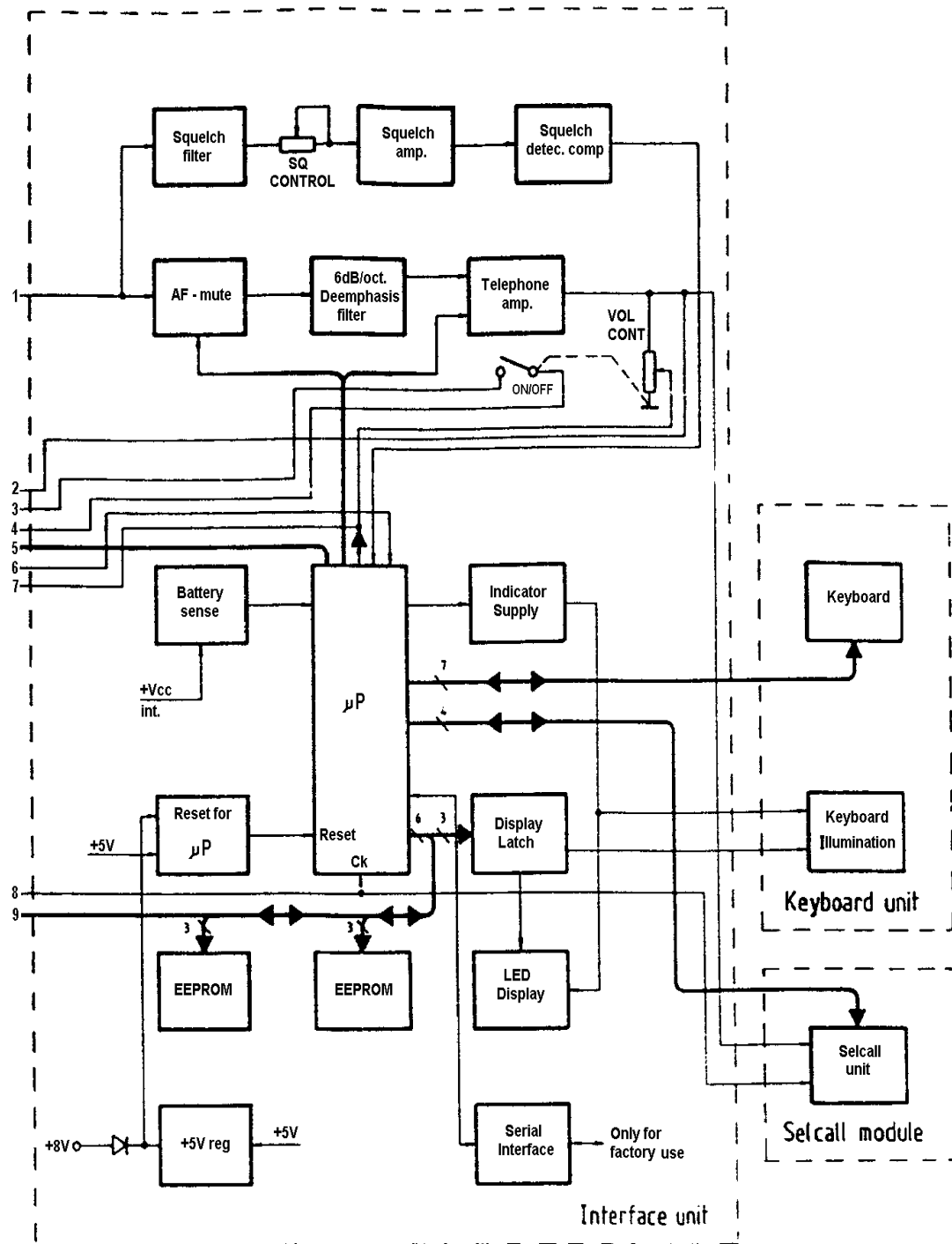


Fig. 2.3. Interface board

The KEYBOARD. The keyboard consists of 12 digital buttons for selecting channels, but after pressing the button SHIFT some of them can perform the other functions: to change the power, brightening etc. Besides, this station can be switched to the service mode by using the jumper in the interface unit (Fig. 2.1.), in this mode the hexagonal numbers can be entered from the keyboard (Fig. 2.4.) and program the station.



Fig. 2.4. Keyboard for input the hexagonal numbers.

We can select one of 16 service programs with numbers from 0 to F. For example, program 7 permits to program private channels, program 1 – to select various versions of the channel distribution.

In EPROM 16 different versions of frequencies and channels are recorded. Code 0 corresponds to the standard version (Radio Regulations, Annex 18), code F corresponds to the US version given in table 3.2. and etc. Programming of the private channels P1 – P4 to weather channels Wx1 – Wx4 (code 4) is performed in the following way:

1. To set up a jumper, the display shows symbols: **5.-**
2. To enter the service program number: **1 ENTER**
3. To enter the channel version code: **4 ENTER**
4. To check the correct selection: **SHIFT REVIEW**
5. To leave the service program: **SHIFT RETURN**, to remove the jumper .

The service engineer carries out the setting of the station unconventional functions.

VHF radio installation capable of voice communication and digital selective calling

VHF radio installation capable of voice communication and digital selective calling (JHS-32 for example) is given in Fig. 2.5.

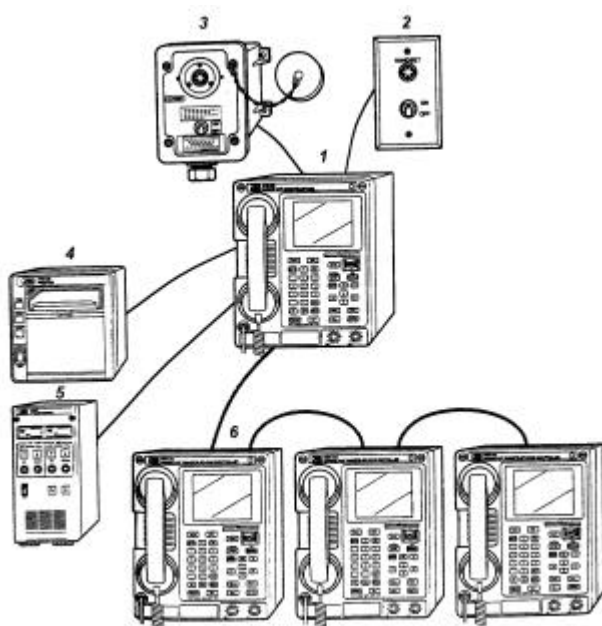


Fig. 2.5. VHF radio installation

The complete installation contains:

1. VHF radio station main unit;
2. Connection unit for TO located inside the vessel;
3. Watertight connection unit for TO;
4. Printer for DSC messages;
5. Watch receiver for simultaneous keeping of listening watch on 2 channels;
6. Remote control units

The block-diagram of the main unit

The block-diagram (fig.2.6.) consists of two super- heterodyne receivers; one is adjusted to channel 70 and is a DSC watch receiver, transmitter, and control unit, connection board.

Each receiver and transmitter have their own frequency synthesizers based on PLL, so they can operate simultaneously in a duplex mode. A duplexer consisting of a

bandpass filter and LPF provides the operation with one antenna in duplex communication. The indirect method of obtaining PM is used. The corrector networks (6dB/oct.) are included into the audible processor (Fx505).

DSC watch receiver integrated into the main unit with the main receiver is superheterodyne with double frequency conversion. For reducing mutual interference from the first local oscillators the first IFs in the receivers are different. The transmitter output power can be reduced from 25 to 1W by the operator's command or automatically. In the first case the signal from the microprocessor is sent to the power control circuit (APC), in the second case – from the emitted power sensor P_f .

The switching to the reserve power supply is carried out automatically.

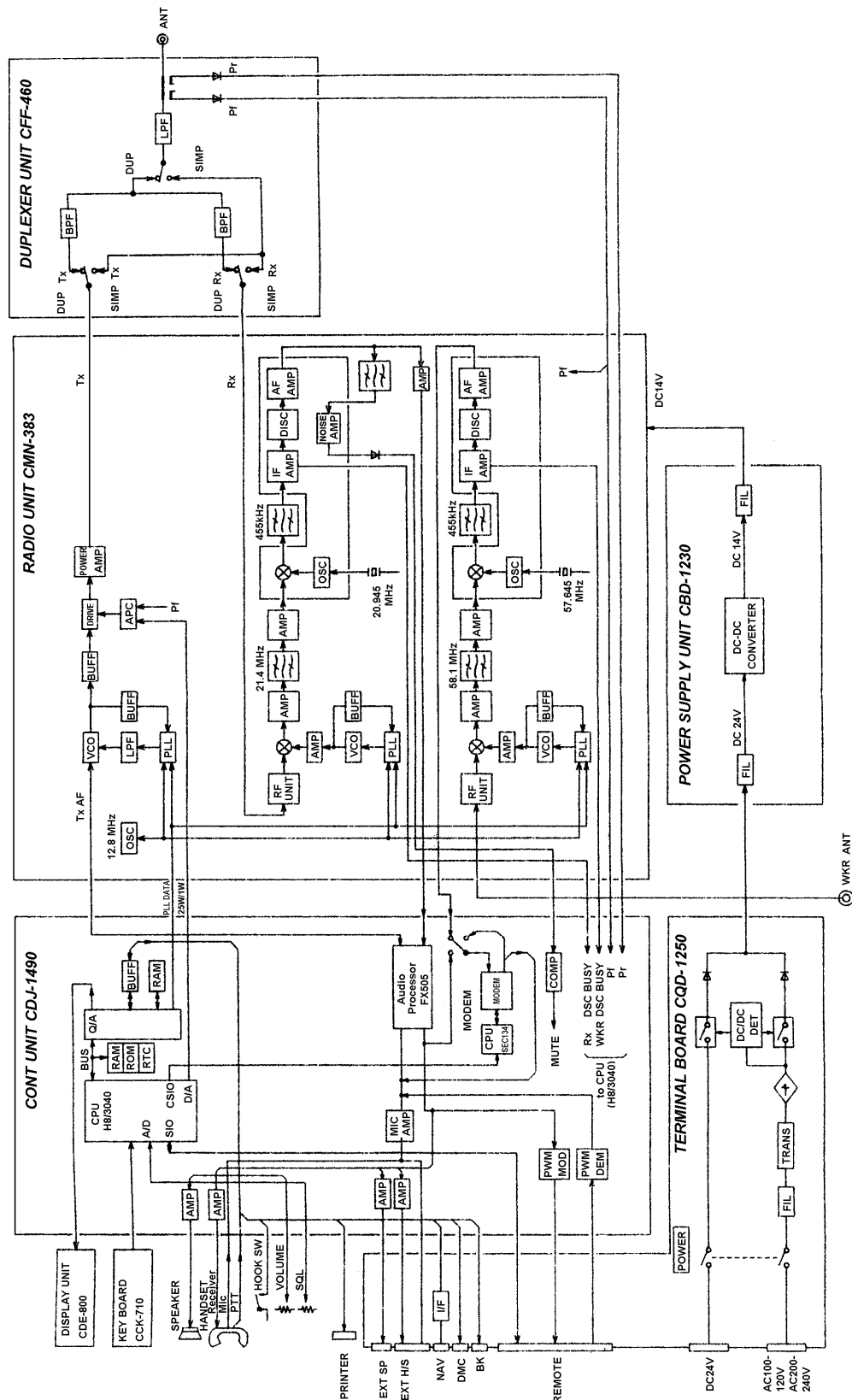


Fig. 2.6. Block-diagram of main unit

Programming of VHF radio stations

In the microprocessor-based VHF radio stations the adjustment is carried out at the programming level. For this purpose built-in service programs and the station keyboard are used (see RT2048 and fig. 2.4.). In some stations programming and adjustment are performed by the computer with the appropriate software that is connected to the VHF radio station while programming.

Fig. 2.7. shows the software main menu for VHF radio station STR8400 programming as an example. The menu item EDIT DATA permits to program conventional or private channels (fig. 2.8.)

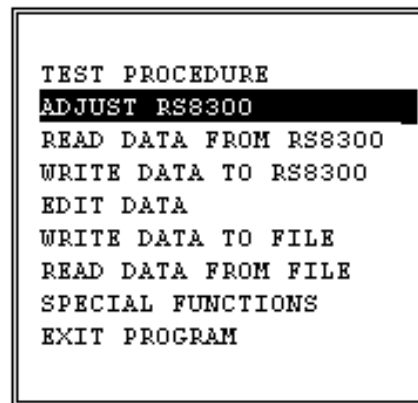


Fig. 2.8. The main menu.

For changing the station functions the item SPECIAL FUNCTION (fig. 2.9.) is selected and for checking and changing the parameters the item ADJUST RS 8300 (fig. 2.10.) is selected. Pressing the appropriate buttons with the arrows on the computer keyboard effects the change of the output power, carrier, modulation depth etc.

The parameter values are controlled by means of measuring devices connected instead of the antenna.

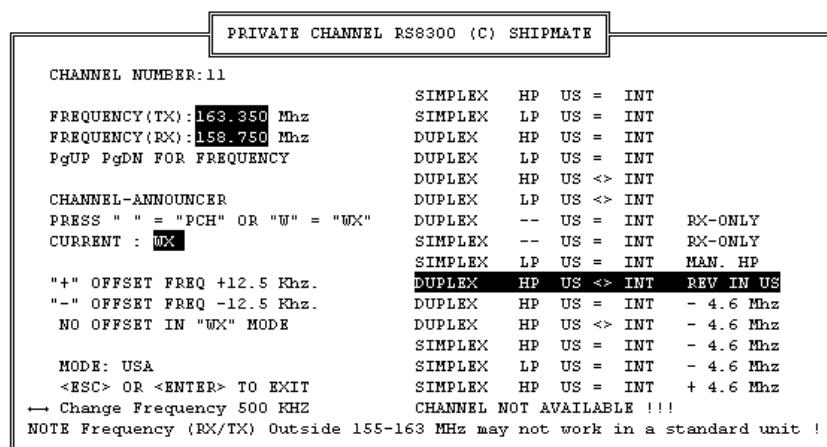


Fig. 2.8. Window of the private channel programming

EDIT COUNTRY PARAMETERS - (C) SHIPMATE		
	0: US ALLOWED	ON
	1: DW ALLOWED	ON
	2: SCAN ALLOWED	ON
	3: SCAN - PRIO. ALLOWED	ON
	4: VOL = 0 ALLOWED	ON
PRESS 0..D KEY's TO TOGGLE PARAMETER	5: LIGHT = 0 ALLOWED	ON
	6: SQ STEP 4 ALLOWED	ON
PRESS <ESC> TO EXIT	7: DUAL	ON
	8: INTERCOM ALLOWED	ON
	9: ATIS IMPLEMENTED	OFF
	A: SOS IMPLEMENTED	ON
	B: TX TIMEOUT	OFF
	C: WRITE WX	OFF
	D: INTERCOM ALWAYS	OFF

Fig. 2.9. Configuration window

After completing the station adjustment data is recorded in EEPROM (the item WRITE DATA TO RS8340).

Service engineers carry out the above-mentioned operations on board ship.

RS8300 MANUAL ADJUSTMENTS	
	↑ ↓ SELECT ADJUSTMENTS ← → CHANGE ADJUSTMENTS
File.1 Simp.24	-----*
File.2 Simp.16	-----*
File.3 Simp.10	-----*
File.1 Dupl.45	-----*
File.2 Dupl.25	-----*
File.3 Dupl.17	-----*
Power HIGH.24	-----*
Power LOW .22	-----*
Ref. OSC. 21	-----*
VCO-Coarse. 4	-----*
Modulation. 6	-----*
AF Level 2	-----*
SQU.Adjust. 1	-----*
VCO Filt. 3	-----*
MOD SOS. 1	-----*
MOD ATIS. 7	-----*

ADJUST FOR MAX SINAD.
 CH17 = 156.850 MHZ
 MIN 12 dB at 0.3 uV

Fig. 2.10. Adjustment window

2.3. MF/HF Radio installations with DSC and NBDP

The performance standards to GMDSS MF/HF shipboard radio installations are given in IMO Resolution 7.806.

The main technical characteristics of some existing GMDSS radio installations are shown in tab. 2.3.

Tab. 2.3 the Comparative characteristics of MF/HF radio installations

	Atlantica	STR2000	Sailor 2000
Working frequency range, kHz:			
- The transmitter	1605-27500	1605-26500	1600-30000
- Receivers	10-30000	100-30000	100-30000
Frequency spacing, step, Hz	10	1	10
Frequency tolerance, Hz	$1 \cdot 10^{-7}$	$1 \cdot 10^{-7}$	$1 \cdot 10^{-7}$
Frequency setting time, ? sec	30	<10 msec	...
Emission modes	A1A, F1B, J2B, G1B, J3E, H3E, A3E (reception)	A1A, F1B, J3E, H3E, R3E, A3? (reception)	J2B, J3E, H3E, R3E, A3E (reception)
Sensitivity of receivers (S/N = 20 dB), ? V	1,2 – DSC 1,9 – J3E (S/N=10dB)	4 - MF 1 - HF	< 10 dB/? V- J3E < 24 dB/? V-H3E
The input protection	100 V	5 W continuously, 18 W - 15 minutes	no information
Transmitter output power, W	200-400-800	250-400-800	250-600-1200
Carrier suppression, dB	-50	- 80	-46 dB

The block- diagrams of MF/HF radio installations

At the outset of GMDSS introduction into MF/HF radio installations the existing at that time radio installations of MF/HF range ensuring single-sideband telephone and direct-printing radio communication were used which were added by the DSC modem and consisted of separate modules. Now MF/HF radio installations are designed according to the requirements to GMDSS equipment and combined in one unit.

The block- diagrams of MF/HF radio installations manufactured by different firms are similar and described below taking Sailor Compact 2000 radio installations on module level and Standard Radio STR2000 integrated radio installations as examples.

The block-diagram of MF/HF modular radio installation capable of voice communication NBDP and DSC

The block-diagram of MF/HF modular radio installation capable of voice communication NBDP and DSC (SAILOR Compact 2000 for example) consists of the main control module RE2100, called also an exciter/receiver and transmitter with different levels of emitted power (250, 600 or 1200). For the operation with different types of antennas the radio station contains ATU with automatic adjustment usually

placed on the upper deck. This configuration ensures SSB communication. For operation in GMDSS (fig. 2.11) the following equipment is additionally used:

- MF/HF DSC watch receiver with the built-in modem (RM2150);
- Telex / DSC scanning receiver with the built-in modem (RM2151);
- Telex communication terminal.

The power supply of the radio station is provided from an alternating-current power source 110/220V and from 24 V batteries. For the charge of the batteries the station contains the battery charger of 30 or 60?, type N2174. These battery-chargers can be used for charging lead-acid and nickel - cadmium batteries.

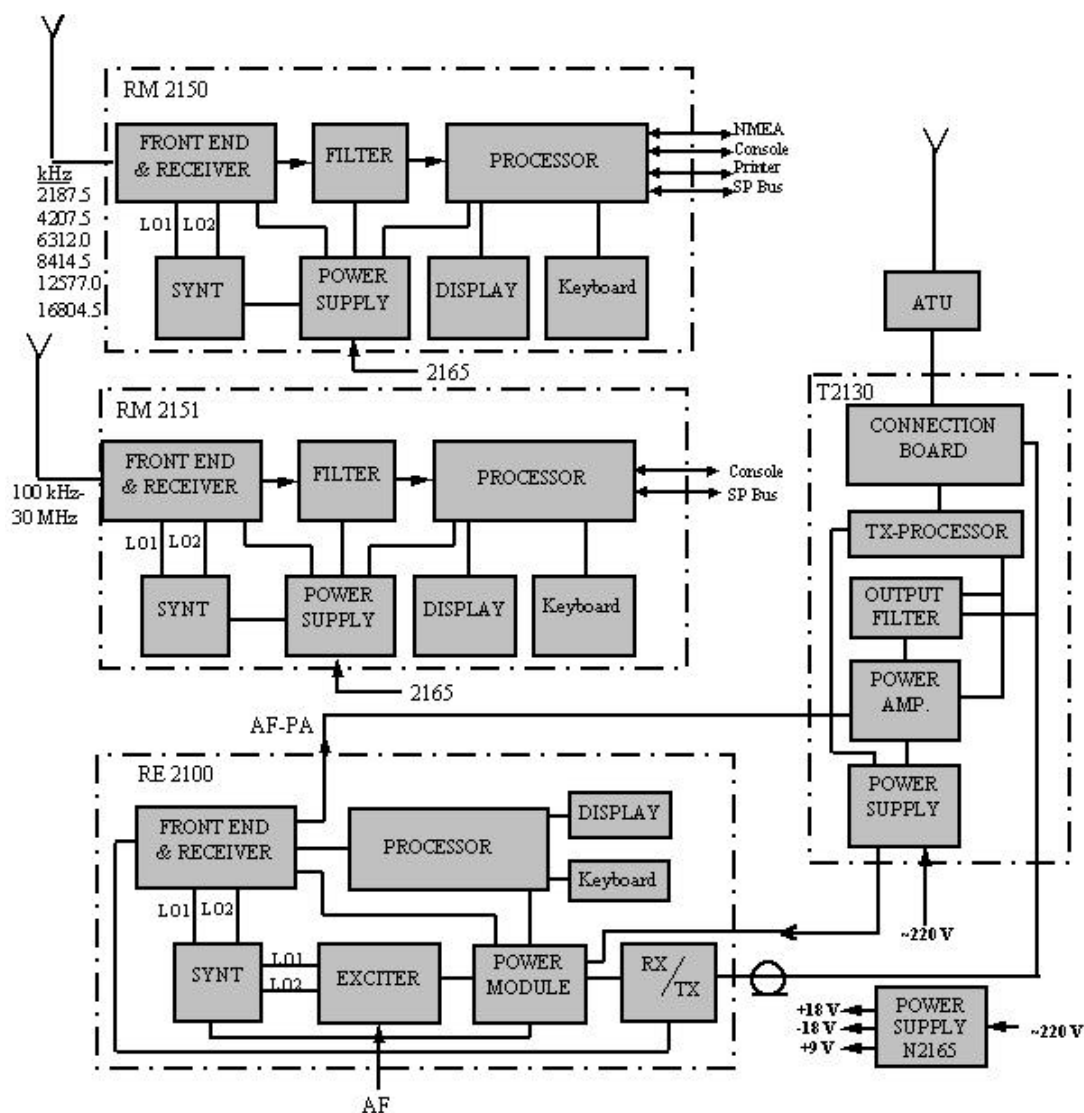


Fig.2.11 The block- diagram of MF/HF modular radio installation

The exciter/receiver unit RE2100

The RE2100 unit consists of the receiver, exciter, frequency synthesizer, processor, display, power unit and keyboard.

The receiver

The receiver front end.

This unit (fig. 2.12.) contains transmission-reception relay, receiver front-end protection circuit, input filter, mixer and IF path 70 MHz. The input filter is LPF-PF-LPF combination and serves to ensure image channel selectivity in the entire range from 100 kHz up to 30 MHz.

The mixer is based on field-effect transistors. The first local oscillator frequency ranges from 70 up to 100 MHz. The first intermediate frequency is selected by the symmetric crystal filter 70 MHz with bandwidth 15 kHz.

The receiver.

The receiver unit (fig. 2.13) contains conversion circuits of an IF signal 70 MHz into an audio signal. The second mixer is based on field-effect transistors. The second intermediate frequency is selected by crystal filters: one for an amplitude modulation (AM), and the other - for single-sideband modulation. At the first conversion there was a sideband conversion, therefore after the second mixer it is necessary to select the lower side band (LSB). The selection of the filter type is performed by the microprocessor.

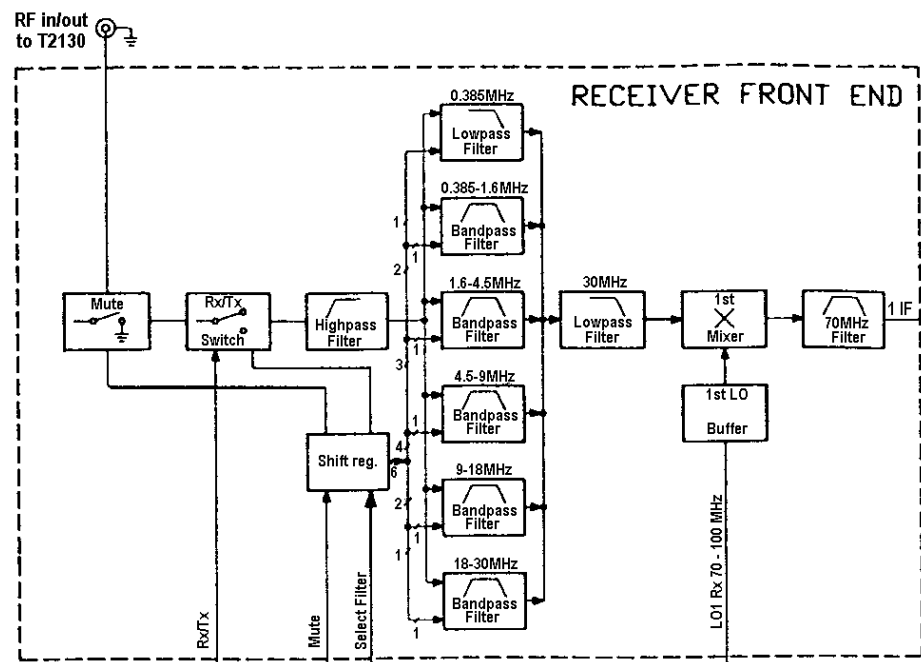


Fig.2.12 Receiver Front End

From the output of the filter the signal is fed to the intermediate frequency amplifier 10,73 MHz. The gain of this amplifier is adjusted by an amplifier circuit of an automatic gain control (AGC). The adjusted IF amplifier is followed by the ceramic filter intended for reduction of a broadband noise.

the microprocessor to the first mixer, where sub-carrier frequency of LO1 is also passed. SSB spectrum by means of the second sub-carrier is transferred to frequency band about 70 MHz. If the sub-carrier is equal to 59,27 MHz, then after the mixer and filter the lower side band will be obtained. If sub-carrier 80,73 MHz is used, then after the mixer and filter the upper side band will be obtained.

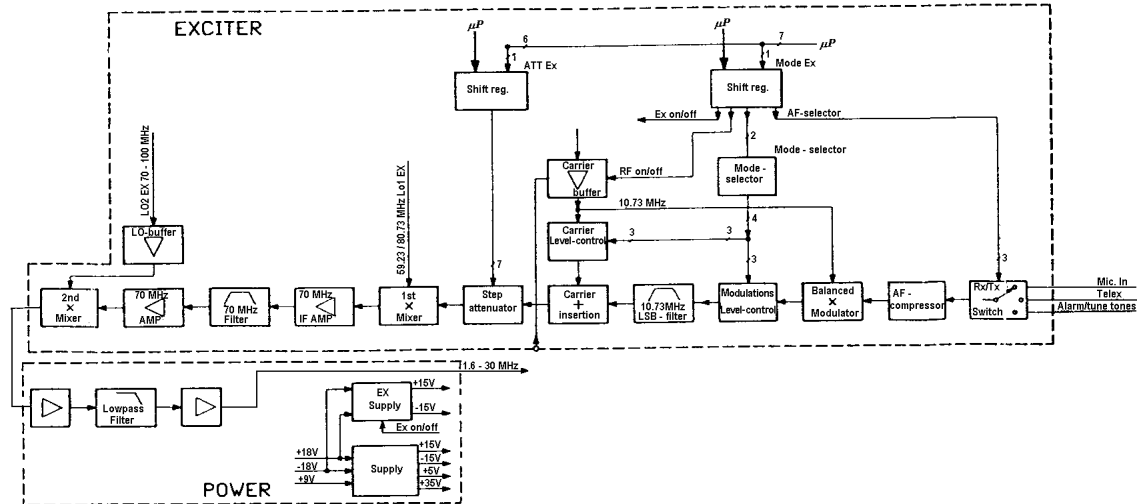


Fig. 2.14 Exciter

After the amplification, the single-sideband signal is fed to the second mixer. The LO1 frequency ranging 70-100 MHz is also passed to the second mixer and the spectrum of a single-sideband signal is transferred to the range of working frequencies from 1,6 MHz up to 30 MHz. Thus, there is an inversion of sideband frequencies: the LSB spectrum will be converted to a HSB spectrum, and HSB spectrum to a LSB spectrum. The signal from the mixer output is fed to the power amplifier unit.

The exciter output amplifier (power).

In this amplifier the final amplification and filtering of a radio frequency signal occurs, and required power supply voltages for all modules, which are included in the RE2100 unit, are generated. The signal coming from an exciter is amplified at first and then is filtered by a low-pass filter with an upper frequency cut off 30MHz, then it is amplified up to the level of about 2 mW and passes through the Rx/Tx switch, located in the receiver front end (fig. 1.14), to the transmitter power amplifier.

The exciter-receiver RE2100 obtains power supply voltages from the transmitter ?2130, which are $\pm 18V$ and $+9V$. These voltages pass through seven serial stabilizers for ensuring sufficient power supply voltage for all circuits. The processor controls the special voltage of $\pm 15V$ for an exciter, and the transmitter is not used more than 2 minutes, the exciter is switched off for reducing the power consumption in the watch mode.

The synthesizer.

In the synthesizer the principle of indirect synthesis of frequencies with PLL utilizing the elements of digital circuit theory will be used.

Crystal oscillator with the temperature stabilization (fig. 2.15) generates a reference frequency 10,73 MHz. The receiver and exciter in the converters use the same auxiliary frequencies. These oscillations are formed in two separate circuits with PLL: one of them generates sine oscillations in the range of 70 - 100 MHz with a step of 10 Hz, and the other - two spot frequencies: one (80,73 MHz) for the lower side band, and the other (59,27 MHz) - for the upper side band.

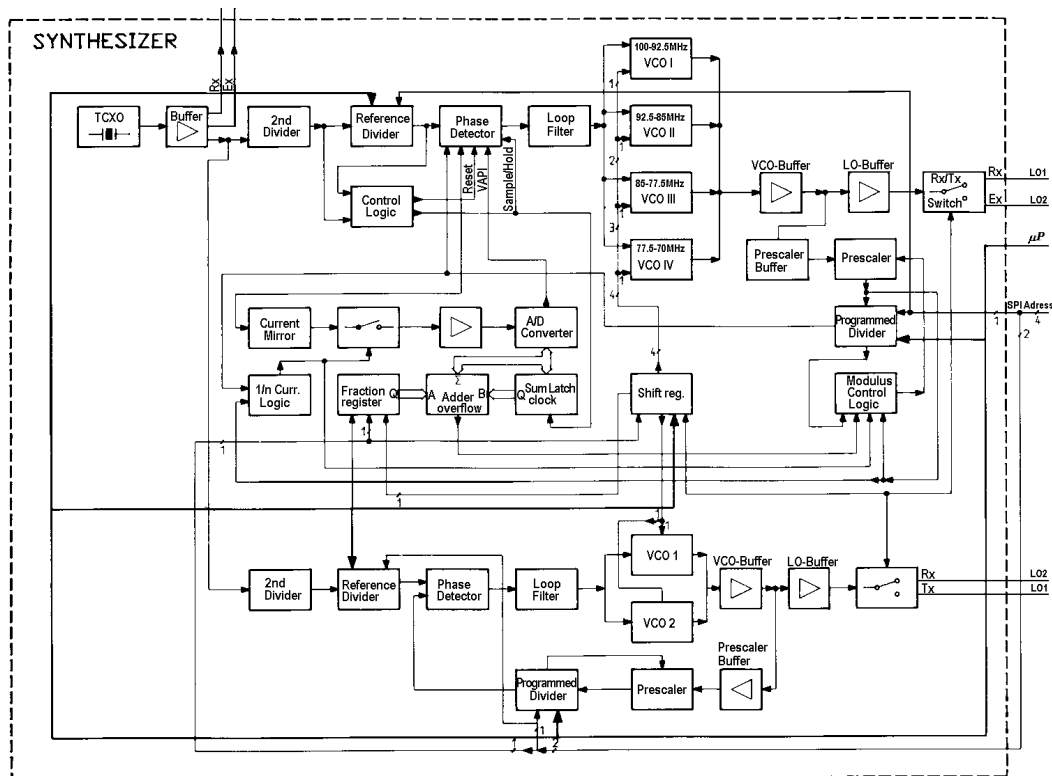


Fig. 2.15 Frequency Synthesizers

The processor.

The processor (fig. 2.16) controls all modules and ensures communication between the user and radio station (display and keyboard).

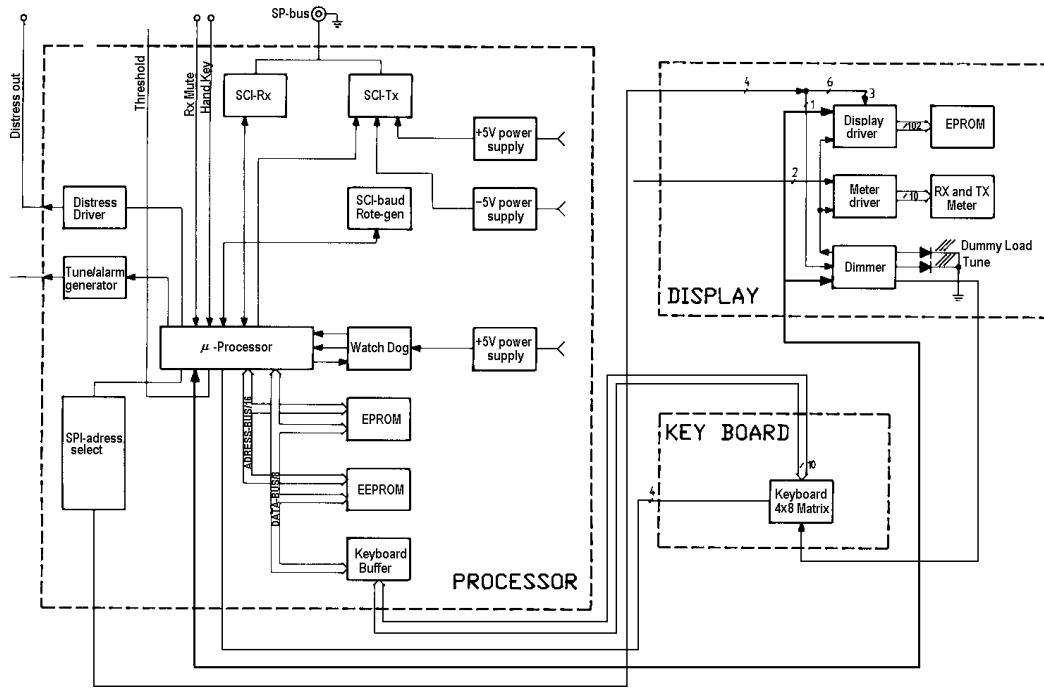


Fig. 2.16 Processors

The interface between the microprocessor and modules is carried out by the internal serial data bus (SPI). The electrically programmed ROM contains all parameters set by the user, which are stored even in case of power supply failure. If power supply voltage of the RE2100 device is reduced to the very low level, the display will show an error 20, and the performance standards of RE2100 will get worse. There is also an external serial data bus (SP-bus). This bus will be used for connection with other devices of SAILOR Compact 2000 MF/HF radio installations, for example, with the transmitter ?2130.

The display.

This unit contains the display indicating the information of the receiver and the transmitter adjustment (frequency, channel, emission mode etc.) and the output power level indicator.

DSC controllers and scanning receivers RM2150/2151

The DSC devices RM2150 and RM2151 differ, generally, with software. Their block diagrams are identical and consist of a FSK signal receiving path, filter units, processor, power unit, display and keyboard.

The receiver.

The input circuits are similar to RE2100, and the further circuit has some differences, concerning the features of frequency-manipulated signal reception (fig. 2.17). The IF signal 70 MHz is fed to the second mixer, after which there is a crystal filter, tuned to the second intermediate frequency 10,73 MHz. After the filter the second IF signal is passed to an IF amplifier 10,73 MHz. The gain of this amplifier is adjusted by the detector / amplifier circuit of AGC (automatic gain control). The IF amplifier is followed by the ceramic filter and detector operating according to the single-sideband demodulator circuit. From the demodulator the LF signal is fed through

LPF-HPF connected in series with cut-off frequencies 1450 and 1950 to the buffer (linear) amplifier with output resistance of 600 Ohm. For transmitting F1B emissions the frequency channel of width 500 Hz is allocated, and such DSC parameters, as frequency shift (170 Hz) and speed (100 Bauds), coincide with the NBDP parameters.

The level of an output signal on a matched load is 0 dB/mW.

The increased signal representing code (DSC or NBDP) sequence of sending with frequencies 1615 and 1785 Hz and minimum duration 10 ms is fed to a filter unit.

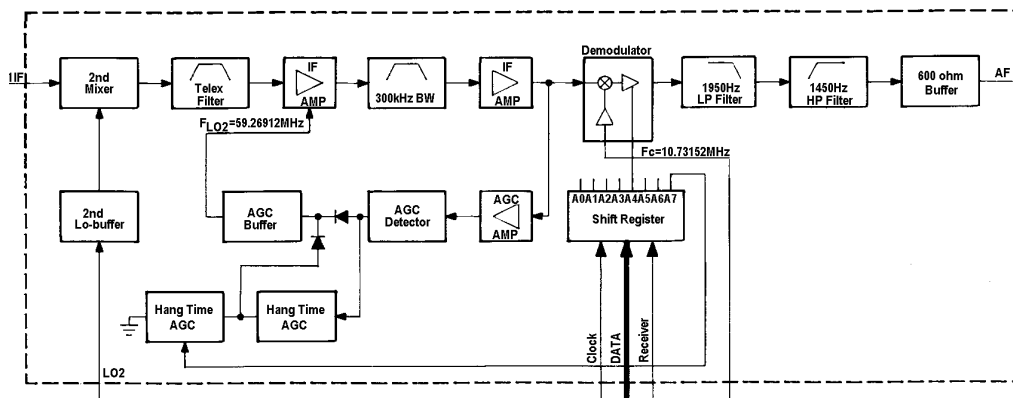


Fig. 2.17 DSC/NBDP Receiver

Filter unit.

A filter unit (fig. 2.18) converts tone sequence, by means of which messages encoded by NBDP 7-element code or DSC 10-element code in a digital form are transmitted for the further decoding in the processor.

The power supply unit.

The power supply unit generates all necessary power supply voltages for modules of RM2150/51 devices. The input voltages + 18V, -18V and -9V comes from the separate power supply unit N2165. These voltages pass through seven serial stabilizers, which ensure sufficient voltages for RM2150/51 operation.

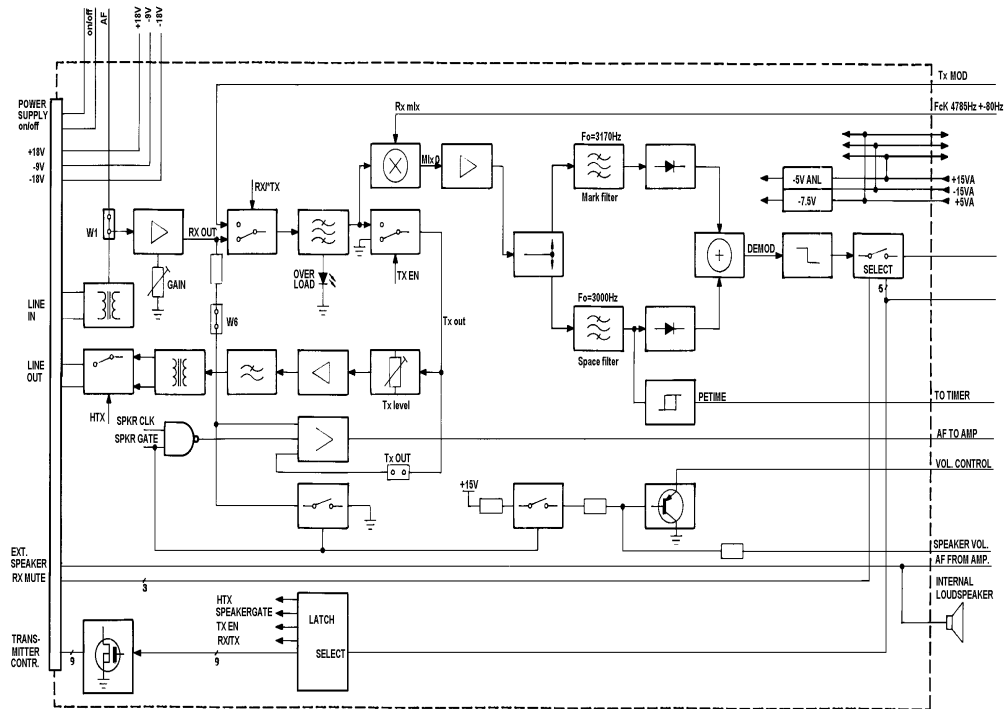


Fig. 2.18 Filter units

The processor. The processor (fig. 2.19) controls the display, keyboard, filter unit, receiver and SP-BUS.

The 80188-type microprocessor with the clock frequency of 10MHz is used in it. The control program is recorded in three microcircuits of PROM with the capacity of 128 kilobytes.

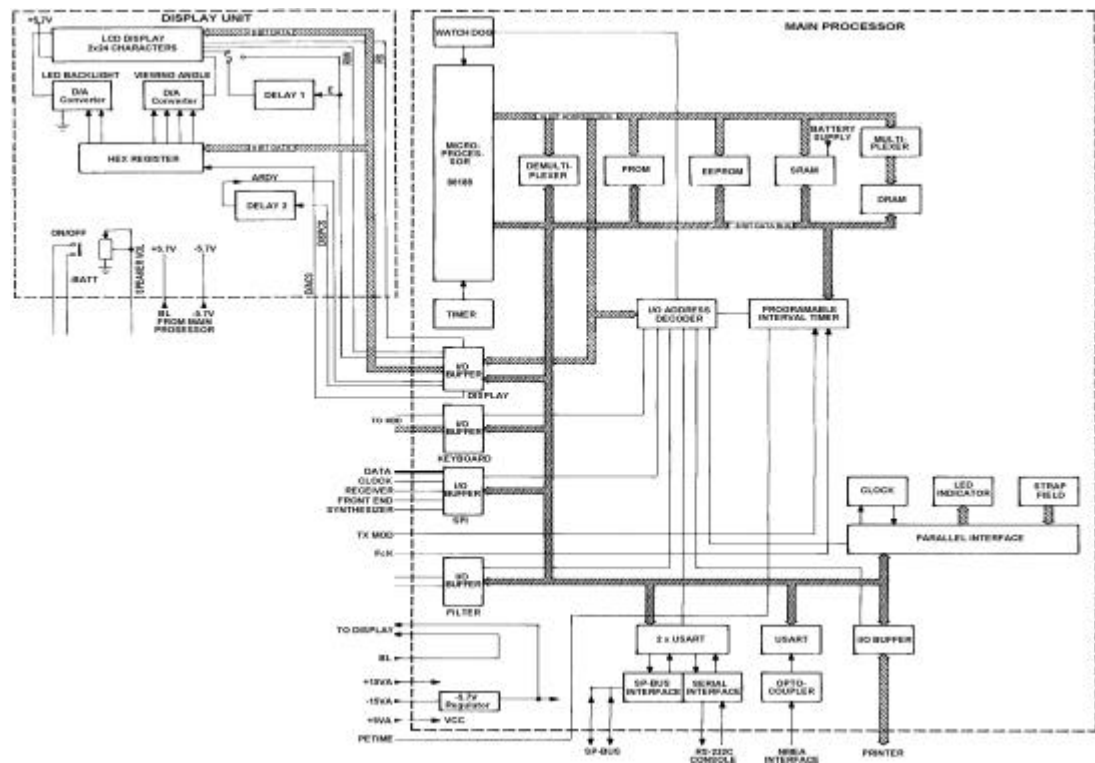


Fig. 2.19 Display and main processor

With the help of switches located on a processor unit, it is possible to set the functions of a DSC watch receiver RM2150 or radio telex modem RM2151. While connecting the computer (message terminal) to the ports RS-232C CONSOLE in EEPROM the appropriate software, as well as MMSI and Selcall, are recorded.

The display.

LED alphanumeric display consisting of two lines with 24 signs each is used as a display (fig. 2.19.) The controller has the built-in character generator and RAM of the indicated data. The functions of the display are changed by commands coming from the main processor.

The synthesizer.

It is similar to the synthesizer RE2100.

The transmitter

250-W transmitter ?2130 contains the power amplifier, output filter, transmitter processor, power supply unit and connection unit.

The power amplifier.

The power amplifier (fig. 2.20) is based on the push-pull circuit with the broadband transformers, including square-wave transformers (SWT). The modulated signal from an exciter RE2100 is fed through the output filter reception/transmission switch to the power amplifier input. The signal is amplified approximately up to 280 W (peak value). At the excessive temperature increase, large SWR etc. the power amplifier stages are locked by the microprocessor command. Thus the output power is reduced for more than 60 dB.

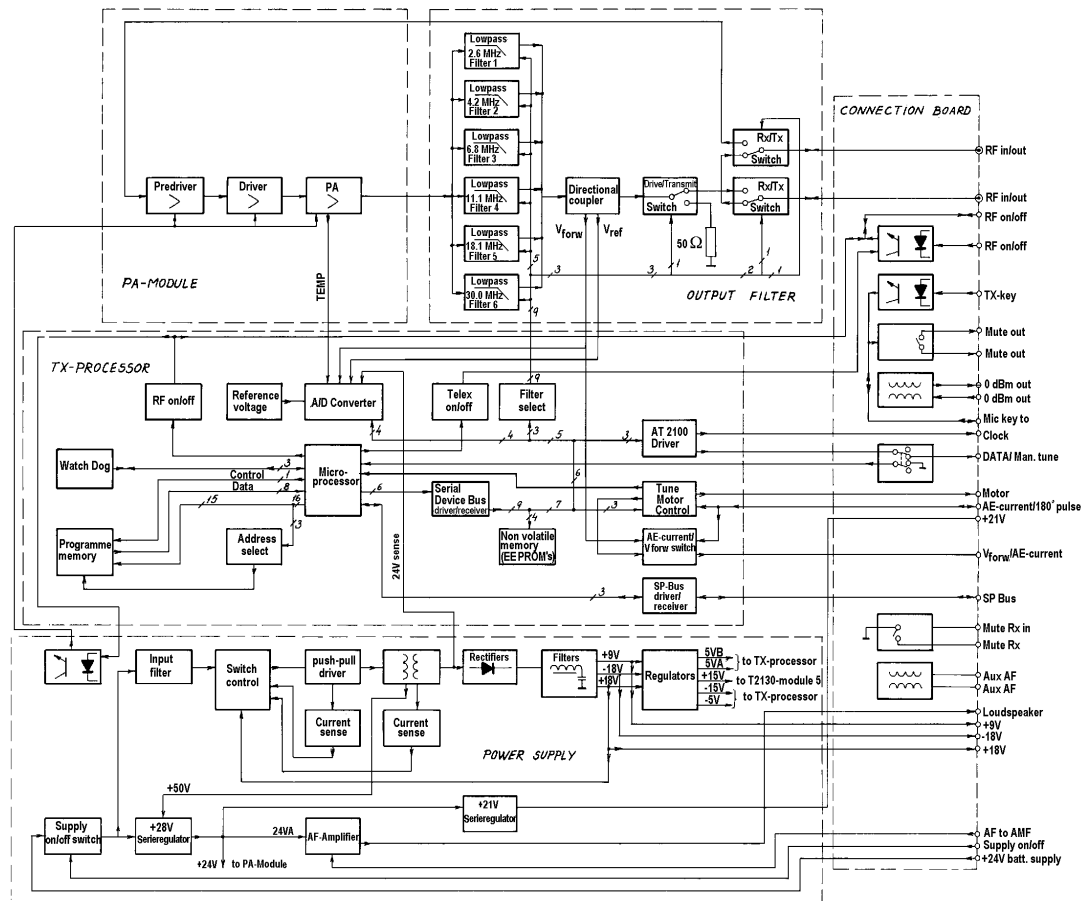


Fig. 2.20 250-W transmitter

The output filter.

The output filter consists of six low-pass filters, directional coupler (DC), tuning/transmission switch and transmission/reception switch. From the power amplifier the signal passes to a low-pass filter, which reduces all harmonics. Then the signal passes the directional coupler, which gives the information of the antenna tuning in resonance (standing wave ratio) with the transmitter processor. After passing DC the signal is fed to the transmission/reception switch. While pressing the button TUNE 50-Ohm artificial antenna is connected permitting to measure the output power and to avoid interference from other stations. After this switch the signal is fed to the transmission/reception switch. In the position "reception" the signal from ATU ??2110 or antenna passes to RE2100. In the position "transmission" the signal from RE2100 is fed to the power amplifier input, is amplified and through ATU ??2110 passes to the antenna.

The transmitter processor.

The processor controls the power amplifier, output filters, signal ATU ??2110 and connection with the processor RE2100.

The transmitter processor receives the information about the frequency and transmission/reception mode from RE2100 and indicates the information about tuning / readiness and the attenuator adjustment in RE2100.

During the adjustment the transmitter processor controls ATU, adjusting the antenna in resonance (minimum value of SWR).

While transmitting the transmitter processor checks the temperature of the transistor power amplifier, power supply voltage and SWR. Using this data, it calculates the maximum power and then, sends this information to RE2100, where the central processor selects the necessary attenuation value of the attenuator in an exciter

The power supply unit.

This unit consists of two power supply sources and audible amplifier.

The DC 24V voltage is fed to the relay at first, which applies the voltage to the power supply sources.

One power supply source will be used for obtaining voltages+ /18V and 9V for all small charging circuits in ?2130 and RE2100. Power supply voltage for the power amplifier and AFA is fed through the serial regulator, which limits the voltage up to 28V.

AFA increases a receiver output signal and sends it to the loudspeaker

The connection board.

The connection board serves for connecting ATU ??2110, control unit (exciter/receiver) RE2100, power supply source 24V and other devices. A galvanic uncoupling with the external equipment is carried out by means of transformers or optoelectronic couplers.

The transmitter ?2131 generates peak power at the output of 600 W and differs from ?2130 mainly by more powerful transistors and transformers in the power amplifier and power supply unit.

The transmitter ?2135 contains two power amplifiers of 600 W and power summing circuit permitting to obtain the transmitter output power 1200 W and to ensure mutual uncoupling of amplifiers.

If the transmitter is supposed to be used mainly at frequencies lower than 4 MHz, the entire antenna length of 12-14 meters for ?2130 and 15 meters for ?2131/35 is recommended.

If the transmitter operates generally at frequencies higher than 4 MHz, the whip antenna with the height of 8.5 meters is recommended.

Antenna-tuner unit(ATU).

The block-diagram of an antenna-tuner unit of Sailor2000 radio station is given in fig. 2.21.

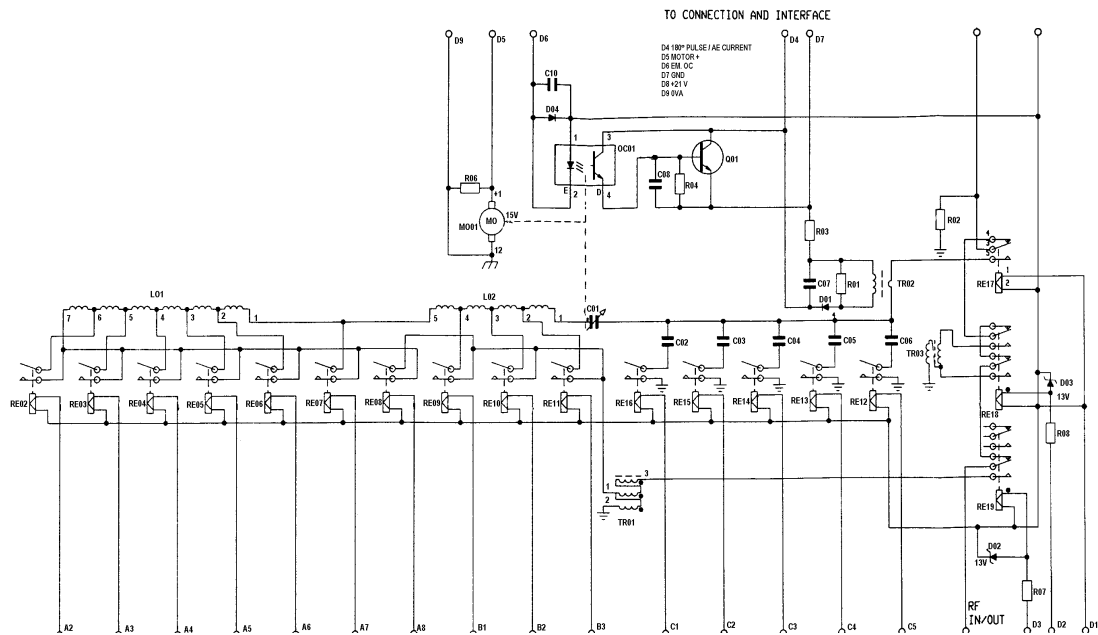


Fig. 2.21 Antenna-tuner Unit

The adjustment is performed by the microprocessor command placed in the transmitter, by means of a variable capacitor ?01, rotated by a motor. The microprocessor also sends commands to the relay RE02-16, commuting discrete reactive components (condensers and inductors).

The relay R17-19 will form the antenna switchboard, which can connect it to a transmitter output through ATU (while transmitting)), or to the receiver RE2100 through closed contacts of the relay, avoiding tuning elements (while receiving).

The block-diagram of MF/HF integrated radio installation capable of voice communication NBDP and DSC

MF/HF integrated radio installation capable of voice communication NBDP and DSC (STR2000 for example) consists of the control unit (Bridge Terminal), the antenna with ATU (is not given in fig. 22) and the main cabinet

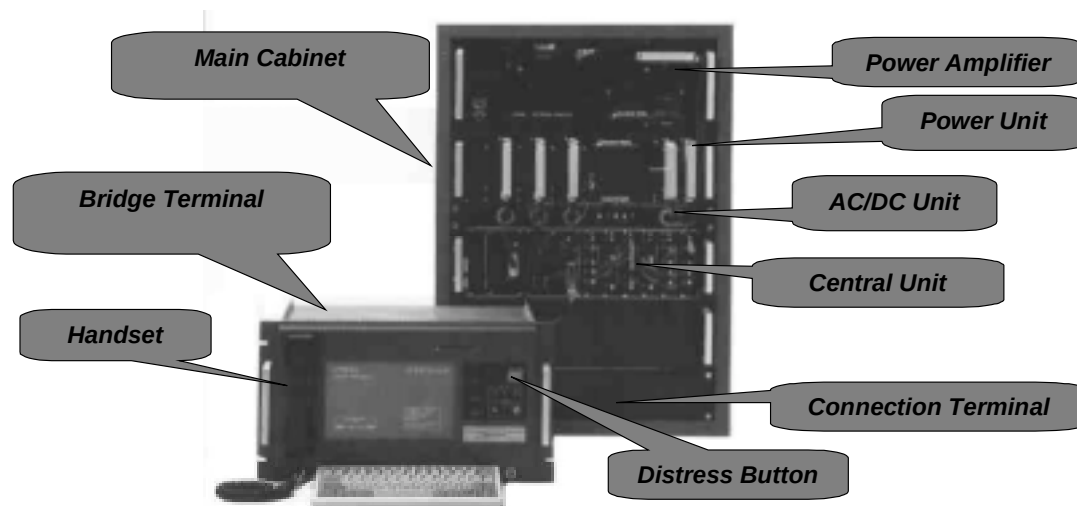
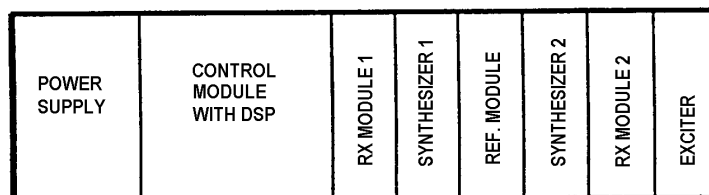


Fig. 2.22 MF/HF MF/HF integrated radio installation

including the transmitter power amplifier, transmitter power unit, AC/DC Unit, connection terminal and central unit (fig. 2.23).



The Fig. 2.23 Central unit

The central unit consists of an exciter; two receivers (RX Module 1, 2); two synthesizers (Synthesizer 1, 2); Reference frequency module; the control module with DSP; power supply unit.

The block- diagram of STR2000 is shown in fig.2.24, after which each unit is described in details.

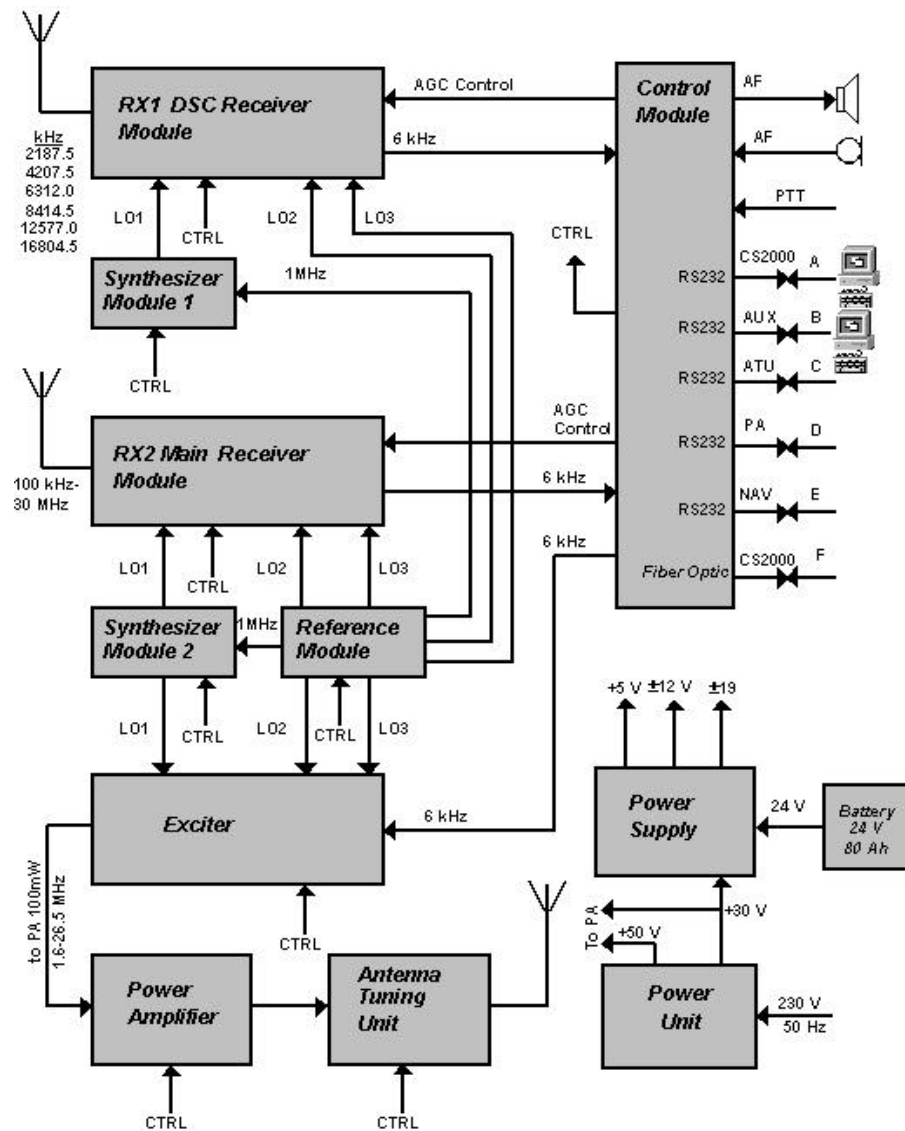


Fig. 2.24 Block- diagram of MF/HF integrated radio installation

Receivers.

The receiver RX1 is a DSC watch receiver. It continuously monitors DSC signals on 6 frequencies in a scanning mode. The receiver RX2 can receive DSC, NBDP, SSB and AM signals in the range of 0,1 - 30 MHz. The principal block-diagrams of receivers are absolutely identical, and their functions are determined by their place in the central unit.

From the antenna the signal is fed to a low-pass filter filtering interferences with frequencies higher than 30 MHz (fig. 2.25). The low-pass filter is followed by the attenuator activated automatically when the signal level in the antenna is + 10 dB/mW. The attenuator reduces the received signal for 20 dB. Besides, the receiver input is protected by the circuit based on the Zener diodes. After the software-controlled bandpass filter unit ensuring the main selectivity by the image channel, the signal is fed to a balanced diode mixer.

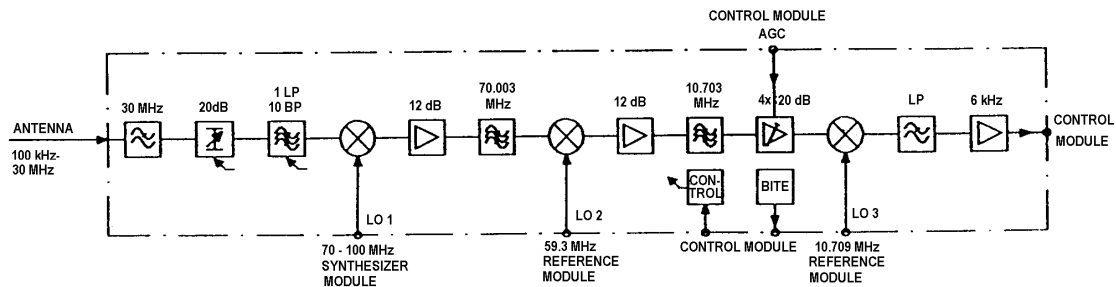


Fig. 2.25 The receiver unit RX1 or RX2

The frequency of the first local oscillator ranges from 70 up to 100 MHz. The first intermediate frequency is selected by the crystal filter 70,003 MHz. The 12 dB amplifier serves for compensation of losses in filters and mixer. The second mixer is based on the similar circuit. The second IF is selected by the crystal filter 10.703 MHz.

From the filter output the signal is fed to the second IF amplifier. The gain of this amplifier is adjusted by an AGC amplifier circuit, which changes the number of IFA stages, depending on a received signal level. The second IF will receive the maximum amplification when all four amplifiers ensure the total amplification of 80 dB (4x20). The automatic gain control system is controlled by the digital signal processor (DSP), located in the control unit.

After the amplification the second IF is fed to the 3-rd mixer, after which there is a low-pass filter selecting the third IF, equal to 6 kHz. This very low IF is due to the limitations, concerning further digital signal processing

For obtaining the second IF a heterodyne frequency 59,3 MHz is used, and the third - 10,709 MHz. The inversion of the spectrum sideband frequencies of a received signal, which has appeared during the first conversion, was compensated at the third conversion.

After the amplification the third IF signal is fed to the analog-digital converter (ADC) of the digital signal processor unit located in the control unit, where there is the main filtration by the adjacent-channel and demodulation.

Exciter.

The signal is fed to the exciter input from the control unit (fig. 2.26), where by means of digital signal processing method the single-sideband modulation of the auxiliary frequency 6 kHz is carried out by an audible signal obtained from the microphone, two-tone generator or frequency shift keying by using DSC and NBDP code.

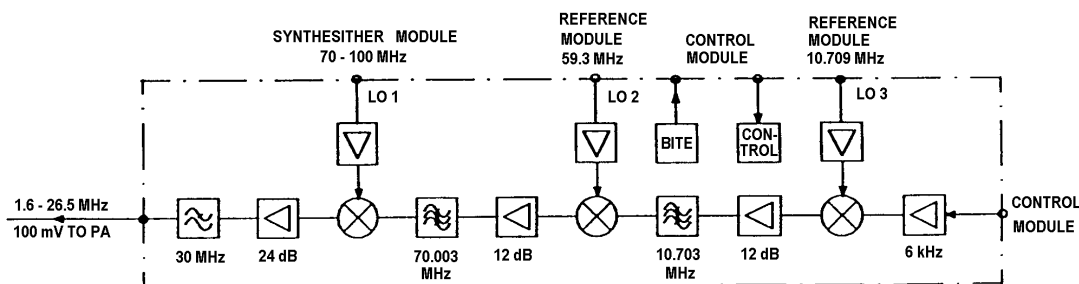


Fig. 2.26 Exciter

Digital filters effect the narrow-band filtering at all modulation types. After digital demodulation the signal is fed to the digital-analog converters (DAC1, DAC2) and AFA. Then AF voltage is passed to the loudspeaker and telephone output (TO), placed on the control panel.

In the transmission mode the voltage from the microphone passes to AF TX input of AF amplifier board (AF-1 Board), is amplified and fed to the multiplexer input (MUX). The multiplexer sends the audible modulating voltage to the analog-digital converter input (ADC-2) in a transmission mode or the 3-rd IF voltage- in the receiving mode. In an analog-digital converter the analog signal is converted into digital and is fed to DSP, where modulates sub-carrier 6 kHz. After the modulation in DSP the single-sideband signal in a digital form is fed to the analog-digital converter, is converted to an analog form and after the multiplexer is passed to the exciter input. The DSC and NBDP messages are fed to DSP from the control panel (computer) ?S2000 through port A, universal asynchronous transceiver and internal bus.

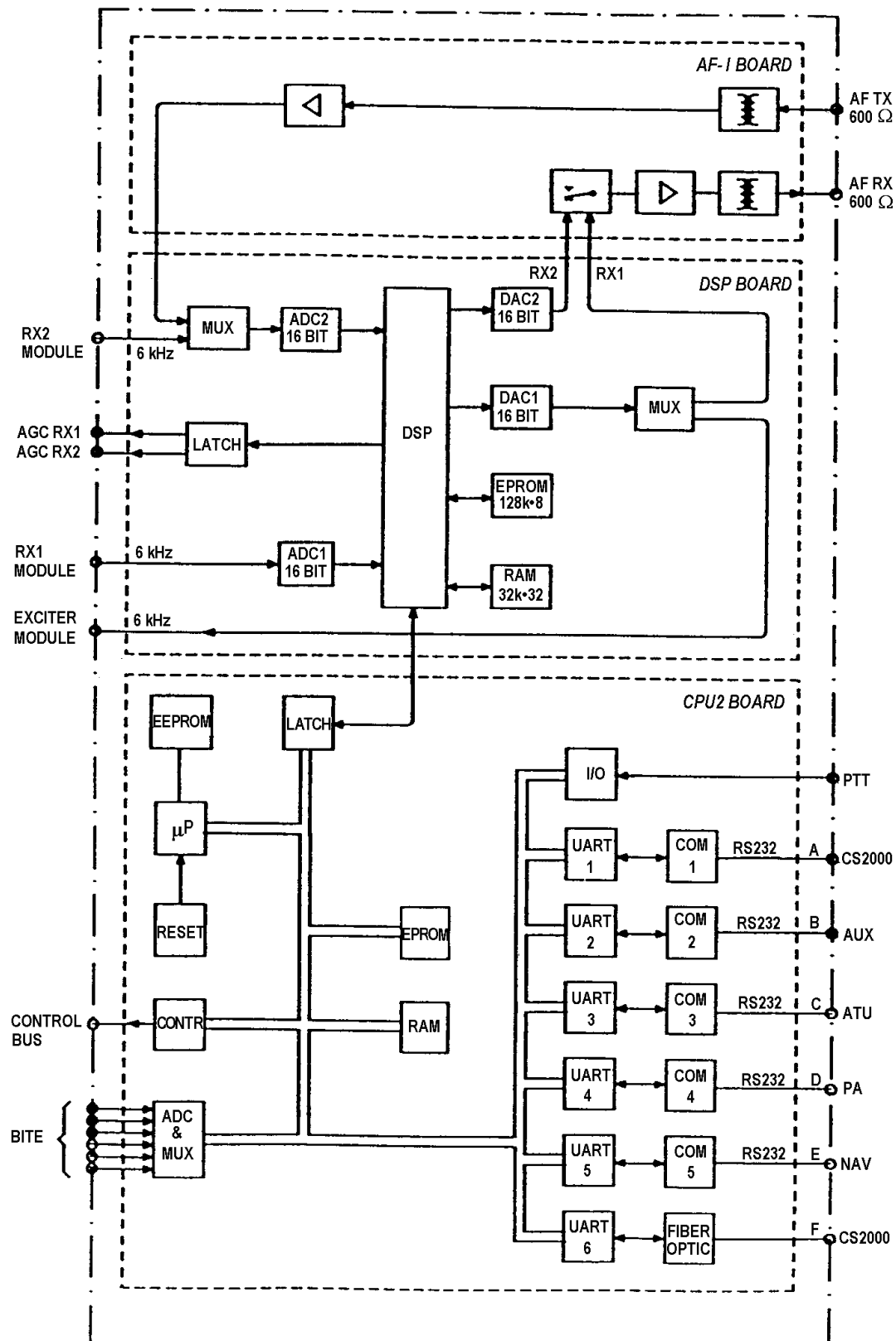


Fig. 2.28 Control unit

All devices included in the central unit, are controlled by the microprocessor through the high-speed internal data bus. The 8-bit microprocessor, Z8800 is with clock frequency 16 kHz. The program is recorded in EPROM of 64 ?. RAM - 32 ?. EEPROM stores all data entered by the user, for example, scanning tables, in case of power failure.

The control of external devices is performed by means of five communication ports (Com1-5), which are connected to the control unit (CS2000), antenna-tuning unit (ATU), and power amplifier (PA), GPS (NAV). The output AUX connects the auxiliary computer, from which direct printing communication and DSC can be performed.

Connection through ports COM1-5 is serial, asynchronous under the standard RS232.

Through port F it is possible to connect the control unit by means of optical fiber lines.

The power amplifier unit.

The 400W power amplifier unit (fig. 2.29) consists of PA Driver, PA Board, PA Filter and PA CPU 3, for control of all these units.

PA driver.

RF signal of 100 mW power is fed from an exciter to the 7 step attenuator with maximum attenuation of about 20 dB. While selecting the transmitter output power the operator programs the attenuation degree. After the attenuator the signal is passed to a two-stage, push-pull amplifier based on MOS-transistors, ensuring signal amplification for 13 dB. Maximum output power is about 2 W.

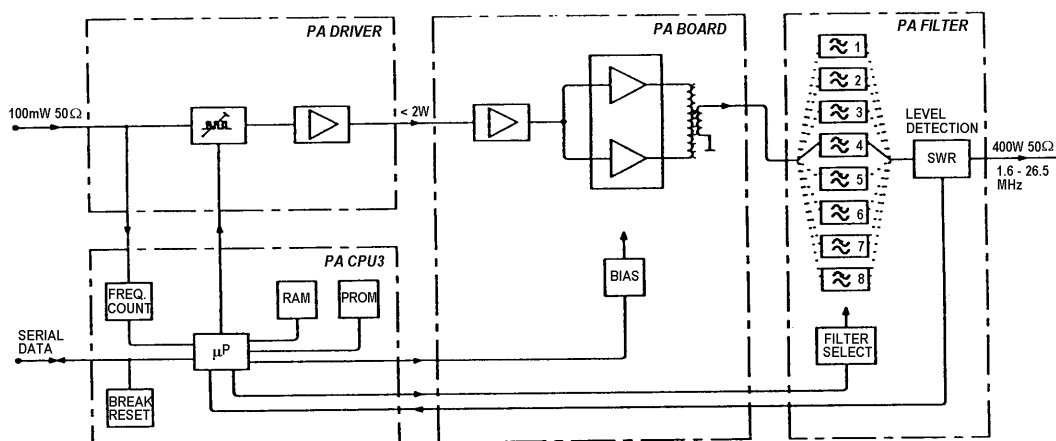


Fig. 2.29 The power amplifier unit

The power amplifier.

The power amplifier contains two stages based on a push-pull circuit on SWT. At the output stage two 250W transistors are used cooled by a heat sink and 4 fans.

Filter unit.

The filter unit serves for filtering the harmonics formed at the output stage, working as B class oscillations. It consists of eight low-pass filters. The standing wave ratio (SWR) is determined by means of SWR sensor, connected to a filter output. By using BITE the dropping and reflected power is determined by means of SWR sensor.

AM Processor unit CPU 3.

The data about frequency and output power is transmitted by means of the interface RS232 in the processor CPU2 of the control unit. The processor of the power amplifier (CPU3) determines frequency coming from an exciter compares it to the set-up frequency in the control unit and generates a command for the selection circuit of the filter. Depending on the emitted frequency the filter is selected. The bias voltage at the output stage transistors can be changed by the microprocessor command through the BIAS circuit. It occurs adjusting the radio station and in case of the antenna disadjustment by the SWR sensor. The microprocessor also adjusts the attenuation degree of excitation voltage passing to the PA driver by means of the attenuator, controlled by the pin-diode switches, connected to the data bus. Thus the change of the transmitter output power is achieved. The level of the output power is set by the operator in a window "Power Level".

The power unit.

The main power unit will convert alternating voltage 230V into direct voltage 50V for feeding the transmitter output stage and 30V for feeding the remaining circuits of the power amplifier, and other units, which obtain power from the batteries in case the ship's mains fails. The pulse power unit provides a power ratio of about 1.0 at any loads.

AC/DC Unit

Automatically connects batteries in case of the voltage loss 230V, 50 Hz. The power of the power amplifier output stage decreases up to 24V, that results in reduction of output power more than in 4 times.

Bridge terminal.

The bridge terminal CS2000 consists of the specialized computer supplied with the panel with the DSC distress alert button; light indication of DSC and ARQ received calls, condition of power sources, and also telephone handset and monitoring loudspeaker.

Antenna-tuning unit ATU.

The simplified block- diagram of a Scanti antenna-tuning unit, included in a STR2000 configuration is given in fig. 2.30. ATU contains the built-in processor and adjusts without using the radio station processor. Its connection requires power of + 24V, RXD lines and interface "Current Loop", TXD, coaxial cable, by which RF oscillation are fed from the power amplifier.

The initial adjustment is performed by means of a reduced emitted power in a tuning mode TUNE.



In this case the antenna feeds through the -35 dB directional coupler, and there is no voltage at its output while tuning in a resonance. If during the operation the antenna parameters vary, at the directional coupler output the voltage will appear, the value

and polarity, which depends on the detuning degree. This voltage is fed to the microprocessor, which will select inductor bank, until the resonance is restored.

The antenna tuning is also controlled by means of current and voltage sensors at different feeding circuits.

The antenna-tuning unit can also contain antenna switchboard and an artificial antenna (they are not given in the block-diagram).

Manual antenna tuning. If the microprocessor fails the antenna-tuning unit should adjust the antenna to frequency 2182 kHz. For this purpose the station is automatically adjusted and by means of switches S1-S4 (fig. 2.31) the relay condition is stored, which is indicated by light emitting diodes. If the auto tuning fails, ATU can be adjusted to frequency 2182 kHz while changing switches S5 to the position " 2182 kHz ". At the DSC transmission frequency 2187.5 kHz the resonance will not be kept, but there will be the emission. The preparation for manual tuning is carried out as follows:

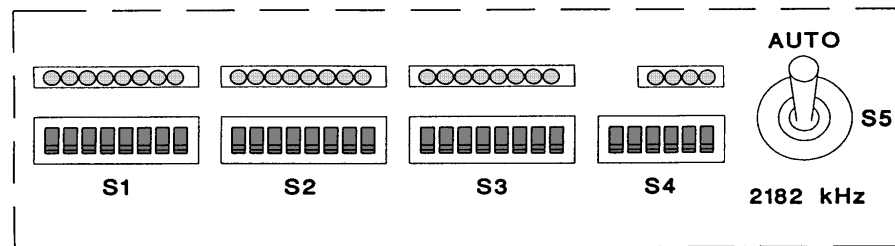


Fig. 2.31 Manual Tuning

1. S5 is set in the position AUTO;
2. The transmitter is adjusted to frequency 2182 kHz;
3. Switches S1- S4 are set in position ON, if it is illuminated by an indicator, otherwise - OFF;
4. At switching S5 to the position " 2182 kHz " ATU will be adjusted to frequency 2182 kHz, while using the same antenna.

Thus, it is possible to tune ATU manually to other frequencies by composing the tuning table but it is, on the one hand, tiresome, and on the other hand, if the tuning unit is established on upper deck, close to the antenna, and is hermetically closed, I

2.4. Ship Earth Stations Inmarsat -C

The characteristics of the ship earth stations should meet the requirements of Inmarsat system and the IMO requirements, given in Resolution 7.807 (19).

Despite a great number of station designations the most of them use the same software and hardware.

The comparative characteristics of some marine stations of Inmarsat - C are given in tab. 2.4.

Tab. 2.4 Characteristic of ship earth stations of Inmarsat – C

The manufactures	1. Thrane & Thrane Philips, 2. MTL, 3. Sailor	1. Trimble, 2. Marconi, 3. Scanti	JRC	SEA
The station type	1. ? -3020? Safecom ?? /2, 2. Mascot-C, 3. ? 2095?	1. Galaxy, 2. Orcades, 3. Scansat CG	JUE-75C	SEASAT 2
Working frequencies, MHz reception: transmission GPS:	1530,0-1545,0 1626,5-1646,5 1575,42			
Frequency spacing, kHz	5			
Data transmission speed	600 bits / s			
Modulation type	BPSK at a speed of 1200 Bauds			
Number of channels GPS	5	8	...	...
The terminal interface	Serial CCITT Rec. V.24/28, (RS-232C)			
The printer interface	Centronics	RS-232? (600)	Centronics	
Power supply voltage, V	10 - 32	9,6 -31,2	12 - 24	9,5 – 32
Power consumption (reception / transmission), W	9,5 / 80	12 / 110	10/100	9,5 / 80
Working temperature range	station:-25° up to 55°C antenna:-35° up to 55° C			
Transceiver dimensions, mm	62? 214? 279	60? 215? 245	50? 210? 280	65,9? 213,9? 278
Weight, kg	3,2	2,9	4	3,2
The antenna	Omni-directional with right circular polarization			
Dimensions (diameter X height), mm	124? 150 (237? 150)	170? 187	450? 110	130? 150 (237? 150)
Weight, kg	0,75 (2,2)	2,0	4	0,75 (2,0)
Antenna cable length, m	Up to 100	Up to 30	Up to 100	

SES Inmarsat -C consists of the antenna unit, transceiver, signalling unit system with a separate distress button, specialized computer with the printer and power unit. Additionally, the station can contain a remote alarm with the built-in printer for printing the EGC - messages.

The transceiver and computer obtain continuous power from batteries or separate power unit converting ship's mains voltage to the direct current voltage 24V. The antenna unit is fed from the transceiver by a coaxial cable together with RF signal.

The printer can be connected directly to the transceiver or to the computer. The GPS receiver can be contained into the transceiver as a separate circuit board.

The information about the hardware of satellite stations can be received (for example) from STR1500 SES (fig. 2.32), using the Thrane & Thrane software.



Fig. 2.32 SES INMARSAT-C

The transceiver configuration

Except the computer and printer connected through the conventional interface of Centronics -type(fig.2.33), to the transceiver it is possible to connect the external devices through port ?5 .

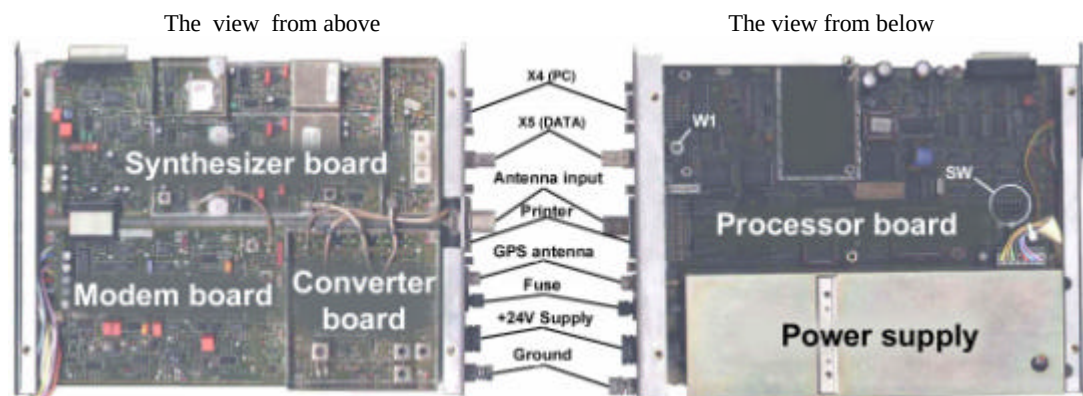


Fig. 2.33 The transceiver configuration

The external receiver GPS tuned to the transmission of the navigational data in the NMEA0183 format, using interface RS-232, is connected to the port ?5 by a coaxial cable with a standard bayonet socket. The switches 1 and 3 of the switch unit SW on a processor board should be set in position OFF.

Data transmission from the built-in receiver GPS to the external devices. If there is a receiver GPS, placed in a processor unit, its data in the NMEA0183 format can be sent to the external devices, for example DSC receivers. For this purpose switch 1 of a switching unit (SW) in a processor board (fig. 2.33) should be in position OFF, and switch 3 - ON. The data is sent through the port ?5 in the form of bipolar pulses (RS-232), if the jumper W1 is connected, and in the form of unipolar pulses, if it is disconnected.

The switching of the port X5 in the communication mode by Tbus. If the switch 1 is set in position ON, it is possible to connect external alarms with EGC printers having their own T-bus address from 0 up to 7 to the port ?5 8.

Block-diagram

The antenna unit.

The antenna unit (fig.2.34) contains a corkscrew antenna, low-noise amplifier (LNA), power amplifier (PA) and duplexer. In the receiving mode the current consumption is about 0,1A and in a transmission mode - 2-3?.

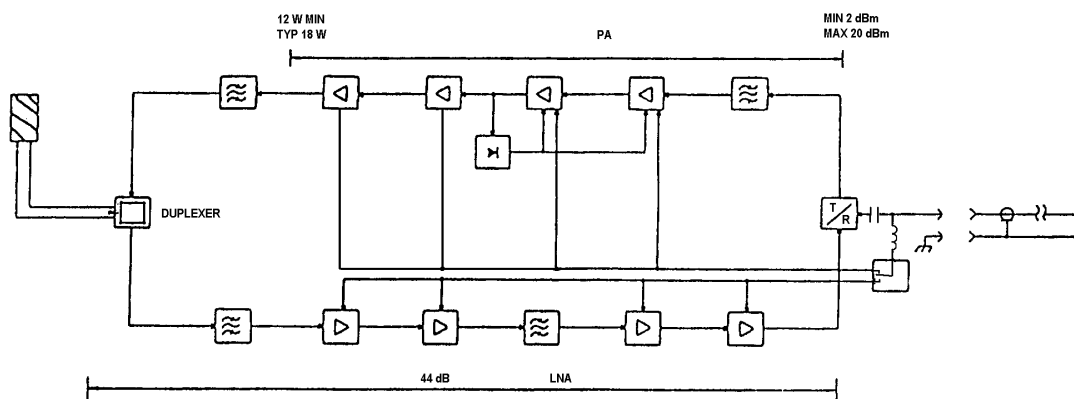


Fig. 2.34 The antenna unit block-diagram

The RF voltage value coming from the transceiver to the antenna unit depends on the cable length, therefore for maintaining the constant output power the power amplifier is enveloped by the AGC power circuit.

The duplexer acts as a bandpass filter system tuned to the reception and transmission frequency bands (duplex filters) and allows switching of the antenna from reception to transmission without using the antenna relay.

It is necessary to take into account, that some antenna types limit information capacity transmitted by the station. It is explained by their design not permitting to cool the power amplifier transistors effectively. Because of it the time of continuous transmission, as well as capacity of the transmitted information is limited.

The antenna unit design is not practically dismountable and the unit should be exchanged if it is out of order.

The transceiver.

The transceiver (fig. 2.35) consists of a synthesizer unit, converter unit and modem, processor unit and power unit.

Frequency synthesizers are digital with PLL. The reference oscillator frequency (Master OSC) is crystal-controlled and is tuned to a received signal.

The first synthesizer generates frequency in the range of 1626,5-1646,5 MHz depending on the communication channel. This frequency is used as carrier, which is modulated in the BPSK unit (PSK MOD), pre-amplified by a two-stage amplifier (TX - DRIVER) and is fed to the antenna unit.

In addition, the same frequency is fed to the first mixer as the first local oscillator frequency (1LO). The 2-nd and 3-rd local oscillator frequencies are fixed: 2LO = 80.1 MHz, 3LO = 21.5 MHz.

After triple conversion the received signal spectrum is selected by the bandpass filter, tuned to 100 kHz, and is fed to the carrier recovery loop circuit. This circuit for monitoring the second harmonic offered by D.Kostas (USA) allows to receive highly stable frequency 100 kHz, which will be used then for RO frequency tuning and demodulation.

The data recovery loop circuit ensures BPSK- signal demodulation, after which the data is converted into a digital form in an analog-digital converter (ADC) and is fed to a processor unit.

The Viterbi decoder, which algorithm is recorded in ROM, ensures the increase of the received information reliability, which is encoded by a cyclic code at the transmitting end. The central processor under the program stored in a ROM controls the transceiver. There is also re-programmable ROM for storing a serial number, access codes in an Inmarsat -C system, station identifier (IMN), the user settings etc. Some of this data can be changed in shipboard conditions.

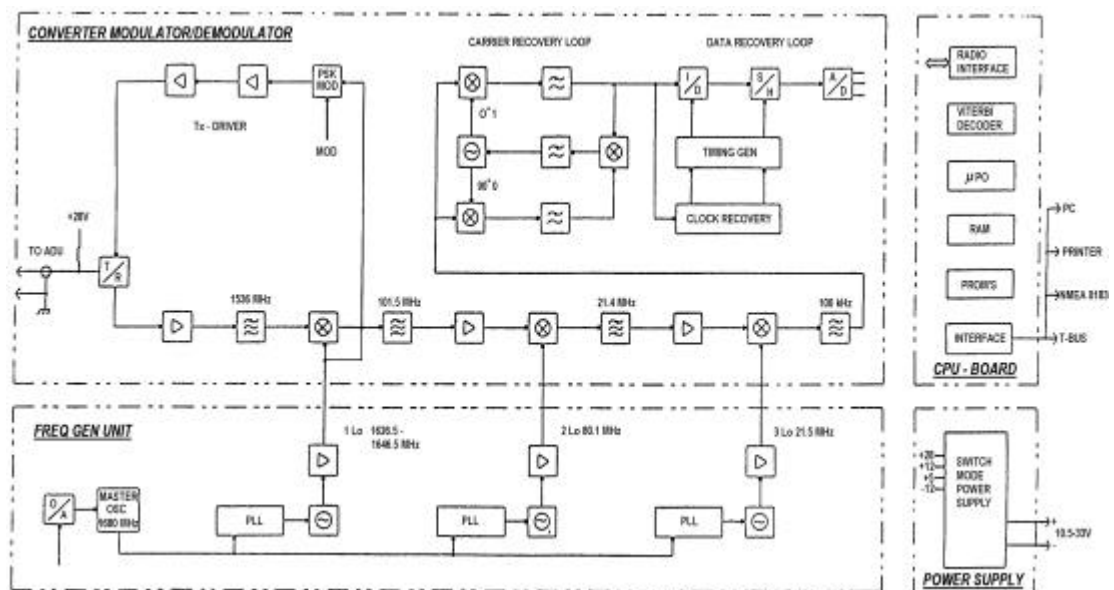


Fig. 2.35 The transceiver block-diagram

The transceiver is controlled by the computer, connected to standard port RS-232, placed on a rear panel (?4).

2.5. GMDSS Shipboard radio equipment control

For the satellite shipboard equipment and MF/HF radio installation control the specialized computers with the appropriate software are used.

The serial interface is used for connection with the radio equipment.

Specialized computers



Fig. 2.36 Specialized computer

The specialized computers are designed as a single-board, combined in one cabinet with the liquid-crystal or electro-luminescent monitor (fig. 2.36). In the same cabinet the radio-telex modem and sometimes the satellite station transceiver (fig. 2.43) can be housed.

The main characteristics of specialized computers used in the GMDSS shipboard equipment are given in tab. 2.5.

Tab. 2.5 the Main characteristics of specialized computers

	PC9000	PC H1640	CS2000
Power supply voltage:	10.8-31.2 1V (battery 12 or 24 V)		
Power consumption, W	45	20	...
Processor type:	INTEL 80386 SX 33 ? ? ? ??? 80486 SLX 33 ? ? ?	486DX2 - 40 ? ? ?	INTEL 80386 SX
RAM capacity:	4 Mbytes	4 Mbytes	2 Mbytes
External memory stores:	ROM with MS-DOS, SCANSAT-CG (Inmarsat - C) or SCANCOMM (radiotelex)	ROM with MS-DOS, Capsat (Inmarsat - C)) or radiotelex	Hard disk ST 3290 with MS-DOS STR1500 (Inmarsat - c)) or STR2000 (radiotelex)
	3 5 " a diskette of 1.44 Mbytes		
	The installation of the hard disk is possible.		
Interfaces:	Parallel, for the dot-matrix printer connection		

	Two serial, RS-232	
	Connection of the PC/AT-compatible keyboard	
	CRT display connection	
The display:	Monochrome VGA, LCD with illumination	Electroluminescent

The majority of specialized computers controlling GMDSS shipboard equipment has much in common, and are described taking PC9000 and SC2000 as examples.

The PC9000 block-diagram

The specialized computer a PC 9000 consists of 3 parts: PCU (PCU9000) unit, keyboard (KBU 9000) and printer (PRN 9000). The keyboard and printer are conventional.

The PCU 9000 block-diagram (fig. 2.37) consists of mother (system) board (ISA Bus Board), processor board (CPU Board), display controller board, LCD display, solid-state disk, floppy disk drive (FDD) and DC power supply unit.

While using PC as the radiotelex terminal, it is added by radio telex modem board.

The connection of the hard disk drive (HDD) is also possible. The boards, which designation includes the number (for example, RTM986) are designed by Scanti especially for PC 9000, the rest are conventional.

The system board.

The ISA Bus Board 980 controls internal communication and interfaces with other external devices through interruptions.

As in any microprocessor system a bus is called lines of data exchange between its parts in the computer. These lines are divided into 3 types:

- The address bus,
- The data bus,
- The control bus

The data bus serves for data exchange between the central processor unit CPU, extension board placed in special slots and memory. Through the direct memory access controller (DMA) there is a data transmission control avoiding CPU.

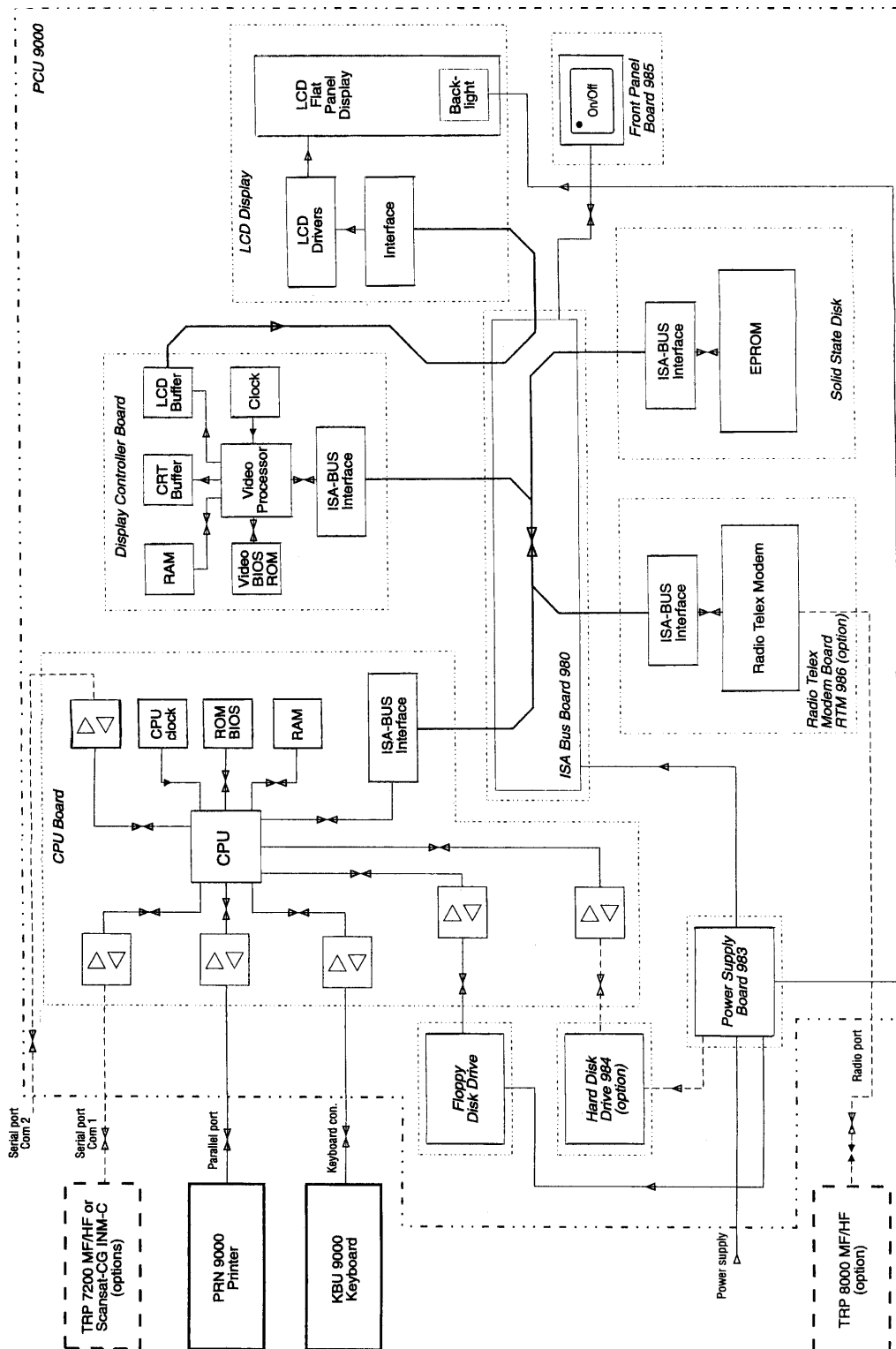


Fig. 2.37 Specialized computer block-diagram

The address bus serves for indicating the memory cell address, in which data should be stored. The memory capacity, which CPU can use, depends on the order of the address bus and is equal to 2^n ; where n is the number of lines in the address bus.

The control bus.

The controller bus called the control bus or the system bus performs the control of data transmission or their temporary accommodation. As the system board terminals the extension slots that contain extension boards (graphic adapter, serial and parallel interfaces etc.) can be used and thus are connected to the bus.

The ISA bus (Industry Standard Architecture) is used not only for household, but also for industrial computers, used in GMDSS shipboard equipment. The main disadvantage of the ISA bus is that the data transmission speed is less than the speed of their processing in the processor. In the GMDSS equipment the data processing speed is provided by the ISA bus, its detailed description is given in Module 9.

Processor board.

The processor board includes the microprocessor, floppy disc drive controller, hard disk controller, parallel port, two serial ports, keyboard interface and RAM. The external connection of FDD, ? DD and a printer with a parallel interface is ensured.

The RAM - dynamic (DRAM), consists of 4 SIMM-modules, each is based on the board with 30 contacts. The contacts are made by a printed way and are at one board end. By this end the SIMM-modules are fit in special slots in a processor board. Due to this design an electrical contact reliability and module mechanical strength is improved in the connector (all contacts are gold plated). Total RAM capacity is 4 Mbytes.

The microprocessor board was designed for the processor 80286/16, and then is improved for the processor 80386/33.

The solid-state disk.

This memory store, which is used instead of the hard disk drive, is intended for the program storage. For changing the program it is necessary to exchange ROM. The advantage of this disk is smaller sensitivity to vibration and low temperatures, than in FDD and HDD. The diskette is used for recording the information in computers with the solid-state disk.

The display controller board.

The board is placed in the system board, and is connected to the liquid-crystal display by an internal flat cable through the 26-contact connector.

The display controller can also ensure an information output on the cathode-ray tube display, connected to the PC connector by the external cable.

The LCD display. It is a flat LCD-screen placed on the front panel and connected to a display controller by a flat cable through the system board. Separate conductors connect this board with the power unit.

The power supply board.

It generates different voltages for all parts of the computer, receiving them by means of a pulse converter from input voltage 10,8 - 31,2?.

The radiotelex modem (RTM 986).

It is connected if the computer is used for a narrow-band direct printing communication through MF/HF radio station by means of the program SCANCOMMTM. The modem board is placed into the connector OPTION of the computer system board and is connected to the control unit of MF/HF transceiver TRP 8000 by a 25-contact connector of the interface RADIO.

Serial interfaces

In the microprocessor technology the term interface means a way of connecting microprocessor systems and external devices.

This concept includes:

- The transmitted signal type (digital or analog);
- Transmission type (bit behind bit in series or some bits in parallel);
- The purpose and use of different signals for traffic control;
- Voltage or current levels corresponding to signal values;
- Connector design and connecting cable circuits;

In most cases all these requirements are standardized, that allows easily to connect different purpose devices to the computer.

For the description of interface, designations DTE and DCE are used.

DTE (Data Terminal Equipment) is a device, which has data access from other similar devices and process it. The second associating device is also DTE. If they cannot be directly connected with each other by cable, called “zero - modem”, the long communication line is required, then the device ensuring interface with this line will be used. Such device is called DCE (Data Communication Equipment).

The interface RS-232 (V.24/V.28)

The standard RS-232 was designed in 1969 by a number of large industrial corporations and is published by the USA Electronic Industries Association — EIA as version “1” of the recommended standard number 232 for connection of the computers and different serial peripherals.

The ITU-T will use the similar recommendations designated as V.24 and V.28.

The recommendation V.24 contains the description of lines and set-up of traffic signals between DTE and DCE. In RS-232 other line designations will be used, however the interface lines RS-232 and the recommendation V.24 perform completely identical functions. V.24 determines more lines than RS-232, as the standard V.24 is also used in other interfaces. The recommendation V.24 does not determine the electrical characteristics, the connector type, and contact arrangement, cable length and traffic speed.

The technical problems of the interface are described in the standard V.28.

The recommendation V.28 determines the electrical characteristics of the interface V.24, ensuring the operation on asymmetrical bipolar communication lines at the speed of up to 20 Kb/s. These characteristics include the used signal level,

capacitance etc. The recommendation does not contain the requirements to the cable length, connector type and their contact arrangement.

The standard RS-232 generally describes four functions:

- Definition of control signals through the interface;
- Definition of the user data format transmitted through the interface;
- Transmission of timing signals for synchronization of the data flow;
- Formation of the interface electrical characteristics.

The interface signal. The interface RS-232 is a serial asynchronous interface. The serial transmission means, that the data is transmitted on one line. For synchronization the data bits will be preceded by special start bit, data bits are followed by the parity bit (parity check) and one or two stop bits. Such group of bits together with the start and stop bit, as well as a parity bit is called a start-stop character.

Each start-stop character, as a rule, contains one information character. For example, the American Standard Code for Information Interchange (ASCII) character is represented by seven bits (code of the Latin letter A, for example, 1000001). For transmission the characters through interface RS-232 the most useful is the format consisting of start bit, one parity bit and two stop bits.

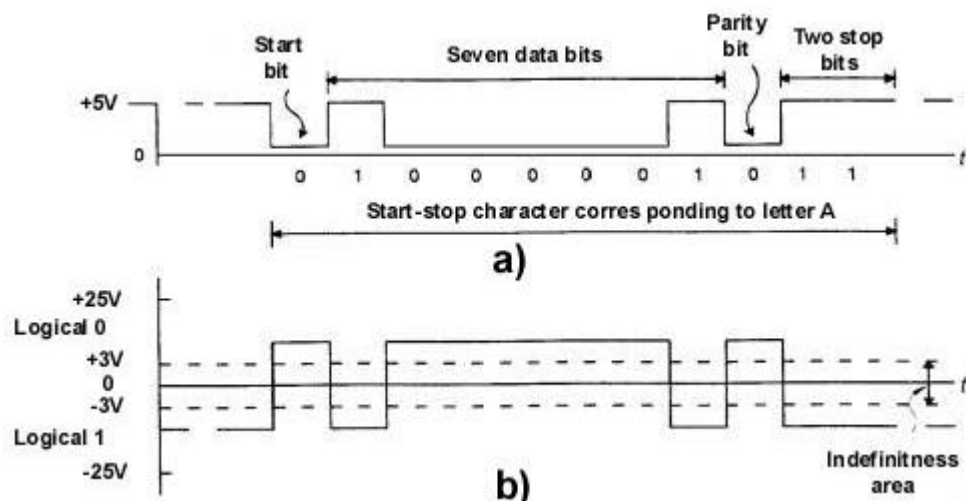


Fig. 2.38 The letter A code representation.

The signal with levels of TTL while transmitting the Latin letter A is shown in a fig. 2.38a. The beginning of an asynchronous character always marks the low level of a start bit. 7-bit data character of code ASCII follows after it. The parity bit is set at "1" or "0" so that the total number of units in 8 bit group was odd parity or even parity. Two stop bits, represented by the voltage high level, are transmitted the last.

The national codes are often used, which include 128 standard ASCII-characters and additionally 128 characters with "1" in the top bit. Among additional characters the letters of some European and Greek alphabets, mathematical characters and characters of the pseudo-drawings are used.

Thus, the total asynchronously transmitted data character consists of 10 — 11 bits, though the user's data consists of 7 — 8 bits. For this example the start-stop character

corresponding to the Latin character A consists of 11 bits and is recorded as 01000001011. Even parity is used here; therefore the ninth bit contains 0.

The signal levels used in the interface RS-232 differ from the levels, which are used in the modem or the computer. Logical 0 (SPACE) is represented by the positive voltage within the range from + 3 up to + 25V, and logical 1 (MARK) — negative voltage within range from — 3 up to — 25V. Fig. 2.38b, shows the asynchronous signal for the letter A as it is represented in lines TxD or RxD of the interface RS-232.

The interface lines.

It is possible to divide all lines of signal exchange between DTE and DCE, determined by the standard RS-232, into four main groups:

- Data lines
- Control lines
- Synchronization lines
- Signalling lines and "ground".

The electrical characteristics.

Logical 1 in circuits RXD and TXD usually corresponds to the voltage from -3 up to -12 V and logical 0 — to the same voltage of positive polarity (+ 3... + 12 V). Sometimes these conditions similar to the telegraphic equipment are called as "button-pressing" (MARK) and "button release" (SPACE). For the remaining circuits the positive voltage corresponds to the switched-on condition and the negative voltage – to the switched off condition. The load resistance of every circuit at the direct current should not be less than 3 kOhm.

In the spaces of word (bytes) transmission in a line the level of logical 1 is supported. The transmission starts with the start bit always having a logical 0 level. This bit serves for activating the receiver, which on detecting it starts the time period readout assigned for each subsequent bit, and at he certain moments fixes their values. The information bits follow, in turn, the start bit. They can be followed by the check bit. If the parity check is switched - off, the check bit is not transmitted.

The transmission is finished by stop bits, the first of which stops the receiver operation, and moves to the stand-by mode for the next start bit. The stop bits always have the level of logical 1.

All the described operations in computers are carried out by special microcircuits - controllers of a serial interface and do not require the use of the main processor in a transmission and reception mode. Its task is to tune the controller to the set traffic mode, to load data for the transmission and reading of the received data.

The communication through the interface RS-232C can be conducted not only at different speeds, but also with different number of formation and stop bits in a word, with different ways of parity check. There are no generally accepted standards here. For this reason it is necessary to take care for all recommendations of the interface tuning included in the manuals of certain devices and software.

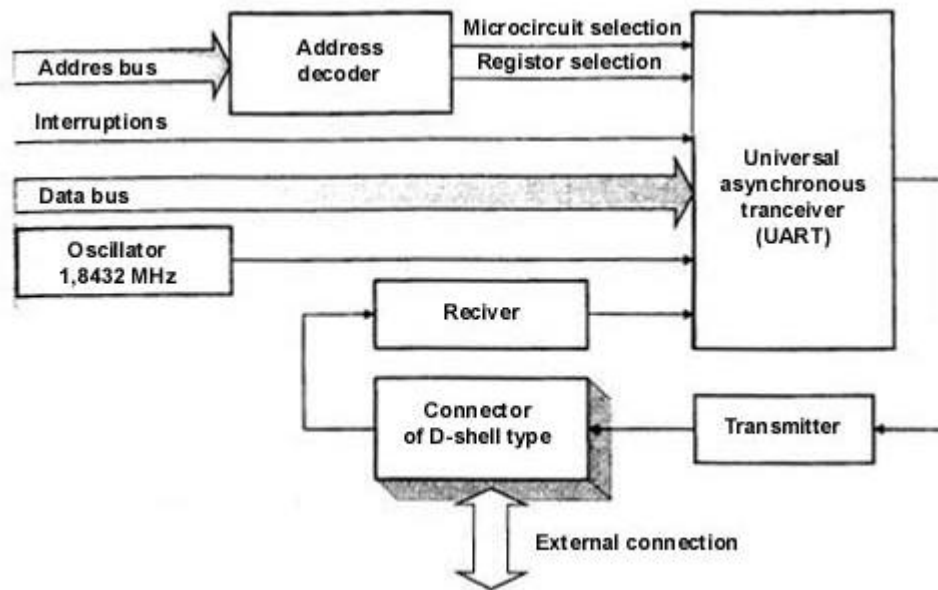


Fig. 2.39 The adapter RS232 block-diagram

Hardware realization.

The interface RS-232 includes the serial adapter and plug contacts.

The adapter.

The adapter serves for a data conversion from the parallel form to serial in the ASCII format, and for matching the levels of electrical signals of TTL with the level of the interface RS-232. The block-diagram of a typical adapter version of a serial port RS-232 is given in fig. 2.39.

Connectors.

The asynchronous serial port is connected to external devices through special connectors. There are two standards for the connectors of the interface RS-232 — these are DB-25 and DB-9. The first has 25, and second — 9 contacts.

The general view of connectors DB-25 and DB-9, used in the interface RS-232 is given in fig. 2.40. (M character means “Male”, and F = “Female”).

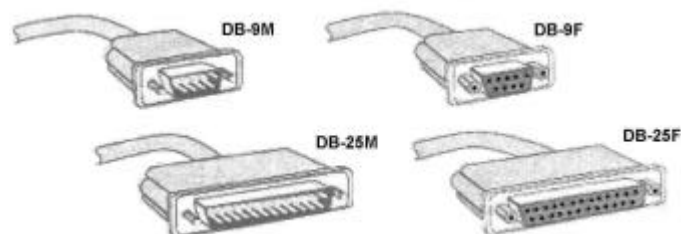


Fig. 2.40 General View of connectors DB-25 and DB-9

Connections by the interface RS-232.

Devices DTE and DCE use the inputs TxD and RxD differently. The device DTE uses line TxD for data transmission, and line RxD — for data reception. And vice versa, the device DCE uses line TxD for reception, and line RxD — for data

transmission. Therefore the terminal device and data transmission device are connected directly, as shown in fig. 2.41 (for DB-25).

The computer is connected by the female part of the connector (DB-9F, DB-25F), and the modem or transceiver (DCE) - by the male part (DB-9M, DB-25M).

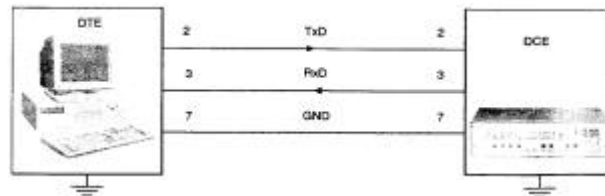


Fig. 2.41 Connection of DTE to DCE

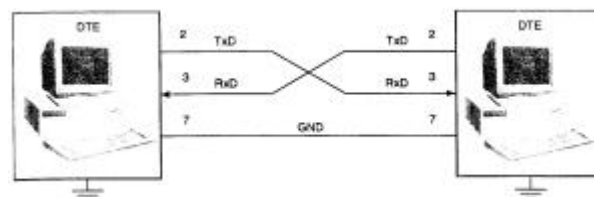


Fig. 2.42 Connection of DTE to DTE

If it is required to connect two computers with each other, it is necessary to make a cross connection of lines TxD and RxD, as shown in fig. 2.42.

But it can be insufficient, since the DTE and DCE functions performed by the lines DSR, DTR, DCD, CTS and RTS, are asymmetric. The device transmits the DTR signal and waits for the reception of the DSR and DCD signals. DCE transmits DSR signals; DCD waits for reception of a DTR signal. Thus, if two DTE devices are connected asymmetrically, they cannot acknowledge communication.

For solving these problems while connecting two devices of a DTE type the special cable called zero - modem is used, as it simulate the modem.

The comparative characteristics of RS-interfaces

The standard RS-232 does not always meets the requirements to the speed and transmission range at present. It explains the appearance of other interfaces.

The standard configuration of the IBM compatible computer permits its connection with external devices through two communication ports based on the standard RS-232C. It is sufficient for the computer, to which only "mouse" and modem are connected. But if the PC is the base of information control system and should be connected to the most of sensors, the equipment controllers and actuators with the ports, which do not ensure the necessary quality and communication range. Their incorrect usage becomes the reason of the computer failure. The alternative standards of a serial interface are designed for the connection of the computer with the remote equipment, their characteristics are given in tab. 2.6.

Tab. 2.6 The Comparative characteristics of RS-interfaces

Parameter	Value according to the specification			
	RS-422	RS-485	RS-423	RS-232
Type of communication line	Symmetrical	Symmetrical	Asymmetric al.	Asymmetrical.
Transmitter output voltage without load, V	± 10	$\pm(1,5...6)$	$\pm(4...6)$	$\pm(5...25)$
Transmitter output voltage with load, V	± 2 ($R? = 100 \text{ Ohm}$)	$\pm (1,5... 5)$ ($R? = 54 \text{ Ohm}$)	$(3,6... 6)$ ($R? = 450 \text{ Ohm}$)	$\pm (5... 15)$ ($R? = 3... 7 ?0?$)
Short-circuit current of any output in common wire, mA	? 150	? 250	? 150	? 500
Inphase voltage at the transmitter output, V	± 3	$-1...+3$	–	–
Transmitter output resistance, Ohm	100		50	300
The receiver input resistance, kOhm	? 4	? 12	? 4	3...7
Receiver sensitivity, V	$\pm 0,2$	$\pm 0,2$	$\pm 0,2$	± 3
Inphase voltage at the receiver input, V	± 7	$-7...+12$	–	–
Maximum load capacitance. Bandpass filter				2500
Adjustment time of the transmitter output signal, % bit duration	? 10	? 30	= 30, but not more than 300 ?s	= 30 V/?s (speed of increase)

The serial port RS-232C has two disadvantages limiting the distance and quality of communication:

- The asymmetric and mismatching communication line is badly protected from interference and distorts transmitted signals.
- The common lead of all port circuits is electrically connected to the computer body, therefore while connecting it to the distant devices the spurious currents can flow in it causing not only interferences, but can also damage the computer.

All these disadvantages are eliminated in communication interfaces, which information and control circuits are symmetrical and insulated (galvanic uncoupling) from bodies and all other circuits of the connected devices.

It is possible to ensure a galvanic uncoupling of information circuits by means of transformers or optrons, but the requirements to the characteristics of these transformers are rather high, as they should transmit broadband pulse signals with small distortions. Besides, the transformer does not pass constant signal component, therefore it is necessary to use codes containing the equal number of pulses of positive and negative polarity. The optron decoupling does not require special data coding, but there should be a separate power source of formers and receivers of information and control signals insulated from the computer common lead.

RS-422

RS-422 — Balanced serial interface, i.e. each signal of TxD and RxD is represented by two signalling lines, which conduct paraphase voltage, as well as ground signal (they form a screened twisted pair).

The signalling lines are called A (negative) and B (positive). The voltage difference between them is used for the binary information transmission. If B is more than A the signal is logical 1, if A is more than B, the signal is logical zero.

To determine, which of the signalling lines are A or B, its voltage can be measured while there is no data exchange: the positive values of line B should be higher than of line A.

At the maximum distance of 1200 meters the transmission speed is 100 Kb/s. The maximum transmission speed of 1.0 Mb/s is achieved at the distance of 12 meters.

RS-485

RS-485 in comparison with RS-422 allows to use one pair of wires for the information transmission, that reduces the overall cost of a communication system at large distances. Besides, it supports multipoint connection — it is determined by insufficient difference of input and output stage circuit theory.

In comparison with RS-232C, used for data transmission only between two subscribers, the high input resistance of receivers RS-422/485 enables to connect up to 32 subscribers to the same line of length not more than 1200 m. The special devices (repeaters) allows to integrate up to four these segments, resulting in distance increase up to 4800 m, and subscriber numbers — up to 128.

There are no problems, if only one of the subscribers, integrated by interface RS-485 (for example, the control computer), has the right to transmit the data, and the others only receive it. The situation is complicated when any subscriber can transmit, but only from the central computer command. If all subscribers are equal, and each of them can begin transmission not informing the others, the problems arise. Using the software solves the problem but it can be complicated in this case.

The standard RS-485 has no description of data transmission protocol. As a result, fieldbuses that differ from each other by the transmission protocol are based on its electrical parameters.

RS-485 differs not only by multipoint connection. It selects connecting cables more carefully; therefore the standard recommends applying screened twisted pairs and terminators.

RS-423

RS-423 differs from RS-422, it is unbalanced: its lines B are closed to the body. At the maximum distance of 1200 meters the transmission speed is 1Kb/s. The interface has the maximum transmission speed of 100 Kb/s at the distance of 15 meters.

V.35

V.35 was determined by CCITT at first as the interface for data transmission at the speed of 48 Kb/s, and is used at present only for synchronous communication at the speed of 56-64 Kb/s. All signalling lines have common ground as in RS-232, and all handshake and clock signals are based on the balanced circuit as in RS-422. The connector in V.35 is not D-shape, but rectangular with dimensions of about 20x35 mm and gold plated contacts. At the maximum distance of 1200 meters

the transmission speed is 100 Kb/s, and the maximum speed of transmission 10 Mb/s is reached at the distance of 90 meters.

Current loop.

Sometimes there is a type of a serial interface known as "a current loop". This interface is similar to the above-mentioned RS-232C, though the control signals in it, as a rule, are not used (they are considered to be in permanent switched off condition). The differences are in electrical realization of communication circuits.

- Logical 1 and 0 correspond to the current value flowing through the communication lines but not to the voltage levels. It allows increasing the communication distance, as the voltage drop in the wire resistance in this case is not important.
- It is possible to connect some receivers and transmitters in series in this line;
- Advantage " of a current loop " is also circuit galvanic uncoupling of the transmitter and receiver from the communication circuit.

The simplified block-diagram of connection between the data transmitter and receiver by the interface " Current loop " is given in fig. 2.43.

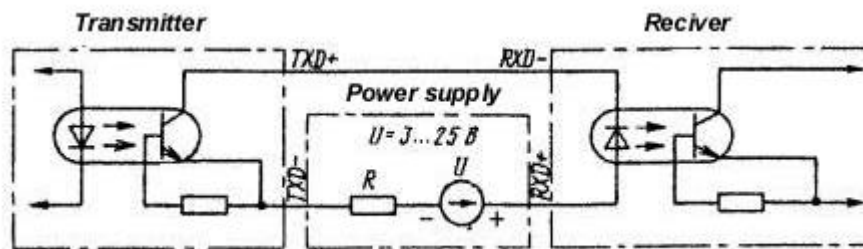


Fig. 2.43 Current loop

The current source can be both in the transmitter and in the receiver. The transmitter output circuit is an electronic key, which closed condition (the current flow in a communication line) corresponds to the transmission of logical 1. The standard value of this current is 20 ± 5 or 40 ± 10 mA. The voltage drop in the receiver should not exceed 1.5 V. When the key is disconnected there is no current in a communication line that corresponds to the transmission of logical 0. Two-way communication requires one more similar loop.

The circuit distribution by connector contacts is not determined in the standard. There is no connector in this interface adapter and the connection board is used where the screws grip the wires. Thus, for example, ATU of STR2000 MF/HF radio station is connected. For checking the communication channel performance it is sufficient to connect a milliammeter.

The most useful is a digital unipolar current loop of 20 mA. This interface is well known due to its characteristics: it allows to transmit the information at the distance of up to 500 meters with the speed of 19200 Bauds by two wires.

All the above-mentioned interfaces have the elementary adapters with RS-232. They are connected either directly to the output connector of COM - ports, or through a short connecting cable. One of them does not require the additional power source, converting voltages of RS-232, the others require external one or two-polar sources. There are also specialized adapters having the bus ISA. Thus it is possible to form a communication system on any interface.

The serial interface has appeared to be so convenient, that the standard USB (Universal Serial Bus) was based on it, by means of which a display and mouse and keyboard, joystick etc can be connected by one channel.

The standard of IEC 1162-1 (NMEA 0183)

The digital interfaces of the equipment and marine navigation and radio communication systems are determined by the standard of IEC 1162-1. It is based on the standard of the USA National Marine Electronics Association - NMEA 0183, version 2.01, 1994.

According to these standards the information source (Talker) and its receiver (Listener) are connected by a symmetrical line.

Recommended signal parameters in line

$U_{\text{dif.min.}} = 2.0 \text{ V}$ (EIA-422).

Transmission speed - 4800 Bauds..

The parity - no

$I_{\text{in.}} \approx 2.0 \text{ mA}$

The data - ASCII - 8 bits (D7 = 0)

Stop bit - one

The circuits, shown in fig. 2.44, protect the receiver input.

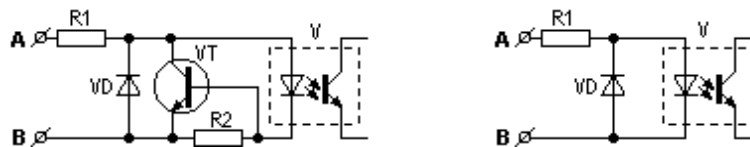


Fig.2.44 Protection of a receiver input

The optoelectronic pair V provides a galvanic uncoupling of the power source and information receiver circuits.

The diode VD protects light emitting diodes of an optoelectronic coupler from the excessive "return" voltage (applied between currents B and A, plus to point B, and minus - to point ?).

If it is necessary to protect the light emitting diode from the excessive "direct" voltage, the transistor VT is actuated. At the increase of the point A potential as to the point B the current flowing through the light emitting diode and the resistor R2 is increased. It results in the increase of voltage drop on R2, mixing the emitter transistor junction in forward direction. The transistor is opened and shunts the light emitting diode, reducing its forward current.

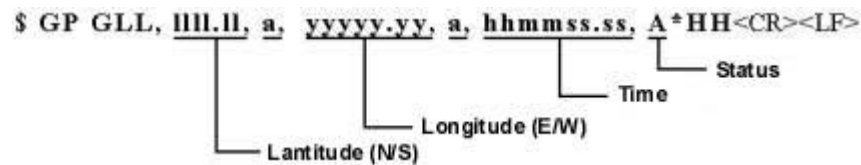
The resistor R1, on the one hand, limits the current in the light emitting diode of an optoelectronic coupler. On the other hand, it can be considered as a part of a voltage stabilizer formed by R1 and p-n junction of the light emitting diode.

The protocol format

The information in the standard of IEC 1162-1 (NMEA0183) is transmitted as sentences, using the standard form, representing the GLL format as an example, which is used as latitude and longitude transmission (example 1).

Example 1.

A transmission format of a latitude and longitude (GLL):



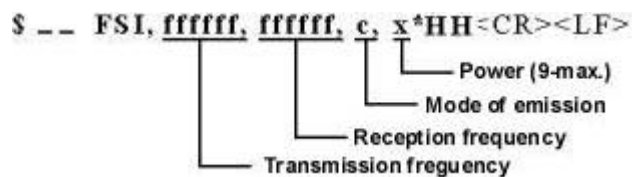
In this sentence the following signs are used:

- \$ - sign of the sentence start;
- GP - address of a message source (GPS);
- GLL – message identifier;
- L, y, h, m, s - data (latitude, longitude, time);
- A -Data status (A-reliable);
- *HH - checking sum in the hexagonal form;
- <CR> <LF> - end of the sentence;
- -Data field separator.

The control command in the radio communication equipment has the similar form

Example 2.

The command format of FSI (Frequency Set Information) radio station remote control:



The sentence: `$ CT FSI, 020230,026140, m, 5*11 <CR> <LF>` means, that MF/HF the radio station should be adjusted in a mode of SSB telephony, J3E (m), to a medium emission power (5). The transmitter frequency is 2023 kHz, the receiver-2614 kHz.

2.6. Search And Rescue Transponder

The Search And Rescue Transponder (SART) is actuated in case of emergency situation and responds on ship or air radar station request operating at frequency 9 GHz, by the signal with sweep frequency, which is indicated on the SART screens as a group of 12 blips. They are easily identified at the distance of more than 8 nautical miles, along the transponder bearing. On detecting the request the radar station also sends an audio signal attracting the attention of casualties.

When locating SART at the height of 1 m above the sea level the navigational SART should detect it with the antenna mounted at the height of 15 m, at the distance not less than 5 nautical miles. It should also operate correctly on air SART request from the distance not less than 30 nautical miles at peak power, at least, 10 kW at the height of 3000 feet.

The performance standards to the lifeboat and raft SART for using in search and rescue operations are determined in the Resolution 7.802 (19).

The SART technical characteristics are given in the ITU-R M.628-3 Recommendations; some of them are shown in tab. 2.7

Tab. 2.7 the Main SART characteristics

	Parameter	Value
1.	Range:	9200-9500 MHz
2.	Law of emitted frequency change:	Sawtooth, 12 retuned pulses
	Duration of front edge:	7,5 μ s
	Duration of back edge:	0,4 μ s
3.	Regeneration period:	10 μ s
4.	Polarization:	Horizontal
5.	Transmitted power, not less than	+ 26 dBm (400 mW)
6.	The receiver sensitivity	-50 dBm (0,1 mW/m ²)
7.	Duration:	96 hours in a standby mode + 8 hours in a transmission mode.

Principle of operation

The principle of SART operation is explained by means of fig. 2.45.

Having detected the SART pulse (1) operating in the range of 3.2 cm, SART emits a pulse with the duration of 100 μ s. This pulse is frequency modulated by a sawtooth voltage (2).

This emission is performed on carrier 9350 MHz, and the frequency deviation (maximum frequency deviation from the average value), is 150 MHz.

12 smooth pulses are transmitted for 100 μ s, which parameters are given in tab. 2.7.

The radar receiver receives SART response signals during the time, proportional to the bandwidth of the radar receiving path, by which the length of each 12 marks (3) will be determined.

$T_e = T_s \cdot B_r / \Delta F$, where: B_r - bandwidth of radar receiving path, ΔF - range of the radar frequency sweeping.

Thus, at the bandwidth of radar receiving path $B_r = 10$ MHz:

$$T_e = 7.5 \cdot 10^{-6} \cdot 10 \cdot 10^6 / (9500 - 9200) \cdot 10^6 = 0.25 \cdot 10^{-6} = 0.25 \mu s.$$

The pulse duration of 0.25 μ s corresponds to a flare on a radar screen within 37.5 m or 0.02 nautical miles.

All 12 target marks on the radar screen (4) are placed in the direction from the start of scanning to SART (4) at the distance from the 1-st up to the 12-th mark of about 8 nautical miles.

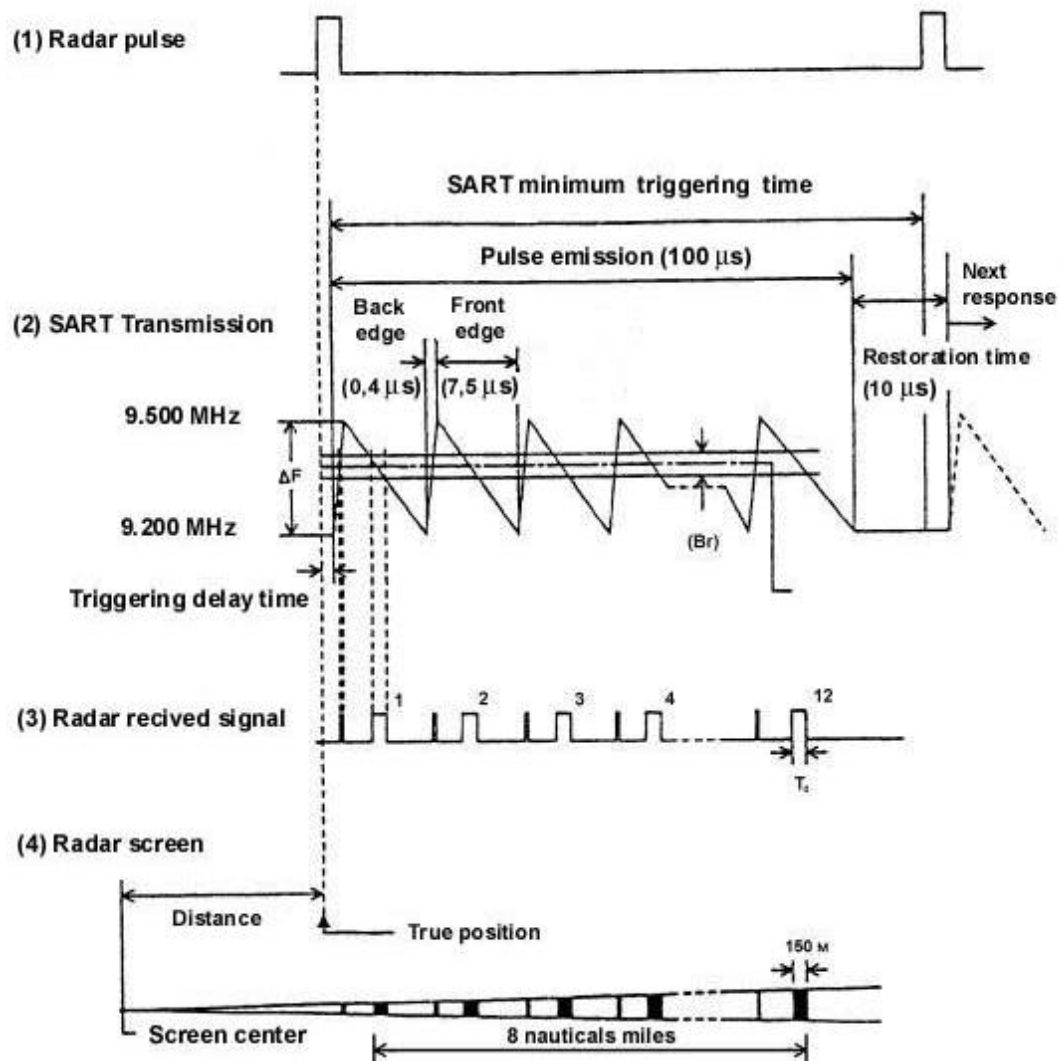


Fig. 2. 56 Principles of SART operation

The block- diagram

The block diagram of SART is given in fig.2.46. The SART pulse received by the antenna is passed to the microwave amplifier, is amplified by it, then is detected, amplified in a video amplifier and is fed to the control circuit.

The control circuit generates commands by which:

- The audio oscillator with a pulse repetition rate requested by radar is actuated;
- The receiving path is locked;
- Microwave FM oscillator is activated;
- The pulse oscillator is activated; the sawtooth oscillator forms the sawtooth pulses modulating microwave oscillator frequency.

The green light emitting diode indicates that SART is in operation. If the humidity inside SART increases, for example, when the watertight envelope is damaged, the red light emitting diode is lit.

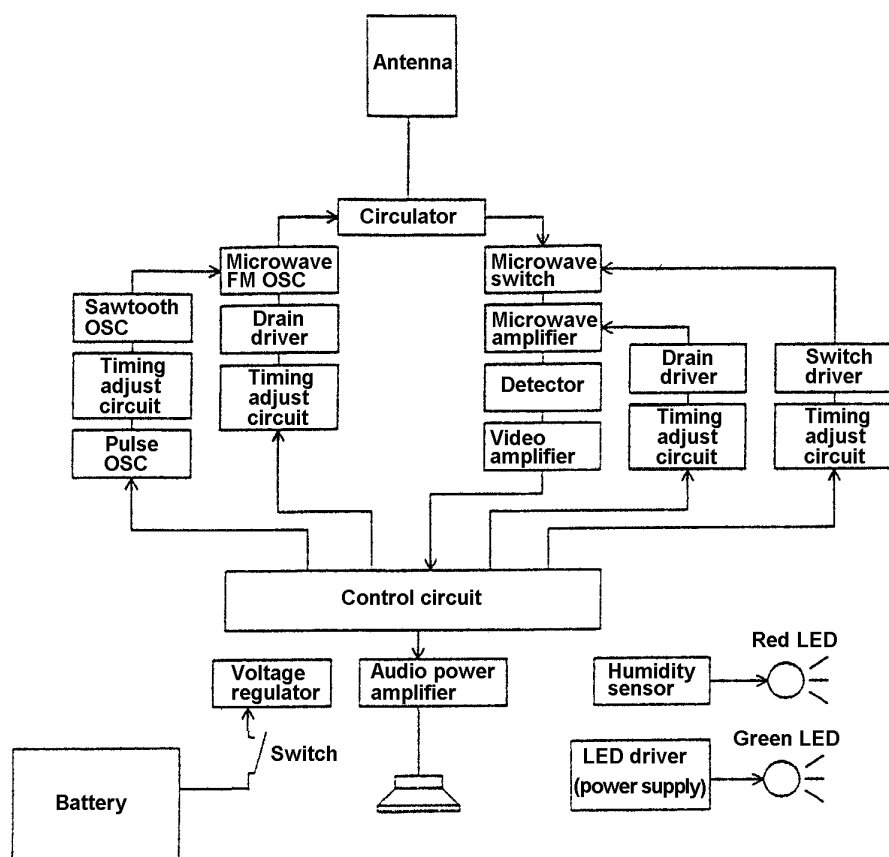


Fig. 2.46 SART block- diagram

2.7. EPIRBs

The EPIRBs are actuated in distress automatically or manually and transmit the formalized distress messages. Three types of the EPIRBs operating in different systems are used: COSPAS-SARSAT (EPIRB-406), INMARSAT –E (EPIRB-1.6 GHz) and VHF DSC (channel 70, 156.525 MHz).

The performance standards to the EPIRB are determined in IMO Resolutions ?.810 (19), ?.812 (19) and ?.805 (19), respectively.

The technical characteristics of the EPIRB are given in ITU Recommendations and some of them are shown in tab. 2.8

Tab. 2.8 the Main characteristics of the EPIRB

	EPIRB-406 MHz	EPIRB 1.6 GHz	VHF EPIRB ¹
The ITU-R recommendations	? .633	M.632	? .693 + M.493
Carrier frequency, MHz	406,025 and 121.5	1645,5-1646,5	156,525 and 9,2-9,5 GHz
Frequency tolerance	$2?10^{-9}$ for 0.1 s	$2?10^{-8}$ for 1 min	$10?10^{-6}$
Output power, not less than	5 W	0 dBW	0.1 W
Coding	NRZ-L (Manchester code)		DSC
Modulation	G1B	F1B	G2B
Frequency or phase	$1.1 \pm 0,1$ rad	$120 \text{ Hz} \pm 1 \%$	$2.0 \pm 0,1$ rad

deviation			
Frame length, bit	112 / 144	160	"Distress" DSC format
Transmission speed	400 bits per second	32 Bauds	1200 Bauds
Polarization	Right-handed circular		Vertical
Temperature range	From - 20 ⁰ up to + 55 ⁰ C		
Operation period	Not less than 48 hours	Not less than 48 hours ²	Not less than 48 hours

¹. In addition to distress alert in the DSC format, VHF EPIRB should ensure signal transmission of the position by means of SART, described above.

² 4 hours without built-in devices for automatic data-updating of position (for example, receiver GPS).

The block- diagram

The EPIRBs cannot be repaired in shipboard conditions. Even the replacement of batteries should be made by the official service agents. Fig.2.47 gives the general block- diagram of the satellite EPIRB.

The digital message, which is transmitted by the EPIRB, can contain the information of a vessel identification number, nature and time of distress, as well as vessel's position. The vessel's identifier is entered into PROM, and the remaining data are entered into the microprocessor memory store by means of a serial interface I/O or through the modem, connected with the data input device.

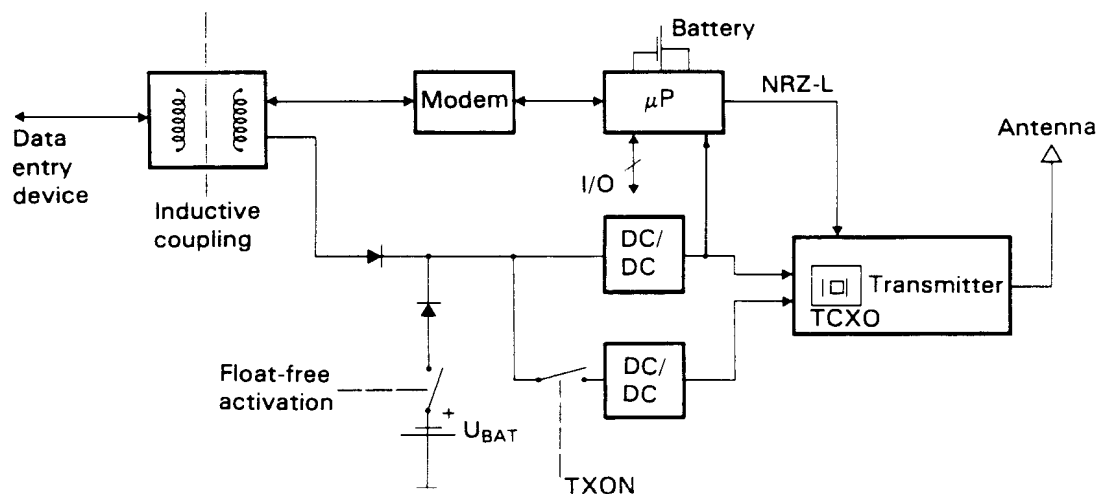


Fig. 2.47 Block- diagrams of the EPIRB

This data is subject to noise protection coding, then in satellite EPIRBs additionally to a linear coding using Manchester code and is sent to the transmitter modulator. The transmitter frequency is crystal-controlled.

The EPIRB-406 MHz should contain a radio beacon for aircraft tracking operating at frequency 121,5 MHz.

The tracking signal at frequency 121,5 MHz should be emitted continuously (can be interrupted during the time of a signal transmission on 406 MHz). The emitted signal is formed as a result of an carrier amplitude modulation by audio frequencies changing within 300 up to 1600 Hz from 2 up to 4 times per second.

2.8. NAVTEX Receiver

The international service NAVTEX will use frequency 518 kHz, on which the coast stations transmit MSI in English. The transmission of each station is spaced in time for avoiding mutual interference and accomplished on schedule given in the ITU reference books.

The main characteristics

The performance standards to shipboard NAVTEX receivers are determined in the IMO Resolution 7525 (13). The main characteristics are shown in tab. 2.9.

Tab. 2.9 The typical characteristics of the NAVTEX receiver

Parameter	Value
The receiving frequency	518 kHz (possible to receive at frequencies 490 kHz and 4209.5 kHz)
The emission class	F1B, FEC
The sensitivity	Is not worse 2 μ V
Passband	300 Hz at a level 6 dB
Input protection	30V (RMS) of a radio-frequency signal
The antenna	Can be active (whip of 1.5 m with the preamplifier)
Working temperature	From -15 up to + 55° C
Power supply	9-40V of a direct current,
Average power consumption	5-15 W.
Number of the message identifier in memory:	30
Storage period of an identifier	60-72 hours,
Error factor	is lower than 4%

The block- diagram of a receiving path

The shipboard NAVTEX receiver receives the information transmitted at the given frequency selects the necessary frequency and automatically prints out it.

Thus, the following units should be included in it:

- Receiver unit
- The microprocessor
- Printer,
- The power unit

The block- diagram of the NAVTEX receiver is given taking PNW901 as an example. The receiving path circuit is shown in fig. 2.48. The receiving path is based on the superheterodyne circuit with a single frequency conversion 518 kHz. The signal received by the antenna through the protection circuit of input circuits and input filter reducing interference on an image channel is fed to the relay contacts 30. These contacts on receiving the transmissions at frequency 518 kHz are closed, and the relay contacts 15 are disconnected. Then the desired signal is selected by

the crystal filter with passband of about 300 Hz, is amplified by three-stage AFA and is fed to the mixer. To the second mixer input the local oscillator voltage is fed with frequency 519.7 kHz obtained as a result of division of stable the reference frequency 4157.6 kHz by 8. The frequency difference 1.7 kHz is amplified and fed to the analog signal switchboard D204, D205.

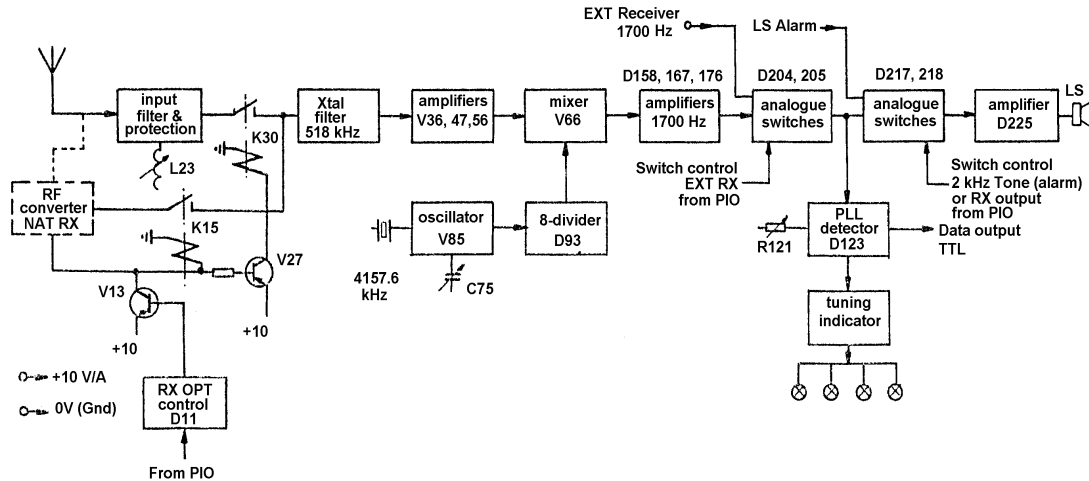


Fig. 2.48 The block- diagrams of a receiving path

With the help of this switchboard it is possible to connect the external receiver, tuned to frequency 518 kHz capable to receive the emission class F1B and having tone output of 1700 ± 85 Hz. After the switchboard the tone signal consisting of frequencies, changing in different combinations 1615 and 1785 Hz, is passed to a listening monitoring circuit (D217, 218, 225, loudspeaker) and to the detector D123. The detector converts an analog two-tone signal into a pulse sequence of TTL level, which is fed to the processor.

The converter converting the received frequency into 518 kHz is necessary for reception at the other frequency. For example, if the converter uses the crystal resonator at 1008 kHz, the receiver will be tuned to 490 kHz ($518 = 1008 - 490$).

While sending a command to base V13, it is disconnected; the relay ?15 obtains power and closes the contacts connecting an output of the converter to the filter. Besides the transistor V27 is locked, eliminating the power from the relay ?30, which disconnects the antenna by the contacts, and input circuits from the filter 518 kHz. The converter signals are fed to this filter

The block- diagram of the processor

The block- diagram of the processor is given in fig. 2.49.

The Z80A microprocessor is synchronized by frequency 4 MHz obtained in the frequency divider D294 from the crystal oscillator frequency of 8 MHz. The RAM capacity is 64?. The program is recorded in EPROM D331, with capacity 128? .

The memory stores, timer D378, input/output circuit D332 and input/output ports are connected to the data bus:

- D534 - input from the front panel keyboard and built-in switches DIL (used while maintaining and checking).
- D532 – output to the front panel indicators and keyboard.

The brightness of the indicators URG and PAP is not adjusted.

- D391 – output to printing on the coordinates X and Y.
- D399 – output to printing, axis Z. Control of a writing edge.

The hexagonal digit order address bus is connected to the RAM and PROM. The separate address bus is connected to the address decoding circuits, timer and to PIO input / output circuit.

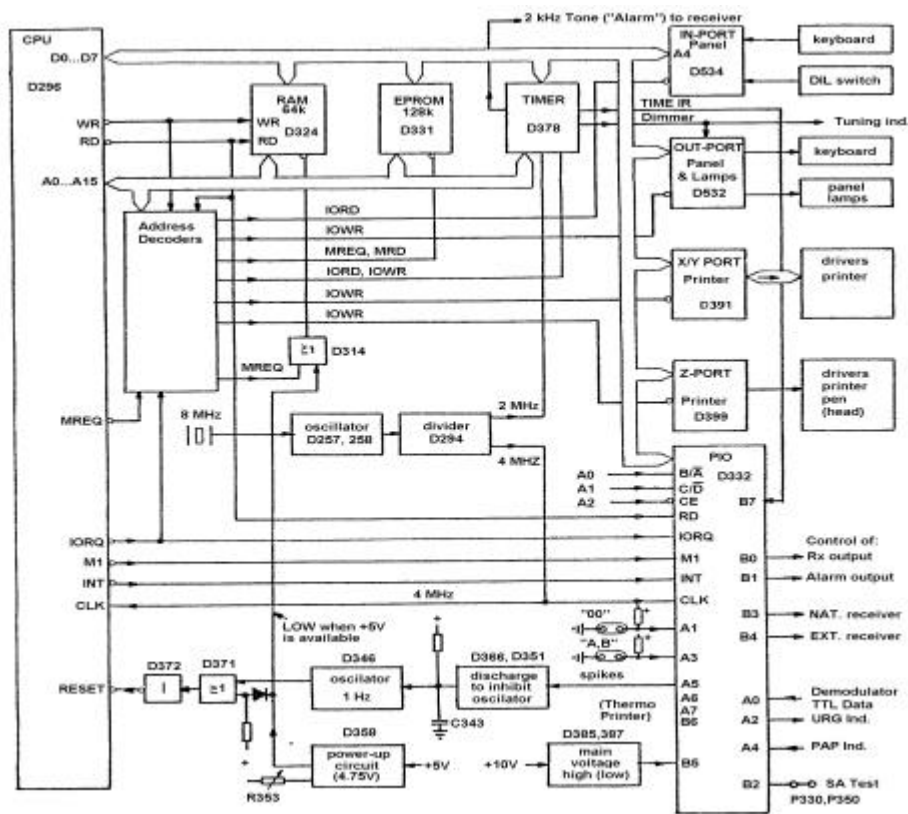


Fig. 2.49 The block-diagram of the processor

Functions of the PIO input / output circuits:

- Connection of the second receiver to main receiver, 518 kHz (NAT or EXT);
- Signal control, which should be fed to the loudspeaker;

TTL signal demodulation coming from a receiving path;

- Indication of a paper roll edge;
- Indication of the excessive level of a supplied voltage from microcircuits D385, D387;
- Connection of the sign analyzer test program through port ?2.

By means of two jumpers connected to the ports ?1 and ?3 ("00" and "A, B"), the alarm signal is actuated, which sounds, when the elements 00, A and B will be found in a technical code identifier. If there is no jumper, there is no alarm signal.

CPU start circuit is based on microcircuits D358, D371 and D372.

2.9. Power supply of the GMDSS equipment.

There are primary and secondary electrical power sources.

The primary electrical power sources of GMDSS shipboard equipment consist of:

- Main - from ship's mains;
- Emergency - from an emergency shipboard generator;
- Reserve - from batteries connected by means of an uninterruptible power supply (UPS) system.

One of the uninterruptible power supply circuit versions of the GMDSS radio installation is given in fig. 2.50:

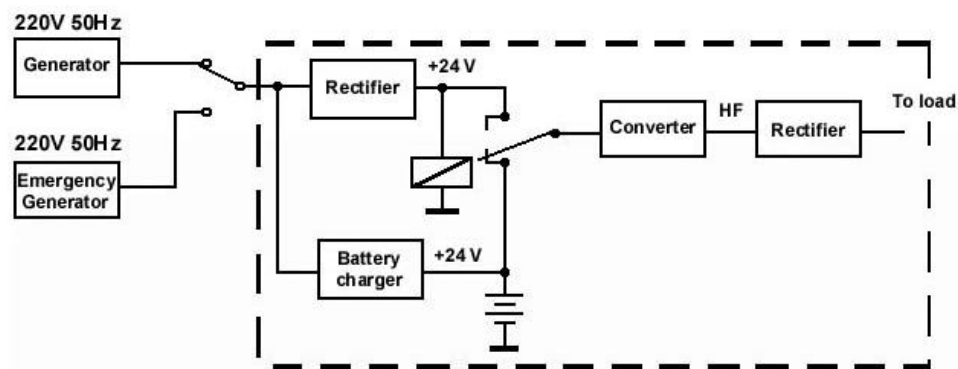


Fig. 2.50 Uninterruptible power supply circuit

When the main generator is out of order the power should be supplied from an emergency generator. During the time of emergency generator activation for the converter being a part of the pulse power source circuit, the power is fed from a battery through the normally closed relay contacts.

Reserve power sources

As a reserve power source of the GMDSS equipment the lead-acid batteries including an electrolyte as jelly, as well as alkaline (nickel – cadmium) batteries can be used.

The lead-acid batteries with a jelly-like electrolyte are more sensitive to a temperature variation of the environment; therefore they should be kept in places with constant temperature. For example, the batteries with life period of 5 years at the temperature of + 20°C, work only for 2.5 years at constant temperature of + 30°C.

If the alkaline batteries (consisting of 20 cells requiring charging voltage not less than 1.6 volts at each cell) are used the standard charger in an automatic mode will charge them approximately on 80 %, since each cell requires about 1,4V.

Full charge of alkaline batteries needs 32-33V, but if during the charge the GMDSS equipment is switched on, it can be damaged. Therefore, the alkaline batteries in the GMDSS equipment can be used, provided the voltage at each cell does not exceed 1.4V during the charge, and the battery capacitance is 25 % more than estimated.

Estimation of the reserve power source capacitance

- On ships with the emergency power source the batteries should provide GMDSS radio equipment operation, at least, for 1 hour.
- On ships without the emergency power source this time should not be less than 6 hours.
- The capacitance of a secondary electrical power source is determined by the sum of three values: ½ of current force consumed for transmission, current force consumed for reception and current force, consumed by additional loads (emergency lamp, GPS receiver etc.).

While calculating battery capacitance the following should be taken into account:

- To meet the requirements, irrespective of environment temperature, an aging rate of batteries, their nominal capacitance is recommended to be with a reserve not less than 40%.
- To remember, that the nominal capacitance of batteries indicated by a manufacturer, is measured under certain conditions.
The lead-acid battery capacitance is usually determined during the 20- hour discharge at temperature 20°C, thus:
 - during 1-hour discharge is about 50% from the 20 hour discharge capacitance
 - during 6- hour discharge is about 80% from the 20- hour discharge capacitance

The capacitance of the other types of batteries is often determined during the 10hour discharge. In this case:

- during 1- hour discharge - about 60% from the 10- hour discharge capacitance
- during 6-hour discharge - 90% from the 10-hour discharge capacitance

The battery capacity should be checked up not less than once a year, when the vessel is not in at sea.

The residual capacitance is determined as multiplication of the average value of charging current force by discharge time:

$$Q = \frac{I_{in} + I_{end}}{2} \cdot t_{dis.}, \text{ where}$$

Q - Residual battery capacitance, A-hr;

t_{dis.} - discharge time, hours;

I_{in} - initial discharging current, A;

I_{end} - current at the end of discharge, hr

Before the calculation of a battery residual capacitance it is necessary to conduct a testing discharge-charge cycle.

The example of calculation of the necessary battery capacitance offered by the Standard Radio is given in tab. 2.10.

Tab. 2.10 Example of calculation of the reserve power source capacitance

The name of the Equipment	Current consumption in a mode:		
	Transmission	Reception	Permanently
MF/HF installation	15 A	4 A	-
VHF installation № 1	5 A	0,15 A	-
DSC installation № 1			0,5 A
VHF installation № 2	5 A	0,15 A	
DSC installation № 2			0,5 A
SES INMARSAT-C	5 A	1,8 A	
Emergency indication			2,5 A
Total current consumption, A	30	6,1	3,5

When a vessel has an emergency generator the battery capacitance is:

$0.5 \text{ hours} \times 30 \text{ A} + 0.5 \text{ hours} \times 6.1 \text{ A} + 1 \text{ hours} \times 3.5 \text{ A} = 21.6 \text{ ?}$, it is recommended to use battery capacitance of 80 ? /hr.

When there is no emergency generator on board vessel the battery capacitance is:

$3 \text{ hours} \times 30\text{A} + 3 \text{ hours} \times 6.1 \text{ A} + 6 \text{ hours} \times 3.5 \text{ A} = 129.3 \text{ ? /hr.}$, it is recommended to use battery capacitance 200? /hr.

If the reserve electrical power source consists of a rechargeable battery, it should contain the automatic charger recharging a battery for 10 hours.

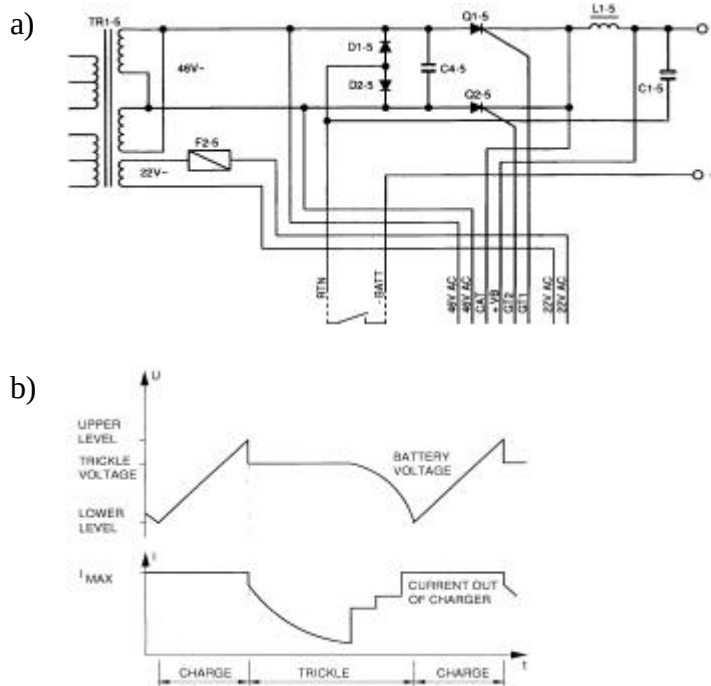


Fig. 2.51 Parts of the battery charger circuit (?) and drawings of battery charging (b)

Part of the automatic charger circuit Sailor N2174 (as example) and the drawing of battery charging are given in fig. 2.51.

The primary transformer winding of TR1-5 at the appropriate switching allows passing voltages of 110, 127, 220 or 240V to the charger.

The voltage from a secondary winding is fed to the rectifier based on diodes D1-5, D2-5 and the thyristors Q1-5, Q2-5 by a bridge circuit. The time, during which the thyristors Q1-5 and Q2-5 are disconnected, can be changed by means of the voltage applied to the control electrodes by wires GT1 and GT2. Thus the constant component of rectified voltage after the filter L1-5, C1-5 passing to an battery connected to terminals «+ and «-», will be also changed. The control voltage is generated in the automatic control unit. If there is failure, the control voltage can be established manually by selecting a mode MANUAL.

In an automatic mode the charger can work in a charge and trickle mode. In a charge mode the direct current is supported, while the voltage on the battery will reach the maximum value. After that the charger changes to a mode of voltage generator (fig.2.51, b), supporting constant voltage at the battery and compensating its self-discharge. During the ship's mains interruptions the GMDSS equipment is fed from the battery, it is discharged, and after power restoration from the mains is automatically actuated for charging.

SECTION 3

MICROPROCESSORS

The purpose of this section is to provide knowledge of microprocessors (MP) operation.

The entry standards:

The candidates should have knowledge of:

- main signal conversions in electronic schemes;
- time and frequency signal representation;
- main principles of information and coding theories;
- basic principles of work with PC;
- rules of assembling and disassembling elements of radioelectronic equipment;

After completion of the this course the trainees should have knowledge of:

- principles of microprocessor operation;
- technical and operational characteristics of microprocessor systems;
- serial and parallel data transmission;

Outline

?	Learning objectives	Class hours		
		Total	Theoretical	Practical
1	Tasks of control MP system	1	1	-
2	Microcomputer architecture	4	4	-
3	Interrupts, interrupt request lines	4	1	3
4	Direct memory access	2	1	1
5	Input/output ports	2	1	1
6	ROM BIOS	4	2	2
7	Buses: data bus; address bus; check bus	2	2	-
8	Kinds of buses (MCA, PCI, USB, IEEE1394)	6	2	4
9	Sequential and parallel data transmission	6	3	3
Total		31	17	14

Introduction.

Microprocessors and microcomputers application provides better operation reliability and possibility of failure self diagnostics; decrease in energy consuming; reducing time and labour spent for developing new types of equipment and their up-dating; reducing mass and size of equipment.

Applying a microprocessor system in r/communication and navigation equipment requires knowledge of their operation principles, and of interfaces with different external structures.

Extremely rapid development and updating MP equipment in conjunction with operation and technical maintenance of the equipment in current use require knowledge of both kinds of Equipment.

3.1. Tasks of control MP system.

Use of MPs, microcomputers and PCs increases the automation level of control processes. These devices allow solving complex problems of automation much more effectively than conventional means. Moreover, many such tasks became solvable only with the help of modern MP equipment, comprising hardware and software features stored in read only memory (ROM) memory, which cannot be altered, and variable program modules.

The best effect of MP and microcomputers application is achieved in units and systems of local automation and also in such fields in which usage of digital data processing means and methods had been unprofitable until MPs appearance. Low cost, small sizes, small energy consumption, high reliability, and extreme flexibility in operation give MP sets great advantages in comparison with any other basic elements of digital systems.

One more reason for application of MPs and microcomputers – is the opportunity to effect a transition from centralized data processing by means of big computers to local processing by control computers. Such integrated structures composed of conventional automatic units and MP equipment have high efficiency, reliability and low cost, and they comprise information and computing systems.

“In house” programmed digital control computer is a new technical means in which functional units rigidly connected to each other with the help of joints and soldering and blocks of variable programs can be exchanged and added to each other.

Nowadays with introduction of microcomputers into automation systems there is a transition from centralized to distributed information processing by many monitoring microcomputers.

Monitoring computers as information processing devices within a separate element of the structure are combined in one complex block together with traditional automation means.

This leads to appearance of new ways of solving automation problems, which provide growing efficiency, reliability, and reducing equipment cost.

3.2. Microcomputer architecture.

Fig 3.1 shows basic simplified architecture of all types of computers.

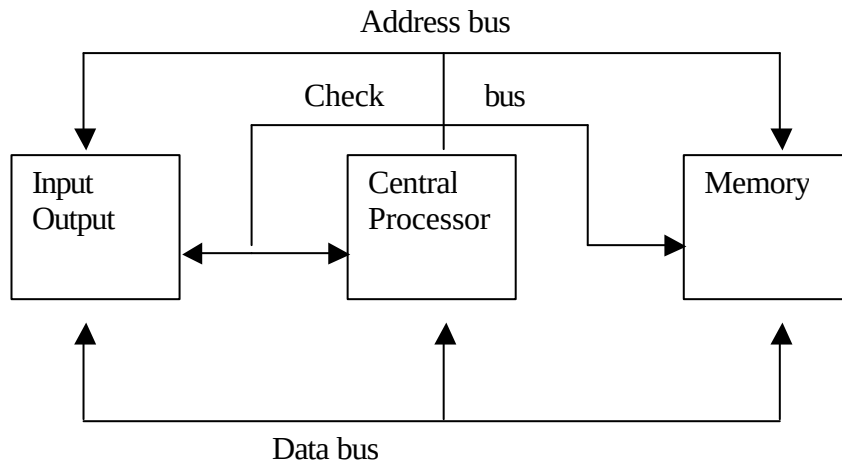


Fig 3.1 Basic simplified computer structure.

The central processor, i.e. microprocessor in a microcomputer has 3 buses connecting all its components. The programme executed by central processor (CP) is in memory. The processor reads every instruction from memory in its turn analyses it and executes it. 3 following actions can present the sequence of every instruction execution:

- CP gives the address of the next instruction to the address bus
- The contents of location/storage cell according to the indicated address appears in the data bus;
- CP reads the instruction and executes it.

The signals required for performing the check bus passes such actions.

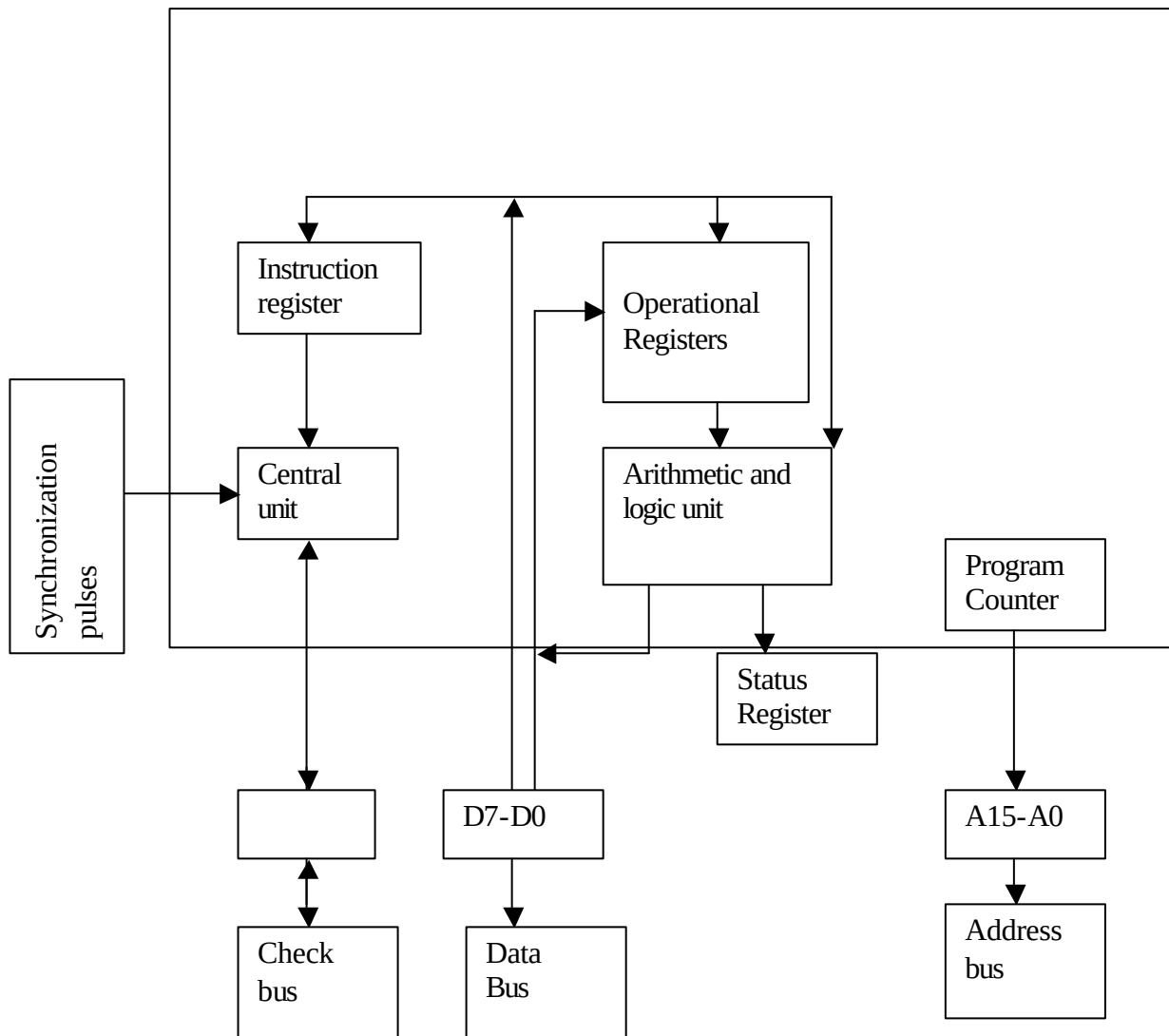
Besides instructions of the programme the computer memory stores the values of variables. They can be numbers represented in binary notation or symbols, which are easily seen on the display screen or printing unit (the symbols are represented in so called ASCII code).

In the input /output module there are schemes by means of which programme and data exchanges with periphery units (for example, external memory, printer, display, user terminal) is effected.

In simplest microcomputers, for example, in a pocket calculator or a washing machine controller all 3 modules (CP, memory, input/output) are located in one microscheme.

Central processor.

The typical organization of central processor is shown in fig 3.2



Synchronization pulses initiate all actions in the central processor and its inner elements perform the following functions:

The contents of the Program Counter are passed to the Address Bus and the next program instruction can be passed from the memory to central processor.

The instruction register receives the instruction.

The control Unit decodes the instruction and initiates in the control processor such actions, which are necessary for the execution of the instruction.

The operation registers contain data elements processed by the instruction (a specialized operation register which can receive the results of operations of arithmetic and logic unit is called an accumulator).

All CP operations are realized in arithmetic and logic unit (ALU). It can alter the data values by using arithmetic (addition, subtraction and others) and logical (logical “and”, logical “or” and other) functions.

The status register contains flags registering peculiarities of ALU operations results, for example a zero result.

The central processor word length is determined by a number of bits, which is processed in one operation by ALU, for example, 8-bit Central Processor can perform operation of arithmetic addition of 2 8-bit numbers.

Successes of semiconductor electronics led to appearance of big integrated schemes in which one silicon chip the size of which is 4x5 mm can be equivalent to a scheme with 10-100 thousand transistors. Nowadays integrated schemes contain up to 2.5 million transistors. Use of big integrated schemes (BIS) and super big integrated schemes (SBIS) permitted to increase effectiveness of digital systems, to increase their efficiency and reliability, to decrease mass and sizes, consumption of power and in case of serial production – to decrease cost.

Emergence of BIS considerably influenced architecture of digital systems, that is, principles of their construction, logical structure and software. However, the possibility of locating on one chip thousands of components did not simplify, but in many cases complicated, the problem of BIS usage.

On one hand, because of versatility and sophistication of logical digital devices necessary for control purposes, it is not possible to organize their serial production.

On the other hand, increase of integration level together with restricted number of microscheme terminals leads to increase of BIS level and, as a result, to higher specialization of automatic control systems on the basis of these BIS, which restricts the area of their application. Small series BIS and automatic control systems on their basis, as a rule, are economically unprofitable.

The mentioned circumstances led to arising of standard universal SBIS with program management, which allows to use them while producing any automatic control system required for the customer. Automatic control system specialization is achieved by using a specific program controlling BIS work. Such standard universal BIS is called a microprocessor.

Microprocessor.

Microprocessor (MP) – is a functional logical device created by means of integrated technology and intended for program data processing. MP is the basic part of computing and controls systems created on the basis of microelectronic means. Its structure and possibilities determine operation parameters of all the control system. Fig 3.3 shows a generalized and considerably simplified scheme of MP.

Arithmetic and logic unit (ALU) is intended for performing arithmetic and logic operations with binary codes of numbers and instructions.

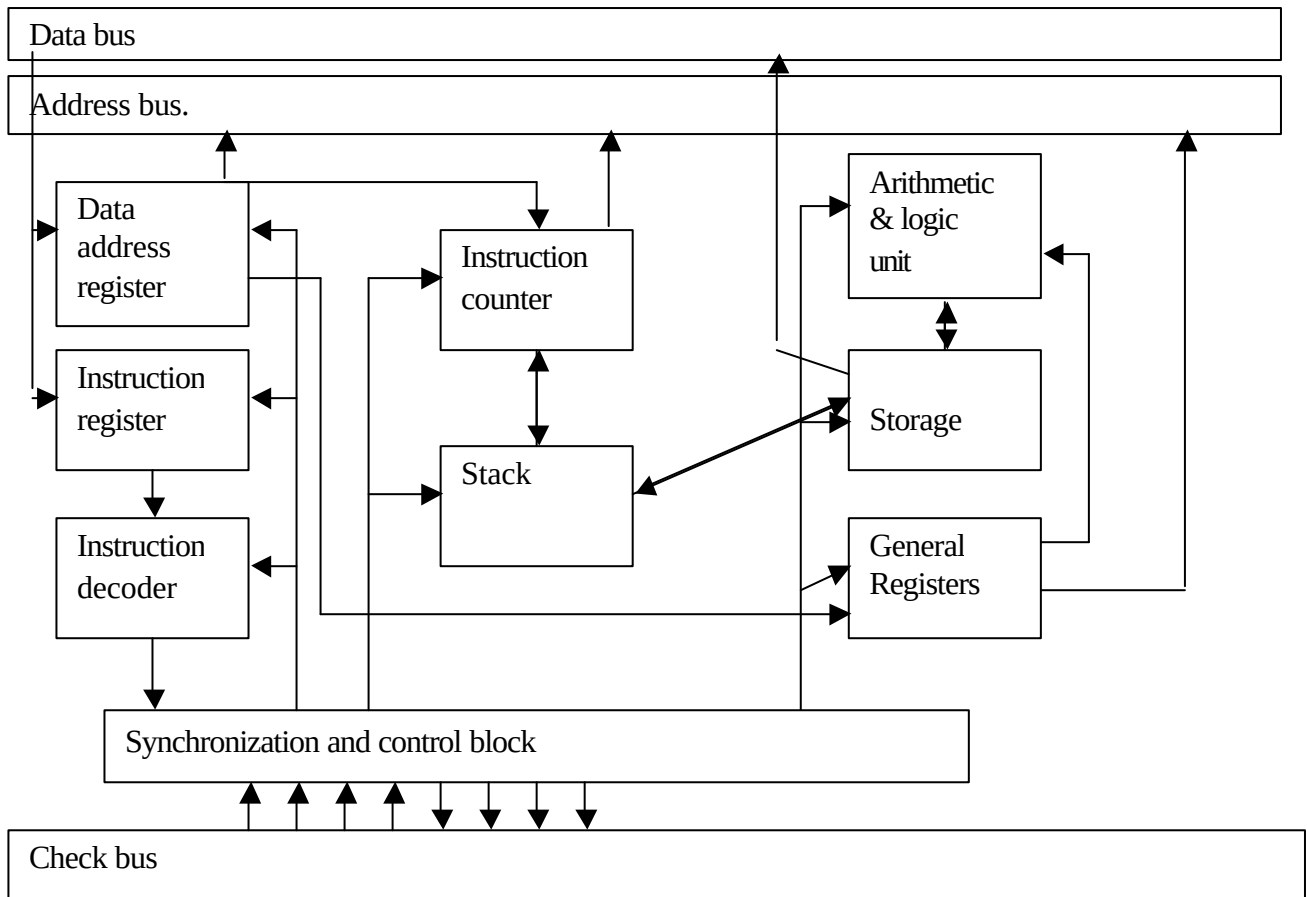


Fig 3.3 A simplified MP scheme.

The storage (accumulator) – is the register intended for temporary storage of operand or intermediate result of operations performed by ALU. It is the main operation register in which memory data and operation results directed back to memory and passed to input/output unit are registered.

The general registers the number of that can be from 4 to 64 are locations of scratchpad memory and serve for temporary storage of operands during the process of program execution.

The data address register serves for indicating operand address (for instructions referring to memory), port addresses (for input/output instructions) or the next instruction address (for transition instructions).

The instruction counter organizes reading the program instructions following the order set by the program. Usually program instructions are in sequential locations. The instruction counter contains the address of the location where the next instruction, which must be executed after the current instruction is contained.

The stack is the addressless set of sequentially organized registers used for temporary storage of rollback instructions addresses when subprograms are referred to or for memorizing inner registers conditions when interrupts are processed. Inserting words into the stack and reading them from it is effected according to the principle “the last to come – the first to leave”.

The instruction register receives and stores the next instruction code, the address of which is in the instruction counter. With the beginning of the next instruction execution this instruction is passed to the decoder.

The instruction decoder is intended for determining the type of operation to be executed by ALU according to the instruction code, which came from the instruction register. Usually instructions are divided into groups in every of which one – type operations are executed.

The synchronization and control block and instruction decoder comprise the control unit. In the composition of the block there is a clock/computer, which is the source of time step signals starting and synchronizing the rhythm of all the system blocks operation.

The sequence of operation execution in MP is organized by the MP storage or main storage program capable to react to outer signals – interrupts. Appearance of the interrupt means that it is required to suspend sequential execution of commands of the main program and to transfer to another, a more important, at the current time, program.

The clock or time pulse oscillator works out timing and synchronized pulses.

Microprocessor system.

MP is not sufficient for creation of automatic control systems for technical means. Additional memory communication, conversion, information presenting and some other systems are required. They are manufactured as MP – compatible big integrated schemes and they form microprocessor control systems.

A microprocessor system (MPS) – is a set of compatible BISs, which is necessary and sufficient for construction of main units of computing or control chipset equipment.

The MPS comprises 3 groups of integrated microschemes: the central MP, memory system and input/output system.

All periphery units are switched to central MP through the intermediate control registers, which are called input/output ports.

Nowadays local individual MP systems are giving way to control computers constructed on PC basis. In future this tendency will grow.

Standard equipment having great opportunities together with constant cost reduction

Is more economically profitable. This is also confirmed by construction of GMDSS equipment set. In ship conditions maintenance of and repairs to such equipment are reduced to PC maintenance (described in detail in Module 4) and software – hardware interface.

Interface – is a totality of certain periphery unit characteristics, determining organization of information exchange between this unit and the central processor. These are electrical and time parameters, a set of control signals, data exchange protocol and construction details of joining the units. Data exchange between MP system components is possible only in case of their interface compatibility. The principle of IBM compatibility means standardization of separate components interfaces, which, in its turn, determines flexibility of the system as a whole, i.e. possibility, when necessary, of changing the system configuration and of

connecting/joining different periphery devices. In case of interface incompatibility (for example, interface of the system bus and hard disk interface) controllers are used. Besides, flexibility and standardization of the system is achieved through introduction of intermediate standard interfaces, such as interfaces of serial and parallel data transmissions, which are indispensable for operation of the most important periphery input/output devices.

3.3 Interrupts interrupt request lines.

For units of the computers to cooperate with CP a system of interrupts is provided in IBM compatible computers. This system of interrupts allows the computer to suspend the current processes and to switch to others as an answer to the received enquiry, for example, to pressing the key on the keyboard.

On one hand, it is desirable that the computer should be busy with the work given to it, on the other hand, its instant reaction to any inquiry drawing its attention is needed. The interrupts provide the immediate reaction of the system.

Every computer component, which may require the MP attention, is given its interrupt number. In IBM-PC compatible computers there are 2 kinds of interrupts: hardware interrupts and software interrupts. To hardware interrupts are referred, first of all, interrupts which are built into the processor, interrupts when division by zero is effected, interrupts when there is power supply emergency; also there are interrupts with the help of which the processor is given information about hardware events, for example, absence of paper in the printer or about disk operation end.

With the help of interrupts application, programs can perform options programmed in the operation system, ROM BIOS and other service programs.

In the PC control over hardware interrupts is effected by special micorschemes – interrupt controllers. On up-to-date motherboards interrupt controllers are integrated in chipset periphery controller microscheme. In PC XT with the 8-bit ISA bus there are only 8 external hardware interrupts. In PC AT with the 80286 processor the number of interrupt lines was doubled thanks to use of 2 controllers.

3.4 Direct memory access.

Data transfer in the Direct Memory Access (DMA) mode is required when there is data exchange between the main storage/operation memory and high-speed devices. In the DMA mode a peripheral is linked with main storage/operation memory directly through the direct-access channels (DMA channels) but not through the inner MP registers. Such a mode can be the most effective in situations when high speed for big information transfer is required (for example, when loading compact disk data into memory). To initiate the process of direct access the system bus uses appropriate signals. So, the unit requiring direct memory access addresses the controller by one of the vacant DMA channels informing it of the address where the data should be transferred, the initial address of the data block and the data amount.

IBM PC/AT compatible computers have 7 DMA channels. As for interrupt controllers, the direct memory access is achieved by cascade/one-by-one/serial insertion of the two i8237 microschemes integrated into the periphery controller microscheme; one of the lines (DMA 4 channel) is used for joining DMA-0-DMA-3 channels.

Of all the DMA channels only DMA 2 channel is typically employed for data exchange with a floppy disk drive. Sound cards usually employ DMA-1 and DMA-2 channels.

Different devices can use one DMA channel but not simultaneously, for example, DM-1 Channel – for the sound card and streamer. In this case it is not possible to listen to the music and to record the file on the streamer at the same time.

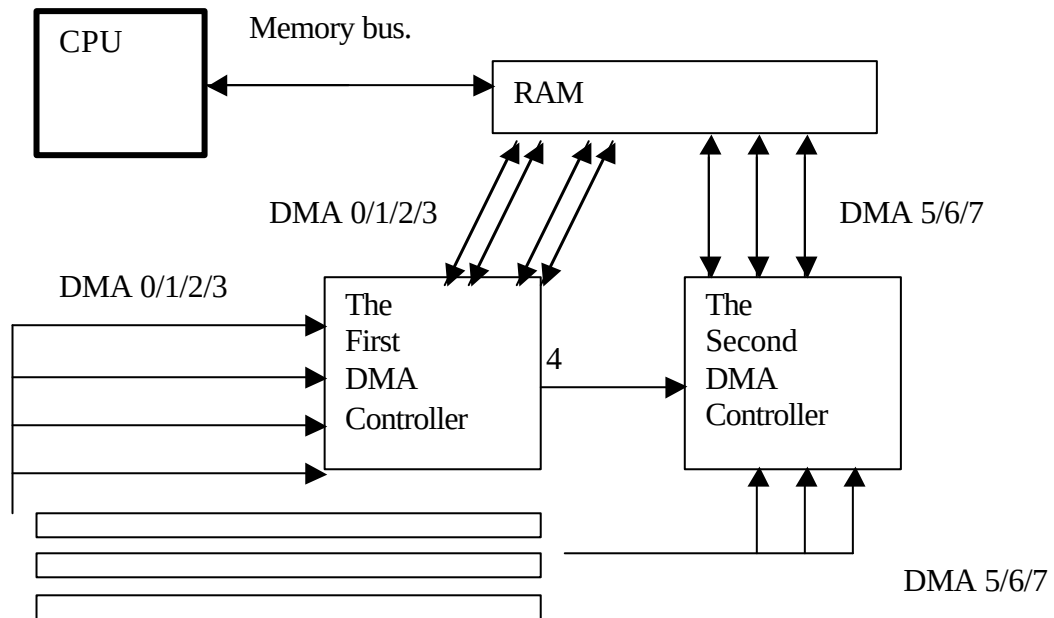


Fig 3.4 DMA channel purpose.

3.5 Input/output ports.

Any device in the PC (controllers, installed on extension cards or on motherboards) with the exception of operation memory is regarded by the central processor as peripheral.

The data exchange between the central processor unit (CPU) and peripherals is effected through input/output ports. Constructively an input/output port - is a buffer or is a register of the controller or the message processor etc., which are switched directly to the PC input/output bus.

For monitoring data exchange between hardware computer components every input/output port is given its unique HEX number (port address) for example, 2F8h, 370h.

It should be noted that peripherals could use several input/output ports.

Addressing ports is performed by the central processor when executing this or that program. In order to exclude this or that program. In order to exclude the need of indicating a definite address of each input/output port, and the necessity of their operative changing depending on a definite computer configuration, there is a term "Base address In/Out"

3.6 ROM BIOS.

This element (ROM BIOS) is often called BIOS (basic input-output system). From hardware point of view it is a memory block with the capacity of 64kb. The leading manufacturers of ROM BIOS are AMI, AWARD and PHOENIX companies. The functions performed by BIOS systems are the same and do not depend on the manufacturer.

ROM BIOS performs 3 main functions:

- provides hardware drives for the operation system and effects interface between the motherboard and other PC means; ROM BIOS must correspond to a definite motherboard.
- contains system check test program, so called POST (Power On Self-Test), which checks all the most important components in time of PC switching on.
- contains CMOS (Complementary Metal Oxide Semiconductor) setup program for identifying BIOS parameters and PC hardware configuration.

BIOS contains a set of main functions for standard external PC devices monitoring. Changes in configuration (for example, information about a new hard disk, are recorded into a special area of memory and from there are read out by ROM BIOS), which is called CMOS RAM (Random Access Memory). This memory area (100-129 byte capacity) is placed in the 82C206 periphery controller.

3.7 Buses.

A bus is a combination of lines (semiconductors on the motherboard) by which PC components and units exchange information.

A bus is intended for information exchange between 2 and more units. A bus connecting only 2 units is called a port.

The bus has its own architecture, which allows it to put into practice its most important features – the possibility of parallel connection of practically unlimited number of external devices and information exchange between them. The architecture of any bus includes the following components:

- lines/channels for data exchange (data bus)
- lines/channels for data address (address bus)
- lines/channels for data check (check bus)
- bus controller

Bus controller effects control of data exchange and of service signals and usually are made as a separate microscheme or are integrated into Chipset microschemes. For example, the i440BX chipset controller of the PCI (Peripheral Component Interconnect) bus is integrated into the 82443BX microscheme.

Data bus

By this bus data exchange among CPU, extension cards inserted into slots and memory is provided. Data exchange control in this mode is effected by means of a corresponding controller avoiding CPU.DMA controller, earlier included into the 82C206 microscheme is now integrated into one of chipset microschemes, or example, the 82443BX.

The higher the bus capacity, the more data can be passed at a certain period of time and the PC efficiency is higher. Computers with the 80286 processor had a 16-bit

data bus, with the 80386 and 80486 CPU – a 32-bit data bus and Pentium computers have a 64-bit data bus.

Address bus

The process of data exchange is possible only in such a case when the sender and the receiver of the data is known. Every PC component, every input/output register and a RAM cell have their address and are included into the common address space. For addressing some PC component the address bus is used by which a unique identification code (address) is passed.

For acceleration of data exchange a unit for intermediate data storage (RAM) is used. The data size which can be temporarily stored there is very important. This size depends on the type of address bus (the number of lines) and in such a way on maximal possible number of addresses generated by the processor on the address bus, on the number of RAM cells to which addresses can be assigned. The number of RAM cells must not increase 2^n where n – is the type of address bus. In the opposite case a part of cells will not be used because the processor will not be able to address them.

In binary code the expression for determination of the maximum addressable memory volume is the following: addressable memory size is 2^n where n is the number of lines / channels of the address bus.

The 8088 processor, for example, has 20 address lines and can pass the memory size of 1Mb. In the 80286 processor PC the capacity of the address bus is already 24 bits and modern 80486, Pentium, Pentium MMX and Pentium II have a 32-bit address bus with the help of which 4 Gb of memory can be addressed.

Control bus.

For successful signals transmission by the bus it is necessary to have a number of service signals. For the data to be recorded/read to the registers of units connected to the bus and addresses of which are indicated on the address recording/reading bus, signals of readiness for data receiving /passing, signals of confirming data reception, signals of hardware interrupts, of control and DMA controller initializing are needed. The check bus transmits all these signals.

Bus type and throughput.

The most important bus characteristic is the capacity of the bus, which is determined by data amount “going” through it at the same time. Here and further under the capacity of the bus is understood the capacity of the data bus.

3.8 Bus types.

ISA (Industry Standard Architecture) bus was earlier a standard in PC and is still used even in the most modern PC models. There are still many peripherals using ISA standard (mouse, keyboard, modems, hand scanners, FDD etc.) for which the operation speed of this bus is sufficient.

Intel Corporation together with Microsoft does not intend to use this bus any more. They propose to switch floppy disk drives, mouse, keyboard, scanner and other

devices to the USB bus and for connecting for example, hard disks, CD-ROM and DVD-ROM drives, videocameras - to use the IEEE 1394 new bus.

MCA (Microchannel Architecture) bus.

Decrease of the system efficiency because of low clock frequency of the bus stimulated development of the so-called Microchannel bus.

The characteristic feature of this bus is its increased throughput up to 20 Mb/s owing to increase of clock speed up to 10 MHz and bus capacity up to 32 bits.

When the MCA bus was employed there was no necessity to configure external units inserted into MCA extension slots manually.

PCI bus.

Periphery Component Interconnect was developed by Intel company for the new, highly efficient Pentium processor. The PCI bus unlike the EISA and VLB is a completely new type.

In modern PCs the clock frequency is driven as half a clock speed of the system bus, that is if the system bus has the clock speed of 66 MHz, the PCI bus will work at 33 MHz frequency.

The principle laid as basis of the PCI bus is employment of bridges, which effect connection between the PCI bus and other buses (for example, the PCI to ISA bridge). The important characteristic of the PCI bus is that it follows the principal "Bus Mastering" which means the ability of the external unit to master/control the bus (without CPU participation). During information transfer the unit working on such a principle effects the bid of the bus and becomes the master. This releases the processor from performing other tasks when the data transfer takes place.

The PCI bus uses its own technique of data transfer. This technique is the following: 2 devices/units are selected in the system: a transmitting one (initiator) and a receiving one (target). When the initiator is ready for transmission it gives data to the data channel/line and supplies them with the corresponding signal (indicator ready) and, doing this, the receiver records data into its registers and gives a signal "Target ready" confirming data record and readiness to receive the new amount of data. Setup of all signals and also reading/recording data is effected strictly in accordance with clock pulses of the bus, the frequency of which is 33 MHz.

USB bus.

Peripheral USB bus (Universal serial bus) was developed by Compaq, DEC, IBM, INTEL, Microsoft, NEC and Northern Telecom companies for connecting peripherals outside the PC case. The USB is supported of plug and play technology. The speed of information exchange by means of the USB bus is 12 Mbit/s. On new motherboards there is a special socket unit for connecting the USB concentrator (USB HUB). It is possible to connect peripherals (a keyboard, mouse, joystick, printer) to computers equipped with the USB without switching off the power supply. As soon as such a peripheral is connected, its configuration is effected automatically. All peripherals must be fitted with the USB socket units/joints and should be connected to the PC through a separate block called the USB-hub or

concentrator with the help of which it is feasible to join up to 127 peripherals to a PC.

Special drivers are developed for use of the USB bus under control of Windows 95/98, Windows NT and OS/2 Warp operation systems.

IEEE 1394 bus.

IEEE 1394 is a standard of a high-speed local serial bus, which was developed on the basis of FireWire technology by Apple and Texas Instruments companies. It is a part of the new Serial SCSI (SCSI-3) standard.

The IEEE 1394 bus is intended for digital information exchange between PC and other electronic devices. Owing to high speed of data transmission this bus becomes a new standard for input/output bus for a PC: Fire Wire Variable architecture and one-rank topology is an ideal variant for connecting hard disks and audio-video information processing devices. The bus is suitable for work of multimedia applications in real time.

Local serial bus IEEE 1394 can pass data at the speed of 100,200,400,800 and 1600 Mbits/s (12.5,25,50,100 and 200 Mb/s) and, working with files of some types, up to 1Gbit/s. High speed is attained because of information transmission in packet/batch mode. Besides, the IEEE 1394 bus provides simultaneous work of several devices, already produced. The BIOS developing and supporting companies begin to pay more attention to self loaded devices.

Intel recommends to use the IEEE 1394 bus equally with the USB (the USB is already included into the register/list of modern PC compulsory components) in all computer types.

Parallel data transmission.

Parallel communication means that bits are sent and transmitted not one by one, but all 8 bits (or 1 byte) simultaneously (parallel). The cable for parallel transmission must contain, as minimum, 8 lines, each of which is intended for transporting 1 bit of data.

Centronics company develops parallel interfaces. Such an interface is often called a printer interface or Centronics. Parallel transmission is, as a rule, one way. Some new printers may be configured and controlled with the help of software. They require a two-way printer cable for communication. A special cable is required for data exchange between 2 PCs through a parallel interface with the help of such a program as LapLink.

Signal distribution in the interface corresponds to the Centronics 36 contacts – socket.

Use of parallel interfaces.

In manuals parallel interfaces are usually called in abbreviated ways like LPT or PRN. The latter abbreviation for a printer is to LPT1.

A standard parallel port is used only for one-direction transmission of information from the PC to the printer, which results from the port electrical construction. It (the port) provides maximum data transmission speed from 120 to 200 Kbits/s.

Sequential data transmission.

For sequential interfaces the choice of connected devices is considerably wider, that is why most PCs are equipped with 2 sockets for sequential data transmission. The socket of the sequential interface in a PC is 9 contact Sub-D connector and the 25 contact Sub-D connector. As a standard notation for a sequential interface most often RS-232 is used.

The main element of the sequential interface is the 8250 microscheme for old and the 16450 UART (Universal Asynchronous Receiver Transmitter) for new controller cards. The controller with the 8250 chip provides maximum data transmission speed 9600 baud, and the one with the 16450 – 115200 baud.

Unlike parallel data transmission, sequential data transmission is effected bit-by-bit. Separate bits are transmitted (or received) sequentially one after another and data exchange in two directions is possible. The level of voltage of the sequential interface varies in the range from –12v to +12v. Thanks to this relatively high voltage, the resistance to interference is increased and data can be transmitted without losses by the cable, the length of which is 50m and more.

In asynchronous mode which is used by PCs (the transmitted instruction is composed of a start bit, 8 bits of data and one stop-bit) reception and transmission of data are effected with the same clock frequency.

Data transmission speed.

The nominal speed of data transmission is determined by the number of elements of binary information transmitted per 1 second.

Effective (real) speed is the speed of transmission which takes into account necessity of transmission of service information (which decreases the effective speed as compared to nominal) and compression of data (which increases the effective speed). The rate of transmission is determined in baud. Sometimes instead of baud the notation bps (bit per second) is used or bit/s. But these are different things. The value in baud shows the number of transmitted bits taking into account service bits (start bits, stop-bits, and parity bits). And the value in bps shows effective speed of data transmission only. Typical values of data transmission speed through the sequential interface for PCs and peripherals (such as modems) are 1200,2400,4800,19200 baud and higher.

When there is data transmission between 2 modems, one of which is a high-speed 33600 baud modem and the other can provide data transmission only at the speed of 2400 baud both computers will communicate at the speed of 2400 baud.

Start bit, stop-bit, data bits.

During sequential transmission the data are separated by means of service bits, such as start bits and stop bits. These bits show the beginning and the end of sequential transmission of data bits. This method of transmission allows to synchronize receiving and transmitting parts and to level the data exchange speed.

Parity bit.

For identification of errors during sequential transmission a parity bit is additionally included into the service bits. There exist several different variants of the parity bit:

- no parity
- even parity
- odd parity

The value of the parity bit is determined by binary sum of all transmitted data bits. For establishing connection/communication between two sequential interfaces it is necessary to configure them appropriately beforehand, that is, to indicate how data exchange will be effected: the speed of exchange, the data format, parity and so on.

In practice these parameters are indicated only in brief. For example, "8E1" means data exchange protocol with the number of bits – 8, even parity and one stop – bit. "7N2" stands for 7 bits of data, no parity and 2 stop bits.

Wiring the terminal, in our case, the PC for data transmission is not always easy. The cable attached to the peripheral should be used.

If two PCs need to be connected through the sequential interface, the so-called Null-Modem cable should be used because special equipment for data transmission, for example, modem, does not take part in the process of communication. Possible schemes of connecting 2 PCs through the DB9 joints are given in Fig 3.5

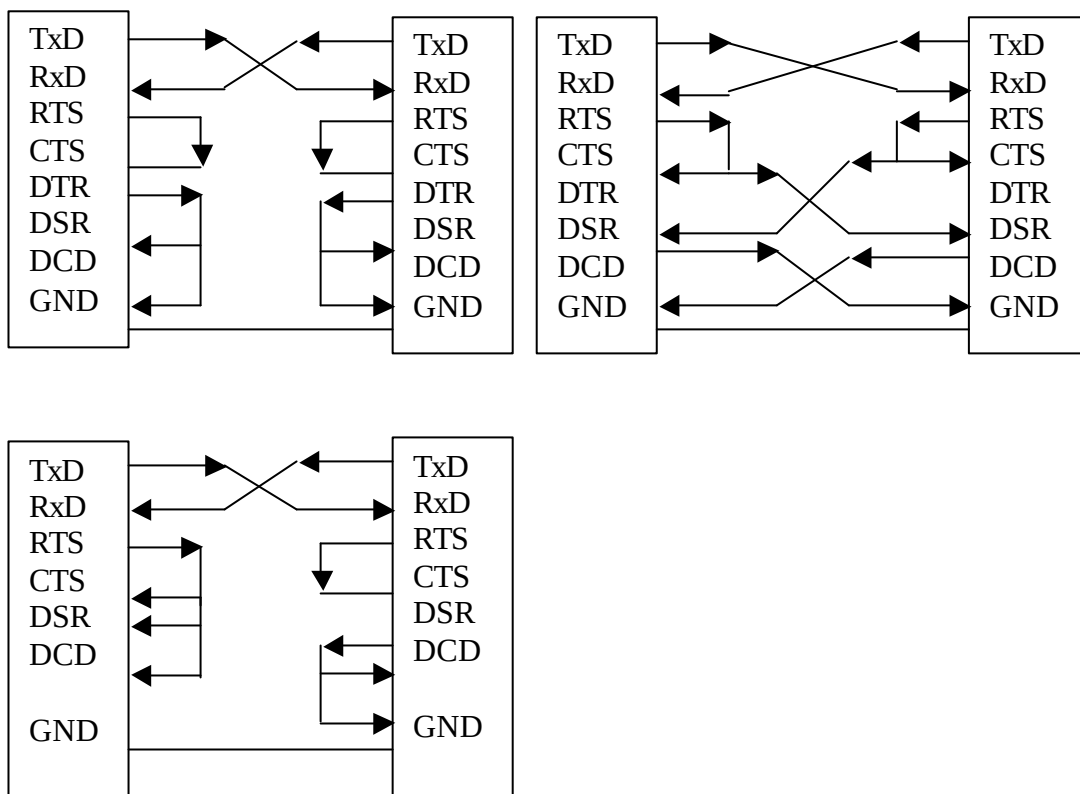


Fig 3.5. Connection of 2 PCs through the Null-Modem cable.

Interruption and addresses.

COM ports may be configured in different ways. BIOS PC has up to 4 consequential interfaces. Usually there are no problems with configuration of two of them because standard sets on the interface plate usually correspond to optimal. Problems can arise during the COM3 and COM4 ports configuration, because for them it is necessary to indicate addresses and numbers of interruption lines, which do not cross with other devices.

SECTION 4

PC SOFTWARE AND HARDWARE

The purpose of the section is to provide users with knowledge concerning hardware and software of the modern PC and skills of PC usage and maintenance as an element of a ship radio station.

Entry standards:

The candidate should have knowledge of:

- the structure and basic principles of PC work,
- composition and purpose of PC external devices,
- the function of operational system,
- algorithmic language conception,
- applied program and driver conception.

After completion of this course the trainees should have knowledge of:

- PC hardware, software,
- basic local and worldwide computing network notions;
- diagnostic, troubleshooting and upgrading procedures.

Outline

No.	Learning objectives	Class hours		
		Total	Theoretical	Practical
1	PC hardware; Video subsystem; Peripheral devices; System unit	10	4	6
2	PC operational system; OS MS DOS; OS MS Windows, multitasking, file systems; Software installation	14	6	8
3	System software; Disk diagnostic& maintenance tools; File compressing; Antivirus software	6	2	4
4	Local and worldwide Computing networks; Local network conception; Network software; Worldwide network Internet	16	4	12
5	PC maintenance; Installation; Error diagnostics; Installation, replacement and connection of mother-boards; Components: installation and configuration; Electro supplying and safety of PC servicing	12	6	6
Total		58	22	36

Introduction

Computing means are the basis of control, storage and processing system automatization on board the ship as well.

The most part of data processing is performed with the personal computers (PC). GMDSS ship station, electronic cartography, loading monitoring and stability of a shipsystems, ship-office systems are developing with the PC as a basis. Two aspects can be distinguished in the PC architecture - hardware and software.

Hardware – is the physical devices and electronic components of which the computer consists. Software – is the program, which provides the coordinated work of facility

and solution of the applied tasks. Both aspects are covered in the given chapter. The basic principles of building up local and global computing systems and their usage are examined as well.

4.1. PC hardware

Three basic components can be distinguished in the PC: system unit, keyboard and monitor; all basic elements are located in the system unit; power unit, motherboard, plug-in cards, (expansion boards), drives. Keyboard is the universal means to enter information into the PC by user. Monitor is the universal means to present information (textual and graphical) for user. These basic components are connected with each other by means of special cables with connectors and provide entering, processing and presentation of information. The basis of IBM PC is open architecture, based on total data base and expansion connectors to connect different additional devices.

4.1.1 System unit

Case and power

Dimensions and system board location, min power of power unit and max quantity of installed drives are dependent on the type of system unit. Power unit is mounted in PC case and overall sizes of such unit correspond to the type of frame. That's why while replacing the power unit one should take into accounts that power unit for the frame of desktop type doesn't correspond to the dimensions of the case of slim line type. Besides the power of PC power source should fully and even with some margin provide power to all connected devices. Power of Power units varies from 100-150 to 300-330W. The most of PC electronic components require the power voltage of "+5V", drives - "+12V", some other devices – "-5V" and "-12V". Processors require power voltage of +1.3..3.2. two 6- contact connectors (more seldom – 1 total) are used to provide power for system board. 4-contact – connectors are designed for supplying drives: two contacts "ground" (black lines) and two contacts "+5V" and "+12V" – respectively red and yellow lines.

In line with two existing standards of system boards AT and ATX at present PC case are divided into AT type and ATX type. In ATX cases (the most modern) the location of connectors at the back panel is changed, and the power unit, which can provide voltage of +3.3V is installed.

System (mother) board

System board of the PC is the basic component. It is a printed circuit on which all basic electronic elements are placed: microprocessor, memory, BIOS, cache, crystal resonator, set of auxiliary chips, expansion slots and connectors to connect keyboard and a mouse as well.

There are PC, in which all components, necessary for its work are placed on the board. They are called All-In-One boards. However, the system boards of the most PC contain only main nodes but elements of communication with the monitor and other peripheral devices are absent. These elements are placed on separate plug-in cards, which are put in special expansion slots provided for that on system board.

Additional cards are called daughter boards and system board – mother-board. Functional devices, placed on daughter boards are called controllers or adapters and daughter- boards themselves – expansion boards.

At present two types of mother -boards are used in PC – AT and ATX. ATX is the up-to-date standard for system boards. ATX standard system boards are placed in lengthwise along back edge of the system unit. It makes possible to install more expansion boards They have one _connector for power (not 2 as AT boards), and require additional voltage supply +3.3v. That's why ATX standard boards are placed into cases, supporting ATX standard with the power supply, which provides the required voltage. The most up-to-date boards for the processors Pentium II, III, are manufactured in ATX standard.

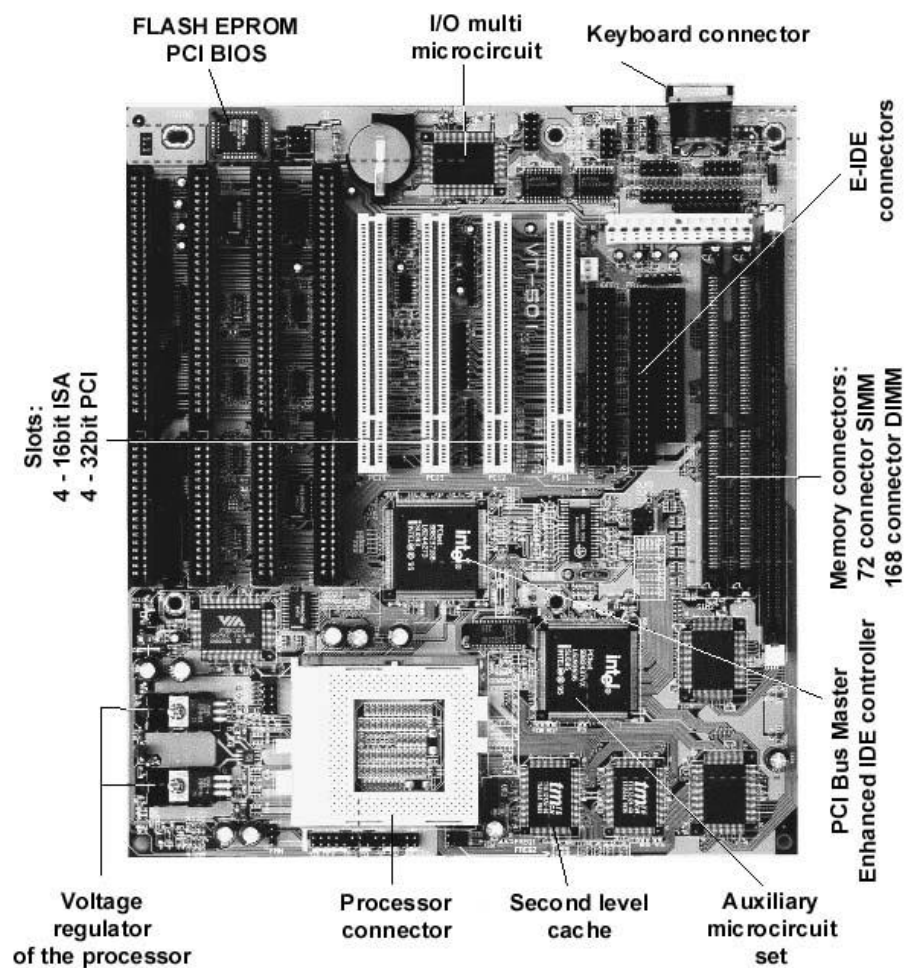


Fig. 4.1 AT format motherboard

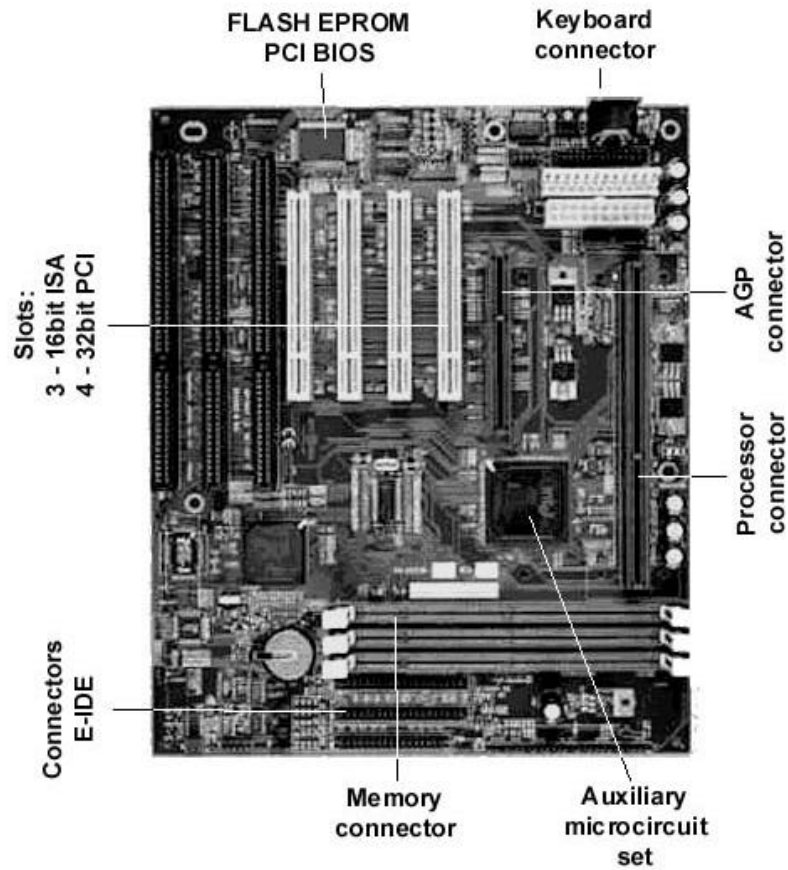


Fig. 4.2 ATX format motherboard

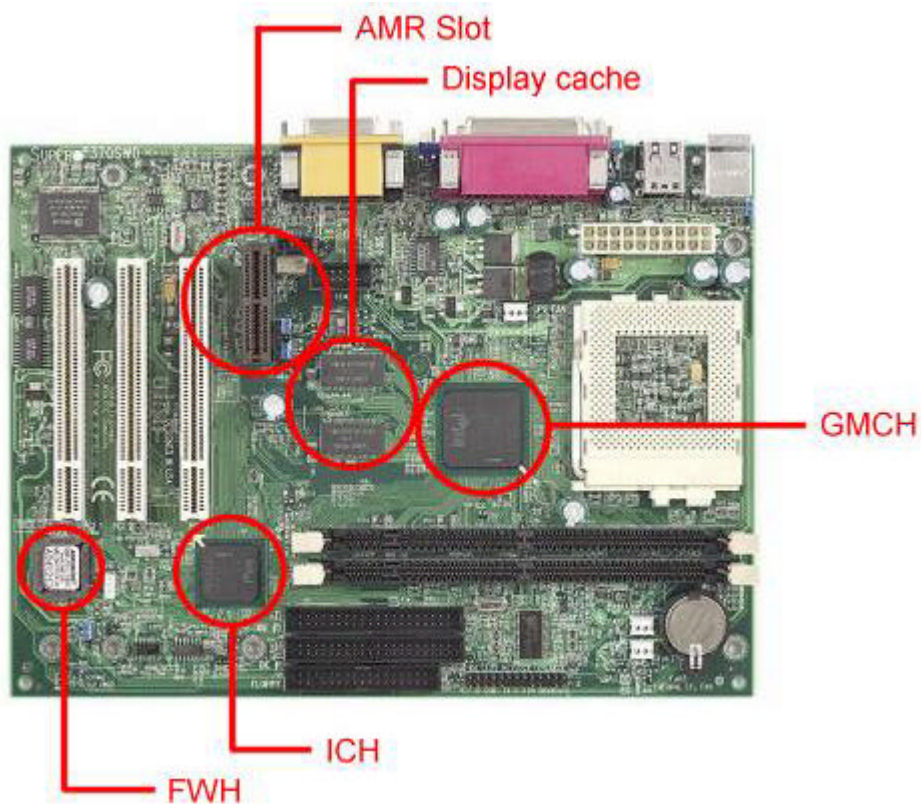


Fig. 4.3 Motherboard for Socket 370 (Chipset Intel 810)

Chipset

Chipset is a kit of chips, which is on system board provides the connection of all electronic components, placed on it. Chipset characteristics define all functional peculiarities of system board – frequency of system bus, types and max size of system memory, max size of cached memory, _ supporting of modern interfaces USB, AGP and so on. That's why all system boards are defined by the mark of the chipset installed on them. The main manufacturers of chipsets – Intel, Ali, VIA companies.

Central processor unit

Processor (CPU – Central Processor Unit) is one of the most important elements of any PC. Its function is to control all other elements of the PC and to perform specific applied programs. Features of the processor to a greater extent define a possibility of the entire computing system. Processor is defined as a super large integral scheme (chip) realized in a single silicon chip.

Processor includes arithmetical-logical device, control unit and cache memory. They are characterized by speed (clock frequency) capacity (internal and external), a set of commands and architecture. With the external devices processor can come into contact by means of address, data and control buses led on special contacts of chip package. As it takes place, the capacity of internal processor registers is able not to accord with a number of external leads for data line. Volume of he physically addressed by a processor memory is defined by the capacity of external bus as 2^n , where n is a number of address lines.

Intel processors

The recognized leader among PC manufactures is Intel (INTEgrated Electronics). It is one of the first companies producing mono crystal microprocessors for PC and it was a great success for it to cooperate with IBM. The first IBM PC were produced with Intel processor. At present, the architecture of processors, produced by this company (namely architecture x 86) is a standard for all other manufacturers. In PC processors compatible with Intel PC are used. All latest types of PC include command systems and architectures of the previous models, providing compatibility with the previously created software.

Hand in hand with Intel processors for PC are produced by other companies. Primarily they are – IBM, AMD, IDT companies. The main competitor to Intel is Advanced micro Devices (AMD). Manufactured by AMD processors K-6 are analogous to Pentium II, III but cheaper ones.

At the end of 1999 the processor K-7 Athlon-600 was produced by AMD. The processor is designed for working on system bus with the frequency of 200 MHz. It has a cache memory of the first level 128 Kbt, the second level – 512 Kb (works on the half of the processor frequency). At that time Athlon was the most powerful processor (10-20 % more than Pentium III – 600). It is performed in Cartridge and is installed into slot A on system board (not compatible with slot 1 for Pentium II-III).

Memory

Processor memory is designed for storage of programs, which control the processor and data processed by PC. It can be divided into four types: cache, RAM, external, ROM.

SYSTEM MEMORY (RAM). RAM is designed for temporary storage of information, which can be changed in the process of computing. Access to the memory can be achieved very quickly, information in it can be changed repeatedly, but the main disadvantage of that kind of the memory is full power dependence – when the power is cut off, the stored information disappears. RAM allows the access at any time to the free chosen cell – memory with the free choice – RAM (Random Access Memory). At present to build up RAM two types of chips are used:

DRAM (DYNAMIC RAM) – dynamic memory – each byte of the memory is given by the presence or absence of the charge on the condenser, formed in the structure of silicon crystal. Time of data selecting – 50-150 ns.

DRAM is configured as a matrix of lines and columns. The process of reading data out of line is arranged so that the process of reading of entire line in buffer performed on static memory elements occurs. As this takes place the discharge of condensers in the given line DRAM occurs. To restore the content of the memory after the reading of data out of it, it is necessary to record the read line secondly out of buffer into DRAM. The next disadvantage of DRAM is the effect of charge leaking out of condensers, that results in necessity to periodically restore the record information in refresh cycle with the period of approximately 300 ms. It to some extent diminishes the speed of work of dynamic memory in comparison with the static one though as for information capacity, cost and power consumption of this type of memory is preferable.

SRAM - static memory – Static trigger shows each byte of the memory. Static memory is faster – 12-20 Ns but more expensive, that's why it is used generally to arrange cache memory.

CACHE MEMORY is used to agree the speed of work of dynamic memory and processor. Internal memory of processor (registers) is built similar to static memory, which works much more faster than dynamic one. The time of selection for chips of dynamic memory is 50-150 ns. For the processors with high clock frequency, it corresponds to several cycles. During this period the processor is forced to wait for information. If the all RAM memory of the processor was performed on chips of static memory, it should essentially increase its cost. The use of cache memory is a compromise agreement. It implies that all necessary information is read by the processor not directly out of RAM memory but rewriting it into cache one. For that the specific memory unit is read, which occupies the line of cache memory. While selecting the next portion of data (or commands) there is a great chance that they are in the given unit as well and can be selected out of cache without RAM memory. Cache memory contains some lines (e.i. selected out of memory units) and if it is necessary to select a new portion of data, its the least used line is replaced.

ROM MEMORY (Read Only Memory) is a power-dependent memory with relatively long procedure of rewriting, used to store unchangeable data (for example – BIOS). There are the following types of ROM:

PROM (Programmable ROM) – a single programmed memory.

EPROM (Erasable PROM) – a reprogrammed memory (with ultraviolet erasing).

EEPROM (Electric EPROM) – electrically rewritten memory.

Flash-memory – power-dependent memory, which allows to repeatedly re-write directly in the device, has a special rewriting buffer to correct and check the contents. Rewriting from buffer into drive is performed on special request if there is an additional power of +12 B.

CMOS RAM (Complementary Metal-Oxide-Semiconductor) – memory with the minimum of power consumption and low fast activity. It is used with battery power to store system parameters.

BIOS (Basic Input Output System) – basic system of input-output the contains the following elements:

- Set of interactivity functions with the PC hardware (interruptions and devices)
- Test program for the hardware when the power is switched on of PC POST (Power-On-Self-Test)
- Program of calling the loader of operational system.

The most up-to-date Video adapters and _drive controllers have their own system BIOS, which adds the system program and in a number of cases some programs, involved in them, replace the proper modules of the main BIOS. BIOS is realized as a chip installed on system board of PC. Before BIOS was a constant memory – ROM (Read Only Memory). At present it is performed on flash memory chips. The use of flash memory allows to re -write information several thousands times. It is convenient to modify BIOS installed in PC. Together with system board, having flash-BIOS, diskette with special _utility is provided. However, it is possible to allow such a recording only by "hardware" method – by switching fuses on system board.

BIOS programs use some data on PC configuration: volume of memory, types of drives, system hours (clocks) readings. These data are stored in special "power-independent" memory CMOS RAM. This memory is constantly fed by accumulator placed on system board. To change the content of CMOS in BIOS special program setup is provided. This program is activated by special combination of keys in the process of loading, after the proper loading or after an error occurs.

VRAM (Video RAM) – two -port memory for video adapters- provides access from the side of bus simultaneously with the reading in RAMDAC (RAM Digital-to-Analog Convectector) to regenerate picture.

MDRAM (Multibank DRAM) – memory for video adapters, consisting of 32 independent 2 kByte banks DRAM, which provide possibility of independent appeal to different areas.

WRAM (Windows RAM) – more quickly active and expensive two-port memory for video adapters.

SGRAM (Synchronous Graphic RAM) – special version of SDRAM, Synchronous Dynamic memory with working frequency of 125 MHz for video adaptors.

System and local buses

System bus is designed for transmitting information between the processor and PC RAM memory.

Bus can be characterized by:

- a number of data lines, which uniquely define the capacity of transmitted information;
- a number of address lines, which uniquely define max size of addressed RAM memory;
- a number of apparatus interruptions (IRQ);
- a number of direct access line into memory (DMA – Direct Memory Access)
- rate of data transmitting.

Local buses are designed to connect the processor directly with the peripheral device controllers, primarily controllers of drives and adapters. At present the following buses are used in PC:

PCI bus (Peripheral Component Interconnect). It is designed to work on fixed clock frequencies of 33 and 66 MHz and uses 124 contact (32-charge) or 188 contact (64-charge) connectors. When it takes place, the rate of data exchange can achieve respectively 132 and 264 Mbytes/sec. A new specification of PCI bus designed to work with Pentium 100 and higher define the rate of data exchange up to 500 Mbytes/sec.

PC Card Bus (PCMCIA) – is designed by Personal Computer Memory Card International Association generally for Notebooks, however now it is used for desktop PC. It allows to connect memory expander, modems, disk and strimmer controllers, SCSI adapters, Network adapters and so on.

The bus addresses up to 64 Mbytes, 16-chargable, frequency up to 33 MHz. PC Card adapters are performed as thin (3-13 mm) plates, inserted into special plugs of PC.

SCSI Bus (Small Computer System Interface) – is standardized to be connected to the computer of internal and external additional devices, such as scanners, digital cameras, strimmers. Its productivity is 10-160 Mbytes/sec.

Up to 15 devices can be connected.

IEEE 1394 Bus (Fire Wire) – the development of SCSI, has a serial interface with the productivity of 100-400 Mbytes/sec (up to 1600 in the future) to connect disks, strimmers, scanners, digital facilities and so on, supports Plug and Play technology. Up to 254 devices can be connected (127 if simultaneous work of 2 and more devices is needed) according to tree topology.

USB Bus (Universal serial bus) – Universal Serial Channel – up-to-date high-speed serial bus used to connect external peripheral devices. Two -directional data transmission with the speed of 1.5 or 12 Mbytes/sec (USB 2.0 specification provides pass capability of bus up to 480 Mbit) is provided. This Bus is designed to make the connection of different devices universal. USB-devices (monitors, scanners, keyboards, video cameras and so on) having two USB-connectors can be connected

in serial. Peripheral devices can be connected by means of special concentrator as well, forming _tree structure up to 127 units.

Storage devices

Hand in hand with RAM memory, external memory is of great importance. External memory is power- dependent and its size as a rule considerably exceeds the size of RAM memory.

The storage devices can be considered as a totality of media and an appropriate drive. That's why devices with removable and non-removable carrier can be distinguished. The storage devices itself can be either of disk or tape type.

The storage devices with tape media (on magnetic tape) are the devices with serial access, when in order to get an access to definite data division it is necessary to read all previous information. This is storage with the tape, working in start-stop regime and streamers, working in flow mode.

Disk storage are devices of free access and are divided into:

- fixed disk (hard) drive
- removable disk drive
- floppy disk drive
- high density disk drive
- magnetic-optical disk drive
- CD drive
- DVD drive

4.1.2. Video subsystem of PC

Video subsystem is the main means of information output and presentation for the PC user. At present time it is becoming more and more important in connection with the graphically oriented operational systems, programming means and applied programs. Video system involves monitor, video adapter card and the set of proper program-drivers.

Monitors

The most up-to-date PC (excluding portable) use monitor based on ERT (Electro-Ray Tube) or CRT (Cathode Ray Tube). The principle of monitor operation is that emitted beam of electrons is fed to the screen, covered with luminophore and makes it shine. There is a deviation system on the way of electrons (permitting to alter the beam direction) and modulator (regulating the brilliance of the image). In colour monitors three electron guns are installed, every with its own control system, and the surface of the screen is covered with luminophore of main colours: R-red, G-green & B-blue. In order for every electron gun to come to luminophore of needed colour in special shadow marks and aperture grilles (plates out of special alloy with opening system or slots) are installed inside ERT. Electron beam of each colour periodically scans the screen forming line scan on it. As the beam is moving along lines, videosignal fed on modulators changes the intensity of light of some luminophore dots (pixel – picture element) and forms the picture of its colour. Overlapping, pictures of 3 main colours form the seen colour picture.

Main monitor parameters:

- screen dimension (diagonally) – 14, 15, 17, 19, 20, 21 inch
- resolution – a number of picture elements, which is given on a screen horizontally and vertically (320x200, 640x480, 800x600, 1024x786, 1280x1024)
- point dimension – distance between grains of one colour luminophore. Point dimension define the size of min picture element (0,28-0,24 mm)
- type of shadow mark, which is installed on the way of electron beams to focus them on the grain of one colour luminophore

At present three type of such masks are used:

- 3 point dot shadow mask
- aperture grille
- slot mask

Frequency of vertical scan in Hz (60-200)

Passband of videosignal (100-200 MHz)

CRT MONITOR SAFETY STANDARDS. Recently a great attention is given to the safe service of monitors. To regulate ergonomic and ecological characteristics of monitors a number of standards are developed. Swedish Trade Union Federation plays a great role here. The first popular Swedish Standard, adopted in 1990 was called MPR II. Before it was MPR (adopted in 1987) but it was not recognized everywhere. MPR II very strictly regulated radiation requirements. That is why one can meet sometimes models marked "low radiation", but without MPR II Standard in this way is not actual up to now. But really national and honoured for monitor manufacturers are strict TCO Standards: TCO-92, 95, 99 are now developed. Abbreviation TCO is decoded as Swedish Trade Union Organization. TCO Standards are backed up by 4 Administrations, namely – NWTEK, SEMKO, Swedish Committee on Nature Safety and Trade Union Organization itself. While developing the standards the most modern innovations are taken into considerations as well as the recommendations of different world known institutions like VESA, EPA and UN and UNESCO Committee TCO-99 at present is one of the rigid standards in the world, it concerns not only monitors but to the entire computer and all its elements, including peripheral ones.

LIQUID CRYSTAL MONITORS (LCD) primarily were being developed and used in mobile computers. However, at present rather widely LCD monitors are produced for desktop PC.

While manufacturing LCD panels possibility of special organic composition (liquid crystal) to change their optical features (particularly – polarization feature) in dependence of external electricity are used. In this way if polarized in one plain light flow is passed through liquid crystal and some electrical field is applied, the plain of polarization will be changed in dependence of electrical field intensity. By this the brilliance of output light blow can be changed if an output polarizator is installed. LCD panel is 2 connected with each other glass plates, on which polarizators are sprayed as well as electrode system. Liquid crystal mixture is placed between these glass platers. In the points of electrode crossing condensers are formed, which produce necessary electrical field. Behind LCD panel a powerful light source is installed and changing the transparence of liquid crystal along its surface it is possible to change picture brilliance.

To produce colour picture like in ELT monitors RGB filter system is used. At present two types of LCD panels are produced with passive and active matrix.

Video adapters

Video adaptor is a special card designed form video signal fed on to monitor. Together with video signal, video adapter forms signals of vertical and horizontal synchronization. As a rule video adapter is installed in one of the mother board slots, however in some cases video adapter can be placed on mother board itself. Video adapter consists of:

VIDEO CONTROLLER , on which quick activity and possibilities of adapter are dependent. It is responsible for transmit the image from video memory, regenerating of its image, and forming signals of scan for monitor and processing of central processor request.

Modern video controller contains some units to process information: processing unit for 2D graphics, consisting of SVGA-core and cores of graphical accelerators, processing unit for 3D-graphics, which consist of geometric core (plus cache peaks), raster unit (plus cache texture) and processing unit for video data.

RAMDAC (Random Access Memory Digital to Analog Converter) serves to convert digital data, formed by video controller into analog signals, fed to monitor. RAMDAC has three digital-analog converters; one for each colour channel and SRAM to store data on gamma connection and cursor mask.

Video memory serves to store pictures. Max possible quantity of colours depends on video memory volume. Memory volume can be defined as $A \times B \times C$, where A is a number of dots horizontally, B-vertically, C-a number of colours (in bits).

The following additional elements can be installed on the board of video adaptor.

- Converter of input video signal to express in figures video data from external sources (video camera, video recorder and so on)
- Video signal coder, which can be fed to the TV or video player input
- Expansion connector of video memory to install the proper memory modules
- BIOS of video adapters

All modern video subsystems can work in two modes – text and graphic.

In text mode the monitor screen is divided into separate sign-places, in each of them one symbol can be led. For each sign-place in video memory two bytes are reserved – the code of a symbol itself (number from code table ASC II and symbol attribute (brilliance, colour of symbol and background blinking). To convert symbol codes into pictures on the screen stored in video memory a special sign-generator is used, which according to symbol code generates dual sequence, which is converted into video signal.

Graphical mode is a mode of addressing all points (All Point Addressable). From 1 (monochromes mode) to 32 bits are provided in it for each picture pixel. Max resolution and a number of reproducible colours by video subsystem depend on video memory size and quantity of bits, accounted for 1 picture element.

AGP adapters

Up to now video adapters were performed as expansion card for PCI bus. However, the productivity of this bus is not sufficient for modern multimedia supplement particularly images of 3D graphics. Intel has developed a new bus, specially designed to transmit graphic information – AGP bus. AGP bus works on the frequency of 66 MHz (as opposed to PCI – 33 MHz) and connects directly video adapter and the RAM memory of a computer. Specification of AGP1x defines the speed of data transmission – 264 Mbit/sec, AGP 2x – 528 Mbit/sec and AGP 4x – 1 Gbit/sec.

4.1.3. Peripheral devices

Input-output ports

To connect peripheral devices (printer, modem and so on) with a computer special facilities (adapters) are used. Up to recent time such devices were produced as separate input/output boards (I/O card) inserted into expansion slots of mother-board. At present these adapters are contained on mother-board itself. These adapters used standard interfaces (connective wires and exchange protocols) that are called input/output ports. Two types of ports are used – parallel and serial. Parallel ports are used to connect a printer. It allows to transmit information simultaneously through several channels. However, max length of a connecting cable of parallel port is often limited by 2.5-3 m. As an interface interface Centronic_ is used, and the recent trend is to use interface IEEE12184. In PC up to 4 parallel ports with the names LPT1-LPT4 can be used.

Serial port is used to connect such peripheral devices, as mouse, external modem, remote printer and so on. It allows to transmit information only in serial in comparison with the parallel port. However, the advantage of a serial port is a possibility of data transmission over considerably larger distance (more than 30 m) standard interface of a serial port - RS232C. In a PC up to 4 serial ports named - COM1- COM4 can be used.

INPUT DEVICE. The main device of putting in data from a user is a keyboard and manipulators: a mouse and a trackball.

Keyboard is generally used to input a symbol information into a computer. It includes a field of keys (101 and more) and a micro controller. When pressing and releasing a key, a special digital signal is produced – scan-code, which is fed to the controller of a keyboard. To analyze it with a processor, a special program included in BIOS is used. Then scan-code is interpreted into a symbol code (using information on pressing special keys: Shift, Alt. Ctrl, which is stored in special field of a memory) and is recorded into keyboard buffer (which can contain up to 15 immediately inserted symbols). In the process of reading a symbol from the buffer of applied program this symbol is removed from there.

Manipulators mouse and trackball are used in graphically oriented user interfaces. The principle of work is to define the direction and speed of rotation of a special rubber ball with built in manipulator sensors, which will further convert the information into the parameters of a pointer transferring on a computer screen. To transmit signals of user choice on a manipulator 2 or 3 buttons are used. In case a

mouse is used, a ball is moving along the horizontal plain and in case of a trackball, a ball (larger one) is rotating by the palm of a user.

OUTPUT DEVICES. The device serves to put information out of a computer. At present, the main devices to put out the information besides a monitor are printers and modems.

Printers

Printers serve to put out text and graphic information on a paper carrier. At present there are several different principles of printing and respectively several types of printers.

MATRIX PRINTERS are percussion printing devices. The principle of their work is based on usage of needle heads, which in the process of printing "hammer" colours from a tape in a paper. Printer heads can contain 9, 18, 24 needles, speed of printing in such computers is up to 3-4 pages per minute. The main disadvantage of matrix printers is rather high noise level and white-black printing; though they are rather cheap.

INK PRINTERS are non-percussion printing devices. The principle of their work is based on splashing ink through special nozzles on printing heads. The size of nozzle is considerably less than the size of needle in a matrix printer and it allows to use more nozzles (12-64) and respectively to improve a quality of printing (360 dots per inch). There are black-and-white and colour ink printers. The speed of printing is 2-3 pages/min in the mode of high quality, and up to 7 pages/min in the mode of quick printing.

LASER PRINTERS use electrographically principle of producing a picture. By means of a laser and system on a special photo conductive printing drum, an electrostatic field is formed to which parts of a toner are stuck. Then these parts are transferred on paper and are secured there at the sacrifice of heating up to smelting temperature. The quality of laser printing is rather high (up to 600 even 1200 dots/inch). There are both black-and-white and colour laser printers. The speed of printing is from 4-6 up to 12 pages/min.

Printers with thermotransferring of wax mastic relates to non-percussion printing devices. The principle of their work is that thermoplastic colour substance entered on a tape is heated by microscopic heating elements placed on a printing head corresponds to the entire width of a paper and it allows to print line by line and makes a system of head transferring along a line unneeded. The quality of printing in this case is 200-300 dots/inch: the speed is not high – 1-2 pages/min.

Modems

Modem is a device performing modulation and demodulation of information signals. Modems are used to provide connection between computers and phone lines. The necessity of such a device as modem is connected with the fact that in phone line generally analog signals are transmitted, but inside a computer – digital ones.

Modems are performed either as small expansion card (built in modems) or as separate devices connected with a computer through serial ports (external modems).

They provide not only data modulation/demodulation but compression and decompression of information and errors correction.

The following modulation method are used in them

FSK – frequency shift keying

PSK - phase shift keying

QAM – Quadrature Amplitude Modulation-a modulation when the phase and amplitude of a signal are changed.

The order of communicating between modems and format of transmitted information is regulated by a protocol. Some common protocols are considered as standards. Modem standards are defined by ITU (International Telecommunications Union). In the table 4.1 some modem standards are given.

Table 4.1

Standard	Max. speed of transmission bit/sec
V.21	300
V.22	1200
V.22 bis	2400
V.23	1200
V.32	9600
V.32+	14400
V.34	28800
V.34+	32600
V.90	56600

4.2. PC operational system

4.2.1. Operational system notion

The basis of software is an operational system. Operational system (OS) is a set of programs providing:

- PC and its resources control (memory, screen, disk space, input/output ports and so on
- Starting and execution of other programs
- dialogue with a user

PC operational system is loaded from external drive into RAM memory while switching on and is in it in the process of work. OS stands between a user or applied programs and PC hardware itself (processor, controller and so on). It interprets all commands entered by a user or applied programs and provides execution of low-level operations – memory control entering of commands by drive controllers,

changing of information in location file tables, error processing and so on. While executing applied programs OS provides:

- program loading from drive into RAM Memory
- executing of different activities on program request
- releasing of a memory after finishing (successful or fault) a program.

At present a great number of different operational systems have been developed. However PC in most cases are provided with operating system developed by Microsoft – MS DOS (Disk Operating System) and MS Windows. Below basic features of above-mentioned OS will be given.

4.2.2. MS DOS operating system

MSDOS OS consist of the following elements:

- OS loader – a short program, which is in system disk boot sector and designed for operating system loading
- IO.SYS and MSDOS.SYS files – DOS core files – extension BIOS function and realize the basic MSDOS functions.
- Command processor COMMAND.COM – a program providing dialogue with a user – interprets and performs commands entered by a user. A part of the commands is performed by a command processor itself (inner commands DOS). The rest is interpreted as the named of launched command processor tries to find files, appropriate program and execute them.
- External commands DOS – programs provided together with OS as separate files and complementing an inner command system
- Configuration files CONFIG.SYS and AUTOEXEC.BAT – text files, used in the process of initial loading DOS – to adjust working environment – loading of appropriate drivers, automatic launching a program, which is to be executed at each computer loading (antiviral, shells to work with file system and so on)
- Device drivers – special programs, complementing input/output system and providing work with different external devices

File-system MS-DOS

Information stored in drives in MS-DOS is represented as files. File – is a named area on a disk, storing some similar data. The name of a file in MS-DOS can be compiled of letter – digital and some other symbols and is limited by a length of 8 symbols plus 3 symbols of the extension of file name (define file type). Physically file can not be necessarily recorded continuously on a disk – it can be divided into some fragment physically placed in different part of a disk. File integrity is provided by means of a file allocation table (FAT). For each file in FAT there is a chain of elements, to every of which one cluster on a disk corresponds. These clusters contain the file itself. Cluster dimension for every logical disk is fixed and in dependence of a size it is from 2 to 64 sectors (sector size 512 bites). To accommodate a file a whole number of clusters is provided, but as file length in fact usually is not a multiple of the length of a cluster, the last cluster of each file as a rule is not filled fully and there is free area on the disk. However, this area can not be used by any other file, as it is written from the beginning of a next cluster. It is necessary to bear in mind, that the last cluster of each file is approximately half filled, then each file consumes additionally from 0,5 to 16 Kbytes (in dependence of cluster dimensions in sectors).

Some files can be united in one list, called directory. Directory system is enclosed: root directory contains a number of other directories, and they, in their turn, contain directories (called subdirectories) as well. In fact directory is a file, stored in the field of data on a disk, as any other file. The content of the file defines information on all entering in it files and subdirectories. File system – is a system of file storage on drives. It uses the following system disk areas.

DATA AREA – stores files themselves.

ROOT CATALOG – stores information on root directory files (name, attributes, date of a latest modification, number of the first cluster).

FAT – file allocation table – stores information on physical position of each file on disk (clusters, occupied by each file on a disk).

While recording file on a disk, DOS is searching a free element in FAT and begins to record the file itself into appropriate cluster of data area. If it is necessary to have a size more than 1 cluster, the following free element is being searched, and recording of a file into appropriate cluster is continuing and a reference to this new element is marked into a previous FAT element. A FAT element, corresponding to the latest cluster occupied by the file is marked <EOF> - End Of File. Such a chain is formed in FAT – a sequence of elements, every of which is connected by a reference to the next element, and the latest – a mark of file end. The procedure being finished, and file data are recorded into a catalog (involving number of the first occupied cluster). To read a file from the disk, DOS searches an appropriate entry in the catalog according to the file name, defines number of the initial cluster occupied by the file, addresses to FAT, where using the sequence of references defines the chain of clusters occupied by the file, and then reads the data area information out of given clusters.

Process of MS-DOS loading

Operating system MS-DOS is stored on a disk and when switching on a computer (or system restarting after pressing the "Reset") is loaded into RAM memory. This process is called the process of initial loading (booting). However, before the beginning of loading procedure by OS directly the procedure of a computer self testing- POST- should be carried out, recorded in BIOS. Having finished POST program one should execute initial loading program (ROM Bootstrap Routine) stored in BIOS.

ROM Bootstrap Routine program tries to read sector 1 (head 0, cylinder 0) from a device. If a diskette is installed in a drive when it is not a system one and its boot sector is damaged, an information runs: *Non-system disk or disk error, replace and press key when ready.*

When it takes place, it is necessary to remove the disk out of drive and press any key. In this case, and in the case there is no disk in a drive, loading program tries to read sector according to the same address, but out of C: disk (in CMOS another sequence of questioning disks to search operating system can be defined by a user). In case an operating system is not found on the disk C: the next message runs: *Operating system not found.*

In case the required sector is read, and it is Master Boot Record, then further it is controlled by the IPL 1 program. IPL 1 program scans the contents of Partition Table, defines the accommodation of loading sector (Boot Record) of active volume on the disk and it loads it into a memory. The initial instruction of a loading sector performs the transferring to IPL 2 program.

IPL 2 program using information out of parameter unit Boot Record define if two first files in a root directory of a disk are the modules DOS (MS DOS.SYS and IO.SYS), load these files into a memory and transfer the control to IO.SYS.

IO.SYS Module File CONFIG.SYS is read out of root directory of a disk and the drivers of device and operating system installation described in this files are loaded. If the required file is not found, the default parameter's value is installed. After this Command.com processor is read from the disk and it is transferred a control.

Command.com processor performs a file AUTOEXEC.BAT, which should be in root directory of a loading disk. Meanings for _variables of DOS environment are defined in this file, and programs performed every time as a computer is launched are enumerated. If AUTOEXEC.BAT is not found, then MS-DOS request current date and time from a user. With it the loading process is finished and MS-DOS gives an invitation, which shows that she is ready to receive the commands of user.

4.2.3. Operating system MS WINDOWS

Architecture and possibilities of WINDOWS 3x

Windows 3.0 manufactured by Microsoft in 1990 was not operating system in full measure – for its work a loading of MS-DOS was necessary. However, the system had the following possibilities:

- Used all address space of memory, addressed by the processors I80286 and 80386;
- Used virtual memory – that is worked with a part of hard disk as with the extension of RAM memory;
- Provided multitask in a cooperative mode;
- Had a handily graphic interface.

Architecture and possibilities of WINDOWS 95

In 1995 appeared a new version of Windows 3x – Windows 95. A new operating system provided the following possibilities:

- 32 bit capacity
- real multitasking
- didn't require MS-DOS for its work
- was got in 4Mbytes of RAM memory

Microsoft officially declared the min configuration of PC on which Windows 95 can be installed. CPU: 80386 DX, RAM: 4 M, VGA 640x480x256, HDD 300 M. However, at the above-mentioned configuration the installation of Windows 95 is possible, but not its normal work. For its normal work with appendixes of Windows 95 it is necessary to have not less than 8Mbites of RAM memory.

The core of Windows 95 like Windows 3x consists of three modules.

- Kernel module – controls the distribution of a memory, processes, file system, input/output and so on
- User module – serves to work with a keyboard, timer, mouse and control of windows and elements of interface
- GDI (Graphic Device Interface) module supports graphical procedures – showing off lines, painting over, reflecting of print and interactivity with the drivers of graphic devices.

Features of file system in Windows 95 as differentiated from file system MS-DOS in Windows95 32 bitc file system VFAT (Virtual FAT) is realized, however it is fully compatible with the previous version FAT. The main features of a new system for a user lies in the fact that files can have additional attributes (together with the date of forming a file are stored as well as the date of its latest access to this file) and long names. As differentiated from the file names in DOS (length of a name 8 symbol plus 3 symbols – expansion of a name) the length of a file name in Windows 95 can achieve up to 255 symbols (however, the combined length of a name with a path should not exceed 260 symbols). The name of a file can contain symbols, which were not used before (spaces, punctuation and so on) there can be distinguished the register of symbols and a number of dots can be present. In this case the sequence of symbols after the latest dot can be considered as the expansion of a file name. To support compatibility with the previous version of FAT while creating a long file name, the system automatically generates the appropriate short name (MS-DOS name). The rules of forming a short name are as follows:

- Spaces and symbols \:*?!" <> are removed from a long file name
- As a name are used 6 symbols of a long name plus symbol ~followed by an ordinal number (for the files, whose first six symbols of a name coincide)
- As an expansion are used the first three symbols of a long name expansion.

Device drivers in WINDOWS 95

Drivers are designed for providing work with peripheral PC devices. In Windows 95 architecture of mini drivers is used. It means that in the operating system itself by hardware independent drivers are realized to work with many peripheral devices (modems, printers, graphical and audible boards, CD-ROM and so on and for the designers of a proper models of these devices it is necessary only to write needed additional mini drivers to support by hardware dependent functions. In the kit of supplying Windows 95 a large set of mini drivers of different peripheral devices is provided for off-dimension devices, their manufacturers provide drivers. Windows' 95 supports the following driver types of devices:

- - Drivers of real mode MS-DOS (with extension SYS)
- - 16 bit drivers for Windows 3x (with extension DRV)
- - 32 bit drivers for 386 Enhanced mode Windows 3x with extension 386)
- - 32 bit virtual drivers Windows 95 (with extension VXD)

While installing Windows 95 necessary VXD drivers are copied in sub catalog SYSTEM\VMM32 and out of them file VMM32.VXD is built up, which is used by a system. When new devices are added to PC, the appropriate virtual driver is being found and this file is made again.

Loading modes of WINDOWS 95

Loading of Windows 95 is performed in the following manner:

BIOS performs the diagnostic program POST, then reads the first sector of C: disk (Master Boot Record) and Launches IPL 1 program, which is on it. IPL 1 analyzes Partition Table, defines the address of loading disk and reads the first sector of this disk, which should be a boot sector. Further IPL 2 program is launched, which is in the loading sector.

IPL2 finds in a root catalog of a disk and reads into a memory the file IO.SYS. And transfer a control to it. IO. SYS combines functions of the files IO.SYS and MSDOS.SYS of the previous version DOS. This module provides the led of the graphical head-piece of Windows 95 onto the display. While loading the user is given an info: *Starting Windows 95*.

During 2 seconds the user has a chance to get a control of the operating system. It's only necessary to press the key F8 and get an access to mode menu of Windows 95 loading. The menu presents the following options:

- Normal – normal loading mode
- Logged – normal loading mode with the storage of loading results in the log file BOOTLOG.TXT. This mode is used to find the reasons of errors in the process of loading (if any).
- Safe mode – loading with minimum of drivers
- Safe mode with network support – the same as the previous mode but with the support of a network
- Step-by-step configuration – step-by-step execution of loading.
- Command prompt only – loading without graphical shell of Windows 95 (only command line).
- Safe mode command prompt only – loading in the safe mode from errors and without graphical shell.
- Previous version of MS-DOS – loading of previous version MS-DOS. When it takes place, stored in a root directory of disk files Config.DOS, AUTOEXEC.DOS are used for configuration of DOS mode. Which are automatically re-named into CONFIG.SYS, AUTOEXEC.BAT. When the loading of Windows 95 is continued, program WIN.COM is launched, the core of Windows 95 is loaded drivers of protection mode, graphical shell of Windows 95 and further. The control is transferred to the operator of virtual facilities.

Features of operating system WINDOWS 98

In 1998 a new version of OS Windows 98 was produced. This operational system is an improved version of Windows 95 (more accurately- Windows 4.1). Architecture and main function of operating system core haven't been changed practically (only some bugs in a code are fixed). The main distinguishing feature is an integration of OS with browser Internet Explorer 4.0

New features: - File system FAT 32 is supported. In the file system FAT 16 a logical disk maximum $2^{16}=65536$ clusters could be placed. That provided clusters with the volume of 32 kbyte on the disk of 2 Gbytes. File system FAT 32 allows to use in FAT 32-bit units that, in its turn, allows to considerable decrease cluster dimensions on a disk and to decrease non- productive losses of a space on hard disk. It allows to use 4 Kbyte clusters on a disk with the size up to 8 Gbyte (or 8 Kbyte on a disk up to 16 Gbyte). Max size of a logical disk supported by FAT- 32-2 Tbyte. While

installing Windows offers to convert introduced on a logical disk file system in FAT 32 without the loss of information

- built in support of new devices (USB, Fireware, DVD, Intel MMX, infrared ports, system of power supply ACPI);
- improved support of multimedia and communicating means, Direct X-5.0, client WebTV;
- built in support of new NT-compatible WDM-drivers, Scripting Host, DCOM;
- built in support of several monitors (up to 9).

WINDOWS 2000

In February 2000 Microsoft produced Windows 2000. This OS is a continuation of OS line – Windows NT. It as differentiated from Windows NT 4 will be able to support not only file system FAT, NTFS, but FAT 32 as well, to have interface similar to interface of Windows 98, to support a wide range of hardware.

As this takes place, a high level of information protection and control of user rights, common for OS family of Windows NT are provided.

4.3. System software

System software provision combines the whole class of testing, tuning and servicing programs for a computer itself and peripheral equipment. In this chapter only some the most often used programs, connected with the servicing of hard disks and file archiving will be examined.

4.3.1. Programs of hard disk and diskette servicing

Hard disk at present is the main device of information storage in PC, that's why the problems of its servicing are of great importance. A user can carry out the following operations on it:

- formatting of a disk
- checking of disk surface quality and information stored on it
- defragmentation of a disk

There are different programs for it (they are also called utilites). While carrying out measures on hard disk servicing one should take in consideration that it is not recommended to use system utility working for DOS on a computer with the installed Windows 95, as it can result in an information losses on a disk.

Disk and diskette formatting

The process of formatting can be of two types: physical and logical ones. On logical formatting a logical structure is transferred on a disk; loading sectors are written, file allocation tables are formed, a place is reserved and system files DOS (IO.SYS, MSDOS.SYS) are copied.

Operations of physical and logical formatting for hard disk are separated. Physical formatting is usually carried out by a manufacturer, a logical one can be performed by a user, using utilities FORMAT PCTOOLS, STORMAT and others (in Windows 95 – disk formatting operation is built in an shell). As it takes place a space of a hard disk should be preliminary divided into volumes (by means of utilits FDISK) and

then it will be possible to format each of the volume (logical disk). For diskettes procedures of logical and physical formatting are combined, and as it takes place, it is possible to format diskettes as a system ones or as diskettes to store data. In the first case system files DOS are transferred on it.

On formatting diskettes a choice of one out of 3 formatting mode is possible:

- unconditional – physical and logical formatting, search of _failed sectors is carried out, areas of root catalog and FAT are filled of 0, and data area is filled with bytes F6h
- safe – search of failed sectors is carried out, information written in a root catalog and FAT is stored and they are filled of 0, data area is not changed
- quick – similar to safe, but search of failed sectors is not carried out.

As in case of two last modes data area on a diskette is not changed and all the information on a root catalog and FAT is stored, there is a possibility of undo - restoring of initial conditions of formatted diskette (in case a new information wasn't written on it after formatting).

Quality checking of disks and diskette

Information written on a disk can be damaged according to different reasons both physical (connected with the defects or depreciation of a magnetic layer) and logical ones (connected with the work of different programs, generally incorrect work with a file system, virus activity and so on).

To check a file system and disk surface special programs are used; such as PC Tools, Norton Disk Doctor, ScanDisk. These programs carry out:

- checking of a file system integrity
- checking of logical FAT structure
- searching and marking of failed sectors an a disk

For the proper PC work, it is necessary periodically to perform checking of disk quality. On using System Agent in Windows 95 it is possible to bring a work of ScanDisk in two modes in a schedule – standard (checking of file system only) and full (checking of file system and disk surface quality). A launch of this program in standard mode is reasonable to perform daily, and a full - once a week.

Utilities for WINDOWS

Windows 95/98 has rather wide range of built in diagnostic means, deinstallation, viewing files and restoring removed files. However, the outside designers produced a number of separate system utilities designed for servicing a PC itself and operating system. These utilities are distributed as freeware or shareware. A number of companies produced special package, which through a single interface provide an access to the whole series of system utilities. These are packages Norton System Works of Synatec Company, Nuts and Bolts of McAfee Company, Fix-It Mijenix Co.

In the most cases Utilities, designed for DOS can't be used in Windows9x, as they don't support long file names. Below some classes of utilities for Windows are given:

VIEWING UTILITIES – provide viewing of text processor documents, graphical files, data basis files without an installing of application, which produced these files (Drag and View, Key View Pro, Quick View Plus).

DIAGNOSTIC UTILITIES – make diagnosis of a hardware, eliminate device driver conflicts, check system schedule of Windows (CheckIt, Discover Pro(N & B), Registry Wizard (N & B), Norton Diagnostic (NU) WinDoctor (NU)).

DISK SCANNERS – check file system and disk surfaces for failure (ScanDisk, DiskMinder (N & B), Disk Doctor (NU)).

DEFRAGMENTATION UTILITIES – eliminates file fragmentation on hard disk (Disk Defragmenter, Disk Tune (N & B), Speed Disk (NU)).

UNINSTALLATORS – allow to remove the remains of removed program packages (Clean Sweep, Norton Uninstall (NU) uninstallers)

RESTORING OF REMOVED FILES – allow to recover not only occasionally removed by a user files but to cover any of 100 stored versions of one file or files damaged by either virus or hardware failure (GoBack, FlashBack).

RECOVERY UTILITIES – allow to create emergency diskets, having loaded from which it is possible to recover system after crash to its work (FirstAid, Norton Crash Guard (NU)).

4.3.2. Archivators

Programs of data compression are used to save space on a hard disk and the process of information transmitting through communicating lines (especially in the worldwide networks). Those makes it cheaper and increase a reliability of the process of transferring the information.

There are two types of file compressing programs:

- programs working in real time
- programs archivators.

Data compaction programs in real time executing in a background mode, being residentially in a PC memory. For their work on a hard disk a separate logical disk is created, with which a user works as with any other logical disk. Really, this disk is a single file on a hard disk, containing all compressed files, and an access to it as to a logical one (with an emulation of file system) is provided by a compressing program, which is constantly in a memory. Its size in comparison with a normal (not compressed) is 1,5-2,5 greater.

The procedure of pressing of all files is carried out directly at the moment of their saving on a disk. In fact, file size is recovered on their reading from the disk and loading into memory. It somewhat slows down the speed of operation while working with the disk however gives a user additional free space on the disk.

Second and more widespread types of data compression utilities are program-archivators. These programs allow to compact several files (or directories) in one

archive file, with which It is possible to manipulate as with any other file: to copy, send by e-mail to re-name, to remove and so on... However, to use compressed file it is necessary to extract files from archives on a disk. As distinguished from pressing programs in real time, the work with archivators is carried out in interactive mode, that is a user should launch an appropriate program himself, give a command to pack-unpack files, to indicate with what files one should work and in what mode. At present there are a large number of program-archivators, distributed shareware software. The most known programs are PKZIP.EXE/PKUNZIP.EXE, LHA.EXE, ARS.EXE, WINZIP.EXE program works in Windows 95 and support long file name.

4.3.3 Data protection and a computer antivirus software

Computer virus notion

Computer virus is a specially created usually not large, program, which has the following features:

- independently without a user permission saves on disk in a magnetic carrier (usually in any useful program body);
- being on a disk use means of camouflage to make difficult to discover its presence;
- reproduces i.e. saves into other programs on a disk;
- being in a user unauthorised activities defined by contained in it algorithm from producing information or melodies to irrevocable data losses and damage to a disk;

Computer virus is produced abundantly in the world. The main danger is a high speed of a virus distribution. It is a result of two reasons:

- compatibility of PC – i.e. the usage of monotype OS in the most of them ; It means that the program (and its virus) working in one PC will work in millions of others;
- integration of PC – a tendency to unite PC in local and global computer networks, that gives a possibility of quick distribution of a virus by means of these networks.

A manifestation of concrete viruses can be very different e.g.

- information or visual effects on a monitor display (jumping ball over display), "eaten up" of a picture on a display and so ?n;
- Audio signals
- Re loading of OS
- Changes or damage to FAT
- Changes of data in files on a disk and their removing
- Changes in CMOS
- Formatting of hard disk
- Lodging of data transmission channels in networks.

Ways of infection and accommodation of viruses on a disk

The main reason of infection of the computers with viruses is a carelessness of users. The presence of an infected file on a computer hard disk doesn't mean that the computer is infected. A computer is infected if a virus is in its memory. It can occur if an infected program is executed on a computer or a computer was booted from an infected diskette. As this takes place, a virus is installed into memory of OS, infects

boot sector or system file of OS providing by it its loading at the next starting of a computer.

Anti virus programs

To protect a computer against viruses special program means are used – anti virus program. They are divided into several classes:

- Scanners and doctors – tries to discover virus in files on a disk, checking if a file contains combinations of bytes specific for a known viruses. When an infected files are found program- detector tries to recover a file. However, these programs discover only known (at the moment of their writing) viruses and practically don't find unknown viruses, though a method of evrestic analysis of a file contents is used in a number of programs, discovering suspicious places which can correspond to virus code. The work of these programs is complicated by the fact that at present the virus uses methods of their coding and code parameters are changed with time. It results in the fact that virus code has no contact chain of bytes according to which it can be identified. In case a virus is in a memory, it can counteract the process of its detection as it is described in the previous chapter. That is why it is necessary to conduct anti virus checking of a computer, which is loaded not from a hard disk but from a system diskette. As it takes place, one is recommended to remember about the existence of viruses, capable to over live “ warm” re-loading and to re- load using a “Reset” key on a system unit.
- Programs-inspectors – have two stages of work. At first, they remember information on program and system disk Area. In this case it is considered that a computer is not infected with the virus. Later, while starting these programs, they check programs and system disk Area in fact and compare them with the standard ones. If an inconsistency is found, a user is given a warning. Some programs of this class have a recovery mode using for this a stored information about a file. It should be noted that when a virus is found in a core memory it can catch an appeal of a program-inspector to the file system and give it uninfected recovery files (by means of temporary “cutting out” self code). To avoid it some programs-inspectors use non-standard means of access to the files.
- Programs-watchdogs –as distinguished from programs of previous classes (launched periodically by a user) should residentially be in a memory. They catch appeals to an OS, which can be used by viruses to reproduce and to cause damage, such as:
 - modification of executable file's codes (which have an extension COM or EXE)
 - removing file attributes “read only”
 - direct saving information on a disk at the absolute address
 - formatting of a disk
 - installation of a resident program

When a request to OS is got, program-watchdog informs a user of it and he decides to allow or prohibit the action. However, a lot of viruses appeal to OS ignoring standard function calls (interruptions) which are under control of program-watchdog. Besides, programs-watchdogs are useless against loading viruses which, when a computer is booting, are activated before these programs and at the moment of their launching have already been checking all necessary functions of OS.

Preventive measures

It is clear that the usage of anti virus programs doesn't guarantee the solution of the problem. However, the efficiency of a protection can be improved if a number of preventive measures are taken. The usage of the following preventive measures allows to avoid the infection of a computer or to decrease the consequences.

- It is necessary always to have copies of used programs on diskettes protected against recording or CD ROM);
- It is necessary periodically make the back-up copies of data and results of the work. As it takes place, it is necessary to check if there are any viruses in a computer;
- It is necessary to use only licensed software and the firm's own diskettes;
- It is necessary to provide protection against recording to system disk area (in some computers it can be done in CMOS).
- It is necessary to provide protection against recording on diskettes with unchangeable files;
- It is necessary to have copies of a partition tables, information of boot sectors, all logical disks and CMOS;
- Always to have the latest versions of anti virus software;
- Always to check for virus all ignoring diskettes;
- Always to keep a system diskette with OS, file-servicing programs and anti virus programs handy. This diskette should be protected against recording;
- Periodically check a computer if there are any viruses in it by means of anti virus programs.

User activity in case of infected PC

It should be clear that it is impossible to guarantee the protection of a computer against infection, especially in case of a computer working in a network or having access to Internet. That's why it is always necessary to remember a number of measures to be taken in case of PC infection with viruses. If it occurs one should:

- immediately turn off a computer to stop further distribution of a virus. If a local net is used, cut physically off;
- switch on a computer and boot it from a bootable diskette (protected against recording);
- in the process of re-loading to enter the program SETUP and check the content of CMOS;
- check the integrity of file system by means of system programs of NORTON DISK DOCTOR or SCAN DISK types;
- scan the disk C: by anti virus program;
- recover lost or damaged information using standard diskettes and archive copies;
- re-write again boot sector and system files on disk C: using the command "SYS C:";
- after that it is possible to boot from the disk C: and use anti virus programs for other disks;
- in case of Windows' 9x it is necessary to re install Windows' 9x.

4.4 Local and global computing networks

4.4.1. Local computing net notion

Computing network is a totality of the computers working independently under control of their OS, but connected with each other by means of communication channels. Interactivity of computers in a net is performed by means of transmission through communication channels.

Local Area Network is the computing networks, allowing to provide co-operative work of several computers. LAN makes it possible to separate computing and information resources between users and solves the following problems:

- sharing information - allows to work different users simultaneously with the same files stored in the central file server;
- information sending – allows quickly to send files and information between computers;
- applied program sharing – allows different users to use simultaneously one copy of a software placed a file-server;
- simultaneous introduction of information – allows different users to introduce data into one and the same applied program simultaneously;
- system resources sharing – allows different users to get access to general resources such as printer, hard disk, CD ROM and so on.

Components of a network.

Every computing network consists of the following components:

WORKSTATIONS – usual PC connected to a network. They are used for a work of users and applied programs, however, all network resources are accessible for them;

FILE – SERVER – a computer providing functioning of all network and servicing workstations. Powerful PC, mini and super computers can be used as servers. It should be noted that some small networks could work without selected file-server. Such networks are called single rank LAN.

NETWORK OPERATIONAL SYSTEM – program network platform allowing to control its resources to provide user interactivity, data protection and so ?n.

COMMUNICATION CHANNELS – communication equipment (bridges, routers and so on) and data transmissions media (cables, radio ether and so ?n).

NETWORK SUPPLEMENTS – software working in a network. This software is the distributed program which consists of several parts performed on different workstations and server: server and client parts. The important examples of network supplements are network services- program modules client server providing an access to definite type of network resources: file service, printing service, Email , remote access service and so on.

Basic network topologies

Network topology is a principle of geometric accommodation and connection of the computers with each other in a network. Network topology is defined by a graph,

nodes of which correspond to workstations and other network equipment and edges (ribs) - to connections between them. Physical connections reflecting physical unit connections define the physical topology of a network. Logical connections reflecting routes of data transmission through a network define logical topology of a network. For many networks these two topologies don't coincide

There are several typical topologies: general bus, star, ring and others.

Network devices

Network devices mostly are designed for structurization of a network. In small networks with a small number of computers a simple topology can be used, however, in large networks the usage of a simple topology has a number of disadvantages.

Length of communications between nodes is limited

- a number of nodes is limited
- traffic intensity is limited

To eliminate these disadvantages physical and logical structurization of a network is used. For physical structurization the following network devices are used:

REPEATOR – is used for physical connection of network cable segments. Repeater improves the signal characteristics, allowing to transmit it over large distances and increase lengths of communications in a network.

HUB – a repeater having several ports and connecting several physical segments. The usage of hubs allows not only to increase a network dimensions but increases the reliability of it. In case of fault condition a network adapter can begin unauthorized generation of information in a network. In this case a hub can blockade this port and to preserve its capacity for a work.

BRIDGE shatters transmission media into parts (segments) localizing traffic in them and transmitting information from one segment to another only if an addressee of this information is in this segment.

SWITCH works on the same principle as Bridge but every its port is provided with a special processor; there appears a possibility of parallel moving of information along all ports improving its capability.

ROUTER uses a compound number addresses in its work, which contain the number of a network in themselves. All nodes with the similar number of a network form a subnet. It allows not only more effectively to separate traffic in a network, but to use excess communications to improve capability and reliability of the entire network.

GATEWAY is used not for a network separation, but vice versa for connection of different nets using different net technologies

Principles of communication in LAN

Communication in LAN is performed between adapters through cables. Computers in a network exchange information packages with each other. Net adapters under control of a net software perform transmission and receipt of these packages. Packages are not large data portions (1.5-4 kbytes), that's why data of great size are

divided into a number of packages of standard length. Packages carry different information, among them:

- beginning of data exchange session
- data transmission
- acknowledgement of data package receipt
- information broadcasting to all adapters
- end of data exchange session
- Besides, a package transmitted through a net contains the following data (Fig.4.4)
- a unique address of a sender
- a unique address of a receiver
- signs defining a package contents
- data or message
- check sum to find errors while transmitting

address of a sender	address of a receiver	package type	data/message	CRC

Fig. 4.4 Basic scheme of an information package

Network Protocols

Network protocols are the rules of functioning of all local network. They describe features and aspects of hardware, principles of signal forming, arrangement of data transmission and so on. That's why these protocols are divided into several levels. The most fully LAN is regulated by OSI model.

International Standards Organisation published the module of a computing net architecture – Open System Interconnection, in which seven protocol levels, recommended to be used in a network are described. Interaction of levels with each other is performed by specially developed interfaces. The most manufacturers try to follow this model, however, up to now there are no products which meet its requirements fully. OSI model divides communication functions in LAN into 7 layers.

PHYSICAL LAYER - on this layer a physical data transmission through a communication channels take place. Nothing is known about the route of information, addresses of workstations and contents of transmitted information on this layer. Physical and electrical channel characteristics, types of coding and speed of signal transmission are defined on this layer. All types of used connectors are standardized here as well.

CHANNEL LAYER provides the computing of a check sum for every frame and its transmission in service fields of this frame. When a frame is received, a check sum is calculated again and collated with the transmitted value. In case of error detection in a received frame on a channel layer a second transmission of damaged frame can be requested.

Channel layer provides information transmission in the limits of one network of typical topology.

Channel layer - this layer includes the rules of bit sequence transmission, which are called frames. It is divided into two sublevels, on which 2 main problems are solved.

MEDIA ACCESS CONTROL (MAC) – control of transmission media occupation is performed and procedure of enter to a net-media to send its frame is carried out.

LOGICAL LINK CONTROL – realizes error detection and correction mechanisms.

Channel layer provides information transmission in the limits of one network of typical topology.

NETWORK LAYER – the information routing in compound networks are performed on a Network layer. Information of a network layer is called package.

To achieve an addressee packages can go through the networks with different topologies and different protocols of physical layer. These nets are combined by means of special devices – routers which exchange and store information on different routes in combined networks. Two types of protocols are defined on a network layer.

ROUTING PROTOCOLS – with the help of which routers collect information.

ROUTED PROTOCOLS – realizing moving of packages in a combined network.

TRANSPORT LAYER – this layer is responsible for the fact that information transmitted by one workstation will be correctly received by another one. Detection and elimination of errors is carried out on a transport layer .

Information is transmitted as a sequence of packages a checking of a sequence of their detection and removing of doubled packages is carried out on this level.

SESSION LAYER – on a session layer are used computer addresses to make a contact with an addressee and a control of calling procedures. The layer is responsible for coordination of a dialogue between workstations: it fixes which of the parties is active in the dialogue and provides means of synchronization.

PRESENTATION LAYER – on this layer a request from applied layer takes place. The layer is designed for masking differences in computer types for applied software. When the computers of different types are used together in one and the same network (IBM, Apple, DEC, NeXT), some work is necessary to translate and re-group bytes to convert data into internal digital format for each proper facility and inversaly. Data coding with the purpose of protection against unauthorised access is performed at the same layer (at the receipt – decoding).

APPLICATION LAYER – is an upper one. Interaction with a user, extraction of information out of reserved data and transmission of a file as a whole is performed in it. Application layer is a seen (for a user) part of OSI model. The transmission of messages is considered on application layer.

The above mentioned architecture is recommended by ISO, but the most manufacturers of a net OS use three layers of protocols combining some layers of ISO models. Used in LAN protocols are divided into protocols of low, middle and upper levels.

Network adapters

Network adapter cards are daughter-cards inserted into the appropriate slots of mother-board on each workstation and file servers. Workstation transmits a request and gets a reply through a network adapter. Only two net adapters can exchange information with each other at the same time. Other workstations should wait for its turn. However, these delays in LAN are practically unessential, that's why an impression is made that an access of all users to a server is performed simultaneously.

At present there are different types of net adapters. They differ in speed of work in a net and used cables. The developers of net adapters design them for an application of one of the low layer protocols EtherNet, Token Ring, FDDI, ARCnet and so on. All existing at present adapters have sufficient set of hardware to define a permission to transmit a frames into a physical media or a receipt of an addressed to it messages.

4.4.2 A network software

A network software is necessary for PC to work in a local network. It is divided into net OS providing functioning of a network and net applied programs using a net in its work. Some net OS will be considered below briefly. A net OS is necessary to control a message traffic between an operational station and servers. A net OS allows any workstations to work with a net printer or net server disk as if they are directly connected to the given workstation. The core of a net OS is installed on a server and it is necessary to launch small residential programs – net clients- on workstations. The main net OS are as follows:

- NetWare Lite and Personal NetWare
- NetWare
- Windows NT Advanced server
- Windows for workgroups, Windows 95/98
- OS/2 LAN Server and OS/2 LAN Manager
- LANtastic

4.4.3 Global computer network Internet

Possibilities provided by Internet

Internet provides its users with the following possibilities:

E-MAIL – allows to exchange messages and send files between computers located in different parts of the world with a fantastic speed.

NEWSGROUP – is a set of messages according to some (in other nets they are called conferences, or forum or notice-board) theme group. There more than 5000 of such groups in different languages now and they include everything – from art to zoology, from science fiction to South Africa.

MAILING LISTS – is another chance of user interaction. As distinguished from Usenet messages which are stored somewhere centrally, messages of mailing lists are sent directly to the address of a proper user subscribed for the required topic. To join a mailing list it is necessary to ask permission. As opposed to Usenet, where every message is distributed all around the world, in a mailing list a message is sent to Central moderator, which defines to transmit it to the rest members of the list or to include it into a periodically compiled «digest» supplied to subscribers.

TELNET – provides an access to data bases, catalogs of computerized libraries, weather forecasts, and other information services, real time computer games with other players all over the world.

WAIS - Wide-area Information Server – a program which can view lots of data bases in one list.

GOPHER – program which provides an access to lots of electronic data bases and services by means of selecting possibilities out of menu. It can be used to copy text and program files to your own mail box as well.

IRC – Internet Relay Chart – radiophone emulator which allows to provide live talk from a keyboard with people all over the world.

FTP – File Transfer Protocols – allows an access to hundreds of file libraries and provides a possibility to load files out of net to local computer disk. At present using this protocol a software allowing a user to work with the file system of a remote computer is created. It allows to consider a file system of PC as one of the millions subdirectories of one large file tree (the remained branches of which are accessible only for reading)

HTTP – Hypertext Transfer Protocol is the most up-to-date and constantly developing means of Internet. It allows to transfer files of different formats and ?n its usage is built up WWW (World Wide Web) system – system of hyper text documents containing references to other documents in such a manner that they form a communicating system enveloping the whole world.

Internet – television - recently a great attention is paid to the integration of Internet resources with a television. Among other factors methods of high speed data transmission through channels of a cable and satellite TV are developing, so as are developed special TV devices allowing to work in Internet and present information ?n displays.

Working and addressing principles in Internet

Internet includes a lot of high data transmission lines, connecting domains, to which domains of lower level are connected. Computers can be connected to them as well.

All computers connected according to TCP/IP have their own address IP, which is used to route messages. Address IP is a 32 bit number. It is written as 4-byte expression – for example 123.45.67.89.

The unique feature of each address is guaranteed by Network Information Center, which coordinate licence distribution to give IP addresses. There are three classes of licences: A, B, C.

The licence of A class allows to give addresses with the fixed first byte, i. e. Addresses of 123.xxx.xx.xxx. type. So licence of A class includes up to 16777216 IP addresses and is the largest provider of Internet services in the world.

The licence of B class allows to give addresses with the fixed two first bytes, i. e. addresses of 123.45. xx.xxx. type – all in all 65536 addresses.

The licence of C class (granted to small providers of Internet services) allows to give addresses of 123.45.67.xxx. type – all in all 256 addresses.

A limited number of addresses doesn't mean that there will be not more than $2^{32} = 4294967296$ Internet users in the world or that the provider with the licence of Class C can not provide services of Internet to more than 256 clients. The most users are connected to Internet through commutated lines (by means of Dial Up service) and don't rent a line round the clock. That's why the provider of Internet can not assign a fixed IP address to a user, but dynamically distinguish it from the rest at the user's connection.

It should be noted, that the usage of numerical addressing (the most convenient for processing) is not convenient for users. That's why domains in Internet can be awarded their own names. This method of addressing is called a domain-naming. The translation of a domain name in IP address is performed automatically on special DNS (Domain Name System) servers. The names to concrete domains are given by the domains of higher levels. The name of a domain consists of several parts which are separated from each other with a point, e.g. www. microsoft. com, and the name of the domain of the lowest level comes first, and is followed by the name of a domain of higher level and so on. The first part of the domain name can carry information on a type of organisation which is in charge of the given system or country where it is situated. So for the domains in the USA the following suffixes are usually used:

.Gov and mil. – government and military institutions

.Net – network companies or institutions

.Com – commercial institutions

.Edu – educational institutions

.Org – uncommercial institutions

Other countries often use two –letter suffixes to mark the country (e.g ru – Russia, uk – United Kindom, no – Norwegia, ca – Canada and so on). In any case the name of a domain (as IP address) must be a unique in a network.

Knowing the domain name one can address to a proper directory or file on the computer having given its name after the domain name, e.g. www.microsoft.com/products/ie/index.html. however, as the most systems

supporting Internet work in OS UNIX, while giving name to files or directory one should take into consideration some differences for MS-DOS in the rules of file naming:

- directories are separated by / not \ as in MS DOS and Windows;
- directory and file name can have a length more than 8 symbols and contain all points (e.g. a file name of a sort index-of-document.ps.Z is possible).
- Capital and small letters are made out in the names;
- Extension of a file can be more than three symbols;

Email addresses are recorded into Internet in the following manner User_name@domain name, for example: g.wasily@marine.com.

World Wide Web

At present, a world wide system is roughly developing in Internet, based on hyper text documents – WWW (World Wide Web). Hypertext document (www page) is a text file written in HTML language (Hyper text Markup Language) and containing besides text information references to different resources – graphical, audible and animation files so as references to other similar files, placed both on a given server and any other servers in Internet. To include a reference in a document the address of its source is used – URL (Uniform Resource Locator), which is a file address in Internet, as it is described in the previous chapter.

To view www pages special programs are used – browsers. They provide HTML - file loading from a network into a computer, interpretation of contained information, loading and reflecting of connected with the given file resources (graphical, audible and animation files). References to other pages are made out when the user presses with a cursor of a mouse an assigned by a browser area and its searching in a network and loading in a computer is provided. So using connective references a user can as long as he wants to move along a network. As it takes place, he can save the required information on a local disk or simply view it and move further.

At present a large number of browsers are developed but the main are the browsers of Microsoft (the latest version: Internet Explorer 5.0) and Netscape (the latest version: Netscape communicator 5.0) These are rather improved programs with a convenient interface, working under MS Windows. As many other resources of Internet they are freeware.

Information on Safety of Navigation in Internet

At present more and more companies and institutions connected with the problems of navigation have its information pages in Internet. They are:

- international organisations (IMO, IHO, ITU, INMARSAT, NMEA and so on)
- national organisations (marine departments, hydrography, coast guards and so on)
- educational institutions (marine academies, simulator centres and so on)
- marine social organisations (Institute of navigation, Institute of Marine Engineers and so on)
- special marine information servers
- and many others

The list of these organisations is continuously increasing and it is more convenient to search a required organisation with the help of searching services, which present rather fresh information on the current state of a network. In this chapter a list of information types, concerning safety of navigation will be given. The main advantage of information in Internet is its efficiency and accessibility.

One can find the following information on navigation and communication in Internet:

- notices to mariners published by national hydrographies
- local warnings to mariners published by national Coast Guards and Port Authorities;
- operational information on the state of global satellite systems (GPS, GLONASS);
- operational information on the state of global navigational systems (LORAN-C, OMEGA);
- operational information on navigational satellite orbit elements (NORAD two line records);
- operational information on amendments in the served areas of differential systems (DGPS);
- operational information and ebb and flow of the tide prognosis in coastal areas;
- operational information, pictures from the space and weather forecast for any area of the globe;
- standards, information materials and other documents of international and national marine organisations;
- independently distributed and freeware software (both navigational and general)
- conference documents concerning marine navigation and communication
- advertisements of hardware and software manufacturers, the latest driver versions, user manuals and other files (update), servicing support and demonstration programs.

4.5. Maintenance of PC

First of all, it is necessary to estimate the most frequent defects, appearing in the process of PC exploitation including the composition of communication and navigational system equipment. Preliminary analysis shows that severe conditions of exploitation caused by serious vibration, high moisture level, instability of ship's mains parameters and so on result in losses of electrical contacts, hard disk damage, defects of monitors, power units and fans, mother-boards and interface modules with peripheral devices.

A lot of problems can be caused by natural discharge of the battery, feeding CMOS incorrect grounding and dust on the equipment.

Taking into accounts the fact, that PC equipment is a unit-module construction, error diagnosis on the level of faulty module localisation is of great importance.

4.5.1. Error diagnosis

There are a lot of reasons resulting in fault condition of PC. However, in some rare cases PC can be fully out of order.

The most common errors and data loss

All PC problems can't be solved on your own. Following the given below recommendations it is possible to correct or avoid the most common errors. It is necessary to clear up in what cases error occurs and try to localise it. E.g. if we are speaking about the hanging of a system, clear up, if it occurs in case of some appropriate program and can be found in supplements of Windows or DOS.

Remember what was the latest message of your PC before hanging of the system. Sometimes it allows to come to the conclusion about the source of error.

Fix, when an error appeared firstly,

A) On launching a new program.

B) After the installation of a new card or connecting a peripheral devices.

Diagnostics by means of software

The main test of system checking – POST (Power on, Selftest) which is integrated in ROM-BIOS. By the help of this test on launching a computer the most important PC functions are checked, first of all, CPU and RAM.

Error or constructive element defect information is given on a monitor display as: Error at...

Enumerating errors it is supposed that the monitor and video card are installed in the PC. For acoustic error diagnostics it is necessary to connect a loud speaker to the connector marked SPEAKER or SPIK. A video card should be installed but a monitor connecting is not necessary. If a video card is absent, the loud speaker will produce eight audible signals.

Acoustic error messages indicate, as a rule, errors of mother- board. Such errors are rectified only by its replacement. Having detected an error, before the beginning of PC hardware diagnostics, it is necessary to try to define and localise an error by means of special program tests. Naturally, it is possible if the PC is in such a condition, when a test program can be launched. In other case, one can operate only with hardware.

Similar errors are found rather seldom. More often the case at hand is incorrect installation or defects, identified by means of software which should not be necessary rectified by replacing and configuration of hardware. Typical examples of such cases are interruption conflicts, which result in hanging of external device.

There are programs, which make a diagnosis of a PC, fix it and render assistance in repairing. First of all they are specialized diagnostic utilities Checkit 8, Norton Utilities 4.0 for Windows 95/98, Nuts & Bolts, PC Care 97 and so on.

Diagnostic utilities deal with not only diagnostics of installed equipment and solving hardware problems. They also seek for software errors (removing of unused data, detection and solving the problems of «hanging» data in a system schedule and so on). Hand in hand with the above-mentioned software there are programs to test separate system elements, e.g. Landmarktest or CoreTest to test a hard drive.

One should take into accounts that PC hardware is developing more quickly than software.

Rectification of important component errors

Usually errors become evident when the reconstruction of a PC occurs. We shall cover the main reasons of fault condition and recommendations to rectify them.

MOTHER – BOARD. Errors in Mother – board as a rule are identified by POST program. In the process of exploitation mother board is seldom replaced. The most often reason of its malfunction is its over-heating. The case of PC should be cooled with fan. Powerful CPU 80486 DX/4 and Pentium should be provided with standard radiators and fans.

The problems with mother-board usually appear immediately after its installation. In connection with it pay your attention to some features which can cause the problems.

A 2- contact jack, which should be connected with the key “Reset” is placed on mother-board (Fig. 4.5).

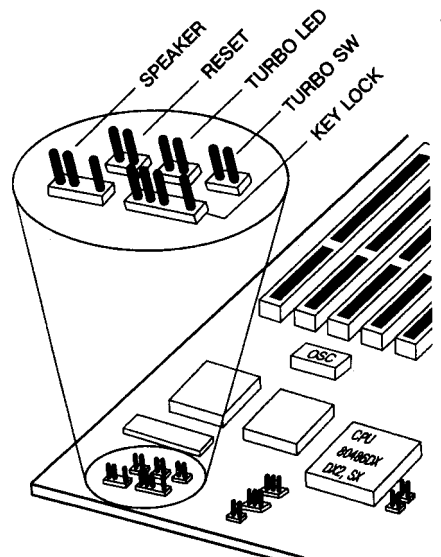


Fig. 4.5 Connector for the elements of PC front panel

While pressing “Reset”, the system is re-starting. If, by mistake, another cable is connected to this jack, it can result in continuously re-starting of a system. If in the process of testing a system POST doesn’t give sound signals, but in accordance with the test a core memory differs from an installed one, check the installation of memory chips. More likely we deal with the absence of contact and not of memory malfunction. First of all it is important for SIMM modules. From time to time compare recordings in CMOS Setup with ones done before. If a PC produces messages like “CMOS Battery State Low CMOS Configuration Error “ or all your installations in CMOS Setup are absent, then, the most likely, battery providing power for CMOS Setup is out of order. To avoid demanding process of system configuration, it is recommended to re-write the information in advance and store it. The first signs of battery discharge appear when system time and date begin to lag behind. In case the battery is out of order it should be replaced. In this case It is

better to use a jack to connect an external battery. Pay attention to the red wire, which should be connected to the contact 1 (Pin1) of the appropriate jack. Check the document to know if the battery is activated by jumpers on board. If your PC is constantly hanging and indicate one and the same error, then may be CMOS Setup parameters are tuned incorrectly. In this case it is necessary to put CMOS Setup in standard meanings (Auto Configuration with BIOS Defaults).

HARD DISK DRIVE (HDD). The errors of a Hard Disk Drive (HDD) can appear either at hardware or software level.

The characteristic sound can accompany its work. A HDD with a faulty drive or damaged reading/recording head doesn't produce any sounds. Besides, changes in tones of the characteristic sound resulting from low or too fast HDD rotation can be noticed.

To connect IDE HDD to data bus 40 or 80-line cable is used.

In the process of cable connecting errors are possible both in the process of connecting to HDD and controller. Such an error can result in incorrect work of a power unit.

Before checking a power unit, check the correction of HDD connection. Another reason is HDD incompatibility with the higher frequency of a bus. For IDEHDD the limit is 10 MHz- the higher frequency results in its crash. Change the clock frequency of data bus in Advanced CMOS Setup at the point Bus clock Rate. If more than one HDD is expected to be installed they should be identified in proper manner. For IDE HDD there are two possible states defined by jumper location that characterise which of two possible hard disks is primary (Master) and which is secondary (Slave). Thus, before installation, check the HDD state defined by these jumpers.

Every type of a board and every model identifies itself in its own manner as either Master or Slave. Standards state for IDE HDD is Master without Slave. If only one hard disk is installed, It is always Master. On installing a second IDE HDD it is necessary to insert jumpers not only on the second (new) disk, but on the First as well.

Before formatting HDD by means of DOS, make the appropriate changes in CMOS Setup. Faulty parameters can result in faulty functioning of HDD and the entire system. IDE HDD can't be formatting at a low level. If the above-mentioned action took place the can become insufficient for further usage.

If some logical disks are arranged on HDD but the First logical disk is not marked as an active, the message will appear: Error loading operating system.

Error rectification is achieved by an appropriate menu option of FDISK program.

One of the common reason for incapability of HDD is «clinging» of reading/recording head.

There is no noise in PC in this case. If HDD disks don't rotate, the reason of it can be not only «clinging» but absence of contact in power cable as well.

Probably control board of HDD, which is placed directly in its case is out of order. To check the board one can install the board of the same type of working HDD into his own one.

If the reason of fault condition is really in a control board, It is possible to re-write data out of faulty HDD. Maybe the first claters of-HDD will be «bad» with time. In this case a disk can't be a loading one. FAT can be damaged as well. It is necessary to copy all required files to another drive (diskette, Zip and so ?n), and then with the help of FDISK to create two logical disks, the First of which will have a volume of about 6-10 M. Then with the help of FORMAT command to format only the second logical disk.

CD-ROM. The most common reason of CD-ROM malfunction is in its faulty configuration in CONFIG.SYS and AUTOEXEC.BAT. files.

Pay you attention to the fact that to install CD-ROM two drivers are always necessary: of higher and low levels. It concerns both CD-ROM which are controlled with its own card of interface or audible cards and those which are controlled by IDE controller.

The driver of high level is called MSCDEX.EXE (Microsoft CD Extension for DOS) and usually is supplied together with CD-ROM. However, one can find It in DOS (versions 6.0 and higher) and in Windows 3.1 (latest versions). It is necessary to integrate a start of MSCDEX.EXE in AUTOEXEC.BAT. If It is found that the driver supplied with CD-ROM takes more space than DOS or Windows drivers, select the most actual one. Sometimes it can result in malfunction: False DOS-Version

If the operational system Windows 95/98 is installed in PC, CD-ROM system installs all required drivers itself – driver of low level (ATAPI) and driver of higher level (CDFFS.VxD analog to MSCDEX).

There are the following reasons of faulty CD-ROM drive:

CD-ROM drive should be placed only horizontally.

Some removable containers (Caddy) don't load compact-disk if there is some deformation or incorrect embedding in a container. Error in reading can also appear if an object-lens of optical system drive CD-ROM is dirty. Some CD-ROMs are provided with automatic cleaning of scanning objective and react to dirty lens in proper manner.

Sometimes the firm's own CD-ROMs refuse to read unlicensed disks CD-ROM. It is normal and doesn't mean that CD ROM is faulty.

VIDEO CARD. The most malfunctions in information reflecting system (video adapter, monitor) is connected not with the equipment malfunction but with incorrect installation of appropriate jumpers or tuning of program drivers.

Usually the installation of a video card doesn't create any problems. However, when passing from monochromous card to color one it is necessary to know some features connected with it.

On some old mother-boards there was a jumper, which was redirected in dependence of color or monochromatic chart in PC.

It is necessary to know the type of your card in CMOS Setup. If, e.g. we are speaking about VGA card, then choose: Primary display: VGA or EGA.

4.5.2. Installation, replacement and connection of mother-boards

Unification and standardization of mother-boards

Unification and standardization of PC components can be extended to system boards designed for installation in the usual cases. Typical boards Full AT (305x350) and Baby AT (220x330) for Desktop cases, Baby At, Mini-, Midi- and Big Tower have a fixed position of slots and keyboard connector relatively to back edge of the board and unified system of board mounting holes that facilitate repairing modernization of system units.

Connection of AT standard power unit

Many modern mother-boards have connectors to connect a usual case and ATX standard Case. The type of a used unit is indicated by installation of an appropriate jumper on a mother board. Typical power unit is connected to the mains by a power cable with a plug having an earth. The cable with an earth is connected with the device case and its «scheme earth». Power cables run through. HF filter eliminating impulse noises, filter condenser capability is proportional to power of a device.

Errors in power unit connection

If a load is not connected to the power unit It can't be started. The same can occur if data cable is connected incorrectly. If the connectors P8 and P9 are connected conversely a mother board will go out of order on starting a power unit.

New standard of ATX system board and PC case substantially facilitate connections giving rather convenient location of important system board components.

Connection of ATX standard power unit

ATX model is provided with a new connector to provide power to mother-board. It is a single connector with a key and It contains 20 contacts. It can't be connected incorrectly. Power circuit + 3,3.B is provided in a new connector.

Some modern mother-boards of Baby AT and LPX type have simultaneously both 20-contact connector for ATX and AT.

Constructively all connectors and appropriate pinjacks are provided with special directionals and openings, which rule out incorrect connection. In case these directionals are absent It is necessary to orient in accordance with the color marking of the cables. Yellow - +12B., Red - +5B. Black one is always an earth. Connectors always have special directionals to be connected to disk.

Cooling of PC system unit

While inspecting the power unit it is necessary to check if it is provided with a fan. Fans can be divided into two groups in dependence of their rotation speed. Fans,

wings of which rotate with a constant speed belong to the first group and fans in which rotation speed of their wings depends on temperature belong to the second one.

Traditionally fans were placed on a back side of the power unit and air was escaped outside. As opposed to such constructions a fan of the standard ATX power unit is located on a side of the power unit case and is directed to the components of mother board, which produces as much heat as possible.(CPU, SIMM modules and expansion cards).

4.5.3. Components: installation and configuration

Modern system boards have a number of removable or added components. In the process of upgrading or repairing processor can be changed, memory – increased, additional HDD, CDROM Video Card and so on – replaced or installed. Such operations usually are connected with the change of hardware or software adjustments.

Processor

The processors installed in Pc XT, AT-286 and AT-386 usually are not replaced. They very seldom go out of work. More often there we deal with the installation of mathematic co-processor. For that it is enough to install a chip into appropriate card (paying attention to the key) and activate the co- processor option in BIOS Setup). Some BIOS versions have no special permitting options and automatically discover its presence during POST. To start the processor in XT it is necessary to switch DIP-communicator of configuration.

Beginning with the processors 486dx co-processor is a part of the main processor. The introduction of inner frequency multiplier, architecture progress and configuration of system boards has made It possible to replace the processor by the more powerful one.

CPU installation

To produce mother-boards designed to work with the CPU of one type is at a loss, that's why all of them are universal, i.e. designed to be installed in different CPU with different clock frequencies and voltage power. However to install different CPU different connectors are used. Before CPU Pentium II in S.E.C.C. cartridge the connectors of Socket type were used, which were different in amounts of contacts and their location. Amounts of contacts was different in each CPU of a new class.

Power supply and cooling of PC

Processors of previous generations (before the first models 486) used power voltage of 5 V (except some processors for portable PC). The know-how development has resulted in the necessity and possibility to decrease power voltage to 3.3 V and less. Standard power unit for the processor supplies only +5 V, that's why additional VRM (Volt Regulation Module) are now used on system boards of the processors with decreased power voltage. These regulators are chip of voltage stabilizer of fixed or controlled level. To supply powerful processors It is installed on a radiator. On some system boards for 486 a copper square under a chip on the printing board itself is used as a heat tapping. The voltage of controlled regulators is given by jumpers,

sometimes they are done red. The given power voltage should correspond to processor nominal. Too low voltage results in unstable operation, too high one can result in processor malfunction. For the processors with separated power supply (the latest Pentium including MMX and others) there should be two or even three regulators. ? n ATX board it can be one regulator as to supply processor interface 3,3 V can be directly used the additional bus of the supply +3,3V. When only one VRM is installed ?n a board and there is a connector to connect an additional one there can be a choice. For processors with one supply in this connector several contacts are connected by jumpers. For processors with separated supply an additional VRM should be installed.

With the max permitted power of regulator while using Cyrix processors, which are characterised by an increased power supply, there can appear some problems.

The problem of cooling is of great importance beginning with the processors 486. The processor 486SX didn't require the installation of a special radiator. However, with the increasing of a clock frequency a power dissipated by the processor is increased as well. Besides, power consumption depends ?n the processor intensity: different constructions use different body of inner equipment and when power consumption is increased, the power dissipated by the processor is increased as well. There are even special test programs to check heat mode, which can over heat the processor with insufficient cooling that will result in its malfunction.

To cool processors the radiators Heat Sink are used. The radiator works effectively if its tight contact with the upper surface of the processor case is provided (even thin air gap has a low heat conductivity). The use of heat-conductive mastic is of great efficiency. Rather effective is a sticking of a radiator to a processor with a tape. If a passive heat sink provided only by the radiator with the natural circulation of air inside the PC case is not enough , active heat sinks are used (Cooler). They have additional fans installed ?n a processor radiator. Usually radiators are removable devices supplying from a source of +12 V by means of special connector. Some processors have fans stuck ?n a factory. Processors Pentium OverDrive (replacement of 486) are produced with the installed fans supplying directly from special socket contacts. Fan and radiator dimensions (gabarit and installation) for the processors 486, Pentium and Pentium PRO are different (the older is the processor the larger are radiator and fan). More high radiator with the more powerful fan is required for the processors with the frequency more than 200 MHz.

ATX standard requires the installation of the processor directly under a power unit and as this takes place both internal fan of power unit and additional external one installed outside the power unit and processor fan are needed to blow radiator ?n. All of them should operate in coordination – to blow the processor radiator ?n. In other case their total efficiency will be decreased. In case of a large radiator ?n a processor in ATX case it is possible not to use another fan ?n a processor.

A fan as an electro mechanical device has the less reliability than a processor. Troubles of different extent can be associated with fans.

The most often reason of fan malfunction is a contact with the inner connection cables (data cables of HDD or CD ROM, connection buttons and front panel indicators). There are fans with error indicators: they have rotation sensor and

electronics card mounted in a fan. This card is between standard dynamic connector and dynamic itself. If the fan is stopped the dynamic is activated. If there is such a facility in the fan one can hear a typical melody while switching the power.

The most improved systems (used for servers) can have temperature sensors as well giving interruptions in case of exceeding. The processors Pentium Pro and Pentium II have inner temperature sensor stopping the processor in case of emergency or overheating. The fan of Pentium II cartridge has a rotation sensor. The sensor signal is led to the fan power connector and its processing is carried out by system board components.

Processor configuration

CLOCK. The main clock generator of a system board produces high-stable impulses of reference frequency used to clock processor, system bus and input/output buses. The standard frequencies of generator are: 4, 7, 8, 10, 12, 16, 20, 25, 33,3, 40, 50, 60, 66,6 MHz; for the new boards the characteristic frequencies are – 75, 83 MHz and for the latest – 100, 133 MHz and higher. When the computers with the clock frequency providing productivity more than standard model XT (4,77 MHz) or AT (8MHz) appeared, mode and switch TURBO were introduced to provide compatibility with the programs where any delays were formed by means of processor cycle calculation. In TURBO mode a processor operate with the max rate, and in «normal» mode –with the reduced, providing «standard» productivity.

As the speed of different components operation (processor, memory, adapters for ISA, PCI buses) sufficiently differs, reference frequency division to clock input/output buses and inner frequency multiplication in processors is used in the computers with the processors of 486 class and older. There are the following frequencies:

- Host Bus Clock – this frequency is a reference one for all others and is installed by Jampers. The modern processors of Pentium class and older use frequencies: 50, 55, 60, 66,6, 75, 83, 100, 103, 112, 124, 133 and so on. The processor input clock signal is sometimes called CLKIN and in the computers AT-286 and 386 whose input frequency was divided inside in two, was often called CLK2IN.
- CPU Clock or Core Speed - inner frequency of the processor , on which its computing core works. The modern know-how allows to increase sufficiently limited frequencies of integral components and in connection with the above-said inner frequency multiplication is widely used at 1.5, 2, 2.5, 3, 3.5, 4, 4.5 and 5. Multiplication factor is defined by Jampers in a system board, earthing the proper processor leads or CMOS Setup. However, not all processor models perceive all signals of division factor control. Besides, different meaning of factor can correspond to one and the same jumper position – control signals can be treated depending on mark and model of the processor.
- PCI Bus Clock – frequency of PCI bus that should have 25-33,3 MHz (specification PCI-2.1 allows frequency up to 66,6 MHz). It provides division of Host Bus Clock by 2 (sometimes 3) and when the external processor frequency is used not exceeding 33,3 MHz (in systems on 486) frequency division is not used. Too low frequency of PCI bus slows down data exchange that is especially noticeably in graphical adapters, adapters of speed local networks installed in PCI slots. Too high frequencies can result in unstable operation of adapters. Taking into account the above-said optimal frequencies of external processor bus

should be 33,3 MHz for 486 and 66,6 MHz for the processors of 5 and 6 generations. Frequency 41,5 or 37,5 for a number of buses can be too high, that's why the external frequency of processor bus 75 or 83 MHz should be used with caution.

- ISA Bus Clock or ATCLK – frequency of bus ISA, which should be close to 8 MHz. It is usually given in BIOS Setup by division factor of system frequency. Sometimes when old expansion cards are being installed. It could be decreased by BIOS Setup options.

Beside these clock frequencies there can be other ones on a system board - to clock COM ports, CMOS timer, NGMD and other peripheral adapters but they don't attract attention. Bus ISA has a signal OSC with the frequency of 14,138 MHz used only to clock graphical controller 6845 (MDA, HGC, CGA).

One should remember that internal frequencies of Pentium-compatible processors are often not in line with their marking, which reflects P-rating – frequency of processor Intel Pentium having analogous productivity.

RAM memory

In PC 286 and previous 386 RAM was installed directly on mother-boards. Additionally the first models (XT, AT-286) allowed to increase RAM by means of installation of special expansion cards in slot ISA. Later, memory modules were used. Each module is installed in a slot on the mother-board. These connectors (they can be several) are arranged in groups (2 or 4 depending on system bus capacity and memory modules) – banks. Bank should be always filled. As RAM memory chips of different architecture types are used.

For installation and configuration of RAM one should know a lot of different characteristics both memory modules and mother-boards.

Up-to-date chipsets sometimes allow during POST to carry out automatic identification of used memory module types (sometimes speed of operation).

There are some peculiarities in filling the banks while installing memory modules. Firstly, the bank is in operation only if it is filled. The bank for AT –286 and 386 SX consists of 2 bytes (16 bit), for 386 DX and 486 – of 4 bytes, and for older processors – of 8 bytes. In accordance with that necessary number of memory modules should be selected.

Secondly, if a system board supports Bank Interleaving, memory productivity will be increased by means of filling of all banks. As this takes place, the increase of memory volume will be complicated in future. The size of correctly installed memory is defined automatically on modern system boards (as distinguished from the first computers where it was necessary to give it by switches or jumpers). However, the memory of more than 16 Mbyte can not be accepted if in BIOS Setup accommodation of ROM BIOS image under level 16 Mbyte is permitted.

SIMM - modules

SIMM- modules are installed in special slots on mother board. Due to such construction of SIMM modules reliability of electrical contact in a connector and rigidity of a module as a whole is sufficiently increased.

Failure of RAM operation the most often occurs as a result of improper connector contacts ?n mother-board.

Convenient construction of SIMM modules allows independently to change memory configuration without damage to leads.

DIMM- modules

One DIMM- module owing to more wide bus can be installed on mother-board with 64 capacity system bus (for CPU of Pentium class).

Beside memory chips buffer chips of input/output and SPD (Serial Presence Detect) can be installed on modules.

SPD chip – a chip of power-dependent EPROM memory, in which module and manufacturer information is recorded. DIMM-modules of «Noname» manufacturers usually don't have SPD chips. It results in the fact that some mother-boards (e.g. with Chipset 440 LX) refuse to work.

Floppy disk drive

CABLE CONNECTING. There are two connectors to connect to PC ?n all disk drivers. The first of them (informational) is designed for connecting by 34-line flat cable to controller. The other connector (supplying) is designed for connecting the cable supplying disk driver. Modern disk drivers requires voltage power of +5V, however, additionally, by cable connected to power unit. The voltage of +12V is provided.

In the process of connecting information cable errors are possible. Not only connectors are different, but the cable itself can be connected in different manner and only one of them is correct.

The correct connecting of disk drivers is important not only for providing their functioning but for defining their priority.

Disk driver connecting

There are two main rules to connect cables.

There are some jumpers, as a rule, ?n FDD board, by switching of which the priority of disk drivers is given. The priority is marked with symbols DSO, DS1, DS2, DS3 (Driver Select). The availability of 4 possible versions of priorities is explained by the fact that the controller can control maximum 4 disk drivers, though usually only one is used in PC.

The priority is given by commutation of 34-line information cable. And only in case of such cable absence or in the process of off- standard disk driver connecting one can try Driver Select Jumpers.

Another position of Jumpers can give e.g. that 3,5” HD FDD is installed as 3,5” DD FDD.

Changing of disk driver name

To change the name of a disk driver there is no necessity to switch over Jumpers. It is only enough to carry out the following:

1. To change places of data cable connectors
2. To make changes in Standard CMOS Setup installations in accordance with the disk driver configuration.

Connecting of the second HDD

CONNECTING OF THE SECOND IDE HDD. The information on Jumper position to install HDD both Master and Slave is contained in the documentation on HDD and usually is shown on its case.

It is necessary to make the appropriate changes in CMOS Setup before testing of the second HDD. After recording of new options into the memory, load the PC again. But the second HDD has not been active yet as it though registered by PC is not initialised by OS.

Probably, on finishing POST operation, the message d: Drive Failure or d: Drive error, which means that you should prepare Winchster to work with OS, will appear on the display. For that it is necessary to call FDISK program, which allows to accommodate HDD, to produce logical disks on it and give them identifiers.

Connecting of CD-ROM

Connect power cable and data cable to the drive of CD-ROM. From the very beginning it is necessary to fix horizontal position of the wire, in other case results of the test will be incorrect.

Possibly, it will be necessary to connect a drive to already given audible card. In this case a data cable between CD-ROM and audible card and 2 or 4 line audio cable are necessary. As this takes place the documentation on audible card and identification of proper connections will be necessary as well.

By means of Jumper placed on rear side of the CD-ROM drive case, define the drive operation mode (Master or Slave). If the drive and HDD are connected to one and the same data cable CD-ROM drive will be declared as Slave. Though it is better to connect the drive to the second IDE – Master mode. In this case speed of information exchange between Winchester and the drive is increased. Having connected CD-ROM drive, switch the PC on. In the process of loading modern BIOS defines the availability of CD-ROM drive in a system and gives the proper message.

If OS Windows 95/98 is installed then, as a rule, there is no necessity to install drivers for CD-ROM manually. The system itself defines the availability of the driver and defines the drivers of high level –CDFS.VxD (analog of MSCDEX.EXE for DOS) and of low level, which is selected out of Windows database for the proper CD-ROM drive model.

If after the loading of Windows in dialogue window «My Computer» there is no CD drive pictogram or you are working in DOS, it is necessary to install and write in starting files drivers of high and low levels (MSCDEX).

4.5.4. ELECTRICAL- SUPPLY AND PC SAFETY

Problems of electric supplying are of great importance both for stable operation of PC, their networks and peripheral devices and their long-living.

Earthing problems

Practically each PC power unit has a electrical filter. Capacitors of this filter are designed for -----of high frequency noise of mains to the earth through protection earth wire and the proper 3- pole plug and socket. However, if a nil power cable to separate the mains with 3- pole sockets by means of dual conductive cable will be used as an earth there appear a potential difference ?n it caused from voltage falling.

To provide electrical safety socket earth contacts connected with each other should be connected with the general grounding cable or with a nill cable of the mains (Excluding the possibility to switch It over to phase cable).

Ignoring of the rule results in appearing ?n a device case a touch voltage of 110 V AC.

Level of limitation of Squirrel cage current is defined by condenser filter capacity and depends ?n a device power. Current through a man having a contact with the ground (e.g. floor) and touching a device can achieve tens of m amp that is dangerous to life.

Additional equipment supply

PC power units are designed for power from 70 to 300..500W.

Requirements to the power of units are defined by a set and number of inner devices. For the units with transit connector of monitor supply, power consumption is shown in terms of additional 100 W for the monitor.

In case when It is necessary to connect not only one monitor and a system unit but another peripheral equipment as well, a long wire with a lot of sockets, electrical filter or trouble- free supply is used.

If a monitor having a display of 17” is used (such monitors require sufficiently more power in comparison with 14” or 15” monitors) It is connected by means of separate power cable. In other case its connection to an appropriate PC connector through a power switch can result in exceeding the allowed current for a given switch type and going out of order.

UPS

Un-interruptible operation of any electrical equipment depends on parameter stability of the mains. The mains parameter stability is expressed in a power noise, the basic of which are high-volt impulse voltage drops (up to 3 m), periodical drops with the less amplitude, long voltage level falling up to 150-170 V, periodical voltage drops ?n connecting a powerful equipment.

All these factors affect the PC operation and can result in data loss, over-heating, hanging, up to full failure. A single PC and other equipment protection against net noise are Uninterruptible Power Supply (UPS).

4.5.5. PC SERVICING

PC is a complicated device consisting of a number of chips, which have a high degree of integration.

In terms of element exploitation there is a notion MTBF (Mean Time between Failure), which means an average time of element operation between two failures. It is measured in hours. The second notion MTTR (Mean Time to Repair) means an average time of repair.

In case of any servicing all patchtips should be switch off.

Case

Dust is the most common reason of PC failure. It either influences the operation of mechanical devices or e.g. causes PC failure falling onto reading/recording heads in diskette drives or over-heating.

To clean PC “ inner structure” it is necessary to remove the largest amounts of dust ?n mother-board, in the place of element location and on a power unit.

It is possible to cover air openings with filters. When opening PC case, one should check not only the correction and reliability if proper cable connection to mother-board and drives, but pay attention to free cables as well, as they can result in cut off. Twisting cables into a rope is used to avoid that.

Disk drivers

HDD needn't servicing. Considerable problems are created by dust ?n reading/recording heads. As a result of the above –said the following messages can appear: can't read disk in drive A. One should use special cleaning diskettes or Spray to clear them carefully.

Remove diskettes out of drive only when an indicator is turned off.

CD-ROM drive

Dust is the main reason of CD-ROM drive failure, especially if It is in optics.

Usually CD-ROM drive optics is covered with a special layer, which is damaged with wet cleaning. That's why such a drive should be cleaned with a n air flow special cleaning CD-DISK.

Keyboard

Keyboard is one of the several components not placed in closed case.

Plastic covering to avoid keyboard contamination, with which a keyboard is covered out of service hours is a sufficient preventive measure.

Common cleaning means can be used to clear keyboard but It is impossible to use substances containing acetone or other dissolving liquids.

If there is no reaction to key pressing it is necessary to open a keyboard to clear up the reason of failure.

Mouse

Contamination of a mouse can occur because of tight contact of the mouse with the rug surface. It can result in an unstable work of a mouse pointer. Cleaning of the

mouse should be carried out regularly. Optical mice needn't such a servicing. In that case only cleaning of surface and lens of a mouse is necessary.

Monitor

Monitor servicing – only cleaning of a display and case is necessary. Dust prevents heat tapping and results in the monitor over-heating decreasing its exploitation.

There are monitors with a special protective layer having anti-light coverage. Usage of common cleaning means is impossible.

In any case, consult the monitor manufacturer manuals and take the given recommendations into accounts.

SECTION 5

ELECTRONIC NAVIGATIONAL AIDS

Section 5. Electronic navigational aids

The purpose of this section is to provide knowledge of shipborne electronic navigational equipment operation, maintenance, including provision of operational conditions and fault detection down to replaceable unit (module).

The entry standards:

The candidates should have basic competence in physics, mathematics and electronics sufficient for study of electro navigational equipment operation principle.

After completion of this course the trainees should have knowledge of:

- electronic navigational equipment construction;
- factors affecting technical and operation parameters of electro navigational equipment;
- operation testing and fault detection of shipboard electric navigational equipment.

Outline

No.	Learning objectives	Class hours		
		Total	Theoretical	Practical
1.	Basic concept of navigation Basic points, lines and planes used for position fixing at sea Coordinate system (frame) Units of distance and speed in navigation	2	1	1
2.	Magnetic compasses Magnetic compasses with magnetized needle sensor Magnetic flux-gate compasses (induction compasses) Digital magnetic compasses Classification of the magnetic compasses Magnetic compass maintenance	2	1	1
3.	Gyrocompasses and gyrocompass and attitude reference system Basic properties with of gyroes with 2 and 3 degrees freedom Gyrocompasses Gyrocompass and attitude reference systems Gyrocompass maintenance and repair	12	6	6
4.	Rate of turn indicator Theory of rate of turn indicator Functional configuration of the rate gyro General information about rate gyro maintenance	3	2	1
5.	Auto pilots. Conventional autopilots The selection of optimum parameter value of conventional autopilot Adaptive autopilots	4	2	2

6.	Logs. Electromagnetic logs Sonar logs Radio Doppler logs Sonar correlation logs General information about log maintenance	13	7	6
7.	Depth measuring systems (navigational echo-sounders) Echo-sounder operation principles Echo-sounder main parameters Echo-sounder main errors General information about echo-sounder maintenance	3	2	1
Total		39	21	18

5.1. Basic concepts of navigation

5.1.1. Basic points, lines and planes used for position-fixing at sea

To solve major problems of navigation the Earth is assumed to be an oblate spheroid with a radius of 6371.1 km. To determine the observer's position on the surface of the Earth the following points, lines and planes are used. (**fig. 5.1**)

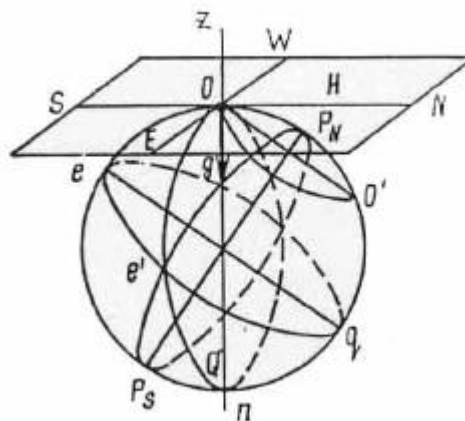


Fig.5.1

Axis of rotation (polar axis) is an imaginary line $R_N P_S$ about which a diurnal rotation of the Earth is effected. This axis is equal to the diameter of the Earth.

Geographical poles of Earth P_N and P_S are the points of intersection of the axis of rotation and the surface of the Earth. Pole N from the side of which the Earth rotates in the counter clockwise direction is called the North Pole, the opposite one is the South Pole. Parallels are lines $00'$ formed by intersection of the planes perpendicular to the axis of rotation. Equator is the longest parallel whose plane intersects the center of the Earth. Planes of the true (geographical) meridians are the planes intersecting the axis of rotation. The observer's meridian is the meridian through the place of observation. If, for example, the observer is in point 0 the observer's meridian will be the line $P_N0 P_S0'$.

Plumb (vertical) line is the line ZOn corresponding to the direction of gravity force in this point.

Observer's zenith Z and nadir n are the points of intersection of the plumb line and imaginary celestial sphere. Observer's true horizon plane is horizontal plane H through the observer's position perpendicular to the plumb line. Line NS is formed by intersection of the observer's meridian plane and the true horizon plane. Direction from O to N is called the northern part of the true meridian and from O to S – the southern part of the true meridian.

Planes of verticals or vertical planes are the planes through the plumb line. Prime vertical plane is the vertical plane Q perpendicular to the plane of observer's meridian. The line East-West (EW) is the line of observer's true horizon plane and the prime vertical plane. This line corresponds to eastern and western directions from the observer's point. Lines NS and EW are the main rhumbs. Position of objects on the surface of the Earth and their directions from one point to another and given with reference to these points, lines and planes.

Basic directions used in navigation are heading (course), bearing and relative bearing.

True heading (course) is angle in true horizon plane between the northern part of the true meridian and fore-and-aft line of the ship in direction of its movement. (**Fig.5.2**)

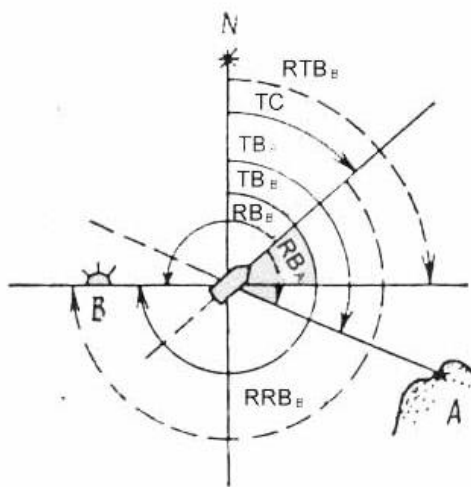


Fig. 5.2

True bearing is an angle in true horizon plane between the northern part of the geographical meridian and direction to the object. Direction different from the true bearing for 180° is called true reciprocal bearing. Navigational marks, vessels and objects relevant for safety of navigation can be used as objects for taking bearing. Relative bearing ($R.B$ or q) is an angle in true horizon plane between the bow part and the fore-and aft line of the ship (heading / course line) and direction to the object (bearing line). True courses are usually measured from 000° through 360° . Reference scales of compasses, scale and limbs of visual and technical aids to navigation are

calibrated from 000^0 through 360^0 . Relative bearing are measured right or left from 0^0 at the ship's head through 180^0 . For calculations relative bearing to the starboard of the ship's head are assumed to have sign "+", to the port side to have sign "-". For example, relative bearing of 45^0 from the ship's port side can be put down like this: R.B = $q = -45^0$; relative bearing of 110^0 from the ship's starboard side can be put down like this: R.B = $q = +110^0$.

Some bearing taking and observation devices (e.g. magnetic compass) have relative bearing scales calibrated from 000^0 through 360^0 . Reading is started from fore-and-aft line. The dependence between true course, true bearing and relative bearing is expressed by the following formulae:

$$TB = TC + RB; \quad TC = TB - RB; \quad RB = TB - TC$$

Formulae 1.1 are algebraic. It means that arguments are inserted with their signs. If calculations of true course and true bearing result in the "-" (minus) the exponent to 360^0 is taken with the "+" (plus) sign. If relative bearing is more than 180^0 it must be subtracted from 360^0 and direction of the side must be changed. Direction to the object perpendicular to the fore-and-aft line of the ship (port or starboard side $RB = 90^0$) is called beam. True and back true bearing are connected by the following relation: $TB = BTB \mp 180^0$ $BTB = TB \mp 180^0$

5.1.2. Coordinate system (frame)

Geographical and polar coordinate systems are the most important for navigation. In geographical system of coordinates position of point on the surface of the Earth is determined by latitude and longitude (**fig. 5.3**).

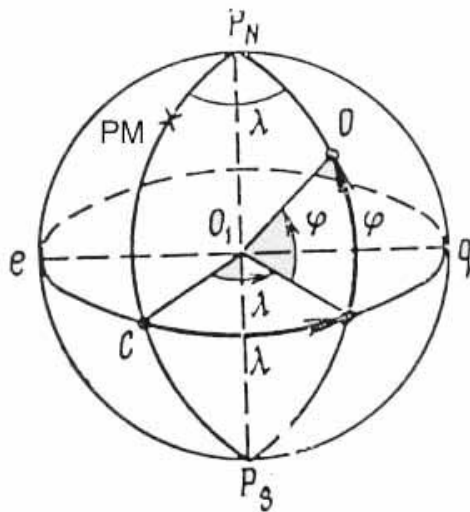


Fig. 5.3

Coordinate axes of this system are equator eCq and prime meridian which is assumed to be Greenwich meridian (meridian $P_N CP_S$). Geographical latitude of the point is an angle between the equator plane and the normal to the surface of the oblate spheroid in the particular point. Latitudes are measured in degrees, minutes and fractions of minute from 0^0 to 90^0 (from equator to poles). Latitudes of the Northern

hemisphere are designated North (N) or sign "+" (plus) (for calculations). Latitudes of the Southern hemisphere are designated South (S) or sign "-" (minus). Geographical longitude of the point is an interfacial angle between the plane of the Greenwich meridian and the plane of the meridian of a point on the Earth. Longitude is measured by the smallest arc of the equator from Greenwich meridian to the meridian of the point. It is measured in degrees, minutes and fractions of minute from 0^0 to 180^0 . Longitudes of the Eastern hemisphere are designated East (E) and sign "+" (plus), longitudes of the Western hemisphere are designated West (W) or sign "-" (minus). This is how geographical coordinates can be put down:

$$\begin{array}{ll} \varphi = 59^0 46,3' N; & \lambda = 28^0 14,0' W \\ \text{or} & \\ \varphi = +59^0 46,3'; & \lambda = -28^0 14,0' \end{array}$$

5.1.3. Units of distance and speed in navigation

To solve navigational problems connected with movement and position fixing on the water surface of the Earth one has to measure and calculate the distance. A so called standard nautical mile is used for this purpose. A nautical mile is equal to 1852 meters. A cable, which is equal to 1/10 a nautical mile is used to measure relatively small distances. Meter is used to measure depth of water, underkeel clearance, height of beacons and light structures etc.

A knot is used to measure speed from the times of sailing ships. It is equal to the speed at which the ship covers a nautical mile per 1 hour.

$$1 \text{ knot} = 1 \text{ m}/1 \text{ h} = 0,17 \text{ cbl}/\text{min} = 0,51 \text{ m/s} = 1,85 \text{ km/h}$$

5.2. Magnetic compasses

A magnetic compass is a navigation device designed to seek the magnetic meridian and to hold that direction permanently, for unlimited time. A magnetic compass acts as an indicator of the magnetic direction owing to the existence of the Earth magnetic field. The magnetic compass is intended to determine the ship's course at sea.

In accordance with the Requirements of the international Maritime Organization (IMO) every ship-big and small-should be equipped with a standard magnetic compass.

There are two types of the ship magnetic compasses: (1) a compass with the set of magnetized needles as a sensor (sensitive element); (2) a compass with the flux-gate (ferro-sonde) sensitive element.

All errors of the magnetic compass may be classified as variation and deviation. Variation is the angle between a magnetic and a terrestrial meridian. Deviation is the angle included between the magnetic meridian and vertical plane passing through the poles of sensitive compass element (compass meridian). Deviation is the error caused by the ship's iron.

5.2.1. Magnetic compasses with magnetized needle sensor

Magnetic compasses with magnetized needles sensor are the widespread course indicator on board of sea vessels. The modern types of these compasses are equipped with the remote optical or electrical system for reading the ship's course. The main part of this compass (**fig. 5.4**)

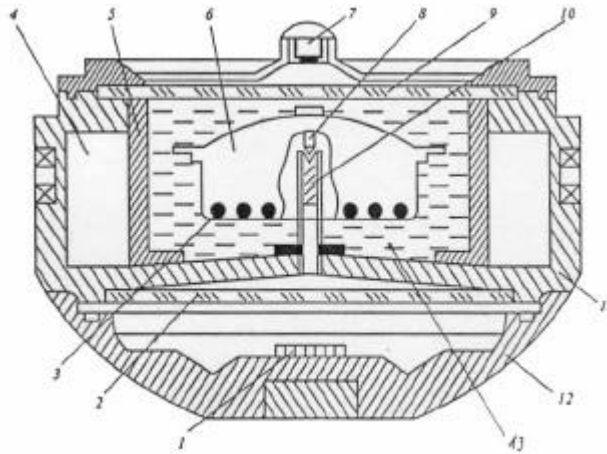


Fig. 5.4

is a magnetic sensitive element (sensor) which consists of a system of magnetized needles (usually – six needles), attached to the float.

The magnetic sensor is placed in the bowl filled with the special unfreezing liquid. Owing to the floating affect the gravity of the sensor is partially compensated. As a material for the sensor the special magnetic alloy is used. It guarantees the constant magnetic parameters of the sensor for long time of exploitation.

The magnetic sensitive element is placed in the hermetic case (bowl) 11, which filled with the liquid and from above (and from below) with glass covers 9 and 2. The weight 12 allows the bowl to keep the plumb position while rolling and pitching. There is a flux-gate sensor 1 attached to the bowl. It forms (produces) the electrical signal for remote course-reading system of repeaters. On the upper glass cover 9 there is a unit 7 for the lighting the compass card. Inside the bowl there is a screen 5, behind which the air compensator 4 is placed. It compensates the change of the liquid volume with the alteration of the temperature. In the lower part of the bowl there is a prop detail 10 for supporting the iridium pivot 8 of the sensitive element 6. There are two openings with the stoppers. One opening is intended for initial filling of the liquid and the other – for additional filling if necessary. The magnetic bowl is placed in the upper part of the binnacle in the gimbals. For reading the ship's course there is a round scale (card) and the heading line, situated in the center-line (fore-and-aft) plane of the ship. The magnetic compass with the magnetized needles sensor is utmost autonomous. Its action does not depend upon the ship's electrical supply.

The remote reading of the ship's course is realized by means of the optical system. The card image from the sensor transmits to the screen of the optical repeater through the fiber-glass line.

In accordance with the international requirements the magnetic compass should be provided with the devices for correcting (compensating) all the types of deviations. These devices are placed inside the binnacle 1 (**fig.5.5**).

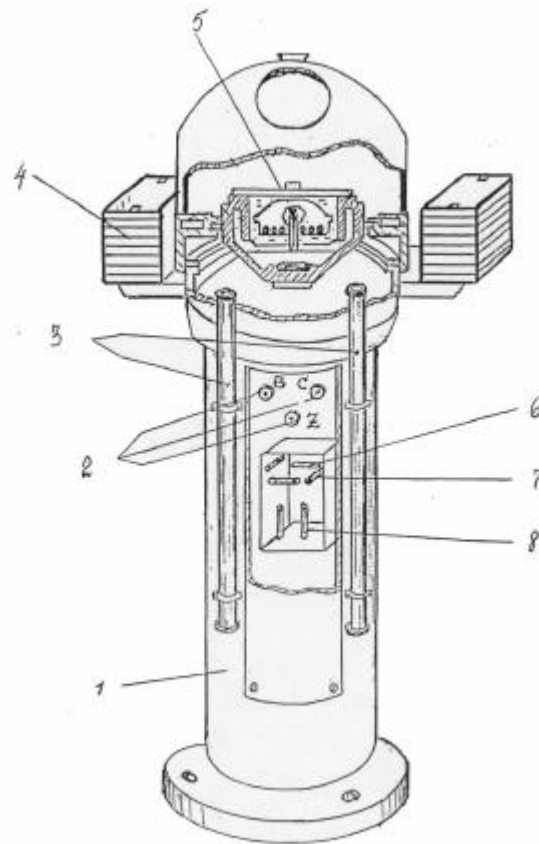


Fig. 5.5

Besides the bowl of the compass 5, there are: longitudinal 7 and transverse 6 magnets for compensating the semicircular deviation and vertical magnets 8 for compensating the heeling error. Compensating the semicircular and heeling deviations, that is setting magnets 6,7,8 is being made by means of regulator B, C, Z.

For compensation of the quadrantal deviation, arising from influence of soft ship's iron, there are two boxes 4 with the set of ferro-magnetic horizontal plates, situated outside the binnacle, in the upper part of it.

The modern magnetic compass also should be provided with the additional compensator— flindersbar. It is a vertical soft iron bar placed before the compass binnacles. Instead of one bar may be used two vertical bars (3). The flindersbar is intended to correct the influence of vertical soft iron in the ship, for example ship's funnel. The flindersbar is a compensator which ensures the stability of the semicircular deviation during the ship's voyage in different latitudes.

The examples of the magnetic compasses with the magnetized needles sensor are: "Jupiter" (Germany); KM-145 (Russia); "Tokimec" (Japan).

5.2.2. Magnetic flux-gate compasses (Induction compasses)

Induction compass is based upon use of flux-gate – magnetic modulation transducer, which changes (transforms) magnetic field into electrical signals.

Flux-gate consists of cores and coils. Earth magnetic field makes induction in the cores and changes its magnetic state. Due to this fact we call an induction magnetic compass.

The induction magnetic compass has one main demerit: it is unable to work without electrical supply. At present induction compasses are seldom applied on board the ocean-going ships. But they are often used on yachts and other small vessels. Flux-gate units are widespread as transducer of the remote-reading system in standard compasses.

5.2.3. Digital magnetic compasses

The magnetic compasses of the new generation are equipped with the interface system for remote-reading of the ship's course. Owing this unit the magnetic compass may be included into the common integrated navigation system. The operator's work with this compass is based on the principle of the dialogue with the compass computer system. Magnetic compass KM 115–07 (Russia) is an example of such a device.

5.2.4. Classification of the magnetic compasses

The compasses placed on the upper deck of the bridge are called standard magnetic compasses. The bowl of standard magnetic compass has an azimuth ring divided into 360 points (1 point is equal 1^0). This scale is intended for measuring azimuth angles, between plane of the ship and the direction to the object. The direction finder device is used for this purpose. It is intended also to determine the bearings – angles between the magnetic North and the object direction.

For steering aims the second magnetic compass may be used. It is placed on the navigating bridge of the ship. Instead of the steering compass the optical system of the standard magnetic compass may be applied too.

5.2.5. Magnetic compasses maintenance

Magnetic compasses are very reliable devices. They require minimum of the service during its exploitation. The deviation works are fulfilled by the specialists of the port navigation base.

5.3 Gyrocompasses and Gyrocompass and Attitude Reference Systems

5.3.1. Basic properties of gyroes with 2 and 3 degrees of freedom.

The simplest variant of the gyro with 3 degrees of freedom is a gyro in gimbal suspension (**fig. 5.6**). Rotor 1 is suspended in a system of rings in such a way that it

can spin about axis X–X with a reference to an inner gimble ring, an inner gimble ring with a reference to an outer gimble ring 3, and the latter about axis Z–Z with a

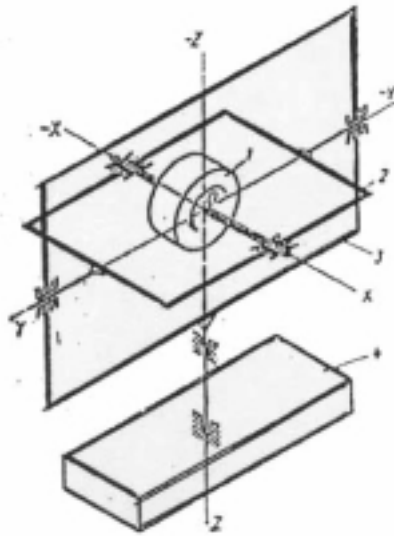


Fig. 5.6

reference to the base 4. The point of intersection of axes X–X, Y–Y and Z–Z is the center of a gyro suspension.

The gyro understudy has the following properties:

The first property is that the original direction of the gyro axle is not changed in spite of the movements of the supporting base. The friction of the supporting pivots, instead of dragging the gyro around, as it would be in the absence of spin, is now opposite by gyroscopic inertia. It should be noted that if the pivots and bearings are dirty and worn, the friction may be great enough to cause the gyro to precess when this experiment is tried.

The second property is that under the influence of a force applied to inner or outer gimble rings and forming torque which does not correspond to the main axis of the gyro the latter rather than rotate (spin) in direction of the force applied will rotate at a right angle to this direction. Such a property is called precession. Precession motion takes place at a constant angular rate thus being free from inertia. Inertia of a gyro is visible in its nutation. Precession angular rate is determined by the following formulae:

$$\omega_{py} = \frac{L_Z}{H} \qquad \omega_{pz} = \frac{L_Y}{H} \qquad (5.1)$$

where L_Y , L_Z – is a torque applied to appropriate axis

H – angular momentum

ω_{py} , ω_{pz} – angular rate of the precession motion about the appropriate axis

The third property consists of the following: under the impulse of the force applied to the main axis of the gyro the latter practically does not change its initial motion but only makes oscillations almost in a position equilibrium. These oscillations are called nutation. These oscillations are observed at a small angular rate of wheel rotation. Properties of a gyro with 3 degrees of freedom are used in such devices as gyrocompasses, gyroverticals, gyrocompass and attitude reference systems and other devices.

Property of a gyro with 2 degrees of freedom. A gyro with 3 degrees of freedom can be converted into a gyro with 2 degrees of freedom if it is deprived of one degree of freedom e.g. about axis Z–Z (**fig. 5.6**) by a rigid fixation of ring 3 with base 4. As a result we will have a device shown on **fig. 5.7**.

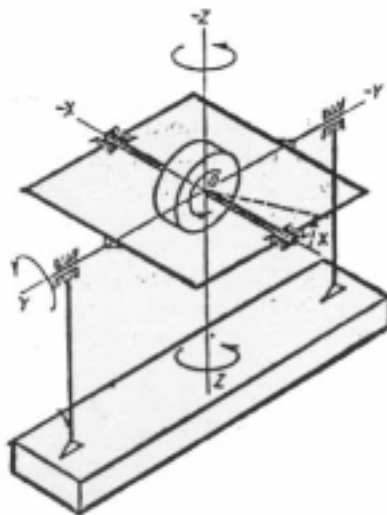


Fig. 5.7

Gyro with 2 degrees of freedom does not possess any of the properties a gyro with 3 degrees of freedom has. It possesses its own property. If the base to which the gyro fitted starts rotating about axis Z–Z i.e. the axis which does not correspond with the axis of wheel rotation and axis of suspension Y–Y, the wheel together with the suspension ring rotates about the suspension axis until axis X–X corresponds with the axis of the base rotation i.e. axis Z–Z of the enforced rotation of the gyro. Rate of turn indicators, integrating gyroes etc work on the basis of this property.

5.3.2. Gyrocompasses

A gyrocompass is a navigation device intended for indication of the true meridian plane which helps to determine the ship's course, bearing to objects and effects azimuth stabilization of different devices. North-seeking effect appears as a result of combination of a gyro and a compound pendulum. In such a device called sensitive element of a gyrocompass a special direction torque appears which gives a sensitive element the property of sensitivity with a reference to true meridian plane due to

force of gravity and angular speed of the diurnal rotation of the Earth. Direction torque is determined by the formula:

$$R_Z = H \cdot \omega \cdot \cos \varphi \cdot \sin \alpha \quad (5.2)$$

where R_Z – direction torque;

ω – angular speed of the Earth's rotation;

φ – latitude;

α – the angle between spin axis of the gyrocompass and true meridian.

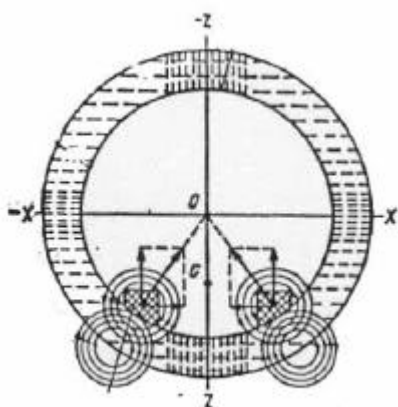
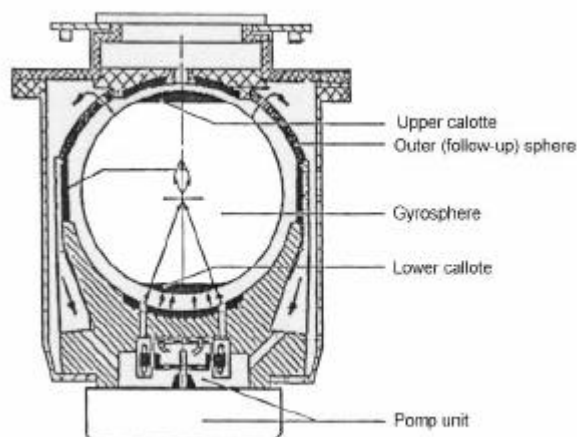
Direction torque has maximum value at the equator. Its value gradually decreases with the increase of the ship's latitude, it sharply decreases in circumpolar latitudes ($85^\circ - 87^\circ$) and as a result in these conditions the gyrocompass cannot keep a constant meridian position and consequently stops functioning as a gyrocompass.

The above mentioned combination of a gyro and pendulum can be achieved by two means. In the first case a gyro and a pendulum are connected and as a result a pendulum by means of its gravity force effects a direct control of a gyro's motion.

In the second case connection is achieved by means of a remote electromagnetic connection between the gyro and the pendulum (in this case a pendulum is included into a separate block which is called accelerometer or level sensor). On the basis of the above remote connection a so called indirect control is effected. All gyrocompasses with indirect control are two-mode heading indicators. The first mode "Gyrocompass" is realized when there is a connection between the sensor and gyrocompass. The second mode "directional gyro" is realized when the above connection is switched off. In "direction gyro" mode a heading indicator can only keep some given azimuth direction. The advantage of this mode is the following: it can be used at any latitude including the pole (which cannot be done in case of "gyrocompass" mode). The disadvantage is gradually increasing error of the course (which is not the case with "gyrocompass"). The most distinguishing feature of the gyro construction is the method of sensor element suspension. A specific requirement is the necessity to ensure its maximum angular freedom of motion and at the same time decrease to minimum its displacement in any linear direction, i.e. to ensure its centering.

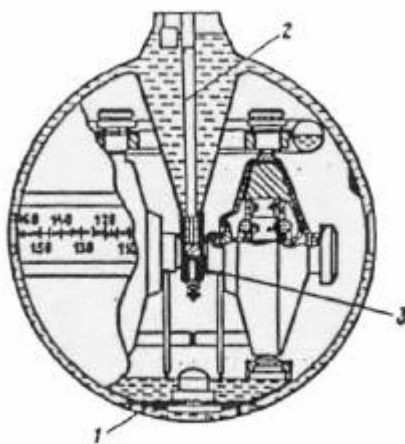
Following types of sensor element suspension became widely spread in modern gyroes:

1. Hydrostatic effected by support liquid of a special composition and in this case a sensor element (including one or two gyroes) is placed in a hermetic cover of a spherical shape. Such a construction is called "gyrosphere". Hydrostatic support cannot ensure centering (alignment) of a gyrosphere with the reference to outer sphere with support liquid into which the gyrosphere is submerged because it cannot create a neutral buoyancy of the gyrosphere in varying temperature conditions. That is why an additional centering device is used. There are two types of additional centering: the first one is electromagnetic (**fig. 5.8**)

**Fig. 5.8****Fig. 5.9**

on the basis of interaction of electromagnetic force of the coil placed in gyrosphere with eddy currents which the above coil inducts in the metal body of the outer sphere (e.g. gyrocompass Kurs 4M, Standard 4). The second one is hydrodynamic (**fig. 5.9**) on the basis of additional pressure, created by a hydraulic pump placed in the lower part of the outer sphere (e.g. gyrocompasses Standard 12, 14, 20).

2. Hydrostatic in combination with construction (**fig. 5.10**)

**Fig. 5.10**

made in the form of a pivot (pin) on which gyrosphere (which in this case has a conical turning) rests by its thrustbearing made of precious stones (sapphire, ruby e.g. gyrocompasses "Navigat X, XII").

3. Hydrostatic in combination with gimbal suspension, pivots of which have stone basis (e.g. "Sperry MK-37").

4. Hydrostatic in combination with gimbal suspension where pivots are replaced by torsion bars (Vega-M, Brown-1000).

5. Suspension designed on the basis of a rotating gimbal suspension effected on elastic (rotating) torsion bars (**fig. 5.11**. e.g. Yahta, SKR –82).

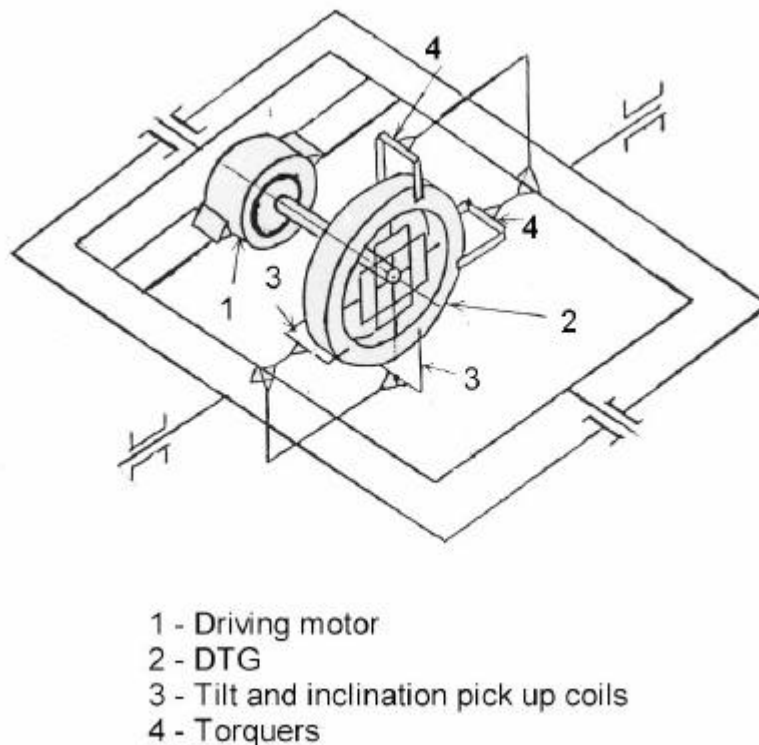


Fig. 5.11

Unique peculiarity of this suspension is that at some definite parameters of suspension and angular velocity of rotation elastic restoring moment of torsion bars is fully compensated by anti-elastic moment of inertia developed by rotating rings of the gimbal suspension. This helps to achieve a complete angular freedom of the gyro with rigid fixation with reference to liner displacement. Such an effect is known as an effect of dynamic tune and the gyro is called a dynamically tuned gyroscope (DTG). This gyroscope is widely used in gyrocompasses of a new generation. An important element of any gyrocompass is a follow-up system. A follow-up system becomes operational by means of a special servomotor (a follow-up motor) when the misalignment signal from the angle pick off is received; a follow-up system constantly monitors the position of the sensor element at all ship's turns on the course angle, this information is reflected on a compass card which is the heading indicator. The course transmission system allows to transmit the ship's course to all the users: information and bearing repeaters, autopilots, ARPA etc. Course transmission system can be synchronized of step type and digital – in international NMEA code through several common interfaces. Two channel follow-up system (stabilization system) are used in gyrocompasses with hydrostatic suspension gyro combined with elastic or dynamically tuned gyro with elastic rotating suspension. These system by means of servo motor eliminate misalignment of the suspension torsion and at the same time ensures functioning of the course transmission system by means of an azimuth

channel. In this case follow-up system have much higher sensitivity in comparison with the systems of gyrocompasses where elastic elements are not used in the suspension.

An important system which ensures normal functioning of gyrocompasses where hydrostatic pressure of the liquid in combination with electromagnetic or hydrostatic force is used for gyro suspension is the support liquid temperature stabilization system. This system is used to ensure that the value of the gyro buoyancy is closed to neutral. There are three types of temperature stabilization systems: cooling, heating and combined one. Water and air activated by the appropriate power supply system (pump or fan) are used for cooling. Heating systems use controlled electroheating elements; they are used in gyrocompasses where gyro suspension uses synthetic liquids obtaining required properties (mainly viscosity) at sufficiently high temperatures (60° – 70° C). In gyrocompass models where the "conical turning" gyro suspension as well as a sensor element suspension effected on dynamically tuned gyro are used, artificial cooling or heating are not used and a required constant temperatures kept by means of natural heat exchange with the surrounding air.

The error which is called speed error appears on a ship proceeding at constant speed and on constant course. Speed error depends on a ship's course, speed and latitude. There are two formulae of a speed error 5.3 and 5.4.

$$\operatorname{tg} \delta_v = -\frac{V \cos TC}{R \omega \cos \varphi + V \sin TC} \quad (5.3)$$

and

$$\sin \delta_v = -\frac{V \cos CC}{R \omega \cos \varphi} \quad (5.4)$$

where δ – angle of speed error;

V – ship's speed;

R – radius of the Earth;

ω – angular speed of the diurnal rotation of the Earth;

TC, CC – are true and compass courses respectively.

As the regularity of the speed error is known there is a possibility of a gyrocompass correction, i.e. elimination of the error from the gyrocompass's indications if the information about the ship's speed and latitude is available (e.g. the ship's speed can be obtained by log or GPS, latitude – by GPS or dead reckoning or by any other radionavigation system. All gyrocompasses can be divided into 2 groups depending on the method of used to correct indications:

1. Gyrocompasses with uncorrected sensor element where only indications of the repeaters are corrected by means of electromechanical or electronic adjuster (in the most primitive gyrocompasses speed error is not corrected at all and navigational account of error is effected by means of special tables and schemes).

2. Gyrocompasses with corrected sensor element (they are called corrected gyrocompasses) where correction is effected by the influence of the artificially created momentum on the sensor element or by means of direct influence on the gyro by electromagnetic torque (**fig. 5.11**).

In any variant a required value of the correcting torque is constantly calculated in special calculating devices of electromechanical type and in gyrocompasses of a new generation by means of electronic digital schemes.

A very important feature of a gyrocompass's quality is its accuracy when the ship is maneuvering i.e. when she alters her course or her speed or both simultaneously (in all these cases there is a linear acceleration of the ship). Deviation which appears as a result of the ship's maneuvering is called inertia deviation or deviation of acceleration. This deviation has a very complicated mathematical dependence, can attain a sufficient value and is of temporary character, i.e. having appeared as a result of the maneuver it within some period of time (1–1.5 hours in low and middle latitude and 2–2.5 hours in high latitudes) gradually disappears. In spite of its temporary character inertia deviation can greatly influence accuracy and safety of navigation in congested waters. To decrease the value of inertia deviation of gyrocompasses with uncorrected sensor element the following method is used. A sensor element is given the value of the period of its own self-sustained oscillation equal to 84.4 min. In compliance with the theorem proved by M. Shuller a gyrocompass with such a value of the period becomes invariant to the ship's acceleration during the maneuvering.

In widely spread gyrocompasses of a simple construction (e.g. Kurs 4M (Russia), Standard 12 and 14 (Germany)) execution of Shuller's theorem conditions is possible only at one definite latitude, it is called calculating and labeled φ^* (for Russian gyrocompasses it is 60° , for German ones 54.4°). In the most up-to-date compasses with uncorrected sensor element elimination of inertia deviation is achieved by means of mathematical model. The system of differential equations which reflects the gyrocompass's behavior during the maneuvering and after its completion is inserted into the microprocessor included into the gyrocompass.

Numerical integration of the above system of the differential equations with indication of the exact time (when constants of the sensor element are known and information about the ship's speed from GPS or log are available) allows to calculate the value of inertia deviation together with speed error for any moment of time and perform discrete correction of gyrocompass repeaters indications. The above method is the most effective way to increase the accuracy of gyrocompasses with uncorrected sensor element during the maneuvering (e.g. Standard – 20 (Germany)).

In corrected gyrocompasses inertia deviation is decreased by several means. The first method is to choose basis parameters of the gyrocompass which results in increase of its self-sustained oscillations' period. From the comparison of the formula of inertia deviation δ_j for the moment of the ship's maneuver completion t_1

$$\delta_{j_{t=t_1}} = -\frac{A_y \Delta V_N}{Hg} \quad (5.5)$$

and formula of gyrocompass period of oscillation

$$T_0 = 2\pi \sqrt{\frac{H}{A_y \omega \cos \varphi}} \quad (5.6)$$

(where H —angular moment ; A_y – the module of the torque control which depends on a signal of the north sensor; δ_j – inertia deviation) It is clear that the more is the ratio of H/A_y the less is deviation δ_j .

As the time of setting meridian is limited by IMO requirements (not more than 6 h.) period T_0 cannot be too long. Thus in gyrocompasses "Vega–M" (Russia) and Brown –1000 (Great Britain) it is 140–150 min (in middle latitudes). To solve the problem it is necessary to transfer to two-period system when at the time of actuation the period has the value 15–20 min and after setting meridian it is automatically switched to 250–300 min keeping the same value during the voyage (gyrocompasses SKR–82 (Norway), Yahta, Geus (Russia), Meridian (joint production of Russia and Great Britain etc.).

From formula (5.5) it is clear that inertia deviation of the corrected gyrocompass does not depend on the latitude which is the great advantage of this generation gyrocompasses in comparison the Shuller's ones. The second method to decrease deviation is to switch from "gyrocompass" to "directional gyro" mode during the maneuvering. In the most advanced gyrocompasses this operation is effected automatically. The third method is to limit the output signal value of the accelerometer during sufficient acceleration by introduction of non-linear characteristic (SKR–82, Yahta, Geus).

The important sign of a gyrocompass's quality is its accuracy during rolling and pitching. The error which appears in such conditions is called intercardinal deviation of the gyrocompass (it has the biggest value at the following rhumbs -45^0 , 135^0 , 225^0 , 315^0). There are several methods to decrease the above deviation. The most widely spread are the following: 1. use of twogyro system (Kurs, Standard), 2. heavy damping of accelerometer pendulum by means of the liquid (corrected gyrocompasses of the previous generation), 3. Use active electronic filter devices (the latest generation of the corrective gyrocompasses).

Systems of fast sensor settling meridian provide gyrocompass's readiness for navigational use in case of necessity. There are two types of fast settling meridian systems.

1. Manually settling systems require information about the true course of the ship (sensor element must be tuned to this course) from some other source of information (e.g. magnetic compass, or bearing of the berth the ship is moored at). In this case operator influencing the sensor element tunes it to the required reading (indication) of the course.

In the above case fast settling takes 30-40 min. The accuracy depends on the accuracy of the ship's course obtained. In a period of time gyrocompass will choose the fast settling error and will settle meridian with sufficient accuracy (e.g. gyrocompasses Kurs-4M Russia, TG-5000 Japan).

2. Automatic fast settling meridian systems which do not require information about the ship's course. These systems are used in corrected gyrocompasses of the latest generation.

Principle of automatic systems is based on the following: at the moment of actuation (due to change in parameters of sensor element control) the sensor element is added a small value of its oscillator period (several times less than the one it has during the sailing). As a result the sensor element performing convergent oscillations at a reduced period settles meridian without an operator within 45-60 min for different types of gyrocompasses.

When gyrocompasses are fitted on average and big ships the system of automatic registration of the course alterations within time is included into the set of equipment. It is called course recorder. In simple constructions the registration is effected on the basis of 2 electromechanical units: selsyn and electric driving motor.

In gyrocompasses of the latest generation with digital output of the ship's heading the registration system has construction similar to that of the matrix printer used in computers.

Signaling systems of gyrocompasses are meant for control and information (visual and sound) of personnel about the failure of the gyrocompass's basic systems (e.g. cooling, heating, follow-up etc.). In most up-to-date corrected gyrocompasses of the latest generation there is a very important system which informs the user when the gyrocompass leaves the meridian (Yahta, Gyking).

An important feature of the gyrocompass is the level of its adjustment to different systems of power supply.

In gyrocompasses of the previous generation only ship's alternating current (50 Hz and 220/380 V) network is used as power supply. Transformation of this voltage into the voltage of the other frequencies is effected by means of motorgenerator. Due to this the above stated gyrocompasses react very critically even to a short period of blackout.

Direct current (24 V) is used as power supply in gyrocompasses of new generation. Electrostatic converter included into a gyrocompass set provides direct current (24 V) for all known ship's networks both 50 Hz and 400 Hz. Advantage of such power supply is that batteries can be used for power supply in case of emergency.

Generalized characteristics of the most widely spread gyrocompasses are given below:

1. Gyrocompass ("Kurs-4M"Russia)

Autonomous two-gyro sensor with direct control, hydrostatic suspension, electromagnetic alignment, air cooling, electromechanical correction of speed error with manual control, remote course transmission of analog type, fast manual meridian settling (electromagnetic type), automatic defense of repeaters, engine power supply.

2. Gyrocompass “Standard-14” (Anshutz, Germany)

Autonomous two gyro sensor with direct control, hydrostatic suspension, hydrodynamic alignment of sensor, additional information about angular rate of the ship’s turn (RoT), electrostatic converter, automatic switch to emergency direct current power supply.

3. Gyrocompass “Standard-20” (Anshutz, Germany)

Highly automatic analog of “Standard-14”, microprocessor, digital control, mathematical model, digital self-synchronizing systems of remote information transmission, additional two-type analog system of remote course transmission, electrostatic converter.

4. Gyrocompass “Navigat X” (Plath, Germany)

Autonomous two gyro sensor, hydrostatic suspension, constructional centering, natural cooling, microprocessor control, electrostatic converter.

5. Gyrocompass “Vega-M” (CRI “Delfin”, Russia):

One-gyro sensor, hydrostatic suspension with heating, elastics torsion bars alignment, indirect control, analog correction system, analog remote transmission (selsyn), engine power supply.

6. Gyrocompass “S.G.Brown 1000” (Brown, GB) with modifications is analog of Russian gyrocompass “Vega-M” with highly automatic control, digitized equipment and electrostatic converter.

7. Gyrocompass “TG –5000” (TG-3000) (Tokimec, Japan)

Autonomous one gyro sensor, one vertical torsion bar suspension with hydrostatic discharging, electronic correction of speed error, electrostatic converter, natural cooling.

8. Gyrocompass “Yahta” (CRI “Delfin”, Russia):

Highly automatic one gyrocompass based on dynamically tuned gyroscope, digital indirect control and correction, digital and all type analog remote transmission, power supply – 24 V, additional information about angular rate of ship’s turn, electrostatic converter, emergency power supply from battery.

9. Gyrocompass “Geus” and “Geus-M” (Perm scientific and device manufacturing enterprise, Russia)

Analog of gyrocompass “Yahta” (see p.4).

10. Gyrocompass “Meridian” (joint Perm SDME (Russia) and S.G.Brown (GB) design

Single block modification of gyrocompass “Geus” (see p. 5), digital microprocessor control and correction, Gyrocompass “Gyrokin” (“Gyking”) (joint CRI “Delfin”

(Russia) and Sarako Company (S.Korea) design), single block modification of gyrocompass “Yahta” (see p. 4), digital microprocessor control and correction

11. Gyrocompass “SKR-82” (Norway)

Corrected one-gyro sensor based on dynamically tuned gyroscope, indirect control, in-built testing system, electrostatic converter, manual input of latitude, manual and from the log input of speed, manual switch “Directional gyro” mode.

The configuration of device connections of most wide spread gyrocompass “Standard-14” (Anshuz, Germany) is shown in fig. 5.12. Navigation devices which require the information of course and are connected with gyrocompass are also shown in fig. 5.12.

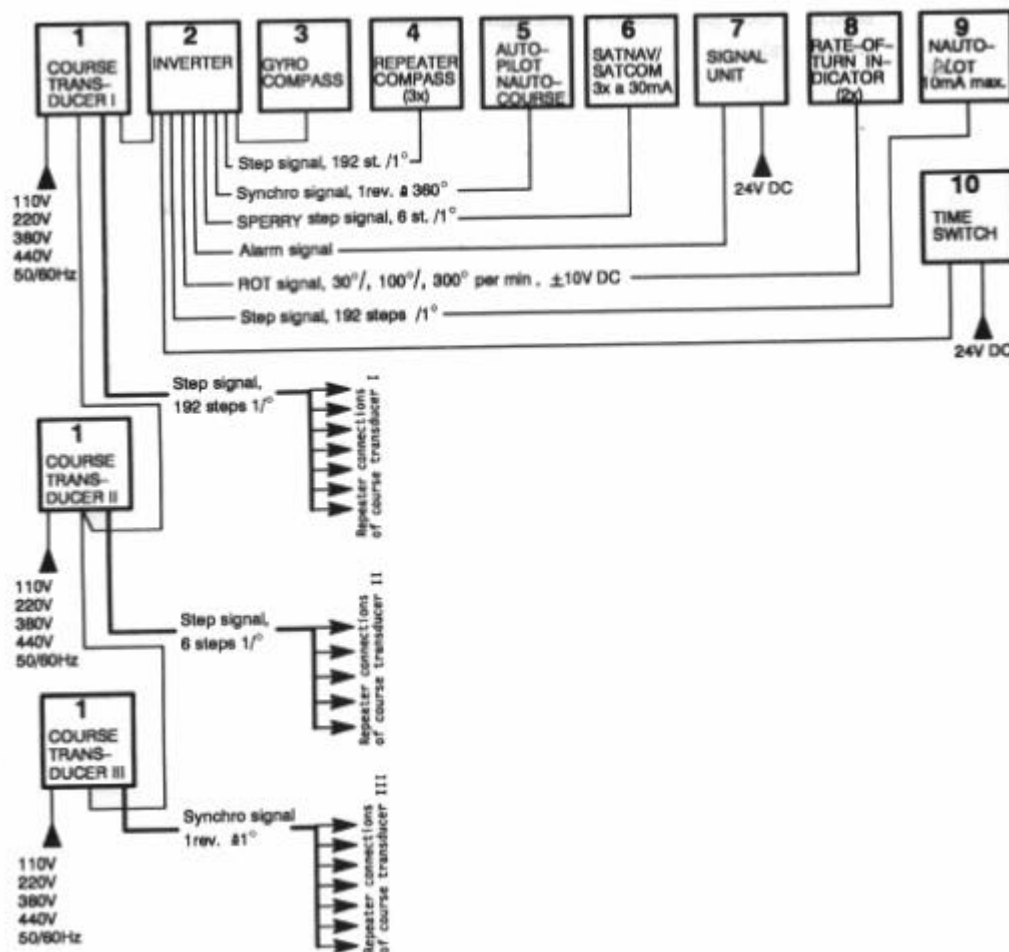


Fig. 5.12

The diagram of information exchange of most advanced gyrocompass of latest generation – “Meridian” is shown in fig. 5.13.



Fig. 5.13

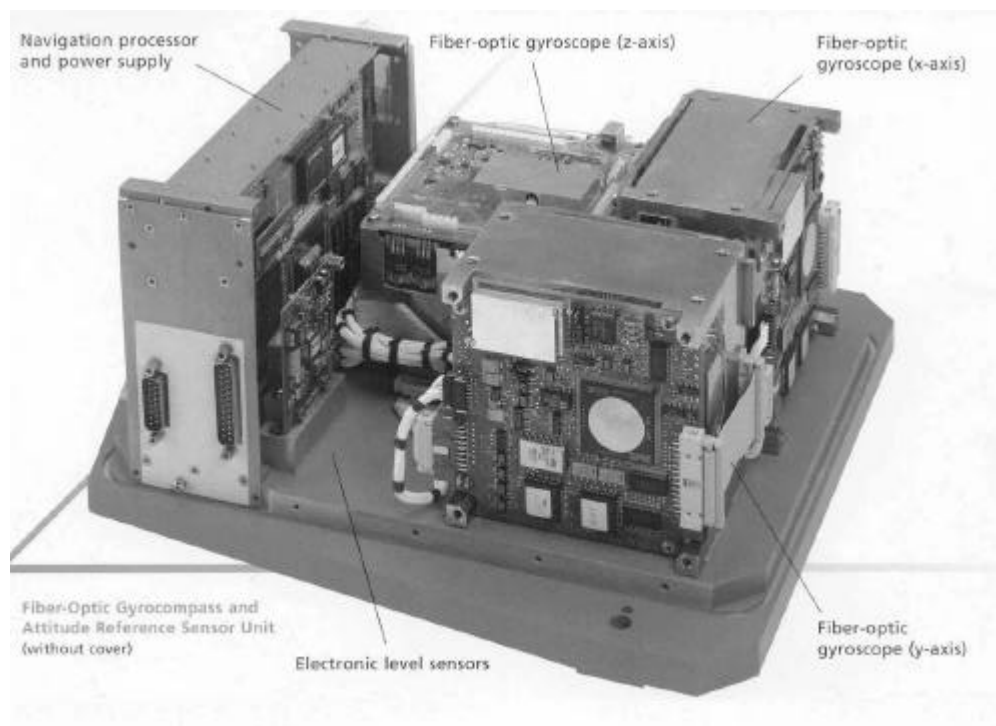
5.3.3. Gyrocompass and Attitude Reference System (GARS)

Modern systems of course indication designed for merchant and passenger ships are realized in GARS of strapdown (nonplatform) type. These GARS are double mode course indicators and their sensor is made as triad of optic (laser or optical fiber) gyroes and triad of accelerometers. Determination of the ship's course, its list, trim and angular speed in all coordinates is based on calculation made by navigation microprocessor according to preset algorithm. Control and correction are carried out in digital mode. Examples of such navigation devices are Russian GARS GGK-1 (designed by Perm scientific and device manufacturing enterprise) and joint American-Germany system SR-2100 (Litton C. Plath). The general view of the main device (without cover) of SR-2100 system is shown in fig. 5.14.

Principle of nonplatform GARS operation is based on the possibility to determine the vector of diurnal rotation of the Earth angular speed (ω) by measuring its three components by means of the three optical gyro unit and to determine the acceleration gravity vector (g) by measuring its three components by three accelerometer unit.

It is known that using two vectors (ω and g , except $\varphi=90^\circ$) one can determine the only one plane which is the plane of true meridian. The plane which is orthogonal to the vector g determines the plane of true horizon. N-S line is lying on intersection of true meridian and true horizon planes, its northern part is determined by projection of vector ω on horizontal plane - $\omega \cos \varphi$.

There is also a variant of determination the E-W line as direction orthogonal to the plane built using the vectors ω and g .

**Fig. 5.14**

Determination of the true horizon plane position is completely realized on the basis of two accelerometers data. As all measurements are performed by means of gyroes and accelerometers with definite orientation with reference to coordinate frame rigidly connected with the object it is always possible to calculate the value of angular data of the ship with reference to the planes of true meridian and true horizon (i.e. course, list and trim angles and appropriate angular velocities).

5.3.4. Gyrocompass maintenance and repairs.

Modern gyrocompass do not require constant and daily maintenance. The main obligations of operators are to actuate and stop the gyrocompass. In modern gyrocompasses these operations are highly automated and require just two or three manual operations. It is also necessary (if these operation is not effected automatically) to insert the information about ship's speed and latitude info the corrector of speed deviation.

However, there are determined periods and order of scheduled checkups which are strictly individual for different classes and types of gyrocompasses. Information about the above examinations is given in the manufactures manuals.

For example, such a scheduled operation for widely spread gyrocompasses "Standard" class is a replacement of the sensor and suspension liquid.

Actually this operation can be fulfilled by the ship personnel according to the order of actions which are illustrated and described in details in the manuals.

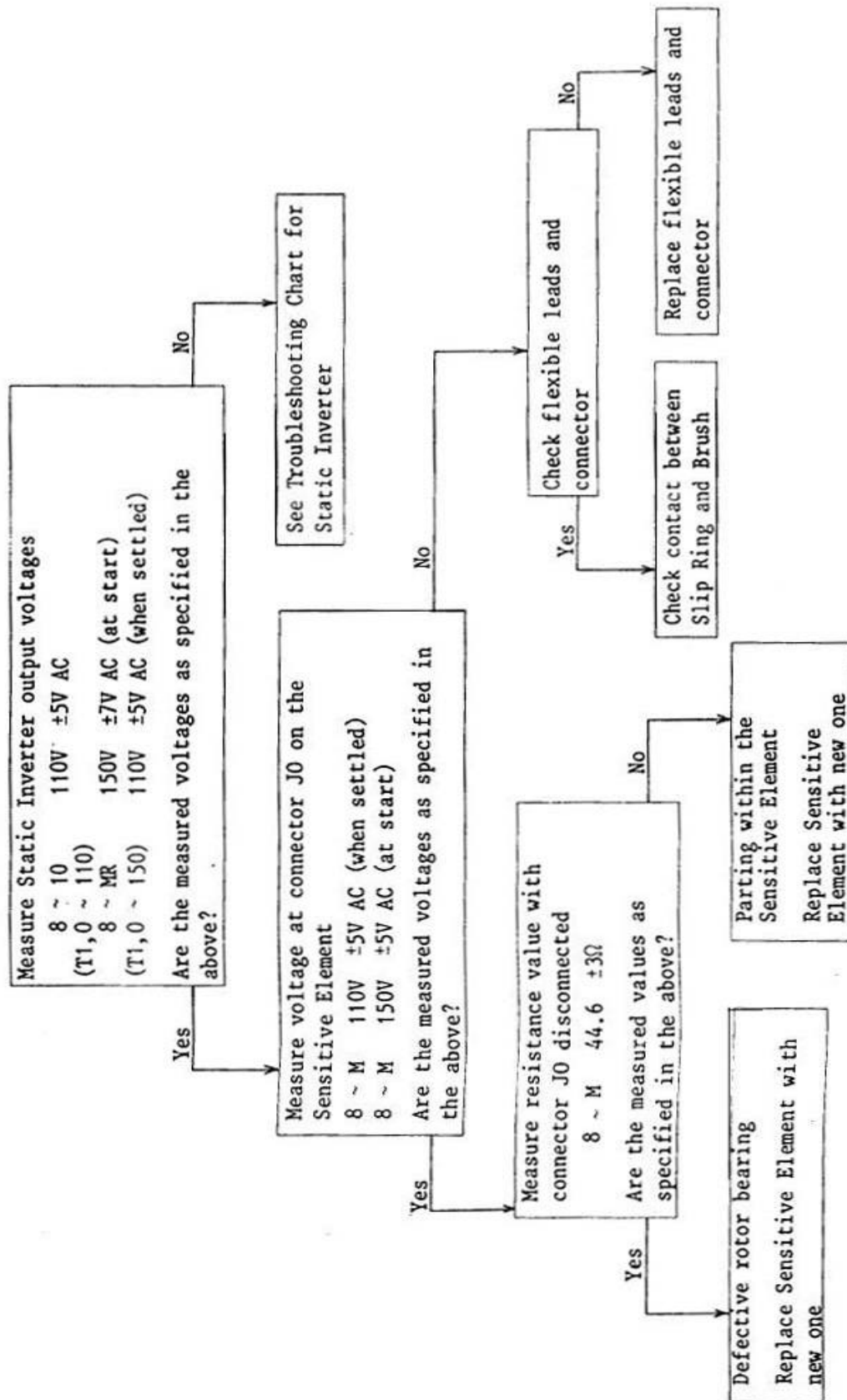
However, it is preferable if these operations are fulfilled by the specialists from the service center. In gyrocompasses of latest generation ship personnel may only replace fuses and lamps (signaling and lighting).

Operations connected with gyrocompass sensor or electronic units replacement are effected only by specialists of the service center.

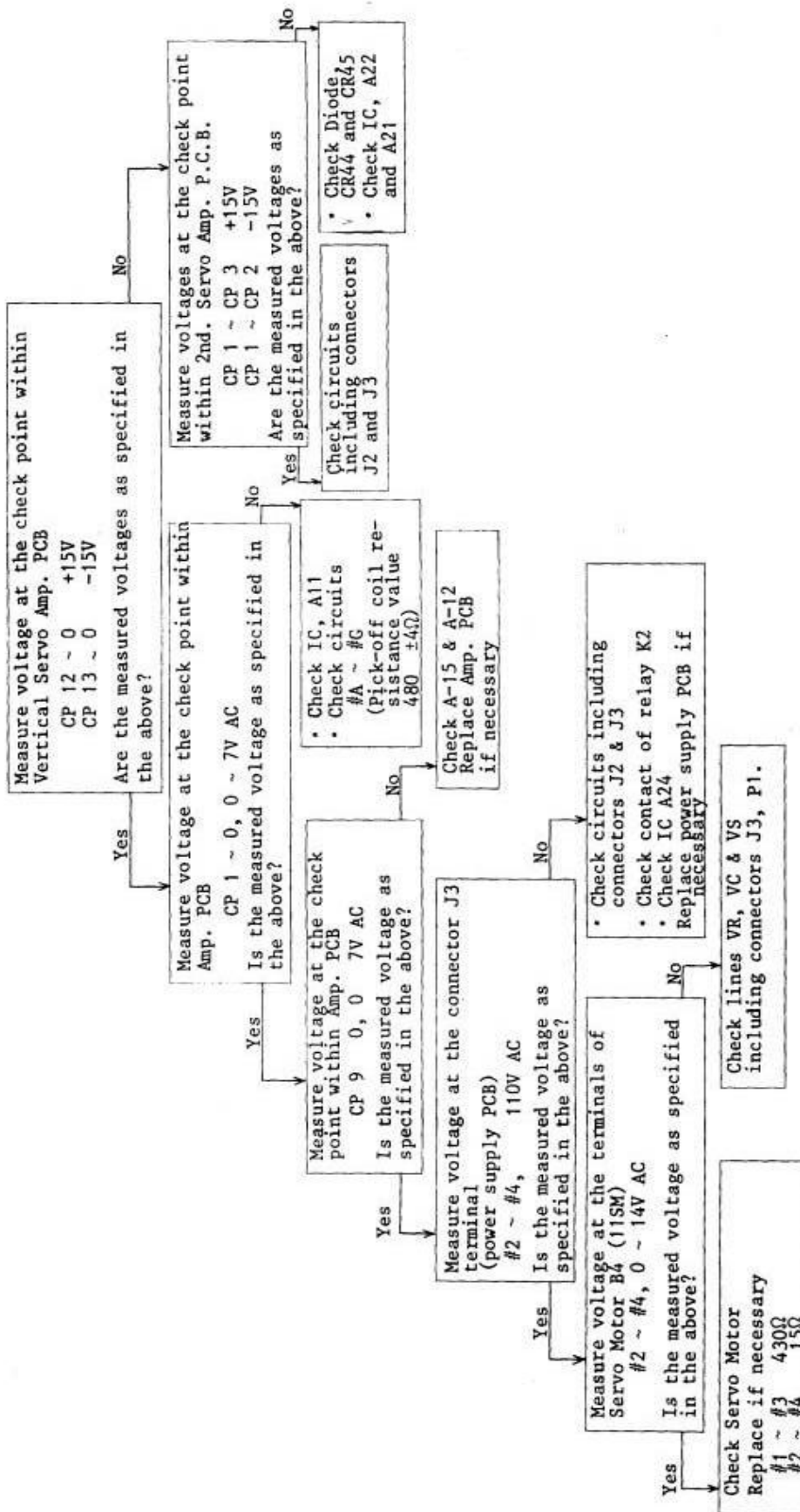
For more efficient work of the above specialists ship personnel must used tables of failures attached to the manual.

E.g., an extract of the trouble-shooting process description for the gyro-compass TG-5000, Tokyo Keiki Co., Ltd, is given below.

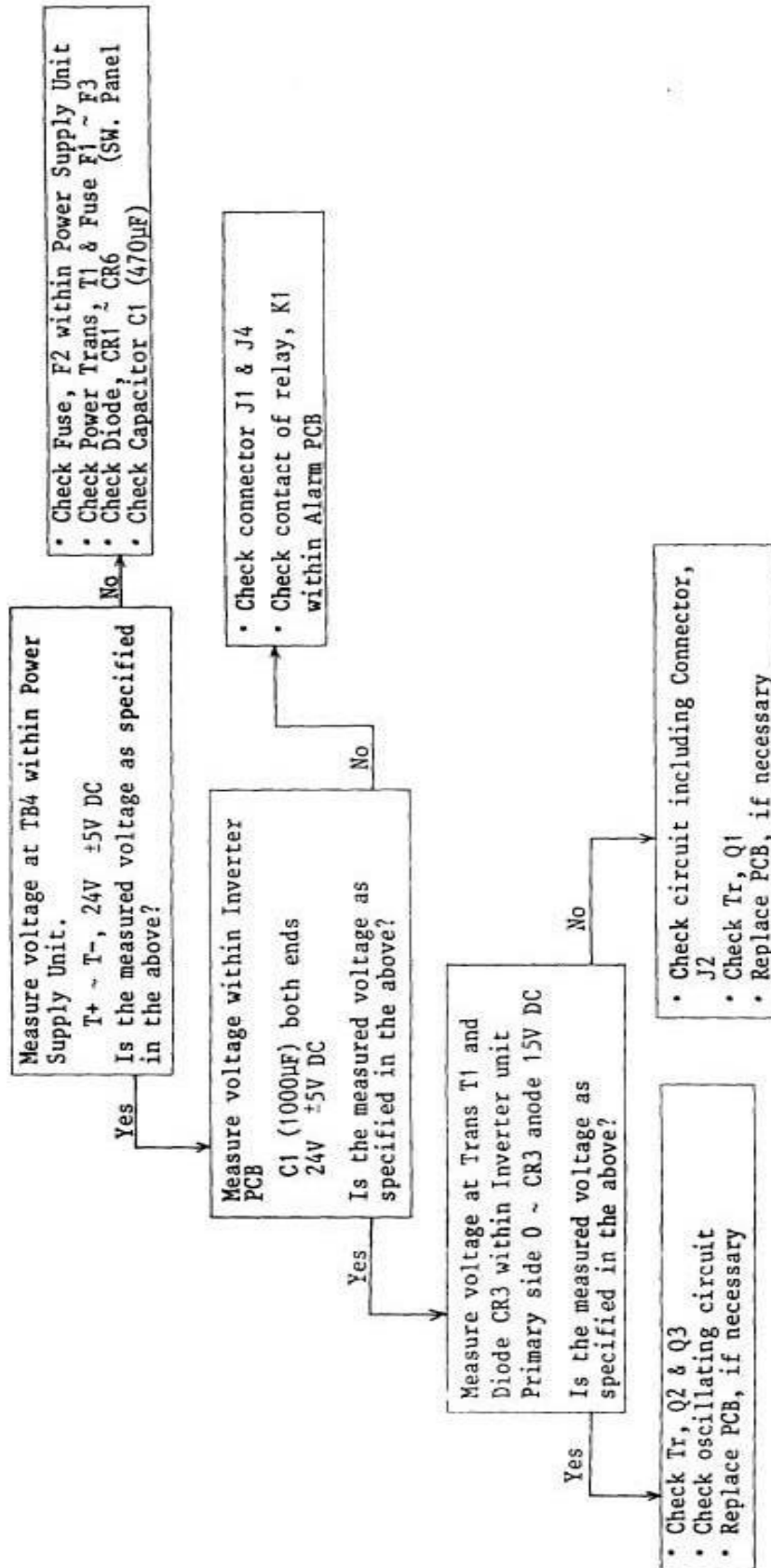
ROTOR WHEEL FAILS TO TURN



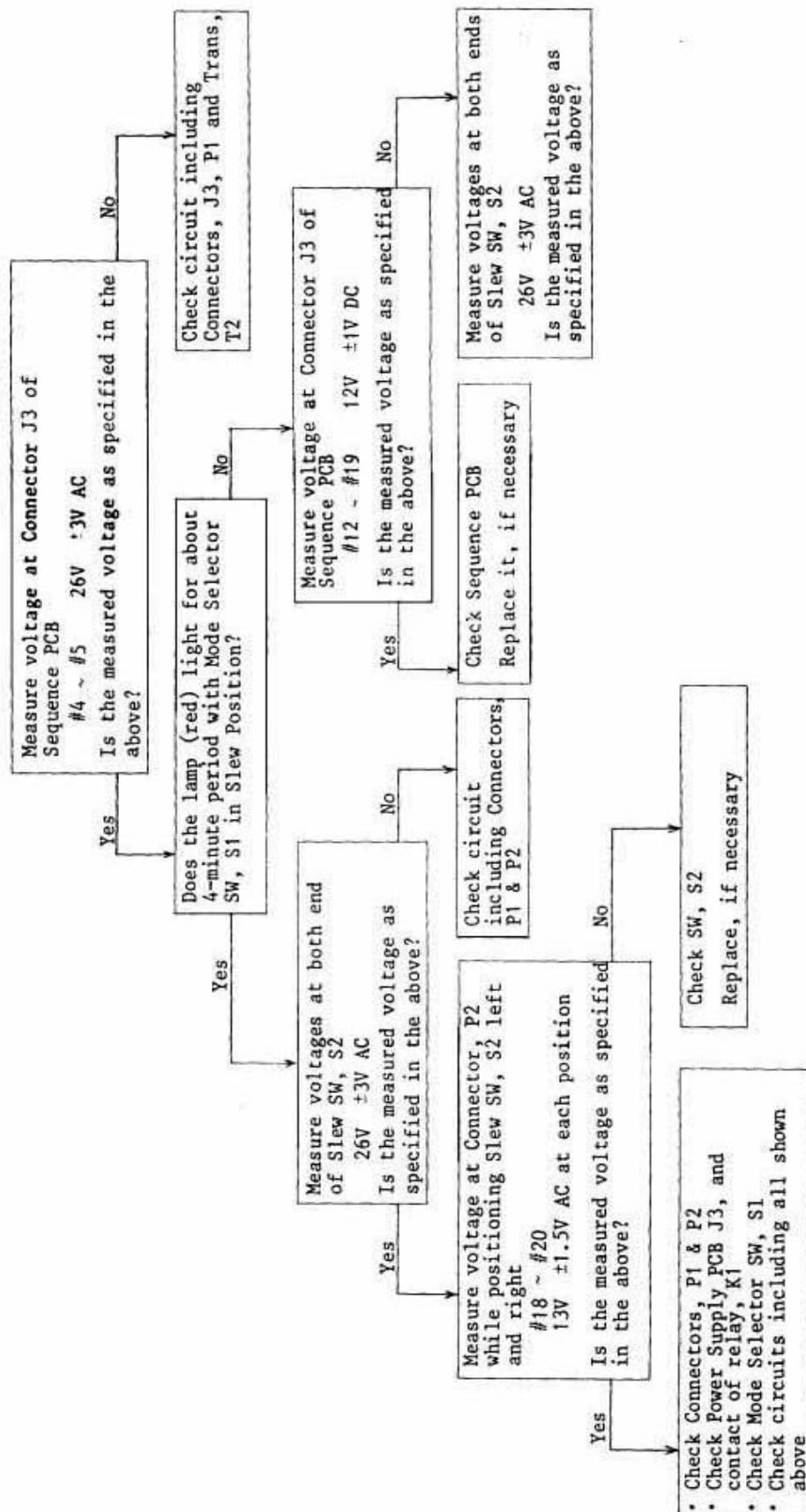
VERTICAL SERVO SYSTEM FAILS TO FOLLOW-UP



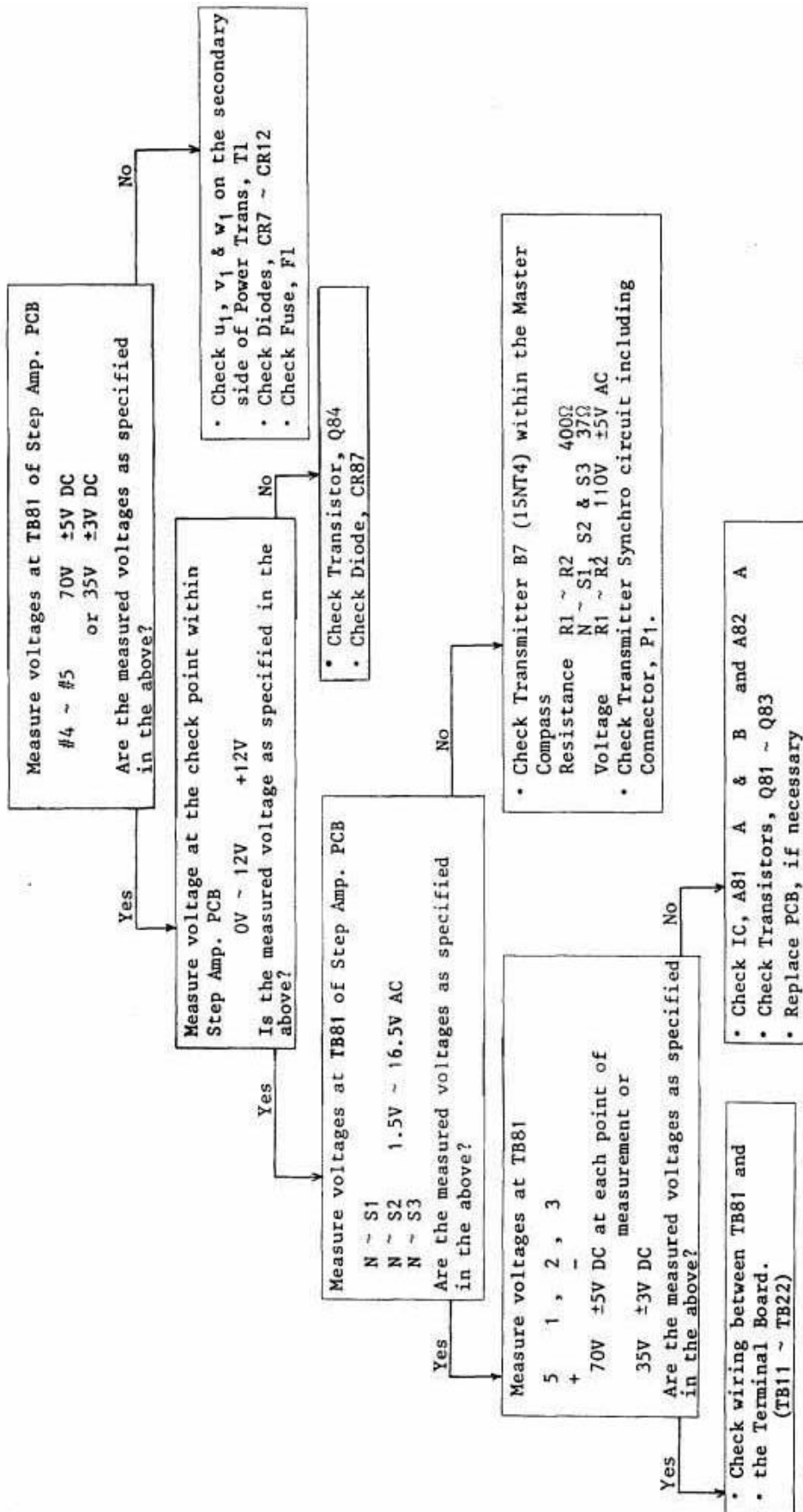
INVERTER FAILS TO OSCILLATE



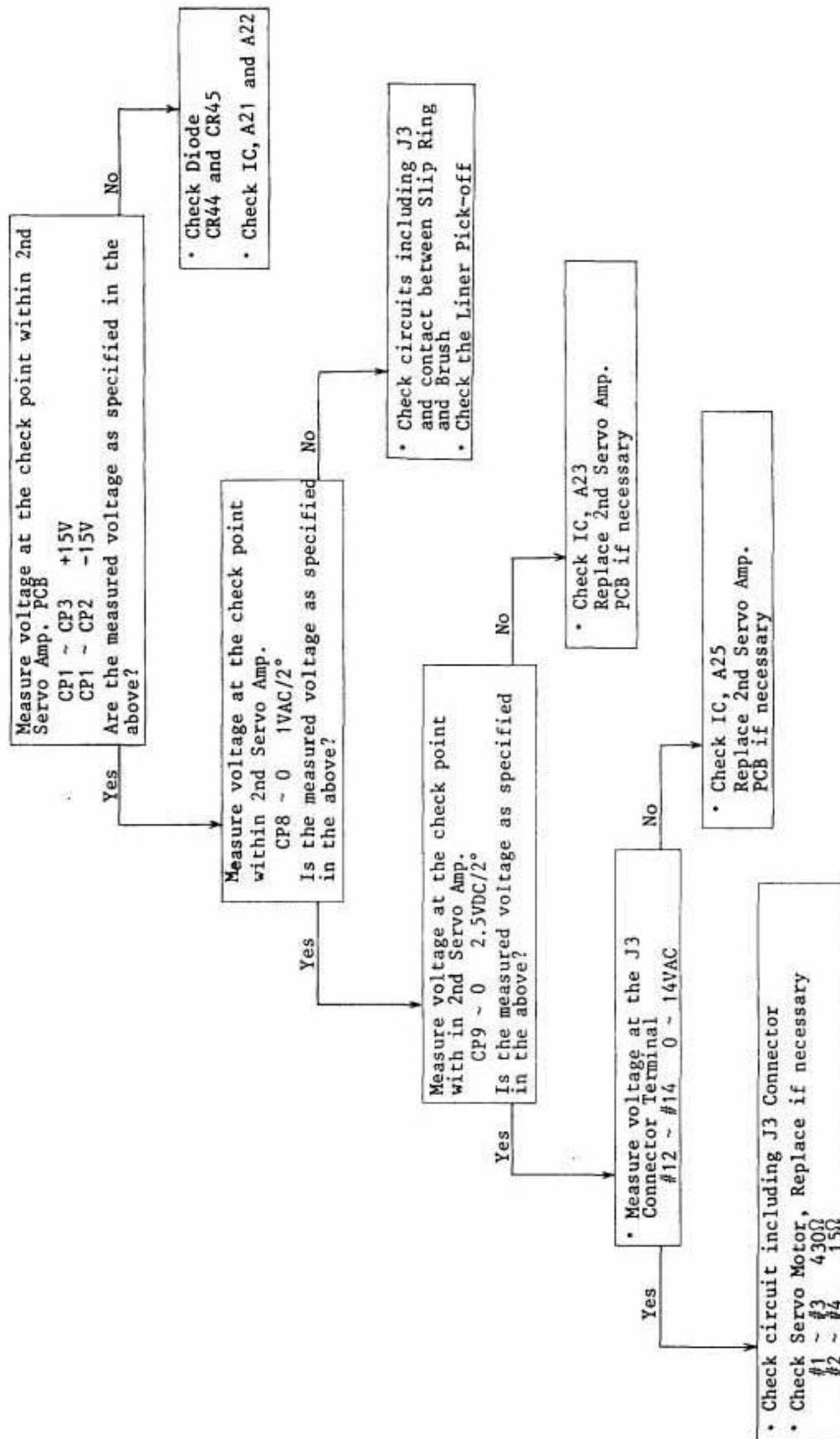
MASTER COMPASS FAILS TO SLEW PROPERLY IN SLEW MODE



NO SYNCHRONIZED OPERATIONS AVAILABLE ON ALL REPEATERS



2ND SERVO SYSTEM FAILS TO FOLLOW-UP



5.4. Rate of Turn Indicator (Navigational rate gyro).

5.4.1. Theory of a rate gyro.

Rate gyro (RG) is a gyroscopic device used to measure a speed of angular turn of the object on which it is fitted. Very often it is called rate of turn indicator (RoT). In compliance with IMO regulations all vessels of more than 100th. GRT must be equipped with a RoT. At present rate gyroes with 2 degrees of freedom neutral (balanced) gyroes are most widely used for the purposes of navigation.

A model of RG based on 2 degrees gyro with a mechanical element providing a superposition of restoring and damping torques is given in **fig. 5.15**.

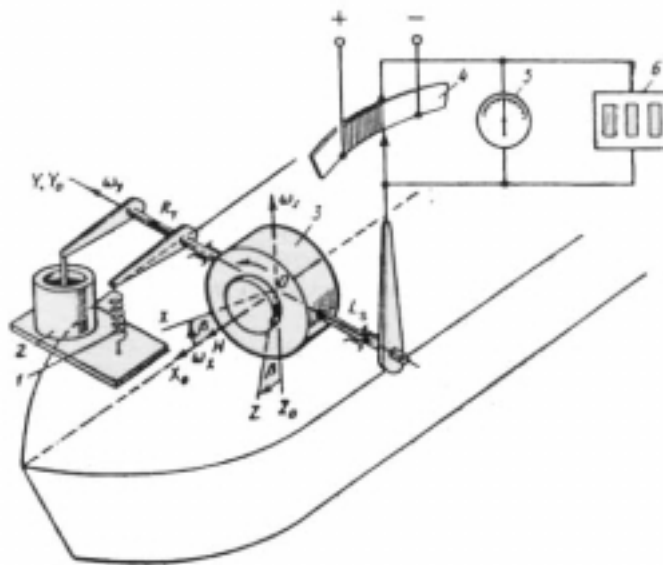


Fig. 5.15

The following elements are given in this figure: a gyrohousing with a rotor rapidly rotating inside (3), elastic element (mechanical spring) producing restoring moment of angle β ; damping element liquid or air piston, providing damping of a gyro oscillations (2), converter of the angle of the gyro turn β into an electric signal by means of potentiometer (4) angular speed, indicator of the analog (voltmeter 5) or digital type (simultaneous installation of both indicators is also possible)

When gyro is oriented as given in **fig. 5.15**. rate gyro is installed on board the ship to measure its angular speed by means of a yaw angle. It is evident that when differently oriented it can measure angular speed of rolling or pitching.

The theory of rate gyro can be explained as follows.

Gyroscopic torque appears with appearance of angular speed of ω_z (**fig. 5.7**) of the object's turn at yaw angle (5.3.1).

Vector of this gyroscopic torque to applied about axis OY and for small angles β it has the value $R_y = H\omega_z$. The above torque will rotate the until the action of torque R_y

is balanced by elastic force torque of the spring $L_s = C\beta$ (where C is spring force coefficient). As a result angle β of the gyro's main axis will be proportional to angular speed of the basis turn because from the equality $R_y = L_s$ or $H\omega_z = C\beta$ it is clear that:

$$\beta_r = (H/C)\omega_z \quad (5.7)$$

One should pay special attention to the fact that in compliance with its properties rate gyro measures only absolute angular rate (velocity) and here (as well as furtheron) the Earth's rate of rotation and the rate of the object's rotation around the Earth are not taken into consideration because they are either beyond the threshold (instrument's) of sensitivity or included into the error of the measurement or their influence is balanced by the torquer on the basis of the appropriate information (in most up-to-date models).

5.4.2. Functional configuration of the Rate Gyro

A special device which is called "electric spring" and electric damper instead of mechanical one are used in modern Rate Gyro.

Electric spring is designed on the basis of feedback and is functioning as follows (**fig. 5.16**).

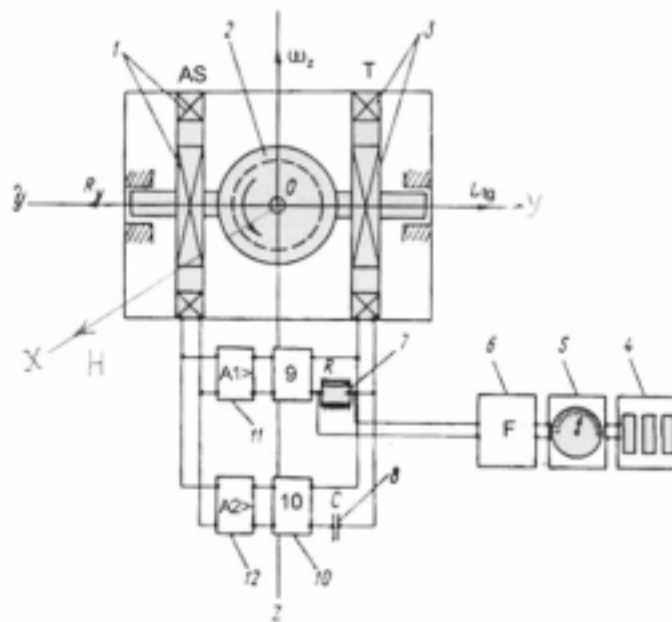


Fig. 5.16

Electric signal proportional to angle β of the gyro 2 turn together with the ship is taken from an angular sensor 1 of a contactless type (usually inductive). After amplifier this signal is passed to a phase-sensitive detector (9) and further to torquer generator coil (3), as a result a torque proportional to angle β of the gyro's turn appears. An amplifier with a big coefficient of amplifying allows to obtain a high

frequency of oscillations of the rate gyro which provides a good amplitude characteristics.

Let us prove that voltage U_{out} obtained from the resistor 7 is proportional to measure angular rate (speed) ω_z . As it was stated above the voltage obtained by the angular sensor is defined by the expression $U_{as} = K_1\beta$ where K_1 is proportion coefficient. The voltage equal to $U_a = K_2U_{as}$, where K_2 is amplifying coefficient of the amplifier. Torque created by torquer generator is defined by an expression $L_{tg} = K_1I = K_uU_a$ where K_1 is coefficient of torquer generator in its coil, K_u is voltage torquer generator coefficient, I – current in the circuit including a resistor and torquer generator's coil. When at balance (equilibrium) torque L_{tg} balances gyroscopic torque $H\omega_z$

$$K_1I = H\omega_z \quad (5.8)$$

or

$$I = (H/K_1)\omega_z \quad (5.9)$$

Current in the resistor R causes decrease of voltage

$$U_{out} = IR = (HR/k_1)\omega_z \quad (5.10)$$

This is what was to be proved.

Damping in Rate gyro with electric spring is effected by means of feedback including an amplifier (12) phase-sensitive detector (10) and capacitor (8). The above capacitor effect by the phase shift of the signal proportional to angles β acts as a differential element. Display of the measured angular speed value is performed by means of analog (5) and digital (4) indicator.

An output signal of the Rate Gyro inevitable contains interference caused by pitch and roll. In order to decrease the above influence, in accordance with IMO requirements, electronic filter 6 with a regulated(tuned) time constant value from 0 to at least 10 sec. is included into the construction of the navigational Rate Gyro.

Such a requirement is explained by different conditions of the Rate Gyro operation when it is used in autopilots as a device producing a control signal proportional to the angular yaw speed of the ship. Thus for accurate keeping of the ship on the preset course or for accurate circulation at a given speed on calm sea it is necessary to have a signal about angular speed with the least possible delay which is equal to minimum value of the time constant (0.5–1 sec). On the contrary on heavy seas it is necessary to have much bigger time constant (10 sec and more) to avoid extra load on the steering gear.

Basic characteristics of the most widely spread rate gyros are given in table 5.1.

Table 5.1

Company, type, country	Threshold of sensitivity degrees/m in	Range of speed measure-ments	Type of sensor element suspension	Accuracy of measurements, degrees/min	Time of prepared-ness after switch	Filter time constant, sec
Gals-3 (Russia)	0.25	$\pm 6 \pm 30$ ± 90	Two degrees of freedom gyro with "dry suspension" ball bearing	$0.25+2.5\% \omega_z$	4	0, 3, 6, 12, 18, 30
Naviturn, Plat (Germany)	0.6	$\pm 30 \pm 90$ ± 300		—		
Anshutz (Germany)	0.1	$\pm 10 \pm 30$ ± 100 ± 180 ± 300				
ATEW (Sviden)	0.018	—	Three degrees of freedom gyro with aerodynamic suspension	—	0.5-3	—
RH-4326 (Holland)	0.18	—	Two degrees of freedom gyro with hydrostatic suspension	—	1	—
Sperry (USA)	0.5	$\pm 90 \pm 180$	—	—	1	—

Control panel of navigational rate gyro GAL-3 (Russia) is given in **fig 5.17**

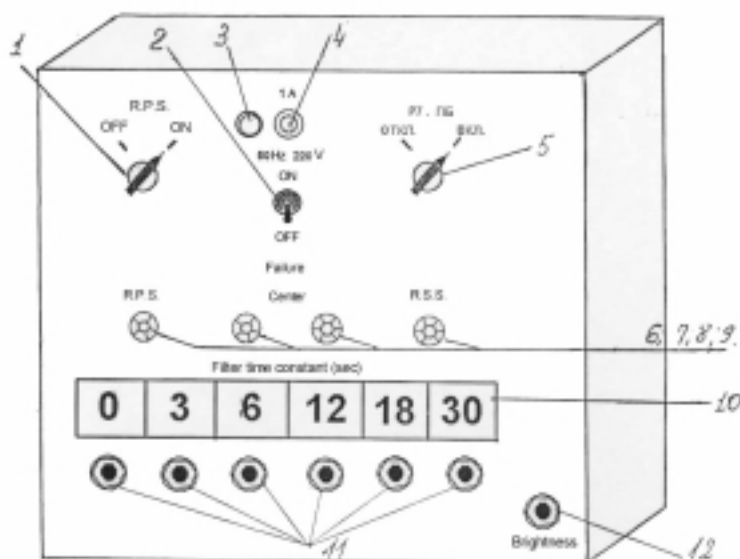


Fig. 5.17

Switch key of the port side repeater

Switch key of the port side repeater

Switch key of the rate gyro;

Light –emitting diode (indicating fuse sound conditions)

Fuse

Toggle switch of starboard side repeater

6, 7, 8, 9– signaling lamps indicating central device and repeaters failure

panel of filters time constants value

the time constant buttons

dimmer

5.4.3. General information about rate gyro maintenance

Rate gyro's operational condition is checked by signaling lamps fitted on the control panel. Rate gyros are repaired by the replacement of damage unit of electronics. Modern rare gyros do not require constant maintenance. If rate gyro cannot be repaired on board the ship shorebase service should be obtained.

5.5. Autopilots

5.5.1. Conventional autopilots

Irrespective of constructional peculiarities, type of steering gear and element base used, a conventional autopilots includes the following units (**fig. 5.18**):

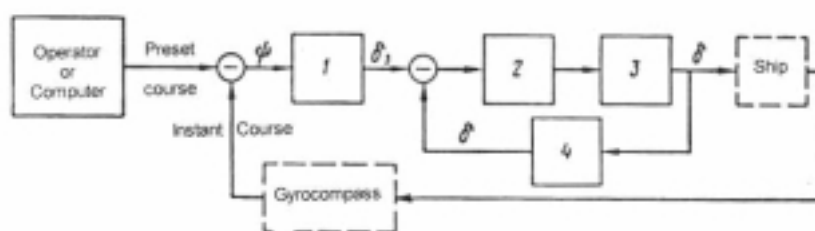


Fig. 5.18

1steering gear rudder control unit, 2 amplifier-converter unit, 3 actuator. Amplifier and actuator are involved in inner negative feedback 4, which is effected by the device mechanically connected with rudder stock and producing electric signal proportional to the set rudder angle δ_s .

Outer feedback is provided by a gyrocompass or distant-reading magnetic compass which converts variations of the ship's set course into appropriate electric signal. Rate of turn indicator can also be used for outer feedback.

Nowadays, conventional autopilots based on proportional-differential integral (PID) – regulators are widely spread.

$$\delta_3 = K_1\psi + K_2\dot{\psi} + K_3\int\psi dt \quad (5.11)$$

δ_3 – set rudder angle

ψ – course deviation angle

$\dot{\psi}$ – ship's turn angular rate.

K_1, K_2, K_3 – feedback coefficients (they are also parameters of autopilot tuning)

Signal $K_1\psi$ is the basic control signal ensuring the ship's selectivity relating its course

Signal $K_2\dot{\psi}$ increases the ship's course stability and improves the quality of its conning.

Signal $K_3\int\psi dt$ creates the rudder shift with the reference to fore-and-aft line of the ship ensuring symmetric yawing.

In more up-to-date autopilots of this type electronic integrating and differentiating devices provided with low frequencies filter which ensure control signal filtration to the angular rate of the ship's turn are used. This ensures and decreases in rudder actions in rough sea.

There are autopilots with a special device limiting rudder angle thus limiting an angular speed of the ship's turn. The input of maximum rudder angle effected either manually or automatically by the signals about the ship's speed obtained from the log. At high speed of the ship a smaller rudder angle is allowed and vice versa.

The above device prevents the excessive listing when the ship's course is changed. This device is especially useful for high-speed container carriers (to prevent the loss of containers).

5.5.2 The selection of optimum parameters value of conventional autopilot.

The quality of the autonomous steering system depends on the dynamic properties of the ship steerability as an object of regulation, weather conditions and the choice of the autopilot tuning parameters. That is why autopilots of the same type installed on different ships will function differently. This explains the fact that there are no universal tables and shames which allow to determine optimum value of autopilot tuning parameters when condition of the ship operation change.

Tuning of the conventional autopilot should be changed when:

the loading conditions change (empty, half loaded, fully laden).

when the speed is change (full, half, slow speed)

weather conditions change

Following regulations should be complied with in this case:

tuning parameters should be chosen to keep the ship on her course with appropriate accuracy at minimum rudder angles;

one should not try to decrease the value of the ship yawing when the sea is rough increasing the sensitivity of the autopilot as in this case the number of rudder actions rapidly increases.

at big number of rudder actions (more than 400 per hour) the accuracy of the ship course does not increase. This results only in wear of the steering gear and loss of net power of the ship's engine.

Regulation of two parameters is foreseen for autopilot tuning in the process of operation. These parameters ensure stability of the system functioning when conditions of sailing change. One of the main regulated parameters is setting of regulator K_1 (feedback factor – ratio of rudder angle to given change of ship's head), which value is defined during the autopilot trials. For sea-going merchant ships the value of K_1 varies from 0.2 to 0.8. When the ship is fully loaded K_1 should be decreased, when the ship is in ballast K_1 should be increased.

The second regulated parameter is coefficient of K_2 signal, which determines the slope of its characteristics. To increase the sensitivity of the autopilot in calm weather K_2 should be increased. Thus the accuracy of the ship course increases. With winds and rough sea K_2 should be decreased not to overload the steering gear by a big number of rudder actions. If with degree correction in "auto" mode the ship slowly reaches the new set course signal K_2 should be decreased. The ship must not cross the line of the value of a new set course for more than 10% of the value of the set degree correction. Regulator "rough / smooth" allows to change amplification factor of the whole system. The number of the regulator is set in position "smooth" in calm weather and in position "rough" in fresh weather, when the regulator of K_2 signal is set on minimum.

If the ship in "auto" or "follow-up" mode stops answering the helm it is necessary to try the following steering modes:

switch to another pump;

switch to usual steering;

switch to manual steering.

Both pumps must be used when sailing in narrow waters or entering the port. This will increase the safety of navigation.

On fig. 5.19

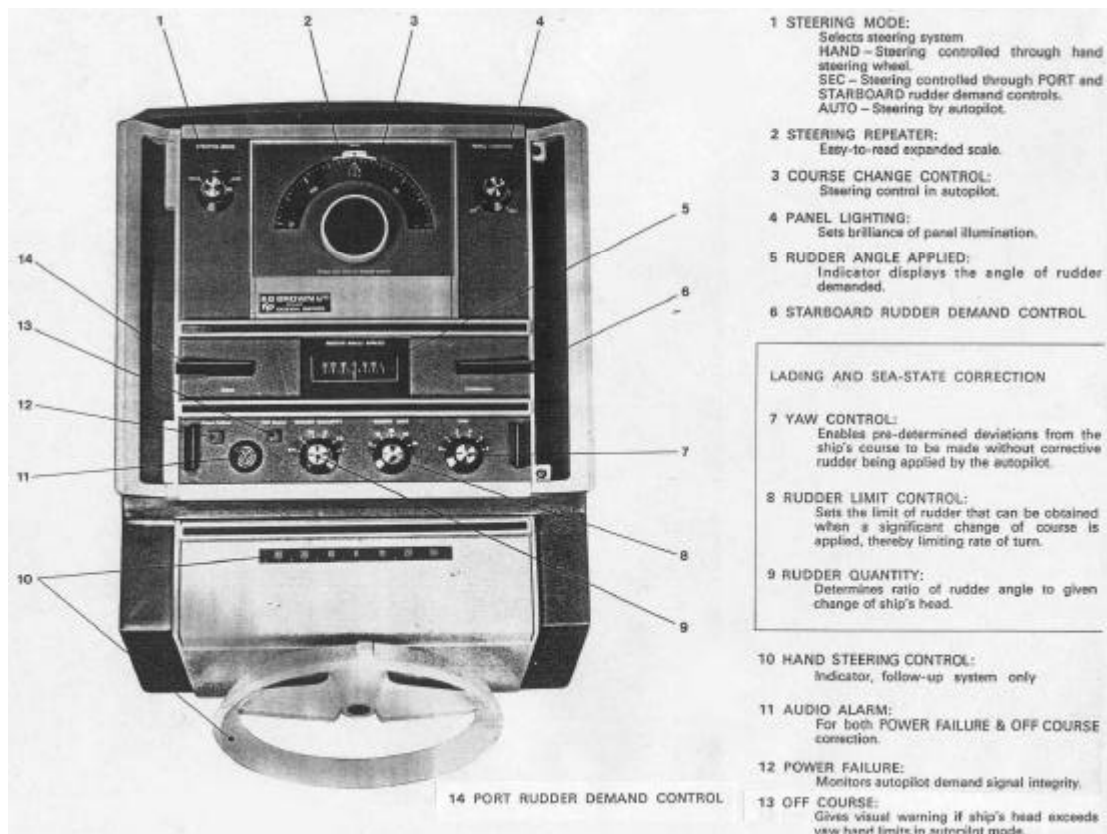


Fig. 5.19

one can find the control panel of one of the most advanced conventional autopilots manufactured by SG Brown (A Hawker Siddeley Company) Great Britain.

5.5.3. Adaptive autopilots

The above discussed autopilots to this or that extent have the following disadvantages:

low interference protection on rough sea;

low sensitivity in calm weather;

low efficiency of manual parametering which does not ensure the system optimum operational mode both during automatic stabilization of the ship on the course and during the manoeuvring. Efficiency of ship course automatic control system depends on the level to which the set values of autopilots regulated tuning parameters are close to optimum for the actual conditions of sailing. The optimum is such a tuning of autopilot parameters when maximum operational speed at minimum loss of net power for steering are ensured.

Three types of adaptive autopilots are used at present time. Autopilots where partially automatic tuning of parameters with the use of indirect criteria of operational quality is effected belong to autopilots of the first type. For example adaptation unit changing the initial sensitivity of configuration, slope of the signal proportional to angular speed of the ship swing and value of signal shifting the "zero" position of the rudder depending on yawing characteristics of the ship is included into TRANSMITTING

STATIONS type autopilot (Poland). Adaptation to new conditions of sailing takes about 10 min. After that the system ensures minimum possible yawing amplitudes at limited number and value of rudder angles. Quality criteria are based on the evaluation of amplitude value and angular speed yawing modules.

Mathematical model of the ship is used in adaptive autopilots of the second type. Adaptation principle based on the use of a reference model and realized in some autopilots becomes clear if we study a simplified configuration on **fig. 5.20**.

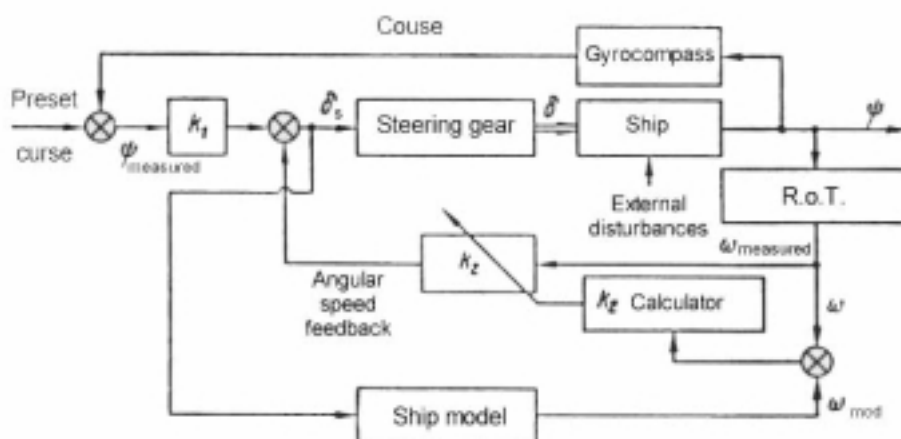


Fig. 5.20

Continuous comparison of the measured ship angular speed ω_{mes} and reference angular speed ω_{mod} obtained from the model take place. The preset parameters of the model movement are ideal (e.g. sailing when the sea state is calm and without disturbance actions). Preset value of rudder angle δ_s is inserted into the model. Mathematical model of the ship is a combination of a ship movement differential equation solved in the real time scale. The autopilot itself belongs to PD regulators but unlike conventional autopilots has a variable coefficient K_2 of angular speed feedback.

Constant calculation of the difference is effected for the purpose of adaptation: $e = \omega_{mes} - \omega_{mod}$

The value of ω_{mes} is obtained from the rate gyro. The obtained value e is used for coefficient K_2 automatic tuning to satisfy the criterion $G_e^2 = \min$, where G_e is root mean square value of e . The appropriate value of K_2 coefficient gets into the regulator's configuration. A closed system with automatic angular speed feedback tuning is formed. It is evident that in this case adaptation is not effected in compliance with strict regulations but on the basis of the ship's reaction to controlling and disturbance actions of applied to angular speed of yawing. Control panel of one of the most advanced adaptive autopilots of SEM 200 type manufactured EMRI Denmark is shown on **fig. 5.21**.

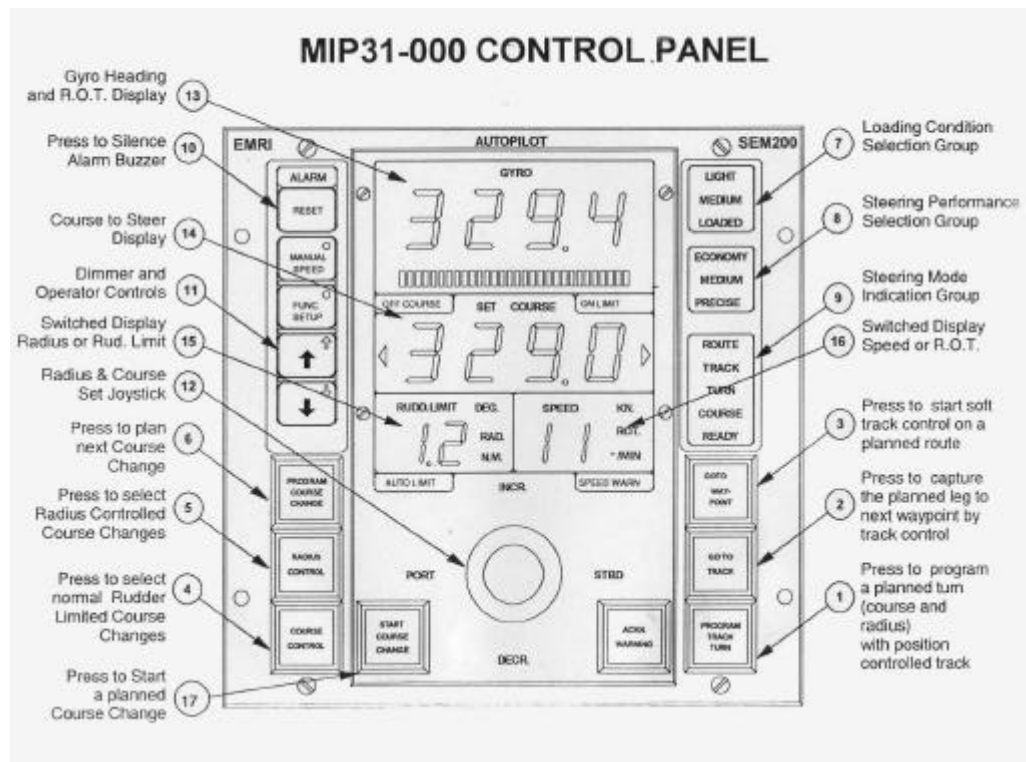


Fig. 5.21

The other widely spread representative of the second type autopilots is RECAL-DECCA 780 (Great Britain).

Auto-tuning systems belong to the third type of autopilots. They determine optimum values of tuning parameters directly by means of mathematically proved quality criterion. Functional ensuring minimum loss of net power of the engine and as a result minimum fuel consumption.

Additional correction loop is used in autopilots of the third type. It has the following functions: obtaining information about outside disturbance and dynamic properties of the main loop in the process of functioning, calculation of the numerical value of quality criterion on the basis of the information obtained, formation of the appropriate controlling signal to ensure system's optimum operational mode at minimum preset criterion.

5.6. Logs

5.6.1. Electromagnetic logs

Operational principle of an electromagnetic log is based on electromagnetic induction. Log sensitive element (speed sensor) is electromagnetic transducer, which develops a signal proportional to the ship's speed over the water.

Electromagnetic transducer consists of the following elements (see fig. 5.22)

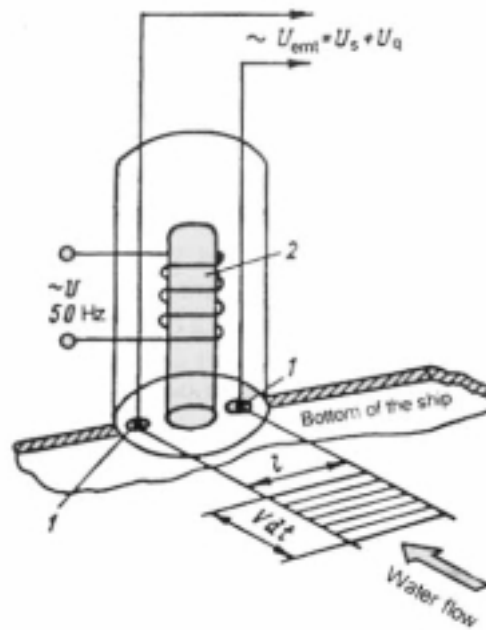


Fig. 5.22

The electro-magnet 2 is mounted in the brass housing 1 of circular section, the winding being powered by alternating current. Two metal contacts 3 (electrodes) made of insulating material are mounted on the end surface. The electromagnetic transducer is mounted on the outer surface of the ship's bottom and is in contact with sea water, the line drawn through the contacts 3 being perpendicular to the middle line plane of the ship.

When the vessel is moving, water flows under the end surface of the electromagnetic transducer and is pierced by magnetic field created by the electro-magnet 2, which moves together with the ship over the water. Sea water is a conductor, electromotive force is therefore created, which can be defined by the following formula in accordance with law of electromagnetic induction

$$E = -\frac{d\Phi}{dt} \quad (5.12)$$

where Φ - field current, $\Phi = B \cdot S$, B – magnetic induction, S – cross-section area of the magnetic current.

In general, the expression (5.12) can be shown as

$$E = -\frac{d(B \cdot S)}{dt} = -\left(\frac{dB}{dt} \cdot S + B \frac{dS}{dt}\right) \quad (5.13.)$$

Sea water flowing between the electrodes forms a continuously moving conductor of length l (see fig. 5.22). With the ship moving at a speed V in time dt the conductor covers the way $V \cdot dt$, and the area covered by the conductor during this time will equal

$$DS = 1 \cdot V \cdot dt \quad (5.14.)$$

As the electro-magnet is powered by alternating current of ω frequency, magnetic induction is defined by

$$B = B_m \cdot \sin \omega \quad (5.15.)$$

As $\frac{dB}{dt} = B_m \omega \cos \omega t$ the output voltage will be defined by

$$E = -(B_m \omega \cos \omega t \cdot S + B_m \sin \omega t \cdot l V dt) \quad (5.16.)$$

The first item in the formula (5.16) expresses quadrature interference, which should be excluded for signal processing.

Figure 5.23 shows a typical functional scheme describing signal transduction principle in a modern electromagnetic log.

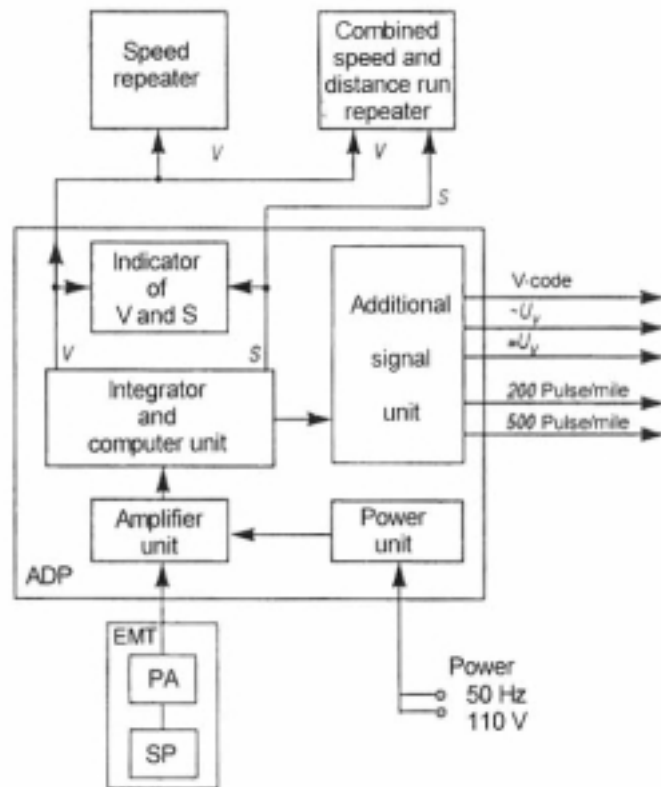


Fig. 5.23

Voltage U_{eml} taken from signal pickup SP, comprising desired and interfering signals, is supplied to the preliminary amplifier PA mounted inside the electromagnetic log EML. The amplified signal is directed by cable to the central device (analog-digital processor ADP).

The final signal amplification, reduction of common-mode $U_{c\phi}$ interference to 10^{-4} of the initial value, total elimination of high frequency and direct current interference are performed by ADP amplifying unit.

The main unit of the ADP is the integrator and computer unit, which cancels quadrature interference and transforms analog signals into digital signals. Besides, this unit performs correction of speed signal, i.e. introduces continuous linear and non-linear correction. A special corrector is mounted for the purpose, which is governed by a special program.

The ADP unit has a special speed V and distance S range indicator.

Additional information signal unit is intended for indication of speed range and distance range information to be supplied to the ship's automation systems. Speed range information is in digital form – as a digit-pulse code (v code) - and in analog form – as an alternating and direct current voltage proportional to the ship's speed – $U_v = U_v$. Distance range information is provided in the form of consequent pulses (200 or 500 p/mile). Speed repeater and speed and distance repeater are mounted on the ADP unit for navigational purposes.

The ADP is fitted out with a supply unit for different types of direct and alternating current voltage necessary for the log operation.

Electromagnetic log speed range error

The log accuracy depends to a great extent on the position of the transducer on the ship's bottom. This can be explained by the turbulent water layer adjacent to the hull surface of the moving ship. This turbulent water layer has irregular thickness and water particles velocity. Besides, magnetic induction B distribution in the water is irregular throughout the hull length, being of a complicated character not liable to analytical assessment. This factor together with other stochastic factors account for the fact that the speed measured by the log is not equal to the actual ship's speed, the correlation between the data being of non-linear nature.

Thus the electromagnetic log has an error which is to be compensated by corrective ΔV . In general, log error is a function of the ship's speed

$$\Delta V = f(V). \quad (5.17.)$$

This function can be shown as a sum of three components (fig. 5.24)

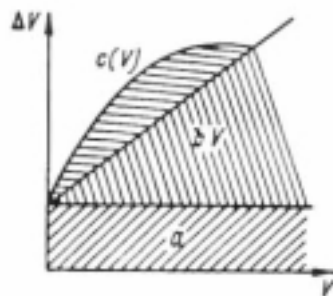


Fig. 5.24

$$\Delta V = a + bV + c(V) \quad (5.18)$$

where a is constant, bV – linear, $c(V)$ – non-linear error components.

Constant error component is introduced during the adjustment of the device in port or at sea with zero speed and calm weather. After such adjustment corrective ΔV has a linear and non-linear components.

Linear component is determined and introduced as a result of the log trials on a measuring line.

After this kind of adjustment only non-linear component is left. Non-linear part is introduced with the help of the corrector. The data required for the corrector is obtained also during the log trial on the measuring line.

The main idea of the operation consists in approximation of the curve by direct lines (fig. 5.25),

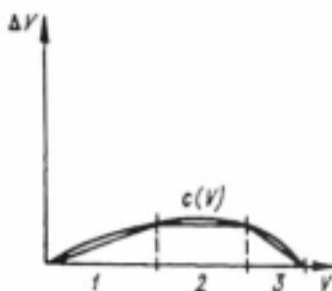


Fig. 5.25

the speed range being divided into sections. After that the corrector is programmed to increase or decrease the log conductance as compared to the initial value. Thus the log error is reduced to minimum throughout the speed range.

It is necessary to carry out the above log adjustment annually as error variation during the year can be as high as 2-3% due to the ship's hull fouling.

Modern electromagnetic logs of the leading companies afford relative speed measurement with the instrumental error of 0.05...0.2 knots.

This is the list of the most sophisticated electromagnetic logs in use on sea-going vessels:

“Aquaprobe MK5” (“Chemikeeff”, Great Britain)

“Galatee MK3” (“Ben marine”, France)

“SAL-EM” (Janger Marine AB, Sweden)

“ЛН2-1МЭ” (“Shturmanskije prybory”, Russia)

«ЛЭМ2» (“Azimut-Electroprybor”, Russia)

“Naviknot II” (“Plath”, Germany)

“Skipper EML2” (“Skipper Electronics A/S”, Norway)

Figure 5.26 shows the control panel of the electromagnetic log “Aquaprobe MK5”.

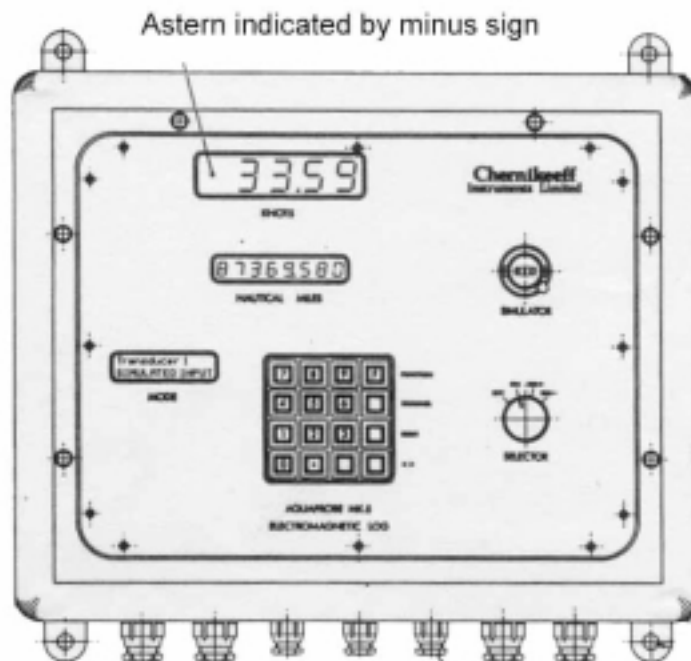


Fig. 5.26

5.6.2. Sonar Doppler logs

Operational principle and the theoretical basis

Operational principle of sonar Doppler logs is based on Doppler effect. The Doppler effect consists in the fact that with relative motion of the sound waves source or receiver the frequency of the received oscillations differs from emitted ones, the difference, known as Doppler shift, being proportional to the relative motion velocity.

In sonar Doppler logs the transmitter and receiver are located on board ship while the sea bottom acts as a signal retranslator, the Doppler shift value being therefore doubled. In the bottom track mode the Doppler log measures the ship's absolute velocity over the ground.

The main theoretical correlation for the Doppler shift f_d with one-beam longitudinal scheme (fig. 5.27) can be defined as

$$f_d = 2 \frac{V_x \cdot f_0}{C} \cos Q_0 (1 + \frac{V_x}{C} \cos Q_0) \quad (5.19.)$$

where V_x – the ship's longitudinal velocity;

f_0 – transmitted frequency;

C – the sound velocity in sea water;

Q_0 – the angle between the speed V_x direction and the acoustic beam direction.

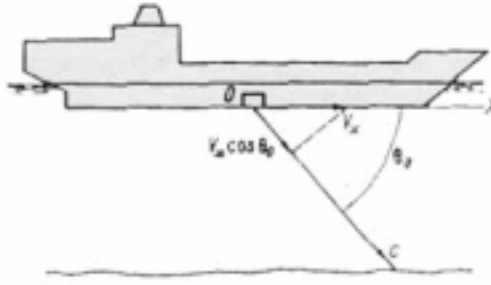


Fig. 5.27

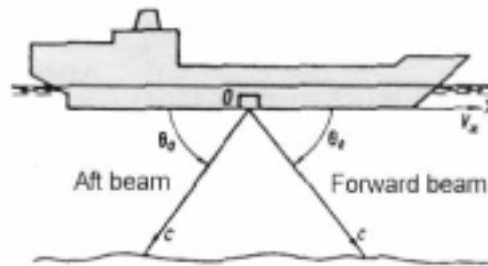


Fig. 5.28

This formula (5.19) shows that f_d is a non-linear function of the ship's velocity.

The best way to eliminate this effect is to use of two-beam system ("Janus" system). According to this system, to obtain the ship's velocity acoustic signals are transmitted along the longitudinal plane of the ship forward and aft at the same angle Q_0 (fig. 5.28).

In this case the Doppler shift formula can be expressed in a following way:

$$f_d = 4 \frac{V_x \cdot f_0}{C} \cos Q_0 \quad (5.20.)$$

From this formula we can assume the fundamental speed equation for two-beam log

$$V_x = \frac{f_d \cdot C}{4f_0} \sec Q_0 \quad (5.21.)$$

Obviously, use of four-beam system (with pair orthogonal orientation) allows to measure both longitudinal V_x and transverse V_y components of the ship's speed.

It is obvious that the four-beam pattern fully meets the requirements of navigation. (It is also possible to use a three-beam pattern on the basis of the defined algorithm). A six-beam or, for the sake of standardization, two four-beam (i.e. eight-beam) patterns, are used for mooring when the information of the ship's transverse speed forward and aft is required.

It should be pointed out that the Janus system has another important advantage, viz., it considerably (by tens times) decreases the error due to the ship's list and trim, as well as by rolling and pitching. It is possible to find a radical solution of the problem by using phase grid antenna which affords beam "electronic stabilization" receiver-transmitter assembly (antenna) or gyroscope stabilization.

Main Doppler sonar log errors

Effects of irregular sound velocity in sea water

As it can be assumed from the formula (5.21) actual variations in sound velocity $\pm 5\%$ will cause inadmissible high errors in speed measurement.

It has been proved that sound velocity variations along the acoustic signal propagation path does not influence the Doppler frequency shift value. It is the sound velocity value at the point of the receiver-transmitter location that matters.

Several techniques of the error compensation exist, which are practically used:

- measurement of sound velocity in the area of the antenna by means of the device known as speedmeter;
- antenna mounting in a hermetic casing filled with a liquid of a constant temperature;
- use of frequency independent antennas (the most sophisticated technique).

Fluctuation error

Fluctuation error is caused by diffused character of sound reflection from bottom.

This error can be effectively reduced by means of averaging of measurement results in a given time T_0 .

External factors of Doppler sonar logs limitations

Clearance under the keel limitation

Maximum depth is limited by the antenna power as the transmitted signal intensity considerably decreases with the depth increase due to widening of the wave front and acoustic wave damping. The essential factor is the frequency of the transmitted signal. Most of the widely used Doppler logs use transmission frequency 100...300 kHz, while the operational under-keel clearance is 200...400 m.

There are limitations connected with a minimum clearance. The minimum clearance is less for a joined receiver-transmitter antenna and is limited by the pulse duration (approximately 1-3m.)

Limitations caused by the vessel's rolling and pitching and circulation.

As most of the Doppler logs have rather narrow directionality characteristics (3-6°) and antennas not stabilized in relation of the true horizon plane, with rolling and pitching, particularly rolling, hydro-acoustic contact can be lost with the bottom (it is actually possible with depths over 200 m).

This contact loss may occur during the ship's circulation if her angular velocity exceeds the highest admissible value (this can actually happen to fast highly maneuverable ships).

Limitations caused by water aeration

A moving ship causes disturbance of the water and mixing of water and air due to which water is saturated with air bubbles. Besides, a similar phenomena occurs when wind destroys wave crests. The presence of such air-water (aerated) layer results in reduction of acoustic signal up to complete loss on account of both sound power dispersion and damping. This phenomenon commonly occurs during the mooring of large vessels when they use their own propellers or when propeller-type tug-boats are used.

No effective techniques have been developed to overcome this factor.

4. Main characteristics of Doppler sonar logs

Acoustic beam number (from 2 to 8)

Beam inclination angle (45-60°)

Signal frequency (150-350 kHz)

Signal character (continuous or pulse)

Water track Doppler sonar logs

Nowadays Doppler sonar logs measuring ship's relative speed, i.e. water track logs, have become common.

They measure the ship's speed on the basis of reverberation signals, i.e. signals reflected from different particles in the water or air bubbles. High emission frequency is used to obtain reliable reflection (MHz). With high frequencies there is always sufficient quantity of minute particles of dimensions correlated with the wave length (hundredth part of millimeters). At these transmission frequencies reflective layers are 15 or 50m. deep, i.e. they are located far below the surface layers disturbed by the ship's movement. This is a great advantage of Doppler sonar logs as compared to electromagnetic logs.

There are two-frequency logs which simultaneously measure bottom and water speed, defining also current characteristics (rate and direction).

Figure 5.29 shows operational scheme of a typical Doppler sonar log, while Figure 5.30 shows the control panel and coded commands of a common Atlas Electronic (Germany) Atlas Dolog21 (22, 23) log.

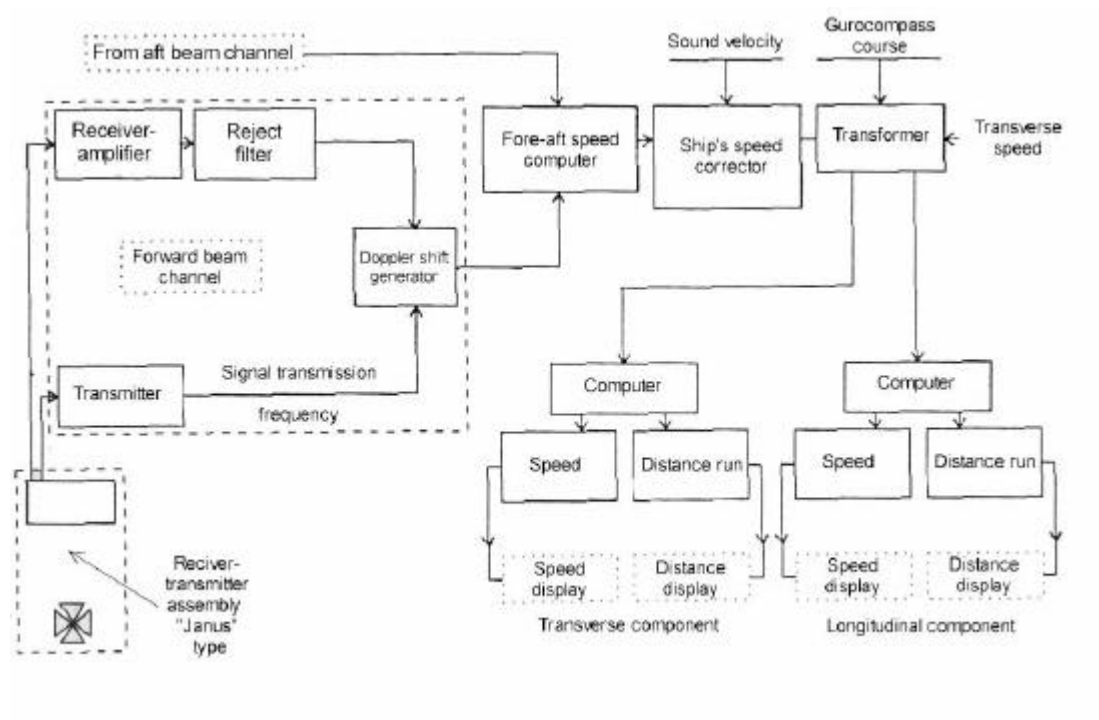
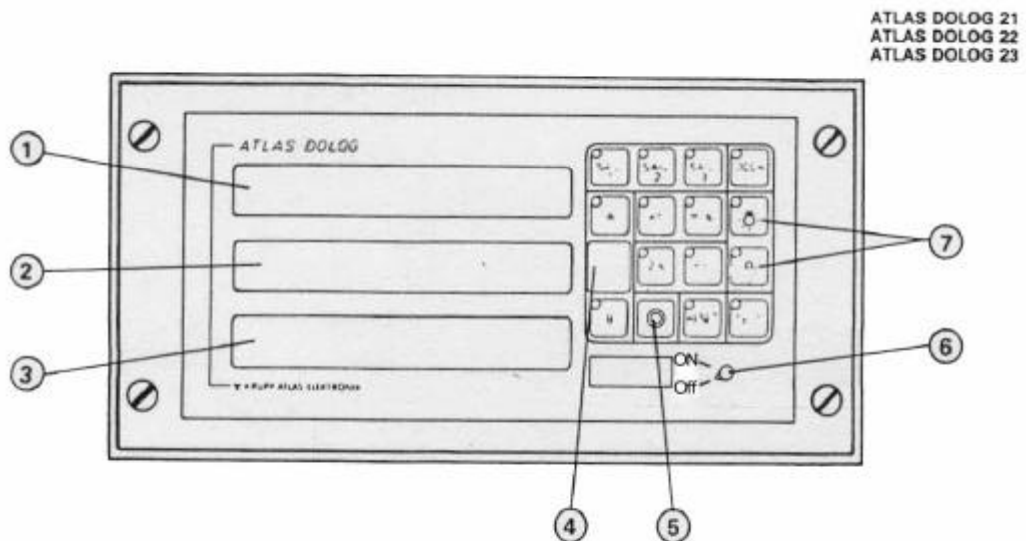


Fig. 5.29



Starting up

- Turn the switch ⑧ to ON; the equipment is running if the green lamp ⑤ is alight.
- Adjust the brightness of the display by pressing a key ⑦.
- Select the unit of measurement for the display: **[kt]** or **[m/s]**.
- Set the distance counter to zero by pressing the key [RESET].
- Manual selection of mode: press the key [B] for bottom track or [W] for water track; mode is displayed at ④: If echo is missing, **[F]** is displayed.

Selecting the display program

Key to be pressed	Display line	Display parameters	Symbols
[SAIL 1]	① ② ③	Transverse speed Longitudinal speed Longitudinal distance travelled	< to port; > to stb ^ ahead; v astern — astern after return to zero
[SAIL 2]	① ② ③	Drift angle Resultant speed Resultant distance travelled	deg. Δ degrees — — astern after return to zero
[SAIL 3]	① ② ③	Depth from external echosounder Resultant speed Resultant distance travelled	m Δ meter — — astern after return to zero
[DOCK]	① ② ③	Transverse speed at bow Longitudinal speed Transverse speed at stern	> to stb; < to port ^ ahead; v astern > to stb; < to port

For a self-test of the equipment, press the key [TEST]

Fig. 5.30

Table 5.2 demonstrates the main characteristics of logs manufactured by the leading companies.

5.6.3. Radio Doppler logs

Craft of air-cushion or aerodynamic type have no direct contact with the water required for sonar or electromagnetic logs operation.

It may also happen that ordinary water-borne vessels are unable to change speeds easily, e.g. during ice navigation (possible antenna damage). Radio Doppler logs are used in this case.

Radio Doppler log operation principle is absolutely similar to that of Doppler sonar log. As the substrate, however, is mainly water or ice, which have their own speed over the ground, radio Doppler logs measure relative speed.

Table 5.2

Company, type, country	Speed range measured, kn			Sound velocity correction method	Operation mode	Operating frequency, KHz	Antenna beam number
1. Atlas Elektronik, Atlas DOLOG* 21/22/23 Germany	Bottom track		Depth	The same	_____	79	4
	Fore/aft –5–30 Port/starboard ±5	0,1 kn or 0,2% whichever is higher	1–600				
	Water track						
	Fore/aft –5–30 Port/starboard ±5	-----	40 – 600 > 6000				
2. Sperry SRD-401, (Docking system), USA	Bottom track		Depth	Automatic (thermister data)	Continuous	400	6
	Fore/aft 0 – 35 Port/starboard- --	1%	0,3 - 90				
	Water track						
	-----	-----	-----				
3. Ametek (Straza division), MRQ-4012 D**, USA	Bottom track		Depth	-----	Pulse	300	2
	Fore/aft 0– 39,9 Port/starboard ----	±5% distance run	1,2-200				
	Water track						
	Fore/aft ---- Port/starboard ----	-----	----				

4. Magnavox, MX 880-3, USA	Bottom track			Automatic (thermister data)	The same	600	6
	Fore/aft 0-38 Port/starboard 0-8	0,01kn or 0,5% distance run	0,6-50				
	Water track					2400	
	Fore/aft 0-38 Port/starboard 0-8	-----	>50				
5. Furuno Electric, C1-30 (Speed log and current indicator), Japan	Bottom track		Depth		Pulse	130	3
	Fore/aft. -10- 20 Port/starboard ± 9,9	1% + 0,1kn	3-600				
	Water track						
	Fore/aft. -10- 20 Port/starboard ± 9,9						
	Current over the bottom						
	0-5 y3	± 2% ship's speed 0,2 kn	3-200 3- levels simultane- ously				

DOLOG-23 comprises navigational rate of turn indicator (R_oT).

** Comprises depth measurement mode.

The main mathematical correlation for radio Doppler log may be derived from (5.19), assuming that that $V_x \ll c$ (where c – electromagnetic waves propagation velocity). Consequently, the following formulae can be derived with high accuracy:

$$f_d = 2 \frac{V_x f_0}{C} \cos \gamma_0 \quad (5.22.)$$

$$V_x = \frac{f_d \cdot c}{2 f_0} \sec \gamma_0 \quad (5.23.)$$

Inclination angle γ_0 is shown in Fig. (5.31)

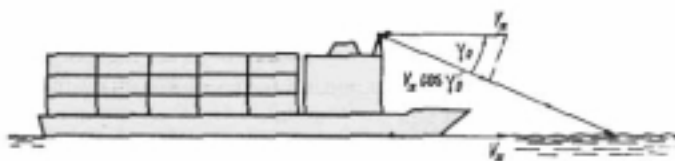


Fig. 5.31

It should be pointed out that the basic difference of radio Doppler log from Doppler sonar log is that radio waves propagation velocity is constant with a high degree of accuracy. Consequently, no correction device is required for errors in speed measurement as a result of radio wave velocity deviation.

Radio Doppler logs use GHz range frequencies (10 –15 GHz) (wave length – 3-5 cm.). This accounts for an important operation feature of Radio Doppler log: it cannot be reliable on smooth water (in calm weather) and on smooth ice, as if irregularity of the reflecting surface is much less than wave length, beam reflection is governed by geometrical optics law - the angle of incidence is equal to the angel of reflection (the surface acts as mirror), therefore the reflected impulse does not come to the antenna.

Radio Doppler log antenna systems may be one-, two-, three- or four-beam with all the resultant effects considered in the section devoted to sonar logs.

Table 5.3 shows the main technical characteristics of modern radio Doppler logs.

Table 5.3.

Manufacturer,type, country	Speed measured (kn) and drift angle	Error of measurement	Antenna type and number	Beam width, degrees	Transmission mode	Operating frequency, GHz
1.RDL-3, Russia	0,3-400 $\pm 40^\circ$	0,1 + 0,001 V	2 two-beam leaky-pipe antennas	-----	Continuous frequency modulation	-----
2.JUHANA YULINEN, Electronics Co., NMD, Finland	0,2-20	Distance run error maximum 1%	2 mirror parabolic	Less than 6	Continuous	10.525
3.Marconi,SRN-5A, Great Britain	0-100	Distance run error maximum 3%	2 mirror parabolic	4	The same	14
Rual Aeronautical, 547C, US	0-100 $\pm 30^\circ$	Instrumental speed error $\pm 0,1\%$	Two-beam leaky pipe	5	The same	13,3
Decca 71 H, Great Britain	0-90	Distance run error maximum 1%		-----	The same	-----
Sadelek Radio International, for navigation system SVP No.500, France	Ahead/astern – 50..-186 Port/starboard - ± 50	RMS 0.22 kn with $V < 22$ kn, 1% with $V > 22$ kn	3 mirror parabolic in one unit	-----	Continuous with frequency modulation	15 (modulation frequency 450-800 KHz)

5.6.4. Sonar correlation logs

5.6.4.1 Operational principle and basic theory

Sonar correlation log measures ship's linear speed, the main operational principle being based on determination of a time shift between acoustic signals reflected from the bottom and received by two shipboard antennas positioned at a definite distance.

Let us consider the operational principle of measuring one – ahead /astern - component of the ship's speed.

Let us assume that 3 antennas are placed longitudinally in a ship (fig.5.32).

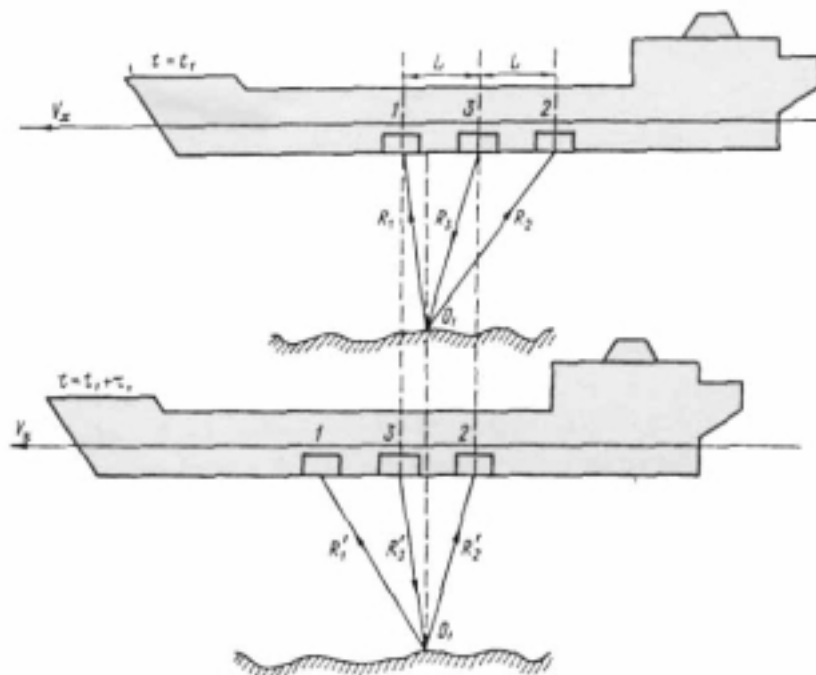


Fig. 5.32

The transmitting antenna 3 is positioned right in the middle between two receiving antennas 1 and 2. Let us assume that antenna polar diagrams of the three antennas are similar, they are overlapping, and their axis orientation is directly downwards.

Sea bottom surface is known to be formed of a great number of elementary reflectors with random displacement.

Let us suppose that the antenna 3 transmits a signal to the elementary reflector O_1 , inter alia, at time $t = t_1$. Echo-signal from the reflector O_1 is received by antennas 1 and 2. The signal amplitude and phase, received by the antenna 1 is defined by geometry of rays R_3 and R_1 .

As the ship continues her movement at time $t = t_1 + \tau_T$, she will come to a position when the antenna 3 takes the position of the antenna 1 at time t_1 . The geometry of rays R'_3 and R'_2 is obviously similar to rays R_3 and R_1 except the direction of acoustic

wave propagation. The change of the signal propagation direction, however, does not result in change of its phase and amplitude.

The same pattern can be applied to any n-reflector located within signal transmission active area on the sea surface.

Consequently, we can formulate the following important conclusion: whatever the total signal received by aft antenna is at time $t = t_1 + \tau_T$, it repeats the total signal received by forward antenna 1 at time $t = t_1$, as it is formed by the same group of signals from the same group of elementary reflectors. It is essential that the above repetition will happen with the time lag τ_T , which is called transport lag. The τ_T is defined by:

$$\tau_T = L / V_x \quad (5.24)$$

where τ_T is equal to time required by ship having a speed of V_x to run half the distance between the receiving antennas.

Therefore to measure the speed of ship V_x it is necessary to define the time shift t_T between the signals received by the antennas displaced at known distance of L apart, i.e. $V_x = L / \tau_T$.

The whole picture within the time of the ship's movement can be shown as repetition with an interval t_T of some functions $U_1(t)$ and $U_2(t)$ which represent signals received by antennas 1 and 3, the above signals being stationary random functions (fig. 5.33. a,b).

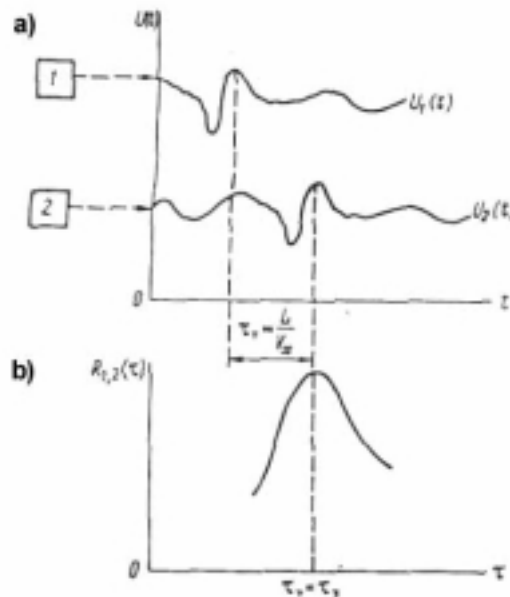


Fig. 5.33

5.6.4.2. Sonar correlation log functional scheme

Figure 5.34 shows the functional scheme of the log. In connection with this scheme the main units operate in the following way. One of the three antennas, forming a

system of sonar antennas, that is the central antenna 3, transmits acoustic pulses. The sound waves reflected from the sea bed are transformed by the receiving antennas 1 and 2 into identical, but delayed electric signals $U_1(t)$ и $U_2(t)$. After signal processing in the receiving-transmitting device the signal envelopes and centered values are defined $\overset{\circ}{U}_1(t)$ и $\overset{\circ}{U}_2(t)$, by finding remainder between the instantaneous values of random functions $U_{1,2}(t)$ and their mathematical expectations $\bar{U}_{1,2}(t)$. These signals come separately to automatic correlation device which estimates cross-correlation function and automatically identifies its maximum. This is done in the following way. Signal $\overset{\circ}{U}_1(t)$ comes into the regulated delay unit. The output signal is $\overset{\circ}{U}_1(t - \tau_3)$, which goes to multiplying device,

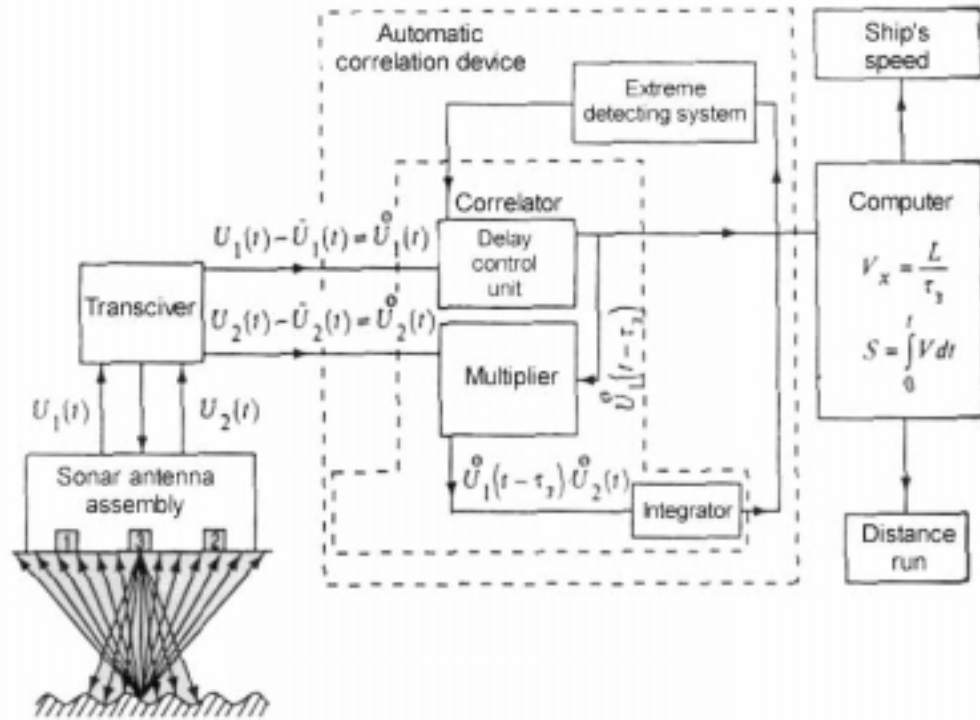


Fig. 5.34

where comes signal $\overset{\circ}{U}_2(t)$ through a separate path. From the multiplying device exit the signal $\left[\overset{\circ}{U}_1(t - \tau_3) \cdot \overset{\circ}{U}_2(t) \right]$ goes to the integrator, which forms the desired function

$$R_{1,2}(\tau) = \lim_{T \rightarrow \infty} \int_0^{T_u} \overset{\circ}{U}_1(t - \tau_3) \cdot \overset{\circ}{U}_2(t) dt.$$

Extreme follow-up system interfaced to the correlator exit continuously maintains maximum value of cross-correlation function by regulating time delay value τ_3 . on the basis of the property of the two signal function to attain their maximum if there is no time delay between the functions, extreme detecting system finds τ_3 value equal to τ_T . After that the computer defines instantaneous speed V_x by $\tau_3 = \tau_T$, and distance run by time integration.

5.6.4.3. Correlation log main parameters

Sonar correlation logs are characterized by a number of technical parameters, i.e. transmission mode, number of receivers and their displacement on the ship, signal frequency, directivity diagram width.

Transmission mode. Correlation logs can use any mode – continuous-wave or pulsed. However, like Doppler sonar log, it has depth limitation (maximum 100 m) for continuous wave mode, as in this case it is very difficult to eliminate volume reverberation effect. In case of pulsed mode this problem can be solved in a more efficient way, as reverberation can be considerably reduced, and transmitted and return signal paths are not interconnected. Besides, pulsed mode makes it possible to measure under-keel depth, i.e. to combine log and echo-sounder functions. Therefore, pulsed mode correlation logs are most commonly used.

Pulse duration selection is governed by the following factors. On the one hand, pulse duration τ_p should be longer than the transport lag τ_T at all speeds to be measured. As it was stated above, τ_T value is connected with the ship's speed V_x by (5.24). So this requires that

$$\tau_u > \frac{L}{V_x} \quad (5.25.)$$

On the other hand pulse duration should be less than two-way propagation time, i.e. this requires that

$$\tau_u < \frac{2H}{c}, \quad (5.26.)$$

where H is the under-keel depth.

Therefore, pulse duration should be within the interval

$$\frac{2H}{c} > \tau_u > \frac{L}{V_x}, \quad (5.27.)$$

Number of receivers and their displacement on the ship. Number of receivers depends on the log tasks. So if it is necessary to measure ahead/astern component of the ship's speed V_x , it is sufficient to have two receivers displaced along the middle lone plane of the ship. In order to measure the entire speed vector V and drift angle β , at least three receivers are required.

Signal frequency and directivity diagram width. It can be stated that the wider the diagram $\Delta\theta$ and the higher the signal frequency f o, the sharper is the cross-correlation peak. This allows to define more accurately the time $\tau_3 = \tau_T$, and consequently to measure more accurately the ship's speed. Use of a wider diagram, however, has negative effects, as it results in the antenna's concentration coefficient

reduction, which makes it necessary to provide higher transmission power to ensure normal operation of the log on given depths.

Transmission frequency f_0 increase has also negative effects of absorption coefficient increase, which results in decrease of the measured depth. A compromise solution of the problem is to use the most common parameters $\Delta\theta = 30^\circ$ and $f_0 = 150$ KHz.

An important achievement of the recent years is dual frequency correlation log, which measures simultaneously absolute speed (by signals reflected from sea bed), using low frequency radiation, and relative speed (by volume reverberation signals), using high frequency radiation (MHz).

5.6.4.4. Correlation log errors

1. Fluctuation error. Similar to the same error of sonar Doppler log.
2. Drift, heel and trim error. It is caused by correlation maximum shift.

5.6.5 Comparison of Doppler and sonar correlation logs.

The following conclusions can be made as a result of comparison:

- in accordance with the operation principle correlation log accuracy does not depend on sound velocity in water, and therefore, the construction of the log, in contrast to Doppler log, is not to be modified to include any other devices intended to reduce influence of this factor on the log readings.
- due to a considerably wide directivity diagram (approximately by order as compared to Doppler log) correlation log is not actually subject to sonar contact loss with sea bed, even during heavy rolling and pitching and very rapid circulation.
- as the directivity diagram beam axis of correlation log has orientation directly downward, technical implementation of log operation simultaneously for linear speed and under-keel depth measurement is easier.
- Doppler log has an advantage over correlation log in obtaining operational information concerning fluctuation error reduction. To obtain the same degree of accuracy correlation log requires much more time for data averaging.

In view of the above said the following conclusion can be made: for navigational purposes correlation log is more preferable than Doppler log, while during maneuvering, anchoring and particularly mooring, Doppler log is much more practicable as compared to correlation log.

Table 5.4 contains the main characteristics of the most common correlation sonar logs.

Table 5.4

Company, type, country	Speed range measured, kn	Speed measurement error	Depth range, m	Working frequency kHz	Echo-sounder mode range, m	Depth measurement error %
1.“Consilium Marine”, SAL-865, Sweden	Ground track mode				2 - 300	± 1
	Longitudinal –8 – 40 Transverse ±8	0,1 kn or 005 V, whichever is higher*	2 – 300	150		
	Water track mode					
	Longitudinal 0 -40	0,1 kn or 0,01 V, whichever is higher	>2	4000		
2.“Consilium Marine”, SAL-840, Sweden	Ground track mode				3 -300	±5
	Transverse -8 - 30	0,1 kn with V<20 kn 0,5% with V>20 y3	3 – 300	150		
	Water track mode					
	Longitudinal 0 -30	0,1 kn with V<10 kn 0,1% with V>10 kn		4000		
3.“Consilium Marine”, SAL-Imcor, Sweden	Ground track mode				—	—
	Is not intended					
	Water track mode					
	Longitudinal 0-25	±0,1% with V>10 kn 0,1 kn with V<10 y3	>3	4000		
4.“General Electric”, Quo Vadis, USA	Ground track mode				Up to 6000	—
	Longitudinal ±50	0,02 kn with V=10 kn 0,2% with V>10 kn	Up to 6000	12		
	Water track mode					
	Longitudinal ±50		Automatic with depth>6000 m			
5.“Magnavox”, MX-810. USA	Ground track mode				Up to 5000	—
	Longitudinal ±30 Transverse ±10	0,1 kn with V>10 kn	5 – 5000	18		
	Water track mode					

In interpolation mode where $V < 41/H$ kn, (H – depth, m.,) the error is 0.2 kn.

5.6.6. General requirements to log maintenance and repair

Modern logs of any type do not require constant every day maintenance.

Most of the logs have a test mode for fault detection, which helps to detect defective unit. In some cases when there is no test mode, test tables are included into the log documentation.

On board specialists responsible for log maintenance may only eliminate those defects which can be repaired by replacement of the faulty unit with a new one, if there is such in the spare part container. During the replacement all manufacturer's instructions must be strictly followed and only proper instruments/tools can be used. It is necessary to update constantly the reserve of spare units.

If a defect cannot be eliminated in this way, appropriate service centre should be notified. The notification should include information about the name and type of the unit, and a very detailed description of the malfunction. This information will help the centre to reduce the repair time and consequently the expenses.

Manufacturer's instructions of the new generation logs permit on board specialists to replace only safe fuse and bulbs (signal and illumination lamps). If after replacement safe fuse burns out again, the device should be repaired only by qualified specialists of a service centre.

E.g., the trouble-shooting process description for two most common Doppler speed logs - Sperry SRD-331 and DOLOG –21,22,23(Atlas-Elektronik, Bremen, Germany) – are given below.

TROUBLESHOOTING

Sperry SRD-331

GENERAL

Information contained in this section will permit service personnel to isolate malfunctions of replaceable printed circuit cards in the Sperry SRD-331 Doppler Speed Log's Electronics Unit and Master Display Unit, and to determine if the Transducer Assembly is operating correctly.

TEST EQUIPMENT

The following test equipment is required for troubleshooting, maintenance, and alignment:

Description

Oscilloscope: Frequency Response 2 MHz, minimum 1 Vertical Sensitivity

10 mv/cm minimum, 1 mv/cm preferred External Synchronization

Capability Volt-Ohmmeter, Simpson 260 AVO or equivalent– 1 unit

Resistor, 90 ohms,2 watts – 2 units

TROUBLESHOOTING PROCEDURE

Troubleshooting should be a systematic process of elimination that leads to finding and correcting the cause of failure. Information is provided to aid in isolation of faults to a replaceable Printed Circuit Board (PCB). Defective printed circuit assemblies should be returned to Sperry for repair.

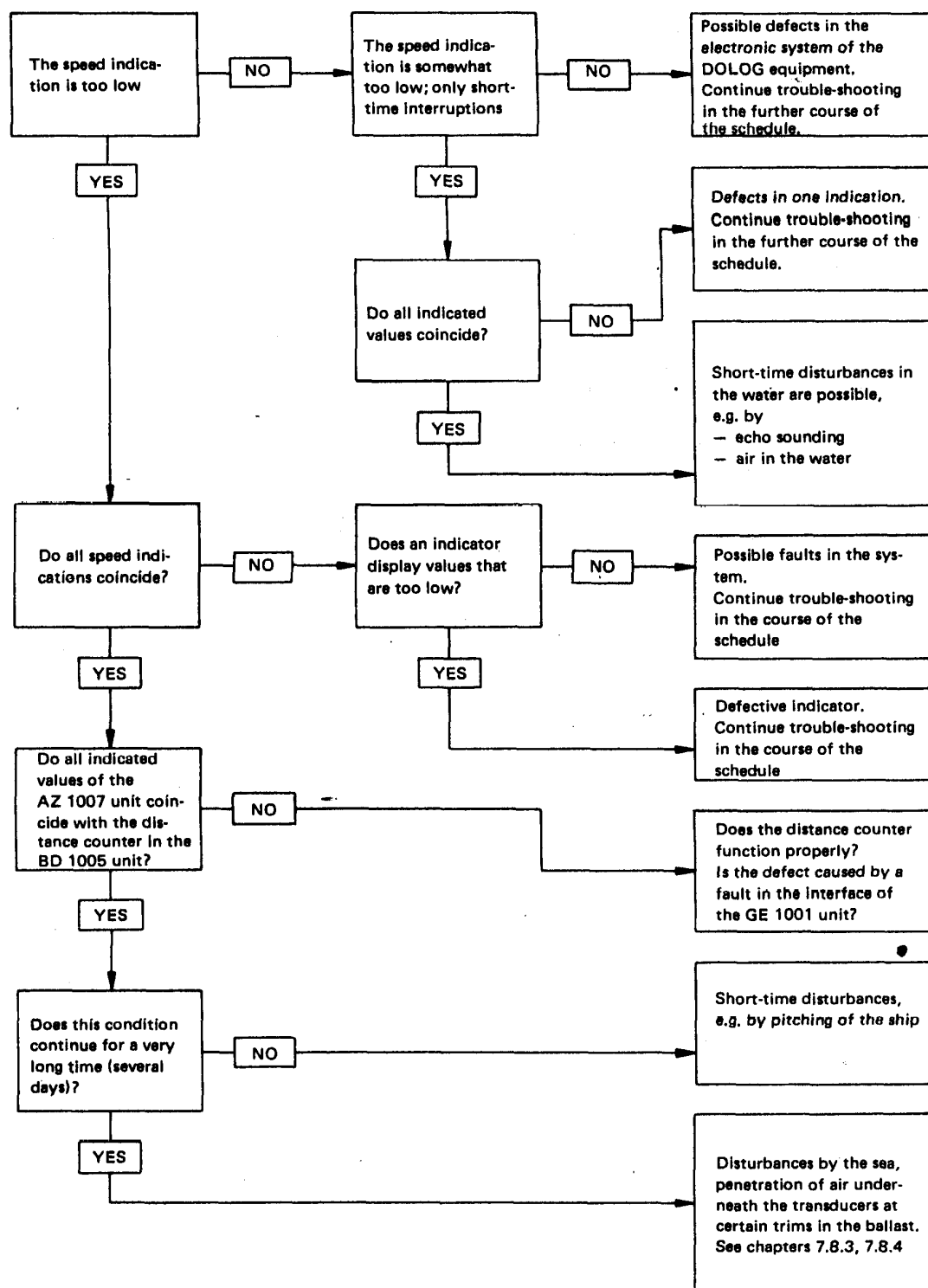
Table 5.5. gives a test procedure which should detect most faults.

Table 5.5. Test Procedure

Action	Response
1. Press POWER ON	a. Audible "click" from K1 latching relay b. Speed in knots indicated on Speed/Distance Display c. OPERATE and KNOTS status lights and K indicator illuminate
2. Press KNOTS/MILES switch	a. Accumulated miles indicated on Speed/Distance Display b. MILES status illuminates c. M indicator illuminates
3. Press TEST switch	Observe in this order a. Display blanks b. All status indicators light a. Speed/Distance Display cycles from 0000.0 to 9999.9 b. Returns to OPERATE Mode
4. Press DISPLAY INTENSITY and then press INCREASE after observing the above press DECREASE	a. Speed/Distance Display backlighting increases intensity b. Speed/Distance Display backlighting decreases intensity
5. Press PANEL INTENSITY and then press INCREASE after observing the above press DECREASE	a. Observe front panel backlighting increases b. Observe front panel backlighting decreases
6. Press STATUS INTENSITY and then press INCREASE after observing the above press DECREASE	a. Observe that lit status lights increase intensity b. Observe that lit status lights decrease intensity
7. Press MANUAL. If MILES is selected also press KNOTS and then press INCREASE switch after observing the above press DECREASE	a. MANUAL status light illuminates b. Observe Speed/Distance Display speed increases c. Observe Speed/Distance Display speed decreases

DOLOG 21,22,23

Trouble-shooting Schedule in the Case Environmental Influences



5.7. Depth measuring systems (navigational echo-sounders)

5.7.1. Echo-sounder operation principle

Navigation echo-sounders are devices used for measuring sea depth under keel.

Operation principle of echo-sounder is based on measuring time Δt between probing pulse directed to the sea bed and received return signal of reflected pulse from the depth H with further transformation of the time Δt into depth reading.

Figure 5.35 shows a typical structure scheme of echo-sounder. In the scheme A is transmitter of sound pulses, B – receiver of signal reflected from sea bottom, called echo-signal. The AB segment between the transmitter and receiver is called antenna base, which is marked la . The following elementary equation can be obtained from figure 5.35

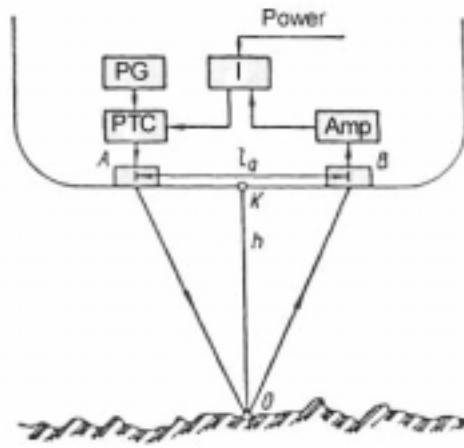


Fig. 5.35

$$H^2 = (OK)^2 = (AO)^2 - \left(\frac{AB}{2}\right)^2 \quad (5.28.)$$

Sound velocity in sea water is C , while time between pulse transmission and receiving is Δt . Let us make transformation of the equation (5.28) into

$$H = \sqrt{\left(\frac{C\Delta t}{2}\right)^2 - \left(\frac{la}{2}\right)^2} \quad (5.29.)$$

With greater depths (practically with $H > 10$ m.) $\left(\frac{C\Delta t}{2}\right)^2 \gg \left(\frac{la}{2}\right)^2$ and so we can use the following formula

$$H = \frac{C\Delta t}{2} \quad (5.30.)$$

In new generation echo-sounders transmitter and receiver are mounted on one antenna, i.e. $l_a = 0$, so formula (5.30) is appropriate for all depths.

It follows from (5.29) and (5.30) that the main task for measuring depth by means of echo-sounder is to measure the interval Δt , which with small depths will be rather small (with $H=10$ m. $C = 1500 \text{ ms}^{-1}$, $\Delta t = 0.013$ s)

Echo-sounder works in the following way. At a definite time t_0 on command from indicator (I) pulse transmission control scheme (PTC) will connect pulse generator (PG), producing probing pulses, to transmitting antenna A. Antenna A will transform electric power of the probing pulse into mechanic oscillation of magnetostrictional or piezoelectric element which goes to sonar antenna membrane in contact with sea water. This signal is amplified by amplifier and goes to indicator, which defines interval $\Delta t = t_1 - t_0$ and provides information about the depth H. Depth indicators and recorders are used both of electro-mechanical type and electronic digital displays.

Depth measurement accuracy depends on probe pulse duration. In order to increase accuracy at small depths short pulses and high frequencies are used, while at greater depths long pulses and low frequencies are used.

Different methods are used in navigation echo-sounders for defining time interval Δt :

Simple older systems use discs with lamps, revolving drums, revolving pens, closed-loop with pens, while modern echo-sounders use electronic indicator boards.

It should be pointed out that depth readings of echo-sounder indicate depth from the antenna level. If depth from the water surface is to be defined, the ship's draught at the antenna level should be taken into consideration.

5.7.2. Echo-sounder main parameters

1. Pulse parameters

- a) Pulse duration τ . The shorter the pulse is, the higher the cavitation level. Reduction of τ results in echo-sounder depth resolution increase.
- b) Pulse energy. It is proportional to τ , so the higher its value is, the longer the propagation distance. This value of modern echo-sounders is within $10^{-3} \dots 10^{-5}$
- c. Pulse frequency ω_n Depends on project maximum depth of the given range.

2. Depth resolution.

Echo-sounder depth resolution is minimum spacing between two reflecting objects displaced one after another along the ray path, which the echo-sounder is capable to distinguish. Resolution is within 0.1...1m.

3. Antenna directivity.

This parameter of navigation echo-sounder governs reliability of receiving echo-signal during the ship's roll and pitch. This parameter normally lies within 30-35°.

4. Transmission frequency

A compromise solution should be found between echo-sounder range and its accuracy. Optimal solution is found by using several working frequencies for the constant number of ranges.

5.7.3. Main errors of echo-sounder

- A. Error caused by deviation of actual sound velocity from the project one. The echo-sounder is designed for a constant sound velocity in water. Actual sound velocity is not constant and depends on a number of factors. Therefore water depth measured is liable to error.

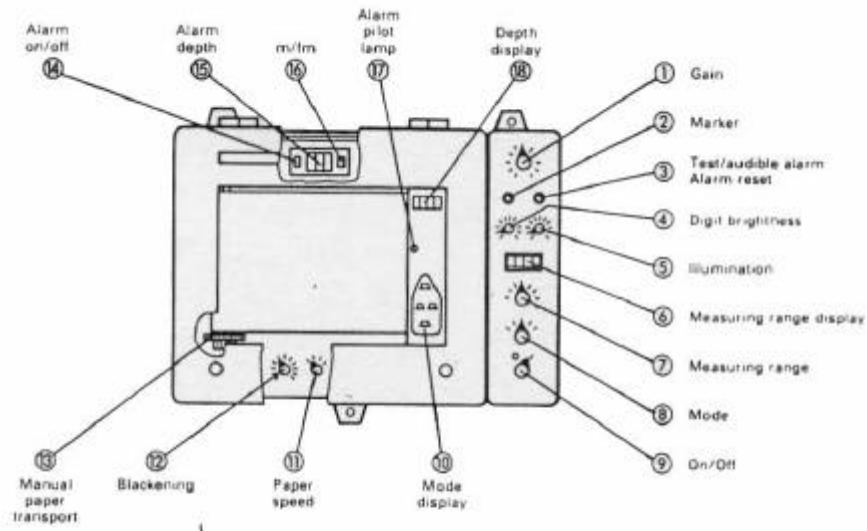
As it is known maximum deviation of sound velocity in sea water from the assumed value (normally $C = 1500 \text{ mc}^{-1}$) does not exceed approximately 5%. This error can be neglected for navigational purposes.

- B. Bottom inclination error

Analysis shows that sea bed inclination of over 15% results in a perceptible error (over 3%). Actually sea bed inclination in coastal waters does not normally exceed 5° . It only near volcanic coasts that inclination may attain 20-30°. So it may be assumed that this error can be neglected from navigational point of view.

Table 5.6 shows main technical characteristics of modern navigation echo-sounders.

Picture 5.36 shows control panel of ATLAS ECHOGRAPH echo-sounder with all controls and a table of operation modes.



Basic adjustment

GAIN: turn switch (1) to position 5.

BLACKENING: turn knob (12) to position 5.

Switching on: turn mains switch (9) to I (on).

Illumination ☀: turn knob (5).

Digit brightness ☀: turn knob (4).

Metres(m) / fathoms(fm): move switch (16) to the desired unit.

Measuring RANGE: turn switch (7) to position 7; the measuring range display (6) then shows "1000" (m) or "F500" (fm).

At the "STAND-BY" setting, the recorder does not operate; only the digital depth display (18) and, if connected, one or more ATLAS FILIA 520 digital depth indicators and/or ATLAS ALARM 525 depth alarm units operate.

MARKER: press button (2).

Operational adjustment

MODE switch (8) – related to display (10) –

Echosounders with

1 transducer: has no effect

2 transducers: see table

4 transducers (fore, aft, stb, pt): additional external selector switch for 6 combinations (see Operating Instructions, page 2-2, table 2-2, transducer pairs "A" and "B")

GAIN: turn switch (1) until bottom echo is recorded clearly.

Measuring RANGE: turn switch (7) to the measuring range corresponding to the depth.

PAPER SPEED: turn switch (11) for desired resolution of echogram.

BLACKENING: turn knob (12) so that there is no "smoke" (minimum "soot production").

Alarm depth display/ buttons (15): input desired depth with + buttons. Alarm depth is displayed digitally.

Switching on the alarm: move switch (14) to "ON"; (17) then lights up;

Alarm pilot lamp (17) (lights when alarm device is switched on).

ALARM RESET: press button (3).

If depth is less than alarm depth:

- Measuring range display (6) flashes
- Audible alarm is given.

Testing the audible alarm: press button (3).

MODE – echosounders with 2 transducers (example: installation fore/aft)				
MODE switch (8) position	In operation: 2 transducer	Echo recording		Digital display of depth for transducer
		Shade	for transducer	
I	fore	black	fore	fore
II	aft	black	aft	aft
III ¹⁾	fore and aft simult.	black	fore aft	fore (small depth only)
IV ¹⁾	fore and aft alternately	light grey dark grey	fore aft	fore only
V ¹⁾	fore and aft alternately	light grey dark grey	fore aft	aft only

1) Two transducers ("A" and "B") are in operation in the measuring ranges 0 - 10 m (5 fm) and 0 - 20 m (10 fm) only; in the other measuring ranges, transducer "A" only.

2) Corresponding symbols light up in the mode display (10).

Fig. 5.36

Table 5.6

Company, type, country	Depth range m	Depth measurement accuracy	Directivity diagram width, degrees	Ambient temperature range, C°	Transmitter's number, kGz	Cost, USD	Ship's speed, kn
Promelectronica, HЭЛ-20 K, Russia	0,3 - 500	$\pm 0,5$ m on range scale to 40 m, $\pm 1\%$ on range scale over 40 m	—	From – 10 to +40	1(95, 380)	6500	25
“Simrad”, EN 200, Norway	0,3 - 500	± 1 m on range scale to 40 m, $\pm 2\%$ on range scale over 40 m	—	From – 15 to +55	1 (27, 38, 49, 70, 120)	1100	40
“Honeywell ELAC” Laz 50 AT, Germany	0,6 - 400	$\pm 2\%$ on all rangers	17/29	From 0 to 55	1(50)	—	30
“Atlas Echograph”, Germany: AE-461 AE-481	0,8 - 500	± 1 m on range scale to 40 m, $\pm 2\%$ on range scale over 40 m	14/19	From – 10 to +55	1 (33, 100)	10290	40
	0,8 - 500	The same	14/19	From –10 to +55	2 (33, 100)	12510	40
“Japan Radio Company”, Japan: JFE-570 S JFE-570 SD	2 - 450	—	5	From –15 to +55	1 (200)	5000	30
	2 - 450	—	36	From – 15 to +55	1 (50)	4500	30
“Furuno electronic”, Japan: FE-680 FE-880	1 – 400	± 1 m on range scale to 40 m, $\pm 5\%$ on range scale over 40 m	28	From – 15 to +55	1 (50)	4854	40
	1 - 400	The same	28/5,4	From – 15 to +55	1 (28, 50, 200)	10470	40

5.7.4. General information about echo-sounder maintenance

Modern highly automated echo-sounders do not require constant maintenance.

Echo-sounder can be normally switched on by one or two operations. Before starting the device should be tested by built-in test system, including all modes, indicators and signals.

For depth measurement the main operation is selection of depth range and amplifier rate.

The most sophisticated echo-sounders afford automatic range switchover and indication of previous depths. Depth readings for last 2 –3 hours work are normally stored.

Later the outdated data are replaced by new information. The stored data are indicated both on the echo-sounder display and PC display.

Modern echo-sounders have built-in technical control systems, covering all devices of the echo-sounder set, which help to detect a faulty unit. Normally only repair by replacement of defective unit if allowed, using spare part set. In case the replacement fails to eliminate malfunction appropriate service station should be applied. Sonar antennas are not to be repaired but to be replaced by new ones.

E.g., The trouble-shooting process for a modern digital echo-sounder

Is given below.

Faults and methods of their elimination

Very important skill ensuring successful usage of the echo-sounder is fast finding and removal of faults which can eventually arise in service. It is assumed that before finding the faults the personnel attending the echo-sounder have gained sufficient knowledge regarding principles of the echo-sounder.

There is a system of built-in checking to reduce time for troubleshooting in the echo-sounder.

The design of the echo-sounder admits repair of all its units in ship conditions by replacement of failed blocks for serviceable ones included into single SPTA -0 set

The service capability of faulty blocks is restored in specialised base workshops.

The transducer is not subject to repair and in case of being faulty it is substituted for serviceable one.

After the fault is removed it is necessary to register the time of reconditioning (time of searching a fault and time of its elimination) into the Log book of the echo-sounder.

Possible faults of the typical last generation echo-sounder, their probable reasons and methods of elimination are given in table.

Table 5.7.

Fault indication	Probable cause	Methods of elimination
1. The front panel indicator- SHIPS POWER SUPPLY" does not shine	There is no on-board power supply	To test circuits of onboard power supply
2. The instrument does not switch on, indicator" SHIPS POWER SUPPLY " is shining	The fuse is blown, the button-® is faulty	To replace the button or the fuse
3. The name of faulty DCI module is highlighted, f.ex. "X IS FAULTY"	Indicated module is faulty	To replace the module for serviceable one from single SPTA set
4. The inscription "SONAR GOOD COND" is shining, depth indications -zeroes in all digits, the echo-sounder is in automode	The under-keel depth is less than 0,3 m or exceeds 400 m. A module of transceiver is faulty	To switch the echo-sounder manually over into LF (HF) mode, if there is no depth indication to switch it over into "TEST" mode and to test the transceiver
5. Echo-sounder does not operate. Indicator is not shining.	Connector contact is faulty. HV power supply is faulty. Y unit is faulty.	To test the module installation. To replace HV power supply. To replace Y unit
6. Echo-sounder operates. There are distorted data symbols, additional symbols, signs, short lines etc	Faulty contact in connectors of modules Y and Z. Z unit is faulty.	To test installation of modules Y and Z. To replace module Z
7. On marker moving depth data are distorted	Faulty contact in connectors Y and Z. Z unit is faulty.	To test the-installation of modules Y and Z. To replace module Z
8. On switching the TEST mode: 8.1. No indications of HF and LF channels. Inscription TRV IS FAULTY is shining	Breakout of cable between TRV and DCL The N module of DCI is faulty	To check the cable and connectors. To replace N module for workable one from single SPTA set
8.2. Inscription TRV IS FAULTY is shining HF channel indications are absent or fall beyond the range 4-8 m, LF channel indications are within range 40-80 m	HF TRV module is faulty	To replace the HF TRV module for workable one from single SPTA set
8.3. Inscription TRV IS FAULTY is shining LF channel indications are absent or fall beyond the range 40-80 m, HF channel indications are within range 4-8 m	LF TRV module is faulty	To replace the LF TRV module for workable one from single SPTA set
8.4 Inscription TRV IS FAULTY is shining. Indications of HF and LF channels are in allowable range.	TRV - transducer cable is faulty. Transducer is faulty.	To check cable and transducer

*TRV - transceiver

SECTION 6

SHIPBORNE RADAR. ARPA

The purpose of the section is to provide knowledge of shipborne radar systems operation, maintenance, including provision of operational conditions of the equipment and fault detection down to replaceable unit (module).

Entry standards:

The candidates should have knowledge of:

- basic signal transformation devices in electronic systems;
- basic information and coding;
- radio electronic device schemes: operation principles and main characteristics of analogue, digital analogue and digital electronic devices;
- signal parameters measurement methods and means, main technical characteristics of electronic devices;
- wave propagation for different wavebands;
- radio transmitting devices: operation principles and main characteristics;
- radio receiving devices: operation principles and main characteristics;
- basic equipment maintenance, including diagnostic means;
- basic PC, architecture and software, microprocessors, basic local computer network;
- basic environment protection and occupational safety, fire safety regarding electronic equipment maintenance;
- electronic elements mantling and dismantling;

After completion of this course the trainees should have knowledge of:

- wave propagation for centimeter and millimeter wavebands;
- construction principles of radio location systems and their elements;
- factors affecting technical and operational parameters of radar;
- operational tests and fault detection for radar;
- ARPA use, operational tests and fault detection;
- Electronic chart principles, operational tests;

Outline

No.	Learning objectives	Class hours		
		Total	Theoretical	Practical
1	2	3	4	5
1.	Shipborne radar:			
	Navigational radar functions	1	1	-
	Radio location pulse principle	1	-	1
	General radar structure scheme	1	1	-
	Range and direction measurement principle in navigational radar	1	-	1
	Radar picture formation on radar display	2	1	1
	Main operational characteristics of shipboard radar	1	1	-
	Main technical characteristics of shipborne radar:			

	- Radar transmitter technical characteristics	1	-	1
	- Radar receiver technical characteristics	1	-	1
	- Antenna technical characteristics	1	-	1
	Interfering factors	2	1	1
	Shipborne radar construction	1	1	-
	Antenna and wave-guide track	2	-	2
	Transmitter	2	-	2
	Receiver	2	-	2
	Display	9	2	7
2.	Automatic radar plotting aid, auto tracking aid and electronic plotting aids:			
	ARPA, ATA and EPA functions	2	2	-
	Operation and data information principles	2	1	1
	Manoeuvre planning and play principle	2	1	1
	Main operation and technical characteristics	2	1	1
	Information processing and presentation	2	1	1
3.	Ship and Coastal Radar -tracking transponders (SART and RACON)	3	2	1
4.	Automatic Identification Systems (AIS)			
	AIS function, operation principles	1	1	-
	Transmitted data, modes, provided data	2	-	2
5.	Voyage Data Recorder (VDRs), Information system function, operation principle	2	2	-
6.	Electronic chart navigation information systems (ECDIS):			
	ECDIS operation principles:	2	1	1
	Provided information, tasks, information correction, coupling with information sensors, operation tests	4	1	3
7.	Navigational complexes Operation principle, complement and joint information processing, operation tests	2	1	1
8.	Technical operation of shipboard radars, ATA, EPA, ARPA, ECDIS, AIS, navigational complexes			
	Main stages of operation	1	1	-
	Main features of operation	9	1	8
	Total	64	24	40

6.1. Shipborne navigational radar

6.1.1. Shipborne radar functions.

Radar is intended for indication, in relation to the craft, of the position of other surface craft and obstructions and of buoys, shorelines and navigational marks in a manner, which will assist in navigation and in avoiding collisions.

According to operation principle all radar systems can be divided into active and passive. Active radar may be of continuous and pulse emission type, which can be sub-divided into active- and passive-response radar.

Passive-response system consists of an active radar, transmitting electromagnetic energy reflected from passive objects and returned to radar receiver. From the receiver terminal output signals go to the display and allow to define reflecting objects and their positions.

Active response systems also use active transmitter of electromagnetic signals to active objects, which have receiver, transmitter and controls. From the receiver electromagnetic energy is directed to control device. The control device gives command to the receiver to transmit response signal or several signals. Response signals go the radar receiver and display respectively. In this case it is possible to obtain both position and data for the object identification.

6.1.2. Pulse principle of radio location

The operation principle of shipborne pulse radar consists in pulsed transmission by the transmitter of electromagnetic energy, which is propagated in space and is reflected from radio location objects, returning to the radio receiver antenna. The received energy is transformed in the receiver and directed to the display in an appropriate form.

6.1.3. Radar general structure scheme

The most common radar system used by ships is passive response pulse radar (fig. 6.1).

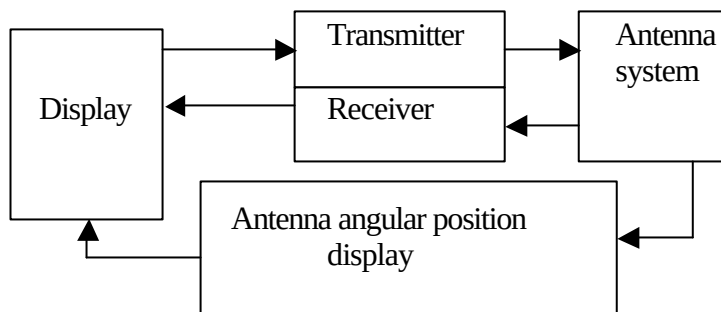


Fig. 6.1 Pulse radar general structure scheme

Transmitter consisting of modulator and ultra high frequency generator, is intended for generation of powerful short radio pulses of ultra high frequency.

Antenna system consisting of receiving antenna and transmitting antenna, antenna rotation device and wave guide track, is intended for transmission of ultra high frequency energy, switchover between receiving and transmitting antennas, receiving of ultra high frequency energy reflected from objects. Wave guide track of the antenna system is intended for transmission of ultra high energy.

The receiver transforms and amplifies reflected signals, transforms and effect preliminary processing of signals for the display.

Antenna angular position display is intended for antenna rotation angle data transmission to the display.

The display transforms signals from the receiver into visual appropriate image, forms additional navigational symbols, which allows operator to receive information effectively.

6.1.4. Range and Bearing measurement by shipborne radar

Radar bearing measurement principle consists in measuring maximum amplitude of a reflected signal while the antenna is slowly rotating. As the beam axis comes to object, the receiver exit voltage attains maximum. Antenna angular position value allows to obtain relative bearing to the object. The antenna position should be defined in relation to fore-and-aft plane of the ship. The antenna directivity diagram at this moment should be possibly sharp.

Range measurement principle consists in an accurate measurement of signal return time. Shipborne navigational radar forms image in the radar display. For a more accurate range measurement navigational symbols are used. Their values are transformed into a digital form and provided in a convenient form.

6.1.5. Radio location image formation on radar display

For object radio location, radar periodically radiates signals to a certain area. Reflected signals received are directed to display as they return from objects according to the range scale of the radar. Antenna, slowly rotating, scans objects. Display information is periodically changed while the antenna is scanning objects, and is shown in radial-circular form. Transmission source directly corresponds to the ship's position. Objects disposition is defined correspondingly by echo-signal return time, antenna angle, and return signal level. The objects are shown on the display proportionally to the range scale. While the antenna passes the fore-and-aft line of the ship heading display is formed on the display as well as electronic fixed range rings for object range assessment, electronic variable range marker for accurate range measurement, electronic bearing line – EBL for direction measurement an additional electronic elements for convenient information acquisition. Mechanical elements (bearing line, parallel lines etc.) can be used together with electronic elements for the operator's convenience. Information can be presented in different motion modes (true and relative motion) and orientation modes (course-up, north-up), the modes being formed by different data sensors. The radar provides interface with external navigation data sensors (log, compass, radio navigation transceiver, electronic navigational system etc.). Information can be presented in the form of both radar picture, and in digital form both on the display and digital displays. Radar

information can be used in analogue form directly from the display or processed by computer; it may have analogue and analogue-digital form. Radar picture may be monochromes or colored. Display is the most difficult radar device.

6.1.6. Radar operation characteristics

Main operation characteristics: maximum and minimum range scale, resolution, accuracy, scanning area and time, reliability, anti-clutter etc.

Maximum range performance is one of the main radar characteristics, which accounts for expected range of observed objects. Maximum range is described by the well-known main equation of radio location and depends on radar main parameters: transmitter power, receiver sensitivity, antenna amplifying coefficient, objects' features (material, size, form, aspect), substrate form and condition, antenna height etc. Equal conditions are selected for comparison of radars (Resolution MSC 64 (67) – normal conditions of wave propagation, antenna height – 15 meters, jam absence. Shore line of 60 m. height shall be identified at a distance of at least 20 nautical miles, while with 6 m. height – at least 7 nautical miles. Ships of 5000 grt shall be identified at minimum 7 nautical miles irrespective of their aspect. Smaller vessels of 10 m. length – at a distance of at least 3 nautical miles. Sea navigational buoy – at a distance of at least 2 nautical miles.)

Maximum range performance depends to a great extent on atmospheric and meteorological conditions, including attenuation in air oxygen and water steam, fog, rain, snow etc. Range performance also depends on substrate and earth surface curve.

Minimum range means minimum distance at which object detection is possible. Minimum range depends on probe pulse duration, time required by radar to restore sensitivity (including antenna switch over time), antenna elevation, directivity diagram width of vertical plane. PPI should clearly identify objects at a distance of 50 m.

Blind sector is the area where radar is unable to detect objects (depends on antenna elevation and directivity diagram width on vertical plane)

Shadow area is the area of radio location on horizontal plane with sectors of radio location shadow, depending on masts, funnel and other superstructures location on board.

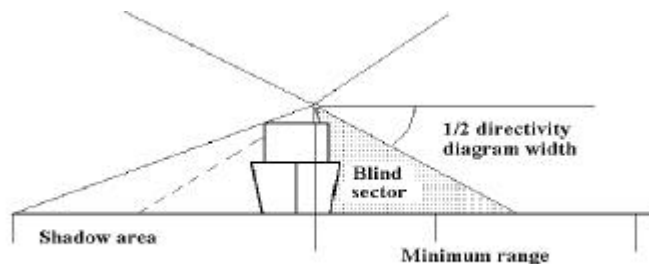


Fig. 6.2. Shadow, blind and minimum range areas

Every vessel should have a scheme of shadow areas, obtained by comparison of visual and radio location observation of surrounding objects. The scheme must indicate areas in radial-circular form where objects of radio location are not reflected on PPI.

Resolution is the ability of radar to discriminate separate targets. Resolution can be of two types: discrimination range and discrimination bearing.

Discrimination range depends on pulse duration, blip diameter on PPI and range to the target. Range scale should be selected so that target blips could be located half radius distance from the display edge, the distance between similar small targets being maximum 40 m.

Discrimination bearing depends on antenna directivity diagram width on horizontal plane, blip diameter on PPI. With 1.5 mile range scale and target half radius distance from the display range, the angle between similar small targets should not exceed 2.5. degrees, targets being identified separately. 3 cm. discrimination range is better than 10 cm. discrimination range.

Discrimination area is a sum of discrimination range and bearing. Discrimination area is the area where targets are identified separately.

Range accuracy is identified by measurement error. For modern radars it is 1 –1.5 per cent of the range scale selected. Accuracy depends on many factors: propagation conditions (rate), reflection center fluctuation, measuring device error, noise, resolution limitations, operator's eye limitations etc.

Bearing accuracy is the value of bearing measurement error. It depends on antenna directivity diagram, noise, instrumental error, accuracy of antenna rotation angle measurement etc. For modern radars the accuracy is 0.1-0.5 degrees for 3-cm range and 1.5-3 degrees for 10-cm range.

Observation sector and time (meaning visual scale, range scale, center shift, antenna elevation) depend on antenna rotation rate. Modern radars have antenna rotation rate of at least 20 revolutions per minute. For high speed vessels antenna rotation rate should be at least 40 revolutions per minute.

Radar reliability is the property of the radar to retain good operational condition within definite time. Reliability can be expressed quantitatively by time of operation without failure, average proper work time and failure frequency.

Anticlutter is the property of radar to retain its characteristics (radio location observation range) in conditions of interference. Anticlutter depends on power, intensity of side lobe elimination, receiver's dynamic range, field polarization of signals, specific statistical methods of signal processing, schemes of receiver protection.

6.1.7. Technical characteristics of shipborne radar

The radar main technical characteristics comprise technical characteristics of the transmitter, receiver, antenna and display.

Radar transmitter technical characteristics

Wave length of radio pulse (pulse filling frequency) is selected in accordance with designated bands for sea radio location purposes:

3.2 cm = 9.3-9.4. GHz (X-band);

10 cm = 3 GHz (S-band)

8 mm = 33 GHz (Ka-band)

Smaller bands provide greater location range, but in this case attenuation is increased due to energy loss. Ten-centimeter band has a better anticlutter as compared with 3-cm band (the best radar picture in fog and rain), while 3-cm band affords a clearer radar picture and better accuracy.

Pulse duration accounts for minimum detection range and discrimination range. A shorter pulse is used on smaller scales, the longer – on larger scales. Modern radars use pulse duration from 1 to 0.02 microseconds.

Pulse occurrence is selected in accordance with radiation quantity of an object which is connected with detection probability and depends on range scale selected. Radar's have pulse occurrence on different range scales from 400 to 4000 pulses per second.

Detection range is directly connected with pulse and average power of the transmitter. Pulse and average power is connected with pulse duration and occurrence. Pulse and average power relation is called off-duty factor. Power increase results in detection range increase. Power decrease requires proportional receiver sensitivity increase.

Radar receiver technical characteristics

Receiver technical characteristics: actual (threshold) and maximum sensitivity is connected with the ability of the receiver to detect a signal in noise. Actual sensitivity is minimum power of receiver's input at which output signal power relation to noise level equals discrimination coefficient. Discrimination coefficient shows by how many times signal level exceeds noise level. Maximum sensitivity is the sensitivity level at which relation of output signal power to noise power equals 1. Sensitivity increase causes detection range increase. Radar sensitivity is measured in decibels (in relation to reference value). Sensitivity is limited by the device own noise. Sensitivity of modern radars is 110-130 dB with reference of 1 Vt.

Receiver's transmission band is selected in accordance with pulse duration and occurrence, and it is connected with the receiver's noise level. Transmission band varies depending on the range scale chosen. Radar transmission band varies from one to tens MHz.

Dynamic signal range is characterized by level variation of signals coming to the receiver. It is 110-120 dB for shipboard radars.

Antenna technical characteristics

Technical characteristics of antenna are: directivity diagram features, antenna directivity (amplification) coefficient, side lobes elimination intensity, electromagnetic field polarity etc.

Directivity diagram form means radiation direction both horizontally and vertically. Directivity diagram is radiation lobe by form. Directivity diagram width vertically and horizontally is defined at half power level. For 3-cm range horizontal width of directivity diagram is from 0.1 to 1.5 degrees, for 10-cm range – from 1.2 to 3 degrees. Directivity diagram value is connected with antenna construction features and depends on antenna size. For 3-cm and 10 cm range vertical directivity diagram value is 20 degrees. This selection is governed by ship's roll and pitch and minimum detection range, vertical diagram directivity width for ships is 5-7 degrees.

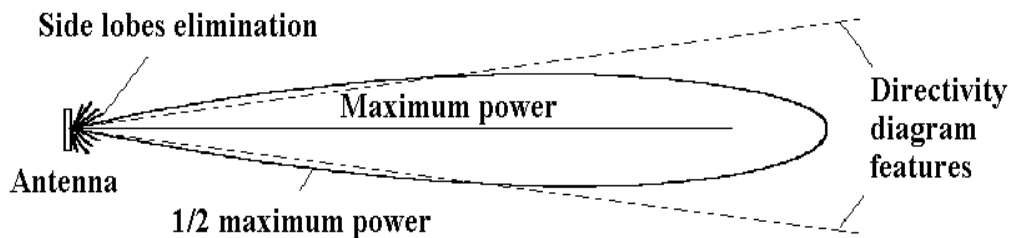


Fig. 6.3. Antenna directivity diagram

Antenna directivity (amplification) coefficient shows relation of maximum power to medium power.

Side lobes elimination intensity shows side lobe elimination intensity in relation to the main lobe power. Intensive side lobes elimination decreases negative effects of radiation and minimizes false signals. Side lobes elimination level is 20-30 dB of the main lobe level.

Electro magnetic field polarization shows direction vector of the field electric component. Use of electromagnetic field circular polarization reduces power refraction from rain.

6.1.8. Interfering factors

Radar performance and detection range are affected by both positive and negative factors. Positive factors are: normal refraction, super refraction in some conditions etc. Negative effects are: atmospheric factors (energy absorption and dispersion), earth curvature, agitated surface, false echoes form re-radiation, interference from other radars etc. Radar performance and detection range primarily depend on reflective properties of objects.

Reflective properties of objects is the property of objects to reflect electromagnetic energy. Reflection of electromagnetic energy depends on material's conductivity

(dielectric and magnetic permeability) of the object. Reflective properties of objects depends on scattering area. Essentially, scattering area is an assumed metal sheet with an area of an object. For example, scattering area of an angular reflector with a side of 43 m. corresponds to a metal sheet of about 149 square meters, Scattering area of a launch 4 meters high is 75 – 250 sq. m.; Scattering area of a medium size vessel 4-6 meters high is 12000-30000 sq. m.; scattering area of a large vessel 14-20 meters high is 30000-50000 sq. m.; scattering area of a man is 0,8 sq. m.

Atmospheric refraction

Normal atmospheric refraction is variation of linear propagation of electromagnetic energy. Linear propagation variation of electromagnetic energy results in a small increase of detection range. Detection range increase results from pressure, temperature and air humidity decrease at higher levels above sea. At the same time dielectric permeability is decreased, while electromagnetic energy group velocity is increased. Propagation velocity at higher levels becomes higher that at lower levels.

Energy propagation diagram lobe tends to move to the earth surface, while detection range increases. With normal refraction radar can detect objects by 15-30 per cent farther than in conditions of direct visibility in good weather. Normal refraction occurs in most of the cases, in tropical areas detection range can increase.

Sub refraction means decrease in detection range due to sharp fall of temperature and humidity at higher levels of atmosphere. This results in detection range reduction by 80-95 per cent as compared to direct visibility. This phenomenon occurs at northern latitudes and causes late detection.

Super refraction means alternation of normal and sub refraction. This alternation results in super distant VHF communication, and may cause false echoes in radio location. False echo occurs when there is a target in the conditions of super reflection. Echo from first pulse at a great distance comes tot the receiver together with the next pulse echo. This causes false echo on display, its range being divisible by pulse recurrence, but on display the false echo will be observed as a regular target (if there is no possibility to compare). To eliminate such effects, radar can transmit

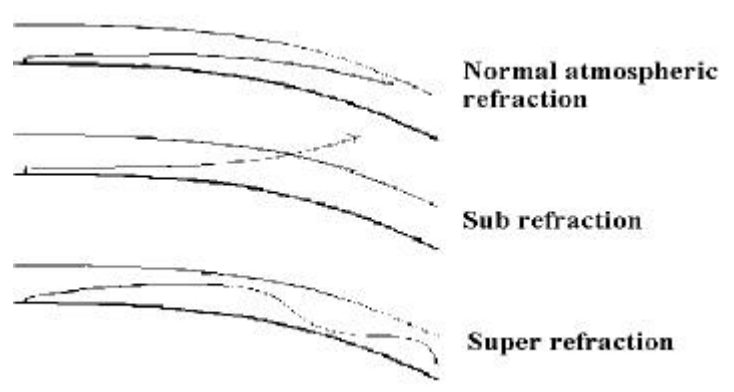


Fig. 6.4. Electro magnetic energy propagation in different conditions

probe pulses with different recurrence. On display close range targets (limited by range scale) will not change. The echo of a distant target will start moving proportionally to pulse recurrence. This will help to identify false echo. If such mode

is not provided, range scale can be changed, which will involve pulse recurrence change. Targets will change their positions proportionally to the range change, while false echo will change its position proportionally to pulse recurrence, i.e. not proportionally to the range scale.

Normal refraction – Pressure, temperature and humidity change with altitude. Dielectric permeability increases, while propagation velocity increases.

Sub reflection – caused by sharp temperature decrease at higher levels.

Super refraction – due to sharp humidity decrease.

Electro magnetic energy loss

Electro magnetic energy attenuation directly affects detection range. Power attenuation involves attenuation in oxygen, steam, water, rain, fog etc. Attenuation is described by diagram in dependence on atmospheric pressure, humidity, air temperature, wave length.

Absorption of energy means numerical reduction of energy, connected with resonance absorption of energy, used for obtaining expected detection range.

Energy dispersion means the process of energy reflection from different surfaces. This may be of mirror or diffusion character.

Dispersion of energy - process of a reflection of energy from various surfaces, which may be of as a mirror or diffuse (scattered) character.

Other factors, influencing radar-tracking image

Influence of a terrestrial surface (curvature of the Earth) - restriction of detection range owing to spherical character of the Earth or water surface. The detection range depends on antenna elevation and height of observed object. It is determined by the following formula.

Influence of the Earth curvature:

$$D_{\max(\text{km})} = 4.12 (\sqrt{h_1(\text{m})} + \sqrt{h_2(\text{m})})$$

$$D_{\max(\text{nm})} = 2.22 (\sqrt{h_1(\text{m})} + \sqrt{h_2(\text{m})})$$

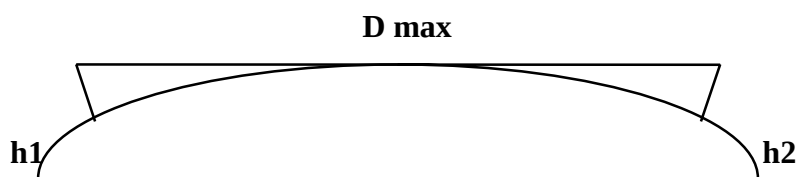


Fig. 6.5. Influence of the Earth curvature on detection range.

Influence of the excited surface - decrease of detection range of surface objects because of the excited marine surface. The excited marine surface creates elimination on a display in a near zone of observation. It effects to a courser extent detection of small close range objects with a small effective surface of dispersion. The phenomenon can be used for an evaluation of a condition of the transceiver. The table of expected distance elimination is used depending on magnitude of a wave

(with switched off suppression of interference at close range - button "waves"). For compensation of large signals in a nearby zone of observation in the receiver the linear-fractional performance of an amplification is changed.

During radar operation the fluctuations of a level of an echo - signal are observed depending on target range (intensity elimination of a disappearing vessel is changed in a wavelike manner). It is connected with summation of a linear signal reflected from water surface.

False echoes from re-emission of electromagnetic energy - mark on a display caused by echo-signals, occurring due to a reflection of energy from the close located objects. They can be caused by a reflection of energy from the adjacent targets, own masts, funnels. The "mirror" targets - target reflected on the display owing to a reflection of energy (radiation and / or echo-signal) from funnels, superstructures, large objects. They cause a "mirror" mark to marks of the target on the opposite part of the display.

Interference's from working radar - interference on the display in the form of eliminated, caused by hit on an input of a receiving device of probe signals from adjacent, working on close frequency from one or several radars. The radar receiver is most subject to these interference during use of a broad pass band (work with short pulses).

6.1.9. Shipborne radar structure

Shipborne radar consists of antenna, wave guide track, signal processing device and display.

Antenna wave guide track

The radar antenna systems are intended for a radiation of electromagnetic energy received from the radar transmitter and reception of electromagnetic energy reflected from target and transmission of radio signals to the receiver input.

The antenna systems together with the antenna rotary device perform scanning of space and allow to observe azimuth in specific limits. The antenna systems have a high directivity, broad pass band of frequencies (40-50 MHz), high suppression of side lobes (20-30 dB). They should be rather strong, to have a small mass, sizes and windage. Main performances characteristics of an antenna are a breadth of the directivity diagram in a horizontal and vertical plane, amplification factor, factor of operational directivity, input resistance, resistance of a radiation and losses, efficiency, frequency characteristic etc.

In ship radar, the horn and slot antennas in a combination with parabolic reflector are sometimes used and the slot antennas in a combination with horn are most widely used.

The horn antenna is the horn reflector, open from one extremity, radiating electromagnetic energy into space. The horn reflector forms the directivity diagram in a vertical plane.

The slot antenna is a slot transmitter, which forms the directivity diagram in a horizontal plane. The slot transmitter represents a wave guide of a rectangular cut sloping slots, cut on the narrow side. The declination of slots, size of slots, distance (span) from the closed extremity of a wave guide is calculated and influences the directional diagram. The slots are separated by metal partitions forming limiting wave guide filters, serving for suppression parasitic vertical component fields, that has an effect on suppression of additional lobes of the directivity diagram. The slot antenna, part of which is a horn, is covered with a dielectric plate for tightness.

The radar domes are intended for a diminution of a dynamic wind load on the antenna rotary device and antennas. It is a dielectric cylinder, inside which, as a rule, slot antenna rotates. The application of a radar dome is most actual on high-speed ships, where the wind load develops with high-speed component of a vessel.

The rotary device of a ship antenna ensures circular, uniform radar scanning on account of rotary and uniform motion of an antenna.

Radar wave guide ensures channeling of high-frequency energy between an antenna, receiving and transmitting device. The high-frequency energy of the transmitter is transmitted to an antenna, the part of energy is transmitted to a receiving device for operation of a system of automatic tuning of frequency, while the received energy from an antenna goes to the receiver. Wave guides ensure antenna receive/transmit switch over, protection of the receiver from energy of the transmitter, merging of frequencies. Coaxial cables, rectangular and elliptic wave guide section are used for high energy transmission by radar.

The coaxial cable is used in ten centimeter range and has restriction on magnitude of a transmitted energy. The transmitted energy is limited by a dielectric permeability of a used dielectric. An external diameter of a coaxial cable, diameter of conductive thread, damping and wave resistance are designed in accordance with magnitude of a transmitted power.

The rectangular wave guide is a wave guide of a rectangular section, which is used for a ten-centimeter range and less. It allows to transmit higher power than coaxial cable, and has smaller damping, but is critical to a wavelength. The breadth of a narrow and broad wall of a wave guide is connected with a transmitted power and wave length respectively. For a connection with different sections of a rectangular wave guide, a special choke-flange junction is required.

The elliptic wave guide most frequently is applied in sophisticated radar and is convenient for laying wave track lines on a vessel. It has larger damping in comparison with rectangular. It allows to ensure smooth curving and lessens the dependence on vibration.

Elements of wave guide lines - elements, from which the line from an installation site of the transceiver up to an antenna consists. The power loss of wave guide line develops of power losses of each element of a path. Factor of a combination of majority of sections is approximately 0,92 - 0,95. Factor of a progressive waves, taking into account an incident and reflected power, is also - 0,95.

The transmitter

The transmitter is intended for shaping high-frequency pulses of the certain power with specific frequency and off-duty factor of pulses.

The transmitter works on one carrier frequency, has large output power, very short pulse duration.

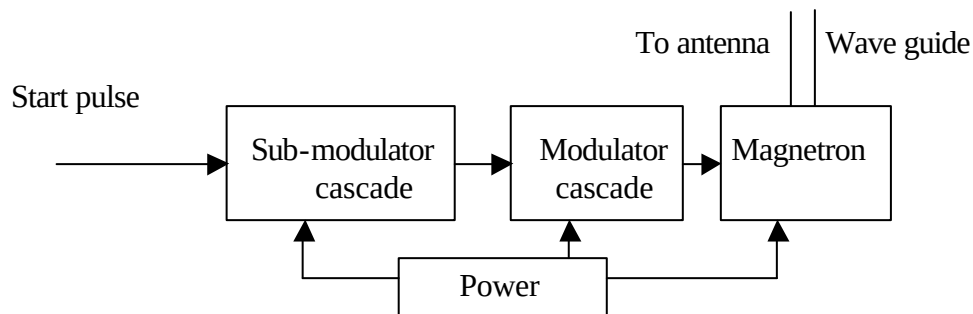


Fig. 6.6. The generalized block scheme of the radar transmitter.

The starting pulse is formed in synchronizing device, where in accordance with a selected range scale the pulses of the certain frequency of a recurring are produced. The synchronizer structurally can be placed both in the display device, and in the transceiver. The pulse produced by the synchronizer, goes to the block of the modulator of the transmitter, which consists of sub-modulator and modulator cascade. Sub-modulator cascade forms pulse duration in accordance with a selected range scale. Modulator cascade forms super high frequency amplitude of pulse sufficient for work of the generator. The main device of the transceiver is the generator of super high frequency, which during an operation of pulse, generated high-frequency oscillation. Magnetron is used as the generator of high-frequency oscillation. For maintenance of serviceability of cascades of the transmitter, the power supply unit producing necessary feeding voltages is used.

The magnetron is a two-electrode vacuum high-power generating device with a self-excitation and with electromagnetic management, it is intended for generation of microwave energy.

The principle of an operation of a magnetron is based on excitation between the anode and cathode of an electrical stream under effect of an electrical and external magnetic field in mutual perpendicular planners.

The scheme of inclusion of a magnetron has super high-frequency, anode and incandescent circuit. The cooling of a magnetron is carried out the by radiator ventilation by a ventilator.

The pulse modulators are intended for management of oscillations of a magnetron. The principle of operation is based on slow build up of energy in a special accumulator in gap between pulses with consequent, fast return of energy load to the modulator (magnetron). The time appropriate to a return of energy is equal to pulse duration. In radar transmitters various schemes of modulators are used.

The magnetic pulse modulators use nonlinear inductance (special ferromagnetic core), permitting to receive a rectangular closed loop of a hysteresis. The terristor-magnetic circuits (schemes) of the modulator with terristor on an input (entrance), with terristor in the first cascade of compression (sequential circuit), with terristor in the first cascade of compression (parallel circuit), terristor-magnetic circuit of the pulse modulator of different duration are applied.

The receiver

The radar receiving device is intended for transformation of high-frequency energy echo-signals in electrical video pulses coming to the display system.

Features of a radar receiver are high sensitivity, broad pass band, large dynamic range, small time of restoring of sensitivity, fixed set-up, high noise stability (Auto Gain).

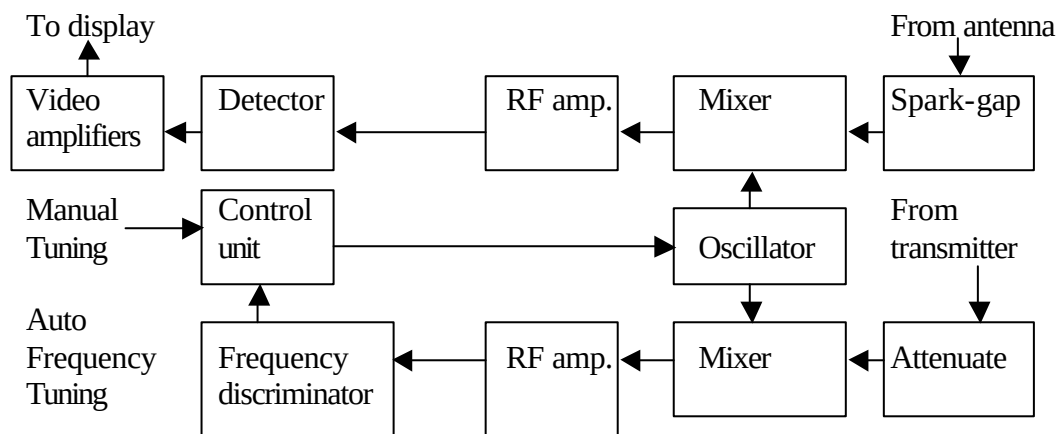


Fig. 6.7. The generalized structurally functional scheme of the receiver

The echo - signal from an antenna through the antenna switch goes to the discharger of the receiver protector, which prevents hit on an entrance of the receiver of the transmitter energy. The high-frequency energy merges with frequency oscillator, which is set up by the Automatic frequency tuning scheme AFT. The difference frequency amplifies by the intermediate frequency amplifier and is detected. The video signal amplifies up to a level necessary for normal work of the display. The circuit of automatic tuning of frequency compares oscillator frequency with frequency of the transmitter and produces control voltage proportional to difference value of intermediate frequency. The produced voltage controls oscillator set-up automatically. The search, lock and deduction of frequency modes are provided. The manual tuning of frequency is provided in super oscillator scheme of the receiver.

The frequency transducer is the input cascade of the receiver and consists of the mixer and oscillator. The mixers consist of mixing chamber and mixing diode. Balanced mixers on double T-shape bridge, ring allocators, ring bridges of wave guide type are used as mixing chambers. Point-contact diodes and diodes with a Schottky barrier are used as mixing diodes. Mixing diodes are very sensitive to overloading.

Oscillators ensure frequency transformation, have a possibility of frequency control by an electronic method. Semiconductor oscillator contain an oscillatory system as a resonator. Diodes and Gunn diodes (diode with volumetric effect) are used. For electronic reorganization the varicaps are used, which capacity is changed with displacement voltage variation.

The intermediate frequency amplifiers (IFA) are intended for a main amplification of an echo - signal and are characterized: by magnitude of intermediate frequency, pass band, amplification factor, efficiency, time of restoring of sensitivity, stability of parameters, stability, reliability of work etc. Intermediate frequency amplifiers can be preliminary, main and adjustable. Broadband aperiodic circuits (schemes) on the basis of differential amplifiers are used as main IFA. Adjustable IFA allow to realize specific performance of an amplification. Radar scale switch over results in necessity of switching of a pass band, which is changed depending on duration of probe pulse.

The video amplifiers are broadband amplifiers with the lower boundary frequency close to zero.

The automatic tuning of frequency (AFT) is intended for retaining of a constant intermediate frequency, which is caused by instability of feeding voltages, modification of elements parameters, modification of a load of a magnetron, assymetry in gyratings junctions of wave guide path etc. The manual and automatic tuning of frequency is provided. We distinguish a difference and absolute system AFT. The one-channel and two-channel schemes are used. In the one-channel scheme one channel both for an amplification, and for tuning of frequency is used. In the two-channel scheme the sepacourse channels are provided. Mixer, intermediate frequency amplifier, frequency discriminator, controlling device are included into two-channel scheme. The controlling device can be divided into preset (tracking) and search type. Preset scheme performs automatic tuning in more broad limits. The controlling device depending on type, ensures operational modes of search, acquisition and retaining of frequency.

Features of automatic amplification adjustment.

The radar receiver should ensure a reception in a broad dynamic range, compensating variation of reflected signals level depending on time and range. For this purpose schemes of logarithmic amplifiers and temporary automatic adjustment of amplification. Automatic adjustment of amplification forms voltage amplification performance proportionally to square time and range. Amplification is made simultaneously with a radiation of sounding pulses. The amplification consists of rectangular and exponential component. Rectangular component in addition closes an amplification of the receiver for the time of probe pulse. Exponential component smoothly increases an amplification of the receiver in time. The large signal on input of the receiver from small object at a small range is reflected practically in the same way as a small signal from large object at a great distance.

The logarithmic amplifiers are intended for slacking interference from a marine surface and own noise of the receiver. Linearly - logarithmic performances of an amplification are applied both in intermediate frequency amplifiers, and in video amplifiers.

The circuits of a small constant of time (rain) are intended for reduction of pulse interference of longer duration. They are an adjustable differentiating circuit, which is installed after the video amplifier. The elimination of pulse interference ensures suppression of interference from a rain, fog and other meteorological factors. Besides “rain” allows to increase range discrimination by peaking of pulses from objects.

The special processing of radar-tracking signals in receivers is intended to realize special methods by appropriate signal processing.

Special circuits improving quality of an received signal are used. The statistical processing of a signal - special methods and circuits (scheme) permitting is widely applied to improve quality of a signal by accumulation of information. A variety of statistical processing is the correlation method - method permitting to select a signal from under an exceeding level of interference.

The display

The plan position displays (PPI) are intended for submission of video signal in a convenient form, shaping overhead information. According to the principle of operation, there can be displays with a mobile deflection field, displays with a fixed deflection field, displays with digital scanning, displays of computer (raster, television) type.

Radially - circular display on the display in polar coordinates is formed by transition of a beam of an electron-beam tube from center to an edge of a display with simultaneous its rotation in an azimuth plane. For each period of pulse the beam from the center of a handset draws a line of range scanning and returns back. The signal, reflected from the target, after processing by a receiving device modulates a beam and is registered on a line of scanning as a eliminated mark. The distance (span) from center of scanning to registered point corresponds to distance to object. Turn angle of an antenna and accordingly declination of a line of scanning corresponds to an angular coordinate.

Image control modes

In radar and ARPA use the following kinds of image orientation on a display:

- Orientation Course-up;
- Orientation North-up;
- Stabilization of an image with various kinds of orientation - stabilized display.

Course-up implies a synchronization of scan rotation with rotation of an antenna. The antenna and display are installed in parallel of diametrical plane of a vessel. When antenna is passing through a diametrical line (or parallel to it) on the display, the electronic mark appropriate to the vessel's speed is formed. At the same time, the targets on a certain visual bearing correspond to an electronic bearing on the display.

North-up display implies a turn of an image on a course angle. The value of a course angle is entered manually or automatically from course detector. During the turn of a vessel the image turns and course mark corresponds to current course detector data.

The stabilization of an image with various kinds of orientation stabilized display is intended for an elimination of influence of a yaw of a vessel during small speed variations. The turn of an image on the display is made during stable turn of a vessel.

Relative and true motion modes

Relative motion mode, with which the mark of the vessel is in the center of the display (or is displaced in relation to the center for not more than $2/3$ radius of the display) without motion. During movement of a vessel all targets are reflected on the display proportionally to an image scale.

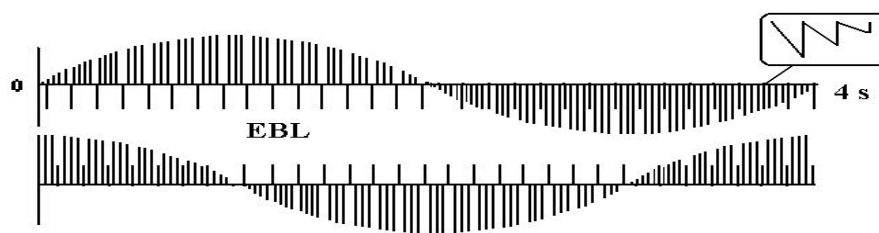
True motion implies movement of the mark of a vessel on a display proportionally to the vessel's speed in the course direction according to the image scale. Course and speed are entered manually or automatically from course detector and speed detector. During the vessel's movement coastal line will be in this case motionless, and mark of an own vessel will move on the display. The automatic return of a mark of the own vessel is provided when it is closing the display edge.

The display with a fixed deflection field

The display systems with a fixed deflection field implements main operational modes of the display system, and are constructed on the principle of shaping radial and circular scanning with the help of synchronous and in-phase turning of the magnetic field created by deflection the field, which is located on the port of an electron-beam tube.

Structure of the display includes antenna communication path, true motion path, temporary synchronization path, temporary scanning path, electron-beam tube with a deflection field, path of shaping of mobile range marks, path of shaping of fixed range marks, range and bearing data units, video signal mixer, eliminates adjustment unit. In addition structure of the display system can include automatic range and bearing detection paths.

The principle of scan shaping consists in formation of sawtooth voltages (currents) components of beam movement on the display of an electron-beam tube. Amplitude of sawtooth voltages is modulated by sine and cosine component of the antenna rotation. Full period of sine and cosine component are derivated by full period of antenna turn. The amount of pulses of sawtooth voltages (currents) corresponds to the amount of radar pulses. The scan pulses are synchronized with probe pulses.



Pulses of scan

Scan pulses

Fig.6.8. A principle of shaping of display scan with a fixed deflection field.

The principle of shaping of an electronic direction finding system consists in variable work of pulses of scan and pulses of an electronic direction finder. At a definite time the synchronized pulses of an electronic direction finder send a beam CRT to EBL. The modification of a direction EBL on a display is made by a proportional modification of sawtooth component voltages (currents) of EBL beam control.

The principle of shaping of a mark Heading indication consists in illumination of a beam of push stroke of scan, during the passage of a rotating antenna through a diametrical plane of a vessel. At the same time the control voltage is supplied to the videomixer causing full or partial eliminated of heading line. With north-up mode the course mark is shifted by compass angle, by which the information coming from the receiver "is shifted" also.

The principle of shaping of fixed range marks (rings) consists in shaping equidistant from probe pulse of a series of pulses, the pause between which is identical. The pulses passing through the videomixer, come to CRT and will derived with each pass of a beam of scan illumination, permitting to graduate the display into equidistant circular rings. The amount of rings and their appearance can be changed in various radar.

The principle of shaping of a mobile range mark (ring) consists in shaping delayed on time by various methods of a mark, both during an operation of main scan, and during scan EBL. The delay factor is adjusted by an operator and corresponds to distance to the target.

The principle of shaping of a digital, character and graphic information on a display consists in creation on a display CRT radial and circular scan and scan of a raster type alternately. The raster scan is used for formation of numerals, figures, elements of a cartographical information. The frequent change of scans on CRT display creates a joint image, similar to EBL.

The display with a rotating magnetic system

The display with a rotating magnetic system performs main operational modes of the display system and the deflection fields on a port of an electron-beam tube and is constructed on a principle of shaping radial and circular scan with the help of turning synchronously and in-phase. The principle of an operation is similar to the display system of a fixed deflection field. The pulses of scan are not modulated by sine and cosine component of antenna rotation. The turn of an image with turn of an antenna is made by a turn of all deflection field. During the use of a mobile deflection field the displacement of scan, true motion and EBL is not made.

The display with digital scan

The display with digital scan performs all main operational modes of the display system and is constructed on a principle of shaping linear and graduated transition of a beam as a step-function. The value of discrete transition is less than the diameter of a focusing spot. Radially - circular scan is perceived as fixed. The step-function is formed by an built up of two digital sawtooth functions with a steepness of increase, proportional to sine and cosine of a turn angle of radial and circular scan.

The display of (raster) computer type

The display systems of (raster) computer type perform all main operational modes of the display system and are constructed on a principle of image generation in memory of the computer. All processes are executed in a digital kind and are implemented by program - algorithmic methods.

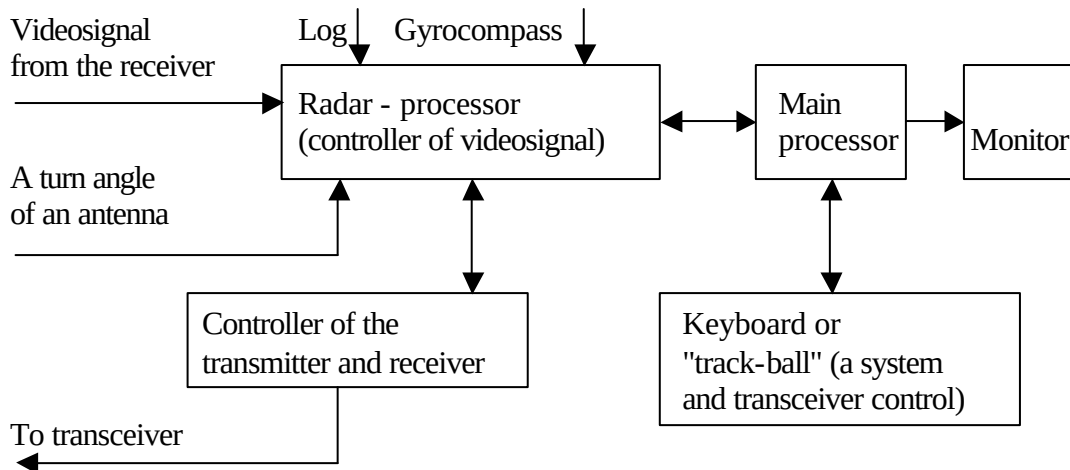


Fig. 6.9. The generalized block scheme of the display of (raster) computer type.

The display of (raster) computer type consists of the radar - processor, main processor, display monitor, the transmitter and receiver controller, control unit of the system.

The radar - processor executes primary processing of a signal, transformation of an analog signal of the receiver to the digital form, processing of a digital information about the targets, transfer of an information about the targets to the main processor, receives information from the antenna-rotary device, course detector and speed detector and its preliminary preprocessing, executes a number of other tasks.

The main processor receives information from the radar - processor, transforms polar coordinates of the target to the cartesian coordinates, processes commands, executes navigational calculations (ARPA function), forms information for transfer to the display monitor, dispatches processes, controls the system operation and can execute a number of the tasks. The display monitor displays information on CRT.

The transmitter and receiver controller forms, transmits and receives commands between the computing system and transceiver.

The system control unit allows an operator to control the radar-tracking system, including the antenna-rotary device, transceiver, radar processor and main processor.

Depending on concrete realization structure and the functions of sepacourse blocks can be incorpocoursed or divided.

The interface to speed add heading information gauges can be made of an analog and digital kind. In concrete radar types various kinds of radar interface for various kinds of devices are used.

The power supplies of systems (devices), which are included in radar, ensure feed of blocks with various voltages, including starting regulator procedure, stabilization of voltage and protection of blocks with feeding from ship sources of voltage of various nominal value.

6.2. Automatic radar plotting aids, automatic tracking aids and electronic plotting aids

Automatic radar plotting aid (ARPA)

Automatic radar plotting aid is a radiolocation computer system, in which navigational problems solution, dealt with by deck officer, operating radar, is automated. ARPA is intended for automated deriving of information for solution of a navigational problem with many targets and maintenance to a continuous, accurate, fast evaluation of a situation. The following operations are executed in accordance with objectives:

- Detection of the targets;
- Target acquisition and tracking;
- Positioning;
- Determination of motion parameters and smoothing of coordinates;
- Assessment of point of approach;
- Evaluation of a meeting situation;
- Planning of a passing manoeuvre;
- Information display.

Automatic tracking aids (ATA)

Automatic tracking aid (ATA) is intended for automated deriving of an information for solution of a navigational problem with many targets and maintenance of a continuous, accurate, fast evaluation of a situation. The following operations are executed in accordance with objectives:

- Detection of the targets;
- Target lock-on and tracking;
- Positioning;
- Determination of motion parameters and smoothing of coordinates
- Assessment of meeting parameters;
- Evaluation of a meeting situation
- Information display.

Electronic plotting aids (EPA)

Electronic plotting aid (EPA) is intended for manual plotting of coordinates of the targets for maintenance of an accurate, fast evaluation of a situation. The following operations are executed in accordance with objectives

- Measurement of coordinates;
- Determination of motion parameters and coordinates of the targets;
- Information display

Depending on displacement vessels should be equipped with various means of radio electronic plotting. Depending on functions the realization of radio electronic plotting can be executed as the additional system to radar or as the combined system on display with a fixed deflection field or display of computer (raster) type.

Principles of operation and information processing

In accordance with the international recommendations, operational requirements determine a velocity of the target and their number in automatic and manual target acquisition and tracking, necessary range scales, image control modes, motion modes, submission of an information in the vectorial and graphic form, time of a dumping of a processed information, time of motion parameters evaluation, reason of operation of the alert system. These recommendations differ for electronic plotting aid (EPA), auto tracking aid (ATA), automatic radar plotting aids (ARPA).

The display of radiolocation (primary) information in various types of radio electronic plotting has priority before an evaluated and displayed information.

Target detection and classification is the process of selection of a useful signal at a level of interference and can be completely automatized (« automatic acquisition») or is not automatized (« manual lock-on») The concept " a criterion of detection " is applied for selection of a signal which corresponds to the number of adjacent images (detection) of the target with adjacent turnovers of an antenna. Accordingly " the criterion of a dumping " determines the number failure to appear of a target with adjacent turnovers of an antenna.

For a classification of the marine targets and elimination of coastal feature auto tracking we distinguish the dot and extended targets.

The determination of coordinates of the target is completely automatic, and for each auto followed target on each the review of an antenna receive a pair of readout of coordinates of distance and direction on the target.

The determination of target motion parameters is completely automatic, the current coordinates of the targets range and bearing being produced. The current coordinates are produced by statistical average (smoothing of readout of a distance and direction). As a result the coordinates error decreases. The smoothing - average is made with allowance for movements of the own vessel. The special recurrent algorithm (filter) is applied to smoothing.

Recurrent - the sequential algorithm consists in deriving of a pair of readout of range and bearing on the target, which are stored. During consequent receipt of the following pair they are averaged and the result is again stored, the following pair averages with an earlier obtained average result.

With recurrent smoothing it is not required to have a large memory volume, and the result with the necessary exactitude will be achieved in a short period.

The motion parameters are produced under two adjacent coordinates readings and are also smoothed out.

The operation motion determination and smoothing of coordinates is executed during auto tracking of the target, also called coordination of trajectories of the targets. Coordination of a trajectory of the target - procedure verifying the fact of belonging of the given target of the next pair of readout of coordinates. The auto tracking is carried out with the help of strobe of auto track (? T) set up on the target mark. If the

following mark hits in this strobe (certain sizes), it is recognized as belonging to this target.

Automatic and manual targets acquisition.

The automatic acquisition consists in primary set up of a strobe ? T automatically.

The manual acquisition on ? T consists in primary set up of a strobe ? T manually.

We distinguish automatic and semi-automatic tracking of the target. The semi-automatic tracking implies assessment of motion of the target elements on indicated by an operator coordinates.

The meting parameters operation is completely automatic and is aimed at obtaining of parameters of position of closest approach and time of position of the closest approach. The evaluation of a situation of meeting is automatic check of exceeding factor of range and time of the closest position of approach above allowable parameters, which are beforehand selected by an operator and entered in ARPA. For each target the data card is produced:

- Present range and bearing of the target;
- Calculated true course and speed of the target;
- Distance and time of the closest approach (???, ????).

Function of planning and playing of a manoeuvre

In ARPA the problem of planning of a manoeuvre is made on the basis of parameters of a manoeuvre (course of a prospective manoeuvre, speed of a prospective manoeuvre and delay of time of performance of a manoeuvre), which are selected by an operator on the basis of data received from ARPA. The operation of playing or imitation of a manoeuvre allows to help operator in an evaluation of quality of a manoeuvre, selected by him. Playings of a manoeuvre consists of input selected intuitively by operator of a course of a prospective manoeuvre, velocities of a prospective manoeuvre and delay time of a manoeuvre performance and includes the objective of playing. The computing system predicts a situation in an ac select coursed time scale (dynamic playing) or – for the moment of the manoeuvre termination (static playing) in the conditions of:

- Only own vessel manoeuvre;
- In the prognosis average manoeuvrable elements of the vessel are used, which are entered in ARPA during the installation on the vessel.
- Main operational and technical characteristics
Main characteristics accordingly for radar:
 - for vessels of displacement from 150 up to 1000 register tons - effective display diameter should be not less than 180 mm.;
 - For vessels of displacement from 1000 up to 10000 register tons the effective display diameter should be not less than 250 mm.;
 - For vessels of displacement from 10000 ? and more register tons the effective display diameter should be not less than 340 mm.

- Mandatory range scales should be used: 0.25; 0.5; 0.75; 1.5; 3; 6; 12; 24 nautical miles.
- The priority of a radiolocation image before a system electronic navigational chart should be observed.
- The manual input of a velocity with an exactitude not less than 0.2 knots should be provided.

ARPA should ensure:

- Auto detect of the targets.
- Manual and automatic acquisition not less than 20 targets.
- Auto tracking of the targets with velocities up to 100 knots.
- Range scales: 3; 6; 12 nautical miles.
- To have interface with log and gyro-compass.
- There should not be more than 12 parameters on display.
- The playing of a manoeuvre should happen with account for manoeuvring characteristics of the own vessel.

ATA should ensure:

- Manual acquisition and auto tracking of not less than 10 targets.
- Auto tracking of the targets with velocities up to 100 knots.
- Range scales: 3; 6; 12 nautical miles.
- To have interface with log and gyro-compass.
- To have built-in monitoring of serviceability with the help of tests with indication.

EPA should ensure:

- Manual acquisition and auto tracking of not less than 10 targets.
- Auto tracking of the targets with velocities up to 75 knots.
- Range scales: 3; 6; 12 nautical miles.
- Interface to a gyro-compass.
- Availability of the data card for each target and number of the plotting point.

Specific Features of processing and submission of information

The evaluation of a situation in modern electronic plotting aid (EPA), auto tracking aid (ATA), automatic radar plotting aids (ARPAs) can be supplemented by a number of additional functions (automatic depth monitoring, with use of a system electronic chart, off-heading alarm, serviceability monitoring etc.).

The overlapping of a radar information with elements of an electronic chart allows additionally to show on display fragments of a navigational electronic chart for a possibility of overlapping with a radar image. The priority to a radar image is given. In case of differences the system electronic navigational chart is guided and is scaled at a course of a used range scale.

The availability of the computing system allows to make recalculation of geographical coordinates of a vessel for the indicated known point of a shore and to conduct recording of a vessel on the basis of the information about the ship's speed and course. As additional navigational problems the navigation in a radar fairway with signaling about points of turn and dangers and other problems is made.

6.3. Ship and coastal radar-tracking transponders (SART and RACON)

The ship and coastal radar transponders are intended for determination of objects location by signaling, which on radar-display will be represented by a series of points. The ship radar- transponders SART and coastal radar-transponder beacon RACON are distinguished. The coastal RACONs are installed on beacons, obstructions, and they differ by level of an emitted power on radar-tracking beacons - transponders of long, medium and short range.

The coastal and ship radar transponders work on a principle “ request – answer-back” and consist of an antenna, broadband receiver, transmitter and control unit. The signals, received by the transponder, are amplified and after appropriate transformation are transmitted by the transmitter of the transponder. The delay time of answer-back signals varies and can be in limits from fractions up to tens milliseconds.

The antenna is a undirected antenna with the circular or sector directivity diagram ensuring reception and transfer of high-frequency signals from any direction. The broadband receiver ensures reception of radar signals in a range 9,2 - 9,5 GHz. The control unit ensures operation of the transmitter in minimum possible time. The transmitting system of the coastal radar transponder radiates high frequency in the indicated range. The frequency of signals is coded by an pulse signal or Morse code for identification. On display of the receiving radar, an answer-back signal code combination or Morse code as discontinuous illumination on a bearing of deriving of a signal is highlighted. Each turn-over of an antenna repeats elimination on a display.

The transmitting system of the ship radar transponder ensures a radiation of high frequency in a broad band by means of a hunt effect of frequency. On display of the receiving radar an answer-back signal radar twelve points elimination on a bearing of deriving of a signal are highlighted. Each turn-over of an antenna repeats illumination on a display. As the vessel comes closer to the working radar transponder points on display will be transformed into 12 arcs due to operation from side lobes of a radiation of an antenna.

The radar transponder is installed on all vessels of displacement more than 300 register tons. On vessels of more than 500 register tons at least two radar transponders should be installed. When radar transponder is located at height of one meter above a sea level it ensures a reception of signals on a vessel with height of antenna installation of not less than 15 meters at a distance of not less than 5 miles. On aircraft radar on height of 1 kilometer the reception of signals of the radar transponder at a distance of not less than 30 nautical miles is ensured. Ship or aircraft radar should have a pulse power of not less than 10 kW.

All ship SAR transponders should:

- be capable of manual activation and deactivation;
- withstand drop into water from height of 20 meters;
- have of manual on-off controls;
- provide indication of the standby condition;
- have buoyant line for towing;
- be bright yellow or orange colors;

- have maintenance instruction;
- have the battery expiry date.

The power supply elements should ensure operation in the standby condition for not less than 96 hours and consequent 8 hours for transmission.

It is planned to use on ships the radar transponder of a 10-centimeter range, the principle of which work is similar.

6.4. Automatic identification systems AIS

AIS is intended for increase of safety of navigation, environment protection, efficiency of traffic control systems by means of fulfillment of the following functions:

- In a mode a vessel - vessel - for collision avoidance;
- As a means for deriving of appropriate information about a vessel and cargo;
- As the constituent of a traffic control - in a mode a vessel - shore.

AIS should provide ships and competent services with information from ships automatically, with a required accuracy and discretization, and also to increase efficiency of ships tracking. The data exchange should be carried out with minimum participation of ship's personnel and with a high level of reliability.

AIS ensures work in the following modes:

- Independent (autonomous) and constant - for work in all regions;
- Designated- for work in regions, where the traffic is inspected by competent services;
- By the request - the data is transmitted if requested from a vessel or from appropriate services.
- Structure of the system:
- The processor which is capable of controlling a number of marine frequencies;
- The processing device of data from a positioning system;
- The device ensuring data input from various sources of an information;
- The device for input and updating of dates manually;
- The device of monitoring of reliability of transmitted and received data;
- The built-in system of monitoring of serviceability.

AIS should be capable

- To transmit automatically and constantly information to competent services and other ships without participation of ship's personnel;
- To receive and to process information from other sources, including information from other ships;
- To answer signals relating to distress, safety and other categories with minimum possible delay;
- To provide information about a location and manoeuvring with appropriate intensity for ensuring tracking by competent services and other ships.

The information update time for a various mode differs and varies from several seconds to several hours. AIS ensures processing minimum 2000 messages per one minute in any mode. The prevention of a possibility of unauthorized access to an entering and transmitted information is ensured. AIS and the appropriate gauges are

powered from main and from alternative sources. Coastal, ship and stationary AIS transponders can be distinguished according to functions.

6.5. VDRs - Voyage Data Recorders

This is the system ensuring on a vessel continuous automatic registration of device readings and systems, commands with a possibility of determination of date and time of registration.

For maintenance of reliability of information preservation, the information carrier is in a special container. The possibility of registration is provided during failure. For a correctness of data the correction protection is provided. The detection system of voyage data recorder included in structure of the system helps to simplify a procedure of search of the information carrier in case of distress or foundering of the ship.

The system registers the information including:

- Date and time on UTS from an external source;
- Breadth and longitude from receiver of a radio navigational system with the indication of a type and operational mode;
- Course of a vessel from a gyro-compass or magnetic compass;
- Velocity from log with the indication of a method of a measurement;
- Voice communications, commands and sound signals;
- VHF radio communications;
- Radar information in an oblate form (radar condition and information);
- Depth with the indication of a scale and operational mode;
- Alert signals;
- Commands in the control machine and their fulfillment;
- Commands to steering system and their fulfillment (including tractors);
- Condition of overboard holes of a vessel (coming to the bridge);
- Condition of water- and fire-tight doors;
- Acceleration and voltage of the vessel 's hull;
- Velocity and direction of wind (if appropriate gauges are available).

The registration and storage of information is made in memory for preceding 12 hours of a voyage. In a system the registration of attempts of unauthorized interference and condition – alert signal is provided in case of detection of an incorrigible error during registration.

The system is powered from the ship's net and in case of blackout the automatic transition to own batteries is provided which should ensure serviceability during two hours.

The system or floating system of memory, is in watertight tank, and should withstand immersion up to depth of 3000 m.

The information to a system comes by the standard interface RS422, the format of information is determined in accordance with IEC 1162.

6.6. ECDIS - electronic chart display and information system

The electronic chart display and information systems are intended for display of a cartographical information, current place and tracks, preliminary plotting of a route and solution of additional tasks with use of a cartographical information.

ECDIS allows to conduct:

- Automatic change of charts in case of movement of a vessel with choice of appropriate scale charts;
- Information display in true and relative motion modes;
- Perform course-up and north-up orientation with symbols orientation change;
- Orientations of symbols;
- Determination of a current coordinate of position by recording and radio navigational system;
- Overlapping of a radar and cartographical image;
- Precomputation of navigational data;
- Error corrections;
- Chart correction;
- Playing of a manoeuvre;
- Display of help information;
- Automatic evaluation of a situation with the appropriate signaling system.

The principles of ECDIS construction are based on possibilities of modern computing systems. ECDIS is a computer with the special software. To a great extent the ECDIS is a computer program, implementing majority of functions, which can be used by a paper chart. According to the number of details and automation degree we distinguish ECDIS, electronic cartographical systems ECS and charts of navigational instruments. By the form submissions of a cartographical information in memory we distinguish the vectorial, raster and combined charts. The cartographical information has standards. The cartographical systems can support various standards of a cartographical information.

The information updating consists in replacement of a cartographical information partially or completely by a duplication of an out-of-date chart. Adding and the modification of a cartographical information is made manually with the help of programs of the editors, duplication of a part of an information in memory and by a replacement of all information by means of various carriers (cartridges, flexible and hard disks etc.)

The interface to gauges of an information is made through the interface of the computer or special controllers in a digital and analog form for deriving current values of navigational parameters. ECDIS allow to make information interchange with other electro, radio, navigational and appropriate instruments.

6.7. Navigational complexes

The navigational complexes (NC) are a complex of navigational instruments and systems intended for collection and processing to a navigational information from independent (autonomous) navigation aids.

Mandatory component of a navigational complex are:

- Satellite receiver or hyperbolic radio navigational systems;

- Two-dimensional log for reckoning of distance run;
- Automatic radar plotting aids.

The navigational complex ensures a minimum exactitude of a fix: it is not worse than four percent from a distance to the nearest obstruction, but less than 4 miles.

The complex executes the following functions:

- Continuous fix of a place in coastal regions and high sea;
- Automatic plotting on the vessel's navigational chart;
- Autonomous work of navigational instruments in case of NC failure;
- Automatic input of an information from other navigational equipment;
- Data transfer in other systems.

It provides:

- Signals permitting use of information from navigational equipment for equipment operation control;
- Main control panel;
- Signaling system of a regularity of work of main knots and correctness of navigational problems solution;
- Protect NC from logic errors of the navigation officer during input of data into the complex.
- Built-in testing system for control of each system trouble alarm.

6.8. Technical operation ship RADAR, EPA, ATA, ARPA, ECDIS, SART, AIS, NC.

Features of technical operation of radar systems

Before study of stages of technical operation first of all it is necessary to study the safety precautions regulations for work with dangerous voltages used in radar systems.

The modern radar systems are a complicated complex of equipment, which operation requires special training.

During the study concrete equipment it is necessary to pay attention to rules of switch on and set-up, operation of testing systems and switch-off procedures.

The study of the maintenance instruction is to be provided on the working system with a possibility of demonstrating of modes and sub-modes of the system operation. During technical operation it is necessary to pay attention to preparation for switch-on, monitoring of feeding voltages, time of preparation of the system for emission, set-up of service marks, set-up of the receiver (gain, tuning, etc.). During the switch on of radar systems it is necessary to check bearing and range system, compass and log error.

The evaluation of quality of work can be performed on the basis of sea noise range with auto noise system switched off. The appropriate operation can be evaluated by means of alarms. It is necessary to pay attention to switch-off operation dependence on idle time.

During the maintenance it is necessary to pay attention to check of serviceability, both by the built-in testing system, and by performance monitoring. Performance monitor includes an additional antenna for a reception and evaluation of a level of a signal of the own transmitter. The delayed signal creates special picture on display, which size allows to evaluate serviceability of the transmitter, receiver and display simultaneously. It is expedient to be formularized with various performance monitoring systems.

Maintenance works are made in accordance with the maintenance instruction. It is necessary to pay attention to lubrication of gyrating elements, redactors, belt gear. The clearing of filters, and protective elements is made by special solutions. If the equipment is operated in aggressive media conservation lubricants should be used.

For repair purposes it is necessary to distinguish warranty service and repair, post-warranty service and repair on board ship. Some kinds of repair works can not be executed on board ship, at the same time the recommended procedure of troubleshooting should be performed. The search of malfunctions in various radar systems is based to knowledge of appropriate flow chart. The sufficient knowledge of the systems correlation of channels and units will help to detect failure in an expedient way. During troubleshooting built-in diagnostic systems are used. The study of principles of work and possibilities of such systems facilitates localization of malfunctions. In a practical repair works of the equipment it is necessary to use recommended procedures.

The following procedures should be ensured for every concrete station:

- Location of components of radar systems;
- Power supply for radar components;
- Antenna painting (special paint);
- Monitoring of uniform antenna rotation;
- Replacement of the redactors, rotation elements;
- Replacement of wave guide units;
- Drying of wave guide;
- Check of serviceability of a magnetron;
- Replacement of a magnetron;
- Training of a magnetron;
- Cooling of a magnetron;
- Check and replacement of mixing diodes;
- Specific features of troubleshooting display system
 - o The use is block - channel of trouble shooting schemes;
 - o Service marks tuning;
 - o Set-up of image quality;
 - o Interface with other navigational equipment;
 - o Use of the software of displays of a computer type (set-up and initialization);
- Trouble shooting:
 - o With use of performance monitoring systems;
 - o With use of built-in testing systems.

During the repair attention should be given to specific features of a replacement of faulty elements and blocks, soldering and fastening of elements, technical documentation management, post-repair tuning.

During SART check-up attention should be paid to the built-in testing system, regular check up and replacement of batteries (once in two years). If the built-in testing system is not available SART check up can be performed by means of a working radar.

SECTION 7

RADIONAVIGATION SYSTEMS

The purpose of this section is to impart knowledge of ship borne radionavigation systems maintenance including provision of operational condition and trouble shooting at the plug-in unit (module) exchange level.

The entry standards:

The candidates should have knowledge of:

- basic signal transformation devices in electronic systems;
- basic information and coding;
- radio electronic device schemes: operation principles and main characteristics of analogue, digital analogue and digital electronic devices;
- signal parameters measurement methods and means, main technical characteristics of electronic devices;
- wave propagation for different wavebands;
- radio transmitting devices: operation principles and main characteristics;
- radio receiving devices: operation principles and main characteristics;
- basic equipment maintenance, including diagnostic means;
- basic PC, architecture and software, microprocessors, basic local computer network;
- basic environment protection and occupational safety, fire safety regarding electronic equipment maintenance;
- electronic elements mantling and dismantling.

After completion of the course the trainees should have knowledge of::

- radionavigation systems and their separate devices structural principles;
- technical and operational characteristics of shipborne radionavigation systems;
- operation and maintenance of terrestrial and space-based radionavigation systems receivers COSPAS–SARSAT radio beacons;
- factors affecting technical and operation parameters of radionavigation systems
- structural principles of local differential and wide range systems;
- structural principles and use of monitoring systems based on radionavigation systems;
- digital interfaces for data communication between maritime electronic instruments, navition and radiocommunication equipment;
- Tracing and repair of faults to component level of shipborne receiver equipment.

Outline

No.	Learning objectives	Class hours		
		Total	Theoretical	Practical
1	Radionavigation systems (RNS):			
	Classification, structure and purpose	1	1	-
	Prospects of use	1	1	-
2	Pulse, phase and combined radionavigation systems:			
	Structure and purpose of RNS;	1	1	-
	Principle of position-fixing;	3	1	2
	General configurations of receivers	5	1	4
3	Satellite RNS:			
	Satellite COSPAS-SARSAT system:			
	Structure and purpose of systems segments, principle of position-fixing, radio-beacons	4	2	2
	GPS, GLONASS systems	1	1	-
	GPS:			
	Principle of position-fixing, structure of the frame, information transmitted.	3	2	1
	GPS receivers equipment, accuracy of position-fixing;	8	2	6
	GLONASS:			
	Structure of the system, receivers, accuracy of position-fixing;	6	2	4
	Joint use of GPS and GLONASS systems	3	1	2
4	Differential GPS and GLONASS:			
	Principle of differential mode, reference station, information transmitted, receivers	4	2	2
5	Wide Area Differential systems			
	Structure, information transmitted, accuracy of position-fixing	4	2	2
6	Maintenance and repairs of shipborne radionavigation systems	14	4	10
	Total	58	23	35

7.1 Radionavigation systems (RNS)

Radionavigation systems is a complex of radioengineering devices intended for position-fixing and provision of navigational data to users. Principle of RNS functioning is based on position-fixing by obtained radionavigation objects. Terrestrial transmitting station and space transmitting stations can be used as radionavigation objects. Classification of RNS is given in fig. 7.1.

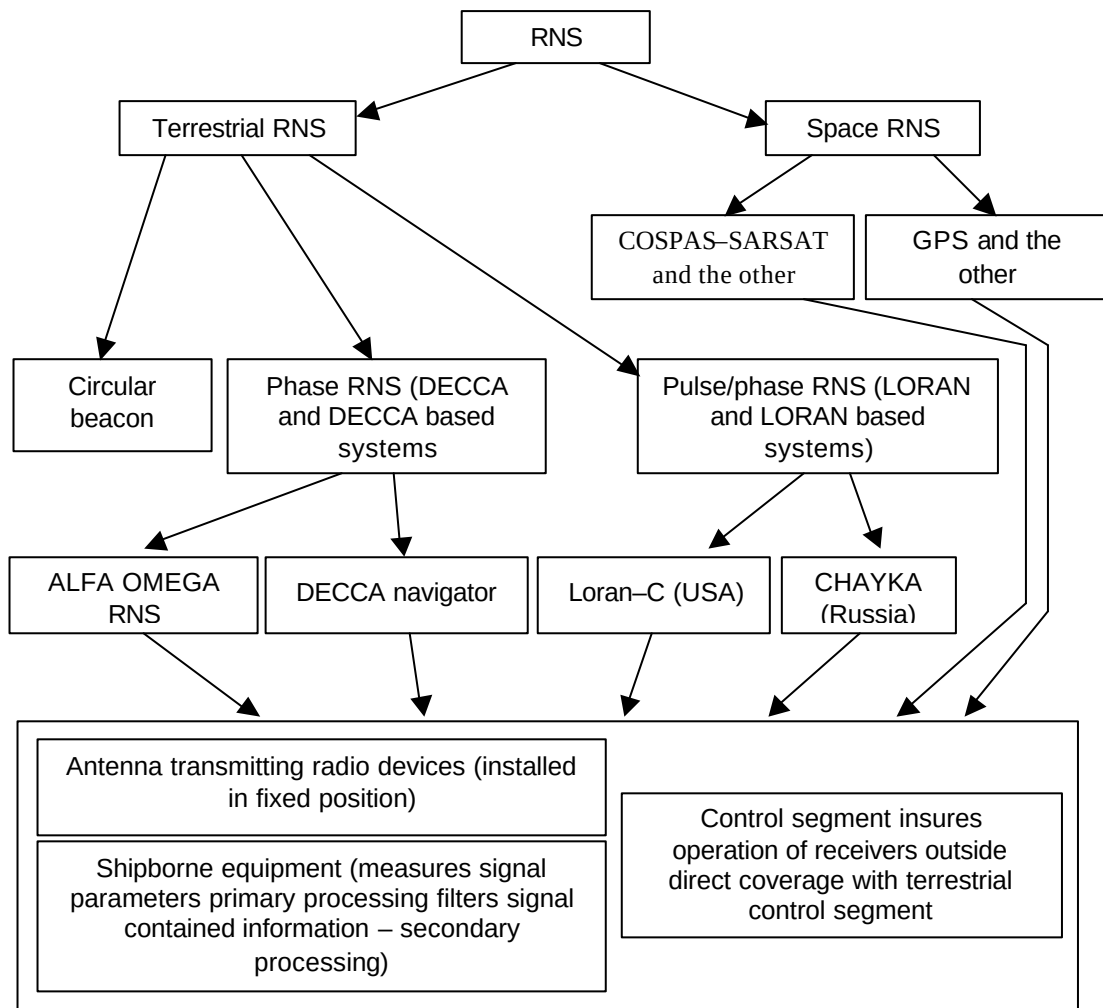


Fig. 7.1. Classification of RNS

Prospects of RNS use

Prospects of terrestrial RNS use are stated in IMO resolution A.860 (20). It is supposed that both terrestrial (LORAN-C, CHAYKA) and space based (GPS, GLONASS) system will be in use. DGPS, DGLONASS, WAAS differential subsystems are widely used. Several other systems are being developed:

GNSS/I – Global Navigation Satellite System based on GPS and EGNOS designed by EC.

EGNOS – European Geostationary Navigation Overlay Service designed by EC.

GNSS/II – future Global Navigation Satellite System partly designed by EC.

7.2. Pulse, phase and combined radionavigation systems.

Hyperbolic radionavigation systems with terrestrial transmitting station use two basic principles of RNS operation:

- phase principle (DECCA);
- pulse–phase (LORAN-C, CHAYKA, OMEGA, ALFA,).

LORAN-C and CHAYKA consist of transmitting stations chains. The chain of the system consists of 1 master station and from 2 to 5 slave stations. At the present time there are 56 world-wide transmitting stations. Special charts with hyperbolas are used for position-fixing. To determine line of position receiver defines the delay of the slave station signal in relation of the master station. Hyperbola on special chart is determined by defined delay, which is one of the lines of ship's position. The second measurement of delay from the second slave station in relation to master station is made. The second delay is found on the chart. The points of their intersection are determined by intersection of two hyperbolas. To resolve the ambiguity in position-fixing the third measurement of delay between the master and the third slave station is used. Groundwave is used for this purpose. A reflected wave, which can be used for computation of appropriate correction, predominates at a considerable distance from transmitting station (master or slave). Corrections depend on time of the day, season and determined by special tables. This system is long-range radionavigation system. Range of coverage is up to 1200 miles when working on ground wave or up to 2400 miles when working with one time reflected wave (using special correction tables). The automated receivers may allow corrections calculation from time difference measurements. The values of time delays are converted into latitude and longitude values. The accuracy of position-fixing at a distance up to 1200 miles is 0.05...1.5 miles when working with ground wave. At a distance up to 2400 miles from the transmitting station the accuracy decreases to 1.5 ... 5.0 miles when using one time reflected wave.

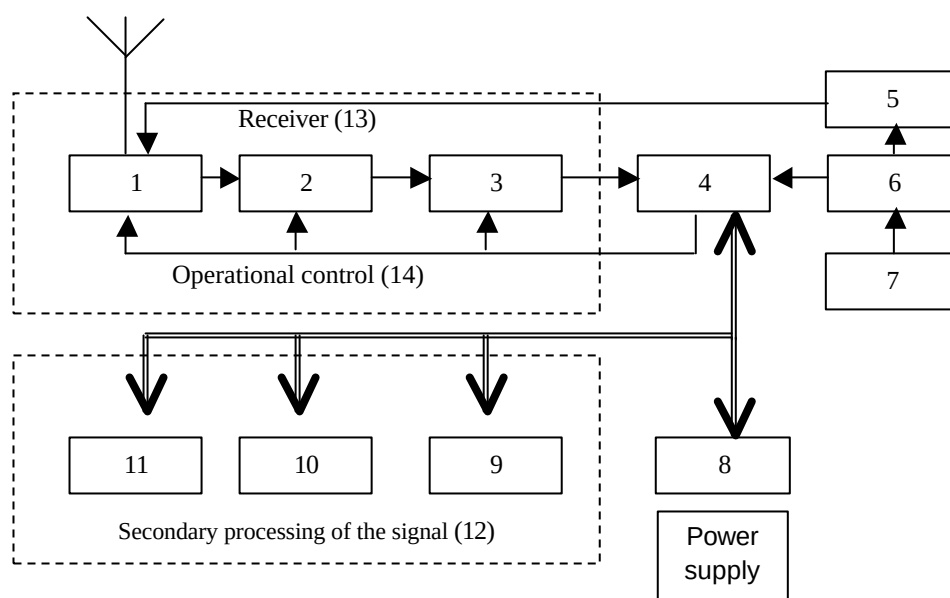


Fig 7.2. Configuration of the automated receiver.

1. Input amplifier
2. Black spotter (1...4 notch-filters)
3. Selective amplifier
4. Primary processing of the signal
5. Simulate
6. Timer
7. Synchronizer
8. Display
9. Control panel
10. ROM
11. RAM
12. Secondary processing of the signal
13. Receiver
14. Operational control.

Input amplifier is used to amplify the signal transmitted from antenna on frequency 100 kHz.

Black spotter uses from 1 to 4 notch filters automatically tuned to narrow band interference frequency. Selective amplifier changes the bandwidth depending on the problem solved by the receiver. Synchronizer together with the timer ensures formation of consecutive strobes and frequency net to solve the problem of signal acquisition and measurement of time difference in receiving signals from master and slave station. The time scale formed in the timer is normally shifted in relation to time scale formed by the terrestrial stations of the system. Pre-processor solves the problem of primary processing of the signals:

- converts the received signals into digital code;
- provides statistic proceeding of the signals during time search;
- realizes the algorithm of the lock-on system;
- controls black spotter and separate automatic amplifier tuning;
- digital filtering process

Specialized processor with ROM and RAM devices solves the problem of secondary processing conversion of the measured hyperbolic co-ordinates into navigational ship's parameters. Simulator is used to check operational condition of the device.

Modern Loran-C and CHAYKA receivers are reliable supplement and reserve of the satellite systems, they also provide:

- determination of geodesic coordinates;
- solution of additional navigational problems (routing, way points, motion calculation, etc).

7.3. Satellite systems

COSPAS-SARSAT international satellite system for search and rescue

Cospas-Sarsat is a satellite system designed to provide distress alert and location data to assist search and rescue (SAR) operations, using spacecraft and ground facilities to detect and locate the signals of distress beacons operating on 406 MHz or 121.5 MHz.

The Cospas-Sarsat system is composed of:

- Space segment (the instruments on board satellites in geostationary and low earth orbits which detect the signals transmitted by distress radiobeacons);
- Ground receiving stations, referred to as Local Users Terminals (LUTs), which
- receive and process the satellite downlink signal to generate distress alerts;
- Mission Control Centers (MCC) which receive alerts produced by LUTs and
- forward them to Rescue Coordination Centers (RCCs), Search and Rescue Points of Contacts (SPOCs) or other MCCs.
- Emergency Position Indicating Radio Beacons (EPIRBs) which transmit signals during distress situations;

The Cospas-Sarsat space segment consists of satellites placed on the low-altitude (about 1000 km) near-polar orbit. These polar orbiting satellites have an inherent capability of covering the whole surface of the globe. The nominal configuration of the Cospas-Sarsat space segment comprises four operational satellites.

The Cospas-Sarsat satellites have two operational modes for the detection and location of emergency beacons, namely the real-time mode and the stored data mode. In the real time mode the spacecraft immediately relays to the ground all information received on 121,5 and 406 MHz. The 406 MHz EPIRB signal are also stored on board the spacecraft for subsequent multiple transmission to any LUT in its view. This type of processing is known as the stored data mode.

The main function of the ground station is to receive the data relayed by the Cospas-Sarsat satellites, process it and determine the geographical location of the transmitting EPIRBs. After completion of this processing all the useful information derived from the data is forwarded to the associated MCC where, after its final processing the emergency information is distributed to the appropriate search and rescue authorities and other MCCs of the system.

There are 38 LUTs currently in operation, which form an international ground network of the Cospas-Sarsat system. The overall coverage of the Cospas-Sarsat system in the real-time mode is dependent upon the number and geographical position of LUTs, each serving an area with a radius of approximately 2500 km.

Accuracy of radiobeacon position-fixing is 3–5 km, waiting time of the nearest LUT depends on the latitude and on average it is 2 h in the Southern hemisphere and 1.5 h in the Northern hemisphere.

The Cospas-Sarsat System calculates the location of distress beacons using Doppler processing techniques. Simply stated the Doppler effect is a term used to describe the phenomena that the frequency of a signal "as heard" by a receiving device is affected

by the magnitude of the relative velocity between the transmitter and the receiver. If the distance between the transmitter and the receiver is reducing, the frequency as heard by the receiver is raised by the Doppler effect. If the distance is increasing, the Doppler effect reduces the frequency as heard by the receiver. If there is no relative velocity, the frequency heard by the receiver is exactly the transmitted frequency.

The frequency time plot to the left is representative of a signal heard by a LEO satellite passing over a stationary transmitter on the surface of the Earth. The point of inflection of the curve represents the point in time where the satellite was closest to the transmitter (TCA - Time of Closest Approach). The actual shape of the curve can be processed to indicate the distance the transmitter was from the satellite track.

Using this information, and by knowing where the satellite was at all times during the pass, it is possible to plot two lines which represent the distance from the satellite track where the transmitter could have been. Then knowing the time of closest approach of the satellite, it is a simple matter of drawing perpendicular lines from the point on the satellite track at TCA to the lines representing the distance between the transmitter and the satellite track. Where these lines intersect represent two possible locations for the transmitter, one being the actual location and the other being its mirror image. A subsequent satellite pass on a different satellite track can be used to resolve the ambiguity. The ambiguity can also be resolved by taking into account the Earth rotation when computing the Doppler solutions. However, this ambiguity resolution technique is dependent upon the stability of the transmitted frequency and can only be used reliably with 406 MHz distress alerts.

Performance standards for float-free satellite EPIRBs operating on 406 MHz are described in IMO Resolution A.810(19).

Global Position System (GPS)

Global Positioning System is a global space-based positioning, velocity and time system developed by the U.S. Department of Defense. It provides 24 h, global, high accuracy service to military and civilian users at all altitudes.

The system consists of Control segment, Space segment, and User segment. Control segment consists of Monitor Network and Master Control station. Monitor Networks measure satellite's ephemeris data, control their operational condition and transmit special data. GPS constellation includes 24 satellites (21 operational and 3 spare), are placed on 6 orbits with altitude of 20200 km. Each satellite continuously transmits spread-spectrum signals on which receivers can perform pseudorange measurements. (A pseudorange is equal to the true range plus an unknown bias due to the offset between the user clock and the satellite clock). A pseudorandom sequence with a 10 MHz chipping rate modulates the phase of carrier at 1575.42 MHz (L1) and it also modulates a carrier at 1227.60 MHz (L2). A pseudorandom sequence with a 1 MHz chipping rate modulates a quadrature carrier at L1 only.

Authorized users have access to the Precise Positioning Service (P), which provides accuracies of 10 to 20 m (95 percentile level), depending on platform dynamics. Civilian users have access to the standard positioning service (Selective Availability - SA), which provides 100 m accuracy.

Satellite data is transmitted in 6 sec subframes, 5 subframes form one 30 sec frame, 25 frames form 12.5 min superframe. Each subframe is preceded by a key word, clock correction data and ephemeris data transmitted in data frame. The 4th subframe contains ionosphere state data and operational readiness of the satellite. Year, month and time are transmitted in operational data. The last subframe contains 1/25 part of the almanac. Ephemeris data is changed every hour and contains data for one satellite, while the almanac contains data about all the satellites

Subframe 1

0bit 30 60 300

TELEMETRY WORDS		CLOCK CORRECTION	6 sec

Subframe 2

300 330 360 600

TELEMETRY WORDS		EPHEMERIS	12 sec

Subframe 3

600 630 660 900

TELEMETRY WORDS		EPHEMERIS	18 sec

Subframe 4

900 930 960 1200

TELEMETRY WORDS		MESSAGE (changes through 25 frames)	24 sec

Subframe 5

1200 1230 1260 1500

TELEMETRY WORDS		ALMANACH/HEALTH STATUS (changes through 25 frames, then repeats)	30 sec

Fig 7.4 Structure of the data frame.

GPS Receivers Equipment

For position-fixing the GPS receiver equipment collects data from all the visible satellites (maximum number can reach 11). The data received is divided into operational data and almanac data. The receiver chooses 3 or 4 best satellites by means of position dilution. Pseudoranges to the satellite are calculated by means of ephemeris data and use for calculation of the position in relative coordinates. Relative coordinates are converted into geographical coordinates of the geodetic system, parameters of which are chosen by the user. Three satellites are used to determine latitude, longitude and time and 4 satellites are used to determine additionally the altitude.

Accuracy of position-fixing

Accuracy of position-fixing primarily depends on the error introduced. Accuracy is influenced by errors of:

- clock degradation;
- ephemeris degradation;
- ionosphere delay compensation;
- troposphere delay compensation;
- multipath mobile (using phase smoothed pseudorange)
- receiver noise and inter channel calibration

The ionospheric delay is depending on solar activity, on diurnal and seasonable lighting from the sun, and on the elevation angle. Tropospheric delay is low and easy to modelize for high elevation satellites. The delay is of the order of 2,6 m at vertical for the "standard atmosphere". Multipath error depends on antenna site, on the quality of antenna itself: efficiency of reflection attenuation by the capability of the antenna to attenuate the reverse polarized signals or reflected signals, on the local protection of the antenna against reflection of near by objects just close and under the antenna.

The sum error is influenced by position dilution of precision (PDOP). This is a mathematical value, which indicates the level of difference between the actual position of satellites and their optimum position. The optimum position is position in the shape of triangle with 120^0 spacing in relation to the observer's point.

In real conditions value of PDOP can vary from 1.5 to 8 (an average value is 2.7) and consists of horizontal dilution of precision and vertical dilution of precision (VDOP equal to 2.1 to 2.4). According to IMO Resolution A.819 (19) the GPS receiver equipment should have static accuracy such that the position of the antenna is determined to within 100 m 95% with horizontal dilution of position (HDOP) < 4 (or PDOP ≥ 6).

The first observation without almanac should be made not later than 30 min after switching, with almanac not later than 5 min. The receiver should store the observation data if blackout lasts not more than 1 min.

GLONASS radionavigation system

The structure of the system is similar to that of GPS and includes Satellites segment, Control segment and User segment.

After full deployment the satellite constellation must consist of 24 satellites, 21 of which will be operational and 3 - spare. Satellites are placed on 3 orbits, 8 satellites on each orbit with altitude of 19100 km. Each satellite transmits data on two bands of frequencies 1602.5625 – 1615.5 MHz with 0.5625 MHz pitch (step) and 1246.4375 – 1256.5 MHz with 0.4375 MHz pitch (step) on the assigned pair of frequencies. Two channels, "rough" and "accurate", are used (accuracy ratio is 1/10).

Data transmitted consists of operational data and almanac data. Operational information includes time markers, satellite clock scale shift, value of the carrier

determining, ephemeris data. Almanac contains time scale shift, number of days from the beginning of the leap year, satellite identification and satellite health. Operational information has a cycle of 30 sec and it is changed every 30 min, a cycle of almanac being 2.5 min.

GLONASS RECEIVERS are tuned to satellite's frequency and calculate coordinates in SGS 90 system of charts. When other types of charts are used special corrections for error elimination are allowed. On the basis coordinates direction and speed of movement are calculated as the difference between subsequent and previous positions. Receivers allow to effect automatic uninterrupted position and time fixing, to determine speed vector, second discrete coordinate display (in the selected coordinate system), evaluate the accuracy of position-fixing, reception, storage, and renewal of almanac, automatic selection of satellites with account of their condition, automatic control of functioning, display of failures, presentation of functioning modes, to work with way points and routes, calculate bearings and distances between way points, calculate route deviations.

Accuracy of position-fixing primarily depends on the error introduced. Accuracy is influenced by errors of:

- clock degradation;
- ephemeris degradation;
- ionosphere delay compensation;
- troposphere delay compensation;
- multipath mobile (using phase smoothed pseudorange)
- receiver noise and inter channel calibration

The sum error is influenced by position dilution of precision. Accuracy of GLONASS receivers is determined by the appropriate IMO Resolution MSC.53(66). The first observation without almanac should be made not later than 30 min after switching, with almanac not later than 5 min. In case of power supply disruption for not more than 1 min observation data should be stored.

GPS and GLONASS combination receivers ensure joint use of the satellites. Accuracy of GPS and GLONASS receivers with PDOP not worse than 4 it is not worse than 35 m.

7.4. Differential GPS and GLONASS

A DGPS system general principle is shown in Fig 7.5. DGPSsystem includes a local reference station, which has a high quality GPS receiver and an antenna at a known, surveyed location. The reference station continuously measures the pseudoranges for every satellite in view. It also computes the true range to each satellite, based on the satellite ephemeris data and the known location of the GPD antenna of the reference station. The difference between the measured pseudorange and the true range is the error (within a common bias) associated with each satellite. These errors are broadcast as corrections to the users of differential GPS. Users near the station are expected to achieve accuracies of 2 to 8 m, depending on platform dynamics and receiver/processor sophistication. The accuracy of the corrections is reduced as the user-reference station separation increases and as time passes. DGPS provides an additional benefit as well: the reference station acts as a monitor, and can inform the users if any of the satellite signals are unhealthy.

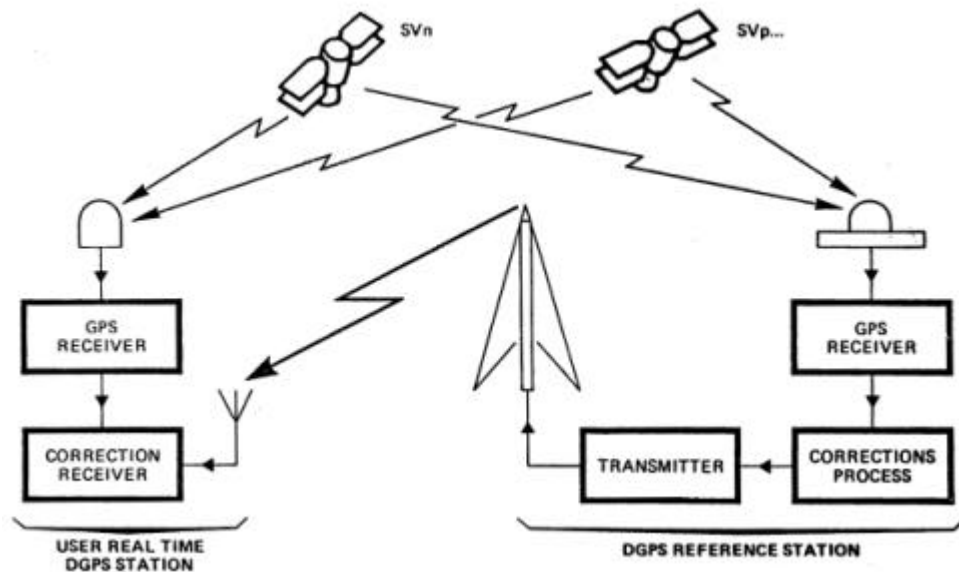


Fig. 7.5 DGPS general principle

Differential corrections are transmitted in the range of 190–415 kHz and 510–535 kHz frequencies with minimum frequency modulation (MSK) and they are transmitted in different frames.

Technical goals and standards for DGPS broadcast system are based on the standards were established by Special Committee 104 of Radio Technical Commission for Maritime Services (RTCM). DGPS reduces errors, which vary slowly with time and space. DGPS correction is valid for tens of seconds and hundred of kilometers. After tens of seconds, the transmission time dithering by SA is no longer predictable. Beyond several hundred kilometers, ephemeris data manipulation by SA impacts the reference station pseudorange and the user pseudorange quite differently. Also at longer ranges, the probability of poor satellite geometry increases, because a satellite visible to the user may not be visible to the reference station. Consequently, a DGPS broadcast system must not introduce more than 10 or 20 s of delay. To be most cost effective, its reliable broadcast range should be hundreds of kilometers (200–300 km.). The accuracy of position-fixing of differential mode with PDOP not worse than 4 it is not worse than 10 m.

The Special Committee recommends which data to broadcast, a message format, and set of rules for applying the corrections. Briefly, the RTCM messages contain pseudorange corrections and range rate corrections for each satellite in view of the reference station. They also include satellite identification, satellite health, estimated accuracy, and the “age” of the data being used by the reference station. The format also allows for messages which contain auxiliary data.

Each frame of message format consists of several words and has variable length. 30 bit are transmitted in every word, the last 6 bit are controlling. Identifier of the frame is transmitted at the beginning of each frame.

Frames of 1,2,3,5,6,7,16 types are used for transmission of corrections for position-fixing in DGPS, and frames 31,32,33,34,35,36 types are used for this purpose in

DGLONASS sub-system. The structure of the appropriate frames for both systems is the same but for the fact that in DGPS coordinates of reference station are transmitted in WGS-84 coordinate system, and in DGLONASS in SGS-90 coordinate system.

Shipborne receiver automatically chooses the nearest station of differential corrections by means of almanac data, corrects the data received from the satellites and calculates navigational parameters with high accuracy. When switching from station to station ranging receiver automatically switches to the nearest station. On leaving the area of differential correction stations coverage ranging receiver determines navigational parameters by satellites of satellite systems with less accuracy.

7.5. Wide area differential systems

Wide area differential systems are designed to transmit differential corrections in sufficiently wide area by transmitting correction data and operational data through radionavigation systems by means of geostationary satellites. WAAS (Wide Area Augmentation System), EGNOS (European Geostationary Navigation Overlay System), MTSAS (Multy Functional Transport Augmentation System) belong to this type of systems.

Wide area differential systems consists of twenty-thirty terrestrial reference stations coordinates of which are known. Precision ranging receivers with highly accurate frequency standards simultaneously measure quasi-range and quasi-doppler values of frequencies for all visible satellites, calculate differences between measurements and calculated values and send their results to central control stations. Central control station calculates the value of time and ephemeris error corrections for every satellite on the basis of the statistical processing. Ionosphere error corrections for operational areas are determined processing data received from the network of ionosphere sounding stations.

Value of errors corrections are relayed by INMARSAT-3 generation satellites on the GPS carrier (1575, 42 MHz) at a speed of 500 baud. Similarity of formats allows to receive and process data in WAAS system by ranging receivers without additional receivers. Data transmitted by geostationary satellites include satellite identification, satellite health, ephemeris data, which are automatically inserted into measured quasi-ranges and quasi-doppler values of frequencies. Data is transmitted in blocks, which are synchronized with GPS data frames. Time of each block transmission is 1 sec. There are two types of error corrections: fast and slow. Fast error corrections are transmitted every 60 sec and exclude specially inserted errors. Slow error corrections are transmitted every 60 sec and are used to eliminate clock and ephemeris degradation errors for GPS satellites and ionosphere delay compensation errors.

Ionosphere delay compensation errors are transmitted every 5 min. Troposphere delay compensation errors are not transmitted. For highly accurate position fixing they are determined by the use with the help of barometer, latitude, day and the input is effected manually from the receiver's panel.

Description of the receiver's operational algorithm and parameters of signals are determined in RTCA/DO-229. Accuracy of position-fixing by Wide Range Systems is 10 times better than by GPS.

7.6 Maintenance and repairs of shipborne radionavigation systems

GPS system is predominantly used as navigational data source for the GMDSS equipment. If necessary, other types of navigational equipment can be included into teaching syllabus.

Maintenance of this equipment (operational tests, trouble shooting and repairs) is to be studied on the basis of technical characteristics and description of concrete equipment types.

SECTION 8

REGULATIONS AND COMMUNICATION PROCEDURES

Purpose of the section

The purpose of this section is to provide the knowledge of GMDSS fundamental principles and functions, to develop the skills of trainees in the use of terrestrial and satellite emergency communication procedures and public communication procedures.

Entry standards:

The candidates should have knowledge of:

- o basic skills in PC use;
- o knowledge of the spoken and written English language (as a second language).

Moreover, it would be useful if trainees had experience in radiotelephone communication in the English language.

After completion of this course the trainees should have:

knowledge of:

use, operation and service areas of the GMDSS subsystems, including satellite system characteristics, navigational and meteorological warning systems and selection of appropriate communication circuits;

GMDSS radiocommunication equipment including:

- o radiotelephone transmitters and receivers;
- o Digital Selective Calling equipment;
- o Narrow Band Direct Printing systems;
- o Ship Earth Stations;
- o EPIRBs;
- o ship antenna systems;
- o emergency equipment for survival craft together with auxiliary equipment including power supply sources;

International Convention SOLAS 1974 with amendments particularly related to distress radiocommunication, prevention of unauthorized transmissions and harmful interference;

documents, regulating distress, safety and public correspondence service;

International Code of Signals and IMO Standard Marine Communication Phrases.

practical skills in:

correct and efficient operation in all GMDSS sub-systems with the use of equipment under normal propagation conditions and under typical interference conditions;

safe operation of all GMDSS equipment and auxiliary devices including safety precautions;

key-board skills for satisfactory exchange of communications;

tuning of receiver and transmitter for appropriate operations including DSC and NBDP;

tuning of antenna and its orientation (if necessary);

use of life saving appliances radio equipment;

use of EPIRBs;

use of procedures:

- o communication in GMDSS sub-systems complying with discipline and preventing interference ;
- o selection of optimum frequencies for radiocommunication;
- o watch keeping relating to all GMDSS systems;
- o radiocommunication especially in case of distress, urgency and safety;

- o use of International Phonetic Alphabet;
- o maintaining watch on distress frequency with simultaneous work or watch on at least one other frequency;
- o ship reporting systems;
- o radiocommunication with due regard to IAMSAR recommendations;
- o obtaining Radio Medical Advice;

Course outline

The Section is based on IMO Model Course 1.25 “General operator’s certificate for the Global Marine Distress and Safety Systems”. Amendments to IMO 1.25 Model Course resulted from the fact that this is not a separate course but only an integral part of the 2d Class Radioelectronics training. All discrepancies with 1.25 IMO Model Course in relation to training hours are commented on in the notes to the table. The figures under 1.25 IMO Model Course being given in parentheses.

No.	Learning objectives	Class hours			Notes
		Total	Theoretical	Practical	
1	2	3	4	5	6
1.	Introduction.	1 (3.5)	1		1
2.	Fundamental Principles of Radiocommunication.				
2.1	Principles and basic features of maritime mobile service.	5 (15)	5		2
2.2	Principles and basic features of maritime mobile – satellite service.	4	4		
2.3	GMDSS	8	8		
3.	GMDSS Communication Systems.				
3.1	Purpose and use of Digital Selective Calling.	15 (22.5)	4	11	3
3.2	General principles of Narrow Band Direct Printing (NBDP).	4	2	2	
3.3	INMARSAT System.	15 (7)	3	12	4
3.4	Shipborne radio equipment.	15 (18)	4	11	5
3.5	Radiotelephony	6 (0)	2	4	6
3.6	Trouble shooting and radio equipment technical maintenance.	0 (3)			7
4.	GMDSS Alerting Systems				
4.1.	EPIRBs Emergency Position-Indicating Radio Beacons	2	1.5	0.5	

4.2.	Search and Rescue Radar Transponders (SART)	1	0.5	0.5	
4.3.	Maritime Safety Information Service	4	2	2	
5.	Distress and Safety Communication Procedures				
5.1.	SAR Operations Organization	4	3	1	
5.2.	Distress and Safety procedures	15	4	11	
5.3.	Distress Frequencies protection	3 (2)	1	2	8
6.	Miscellaneous skills				
6.1.	Spoken and written English Language for emergency exchange.				9
6.2.	Compulsory documentation of Maritime Mobil Service radiostation	4 (0)	4		10
6.3.	Public correspondence procedures	20 (11)	5	15	11
7.	Final tests and trainings.	8		8	
	Total	134 (132)	54	80	

1. Time for introduction is reduced by 2.5 hour in comparison with 1.25 IMO model course because Module 8 is the integral part of the 2d Class Radio Electronics training course and information should be partly presented at the introductory class of the 2d Class Radio Electronics training course.
2. The quantity of hours in comparison with 1.25 Model course is reduced by 10 hours because the problem of frequency analysis, frequency ranges of marine mobile service, radio wave propagation parameters, frequency spectrums, emission mode, modulation are studied in Module 1 "Fundamentals of Radio Systems" and only overview is required.
3. The quantity of hours for basic principles of Digital Selective Calling and Digital Selective Calling equipment use was reduced in comparison with 1.25 Model Course because this material is partly overlapped by Module 9 "Technical Maintenance Of Shipborne GMDSS Equipment"

4. Duration of the classes is increased by 8 hours in comparison with 1.25 Model Course for development of trainees skills in use of ship INMARSAT – equipment.
5. Hours for ship antennas and batteries are excluded. These problems are discussed in Modules 1 and 9.
6. Module “Telephony” is not provided in 1.25 Model Course. Such a section in Module 8 is explained by the fact that the trainees might have no experience in marine telephony and as a result they should develop skills in radiotelephony communication. Minimum material required for this section is given in section 10 “Radiotelephony procedures” of 1.25 Model Course Compendium.
7. Module “Trouble shooting and ship radio equipment maintenance” (3 hours) of 1.25 Model Course can be excluded from the course of the 2nd class Radioelectronics training as they are fully covered by Module 5, 6, 7 and 9 of this course.
8. Duration of classes is increased by 1 hour in comparison with 1.25 Model Course for additional trainings to develop stable skills in canceling false alerts.
9. The required classes are hold in Module 10 “The English Language”.
10. Information about compulsory ship documents received by trainees when they studied emergency procedures and public correspondence radio communication is generalized in this section. Moreover rules of Radio Log completion are listed is this section.
11. The quantity of hours is increased to provide additional training in INMARSAT use and radio telex use for communication with the users of different coastal networks.

Laboratory equipment.

GMDSS simulator meeting STCW 78/95 requirements as to GMDSS systems and shipborn equipment simulation

GMDSS areas A1, A2 and A3 equipment including:

- o VHF and HF/MF radio equipment
- o SES INMARSAT-C with EGC Receiver.
- o SES INMARSAT-C and INMARSAT-A.
- o NAVTEX

Demonstration (dummy) equipment (SART, EPIRBs)

Demonstration and live VHF portable radios.

Projectors, white board and black board.

Detailed Teaching Syllabus

The defiled teaching syllabus of 1.25 IMO modal course “General operators certificate for the Global Marine Distress and Safety System” was taken as the basis for the detailed teaching syllabus. Amendments made to 1.25 model course detailed teaching syllabus are explained by the differences in the programs of radio electronics and GMDSS operators training.

The detailed teaching syllabus has been written in learning-objective format in which the objective describes what the trainee must do to demonstrate his/her competence.

All objectives are understood to be prefixed by the words, "The expected learning outcome is that the trainee..."

Teaching aids (indicated by A),
IMO references (indicated by R),
Textbooks (indicated by T), and
Bibliography (indicated by B)

The abbreviations used in the detailed teaching syllabus are:

Ch.	Chapter
Fig.	Figure
p., pp.	Page, pages
AP	Appendix
Pt.	Part
RR	Radio Regulation
Reg.	Regulation
Res.	Resolution
Sect.	Section

For example, 'A1 -Sect. 6' means section 6 of the course compendium; 'R1 - Pt 3.5' means part 3.5 of the IMO GMDSS Handbook; 'T1 - Ch. SVII' refers to Chapter SVII of the Radio Regulation in ITU Manual for Use by the Maritime Mobile and Maritime Mobile-Satellite Service; 'T1 - RR S30' means Article S30 of the Radio Regulation in T1; 'T1 -AP S13' refers to appendix S13 to the Radio Regulations and 'T1 -ITU-R ? .541' means Recommendation M.541 in T1.

Learning Objectives	IMO Reference	Textbooks, Bibliography	Teaching Aid
1 INTRODUCTION			
1.1 The course (2.0 hours)			
1 States the background and purpose of the GMDSS: – definition of sea areas • . areas A1, A2, A3 and A4 – methods of distress, urgency and safety alerting	R1-Pt4		A-I-Sect.1
2 States the requirements for radio installations in the GMDSS: – details of carriage requirements – details of the communications equipment used in each sea area	R1-Pt4 R7		A-I-Sect.1
3 States the certification requirements in the GMDSS	R7		A-I-Sect.1

2 PRINCIPLES OF MARITIME RADIOCOMMUNICATIONS 2.1 Principles and basic features of the maritime mobile service (5.0 hours) 1 States the types of communications in the maritime mobile service: - distress, urgency and safety communications - public correspondence - port operations service - ship movement service - intership communications - on-board communications 2 States types of station in the maritime mobile service: - ship stations - coast stations - pilot stations, port stations, etc. - aircraft stations - Rescue Co-ordination Centres (RCCs) 3 Frequency allocations in the maritime mobile bands: - describes the usage of bands and frequencies in the maritime mobile service - lists frequencies for distress, urgency and safety communications for GMDSS purposes as required by the Radio Regulations - lists frequencies for routine call and reply	R1-Pt3	T1-RRS1 T2.1.T2.2, T2.4	A1-Sect. 18
2.2 Principles and basic features of the maritime mobile-satellite service (4.0 hours) 1 Basic operation of satellite communications: - describes the Inmarsat system - lists the services available on Inmarsat-A, Inmarsat-B, Inmarsat-C, Inmarsat-E and Inmarsat-M - describes the function of Enhanced Group Call (EGC) system - describes distress, urgency and safety communications via satellite 2 Lists types of station in the mobile-satellite service: - Coast Earth Stations (CESs) and their functions - Network Co-ordination Stations (NCSs) and their functions	R1 -Pt3.2	T3.1.T3.2	A1-Sect. 11 A1-Sect. 1 & 11

- Ship Earth Stations (SESS) and their operation			
2.3 Global Maritime Distress and Safety System (GMDSS) (8.0 hours)	R7-Ch4		
1 Functional requirements of ship stations:	R1 -Pt1,		A1-Sect, 1 & 2
- details of equipment specifications	2,4,7 & 8		
- states definitions of coverage and sea areas for Digital Selective Calling (DSC)	+Annex I R4		
- states details of carriage requirements	R5		
- describes Maritime Safety Information (MSI) services			
- states watchkeeping procedures as defined in the Radio Regulations and the STCW Code			
2 Sources of power:	R1 - Pt. 1,		A1-Sect. 15
- describes reserve power supplies, capacity and duration as defined by the SOLAS Convention	2, 4, 7 & 8		
- describes prohibitions on the connection of non-GMDSS equipment	+Annex I		
3 Means of ensuring availability of ship station equipment:	R1 -Pt. 1,		A1-Sect. 1
- describes equipment duplication	2,4,7 & 8		
- describes maintenance strategies and requirements for the GMDSS as defined in the SOLAS Convention and the Radio Regulations	+ Annex I		
4 Describes primary and secondary means of alerting			A1-Sect. 1
5 Ship licenses and radio safety certificates:	R1 -Pt. 1,		
- lists details shown on the ship licence	2,4,7 & 8		
- describes requirements for radio safety certificates	+ Annex I		
6 Record keeping and log-book requirements for ship stations:	R5		A1-Sect. 10
- lists details of log-book daily entries			?5
- lists details of all other periodic entries to include results of equipment tests etc. as required by the Radio Regulations			
3 GMDSS COMMUNICATION SYSTEMS			
3.1 Purpose and use of Digital Selective Calling (DSC) facilities (15.0 hours)	R1 – Pt 3.5.	?1 -RRS31, RRS32,	?1 - Sect.5
1 Describes and demonstrates basic functions of DSC		RR33,	& 6
- DSC message types		RRS54,	? 2.4,
- calling frequencies		PART ?,	A3
– distress and safety		ITU-RM.541	
– international and national calling			
- Maritime Mobile Service Identity (MMSI) and selection of the MMSI for calling		T 2.1, T2.3	

• Maritime Identification Digits (MID) • ship station allocation numbers • group calling numbers • coast station numbers - call acknowledgement - call relay process .2 Describes DSC call format including - format specifiers - list of priorities - types of addresses - list of telecommands and traffic information • distress alerts • undesignated distress messages • designated distress messages • distress co-ordinates • time and validity of distress co-ordinates • other calls and messages • working frequency and channel selection - self identification .3 Describes DSC facilities and usage - DSC watchkeeping functions and control - methods of DSC data entry and retrievals • updating vessel position • entering preset message • entering traffic information • reviewing received messages			
3.2 General principles of Narrow-Band Direct Printing (NBDP) (4.0 hours) 1 Describes and demonstrates NBDP systems: - automatic, semi-automatic and manual systems - acknowledge/request (ARQ) mode - forward error correction (FEC) mode - SELCALL numbers for ship and coast stations - controls and indicators - shore and ship station procedures - answerback procedures - keyboard operation	R1 - Pt 5	T1–RRS31 RRS32, RRS56, ITU-RM.492	A1 - Sect.7 A2.3
3.3 Knowledge and use of Inmarsat systems (15.0 hours)	R1 -Pt3.2		A1- Sect 11

1 Inmarsat satellite systems and network - describes the basic features of the Inmarsat network, including • extent of global coverage • ocean regions • network co-ordination stations (NCS) - provides overview of Inmarsat-A/-B/-C/-E and -M systems - describes the use of different Inmarsat systems within the GMDSS		T3.1.T3.2	
2 Describes, in operational terms, Inmarsat-A/-B and -C ship earth stations - methods of satellite acquisition - use of telex services - use of telephone services - use of data and facsimile communications		T3.1,T3.2	
3 Describes and demonstrates an Inmarsat-A ship earth station - components of an Inmarsat-A ship earth station - method of acquiring satellite both manually and automatically - usage of an Inmarsat-A ship earth station - procedure for sending a distress message or call using Inmarsat-A - use of 2-digit code services via Inmarsat-A - basic procedure for sending and receiving Inmarsat-A telex messages - basic procedure for making a telephone call using Inmarsat-A		T3.1,T3.2	A2.2
4 Describes and demonstrates an Inmarsat-B ship earth station - components of an Inmarsat-B ship earth station - the basic difference between Inmarsat-A and Inmarsat-B ship earth stations - method of acquiring satellite both manually and automatically - usage of an Inmarsat-B ship earth station - procedure for sending a distress alert/message or call using Inmarsat-B - use of 2-digit code services via Inmarsat-B - basic procedure for sending and receiving Inmarsat-B telex messages - basic procedure for making a telephone call using Inmarsat-B		T3.1,T3.2	A2.1

5 Describes and demonstrates an Inmarsat-C ship earth station - components of an Inmarsat-C ship earth station - entering and updating the ship's position both manually and automatically - usage of an Inmarsat-C ship earth station - procedures for distress alerting and sending a distress message using Inmarsat-C - sending and receiving Inmarsat-C text messages - overview of SafetyNET and FleetNET services - data reporting and messaging using Inmarsat-C		T3.1.T3.2, T3.4	A2.2
6 Describes and demonstrates an Inmarsat Enhanced Group Calling (EGC) receiver - components of an EGC receiver - entering and updating ship's position both manually and automatically - usage of an Inmarsat EGC receiver		T3.1.T3.2, T3.4	A2.2
7 Describes, in operational terms, an Inmarsat-M ship earth station - components of an Inmarsat-M ship earth station - the basic difference between Inmarsat-A/-B and Inmarsat-M ship earth stations - the limitations regarding Inmarsat-M and the GMDSS - method of acquiring satellite both manually and automatically - usage of an Inmarsat-M ship earth station - use of 2-digit code services via Inmarsat-M - basic procedure for making a telephone call using Inmarsat-M		T3.1	
3.4 Knowledge and practical use of terrestrial ship station equipment (18.0 hours)			
1 Describes and demonstrates the purpose and usage of watchkeeping receivers - the controls and usage of a 2182 kHz watch receiver - the controls and usage of a VHP DSC watch receiver - the controls and usage of an MF/HF DSC watch receiver			A3
2 Describes the usage and functions of the VHF installation - usage of controls - selection of channels - DSC facilities			A3

3 Describes and demonstrates the usage and functions of the MF/HF installation - use and selection of frequencies - use and functions of controls - connection of power - selecting receive frequency - selecting transmit frequency - selecting ITU channel number - tuning the transmitter - selecting class of emission - using of clarifier or receiver fine tuning - controlling RF gain - using automatic gain control (AGC) - using 2182 kHz instant selector - using the alarm generator - testing the alarm generator - selection of transmitter power level			A3
4 Describes and demonstrates survival craft radio equipment - portable two-way VHF transceivers - Emergency Position-Indicating Radio Beacons (EPIRBs)			
3.5 Radiotelephony procedures (6.0 hours) Describes and demonstrates usage of - general procedures - call, replay and working frequencies - calling procedures - working procedures - on-board communications		T1-RR S57 APS18	A1-Sect. 10
4 OTHER GMDSS EQUIPMENT			
4.1 Emergency Position-Indicating Radio Beacons (EPIRBs) (2.0 hours)	R1 - Pt3.2, 3.3		
1 Describes the COSPAS-SARSAT satellite system and EPIRBs - the basic operation of the COSPAS-SARSAT satellite system - the operation of a 406 MHz EPIRB - the information content of a distress alert - the registration and coding of a 406 MHz EPIRB - manual operation - the float-free function			A1 -Sect 13 A3 A6

- the correct use of the lanyard - routine maintenance procedures • testing requirement and test operation • checking battery expiry date • cleaning/checking float-free mechanism			
2 Describes the Inmarsat-E EPIRB - the basic operation of the 1 6 GHz (L-band) EPIRB - the information content of a distress alert - the registration and coding of an L-band EPIRB - manual operation - the float-free function - the correct use of the lanyard - routine maintenance procedures • testing requirement and test operation • checking battery expiry date • cleaning/checking float-free mechanism		T3.1.T3.2, T3.3	A1 -Sect 13 A3 A6
3 Describes precautions taken to avoid false distress alerts - safe handling procedures - transportation precautions	R6	T3.1	A1 -Sect 13
4 Describes additional EPIRB features - the 121 5 MHz SAR homing function - the strobe light function			A1 -Sect 13 A6
4.2 Search and Rescue Radar Transponder (SART) (1.0 hour)			
1 Operation and use of SARTs - lists the main technical details - explains operating height and range considerations - describes the effect of a radar reflector - describes the radar screen indication - describes SART testing procedures - describes routine maintenance procedures • checking battery expiry date	R1-Pt3.5		A1 -Sect 13 A3 A6
4 3 Maritime Safety Information (MSI) services (4.0 hours)	R1-Pt3.7 +Annex 4.2	T1-RRS33	A1-Sect. 12
1 Purpose and use of MSI services - describes message types constituting MS - lists availability of MSI services - describes use of published data on MSI services			

2 Describes services available and methods of transmission			
- MSI by satellite			
- MSI by MF and HF			
- MSI by HF telex			
3 Operation and use of the NAVTEX system			A3
- describes operation of the NAVTEX receiver			
- lists frequencies			
- describes coverage areas of transmissions			
- states range of transmitters			
- describes message format and identification			
• selection of transmitters			
• selection of message types			
• message types which cannot be rejected			
- describes use of receiver controls			
- demonstrates method of changing paper			
4 Operation and use of the International SafetyNET system		T3.4	A3
- describes EGC facilities			A2.2
- programs EGC receiver/Inmarsat-C equipment for reception of EGC/SafetyNET messages			
- updates ship's position both manually and automatically			
- selects mode for EGC reception			
5 DISTRESS ALERTING	R4		
5.1 Search and Rescue (SAR) operation (4.0 hours)			
1 Describes the role of the Rescue Co-ordination Centre (RCC)	R2		
- knowledge of SAR systems worldwide	R1-P12.2		
- knowledge of SAR system interconnection	&3.2		
2 Describes the role of SAR units			
- Merchant Ship Search and Rescue Manual (MERSAR)	R2		
3 Describes the role and method of use of ship reporting systems	R1-Pt2.2		
-AMVER, JASREP, AUSREP, etc	&3.2		
5.2 GMDSS terrestrial distress, urgency and safety communication procedures (11.0 hours)	R2, R7	T1-ChSVII APS13, APS15	
1 Describes and demonstrates distress communications and DSC alerts			A-I-Sect.7 A3
- the definition of a distress alert			

- transmission of a distress alert - transmission of a shore to ship distress alert relay - transmission of a distress alert by a station not itself in distress - receipt and acknowledgement by a coast station - receipt and acknowledgement by a ship station - preparations for handling distress traffic - distress traffic terminology - on-scene communications - related SAR operations			
2 Describes urgency and safety communications - the meaning of urgency and safety communications - procedures for DSC urgency and safety calls - urgency communications - medical transports - safety communications			A1- Sect.9 A3
3 Describes radiotelephony procedures communications - the radiotelephone 2182 kHz alarm signal - the distress signal - the distress call - the distress message - acknowledgement of distress messages - distress traffic terminology - transmission of a distress message by a station not itself in distress - request for medical advice			A1-Sect.8 A3
5.3 GMDSS satellite distress, urgency and safety communication procedures (4 0 hours)		T3.1	A1-Sect. 11
1 Describes and demonstrates the Inmarsat-A/-B ship earth station alerting functions - distress and safety procedures - methods of initiating alerts - satellite acquisition - telex and telephony distress calls - telex and telephony urgency and safety calls - procedures for preparation of calls - details of Rescue Co-ordination Centres (RCCs) associated with Coast Earth Stations (CESSs)			A2.1
2 Describes Inmarsat-C ship earth station alerting functions			A2.2

- distress and safety procedures - methods of initiating alerts - satellite acquisition - sending a distress priority message - Inmarsat-C safety services - 2-digit special access codes and their purpose			
5.4 Protection of distress frequencies and avoidance of false distress alerts (3.0 hours)			
1 Describes methods of preventing false distress alerts	R6		A1- Sect.6, 11 & 13
2 Describes and demonstrates usage of procedures to minimize the effect of a false distress alert	R6	T1-RES 349	A1-Sect.6, 11 & 13
3 Describes testing procedures for GMDSS equipment			A1-Sect.6, 11 & 13
4 States prohibitions on transmissions during distress traffic			A1-Sect.6, 11 & 13
5 States procedures to avoid harmful interference			A1-Sect.6, 11 & 13
6 States regulations regarding unauthorized transmissions			A1- Sect.6, 11 & 13
7 States guard-bands protecting distress frequencies			A1- Sect.6, 11 & 13
6 MISCELLANEOUS SKILLS AND OPERATIONAL PROCEDURES FOR GENERAL COMMUNICATIONS			
6.1 Ability to use the English language, written and spoken, for the exchange of communications relevant to the safety of life at sea	R5		
1 Explains the use of the IMO Standard Marine Communication Phrases and the International Code of Signals	R3		
2 States recognized standard abbreviations and commonly used service codes			
3 Describes the use of International Phonetic Alphabet		T1 -?? S14	A1-Sect. 10
6.2 Obligatory procedures and practices (4.0 hours)			
1 Explains the use of obligatory documents and publications - details methods of updating information		T1 -Ap11 T2.1 toT2.4	A1-Sect. 14 ?4
2 Describes procedures for radio record keeping	R5	T1	A1-Sect. 10 ?5
- details log-book requirements and mandatory entries			
3 Demonstrates a detailed knowledge of the regulations and agreements governing the maritime			

mobile service and the maritime mobile-satellite service			
6.3 Practical and theoretical knowledge of general communication procedures (11.0 hours)			
1 Describes how to select appropriate communication methods in different situations - use of obligatory documentation to determine frequencies, etc - use of propagation tables		T1 T2.1.T2.2	A1.Sect.14 ?4
2 Describes the use of obligatory documentation to receive traffic lists and meteorological information		T2.1.T2.2	
3 Describes procedures for radiotelephone calls - method of calling coast station by radiotelephone - requesting a manually switched link call - terminating a call - special facilities available - methods of calling a coast station by DSC - selecting an automatic radiotelephone call		T1	A1–Sect.10 &17 A3
4 Describes details of a radiotelegram - component parts of a radiotelegram - types of addressing available - counting of words - transmission of telegram by radiotelephony - transmission of telegram by radiotelex		T1 - Pt E	A1-Sect. 17
5 Describe procedures of data transmission to coastal networks users (telex, E-mail users, FAX users) - with use of radio telex - with use of INMARSAT ABC station.			A2.3
6 Describes methods of charging - the international charging and accounting system - Inmarsat charging systems - the AAIC and use of documentation to determine/verify it - the meaning of landline, coast station and ship station charge - currencies used in charging and conversion - gold francs and special drawing rights, etc		T3.1 - Pt D, PtE T3.1	A1-Sect. 17
7 ASSESSMENT AND DISCUSSION (8.0 hours)			
to be arranged by course instructor			
In addition to the 132 hours above, 4 hours should be added for trial examinations			

SECTION 9

MAINTENANCE OF SHIPBORNE GMDSS EQUIPMENT

The purpose of the Section is to give the trainees knowledge and skills necessary for at sea maintenance capability of the shipborne GMDSS radio equipment, including the ability of a trainee to localize failures in replaceable blocks (modules) and to replace such blocks.

Entry standards:

The candidate should have knowledge of:

- principles of operation and structural schemes of the shipborne GMDSS equipment,
- use of measuring devices,
- and practical skills in performing assembly works.

After completion of the course the trainees should have

knowledge of:

- rules of occupational safety for repairs of GMDSS equipment;
- general measures for maintenance in accordance with rules of operation and with instructions of the manufacturer;
- construction and marking of the GMDSS radioelectronic equipment components;
- rules of performing measurements;
- rules of repairing and replacing components of radioelectronic equipment;
- technology of replacing block and modules;
- means of protection against condensate and water access;
- means of increasing radiation safety and electromagnetic compatibility of the ship GMDSS equipment;

practical skills in:

- use of corresponding instruments and control-measuring devices;
- use of multimeter for determining working ability of a semiconductor diode, transistor, inductance coil, electrolytic condenser, transformer;
- use of in-built testing programs and other means of control and diagnostics;
- use of lubricants and means of cleaning mechanisms;
- maintenance of ship antenna systems, antenna cables and wave-guides;
- maintenance of reserve sources of power and charging devices;
- localization of failures at block and module levels by means of processing the information received with the help of in-built diagnostic programs, in-built measuring devices which correspond to standard ones (testers, oscillographs, frequency meters, generators) and with the help of analysis of schemes and technical drawings available from technical documentation;
- elimination of failures of the GMDSS ship equipment by means of replacing blocks and modules;
- to solder connectors, to connect radiofrequency cables and waveguides;
- to make orders for GMDSS equipment spare parts.

Course outline.

Learning objectives.		Class hours.		
		Total	Theoretic	Simulators and real equipment
1	Maintenance. - Occupational safety for ship GMDSS equipment operation. - Maintenance of reserve power supply sources. - Maintenance of antenna systems. - Maintenance of EPIRBs. - Software servicing. - Maintenance of matrix printers.	12 2 2 1 1 5 1	5 2 1 - - 2 -	7 - 1 1 1 3 1
2	Localizing failures. - General principles of finding failures in ship radiocommunication equipment. - Localization of failures in ship radioinstallation without built-in diagnostic systems. - Localization of failures in ship radiostations with built-in diagnostic systems. - Localization of failures in ship satellite communication radiostations.	48 4 10 18 16	6 1 1 2 2	42 3 9 16 14
3	Repairs. - Replacement of electronic schemes components. - Replacement of blocks and modules. - Elimination of failures connected with software. - Assembling cables in high-frequency connectors.	38 6 10 20 2	2 - - 2 -	36 6 10 18 2
4	Record-keeping.	4	2	2
	Total	102	15	87

9.1 Maintenance of ship radiocommunication means.

The allocated period of time and extent of maintenance are determined in accordance with Rules of Radiocommunication Equipment Technical Operation and instructions of the manufacturer.

As a rule, the ship GMDSS equipment is produced for continuous round-the-clock operation and does not require everyday maintenance.

General regular prophylactic measures comprise:

- check of accumulators condition;
- check of antennas, earthing and cables conditions;
- check of EPIRBs, SARTs and VHF radiostations conditions;
- check of transceiver and computer systems of ventilator;
- check of mechanical connections in HF and LF connectors and of blocks fastening;
- check of printers and clearing computer memory from unnecessary files.

Occupational safety for ship GMDSS equipment operation.

While carrying out shipborne radioequipment maintenance it should be remembered that electric current, static electricity and electromagnetic fields influence human organism and protective measures should be taken against their adverse effects.

Injuries caused by electricity. Among all the causes of occupational accidents electric current injuries make up about 3%, but most of such cases are serious and frequently have lethal outcomes.

There are two main kinds of electric current action:

- electric burn of skin, inner tissues and different organs of human body;
- electric shock, which may cause affection of nervous system, disorders in heart and lungs functioning, muscle paralysis, shock, loss of consciousness with lethal outcome.

Most dangerous for people are industrial electric currents (50 or 60 Hz frequency), the strength of which depends on the applied voltage and on the state of the person's skin.

Voltage up to 36V is considered to be comparatively safe.

To protect people from electric injuries it is necessary:

- to apply low voltages (less than 36V);
- to check the condition of insulation;
- to use protective earthing;
- to use different blocking and protective switch-off schemes.

When working with higher voltages the specialists should use individual protective appliances: insulating rugs, boots and gloves made of special rubber, instruments with isolated handles, protective earthing and so on.

Radiofrequency currents contact the person's skin and can cause heavy burns.

Static electricity. Static electricity charges are generated as a result of friction between two dielectrics. Appearance of static electricity in industrial conditions is usually connected with movement of gases, vapours, dust, liquid etc.

Prolonged action of static electricity on people affects/depresses central nervous and cardio-vascular systems and causes headaches. After withdrawal of static charges such negative symptoms disappear.

Main means of protection against static electricity are:

- earthing;
- moisturizing and ionization of air;
- individual protective means.

Electromagnetic fields. Most dangerous for people are electromagnetic fields of SHF, with frequency more than 300 MHz. Exposure to SHF causes fatigability, frequent

headaches and heartaches, insomnia, irritability, memory problems, faints and breathlessness. In some cases cataract, hair fall out, mental disorders and problems with sexual potency can develop.

The sources of SHF are INMARSAT and radar antennas.

To guard against SHF protective screens, individual protective glasses covered with SnO_2 film and special protective clothes (when working in the areas where the antenna emission is more intensive than permissible) are used.

When radioelectronic equipment repairs take place the obligatory occupational safety requirements are:

- working, when possible, with switched-off power supply;
- placing warning signs near the electric network switches;
- first-aid kit containing cotton wool, bandage, 5% sodium solution, 2% boric acid solution, tincture of iodine, liquid ammonia, vaseline and plaster must be available at the working place.

To avoid accidents when the equipment is switched on it is forbidden:

- to substitute blocks;
- to substitute cut-outs;
- to solder and assemble scheme elements;
- to check the temperature and voltage of radiodetails by touch,
- to use measuring devices with non-insulated feelers and wires;
- to connect devices and blocks by means of wires with damaged insulation.

In case of a short-time electric current shock it is necessary to stop the work until recovery of normal condition (disappearance of giddiness, sight and sound hallucinations, etc).

In case of a strong electric current shock the injured person, as a rule, is unable to get away from the electric current wire. In such a case it is required:

- to switch off the current immediately;
- to unfasten the clothes of the injured person and to bring to his nose a piece of cotton wool wetted with liquid ammonia;
- to start resuscitation measures;
- to call the doctor.

One must be very careful when working with hot soldering irons, metalwork instruments, glues, varnishes, acids and alkalies.

When working with chemical substances it is necessary:

- to adhere strictly to all the rules which determine their dissolving and mixing, sequence of operations and temperature conditions;
- to wear special working clothes and in some cases (for example, when changing electrolyte in the accumulator) - protective gloves and glasses.
- to protect eyes, lips and nose and throat mucous membranes which are most vulnerable to chemical substances influence;
- the places of acid burns must be watered abundantly and wetted with soda solution;
- the places of alkali burns must be treated with boric acid solution.

Cuts and scratches must be treated with iodine solution (but it should not be poured over, otherwise it may cause a chemical burn) and covered with bactericidal plaster.

Maintenance of reserve power supply sources.

The voltage of accumulators under load is to be checked daily. If the voltage of 24V acid accumulators under load falls below 22V, it means that the accumulators are discharged and they must be charged immediately.

Every week the intact condition of cells and reliability of electrical contacts should be checked and rust is removed with cloth wetted with kerosene.

Unpainted metal surfaces of the cells should be lubricated with vaseline.

The electrolyte level and density is checked weekly (or the voltage of every cell - with the help of battery cell tester).

The level of electrolyte should be 10-15mm higher than the level of the plates.

If the level is reduced due to evaporation, distilled water is added.

Nominal voltage of every separate jar of acid accumulators is about 2V, and alkaline ones - 1.4V. If the voltage is reduced by 0.2V, the accumulators are considered to be discharged and are liable to immediate charging.

The density of electrolyte in acid accumulators depends on the state of charge and varies from 1.28 (fully charged) to 1.11 (fully discharged). In alkali accumulators density does not depend on the degree of discharge and is within the range between 1.19 and 1.21.

In case of transferring accumulators to another space, the following should be taken into consideration:

accumulators must be placed in a room located not lower than the navigating bridge. This room must have electrical lighting, ventilation and heating systems, which provide temperature of accumulators (both when being charged and on no load) within the range set by the manufacturer.

accumulators must be electrically isolated from the hull of the ship and placed on the shelves at the level not lower than 100mm from the deck.

accumulators with different electrolytes must not be placed in one room.

the length of cable runs to radioequipment must not exceed 15m. The voltage loss in copper conductors can be calculated using the following formula: $U = (0.35 * L * I) / S$, where "L" is the length of the cable; "I" is consumed current; "S" is the cable cross-section, mm².

Maintenance of antenna systems.

The appearance of typical antennas supplied together with the GMDSS equipment is shown in (Fig.9.1).

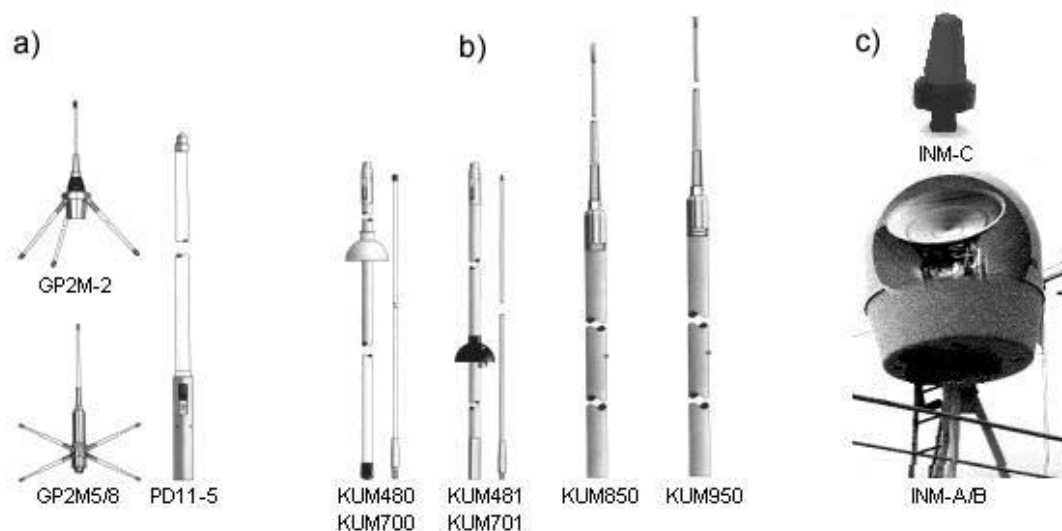


Fig.9.1.VHF(a),MF/HV(a) and SES(b) antennas.

When installing the SES INMARSAT-C antenna, the recommendations of A.807(19) IMO Resolution shall be taken into consideration. The antenna should be located in such a place where there are no obstructions which screen the antenna and which could considerably spoil operational characteristics of the equipment (in the fore-and-aft direction up to -5 degrees and athwartships up to -15 degrees in respect to the horizon level) .For non-directional antennas the objects located within 1m from the antenna and giving a blind sector of more than 2 degrees can make operational characteristics of the equipment considerably worse (Fig.9.2)

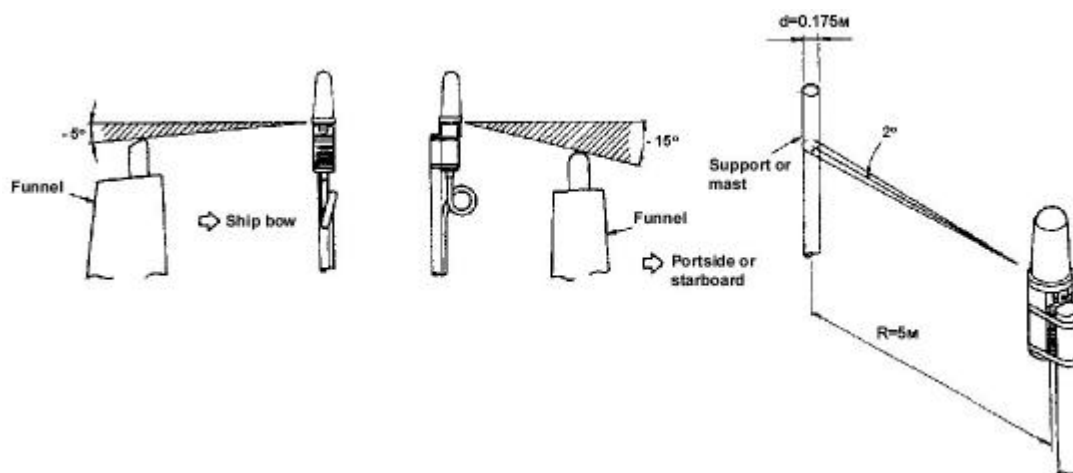


Fig.9.2 Antenna location.

Many manufacturers recommend to choose the distance R to the obstructing object considering the relationship: $R \geq 20d$, where " d " is the diameter of the obstruction.

It is recommended to install the antenna:

- not closer than 5m from the HF antenna;
- not closer than 4m from the VHF antenna;
- not closer than 3m from the magnetic compass;
- beyond the radar scanning zone.

The antenna should not be subject to strong vibration and shocks, it should be located away from places where heat, soot from the funnel and big amounts of dust can get to it.

The antenna block is switched to the transceiver by means of a single coaxial cable, which must not:

- introduce decay of more than 16dB at 1.65 GHz frequency;
- generate resistance to direct current of not more than 0.8 Ohm.

When the antenna is installed at the distance of up to 40m from the transceiver, the RG214 cable meets these requirements.

When checking the antennas of VHF, HF, and MF ranges the following conditions must be considered:

- coaxial cables feeding the antennas must be installed in separate signal cable chutes at the distance of not less than 10cm from feeding cables.
- the cables must cross each other at the right angle (90 degrees). The antennas condition is to be checked every month.
- the resistance of antennas insulation in respect to the hull of the ship must not be lower than 10 MOhm at normal climatic conditions and not lower than 1 MOhm in conditions of increased humidity.
- separate parts of antenna cables must not be located closer than 1m to tubes, masts and other metal parts of the ship and must not contact ship's metal constructions in any conditions of its work.

Once every half a year antenna equipment and earthing of antenna tuning units (transmitters) should be checked, when:

- insulators must be cleaned, damaged details restored, steel halyards covered with anticorrosion lubricants, blocks for raising beam antennas cleaned and lubricated etc.
- earthing resistance of the antenna tuning unit and of the transmitter casing is checked; it must not exceed 0.02 Ohm.

When a beam aerial is used in MF range, a reserve antenna or antenna trigger cable for its raising, antennas insulators (including partition insulators) and rigging details (brackets, thimbles, clamps etc) must be ready allowing to assemble an antenna equivalent to the one which is already installed on board ship.

Maintenance of EPIRBs.

Running inspections, maintenance and check of EPIRBs are carried out in compliance with instructions of the manufacturing company.

General recommendations:

- EPIRBs should be kept clean for which they can be washed with fresh water.
- On the EPIRB itself and near it there must not be any objects, which can obstruct its automatic detaching from the bracket.

During periodic testing it is required:

- to check how the fastenings of the bracket are tightened.
- to check if there are any signs of corrosion on the antenna, bracket and fastenings. If corrosion is found, the fastening should be either cleaned from it or replaced with a new one.
- to inspect the casing of the EPIRB for fractures and other damage.

- to check the expiry date of the accumulator and hydrostatic release sensor. If they are to be substituted, an order should be placed with the servicing company.
- to test the EPIRB in accordance with its instruction.

Periodical inspections of COSPAS SARSAT EPIRBs should include checking:

- Identification number.
- Message contents.
- The frequency stability of the 406 MHz signal without transmission of a distress call.
- The hydrostatic release mechanism and its expiry date.
- Flashing light condition.
- Availability and quality of marking.
- The battery expiry date.

Maintenance of the GMDSS equipment, which includes computers.

For heat dissipation a ventilator is introduced in the system block of the computer. The ventilator brings a big amount of air into the computer and together with the air particles of dust contained in it get into the computer. Dust influences working ability of mechanical devices, for example, when it gets on reading/recording heads in floppy disk drives or causes overheating of the system components.

Before maintenance (cleaning) the computer must be switched off from power supply.

For cleaning outer surfaces any cleansing means not containing substances destroying plastic (for instance, acetone) can be used.

For cleaning inner surfaces the casing of the computer should be taken off and with the help of soft brush big accumulations of dust from the motherboard, in areas of memory microschemes installations and on power supply block can be removed. In easily accessible places dust can also be removed with the help of a vacuum cleaner.

Inserting the head of the vacuum cleaner into the slots of floppy drive is forbidden because it can damage reading/recording heads and other small mechanical parts inside.

If there is dust on a reading/recording head, there can appear a message of the type "Can't read disk in drive A:". Reading/recording heads may be cleaned by means of special cleaning diskettes. If such diskettes are not available it is possible in case of urgent necessity to clean them carefully with a stick around which a piece of wetted cotton wool is wrapped. Every head is located on a thin plate made of steel and fastened with a spring. The spring must not be touched or bent.

To keep the keyboard clean it should be protected with plastic cover when not used. Practically every detail of the keyboard is made of plastic. For removing dirt from the keyboard, any cleaning substances except those containing acetone and plastic dissolvents can be applied.

Preliminary/crude cleaning can be effected with the help of a vacuum cleaner. Monitor servicing includes the display and casing cleaning. The openings on the sides and at the rear side of the monitor are cleaned with a vacuum cleaner. When wetted cloth is used, liquid from it must not get inside the monitor through the openings.

The dust, accumulated inside the monitor prevents heat from dissipating which causes overheating the monitor, reducing its workability period. There is high voltage on the beam-deflection tube of the monitor. When such a monitor is uncovered, one must wait until the condensers are discharged. There exist monitors with a special protective anti-glare film. If usual cleaning means are applied to such monitors, they can damage this film. Familiarisation with the manufacturer's documentation and the recommendations on cleaning the surface is necessary.

Persistent stains are better to be wiped several times with slight pressure, as the anti-glare film on the glass is very thin and can be damaged by strong mechanical action.

Software servicing.

Modern approach to construction of communication equipment with computer control of transceivers presumes, together with traditional kinds of failures connected with damage to electronic schemes components, a new type of failures linked with failures in software operation, which can take place due to:

- failure of information medium where software is recorded (hard disk failure). In this case such an information medium should be substituted or a reserve (emergency) diskette should be run. Such a diskette must perform the functions of a boot up diskette, include a communication program and preserve the received and sent files.
- virus action. To restore the working ability of the station, reserve copies of the programs must be available.
- upset of operation regime balance (for example, abrupt changes of voltage in the ship's power supply network) as a result of which there can be erasing of software recorded in EEPROM.
- unqualified actions of the servicing personnel.

Getting ready the emergency diskette.

The emergency diskette must contain the operation system nucleus. Such a system will be of use also if the system is by some reason not loaded from the hard disk.

Usually corresponding DOS files are located on C: disk in DOS directory.

Sequence of actions:

1. To run the computer and to wait for DOS prompt: C:\>.

2. To insert the diskette into A: disk drive and to format it by printing the command: `FORMAT A:/F:1440/S *`

By this the three files comprising the operation system nucleus: IO.SYS, MSDOS.SYS and COMMAND.COM will be transferred onto the diskette.

After the end of formatting the corresponding message will appear on the display.

*Format of the command: `format Drive:[/f:size][/s]`.

- Drive: - is a drive into which the diskette liable to being formatted is in - It is an obligatory parameter, other parameters are not obligatory.
- /f:size - is the size of the formatted disk. For 3.5" diskettes it is 720 and 1440. The size of the formatted 3.5" diskette can be determined by the number of openings in the diskette (for example, a 1440Kb diskette will have two openings and a

720Kb diskette -one opening). If the size of the diskette is not indicated, the formatting is effected for the maximal volume of the drive;

- /s -copying system files on the formatted disk.

To learn the purpose of other parameters FORMAT/? command should be typed.

3.If the diskette is intended to be used for formatting the hard disk, it is necessary to copy three more DOS utility programs on the system diskette: SYS.COM, FORMAT.COM and FDISK.EXE*.For this the following commands are introduced:

```
COPY C:\DOS\SYS.COM A:**
```

```
COPY C:\DOS\FORMAT.COM A:
```

```
COPY C:\DOS\FDISK.EXE A:
```

*Attention: the peculiarity of SYS.COM,FORMAT.COM and FDISK.EXE utilities is their dependence from the operation system version. For example, if the given FORMAT.COM utility was provided from the 6.20 OS version, it will work only in the OS of this version. With other operation systems versions there will be a message on the display "Incorrect DOS version". By printing command VER it is possible to learn OS version, and the FORMAT.COM utility version is reflected in the time of creating the file (for example, if the version is 6.20 the time of creating the file is 6.20a).

**on condition that sys.com, format.com, and fdisk.exe files are in DOS catalogue on disk C:.

Communication programs may be made as a single executable file, for example,STR1500.exe, Capsat.exe or be composed of several files, as in STR2000 and Galaxy.

Disk servicing.

In all the given examples it is presumed that the serviced disk is C: disk. For servicing another disk it is necessary to indicate a letter corresponding to it.

Checking the disks.

In the course of hard disk operation lost clusters, which do not belong to any file or register, defective clusters, etc can appear on it. Errors in the logical structure of the disk can cause failures in program operation.

For testing the disk structure (checking the virtual table of file location, table of hard disk division, search for physical errors on the surface of the floppy or hard disk and restoring damaged data) ScanDisk (DOS utility) program is used, NDD from the Norton Utilities complex of programs can also be applied.

For disk C: checking the following command is entered:

```
SCANDISK C:
```

In case of finding an error, ScanDisk gives the dialog window "Problem Found" with a brief description of the error and of what will happen after its correction .In the window "Problem Found" there are commands: "Fix it", "Don't Fix It" and "More Info".

If the "Fix It" command is chosen, ScanDisk corrects the found error. Before effecting changes on the disk, ScanDisk offers to create the "Undo" diskette, which

allows to cancel the introduced corrections. This diskette contains information about the changes introduced in the disk.

To cancel the introduced corrections is possible only if no changes were made after the corrections. To cancel the corrections introduced earlier the following command is entered:

Scandisk /undo[disk drive:]

[disk drive :] containing the Undo disk is indicated.

Optimization of files location on the disk.

When the disk is used intensively, when files are removed and transferred, there appear many fragmented, i.e. located in different parts of the disk, files. Fragmentation of files increases the number of movements of enter-exit heads, the time of recording and reading the files (slows down the disk work).

Defragmentation programs transfer all the files to the beginning of the disk. After the end of the program work every file occupies a single continuous fragment on the disk, the empty spaces are combined into one continuous field which speeds up the disk operation.

Defrag (DOS Utility) program is used for disk defragmentation, as well as SpeedDisk from the Norton Utilities program complex.

For disk C: defragmentation the following command is entered:

DEFRAG C:

Usually scandisk.exe and defrag.exe files are in the DOS catalogue.

All the above operations can be effected for diskettes, which are worked with intensively.

Anti-virus measures.

The following measures are recommended for being taken:

1.Reserving information and providing separate access to its different pieces. It is necessary to have archive or model copies of the used packets of programs and data and periodically place the newly created or modified files in the archive, then the loss of information in case of its accidental erasing will not be so big.

It is useful to copy the sector with the table of hard disk division, loading sectors of all the logic disks and the contents of CMOS on the diskettes. It can be done with the help of "Create rescue diskette" option of the DiskTool program from Norton Utilities complex.

Protection from recording should be set on the files, which must not be changed.

Strangers with their diskettes and especially computer games fans should not be allowed to work with the computer.

2.Check of the coming information.

Before use all the new diskettes should be checked for viruses with the help of detecting programs.

3.Computer check for viruses.

The computer must be regularly checked by means of anti-virus programs. Use of instant anti-virus programs checking the files at the moment of being addressed.

4.Preparation of repair set.

The system diskette should be prepared in advance. The repair set must contain programs for locating and destroying different computer viruses. The repair set diskettes must have protection against recording, for the copied files not to be accidentally changed or damaged.

Maintenance of matrix printers.

Maintenance of a printer comprises periodic supply of paper, of painting tape, cleaning inner and outer surfaces.

There is a smooth guide/slide along which the head moves inside the printer. If this guide is covered with dirt and dust, the head of the printer may with time lose its ability to move. That is why from time to time it is necessary to clean this guide. The frequency of these procedures depends on how much time the printer was or was not used. The guide itself looks like a well polished rod/bar approximately 1cm in diameter.

The head of the printer must also be regularly cleaned by means of special sprays or with a wad wetted with alcohol. Before cleaning the cassette with the tape is removed. To take care when cleaning is necessary, otherwise the needles protruding from the head may be bent.

9.2 Localization of failures.

General principles of finding failures in ship radio communication equipment.

Such failures may take place in electronic schemes, also there may be problems with software and tuning.

According to their degree of complexity and possibility of being localized and eliminated the equipment failures may be classified in the following way:

(Table 9.1).

Table 9.1.Classification of failures.

Type	Classification	Examples of failures
1.	Failures which may be found with the help of special devices	1.Frequency drift of crystal oscillator 2.Transmitter output power decrease 3.Decrease of the receiver sensitivity. 4.Decrease of the transmitter modulation depth etc. 5.Defects in microschemes.
2.	Failures detectable with the help of a tester	1.No voltage in power supply. 2.Defects in inner assembling and wiring.

		3.Defects in resistors, condensers, inductance coils, relays. 4.Defects in diodes and transistors.
3.	Failures which can be determined without measuring devices	1.Burnt cut-outs of the power supply block. 2.Poor contacts in connectors. 3.Antenna cable break. 4.Defects in switches, potentiometers, etc. 5.Other defects noticeable visually.

Defects of the second and third class can be eliminated on board ship if technical documentation and spare parts are available. Failures of the first class are not repairable on shipboard.

Localizing failures in electronic schemes has two stages: at the first the faulty block or module is found, at the second -the faulty element of the scheme. In most cases modern technology does not provide the opportunity to repair scheme elements. However, in separate blocks, as, for example, MF/HF transmitter power amplifiers, tune units, input circuits of the receivers, power supply blocks it is possible to substitute separate elements (transistors, inductance coils, condensers, relays). If we take into consideration the fact that the blocks mentioned above are most unreliable, then the necessity to know their principal schemes and ability to localize and replace the faulty element in ship conditions becomes evident.

As an example, Table 9.2 gives the classification of possible failures of the STR2000 MF/HF radio installation. This table shows that the number of failures linked with loss of control due to the computer, interface, wrong configuration, etc is very big and these questions should be studied as thoroughly as questions of traditional failures of electronic schemes.

Table 9.2.Classification of MF/HF radio installation failures.

No.	Characteristic of the failure	Causes
1.	Failures connected with electric power supply	1.No voltage in the network. 2.Break of power supply wire. 3.Burnt cut-out. 4.The command to switch on power supply does not function. - power switch is either not switched on or broken. - there is no command "power on" from CPU. 5.The electronic scheme is damaged.

2.	Failures connected with loss of control over the radiostation.	1.Computer failures. -no power supply. -program failures. -configuration is incorrect. -hardware is damaged. 2.Connection between the computer and control block of the transceiver is broken. -COM ports are mixed up. -RxD or TxD interface lines are damaged. -no signals on interface lines.
3.	Failures in transceiver.	1.Connections between blocks are damaged. 2.Blocks are damaged. 3.Failures connected with wrong configuration. -antenna tune unit (ATU) is switched off. -power amplifier (PA) is switched off. -printer is switched off. 4.Problems connected with incorrect tuning of the station. -frequencies are chosen incorrectly. -emission type is chosen incorrectly. -mode of operation is chosen incorrectly.
4.	Antenna tune unit failures.	1.+24V voltage is not supplied. 2.One of voltages (-15V, +12V, +24V) received by the ATU is not available. 3.RxD or TxD chain break. 4.Breakage of the antenna or short circuit in it. 5.High resistance of the antenna earthing. 6.Low resistance of the antenna isolation. 7.Failures connected with CPU. -manual tuning is chosen. -electronic relay drivers are damaged. -condensers and inductance coils are damaged.
5.	Printer failures.	1.No power supply.

		2.No paper on the reel or reel shifting. 3.Not connected/switched to the line. 4.Interface failures.

Computers are widely used for monitoring transceivers of the ship GMDSS radio equipment and that is why the ability to work with the computer software, Localization of failures in ship radio stations without built-in knowledge of their architecture, ability to change their configuration, to perform diagnostics and replacement of blocks become evident.

Localization of failures in ship radiostations without built-in diagnostic systems.

For localizing failures in the ship GMDSS radio equipment different systems of built-in control and also general-purpose devices (testers, multimeters, oscillographs etc) are used.

For localizing failures in radio equipment without built-in diagnostic systems generally it is necessary:

- to check power supply system: voltage in the network, cut-outs, good condition of connections etc;
- to analyze on the basis of visual signs what kind of failure it can be. Table 9.3 gives examples of general signs and possible causes of VHF radio station failures;
- to check voltage in test points with the help of a multimeter and compare them with nominal values given in technical documentation.

Table 9.3 General failures of radio station.

?	Sign of the failure	Possible cause
1.	Channel number is not shown on the display,	1.Power supply cut out is burnt. 2.Defect of power switch in the main block. 3.Defect in the display circuit. 4.Defect in the display controller circuit.
2.	The inscription "TX" appears on the display, but there is no answer to the call.	1.Defect of the microphone or of the microphone amplifier in the receiver. 2.Defect of audio-frequency amplifier or of the transmitter modulator.
3.	The called station does not answer.	1.Antenna is damaged. 2.Antenna cable is damaged. 3.There is no contact in the antenna connector. 4.The frequency is chosen incorrectly.
4.	No sound from the	1.Defect of the loudspeaker

	loudspeaker when the SQL handle is turned fully anticlockwise	2.Defect of the potentiometer. 3.The audio frequency circuit is damaged. 4.The SQL circuit in the receiver block is damaged.
5.	The sound level from the loudspeaker is lower than usual.	1.Defect in the circuit of audio frequency 2. Defect in the medium frequency circuit of the receiver block.
6.	The sound in the loudspeaker is heard, but other stations cannot be received.	1.Antenna is broken or cable is damaged. 2.Defect in the high frequency circuit of receiving block. 3.Defect in the PLL circuit of the frequency synthesizer. 4.Frequency shift of the reference generator
7.	There is no noise suppression even if the SQL handle is adjusted.	1.Defect of the SQL adjuster. 2.Defect in the SQL circuit of the receiving block.
8.	Transmission is impossible. "TX" does not appear on the display.	1.Failure of the receiver. 2.Failure in the circuit of transmission control. 3.Defect of the speaking key in the microtelephone receiver.
9.	The transmitted signal is emitted, but there is no modulation.	1.Defect in the microphone circuit of the receiver. 2.Defect in the audio frequency amplification circuit of the control block. 3.Defect in the modulation circuit of the transmitter.
10.	There is no emission only in the duplex mode or poor sensitivity .	1.Antenna switch is broken.
11.	No signal at the output only in the simplex mode or poor sensitivity.	1.Antenna switch is broken.

Localization of failures in radio installations with built-in systems of diagnostics.

When a failure takes place in the station, which is equipped with the system of built-in control, corresponding information is shown on the display. Built-in control systems in MF/HF stations are such that in some stations displays with limited characteristics (having no opportunity to give detailed information) are used. That is why the error code is displayed. Then, after the command of the operator, the built-in control program allowing to get more detailed information is switched on.

In other radio installation control is effected by a computer having better opportunities for showing information on the monitor display or on the printer.

This information (warning) appears in the form of the text immediately after the built-in testing system finds the failure. After this the diagnostic program must also be run. This program shows on the display and, when desirable, on the printer, the list of the tested blocks with the indication of test points and their voltages. Permissible limits and status (OK or error) are also shown.

In any case, the final conclusion, whether the block is faulty or it is the result of other circuits faults, must be made by the specialist after proper analysis of the information received from built-in testing systems.

The STR2000 MF/HF radio installation.

The STR2000 provides everyday DSC equipment testing, it also controls operation of several blocks. Test points in the blocks are checked after starting the BITE (Built-In Test Equipment) program. The results can be shown on display or printer.

The BITE starting is effected from the main menu after pressing the F10 key. Self-testing is effected from the BITE menu (Fig 9.3.)

BITE Menu	
Run Test	F1
Vew Test report	F2
Print Test report	F3
Unit Test Menu	F4
Report Menu	F5
Report File Menu	F6
Setup Menu	F7
Quit BITE	ESC

Fig. 9.3 BITE menu.

Before running the test, Set-up menu should be entered (Fig.9.4) and the radiospecialist should make sure that selection of tested blocks, power and frequencies at which emission is planned is made correctly. If necessary, corresponding changes can be introduced with the help of prompts, given in the lower part of every page.

After this testing can be started by choosing "Run Test".

Before beginning the test with emission the program requires to confirm that antenna or its dummy load is switched to and to agree to emission at the indicated frequencies.

The quality of tuning can be judged by comparing the value of power going to the antenna (PowerF) and reflected power (PowerR) in the PA UNIT ACTIVE TEST report (Table 9.4). The lower the reflected power, the better the tuning. If the

reflected power is too high, it is necessary to check the resistance of the antenna insulation and quality of ATU block earthing.

If there are problems in ATU or there is no connection with it, "Data may be incorrect" sign may appear on the screen. No more detailed testing of the ATU is effected and further search of failures in it is performed with the help of general purpose measuring devices.

An example of the BITE system report is given in Table 9.4.

Setup Menu. Page 1

Com Setup

Current Settings: 9600,COM2

Baud rate	Port
1: 2400	F1: COM1
2: 9600	F2: COM2

Continuous Test Setup

Continuous test update: No

Select keys

Y: Yes

N: No (Must be activated manually)

PA Power Setup

Key	Pow lev	Status
Alt+1:	1 (55 W)	Test
Alt+2:	2 (70 W)	Skip
Alt+3:	3 (85 W)	Skip
Alt+4:	4 (100 W)	Skip
Alt+5:	5 (150 W)	Skip
Alt+6:	6 (200 W)	Skip
Alt+7:	7 (250 W)	Skip
Alt+8:	8 (300 W)	Skip
Alt+9:	9 (350 W)	Skip
Alt+0:	10 (400 W)	Skip

PA Frequency Setup

Nr	Key	Frequency	Key	Stat
1	A:	04166500 (Hz)	a:	Test
2	B:	06275500 (Hz)	b:	Test
3	C:	08394500 (Hz)	c:	Test
4	D:	12522000 (Hz)	d:	Test
5	E:	16728500 (Hz)	e:	Test
6	F:	25320000 (Hz)	f:	Test
7	G:	25320000 (Hz)	g:	Test
8	H:	27500000 (Hz)	h:	Test

(ESC: Exit) (F9: Save setup) (PgDn: Next Page)

Setup Menu. Page 2

DSP Frequency Setup

Nr	Key	Frequency	Key	Stat
01	A:	00032000 (Hz)	a:	Test
02	B:	00136000 (Hz)	b:	Test
03	C:	01611000 (Hz)	c:	Test
04	D:	02186300 (Hz)	d:	Test
05	E:	02311000 (Hz)	e:	Test
06	F:	04121000 (Hz)	f:	Test
07	G:	06123000 (Hz)	g:	Test
08	H:	08244000 (Hz)	h:	Test
09	I:	10130000 (Hz)	i:	Test
10	J:	12123000 (Hz)	j:	Test
11	K:	12454000 (Hz)	k:	Test
12	L:	14300000 (Hz)	l:	Test
13	M:	14312000 (Hz)	m:	Test
14	N:	15221000 (Hz)	n:	Test
15	O:	16897000 (Hz)	o:	Test
16	P:	17324000 (Hz)	p:	Test
17	Q:	19429000 (Hz)	q:	Test
18	R:	22899000 (Hz)	r:	Test
19	S:	25322000 (Hz)	s:	Test

Test Setup

Key	Module	Status
ALT-A:	CPU2	Test
ALT-B:	Exciter	Test
ALT-C:	RX1	Test
ALT-D:	RX2	Test
ALT-E:	Synt1	Test
ALT-F:	Synt2	Test
ALT-G:	Ref/mux1	Test
ALT-H:	Ref/mux2	Test
ALT-I:	CPU1	Test
ALT-J:	DSP	Test
ALT-K:	LF	Test
ALT-L:	PA active	Test
ALT-M:	PA passive	Test

(ESC: Exit) (F9: Save setup) (PgUp: Prev Page)

Fig.9.4.Setup menu.

Report explanation.

As seen from the report, BITE cannot determine the cause of the failure, but shows the blocks in which departures from the norm are found. To localize the fault the results of the report should be analyzed with the use of the STR 2000 structural scheme.

Example of analysis.

From the general report it is seen that errors were found in the Exciter, the 1st and the 2nd receiver (RX1 and RX2), the 1st and the 2nd synthesizer (SYNT1 and

SYNT2) and reference frequencies block (REF/MUX2). The probability that 5 blocks are faulty at the same time is very small.

From the analysis which followed the report about every block it is clear:

- the Exciter and the 2nd receiver are broken because of absence of the 1st heterodyne(LO1) voltage, which comes from the 2nd synthesizer.
- the 2nd synthesizer does not generate LO1 voltage because of the absence of the reference frequency of 1MHz coming from the REF module (reference frequency block).
- the 1st receiver does not work for the same reason.
- at the same time the block of reference frequencies (REF) generates the reference frequency of 1MHz.

So, the failure is localized within the area "output of the reference frequencies block-inputs of the 1st and 2nd synthesizers".

Possible causes of the failure:

- break in wires connecting the reference frequencies block and synthesizers;
- poor contact in connectors;
- a microfracture in the board/card of the area between output connectors inside REF block and the cascade generating 1MHz frequency.

After the check of wires and connectors it is necessary to make sure with the help of oscillograph that there is no 1 MHz frequency at the REF block output, and only after this to unseal the block (if the guarantee period is expired) and continue the failure search.

Table 9.4. BITE report

STR2000 BITE REPORT: 1999-03-16
SER. NO: -----

UNIT STATUS

EXCITER ERROR
RX1 ERROR
RX2 ERROR
SYNT1 ERROR
SYNT2 ERROR
REF/MUX1 OK
REF/MUX2 OK
CPU1 --
DSP OK
LF --
PA PASSIVE OK
PA ACTIVE ERROR

TESTPOINT FORMAT MIN VALUE MAX DEC STATUS

1.LO3 LEVEL DBM 4.72 7.58 9.95 35 OK
2.LO2 LEVEL DBM 4.74 6.08 9.88 13 OK
3.LO1 LEVEL DBM 4.60 0 9.89 1 ERROR
4.V4 DC BIAS MA 89 101 121 96 OK
5.V3 DC BIAS MA 73 91 126 87 OK
6.V2 DC BIAS MA 52 60 100 57 OK
7.V1 DC BIAS MA 24 43 63 41 OK
8.RF OUT DBM 16.85 0 22.95 0 ERROR

TESTPOINT FORMAT MIN VALUE MAX DEC STATUS

1.V1 DC BIAS MA 65 97 125 97 OK
2.V2 DC BIAS MA 65 98 125 98 OK
3.LO2 LEVEL DBM 4.58 7.17 9.91 21 OK
4.LO1 LEVEL DBM 4.65 0 9.91 0 ERROR
5.LO3 LEVEL DBM 4.59 6.85 10.00 34 OK
6.BP FILT. V 0.50 1.00 OK
FILT 1: 0.90 OK
FILT 2: 0.87 OK
FILT 3: 0.90 OK
FILT 4: 0.87 OK
FILT 5: 0.90 OK
FILT 6: 0.87 OK
FILT 7: 0.87 OK
FILT 8: 0.87 OK
FILT 9: 0.90 OK
FILT 10: 0.90 OK
MUTE : 0.90 OK
7.6 VOLT V 5.28 6.16 6.68 202 OK
8.MF AMP. V 1.58 2.04 2.29 98 OK

TESTPOINT FORMAT MIN VALUE MAX DEC STATUS

1.V1 DC BIAS MA 65 97 125 97 OK
2.V2 DC BIAS MA 65 98 125 98 OK
3.LO2 LEVEL DBM 4.58 7.17 9.91 21 OK
4.LO1 LEVEL DBM 4.65 0 9.91 0 ERROR
5.LO3 LEVEL DBM 4.59 6.85 10.00 34 OK
6.BP FILT. V 0.50 1.00 OK
FILT 1: 0.90 OK
FILT 2: 0.87 OK
FILT 3: 0.90 OK
FILT 4: 0.87 OK
FILT 5: 0.90 OK
FILT 6: 0.87 OK
FILT 7: 0.87 OK
FILT 8: 0.87 OK
FILT 9: 0.90 OK
FILT 10: 0.90 OK
MUTE : 0.90 OK
7.6 VOLT V 5.28 6.16 6.68 202 OK
8.MF AMP. V 1.58 2.04 2.29 98 OK

SYNT1
TESTPOINT FORMAT MIN VALUE MAX DEC STATUS

1.VCO V -7.94 10.98 OK
VALUE 1 VALUE 2 VALUE 3 VALUE 4
10 KHZ: 6.27 6.27 6.27 6.27 OK
29 MHZ: 6.27 6.27 6.27 6.27 OK
2.+15 V1 REG V 13.94 15.20 15.96 181 OK
3.+15 V2 REG V 13.94 15.04 15.96 179 OK
4.-15 V1 REG V -15.91 -15.39 -13.94 148 OK
5.-15 V2 REG V -15.91 -15.29 -13.94 147 OK
6.AGC POWER V -14.98 -12.46 0.56 18 OK
7.OUTPUT POWER DBM 0 0 9.93 1 OK
8.REF IN V 1.50 0.00 3.49 0 ERROR

SYNT2
TESTPOINT FORMAT MIN VALUE MAX DEC STATUS

1.VCO V -7.92 10.98 OK
VALUE 1 VALUE 2 VALUE 3 VALUE 4
10 KHZ: 3.62 3.75 3.61 3.61 OK
29 MHZ: 3.61 3.61 3.75 3.61 OK
2.+15 V1 REG V 13.94 15.04 15.96 179 OK
3.+15 V2 REG V 13.94 15.20 15.96 181 OK
4.-15 V1 REG V -15.91 -15.29 -13.94 148 OK
5.-15 V2 REG V -15.91 -15.18 -13.94 146 OK
6.AGC POWER V -14.98 -12.32 0.56 19 OK
7.OUTPUT POWER DBM 0 0 9.93 1 OK
8.REF IN V 1.50 0.00 3.49 0 ERROR

REF/MUX1
TESTPOINT FORMAT MIN VALUE MAX DEC STATUS

1.NOT USED V 0.00 0.00 6.63 0 OK
2.+5 V REG V 4.00 5.12 5.98 160 OK
3.LO3 LEVEL DBM 9.88 10.11 15.90 8 OK
4.LO2 LEVEL DBM 9.94 9.90 15.90 34 OK
5.NOT USED V 0.00 0.70 5.98 27 OK
6.LO3 VCO V 0.00 4.32 9.98 94 OK
7.SYS-CLK VCO V 0.00 3.63 10.07 79 OK
8.LO2 VCO V 0.00 6.72 9.98 146 OK

REF/MUX2
TESTPOINT FORMAT MIN VALUE MAX DEC STATUS

1.GND 0 VOLT V 0.00 0.00 0.40 0 OK
2.REF IN/OUT DBM 4.59 6.82 9.86 31 OK
3.LO2 DIV. V 0.69 1.39 2.08 67 OK
4.NOT USED V 0.00 0.00 0.00 0 OK
5.SYS-CLK DIV. V 0.29 0.48 0.90 23 OK
6.LO3 DIV. V 0.58 1.21 1.79 58 OK
7.POWER REF OUT V 0.58 0 1.79 57 OK
8.REF-CLK V 0.19 0.37 0.58 18 OK

PA-UNIT PASSIVE TEST.

FREQUENCY (15 MHZ)

BP-FILTER..... 8
COMPARATOR..... 0
TEMPERATURE..... (C) 25
POWER SUPPLY 50 V.... (V) OK
POWER SUPPLY 12 V.... (V) 13.1
DRIVER CURRENT T1... (MA) 34
DRIVER CURRENT T2... (MA) 34

PA-UNIT ACTIVE TEST. POWER LEVEL 10 (400 W)

FREQUENCY (MHZ) 1.65 2.13 3.81 6.23 8.15 12.33 16.54 25.32
BP-FILTER... 1 2 3 4 5 6 7 8
ATT..... (dB) 10.0 4.6 4.0 4.0 3.6 4.2 5.0 3.4
COMPARATOR... 0 0 0 0 0 0 0 0
TEMPERATURE (C) 45 45 47 47 47 47 47 47
POWER 50 V. (V) OK OK OK OK OK OK OK OK
POWER 12 V. (V) 13.1 13.1 13.1 13.1 13.1 13.1 13.1 13.1
CURRENT T1. (MA) 34 34 34 34 34 34 34 34
CURRENT T2. (MA) 34 34 34 34 34 34 34 34
POWER F... (W) 0 0 0 0 0 0 0 0
POWER R... (W) 0 0 0 0 0 0 0 0

END

Sailor Compact 2000 MF/HF radio installation.

In case of a failure or wrong actions of the operator the inscription ERROR appears on the display, after which the code of the error is indicated.

Error codes, their possible causes and recommendations as to their elimination are shown in Table 9.5.

Table 9.5. Error codes.

Error code	Cause	Recommendations
00	The voltage in the inner power source is lowered.	To check the power supply connector of the RE2100 or built-in voltage stabilizers.
11	The frequency of the transmitter is not permitted for use.	To choose the permitted frequency.
12	A prohibited emission type is chosen.	To establish the permitted emission type.
15	Printing the command is not finished with pressing "stop/ent" key.	To press "stop/ent" key.
20	The communication between the receiver and transmitter is impaired.	To check the condition of SP bus.
21	The communication between the RE2100 and DSC modem is impaired.	To check the cable of SPbus, bus interrupt line (+5V at the 6th contact).
22	The communication between the RE2100 and R2120/T duplex telegraph receiver is impaired.	To check the coaxial cable between them.
70	Breakage in the motor circuit of ATU.	To follow the algorithm given in the technical documentation.
71	The output voltage of the transmitter power amplifier is lowered or absent.	1.To run the SP-22-0 service program and to check the actual voltage. 2.To follow the recommendations given in the technical documentation.
72	The output voltage of the transmitter power amplifier is increased.	
73	The ATU cannot tune the antenna (Standing waves ratio is more than 2.5).	1.To check the antenna condition and earthing. 2.To check the cable from the transmitter to ATU. 3.To check the sensor of standing waves ratio in the block of filters.
74	The temperature of transistors in the transmitter power amplifier is higher than permissible.	To check the transmitter ventilator. To clean the filters.

75	The standing waves ratio is big during the transmission.	1.To check the antenna condition and earthing. 2.To repeat the tuning. To press"TX", then"TUNE". 3.To run the service program SP-23-0 and to follow the recommendations given in the technical documentation.
76	The accumulators resistance is lowered.	To check the condition of the accumulators and the power supply cable.
77	The temperature sensor is broken.	To replace the sensor.
78	Standing waves ratio at the built-in antenna equivalent.	1.To make sure that the resistance R27 and R28=50 Ohm. 2. To check the RE14 relay.

As seen from the table, Error codes give only a general idea about the failure and some additional information is necessary. It can be received with the help of service programs. For example, after appearance of the inscription ERROR75 (big standing waves ratio during the transmission) on the display, "23-0<ENT>" should be printed on the RE2100 control desk. The service program SP-23 is run and on the display the information about the last standing waves ratio measurement should appear:(standing waves ratio=1.6).

In the absence of such programs, general-purpose control measuring devices are used.

Detailed recommendations how to determine and eliminate failures are given in technical documentation.

The TR8000 MF/HF radio installation.

To run the system of built-in control, 2,0,0,ENTER keys are pressed one after the other. The testing takes several seconds and finishes after completing all tests or when the 1st failure is localized. Appearance of OO code on the display means that the equipment is in good condition. The error code will be shown on the display for 10 seconds, after which the radio station returns to its initial regime/condition.

To run the program of built-in control not from the 1st, but from some other chosen test, keys 2, 0 ,2, ENTER should be pressed. Then the number of the test is entered and ENTER key is pressed.

The built-in control system in the regime of sequential tests is run by pressing 2, 0, 1,ENTER keys. After this every subsequent or preceding test is run by pressing DIMMER UP and DIMMER DOWN keys respectively.

Return to the initial condition will occur after performing the last test. Step-by-step running the built-in test system is effected by pressing 22, 0, 33, ENTER keys one after the other. Then every pressing ENTER key will continue the work of the system.

Numbers of tests, failure codes and suspected blocks are enumerated in Table 9.6.

Table 9.6.Failure codes.

Test number	Failure code	Faulty block	Notes
1	01	Signal processing low frequency block 601, control board 600, cable between them.	
2	01	Signal processing low frequency block 601, control board 600, cable between them, loudspeaker.	With switched on loudspeaker a tone is heard, the frequency of which is 800 Hz.
3	01	Signal processing low frequency block 601, control board 600, cable between them.	The test duration is 5 seconds.
4	01	Signal processing low frequency block 601, control board 600, cable between them.	The frequency of audio oscillator is 800 Hz.
5		Display indication check.	The duration is 10 seconds.
6	01,98	612,613,614 boards of driving oscillator or cable between 611,612 or 116 boards, 116 synthesizer board, cable between 611 and 624 boards, 624 control board.	
7-21	01,98	611 synthesizer board, cable between 611 and 624 boards, 624 control board.	Different frequencies are applied.
8		Microprocessor control is tested.	50 MHz signal is blocked.
22	01,02,98	Exciter board 610, cable between 610 and 624, 624 control board.	J3E signal.
23	01,98	601 board, 610 board, cable between 610 and 624, 624 control board.	A1A signal, 14.250 MHz frequency.
24	01,02,98	Exciter board 610, cable between 610 and 611, cable between 610 and 624, 624 control board.	800 Hz frequency tone, 14.250 MHz frequency.
25	01,02,98,	Exciter board 610, cable between 610	Frequencies 45.0

	99	and 611, cable between 611 and 624, control board 600, 601 board.	MHz, 43.601 MHz, 1.4 MHz.
26	01,02,03, 98,99	Exciter board 610, cable between 610 and 611, cable between 611 and 624, 600 control board, 601 board.	Frequencies 45.0 MHz, 43.601 MHz.
27-30	01,02,03, 98,99	Exciter board 610, cable between 610 and 611, cable between 611 and 624, 600 control board, 601 board, loudspeaker.	Frequencies 45.0 MHz, 43.601 MHz, 1.4 MHz, tone from 15 Hz to 1.5 KHz.
32	01,02,03, 04	624 board, 626 power amplifier.	Power amplifier test.
33-41	01,99	Filter boards.	Testing at different frequencies.

Detailed recommendations as to localizing and eliminating failures are given in technical documentation.

The JRC JSS 800 MF/HF radio installation.

From the initial parameters setup menu "Self-Check" option is chosen. Then a separate block is offered for testing: Tuner, Exciter, Drive Amplifier (Drive AMP), Power amplifier (Power AMP), Receiver, DSC watch keeping receiver (WKR), DSC controller (DSC) or all units.

The test results are presented as follows (Table 9.7).

Table 9.7. Error codes.

Block	Test result		
Exciter	Excite...	OK	
	Excite...	ERR(20)	SSB GENE.
	Excite...	ERR(21)	Freq. CONV.
	Excite...	ERR(22)	Key line error
Drive AMP.	DA...	OK	
	DA...	ERR(80)	DA alarm
Power AMP.	PA...	OK	
	PA...	ERR(30)	PA unbalance
	PA...	ERR(31)	Detune
	PA...	ERR(32)	Module (A)
	PA...	ERR(33)	Module (B)
	PA...	ERR(34)	Module (A), (B)
Tuner	Tuner...	OK	

	Tuner...	ERR(40)	Over power
	Tuner...	ERR(41)	CPU error
	Tuner...	ERR(42)	+24 V alarm
	Tuner...	+24 V OK	
	Tuner...	ERR(44)	Tuning level alarm
DSC	DSC...	OK	
	DSC...	ERR(90)	DSC
Receiver	Receiver...	OK	
	Receiver...	ERR(60)	RF Tune
	Receiver...	ERR(61)	RF AMP.
	Receiver...	ERR(62)	IF Filter
	Receiver...	ERR(63)	IF AMP.
	Receiver...	ERR(64)	Loop 1
	Receiver...	ERR(65)	Loop 2
	Receiver...	ERR(66)	REF/BFO
	Receiver...	ERR(67)	CPU
WKR	WKR...	OK	
	WKR...	ERR(70)	RF Tune
	WKR...	ERR(71)	RF AMP.
	WKR...	ERR(72)	IF AMP.
	WKR...	ERR(73)	DSC DEM.
	WKR...	ERR(74)	Loop 1
	WKR...	ERR(75)	Loop 2
	WKR...	ERR(76)	REF./BFO
	WKR...	ERR(77)	CPU

Additional DSC testing with Modem loop test is effected from the window of initial parameters for DSC mode. The test result is positive if DSC format received by the modem corresponds to the one transmitted by it. The files transmitted and received by the modem are shown on the display.

From the same window printer and some other tests for tuning/adjusting at the manufacturer's plant are affected.

For NBDP system self testing, from the initial parameters window for the telex mode "Self check" option is selected, then the display will clean itself, testing will start and "Self check start ..." message will appear. The results are shown on the display as

"OK" or "BAD". These results are also sent to the printer. ROM, RAM, programmable read-only memory, interrupt timer, synchronization, modem filters, modem loop are tested. From the same window transmission of 1minute signals corresponding to "pressing" and "releasing" can be initiated.

So, the JSS-800 diagnostic system allows to assess the radiostation condition and localize the fault with further replacement of the faulty block or module. Determining the fault and its repairing at the element level are not effected in ship conditions.

Localization of failures in ship earth stations.

Land earth station and transceiver messages analysis. When switching on INMARSAT-C SES, LOGIN indicator does not flick or there is no continuous light 5 minutes after switch on, all the reports on the display and printer should be studied thoroughly. If the report corresponds to the one shown either in Fig. 9.5 or 9.6, the following should be checked:

- if the antenna cable is connected;
- if the antenna cable is damaged;

```
REPORT .004      Page 1 UTC Time: 99-06-18 05:25:04
No antenna connected.
Check Cable and connectors.
```

Fig.9.5. Antenna circuit damage report.

- if the antenna is located in direct visibility of the chosen satellite;
- if the station is registered in the INMARSAT system;
- if access to INMARSAT is temporarily banned due to some reasons.

```
OUT. 043 : Transmission failed.
LES 112 Destination 1111427300188 File OUT. 043
Message from transceiver's
Cannot acquire synchronisation at the satellite channel.
```

Fig.9.6. Report about absence of synchronization in the satellite channel.

If the report is received by the shore earth station, it is acknowledged as shown in Fig.9.7, but it should be remembered that INMARSAT is the system with intermediate storage and it is not excepted that within 24 hours a report about non-delivery will arrive. An example of such a report is shown in Fig.9.8.

```
OUT. 044 : Transmission successful
LES 112 Destination 1111427300188 File OUT. 044 Reference number
514947
```

Fig.9.7. Report about successful transmission.


```

IN. 004          Page 1      UTC Time: 99-05-18 06:06:49
Eik les 20195 Maritex s 18-may-1999 06:42:22 110151
18-may-1999 06:40 (utc)
Maricom service message
notification of cancellation
regret your msg below now cancelled, temporarily no contact
via maritex. please phone/fax/mail us to register for internet
email access to any inmarsat-c terminal on board.

Ph: +46 31 897340
Fax: +46 31 897399
e-mail: helpdesk(at)maricom.telia.com (lower-case letters)
tlx: 20194
427300188= acad x
427300188= acad x
ci
nl burum les 427300188= acad x 17- may -1999 06:13:10 976786
test
427300188= acad x

```

Fig.9.8. Message about non-delivery.

When there is an error on the line of communication, the source of the message is indicated (Message from Land Station or Message from Transceiver) followed by the message itself (Fig 9.9).

```

OUT.001 : Transmission failed.
LES 112 Destination 1111427300188 File OUT. 001
Message from transceiver:
Land Station did not respond to transmission request.
Message from transceivers
Your reception is OK,
but your transmission is not received by Land Station.

```

Fig.9.9. Transceiver message.

In case if the message is not delivered to the addressee, the error code can also appear on the display, for example:

Land Station gives error code: PRF(where PRF is "Protocol failure"). Transmission error codes, land station messages and transceiver messages are given in Tables 9.8., 9.8. and 9.10. respectively.

Table 9.8. Error codes.

Code	Commentaries
ACB	Access barred
ADR	Addressee refuses
ATD	Attempting to deliver the message
BUS	Busy
CCD	Call cut or disconnected
CIE	The LES ran out of processing/communications capacity to process your message
CNS	Call not started

FAU	Faulty
FSA	Fast select acceptance not subscribed
IAM	Was unable to process the address information in the following message
IDS	Invalid data from ship
IDT	Input data timeout
IFR	Invalid facility request
IMS	Message size is invalid, 7932 characters max
IND	Incompatible destination
INH	Was unable to establish the type of message from the following header
ISR	Invalid ship request
LEF	Local equipment failure
LPE	Local procedure error
MBB	Message broken by higher priority
MCC	Message channel congestion
MCF	Message channel failure
MKO	Message killed by operator
MSO	Machine switched off
NAL	No address line was present
NDA	There was no delivery attempt
NFA	No final answerback
NIA	No initial answerback
NOB	Not obtainable
NOC	No connection
NP	No party
NTC	Network congestion
OAB	Operator aborted
OCC	Telex occupied
OOO	Out of order
PRC	Premature clearing
PRF	Protocol failure

RCA	Reverse charging acceptance not subscribed
REF	There was a failure in the remote equipment
RLE	Resource limit exceeded
RPE	Remote protocol error
RPO RPOA	(Recognized Private Operating Agency) out of order
SCC	Call completed successfully
SHE	Mobile unit hardware error
SNF	The satellite network has failed
SPE	Mobile unit protocol error
SUC	Test result being delivered
TBY	Trunks busy
TGR	TDM group reset
TIM	Timeout
WFA	Wrong final answerback
WIA	Wrong initial answerback

Table 9.9.Messages from land stations.

Land station message
Land Station Message store full.
Requested destination not served.
Satellite circuit not available.
Terrestrial circuit not available.
Requested type of transmission not provided.
Transmission request in queue.
You are not allowed to use the system.
Your Transceiver is not logged in.
Your Transceiver is not commissioned.
Will call you up later.
Illegal request.
Land Station out of service.
Did not receive your message.
Transceiver did not follow call procedure.

Fatal Land Station error.
Call cleared by Land Station operator.
Call cleared by Transceiver.
Land Station did not follow call procedure.
Land Station has detected Transceiver error.
Transceiver did not receive message from Land Station.
Land station does not support this message type.
Invalid address.
Your destination is not commissioned.
Your destination is not logged in.
Your destination is not allowed to use the system.

Table9.10.Transceiver messages.

Code	Transceiver message	Commentaries
801	Land station out of service.	The TDM information indicates by a flag in the Bulletin board that the particular LES is out of service.
802	Satellite link occupied.	The transceiver has tried to find a free signalling channel slot 5 times without success, or the TDM Bulletin BOARD indicated "Congestion".
03	No Store and Forward service available.	The TDM information indicates by a flag in the signalling channel descriptor that there are no signalling channels for general use.
804	No Distress service available.	The TDM information indicates by a flag in the signalling channel descriptor that there are no signalling channels for distress use and general use.
807	Your reception is OK, but erroneous information is transmitted from Land Station.	The TDM Bulletin board information indicates 0 or more than 40 signalling channels available.
809	Your reception is OK, but your transmission is not received by Land Station.	The Transceiver tried to send the burst 9 times without success
812	Land Station did not respond to transmission request.	The Transceiver did not receive an assignment to send the message.

815	Land Station did receive request, but did not respond to it.	The Transceiver timed-out waiting for a response from LES.
816	Transmission aborted by operator.	The user or the Transceiver aborted the operation.
817	The Land Station does not exist in this Ocean Region.	The Land Station selected for transmission was not found in the LES table.
819	Cannot acquire synchronization at the satellite channel.	Either the Transceiver synthesizers did not lock after 10 sec, or synchronization was not found within 25 sec (for the OOO version - within 45 sec) after tracking was finished, or the tracking was not successful after 3 minutes.
823	Land Station did not finish message.	The Transceiver tried 4 times to end a message reception with the LES.
822	Did not receive any message from Land Station.	The Transceiver tried 4 times to request message packets from the LES.
824	Reception aborted by operator.	The user or the Transceiver aborted message reception.
831	Transmission hardware error.	Error detected in transmit queue hardware.
834	Frequency cannot be tracked.	The Transceiver could not get the frequency difference within 150 Hz of the TDM carrier within (120 seconds, the OOO version) 25 sec.
840	Land Station did not follow call procedure.	The LES did not reserve a signaling channel slot for the Transceiver as expected.
841	INMARSAT-C System is now in Restoration mode.	The system cannot be used for login, logout and link test as the NCS is out of operation at the moment.
850	No response from Land Station.	The Transceiver sent a login request 4 times, but without a response.

From the examples given above, it follows that when communication problems arise, first of all it is necessary to make sure whether they really arose due to the transceiver, antenna or message terminal failure.

For example, if the ship transmits messages in 8bit code, and the message received ashore differs from the transmitted one, this can happen due to the Land INMARSAT station, which can add its heading to the message.

It is also possible that this problem is connected with coding of symbols.

All the mentioned above refers to all types of INMARSAT-C SES.

Typical failures of the most wide-spread station developed by "Thrane&Thrane" Company and which is supplied with the sets of the GMDSS equipment under different names (Sailor H2095 B, Debeg 3220, TT 3220, STR 1500 etc) are given in Table 9.11.

Table 9.11.Messages of the T&T transceiver.

Code	Message	Commentaries
100	Printer error when printing file command.	Check the printer status with the st-p command.
101	No printer paper.	Insert paper in your printer.
103	Printer not connected Out of paper.	The transceiver cannot see if any printer is connected.
110	Memory available...bytes.	Warning at the 2K filesystem memory limit.
120	Invalid command.	This command does not exist.
122	DMA controller has stopped. Transceiver will be restarted.	A fatal error has occurred in the receiving hardware or the Viterbi Decoder software is incorrect. Check the software version on the U35 EPROM.
123	Comport input error. Transceiver will be restarted.	A fatal serial communications input error has occurred. The Transceiver will restart its program as this is the only way to go to a well-known state.
258	EGC reception in progress.	New commands will not be accepted while the Transceiver is receiving an EGC message (except for distress alerts).
259	Viterbi decoder malunction. Transceiver will be restarted.	The Transceiver has detected an error in the Viterbi Decoder or an incompatible version of Viterbi decoder software. Check the label on the U18 EPROM.
250	Not allowed to transmit as EGC receiver.	If you want to transmit, you must reset the EGC-only status. Type set-e-0.
323	Too many print requests. File removed from queue.	The oldest print request has been removed from the 15 element log print request queue.
324	Too many command requests.	The Transceiver command queue is full, please wait.
330	File error.	Internal file system error. File copy error, file creation error or too many open files.
331	File is missing.	A wrong filename has been given or an incorrect address line for transmit files has been detected. Check the transmit command syntax and the file contents.

332	File is too big for memory.	The filesystem memory is filled.
333	File is empty.	The message could not be sent because the file was empty (no address line).
334	Too many received files. Remove file(s).	There are now 25 received files (INxxx or EGCxxx) in the filesystem.
335	Too little memory. Remove file(s).	Filesystem is filled.
336	Duplicate file exists.	The filesystem has got a file with this name already. This error appears at a file transfer.
337	Invalid filename.	Filenames starting with the '_' underscore character cannot be used.

Analysis of the information about the transceiver condition.

Additional information about the transceiver and antenna block operation can be received from the TRANSCEIVER STATUS window, which opens after pressing Alt, O, T keys (Fig 9.10).

		Transceiver				
Print	Save	Update				
HARDWARE: System Clock 1999-12-20 11:45						
Synth's	LO 1/2	Corr.A/C/R	Dit/Temp	RX/TX/AGC/FIFO	R/C-B/B/S	
1	yes	1000 mV	2240 mV	- 40 Hz	105 mA	06H
1a	yes		2140 mV	30d.C	2500 mA	00H 00H
2	yes	unused	1460 mV		3000 mV	1 1705
3	yes			yes		5
SOFTWARE: Version 2.10, 94-03-04 Service 99-09-17 by ----						
Synchronization.	: yes			Serial no	:5381	
Logged in	: yes			Mobile no	:427300188	
TDM type	: NCS			Preferred ocean	:None	
TDM channel number	:10840					
Current channel	:NCS					
Current protocol	:free					
TDM origin	:344					
TDM frame number	:3215					
BB error rate	:3 of 100					

Fig.9.10.Status Transceiver Window.

Hardware information. In the HARDWARE line the system time is indicated. If instead of the time there appears an inscription "Error in CMOS clock", the battery feeding CMOS memory should be replaced. The meanings of other parameters are explained in Table 9.12.

Table 9.12.Hardware condition information.

Blocks	Commentaries	Permissible values
SYNTH's synthesizers	Whether heterodyne frequencies are generated in synthesizers.	"Yes"

LO1/2 heterodynes	Voltage levels at the heterodyne circuits outputs in the receiver scheme. The inscription "unused" LO.2 means that this version of equipment does not use the 2nd heterodyne.	500 -5000 mV
CORR. A/C/R tracking filter	How software compensates for the drift of crystal frequency, which occurs due to destabilizing factors and ageing. "A" is an actual value of frequency correction voltage used by software for controlling the scheme of frequency generation. "C" is a preset value, "R" are permissible deviations.	$C - R < A < C + R$
Dif/Temp	The parameters characterizing the crystal oscillator operation are presented: Dif-the frequency deviation from the nominal value; Temp-the temperature measured at the reference generator.	Dif=+/- 300 Hz 10-15 degrees above the ambient temperature
RX/TX/ AGC FIFO	Antenna block regime of operation: RX-the current which the station measures in the antenna connector in the mode of watch/duty reception.(0-if the antenna is switched off, "Too high"- in case of short circuit) TX-the current measured during the last transmission. AGC-the voltage of the automatic gain control scheme. The value of AGC serves to control the gain of the low-noise amplifier and for cable control. FIFO-the sheme of information bits servicing immediately before the transmission (first in - first out).	105 mA 2000 -2500mA 2000 -3000mV "Yes"
R/C-B/B N/S	R-the number of Viterbi decoder renormalizations The number shows how many times it was necessary for the processor to guess data from previous information, as a hexadecimal number. C-the number of failures in decoder tracking. D-the number of failed bits. B-N the validity of the data snapshots bulletin board for every 8.64 sec of the reception. N- the number of snapshots, which have passed since the moment of the transceiver switch-on. S-the signal level.	1-true/valid 0 -5

B' - The control is effected by the main processor on the basis of the data received every 8.64 sec of reception. The information received during this time is called a snapshot. The snapshot includes packets, the 1st and the most important of which, is the packet with the bulletin board containing the snapshot number, its identification and the list of possible services of the emitting station and of this given channel.

S' -Level 5 corresponds to the best signal. (S) is measured directly in the path of the receiving signal (after demodulation), and (R) is calculated after the decoding. Thus, (R) is 8.64 sec delayed in respect to (S).

The level of signal (S) will always be true, even when the station loses synchronization.

Software information.

The part of the window referring to software consists of the heading and 2 columns with current information about the satellite communication channel and long-time information containing user's commands expecting to be executed. In the heading line the following information is contained: the transceiver software version number, the date when the version was issued, and also the date and time of the last station technical servicing at which the service key of the 6th block of switches (SW) on the processor board was used, and the initials of the servicing engineer. Table 9.13 explains the contents of the software part of Fig 9.10.

Table 9.13. Contents of software information.

	Commentaries	Variants
Synchronization	Corresponds to the condition of the Login light diode on the front panel.	"YES", "NO"
Logged in	Corresponds to the condition of the Login light diode on the front panel.	"YES", "NO"
TDM-type	To what station channel the transceiver is tuned at the moment.	NCS, LES.
TDM Channel number	The channel number corresponding to receiving or transmitting frequencies of INMARSAT-C system.	8000 – 14000,
Current channel	The information about the channel type used by the transceiver.	NCS, LES, Signalling, Message, Retuning.
Current protocol	The information about the transceiver operation protocol at a given moment.	Free, Pending, Sending Distress, Sending Distress Test, Login, Logout, Changing NCS, Scanning, Link Test, Transmission, Receiving message, Confirmation request, Message delivery, Position report, Data report, Link test request.
TDM origin.	The current station number.	001 - 344
TDM frame number	The number of the current data snapshot (duration 8.64 sec.) at the watch channel in the bulletin board since the beginning of the day.	0000-9999

BB error rate	The bulletin board statistics for the last 100 snapshots. It characterizes the signal quality for the last 15 minutes. During the transmission the error rate will not increase.	
Serial number	The transceiver identifier to which codes of access into INMARSAT-C system correspond and the mobile station number.	
Mobile number	It is not used by the equipment for performing its functions and is shown on the display for reference.	
Preferred ocean	The information is used for "Login" command execution and also for everyday scanning made by the station*.	
Activities in queue	This information will be available only in case of several commands given one after another. Transmission commands have the lowest priority.	

*If in the scanning mode another coordinating station (in another ocean region) with a more powerful signal than the station used at the current time is found, the program will automatically perform the "login" procedure into this ocean region, but the preferred ocean will not be changed.

Localization of failures.

To find failures in electronic schemes functional and in-scheme control is used. Functional control provides checking the tested module operation, while in-scheme control serves for checking separate module elements. These two methods are usually used one after the other.

Search for failures should be effected in a certain logical order, the purpose of which is to find out the cause of the failure and to eliminate it. The number of performed operations should be reduced to minimum, avoiding unnecessary and senseless checks. Before checking a faulty scheme, it must be carefully examined for obvious defects: burnt elements, breaks in conductors on the printed circuit card, etc. If the visual inspection does not give any results, diagnostics can be started.

As to the principles of localizing failures, they are practically the same, irrespective of manual or automatic inspections.

First, a functional test is carried out: the board/plate operation is checked and an attempt is made to determine the faulty block or suspected faulty element.

Before replacing the faulty element, its parameters should be checked to ascertain that its condition is really faulty and to avoid extra work of extracting it from the plate/board.

Functional tests.

Functional tests are of two types: dynamic and static. Dynamic tests are made on the finished electronic device for localizing a faulty cascade or block. In the determined faulty block static tests are carried out to find one or, maybe, two faulty elements (resistors, condensers, etc).

Dynamic tests.

The search for failures should be made from the output of the device to its input according to "division in halves/by two" method. The main idea of this method is the following. First, the equipment scheme is divided into two sections: input and output. To the input of the output section a signal similar to the one which exists at the point of the scheme division is given.

If in this case there is a normal signal at the output, then the failure must be located in the input section. This input section, in its turn, is again divided into two sub-sections and the previous procedure is repeated until the failure is localized in the smallest functionally determinable cascade.

For example, during the dynamic test in a superheterodyne radioreceiver (Fig.9.11) the first scheme division is the division into low frequency and high frequency sections. First, to the low frequency (audio frequency) amplifier (AF) input a 1 KHz signal is given through the separating capacitor with the capacity tens of some tens of microfarads. A weak or distorted signal, or its absence means that there is a failure in AF section.

If AF section is in order, a clear audio signal will be heard from the loudspeaker. In this case the failure should be sought for in the high frequency section, for which it must be divided into two sub-sections: IF and RF sections. First, IF section is checked and to the input of the first IF amplifier a 460 KHz amplitude-modulated signal is given through the separating capacitor with the capacity of some hundreds picofarads.

If the IF section is in order, a clear audio signal will be heard. In the opposite case, the procedure of subdividing IF section should be repeated until the faulty cascade (for example, detector) is found.

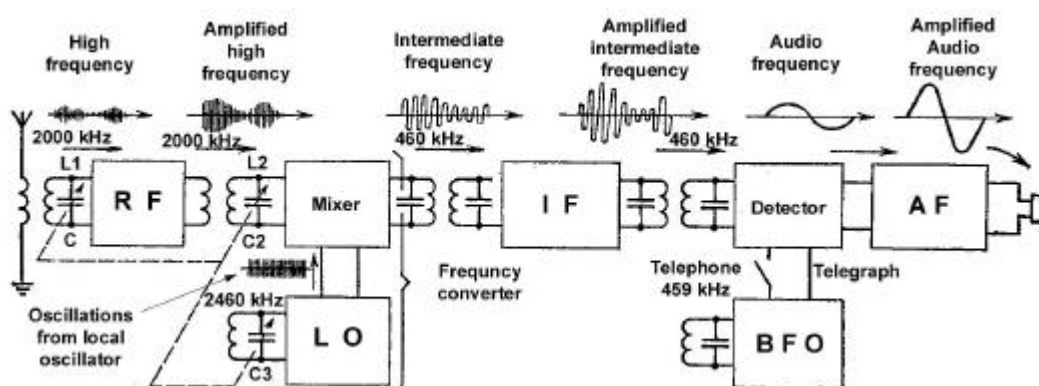


Fig.9.11 Superheterodyne receiver.

If the failure is in the RF section, this section, if possible, is divided into 2 sub-sections and is checked in the following way: an amplitude-modulated signal, with frequency, for example, 2 MHz is given to the cascade input through the separating

capacitor, the capacity of which is some hundreds picofarads. The receiver is tuned into the reception of the 2 MHz signal.

It is also possible to use an alternative method of checking - "cascade--by-cascade" check of passing the signal. The radioreceiver is switched on and tuned in to some station, then, beginning from the output of the device, with the help of oscillograph, the availability of the signal in control points and its correspondence to the required operational readiness criteria as to form and amplitude are checked.

The advantage of the "division in halves/by two" method over the "cascade-by-cascade" one is seen only when there are numerous functional units in the device. When searching for failures in some other electronic device, a nominal signal is given to its input.

The above mentioned principles of dynamic tests may be applied to any other electronic device. The main problem is in matching test signal parameters.

Static tests.

These tests are used for finding a defective element in the cascade, the failure of which was ascertained at the previous stage of checking.

- check static regimes/modes with the help of voltmeter, the input resistance of which is not lower than 20 KOhm/V.
- it is better to measure the voltage. The value of the current is calculated by the measured value of voltage drop in the resistor of a known nominal ($I=U/R$).
- only if direct current measurements did not help to find out the failure cause, start dynamic tests in the faulty cascade.

9.3 Elimination of failures.

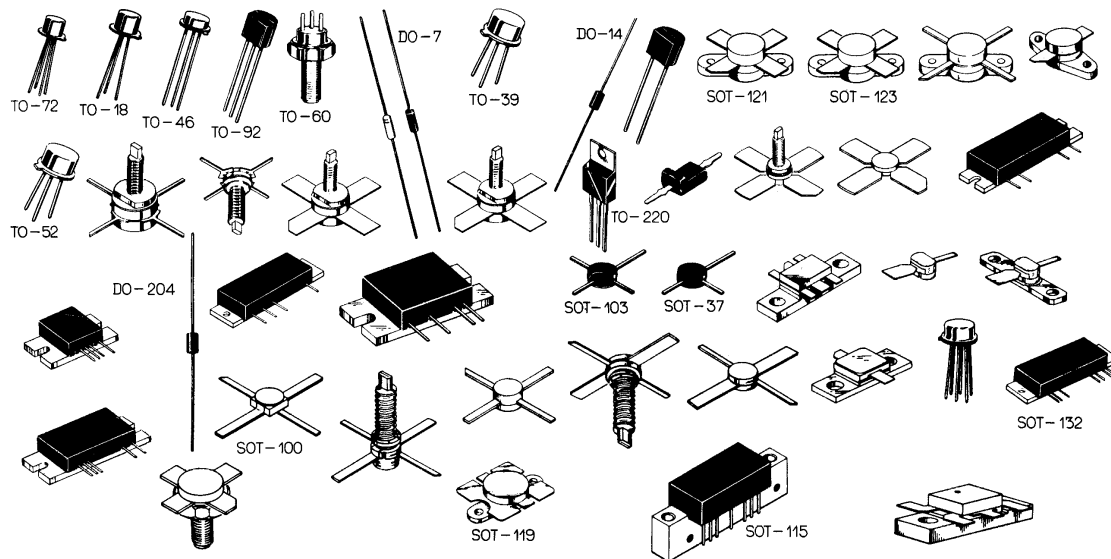
Replacement of electronic scheme components.

In the ship GMDSS equipment, as in most up-to-date radioelectronic devices, printed-circuit wiring, including multilayer wiring is generally used. The advantage of printed-circuit wiring is its small size and rigid fixation of connection places. Plaited wiring can be used for connections between blocks and in power supply blocks, where the influence of stray/spurious coupling between different conductors on the device operation can be ignored.

Replacement of electronic scheme components (semiconductor devices, microschemes, resistors, capacitors/condensers, switches, relays, connectors, etc) by manual soldering must be effected with switched off equipment and with the observance of definite rules.

- The following recommendations for work with an electrical soldering iron should be observed:
 - o there must not be closing between the body of the soldering iron and heater element. This should be checked periodically with an ohmmeter. Such closing can cause an electric current injury and damage to the soldered elements. It is recommended to earth the soldering iron prong;
 - o a steady support should be used for the soldering iron to prevent it from falling down and the person working with it - from burns;

- o soldering is prohibited when the device is in operational condition, as an occasional closing can cause an electric current injury and damage to the device;
 - o parts of the body burnt as a result of contacts with the soldering iron or splashes of solder should be first cooled with water and then wetted with soda. Then the burn should be treated with vaseline or some soothing creme.
- The element terminals during soldering should be held with flat-nosed pliers for heat dissipation. Overheating semiconductor devices and microschemas can lead to unrestorable worsening their parameters.
- The time of soldering semiconductor devices must not exceed 3 minutes.
- The repeated soldering (if necessary) can be effected 5 minutes later.
- For assembling equipment with field-effect transistors and microschemas a low voltage (12 - 36V) soldering iron with controlled temperature of heating is to be used. Such a soldering iron is switched into the network through a reducing transformer with earthed secondary winding. It is inadmissible to use an autotransformer or additional resistors, as they do not provide galvanic reverse isolation.
- -MOS transistors and microschemas can be damaged by static electric charges, that is why for their assembling additional precautionary measures are to be taken:
 - o -assembling works must be performed on the table, the surface of which is covered with cotton material or antistatic linoleum;
 - o -during the work it is recommended to sit on a wooden chair with cotton (not synthetic) upholstery, to stand on flooring which conducts electricity, and to wear leather sole shoes and cotton clothes;
 - o -working instruments (the soldering iron prong, pincers, etc) and the body of the device being assembled should be earthed;
 - o -for discharging static electricity an earthing bracelet should be worn. Such a bracelet is connected with an earthing bar through a 1 - 10 MOhm resistor;
 - o -the possibility of MOS transistor terminals and microschemas contacts with objects which can be easily and strongly electrified must be excluded;
- -If the terminals are to be shaped, they are to be bent at the distance not less than 5 mm from the transistor or diode body, and the radius of the curve must be at least 3 times bigger than the terminal diameter.
- -Melted flux and solder must not get onto the contacts when switch terminals and relays are soldered.
- -It is recommended to replace a faulty element by an analogous one. When ordering a semiconductor device, it is necessary to indicate its frame/shell type, as some devices, though shown on the schemes in a similar way, can be produced in different frames/shells.



FiFig.9.12.types of semiconductor devices frames/shells.

Semiconductor devices classification and marking/labelling.

Faulty semiconductor devices must be replaced with analogous ones, but it is not always possible in ship conditions. In such cases devices of the same class and with the same electrical parameters from another manufacturing company can be used. There are different systems of marking/labelling semiconductor devices. The most wide-spread is the system adopted by the USA Connector Electron Device Engineering Council (JEDEC).

Replacement of blocks and modules in the shipborne GMDSS equipment.

In the GMDSS radioequipment it is often insufficient to replace a faulty block or a module as this block may contain the memory storing MMSI, communication system access codes, tables of frequencies, etc. After such a replacement it is necessary to make corresponding tunings and setups.

Further an example is given of boards replacement in the STR 1500 SES transceiver.

Processor board replacement.

During this replacement it is required to transfer EEPROM U6 in which the serial number and INMARSAT-C (Fig. 9.13.) access codes are stored and EPROM U15, U20, and U21 onto the new board.

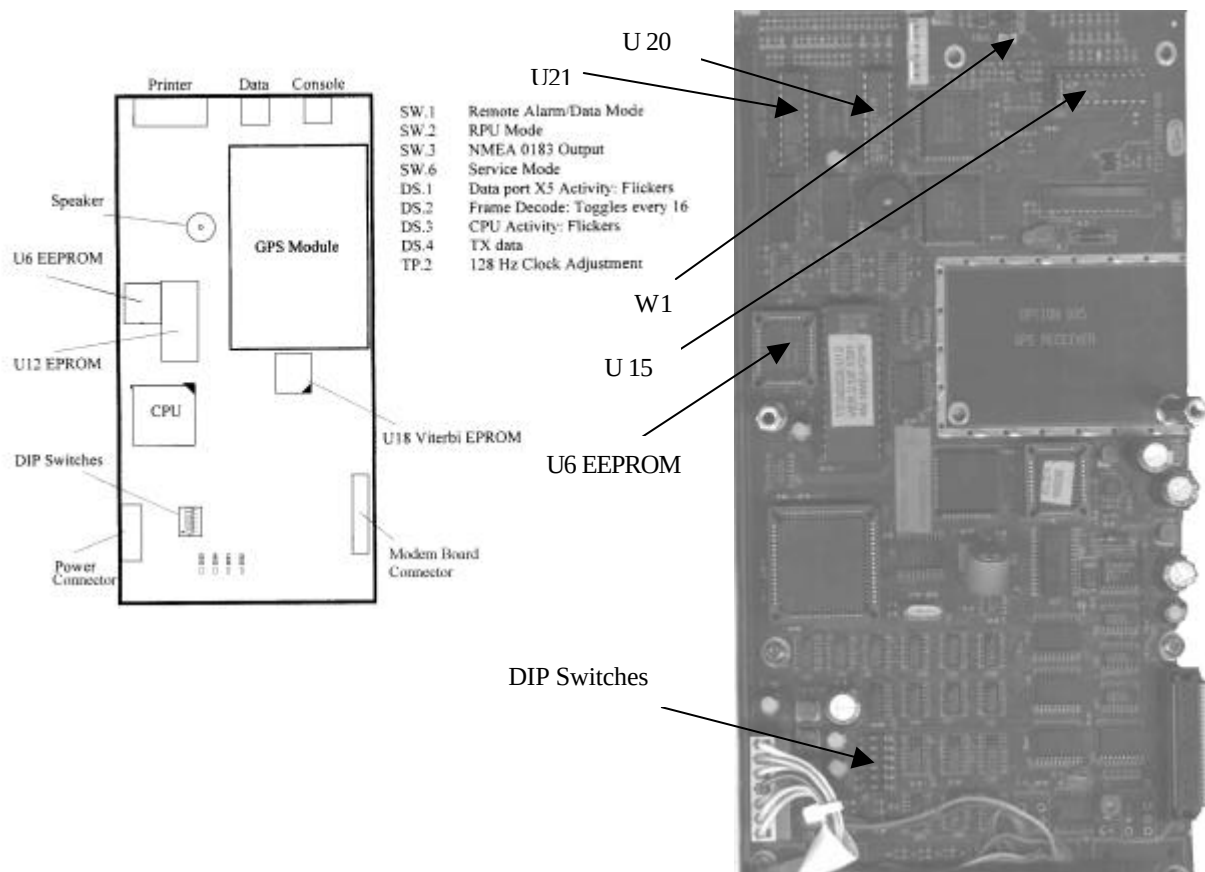


Fig.9.13.The processor board.

Synthesizer board replacement.

After this replacement (Fig.9.14) the data about frequency correction and temperature corresponding to the new board should be recorded into EEPROM of the processor board U6. For this with the help of service switch Sw6 the transceiver should be switched into system generation mode and electrically alterable read-only memory - reprogrammed:

- choose 10 ENTER option (Tracker setup);
- choose 2 ENTER option (frequency correction setup).Print 128 ENTER, ENTER;
- choose 3 ENTER option (temperature correction setup).When the question "Is master VXO temperature xx d.C.? Y/N" appears , print N ENTER. Enter the correct temperature ENTER,ENTER.
- choose 0 ENTER option (Quit), set switch 6 in off position and leave the system generation mode. Reload the transceiver by pressing SET key.

Modem board replacement.

The modem board after replacement does not need any additional setups (fig 9.15).

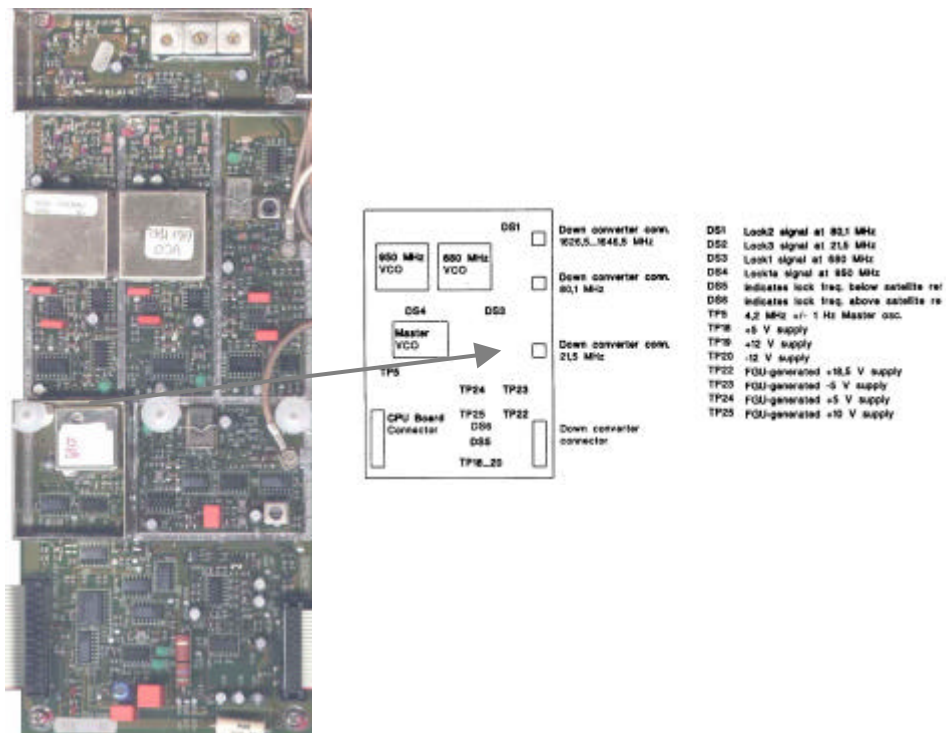


Fig.9.14.Synthesizer.

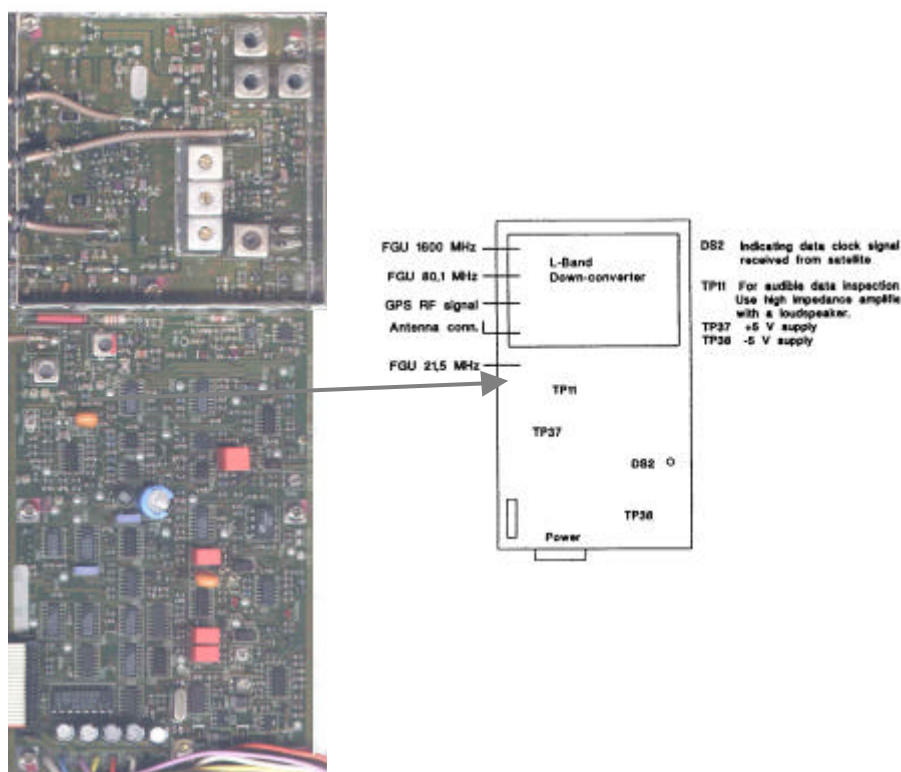


Fig.9.15.Converter and modem.

Power supply block replacement.

After replacement of the power supply block (Fig.9.16) no setups are required.

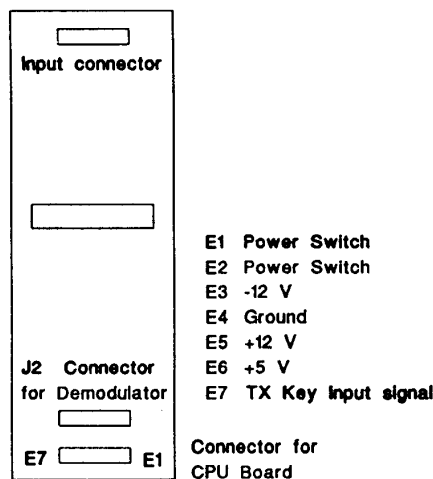


Fig.9.16.Power supply block.

Replacement of a specialized computer.

When a specialized computer of ship land station or NBDP message terminal becomes out of order it can be sometimes replaced by a personal computer (PC). In case of such a replacement manufacturer's recommendations should be considered. The conditions of such a replacement are given below; the equipment of "Thrane&Thrane" company serves as an example.

1.The PC must be compatible with IBM hardware relating to serial communication interface, because the TT-3020B transceiver is designed for CTS and DTR signals of communication acknowledgement.

2.The length of the connection cable between the transceiver and PC using the TT-10202 software must not exceed 8 meters. This is linked with the fact that Capsat software uses the 4800 baud standard data transmission rate and the RS-232C interface (for the TT-3606A message terminal interface the connection cable length can be up to 100m, as it operates at the 4800 baud rate, but uses RS-423).

3.The Capsat message processing program functions in the DOS operation system of 2.0 version and higher. For using this program the PC must be IBM compatible and satisfy the following requirements:

- to support direct access to video buffer memory: for a monochrome (MDA) display the address is B000:0000; for a colored (CGA/EGA/VGA) one - B800:0000;
- to have a serial port and interrupt hardware. The PC must have the INTEL 8259A programmable interrupt controller (PIC) and the 8250, 16450 or 16550 integrated circuit of the universal asynchronous receiver/transmitter (UART) in accordance with characteristics indicated in the IBM Technical Reference Manual: the address for Com1 is 3F8 and IRQ4, for Com2 - 2F8 and IRQ3. When Com3 and Com 4 serial ports are used, the exact address and value of IRQ should be indicated. The recommended IRQ addresses and values are given below.

Computer type	Com3		Com4	
	IRQ	address	IRQ	address
PC/XT	2	3E8	7	2E8

PC/AT	5	3E8	7	2E8
PS2	3	3220	3	3228

Default setting corresponds to PC/AT computer type.

4.It should be borne in mind that, if the computer speed is not sufficient, there may be a loss of symbols. In this case the speed of data exchange should be reduced or a serial port with the UART National 16550 support (if it is possible), which provides high speed and 16-byte reception in FIFO regime is used.

Elimination of failures connected with software.

Restoration of software recorded in EEPROM.

In software recorded in EEPROM there can be operational failures (for example, because of voltage abrupt changes in the power supply circuit). The software recorded in EEPROM can be restored from the reserve diskette. If for this restoration MMSI or SELCALL will have to be entered again, problems can arise in connection with the requirements of IMO Resolutions on protection of self-identification information from changes on the part of the user. Such protection can be made with the help of passwords known only to the servicing engineers, complication of information entering procedures, etc.

For example, the procedure of software replacing in the DSC/NBDP equipment RM2151 is briefly described below.

1.Message terminal software is stored in U9, U10 and U11 of EPROM and can be changed only by replacing them by others on which new software is recorded.

2.Restoration of the RM2151 radiotelex modem (or the RM2150 watch keeping receiver) software is effected with the help of message terminal, into which the INITIAL SET UP OF RADIOTELEX MODEM diskette is loaded. The diskette includes 4 files: RMSET, RMFREQ, RMSTN and READ.ME.

- The modem is switched into the Initializing EEPROM regime by bringing S1-2 (version 3) or S1-4 (version 4) keys on the main processor board into ON position;
- The RM 2151 is connected to the message terminal through the COM1 serial port;
- After switching on the modem and message terminal power supply, the INITIAL SET UP OF RADIOTELEX MODEM diskette is inserted into the drive;
- The (F3-Option-Terminal mode-Enter-Enter) terminal regime is set up;
- By simultaneous pressing Shift and F9 keys, the Transfer file window is brought to the display, the RMSET file is chosen, and the Enter key is pressed 2 times;
- After the message WORKING and the new cursor > appear on the display, the Batch RMSET command is printed and the Enter key is pressed. After this the modem ENT key is pressed and the contents of the RMSET file is transferred from RAM into the RM2151 EEPROM. The end of file copying is confirmed by the appearance of cursor >.
- The RMFREQ and RMSTN files are transferred in the same way. The process of each file transfer takes about 30 sec.

3.The MMSI and SELCALL are entered after the RMSET file transfer. For this they are recorded in a hexadecimal code in accordance with the SERVICE AND

IDENTITY PROGRAMMING FOR COMPACT HF SSB RM 2150/51 of the Technical description.

BIOS setups unset.

If the Setup password is not known and the programs for its determining are not available, the following variants may be used:

- to use one of the manufacturer's passwords. Such passwords for AWARD BIOS are the following: AWARD_SW, TTPTHA, aPAf, HLT, Ikwpeter, KDD, j262, ZBAAACA, j322, ZAAADA, Syxz, %six spaces%, Wodj, %nine spaces%, ZJAAADC, O1322222, j256, ?award. It should be borne in mind that for new AWARD BIOS (4.51 version) the manufacturer's passwords are not available.
- There are no standard passwords for AMI BIOS. In some AMI BIOS the INS key can be kept pressed right after switching on - and in such a way standard parameters are loaded into CMOS memory.
- There are methods of cleaning BIOS from DOS with the help of debug commands (debug.exe is usually stored in DOS catalog). Having been loaded into DOS, print :

For AWARD & AMI BIOS	For Phoenix BIOS
DEBUG -0 70 17 -0 71 17 Q	DEBUG -0 70 FF (or 17) -0 71 17 Q

- Almost on all modern system boards near the battery there is a jumper for CMOS memory reset. If there is no battery, then it is situated together with CMOS microscheme in the solid plastic block with the inscription DALLAS, and the jumper can be near it.
- In case if the jumper for CMOS memory cleaning is not available, an attempt can be made to switch off or to disconnect the battery. For this it is also recommended to switch off the wires from the power supply block, because the charge on its condensers/capacitors can be preserved and maintain CMOS RAM power supply for more than 24 hours.
- If this did not help, the last way which is left is to close/lock corresponding CMOS memory microscheme terminals with the purpose of cleaning the memory.

Anti-virus procedures.

If the virus either penetrated into or is suspected in the computer, one should not make haste or take impulsive decisions, as such actions can lead not only to loss of some restorable files, but also to a repeated virus infection.

- If a virus is found in newcoming files and has not yet penetrated into the system, such a virus is liquidated by an anti-virus program, or the spoilt file is removed.
- If the virus is found and has penetrated into the system, it is required:
 1. To make sure that the virus is not TSR/resident or that the TSR/resident part of the virus is rendered harmless. After starting anti-virus programs (though not all of them) automatically render TSR/resident viruses innocuous. Removing viruses

from memory is necessary to prevent them from spreading. The matter is that for scanning the files anti-viruses open them, and many TSR/resident viruses can intercept this event and infect the files which are being opened. As a result, most files become infected as the virus is not removed from the memory. The same thing can happen in case of loading/boot viruses: all the diskettes which are being checked can become infected.

If an anti-virus in use does not remove viruses, it is necessary;

- -To reload the computer with the system diskette about which it is known for sure that it is not infected and record-proof. Reloading should be effected by pressing RESET or POWER keys, as some viruses survive if reloading is performed by pressing Ctrl-Alt-Del.
- -To set the A:C: sequence of loading in BIOS setups in order to guarantee the loading from the system diskette, but not from the infected hard disk.

2."To cure" the infected files by an anti-virus program and to check their workability.

It should be remembered that anti-viruses, instead of curing the file, can sometimes irreversibly spoil it. That is why, either before or simultaneously with curing it is necessary to create reserve copies of infected files and print them in a kind of register of infected files (Log-file). It is necessary for restoring the files, if the treatment is unsuccessful due to an error in the anti-virus curing module or the anti-virus inability to cure this given virus. In this case another anti-virus program will be needed.

It is much more reliable to restore the infected files from reserve ones, though the anti-virus services can be needed all the same, if not all the copies of the virus are done away with, or files of reserve copies are also infected.

3.To check all the disks which could be infected.

4.To check all the diskettes.

Assembling cables in high-frequency connectors.

During repairs to cables and connectors it may become necessary to use analogous devices. Tables 9.26 and 9.27 show characteristics of some high-frequency cables

and connectors.

Table 9.26. Radio-frequency cables characteristics.

Type	Zw Ohm	V*	Capacity pF/m	Outer diameter, mm	Material**	Umax, kV	Connect or type***
RG-8A/U	52.0	0.66	88.5	10.3	PE	5.0	UHF, N
RG-8/U	50.0	0.80	76.2	10.3	S-PE	1.5	UHF, N
Foam							
RG-11A/U	75.0	0.66	61.8	10.3	PE	5.0	UHF, N
RG-11/U	75.0	0.80	50.7	10.3	S-PE	1.6	UHF, N
Foam							
RG-58A/U	53.5	0.66	85.5	5.0	PE	1.9	BNC

RG-58B/U	53.5	0.66	74.5	5.0	PE	1.9	BNC
RG-58C/U	50.0	0.66	92.4	5.0	PE	1.9	BNC
RG-58/U	53.5	0.79	85.5	5.0	S-PE	1.9	BNC
Foam							
RG-59B/U	73.0	0.66	69.0	6.2	PE	1.9	BNC
RG-59/U	75.0	0.79	50.7	6.2	S-PE	0.8	BNC
Foam							
RG-71A/U	93.0	0.66	46.0	6.2	PE	1.8	BNC
RG-71B/U	93.0	0.66	46.0	6.2	PE	1.8	BNC
RG-71/U	93.0	0.84	92.4	6.2	S-PE	0.8	BNC
Foam							
RG-174A/U	50.0	0.66	92.0	2.5	PE	1.5	SMA
RG-178B/U	50.0	0.70	95.0	1.5	PE	1.2	SMA
RG-179B/U	75.0	0.70	63.0	2.5	PE	1.2	SMA
RG-213/U	50.0	0.66	92.0	10.3	PE	5.0	UHF, N
RG-216/U	75.0	0.66	71.8	10.8	PE	5.0	UHF, N

*Here V is shortening ratio

**PE-polyethylene, SPE-foam-shaped polyethylene.

***Direct connection, i.e. without adaptor.

Table 9.27. Radio-frequency connectors characteristics.

Characteristics	Connector type		
	BNC	UHF	N
Zw, Ohm	50	50...75	50
Working frequencies	? 4GHz	? 50MHz	? 10GHz
Limit frequency	10GHz	180MHz	11GHz
Standing waves ratio	? 1.4 (3GHz)	? 1.15 (100MHz)	? 1.3 (3GHz)
Pmax, Wt for 100 MHz 500 MHz 1 GHz	200 120 80	500	1000 450 300
Introduced	<0.2		<0.3

attenuation,dB	(1GHz)		(1GHz)
Connection	bayonet	thread	thread

When connectors are assembled, a definite sequence of operations should be observed. The sequence of assembling of the most common connectors is described in Fig.9.17 and Fig.9.18.

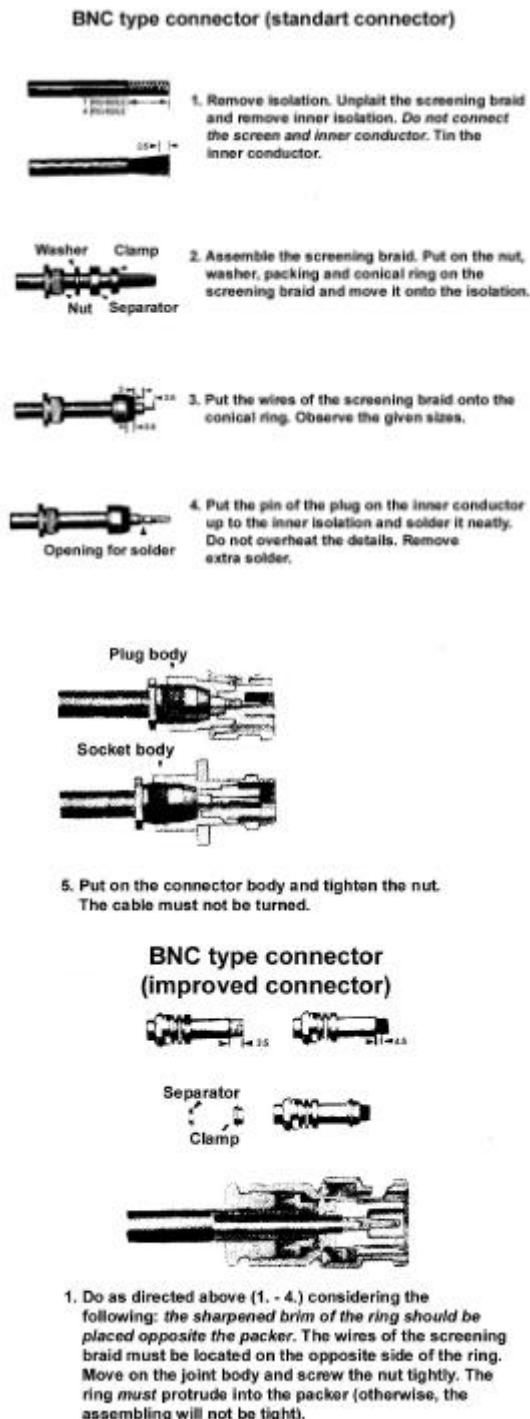


Fig.9.17. Inserting the cable into the BNC connector.

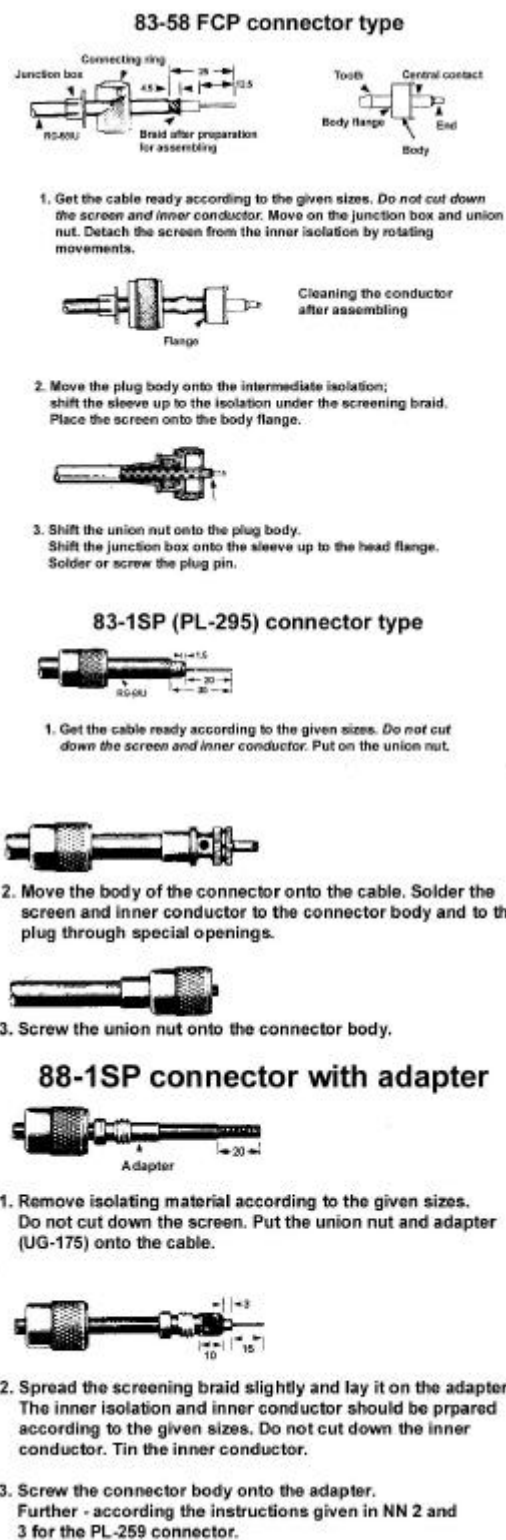


Fig.9.18. Inserting the cable into the UHF connector.

SECTION 10

THE ENGLISH LANGUAGE

Under the requirements of STCW convention, as amended in 1995, part IV, unit IV – 2 the candidates for Second Class Radio Electronic Certification must:

Read and understand technical literature (documents of GMDSS functional requirements, obligatory documents and publications of radio and radio navigational equipment etc.).

Make out technical reports to supply spare parts for GMDSS equipment. Make out business letters in English regarding the repair and exchange of some units, modules.

Use “the English language”, written and spoken, for the exchange of communications relevant to the safety the life at sea.

To observe these requirements a person responsible for the emergency communication should know:

- terms and formats of IMO regulations for search and rescue (IAMSAR section 3);
- IMO Standard Marine Communication Phrases (part III 1.1.);
- minimum knowledge of medical terms for initiating distress or urgency communication in case of the medical problems;
- meteorological terms sufficient to describe the weather conditions at the place of distress;
- transmission and reception of messages during the distress communication.
- the use of International Phonetic Alphabet.

To possess the same entry standards all candidates should be tested in marine English.

The entry standard comprises:

- reading and understanding of manuals and obligatory documents without a dictionary;
- the use of IMO Marine Standard Phrases (part III 1.1.);
- the use of International Phonetic Alphabet;
- understanding and recording of standard meteorological and navigational messages (about 20 words);
- exchange of messages while conducting search and rescue operations and recording of this exchange.