U.S. Department of
Homeland Security

United States
Coast Guard

ET2 UNIT 3: TRAINING

EPQ 5.B.01 Train Personnel in Applicable Safety Procedures

EPQ 5.B.02 Train Personnel in RF Hazards of Electro-Magnetic Radiation to Personnel (HERP)

EPQ 5.B.03 Train Personnel To Operate General Purpose Electronic Test Equipment

EPQ 5.B.04 Train Personnel To Operate Special Purpose Electronic Test Equipment

EPQ 5.B.05 Train Personnel in Operation and Maintenance of Assigned Electronic Equipment

EPQ 5.C.03 Demonstrate How To Eliminate Or Limit Exposure To Radio Frequency (RF) Radiation

Coast GUARD Training Center Petaluma

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ET2 UNIT 3: TRAINING

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QUESTIONS ABOUT THIS TEXT SHOULD BE ADDRESSED TO THE SUBJECT MATTER SPECIALIST FOR THE ELECTRONICS TECHNICIAN RATING

TABLE OF CONTENTS

Acknowledgments and References

Acknowledgments

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The Coast Guard wishes to thank the following individuals for their expertise and support in the development of this document:

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List of References

This pamphlet contains original material developed at the U. S. Coast Guard Training Center, Petaluma, California, and excerpts from the following technical publications:

- *Electronics Manual*, COMDTINST M10550.25 (series)
- *CMplus Job Aids 5.1*
- MLC Standard Operating Procedures
- System Integrated Logistics Support (SILS) Command Policy Manual, COMDTINST M4105.8 (series)

Notice to Students

Purpose

This pamphlet serves to provide you with knowledge of how to address certain administration and documentation tasks required of an ET2.

Important Note

This text has been complied for TRAINING ONLY. It should NOT be used in place of official directives or publications. The test information is current according to the references listed. You should, however, remember that it is YOUR responsibility to keep up with the latest professional information available for your rating. Current information is available from the *Enlisted Performance Qualifications Manual*, COMDTINST M1414.8 (series).

Course Content

This course content is based on the requirements stated in the *Enlisted Performance Qualifications Manual*, COMDTINST M1414.8 (series).

Pamphlet Content

This pamphlet contains four lessons:

Lesson 1: Developing and Delivering Training for Electronics Personnel

Lesson 2: Operating General Purpose Electronic Test Equipment (GPETE)

Lesson 3: Operating Special Purpose Electronic Test Equipment (SPETE)

Lesson 4: Eliminating Or Limiting Exposure To Radio Frequency (RF) Radiation

Performance Qualifications

This pamphlet covers the following enlisted performance qualifications (EPQ) for ET2 from the *Enlisted Performance Qualifications Manual*, COMDTINST M1414.8 (series):

5.B.01 TRAIN personnel in applicable safety procedures for working in and around installed electronics equipment per the Electronics Manual, M10550.25 (series); and the Training and Education Manual, COMDTINST M1500.10 (series).

5.B.02 TRAIN personnel in radio frequency (RF) Hazards of Electro-Magnetic Radiation to Personnel (HERP) per the Electronics Manual, COMDTINST M10550.25 (series); and Navy Electronics Installation and Maintenance Book, General, NAVSEA SE000-00-EIM-100.

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Notice to Students (Continued)

Performance Qualifications (continued)

5.B.03 TRAIN electronics personnel in operating General Purpose Electronics Test Equipment (GPETE) per the Electronics Manual, COMDTINST M10550.25 (series); Navy Electronics Installation and Maintenance Book, Test Equipment, NAVSEA SE000-00-EIM-040; and the manufacturer's technical manual.

5.B.04 TRAIN personnel in operations of Special Purpose Test Equipment (SPETE) per the Electronics Manual, COMDTINST M10550.25 (series); Navy Electronics Installation and Maintenance Book, Test Equipment, NAVSEA SE000-00-EIM-040; and the manufacturer's technical manual.

5.B.05 TRAIN personnel in operation and maintenance of assigned electronic systems per the Electronics Manual, COMDTINST M10550.25 (series); Ordnance Manual, COMDTINST 8000.2 (series); CGPMS; and the equipment technical manuals.

5.C.03 DEMONSTRATE safety precautions required to eliminate/limit exposure to radio frequency (RF) radiation per the Electronics Manual, COMDTINST M10550.25 (series); and Enclosures four, five, six and seven of DODINST 6055.11 "Protection of DoD Personnel from Exposure to Radio Frequency Radiation and Military Exempt Lasers."

Learning Objectives

Read the learning objectives before you begin reading the text. The objectives will guide you through the text and help you answer the questions in the self-quiz at the end of each lesson.

Quizzes

Each lesson has a self-quiz and pamphlets may have a pamphlet review quiz. You will find answers to each quiz on the pages following the quiz. Included are reference pages for the answers.

These self-quizzes are meant to check your comprehension of the material you covered. If you have problems understanding a section, go through it again or ask someone for help. The pamphlet review quiz questions are samples of the type of questions you will find on the end-of-course-test.

SWE Study Suggestion

Servicewide exam questions for your rate and pay grade are based on the Professional and Military Requirements sections of the *Enlisted Performance Qualifications Manual*, COMDTINST M1414.8 (series).

If you use the references from this text and consult the *Enlisted Performance Qualifications Manual*, you should have good information for review when you prepare for your servicewide exam (SWE).

Glossary of Terms

A glossary of terms is included at the end of this pamphlet as Appendix C.

LESSON 1
DEVELOPING AND DELIVERING TRAINING FOR ELECTRONICS PERSONNEL

Overview

Introduction

Section 4.2, “Professional Development,” of the Electronics Manual introduces the subject of training for unit personnel as follows:

> *Training and education is an investment of time and money in our most valuable resource: a dedicated, highly skilled work force. Investments in opportunities for our people are essential to accomplishing assigned missions, staying focused on continuous improvement, and promoting leadership and teamwork. Careful planning and close monitoring of training and education insures an optimum balance of efficiency and effectiveness, maximizing the return on the investment.*

Furthermore…

> *Training is essential for technicians to complete their assigned responsibilities. It is vital for everyone involved to ensure needed training is identified and members are given opportunities to attend.*

As an ET1, you will be expected to take on a greater responsibility for training ET shop personnel (and other unit members as appropriate) in certain topics related to the work that you do, and equipment you use, on a regular basis. This lesson is intended to show you how to set up training sessions in general and to guide you toward the specific information you’ll need to meet the ET1 EPQs related to training.

Lesson Objectives

Given instructional materials, access to tools and equipment, and an appropriate audience from the local unit, **TRAIN** electronics personnel in the following topics in accordance with relevant Navy/Coast Guard technical references and equipment manufacturers’ guidelines:

- Applicable safety procedures for working in and around installed electronics equipment
- Radio frequency (RF) Hazards of Electro-Magnetic Radiation to Personnel (HERP) (including the demonstration of safety precautions required to eliminate/limit exposure to radio frequency (RF) radiation)
- Operating General Purpose Electronics Test Equipment (GPETE)
- Operations of Special Purpose Test Equipment (SPETE)
- Operation and maintenance of assigned electronic systems

Continued on next page

Overview (Continued)

References The following references were used for this lesson:

- *Electroni*cs Manual, COMDTINST M10550.25 (series)
- Schrader's Electronics Communication, 6th
- Tektronix 1502 Time Domain Reflectometer Technical Manual
- IFR 1200S/A Communication Service Monitor Operation Manual
- Tektronix 2245A Operators Guide
- DOD Instruction 6055.11, *Protection of DoD Personnel from Exposure to Radiofrequency Radiation and Military Exempt Lasers*

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Training Requirements

Unit Training Program

Each unit shall have a local technical training program to provide technicians with the skills and knowledge needed to confidently operate and maintain electronic systems required to perform unit missions.

- The program should prepare technicians for duties and tasks associated with their rating, reinforce basic skills, provide on-the-job training, cross training, and professional development.
- Training should be performed for at least one hour per week.

Required Subjects

The following provides a minimum list of required training topics. These should be modified to meet local unit requirements.

- Annual certification in CPR
- Safety requirements and precautions
- Operational capabilities and testing
- Maintenance philosophy and procedures, including support and technical assistance chain of command
- Equipment operation (Operator training)
- Power distribution
- System block diagrams and technical manuals
- Troubleshooting
- General purpose electronic test equipment (GPETE)
- Special purpose electronic test equipment (SPETE)
- Radio Frequency hazards and safety

Scheduling Topics for Training

As you can see from the above, some of the required training topics noted align with the subjects you're expected to train other electronics personnel on to meet your ET2 EPQs. While ordinarily you would confirm with your supervisor the priority of training needed at your unit, for present purposes try to tackle first the training you need to conduct to get your quals signed off (makes sense, right?).

Continued on next page

Training Development

Development Considerations

There are many factors to consider while developing formal training, including:

- Preparation time required for the presentation
- Adequate and up-to-date lesson plans
- Lessons scheduling to maximize attendance
- Suitable training location (space, noise, interruptions, etc.)
- How to measure lesson achievement

Getting Lesson Material

Gather information on your subject from references, user guides, Navy and CG pubs, manufacturer's websites, and even previous lesson plans (make sure they're up-to-date):

- Refer to Section 4.1 of the Electronics Manual for background material on Safety (EPQ 5.B.01).
- Refer to Section 4.1.10 of the Electronics Manual for background material on RF hazards (EPQ 5.B.02); combine your training on this with demonstrating HERP safety precautions (EPQ 5.C.03; Lesson 4 of this pamphlet).
- Refer to Lesson 2 of this pamphlet for background material on GPETE (EPQ 5.B.03) and to Lesson 3 for material on SPETE (EPQ 5.B.04).

Continued on next page

Training Development (Continued)

Lesson Plan Outlines

All training should have a lesson plan outline (LPO). The lesson plan is the instructional instrument that guides the instructor through the material to be covered. It provides the references, objectives, and topic points to be discussed. The LPOs can be a single sheet or a collection of sheets depending on the nature of the training.

Examples of LPOs are shown at the end of this section. Regardless of the subject matter, all LPs should include the following information.

LP Sections	Instructor Actions or Information
Title	Write the title and lesson number, if assigned. The identifying information should facilitate training planning, record keeping, and ease of filing (for example, *OPFAC-TOPIC-PLAN* or *98-70098-SAFETY-004* as shown in the sample lesson plan outlines that follow).
Safety Considerations	CLEARLY STATE ANY SAFETY CONSIDERATIONS. There shall be no compromise to safety of personnel and equipment.
Objectives	Clearly state the learning objectives for the lesson: What do you want the participants to know or do after receiving the training? The objectives should be measurable and realistic.
Materials	You should include a list of all references used to prepare the lesson and ensure they are current. Also, note any training aids, tools, or equipment to be used during the lesson. Finally, list all consumable materials required for the training such as wire, fuses, forms, handouts, etc.
Introduction/ Preview	Write down how you are going to provide the student with the "big picture" and how you will try to build interest in the topic.
Presentation plan	Briefly outline how you will present/demonstrate the information the student will learn and/or procedure you will be teaching the student to perform. Identify the actual lesson activities and how long allotted to each (e.g., 10 minutes lecture and demonstration and 45 minutes hands on practice).
Performance Checks	Note how the students will demonstrate their learning of the subject (e.g., by answering written test questions or performing the procedure while you provide assistance).

Lesson Plan Review

If an LP and/or instructor guide (IG) is already available for the topic you wish to cover, you should carefully review them to ensure that they contain:

- The topic(s) to be presented.
- All points to be emphasized.
- The need-to-know material.
- Only current and correct information and procedures.

Training Delivery

Effective Training

The training presentation is the culmination of your effort and preparation. For training to be effective, the material must be presented in an effective manner:

- Presentations should be interesting, accurate, and to the point.
- Timely insertion of personal experience by the instructor may help emphasize topic points.
- Rehearse presentation of the lesson as much as you can before you actually deliver the training.
- Don't overload the lesson with superfluous information that students don't need to meet lesson objectives for performance.
- Anticipate questions students may have during your presentation and allow time for them to be asked and resolved.

Common Distractions

All of the effort put into preparing for the training session may be negated if the instructor does not give an effective presentation. The following are examples of distractions or situations that may result in a poor training session.

- Talking in a monotone voice without inflection may cause the class to lose interest in the topic (or even go to sleep!).
- Having keys or coins in your pocket while teaching may:
  - Cause noise while walking or shifting weight during the lesson, and
  - Provide you a source of nervous distraction.
- Talking during loud background noise prevents the students from hearing the information presented.
- Use of distracting mannerisms (e.g., wringing of hands, playing with pen, pointers, or other objects) gives the impression that you're nervous and not confident in your lesson.
- Your losing control of class discussion or question periods can cause the class to lose focus and not learn what they're supposed to.
- Reading extensively from printed materials is boring and quickly causes student attention to drift.

Documenting Training

Responsibilities for Recording Training

EMOs and senior technicians (that's you, in this case) shall ensure all successfully completed resident training is documented in a member's Personnel Data Information File. It is your responsibility to make sure this is done for members attending your training sessions at your unit.

Methods to Document Training

The method used to document unit and departmental training is largely dependent on the unit type and size. Use of the Weekly Training Plan (CG- 5288), Departmental Training Record (CG-5289), and the Record of Drills and Exercises (CG-5290) are required on floating units and highly recommended at other units. These tools are easily used for both planning and record keeping.

- Individual Training Record requirements for Coast Guard cutters are described in the Cutter Training and Qualifications Manual, COMDTINST M3502.4 (series).
- Shore units shall maintain an equivalent system for managing training. The training officer, department head, or an assigned member should maintain the training records.
- As a minimum, according to Section 4 of the Electronics Manual, the training record shall among other things contain a "record of lectures attended on general military training, ***departmental/ divisional training*** or those associated with professional development programs (law enforcement, OOD training, etc.)."

LESSON PLAN OUTLINE
98-70098-SAFETY-004

HAZARDOUS CONDITION NOTIFICATION PROCEDURES

SAFETY PRECAUTIONS: No hazards to personnel or equipment this lesson.

OBJECTIVES:

1. **STATE** the informal procedure for reporting hazardous conditions.
2. **PREPARE** an Employee Hazardous Condition Report (CG-4903)

REFERENCES: Safety and Environmental Health Manual, COMDTINST M5100.47 (series), Chapter 3 and Enclosure (1)

TRAINING AIDS: Transparency,.CG-4903 Form
TOOLS AND EQUIPMENT: Overhead projector
EXPENDABLE MATERIALS: 30 Copies of the Form CG-4903
DELIVERY PLAN: 5 Min Discussion; 10 Min Demonstration; 15 Min practice

OUTLINE:

A. Introduction

   1. Informal reporting procedure to supervisor
   2. Consequences of NOT reporting hazards

B. Formal Reporting

   1. Employee Hazardous Condition Report (CG-4903) block by block description.
   2. Give students scenarios.
   3. Have students prepare the report.
   4. Show them the transparency after you mark it up.

C. Feedback and Discussion

INSTRUCTOR NOTES:

LESSON PLAN OUTLINE
07-31299-MAINT-001

ELECTRONIC TROUBLESHOOTING PROCEDURES

SAFETY PRECAUTIONS: Standard electrical safety precautions apply.

OBJECTIVES:

1. **PERFORM** standard troubleshooting procedures per the Electronics Manual, Chapter 11.
2. **COMPLY** with group policy regarding troubleshooting and repair of Depot Level Repairables (APA and NONAV)

REFERENCES: Electronics Manual, COMDTINST M10550.25 (series)
APA Repairable Electronics Program, E/GICPINST 4408.1J
MLCLANT SOP, ANNEX K, Command and Control Systems
Group Electronics Doctrine, USCG Group Warmsand Instruction M10550.1

TRAINING AIDS:
1. Transparencies:
2. Troubleshooting flow chart
3. AN/URC-1000 Block Diagram
4. AN/URC-1000 Power Supply Regulator Module Schematic Diagram
5. DD-1577/2 Unserviceable Tag

TOOLS AND EQUIPMENT: Overhead projector, AN/URC-1000 (spare unit), Oscilloscope, Digital multimeter, In-line Wattmeter, Transistor test set, cables
EXPENDABLE MATERIALS: NONE
DELIVERY PLAN: Lecture & Discussion; 10 Min Demonstration; 10 Min Practice; 10 min per student

OUTLINE:

A. Troubleshooting Procedure

1. Symptom Recognition
2. Symptom Elaboration
3. Sectionalizing - Listing probable faulty function(s)
4. Localizing the faulty function
5. Isolating the failed function/module/component
6. FAILURE ANALYSIS ****The crucial step before repairing****

B. Group Repair Policy

1. ALL equipment failures shall be analyzed to the lowest possible level. If you have access to the component for test purposes, then component level troubleshooting is required. Repair policy shall be whatever applies per higher authority, BUT the DD-1577/2 shall detail as closely as possible the nature of the failure.

2. Group corrective maintenance reporting procedures

3. Casualty Reports per NWP-10-1-10

C. Troubleshooting Drills AN/URC-1000 All Mode Transceiver

D. Feedback and Discussion

INSTRUCTOR NOTES:

Seek troubleshooting problems for any equipment from the equipment

History logs.

Observe the technicians application of knowledge of theory to their use of test equipment, drawings and the technical manual.

Closely monitor their safety practices!

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Practice Exercise

Exercise Instructions

This exercise is meant to check your comprehension of the material covered in this lesson. Read each question and write the answers in the spaces provided. Check your answers in the Feedback section following the exercise. If you are having difficulty understanding a section, go through it again or ask someone for help.

Exercise Questions

1. Training should be performed for at least _____ hour(s) per week.

2. The _____ is the instructional instrument that guides the instructor through the material to be covered.

3. Presentations should be interesting, accurate, and _____.

4. You, as the instructor should ___________ the presentation of the lesson as much as you can before you actually deliver the training.

Feedback

Exercise Question Answers

Compare your answers to the following:

Question	Answer	Reference page
1.	one	1-3
2.	lesson plan	1-5
3.	to the point	1-6
4.	rehearse	1-6

LESSON 2
OPERATING GENERAL PURPOSE ELECTRONIC TEST EQUIPMENT (GPETE)

Overview

Introduction

Electronic Technicians should be thoroughly familiar with the capabilities and limitations of their test equipment to operate it properly. This lesson provides information on two types of general purpose electronic test equipment (GPETE) for use as training material to train other technicians.

GPETE is test equipment that measures or generates a range of parameters of electronic functions common to two or more pieces of equipment, or generates a range of parameters of electronic functions common to two or more equipments or systems of basically different design.

Lesson Objectives

Given instructional materials, **TRAIN** personnel in the operation of the following general purpose electronic test equipment:

1. Time domain reflectometer (TDR)
2. Oscilloscope

- **DESCRIBE** the capability of each piece of general purpose test equipment listed to maintain and repair electronic equipment.
- **DESCRIBE** the availability of each piece of general purpose test equipment listed to maintain and repair electronic equipment.
- **IDENTIFY** the application of each piece of general purpose test equipment listed to maintain and repair electronic equipment.
- **DESCRIBE** the operation of each piece of general purpose test equipment listed to maintain and repair electronic equipment.

References

The following references were used for this lesson:

- *Electronics Manual*, COMDTINST M10550.25 (series)
- Schrader’s Electronics Communication, 6th
- Tektronix 1502 Time Domain Reflectometer Technical Manual
- IFR 1200S/A Communication Service Monitor Operation Manual
- Tektronix 2245A Operators Guide

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Test Equipment Capability

Introduction

This portion of the lesson provides a brief overview of the capability of each of the two types of GPETE listed in "Lesson Objectives."

TDR

The Time Domain Reflectometer (TDR) is capable of sending a pulse down a cable and measuring the reflected pulse back. This measurement provides:

- The cable's impedance
- Distance of the cable
- Visual indication of sharp bends, or kinks
- Visual indication of cuts or nicks
- Visual indication of end of the cable

Oscilloscope

An oscilloscope is used in conjunction with a testing probe to measure electronic signals. Typical operator settings— triggering parameters, SEC/DIV, VOLTS/DIV— allow the operator to view and analyze the displayed results. Below is a list of common measurements using an oscilloscope:

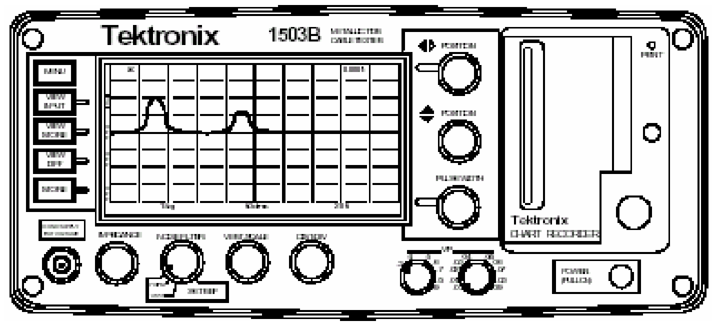
- Voltage (AC, DC, and peak- to- peak)
- Time difference
- Frequency
- Phase differences (comparing one waveform to another)

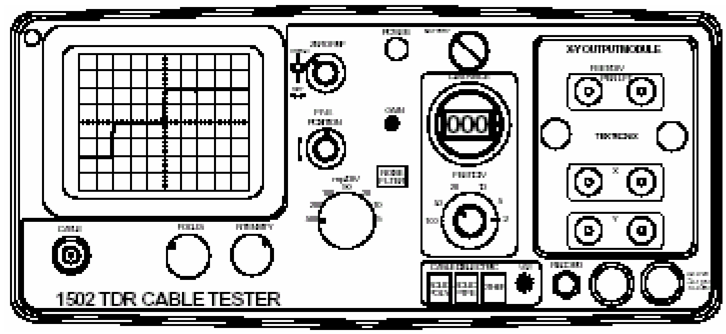
Test Equipment Availability

TDR

Several types of TDRs are available:

- Tektronix model 1503B
- Tektronix model 1502 TDR Cable Tester

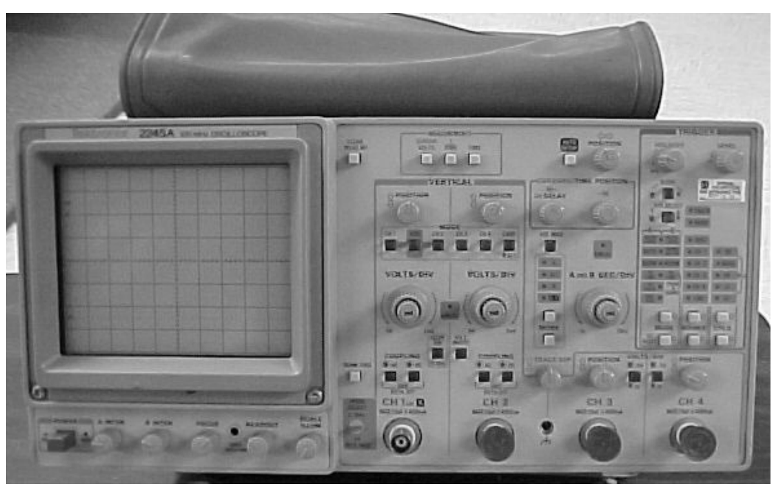




The 1502 is an analog TDR and the 1503B is digital. Both models provide the same information.

Oscilloscope

One of the most common oscilloscopes found in the field is the Tektronix, Model 2245A 100MHz shown below.



Test Equipment Application

Introduction

Matching the right test equipment to the right job gives the electronic troubleshooter a head start in the right direction. This portion of the lesson provides a job aid chart to help technicians select a GPETE based on the problem or situation.

Test Equipment Selection

Use the chart below to assist in determining the type of test equipment to use:

If troubleshooting…	Then use…
Transmission line problem	TDR
Cable problems	
Unknown frequencies or there is a need to measure AC/DC voltage levels	Oscilloscope

TDR Operation

Required Equipment

To complete the procedures in this section you will need:

- A TDR
- The technical or operators manual
- A 6-ft length of RG-58 cable to connect to your TDR

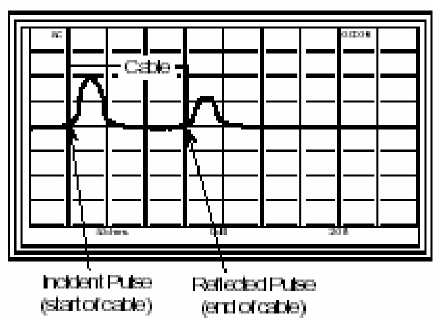
Set-up

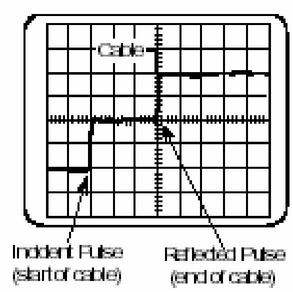
Refer to your TDR operator's manual and the steps below to set-up your TDR:

Step	Action
1.	Turn the TDR on.
2.	Adjust the display controls for a clear, bright trace.
3.	Adjust the vertical position control to center the display.
4.	Line up the rise of the incident pulse (if there is one) on a vertical line.
5.	Connect your six-ft length of RG58 cable to your TDR.
6.	Adjust the amplitude control to full-screen display.
7.	Adjust the feet/division to see both the incident and reflected pulse.

TDR Display

After you have completed the set-up, your TDR display should look like one of the following:





The differences in the displays depend on the type of TDR. While they may not look the same, they provide the same information.

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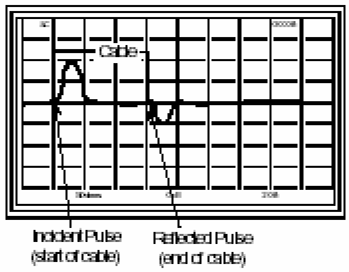
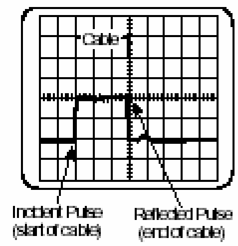
TDR Operation (Continued)

Displaying a Short

Once you have obtained the correct display, short the end of the cable. The display should look like one of the following:





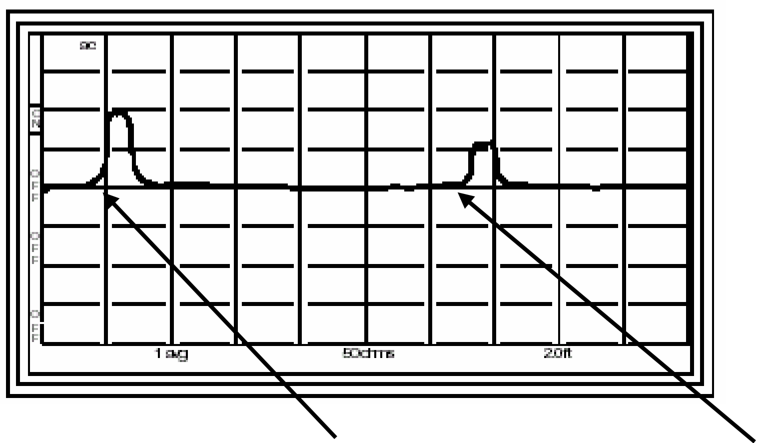
Interpreting the Display

Now that you have something displayed on the CRT, what does it mean? Changes in the cable impedance are represented by bumps and dips on the display. If the cable impedance goes up (as in an open cable), so does the display sweep. Likewise, if the impedance goes down (as in a short), so does the display.

Calculating Distance

To calculate the distance to the end of a cable, multiply the distance, per division, by the number of vertical lines between the *start* of the incident pulse and the *start* of the reflected pulse.

Example:



The distance between the start of the incident pulse and the start of the reflected pulse is 5 ½ units. Multiply this by 2 feet per unit for a total of 11 feet.

Continued on next page

Control Functions

Now that you have a cable displayed on your TDR, you need to manipulate the display. Familiarize yourself with the operators manual to complete the following tasks:

Step	Action
1.	Adjust the power of your transmitted pulse. You should see the size of the display pulse change. Less power will reduce noise. More power will enable you to measure longer cables.
2.	Decrease the value of your distance/division. You should see the reflected pulse moved to the right. This control allows you to stretch the length of the cable across the display.

Locating Cable Problems

Your supervisor informs you that there is a problem in a transmission line that is causing a high VSWR. Initial troubleshooting results show that the transmitter and antenna are operating normally. The problem appears to be within the transmission line, which runs from the transmitter room to the antenna located several hundred feet away. In the next section of this lesson you will learn how to set-up and use the TDR to locate faults in the cable.

Gathering Information

Before troubleshooting the cable, gather all of the information you can about the cable. The information you should look for includes:

- *Type of cable (size, impedance)*
- *Length of cable*
- *Routing path of the cable, including bends and bulkhead feed-through (using diagrams, blueprints, etc.)*
- *Any known connectors or splices on the cable run*
- *Any prior TDR recording on the cable in question*

NOTE

The above information should be included on the NAVSHIP-531 (Resistance Test Record Card) for that transmission line.

Continued on next page

Set-Up Procedure Follow the procedure below to locate a problem in a transmission line:

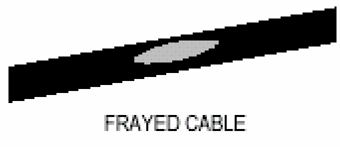
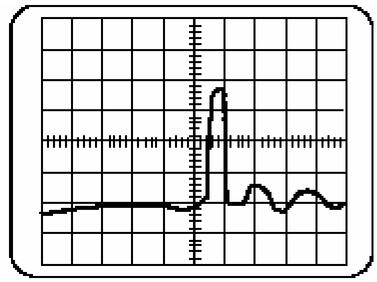
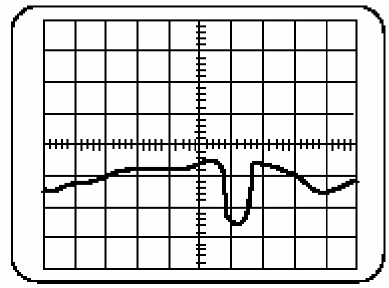
Step	Action
1.	Set up your TDR as described in the previous section.
2.	Disconnect the transmission cable under test at both ends. **Note:** *Bleeding cables of their static charge prior to hooking them up to a TDR will prevent damage. You can bleed cables by connecting a termination matching the impedance of the cable. For example, connect a 50 Ω termination across an RG-58 cable.*
3.	Connect one end of the cable to the TDR and leave the other end opened. **Note:** *An adapter may be required to connect a transmission cable to the TDR.*
4.	Set up the screen on the TDR to display the full length of cable. There should be an open displayed on the TDR. To ensure that you are looking at the end of the cable, short the open end and notice a short displayed on the screen. **Note:** *If no short is displayed, you have an open in the cable.*
5.	Study the trace displayed on the TDR and enlarge the areas of concern.
6.	Determine the type of problem. The most common cable problems include: • Opens • Frayed, cut, or damaged areas • Shorts • Crimps or excessive bends • Faulty connectors • Moisture
7.	Determine the location of the problem.

Continued on next page

TDR Operation (Continued)

Frayed and Crimped Cable

The displays for an open and a shorted cable are shown in the "TDR Display and Displaying a Short" sections. The displays for a frayed and crimped cable are shown below.

Type	Display
	
	

Locating Problems

You now have an idea of where the fault is located in the transmission cable based on the TDR readings. Remember, cable does not necessarily run in a straight line. There could be bends and bulkhead connections along the routing path. Use any available diagrams or blueprints showing how the cable is routed to assist in locating the problem.

> **Note:** *After completing a TDR test on a transmission line, you should make a recording of the display screen and attach it to the NAVSHIP-531 (Resistance Test Record Card).*

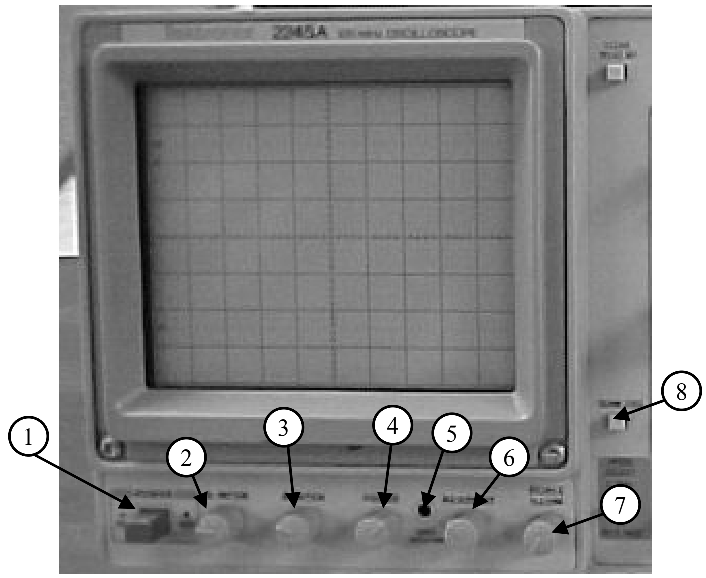
Oscilloscope Operation

Introduction

The Tektronix 2245A 100 MHz oscilloscope has a cursor measurement system for making accurate, direct-readout voltage, time, and frequency measurements. It is one of the most common oscilloscopes found in the field today.

Power and Display Controls

Refer to the diagram call-outs and the table below for power and display controls.

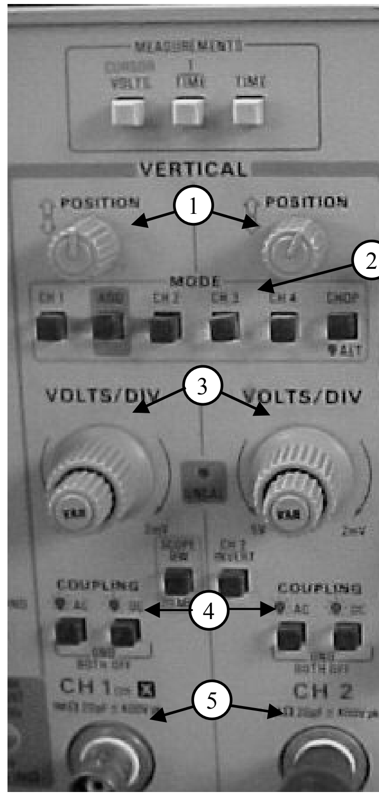


Call-out No.	Control
1	Power on and off.
2	A INTEN control—adjusts brightness of A trace
3	B INTENT control—adjust brightness of B delayed sweep trace
4	FOCUS control
5	TRACE ROTATION control—aligns the CRT trace with the horizontal graticule lines
6	READOUT control—adjust the brightness of the CRT readout display
7	SCALE ILLUM.—adjust the illumination level of the graticule
8	BEAM FIND button.

Continued on next page

Vertical Controls

Refer to the diagram call-outs and the table below for CH 1 and CH 2 vertical controls.



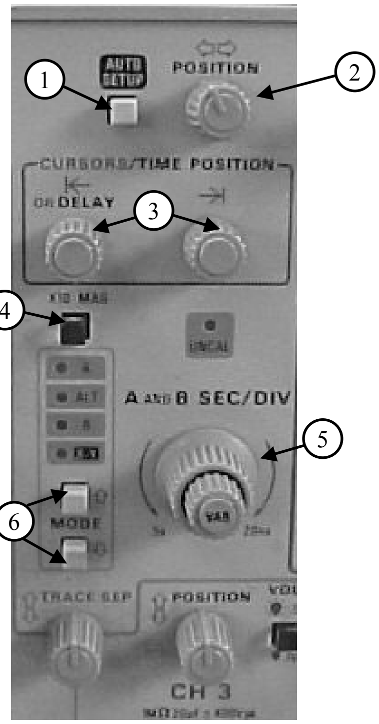
Call-out No.	Control
1	CH 1 and CH 2 POSITION controls
2	MODE buttons
3	CH 1 and CH2 VOLTS/DIV VAR control
4	CH 1 and CH 2 coupling buttons
5	CH 1 and CH 2 input connectors

Continued on next page

Oscilloscope Operation (Continued)

Horizontal Controls

Refer to the diagram call-outs and the table below for horizontal controls.



Call-out No.	Control
1	Auto SETUP button
2	POSITION control
3	Cursors/Time Position controls
4	X10 MAG switch
5	A and B SEC/DIV VAR control
6	MODE button to select the operating mode of the horizontal deflection

Continued on next page

Oscilloscope Operation (Continued)

Setup

Refer to the table below to select the correct procedure chart.

If you need to measure…	Then refer to…
Voltage difference	Chart A
Time difference	Chart B
Frequency	Chart C
Rise-time	Chart D
Phase differences	Chart E

Chart A Procedure

Follow the procedures below for voltage measurements.

Step	Action
1.	Apply the signal to the CH 1 input connector
2.	Set the Vertical MODE to CH 1.
3.	Set the Horizontal MODE to A.
4.	Press the AUTO SETUP button.
5.	Adjust the CH 1 VOLTS/DIV control so the signal fills as much of the screen as possible.
6.	Press the CURSOR VOLTS button to display the voltage cursors.
7.	*Peak-to-Peak Voltage Measurement* • Reposition the cursors to align them with the peaks of the waveform. • Read the measurement value displayed in the top line of the readout.
8.	*Voltage Difference Measurements Between Waveform Locations* • Move the left cursor to the more negative point. • Move the independent right cursor to the more positive point on the waveform. • Read the measurement value displayed in the top line of the readout.

Continued on next page

Chart B Procedure

Follow the procedure below for time measurements.

Step	Action
9.	Apply the signal to the input connector(s). **Note:** *Ensure that the signal used for the trigger source is connected to the lowest numbered channel that will be turned on*
10.	Set the Vertical MODE as desired.
11.	Set the Horizontal MODE to A.
12.	Press the AUTO SETUP button.
13.	Adjust the VOLTS/DIV control so that the measurement points can be viewed on the screen.
14.	Select a SEC/DIV setting, which will provide the fewest number of cycles of the waveform necessary to display the measurements points.
15.	Press the TIME button to display the time cursors. **Note:** *The independent cursor (→I) cannot be positioned in front of the reference cursor (I← OR DELAY).*
16.	Use the I← OR DELAY control to position the reference cursor to the leftmost point on the waveform to be measured.
17.	Use the →I control to position the independent cursor to the rightmost point to be measured.
18.	Read the time difference value on the top line of the CRT readout.

Continued on next page

Chart C Procedure

Follow the procedure below for frequency measurements.

Step	Action
1.	Apply the signal to the input connector(s). **Note:** *Ensure that the signal used for the trigger source is connected to the lowest numbered channel that will be turned on*
2.	Set the Vertical MODE as desired.
3.	Set the Horizontal MODE to A.
4.	Press the AUTO SETUP button.
5.	Adjust the VOLTS/DIV control so that the measurement points can be viewed on the screen.
6.	Select a SEC/DIV setting, which will provide the fewest number of cycles of the waveform necessary to display the measurements points.
7.	Press the 1/TIME button to display the time cursors. **Note:** *The independent cursor (→I) cannot be positioned in front of the reference cursor (I← OR DELAY).*
8.	Use the I← OR DELAY control to position the reference cursor to the leftmost point on the waveform to be measured.
9.	Use the →I control to position the independent cursor to the rightmost point to be measured.
10.	Read the frequency value on the top line of the CRT readout.

Continued on next page

Oscilloscope Operation (Continued)

Chart D Procedure

Making rise-time measurements requires additional signal scaling to use the graticule rise-time measurement aids. Numbers 0%, 10, 90, and 100 are etched near the left vertical graticule line. These numbers provide a convenient reference point for making rise-time measurements. Follow the procedures below for rise-time measurements.

Step	Action
1.	Apply the signal to CH 1 input connector.
2.	Set the Vertical MODE to CH 1.
3.	Set the Horizontal MODE to A.
4.	Set A Trigger SLOPE to _/‾
5.	Press the AUTO SETUP button.
6.	Set the CH 1 VOLTS/DIV and VOLTS/DIV VAR controls to provide an exact five-division display on the screen.
7.	Adjust the CH 1 Vertical POSITION control so the negative amplitude of the waveform is on the 0% reference line and the positive amplitude is on the 100% reference line.
8.	Increase the SEC/DIV setting to stretch out the rising edge of the waveform as much as possible to improve the cursor placement accuracy.
9.	Adjust the Trigger LEVEL control, if necessary, to get the 10% level on the screen.
10.	Increase the A INTEN control if necessary, to brighten the beginning of the trace.
11.	Adjust the Horizontal POSITION control to place the 50% level (center) of the rising edge of the waveform at the center vertical graticule line.
12.	Press the TIME button to display the time cursors.
13.	Use the ⇤ OR DELAY control to align the first cursor to the rising edge at the point where it crosses the 10% reference graticule line.
14.	Use the ⇥ control to align the second cursor to the point where the rising edge crosses the 90% graticule line.
15.	Read the rise-time on the top line of the CRT readout.

Continued on next page

Chart E Procedure

Making a phase measurement requires setting a reference for the full 360-degree waveform period. Follow the procedures below for phase measurements.

Step	Action
1.	Apply the reference signal to CH 1 input connector using the standard 10X attenuator probe.
2.	Select CH 1 for display using the Vertical MODE button.
3.	Set the Input COUPLING for CH 1 and CH 2 to DC. **Note:** *AC may be used if the signal being measured is riding on a dc voltage. Ensure that both inputs are set to the same coupling.*
4.	Set the CH 1 VOLTS/DIV control to display the reference waveform with about five divisions of amplitude.
5.	Vertically center the waveform on the screen.
6.	Set the A SEC/DIV setting (in A Horizontal MODE) to display at least one complete reference waveform period. **Note:** *No more than two complete periods should be displayed. Excessive cycles will reduce the accuracy of the reference setting.*
7.	Select or SLOPE to position the waveform correctly within the graticule area for ease in measurement when viewing a single cycle of the reference signal.
8.	Press the TIME button to display the time cursors.
9.	Adjust the first vertical cursor at the point where the reference waveform crosses the center horizontal graticule line in the positive direction. **Note:** *Use the Horizontal POSITION control to center the waveform period in the viewing area.*
10.	Adjust the delta cursor to the second positive crossing of the center horizontal graticule line by the reference waveform.
11.	Apply the phase-shifted waveform signal to be measured to CH 2 input connector using a 10X probe. **Note:** *The time readout at the top of the graticule is your 360-degree reference time.*

Continued on next page

Oscilloscope Operation (Continued)

Chart E Procedure (continued)

Step	Action
12.	Turn CH 2 vertical MODE to on to display the waveform.
13.	Set the VOLTS/DIV controls to match the amplitude of the phase-shifted waveform to that of the reference waveform.
14.	Adjust the Vertical POSITION control to align the two waveforms vertically.
15.	Adjust the cursors to a positive or negative crossing of each waveform.
16.	Read the delta time at the top of the graticule and use the formula below to calculate the phase difference. $\text{Phase difference (in degrees)} = \frac{\text{delta time}}{\text{reference time}} \times 360°$

Practice Exercise

Exercise Instructions

This exercise is meant to check your comprehension of the material covered in this lesson. Read each question and write the answers in the spaces provided. Check your answers in the Feedback section following the exercise. If you are having difficulty understanding a section, go through it again or ask someone for help.

Exercise Questions

1. How does a TDR work? __________________________
2. What will be displayed on the CRT of the TDR if the cable's impedance goes up? ___________
3. After completing a TDR test, a recording of the display should be printed and attached to what? ________________
4. What is the purpose of the voltage cursors on the Tektronix 2245A? ___________________________________
5. Making a phase measurement on the Tektronix 2245A requires setting a reference for the _______ ________ waveform period.

Continued on next page

Feedback

Exercise Question Answers

Compare your answers to the following:

Question	Answer	Reference page
1.	Sends a pulse down a cable and measures the reflected pulse back	2-2
2.	A bump upwards on the display sweep	2-6
3.	NAVSHIP-531 (Resistance Test Record Card)	2-9
4.	Act as a measuring point for measuring peak-to-peak waveforms	2-13
5.	Full 360-degree	2-17

LESSON 3
OPERATING SPECIAL PURPOSE ELECTRONIC TEST EQUIPMENT (SPETE)

Overview

Introduction

Electronic Technicians should be thoroughly familiar with the capabilities and limitations of their test equipment to operate it properly. This lesson provides information on two types of special purpose electronic test equipment (SPETE) for use as training material to train other technicians.

SPETE is test equipment that measures or generates a range of parameters of electronic functions common to two or more pieces of equipment, or generates a range of parameters of electronic functions common to two or more equipments or systems of basically different design.

Lesson Objectives

Given instructional materials, **TRAIN** personnel in the operation of the following special purpose electronic test equipment:

1. Transmission test set (TTS)
2. Communication analyzer

- **DESCRIBE** the capability of each piece of general purpose test equipment listed to maintain and repair electronic equipment.
- **DESCRIBE** the availability of each piece of general purpose test equipment listed to maintain and repair electronic equipment.
- **IDENTIFY** the application of each piece of general purpose test equipment listed to maintain and repair electronic equipment.
- **DESCRIBE** the operation of each piece of general purpose test equipment listed to maintain and repair electronic equipment.

References

The following references were used for this lesson:

- COMDTINST M10550.25 (series)
- Schrader's Electronics Communication, 6th
- Tektronix 1502 Time Domain Reflectometer Technical Manual
- IFR 1200S/A Communication Service Monitor Operation Manual
- Tektronix 2245A Operators Guide

Continued on next page

Test Equipment Capability

Introduction

This portion of the lesson provides a brief overview of the capability of each of the two types of SPETE listed in "Lesson Objectives."

Transmission Test Set

The Transmission Test Set (TTS), also known as the transmission impairment measuring set, is capable of measuring the performance of analog telephone and data communication lines. The TTS will test and measure:

- Communication network line quality
- Continuity and channel problems
- Audio signal levels and noise
- Frequency response of a channel

Communication Analyzer

The Comms Analyzer (short for Communication Analyzer) provides the functions of several pieces of test equipment, and enables you to complete many different tests required on radios.

The available functions depend on the type and model. The following are examples of test equipment incorporated within the Comms Analyzer:

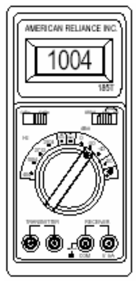
- Signal Generator (AM, FM, SSB)
- Power/Modulation/SINAD meter (RF power and error, distortion, relative signal strength)
- Oscilloscope (basic functions)
- Spectrum Analyzer (frequencies and amplitude)

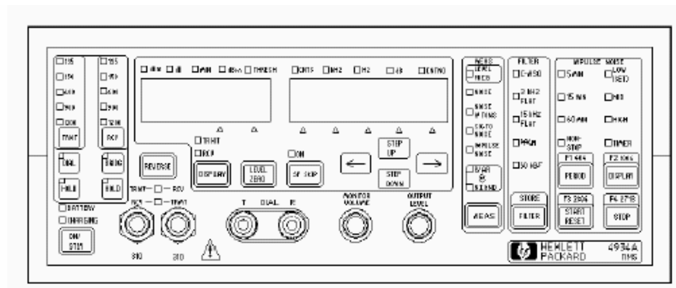
Test Equipment Availability

TTS

Two types of TTS used in the field:

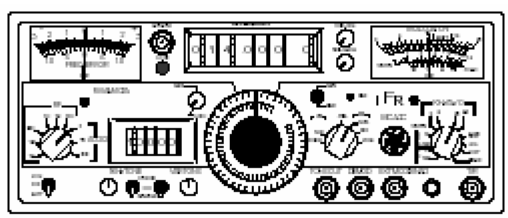
- American Reliance, Inc. model 185T
- Hewlett Packard model 4934A

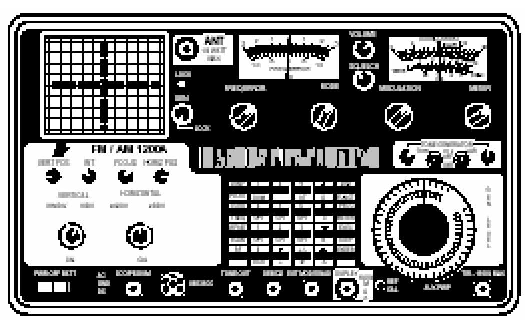




Communication Analyzer

Several types of Comms Analyzers are used in the field. The two most common models are the IFR 500 and IFR 1200S/A shown below. You should always check the operator's manual for specific instructions on your type or model before operating it.





Test Equipment Application

Introduction

Matching the right test equipment to the right job gives the electronic troubleshooter a head start in the right direction. This portion of the lesson provides a job aid chart to help technicians select an SPETE based on the problem or situation.

Test Equipment Selection

Use the chart below to assist in determining the type of test equipment to use:

If troubleshooting…	**Then use…**
Control head for remote radio sending out correct signal, but remote radio not responding	TTS
Audio signal level problems	
Frequency response	
Communication network line quality e.g., telephone line	
Line continuity problems	
A receiver's sensitivity, squelch threshold, SINAD	Comms Analyzer
A duplex operation in an R/T	
A transmitter's power out, modulation, distortion, frequency error	
Monitor "Off-the-Air" transmissions	

Transmission Test Set Operation

Introduction

Before you begin using the TTS you should become familiar with its operation and how to select the following:

- Transmit and Receive
- Type of Mode (Termination or Bridge)
- Transmit Frequency
- Transmit Level

Transmit and Receive

The TTS has a transmit and receive function. Selection between these two functions will depend on the type of TTS at your unit. Refer to your operator's manual for directions on how to select the desired function.

Type of Mode

The TTS has two modes: termination and bridge. Selection will depend on the telephone circuit being tested.

- Termination Mode— allows the TTS to be placed at the end of a telephone line and act as a termination. The most common termination setting is 600 Ω. The actual impedance will depend on the telephone line.
- Bridge Mode— allows the TTS to perform measurements without disturbing the existing hookup

---

Transmit Frequency

The TTS transmits several different frequencies. The most common frequencies are:

- 1004 Hz
- 404 Hz
- 2804 Hz
- 2713 Hz

Basic line tests normally use a frequency of 1004 Hz.

Transmit Level

Transmit level determines the amount of power that the TTS transmits. Typical levels/settings vary from 0 dBm to
-13 dBm. For most testing, the 0 dBm level is used.

Continued on next page

Transmission Test Set Operation (Continued)

Setup Procedure

Refer to your TTS operator's manual and the steps below to set-up your TTS:

Step	Action
1.	Isolate the line being tested. Ensure that both ends have been disconnected. It may be necessary to remove bridge clips or equipment from racks to completely isolate the line being tested.
2.	**NOTE** *Power loss or line loss is a common measurement performed on telephone circuits. This test will require two TTSs, one used to transmit and one used to receive.* Turn the first TTS on.
3.	Select transmit function.
4.	Set transmit frequency to 1004 Hz.
5.	Set the transmit level to 0 dBm.
6.	Select type of mode to termination mode at 600 Ω.
7.	Connect the TTS leads to one end of the test circuit.
8.	Turn the second TTS on.
9.	Select receive function.
10.	Select type of mode to termination mode at 600 Ω.
11.	Connect the TTS leads to the other end of the test circuit.
12.	Transmit from one end to the other end.
13.	Subtract the level received from the level transmitted. This is the loss.
14.	Change the first TTS transmit function to receive.
15.	Change the second TTS receive function to transmit.

Continued on next page

Setup Procedure (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>16.</td><td>Transmit from one end to the other.</td></tr>
<tr><td>17.</td><td>Subtract the level received from the level transmitted. This is the loss in the opposite direction.</td></tr>
<tr><td>18.</td><td>Record the loss for both directions.</td></tr>
<tr><td>19.</td><td>Compare the loss to the baseline reference to determine if the loss is acceptable.
<table>
<tr><th>If loss is…</th><th>Then…</th></tr>
<tr><td>Acceptable</td><td>Go to step 20.</td></tr>
<tr><td>Unacceptable</td><td>Go to step 22.</td></tr>
</table></td></tr>
<tr><td>20.</td><td>Reconnect the circuit and all associated equipment.</td></tr>
<tr><td>21.</td><td>Perform a functional test to ensure that the circuit is operating correctly. This concludes the line test.</td></tr>
<tr><td>22.</td><td>Repeat steps 4 through 19 using other frequencies to thoroughly test the circuit loss over the band pass of frequencies for the circuit.

Note: Losses of less than 3 dB over all of the frequencies should be acceptable. Losses greater than 3 dB may warrant further testing or replacement of the line being tested.</td></tr>
</table>

Active vs. Passive Circuits

There may be times when there are no existing baseline records to compare line loss to. In an ideal world a line should have a 0dB loss, what goes in comes out. Electronic equipment and long runs of copper wire cause most circuits to have some small amounts of loss. Below are the general guidelines for circuits:

- Active circuits from the telephone company typically have a loss of 0 dB
- Passive circuits may have a loss up to 13 dB

Another method of comparison is to test another circuit that is similar and compare the results.

Communication Analyzer Operation

Introduction

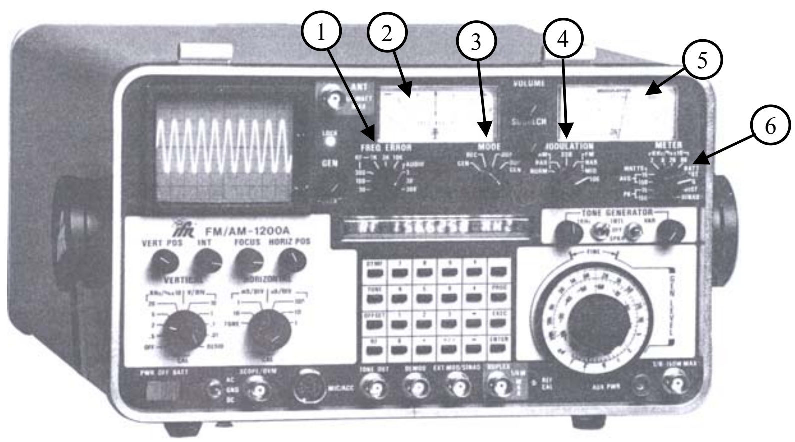
This portion of the lesson provides information on the IFR 1200S/A Communication Analyzer.

The IFR 1200S/A is a multi-functional receiver and generator capable of monitoring and generating AM, FM, and SSB signals within a range of 250 kHz to 999.9999 MHz. Functions include:

- Signal generator with tone and voice modulation
- Receiver
- Modulation meter (percent of modulation, watts, distortion, SINAD)
- Oscilloscope

Front Panel

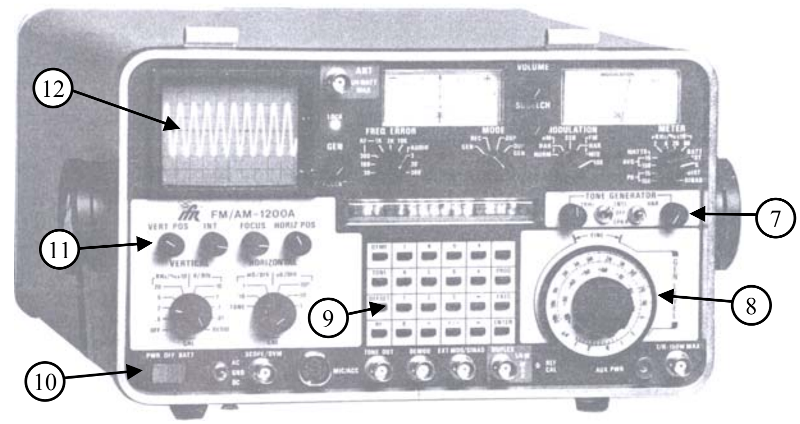
Refer to the diagram call-outs and the chart below for general front panel controls.



Call-out No.	Control
1	FREQ ERROR meter range selector control
2	Frequency ERROR meter
3	MODE Selector Control
4	MODULATION Selection Control
5	MODULATION meter
6	Modulation METER control

Continued on next page

Front Panel (continued)

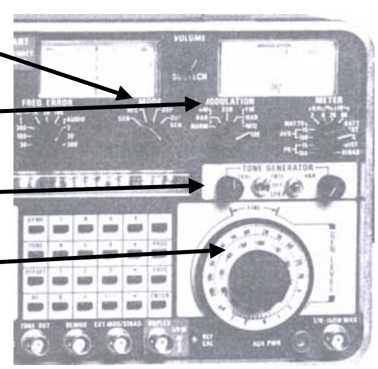


Call-out No.	Control
7	TONE GENERATOR section
8	RF level attenuator control
9	Keyboard
10	Power/Off/Battery switch
11	Oscilloscope vertical and horizontal controls
12	Oscilloscope CRT display screen

Signal Generator

The signal generator function produces the desired frequencies and amplitudes with the necessary modulation for testing circuits. Adjustments and controls for this function include:

Transmit Mode (Generator)
Modulation Signal (AM, FM, SSB)
1 kHz or Variable Tone Generator and the modulation level
Transmit Frequency
Level of RF Output



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Receiver

The receiver function has the capability of receiving and monitoring AM, FM, and SSB signals. Incoming signals are monitored using the Comms Analyzer's antenna or the T/R connector on the front panel. Signal monitoring produces:

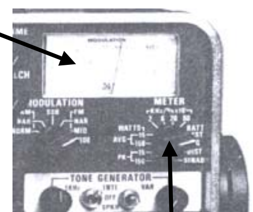
RF error
Transmitter power
Signal Including Noise and Distortion (SINAD)
Distortion
Relative signal strength

Results are displayed on a built-in meter. See Modulation meter.

Modulation Meter

The modulation meter is an analog meter that displays the measurement and/or monitoring of:

RF power level
Relative signal strength
Battery test voltage
Distortion
SINAD

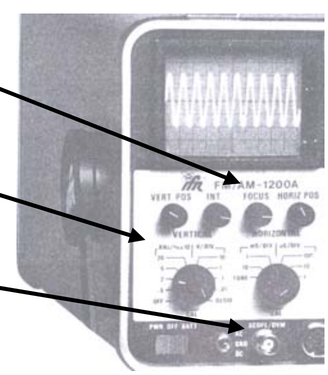


The meter is controlled by the modulation METER control.

Oscilloscope

The IFR 1200S/A oscilloscope function has basic oscilloscope controls. The oscilloscope can display and measure internal signals generated by the Comms Analyzer's generator or external frequencies and voltage using the scope/DVM jack.

Horizontal Position control
Focus control
Vertical Position control
Vertical Attenuator control
Horizontal Sweep Vernier control
Scope/DVM jack



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Communication Analyzer Operation (Continued)

Signal Generator Setup Procedure

Refer to the IFR 1200S/A operator's manual and the steps below for basic simplex signal generator function.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1.</td><td>Select "Gen" on the MODE Selector Control.</td></tr>
<tr><td>2.</td><td>Enter the desired frequency using the keyboard.</td></tr>
<tr><td>3.</td><td>Select the desired modulation:
<table>
<tr><th>If…</th><th>Then select…</th></tr>
<tr><td>AM</td><td>AM NORM on the MODULATION Select Control
Adjust the 1 kHz or VAR tone level controls for percent of modulation (viewed on modulation meter)</td></tr>
<tr><td>FM</td><td>Press "TONE" on keyboard
Enter desired modulation frequency
Select "INTL" with VAR Tone selector switch
Adjust VAR tone level for 5 kHz (viewed on modulation meter).</td></tr>
<tr><td>SSB</td><td>SSB on the MODULATION Select Control</td></tr>
</table>
</td></tr>
<tr><td>4.</td><td>Adjust the RF level attenuator control for the desired RF output.</td></tr>
<tr><td>5.</td><td>Connect a 50 Ω coaxial cable between the UUT (unit under test) and the T/R connector.</td></tr>
</table>

Voice Modulation

The Comms Analyzer may also be setup to generate an RF signal with voice modulation by connecting the external microphone to the MIC/ACC connector. When the external antenna is connected to the ANT connector, the Comms Analyzer will function as a transmitter.

Note: *Maximum output is 0.25 watts.*

Receiver Setup Procedures

There are two basic sets of procedures for receiving transmitted signals. Refer to the table below:

If signal being monitored…	Then refer to…
Is "Off-the-Air"	Chart A on this page.
Is by direct cable	Chart B on the next page.

Continued on next page

Communication Analyzer Operation (Continued)

Chart A Procedure

Refer to the IFR 1200S/A operation manual and the steps below for receiving “Off-the-Air” signals.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1.</td><td>Connect the external antenna to the ANT connector.

CAUTION

Maximum continuous input at the antenna must not exceed 0.25 watts.</td></tr>
<tr><td>2.</td><td>Enter the desired frequency using the keyboard.</td></tr>
<tr><td>3.</td><td>Use the table below to select the proper modulation:
<table>
<tr><th>If monitoring…</th><th>Then set MODULATION Select Control to…</th></tr>
<tr><td>AM signals</td><td>AM NORM or AM NAR</td></tr>
<tr><td>FM signals</td><td>FM WIDE or FM MID or FM NAR</td></tr>
<tr><td>SSB signals</td><td>SSB</td></tr>
</table>
</td></tr>
<tr><td>4.</td><td>Adjust the VOLUME and SQUELCH controls as required.</td></tr>
<tr><td>5.</td><td>Modulation Measurement
Adjust the Modulation METER control to the desired “kHz/%X10” setting (based on the transmitter’s modulation).</td></tr>
<tr><td>6.</td><td>Frequency Error Measurement
Select the desired setting on the FREQ ERROR Meter Range Selector Control.
Depress “2nd FUNCT” and ‘METER” keys on the keyboard.</td></tr>
<tr><td>7.</td><td>Relative Strength Measurement
Select “SIG” on the Modulation METER Control.
Depress “2nd FUNCT” and “METER” keys on the keyboard.</td></tr>
</table>

Continued on next page

Communication Analyzer Operation (Continued)

Chart B Procedure

Refer to the IFR 1200S/A operator's manual and the steps below for receiving direct signals from a transmitter.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1.</td><td>Connect a 50 Ω coaxial cable from the transmitter's output directly to the T/R connector.

CAUTION

Maximum input at the T/R connection must not exceed 150 watts. At 150 watts, transmit cycle should be 1 minute "On" and 5 minutes "Off."</td></tr>
<tr><td>2.</td><td>Enter the desired frequency using the keyboard.</td></tr>
<tr><td>3.</td><td>Use the table below to select the proper modulation:
<table><tr><th>If monitoring…</th><th>Then set MODULATION Select Control to…</th></tr><tr><td>AM signals</td><td>AM NORM or AM NAR</td></tr><tr><td>FM signals</td><td>FM WIDE or FM MID or FM NAR</td></tr><tr><td>SSB signals</td><td>SSB</td></tr></table></td></tr>
<tr><td>4.</td><td>Adjust the VOLUME and SQUELCH Controls as required.</td></tr>
<tr><td>5.</td><td>Modulation Measurement
Adjust the Modulation METER Control to the desired "kHz/%X10" setting (based on the transmitter's modulation).</td></tr>
<tr><td>6.</td><td>Frequency Error Measurement
Select the desired setting on the FREQ ERROR Meter Range Selector Control.
Depress "2nd FUNCT" and 'METER" keys on the keyboard.</td></tr>
<tr><td>7.</td><td>Transmitter Power Out Measurement
Select "WATTS" on the Modulation METER Control.
Depress "2nd FUNCT" and "METER" keys on the keyboard.</td></tr>
<tr><td>8.</td><td>Relative Strength Measurement
Select "SIG" on the Modulation METER Control.
Depress "2nd FUNCT" and "METER" keys on the keyboard.</td></tr>
</table>

Continued on next page

Chart B Procedure (continued)

Step	Action
9.	*AM or FM Transmitter Distortion Measurement* Ensure that transmitter under test has been modulated with a fixed 1 kHz tone. **Note:** *The IFR 1200S/A 1 kHz Tone Generator function should be used as the modulation source.*
10.	Select “DIST” on the Modulation METER control.
11.	Connect a coaxial cable between the DEMOD connector and the EXT MOD/SINAD connector
12.	Monitor the distortion level on the top scale of the MODULATION Meter. **Note:** *Distortion can be observed on the IFR 1200S/A oscilloscope by placing the VERTICAL Attenuator Selector Control to “RESID.”*

Continued on next page

SINAD Sensitivity Procedure

The quickest way to check a receiver's operation is to check its sensitivity. Sensitivity is the capability of a receiver to reproduce very weak signals. The greater the receiver's sensitivity, the weaker the signal that can be reproduced. The IFR 1200S/A has a built-in modulation meter to use for measuring SINAD. Follow the steps below to measure a receiver's sensitivity.

Step	Action
1.	Connect a 50 Ω coaxial cable between the T/R connector and the RF input of the receiver under test. **NOTE** *For UUT SINAD measurements, the IFR 1200S/A internal tone generator should be used as the modulation source. A modulation frequency of 1 kHz is required.*
2.	Connect the audio output of the receiver under test to the EXT/MOD/SINAD connector.
3.	Select "SINAD" on the Modulation METER control.
4.	Adjust the RF level attenuator control for an output level of 500 μV.
5.	Slowly decrease the RF output level until the MODULATION meter displays the desired SINAD value. **NOTE** *The setting of the RF level attenuator control represents the SINAD sensitivity of the receiver under test.*

Continued on next page

Communication Analyzer Operation (Continued)

Oscilloscope Setup Procedure

As mentioned earlier in this lesson, the IFR 1200S/A has a basic oscilloscope that can be used to measure internal frequencies generated by the IFR 1200S/A and external frequencies being transmitted into or connected directly to the SCOPE/DVM jack. Refer to the IFR 1200S/A operator's manual and the steps below for various measurements using the oscilloscope.

Step	Action
1.	*To view Internally Generated Demodulated AM, FM, or SSB Signals* Set the VERTICAL Attenuator Selector Control to the desired "kHz/%X10" position.
2.	Adjust the VERT POS, FOCUS, and HORIZ POS controls as required.
3.	*To View External Transmitter Frequency (Spectrum Analyzer)* Set the HORIZONTAL Sweep Selector Control to 1 MHz/Div or less. **CAUTION** Never connect a transmitter's output directly to the SCOPE /DVM connector. Transmitted power in must always be connected to the T/R connector
4.	*To View External Frequencies or Measure AC/DC Voltages* Connect a probe to the SCOPE/DVM connector.
5.	Connect the probe tip to the test point in the UUT.
6.	Adjust the VERTICAL Attenuator Selector Control as required.
7.	Adjust the HORIZONTAL Attenuator Selector Control as required.
8.	Adjust the VERT POS, FOCUS, and HORIZ POS controls as required.

Practice Exercise

Exercise Instructions

This exercise is meant to check your comprehension of the material covered in this lesson. Read each question and write the answers in the spaces provided. Check your answers in the Feedback section following the exercise. If you are having difficulty understanding a section, go through it again or ask someone for help.

Exercise Questions

1. The TTS measures the performance of ____________________ and ____________________.

2. (True or False) The Comms Analyzer has a built-in SINAD meter ________.

3. Which mode of operation allows the TTS to perform measurements without disturbing the existing hookup? ______________________

4. (True or False) The TTS is capable of measuring power loss because of its capability to transmit and receive simultaneously ________.

5. What two connections does the Comms Analyzer use to receive and monitor AM, FM, and SSB? _______________ ______________

6. What is the maximum input wattage at the T/R connection on the Comms Analyzer? ______________________

Continued on next page

Feedback

Exercise Question Answers

Compare your answers to the following:

Question	Answer	Reference page
1.	Analog telephone and data communication lines	3-2
2.	True	3-2
3.	Bridge mode	3-5
4.	False; two TTS's are required to measure power loss.	3-6
5.	ANT and the T/R connector	3-12, 3-13
6.	150 watts	3-13

LESSON 4
ELIMINATING OR LIMITING EXPOSURE TO RADIO FREQUENCY (RF) RADIATION

Overview

Introduction

Radio frequency (RF) radiation from radar, communications and Loran transmitters are hazardous and cause undesirable effects under certain conditions. As an ET, you may be responsible for the safe operation of radars and weapons. The systems you have control of can be hazardous to you and members of your unit if not operated properly. The Coast Guard has established safety programs to manage the hazards associated with RF radiation.

Lesson Objectives

Given various terms or definitions associated with RF radiation,

- **SELECT** the proper term or definition.
- **DEFINE** various sources of RF radiation.
- **IDENTIFY** hazards associated with RF radiation.
- **DETERMINE** the Permissible Exposure Limit (PEL) for various environments.
- **DESCRIBE** established programs used to limit exposure to RF energy.

References

The following references were used for this lesson:

- *Electronics Manual*, COMDTINST 10550.25 (series)
- DoD Instruction 6055.11, February 1995 *Protection of DoD Personnel from Exposure to Radio Frequency Radiation and Military Exempt Lasers*
- American National Standards Institute (ANSI) C95.2-1981, "American National Standard Radio Frequency Radiation Hazard Warning Symbol," 1981

Continued on next page

Sources of RF Radiation

Introduction

High-power radar, communication transmitters, and Loran equipment creates radiation; all electronics personnel should be aware of this type of hazard.

Sources of RF Radiation

Radar peak power may reach 1 million watts or more. RF radiation hazards exist in the vicinity of radar transmitting antennas. These hazards exist not only in front of an antenna but also to the side and sometimes even behind because of spillover and reflection.

Additional Sources

When operated with electric potentials in excess of 6 kV, modern electron tubes—such as high-power klystrons, magnetrons, thyratrons, cathode ray tubes, and HV rectifiers— may generate x-rays. These rays may emanate from the tube if satisfactory shielding is not provided.

Because of the capability of x-rays to penetrate solid matter and modify, damage, and destroy living tissue, this energy is useful for medical treatments; however, it is also hazardous when not controlled.

Electromagnetic Radiation Hazards

Introduction

Hazards caused by a transmitter/antenna installation that generates electromagnetic radiation near ordnance, personnel, or fueling operations are called electromagnetic radiation hazards (RADHAZ).

These hazards exist when an electromagnetic field of sufficient intensity is generated to:

- Induce or otherwise couple currents and/or voltages of magnitudes large enough to initiate electro-explosive devices or other sensitive explosive components of weapon systems, ordnance, or explosive devices.
- Cause harmful or injurious effects to humans and wildlife.
- Create sparks having sufficient magnitude to ignite flammable mixtures of materials that must be handled in the affected area.

Note: *Also* called *EMR Hazards, RADHAZ, or RF Hazard.*

Categories of RADHAZ Effects

RF radiation from radar, communication, and Loran transmitters is hazardous and causes undesirable effects under certain conditions.

These radiation hazards fall into two categories:

- Induced Voltage Effects
- Personnel Biological Injury

Continued on next page

Electromagnetic Radiation Hazards (Continued)

Induced Voltage Effects

RF voltages induced in structures or other metal objects may cause:

- Shock
- Open sparks when contact is made or broken by personnel or other conductive material

Radiation-induced voltage in small metal objects or tools may:

- Draw an arc sufficient to ignite gasoline vapors or combustible material
- Actuate electrically operated devices
- Heat metal sufficiently to ignite flammable material or vapors; this is also known as Hazards of Electromagnetic Radiation to Fuel (HERF).

Personnel Biological Effects

When electromagnetic energy is absorbed in the tissues of the body, heat is produced. If the body cannot dissipate this heat energy as fast as it is produced, this can cause:

- The internal temperature of the body to rise
- Damage to tissue
- Death of a whole organ

> **WARNING**
>
> Effects produced by exposure to longer wavelength radiation below 30 MHz are not known at this time. However, there is increasing concern that exposure to these frequencies will produce adverse health effects.

Permissible Exposure Limit (PEL)

Introduction

Exposure to RF radiation for no more than 6 minutes in any hour has been determined to be the maximum allowable time before detectable damage to body tissue occurs. This is referred to as the Permissible Exposure Limit (PEL).

Exposure Level

A SAR of 4 W/kg is the threshold above which, there is an increasing possibility for adverse biological effects, but at or below which there is no established evidence of harm to health.

Controlled Environments

In controlled environments, where restrictions on access may be implied, the PEL is based on maintaining exposure below a SAR of 0.4 W/kg.

Uncontrolled Environments

In uncontrolled environments, where access is not restricted, lower levels have been adopted over the human resonance range as a consensus for maintaining lower exposure levels in public areas. The PEL for these areas is equivalent to a SAR of 0.08 W/kg.

Personnel Safety Distance

The PEL will be exceeded when within a 12-foot radius of:

- Mini-loop antennas
- 35 foot whip antennas
- 47 foot whip antennas

Limiting Exposure to RF Radiation

Introduction

Radiation from VHF, UHF, or radar antennas will cause biological injury to personnel who are subjected to prolonged exposure. The greatest harm is caused by heat. Heating is a function of the intensity of the RF field, the exposure time, the ability of the human body to dissipate heat, and climatic conditions at the time of exposure.

Personnel Safety Precautions

RF Radiation Hazard signs shall be posted in locations where personnel can be exposed to radiation hazards; i.e., near antennas, couplers, transmitters, and compartments such as mast trunks.

Personnel shall be warned of the Hazards of Electromagnetic Radiation to Personnel (HERP).

Coast Guard Preventive Maintenance System (CGPMS) has been developed for equipment. The CGPMS has systematic instructions that shall be followed when operating or performing maintenance.

RF Warning Signs

The RF hazard warning sign (illustrated in enclosure 7 of DoD INST 6055.11) is derived from the RF warning symbol published in ANSI C95.2-1981. Variations of the sign for camouflage, tactical reasons, or to provide improved visibility under certain lighting conditions, are authorized provided the general layout of the sign remains the same.

NOTE

In areas where access to levels greater than 10 times the controlled environment PEL may exist, warning signs alone do not provide adequate protection. Other warning devices such as flashing lights, audible signals, barriers, or interlocks are required depending on the potential risk of exposure.

Continued on next page

Limiting Exposure to RF Radiation (Continued)

Emission Control (EMCON)

Unintentional and intentional electromagnetic emissions from a radar or communication system can cause inadvertent detection by adversaries. Various EMCON conditions are imposed to prevent detection. To ensure that the unit's weapons systems meet these requirements, an EMCON test will determine the electromagnetic signature of the unit with mission systems operating in various EMCON scenarios. When intentional emissions are necessary, vulnerability assessments and probability of intercept are determined. The goal is to control electromagnetic emissions and allow mission performance during EMCON conditions.

Special Evolutions

EMCON is also used during HERO, HERF, and HERP operations to ensure the safety of the crew. These conditions may affect the tactical readiness of the unit. EMCON must be considered for safe operation of a unit.

Ordnance Safety Precautions

HERO precautions are necessary to prevent accidental detonation, which would be hazardous to crewmembers and surrounding structures.

Follow this recommended safety guideline during ordnance handling evolutions.

NOTE

Follow when the ordnance is exposed and unshielded. Samples might include: CIWS reloading, ammunition on-loads or off-loads.

If the RF Output Power is…	And the RF hazard is…	Then…
250 watts or less	Within a distance of 25 feet	Do not operate the transmitter.
250 watts or more	Within 100 feet	Do not operate the transmitter.

WARNING

A good rule is to secure all electromagnetic radiation unless it is absolutely necessary.

Continued on next page

Limiting Exposure to RF Radiation (Continued)

Fuel Safety Precautions

Hazards of Electromagnetic Radiation to Fuel (HERF). The HERF program was developed to protect fueling operations. During fueling operations, RF electromagnetic fields with a large enough intensity could produce a spark that could ignite the volatile combustibles. Therefore, certain radars may need to be shut down during fueling operations. Check your HERF publications for specific details.

Personnel Safety Precautions

Hazards of Electromagnetic Radiation to Personnel (HERP). The HERP program was developed to protect personnel from RF electromagnetic radiation. Anywhere a radar or transmitter is operating; there is a danger that the RF electromagnetic fields may produce harmful biological effects in humans exposed to them.

EMCON Bill

Each unit develops an EMCON bill based, in part, on the following factors:

- Specific HERO, HERF, and HERP hazards
- Location of antenna/transmitter
- Amount of power being transmitted
- Type of evolution being performed
- Location of crew in relation to RF source
- Duration of event
- Current tactical requirements

Practice Exercise

Introduction

The following exercise is intended to reinforce the knowledge gained from this lesson. Answers and references are provided in the Feedback section following this exercise.

Exercise Questions

Write your answer to the questions in the spaces provided.

1. What are the categories of RADHAZ effects?

   ____

2. The PEL for this area is equivalent to a SAR of .08 W/kg.

   ____

3. Rising body temperature and possible tissue damage are symptoms associated with…

   ____

4. To reduce the chances of RF-related incidences during ordnance handling, a unit will produce what?

   ____

5. Maximum allowable time before detectable tissue damage occurs is the definition of…

   ____

6. X-rays may be generated from what type of equipment?

   ____

7. Induced heating damage to the human body is a function of what part of the RF radiation?

   ____

8. The time rate at which RF radiation is imparted into human tissue is defined as what?

   ____

Feedback

Exercise Question Answers

Compare your answers to the following:

Question	Answer	Reference page
1	Induced and Personnel Biological Injury	4-3
2	Uncontrolled Environment	4-5
3	Biological effects	4-4
4	EMCON bill	4-7
5	Permissible Exposure Limit (PEL)	4-5
6	High-power radars, electron tubes, or communications equipment	4-2
7	Intensity of the RF field	4-6
8	SAR	C-1

APPENDIX A
PAMPHLET REVIEW QUIZ

1. What is the PEL for a Controlled Environment?
   ____

2. How are personnel informed of potential exposure to RF radiation?
   ____

3. With a transmitter output of 75 watts, how close can exposed ordnance be safely handled?
   ____

4. RF voltage induced into flammable material is also known as what?
   ____

5. Talking in a ___________ voice without inflection may cause the class to lose interest in the topic (or even go to sleep!).

6. When choosing a piece of test equipment for troubleshooting a control head for a remote radio sending out correct signal, but remote radio not responding, then use a _____.

7. If troubleshooting a transmitter's power out, modulation, distortion, or frequency error then uou would use a _______________.

8. The ________________ program was developed to protect fueling operations.

9. The PEL will be exceeded when within a _____ foot radius of a Mini-Loop antenna.

10. Hazards caused by a transmitter/antenna installation that generates electromagnetic radiation near ordnance, personnel, or fueling operations are called ______________.

APPENDIX B
PAMPHLET REVIEW QUIZ – ANSWER KEY

Question	Answer	Reference page
1.	0.4 W/kg	4-5
2.	Hazard warning signs	4-6
3.	25 feet	4-7
4.	HERF	4-4
5.	Monotone	1-6
6.	TTS	3-4
7.	Comms Analyzer	3-4
8.	HERF	4-8
9.	Twelve	4-5
10.	Electromagnetic radiation hazards (RADHAZ).	4-3

APPENDIX C
GLOSSARY

AM	Amplitude modulation
FM	Frequency modulation
GPETE	General purpose electronic test equipment
Incident Pulse	An energy pulse generated by the TDR and transmitted down the cable being tested
Reflected Pulse	Energy reflected back from an impedance change in the cable being tested
SINAD	Signal including noise and distortion
SSB	Single side band
TDR	Time Domain Reflectometer
TTS	Transmission Test Set
UUT	Unit under test
VSWR	Voltage standing wave ratio—the ratio of high voltage to low voltage waves produced in a transmission line whenever the load impedance and source impedance are not equal
Controlled Environment	An area in which there is the potential for personnel to be exposed to RF energy exceeding the permissible exposure limit while performing their duties or passing through the area.
Permissible Exposure Limit (PEL)	Established for the protection of personnel. There are no expectations that any adverse health effects will occur with exposures that are within the PEL, even under repeated or long-term exposure conditions. **Note:** The PEL is based on maintaining exposures below a SAR of 0.4 W/kg.
Uncontrolled Environments	Locations where RF exposures do not exceed the PEL. Such locations generally represent living quarters, workplaces, or public access areas where personnel would not expect to encounter high levels of RF energy.
Specific Absorption Rate (SAR)	The time rate at which RF energy is imparted to an element of biological body mass. Average SAR in a body is the time rate of the total energy absorbed divided by the total mass of the body. SAR is expressed in units of watts per kilogram (W/kg).
Radio Frequency (RF)	Any electromagnetic wave frequencies extending from below 3 kHz to above 300 GHz.

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Request for Feedback – ET2 UNIT 3: TRAINING

Suggestions and Corrections

Please note your suggestions, corrections, and comments below:

Page	Location on Page	What Correction is Needed

Your Comments

If you were writing this pamphlet, what improvements would you make? What was good about it? What did you not like about it? Please be specific in your comments/suggestions.

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