ELECTRONICS
MANUAL

MAINTENANCE

7610-01-GE8-4601

THIS MANUAL SUPERSEDES CG-165-2 DATED 21 JUNE 1976

COMDTINST M10550.14(old CG-165-2)
COMMTINST M10550.14 (Old CG-165-2)

Subj: Electronics Manual, Maintenance

1. PURPOSE. The Electronics Manual provides guidance and direction to all personnel engaged in electronics administration and the procurement, installation, maintenance, and management of Coast Guard electronic equipment.

2. PUBLICATION AFFECTED. Electronics Manual, Maintenance, CG-165-2, dated 6 May 1971, complete with amendments one through eleven, is cancelled.

3. DISCUSSION. The Electronics Manual is divided into three publications to facilitate dissemination of instructions to cognizant personnel as follows:


4. PROCUREMENT. Allowances for these publications and current ordering instructions are established in the Directives, Publications, and Reports Index (COMDTNOTE 5600).

5. ACTION. District commanders, commanding officers of Headquarters units, and unit commanding officers shall adhere to the guidelines concerning electronics maintenance as outlined in this manual.

DISTRIBUTION: SDL No. 109

CHAPTER 3

LORAN-A GROUND STATION EQUIPMENT
MAINTENANCE INSTRUCTIONS

SECTION 3.1. INTRODUCTION

3.1.1. INTRODUCTION

3.1.1.1. As an important Electronic Aid to Navigation System, Loran-A must provide air and surface navigators with information that is consistently accurate and always reliable. Only the highest standards of technical knowledge and equipment maintenance will enable the US Coast Guard to meet fully its responsibility for the successful operation of the Loran system.

3.1.1.2. All technical personnel assigned to Loran-A stations shall read and comply with the following instructions in order that all Loran-A equipment will be operated, adjusted, and maintained in accordance with the standard practices outlined herein.

3.1.1.3. This chapter shall be required reading for all technical personnel upon reporting on board a Loran-A station, and every six months thereafter.

3.1.2. GENERAL DESCRIPTION

3.1.2.1. LORAN SYSTEMS. Since its inception in 1940 several Loran systems have been used or investigated. While each of these systems employ the same basic techniques, each has certain unique features. The following are the current designations and definitions to describe each system:

1. Loran-A — 2MHz envelope matching Loran (previously known as standard Loran).

2. Loran-B — 2 MHz envelope matching Loran supplemented by cycle matching within the envelope.

3. Loran-C — 100kHz envelope matching Loran supplemented by cycle matching within the envelope.

4. Loran-D — Short baseline 100kHz envelope matching Loran supplemented by cycle matching within the envelope.

5. Loran-E — mf-hf envelope matching Loran with skywave synchronization and/or match.

At the present time, only Loran-A, Loran-C, and Loran-D are operational.

3.1.2.2. DEPLOYMENT. The deployment of Loran transmitting stations is determined by the desired service area, the available sites, and to a lesser extent by logistic considerations, attenuation considerations, and orientation of the baseline.
3.1.2.3. INSTALLATION. The installation of all major items of electronic equipment is made in accordance with standard plans and instructions. Deviations from such plans shall not be made unless specifically authorized by the Commandant. Installation instructions pertaining to the various models of individual equipment are included in the technical manuals for the equipment. Two copies of the technical manuals are normally supplied with each electronic equipment.

3.1.2.3.1. Temporary Changes. The primary purpose of any Loran station is to provide reliable service. To this end, any necessary changes may be made in station configuration. However, these changes must be temporary and be approved by the district commander.

3.1.2.4. SYSTEM MAINTENANCE STANDARDS. The System Maintenance Standards Book CG-156 provides a systematic and efficient method for checking Loran-A equipment and for performing routine preventive maintenance. The book is divided into two parts. Part I, Test Procedures and Performance Standards, contains maintenance standard tests which provide indications representing top performance of individual circuits and/or functional sections of the Loran-A equipment. Part II, Preventive Maintenance Check Off Section, contains a schedule for efficient preventive maintenance of the equipment. Applicable sections of CG-156 shall be updated to reflect any changes in equipment.

3.1.2.4.1. Responsibility for Establishing Station Performance Standards. As soon as practicable after installation of new equipment, the district commander shall assign an engineer or other qualified person to establish and record the Performance Standards for the Loran Station in accordance with instructions on page V of the introduction to CG-156.

3.1.2.4.2. Responsibility for Maintaining Performance Standards. In accordance with CG-222-4, Aids to Navigation Manual, Radionavigation, it is the responsibility of the Senior Technical Officer or Senior Electronic Technician assigned to the station to ensure that the equipment performance remains as listed in Part I. This responsibility includes the proper and timely entry of information required in Part II.

3.1.2.4.3. Distribution. Part I of CG-156 shall be filled out in duplicate for each station. One completed copy shall be kept by the District Electronics Engineering Branch for reference. Alternately, this copy may be kept at an appropriate Section Office at the option of the district commander. Part II shall be maintained at the station.

3.1.2.4.4. Replacement Pages. Replacement Check Off Sheet pages for Part II are stocked by the Supply Center, Brooklyn, New York.

3.1.2.4.5. Disposition of Completed Check Off Lists, Part II. Completed check off lists in Part II shall be retained on the station for a period of two years. After this period, the completed check off lists may be destroyed.
SECTION 3.2. EQUIPMENT DESCRIPTION AND MAINTENANCE

3.2.1. INTRODUCTION

3.2.1.1. Maintenance is divided into two categories: preventive maintenance and corrective maintenance. Corrective maintenance is concerned with the repair of equipment and is covered in the technical manual for that equipment. Preventive maintenance is regularly scheduled cleaning, adjustments and lubrication designed to prevent troubles from developing in electro-mechanical systems. The equipment installed at a Loran station is designed to give long, trouble-free service. Nevertheless, preventive maintenance is important because the routine checking and servicing of the equipment will often result in the location of potential sources of trouble. Remedial steps shall be taken before actual component failures occur. By proper maintenance, equipment failures and the resulting discontinuities of service can be practically eliminated. Routine maintenance checks shall always be accompanied by inspection, since the very performance of maintenance such as cleaning may inadvertently cause a broken wire or a loose connection.

3.2.1.2. RECORDS. One of the most important factors in a systematic program of preventive maintenance is the keeping of complete and accurate records on each maintenance operation. These aid in establishing a fixed routine, and the records serve as valuable record material for future use. For this reason, the Loran-A System Maintenance Standards Book, CG-156, Part II (Preventive Maintenance — Check Off Section), was promulgated covering all equipment used on Loran-A stations.

3.2.1.3. PERFORMANCE STANDARDS. Part I of CG-156 contains test procedures and performance standards for all Loran-A transmitting station equipment. The performance standards set in Part I shall be checked periodically against the readings in Part II. If any deterioration in output power readings, pulse shape or standing wave ratio readings is noted, immediate corrective action should be taken. The primary purpose of any Loran station is to transmit an accurately timed signal of proper shape at rated power, and the preventive maintenance program is essential in accomplishing this purpose.

3.2.1.4. COVER PLATES. Throughout the Loran-A equipment, there are various types of cover plates. Two functions of these plates are to protect against accidental contact with high voltages and to act as RF shields. For various reasons, these protective plates are removed and too often are not replaced and eventually become lost. This not only is a safety hazard, but permits a source of interference. Supervisors and responsible personnel shall ensure that all the protective covers are installed. Where these plates have been lost, fabrication becomes necessary for replacements, as these covers are not stocked in the spare parts system.

3.2.2. TIMERS

3.2.2.1. AN/FPN-30

3.2.2.1.1. Maintenance Philosophy. None other than that found in the applicable technical manual.

3.2.2.1.2. Calibration, Adjustment, and Alignment. None other than that found in the applicable technical manual.
3.2.2.1.3. Maintenance Hints 6AS7G Replacement. DC power supplies of the AN/FPN-30 Timer were originally supplied with 6AS7G type tubes. These tubes are not to be replaced with type 6080 tubes. Indicate on requisition document DO NOT SUBSTITUTE 2B in the Advice Block of DD Form 1348.

3.2.2.2. AN/FPN-53 (COLAC). This solid-state timer consists of the following individual subunits mounted in one equipment cabinet (CY-7529/FPN):

1. C-8620/FPN Control Timer Set Loran-A.
2. TD-988/FPN Timer Loran-A.

3.2.2.2.1. Maintenance Philosophy

1. C-8620/FPN. Organizational level maintenance shall consist of preventive and corrective maintenance up to and including the component or piece part level.

2. TD-988/FPN. Organizational level maintenance is limited to repair by replacement of modules, subassemblies, lamps, fuses, and main-frame components. Modules and subassemblies shall be returned to the depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instruction 4408 (Series).

3.2.2.2.2. Calibration, Adjustment and Alignment. None other than that found in the AN/FPN-53 technical manual and the LARE System Manual.

3.2.2.2.3. Maintenance Hints. None other than that found in the applicable technical manual.

3.2.3. ATOMIC FREQUENCY STANDARDS

3.2.3.1. GCF-RWL-1740 (TYPE A1). This frequency standard consists of five individual subunits mounted in one equipment cabinet (GCF-RWL-1740A-1). The individual subunits are as follows:

1. CAQI-5056A, Frequency Standard, Rubidium, 2 each.
2. CDED-525, Distribution Unit, Frequency.
3. CDED-888A, Recorder, Linear Phase.

3.2.3.1.1. Maintenance Philosophy.

1. BB-306/U. Organizational level maintenance shall consist of preventive and corrective maintenance up to and including the component or piece part level.

2. CDED-525. Organizational level maintenance is limited to replacement of modules, subassemblies, lamps, fuses, and main-frame components. Modules and subassemblies shall be returned to the Depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instructions 4408 (Series).

3. CAQI-5056A & CDED-888A. Organizational level repair is limited to replacement of the entire unit and replacement of lamps, fuses, and batteries as applicable. Failed units shall be returned to the Depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instruction 4408 (Series).
3.2.3.1.2. **Calibration, Adjustment, and Alignment.** None other than that found in the applicable technical manual.

3.2.3.1.3. **Maintenance Hints.** None other than that found in the applicable technical manual.

3.2.3.2. **GCF-RWL-1740A (TYPE A2) FREQUENCY STANDARD SET.** This frequency standard consists of six individual subunits mounted in one equipment cabinet (GCF-RWL-1740A-1).

1. BB-308/U, Battery Storage.
2. CCFQ-LMC-28, Power Supply.
3. CDBR-304C, Frequency Standard Rubidium, (2 each).
4. CDED-525, Distribution Unit, Frequency.
5. CDED-888H, Recorder, Linear Phase.

3.2.3.2.1. **Maintenance Philosophy**

1. BB-306/U and CCFQ-LMC-28. Organizational level maintenance shall consist of preventive and corrective maintenance up to and including the component or piece part level.

2. CDED-525. Organizational level maintenance is limited to replacement of modules, subassemblies, lamps, fuses, and main frame components. Module and subassemblies shall be returned to the Depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instructions 4408 (Series).

3. CDBR-304C and CDED-888A. Organizational level repair is limited to replacement of the entire unit, replacement of lamps, fuses, and batteries as applicable. Failed units shall be returned to the Depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instruction 4408 (Series).

3.2.3.2.2. **Calibration, Adjustment, and Alignment.** None other than that found in the applicable technical manuals.

3.2.3.2.3. **Maintenance Hints.** None other than that found in the applicable technical manual.

3.2.3.3. **GCF-RWL-1740B FREQUENCY STANDARD SET.** This frequency standard consists of five individual subunits mounted in one equipment cabinet (GCF-RWL-1740B-1).

1. BB-306/U, Battery Storage.
2. CCUH-203A, Amplifier, Distribution.
3. CDED-304D, Frequency Standard, Rubidium, (2 each).
4. CDED-888A, Recorder, Linear Phase.

3.2.3.3.1. **Maintenance Philosophy**

1. BB-306/U. Organizational level maintenance shall consist of preventive and corrective maintenance up to and including the component or piece part level.

3-5
2. CCUH-203A. Organizational level maintenance is limited to replacing modules, subassemblies, lamps, fuses, and main-frame components. Modules and subassemblies shall be returned to the Depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instructions 4408 (Series).

3. CDED-304D and CDED-888A. Organizational level repair is limited to replacing the entire unit and replacing fuses, lamps, and batteries as applicable. Failed units shall be returned to the Depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instruction 4408 (Series).

3.2.3.3.2. Calibration, Adjustment, and Alignment. None other than that found in the applicable technical manuals.

3.2.3.3.3. Maintenance Hints. None other than that found in the applicable technical manual.

3.2.3.4. TRANSMITTER CONTROL SET. This control set consists of eight individual subunits mounted in one equipment cabinet (GCF-RWL-2144-5).

   1. C-9888/FPN-60, Coupler, Transmitter Control.
   2. GCF-RWL-2144-1, Selector Unit, Transmitter (TSU).
   3. GCF-RWL-2144-2, Interconnection Unit (ICU).
   4. GCF-RWL-2144-3, Switch Unit, Antenna.
   5. GCF-RWL-2144-4, Sensor Unit, Signal.
   6. GCF-RWL-2144-6, Relay Unit, Remote.
   7. GCF-W-686-SAU, Alarm Unit, Status.
   8. IM-105/U, Indicator, SWR.

3.2.3.4.1. Maintenance Philosophy

   1. GCF-RWL-2144-1, 2, 3, 5, 6, and IM-105/U. Organizational level maintenance shall consist of preventive and corrective maintenance up to and including the component or piece part level.

   2. C-9888/FPN-60, GCF-RWL-2144-4, and GCF-W-686-SAU. Organizational level maintenance is limited to replacement of modules, subassemblies, lamps, fuses, and main-frame components. Modules and subassemblies shall be returned to the Depot facility as outlined in CG-165-1, Chapter 5 and E/GICP Instruction 4408 (Series).

3.2.3.4.2. Calibration, Adjustment, and Alignment. None other than that found in the applicable technical manual.

3.2.3.4.3. Maintenance Hints. None other than that found in the applicable technical manual.

3.2.4. ANTENNA COUPLERS

3.2.4.1. All Loran receiving and transmitting antenna installations have coupling units provided to match the antenna impedance to the coaxial transmission lines. In general, the antenna impedance
consists of both reactive and resistive components. With the exception of the comb antenna, the reactive component must be balanced out and the resistive component stepped up or down by the coupling unit so that it matches the transmission lines. The standard antenna coupling units in use are described in Table 3.2.1.

<table>
<thead>
<tr>
<th>NOMENCLATURE</th>
<th>USE</th>
<th>TYPICAL IMPEDANCE RANGE</th>
<th>USED WITH</th>
</tr>
</thead>
<tbody>
<tr>
<td>CU-464/UR</td>
<td>Receiving</td>
<td>4-j600 to 25-j250 ohms</td>
<td>Vertical Antenna</td>
</tr>
<tr>
<td>CU-464A/UR</td>
<td></td>
<td></td>
<td>55- to 95-foot Whip Antennas</td>
</tr>
<tr>
<td>CU-277/URT and</td>
<td>Transmitting</td>
<td>35-j75 to 45-j300 ohms</td>
<td>280- to 300-foot Towers</td>
</tr>
<tr>
<td>CU-277/URT Modified</td>
<td></td>
<td>and 25+j150 to 150-j200 ohms</td>
<td>“T” Antennas, 75- to 90-foot</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cage “T”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Antenna, 75- to 90-foot</td>
</tr>
<tr>
<td>CU-634/URT</td>
<td>Transmitting</td>
<td>25-j10 to 29+j50 and</td>
<td>120- to 130-foot Towers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>48+j40 to 57+j66 ohms</td>
<td></td>
</tr>
<tr>
<td>CU-815-U</td>
<td>Transmitting</td>
<td>48+j40 to 55+j55 ohms</td>
<td>120- to 130-foot Towers</td>
</tr>
</tbody>
</table>

3.2.5. ANTENNAS

3.2.5.1. It is imperative that antennas, couplers, transmission lines and ground systems installed at Loran stations be as efficient as possible. Therefore, proper installation, adjustment and maintenance is mandatory. All are designed for specific usages, depending in some cases on geographical location, transmitting power, assigned frequency, etc. Attention must be paid to the detailed installation to assure each is located and constructed as required by approved Electronic Location Plot Plan. When obstruction lights are installed on an antenna structure, isolation transformers and lightning arrester gaps must be provided. These lights may be mounted on the antenna tower or any antenna supporting poles. Lightning arrester gaps must be provided to prevent lightning from damaging the lightning transformer or the Loran equipment. Lightning gaps should be adjusted with full radiated power to a point where breakdown or corona discharge no longer occurs. For maximum protection, special care must be taken to ensure adequate ground from the lower side of the ball gap to ground. During annual authorized off-air time, meagger all antenna and transmission lines. Record the megger readings on NAVSHIPS 531, Resistance Test Record Card. Table 3.2.2 contains a list of all Loran-A antennas.
Table 3.2.2. Antennas

<table>
<thead>
<tr>
<th>NOMENCLATURE</th>
<th>USE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS-951/TRN</td>
<td>Transmitting</td>
<td>Aluminum Tower, 120- to 130-foot</td>
</tr>
<tr>
<td>AS-1088/TRN</td>
<td>Transmitting</td>
<td>Aluminum Tower, 120- to 130-foot</td>
</tr>
<tr>
<td>129-foot</td>
<td>Transmitting</td>
<td>Steel Tower, 117- to 129-foot</td>
</tr>
<tr>
<td>280-foot</td>
<td>Transmitting</td>
<td>Steel Tower</td>
</tr>
<tr>
<td>300-foot</td>
<td>Transmitting</td>
<td>Steel Tower</td>
</tr>
<tr>
<td>T</td>
<td>Transmitting</td>
<td>75- to 90-foot poles</td>
</tr>
<tr>
<td>Cage T</td>
<td>Transmitting</td>
<td>75- 90-foot poles</td>
</tr>
<tr>
<td>AN/FPA-13</td>
<td>Receiving</td>
<td>Fiberglass comb pretuned</td>
</tr>
<tr>
<td>AT-1018/FPA-13</td>
<td>Receiving</td>
<td>One element of the AN/FPA-13</td>
</tr>
<tr>
<td>Vertical Wire</td>
<td>Receiving</td>
<td>90-foot pole, 60- to 65-foot long</td>
</tr>
<tr>
<td>06047</td>
<td>Receiving</td>
<td>35-foot whip</td>
</tr>
</tbody>
</table>

3.2.5.2. AN/FPA-13. The AN/FPA-13 comb antenna array consists of eighteen AT-1018/FPA-13 antenna elements with individual pretuned matching devices. The comb antenna is an in-line end-fire array with the elements spaced 60 feet apart, connected and phased by means of non-resonant transmission line. See Figure 3.2.1 for typical installation.

3.2.5.3. AT-1018/FPA-13. As previously noted, the AT-1018/FPA-13 is a single element of the AN/FPA-13 comb antenna array. The element consists of a two piece fiberglass pole 43 feet long. The inner conductor is a piece of RG-8A/U, and when used as a single receiving element MUST be shorted not only internally at the top of the fiberglass mast but at the connection to the antenna coupler. By design, this element displays a narrow bandwidth which must be broadened to eliminate pulse distortion. To accomplish this, a 6.2 ohm resistive network is inserted in series with the antenna lead and the coupler. This network can be fabricated locally by connecting four 6.2 ohm, 5 percent, 1 watt, carbon type resistors in a series-parallel arrangement. This network is to be inserted inside the antenna coupler.
Figure 3.2.1. Comb Receiving Antenna
3.2.5.4. TOWERS

3.2.5.4.1. Maintenance Philosophy. Towers shall be maintained in accordance with the Tower Manual (CG-358).

3.2.5.4.2. Calibration, Adjustment and Alignment. None other than that found in the Tower Manual (CG-358).

3.2.5.4.3. Maintenance Hints. Towers will be inspected and maintained in accordance with CG-358. This inspection and maintenance manual is primarily for use with the 280 and 300-foot towers, but will also be applicable to all installed Loran-A towers.

3.2.5.5. "T" AND CAGED "T"

3.2.5.5.1. Maintenance Philosophy. None.

3.2.5.5.2. Calibration, Adjustment, and Alignment. None.

3.2.5.5.3. Maintenance Hints — Inspection. During annual authorized off-air time for antenna maintenance, the operating "T" type antenna will be lowered and the spare rigged for operation. Inspect the downhalls for fraying, chafing or evidence of deterioration. Except under emergency conditions, the downhalls will be removed from the poles and stored in a dry area. Ensure installed blocks are well lubricated and turn freely. The antenna taken down will be cleaned and repaired as necessary to make it ready for immediate use (refer to Chapter 1). Where applicable, the blocks on the emergency antenna poles will be kept in a free running condition and a light nylon line threaded through those blocks to act as a messenger for the downhalls.

3.2.6. ANCILLARY EQUIPMENT

3.2.6.1. There are several equipments in the Loran system that are subunits of the major equipments listed in the previous paragraphs. Although each major equipment has subunits, only those of pertinence will be discussed.

3.2.6.2. CN-235/FPN-30 VOLTAGE REGULATOR

3.2.6.2.1. Maintenance Philosophy. None other than that found in the applicable technical manual.

3.2.6.2.2. Calibration, Adjustment and Alignment. None other than that found in the applicable technical manual.

3.2.6.2.3. Maintenance Hints — Z2301 Failure. Failure of resistor assembly, Z2301, used in the CN-235/FPN-30 Voltage Regulator is the most common cause of failure for this unit. Spares should be locally available; however, an emergency repair procedure has been developed in case spare units are not available. If no spare assembly is available, remove Resistor Assembly, Z2301, and cut off the protective can with a hacksaw 1-3/4" above the base. Use care in sawing around the perimeter of the can. Remove the exposed lamp and replace it with a new type 44 lamp, resoldering it carefully in the circuit. Replace the protective can and tack solder it in place. Upon receipt of a new resistor assembly remove the repaired unit and discard.

3.2.7. GENERAL

3.2.7.1. There are some items in the Loran system that cannot be categorized into specific nomenclatures. These items can be associated with several equipments and therefore will be described separately.
3.2.7.2. **ANTENNA GROUND SYSTEM.** A typical antenna ground system layout is shown in Figure 3.2.2. Ground systems, when installed in accordance with approved instructions, will minimize and stabilize the ground losses for all types of terrain. However, the efficiency of the ground system tends to decrease with time unless carefully maintained.

3.2.7.2.1. **Maintenance Philosophy.** None.

3.2.7.2.2. **Calibration, Adjustment, and Alignment.** None.

3.2.7.2.3. **Maintenance Hints — Inspection.** The exposed portion of the ground system will be examined periodically for broken wires and loose or improper connections, especially after a vehicle has driven across the area. The frequency of inspection will be governed by local climatic conditions. Breaks should be repaired, damaged sections replaced, conductors at joints should be cleaned, wrapped and brazed, making sure that there is a good electrical connection. Loose connections should be opened, cleaned, rewrapped and brazed. Where ground system conductors are connected to plates, connect the conductor through the hole in the plate, wrap the conductor back on itself and braze. Make sure of good electrical connections to the plate. Ground conductors must be wrapped around all rods and brazed. Be sure all strap connections between the antenna coupling units and ground have good electrical connection by brazing where possible at each connection.

3.2.7.3. **TRANSMISSION LINES**

3.2.7.3.1. **Maintenance Philosophy.** Maintenance of coaxial cables shall be in accordance with good engineering practices and special consideration shall be given to the following points:

1. **Avoid Hot Spots.** Do not run coaxial cables near sources of large amounts of heat such as resistor banks, radiators, steam pipes, etc.

2. **Avoid Sharp Bends.** The maximum bend in a coaxial cable shall have a radius of greater than ten times the radius of the cable. If the bend is near a hot spot, the radius shall be not less than twenty times the radius of the cable.

3. **Avoid Exposing Cable to Sharp Edges.** All cable runs should be kept away from points of abrasion or sharp edges.

4. **Avoid Deforming Cables.** Avoid strapping, twisting, bending or any action that will tend to deform the cables.

5. **Do Not Splice.** The splices allowed in Loran installations will be for emergency use only.

3.2.7.3.2. **Calibration, Adjustment, and Alignment.** None.

3.2.7.3.3. **Maintenance Hints — Inspection.** Visual inspection of transmission lines that are exposed above ground should be made periodically. The local climatic conditions will govern the frequency required. During annual authorized off-air time, if a standby is available, the transmission lines will be interchanged, that is, reconnected to make the line that was active now the standby line.
Figure 3.2.2. Typical Loran Station Antenna Layout
3.2.7.4. POWER AMPLIFIER TUBES

3.2.7.4.1. Maintenance Philosophy. None.

3.2.7.4.2. Calibration, Adjustment, and Alignment. Except in emergency conditions, the following will be followed when new 5680, 7C23 or F-7012 tubes are installed:

1. Apply filament voltage for 24 hours, but no plate voltage.
2. Slowly bring up the plate voltage to 2500 volts and operate 3 hours.
3. Slowly bring up the plate voltage to 7500 volts and operate 3 hours.
4. Repeat the above at 2500 volt increments until the full 15,000 volts reached.

If a point is found where the tube will arc over or start gassing when the plate voltage is increased, lower the plate voltage slightly below this point and operate for 2 hours. After 2 hours, again increase the voltage and proceed with the steps as before until full plate voltage is applied. If, after repeated tries, arcing occurs before the full plate voltage is reached, reclean tube in accordance with paragraph 3.2.7.5.3.

NOTE

An accelerated procedure may be used for the 7012 tubes whereby the plate voltage is started at 10KV and increased in 1KV steps every 15 minutes until full plate voltage is reached. In the event of excessive arcing, proceed as stated above.

Bake-in procedure for the 715 or 4PR60 tubes is as follows:

1. Apply filament voltage only for 4 hours.
2. Slowly advance the plate voltage to 3500 volts and operate for 1 hour.
3. Slowly advance to full plate voltage of 7000 volts.

If arcing occurs, proceed as for high voltage tubes above.

3.2.7.4.3. Maintenance Hints — Power Amplifier Tube Cleaning. Past tests and records have proven the need for keeping the 5680, 7C23, and F7012 power amplifier tubes clean and polished. Meticulous care must be exercised to prevent finger contact on the tubes after cleaning or during installation to alleviate arcing problems. At initial installation and during routine preventive maintenance, scrupulously clean off all dust, finger prints and other extraneous matter on terminals, corona rings and particularly the glass envelope. Then polish with a dry lint-free cloth. In the event external arcing does occur across the glass envelope, remove the tube and carefully clean it. Use a very mild abrasive to remove foreign matter or any etched marks from the glass envelope followed by cleaning with a solvent and polishing with a dry lint-free cloth. Reinstall the tube and place equipment back in operation. If external arcing persists when high voltage is applied, make a thorough inspection for any foreign residue. As a last resort, if corona rings are installed, carefully cut them off, reclean, and reinstall. Again apply high voltage. If arcing still occurs and time permits, the tube may be tried in different sockets or even different equipment as a final check before disposing of it.
3.2.7.5. HIGH VOLTAGE METER MULTIPLIER RESISTORS

3.2.7.5.1. Maintenance Philosophy. None other than that found in the applicable technical manual.

3.2.7.5.2. Calibration, Adjustment, and Alignment. None other than that found in the applicable technical manual.

3.2.7.5.3. Maintenance Hints — Improper Voltage Application. Experience has shown that considerable damage can result to the final amplifier pulse forming tubes when improper plate and bias voltages are applied. These improper voltages can be applied even though all associated meters read correct values. This results from a change in value of the meter multiplier resistors. The changes seldom can be detected with the equipment normally available. These multiplier resistors are to be checked monthly to determine if they have changed in value. This will be done in the following manner:

![CAUTION]

Before substituting any resistors, be sure the equipment is deenergized and capacitors discharged.

1. Remove from spares the appropriate multiplier resistors which will be used as a substitute test set.

2. Energize the equipment under test and advance the high voltage control until the high voltage meter indicates the proper operating potential.

3. Carefully note the position of the high voltage control dial.

4. Remove all power. Short all elements to ground with the capacitor discharge rod provided.

5. Substitute the test set of resistors into the meter multiplier circuit.

6. Energize the equipment and adjust the high voltage control until the proper operating potential is obtained. Compare the high voltage dial position with the one previously obtained.

7. If the high voltage control position differs from the position in step (3) above, one or more of the multiplier resistors are defective. The defective resistor may be located by substituting the test resistors one at a time until a change in the dial position is noted. Ensure that equipment is deenergized and capacitors are discharged prior to each substitution.
SECTION 3.3. SPECIAL TESTS, CALIBRATION, AND MEASUREMENTS

3.3.1. LORAN-A SYSTEM PERFORMANCE TESTING PROCEDURE

3.3.1.1. The Loran-A System Performance Test is divided into three general phases:

Preliminary Tests — This phase consists of a review of the condition of equipment and demonstration of proficiency of station personnel. Included are tests to disclose deficiencies in timer and input switching equipment operation in sufficient time to effect corrections prior to conducting the Performance Test.

System Performance Test — The System Performance Test consists of the Master Station, Secondary Station and at least one Monitor Station closely observing and recording rate operation for a period of about four hours. Included in the Performance Test may be baseline extension crossings by a mobile unit such as a ship or aircraft.

Compilation and Review of Data — The final phase consists of review of the data obtained during phases one and two. Review of this data may disclose additional deficiencies in either equipment or procedures, and corrections to Engineering Rate Data not readily apparent during normal operation. This phase is completed by action to correct deficiencies of any nature disclosed by this or any previous phase of the Performance Test.

3.3.1.2. COMMUNICATIONS. When baseline extension crossings are not to be conducted and when the System Performance Test is scheduled well in advance, communications between the participating stations should not be required. When baseline extension crossings are to be performed and when directed by higher authority, communications between the participating stations and the unit performing the crossings are required. When communications between the participating units are required, the circuits to be used during the actual test should be duplicated and tested to the extent practical during the Preliminary Tests.

3.3.1.3. EQUIPMENT TO BE USED. Single rated secondary stations shall use the standby timer for observing own coding delay readings. Single rated master stations shall use the operate and standby timers for observing own rate time delay readings. Single rated monitor stations shall use the standby timer for observing the monitored rate time delay readings. Double rated secondary stations shall use both standby timers for observing the test coding delay readings. Double rated master stations shall use the operate and standby timers of the test rate and the standby timer of the alternate rate for observing time delay readings on the test rate. Double rated monitor stations shall use the standby timers of both rates for observing the monitored rate time delay reading.

3.3.1.4. PRELIMINARY TESTS. The purpose of this phase is to demonstrate proper station operation prior to the scheduled System Performance Test to allow deficiencies in either equipment or method of operation to be disclosed in sufficient time for corrective action to be taken. The tests are to be successfully completed one to two days prior to the System Performance Test. The Preliminary Tests consist of (1) General Requirements, (2) Timer Performance Test, (3) Input Switching Equipment Performance Test, and (4) Determination of Alternate Receiving Antenna Relative Delays.

3.3.1.4.1. General Requirements. To be effective, the tests must be conducted thoroughly. Advance planning and supervision by each station Commanding Officer is required. The presence and
supervision by the senior electronics technician at all preliminary tests is mandatory. All anticipated changes in antennas and equipment must be finished prior to those tests in order for them to furnish a valid standard. It is most important that the same antennas used for each test be used for the rate tests and be identified as primary Loran-A vertical receiving antennas on the Electronics Plot Plan.

3.3.1.4.2. Record Data. The information obtained during the Preliminary Tests shall be recorded on worksheets. Carefully fill out these sheets to identify timers, ESU’s, antennas, time, operators, etc. Time difference readings obtained during Performance Tests shall be recorded on the standard Loran Transmitting Station Log.

3.3.1.4.3. Time Difference Observers. All time difference observers must be carefully instructed in the techniques involved in making time difference measurements, and must demonstrate their ability prior to the tests. For this purpose, each watchstander shall make twenty measurements simultaneously with the most experienced operator, utilizing a standby timer. Ensure that observers can make a full time-difference reading. Individual readings should not differ by more than 0.5 microsecond, and the averages of the individual operators should not differ by more than 0.25 microsecond. All personnel should be instructed in the standard pulse matching procedures.

3.3.1.4.4. Capable Personnel. All personnel involved with the tests must be thoroughly familiar with their duties and cognizant of the importance of the system check. Precise operation must be maintained. Ensure that each watchstander is able to perform all thoroughly familiar with their duties and cognizant of the importance of the system check. Precise operation must be maintained. Ensure that each watchstander is able to perform all operational adjustments. These shall include:

2. Changing timers.
3. Changing switching equipment and ESU.
5. Adjusting synchronizer balance control.
7. Knowledge of the location of Loran receiving antenna inputs.
8. Changing from one Loran receiving antenna to another. (This change should not be made at operating stations unless absolutely necessary.)
9. Correct blink procedures.
10. Correct logging procedures.
11. Making WWV time checks.

3.3.1.4.5. Peak Operation. Each Loran Transmitting Station involved in a System Performance Test shall ensure that the entire station is operating in accordance with standards and at peak efficiency. This check of operation includes test of both personnel and equipment as stated below.

1. Electronic Layout Plan. Check that the electronic layout plan is up-to-date and includes all antennas, including amateur, TV, and recreational radio.
2. Ground System. Check that the ground system of each antenna is in good condition and that the antenna coupling unit ground is connected securely to the ground system.

3. Antennas. Check that the antennas are in good physical condition, guys are broken by insulators, and any electric wiring on the Loran antenna poles is broken by isolation transformers. Tuning of receiving antenna coupling units should be checked. If the station is OFFAIR, check the tuning of the transmitting antenna coupling unit. Log the transmitter line output, coupling unit line input, and antenna currents when the transmitters is operating properly. Make certain no abnormal metal objects, wire, vehicles, junk, etc. are present within 500 feet of the antenna.

4. Transmitters. Check all monitored wave shapes and voltages. Ensure that the transmitter is tuned in accordance with the instruction book. Check the transmitter output and ensure that the pulse shape is within the prescribed standards (refer to Figure 3.3.1). This check is very important and accordingly should be made carefully with the pulse shape set to the centers of the allowable ranges.

Figure 3.3.1. Standard Loran-A Output Pulse

NOTE

Remove P-102 from J102 on the Control Alarm chassis (C-2518/FPA-3) of the AN/FPA-3 prior to taking pulse measurements to eliminate distortion errors caused by loading of this chassis.
5. Timers. RF rejection filters should be adjusted to extreme minimum position and should be left in this position unless interference is present and filters are required for accurate synchronization. Check alignment of timing markers. Check centering of the time delay gates. Check all units in accordance with the timer instruction manual. Check for accurate synchronization. Check alignment of timing markers. Check centering of the time delay gates. Check all units in accordance with the timer instruction manual. Check that the pulse shapes and pulse matches are the same as viewed on all timers. Check for stray signal pickup, noting that the signal involved does not appear when the local or remote signal inputs are removed. Check that blanking connections are properly made so that only the operating timer blanking is in use. Amplitude balance control should be in the OFF position and the signal balance controlled by the local gain potentiometer. The local gain potentiometer should not be operating near the extreme range; if it is, a change in the local gain attenuator on the back of the receiver chassis may be necessary. Stations will make step-by-step synchronizer unit adjustments in accordance with Technical Manual, section 3, paragraph 28 for Secondary stations and paragraph 29 for Master stations. Master stations ensure proper adjustment of standby and operate transmitter trigger in accordance with the technical manual.

6. Switching Equipment. Check that switches for the number of timers and antennas in use are positioned in accordance with the technical manual. Check that no time delays are inserted. Check that the switch for one or two antenna operation is in the one antenna position. Check the local attenuation in use.

3.3.1.4.6. Timer Performance Test. Master, Secondary, and Monitor Stations check the accuracy of the timers by comparing time-difference readings against each other as follows:

1. With timers operating as noted in subsequent paragraph 3.3.1.6.1, on one ESU make ten simultaneous readings. Interchange operators between timers and make a second set of ten simultaneous readings. Interchange operators again (for double pulsed station only) for a third set of simultaneous readings. Record all time differences on a worksheet. Determine average readings taken on each timer. These averages should agree within at least 0.25 microsecond.

2. If the above checks show differences of more than 0.25 microsecond the cause must be located and corrected. A primary cause is defective tubes in the remote amplifier stages of the receiver. Check also for defective RF cable connections between the receivers and ESU units.

3.3.1.4.7. Input Switch Unit Performance Test. Master, Secondary, and Monitor Stations check accuracy of ESU’s by comparing time difference readings against each other. Check operation of ESU units by operating each one on the same antenna, and using the equipment configuration as noted in paragraph 3.3.1.6.1. Record ten simultaneous readings. Change operators and take ten more simultaneous readings. Record all time differences, timer numbers, ESU numbers, antenna employed, and operator’s initials on a worksheet. Determine the average readings taken on each ESU. Average readings should agree within 0.25 microsecond. If not, determine the cause and then recheck. Probable cause for excessive delays are defective tubes in the remote channel or defective RF intercabling connections.

NOTE

Ensure that delay lines are removed from circuits. Proper termination is required to obtain predictable delays, and the fact that the input impedance of various timers and timer installations vary, these delays are not normally used. Only on specific authorization by commandant will they be used.
3.3.1.4.8. Determining Alternate Receiving Antenna Relative Delay. Master and Secondary Stations determine the relative delays of all secondary Loran-A receiving antennas. Determine deviation in time differences relative to the standard antenna for all authorized antennas. Using timers and ESU’s as noted in paragraph 3.3.1.6.1, switch the input of one ESU to an alternate antenna and make simultaneous readings, interchanging operators every ten readings. Record time differences, timer numbers, ESU numbers, antenna employed, and operator’s initials on the worksheet. Determine average readings and the deviation in time differences between the primary receiving vertical antenna and the alternate antennas. Report to the cognizant district or section if this test discloses a deviation of more than 0.25 microsecond from the difference readings of previous tests and thoroughly check system with particular attention to coupling units and antenna tuning.

NOTE
This test is especially important where comb antennas are installed.

3.3.1.5. PERFORMANCE TEST. Upon completion of the Preliminary Tests, and when so directed by competent authority, the System Performance Tests shall be conducted by all units in accordance with the following requirements. The Commanding Officer/Officer-in-Charge shall be in attendance in the Loran signal building to ensure compliance.

3.3.1.5.1. Standby and Operate Equipment. Stations should use different “operate” equipment each time tests are run, that is, timer, ESU, and transmitter that were “standby” in one test should be “operate” on the next test. Delay lines, if authorized in the AN/FPA-2( ), are to be removed from the circuit for the test. All such temporary changes are to be recorded.

3.3.1.5.2. Maintain Accuracy. Clocks used for logging time differences shall be checked with WWV or another time standard immediately before, after, and once during the test if possible. A special effort shall be made to maintain power supply voltages and frequency at the proper value. Use a separate generator for the electronic plant for these tests if possible. Blink instructions shall be observed carefully during the test. Logs shall be carefully kept, all sheets dated and identified as to timer, ESU, antenna, and operator. Each half hour during the test, check and record VSWR, the transmitter or amplifier pulse width, rise time, line current, and antenna current at the coupling unit.

3.3.1.5.3. Measurement Accuracy. Measurements shall be made and recorded to 0.10 microsecond. Readings shall be made each minute as close as possible to the whole minute. Separate logs shall be maintained for each timer used in the test.

3.3.1.5.4. Errors. Due to human errors in reading, changes in pulse shape, effects of noise, crossover, etc. it is improbable that many adjacent readings will be identical to a tenth of a microsecond. Therefore, a log having a long series of identical time-difference readings shall be regarded as incorrectly kept.

3.3.1.5.5. Operate and Standby Timers. On operate timers, the amplitude match of the signals shall be checked every five minute. Prior to taking each time-difference reading on the standby timer, the local signal gain and B-continuous delay controls shall be adjusted to rematch the signals.

3.3.1.5.6. Master Station Only. Simultaneous and independent time-difference observations shall be made on the operate timer. These readings will be taken off the synchronizer phase dial. As many standby timers as available shall be used for readings.

3.3.1.5.7. Secondary Station Only. Synchronization shall be maintained by the auto-synchronization unit. This does not apply to those stations authorized for “free-running” operation. Coding delays shall be measured on the standby timer.
3.3.1.5.8. **Monitor Station Only.** A Loran vertical receiving antenna shall be used for reception during all tests. As many standby timers as available shall be used for readings.

3.3.1.6. **Compilation, Review, and Submission of Test Data.** The procedures to be used regarding the test data are as follows. Monitor stations are to make the applicable checks on their normal rate(s).

3.3.1.6.1. **Preliminary Checks.** Data obtained in preliminary checks is to be compiled for submission as follows.

1. **Timer Check.** Report the following data as applicable with the indicated timers on same ESU: Take the average of 20 simultaneous readings using the following configuration.

   **Single Rated Master**
   a. Timer #1 Avg
   b. Timer #2 Avg
   c. Difference (a - b)

   **Double Rated Master**
   Timer #1 — Operate Rate 1; Timer #4 — Operate Rate 2;
   Timers #2 and #3 on Rate 1
   a. Timer #1 Avg
   b. Timer #2 Avg
   c. Timer #3 Avg

   Timer #1 — Operate Rate 1; Timer #4 — Operate Rate 2;
   Timers #2 and #3 on Rate 2
   d. Timer #2 Avg
   e. Timer #3 Avg
   f. Timer #4 Avg

   **Single Rated Secondary**

   Carefully adjust operate timer prior to this test. Average 20 readings taken at one minute intervals on the standby timer. Switch the functions of the operate and standby timers and average 20 readings taken at one minute intervals on standby timer. Again switch function of timers and average 20 readings taken on the standby timer at one minute intervals.

   a. Timer #1 — Operate; Timer #2 — Standby Avg
   b. Timer #2 — Operate; Timer #1 — Standby Avg

   **Double Rated Secondary**

   Timer #1 — Operate Rate 1; Timer #4 — Operate Rate 2;
   Timers #2 and #3 on Rate 1
   a. Timer #2 Avg
   b. Timer #3 Avg
   c. Difference (a - b)
Timer #2 — Operate Rate 1; Timer #4 — Operate Rate 2;
Timer #1 and #3 on Rate 1

d. Timer #1 Avg
e. Timer #3 Avg
f. Difference (d - e)

Timer #2 — Operate Rate 1; Timer #3 — Operate Rate 2;
Timers #1 and #4 on Rate 1

g. Timer #1 Avg
h. Timer #4 Avg
i. Difference (g - h)

NOTE

If the averages (or differences) differ by more than 0.25 microsecond, correct the fault before proceeding with the scheduled Performance Test and repeat the “Timer Check” until within tolerance.

2. ESU Check. With indicated ESU’s on standard antenna and timers operating on the indicated ESU, make 20 simultaneous readings for each of the following configurations. Readings need not be spaced one minute apart. This test should be repeated for timers #3 and #4 on a double pulsed station. Report items m, n, and p:

<table>
<thead>
<tr>
<th>CONFIG.</th>
<th>ESU #</th>
<th>TMR #</th>
<th>AVERAGE</th>
<th>ESU #</th>
<th>TMR #</th>
<th>AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a.</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>d. Average a and b</td>
</tr>
<tr>
<td></td>
<td>b.</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Average a and b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>e.</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>h. Average e and f</td>
</tr>
<tr>
<td></td>
<td>f.</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>g. Average e and f</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>i.</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>l. Average i and j</td>
</tr>
<tr>
<td></td>
<td>j.</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>k. Average i and j</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

m. Difference (c - d)
n. Difference (g - h)
p. Difference (k - l)
NOTE

The following statements cover only the case where one ESU is at fault and is not valid when differences exist between two or more ESU’s.

If \( m = p = n \); ESU #1 is at fault

If \( n = p = m \); ESU #3 is at fault

If \( n \) is greater than \( p \) and \( p \) is greater than \( m \); or vice versa; ESU #2 is at fault

If readings in \( m \), \( n \) or \( p \) differ by more than 0.25 microsecond, correct the fault prior to proceeding with the scheduled Performance Test and Repeat steps a through p until within tolerance.

3. Alternate Antenna Relative Delay Check. Average of 20 simultaneous readings with antennas, timers, and ESU’s configured as follows. Operators interchanged after every 10 readings.

<table>
<thead>
<tr>
<th>CONFIG.</th>
<th>ESU ON STD ANTENNA</th>
<th>ESU ON ALT #</th>
<th>ANTENNA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ESU #</td>
<td>TMR #</td>
<td>AVERAGE</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Average (a) (1 through 4)

Average (b) (1 through 4)

Alternate Antenna Relative Delay \( c = (a - b) \)
Repeat for each alternate antenna.

3.3.1.6.2. Performance Test Data. When Preliminary Test requirements are satisfied, System Performance Test Data can be taken. Data obtained in the test is to be compiled for submission as follows.

1. Master Station. A Master Station shall report the following items:
   A. Rate
   B. Time and date of test
   C. Operating timer average, standard deviation (see paragraph 3.3.6), and the number of readings.
   D. Standby timer average, standard deviation and the number of readings.
   E. Standby timer average — same as (D) for second standby timer.
   F. Receiving antenna used. (If other than vertical, explain.)
G. Pulse rise time 10 percent to 90 percent.

H. Pulse width at 50 percent amplitude

I. Corrected transmission line current. Low power stations enter directly the reading of the transmission line current meter M-111. High power stations using T-138A/M-1700, or T-138A/AM-701 amplifiers, enter the amplifier output load current meter reading, multiplied by a factor of 1.10. Indicate correction has been applied, namely, "4.6 Amps corrected."

J. VSWR

K. Antenna current and tuning unit line current, respectively.


M. Peak power delivered to the transmission line computed in accordance with paragraph 3.3.2.

N. Peak power delivered to the antenna computed in accordance with paragraph 3.3.2.4.

O. Correction to electronics plot plan since last test.

2. Secondary Station. Except for item C above, Secondary Stations shall report items exactly the same as Master Stations. Item C does not apply to Secondary Station.

3. Monitor Station. A Monitor Station shall report the following items. Data obtained in this test is to be compiled for submission as follows:

A. Average observed monitor time difference, standard deviation and number of readings.

B. Pulse match, namely, good, satisfactory, or unsatisfactory.

C. Readability of master and secondaries, namely, R4, R5, etc.

D. S/N ratio of master and secondaries, that is, the amplitude of the signal as seen on the RF scope, compared to the amplitude of the noise, namely, 10:1, 8:1, etc. If there is no apparent noise (grass) record as greater than 10:1.

E. Average observed monitor time difference from second timer. Same as in 1 above.
3.3.1.6.3. Format Of Submission. The following format shall be used in reporting the data obtained in paragraphs 3.3.1.6.1 and 3.3.1.6.2.

1. PRELIMINARY CHECKS:
   Type Station:
   
   Single Rated ( )
   Double Rated ( )
   Master ( )
   Secondary ( )
   Monitor ( )

   TIMER CHECK

   a. ___________ µ
   b. ___________ µ
   c. ___________ µ
   d. ___________ µ
   e. ___________ µ
   f. ___________ µ
   g. ___________ µ
   h. ___________ µ
   i. ___________ µ

   ESU CHECK

   m. ___________ µ
   n. ___________ µ
   p. ___________ µ

   ALTERNATE ANTENNA RELATIVE DELAY CHECK

   (name of alternate Antenna)
   (name of alternate Antenna)
   c. ___________ µ
   c. ___________ µ

2. PERFORMANCE TEST

   1. ___________
   2. From ____________ Z to ____________ Z on ____________ 19 ___
   3. ____________ µ + ____________ µ No. Readings ____________
   4. ____________ µ + ____________ µ No. Readings ____________
   5. ____________ µ + ____________ µ No. Readings ____________
   6. ( ) vertical wire; ( ) metal whip; ( ) AT-1018/FPA-13
   7. ___________
   8. ___________
   9. ___________ amps ( ) corr.
   10. ___________
   11. ___________ amps
   12. ___________ ohms
   13. ___________ kw
   14. ___________ kw
   15. ___________

   Monitor Data

   1. ___________ µ ± ___________ µ No. Readings ____________
   2. ( ) Good; ( ) Satisfactory; ( ) Unsatisfactory
   3. ___________
   4. ___________
   5. ___________ µ ± ____________________ µ No. Readings ____________
3.3.1.6.4. Submission Of Data To Headquarters. Each station participating in a System Performance Test will complete the applicable portion of form CG-4067 and attach as an enclosure the data compiled during the Preliminary and Performance Test, the minute-by-minute readings taken from the timers throughout the test, and the computations used for determining average delay readings and peak power. This is then submitted to the appropriate Section or District Commander. The Section or District Commander shall review all data submitted by each station and compile the applicable information on one form CG-4067 for the rate conducting the System Performance Test. Only this completed CG-4067 is to be submitted to Headquarters for a routine System Performance Test. The other data submitted by the stations will be retained at the District or Section. When an Accuracy Test is taken in conjunction with a System Performance Test, all the data submitted by participating stations will be attached as an enclosure to the completed CG-4067 submitted to Headquarters.

3.3.2. LORAN-A POWER MEASUREMENTS

3.3.2.1. One of the most important tasks at a Loran-A Transmitting Station, in addition to maintaining proper timing and shape of the transmitter pulses, is to keep the peak power at or near the design value. Loran-A transmitters are designed to deliver approximately 160 kilowatts peak power to a 52-ohm load when single rated and 128 kilowatts when double rated. Loran transmitters with amplifiers are designed to deliver approximately 1000 kilowatts peak power to a 52-ohm load when single rated, and 800 kilowatts when double rated. The Loran-A coverage areas are based on the assumption that the transmitting equipment at each Loran-A station is developing rated peak power. Therefore, in order to produce the maximum coverage, and in order to afford the best possible service to the navigator, Loran station personnel must maintain peak power as near to the design value as possible.

3.3.2.2. REQUIREMENTS ON RADIATED POWER. Loran-A Station personnel should know the peak power at two points in the transmission system. The first is at the input to the RG-147/U transmission line; this value must be held as near to the design value as possible. The second is at the input to the antenna. Measured peak power values of less than 80 percent of the design value shall be reported and commented upon by reviewing authority on the “Report of Loran-A System Performance Test” CG-4067. The peak power input to the antenna is less than the peak power delivered to the transmission line by an amount equal to the losses in the transmission line and the antenna coupler. This percentage loss should remain constant and generally will not exceed 10 percent. A measure of the percentage loss in peak power will serve as a check on proper adjustment and operation of the antenna coupler and losses in the transmission line.

3.3.2.3. DEFINITION AND MEASUREMENT OF PEAK POWER. The peak power of a Loran pulse is defined as the effective (rms) power of a continuous carrier that has the same amplitude as the largest radio frequency cycle in the Loran pulse. To obtain the peak power in a Loran-A pulse, it is first necessary to measure the average power. This is accomplished by measuring the effective (rms) current that the train of Loran pulses causes to flow in a known resistance and taking the product of I R. Inasmuch as the average power and hence the peak power, is proportional to the current squared and is directly proportional to the resistive component of impedance, it is important that these two values be accurately measured. In the Loran-A system calibrated ammeters in the transmitters and amplifiers directly measure the current fed to the transmission line; likewise in the antenna coupler, a direct and accurate measurement of antenna current is obtainable. It is then necessary to know the transmission line impedance and antenna impedance. These two values are obtained by RF bridge measurements at the frequency of operation. The resistive components of these two impedance measurements are then used as the R values in the computation of average power. Paragraph 3.3.3 describes procedures for impedance measurements.
NOTE

Prior to using the monitor oscilloscope to take any pulse width and rise time measurements or measurements relating to the computation of peak power at any station where the AN/FPA-3 series switch gear is installed, disconnect P-102 from J-102 on the Control Alarm Unit C-2518/FPA-3. This will eliminate the loading effect of the alarm circuits on the monitor oscilloscope which causes pulse distortion. The elapsed time meter will run during the time that P-102 is removed. This time will be disregarded in computing the total off-air time from the meter reading.

3.3.2.4. PROCEDURE FOR DETERMINING PEAK POWER WHEN PULSE SHAPE IS WITHIN PRESCRIBED TOLERANCE. When the radiated pulse shape is within the prescribed tolerance (see Figure 3.3.1), the peak power may be determined by substitution of the measured values of currents and resistive components of impedance as in the following equation:

NOTE

Standard Pulse Shape is defined as having 21 ± 1µ sec rise time and 40 ± 1 µ sec width.

Equation (1) \[ P_{\text{peak}} = \frac{K P_{\text{avg}}}{1 \times 10^3} \] (Kilowatts) for a single rated station. For a double rated stations see equation (4)

where:

\[ P_{\text{avg}} = I^2R \] (watts).

\[ R = \text{Resistance in ohms (bridged resistive component of antenna or transmission line impedance).} \]

\[ I = \text{Effective current (amp-rms of antenna transmission line current).} \]

\[ K = \text{Duty ratio: factor involving pulse repetition interval or rate. (Actually } 1/K \text{ would be used conventionally.)} \]

The values of K for all basic and specific Loran rates are shown in Table 3.3.1.

Table 3.3.1. Values of K for Standard Pulse Shape of 21 ±1µs Rise Time and 40 ±1µs Width

<table>
<thead>
<tr>
<th>SPECIFIC RATE</th>
<th>H</th>
<th>L</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>954</td>
<td>1,272</td>
<td>1,590</td>
</tr>
<tr>
<td>1</td>
<td>951</td>
<td>1,269</td>
<td>1,587</td>
</tr>
<tr>
<td>2</td>
<td>948</td>
<td>1,266</td>
<td>1,584</td>
</tr>
<tr>
<td>3</td>
<td>944</td>
<td>1,262</td>
<td>1,580</td>
</tr>
<tr>
<td>4</td>
<td>941</td>
<td>1,259</td>
<td>1,577</td>
</tr>
<tr>
<td>5</td>
<td>938</td>
<td>1,256</td>
<td>1,574</td>
</tr>
<tr>
<td>6</td>
<td>935</td>
<td>1,253</td>
<td>1,571</td>
</tr>
<tr>
<td>7</td>
<td>932 avg 943</td>
<td>1,250 avg 1,261</td>
<td>1,568 avg 1,579</td>
</tr>
</tbody>
</table>
3.3.2.5. PROCEDURE FOR DETERMINING PEAK POWER WHEN PULSE SHAPE IS OUTSIDE PRESCRIBED TOLERANCE. Where the radiated pulse shape is outside the prescribed tolerance (see Figure 3.3.1) the peak power may be accurately determined by the area measurement method. This method takes the actual pulse shape into consideration and provides a greater degree of accuracy than is obtainable using the formula given above. However, the antenna still must be properly matched to the transmission line, as indicated by minimum VSWR, and the load impedances must be accurately known to obtain the desired results. (See paragraph 3.3.3.)

3.3.2.5.1. Area Measurement Procedure. The following procedure is the area measurement method of obtaining the value of $K$ in Equation (1), in paragraph 3.3.2.4. This method should be used when the pulse shape is outside the prescribed tolerances.

![Diagram of Pulse Repetition Interval](image)

Figure 3.3.2. Relationship of the Pulse Voltage Waveform to the Baseline and the Measurement Intervals

$E_n = \text{the last amplitude on the trailing edge of pulse that is greater than two grid division in height.}$
I. USING CFJ-103 OSCILLOSCOPE.

A. Check calibration of CFJ-103 scope on 100 μsec 5R range. It should be accurate to ±0.1 microsecond.

B. Check both pulses of a double rated station to ensure that they are approximately the same shape.

C. Set the Monitor Oscilloscope controls as follows:

<table>
<thead>
<tr>
<th>Control Name</th>
<th>Symbol</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONITORED CIRCUIT</td>
<td>S-116</td>
<td>OUTPUT PA, OUTPUT EXT AMP or ANTENNA (RF), as appropriate</td>
</tr>
<tr>
<td>OSCILLOSCOPE TRIGGER</td>
<td>S-117</td>
<td>EXC A or B, as appropriate</td>
</tr>
<tr>
<td>SWEEP LENGTH</td>
<td></td>
<td>100 usec 5R</td>
</tr>
<tr>
<td>DELAY LOGIC</td>
<td></td>
<td>NORM</td>
</tr>
<tr>
<td>TRIGGER SOURCE</td>
<td></td>
<td>EXT +</td>
</tr>
<tr>
<td>VOLTS/DIV</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

D. Adjust INTENSITY AND FOCUS for a clear trace.

E. Adjust the VERTICAL DEFLECTION (R-128) and VERTICAL CENTERING so that the upper half of the pulse waveform exactly occupies the 30 vertical divisions of the calibrated grid of the scope.

F. Shift the DELAY LOGIC to the R DLYD range.

G. Adjust the R VERNIER DELAY until the leading edge of the pulse waveform crosses the vertical center line of the scope grid two divisions above the base line (1/15 of the peak amplitude). Make measurements on the pulse waveform which is described by the peaks of the RF cycles. Next, manipulate the R VERNIER DELAY and HORIZONTAL CENTERING controls simultaneously to make the R VERNIER DELAY read an even number of microseconds for this condition. This is done for convenience to make all future settings of the R VERNIER DELAY dial an even number of microseconds. Record the amplitude of $E_1$ as 1. See Figure 3.3.2.

H. Increase the R VERNIER DELAY reading by exactly 2 microseconds. Note where the leading edge of the pulse envelope crosses the vertical center line of the grid. Count the number of grid divisions from the base line to this point estimating to the nearest tenth of a division. Record this as the amplitude of $E_2$.

I. Repeat this procedure, increasing the R VERNIER RELAY reading by exactly 2 microseconds for each reading until an amplitude of less than 2 divisions is reached on the trailing edge of the pulse. Discontinue taking amplitudes at this point. Proceed to paragraph 3.3.2.5.1, item 2.
2. COMPUTATION USING THE DATA OBTAINED ABOVE:

A. Square each of the amplitudes and record the results. Add up all the squared values and substitute in the area formula:

\[
A = 2(E_1^2 + E_2^2 + E_3^2 + \ldots + E_{n-2}^2 + E_{n-1}^2 + E_n^2)
\]

B. The K factor may be computed by appropriate substitution in the following formula:

\[
K = \frac{E_p^2 \times PRI}{A}
\]

Ep = peak deflection of voltage pulse envelope (see item 1E above).

PRI = Pulse repetition interval in microseconds (SO=50,000, L1=39,900, H2=29,800, etc.) Average values for the basic rates are:

\[
H = 29,650 \mu\text{sec}, L=39,650 \mu\text{sec}, \text{and } S=49,650 \mu\text{sec}.
\]

A = area computed as shown in item 2A above, which is proportional to the total pulse energy for one rate within one pulse repetition interval.

C. Substitute the K value determined by this method in Equation (1) or (4) paragraph 3.3.2.4.

D. The physical significance of computing the peak power by this method is shown in Figure 3.3.3. The K factor is the ratio of the power area contained in the complete pulse repetition interval \(E^2 \times PRI\) to the power area (A) of the Loran-A pulse shown in Equation (2).

E. This K factor multiplied by the average power equals the peak power of the Loran-A signal. Because the E values are voltage factors (relative), they must be squared to convert to power values (relative). The expression \(E_p^2 \times PRI\) is, therefore, a power ratio.

F. At a double rated station, to be strictly accurate, the K factor should be the mean of the K factor determined for each rate. However, in a properly adjusted transmitter, the pulse width and rise time for each rate are essentially identical and it is considered sufficiently accurate to assure that the pulse areas are equal. Therefore, a double rated station, Equation (1) becomes:

\[
P_{\text{peak}} = \frac{KP_{\text{avg}}}{2 \times 10^5} \text{ (Kilowatts)}
\]

G. Calculation of peak power using the above method takes two technicians about an hour once they become familiar with the procedure. It provides an extremely valuable check on proper operation of transmitters, amplifiers and antenna couplers. Between checks, personnel should ensure that pulse shapes are kept within tolerance and transmission line and antenna currents are maintained at values which are indicative of proper operation. The worksheet in Figure 3.3.4 may be reproduced locally for this method.
Figure 3.3.3. Relationship of Pulse Power Area-A to Total Power Area for the Determination of the Duty Ratio, K
<table>
<thead>
<tr>
<th>Loran Station Transmitter</th>
<th>Rate</th>
<th>Single/Double Pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ser no.</td>
<td>Amplifier Ser no.</td>
</tr>
<tr>
<td>Pulse: Rise Time us</td>
<td>Width (10%) (50%)</td>
<td>VSWR</td>
</tr>
<tr>
<td>Antenna Coupler</td>
<td>Ser. no.</td>
<td>Antenna Height</td>
</tr>
<tr>
<td>Xmission Line/</td>
<td>R</td>
<td>J</td>
</tr>
<tr>
<td>Antenna Impedance</td>
<td>Monitor Scope Waveform Used</td>
<td>Point of Measurement</td>
</tr>
<tr>
<td>Oscilloscope</td>
<td>Ser. no.</td>
<td></td>
</tr>
</tbody>
</table>

Pulse Amplitudes (2 Microsecond interval)

<table>
<thead>
<tr>
<th>E</th>
<th>Amplitude</th>
<th>Amplitude Squared</th>
<th>E</th>
<th>Amplitude</th>
<th>Amplitude Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td>34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td>37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.3.4. Worksheet for Computation of Peak Power
3.3.3. LORAN-A TRANSMITTING ANTENNA AND COUPLER IMPEDANCE MEASUREMENTS

3.3.3.1. Measurements will be made at least once every year or anytime a major change to the antenna or antenna installation has been made. A copy of the impedance measurements will be sent to the Commandant, the district commander and a copy filed at the station. The following procedure is intended for new installations; therefore, paragraph 3.3.3.3. step 2 may be eliminated at an operating station.

3.3.3.2. EQUIPMENT REQUIRED. The following is required to accomplish impedance measurements:

1. Radio Frequency Bridge type GR-1606A or equivalent
2. Signal Generator, RF, type AN/URM-25D or equivalent
3. Signal Detector type NM-20B or standard radio receiver with range in 1.7 to 2.0 MHz
4. Equipment interconnection as illustrated in the diagram below:

![Diagram of equipment interconnection]

NOTE

Ensure that all equipment is bonded together with a braided ground strap to the antenna ground system. (Keep this ground strap as short as possible.)

3.3.3.3. PROCEDURE. The succeeding procedures must be followed:

1. The first step will be to measure the impedance of the antenna at the coupler output. Balance the RF bridge in accordance with the bridge technical manual. Using the shortest lead possible connect the RF bridge to the bowl insulator of the antenna coupler with the elements of the coupler disconnected internally from the bowl insulator. (The finite impedance of the bowl insulator and lead to the antenna must be lumped with the antenna impedance in order to make an absolute antenna power input determination.) Measure the antenna impedance over a minimum range of ± 50 kHz from the Loran operating frequency. The measurements should be made at not more than 10 kHz intervals. The result should be a smooth Frequency Vs Resistance/Reactance curve. Disconnect the bridge and reconnect the antenna lead to the coupler.
NOTE

Impedance measurements are generally difficult on the frequency of operation due to Loran interference from remote stations. Accurate impedances on the required frequency must be obtained by taking several measurements below and several measurements above the desired frequency and interpolating to obtain the desired measurements. If the receiver has a peak limiter, this can be used to reduce Loran interference. It is very important that the signal generator and receiver used with the bridge be well shielded.

2. The next step is to coarse tune the coupler to the antenna using the RF bridge. Disconnect the transmission line input to the coupler. Set up the measuring equipment and balance the bridge. Do not change the REACTANCE dial for this test after setting the initial balance condition. Set the RESISTANCE dial for 52-ohms (when using the "T" antenna and CU-277/URT coupler) or to the value of resistance observed at the operating frequency in step 1, above, (if using CU-815/U or CU-634/URT coupler). The antenna coupler tuning will be adjusted for a null in the bridge output (either aural or visual, or both). This will occur when the coupler is tuned for an input impedance of $52 \pm j0$ when using the CU-277/URT coupler, or the basic antenna resistance $\pm j0$ when using the CU-815/U or CU-634/URT coupler. The coupler will not necessarily transform the resistive component of the antenna impedance exactly; therefore, it might be necessary to adjust the resistance dial of the bridge slightly to obtain a good null. The value of resistive component observed should be recorded. These measurements will be made with the monitor transmission line connected to the pickup capacitors in the coupler and terminated in the monitor oscilloscope and AN/FPA-3A or 3B monitor circuits in the signal power building. Use the minimum amount of monitor circuit coupling necessary to accomplish this to avoid loading effects on the coupler tuning. Disconnect the bridge and reconnect the transmission line to the coupler.

3. Place the IM-105/U VSWR indicator in the OPERATE-REMOTE METER ON position (refer to IM-105/U technical manual) and connect an external meter at the coupler. The coupler will now be fine tuned using the VSWR indication. Turn on the transmitter and adjust output to approximately three-quarters of the full power, taking care not to exceed the recommended maximum transmitter meter readings. Touch up the coupler tuning adjustment by tuning it for a dip in the remote IM-105/U meter reading. Ensure that the IM-105/U has been calibrated in accordance with paragraph 3.3.4. of this manual prior to performing this step. Place the transmitter on full power and recheck. Adjust the monitor pickup capacitor in the coupler to obtain a sufficient signal to operate the AN/FPA-3 monitor circuits and the monitor oscilloscope. Use the minimum coupling necessary to accomplish the adjustment. Recheck the coupler tuning for a dip upon completion of monitor tuning.

NOTE

The reactive components of transmission line impedance, with the antenna coupler properly tuned, should be very low (on the order of $\pm j5$-ohms). The resistive component of impedance of a transmission line terminated in its characteristic impedance has been found to vary $\pm 10$-ohms about the nominally rated 52-ohm value. The further a transmission line is terminated from its characteristic impedance, the more it will act as an impedance transformer. The impedance will be looking into the line (at the transmitter or amplifier output) and therefore, be proportional to the mismatched load and VSWR.
4. Disconnect the transmitter or amplifier from the transmission line in order to measure the impedance at the input of the transmission line with the coupler and antenna connected. Connect the bridge to the transmission line and measure the impedance at the operating frequency and record this reading (it is important that the coupler is properly tuned as outlined in the previous step prior to making this reading). The resistive component of the transmission line impedance will be used in computing the power output of the transmitter. Both transmission lines will be checked because the value may vary slightly with different lines.

NOTE

Prior to using the monitor oscilloscope to take any pulse width and rise time measurements or measurements relating to the computation of peak power at any station where the AN/FPA-3 series switch gear is installed, disconnect P-102 and J-102 on the Control Alarm Unit C-2518/FPA-3. This will eliminate the loading effect of the alarm circuits on the monitor oscilloscope which causes pulse distortion. The elapsed time meter will run during the time that P-102 is removed. This time will be disregarded in computing the total off-air time from the meter reading.

3.3.4. VSWR METER CALIBRATION

3.3.4.1. PREFERRED METHOD USING IM-105/U. With the transmission line disconnected from the Antenna Coupler, determine the input resistance to the coupler, as per paragraph 3.3.3.

1. Determine K Factor by using the following formula:

\[ K = \frac{Z_1 - Z_0}{Z_1 + Z_0} \]

Where: \( Z_1 \) = bridged value from preceding paragraph

\( Z_0 \) = transmission line impedance.

2. Determine VSWR by using the following formula:

\[ VSWR = \frac{1 + K}{1 - K} \]

3. Reconnect the transmission line to the coupler and place transmitter in operation.

4. Place IM-105/U in the CALIBRATE position and adjust meter calibrate dial for a full scale (or 100) deflection.

5. Change IM-105/U selector switch to OPERATE and adjust L4003 and R4002 (or L4004 and R4008, as appropriate) to a meter reading corresponding to the VSWR calculated in step 2.
3.3.4.2. ALTERNATE METHOD USING IM-105/U. At high power stations DO NOT OPERATE THE AMPLIFIER for calibration. The BIRD 8201 load is designed for only 500 watts continuous dissipation; the nominal amplifier average output power is 1000 watts. Make the necessary connections to bypass the amplifier by connecting the driving transmitter to the antenna transmission line.

1. Remove the internal equipment coaxial cables connected to the tops of the input and output connectors at the amplifier (E-113 and E-114, respectively for the T-138A/AM-701 or J601 and J606 for the T-138/AM-1700) and place a copper strap or bar jumper across E-113/E-114 (J601/606).

2. Remove the rear panel of the standby transmitter (T-325), to expose the RF output cable termination J-109. Remove the coaxial cable from the top of J-109 and connect it to the BIRD load. Operate the transmitter and record the transmission line current. Secure the transmitter. Remove the BIRD load and reconnect the internal coaxial cable.

3. Switch transmitters and perform the BIRD load tests, recording the transmission line current on the other transmitter. Secure the transmitter, remove the BIRD load and reconnect the internal coax. The next step requires off-air.

4. At the transmitting antenna coupler, disconnect the line between the transmission line terminal and the tuning unit input. Connect the BIRD load to the transmission line end seal in use, and operate each transmitter in turn BEING ESPECIALLY CAREFUL TO MAINTAIN THE OPERATING CONDITIONS ESTABLISHED FOR THE PARTICULAR TRANSMITTER IN STEPS 2 and 3. Record the transmission line current for each of the transmitters. The current must be exactly the same as the corresponding currents in steps 2 and 3. If not, a change in impedance is indicated and calibration for the effected channel cannot be completed until the condition is corrected. If the currents agree, proceed with step 5. If the currents do not agree, go instead to step 12 to attempt isolation of the problem.

5. At the IM-105/U, locate the internal calibrating controls L4003 and R4002 (or L4004 and R4008, as appropriate). Connect a Simpson model 260 meter set to the 50 microampere range to terminals 3 and 4 of TB6001 (TB-4002). Place front panel CALIBRATE OPERATE switch in OPERATE and move meter switch to IN.

6. Operate the associated transmitter into the BIRD load (still terminating the transmission line at the antenna coupler) adjust L4003 and R4002 (L4004/R4008) successively for an irreducible null meter reading, approaching zero.

7. Transfer the test meter to the other VSWR channel, establish the front panel conditions of step 5 and calibrate as in step 6.

8. Seal all inductor and pot settings with paraffin, glyptal, lacquer, or other quick setting sealant. Place front panel remote meter switches to OUT, VSWR metal calibrated to read VSWR, and record the VSWR into the BIRD load for each transmitter. Both VSWR readings must agree otherwise an adjustment error in one of the channels is indicated.

9. At the antenna coupler, transfer the BIRD load to the other transmission line end seal, shift transmission line links in the Auxiliary Switch Unit, and again record the VSWR for each transmitter. VSWR readings must agree with readings in step 8 or a transmission line fault is indicated.
10. Remove the BIRD load, reconnect normal connections and resume on-air operation. Check antenna tuning using the IM-105/U remote metal method. Record tuning unit dial reading before adjustment.

11. Record VSWR, new antenna coupler tuning dial reading, and transmission line and antenna currents. This completes the calibration.

12. If the transmission line currents in step 4 did not agree, but the disagreement was of the same order for both transmitters, transfer the BIRD load to the other antenna coupler transmission line end seal, shift transmission line links in the Auxiliary Switching Unit, and recheck for transmission line current agreement with steps 2 and 3. If currents now agree, the problem is isolated to the particular transmission line, or its terminal connections.

13. If transmission line current disparity persists, open the Auxiliary Switch Unit and bypass its interlocks. Remove the connecting link from E-101 or E-106, as appropriate, and connect the BIRD load to the link (its other end still connected to K101) and ground, then operate the transmitter being checked, being certain the initial operating conditions of steps 2 and 3 are reestablished. If the transmission line currents still disagree, the problem is likely due to poor RF connections in the VSWR channel under test. If the currents agree, the problem is isolated to the transmission lines, and/or their associated connections to the antenna. In either case, off-air time and a more detailed analysis with RF bridge measurements, will be required.

14. For units having an AN/FPA-3 installed, a simplified procedure can be used.

A. Remove the small panel at the lower left, front, of the AN/FPA-3. This will expose the output end of both VSWR channels.

B. Remove the connecting bar between the transmission line end seal, and the VSWR terminal of the STANDBY channel.

C. Connect the BIRD calibrating load to the VSWR (top) terminal, and a GOOD chassis ground.

D. Operate the associated standby transmitter (amplifier bypassed at high power stations) into the BIRD load. Connect a 50 microampere meter at terminals 3 and 4 (TB-4001/4002) of the IM-105/U to be calibrated.

E. With the front panel CALIBRATE/OPERATE switch in OPERATE, and the remote meter switch to IN (assuming IM-105/U, FC-3A has been completed), adjust R-4002/R-4008, and L4003/L4004 for an irreducible null approaching zero meter reading.

F. Local radiation should be secured during the calibration process, and calibration can be completed in about a minute.

G. While observing the null meter, carefully secure all settings without disturbing the calibrated positions. Seal all settings.

H. Reconnect the channel for normal operation, shift transmitters, and calibrate the remaining VSWR channel in the same manner.
3.3.4.3. FREE RUNNING PROCEDURES. Procedures for free running operation are given in Chapter 3 of CG-222-4 Radionavigation, Aids to Navigation Manual.

3.3.5. SYNCHRONIZATION AND CALCULATION OF TIME DELAYS

3.3.5.1. Since the value of the Loran-A system is primarily dependent upon the accuracy of timing of the signals transmitted, every precaution must be taken by Loran technical personnel to safeguard the functioning of the system. Therefore, it is important that all electronic equipment within the system be properly maintained and adjusted. Take all time delay readings on standby equipments only. Make all checks and record as outlined in Loran-A Equipment Maintenance Manual, CG-156.

3.3.5.2. NECESSITY FOR SYNCHRONIZATION. The timers are designed to retain their precision, despite varying temperature, humidity and any other conditions, within a few parts per billion. However, even this slight deviation could build up an error in the Loran readings unless compensated. Therefore, it is necessary to constantly correct at the secondary station for the slight differences which accumulate between the two timers operating together as a secondary and master. The process of keeping the proper interval of time between master and secondary is known as synchronization and requires the pulse repetition rate of the paired stations to be exactly equal and the relative phase to be properly adjusted. Synchronization is maintained by automatically matching the pulses from the master and secondary of a Loran-A pair. The pulse shape is shown in Figure 3.3.1. Adjustments must be made in accordance with the technical manual, so that the output pulse is held within the allowable tolerances for standard pulse shapes.

3.3.5.2.1. Measurement Conditions. Loran timing equipments provide the functional means of making precise time measurements through a cathode-ray tube display of signals and accurate timing pulses generated within the timing equipment. Thus the basic receiving equipment may be thought of as a calibrated ruler or scale that is used to measure the time interval between two pulses. The ruler itself is as accurate as the result of inherent features of design and construction. The process of applying the ruler to the problem is subject to several types of errors; it is this part of the measurements upon which accurate pulse matching techniques depend. The techniques under which groundwave matching must be done are defined as follows.

1. Steady state conditions consist of differences in pulse amplitude and shape which are inherent in either or both signals as displayed and which do not change in the time required to take a reading.

2. Transient conditions consist of changes taking place in either or both signals during the time normally required to take a reading. Such changes may include variations in pulse amplitude, phase, or shape.

3.3.5.3. PULSE MATCHING TECHNIQUES. Depending on the receiving conditions at a station, two types of pulse matching techniques may be used.

3.3.5.3.1. Steady State Matching Conditions. The steady state condition is representative of the basic Loran pulse matching techniques. Since the display signals are constant in amplitude, phase, and shape, it is only necessary to follow basic procedures to make a match.

3.3.5.3.2. Basic Timing. It is essential to remember that all basic timing for the Loran-A system is measured theoretically from the beginning of each pulse. This is done because better electrical control exists at the initial stage than at any other time during the pulse period. However, from a practical standpoint the actual point of the start of a pulse cannot be readily determined since it would normally fall at some point on the straight portion of the trace ahead of any rise in the voltage pulse that would be apparent from visual inspection. As a consequence, pulse matching techniques are in reality a compromise; pulses are matched at convenient points which have been found by experiments to have close correlation with the actual commencement point of the pulses.

3-37
3.3.5.3.3. Pulse Matching. As a matter of practical convenience, pulse matching is based upon coincidence of the large linear portions of the leading edges of the pulses. This method is reliable because a definite correlation exists between the commencement point and the linear portion of the leading edge of a pulse as long as the pulse amplitude is constant. It follows, therefore, that if the leading edges of two pulses of the same amplitude and shape are coincident, the commencement points of the pulses are also coincident even though the latter cannot readily be identified on the trace.

3.3.5.3.4. Pulse Amplitude. Changes in pulse amplitude will change the basic correlation, and as a consequence, it is necessary to place a numerical limitation upon the differences in amplitude of pulses which may be matched with reliability in this manner. It has been determined empirically that accurate results for timer and synchronizing equipment are obtained when the smaller pulse has an amplitude of not less than 90 percent of the larger. This limit will yield results of the order of accuracy of ±1 μsec in the basic measurement.

3.3.5.3.5. Basic Considerations. Figure 3.3.5 shows the basic considerations for pulse matching of the video pulse and Figure 3.3.6 shows the correlation between the video pulse and the first and second derivative waveform.

3.3.5.3.6. Ideal Case Pulses. In the ideal case pulses displayed on the Loran scope will be of similar shape. It is then only necessary to adjust the receiver control to produce equal pulse amplitude after which a delay adjustment will permit perfect matching. The pulses will be superimposed and will be coincident not only along the leading edges but throughout the entire pulse period.

3.3.5.3.7. Transient Condition Matching. In addition to the normal steady state problems of pulse matching, the operator is confronted with additional difficulties arising from transient effects which alter the amplitude, phase or shape of a pulse during the time required to take a reading.

3.3.5.3.8. Crossover Period. One of the problems of this nature is the effect produced at the moment of crossover in a double-pulsed transmitter. At this moment the pulses transmitted are spaced so closely together that the transmitter power supply does not recover sufficiently after the first pulse to deliver full power to the second. When the transmitter compensation circuit is properly adjusted, a maximum variation of 4 percent in amplitude is experienced. This variation will be repeated approximately every 16 seconds when a basic rate of 25 pulses per second is used and the transmitter is pulsed on adjacent specific rates. The variations of the observed pulse are primarily dependent on their position with respect to time of the pulses of the two rates and upon whether the observed pulse is leading or following the other signal. Figure 3.3.7 shows the approximate cycle variation for a double rated station. The changes that take place during the crossover period may result in changes of amplitude, phase, shape, or a combination of these factors. These conditions are illustrated in Figure 3.3.8.

3.3.5.3.9. Adjacent Rate Skywave Trains. A second problem that may confront the operator in making time difference readings is the effect of adjacent rate skywave trains which compound the problem by distorting the received pulse. The most practical method which may be applied to the technique of making Loran measurements under these conditions is as follows for the AN/FPN-30 Loran A Timer:

1. Observe the variation of the Loran pulses carefully through several complete crossover periods to ascertain the pattern of the variations.

2. Determine the portion of the cycle when the pulses appear to be most stable and make adjustments for matching during that period only. The important point is to wait through the unstable portion of the cycle being careful not to make any adjustments during that period. A satisfactory match can probably be made in the course of four to five complete
The actual point of commencement of the pulse is located on the trace ahead of the visible pulse.

For a given amplitude a definite correlation exists between the commencement point and the smooth portion of the leading edge. This portion is utilized, therefore, as the basis for pulse matching since it is also easy to identify.

The distance between the commencement point and the smooth portion of the leading edge varies with the observed amplitude. As a consequence, the correlation changes with amplitude changes. It is therefore necessary to observe the precautions regarding gain adjustments which are given in the procedure chart.
Figure 3.3.6. Waveforms — Automatic Synchronizer
TIME
CROSSOVER OF OBSERVED PULSE BY A
PULSE OF AN ADJACENT HIGHER
RATE
(example 0 crossed by 1.)

TIME
CROSSOVER OF OBSERVED PULSE BY PULSE
OF AN ADJACENT LOWER RATE
(example 1 crossed by 0.)

Figure 3.3.7. Approximate Cycle of Pulse Irregularity in
Loran-A Double-Rated Transmission
Figure 3.3.8. Crossover Effects in Pulse Matching
crossover periods. The appearances of the pulse pairs when properly matched is the same on either master or slave timer indicators. The next step is to make time difference readings.

3. On the standby timer turn the RF REJECTION FILTER to the extreme counterclockwise position; the AMPLITUDE BALANCE switch to the OUT position; and by use of the drift switch on the synchronization indicator, align the master pulse on the master pedestal. The master pulse may be identified by the fact that when a pulse shows on each of the two traces on the slow scope the master pulse will always be to the left of the secondary pulse.

4. Using the B-1000, B-100, and B-10 controls on the time delay unit, adjust the secondary pedestal until it is under the secondary pulse.

5. Using the LOCAL GAIN CONTROL, COARSE RF GAIN CONTROL AND FINE RF GAIN CONTROL, carefully match the amplitudes of the video signal on the video scope.

6. Properly matched signals are evident on the video scope of the synchronization indicator when the leading edges of the local and remote video signals are coincident or when the first zero crossover of the derivative signals are coincident.

7. Turn the VIDEO-DERIVATIVE switch on the synchronization indicator chassis to the video position. Using the RF GAIN CONTROLS, LOCAL GAIN CONTROL, and B-CONTINUOUS CONTROL, adjust the video signal on the video scope to obtain a match as shown in Figure 3.3.9. As an alternative with VIDEO-DERIVATIVE switch in the derivative position match as shown in Figure 3.3.10. Do not make time delay readings on the operating timer. Do not use the AMPLITUDE BALANCE CONTROL to match amplitudes.

8. Measure the time delay reading as follows: Turn the RF presentation control to the CAL position. Adjust the RF SWEEP SPEED control until twelve 1-microsecond markers are visible on the RF Scope. Adjust the RF SWEEP DELAY to place a 10-microsecond marker on the right edge of the trace. Adjust the RF SEPARATION control so that the 10-microsecond markers on the upper trace just touch the lower trace; count the microsecond intervals between the 10-microsecond marker to the left on the lower trace. Adjust VIDEO SWEEP DELAY to the extreme clockwise position (Delay out). Adjust the video sweep until twelve 10-microsecond markers appear; at least one 100 (or 1000) microsecond marker should appear on each trace. Adjust the video separation until the 100 (or 1000) microsecond marker on the upper trace just touches the lower trace. Count the number of 10-microsecond intervals that appear between the 100 or 1000 microsecond marker on the upper trace and the 100 microsecond marker to the left on the lower trace.

9. Now adjust the VIDEO SWEEP SPEED control until a 1000-microsecond marker appears at the upper right edge of the upper trace. Adjust the VIDEO SEPARATION control until the 1000-microsecond marker on the upper trace just touches the lower trace. Count the 100-microsecond intervals between the 1000-microsecond marker on the right edge of the upper trace, and the first 1000-microsecond marker to the left on the lower trace. Adjust the VIDEO SWEEP SPEED control for a minimum pedestal width on the slow scope. Count the number of 1000-microsecond intervals between the loading edges of the master and secondary pedestals on the slow scope.

10. Add the time intervals obtained in (8) and (9) above to obtain the total time delay.
Match pulses by means of smooth portions of their leading edges.

<table>
<thead>
<tr>
<th>PROCEDURE WITH PULSES OF SIMILAR SHAPE</th>
<th>PROCEDURE WITH PULSES OF DIS-SIMILAR SHAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Bring pulses into approximate position for matching.</td>
<td>4 Bring pulses into approximate position for matching.</td>
</tr>
<tr>
<td>2 Collapse traces and adjust gain for equal amplitude.</td>
<td>5 Collapse traces and adjust gain for equal amplitude.</td>
</tr>
<tr>
<td>3 Bring the pulses together with the fine delay adjust. Since the pulses are identical in shape they can be completely superimposed on each other.</td>
<td>6 Bring the pulses together with the fine delay adjust for an approximate match.</td>
</tr>
<tr>
<td>7 until the slopes equal.</td>
<td>*The amplitude of the pulses is adjusted by means of the gain control are parallel and</td>
</tr>
<tr>
<td>8</td>
<td>The pulses are then brought together with the fine delay adjust.</td>
</tr>
</tbody>
</table>

*Note: A pulse match is not considered reliable if it is necessary to reduce the amplitude of the stepper pulse by more than the amounts given below in order to produce parallel leading edges.

- Timer & Synchronizing equipment --- 90%
- Navigation ------------------------ 75%

Figure 3.3.9. Procedure Chart Loran Pulse Matching Techniques
Match pulse by means of smooth portions of their leading edges on both sides of first zero crossover.

<table>
<thead>
<tr>
<th>PROCEDURE WITH PULSES OF SIMILAR SHAPE</th>
<th>PROCEDURE WITH PULSES OF DIS-SIMILAR SHAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary adjustment pulses are brought into approximate position for matching.</td>
<td>Preliminary adjustment pulses are brought into approximate position for matching.</td>
</tr>
<tr>
<td>After collapsing traces the gain is adjusted to give equal amplitudes. Pulses then appear slightly displaced with respect to each other along the time base.</td>
<td>Collapsing traces and adjusting for equal amplitude indicates visually that pulses are dissimilar and have different shapes.</td>
</tr>
<tr>
<td>The Pulses are then brought together by adjustment of the fine delay control since pulses are of identical shape they can be completely superimposed however, the smooth portion of the leading edge on both sides of first zero crossover is the basis for the match.</td>
<td>Adjustment of fine delay brings pulses into approximate position for matching.</td>
</tr>
</tbody>
</table>

Figure 3.3.10. Procedure Chart Loran-A Pulse Matching Using Derivative Waveform
3.3.6. TIME DIFFERENCE MEASUREMENTS

3.3.6.1. AN/FPN-56. The procedures for time difference measurement using the AN/FPN-56 Loran Receiving Set are given in the Operation Section of the AN/FPN-56 technical manual.

3.3.6.2. CALCULATION OF AVERAGE TIME DIFFERENCE, STANDARD DEVIATIONS AND 3 X DEVIATION OF THE MEAN. Calculation of AVERAGE TIME DIFFERENCES, STANDARD DEVIATIONS, AND 3 X DEVIATION OF THE MEAN for the AN/FPN-30 will be made in accordance with Table 3.3.2 and the example given below.

NOTE

Time difference readings obtained are listed in column (a) of Table 3.3.2. The number of times each reading occurred is in (b). The difference between the individual reading and the assigned time difference is in column (c). The product of the entries in column (b) and (c) is entered in column (d). Enter in column (e) the square of the entries in column (c). Column (f) contains the product of columns (b) and (e).

Equation (5) Average Time Difference = Assigned Time Difference + \( \frac{\text{sum of (d)}}{\text{sum of (b)}} \)

\[
1000.0 + \frac{-10.8}{72} = 1000.0 - 0.15 = 999.85
\]

Equation (6) Standard Deviation

\[\sigma = \text{Standard Deviation} = \sqrt{\frac{\text{sum (f)}}{\text{sum (b)}}} - \left( \frac{\text{sum (d)}}{\text{sum (b)}} \right)^2
\]

\[
- \sqrt{\frac{3.04}{72} \left( \frac{-10.8}{72} \right)^2} = \sqrt{.04 - .02} = .02 = 0.14
\]

Equation (7) Deviation of Mean

\[3 \times \sigma_m = 3 \times \text{DEVIAION OF THE MEAN} = 3 \times \frac{0.14}{\sqrt{72}} = 0.05
\]

Therefore, Average Observed TD = 999.85 ± 0.05

3.3.7. CROSS-RATE MONITORING WITH THE AN/FPN-30

3.3.7.1. Present instructions require that most Loran-A stations periodically perform cross-rate monitoring and also obtain their local-rate Time Delay (TD) readings using their standby timer. Additionally, the standby timer must be periodically used to perform cross-rate monitoring and also obtain their local-rate Time Delay (TD) readings using their standby timer. Additionally, the standby timer must be ready at all times to take over the function of operate timer. When used to take TD readings, the B-10/B-CONT SWITCH (S-502) is in the B CONT position. On the secondary station operate timer, this switch is normally in the B-10 position. Due to the design of the timer, switching between the B-10 and the B-CONT positions will insert an inherent 10 microseconds into the delay. To compensate for this inherent delay, the B-10 CONTROL (R-581) must be readjusted each time S-502 is repositioned.
Table 3.3.2. Calculation of Average Time Differences, Standard Deviations and 3X Deviation of the Mean

<table>
<thead>
<tr>
<th>(a) TIME DIFFERENCE</th>
<th>(b) NUMBER OF TIMER READINGS OBSERVED</th>
<th>(c) DEVIATION FROM ASSIGNED TIME DELAY</th>
<th>(d) PRODUCT (b)x(e)</th>
<th>(e) SQUARE OF DEVIATION (c)</th>
<th>(f) PRODUCT (b)x(e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000.2</td>
<td>1</td>
<td>+0.2</td>
<td>+0.2</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>1000.1</td>
<td>5</td>
<td>+0.1</td>
<td>+0.5</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>1000.0</td>
<td>10</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>999.9</td>
<td>20</td>
<td>-0.1</td>
<td>-2.0</td>
<td>0.01</td>
<td>0.20</td>
</tr>
<tr>
<td>999.8</td>
<td>20</td>
<td>-0.2</td>
<td>-4.0</td>
<td>0.04</td>
<td>0.80</td>
</tr>
<tr>
<td>999.7</td>
<td>10</td>
<td>-0.3</td>
<td>-3.0</td>
<td>0.09</td>
<td>0.90</td>
</tr>
<tr>
<td>999.6</td>
<td>5</td>
<td>-0.4</td>
<td>-2.0</td>
<td>0.16</td>
<td>0.80</td>
</tr>
<tr>
<td>999.5</td>
<td>1</td>
<td>-0.5</td>
<td>-0.5</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Totals</td>
<td>72</td>
<td></td>
<td>-10.8</td>
<td></td>
<td>3.04</td>
</tr>
</tbody>
</table>

3.3.7.2. ASSIGNED DELAY. Reports indicate that this important readjustment is sometimes overlooked when a secondary “standby” timer is shifted to “operate”. Usually, the result is several minutes of needless blink time. This cause of unusable time can be eliminated entirely if, after making the required readings, the timer is returned to true “standby” condition; that is, the assigned delay setup on the timer. One method of ensuring that the assigned delay is set up after making TD readings is through use of the PRESET B DELAYS.

3.3.7.3. PRESET B DELAYS. To use this method entails nothing more than setting the local-rate monitor delay (with S-502 in the B-CONT position) in PRESET 2 and setting the cross-rate monitor delay (with S-502 in the B-CONT position) in PRESET 3. The assigned delay is set up in the normal manner on the front panel controls with S-502 in the B-10 position. To make a cross-rate or local-rate TD reading, switch the PRESET B DELAY SELECTOR SWITCH (S-504) to either PRESET 2 or PRESET 3, switch the B-10/B-CONT Switch to the B-CONT position, manipulate the B-CONT DELAY CONTROL (R-601) to attain a pulse match and read the delay. After completing the reading all that is required to return the timer to “standby” position is to switch S-504 back to the NORMAL position and return S-502 to the B-10 position. Since the assigned delay has previously been set up on the front panel controls, (and these controls have not been used in making the TD readings) the timer is again in true “standby” condition ready to become the operate timer when required. TD readings of own-rate and cross-rate should be consistent enough that readjustment of the PRESET DELAYS is seldom required.