NOTE: Show slide #1

TITLE: Basic Troposcatter Theory

LEARNING OBJECTIVE:
Action: You will be able to describe the basic key concepts of the tropospheric scattering communications theory.

Conditions: You will be given an informal lecture on basic tropospheric scattering communications theory.

Standard: You will be able to correctly describe the basic key concepts of tropospheric scattering communications theory.

SAFETY CONSIDERATIONS:
Be aware of the possibility of electrical shock when working with electronic equipment.

RISK ASSESSMENT:
Low

RESOURCE NEEDS/REFERENCES:
Communication System AN/TRC-170(V)3, PowerPoint Presentation “Unit 1”, Laptop and Overhead Projector, TM 11-5820-934-13-2, CSI Manual 142F009900-1 and AN/TRC-170(V)3 Training Student Studyguide

METHODS OF INSTRUCTION:
Informal Lecture

TIME:
0.5 Academic Hours
INTRODUCTION:

1. In this unit, we will cover basic tropospheric scattering communications theory.

   Overview
   Earth’s Atmosphere
   Troposcatter communications
     Factors affecting
   Take-off angle
   Diversity
Student Studyguide

Unit 1
Basic Tropo Theory

NOTE: Show slide #3

Earth’s Atmosphere

- Troposphere: lowermost portion of the atmosphere
- Weather occurs in this layer of atmosphere
- Weather and atmospheric changes affect the troposcatter signal

BODY:

1. Overview:

   In order to become familiar with troposcatter propagation, students should first be familiar with a few key terms and definitions, then learn how the atmosphere allows this type of communication to occur. Students will see how weather factors affect this type of communication system and the steps that must be taken to diminish the adverse factors.

2. Layers of the Earth’s atmosphere
   
   Troposphere:
   - The lowermost portion of the Earth’s atmosphere.
   - It begins at the surface of the Earth and extends upwards.
   - All weather phenomena occur in this portion of the Earth’s atmosphere.
   - Approximately 75% of what we call the atmosphere is in this region.
   - We’re most interested in the water vapor and temperature changes that occur in this region.
3. Troposcatter Communications

- The AN/TRC-170(V)3 troposcatter method uses a microwave radio to communicate through the lowest portion of the earth’s atmosphere, the troposphere. We can communicate up to 100 miles or sometimes more using this method, depending on circumstances. A microwave radio operates in the microwave frequency band. The microwave frequency band begins at 1,000 MHz (1 GHz).

- The troposphere scatters the microwave signal. The signal can also be diffracted when it bends around an obstacle.

- The AN/TRC-170(V)3 may also communicate using Line-of-Sight (LOS) microwave communication. Using the LOS method and equipment, the range is about 35 miles.

- It is important to understand that the signal loss caused by scattering and diffraction are large compared to the loss incurred in Direct Line of Sight microwave communication.
Here we will discuss several factors that affect troposcatter links. Later, we will learn how to minimize the effects of these factors.

When planning a troposcatter link, system link planners have to take all these factors into account.

Transmission of the signal is affected by:

- Scattering: Loss of signal into space
- Fading: Variations in signal level
The main part of a troposcatter signal is lost and unusable. It continues out of the atmosphere and into space.

As the Radio Frequency energy travels through the atmosphere, it is subjected to scattering, which causes parts of the signal to come back down to Earth.
Fading is a term used to describe variations in signal level. This can be short or long term.
- Long term fading is due to seasonal variations in weather, for example, humidity reductions in
  the winter months or rainy seasons.
- Compensate for the effects of long term signal fading, by increasing the power output.

**NOTE:** If a tropo link doesn’t compensate for these factors, then the link will fade in and
  out too much to be useable.
Factors Affecting Troposcatter Links

Short-Term Fading: Sudden, unpredictable drops in signal for 0.03 – 3 sec
• Ex: Frequency Selective Fading

Short Term Fading: describes a phenomenon where parts of the signal fade suddenly and unpredictably. In this case it happens so quickly and unpredictably that increased power output will not compensate for it.

Frequency Selective Fading

• Different frequencies fade at different points in time.
• This may cause parts of the wanted signal to fade, while other parts of the signal remain strong.
• The signal can effectively disappear for a moment or two during a short term fade.
• The equipment compensates for this. We will talk more about ways to compensate for short term fading and other phenomenon in later units.
Student Studyguide

Unit 1
Basic Tropo Theory

NOTE: Show slide #9

4. Takeoff Angle:

- Take-off angle: Describes the angle at which the antenna has to be set to in order to transmit over the horizon. Normal take off angles for troposcatter links range from 0 to 5 degrees.
- The higher the takeoff angle, the lower the signal will be at the distant end.
- The antenna is usually set at a slightly positive angle with reference to the local horizontal. In some cases, the angle can be slightly negative, or downward pointing.
5. Diversity

- The best way to mitigate the affects of short term fading is through the use of diversity techniques.
- Diversity is a technique which improves the total receive signal over any single path by combining two or more independent paths.
- Independent paths are ones in which the characteristics of the receive signal from each path are different at any given point in time.
- Since diversity paths will not have the same characteristics, they will probably not fade at the same time. The advantage of combining them results in having a combined signal that does not fade.
a. Angle Diversity

- A diversity reception in which beyond-the-horizon troposcatter signals are received at slightly different angles.
- Uses one antenna at each end of a tropo link for both transmit and receive.
- The antennas have an offset feed that have different look angles.
- The main feeds are used for transmit and receive, the offset feed is used for receive only.
- The equipment combines the paths in order to prevent signal loss or degradation.
b. Space Diversity

- Space Diversity uses more than one antenna at each end of a tropo link. (Normally 2 antennas are used). One is used for transmit and receive, and the second is only used for receive.
- Requires 100 wavelength separation between antennas
- Requires only one transmitter and one transmit frequency at each end.

The AN/TRC-170 (V)3 microwave radio uses dual antennas
c. Frequency Diversity

- Frequency Diversity is another kind of diversity where the signal is transmitted using different frequencies on the same antenna.
- Requires two transmit frequencies at each end of the link.
- Reliability and performance are the same as Space Diversity.
- Wastes the radio spectrum and increases the possibilities of interference.
SUMMARY:

1. During this lesson students you received an introduction to basic key concepts of tropospheric scattering communications theory.
2. Ask the instruction questions to clarify any misunderstandings.

THE END
Student Studyguide

Unit 2
Intro to TRC-170

NOTE: Show slide #1

TITLE: Introduction to the AN/TRC-170(V)3 Digital Troposcatter Communications System

LEARNING OBJECTIVE:
Action: You will be able to describe the purpose, capabilities, and major components of the AN/TRC-170(V)3.

Conditions: You will be given an informal lecture on the purpose, capabilities, and general description of the major components of the AN/TRC-170(V)3.

Standard: You will be able to correctly describe the key concepts of the purpose, capabilities, and major components of the AN/TRC-170(V)3.

SAFETY CONSIDERATIONS: Be aware of the possibility of electrical shock when working with electronic equipment

RISK ASSESSMENT: Low

RESOURCE NEEDS/REFERENCES:
Communication System AN/TRC-170(V)3, PowerPoint Presentation “Unit 2”, Laptop and Overhead Projector, TM 11-5820-934-13-2, CSI Manual 142F009900-1 and AN/TRC-170(V)3 Training Student Studyguide

METHODS OF INSTRUCTION: Informal Lecture

TIME: 4.0 Academic Hours
INTRODUCTION:

Elapsed Time

During this period of instruction, you will be given an overview of the purpose, capabilities and limitations, and general descriptions of the major components of the AN/TRC-170(V)3 Digital Troposcatter Communications System. Understanding this information will provide the base which will enable you to become proficient AN/TRC-170(V)3 operators.

Objectives:

- Describe purpose of the AN/TRC-170(V)3
- Describe AN/TRC-170(V)3 capabilities and limitations
- Identify AN/TRC-170(V)3 major components

You will learn the following:

- The AN/TRC-170(V)3 is a transportable, self-enclosed troposcatter terminal (multichannel) capable of transmitting and receiving digital data over varying distances (up to 100 miles).
- This terminal is comprised of modular electronic equipment in various configurations with GFE multiplexers and cryptographic items all housed in a modified S-250/G shelter.
- The QRA is included as part a AN/TRC-170(V)3.
  - It is trailer mounted and contains a "pop-up" dual antenna for space diversity operation.
- The legacy configuration (non-upgraded) is limited to 4.608 Mbps of data.
- The Upgraded Modem configuration will handle 16.384 Mbps of data.

There will be an academic evaluation at the end of this lesson.
Purpose of the AN/TRC-170(V)3

- Air or Ground Transportable
- Tropospheric Scatter Microwave Radio Terminal
- Secure Digital Trunking
- All Major Units are Rack Mounted

BODY:

A. Purpose of the AN/TRC-170(V)3: The AN/TRC-170(V)3 is an air or ground Transportable Tropospheric Scatter microwave Terminal.

1. Air or Ground Transportable:
   - The radio system can also be transported by any cargo aircraft capable of transporting a HUMVEE.
   - The radio system is mounted (bolted on to the frame) of a heavy duty HUMVEE.
   - The antenna is part of a M116A2 trailer and is towed behind the HUMVEE.

2. Tropospheric Scatter Microwave Radio Terminal:
   - This radio system uses troposscatter propagation to transmit and receive data.
   - The radio system can operate as a Line of Sight or as a Tropo Scatter radio.

3. Secure Digital Trunking: This radio system provides secure voice and data circuits.
   - It also provides secure digital trunking between major nodes of a communications network.
   - It can interface with Tri-Service Tactical Area Communications (TRI-TAC) and other current inventory assemblages of multiplexing equipment or various switches.
   - It also provides a link to support dedicated traffic to include analog and digital voice, point to point subscriber circuits, facsimile, and teletype or telemetry circuits.

4. All major units are rack mounted in the shelter.
Student Studyguide

Unit 2
Intro to TRC-170

NOTE: Show slide #4

This is the exterior view of the AN/TRC-170(V)3.
Student Studyguide

Unit 2
Intro to TRC-170

NOTE: Show slide #5

- Actual photos of the AN/TRC-170(V)3 shelter, are pictured here.
- Road-side view (left) and Curb-side (right) view of the shelter.
Road-side (left) and Curb-side (right) shelter interior. Rear and front sides are also labeled.
B. Capabilities and Limitations

1. Frequency Range
   - The TRC operates in the frequency range of 4.4 to 5.0 GHz.
   - The occupied frequency band is 3.5 or 7 MHz. Selectable via a toggle switch. This is for the DAR Modem.
   - The CS6716 Modem occupied frequency band is 7 or 12 MHz.
   - The OAC-170D is used for additional filtering (sensitivity) 2.0 or 3.5 MHz.

2. Transmission Range
   - Transmission range is up to 100 miles for this equipment.
   - This is the effective range over which one can expect to establish reliable troposcatter links using this equipment.
3. Output Power
   This is the power out of the antenna and depends on the mission requirements.
   a. Tropo Maximum output power is 2 kW.
      This is obtained by NOT using the gain compression circuitry.
   b. Tropo Nominal output power is rated at 1 kW.
      This rating is the normal maximum output power level obtained from a
      AN/TRC-170(V)3.
   c. Line of Sight (LOS) output power is rated at 0.4 watt.
Student Studyguide

Unit 2
Intro to TRC-170

NOTE: Show slide #9

4. Data Bandwidth
   - The data bandwidth rating of the AN/TRC-170(V)3 is 128 kbps to 4608 kbps.
   - This rating is from a non-upgraded shelter.
   - The upgraded AN/TRC-170(V)3 can handle up to 16384 kbps.

5. Antenna gain
   - Antenna Gain of the 6' parabolic dish is 36.5 decibels (dBi).
6. Diversity Modes
   • Non-Diversity: All AN/TRC-170 versions are capable of Non-diversity
   • Dual Diversity: All AN/TRC-170 versions are capable of Dual-diversity
   • Quad-Diversity: Only the AN/TRC-170(V)2 is capable of Quad-diversity
Non-Diversity

- All versions of the TRC-170 can operate in this mode.
- Effective for Line of Sight (LOS) shots - approximately 35 miles.
- In LOS mode each antenna HAS to have a clear, unobstructed view (shot) to the other antenna.
Dual-Diversity:

- All versions of the AN/TRC-170 can operate in this mode.
- One transmit / receive antenna and one receive only.
This system block diagram is for the unmodified (Legacy) version of the radio.
C. Major Components of the AN/TRC-170(V)3

- Transmitter
- Receiver
- CS6716 Modem Upgrade
- DAR Modem Equipment
- Digital Voice Orderwire (DVOW) with KY-58
- Quick Reaction Antenna
C. Major Components of the AN/TRC-170(V)3
   - Transmitter
   - Receiver
   - CS6716 Modem Upgrade
   - DAR Modem Equipment
   - Digital Voice Orderwire (DVOW) with KY-58
   - Quick Reaction Antenna
1. Transmitter: This is a brief summary of the transmitter function, not a complete breakdown of the equipment.

AN/TRC-170(V)3
   a. High Power Amplifier (HPA): 1 per shelter
      • Receives Radio Frequency signal from Up-Converter and amplifies it for transmission.
      • In the line of sight (LOS) mode of operation, the signal from the Up-Converter bypasses the high power circuitry and is routed to the output filter in the HPA.

   b. Up-converter: 1 per shelter
      • Converts 70 MHz Intermediate Frequency (IF) output of the modem to C-Band and then amplifies and filters the RF to the High Power Amplifier.

   c. Dual RF Synthesizer: 1 per shelter
      • Provides stable outputs in the 4.4 to 5.0 GHz range, those outputs supply the local oscillator signals to the up-converter.
This is the receiver block diagram.
2. Receiver:

This is a brief summary of the receive function, not a complete breakdown of the receiver equipment.

AN/TRC-170(V)3

a. Down-converter: 2 per shelter (each down-converter has 2 identical outputs)
   • Provides pre-selection, post-selection, and amplification of the received RF signal.
   • The output of the down-converter is the 70 MHz IF signal.

b. Dual RF Synthesizer: 1 per shelter
   • Provides stable outputs in the 4.4 to 5.0 GHz range, those outputs supply local oscillator signals to the down-converters.
AN/TRC-170(V)3

3. CS6716 Modem Upgrade:
   • 1 Modem upgrade kit installed per V3

Components:
   • IF DATA Patch Panel
   • CS6716 Modem
   • VersaMux™ 4000
   • Oscillator Amplifier Converter (OAC)-170D
   • 48 Volts Direct Current (VDC) Power Supply
4. IF Data Patch Panel: 1 per shelter
   a. IF Section
   b. Data Section
   c. Orderwire (OW) Section
Student Studyguide

Unit 2
Intro to TRC-170

NOTE: Show slide #21

a. CS6716 Modem: 1 per shelter.
   Provides a full duplex interface supporting a high-speed user Channel and a digital service channel

   NOTE: CS6716 Modem has a similar menu structure as the AN/FCC-100 Multiplexer (military equipment)
View of the modem with the access panel opened.
b. VersaMux™ 4000:
   - 1 per shelter
   - Provides ability to multiplex up to 4 input groups into a single aggregate group using time division multiplexing (TDM).
   - Each input group can be either a fiber optic or conditioned di-phase (CDI) interface.
   - The total data from the four groups cannot exceed the aggregate data rate of 16.384 Mbps.

Note:
   - Display
     2 lines by 16 characters
   - Keypads
     Left, Right, Up & Down arrow keys
     ENTER key
   - LEDs
     POWER
     AGGR
     CLK REF
     PORTS
     FAULT
   - Power Switch
VersaMux™ 4000 showing the port numbering system. There are five ports:

- Ports 1 thru 4 are identical.
- Port 5 is the aggregate port.
Oscillator Amplifier Converter (OAC-170D):

- 1 per shelter
- Contains four IF Amplifiers with gain adjustment which provides required input level for modem
- Provides selectable IF Filter bandwidths
- High-Stability Redundant 10 MHz Rubidium reference outputs for modem and VersaMux™ 4000
- Automatic or manual Switches of redundant Oscillators
d. 48 Volts Direct Current (VDC) Power Supply: 1 per shelter
   Redundant Hot-Swappable power supplies have current sharing capabilities for normal operation.
4. Distortion Adaptive Receiver (DAR) Equipment:
   Original tropo modem and multiplexing equipment fielded in the TRC-170.
   a. DAR Tropo Modem: 1 per shelter
      • Provides up to 4608 kbps data rate.
      • Provides a full duplex interface with a digital orderwire
b. DAR Digital Group Multiplex Equipment:
   Original multiplexing equipment fielded in the legacy TRC-170s.

1. Loop Group Multiplexer: 2 per shelter
   • Provides up to 16 analog or digital channels operating at 16 or 32 KHz at data rates up to 576KHz.

2. Group Modem: 1 per shelter,
   • 4 modems per Group Modem assembly.
   • Functions as a full duplex protocol converter, converting Conditioned Diphase (CDI) to NRZ in one direction and NRZ to CDI in the other.

3. Trunk Group Multiplexer: 1 per shelter,
   • Combines up to 4 groups of data from the LGMs and GMs and forms an aggregate signal.
5. Digital Voice Orderwire (DVOW) with KY-58
   • The DVOW provides a secure orderwire circuit for link alignment, equipment status and troubleshooting purposes.
   • The DVOW operates with the KY-58 encryption device.
6. Quick Reaction Antenna (QRA)
   • The QRA is a trailer-mounted, dual-antenna, parabolic dish antenna system.
   • It is mobile (towed) and relatively easy to set up.
   • A trained 2-person crew can set one up in 45 minutes.
a. M116A2 Trailer Chassis
   • The antenna system is built as part of the trailer chassis.
   • It can not be physically removed from the trailer itself.
   • All antenna components are stored on the trailer.

b. 6 FT (180 cm) Parabolic Dish Reflectors
   • The gain of the QRA reflectors is 36.5 decibels (dBi).
   • These reflectors are a one piece system and are also stored on the trailer chassis.
SUMMARY:
  • During this lesson you received an introduction to the purpose, capabilities, and a
general description of the major components of the AN/TRC-170(V)3 Digital
Troposcatter Communications System.
  • Ask the instructor questions to clarify any misunderstandings.

THE END
NOTE: Show slide #1

TITLE: Major Systems and Functions

LEARNING OBJECTIVES:
Action:
You will be able to describe the mission data signal flow through the AN/TRC-170(V)3 Digital Troposcatter Communications System and identify each component that the user mission data signal passes through and what it does to or for the signal.

Conditions:
You will be given an informal lecture on the mission data signal flow through the AN/TRC-170(V)3 and descriptions each component that the user mission data signal passes through and what it does to or for the signal.

Standard:
You will be able to correctly describe the key concepts of the mission data signal flow through the AN/TRC-170(V)3 and identify each component that the user mission data signal passes through and what it does to or for the signal.

SAFETY CONSIDERATIONS:
Be aware of the possibility of electrical shock when working with electronic equipment

RISK ASSESSMENT:
Low

RESOURCE NEEDS/REFERENCES:
Communication System AN/TRC-170(V)3, PowerPoint Presentation “Unit 3”, Laptop and Overhead Projector, TM 11-5820-934-13-2, CSI Manual 142F009900-1 and AN/TRC-170(V)3 Student Studyguide

METHODS OF INSTRUCTION:
Informal Lecture

TIME:
16.0 Academic Hours
INTRODUCTION:

Elapsed Time

During this period of instruction, you will be given an overview of the mission data signal flow through the AN/TRC-170(V)3. We will cover each component that the user mission data signal passes through and what it does to, or for the signal. We will cover the transmit signal path, receive signal path, orderwire signal path and Distortion Adaptive Receiver (DAR) Modem Variant signal path. Understanding this information will provide the base which will enable you to become proficient AN/TRC-170(V)3 operators.

Objectives:

Describe signal flow through the AN/TRC-170(V)3
- Transmit Path
- Receive Path
- Orderwire Path
- Distortion Adaptive Receiver (DAR) Modem Variant path

Identify each component the mission data signal passes through and what the component does to or for the signal

There will be an academic evaluation at the end of this lesson.
Student Studyguide

Unit 3
Major Systems and Functions

NOTE: Show slide #3

Transmit Path Signal Flow and Components

Overview
- Provides a path for the user signal from the Shelter Interface Panel all the way to the Transmit antenna
- Up to 4 group inputs from 8 possible connections
- Provides signal conditioning, filtering and amplification

BODY:
A. Transmit Path signal flow and components
   1. Overview
      a. Provides a path for the user mission data signal from the Shelter Interface Panel (SIP) all the way to the Transmit antenna
      b. Up to 4 group inputs from 8 possible connections at the SIP. Up to 4 groups of CDI or FO traffic may be connected.
      c. Provides signal conditioning, filtering and amplification
This is the upgraded modem block diagram.

Transmit path:
- Shelter Interface Panel (SIP)
- VersaMux™ 4000
- IF Data Patch Panel
- CS6716 Modem
- IF Data Patch Panel
- Troposcatter Radio up-converter
- High Power Amplifier
- Antenna
2. Shelter Interface Panel (SIP) Connections
   a. Conditioned Di-phase
      4 CX-11230 cable connectors on SIP
   b. Fiber Optic
      4 CX-11295 cable connectors on SIP
3. VersaMux™ 4000
   a. The VersaMux multiplexes up to 4 inputs of 8 possible from SIP into an aggregate output.
      The VersaMux takes up to 4 trunk group inputs from the SIP and multiplexes it into a single aggregate signal
   b. Non Return to Zero (NRZ) output (the signal varies but will never equal zero)
      The VersaMux accepts FO and CDI inputs and converts them to a NRZ output.
   c. Aggregate rate up to 16 Mbps
      Data rates may vary from 2 Mbps to 16 Mbps
   d. Relay Pass Through Mode
      Any of the 4 Port Inputs can be configured for relay pass through mode. In this mode the port selected can pass the aggregate signal.
   e. Protocol Converter
      The Protocol converter function changes CDI to NRZ Formats.
4. IF Data Patch Panel
   a. IF Section
      1. Connects signal from CS6716 or DAR Modem to Tropo Radio up-converter
      2. Patching is done via U-Link inserted vertically into Patch Panel.
   b. Data Section
      1. Normal through for CS6716 Modem
      2. Ethernet connection available
      3. RS-232 connection for Maintenance and Control
   c. Orderwire (OW) Section
      1. Normal through for CS6716 Modem
      2. Connects OW to DAR using patch
   d. Trunk Encryption Device (TED) patch
      1. For encrypting / de-encrypting of mission data
      2. TED is patched between the VersaMux and the CS6716
5. CS6716 Modem
   a. High speed, Digital Adaptive Modem
   b. Duplex Interface
      1. User Channel is Turbo Product Code (TPC) encoded
         • Improves BER
         • Approximately 5% overhead
         • RS-422 or HSSI
      2. Digital service channel
         • RS-422
         • No TPC encoding
   c. Adaptive Link Power Control
      1. Automatically controls transmitted RF power
      2. Minimizes output power
      3. Reduces the possibility of interference
   d. Fully Redundant
      Automatically switches to standby modem

**Supporting info:**

Modem will not swap if a major fault is already detected in the standby module or if the modem is not in the auto mode. The modem printed circuit board cards (PCBs) are hot swappable (can be swapped without powering off the modem). However, the slide switches on each individual PCB must be off before removing and replacing. Upon replacement, the slide switches must be turned on again.

e. Intermediate Frequency Output
   1. 70 MHz Frequency
   2. QPSK Modulation
6. Troposcatter Radio up-converter
   a. Inputs
      1. IF from modem
      2. LO from Dual RF Synthesizer
   b. Up-converts
      1. Mixes IF with LO
      2. Tuneable Filter dialed to RF frequency to filter out mixing components
      3. Amplifies filtered signal
   c. Radio Frequency (RF) output
      1. Tropo Mode sent to High Power Amplifier for power amplification
      2. Line of Sight Mode bypasses the High Power circuitry and is sent to the
         transmit waveguide after leaving the HPA
Unit 3
Major Systems and Functions

NOTE: Show slide #10

7. High Power Amplifier (HPA)
   a. Maximum output power of the High Power Amplifier is 2 kW
   b. The HPA contains a gain compression circuit that reduces output power by reducing the drive input by 3 dB.
   c. The HPA receives its operating voltages from the High Voltage Power Supply below it. The HPA uses a tunable cavity electron tube to generate the power needed to boost the output level to required levels.
   d. The HPA also contains a High/Low power range setting. By choosing the Low Power setting, the output power level is reduced by half.
   e. The HPA also has a Tropo / LOS LED that illuminates to show which operating mode is selected
   f. There is a Dummy Load / Antenna LED that illuminates to show which output mode has been selected. These LEDs are affected by front panel toggle switches.
8. Antenna
   a. Flexible waveguide
      • Connects output of HPA to the antenna
   b. Antenna feedhorn
      • 36.5 dBi of gain
The following are all types of signals that can be passed by the TRC-170 EXCEPT
A. Digital Phone circuits
B. Analog Phone circuits
C. HF circuits
D. Fiber Optic circuits

Match the following signal types with the cable associated with them.
- Conditioned Diphase  CX-11295
- Fiber Optic  CX-11230

Pick out the true statement from the following list of VersaMux facts:
• The VersaMux converts CDI into a Conditioned Diphase format
• Only Ports 1, 2, or 3 can be relayed to the aggregate
• The VersaMux handles up to 6 group inputs
• The VersaMux is limited to handling any combination of up to 4 groups of CDI and FO concurrently

1. The following are all types of signals that can be passed by the TRC-170 EXCEPT for ___
   a. Digital Phone circuits
   b. Analog Phone circuits
   c. HF circuits
   d. Fiber Optic circuits

4. Match the following signal types with the cable associated with them.
   a. Conditioned Diphase (CX-11230)
   b. Fiber Optic (CX_11295)

9. Pick out the true statement from the following list of VersaMux facts:
   a. The VersaMux converts CDI into a Conditioned Diphase format
   b. Only Ports 1, 2, or 3 can be relayed to the aggregate
   c. The VersaMux handles up to 6 group inputs
   d. The VersaMux is limited to handling any combination of up to 4 groups of CDI and FO concurrently
B. Receive Path signal Flow and components

1. Overview

- The receive Path begins as the received signal is collected at the antenna, then signal is demultiplexed back down to groups and is routed out of the van via the shelter interface panel for the CS6716 Modem or to the signal entry panel for the DAR components.
- Along the way various components add signal conditioning, filtering and amplification.
Student Studyguide

Unit 3
Major Systems and Functions

NOTE: Show slide #14

Receive path:
- Antennas
- Troposcatter Radio down-converters
- IF Loopback Panel
- IF Data Patch Panel
- OAC-170D
- CS6716 Modem
- IF Data Patch Panel
- VersaMux™ 4000
- Shelter Interface Panel
Antenna

The input to the antenna is the 4.4-5 GHz RF signal transmitted by the Distant End AN/TRC-170.

a. Antenna Feedhorn
   36.5 dBi gain
b. Flexible waveguide connects emitters on antenna to waveguide ports on shelter.
   Signal loss through each waveguide is .6 dB.
3. Troposcatter Radio down-converters
   The next stop on the signal flow path is the Troposcatter Radio down-converters.
   a. Low Noise Amplifiers (LNA)
      • 25 to 28 dB gain
   b. Pre and Post Select Filters
      • Signal conditioning
      • Tunable Filter dialed to RF frequency
   c. Down-converts
      • Mixes RF with LO
      • 70 MHz IF output
4. IF Data Patch Panel
   The 4 outputs from the down-converters are routed to the IF DATA Patch panel
   a. Four U-links connect Rx1-Rx4 from radio down-converters to modem
      • Top 2 jacks of each column for CS6716 modem
      • Bottom 2 jacks of each column for DAR modem
   b. Four CS6716 Rx jacks connect receive IF to OAC-170
      • Connect receive IF to OAC-170
      • Amplifies approximately 16dB
      • Connects to CS6716
Student Studyguide

Unit 3
Major Systems and Functions

NOTE: Show slide #18

IF Section of IF Data Patch Panel
5. OAC-170D
   a. 4 IF Amplifiers
      Total gain from the LNAs to the input of the CS6716 is set for 40 dB +/- .25 dB
   b. IF Filter Bandwidths
      - BYPASS for data rates of 8 Mbps or faster
      - 3.5 MHz for data rates up to 4 Mbps
      - 2 MHz for data rates up to 2 Mbps
6. CS6716 Modem
   a. 4 IF input signals
   b. Full duplex interface
   c. Digital service channel (RS-422), used for Orderwire
   d. Turbo Product Code (TPC) Forward Error Correction (FEC) Improves system performance (bit error rate or BER)
   e. Adaptive Link Power Control (ALPC) to the distant end transmitter, letting it know minimum output levels required at the receiver.
**Unit 3**
Major Systems and Functions

**NOTE:** Show slide #21

7. **VersaMux™ 4000**
   a. RS-422 in NRZ format
   b. De-multiplexes the aggregate signal
   c. Fiber Optic and Conditioned Di-phase data groups
   d. Outputs connect to Shelter Interface Panel
   e. Format conversion from NRZ to CDI
8. Shelter Interface Panel

- Connects 4 groups of Fiber Optic or Conditioned Di-phase data to users
- From here users are connected via either CX-11230 cable for Di-phase or CX-11295 Fiber Optic cables.
Student Studyguide

Unit 3
Major Systems and Functions

NOTE: Show slide #23

35. The output of the Troposcatter Radio down-converter is?
   a. NRZ
   b. 4.4-5 GHz
   c. RF
   d. 70 MHz

38. Total gain from the Low Noise Amplifiers through the OAC, to the input of the CS6716 Modem is set for how much?
   a. 36.5 dB
   b. 28 dB
   c. 40 dB
   d. 16 dB

45. Select the incorrect statement about the SIP.
   a. 8 groups of data can be connected to SIP
   b. 4 groups of CX-11230 cable can be connected to SIP
   c. 4 groups of CX-11295 cable can be connected to SIP
   d. 8 groups of CDI can be connected to SIP
C  Orderwire Path signal flow and components

1. Overview

   a. Terminal to terminal secure voice communication via KY-58
      Used for status reporting and troubleshooting with distant end.
   
   b. Provides a path for the Orderwire signal from headset to the modem.
      For normal use with the CS6716 Modem, no additional patches have to be made.
      When used with the DAR Modem a patch must be made between the DAR ORDERWIRE jack and the DVOW jack on the IF Data Patch Panel.
2. DVOW
   a. Headset is attached to Voice Orderwire Control Unit (VOCU) panel
   b. Audio signal (0-4 KHz)
   c. Voice Orderwire Control Unit
   d. Data rate 16Kbps (synchronous)
   e. KY-58 provides encryption (TRI-TAC RS-422 format)
3. Orderwire Data Patch
   a. Orderwire output in TRI-TAC format
   b. Normal through connects OW to OAC-170D for signal conversion
   c. Patched to DAR modem
**Unit 3**
Major Systems and Functions

**NOTE:** Show slide #27

4. **OAC-170D**
   - Converts TRI-TAC to RS-422 format
   - RS-422 Signal routed to CS6716 Modem
5. CS6716 Modem  
   a. Multiplexer/Modulator Function  
      1. RS-422 from the OAC-170D is input on User Service Channel 1  
      2. User channel 1, BERT, High Speed Data Channel and overhead are multiplexed (User SC 2 not used currently)  
      3. Aggregate from the multiplexer is sent to modulator to QPSK modulate it on a 70MHz carrier  
      4. Outputs 70 MHz IF signal to IF Data Patch Panel for Tx1  
   b. De-multiplexer/De-modulator Function  
      1. CS6716 Modem receives the four IF inputs from the OAC-170D.  
      2. The de-modulator removes the 70 MHz carrier and send aggregate to de-multiplexer  
      3. The de-multiplexer separates the channels and routes the OW signal to the User Service Channel 1 output  
      4. The RS-422 outputs from User Service Channel 1 is routed to the OAC-170D inputs.
46. True or False. In order to use the Orderwire with the CS6716 Modem, it must be patched in on the IF Data Patch panel.
51. What component converts the Orderwire signal format?
D. Distortion Adaptive Receiver (DAR) Modem Variant Path

1. Overview
   a. Changes to signal path: The OW has to be patched in to work with the DAR Modem
      IF Data Patch Panel
      U-Links have to be moved from the top 2 rows of jacks to the bottom 2 rows.
   b. Data output maximum of 4.608 Mbps
   c. Digital Group Multiplexer (DGM) gear (LGM, GM, TGM) patched in and data settings made.
   d. DGM thumbwheel settings and switch positions made
   e. Refer to TM 11-5820-934-13-2-1, VOL 1 for specific patching and data thumbwheels settings for the DGM gear.
In this section we will cover the DAR Modem path variant:
1. Transmit Signal Flow
2. Receive Signal Flow
3. Orderwire Signal Flow
2. Transmit Signal flow
   a. Signal Entry Panels
      407L Cable for analog subscriber loops
      CX-11230 Cable for CDI groups
      Field Wire, Phone wire for subscriber loops
   b. Digital Group Multiplexing Equipment
      Group Modems: process DTGs, 128-4608 KHz
      Loop Group Multiplexers: process up to 16 analog and digital loops, 128-576 KHz
      Trunk Group Multiplexer: Highest level multiplexer in the DAR equipment side.
      Operates in Master timing only, up to 4608KHz.
   c. Transmit Tropo Modem
d. IF Data Patch Panel

- Here one can patch each component of the Digital Group Multiplexing (DGM) gear into the system.
- Everything has to be physically patched: Loop Group Multiplexers, Group Modems, Trunk Group Multiplexer, Super Group, TED1 and TED2 are all patched here.
- The timing signal has to be patched in as well as the resync signal.
3. Receive Signal flow
   a. IF Data Patch Panel
   b. Receive Tropo Modem
   c. DGM equipment
      Highest Data rate has to be unencrypted
      Patched to Group 1 of TGM
      Frame format compatible with TGM
   d. Signal Entry Panels

Supporting info:
   • The receive DAR path differs first at the IF Data Patch Panel.
   • U-Links are installed in bottom 2 jacks, RX1-RX4
4. Orderwire Signal flow
   a. DVOW to DAR ORDERWIRE patch
      • That connects the transmit and receive orderwire path for the DAR Modem
      • The rest of the orderwire path is the same as for the CS6716 Modem

Supporting info:
   Patch DVOW connector to DAR ORDERWIRE on the IF Data Patch panel
57. Pick the correct definition for the term DTG.
   a. Digitally Timed Group
   b. Data Test Group
   c. Diphase Transmit Group
   d. Digital Test Group

59. Match the following items.
   a. LGM Digital and analog subscriber loops
   b. TGM Process DTGs, performs signal conversion
   c. GM Operates in master timing only
SUMMARY:

1. During this lesson, you were given an overview of the mission data signal flow through the AN/TRC-170(V)3. We covered each component that the user mission data signal passes through and what it does to/for the signal. We covered the transmit signal path, receive signal path, orderwire signal path and DAR Modem Variant signal path for the AN/TRC-170(V)3 Digital Troposcatter Communications System.

2. Ask the instructor questions to clarify any misunderstandings.

THE END
TITLE: Operations

LEARNING OBJECTIVES:

Action: The student will be able to describe and demonstrate the power-up, setup, and normal operation of each system component of the AN/TRC-170(V)3 Digital Troposcatter Communications System.

Conditions: The student will be given informal lecture and demonstrations on the power-up, setup, and normal operation of each system component of the AN/TRC-170(V)3.

Standard: The student will be able to correctly describe the key concepts of the power-up, setup, and normal operation and to demonstrate the correct power-up, setup, and normal operation of each system component of the AN/TRC-170(V)3.

SAFETY CONSIDERATIONS: Be aware of the possibility of electrical shock when working with electronic equipment. Be aware of lift hazards, observe safety regulations.

RISK ASSESSMENT: Medium to High

RESOURCE NEEDS/REFERENCES: Communication System AN/TRC-170(V)3, Powerpoint Presentation “Unit4”, Laptop and Overhead Projector, TM 11-5820-934-13-2, CSI Manual 142F009900-1 and AN/TRC-170(V)3 Student Studyguide

METHODS OF INSTRUCTION: Informal Lecture, Demonstration and Performance

TIME: 40.0 Academic and Performance Hours
INTRODUCTION:

Elapsed Time
During this period of instruction, you will be given a safety briefing specific to the AN/TRC-170(V)3 and then an informal lecture and demonstrations of the power-up, setup, and normal operation of each system component of the AN/TRC-170(V)3. Understanding this information will provide the base which will enable the operator to become proficient AN/TRC-170(V)3 operators.

Overview:
- Safety
- Prime Power
- Shelter Turn-On Procedures
- System Operation
NOTE: Show slide #3

BODY:
A. Safety:

• Safety is a vital part of this training since this equipment operates using high voltage and emits radiation.
• Part of safety is understanding the risks of electrostatic discharge, moving heavy equipment hazardous materials and hearing loss, which is why special training is required.

Topics:
• High Voltage
• Radiation Hazards
• Electro Static Discharge (ESD)
• Heavy Equipment
• Hazardous Materials
• Hearing Loss
• Training required
NOTE: Show slide #4

Before working on or around energized electrical equipment such as the AN/TRC-170(V)3 van, a safety briefing discussing potential hazards and methods of controlling those hazards is required.

1. Personnel Hazards:
   • These are hazards that can cause death or serious injury to personnel.
   • It is everyone’s responsibility to stop any potential personnel hazard from occurring during this class.
   • Safety training is required to work on and around electrical equipment.
   • Refer to the safety manager for specifics.

   a. High Voltage:
      Power cables, generators, power distribution panels and power supplies are the most common sources of high voltage present around the AN/TRC-170(V)3.
      • Trained safety observer present
      • Remove watches, rings and jewelry
b. Radiation Hazards:
   - HPA
   - Open waveguide ports (found on either side of shelter door (rear of HMMWV))
   - Antenna

**CAUTION:** Do not transmit with open waveguide ports or with someone directly in front of the antenna.

*NOTE: Waveguide ports and antennas are the most common sources of RF energy for this class.*

c. Radiation Hazard Zone (down range)
   - Be aware of radiation hazard zone.
   - The eyes are particularly vulnerable to RF energy in the microwave range, and prolonged exposure to microwaves energy can lead to cataracts.
Student Studyguide

Unit 4
Operations

NOTE: Show slide #6

Here is the Radiation Hazard Zone for the AN/TRC-170 using the QRA.

Please note the following features:

1. The RF Hazard Zone is diagramed out using a zero degree takeoff angle.
2. The RF Hazard Zone is 8.5’ off the ground, it doesn’t extend down; however, it is required to rope off the RF Hazard area at ground level.
3. The RF Hazard area begins 8.5’ from the ground and extends 7’ up. It is a 7’ diameter circle extending out of the QRA.

Remember, this is not practical since the antenna will usually be set at a positive take off angle. Assuming you are on a flat earth plane, a positive takeoff angle will result in the RF Hazard zone being higher above ground as you go down range from the antenna. A negative takeoff angle will result in the RF Hazard zone being lower to the ground as you go down range from the antenna.

Note: A periodic radiation safety check will be conducted at each site.
Electro-Static Discharge (ESD):
- Hazards to equipment
- Damages and/or destroys electronic components
- Precautions
  - Electrostatic Wrist Strap
  - Use Electrostatic Discharge Bag to transport electronic equipment
c. Heavy Equipment:
   • Set-up and tear down of the Quick Reaction Antenna is the most common source of heavy equipment hazards.
   • Items over 35 Lbs require 2 man lift
   • Gloves and hardhats required for set-up / teardown

Remember:
   Lift correctly by bending knees and keeping back straight!
Hazardous Materials

- Flammable – Fuel, Solvents, Paints
- Corrosive – Fuel, Battery Acid
- Reactive – Power Supplies
- Magnetic – HPA Klystron
- Compressed Gas – Fire Extinguishers

- Be aware of the hazardous materials and substances encountered during normal day-to-day operation and maintenance of this radio system.
- Hazardous materials training is also required prior to working on or around hazardous materials. Refer to the training manager for specifics.

- Hazardous Materials:
  - Flammable – Fuel, Solvents, Paints
  - Corrosive – Fuel, Battery Acid
  - Reactive – Power Supplies
  - Magnetic – HPA Klystron
    - As part of the equipment check-out and maintenance, the Klystron tube has to be checked for radiation or leakage, etc. every 3 years.
  - Compressed Gas – Fire Extinguishers
Hearing Loss

Prevent **hearing** loss due to noise and other environmental factors when working in a Hazardous Noise Environment.

- Use Ear Protection when near Hazardous Noise sources such as motor generators, ECU's and pionjars.

**Remember:**

*Long duration and repeated exposure causes the damage.*

**NOISE EXPOSURE TIME LIMITATIONS** (unprotected)

<table>
<thead>
<tr>
<th>Noise Level</th>
<th>Exposure Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 dBA</td>
<td>8 hrs</td>
</tr>
<tr>
<td>95 dBA</td>
<td>4 hrs</td>
</tr>
<tr>
<td>100 dBA</td>
<td>2 hours</td>
</tr>
<tr>
<td>105 dBA</td>
<td>1 hour</td>
</tr>
<tr>
<td>110 dBA</td>
<td>30 minutes</td>
</tr>
<tr>
<td>115 dBA</td>
<td>15 minutes</td>
</tr>
<tr>
<td>120 dBA</td>
<td>8 minutes</td>
</tr>
<tr>
<td>125 dBA</td>
<td>4 minutes</td>
</tr>
<tr>
<td>130 dBA</td>
<td>2 minutes</td>
</tr>
</tbody>
</table>

**SOME EXAMPLES OF ENVIRONMENTAL NOISE LEVELS**

<table>
<thead>
<tr>
<th>Noise Level</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>130 dBA</td>
<td>Pionjar, jackhammer</td>
</tr>
<tr>
<td>120 dBA</td>
<td>Ambulance siren, Thunder clap</td>
</tr>
<tr>
<td>115 dBA</td>
<td>Sandblasting</td>
</tr>
<tr>
<td>110 dBA</td>
<td>Woodworking shop</td>
</tr>
<tr>
<td>100 dBA</td>
<td>Pneumatic drill, Chainsaw</td>
</tr>
<tr>
<td>90 dBA</td>
<td>Lawn mower, generator, 2 ½ ton truck engine</td>
</tr>
</tbody>
</table>
Specific Army provided Safety Training is recommended before working on energized electrical circuits or other AN/TRC-170(V)3 equipment.

1. CPR training
2. First Aid
3. Hazardous Materials

True or False. The Class Leader is responsible for monitoring all potential safety violations.

Pick the correct statement.

a. Prolonged exposure to RF energy can lead to cataracts.
b. A trained safety observer is not required to be present when working on equipment.
c. An open waveguide port is an example of a high voltage hazard.
d. Items weighing 25 lbs require a two man lift.
Prime Power: External power source that provides electrical power to the AN/TRC-170(V)3 radio system.

We will discuss the frequency and voltage required to operate the radio system.

Always check the power requirements for the radio system prior to connecting power.

1. Voltage: This is the operating voltage for the AN/TRC-170(V)3.
   120 / 208 VAC
2. Phase
   3-Phase, 5-wire
3. Frequency:
   The AN/TRC-170 would originally run on 400, 60, or 50 Hz.
   With the upgraded modem, it runs on 50 or 60 Hz only!
   60 Hz for CONUS
   50 Hz for OCONUS
4. Load:
   10 kW without Environmental Control Unit (ECU)
   15 kW with ECU

Note: Check with power production personnel if there is any doubt a generator can handle the load of a AN/TRC-170(V)3, with and without the Environmental Control Unit (ECU) connected.
C. Initial Turn On Procedures: Follow these steps in order:

1. Prime Power Application
   a. Shelter Ground connection
      • Appropriate Ground connected to power entry panel
      • Signal Entry Panel (SEP) grounded
   b. Primary Power Source
      • Connected to shelter but not turned on
   c. Shelter Air Vents Opened
   d. Exterior Circuit Breakers (CB) OFF
Initial Turn On Procedures

Prime Power Application
- Interior Power Distribution Panel CBs OFF
- Rack Mounted Power Switches OFF
- Primary Power Source ON
  - Check Frequency, 50 / 60 Hz

e. Interior power distribution panel CBs off
f. Rack Mounted Power Switches OFF
g. Primary Power Source ON:
  Turn on generator and check the output frequency at the generator itself. Use frequency meter on the generator.
  - Check Frequency, 50 / 60 Hz

Note: Check interior power distribution panel CBs off twice.
Initial Turn On Procedures (cont.)

Prime Power Application
- Exterior Main & Interior Main CBs ON
- Light CB ON
- Set Light Interlock Override switch to Override
- Voltage of each phase should be 120 +/- 12 VAC

CAUTION! Voltage of each phase must agree within +/-5 VAC. Do not continue if the voltages or frequency is out of tolerance.

h. Exterior Main & Interior Main CBs ON:
   - The Exterior Main CB is on the Exterior power distribution panel and the Interior Main is on the inside of the shelter, on the Main Power Distribution Panel.
   - Light CB ON:
     - Interior lights will come on now if Interlock Switch is already in the over ride position and the light fixture on/off switches are in the on position.
     - If lights do not come on, continue to next step, if they do come on, skip the next step.
   - Set Interlock Override switch to override:
     - Interior lights should be on now.
     - If not, check on/off toggle switch on light fixtures.

i. CAUTION!
   - Voltage of each phase must agree within +/-5 VAC.
   - Do not continue if the voltages or frequency is out of tolerance.
Initial Turn On Procedures (cont.)

Prime Power Application
- Phase Select Switch to A
  - Voltmeter reads 120 +/- 12 VAC
  - Frequency Meter reads 60 +/- 1 Hz
- Repeat for Phases B & C

j. Phase Select Switch to A
   - Voltmeter reads 120 +/- 12 VAC
   - Frequency Meter reads 60 +/- 1 Hz - CONUS
     50 +/- 1 Hz - OCONUS

k. Repeat for Phases B & C
   This is accomplished by switching the “Phase Select” to “B” then to “C”
Initial Turn On Procedures (cont.)

Prime Power Application
- DGM CB OFF unless DAR is being used
- CS6716 CB ON
- LVPS 1/2 ON
- FAN PWR CONV CB ON
  - AC to AC converter Input Power indicator on

I. DGM CB OFF unless DAR is being used.
   - If DGM gear is being used, turn on rack power switches for components being used.
     - Example: LGM, GM and TGM power switches.
   - DGM power indicators ON.

m. CS6716 CB ON

n. Low voltage power supply (LVPS) 1/2 circuit breaker ON: Check LVPS front panel indicators on both LVPS. Power indicators ON.

o. FAN PWR CONV CB ON: Listen for the sound of the Blowers coming on when turning on the Circuit Breaker. Look at the AC to AC Converter and make sure the Input Power Indicator is ON.
NOTE:  Show slide #18

p. If HPA is being used, make sure Tropo Mode LED is On and turn ON the HPA CB
q. If HPA is not being used, make sure LOS Mode LED is On and the HPA CB is OFF
r. Verify Dummy Load LED ON
s. If Voice Orderwire Alarm sounds, press and release the SUPPR / TEST pushbutton.
t. If Fault Summary Alarm on VOCU is on, press and release the reset pushbutton.
Student Studyguide

Unit 4
Operations

NOTE: Show slide #19

Hands-on/Performance

• Instructor demonstrates Initial Turn On Procedure (Walk Through)

• Students will perform Initial Turn On Procedure
The operating voltage of the AN/TRC-170(V)3 is:

a. 220 / 440 VAC
b. 110 / 220 VAC
c. 120 / 208 VAC
d. 50 / 60 Hz

True or False. Input voltage to the AN/TRC-170 must agree within +/- 8 VAC of each phase.
D. System Operation

Now the AN/TRC-170(V)3 is powered up and it’s time to discuss the normal operation of each major component.

We will cover the following:

- VersaMux™ 4000
- IF Data Patch Panel
- CS6716 Modem
- OAC-170D
- Troposcatter Radio
- HPA
- DVOW
- QRA

We will finish this block with a section on link activation.
1. VersaMux™ 4000:
   Refer to the VersaMux 4000 Operation and Installation Guide chapters 4 and 5 for more information. This Operation Guide will be on-site. *(Refer to in the Modem Upgrade Manual, 142F009901-1 “Installation Manual for AN/TRC-170 (V3/V5) Modem Upgrade”)*

a. Power-Up and Basic Navigation:
   • The VersaMux assigns ports numbers and refers to them by that number.
   • The VersaMux interface is via the front panel keypads, or the terminal interface (control port).
   • During power-up the VersaMux 4000 performs a series of self-tests to check for correct operation.
   1) Port Numbering Convention:
      • There are 5 ports on the VersaMux 4000: Four group ports and one aggregate port.
      • The 5 ports are numbered from left to right looking at the rear of the VersaMux 4000 with ports 1-4 made up of a group of 4 connectors each and port 5 being the aggregate port.
   2) Front Panel Interface:
      • This contains the display screen and 5 keypads.
      • The LCD screen has 2 lines of up to 16 characters each. Main Menu screens are displayed on the top line, with the bottom line blank.
      • Up Arrow Key - Down Arrow Key - Left Arrow Key - Right Arrow Key - Enter Key
      • Main Menu Options are:
         • Alarm-Status
         • Configure
         • Activate
         • System-Info
         • Statistics
         • Diagnostics.
      • Scroll through these with the Left / Right arrow keys.
      • Sub Menu Options are selected by pushing the Down arrow key.
      • Items can be Read Only or Informational or Read / Write (Edit)
b. Planning the Timing:

The VersaMux 4000 can accept timing from one of the following choices:

1) Aggregate Timing (NRZ Interface): The VersaMux 4000 recovers the master clock from the transmission uplink via the Aggregate Interface.
2) External Clock Input Timing: The VersaMux 4000 can accept an external clock reference such as from a GPS or station clock. *This is the only configuration used. The VersaMux 4000 receives an external 10 MHz clock from the Rubidium Standard coming from the OAC-170D. This is connected via the external clock ref bnc connector on rear of VersaMux 4000.*
3) Port Timing: The VersaMux 4000 can also accept timing from any of its group ports.
4) Internal Oscillator Timing: The VersaMux 4000 can generate its own timing source if required.
c. Operating Instructions

1) Main Menu:
   • Operating instructions are entered by using the keypads and LCD display.
   • Configure the VersaMux 4000 using the Front Panel Interface.
2) Alarm-Status:
   • Alarm status is monitored from the Alarm-Status selection of the main menu.
   • For specific alarm codes, refer to page 5-5 of VersaMux 4000 manual, contained as part of Manual No. 142F009900-1.
   • Scroll down through the active alarms by using the Up and Down arrow keys.
3) Configure: Enter configure parameters via the Configure key on the main menu.

Options are:

- **Select System parameters for:**
  - Clock Reference (Clk-Ref)
  - External Clock type (Ext-Clk-Type)
  - Front Panel lighting brightness level (FP-Lighting)

**Offline:**
- Allows programming the offline configuration without disturbing the online configuration.
- Once done, it can be placed online by using the Activate parameter.
- The parameters can be set for the following parameters:
  - Aggregate
  - Port-1
  - Port-2
  - Port-3
  - Port-4
  - Copy-Configuration

- **Active:**
  - Allows checking the online configuration.
  - Will not allow editing any settings in this mode.

- **CAU:**
  - Crypto Ancillary Unit parameter displays sub-menu parameters and their values.
    - KG-Resync
    - Resync-Delay

- **Management:**
  - Check factory settings (not used by operators)
4) Activate:
   - This parameter allows the operator to make the “Offline” or “Undo” configuration the active one.
   - Select the configuration to make active by selecting the Activate Configuration Option:
     - No:
       - Selecting this option to return to the Activate menu without making any changes.
     - Offline:
       - Selecting this option to activate the offline configuration.
     - Undo:
       - Places the configuration being taken offline as the Undo configuration.
       - Activate the Undo option to reinstate the selection as an active option.
5) System-Info:
   Sub-menu contains the following options:
   • Conditions:
     • Contains system conditions and internal switch settings
   • Inventory:
     • Contains an inventory of card types, hardware and revisions
System Operation – VersaMux 4000 (cont.)

Operating Instructions

- **Statistics**
  - **Alarm-Stats:** Displays a list of the alarms, and the number of occurrences of each, that have occurred since the last reset. In addition, this item enables the operator to reset the alarm statistics.
  - **Aggregate Stats:** Displays the number of frame losses, the number of frames transmitted, and the number of frames received. In addition, this item enables the operator to reset the alarm statistics.
  - **Bandwidth Stats:** Displays the overall bandwidth that includes; Aggregate bandwidth, Total bandwidth utilized (ports + overhead), Spare bandwidth, Overhead bandwidth, Port-1 bandwidth, Port-2 bandwidth, Port-4 bandwidth and Port 5 bandwidth.

Review

The timing configuration used for the VersaMux 4000 is ___.

- a. External Clock
- b. Port Timing
- c. Internal Oscillator Timing
- d. Aggregate Timing
2. IF Data Patch Panel:
   - For normal operation, U-Links, also known as looping plugs, must be installed.
   - Data patches are NOT installed
   a. IF:
      - Contains IF jacks for TX and RX to and from Up and down-converters and IF Loop panel
   b. Data:
      - Contains M & C ports, Ethernet connections, DVOW, TED
Student Studyguide

Unit 4
Operations

NOTE: Show slide #31

- LEDs,
  - Status
  - Alarms
- Keypad
- Display

1. The Status LEDs are Online: if the modem is online and functioning properly
2. Data Traffic: if there is traffic on the modem
3. RX Sync: If the receiver is locked to the RF signal
4. Power Control On: ALPC is active
3. CS6716 Modem
   a. Power-Up Initial Procedure
      • Verify U-links installed for CS6716
      • Remove any digital data patch cables
   b. Power-Up Procedure
      • At AC Distribution panel, switch breaker labeled “CS6716” to ON
      • Verify 10 MHz oscillator
      • Modem automatically performs diagnostics and AGC calibration
Student Studyguide

Unit 4
Operations

NOTE: Show slide #33

System Operation – CS6716 Modem (cont.)

Internal IF Loop
- Verifies correct operation of the modem
- Modem synchronizes
- RX SYNC LED (green) illuminates
- MAJOR ALARM (red) extinguished

C. Internal IF Loop:
- Verifies correct operation of modem quickly, without external equipment.
- From top level menu, select DIAG, then LOOPBACK, then LOCAL IF.
  - Modem synchronizes
  - RX SYNC LED (green) illuminates
  - MAJOR ALARM (red) extinguished
System Operation – Hands-on/Performance Check Point

- Instructors demonstrate *Pre-Power-Up, Power-up, and Internal IF Loop*
- Students perform *Pre-Power-Up, Power-up, and Internal IF Loop*
d. Initial Modem Configuration
   - Modem is shipped pre-configured with an aggregate data rate of 2 Mbps.
   - The VersaMux™ 4000 is configured for Port 1-relay mode and a 2 Mbps aggregate data rate.
Student Studyguide

Unit 4
Operations

NOTE: Show slide #36

Default Configuration

- Starting point for initial link acquisition
- Provides maximum receive sensitivity
- To select default configuration:
  1. Press any key from Opening Screen (to display MAIN MENU)
  2. From the MAIN MENU, select ON/OFFLINE, press ENT
     • Select OFFLINE, press ENT then press CLR
  3. From the MAIN MENU, select CONFIG, press ENT
     • Select DEFAULT, press ENT, press ENT, then press CLR
  4. From the MAIN MENU, select ON/OFFLINE, press ENT
     • Select ONLINE, press ENT, then press CLR

e. Default Configuration

- Starting point for initial link acquisition
- Provides maximum receive sensitivity
- To select default configuration:
  • Press any key from Opening Screen
  • From the Main Menu, select ON/OFFLINE, press ENT
    • Select OFFLINE, press ENT then press CLR
  • From the Main Menu, select CONFIG, press ENT
    • Select DEFAULT, press ENT, press ENT, then press CLR
  • From the Main Menu, select ON/OFFLINE, press ENT
    • Select ONLINE, press ENT, then press CLR
Review Default Configuration settings.

<table>
<thead>
<tr>
<th>System Control</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate (DATA CH RATE)</td>
<td>2 Mb/s</td>
</tr>
<tr>
<td>Service Channel #1 Rate</td>
<td>16 Kb/s</td>
</tr>
<tr>
<td>Service Channel #2 Rate</td>
<td>0 Kb/s</td>
</tr>
<tr>
<td>Loopback</td>
<td>Normal</td>
</tr>
<tr>
<td>Adaptive Link Power Control (ALPC)</td>
<td>OFF</td>
</tr>
<tr>
<td>Forward Error Correction (FEC)</td>
<td>ON</td>
</tr>
<tr>
<td>Bit Error Rate Tester (BERT)</td>
<td>ON</td>
</tr>
</tbody>
</table>

Rate 2Mb/s
Service Channel #1 Rate 16 Kb/s
Service Channel #2 Rate 0 Kb/s
Loopback Normal
Adaptive Link Power Control OFF
Forward Error Correction ON
Bit Error Rate Tester ON
NOTE: Show slide #38

Initial Upgrade Configuration – Hands-on/Performance Check Point

CS6716 Modem Default Configuration
- Instructor demonstrates the procedure
- Students perform the procedure
True or False. The VersaMux 4000 can accept a timing input from a GPS system.
True or False. The VersaMux 4000 can accept timing from any of its group ports.
System Operation

In this section we will cover system operation of the OAC-170, the Troposcatter Radio components and the High Power Amplifier.
4. OAC-170D
   a. Pre-Power-Up Procedure
      • Set FILTER SELECT switch to desired bandwidth
      • Set OSC SELECT to AUTO
b. Initial Power-Up

- Apply +48 Volts Direct Current
- ALARM LED Illuminates
  - Green means no faults
  - Red means unit is in alarm condition
- Possible alarm conditions
  - DC/DC converter failure
  - Internal temperature above 149°F
  - OSC SELECT not in AUTO
NOTE: Show slide #43

Note where the MAINT LED is on the slide above.

The MAINT LED will flash yellow at a 1 second rate.
When the maintenance LED is flashing, output is disabled.
c. Rubidium Oscillator Warm-Up
   • 10 minute delay for oscillator warm-up
   • Oscillator outputs checked at 1-minute intervals
   • First oscillator to stabilize will switch online as long as it is in the Auto Mode
e. Normal Operation
   - Power level of the six 10 MHz outputs 0 dBm ± 1 dB
   - Critical operation maintained during failure of 1 DC/DC converter and/or 1 rubidium oscillator
5. Troposcatter Radio
   a. Up-Converter
      • Set for operating frequency as directed
   b. Down-Converter
      • Set for receive frequency as directed
      • Adjust Pre-Selectors
      • Adjust Post Selectors
      • Noise Test Switches OFF
Student Studyguide

Unit 4
Operations

NOTE: Show slide #47

c. Dual RF Synthesizer
  • Set transmit side to operating frequency and tune Phase Lock Loop (PLL) Circuit by adjusting Tuning knob until meter is in the green area and summary fault is off.
  • Set receive side to operating frequency and tune Phase Lock Loop Circuit by adjusting Tuning knob until meter is in the green area and summary fault is off.
Student Studyguide

Unit 4
Operations

NOTE: Show slide #48

System Operation –
Hands-on/Performance Check Point

- Instructors will demonstrate up-converter, down-converter, RF Synthesizer procedure
- Students will perform up-converter, down-converter, RF Synthesizer procedure
True or False: For normal operation, U-Links must be installed on the IF Data Patch Panel.

Pick the incorrect statement about the OAC.
   a. The oscillator with the highest gain will switch to online
   b. First oscillator to stabilize will switch to online
   c. 10 minute delay for oscillator warm-up
   d. Oscillator outputs checked at 1 minute intervals
d. HPA Setup
   • In this section we will go over HPA tuning procedures.
   • In the System End-to-End block we will put everything we have learned together.
   • HPA Tuning checklist handout

**Warning** – Never have open waveguide ports. Open waveguide ports expose personnel to radiation
Student Studyguide

Unit 4
Operations

NOTE: Show slide #51

Make sure this switch is OFF prior to turning on the HPA power circuit breaker.
• Make sure the CONTROL-BEAM VOLTAGE Toggle switch is OFF prior to turning on the HPA power circuit breaker.
• BITE compartment contains the alarm matrix panel for HPA
System Operation – High Power Amplifier (cont.)

HPA Tuning Compartment
- Match Serial Numbers
- Tune to nearest specified frequency
- Turn TUNERS 1-5 to match CAV values 1-5

HPA Tuning Compartment
- Match Serial Numbers
- Tune to nearest specified frequency
- Turn TUNERS 1-5 to match CAV values 1-5
Student Studyguide

Unit 4
Operations

NOTE: Show slide #53

HPA Tuning Compartment
  • Turn Bandpass Filter Dial to specified transmit frequency
  • Drive Adjust control fully CW

Instruction Notes:

  • Dial up the number, do not dial down to the number.
  • If tuned past the number, go down one complete turn, then back up to the desired setting.
  • Never pass zero on the Klystron.
Before activating the HPA, wait for the filament to warm up. This is done once the “FIL” LED is lit, which takes approximately 5 minutes.

- Note the location of this LED.
- Now turn switch to Beam X 1K.
- The BITE compartment is located at the top left of the HPA cabinet.
- The RANGE toggle switch in the BITE compartment is set for either HI or LO.

_Instructor Note:_

*If the operator attempts to turn on the unit before 5 minutes, the unit will fault out and the five-minute waiting period will re-start.*
• Make sure drive adjust is fully attenuated before proceeding.
• Turn the Control Beam Voltage switch to ON.
• Then rotate Klystron switch to Beam X 1K.
• Observe 6 KV +/- .1 KV in the LO setting, or observe 7.6 KV +/- .1 KV in the HI setting.
NOTE: Show slide #56

- Note the RF INPUT meter on the slide above.
- Rotate meter select to the DRIVE position.
NOTE: Show slide #57

- Note the RF OUTPUT TROPO REFLECTED PWR meter on the slide above.
- Rotate selector to KLYSTRON position.
System Operation – High Power Amplifier (cont.)

- For LO beam voltage setting, turn DRIVE-ADJUST control to obtain a reading of .2 kW on RF OUTPUT-TROPO "FORWARD PWR" meter.
- For HI beam voltage setting, turn DRIVE-ADJUST control to obtain a reading of 0.4 kW on RF OUTPUT-TROPO "FORWARD PWR" meter.

• Note the Drive Adjust control on the slide above.
• Adjust this control for the appropriate drive level according to whether they are in the LO power setting or the HI power setting.
• Observe the RF OUTPUT TROPO FORWARD PWR meter (shown on previous slide) while adjusting the drive adjust control for the proper level.
• Note the RF OUTPUT TROPO FORWARD PWR meter on the previous slide.
System Operation – High Power Amplifier (cont.)

Hold DRIVE-ADJUST/CALIBRATE switch in CALIBRATE, and adjust compression calibration control to obtain DRIVE meter reading in green area

Compression Calibration Control

Drive Meter & Calibrate Switch

Hold DRIVE-ADJUST/CALIBRATE switch in CALIBRATE, and adjust compression calibration control to obtain DRIVE meter reading in green area.

- Note the gain compression control on the slide above, and also the DRIVE-ADJUST/CALIBRATE toggle switch on the slide 2 views prior.
- Go briefly to that slide and note the toggle switch.
- Point out that this switch is spring loaded: Hold it in the calibrate position while adjusting the gain compression adjust.
System Operation – High Power Amplifier (cont.)

- Set KLYSTRON meter select switch to BODY X 0.01
- Meter should not read above 50 milliamps (5 on meter) during the rest of this procedure

• Note the KLYSTRON meter on the slide above. Rotate the meter select switch to the BODY X 0.01 position.
• Meter should never read above 50 milli-amps during the rest of this procedure. A reading greater than 50 means that the unit is improperly tuned.
NOTE: Show slide #61

Hold DRIVE-ADJUST/CALIBRATE switch at ADJUST while adjusting Drive Adjust control to obtain a reading in the green area, or 5 (50 mA) on the KLYSTRON meter, whichever occurs first.
System Operation –
Hands On / Performance Check Point

- Instructor demonstrate HPA Tuning procedure.
- Students perform HPA Tuning procedure.

NOTE: Show slide #62
Student Studyguide

Unit 4
Operations

NOTE: Show slide #63

Time for questions
During this portion of the training we will be covering the DVOW, the QRA, and Link Activation procedures.
6. Digital Voice Orderwire:
   - The following is for informational purposes only.
   - This class will not have access to crypto keys for crypto gear.
     a. KY-58
        - Power switch on
        - Mode switch to zero all
        - Fill device (KYK-13) with key attached to panel
        - Handset: noise only
        - Mode switch to load
        - KYK-13 turned ON, key selected
        - Handset Push-to-Talk
        - Handset: no noise
        - Handset Push-to-Talk
        - Turn off and remove KYK-13
        - KY-58 mode switch to crypto
7. Quick Reaction Antenna:
   - The normal operation of the QRA begins with site preparation.
     - This involves the proper trailer positioning and then proper shelter positioning.
     - After we learn how to do this we will learn about trailer orientation and antenna erection procedures.
     - The key point to remember is that if the antenna isn’t positioned correctly, the radio link will not work!
   - Hard Hats and gloves must be worn when setting up or tearing down the antenna system.
     - Some items are heavy and require 2 man lifting.
     - Watch out for pinch points when removing pins from items that swing out when unpinned.
     - Care must also be taken when jacking up the antenna.
     - Make sure that antenna jackscrew is turned in the proper direction as damage to the trailer can occur if the jackscrew is turned in the wrong direction.
   - Lightning Protection Assembly (LPA) Erection Procedure

We will be reviewing the setup procedures for the QRA. Later on, in System End-to-End, we will actually setup the equipment.
Site Preparation

- **Trailer Siting**
  - Remove Pocket Compass from Accessory case in QRA
  - Mark rough Center position for trailer
  - Mark transmission azimuth direction
  - Mark trailer tongue position
a. Review the Site Preparation and Initial Trailer setup checklists.
b. Antenna Erection
NOTE: Show slide #69

Make sure personnel have safety equipment on prior to actually performing these steps.

Site Preparation:
- **Trailer Orientation**
  - Position Trailer using tow vehicle
  - Pin Dead Leg in place before disconnecting from tow vehicle
  - Disconnect trailer from tow vehicle
  - Make final alignments to trailer and set brakes
Student Studyguide

Unit 4
Operations

NOTE: Show slide #70

(Site Preparation Continued)

- Undo Tarpaulin tiedowns
- Lift Endflaps
- Release Baseplate fasteners
- Remove jack struts
NOTE: Show slide #71

(Site Preparation Continued)

WARNING: Caution needs to be used when unpinning the jacks as they will swing out and down when unpinned from mounting bracket.

- Position Jack Struts and Baseplates
- Unpin Jacks
- Attach jack struts and captive pins
- Position Baseplates
System Operation – Quick Reaction
Antenna (cont.)

Site Preparation
- Adjust Handcrank until jack ball is seated
- Adjust handcranks to raise trailer off ground

(Site Preparation Continued)
- Remove handcranks from tailgates
- Adjust handcrank until jack ball is seated
- Adjust handcranks to raise trailer off ground
System Operation – Quick Reaction
Antenna (cont.)

Antenna Erection

- Trailer Leveling
- Removal of Trailer Tarpaulin
- Unloading of Feedhorns and Spars

Antenna Erection

Make sure trailer is leveled properly before standing on trailer.
- Level trailer using sight bubbles (2) mounted on trailer
- Remove trailer tarpaulin and tarp supports
- Unload Feedhorns and Spars
System Operation – Quick Reaction
Antenna (cont.)

Antenna Erection
• Unloading Reflectors

- Handle Reflectors with care.
- Do not drop reflectors when unloading them.
- Do not place them face down on the ground.
Handle Extension tubes carefully.

Note mounting instructions in checklist and observe slide above.
  • Attachment of Forward and Rear Extension Tubes
System Operation – Quick Reaction Antenna (cont.)

- Attachment of Forward and Rear Azimuth Actuators
- Hand-tight screws

- Handle Extension tubes with care as one end is heavier than the other.
- Line up alignment pins on extension tubes and insert carefully.
- Tighten retaining screws hand-tight only.
System Operation – Quick Reaction
Antenna (cont.)

NOTE: Show slide #77

- Remove and Install Azimuth Actuators.
- Before raising the antenna, release the tie-down strut.
Carefully attach reflectors to mounting hubs as shown above.
Attach Forward and Rear Feedhorns and AZ/EL Sensor on Rear Antenna
Antenna Erection Continued

- Attach Rear Feedhorn
- Attach messenger cables
- Attach Antenna Waveguide and cables
Antenna Erection continued

- Make sure only one person turns jack to raise the antenna, turning it in the counter clockwise direction.
- After being fully raised, engage pintle locks on folding arms.
- Connection of Antenna to Shelter
- AZ/EL Mechanical Adjustment
System Operation –
Hands-On Point, QRA Setup

Instructor demonstrates QRA Setup procedure.
Students perform QRA Setup procedure.

NOTE: Show slide #81
Review Lightning Protection Assembly instructions.

- Refer to T.M. 11-5820-934-13-2-1, para 2-6.3.
- Pass out copies of LPA Setup Procedure.
- For this class we will not be setting up the Lightning Protection Antenna but we have included a checklist for students to use.
8. Link Activation Procedure:

Review link activation procedures.

HANDOUT: Shelter Setup and Grounding Procedures.

- Review Shelter Setup Procedure
- Review Shelter Grounding Procedure
- Review Prime Power Application
- Review Power Up of All Major Components
- 39H55M
Student Studyguide

Unit 4
Operations

NOTE: Show slide #84

SUMMARY:

1. During this lesson you were given a safety briefing specific to the AN/TRC-170(V)3 and then informal lectures and demonstrations of the power-up, setup, and normal operation of each system component of the AN/TRC-170(V)3 Digital Troposcatter Communications System.

2. Ask the instructor questions to clarify any misunderstandings.

END
TITLE: Maintenance

LEARNING OBJECTIVES:

**Action:**
The student will be able to describe and demonstrate general preventive maintenance functions and general troubleshooting, fault resolution, system monitoring and line replaceable units for each area of the system for the AN/TRC-170(V)3 Digital Troposcatter Communications System.

**Conditions:**
The student will be given informal lecture and demonstrations on the general preventive maintenance functions and general troubleshooting, fault resolution, system monitoring and line replaceable units for each area of the system for the AN/TRC-170(V)3.

**Standard:**
The student will be able to correctly describe the key concepts of the general preventive maintenance functions and general troubleshooting, fault resolution, system monitoring and line replaceable units for each area of the system for the AN/TRC-170(V)3.

SAFETY CONSIDERATIONS:
Be aware of the possibility of electrical shock when working with electronic equipment. Be aware of lift hazards, observe safety regulations

RISK ASSESSMENT:
Medium to High

RESOURCE NEEDS/REFERENCES:
Communication System AN/TRC-170(V)3, PowerPoint Presentation “Unit 5”, Laptop and Overhead Projector, TM 11-5820-934-13-2, CSI Manual 142F009900-1 and AN/TRC-170(V)3 Student Studyguide

METHODS OF INSTRUCTION:
Informal Lecture, Demonstration and Performance

TIME: 16.0 Academic Hours

NOTES TO INSTRUCTOR:
1. Ensure all resources and references are present.
2. Observe and be aware of safety hazards
INTRODUCTION:
Elapsed Time

In this lesson we will cover general preventive maintenance functions for the AN/TRC-170(V)3. Then we'll cover the general troubleshooting, fault resolution, general system monitoring, and line replaceable units for each area of the system.

Overview
• General preventive maintenance functions
• General troubleshooting
• Fault resolution
• Line replaceable units (LRUs) for each area of the system
• General system monitoring
BODY:
A General Maintenance

Maintenance procedures are divided into two categories: routine and corrective.
• Routine maintenance includes the cleaning of equipment and filters, checking connectors to ensure they are tight, and inspecting for frayed or damaged cables.
• Routine maintenance also includes periodic maintenance inspections that check for the proper operation of the equipment.
• Corrective maintenance is performed in response to an equipment alarm or interruption of traffic.

1. Cleaning:
• General housecleaning of the equipment includes wiping off surfaces using a clean cloth and a general cleaning agent.
• As part of this make sure all covers are in place and secured and any loose patch cables are stored properly.
  a. Air Filters:
   • Dust and sand can clog the filters, restricting air flow, which could then cause overheating.
   • Filters must be removed, cleaned and or replaced if necessary.
   • Refer to shelter diagrams to locate all filters.
   • Filters must be cleaned more frequently in a dusty or a sandy environment.
   • Exterior Inlet and Exhaust Filters:
     • All exterior filters are secured with cross tip screws.
     • Remove them and pull out the filters.
     • Clean the filters by using compressed air or pressurized water.
     • After drying reinstall the filters and secure.
   • CS6716 Modem Filter
     • The filter is accessed by loosening the front panel retaining screws to open the panel.
     • Remove the six screws the hold the front panel and put them in a safe place.
     • Clean and dry the filter.
     • Replace the filter and use the six screws to secure it in place.
     • Close and secure the front panel.
a. Air Filters:
   - Dust and sand can clog the filters, restricting air flow, which could then cause overheating.
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   - Refer to shelter diagrams to locate all filters.
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   - Exterior Inlet and Exhaust Filters:
     - All exterior filters are secured with cross tip screws.
     - Remove them and pull out the filters.
     - Clean the filters by using compressed air or pressurized water and let dry.
     - When dry, reinstall the filters and secure.
   - CS6716 Modem Filter
     - The filter is accessed by loosening the front panel retaining screws to open the panel.
     - Remove the six screws the hold the front panel and put them in a safe place.
     - Clean and dry the filter.
     - Replace the filter and use the six screws to secure it in place.
     - Close and secure the front panel.

b. Racks:
   - Clean equipment racks with a clean cloth and a general cleaning agent (e.g., water).

c. Component Surfaces:
   - Check all component surfaces looking for bent, damaged or otherwise unserviceable areas.
   - Ensure that switches, knobs and dials are in the proper working order.
2. Inspection:
   Requires the following:
   • Physically checking the equipment for problems
   • Sliding equipment out of the rack shelves and checking the cables and connections in back of the equipment for broken or damaged cables, patches, hardware, brackets, etc.
     • Replace or repair as necessary
     • Refer to PMCS for inspection intervals
Physical Inspection - Waveclamp

Inspect the wave clamp

NOTE: Show slide #6
Physical Inspection – Waveguide Clamp

Waveguide and QRA connectors separating due to excessive Waveguide weight.

NOTE: Show slide #7
Physical Inspection – Waveguide Clamp

A nickel is added to create the tension needed to compensate for the separation.
Student Studyguide

Unit 5
Maintenance

NOTE: Show slide #9
Student Studyguide

Unit 5
Maintenance

NOTE: Show slide #10
Student Studyguide

Unit 5
Maintenance

NOTE: Show slide #11

Maintenance – Performance Check Point

- Instructors will demonstrate cleaning of exterior air filter
- Students will perform cleaning of exterior air filter

Hands-on

- Instructors will demonstrate cleaning of exterior air filter
- Students will perform cleaning of exterior air filter
B. Troubleshooting:

- Refer to Chapter 6 of TM 11-5820-934-13-2-1 and the CS6716 manuals for specific troubleshooting and fault isolation procedures as well as fold-outs (FO).

- Remember to observe safety practices when working on or near electrical equipment.
1. Fault Isolation:
   • This class teaches general fault isolation and troubleshooting.
   • For more information on this subject refer to Chapter 6, table 6-2, of TM 11-5820-934-13-2-1.
   • Troubleshooting is performed with the aid of the 7A2 Alarm Monitor and the BITE circuitry.
   • Faults are referred to the intermediate maintenance level when they cannot be located using fault isolation.
a. HPA:

Fault isolation of the HPA will center on the Alarm Matrix card and the BITE Circuit. For specific information on fault isolation, refer to FO 58 in TM.

1. Alarm Matrix Card:
   - This card identifies symptoms of major problems.
   - For specific troubleshooting of the HPA refer to TM 11-5820-934-13-2-1, Chapter 6, Table 6-2 for fault isolation and troubleshooting procedures. This TM will be referred to in subsequent slides.

2. BITE Circuit:
   - This will alert the operator to a fault condition in the HPA.
b. Troposcatter Up-Converter:
   Refer to FO 56 for fault isolation and troubleshooting.
   Summary Alarm LED:
   Lights when an alarm condition has been detected.
c. Troposcatter Down-Converter:
   • Refer to FO 59 for fault isolation information on the Down-Converter.
   • Summary Alarm LED:
     Lights when an alarm condition has been detected.
d. Dual RF Synthesizer:
   - Refer to FO 57 for specific information on the Dual RF Synthesizer.
   - Summary Alarm LED:
     Lights when an alarm condition has been detected in the Dual RF Synthesizer.
NOTE: Show slide #18

e. DAR Modem:
   • Fault LEDs on DAR Modem indicate transmit, receive, timing and over
     temperature fault conditions.
   • Refer to FOs 60, 61, 62 & 66 for fault isolation flowcharts on the Modulator.
   • Refer to FOs 63, 64, 65 & 66 for fault isolation flowcharts on the Demodulator.
f. CS6716 Modem
   • The CS6716 Modem Major and Minor Alarm LEDs are available on the CS6716 front panel to reflect the current alarm status
   • Detailed status can be obtained via the front panel menu
   • Alarm Code Displayed
   • Use Front Panel Interface
   • Faulty Line Replaceable Units (LRU) are hot swappable. Be sure to slide the power switch on the PCB to the OFF position when hot swapping the cards. Ensure the new card is OFF before replacing it. When card is in place, slide switch to ON.
• **Alarm Code Displayed**
  • A Major Alarm is issued when a fault is detected that could affect user data traffic.
  • An automatic switchover to the redundant modem will be initiated unless a Major Alarm is already present on the redundant card set.
  • A Minor Alarm is issued when a fault is detected that normally does not affect mission (data channel) traffic and there is no automatic switchover on Minor Alarms.

• **Use Front Panel Interface**
  • Alarm detail can be obtained via the Modem front panel alarm menu.
NOTE: Show slide #21

### Fault Isolation – CS6716 Modem Front Panel Operation

#### Menu Option Description

<table>
<thead>
<tr>
<th>Menu</th>
<th>Sub-Menus</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONITOR</td>
<td>SUMMARY, ALARMS, RSL, TEMP, AGC, TX APC, BERT, FAN</td>
</tr>
<tr>
<td>ON/OFFLINE</td>
<td>Modem State: OFF LINE or ON LINE</td>
</tr>
<tr>
<td>CONFIG</td>
<td>RATES, DATA CH, FEC, BERT, DEFAULT, ALPC</td>
</tr>
<tr>
<td>INFO</td>
<td>CONFIGURATION INFORMATION</td>
</tr>
<tr>
<td>SWITCH</td>
<td>AUTOMODE, SWITCH TO MODEM A/B, MANUAL MODE</td>
</tr>
<tr>
<td>MAINT</td>
<td>CALIBRATION, VERSIONS</td>
</tr>
<tr>
<td>SETUP</td>
<td>RXGAIN, DIVERSITY, MISC, FLOWCTL, CLKINV</td>
</tr>
<tr>
<td>DIAG</td>
<td>LOOPBACKS, F.P. LED TEST, F.P. DISPLAY TEST</td>
</tr>
</tbody>
</table>

- Keypad and Display: using the Command/Control keypad ◄ or ► (arrow left or arrow right) keys and viewing the display menu options allows interrogation to determine the source and nature of the reported fault.
- Depending on the severity and nature of a reported alarm, the modem will:
  - Continue operation.
  - Continue operation under reduced capability.
  - Switch to the redundant modem.
  - Be unable to maintain communications.
- There are no user-replaceable components in the CS6716 Modem. Operator actionable items are limited to the replacement of an LRU.
- When a fault occurs, corrective action includes replacing one or more of the following Line Replaceable Units (LRU) subassemblies:
  - Analog Board
  - Processor Board
  - Front panel display board
  - Fans
- If the modem is able to continue operating (Minor Alarm), repairs can be delayed until a convenient maintenance period.
- If the fault has forced the modem to switch to the redundant set (Major Alarm), repairs should be scheduled for a more convenient time to replace the faulty LRU.
- Fatal errors require immediate attention.
- Neither the Processor Board nor the Analog Board is field repairable.
- If a failure occurs on the backplane, the entire modem will have to be replaced.
- If a failure occurs with the front panel or its attached ribbon cables, the modem will continue to operate in its current configuration. Repair of these items will require the modem to be powered down in order to replace them.
- If replacing one or more of these subassemblies did not correct the indicated fault, the entire modem will have to be replaced.
  - Faulty LRU are hot swappable (with PCB power switch OFF)
The user can fully control and monitor the operation of the CS6716 from the front panel using the keypad and display. Nested menus are used, which display all available options, and prompt the user to carry out a required action.

The status LEDs provide a visual indication of the health and operating status of the modem.
g. VersaMux 4000
   - Power On Self Test (POST):
     - This series of tests checks the operational status of the VersaMux.
   - Select Test from Diagnostics menu
   - If a user module requires maintenance, the VersaMux 4000 provides the ability to hot swap user modules.
   - Hot swapping allows a user circuit to be replaced without needing to disable the other active links.
   - The following provides instructions on how to perform a hot-swap.
     1. Initiate the hot-swap operation on the VersaMux 4000 by selecting Enable in the Diagnostics-Hot-swap menu.
     2. Follow the instructions described in “Removing a Module” on page 7-6 and/or “Installing a module” on page 7-7 of Appendix D in the Modem System Upgrade Manual for CS6716 Modem.
     3. Complete the hot-swap operation by selecting the Disable option for the Hot-Swap parameter.

<table>
<thead>
<tr>
<th>LED Label</th>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Green</td>
<td>AC power to the system is present.</td>
</tr>
<tr>
<td></td>
<td>Off</td>
<td>The unit is not powered or the PT-Lighting Parameter disabled the indicators.</td>
</tr>
<tr>
<td>Aggr</td>
<td>Red</td>
<td>At least one fault exists on the aggregate.</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>Aggregate operating in loopback mode.</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td>The aggregate operation is normal with no faults.</td>
</tr>
<tr>
<td>Ckt Ref</td>
<td>Red</td>
<td>The system test synchronization with the timing reference.</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td>The system has synchronization with the timing reference.</td>
</tr>
<tr>
<td>Ports</td>
<td>Green</td>
<td>All ports are in normal operation (no faults, not in loopback).</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td>At least one fault exists on one or more ports.</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>One or more ports operating in loopback mode.</td>
</tr>
<tr>
<td>Fault</td>
<td>Red</td>
<td>One or more system faults exist on the VersaMux-4000. In addition, this indicator illuminates when the Hot-swap parameter is Enabled.</td>
</tr>
<tr>
<td></td>
<td>Off</td>
<td>The VersaMux-4000 system operation is normal (no faults).</td>
</tr>
</tbody>
</table>
Fault Isolation – OAC-170D

• Front Panel Alarm LEDs
• Troubleshooting Chart (Table 5-4) in Modem System Upgrade Manual (available on site and as reference material in class)

h. OAC-170
• Front Panel Alarm LEDs
• Troubleshooting Chart (Table 5-4) in Appendix B in the Modem System Upgrade Manual (Manual No. 142F009900-1)

OAC-170D Troubleshooting Chart
• ALARM LED is not illuminated
  1. No input +48V, Verify +48V PS is turned on.
  2. Both +48V inputs are mis-wired or not connected. Correct wiring.
  3. Main Board Failure. Replace OAC-170D

• ALARM LED is illuminated red
  1. OSC SELECT switch is not in AUTO position. Place OSC SELECT switch into AUTO, if both oscillators are operational.
  2. Chassis internal temperature is above 65°C. Ensure shelter curbside fan is operational and the environmental air is below 52°C.
  3. Main Board Failure. Replace OAC-170D

• OSC A (or B) LED is illuminated red
  1. Oscillator has failed or output power is out of adjustment. Put OSC SELECT switch into the position of the non-failed oscillator. During maintenance down period, replace OAC-170D.

• MAINT LED is illuminated yellow
  1. OSC SELECT switch is not in AUTO position. Place OSC SELECT switch into AUTO, if both oscillators are operational.
  2. Main Board Failure. Replace OAC-170D
Fault Isolation – OAC-170D

70 MHz Amplifier Gain Adjustment
- Gain of each of 4 Amplifiers adjustable to 16 dB
- Gain from LNAs to modem adjusted for 40 dB

70 MHz Amplifier Adjustments
- Gain of each of 4 Amplifiers is adjustable to 16 dB from Down-Converter outputs to CS6716 inputs. The overall system gain from the Down-Converter input to the CS6716 Modem input is set at 40 dB.
- Remove all U Links from IF DATA Patch Panel
- Set Filter Select switch to BYPASS
- Connect TX1 IF output to a 16 dB inline attenuator and RX1 input
  - On CS6716 Modem front panel, select ENT for menu, select Monitor, then RSL. This displays all 4 receive channel RSLs.
  - Adjust RCVR1 potentiometer for -40 dBm on the modem RSL1 display
  - Repeat setup and adjustment for RX IF inputs 2-4
  - Restore to original configuration
- Equalization Procedure:
  This is performed to overcome gain differences found in different receivers and converters. Make sure HPA is OFF.
  - Waveguide coverplates on receiver waveguide ports installed
  - On CS6716 Modem, select MONITOR from the Main menu, then RSL
  - On each down-converter, turn the Noise Test Switch to PRESELECT
  - On CS6716 modem front panel display, adjust RX1- RX4 potentiometers on OAC front panel for the highest common RSL.
  - On down-converters, turn Noise Test Switch to OFF and restore settings
2. Line Replaceable Units (LRU):
   The following items are those at the operator level that can be removed and replaced if required.
   For problems that can’t be isolated to a specific LRU or when replacing the LRU doesn’t fix the problem, refer to the next level, organizational maintenance, for a solution.
Student Studyguide

Unit 5
Maintenance

NOTE: Show slide #27

LRUs – HPA

- Klystron Tube
- Alarm Matrix CCA
- Blower
- RF Protect and Metering CCA
- High Voltage Power Supply

2. Line Replaceable Units (LRU):
   a. HPA:

       Refer to Para. 6-7.1 in TM 11-5820-934-13-2-1 for removal instructions for these LRUs.
       Klystron Tube
       Alarm Matrix CCA
       Blower
       RF Protect and Metering CCA
       High Voltage Power Supply
       Fast Interrupt Assembly
       Inverters
       Control Logic Assembly CCAs
b. Troposcatter Up-Converter:
   Refer to Para 6-7.9 in TM 11-5820-934-13-2-1 for removal instructions for these LRU.
   
   Fan
   RF Filter Assembly
   Intermediate Power Amplifier
   Radio Frequency Assembly
   Up-Converter BITE CCA
c. Troposcatter Down-Converter:
   Refer to Para. 6-7.10 in TM 11-5820-934-13-2-1 for removal instructions for the following LRUs.
   - RF Amplifier
   - Tunable Bandpass Filters
     - Pre-selector Filter FL1
     - Post Selector Filter FL2
   - RF Switch
   - RF Detector Assembly
   - Balanced Mixer/Preamp Assembly
   - BITE CCA
d. Dual RF Synthesizer:
   Refer to Para. 6-7.11 in TM 11-5820-934-13-2-1 for removal instructions for the following LRUs.
   IF CCA
   Reference CCA
   Radio Frequency Converter
   Reference Oscillator
   Multiplier, Dual Frequency CCA
   Cavity Oscillator
e. DAR Modem:
   Refer to Para 6-7.12 in TM 11-5820-934-13-2-1 for removal instructions for the Modulator.
   Refer to Para 6-7.13 in TM 11-5820-934-13-2-1 for removal instructions for the Demodulator.
   Frequency Standard – Rubidium Oscillator
   Voltage Regulator
   Bandpass Filter
   RF Power Divider
   Channelizer CCAs
f. CS6716 Modem:
   Refer to Para 7.5 of the CS6716 Operation and Maintenance Manual (Manual 142F009700) located in Appendix C of the Modem System Upgrade Manual (Manual 142F009900-1) for LRU removal instructions.
   • Analog Board
   • Processor Board
   • Front Panel Display Board
   • Fans
g. VersaMux 4000:
   Refer to Chapter 7 of the VersaMux Operation and Installation Guide (located in Appendix D of Manual 142F009900-1) for instructions on removing the following LRUs.
   - Fiber / Cu module
   - NRZ module
OAC-170 R&R:

1. Remove the four screws securing the Modem Upgrade equipment shelf to the rack.
2. Slide the equipment shelf out of rack to obtain access to rear cabling.
3. Remove the following cables from the OAC-170D:
   - W006 from J1
   - W1003 from J2
   - W1004 from J3
   - W317 from J4
   - W318 from J5
   - W301 to W304 from J10
   - W307 to W310 from J11
4. Ground cable from #8-32 GND Stud.
5. Slide the equipment shelf back into the rack to provide room in front of the equipment shelf.
6. Remove the four screws securing the OAC-170D to the Modem Upgrade equipment shelf and slide the OAC-170D chassis out of the equipment shelf.

NOTE: Installation is the reverse of above.
i. 48 VDC Power Supply:
   Refer to Chapter 5.0 Maintenance, Mercury 1U Power Shelf Installation Manual (located in Appendix E of Manual 142F009900-1), for instructions on removing and replacing the power supply.
   • power supply
In the following section we will be reviewing system monitoring procedures.
C. System Monitoring
   1. Alarms:
      • The 7A2 Alarm Monitor provides a Green/Red fault tree for system monitoring purposes.
      • RSL and Bit Error Rates (BER), are also monitored here.
a. HPA
   • Alarm Matrix
   • Summary Alarm LED
   • Low Power Alarm:
     This alarm is operator adjusted to go off when HPA output power dips below a set threshold level.

Instructor Notes:
Point out alarm matrix
b. Troposcatter Up-Converter
   • Summary Alarm- Indicates a fault in one of the amplifier converter units, an RF inhibit fault or a fault in the filter assembly p/o A3.
c. Troposcatter Down-Converter
   - Summary Alarm- Indicates a failure of a transistor within the low noise amplifier (AR1). This failure is also reported, via a relay closure, to the alarm monitor.
d. Dual RF Synthesizer
   - Summary Alarm- Indicates a fault in the receiver circuitry or incorrect tuning.
Student Studyguide

Unit 5
Maintenance

NOTE: Show slide #42

e. CS6716 Modem
   1) Major Alarm
      • If a major alarm occurs, the redundancy controller will cause an automatic
        switch to the hot-standby modem.
      • The LRUs in the modem are hot swappable.
      • The power to the modem can remain on while replacing an LRU.
        • When replacing an LRU, power off the LRU, then disengage it from the
          modem’s backplane using only the ejectors on the unit’s front corners.
   2) Minor Alarm
      • To eliminate an LRU fault, replace the faulty LRU.
      • If a minor alarm occurs, there is no redundancy switching

Caution
Review all safety procedures and ESD requirements prior to opening the modem front panel. If
the power to the modem is on, take precautions when placing hands inside an operating unit.
Always remove metal jewelry, watches, rings, etc., before working on electrical circuits or any
electrical equipment.

Caution
Do not use any tools to remove the LRU. If one or both ejectors are damaged or broken, remove
board using pliers, and replace the ejectors before replacing the LRU.
Student Studyguide

Unit 5
Maintenance

NOTE: Show slide #43

Now we will cover the alarm indicators on the CS6716.

MAJOR ALARM = A Major alarm exists within the modem
MINOR ALARM = A Minor alarm exists within the modem
DIAGNOSTICS = Modem is configured in a diagnostic mode
MANUAL SWITCH = Automatic redundancy switching has been disabled
System Monitoring – CS6716 Modem
Front Panel and Fan

Front Panel Display Fault
- A display error has missing characters in the display, or the entire display does not illuminate.
- Modem will continue to operate even if entire display is not working.

Fan failure
- A fan failure is a minor level alarm.
- However, in extreme conditions, failure of one or both fans can cause the temperature in the modem to rise and lead to a high temperature alarm. High temperatures may lead to equipment failure of one or more LRUs.
f. VersaMux 4000
   - Main Menu:
     - Alarm –Status
       Displays active alarms
       - Selecting Alarm-Status displays a list of the alarms, and the number of occurrences of each, that have occurred since the last reset.
       - In addition, the alarm statistics can be reset after viewing them.
       - Scroll through the active alarms using the Up and Down arrow keys on the front panel interface.
       - The system displays one alarm at a time.
- **AGGR LED**
  - Red indicates faults in the aggregate
  - Yellow indicates AGGR is in loopback

**NOTE:** Show slide #46
NOTE: Show slide #47

- CLK REF LED
  - Red indicates loss of sync with timing reference
  - Can also indicate that the timing reference may not be present on external source if that has been selected
  - Check connection on external source if external source is present CLK REF LED is red.
**NOTE:** Show slide #48

- **PORTS LED**
  - Red indicates fault on one or more port cards (Fiber/CU)
  - Yellow indicates one or more port cards in loopback
System Monitoring – VersaMux 4000

FAULT LED
- Red indicates one or more faults on VersaMux or the unit is in hot-swap mode

- FAULT LED
  - Red indicates one or more faults on VersaMux or the unit is in hot-swap mode

NOTE: Show slide #49
g. OAC-170D
   • Alarm LED:
     Green – Indicates unit is powered up
     Red – Indicates either the OSC SEL switch is not in AUTO, internal temperature
            is above 65°C or there is a failure on the main board.
   • OSC A ALARM LED:
     Red - Indicates OSC A is failed
   • OSC B ALARM LED:
     Red - Indicates OSC B is failed
   • MAINT LED:
     Solid Amber – OSC SEL switch is not in AUTO
     Flashing Amber – 10MHz outputs disabled, power up.

Instructor Notes:

Faulty Oscillator LED indicates internal phase lock loop not locked or the output power level is
low.
Student Studyguide

Unit 5
Maintenance

NOTE: Show slide #51

h. 48 VDC Power Supply
   • Front panel alarm indicator
     • If green – working properly
     • If off – not working properly
   • To remove failed unit, remove center thumbscrews, pull unit out and replace
   • Units are redundant and hot swappable
The following types of loopbacks will be discussed:
- CS6716 Modem
- VersaMux 4000
- DAR Modem
Loopbacks – CS6716 Modem

Internal IF loop
- Quick verification of proper modem operation
- From the top level menu
  - Select DIAG
  - Then LOOPBACK
  - Then LOCAL IF
- The modem should synchronize
  - RX SYNC LED should illuminate green
  - MAJOR ALARM LED should be off

a. CS6716 Modem
   Internal IF loop:
   - This places the CS6716 into the loopback mode and is a quick way to verify proper operation of the modem.
   - Select DIAG from the top level menu, then LOOPBACK, then LOCAL IF.
   - The modem should synchronize, RX SYNC LED should be green and the MAJOR ALARM LED should be off.

Additional Info:
- The LOOPBACK command may be issued with the modem ONLINE or OFFLINE. If its OFFLINE, it must be put ONLINE for it to lock up.
- IF the RX SYNC LED does not illuminate green or is intermittent green, verify the aggregate rates between the CS6716 and VM4000 are the same.
b. VersaMux:
   - Select from the Loopbacks sub-menu
     - Aggregate
     - Port-1
     - Port-2
     - Port-3
     - Port-4

Instructor Notes:
- Aggregate directs loopback towards the CS6716
- Ports 1-4 direct the loopback to the SIP
• Type Loopback
  • No Loop:
    This ends the loopback procedure
  • Bi-directional:
    This provides a loopback toward both
    • the user port and the Aggregate Port on a port module
    • the Aggregate Port and the mux / demux circuitry on an Aggregate module
  • Internal (more information on following page)
  • External (more information on following page)
• Internal:
  This provides a loopback toward:
  • The aggregate of a port module
  • The mux / demux circuitry on an aggregate module
• **External:**
  
  This loopback provides a loopback toward:
  
  • The user port on a port module
  • The aggregate port on an aggregate module
c. DAR Modem:
   - Selected via the toggle switches on the IF Loopback panel.
   - Attenuation can also be inserted at this point by using the 10dB and 1dB rotating knobs
to select the amount of attenuation to insert.
   - IF Loopback Panel:
     - This panel has 4 toggle switches for RX1-4.
     - Select the normal or loopback position.
     - If the loopback position is selected, one must also check the attenuation knobs
to see how much attenuation is being inserted.
     - This loopbacks the IF signal from the Up-Converter, and routes it back to the
Receivers.
System Monitoring –
Bit Error Rate (BER) Checks

- CS6716 Modem
- VersaMux 4000
- DAR Modem

3. BER Checks
   - CS6716 Modem
   - VersaMux 4000
   - DAR Modem
BER Checks – CS6716 Modem

Bit Error Rate Tester (BERT)
- Automatically enabled based on Service Channel bandwidth
  - View Local & Remote
  - Reset Local & Remote

CS6716 Modem & BER check
Bit Error Rate Test (BERT) is automatically enabled if 32Kbps of Service Channel bandwidth is not being used by Service Channel 1 and Service Channel 2.
- View Local
  - Receive BER rate and estimated FEC rate if FEC is on.
- View Remote
  - Remote site Receive BER rate and estimated FEC rate if FEC is on.
- Reset Local
  - Resets local BER rate
- Reset Remote
  - Resets remote BER rate
NOTE: Show slide #61

a. VersaMux:
   - The VersaMux is equipped with an internal Bit Error Rate Tester.
   - This is capable of providing link quality statistics.
   - Only one slot (aggregate or port) may be connected to the BERT at any given time.
   - Bit Error Rate Tester:
     Refer to table 6-2 of the VersaMux 4000 Operation and Installation Guide for BERT parameter and options.
   - May use either entire bandwidth or unused bandwidth (selectable by user)
b. DAR Tropo Modem:
   • The BER Meter monitors the BER in Long or Short measurements.
     • Long takes an average reading over a 10 minute sliding window
     • Must run 10 minutes before an initial reading is obtained.
     • Short takes an average reading over the last 10⁶ bits.
SUMMARY:

- During this lesson, you were given a general preventive maintenance functions, general troubleshooting, fault resolution, general system monitoring, and line replaceable units for each area of the system for the AN/TRC-170(V)3.

2. Ask the instructor questions to clarify any misunderstandings.

THE END
Student Studyguide

Unit 6
System End-to-End

NOTE:  Show slide #1

TITLE:  System End-to-End

LEARNING OBJECTIVE:

Action:
You will be able to describe the key concepts of site planning, troposcatter communications path considerations, and COMSEC equipment requirements for the AN/TRC-170(V)3. You will be able to setup, power-up, and establish normal operation for a troposcatter communications link using the AN/TRC-170(V)3 system.

Conditions:
You will be given an informal lecture on the key concepts of site planning, troposcatter communications path considerations, and COMSEC equipment requirements for the AN/TRC-170(V)3 and a complete demonstration on the setup, power-up, and establish normal operation for a troposcatter communications link using the AN/TRC-170(V)3 system.

Standard:
You will be able to correctly describe key concepts of site planning, troposcatter communication path considerations, and COMSEC equipment requirements for the AN/TRC-170(V)3. You will also be able to demonstrate the ability to setup, power-up, and establish normal operation for a troposcatter communications link using the AN/TRC-170(V)3 system.

SAFETY CONSIDERATIONS:
Be aware of the possibility of electrical shock when working with electronic equipment. Be aware of lift hazards, and observe safety regulations.

RISK ASSESSMENT:
Medium to High

RESOURCE NEEDS/REFERENCES:
Communication System AN/TRC-170(V)3, PowerPoint Presentation “Unit 6”, Laptop and Overhead Projector, TM 11-5820-934-13-2, CSI Manual 142F009900-1 and AN/TRC-170(V)3 Training Student Studyguide

METHODS OF INSTRUCTION:
Informal Lecture

TIME:  24.0 Academic and Performance Hours
INTRODUCTION:

Elapsed Time

During this period of instruction, you will be given a description of site planning and troposcatter communications path considerations for the AN/TRC-170(V)3. We will also go over the use of cut-sheets and provide basic familiarization of the COMSEC equipment requirements. Once the demonstration is complete, students will practice the setup, power-up, link activation and the power-down and pack-up of the AN/TRC-170(V)3. Understanding this information will provide the base which will enable students to become proficient AN/TRC-170(V)3 operators.

Overview:

- Site and Path Planning Considerations
- Cut-Sheets
- Communications Security Equipment
- Walk-through of system activation
- Hands-on

There will be an academic evaluation at the end of this lesson.
A. Site and Path Planning Considerations
   1. Siting Information
      a. Topographic Conditions:
         • A good take-off angle to distant end is a must; 0 to 5 degrees usually
         • The higher the elevation of the site, the better
      b. Interference:
         • Avoid sources of interference, natural or manmade
         • Avoid bad set-up locations such as in low areas or near buildings, trees, mountains or other obstacles that would interfere with the signal
         • Avoid areas near overhead power lines and metal structures such as buildings or bridges where possible, which could cause interference
         • Near power lines, maintain safety precautions of twice the distance of the height of the antenna
      c. Soil Conditions:
         • Look for areas that are stable, that offer a good means of grounding, and have good drainage for water runoff
         • Avoid areas with sandy, rocky or swampy soil, where possible
      d. Climatic Conditions:
         • Avoid areas that are prone to weather extremes – excessive rain, lightning, wind, etc.
         • Avoid areas of extremely high elevation, high rainfall and/or humidity
         • Look for areas that have average weather conditions where possible
Primary Power considerations:
• When planning for power requirements, remember to consider site access to generators and fuel tanks.
• Do not place equipment where it can not be easily refueled.
• Co-ordinate with the power production personnel.

Accessibility:
• Crew and support personnel must have good access to the site.
• Sites with less than perfect access may still be used if other factors override the lack of good access.
Student Studyguide

Unit 6
System End-to-End

NOTE: Show slide #5

Characteristics

<table>
<thead>
<tr>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountainous – access considerations</td>
<td>Setting up high</td>
</tr>
<tr>
<td>Tactically – exposure</td>
<td>Better shot over the horizon</td>
</tr>
<tr>
<td>Getting a good ground</td>
<td></td>
</tr>
</tbody>
</table>
Student Studyguide

Unit 6
System End-to-End

NOTE: Show slide #6

Site Selections

Good site?

Bad site?

Characteristics

<table>
<thead>
<tr>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good grounding location</td>
<td>If shot needs to go through trees on left,</td>
</tr>
<tr>
<td>too close</td>
<td>too close</td>
</tr>
<tr>
<td>If set up close to trees, provides good cover</td>
<td></td>
</tr>
<tr>
<td>Shot straight, nice takeoff angle</td>
<td></td>
</tr>
<tr>
<td>Good air cover from treeline</td>
<td></td>
</tr>
<tr>
<td>Flat: easy access</td>
<td></td>
</tr>
</tbody>
</table>
Alternate Site Locations:
- Always have one alternate site location that has been approved for use.
- Locate several alternate sites for use in case the primary site will not work.
- Try to locate it somewhat nearby.
NOTE: Show slide #8

B. Cut-Sheet

1. Overview
   - The purpose of Cut-Sheet is to give the crew member concise set-up instructions for the AN/TRC-170(v3).
   - All mission settings and switch positions must be identified prior to deploying for a mission.
   - Cut sheets are called crew assignment sheets in the TM's

a. CS6716 Modem
   - Patching required
     - Insert U links for normal operation
   - Forward Error Correction (Yes or No)
     - Forward Error Correction improves the Bit Error Rate significantly
     - Not required
   - Data Channel
     - Refer to Aggregate Data Rate Chart
     - Aggregate rate is affected by FEC option selected
     - Both ends of link must have same aggregate data rate
     - Interface Type: RS-422
   - Service Channel Rates
     - Two Service Channels
     - Service Channel 1 is used for the Orderwire, rate set for 16 Kbps
     - Service Channel 2 is not used, rate set for 0 Kbps
   - Orderwire and Crypto requirements
     - If Orderwire and Crypto are required they must be identified on the cut-sheet, correct keying material must be on hand at each end of link.
b. DAR Modem (Refer to TM 11-5820-934-13-2-1 for patching options and settings)
   DAR Modem has 3 Timing Options
   1. Timing Source and Patching
      • Rubidium Standard (this is the Master Timing for Link)
   2. Mission Timing obtained from Distant End
   3. Group Timing obtained via DTG on Port 1 of TGM
      • Mission and Group Data Rates
      • Mission Data Thumbwheel is set to a rate between 128 kHz and 4608 kHz
      • Group rate thumbwheel is only used to clock data into port 1 of TGM from cable-side
      • Refer to individual equipment TM for more specific information about DAR Modem equipment
      • Digital Group Multiplex Settings for LGMs, GMs, TGM are identified on the appropriate areas of the cut-sheet
      • Digital Group Multiplex Settings and Patching (Refer to Individual equipment TM for specifics)
      • Refer to individual equipment TMs for more information
   • Orderwire and Crypto requirements
      • Orderwire must be patched in on IF DATA Patch Panel and the TED must be patched in on DATA Patch Panel
c. Tropo Radio (Refer to TM for frequency and HPA settings)
   1. Transmit and Receive Frequency settings
      a. Transmit Frequencies
         • Transmit frequencies are set on the Dual RF Synthesizer Transmit thumbwheels and Phase Lock-Loop, Up Converter tunable filter, and the High Power Amplifier Output filter.
         • In the LOS mode, do not tune the Klystron.
         • In the Tropo mode, tune the Klystron.
      b. Receive Frequency
         • Settings are made on the Dual RF Synthesizer, Receive thumbwheels and the Down Converter Pre- and Post- Selectors.
   2. HPA settings are made at the HPA Cabinet.
      • Refer to klystron tuning chart for specific settings to tune each cavity.
      • HPA settings: Cut sheets will identify high/low power setting and transmit frequency to tune the klystron cavities.
Student Studyguide

Unit 6
System End-to-End

NOTE: Show slide #11

2. Responsibilities:
   • The Cut-Sheet SHOULD be provided
   • Operators may have to make own Cut-Sheet
   • Use the ones in the TM or design for own use

3. Practical
   Given information, complete Cut-Sheet showing all required information.
   a. Practice filling out Cut-Sheet using information provided.
   b. Complete practical exam on Cut-Sheet.
Student Studyguide

Unit 6
System End-to-End

NOTE: Show slide #12

Review main settings on Cut-Sheet being passed out

eample
Student Studyguide

Unit 6
System End-to-End

NOTE: Show slide #14

Cut-Sheet example
Student Studyguide

Unit 6
System End-to-End

NOTE: Show slide #15

Cut-Sheet example
Performance Check Point

- Instructors will pass out copies of crew assignment sheets and place information on the board.
- Students will complete crew assignment sheets and turn them in to instructors.
C. Communications Security Equipment

1. COMSEC Callout In Advance

The purpose of the COMSEC Callout is to identify any COMSEC material needed for a mission in advance. Once all needed material is identified and the matching keying material is listed, then COMSEC Managers are responsible for ensuring appropriate keying material is on hand for mission requirements.

   a. List COMSEC Equipment to be used
      • Refer to local procedures for requesting appropriate Communication Security keys
      • KY-58 Secure Orderwire Unit
         • The KY 58 is used to secure the voice orderwire used for terminal to terminal communication. The KY 58 requires the correct cryptographic key in order to operate.
      • KG-94 Trunk Encryption Device (TED)
         • Used for bulk encryption of mission traffic (TED 1)
         • Used to decrypt / encrypt GP1 data for TGM (TED 2)

   b. List Key Material Required to be on hand
      • Key tape material may be loaded to a DTD
      • DTD may be used to load keys in COMSEC equipment
      • Key material is identified by short title, refer to local COMSEC personnel
      • List Key Material by Short Title
      • Obtain information by checking with local COMSEC personnel
D. Walk-Through of System Activation with instructors demonstrating and students observing.

1. Set Up (Safety Equipment required)
   a. Antenna
      1. Set up QRA using checklist
      2. Lay out Radiation Hazard Fence
      3. Connect Waveguide to AN/TRC-170(v)3

Supporting info:
- Instructors set up QRA antenna. Students observe and assist as needed
- Instructors mark out radiation hazard fence locations (Simulated)
- Instructors connect waveguide to shelter
b. External Power
   1. Connect external power cable and ground to AN/TRC-170(v)3.
      • Open AN/TRC-170(v)3 and ensure all power circuit breakers are off.
      • Turn on external power source and verify frequency and voltage at the power distribution panel.
      • Turn on Main power circuit breaker and the light circuit breaker.

c. AN/TRC-170(v)3 setup
   1. Set up AN/TRC-170(v)3 using Cut-Sheet.
2. Perform Power-Up Procedures
   a. Power Distribution Panel
      Perform Prime Power Checklist
b. Individual System Components
   1. Perform CS6716 Modem Power-Up Procedure
   2. Perform Tropo Radio Power-Up Procedure
3. Normal Operation:
   a. IF Loopback:
      • IF Loopbacks are used to quickly determine if equipment is set up and operating correctly.
      • Equipment should green up on itself in loopback mode.
      • This simulates receiving a signal from the distant end.
      • Refer to the IF Loopback Procedure
   
   b. Establish link with Distant End:
      • This is done by removing the IF Loopback and going normal through.
      • If the antenna is aligned correctly at the start and the radio is set up properly, a signal should be received from the distant end once they begin transmitting.
      • After getting an RSL from the distant end, the antennas may be swept to ensure proper antenna alignment.
4. Turn-off and Pack-up
   a. AN/TRC-170(v)3:
      • Refer to AN/TRC-170(v)3 Power Down Checklist as instructors shut down the radio.
   b. Antenna:
      • While observing instructors tearing down and packing up the Quick Reaction Antenna system, wear hard hats and gloves at all times.
   c. External Power:
      • Observe instructors as they turn off external power and remove power and ground cabling
   d. Review:
      • Review turn-off and pack up procedures with instructors
E. Application: *Students perform with Instructors observing*
   1. Setup Quick Reaction Antenna
      a. Set Up Quick Reaction Antenna using QRA checklist.
         • Ensure proper Personal Protective Equipment is on prior to beginning setup.
         • Hard hats and gloves are required.
b. Students will perform external power set up. Students will cable up external power source and connect shelter ground.
   • Open AN/TRC-170(v)3 and ensure all power circuit breakers are off.
   • Students will turn on external power source and verify frequency and voltage on power meter inside AN/TRC-170(v)3.
   • Turn on Main CB and the light CB on the power distribution panel.

c. Students will set up a AN/TRC-170(v)3 using Cut-Sheet supplied by instructors.
   • Students will set frequencies, perform any patching required, and tune the klystron cavities.

d. Students and Instructors will review the walk-through.
2. Perform Power-Up Procedures  
  a. Power Distribution Panel  
     Perform Prime Power Checklist
b. Individual System Components
   1. Perform CS6716 Modem Power-Up Procedure
   2. Perform Tropo Radio Power-Up Procedure
   c. Review Power-up procedures with instructors
3. Normal Operation:
   • Students will bring equipment up normally, then place equipment in loopback using IF Loopback procedure.

   a. IF Loopback:
      • IF Loopbacks are used to quickly determine if equipment is set up and operating correctly.
      • Equipment should green up on itself in loopback mode. This simulates receiving a signal from the distant end.
      • Refer to the IF Loopback procedure

   b. Establish link with Distant End:
      • This is done by removing the IF Loopback and setting up the equipment according to Cut-Sheet.
      • If the antenna is aligned correctly and the radio is set up right, a signal from the distant end should be received once the distant end begins transmitting.
      • After getting an RSL, sweep the antenna to ensure proper alignment.
      • The link is established when the CS6716 Modems lock up with each other.
      • Instructors will use Cut-Sheet and go over procedures to establish link with distant end. CS6716 Modems will be placed in default mode for link acquisition.
      • Link will be established when CS-6716 Modems lock up with each other.

   c. Repeat procedures
   d. Review Procedures
4. Turn-off and Pack-up
   a. AN/TRC-170(v)3:
      • Refer to AN/TRC-170(v)3 Power Down Checklist and then shut down the radio.
   b. Antenna:
      • Ensure hard hats and gloves are worn while tearing down and packing up the Quick Reaction Antenna system using the QRA checklist.
   c. External Power:
      • Turn off external power and remove power and ground cabling.
   d. Review:
      • Review turn-off and pack up procedures with instructors.
   f. Review
SUMMARY:

1. During this lesson you were given a overview of the mission data signal flow through the AN/TRC-170(V)3. We covered each component that the user mission data signal passes through and what it does to/for the signal. We covered the transmit signal path, receive signal path, orderwire signal path and DAR Modem Variant signal path for the AN/TRC-170(V)3 Digital Troposcatter Communications System.
2. Ask the instructor questions to clarify any misunderstandings.

THE END
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>alternating current; air conditioning</td>
</tr>
<tr>
<td>AFE</td>
<td>adaptive forward equalizer</td>
</tr>
<tr>
<td>AGC</td>
<td>automatic gain control</td>
</tr>
<tr>
<td>ALM</td>
<td>alarm</td>
</tr>
<tr>
<td>ALPC</td>
<td>adaptive link power control</td>
</tr>
<tr>
<td>ASCII</td>
<td>American Standard Code of Information Interchange</td>
</tr>
<tr>
<td>AUX</td>
<td>auxiliary</td>
</tr>
<tr>
<td>BER</td>
<td>bit error rate</td>
</tr>
<tr>
<td>BERT</td>
<td>bit error rate test/tester</td>
</tr>
<tr>
<td>BITE</td>
<td>built-in-test-equipment</td>
</tr>
<tr>
<td>BPF</td>
<td>band pass filter</td>
</tr>
<tr>
<td>bps</td>
<td>bits per second</td>
</tr>
<tr>
<td>BPSK</td>
<td>binary phase-shift key</td>
</tr>
<tr>
<td>BW</td>
<td>bandwidth</td>
</tr>
<tr>
<td>CB</td>
<td>circuit breaker</td>
</tr>
<tr>
<td>CCA</td>
<td>circuit card assembly</td>
</tr>
<tr>
<td>CDI</td>
<td>conditioned di-phase</td>
</tr>
<tr>
<td>CDP</td>
<td>conditional di-phase</td>
</tr>
<tr>
<td>CLK</td>
<td>clock</td>
</tr>
<tr>
<td>cm</td>
<td>centimeter</td>
</tr>
<tr>
<td>CMD</td>
<td>command</td>
</tr>
<tr>
<td>COM</td>
<td>common</td>
</tr>
<tr>
<td>COTS</td>
<td>commercial-off-the-shelf</td>
</tr>
<tr>
<td>CPLD</td>
<td>Complex Programmable Logic Devices</td>
</tr>
<tr>
<td>CPU</td>
<td>central processing unit</td>
</tr>
<tr>
<td>CSI</td>
<td>Comtech Systems, Inc.</td>
</tr>
<tr>
<td>CW</td>
<td>continuous wave</td>
</tr>
<tr>
<td>DAR</td>
<td>distortion adaptive receiver (DAR)</td>
</tr>
<tr>
<td>db</td>
<td>decibels</td>
</tr>
<tr>
<td>dBW</td>
<td>decibels referenced to one watt</td>
</tr>
<tr>
<td>DC</td>
<td>direct current</td>
</tr>
<tr>
<td>DC/DC</td>
<td>direct current to direct current</td>
</tr>
<tr>
<td>DCE</td>
<td>data communications equipment</td>
</tr>
<tr>
<td>DEG</td>
<td>decision error generator</td>
</tr>
<tr>
<td>DEMOD</td>
<td>demodulator</td>
</tr>
<tr>
<td>DGM</td>
<td>digital group multiplexer (DGM)</td>
</tr>
<tr>
<td>DLED</td>
<td>dedicated loop encryption device</td>
</tr>
<tr>
<td>DMM</td>
<td>digital multimeter</td>
</tr>
<tr>
<td>DTCS</td>
<td>Digital Troposcatter Communications System (the TRC-170)</td>
</tr>
</tbody>
</table>
# ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTE</td>
<td>data terminal equipment</td>
</tr>
<tr>
<td>DUT</td>
<td>device under test</td>
</tr>
<tr>
<td>DVM</td>
<td>digital voltmeter</td>
</tr>
<tr>
<td>DVOW</td>
<td>digital voice orderwire</td>
</tr>
<tr>
<td>Eb/No</td>
<td>The ratio of bit energy per symbol to noise power spectral density, in decibels.</td>
</tr>
<tr>
<td>EMI</td>
<td>electromagnetic interference</td>
</tr>
<tr>
<td>ESD</td>
<td>electrostatic discharge</td>
</tr>
<tr>
<td>FEC</td>
<td>forward error correction</td>
</tr>
<tr>
<td>FET</td>
<td>field effect transistor</td>
</tr>
<tr>
<td>FIFO</td>
<td>first in first out (buffer)</td>
</tr>
<tr>
<td>FO</td>
<td>fiber optic(s)</td>
</tr>
<tr>
<td>FOM</td>
<td>fiber optic multiplexer</td>
</tr>
<tr>
<td>GM</td>
<td>group multiplexing</td>
</tr>
<tr>
<td>gnd</td>
<td>ground</td>
</tr>
<tr>
<td>HPA</td>
<td>high power amplifier</td>
</tr>
<tr>
<td>HSSI</td>
<td>high speed serial interface</td>
</tr>
<tr>
<td>HVPS</td>
<td>high voltage power supply</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
</tr>
<tr>
<td>I&amp;C</td>
<td>installation and checkout</td>
</tr>
<tr>
<td>I/O</td>
<td>input/output</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IF</td>
<td>intermediate frequency</td>
</tr>
<tr>
<td>INF</td>
<td>interface</td>
</tr>
<tr>
<td>ISI</td>
<td>intersymbol interference</td>
</tr>
<tr>
<td>k</td>
<td>kilo</td>
</tr>
<tr>
<td>kbps</td>
<td>kilobits per second</td>
</tr>
<tr>
<td>kHz</td>
<td>kilohertz</td>
</tr>
<tr>
<td>kVA</td>
<td>kilovolt ampere</td>
</tr>
<tr>
<td>kW</td>
<td>kilowatt</td>
</tr>
<tr>
<td>LCD</td>
<td>liquid crystal display</td>
</tr>
<tr>
<td>LED</td>
<td>light emitting diode</td>
</tr>
<tr>
<td>LGM</td>
<td>loop group multiplexer (LGM)</td>
</tr>
<tr>
<td>LNA</td>
<td>low noise amplifier</td>
</tr>
<tr>
<td>LO</td>
<td>local oscillator</td>
</tr>
<tr>
<td>LRU</td>
<td>line-replaceable unit</td>
</tr>
<tr>
<td>LVL</td>
<td>level</td>
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### ACRONYMS

<table>
<thead>
<tr>
<th><strong>M</strong></th>
<th><strong>m</strong> mega</th>
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<tbody>
<tr>
<td>mA</td>
<td>milliampere</td>
</tr>
<tr>
<td>max</td>
<td>maximum</td>
</tr>
<tr>
<td>Mbps</td>
<td>megabits per second (military M B/S or MBPS)</td>
</tr>
<tr>
<td>MHz</td>
<td>megahertz</td>
</tr>
<tr>
<td>min</td>
<td>minimum</td>
</tr>
<tr>
<td>mm</td>
<td>millimeter</td>
</tr>
<tr>
<td>MTBF</td>
<td>mean time between failure</td>
</tr>
<tr>
<td>MTTR</td>
<td>mean time to repair</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>normally closed</td>
</tr>
<tr>
<td>NO</td>
<td>normally open</td>
</tr>
<tr>
<td>NO/NC</td>
<td>normally open/normally closed</td>
</tr>
<tr>
<td>NRZ</td>
<td>non return to zero</td>
</tr>
<tr>
<td><strong>O</strong></td>
<td>operation and maintenance</td>
</tr>
<tr>
<td>OAC</td>
<td>Oscillator/Amplifier/Converter</td>
</tr>
<tr>
<td>OSC</td>
<td>oscillator</td>
</tr>
<tr>
<td>OW</td>
<td>orderwire</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td>power amplifier</td>
</tr>
<tr>
<td>PCB</td>
<td>printed circuit board</td>
</tr>
<tr>
<td>PMCS</td>
<td>preventive maintenance check and services</td>
</tr>
<tr>
<td>PS</td>
<td>power supply</td>
</tr>
<tr>
<td>PWR</td>
<td>power</td>
</tr>
<tr>
<td><strong>Q</strong></td>
<td>quadrature phase shift keying (QPSK)</td>
</tr>
<tr>
<td><strong>R</strong></td>
<td>research and development</td>
</tr>
<tr>
<td>RF</td>
<td>radio frequency</td>
</tr>
<tr>
<td>RMS/rms</td>
<td>root mean square</td>
</tr>
<tr>
<td>RSL</td>
<td>receive signal level</td>
</tr>
<tr>
<td>Rx</td>
<td>receive</td>
</tr>
<tr>
<td><strong>S</strong></td>
<td>signal to noise</td>
</tr>
<tr>
<td>S/N</td>
<td>signal to noise</td>
</tr>
<tr>
<td>SCADA</td>
<td>supervisory control and data acquisition</td>
</tr>
<tr>
<td>SEL</td>
<td>select</td>
</tr>
<tr>
<td>SEP</td>
<td>Signal Entrance Panel</td>
</tr>
<tr>
<td>SIP</td>
<td>Shelter Interface Panel</td>
</tr>
<tr>
<td>SNR</td>
<td>signal-to-noise ratio</td>
</tr>
<tr>
<td>SPDT</td>
<td>single pole double throw</td>
</tr>
<tr>
<td>STBY</td>
<td>standby</td>
</tr>
<tr>
<td>T</td>
<td>TBD</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
</tr>
<tr>
<td>TED</td>
<td>trunk encryption device</td>
</tr>
<tr>
<td>TDM</td>
<td>time division multiplexing (TDM)</td>
</tr>
<tr>
<td>TGM</td>
<td>trunk group multiplexer (TGM)</td>
</tr>
<tr>
<td>TMP</td>
<td>temperature</td>
</tr>
<tr>
<td>TPC</td>
<td>Turbo Product Code</td>
</tr>
<tr>
<td>TRITAC</td>
<td>tri-service tactical communications</td>
</tr>
<tr>
<td>Tropo</td>
<td>troposcatter; tropospheric</td>
</tr>
<tr>
<td>TTL</td>
<td>transistor-transistor logic</td>
</tr>
<tr>
<td>Tx</td>
<td>transmit</td>
</tr>
<tr>
<td>V</td>
<td>VAC</td>
</tr>
<tr>
<td>VDC</td>
<td>voltage direct current</td>
</tr>
<tr>
<td>VSWR</td>
<td>voltage standing wave ratio</td>
</tr>
</tbody>
</table>