DEPARTMENT OF THE NAVY
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
WASHINGTON, D.C. 20363-5100

SPAWARINST 2700.1
PMW 152-21B

27 January 1989

SPAWAR INSTRUCTION 2700.1

From: Commander, Space and Naval Warfare Systems Command

Subj: COMMUNICATIONS QUALITY MONITORING SYSTEM

Ref: (a) NAVTELCOMINST C2796.1 (cancelled)
(b) NAVTELCOMINST C2300.19 (cancelled)
(c) PRESINSURV ltr 203/0719v of 4 Feb 87

Encl: (1) Communications Quality Monitoring System

1. Purpose. To promulgate procedures for quality monitoring communications systems in ships of the U.S. Navy.

2. Background

a. Increasing complexity in shipboard communication systems have made the establishment of quality monitoring procedures mandatory for effective communications. This instruction provides guidance to all ships and establishes procedures for achieving optimum communications equipment performance, and identifying equipment operational degradation to preclude complete malfunction.

b. References (a) and (b) were cancelled by the Commander, Naval Telecommunications Command. Reference (c) recommended that a new Communications Quality Monitoring System document be developed and issued to fleet units.

3. Objectives. To provide procedures, standards, and schedules for the timely sampling and evaluation of signal quality, frequency accuracy, and equipment performance in shipboard communications systems to ensure optimum system performance and continuity of service.

4. General. This instruction is considered to be interim in nature pending fruition of programs which will automate communication quality monitoring functions in ships and since programs oriented toward automation will take several years at the minimum, it is expected to have an extended useful life. It will be periodically updated to include any future communications system, equipment and monitoring techniques. In order that this instruction may remain viable, recommendations for improvement are solicited from individual commands.

5. Action. This instruction is effective upon receipt and for the purpose of:

a. Implementing a communication systems quality monitoring program in accordance with the procedures set forth in enclosure (1).

b. Initiating a continuous training program in communication systems quality monitoring procedures.

JOHN C. WEAVER
Rear Admiral, U.S. Navy

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FOREWARD

The Quality Monitoring System for communications systems is a replacement for NAVTELCOMINSTs C2796.1 and C2300.19.

Increasing complexity in shipboard communication systems has made the establishment of quality monitoring procedures mandatory for effective communications. The instruction provides guidance to all ships and establishes procedures for achieving optimum communications equipment functioning, and identifying equipment operational degradation to preclude complete malfunction.

The objective of this manual is to provide procedures, standards, and schedules for the timely sampling and evaluation of signal quality, frequency accuracy, and equipment performance in shipboard communications systems to ensure optimum system performance and continuity of service.

This instruction is produced in two volumes, this unclassified document and a confidential document, C2700.2, that covers cryptographic equipments.

COMMUNICATIONS SYSTEMS QUALITY MONITORING INSTRUCTION

NAVAL ELECTRONIC SYSTEMS ENGINEERING CENTER, PORTSMOUTH, VA.

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DEVELOPING ENGINEER APPROVAL: K. R. Snyder

Project Engineer (Code 636)

DIVISION SUPERVISOR APPROVAL: D. A. Glace

Division Head (Code 630)

DEPARTMENTAL APPROVAL: J. M. Popp — Date: 11-15-88

Department Head (Code 06)

SUBJECT CROSS-REFERENCE SHEET

See: SPAWARINST 2700.1

This instruction provides guidance to all ships and establishes procedures for achieving optimum communications equipment functioning, and identifying equipment operational degradation to preclude complete malfunction.

This instruction located ____

____

RECORD OF CHANGES

Identification of Correction or Change	Date Entered	By Whom Entered

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CHAPTER 2

REQUIREMENTS FOR QUALITY MONITORING AND QUALITY MONITORING SYSTEMS

2-0 Requirements for Quality Monitoring (QM).

2-0.1 QM Definition. Quality Monitoring begins when the communications circuit is established. QM shall identify that the signal parameters present are the values required by the equipment. These parameters and values are defined in Chapters 4 and 5 of this manual.

2-0.2 QM Testing. Once the communications circuit has been established, periodic monitoring of key test points within the circuit shall be scheduled. This scheduled monitoring will provide the communicator with information that will allow timely recognition of degradation of communication or signal parameters. Further QM testing can then be accomplished to provide the following decisions;

a. The cause of the communications failure or degradation is on board or not on board.

b. Identification of the equipment or signal parameter causing the degradation or failure.

2-0.3 QM Testing of Standby Equipment. QM testing of standby or backup equipment shall be accomplished prior to using this equipment in an active communications circuit.

2-1 Requirements for Quality Monitoring Systems (QMS).

2-1.1 QMS Definition. A quality monitoring system for use in determining the quality of Radio Communications Systems (RCS) and equipment shall meet the requirements defined in paragraphs 2-1.2 though 2-1.3.3 of this instruction.

2-1.1.1 Operating Situations. The QMS shall be capable of testing/monitoring in the following operating situations.

a. When the communication system is on-line (active).
b. When the communication system is off-line.

2-1.1.2 On-line (active). The QMS shall be capable of monitoring on-line RCS circuits for the purpose of determining that signal parameters meet the requirements for the equipment used to configure the circuit and for periodic quality monitoring.

2-1.1.2.1 <u>On-line Analysis.</u> On-line analysis shall be made by measuring the signal parameters at key test points within the RCS. Typically these test points are Modem Input/Output, Transmitter Input, Radiated (off-the-air) RF Signals, Receiver Output, and Demod Output.

2-1.1.2.2 <u>Accessing RCS Test Points.</u> Accessing of the RCS test points by the QMS shall be non-interfering with communications traffic and signal quality. This accessing and the QMS shall not require special traffic signals or for the RCS signal parameters to be altered. Accessing and QMS design shall be such that RCS signal line balance and circuit impedance will be maintained. Accessing and QMS design shall be such that failure of QMS equipment or accessing devices will not cause degradation of communication quality or RCS signals.

2-1.1.3 <u>Off-Line Testing.</u> Off-line communications system/sub-system testing is performed to provide the data necessary to determine performance quality of the RCS system or sub-system for a specific communications circuit configuration. Off-line testing of discrete RCS equipment also provides data to allow determination of individual equipment suitability for use in a specific communication circuit.

2-1.1.4 <u>Self-Check Operations.</u> The QMS shall be capable of performing self-check operations to certify the QMS equipment readiness and to identify the need for calibration or repair.

2-2 <u>Operating Functions.</u> For each operational mode the QMS shall provide the following operating functions.

2-2.1 <u>Teletype and Data Signal Analysis of:</u>

a. Distortion
b. Speed Error
c. Signal Shaping
d. Broken Bauds or Signal Elements
e. Signal Level

2-2.2 <u>Audio Signals Analysis of:</u>

a. Level/Linearity
b. Signal/Noise
c. Frequency
d. Harmonic Products
e. Aural Monitoring

2-2.3 RF Signals Analysis of:

a. Signal/Noise
b. Frequency
c. Carrier Suppression
d. Linearity/Bandwidth
e. Frequency Response
f. Harmonic Products
g. Aural Monitoring (off-the-air)

2-2.4 Generation of the Following Types of Signals:

a. Teletype and Data
b. Audio Signals
c. RF Unmodulated
d. RF Amplitude Modulated
e. RF Frequency Modulated
f. RF Swept Frequencies

2-3 Quality Monitoring Systems. Quality Monitoring Systems that serve these requirements are identified in the following paragraphs.

2-3.1 BASIC Quality Monitoring System. Appendix A describes the hardware, fabrication, and assembly necessary to configure a basic quality monitoring system. This BASIC QMS provides minimum QM capabilities. The limiting factors of the BASIC QMS are identified as follows;

a. All operating functions for on-line quality monitoring cannot be made by methods that are non-interfering with communications and may require special test signals to be introduced into the system.

b. The characteristics of some test devices selected for use in the BASIC QMS and the manner in which they are interconnected in the QMS cabinet limit the capability to make quantitative measurements of some functional quality monitoring requirements.

2-3.2 AN/SSQ-88 and AN/SSQ-88A Quality Monitoring Set (QMS). The AN/SSQ-88, 88A QMS described in Appendix B has been designated as the standard for quality monitoring systems by COMSPAWARSYSCOM. This quality monitoring system is found on all classes of surface ships. Operating instructions are found in Technical Manual ET822A-AA-OMP-010/P630 SSQ88/88A.

2-3.3 AN/SSQ-92(V)1. This quality monitoring system - described in Appendix C - is the Monitor-Control Subsystem of the Communications System on board DD-963 class ships. Operating instructions are found in Technical Manual EE 169-DA-MMO-020.

2-3.4 AN/SSQ-92(V)2. This quality monitoring system - described in Appendix D - is the Monitor-Control Subsystem of the Communications System on board DD-993 class ships. Operating instructions are found in Technical Manual EE 169-DB-OMI-020/E110 - SSQ92V2.

2-3.5 AN-SSQ-92(V)3. This quality monitoring system - described in Appendix E - is the Monitor-Control Subsystem of the Communications System on board CG-54. Operating instructions are found in Technical Manual EE 169-DC-MMA-020.

2-3.6 OD-164/SRC. This quality monitoring system - described in Appendix F - is the quality monitoring system on board CG-47 through CG-53 ships. Operating instructions are found in Technical Manual EE 120-AA-OMI-030/E110 OD 164SRC.

CHAPTER 3

QUALITY MONITORING TEST PROCEDURES

3-0 General. This chapter contains sections describing the Test Procedures and Schedule for Quality Monitoring (QM) Functional Areas of shipboard Radio Communications Systems (RCS).

SECTION 1 ---- Teletype / Data Signal Analysis

SECTION 2 ---- Audio Signal Analysis

SECTION 3 ---- RF Signal Analysis

The procedures described in these sections are applicable to the Basic Quality Monitoring System described in Appendix A. Refer to the appropriate operator/technical manual for other QMS systems. Each functional QM test is assigned a QMS test number, e.g., QMS TEST #1. These numbers will be used for reference throughout this instruction.

3-0.1 Testing Limitations. Because of test equipment limitations, the interconnection of equipment in the QMS cabinet, and the interfacing with the RCS, the Basic QMS has limited quality monitoring testing capabilities. These limitations are described as they apply in each section of this chapter.

3-0.2 Test Assumptions. The test procedures in this document assume the QMS test equipment is in current calibration, and that the QMS R-1051/URR is modified, as defined in Appendix A, and is adjusted to meet the receiver's Reference Standards.

CHAPTER 3
QUALITY MONITORING TEST PROCEDURES

SECTION 1
QMS TEST #1 TELETYPE/DATA SIGNAL ANALYSIS

3-1 QMS TEST #1 General Information. The QMS functions to provide on-line and off-line analysis of non-secure (BLACK) teletype and data signals. This function is accomplished using a Distortion Analyzer (DA) and/or an oscilloscope to measure the following signal characteristics.

a. Signal Level
b. Signal Shaping
c. % Speed Error
d. Distortion
   (1) AVERAGE - BIAS or PEAK
   (2) TOTAL PEAK - EARLY PEAK - LATE PEAK

3-1.1 Signal Level and Loop Current Tests. Signal level and loop current measurement tests are designed to analyze the effects of distortion, adjacent circuit interference (feedover), and signal shaping caused by incorrect loop current and signal levels.

3-1.2 Measurement Limitations. Radio Communication Systems (RCS) teletype and data circuits are generally encrypted 75 BAUD or 2400 BAUD synchronous signals. The internal timing of the DA is phase-locked to the signal under test to bring the analyzer and the signal into synchronization. Therefore, the percent of SPEED ERROR of synchronous signals cannot be measured. In making distortion measurements of these signals only AVERAGE BIAS and TOTAL PEAK measurements are possible since there is no END distortion of synchrcnous signals.

3-1.3 Start/Stop Signal Measurements. Some RCS non-secure (BLACK) teletype circuits are not encrypted. These circuits are typically 74.2 BAUD Start/Stop signals. All of the above signal characteristics can be measured for Start/Stop signals.

3-1.4 Corrective Action Measurements. When making distortion measurements for the purpose of defining corrective action, two measurements are required.

a. Measure the AVERAGE BIAS distortion and note this value.

b. Measure the TOTAL distortion and note this value.

If the value of TOTAL distortion is not more than 4% greater than the value of AVERAGE BIAS distortion and both values are higher than desired, then adjustment of controls, such as signal converter bias adjust, will reduce the amount of distortion. If the value of TOTAL distortion is more than 4% greater than AVERAGE BIAS distortion then adjustment of controls, such as signal converter bias adjust, will not reduce the amount of distortion. When the latter is true, the cause of the distortion must be found and corrected. Such causes may be transmitter or receiver frequency error, atmospheric conditions, interfering signals, or defective equipment.

3-1.5 QMS Test #1 Teletype and Data Signal Test Procedures. The following procedures define tests using the Basic Quality Monitoring System described in Appendix A. Refer to the appropriate Operators Manual or Technical Manual for other QMS systems' test procedures. The signal level measurement of teletype and data signals cannot be made with the basic QMS without interrupting communications on an on-line (active) system.

3-1.5.1 QMS Test Equipment Preliminary Control Settings. The names of the controls and their settings are generically described below. For specific names of controls and settings refer to the Operators Manual for that test equipment.

DISTORTION ANALYZER

CONTROL	ENCRYPTED	PLAIN TEXT	DATA
Input Select	LOz 60ma/HIz+M	LOz 60ma/HIz+M	HIz+M
Input Polarity	(+)	(+)	(+)
Input Filter	OUT	OUT	OUT
MODE	SYNC	Start/Stop	SYNC
Baud Rate	75	74.2	1200/2400
Transition Select	ALL	ALL	ALL
Distortion Select	AVG BIAS	AVG BIAS	AVG BIAS
Reset Switch	AUTO	AUTO	AUTO
Current Meter Sw.	OUT	OUT	OUT
Cal Check Sw.	ON	ON	ON
Input Filter	OFF	OFF	OFF
AC Power	ON	ON	ON

Adjust the CAL 25 Control for a RED line indication on the meter. Place the Cal Check Switch to OFF.

OSCILLOSCOPE CONTROL	HIGH-LEVEL	LOW-LEVEL	DATA
Channel Select	"A"	"A"	"A"
Input Type	"DC"	"DC"	"DC"
Vertical Sensitivity	20 v/div	5 v/div	5 v/div
Sweep Mode	NORMAL	NORMAL	NORMAL
Sweep Time	2ms/div	2ms/div	.1ms/div
Trigger Source	INT	INT	INT
Trigger Slope	(-)	(-)	(-)

Ensure that all VERNIER controls are set to CAL

3-1.6 Procedures. At the patch panel, patch the appropriate Distortion Analyzer Input (LOz for high level 60 ma signals), (HIz for low level +/- 6V signals) to the teletype circuit under test.

3-1.6.1 Signal Level Measurement.

3-1.6.1.1 High-Level Signals. For high-level (60 ma) signals, checking signal levels requires that a MARK signal condition be established for the TTY circuit under test. Connect the meter on the patch panel to the looping jack of the circuit under test. The meter should indicate 58 ma to 62 ma. If required, adjust the rheostat associated with the circuit under test for a reading of 60 ma.

3-1.6.1.2 Low-Level Signals. For low-level (+/- 6 volt) polar signals, checking signal levels requires that a constant MARK signal followed by a constant SPACE signal condition be established for the TTY circuit under test. Connect the DC voltmeter on the associated patch panel to the circuit under test. The meter should indicate +5 to +7 volts for a MARK signal and -5 volts to -7 volts for a SPACE signal.

3-1.6.1.3 Rationale. If these meter readings are not correct or if loop current cannot be adjusted, refer the circuit to corrective maintenance.

3-1.6.2 Percent Distortion Measurement. Ensure the signal level is correct as defined above.

a. Place the Reset Switch to MANUAL and release.

b. Read the AVERAGE BIAS distortion on the Percent Distortion Meter

c. Place the Distortion Select Switch to TOTAL.

d. Read the TOTAL distortion on the Percent Distortion Meter.

3-1.6.2.1 Rationale.

a. For a Receive TTY circuit, the AVG BIAS distortion must be less than 15% and TOTAL distortion must be not more than 4% greater than AVG BIAS.

b. For a Send TTY circuit, the AVG BIAS distortion must be less than 5% and TOTAL distortion must be not more than 4% greater than AVG BIAS.

3-1.6.3 Distortion Monitoring. For continuous distortion monitoring of an active circuit, place the distortion analyzer Transition Select Switch to ALL, the Distortion Select Switch to TOTAL, and the Reset Switch to AUTO. If the maximum distortion encountered is to be determined when the analyzer is unattended, place the Reset Switch to OFF.

3-1.7 Percent of Speed Error. For a detailed discussion of measuring speed error, see the technical manual for the distortion analyzer. The following procedures apply to the analysis of unencrypted, 5-level Baudot Code (ITA#2) teletype signals.

a. Place the distortion analyzer TRANSITION SELECT switch to position (1). Place the DISTORTION SELECT switch to AVG BIAS. Read and record the amount of distortion indicated on the meter.

b. Place the TRANSITION SELECT switch to position (6). Read and record the amount of distortion indicated on the meter.

c. Determine the percent of SPEED ERROR:

% SPEED ERROR = (%DIST TRANS 1 minus %DIST TRANS 6)
divided by 5.

3-1.8 Percent of Distortion Measurement with Oscilloscope. Ensure the oscilloscope is set up as described in paragraph 3-1.5.1. Connect the oscilloscope Channel A Input to the TTY circuit under test. When testing a HI LEVEL 60 ma circuit use the patch cord defined in Appendix A, Figure A-18. Connect the patch cord to the oscilloscope input before patching to the TTY Loop.

a. Adjust the oscilloscope FOCUS, ASTIGMATISM, POSITION, and INTENSITY controls for the desired sweep definition.

b. Adjust the TRIGGER LEVEL to display a NEGATIVE (Space) baud of approximately 6.6 divisions for a 75 BAUD signal, or 4.4 divisions for a 2400 BAUD signal at the beginning of the sweep. The remaining sweep will display randomly occurring mark and space bauds. Adjust the HORIZONTAL POSITION control to place the beginning of the sweep on the left edge of the graticule. See Figures 3-1, 3-2, and 3-3.

c. Adjust the VERTICAL POSITION A control as required and observe the amplitude of the display signal for the results defined below.

(1) 60 ma = 6 div (120 volts) for a HI level circuit. See Figure 3-1.

(2) +/-6 volts = 2.4 div (12 volts) for a LO level polar circuit. See Figures 3-2 and 3-3.

d. Observe the oscilloscope display signal shaping, broken bauds, or interference.

e. Place the TRIGGER SLOP switch to NEGATIVE (-). Adjust the TRIGGER LEVEL so that a NEGATIVE transition occurs at the beginning of the sweep. With the Horizontal Position Control, place the beginning of the transition on the left edge of the graticule. The number of divisions from the beginning of the graticule to the first POSITIVE transition on the sweep defines the length of a SPACE baud (Ls). Refer to Figure 3-4. Record this value.

g. Place the TRIGGER SLOPE switch to POSITIVE (+). Adjust the TRIGGER LEVEL so that a POSITIVE transition occurs at the beginning of the sweep. With the Horizontal Position Control, position the beginning of the transition on the left edge of the graticule. The number of divisions from the beginning of the graticule to the first NEGATIVE transition on the sweep defines the length of a MARK baud (Lm). Refer to Figure 3-5. Record this value.

h. Determine the Percent of Distortion (see Figure 3-6).

$$\%DIST = \frac{(Lm - Ls)}{(Lm + Ls)} \times 100$$

A (-) value indicates Spacing Bias.
A (+) value indicates Marking Bias.

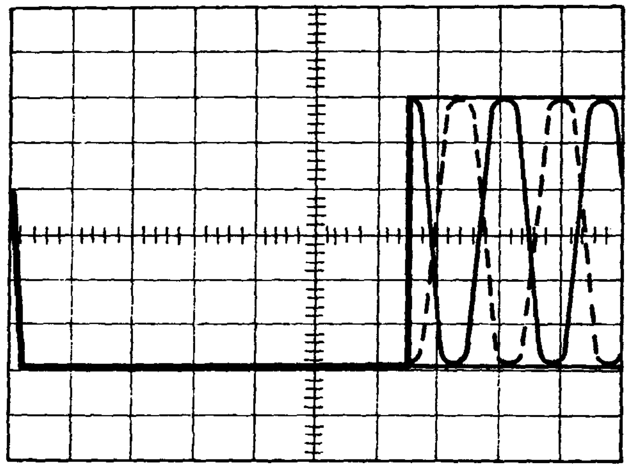


Figure 3-1

60 ma (Hi-Level) 75 Baud Signal

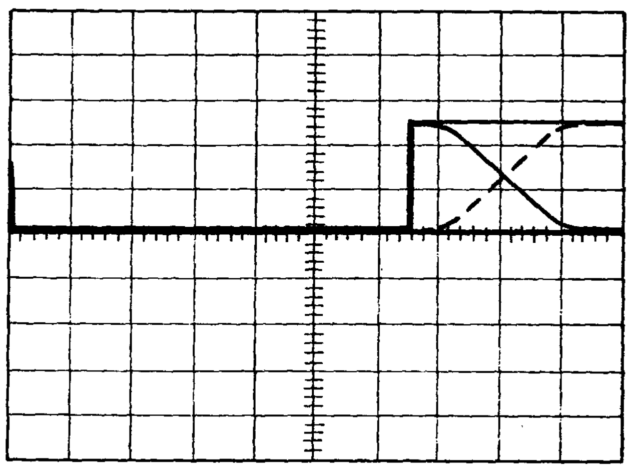


Figure 3-2

Low Level (±6V) 75 Baud Signal

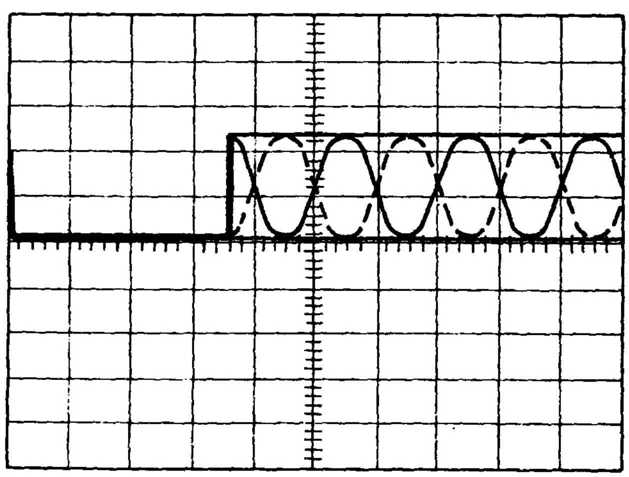
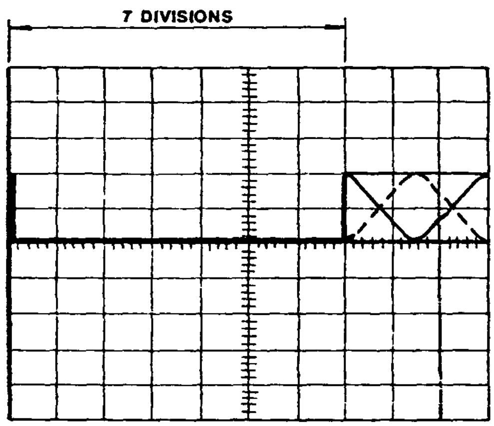


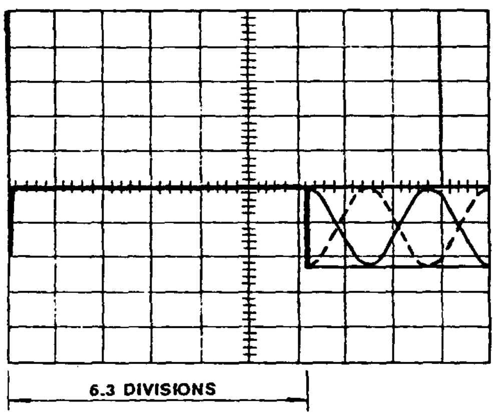
Figure 3-3

Low Level (±6V) 2400 Baud Signal



Length of SPACE Baud

Figure 3-4



Length of MARK Baud

Figure 3-5

Example Percent Distortion

$$\frac{7-6.3}{7+6.3} \times 100$$

$$\frac{.7}{13.3} \times 100$$

$$.052 \times 100 =$$

5.2 % MARKING BIAS DISTORTION

Figure 3-6

CHAPTER 3
QUALITY MONITORING TEST PROCEDURES

SECTION 2
QMS TEST #2 AUDIO SIGNAL ANALYSIS

3-2 QMS Test #2 General Information. Audio signal analysis for quality monitoring described in Chapter 2 requires that the following signal characteristics be determined:

a. Signal Level
b. Linearity
c. Frequency
d. Harmonic Products
e. Aural Monitoring

The following procedures describe testing audio signals using the Basic QMS described in Appendix A. Refer to the appropriate Operator or Technical manual for other QMS test procedures. Because of test equipment limitations and the manner of interconnecting equipment in the cabinet and the interface with the RCS, the BASIC QMS is limited to the following audio signal monitoring capabilities:

a. Signal Level
b. Aural Monitoring (Send Audio Only)
c. Audio Line Balance (Send Audio Only)

This limitation does not apply to the other quality monitoring systems.

3-2.1 Send Audio Signal Analysis.

3-2.1.1 Send Audio Signal Level.

a. At the RCS Transmitter Transfer Switchboard, patch the QMS console to the transmitter under test. This will parallel the QMS console with the audio input source of the transmitter.

b. Read the transmitter audio input (modulation) level on the QMS AUDIO LEVEL METER.

3-2.1.2 Send Audio Line Balance Test.

a. At the QMS SB-82 switchboard, connect the Send Audio to the Bridge-in and connect the db meter (ME-6) to the Bridge-out.

b. Place the ME-6 range switch to -20 db.

c. With an audio signal to the transmitter, the ME-6 should indicate no reading for a balanced signal line. If a reading is observed, an unbalanced signal or ground exists.

3-2.1.3 Send Audio Aural Monitoring.

a. At the QMS console, place the AUDIO SEL SWITCH to XMTR. Adjust the volume control on the Audio Amplifier for the desired hearing level.

3-2.1.4 Send Audio Test Rationale. RCS audio signals are balanced signals, with generally a -10dbm to +10dbm level, but having a nominal level of 0dbm. The audio level and other characteristics are ultimately determined by the discrete equipment used to configure the communications circuit and are discussed extensively for each system in Chapter 4 of this instruction.

3-2.2 Receive Audio Signal Analysis.

3-2.2.1 Receive Audio Level Test Procedures.

a. QMS console setup:

(1) Place the AUDIO SEL SWITCH to RCVR.

(2) On the SB-82 switchboard connect the RCV AUDIO LEVEL MONITOR to the AUDIO AMPL.

b. At the RCS Receive Audio Switchboard, patch the QMS console to the receiver under test. This will parallel the QMS AUDIO SEL SWITCH on the console with the receiver output and the RCS terminal equipment or remote unit.

c. Read the receiver audio output level on the QMS RCV LEVEL MONITOR.

3-2.3 Receive Audio Level Rationale. RCS audio signals are balanced signals with generally a -10dbm to +10dbm level, but having a nominal level of 0dbm. The audio level and other characteristics are ultimately determined by the discrete equipment used to configure the communications circuit and are discussed extensively for each system in Chapter 4 of this instruction.

CHAPTER 3
QUALITY MONITORING TEST PROCEDURES

SECTION 3
QMS TEST #3 RF SIGNAL ANALYSIS

3-3 QMS TEST #3 General Information. Quality Monitoring as described in Chapter 2 functions to provide on-line and off-line analysis of off-the-air RF signals in all frequency bands and modes of operation. This function requires that the following signal characteristics be determined:

a. Frequency
b. Signal/Noise
c. Linearity/Bandwidth
d. Harmonic Products
e. Carrier Suppression
f. Aural Monitoring (off-the-air)
g. Frequency Response

The following procedures are based on the use of the Basic Quality Monitoring System described in Appendix A. Because of test equipment limitations, the manner of interconnecting equipment in the QMS cabinet, and the interface of the QMS with the RCS, the BASIC QMS has limited capability to perform QM testing of RF signals. Frequency Response Tests cannot be made with the Basic QMS. Other limitations are defined in the following paragraphs of this section. These limitations do not apply to other quality monitoring systems.

3-3.1 QMS Test #3A-1 Measure Carrier Frequency of Amplitude Modulated HF Signal.

3-3.1.1 Equipment Connections. At the QMS Console connect the test equipment and devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In. At the RCS receive antenna patch panel, patch an HF antenna to the QMS console.

b. Connect Step Attenuator OUT to the R-1051 antenna.

c. At the SB-82 switchboard, patch R-1051 USB to the USM-117 oscilloscope (Vertical IN).

d. Connect the USM-207 1 KHz (Scaler Out) to the oscilloscope USM-117 Horizontal Input.

e. Connect the R-1051 100 Hz Synthesizer to USM-207 FREQ A Input.

3-3.1.2 QMS Test Equipment Control Settings.

a. AN/USM-207

(1) Set Power Switch to STORE.

(2) Set STD FREQ OUT switch to 10^3.

(3) Set GATE LENGTH to 1.

(4) Set FUNCTION switch to FREQ.

(5) Set SENSITIVITY switch to .1V. The counter should indicate a frequency between 11.000 and 12.00 KHz.

b. R-1051

(1) Set CPS switch to 000. The frequency counter should read 11.000 KHz.

(2) Set CPS switch to 500. The frequency counter should read 11.500 KHz.

(3) Set CPS switch to V or VERNIER.

c. AN/USM-117

(1) Set Horizontal Input to .1 V/CM.

(2) Set Horizontal Centering, Channel A Vertical Centering, and Intensity to produce a horizontal line centered on the scope.

(3) Set Channel A Volts/CM switch to the .2 position.

3-3.1.3 Test Procedures.

a. Set the R-1051 frequency dials 1 KHz below the assigned frequency.

b. Set the Mode switch to USB. An audio tone should be heard at this time. If the signal is from a local transmitter, the receiver may be overloaded and the output distorted. If necessary, adjust the step attenuator to reduce the signal strength to receive an undistorted audio signal.

c. While watching the oscilloscope, turn the R-1051 VERNIER knob slowly clockwise from 000. As the correct frequency is approached, a rapidly rotating circle will appear. Adjust the VERNIER very carefully until a stationary circle (lissajous pattern) is obtained.

d. Read the frequency indicated on the counter. Subtract 10.000 KHz from this reading; add the remainder to the R-1051 dial (window) frequency. The result is the transmitter (RF) Carrier Frequency.

EXAMPLE: A transmitter is transmitting on 2716.200 KHz. The R-1051 window frequency is set to 2715.000 KHz, and the CPS switch set to VERNIER. A lissajous pattern is present on the oscilloscope and the frequency counter is reading 11.200 KHz. First subtract 10.000 KHz from the counter's reading (11.200 KHz) which gives a result of 1.200 KHz, then add the 1.200 KHz to the window frequency of the R-1051 (2715 KHz) which equals 2716.200 KHz. 2716.200 KHz is the actual RF frequency being transmitted.

3-3.1.4 Rationale. Frequency requirements and acceptable errors are determined by the RCS circuit type and equipment use to configure the circuit. These requirements are defined in the communications systems description in Chapter 4.

3-3.2 QMS Test #3A-2 Measure Frequency HF SSB Voice.

3-3.2.1 Equipment Connections. At the QMS console connect the test equipment and devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In.

b. Connect Step Attenuator Out to the R-1051 Antenna.

c. At the SB-82 switchboard, patch R1051 USB to the USM-117 oscilloscope (Vertical IN).

d. Connect the USM-207 1 KHz (Scaler Out) to the oscilloscope USM-117 Horizontal Input.

e. Connect the R-1051 100 Hz Synthesizer to USM-207 FREQ A Input.

3-3.2.2 QMS Equipment Control Settings.

a. AN/USM-207

(1) Set Power Switch to STORE.

(2) Set STD FREQ OUT switch to 10^3.

(3) Set GATE LENGTH to 1.

(4) Set FUNCTION switch to FREQ.

(5) Set SENSITIVITY switch to .1V. The counter should indicate a frequency between 11.000 KHz and 12.000 KHz.

b. R-1051

(1) Set CPS switch to 000. The frequency counter should read 11.000 KHz.

(2) Set CPS switch to 500. The frequency counter should read 11.500 KHz.

(3) Set CPS switch to V or VERNIER.

c. AN/USM-117

(1) Set Horizontal Input to .1 V/CM.

(2) Set Horizontal Centering, Channel A Vertical Centering, and Intensity to produce a horizontal line centered on the scope.

(3) Set Channel A V/CM switch to the .2 position.

3-3.2.3 Test Procedures. A Suppressed Carrier Radio Frequency signal is measured the same way as an Amplitude Modulated Carrier signal, except that a fully suppressed carrier cannot be measured. However, on local transmitters some "leakage" carrier can usually be detected and measured. The measurement can also be made by inserting a full or reduced carrier. To measure the Radio Frequency of a distant station's SSB transmitter, it will be necessary to request that a carrier be reinserted or that the transmitter be modulated with an accurate, known tone frequency.

a. Set the R-1051 Frequency dials 1 KHz below the assigned frequency.

b. Set the Mode switch to USB. An audio tone should be heard. If the signal is from a local transmitter, the receiver may be overloaded and the output distorted. If necessary, adjust the step attenuator to reduce the signal strength to receive an undistorted audio signal.

c. While watching the oscilloscope turn the R-1051 VERNIER knob slowly clockwise from 000. As the correct frequency is approached, a rapidly rotating circle will appear. Adjust the VERNIER very carefully until a stationary circle (lissajous pattern) is obtained.

d. Read the frequency indicated on the counter. Subtract 10.000 KHz from this reading; add the remainder to the R-1051 dial (window) frequency. The result is the transmitter (RF) Carrier Frequency.

EXAMPLE: A transmitter is transmitting on 2716.200 KHz. The R-1051 window frequency is set to 2715.000 KHz, and the CPS switch set to VERNIER. A lissajous pattern is present on the oscilloscope and the frequency counter is reading 11.200 KHz. First subtract 10.000 KHz from the counter's reading (11.200 KHz) which gives a result of 1.200 KHz, then add the 1.200 KHz to the window frequency of the R-1051 (2715 KHz) which equals 2716.200 KHz. 2716.200 KHz is the actual RF frequency being transmitted.

3-3.2.4 Rationale. Frequency requirements and acceptable errors are determined by the RCS circuit type and equipment used to configure the circuit. These requirements are defined in the communications systems description in Chapter 4.

3-3.3 QMS Test #3A-3 Measure Frequency HF Composite Tones.

3-3.3.1 Equipment Connections. At the QMS console connect the test equipment and devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In.

b. Connect Step Attenuator Out to the R-1051 Antenna.

c. At the SB-82 switchboard, patch R1051 USB to the USM-117 oscilloscope (Vertical IN).

d. Connect the USM-207 1 KHz (Scaler Out) to the oscilloscope USM-117 Horizontal Input.

e. Connect the R-1051 100 Hz Synthesizer to USM-207 FREQ A Input.

3-3.3.2 QMS Equipment Control Settings.

a. AN/USM-207

(1) Set Power Switch to STORE.

(2) Set STD FREQ OUT switch to 10^3.

(3) Set GATE LENGTH to 1.

(4) Set FUNCTION switch to FREQ.

(5) Set SENSITIVITY switch to .1V. The counter should indicate a frequency between 11.000 KHz and 12.000 KHz.

b. R-1051

(1) Set CPS switch to 000. The frequency counter should read 11.000 KHz.

(2) Set CPS switch to 500. The frequency counter should read 11.500 KHz.

(3) Set CPS switch to V or VERNIER.

c. AN/USM-117

(1) Set Horizontal Input to .1 V/CM.

(2) Set Horizontal Centering, Channel A Vertical Centering, and Intensity to produce a horizontal line centered on the scope.

(3) Set Channel A Volts/CM switch to the .2 position.

3-3.3.3 Procedures. Measurement of Composite Tone Signal Radio Frequency is similar to measuring SSB Voice signals in that no steady carrier is available. The frequency corresponding to the MARK or SPACE tone of two or more channels may be measured and the error attributed to the carrier frequency. If differing errors are found in two channels, the error may also be due to the Tone Terminal Equipment.

a. Refer to Table 3-1 and set the R-1051 Frequency dials for channel frequencies as follows:

(1) 1 KHz below the assigned frequency for channels 1 through 4.

(2) To the assigned frequency for channels 5 through channel 10.

(3) 1 KHz above the assigned frequency for channels 11 through the MARK tone of channel 16.

(4) 2 KHz above the assigned frequency for channel 16 SPACE tone.

b. Set the Mode switch to USB. An audio tone should be heard at this time. If the signal is from a local transmitter, the receiver may be overloaded and the output distorted. If necessary adjust the step attenuator to reduce the signal strength to receive an undistorted audio signal.

c. While watching the oscilloscope, turn the R-1051 VERNIER knob slowly clockwise from 000. As the correct frequency is approached, a rapidly rotating circle will appear. Extreme caution is necessary in adjusting the VERNIER control to pick out the desired tone. It will be observed that the lissajous on the scope cannot be made entirely stationary if the channel is keying. Also, some noise will be present due to adjacent channels. Adjust the VERNIER very carefully until a stationary circle (lissajous pattern) is obtained.

d. Read the frequency indicated on the counter. Refer to Table 3-1 to verify the correct channel frequency is displayed.

EXAMPLE: A transmitter is transmitting on 2716.000 KHz. The R-1051 window frequency is set to 2715.000 KHz, and the CPS switch set to VERNIER. A lissajous pattern of the first channel to appear is present on the oscilloscope and the frequency counter is reading 11.383 KHz. Refer to Table 3-1 to verify that this is the correct frequency for the MARK tone of Channel 1.

e. A 16-channel composite signal will contain 32 different frequencies (16 Mark and 16 Space) if all channels are being keyed. The frequency counter indication, Mark and Space tone channel frequencies, and the settings for the R-1051 are as shown in Table 3-1 below.

TABLE 3-1 Channel Frequencies

Channel No.	M/S	Channel Vernier	R-1051 Freq. Setting	R-1051 Vern Dial	Counter Read out
1	M	382.5		382	11382
	S	467.5		467	11467
2	M	552.5	1 KHz	552	11552
	S	637.5	Below	637	11637
3	M	722.5	Assigned	722	11722
	S	807.5	Freq.	807	11807
4	M	892.5		892	11892
	S	977.5		977	11977
5	M	1062.5		062	11062
	S	1147.5		147	11147
6	M	1232.5		232	11232
	S	1317.5		317	11317
7	M	1402.5		402	11402
	S	1487.5	Assigned	487	11487
8	M	1572.5	Freq.	572	11572
	S	1657.5		657	11657
9	M	1742.5		742	11742
	S	1827.5		827	11827
10	M	1912.5		912	11912
	S	1997.5		997	11997
11	M	2082.5		082	11082
	S	2167.5		167	11167
12	M	2252.5		252	11252
	S	2337.5	1 KHz	337	11337
13	M	2422.5	Above	422	11422
	S	2507.5	Assigned	507	11507
14	M	2592.5	Freq.	592	11592
	S	2677.5		677	11677
15	M	2762.5		762	11762
	S	2847.5		847	11847
16	M	2932.5		932	11932
	S	3017.5	2 KHz Above Assigned Freq.	017	11017

3-3.3.4 Rationale. The Tone Channel frequency indicated on the frequency counter must be within 3 Hz of the Counter Read Out given in Table 3-1.

3-3.4 QMS Test #3A-4 Measure Frequency of FSK and AFTS Single Channel Signals (MF/HF above 2 MHz). To perform the RF frequency accuracy test for FSK AFTS signals, a constant Mark or constant Space must be transmitted; therefore, this test cannot be made non-interfering with communications.

3-3.4.1 Equipment Connections. At the QMS Console, connect the test equipment and devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In.

b. Connect Step Attenuator Out to the R-1051 Antenna.

c. At the SB-82 switchboard, patch R1051 USB to the USM-117 oscilloscope (Vertical In).

d. Connect the USM-207 1 KHz (Scaler Out) to the oscilloscope USM-117 Horizontal Input.

e. Connect the R-1051 100 Hz Synthesizer to USM-207 FREQ A Input.

3-3.4.2 QMS Equipment Control Settings.

a. AN/USM-207

(1) Set Power Switch to STORE.

(2) Set STD FREQ OUT switch to 10^3.

(3) Set GATE LENGTH to 1.

(4) Set FUNCTION switch to FREQ.

(5) Set SENSITIVITY switch to .1V. The counter should indicate a frequency between 11.000 KHz and 12.000 KHz.

b. QMS R-1051

(1) Set CPS switch to 000. The frequency counter should read 11.000 KHz.

(2) Set CPS switch to 500. The frequency counter should read 11.500 KHz.

(14) CAL OSC LEVEL	Set to OFF position.
(15) INPUT ATTENUATOR	Set to 0 db or as required.
(16) DUAL RF TEST	Set to OFF position.
(17) JUMPER	INTERNAL VFO OUTPUT TO VARIABLE FREQ OSC INPUT.
(18) VAR FREQ OSC	Set to INT, adjust for "red line" indication on RF Level Input/Output meter.

3-3.5.1.3 Procedures.

a. Set BAND SELECTOR as appropriate.

b. Adjust RF MAIN TUNING dial at the correct frequency until the signal is located near the center of the screen. Use the fast, X10 position during this search period to more quickly locate the signal. Use RF COARSE and FINE TUNING as required.

c. Change sweep width to required value for signal being observed.

d. Adjust IF Gain until signal peaks; add attenuation as necessary with 0-120db Step Attenuator to keep signal on scope; reach full-scale deflection.

e. Adjust IF GAIN for full-scale deflection.

3-3.5.1.4 Rationale. This test is to determine the strength of the Radio Frequency signal in relation to the amount of noise present. Figures 3-7 through 3-10, with accompanying notations, provide guidance in analyzing the results of this test. The peak signal should be not less than 15 db above peak noise.

3-3.5.2 QMS Test #3B-2 Measure RF Signal Above Noise (Spectrum Analyzer IF Operation).

3-3.5.2.1 Equipment Connections. At the QMS console connect the test equipment and test devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In.

b. Connect the Step Attenuator Out to the R-1051 antenna.

c. Connect the R-1051 500 KHz IF to the TS-1379A 500 KHz INPUT.

3-3.5.2.2 <u>TS-1379A Control Settings.</u> Set the controls on the TS-1379A Spectrum Analyzer as follows:

(1) Set test equipment power switches to the ON position and allow about 30 minutes for warm-up.

(2)	BRIL	Adjust as required.
(3)	FOCUS	Adjust for sharp trace.
(4)	ASTIG	Adjust for uniform trace.
(5)	AMPLITUDE SCALE	Set to LIN position.
(6)	VERT POS	Adjust trace to coincide with LIN-0 on CRT scale.
(7)	AMPLITUDE SCALE	Set in LOG position.
(8)	HORIZ POS	Center trace on CRT screen.
(9)	CENTER FREQ COARSE	Center position pointer up.
(10)	CENTER FREQ FINE	Center position pointer up.
(11)	IF GAIN	Set in mid position.
(12)	IF ATTEN	Set to 20 db.
(13)	SWEEP WIDTH	Set to 30 KHz.
(14)	CAL OSC LEVEL	Set position as required.
(15)	INPUT ATTENUATOR	Set to 0 db.
(16)	DUAL RF TEST	Set to OFF position.

3-3.5.2.3 Test Procedures.

a. Tune Receiver or SA to Assigned Radio Frequency.

b. Adjust IF Gain until signal peaks; add attenuation as necessary with 0-120 dB pad to keep signal on scope; reach full-scale deflection.

c. Adjust Center Freq Coarse until signal is centered on Screen.

d. Change sweep width to required value for signal being observed.

(1) 2 KHz is recommended for FSK and FAX.

(2) 7 KHz is recommended for multichannel tones so both sidebands will be present.

(3) 1 KHz is recommended for CV-2460/SGC on SSB and 2 KHz if on AM.

3-3.5.2.4 Rationale. This test is to determine the strength of the Radio Frequency signal in relation to the amount of noise present. Figures 3-7 through 3-10, with accompanying notations, provide guidance in analyzing the results of this test. The peak signal should be not less than 15 db above peak noise.

NOTE: Signals will appear as shown in the figures for each mode of operation listed below.

FSK and AFTS signals	Figure 3-7
FAX tones	Figure 3-8
MULTICHANNEL tones	Figures 3-9 and 3-10

3-3.6 QM Test #3C Linearity of Multichannel/Ratt Tones. This test measures the individual tone levels of an HF composite signal. This test requires a special signal to modulate the transmitter; therefore, this test cannot be made non-interfering to communications.

3-3.6.1 Equipment Connections. At the QMS Console, connect the test equipment and devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In.

b. Connect the Step Attenuator Out to the R-1051 antenna.

c. Connect the R-1051 500 KHz IF to the TS-1379A 500 KHz INPUT.

3-3.6.2 TS-1379A Control Settings. Set the controls on the TS-1379A Spectrum Analyzer as follows:

(1) Set test equipment power switches to the ON position and allow about 30 minutes for warm-up.

(2)	BRIL	Adjust as required.
(3)	FOCUS	Adjust for sharp trace.
(4)	ASTIG	Adjust for uniform trace.
(5)	AMPLITUDE SCALE	Set to LIN position.
(6)	VERT POS	Adjust trace to coincide with LIN-0 on CRT scale.
(7)	AMPLITUDE SCALE	Set in LOG position.
(8)	HORIZ POS	Center trace on CRT screen.
(9)	CENTER FREQ COARSE	Center position pointer up.
(10)	CENTER FREQ FINE	Center position pointer up.
(11)	IF GAIN	Set in mid position.
(12)	IF ATTEN	Set to 20 db.
(13)	SWEEP WIDTH	Set to 30 KHz.
(14)	CAL OSC LEVEL	Set position as required.
(15)	INPUT ATTENUATOR	Set to 0 db.
(16)	DUAL RF TEST	Set to OFF position.

3-3.6.3 Test Procedures.

a. Tune the transmitter to the desired frequency for USB fully suppressed carrier operation.

b. Modulate the transmitter with the selected Multichannel Keyers.

c. Provide a MARK tone from all Keyers. This is accomplished at the black DC patch panel by placing a dummy plug in the set jack of all Keyers

d. Adjust the spectrum analyzer controls and the RF attenuator for a visual display on the spectrum analyzer.

e. Observe on the spectrum analyzer the level of each tone of the composite signal.

3-3.6.4 Rationale. The tone level of all channels must be within 2 db of one another as shown in Fig. 3-9.

3-3.7 QMS Test #3D Harmonic/InterModulation Distortion. This test uses the IF operation of the TS-1379A Spectrum Analyzer to measure the HF USB RF signal level in relation to levels of harmonic and intermodulation products. The test requires a special signal to modulate the transmitter. Therefore, this test is conducted when the communications circuit is originally set up.

3-3.7.1 Equipment Connections. At the QMS console connect the test equipment and test devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In.

b. Connect the Step Attenuator Out to the R-1051 antenna.

c. Connect the R-1051 500 KHz IF to the TS-1379A 500 KHz Input.

d. At the QMS SB-82 Switchboard, patch the SG-376A/U to the C-1138 XMTR AF.

e. At the RCS Transmitter Transfer Switchboard, patch the QMS C-1138 to the transmitter under test.

3-3.7.2 Test Equipment Control Settings. Set the controls on the QMS test equipment as follows:

a. TS-1379/U Spectrum Analyzer:

(1) Set test equipment power switches to the ON position and allow about 30 minutes for warm-up.

(2)	BRIL	Adjust as required.
(3)	FOCUS	Adjust for sharp trace.
(4)	ASTIG	Adjust for uniform trace.
(5)	AMPLITUDE SCALE	Set to LIN position.
(6)	VERT POS	Adjust trace to coincide with LIN-0 on CRT scale.
(7)	AMPLITUDE SCALE	Set to LOG position.
(8)	HORIZ POS	Center trace on CRT screen.
(9)	CENTER FREQ COARSE	Center position pointer up.
(10)	CENTER FREQ FINE	Center position pointer up.
(11)	IF GAIN	Set in mid position.
(12)	IF ATTEN	Set to 20 db.
(13)	SWEEP WIDTH	Set to 30 KHz.
(14)	CAL OSC LEVEL	Set position as required.
(15)	INPUT ATTENUATOR	Set to 0 db.
(16)	DUAL RF TEST	Set to OFF position.

b. SG-376A/U Two-Tone Signal Generator:

(1) Set CHAN SELECT to A+B.

(2) Set Power to ON.

(3) Select two tones with CHANNEL A FREQUENCY CPS (1 KHz) and CHANNEL B FREQUENCY CPS (2 KHz).

(4) With OUTPUT set to AF, adjust A.F. BALANCE for minimum reading on the OUTPUT meter.

(5) Adjust ATTEN DB for a reading of 0DB on the QM console SEND LEVEL meter.

3-3.7.3 Test Procedures.

a. Tune to the assigned frequency, CW mode and set to maximum authorized power.

b. Set the QMS R-1051 to the assigned (carrier) frequency of the transmitter. Set the R-1051 to USB mode.

c. Adjust the spectrum analyzer CENTER FREQ COARSE/FINE controls and IF GAIN control so the signal (carrier frequency) is at the 0DB reference, as shown in Figure 3-11.

d. Place the transmitter in USB mode. Patch the two-tone test signal of the SG-376A to the USB audio channel of the transmitter. Ensure the two tones are of equal amplitude.

e. Adjust the TS-1379 IF Gain control so the two tones are presented on the spectrum analyzer at -3 dB, with respect to 0 dB reference, as shown in Figure 3-12.

f. Harmonic and inter-modulation products will be displayed on the spectrum analyzer as spikes. Their levels are measured on the dB scale on the face of the TS-1379A CRT. See Figures 3-13 and 3-14.

3-3.7.4 Rationale. Harmonic and inter-modulation products must be not less than 35 db down from the two-tone signal peaks.

3-3.8 QM Test #3E Carrier Suppression. This test measures the Carrier Suppression of HF transmitters for SSB and FSK signals.

3-3.8.1 Equipment Connections. At the QMS Console connect the test equipment and test devices as follows:

a. Connect the Antenna Patch Panel to Step Attenuator In.

b. Connect the Step Attenuator Out to the R-1051 antenna.

c. Connect the R-1051 500 KHz IF to the TS-1379A 500 KHz Input.

d. At the QMS SB-82 Switchboard, patch the SG-376A/U to the C-1138 XMTR AF.

e. At the RCS Transmitter Transfer Switchboard, patch the QMS C-1138 to the transmitter under test.

3-3.8.2 Test Equipment Control Settings. Set the controls on the QMS test equipment as follows:

a. TS-1379/U Spectrum Analyzer:

(1) Set test equipment power switches to the ON position and allow about 30 minutes for warm-up.

(2)	BRIL	Adjust as required.
(3)	FOCUS	Adjust for sharp trace.
(4)	ASTIG	Adjust for uniform trace.
(5)	AMPLITUDE SCALE	Set to LIN position.
(6)	VERT POS	Adjust trace to coincide with LIN-0 on CRT scale.
(7)	AMPLITUDE SCALE	Set to LOG position.
(8)	HORIZ POS	Center trace on CRT screen.
(9)	CENTER FREQ COARSE	Center position pointer up.
(10)	CENTER FREQ FINE	Center position pointer up.
(11)	IF GAIN	Set in mid position.
(12)	IF ATTEN	Set to 20 db.
(13)	SWEEP WIDTH	Set to 30 KHz.
(14)	CAL OSC LEVEL	Set position as required.
(15)	INPUT ATTENUATOR	Set to 0 db.

(16) DUAL RF TEST Set to OFF position.

b. SG-376A/U Two-Tone Signal Generator.

(1) Set CHAN SELECT to A+B.

(2) Set Power to ON.

(3) Select two tones with CHANNEL A FREQUENCY CPS (1 KHz) and CHANNEL B FREQUENCY CPS (2 KHz).

(4) With OUTPUT set to AF, adjust A.F. BALANCE for minimum reading on the OUTPUT meter.

(5) Adjust ATTEN dB for a reading of 0 dB on the QM console SEND LEVEL meter.

3-3.8.3 Test Procedures. These procedures use the IF operation of the TS-1379A Spectrum Analyzer to measure the relation between HF transmitter USB signals and the suppressed carrier. This test requires a special signal to modulate the transmitter. Therefore, this test is conducted when the communications circuit is originally setup using the following procedures.

a. Tune to the assigned frequency, CW mode and set to maximum authorized power. Take careful notice of the location of the CW carrier signal position on the spectrum analyzer graticule.

b. Set the QMS R-1051 to the assigned (carrier) frequency of the transmitter. Set the R-1051 to USB mode.

c. Adjust the spectrum analyzer CENTER FREQ COARSE/FINE controls and IF GAIN control so the signal (carrier frequency) is at the 0 dB reference, as shown in Figure 3-11.

d. Place the transmitter in USB mode. Patch the two-tone test signal of the SG-376A to the USB audio channel of the transmitter. Ensure the two tones are of equal amplitude.

e. Adjust the TS-1379 IF Gain control so the two tones are presented on the spectrum analyzer at -3 dB, with respect to 0 dB reference, as shown in Figure 3-13.

f. Carrier Suppression is determined by the number of dB between the peak of the two tones and the carrier displayed on the spectrum

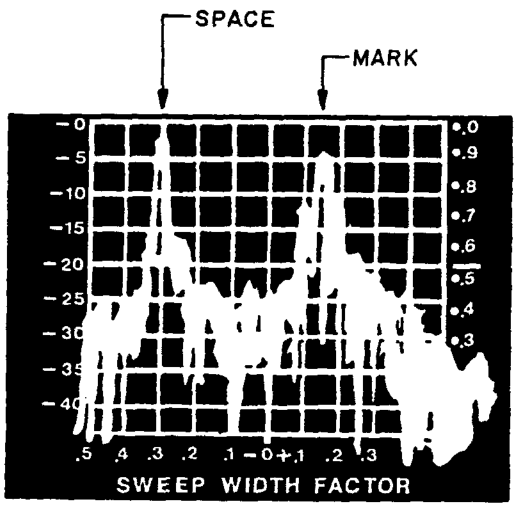


Figure 3-7

- FSK Signal. AFTS 850 Hz Shift.
- 2 kHz Sweepwidth.
- Signal Peaks Approx Equal.
- Average Noise Approx 25 dB Down from Signal Peaks.
- Good Frequency.

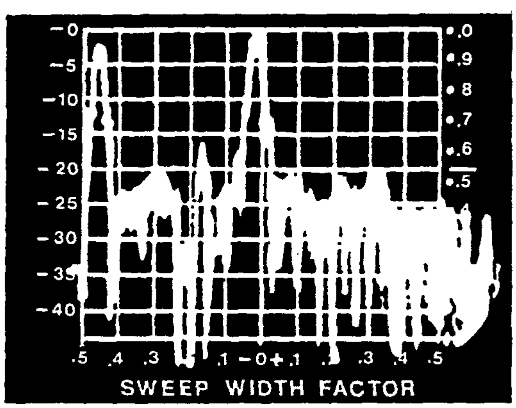


Figure 3-8

- Fax Picture.
  Noise Peaks Approx 25 dB
- Down from Signal Peaks.
  Good Frequency.

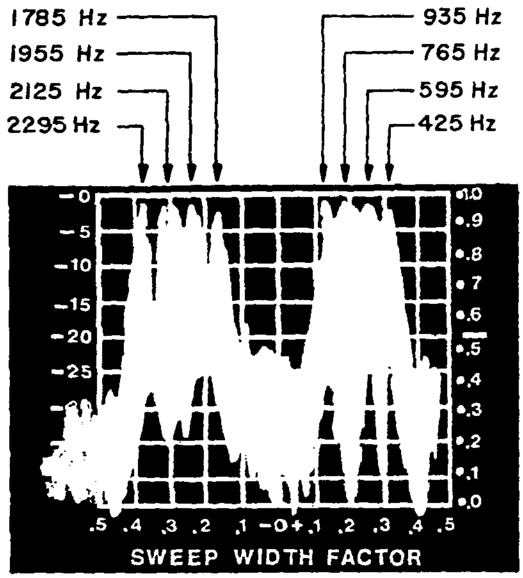


Figure 3-9

- 4 Channel "P" System, Twinned ((8 Tones).
- 3.5 kHz Sweepwidth.
- All Channels on MARK, Avg. Sig. to Noise Ratio 30:1.
- Good Sig.

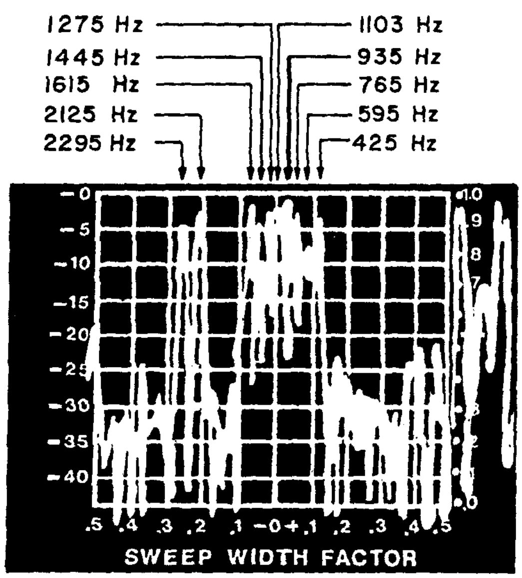


Figure 3-10

- 10 Channel "N" System, Untwinned (10 Tones).
- 7 kHz Sweepwidth.
- Channels Keying, Avg. Sig. to Noise Ratio 30:1.
- Good Sig.

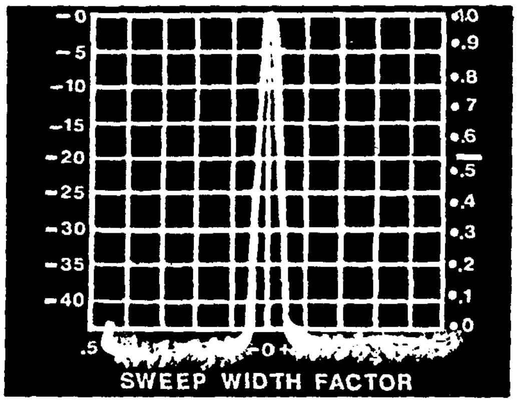


Figure 3-11

- Power Reference Intermodulation Distortion Test Carrier Only.

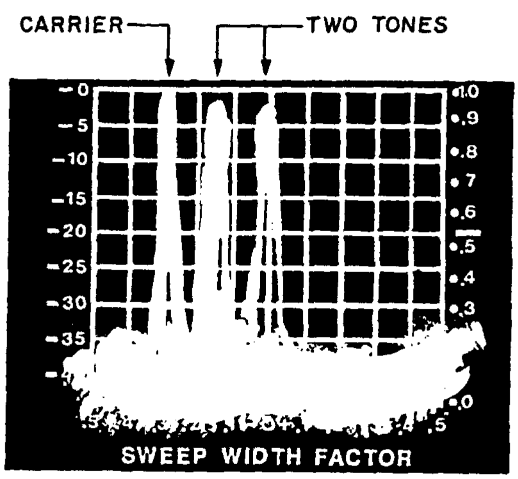


Figure 3-12

- Two Tone Test (USB) Re-inserted Carrier.
- 7 kHz Sweepwidth.
- No Intermod Distortion.

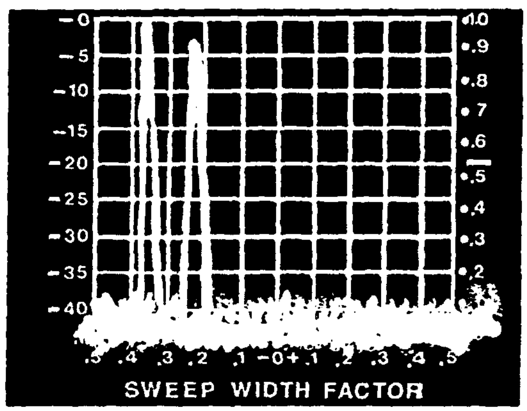


Figure 3-13

- Two-Tone Test (USB).
- 7 kHz Sweepwidth.
- No Intermodulated Distortion.
- Carrier Suppression.

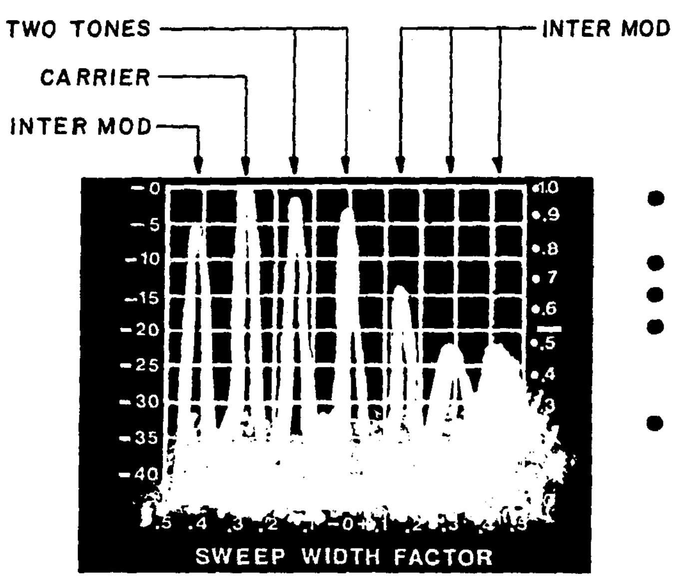


Figure 3-14

- Two-Tone Test (USB) Reinserted Carrier.
- 7 kHz Sweepwidth.
- Intermodulated Products.
- Intermodulated Products should be down -35 dB from Signal Peaks.
- Bad Transmitter.

analyzer. The Carrier will be in the position noted in step a. above. Refer to Figure 3-12.

3-3.8.4 Rationale. The carrier is fully suppressed when the carrier is at least 40 dB below the signal peaks.

3-3.9 QM Test #3H Non-Secure/Secure VHF/UHF Spectrum Analysis. The purpose of this test is to provide the operator with the criteria that associated VHF/UHF radio equipment must meet to ensure proper operation of wideband secure voice systems. The method of spectrum analysis described will allow the operator to visually observe the relative quality of transmit and receive signals and to determine if circuit degradation is caused by interference.

3-3.9.1 Equipment Connections. At the QMS console connect the test equipment and devices as follows:

a. Connect the Antenna Patch Panel to the 0-120 db Step Attenuator INPUT.

b. Connect the Step Attenuator OUTPUT to the AN/URR-52 antenna.

c. At the QMS SB-82 switchboard, connect the AN/URR-52 audio out to the Audio Amplifier.

3-3.9.2 AN/URR-52 SET UP.

a. Set the BAND SWITCH to the appropriate band as determined by the frequency to be tested.

b. Ensure the antenna patched to the QMS console is of the proper frequency range for the signal being tested.

c. Adjust appropriate FREQUENCY DIAL to the desired frequency. With a signal present to the receiver, adjust FREQUENCY DIAL for a ZERO (mid-scale) indication on the TUNING METER.

d. Adjust AUDIO GAIN on the AN/URR-52 and the Audio Amplifier Volume control to the desired level and ensure that the signal being monitored is correct.

e. Adjust PANORAMIC DISPLAY for optimum signal presentation.

NOTE: Set the 0-120 dB STEP ATTENUATOR for a setting between 20 and 50 dB when monitoring local transmissions. If SCOPE presentation appears to be overdriven by the strong local transmission, increase the attenuation until the signal presentation does not peak beyond the top of the scope. When monitoring distant stations, set the attenuator to 0 dB.

3-3.9.3 Test Procedures. During this test the Quality Monitor Operator will observe the AN/URR-52A PANORAMIC SCOPE for the correct presentation. The typical presentations represented in Figures 3-15 through 3-21 are obtained using the following procedures:

a. Transmit Tests will be accomplished by requesting the operator to key the transmitter and give a short count from the remote secure phone unit.

b. Receive tests will be accomplished by having the operator request a short count from the distant station.

3-3.9.4 Rationale. The PANORAMIC SCOPE presentations shown in Figure 3-15 and Figure 3-18 indicate acceptable performance quality. Figures 3-16, 3-15, 3-19, 3-20, and 3-21 show signals that will cause degradation of communications.

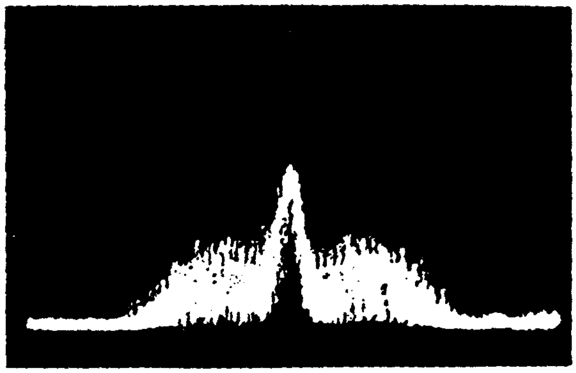


Figure 3-15

AM Wideband Transmitter RF Spectrum
Good signal containing minimum distortion with 100% modulation.

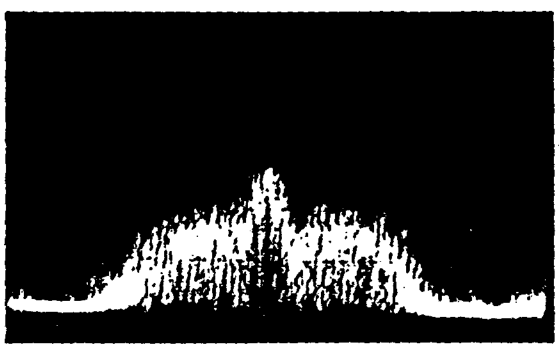


Figure 3-16

AM Wideband Transmitter RF Spectrum. Poor signal, nonlinear distortion introduced by greater than 100% modulation resulting in circuit degradation.

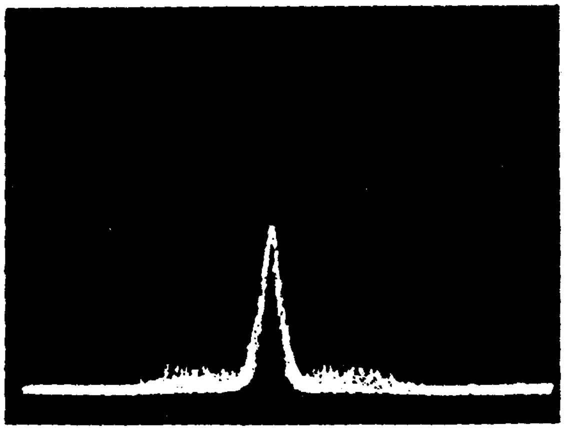


Figure 3-17

AM Wideband Transmitter RF Spectrum.
Poor signal, approximately 20% modulation producing little sideband signal. Distant receiver probably would not "break" this signal.

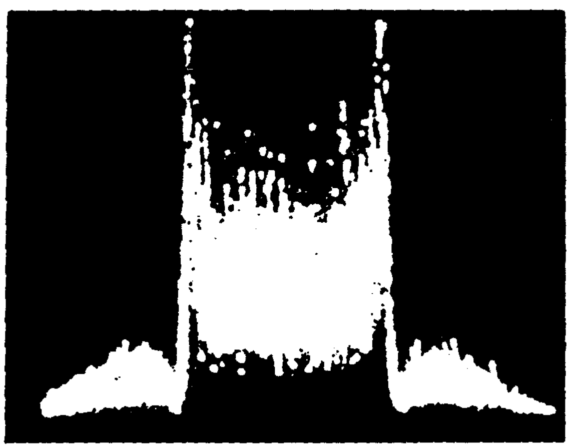


Figure 3-18

FM Wideband Transmitter RF Spectrum. Good signal containing a minimum of distortion. RF energy level is fairly constant from 10 kHz above to 10 kHz below the center frequency.

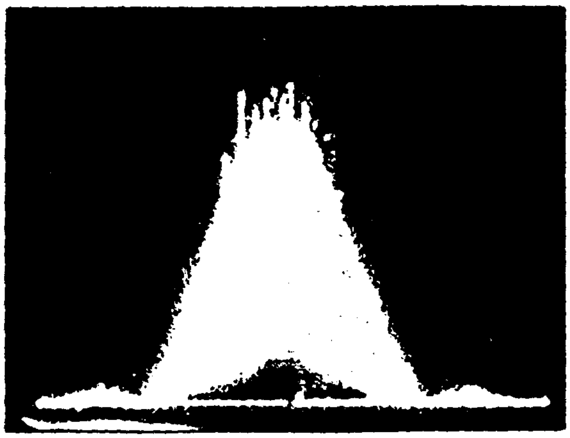


Figure 3-19

FM Wideband Transmitter RF Spectrum.
Poor signal, RF energy is good from 5 kHz above to 5 kHz below the center frequency. The distant receiver's output amplitude would be decreased causing circuit degradation.

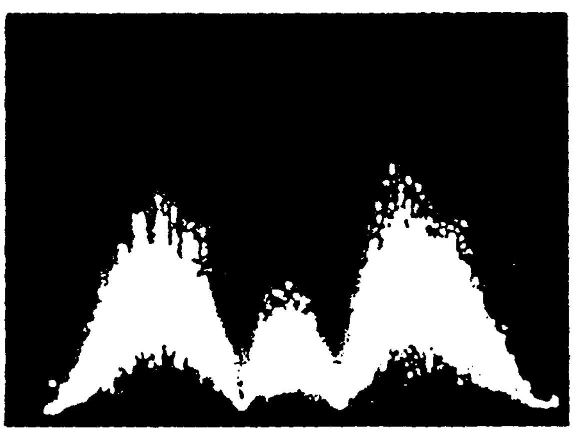


Figure 3-20

FM Wideband Transmitter RF Spectrum.
Poor signal, the major portion of the RF energy is outside the 10 kHz points above and below the center frequency. The distant receiver's output amplitude would be increased; however circuit degradation will occur due to loss of low frequency response.

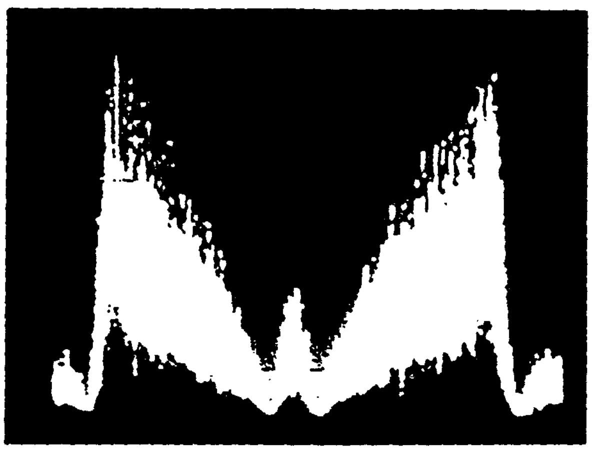


Figure 3-21

FM Wideband Tramsmitter RF Spectrum.
Poor signal, major portion of RF energy is outside the 10 kHz points above and below the center frequency. Major portion of RF energy would occur at the nonlinear portion of the distant receiver's IF strip causing circuit degradation.

CHAPTER 4

SYSTEMS DESCRIPTIONS

4-0 General. This chapter is composed of narrative descriptions and functional block diagrams of typical Navy communication systems. The purpose of this chapter is to acquaint the shipboard communicator with the "systems" concept of analyzing shipboard communications quality and identifying communication degradation or failure. The description and diagrams define the system as a group of inter-connected equipment which acts on a signal and changes it from one form to another.

It is recommended that communication personnel insert their own ship's communications equipment nomenclature into the systems diagrams. This will facilitate training operators by permitting radiomen to relate their own ship's equipment to the communications systems and QM procedures described in this instruction.

The test procedures and parameters defined in this chapter are found in Chapter 3.

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 1
TYPE "B" SYSTEM UHF SIMPLEX
SINGLE CHANNEL AFTS RADIO TELETYPEWRITER SYSTEM

4-1 System Description. The "B" system provides secure, single channel, simplex, Audio Frequency Tone Shift (AFTS) UHF Line of Sight radio teletype communication. Refer to Figure 4-1. The type "B" system operates netted (SIMPLEX) with all transceivers tuned to a single frequency, and the tone terminal equipment operates in the SIMPLEX mode. This system consists of the antenna and associated multicouplers, transceiver, transmitter and receiver audio switchboards, the tone terminal equipment, BLACK DC patch panel, crypto device, RED DC patch panel, and teletypewriter equipment. Refer to Table 4-1 for nomenclature, and Table 4-2 for signal parameters typical to a "B" system.

4-1.1 System Signal Flow. System signal flow and equipment functional relationships are shown in Figure 4-1, and described in the following paragraphs.

4-1.1.1 Receive Operation. The Amplitude Modulated (AM) UHF signal is received at the antenna and patched via a multicoupler to the receiver portion of the transceiver where demodulation takes place. The resulting Audio Frequency Tone Shifted (AFTS) signal, one tone (700Hz) for a MARK and one tone (500Hz) for a SPACE, is patched to the tone terminal equipment via the receiver audio switchboard. The tone terminal equipment in the simplex mode, when not sending, will automatically go into a receive condition the instant an incoming signal is received. The tone terminal equipment converts the AFTS into a DC signal which is patched via the BLACK DC patch panel to the crypto device. The decrypted signal from the crypto device is patched to the teletypewriter via the RED DC patch panel.

4-1.1.2 Transmit Operation. The teletypewriter keyboard or Transmitter Distributor (TD) generates the RED DC signal which is patched to the crypto device via the RED DC patch panel. The encrypted (BLACK) DC signal, from the crypto device, is patched to the tone terminal equipment via the BLACK DC patch panel. The tone terminal equipment converts the DC signal to an AFTS signal, 500Hz tone for a SPACE and 700Hz tone for a MARK. The tone terminal equipment, when not receiving, will automatically go to the SEND condition the instant the BLACK DC SEND loop is keyed. The tone terminal AFTS output signal is patched to the transmitter audio input via the transmitter transfer switchboard. The transmitter amplitude modulated RF signal is then routed to the antenna via the antenna coupler.

4-1.1.3 Phasing. Phasing control of the send TSEC/KW-7 is accomplished locally at the TSEC/KW-7 or by a Functional Remote Unit (FRU) KWX-8/TSEC, located at the teletypewriter position. FRUs are either hardwired or patched through a FRU switchboard to the KW-7. Phasing for the TSEC/KG-84 does not require operator intervention.

4-1.2 Verification of System Quality. Prior to entering the net and periodically during on-line operation the system configuration must be tested using QMS testing procedures. Refer to Table 4-2 for the test points and signal parameters for initial set-up and on-line QM tests.

TABLE 4-1 LIST OF TYPICAL EQUIPMENT FOR THE "B" SYSTEM

ANTENNA

AS-390/SRC
AT-150/SRC
AS-1018/URC
AS-2877/SRC
AS-1735/SRC

ANTENNA COUPLER

AN/SRA-33

TRANSCEIVERS

URC-9 (FAMILY)
RT-1107(V)WSC-3

SWITCHBOARDS

SB-863/SRT
SB-973/SRR
SB-2727()/SRR
SB-988/SRT

TELEGRAPH TERMINAL
KEYER/CONVERTER

CV-2460/SGC

TELETYPE PATCH PANELS

SB-1203A/UG
SB-1210A/UGQ
SB-4034/UG
SB-4035/UG

SECURITY DEVICES

TSEC/KG-84
TSEC/KW-7

KWX-8/TSEC

TELETYPEWRITER EQUIPMENT
(See Note)

Automatic Send/Rcv (ASR)
Keyboard Send/Rcv (KSR)

Receive only (RO)
Transmit Distributor
(TD)

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

TABLE 4-2. TESTS FOR THE "B" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameter
1 and 2	TTY Signal	
	a. Signal Level	
	1. High Level	58 to 62 ma.
	2. Low Level	+5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum.
	d. Distortion	5% Maximum.
3	Audio Signal	
	a. Send Level	0 dBm.
	b. Frequency	697 - 703 Hz (MARK) 497 - 503 Hz (SPACE)
4 (SEND)	R.F. Signal	Refer to Section 3, paragraph 3-3.9, QM test #3H.
4 (RECEIVE)	R.F. Signal	Refer to Section 3, paragraph 3-3.9, QM test #3H.

TABLE 4-2 TEST FOR THE "B" SYSTEM (CONT)

INITIAL SET-UP

Test Point No.	Test	Parameter
5	*Audio Signal*	
	a. Signal Level	0 dBm.
	b. Frequency	697 - 703 Hz (MARK) 497 - 503 Hz (SPACE)
6 and 7	TTY Signal	
	a. Signal Level 1. High Level 2. Low Level	 58 to 62 ma. +5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. Distortion	15% Maximum.

ON-LINE TESTS

Test Point No.	Test	Parameters
1 and 2	TTY Signal	
	a. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	b. Distortion	5% Maximum.

TABLE 4-2 TEST FOR THE "B" SYSTEM (CONT)

ON-LINE TEST

Test Point No.	Test	Parameter
3	Audio	
	a. Signal Level	0 dBm.
	b. Frequency	697 - 703 Hz (MARK). 497 - 503 Hz (SPACE)
6 and 7	TTY Signal	
	a. Distortion	15% Maximum

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 2
TYPE "C" SYSTEM UHF DUPLEX
SINGLE CHANNEL AFTS RADIO TELETYPEWRITER SYSTEM

4-2 System Description. The Type "C" system provides, secure, single channel, full-duplex Audio Frequency Tone Shift (AFTS) UHF line of sight radio teletype communications. Refer to Figure 4-2. Full-duplex operation requires a separate transmitter and receiver and separate send and receive frequencies. This system consist of the antenna and associated multicouplers, two transceivers (their respective transmitter and receiver audio switchboards), tone terminal equipment, BLACK DC patch panel, crypto device, RED DC patch panel and teletypewriter equipments. Refer to Table 4-3 for equipment nomenclature, and Table 4-4 for signal parameters typical to a "C" system.

4-2.1 System Signal Flow. System signal flow and equipment functional relationships are shown in Figure 4-2 and described in the following paragraphs.

4-2.1.1 Receive Subsystem. The Amplitude Modulated (AM) UHF signal is received at the antenna and connected via a multicoupler to the receiver portion of the transceiver where demodulation takes place. The resulting Audio Frequency Tone Shift (AFTS) signal is patched to the terminal equipment via the receiver audio switchboard. The tone terminal equipment converts the (AFTS) shifted signal, 700 Hz for a MARK, 500 Hz for a SPACE, into a DC signal which is patched via the BLACK DC patch panel to the crypto device. The decrypted signal from the crypto device is patched to the teletypewriter via the RED DC patch panel.

4-2.1.2 Transmit Subsystem. The teletypewriter keyboard or Transmitter Distributor (TD) generates the RED DC signal which is patched to the crypto device via the RED DC patch panel. The encrypted (BLACK) DC signal, from the crypto device, is patched to the tone terminal equipment via the BLACK DC patch panel. The tone terminal equipment converts the DC signal into an AFTS signal. This signal is patched to the transmitter via the transmitter transfer switchboard. The audio signal amplitude modulates the transmitter. The AM modulated RF signal is then routed to the antenna via the antenna coupler.

4-2.1.3 Phasing. Phasing control of the send TSEC/KW-7 is accomplished locally at the TSEC/KW-7 or by a Functional Remote Unit (FRU), KWX-8/TSEC, located at the teletypewriter position. FRUs are either hardwired or patched through a FRU switchboard. Phasing for the TSEC/KG-84 does not require operator intervention.

4-2.2 Verification of System Quality. Prior to placing the system into operation, and during on-line operation, the system configuration must be tested using QMS procedures. Refer to Table 4-4 for the test points and signal parameters for initial set-up and on-line QM tests.

TABLE 4-3 LIST OF TYPICAL EQUIPMENT FOR THE "C" SYSTEM

ANTENNA

AS-390/SRC
AS-1018/URC
AS-1735/SRC

ANTENNA COUPLER

AN/SRA-33

TRANSCEIVERS

URC-9 (FAMILY)
RT-1107(V)/WSC-3

SWITCHBOARDS

SB-863/SRT
SB-973/SRR
SB-988/SRT
SB-2727()/SRR

TELEGRAPH TERMINAL
KEYER/CONVERTER

CV-2460/SGC

TELETYPE PATCH PANELS

SB-1203A/UG
SB-1210A/UGQ
SB-4034/UG
SB-4035/UG

SECURITY DEVICES

TSEC/KG-84
TSEC/KW-7
KWX-8/TSEC

TELETYPEWRITER EQUIPMENT
(See Note)

Automatic Send/Rcv (ASR)
Keyboard Send/Rcv (KSR)
Receive Only (RO)
Transmit Distributor (TD)

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

TABLE 4-4. TESTS FOR THE "C" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameter
1 and 2	TTY Signal	
	a. Signal Level	
	1. High Level 2. Low Level	58 to 62 ma. +5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	5% Maximum
3	Audio Signal	
	a. Send Level	0 dBm.
	b. Frequency	697 - 703 Hz MARK 497 - 503 Hz (SPACE)
4 (SEND)	R.F. Signal	Refer to Section 3, paragraph 3-3.9, QM test #3H.
5 (RECEIVE)	R.F. Signal	Refer to Section 3, paragraph 3-3.9, QM test #3H.

TABLE 4-4 TEST FOR THE "C" SYSTEM (CONT)

INITIAL SET-UP

Test Point No.	Test	Parameter
6	Audio Signal	
	a. Signal Level	0 dBm.
	b. Frequency	697 - 703 Hz (MARK) 497 - 503 Hz (SPACE)
7 and 8	TTY Signal	
	a. Signal Level 1. High Level 2. Low Level	 58 to 62 ma. +5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. Distortion	15% Maximum.

ON-LINE TESTS

Test Point No.	Test	Parameters
1 and 2	TTY Signal	
	a. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	b. Distortion	5% Maximum.

TABLE 4-4 TEST FOR THE "C" SYSTEM (CONT)

ON-LINE TEST

Test Point No.	Test	Parameter
3	Audio	
	a. Signal Level	0 dBm.
	b. Frequency	697 - 703 Hz (MARK) 497 - 503 Hz (SPACE)
7 and 8	TTY Signal	
	a. Distortion	15% Maximum

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 3
TYPE "D" SYSTEM HF SIMPLEX
SINGLE CHANNEL FSK/AFTS RADIO TELETYPEWRITER SYSTEM

4-3 System Description. The type "D" system provides secure, single channel, SIMPLEX, FSK or FTS HF radio teletypewriter communications. The type "D" system operates netted simplex with all transmitters and receivers operating on the same frequency. A type "D" system consists of receiving and transmitting antennas and their respective couplers/multicouplers, HF receiver and HF transmitter equipment, receiver audio and transmitter transfer switchboards, a Transmitter Teletype Control Unit, tone terminal equipment, a BLACK DC patch panel, crypto equipment, RED DC patch panels, and teletypewriter equipment. Refer to Table 4-5 for the nomenclature of equipment types typical to the "D" system.

4-3.1 System Signal Flow. System signal flow and equipment functional relationships for an FSK system are shown in Figure 4-3 and for an AFTS system in Figure 4-4.

4-3.2 Receive Operation. The Frequency Shift Keyed (FSK) signal is received at the antenna and patched via the antenna multicoupler to the receiver where demodulation takes place. The resulting audio tone shifted signal, 1575 Hz for a MARK and 2425 Hz for a SPACE, is patched via the receiver transfer switchboard to the tone terminal or converter/comparator equipment. The audio tone shift signal is converted into a DC signal which is patched via the BLACK DC patch panel to the crypto device. The decrypted signal from the crypto device is patched to the teletypewriter equipment via the RED DC patch panel. In an FSK type "D" system switching between Send and Receive is manually accomplished with a C-1004/SG Transmitter Control Unit. The C-1004/SG does not disable the Receive input/output when in the Send mode. In an AFTS type "D" system, Send and Receive switching is accomplished by the tone terminal equipment.

4-3.3 FSK Transmit Operation. Refer to Figure 4-3. For an FSK type "D" system the transmitter key is controlled by the operator with a C-1004/SG. The teletypewriter keyboard or Transmitter Distributor (TD) generates the RED DC signal which is patched to the crypto device via the RED DC patch panel. The encrypted (black) DC signal, from the crypto device, is patched to the Transmitter via the BLACK DC patch panel and the FSK transfer switchboard. The DC signal causes a shift of 425 Hz below the carrier RF frequency when the DC loop is in a MARK condition and a shift of 425 Hz above the carrier RF frequency when the DC loop is in a SPACE condition. The resulting output from the transmitter is an FSK signal which shifts a total of 850 Hz between MARK and SPACE frequencies. The FSK RF signal is then routed to the antenna via the antenna coupler.

4-3.4 AFTS Transmit Operation. Refer to Figure 4-4. The Teletypewriter keyboard or Transmitter Distributor (TD) generates the RED DC signal which is patched to the send crypto device via the RED DC patch panel. The encrypted (BLACK) DC signal from the crypto device is patched to the tone terminal equipment via the BLACK DC patch panel. The tone terminal equipment converts the DC signal to an AFTS signal, 1575 Hz tone for a MARK and 2425 Hz tone for a SPACE. The tone terminal equipment, when not receiving, will automatically go to the SEND condition the instant the send loop is keyed by the teletype. The tone terminal AFTS output signal is patched to the transmitter via the transmitter transfer switchboard. The transmitter modulated RF signal is connected to the antenna via the antenna coupler.

4-3.5 Phasing. Phasing control of the send TSEC/KW-7 is accomplished locally at the TSEC/KW-7 or by a Functional Remote Unit (FRU), KWX-8/TSEC, located at the teletypewriter position. FRUs are either hardwired or patched through an FRU switchboard. Phasing for the TSEC/KG-84 does not require operator intervention.

4-3.6 Verification of System Quality. Prior to entering the net and periodically during on-line operation, the system configuration must be tested using QMS procedures. Refer to Table 4-6 for the test points and signal parameters for initial set-up and on-line QM tests.

TABLE 4-5 LIST OF TYPICAL EQUIPMENT FOR THE "D" SYSTEM

ANTENNA	**ANTENNA COUPLER**
AS-2537A/SRC AS-2802/SRC AS-2865/SRC AS-2803/SRC AS-2866/SRC	AN/SRA-12 AN/SRA-49 AN/SRA-56 AN/SRA-57 AN/SRA-58 AN/URA-38
TRANSMITTERS	**RECEIVERS**
AN/URT-23() AN/URT-24 T-1322/SRC	R-1051()/URR R-1903/UR
SWITCHBOARDS	**TELEGRAPH TERMINAL KEYERS/CONVERTERS**
SB-863/SRT SB-973/SRR SB-988/SRT SB-2727()/SRR	AN/URA-17() CV-2460/SGC
TELETYPE PATCH PANELS	**SECURITY DEVICES**
SB-1203A/UG SB-1210/UGQ SB-4034/UG SB-4035/UG	TSEC/KG-84 TSEC/KW-7 KWX-8/TSEC
TRANSMITTER TELETYPEWRITER CONTROL	**JACK BOX**
C-1004B/SG	J-939B/U
TELETYPEWRITER EQUIPMENT (See Note)	
Automatic Send/Rcv (ASR) Keyboard Send/Rcv (KSR) RECEIVE ONLY (RO) TT (RO)	

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

TABLE 4-6 TESTS FOR THE "D" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameter
1 and 2	TTY Signal	
	a. Signal Level	
	1. High Level	58 to 62 ma.
	2. Low Level	+5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interferance.
	c. % Speed Error	2% Maximum
	d. Distortion	5% Maximum
3 (CV-2460)	Audio Signal	
	a. Send Level	0 dBm
	b. Frequency	2420 - 2430 Hz (MARK) 1570 - 1580 Hz (SPACE)
4	R.F. Signal	
	a. Frequency	±25Hz
	b. Harmonic Product	Not less than 35 dB down from two-tone signal peaks.

TABLE 4-6 TEST FOT THE "D" SYSTEM (CONT)

INITIAL SET-UP

Test Point No.	Test	Parameter
4 (continued)	c. Carrier Suppression	Not less than 40 dB down from two-tone signal peaks.
5	R.F. Signal	
	a. Signal/Noise	15 dB minimum signal above noise.
6	Audio Signal	
	a. Signal Level	0 dBm
	b. Frequency	2420 - 2430 Hz MARK 1570 -1580 Hz (SPACE)
7 and 8	TTY Signal	
	a. Signal Level 1. High Level 2. Low Level	 58 to 62 ma +5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	15% Maximum

TABLE 4-6 TEST FOR THE "D" SYSTEM (CONT)

ON-LINE TESTS

Test Ponit No.	Test	Parameter
1 and 2	TTY Signal	
	a. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	b. Distortion	5% Maximum
3 (CV-2460)	Audio	
	a. Signal Level	0 dBm
4	R.F. Signal	
	a. Frequency	±25 Hz
7 and 8	TTY Signal	
	a. Distortion	15% Maximum

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 4
"G" SYSTEM HF DUPLEX TYPE
SINGLE CHANNEL FSK/AFTS RADIO TELETYPEWRITER SYSTEM

4-4 System Description. The type "G" system provides full duplex, secure, single channel, FSK or AFTS, HF radio teletypewriter communications. This system consists of the receiving and transmitting antennas, couplers/multicouplers, the receiver and transmitter equipments, receiver audio and transmitter transfer switchboards, tone terminal equipment, BLACK DC patch panel, crypto equipments and functional remote units, RED DC patch panels and the teletypewriter equipment. Refer to Table 4-7 for the nomenclature of equipment typical to the "G" system.

4-4.1 System Signal Flow. System signal flow and equipment functional relationships for an FSK system are described in paragraph 4-4.2, and for an AFTS system in paragraph 4-4.3.

4-4.2 FSK "G" System Operation. Refer to Figure 4-5.

4-4.2.1 FSK "G" Receive Subsystem Operation. The HF frequency shift-keyed (FSK) signal is received at the antenna and patched via a multicoupler to the receiver where the signal is demodulated. The resulting audio tone shift signal, 1575 Hz for a MARK and 2425 Hz for a SPACE, is patched at the receiver audio switchboard to the Converter/Comparator equipment. The Converter/Comparator converts the audio shifted signal to a DC MARK/SPACE signal. This DC signal is patched to the crypto equipment at the BLACK DC patch panel. The decrypted RED DC signal from the crypto equipment is patched to the teletypewriter equipment at the RED DC patch panel.

4-4.2.2 FSK "G" Transmit Subsystem Operation. The teletypewriter keyboard or Transmitter Distributor (TD) generates the RED DC MARK/SPACE signal which is patched to the crypto device at the RED DC patch panel. The encrypted signal is patched by the BLACK DC patch panel and FSK switchboard to the transmitter. The DC signal shifts the transmitter frequency 425 Hz below the carrier frequency when the DC signal is a MARK, and 425 Hz above the carrier frequency when the DC signal is a SPACE. The resulting output from the transmitter is a FSK signal which shifts a total of 850 Hz between MARK and SPACE frequencies. The FSK signal is routed to the antenna via the antenna coupler.

4-4.3 AFTS "G" System Operation. Refer to Figure 4-6.

4-4.3.1 AFTS "G" Receive Subsystem Operation. An Amplitude Modulated (AM) HF signal is received at the antenna and connected via a multicoupler to the receive HF receiver. The Audio Frequency Tone Shift (AFTS) receiver output signal is patched at the receive audio switchboard to tone terminal equipment. The tone terminal equipment converts the AFTS signal to a DC signal, 1575 Hz for a MARK and 2425 Hz for a SPACE. The DC signal is patched at the BLACK DC patch panel to the receive crypto. The decrypted DC signal is patched at the RED DC patch panel to the teletypewriter.

4-4.3.2 AFTS "G" Transmit Subsystem Operation. A teletypewriter keyboard or Transmitter Distributor (TD) generates a RED DC MARK/SPACE signal that is patched at the RED DC patch panel to the send crypto device. The encrypted DC signal from the crypto device is patched at the BLACK DC patch panel to the tone terminal equipment. The tone terminal equipment converts the DC signal to an AFTS signal, 1575 Hz for MARK and 2425 Hz for a SPACE. The AFTS signal is patched at the transmitter transfer switchboard to the the HF transmitter. The amplitude modulated signal (AM) from the transmitter is connected to the antenna via a multicoupler.

4-4.4 Phasing. Phasing control of the send TSEC/KW-7 is accomplished locally at the TSEC/KW-7 or by a Functional Remote Unit (FRU), KWX-8/TSEC, located at the teletypewriter position. FRUs are either hardwired or patched through an FRU switchboard. Phasing for the TSEC/KG-84 does not require operator intervention.

4-4.5 Verification of System Quality. Prior to placing the system in operation, and during on-line operation, the system configuration must be tested using QMS procedures. Refer to Table 4-8 for the test points and signal parameters for initial set-up and on-line QM tests.

TABLE 4-7
LIST OF TYPICAL EQUIPMENT FOR THE "G" SYSTEM

ANTENNA

AS-2537A/SR
AS2802/SRC
AS-2865/SRC
AS-2803/SRC
AS2866/SRC

ANTENNA COUPLER

AN/SRA-12
AN/SRA-49
AN/SRA-56
AN/SRA-57
AN/SRA-58
AN/URA-38

TRANSMITTERS

AN/URT-23()
AN/URT-24
T-1322/SRC

RECEIVERS

R-1051()/URR
R-1903/UR

SWITCHBOARDS

SB-863/SRT
SB-973/SRR
SB-988/SRT
SB-2727()/SRR

TELEGRAPH TERMINAL KEYERS/CONVERTERS

AN/URA-17()
CV-2460/SGC

TELETYPE PATCH PANELS

SB-1203A/UG
SB-1210/UGQ
SB-4034/UG
SB-4035/UG

SECURITY DEVICES

TSEC/KG-84
TSEC/KW-7
KWX-8/TSEC

TRANSMITTER TELETYPEWRITER CONTROL

C-1004B/SG

JACK BOX

J-939B/U

TELETYPEWRITER EQUIPMENT
(See Note)
Automatic Send/Rcv (ASR)
Keyboard Send/Rcv (KSR)
RECEIVE ONLY (RO)
TT (RO)

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

TABLE 4-8. TESTS FOR THE "G" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameter
1 and 2	TTY Signal a. Signal Level	
	1. High Level	58 to 62 ma.
	2. Low Level	+5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	5% Maximum
3 (CV-2460)	Audio Signal	
	a. Send Level	0 dBm
	b. Frequency	2420 - 2430 Hz (MARK) 1570 - 1580 Hz (SPACE)
4	R.F. Signal	
	a. Frequency	±25Hz
	b. Harmonic Product	Not less than 35 dB down from two-tone signal peaks.

TABLE 4-8 TEST FOR THE "G" SYSTEM (continued)

INITIAL SET-UP

Test Point No.	Test	Parameter
4 (continued)	c. Carrier Suppression	Not less than 40 dB down from two-tone signal peaks.
5	R.F. Signal	
	a. Signal/Noise	15 dB minimum signal above noise.
6	Audio Signal	
	a. Signal Level	0 dBm
	b. Frequency	2420 - 2430 Hz (MARK) 1570 - 1580 Hz (SPACE)
7 and 8	TTY Signal	
	a. Signal Level 1. High Level 2. Low Level	 58 to 62 ma. +5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Errror	2% Maximum
	d. Distortion	15% Maximum

TABLE 4-8 TEST FOR THE "G" SYSTEM (continued)

ON-LINE TEST

Test Point No.	Test	Parameters
1 and 2	TTY Signal	
	a. Signal Shaping	Observe O"scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	b. Distortion	5% Maximum
3	Audio	
	a. Signal Level	0dbm
4	RF Signal	
	a. Frequency	$\pm$25Hz
7 and 8	TTY Signal	
	a. Distortion	15% Maximum

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 5
FLEET SINGLE CHANNEL RADIO TELETYPEWRITER BROADCAST TYPE 'M' SYSTEMS

4-5 System Description. The fleet single channel broadcast provides receive only VLF, LF, HF, and frequency shift-keyed (FSK) radio teletypewriter communications. Diversity or non-diversity operation may be employed. Refer to Table 4-9 for the nomenclature of equipment typical to the single channel broadcast system.

4-5.1 System Signal Flow. System signal flow and equipment functional relationships are shown in Figure 4-7 and described in the following paragraphs.

4-5.2 System Operation. The frequency shift-keyed (FSK) RF signal is received at the antenna and patched to the receiver via a multicoupler. The FSK signal is demodulated by the receiver to produce an audio tone shift signal, 1575 Hz for a MARK and 2425 HZ for a SPACE. The audio signal is patched at the receiver audio switchboard to the Converter/Comparator which converts the audio tone shift into a BLACK DC signal. When diversity operation is employed, two receivers are used and the converter/comparator selects the signal which has the highest instantaneous audio level and allows this signal to control the DC keying. This DC signal is normal-through or patched at the BLACK DC patch panel to the crypto device. The decrypted (RED) signal from the crypto device is normal-through or patched at the RED DC patch panel to the teletypewriter.

4-5.3 Synchronization: Synchronization of the system is automatic or by operator intervention. This action is determined by the operating situation and is described in Naval Telecommunications Procedures (NTP-4).

4-5.4 Verification of System Quality. Prior to placing the system into operation, and during on-line operation, the system configuration must be tested using QMS procedures. Refer to Table 4-10 for the test points and signal parameters for initial set-up and on-line QM tests.

TABLE 4-9
LIST OF TYPICAL EQUIPMENT FOR THE FLEET SINGLE CHANNEL (FSK) BROADCAST SYSTEM

ANTENNA

AS-2537A
AS-2803/SRC
AS-2866/SRC

RECEIVERS

R-1051()/URR
AN/SRR-19B
AN/WRR-3B

TELEGRAPH TERMINAL CONVERTER

AN/URA-17()

SECURITY DEVICES

TSEC/KW-37
TSEC/KW-46

ANTENNA COUPLER

AN/SRA-12
AN/SRA-49
CU-2007/SRR
SB-3332/SR

SWITCHBOARDS

SB-2727()SRR

TELETYPE PATCH PANELS

SB-1203A/UG
SB-1210A/UGQ
SB-4034/UG
SB-4035/UG

TELETYPEWRITER EQUIPMENT (See Note)

PP (RO) RECEIVE ONLY
TT (RO)

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

TABLE 4-10. TESTS FOR THE FLEET SINGLE CHANNEL (FSK) BROADCAST SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameter
1	R.F. Signal	
	a. Frequency	±25Hz.
	b. Harmonic Product	Not less than 35 dB down from two-tone signal peaks.
	c. Carrier Suppression	Not less than 40 dB down from two-tone signal peaks.
	d. Signal/Noise	15 dB minimum signal above noise.
2	Audio Signal	
	a. Signal Level	0 dBm
	b. Frequency	2420 - 2430 Hz (MARK) 1570 - 1580 Hz (SPACE)
3 and 4	TTY Signal	
	a. Signal Level	
	1. High Level	58 to 62 ma
	2. Low Level	+5 to +7V (MARK) -5 to -7V (SPACE)

TABLE 4-10 TEST FOR THE FLEET SINGLE CHANNEL (FSK) BROADCAST SYSTEM (continued)

INITIAL SET-UP

Test Point No.	Test	Parameter
3 & 4 (continued)	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	15% Maximum

ON-LINE TEST

Test Point No.	Test	Parameters
3 and 4	TTY Signal	
	a. Distortion	15% Maximum

CHAPTER 4
SYSTEMS DESCRIPTION

SECTION 6
FLEET MULTICHANNEL RADIOTELETYPEWRITER BROADCAST SYSTEM (LF/MF/HF/UHF AND UHF SATCOM TYPE "N" SYSTEMS)

4-6.0 System Description. The type "N" system, shown in Figures 4-8 and 4-9, is the primary method of delivering record traffic to a large number of ships operating in broad ocean areas.

4-6.0.1 LF/MF/HF/UHF "N" System. A typical LF/MF/HF/UHF system consists of receiving antenna(s), the multicoupler, a receiver (two if HF diversity operation is employed), the demultiplexing equipment, the crypto equipment and a teletypewriter for each channel copied. The receiver(s) is/are patched via the receiver audio transfer switchboard to the demultiplexing equipment (AN/UCC-1). The AN/UCC-1 outputs are patched via the BLACK DC patch panel to the crypto equipments. The decrypted signals (RED) from the crypto devices are patched to the teletypewriter equipments via the RED DC patch panel. The multichannel broadcast can be retransmitted in the UHF (AM) range, primarily for ships to maintain reliable copy while in port and/or where difficulty is encountered in copying frequencies in the LF/MF/HF range.

4-6.0.2 UHF SATCOM "N" System. This system is similar to the LF/HF/UHF system, except for the type of reception and the receiver (AN/SSR-1) used. The function of the AN/SSR-1 is to receive fleet multichannel radio teletypewriter broadcasts which are transmitted from a ground station and relayed to naval vessels by satellite. The receiving system consists of four antennas and Amplifier-Converter units, a Combiner-Demodulator unit and a Demultiplexer unit. When installed, the Antenna and Amplifier/Converter units are mounted above deck, and the Combiner-Demodulator and Demultiplexer units are mounted in equipment racks in the communications center.

4-6.1 System Signal Flow.

4-6.1.1 Receive (LF/MF/HF/UHF) Subsystem. (Refer to Figure 4-8) The RF signal is received and demodulated by the receiver. The output from the receiver consists of composite audio tones which are patched via the receiver transfer switchboard to the AN/UCC-1. The AN/UCC-1 separates each tone, and if operated in diversity mode combines the signals (the highest amplitude signal contributes more to the output than the lower level signals contribute) and converts the tone-shifted signal into a BLACK DC keying signal. The individual channels now appear on separate lines at the BLACK DC patch panel. For ships not equipped with TSEC/KW-46s, channels 3 and 6 are normalled-through (patched if necessary) to a TSEC/KWR-37. All other channels are normalled-through (patched if necessary) to TSEC/KG-14 crypto equipment. The RED outputs from the TSEC/KWR-37 and TSEC/KG-14 equipment are normalled-through or patched as necessary via the RED DC patch panel to the teletypewriter equipment. TSEC/KW-37 receive signal contains both synchronization and intelligence (encrypted) information. The TSEC/KG-14's channels contain only intelligence (encrypted) information. In order to operate, the TSEC/KG-14s must receive synchronization, timing, and key signals from the broadcast TSEC/KW-37. This is normally accomplished through a switch panel (SB-3195/U) which distributes the TSEC/KWR-37 "sync" signals to one or more TSEC/KG-14s. The broadcast TSEC/KWR-37 must be in synchronization before the TSEC/KG-14s can be synchronized. The number of channels a ship copies is determined by the size and type of ship, operational requirements and available demultiplexing equipment. Ships equipped with a TSEC/KW-46 follow the same signal flow path. The TSEC/KW-46 encrypts all channels of the broadcast.

4-6.1.2 Receive (UHF SATCOM "N" System). (Refer to Figure 4-9) In this system the transmitted carrier may be frequency modulated (FM) or phase-shift-keyed (PSK) modulated. Selection of the applicable demodulation mode is accomplished manually by the operator at the AN/SSR-1 receiver. The receiving antennas for this system are positioned about the ship in such a manner (normally one in each quadrant of the ship) so that at no time is the line-of-sight blocked between the relay satellite and one or more antennas. Each Amplifier-Converter is located within 10 cable-feet of its associated antenna. The IF signal from each Amplifier-Converter is routed to the Combiner-Demodulator. Operating power and local-oscillator signal are coupled from the Combiner-Demodulator to each Amplifier-Converter via the same twin axial cable used for the IF signal. Because of signal path variations, shading and reflections, the four IF signals are subject to random phase and amplitude variations. The Combiner-Demodulator removes the phase variations from each input signal, weighs the amplitudes of the signals for optimum combining and then sums the signals. After being combined, the signal is demodulated and coupled to the demultiplexing equipment. When operating in the FM mode, the output of the Combiner-Demodulator is coupled via the receiver transfer switchboard to the AN/UCC-1. The remaining portion of the system is the same as described for the LF/MF/HF/UHF "N" system.

When operating the AN/SSR-1 in the PSK mode, the output is coupled to the Demultiplexer unit of the AN/SSR-1. Here the PSK signal from the Combiner-Demodulator is converted into 15 BLACK DC output channels and a sync-word output channel. These output channels provide inputs to the shipboard crypto and teletypewriter equipment.

4-6.2 Verification of System Quality. Prior to placing the system into operation, and during on-line operation, the system configuration must be tested using QMS test procedures. Refer to Table 4-12 for the test points and signal parameters for initial set-up and on-line QM tests.

TABLE 4-11
LIST OF TYPICAL EQUIPMENT FOR THE "N" SYSTEM

ANTENNA

AS-2410/SWC-1(V)
AS-2537A
AS-2802/SRC
AS-2803/SRC
**AS-2815/SSR
AS-2865/SRC
AS-2866/SRC
**AS-3018A/WSC-1(V)

ANTENNA COUPLER

AN/SRA-12
AN/SRA-49
CU-2007/SRR
SB-3332/SR

RECEIVERS

R-1051()/URR
AN/SRR-19B
**AN/SSR-1

SWITCHBOARDS

SB-2727()SRR

TELEGRAPH TERMINAL CONVERTER

AN/UCC-1()(V)

TELETYPE PATCH PANELS

SB-1203A/UG
SB-1210A/UGQ
SB-4034/UG
SB-4035/UG

SECURITY DEVICES

TSEC/KW-37
TSEC/KW-46
TSEC/KG-14

TELETYPEWRITER EQUIPMENT (See Note)

PP (RO) RECEIVE ONLY
TT (RO)

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

** Satcomm use only

TABLE 4-12. TESTS FOR THE "N" SYSTEM

Not for SATCOM system

INITIAL SET-UP

Test Point No.	Test	Parameters
1	R.F. Signal	
	a. Signal/Noise	15 dB minimum signal above noise.
2	Audio Signal	
	a. Signal Level	Not less than -10 dBm and not more than 0 dBm.
3 and 4	TTY Signal	
	a. Signal Level	
	1. High Level	58 to 62 ma
	2. Low Level	+5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	15% Maximum

TABLE 4-12 TEST FOR THE "N" SYSTEM (continued)

ON-LINE TEST

Test Point No.	Test	Parameters
3 and 4	TTY Signal a. Distortion	 15% Maximum

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 7
MULTICHANNEL RADIOTELETYPEWRITER SHIP/SHORE/SHIP SYSTEM
HF DUPLEX TYPE "P" SYSTEM)

4-7 System Description. The type "P" system provides full period termination capabilities of up to 16 full-duplex teletypewriter channels, with a shore station or another ship similarly equipped. The system is composed of transmitting and receiving antennas, their respective couplers and multicouplers, transmitters and receivers, transmitter transfer and the receiver audio switchboard, multiplexing/demultiplexing equipment, a BLACK DC patch panel, crypto devices, a RED DC patch panel and the teletypewriter equipments. Refer to Table 4-13 for the nomenclature of above listed types of equipment typical to this system.

4-7.1 System Signal Flow. Refer to Figure 4-10.

4-7.1.1 Receive Subsystem. The RF signal containing up to 16 AFTS (Audio Frequency Tone Shift) tones is received at the antennas and routed via the multicouplers to the receivers. Frequency diversity is normally used, i.e., two receivers each tuned to different Radio Frequencies. The outputs of the receivers are audio tone shifted signals consisting of composite tones identical in frequency to those signals which appear at the input of the transmitter at the transmitting station. The composite tones from the receivers are patched via the receiver audio switchboard to the RCVR "A" and RCVR "B" inputs of the AN/UCC-1(). Each converter of the AN/UCC-1 selects only the tone which corresponds to its particular channel frequency, and if operated in the diversity mode, combines the signals and converts the tone shifted signal into a BLACK DC keying signal. The DC signal is applied to a BLACK DC patch panel. Each AN/UCC-1 channel appears on a separate loop on the BLACK DC patch panel. The DC signals are patched to the crypto equipment. Each channel is decrypted and appears at the RED DC patch panel where they are patched to the receive teletypewriter equipment.

4-7.1.2 Transmit. The teletypewriter keyboard or Transmitter-Distributor (TD) generates a DC signal which is patched via the RED DC patch panel to the crypto device. The encrypted BLACK DC signal is routed via the BLACK DC patch panel to the keyer channels of the AN/UCC-1. Each information channel (BLACK DC loop) of the system normally keys a pair of tone channels in the AN/UCC-1() (referred to as "twinned" operation). The keyers convert the DC signal into a pair of audio tones. The resulting output from the AN/UCC-1 is a composite signal consisting of as many as 16 tones. These tones are patched to the transmitter(s) via the transmitter transfer switchboard. This composite audio signal, which occupies approximately a 3 kHz bandwidth, is used to modulate the transmitter which is normally operated in the USB mode. The RF carrier and the lower sideband are filtered out (suppressed) in the transmitter, permitting sideband only. The transmitter RF signal is routed to the antenna via the antenna coupler/multicoupler.

4-7.1.3 Phasing. Phasing control of the send TSEC/KW-7 is accomplished locally at the TSEC/KW-7 or by a Functional Remote Unit (FRU), KWX-8/TSEC, located at the teletypewriter positions. FRUs are either hardwired or patched through an FRU switchboard. Phasing for the TSEC/KG-84 is automatic and does not require operator intervention.

4-7.2 Verification of System Quality. Prior to net activation the system configuration must be tested using QMS procedures.

TABLE 4-13
LIST OF TYPICAL EQUIPMENT FOR THE HF "P" SYSTEM

ANTENNA	ANTENNA COUPLER
AS-2537A/SR AS-2802/SRC AS-2865/SRC AS-2803/SRC AS-2866/SRC	AN/SRA-12 AN/SRA-49 AN/SRA-56 AN/SRA-57 AN/SRA-58 AN/URA-38
TRANSMITTERS	**RECEIVERS**
AN/URT-23() AN/URT-24 T-1322/SRC	R-1051()/URR R-1903/UR
SWITCHBOARDS	**TELEGRAPH TERMINAL KEYERS/CONVERTERS**
SB-863/SRT SB-973/SRR SB-988/SRT SB-2727()/SRR	AN/UCC-1()(V)
TELETYPE PATCH PANELS	**SECURITY DEVICES**
SB-1203A/UG SB-1210/UGQ SB-4034/UG SB-4035/UG	TSEC/KG-84 TSEC/KW-7 KWX-8/TSEC
TELETYPEWRITER EQUIPMENT (See Note)	
Automatic Send/Rcv (ASR) Keyboard Sendk/Rcv (KSR) TT (RO) Receive Only (RO)	

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

TABLE 4-14. TESTS FOR THE HF "P" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameter
1 and 2	TTY Signal	
	a. Signal Level	
	1. High Level	58 to 62 ma
	2. Low Level	+5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	5% Maximum
3	Audio Signal	
	a. Send Level	In accordance with Table 5-8, page 5-36
4	R.F. Signal	
	a. Frequency	±25Hz
	b. Harmonic Product	Not less than 35 dB down from two-tone signal peaks.
	c. Carrier Suppression	Not less than 40 dB down from two-tone signal peaks.

TABLE 4-14 TEST FOR THE "P" SYSTEM (continued)

INITIAL SET-UP

Test Point No.	Test	Parameter
5	R.F. Signal	
	a. Signal/Noise	15 dB minimum signal above noise.
6	Audio Signal	
	a. Signal Level	Not less than -10 dBm and not more than 0 dBm.
7 and 8	TTY Signal	
	a. Signal Level	
	1. High Level	58 to 62 ma
	2. Low Level	+5 to +7V (MARK) -5 to -7V (SPACE)
	b. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	15% Maximum

TABLE 4-14 TEST FOR THE "P" SYSTEM (continued)

ON-LINE TESTS

Test Point No.	Test	Parameters
1 and 2	TTY Signal	
	a. Signal Shaping	Observe O'scope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	b. Distortion	5% Maximum
3	Audio	
	a. Signal Level	In accordance with Table 5-8, page 5-36
4	R.F. Signal	
	b. Frequency	±25 Hz
7 and 8	TTY Signal	
	a. Distortion	15% Maximum

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 8
MULTICHANNEL RADIOTELETYPEWRITER SHIP/SHORE/SHIP SYSTEM
UHF DUPLEX TYPE "P" SYSTEM

4-8 System Description. The "P" system provides the ship with the capability for full period termination of up to 16 teletypewriter channels, send and receive, (FULL-DUPLEX), with a shore station or another similarly equipped ship. The system is composed of transmitting and receiving antennas patched via their respective multicouplers to transceivers. The transceivers are patched via the transmitter transfer switchboard and the receiver audio switchboard to the multiplexing/demultiplexing equipment. The multiplexing/demultiplexing equipment is connected through the BLACK DC patch panel to the crypto devices which are further connected via the RED DC patch panel to the teletypewriter equipments. Refer to Table 4-15 for the nomenclature of above listed types of equipment typical to this system.

4-8.1 System Signal Flow. Refer to Figure 4-11.

4-8.1.1 Receive Subsystem. The RF signal containing up to 16 AFTS (Audio Frequency Tone Shift) tones is received at the antenna and routed via the multicoupler to the receiver section of the transceiver. The output of the receiver is an audio signal consisting of composite tones identical in frequency to those which appeared at the input of the transmitter at the transmitting station. The composite tones from the receiver are patched via the receiver audio switchboard to the RCVR "A" or RCVR "B" inputs of the AN/UCC-1. Each converter of the AN/UCC-1 selects only the tone that corresponds to its particular channel frequency. The audio tone shift signal is converted to a DC signal which is applied to a BLACK DC teletypewriter loop. Each AN/UCC-1 channel appears on a separate loop on the BLACK DC patch panel. The DC signals are patched to the crypto equipment where the signals are decrypted. Each decrypted channel appears at the RED DC patch panel where they are patched to the receive teletypewriter equipment.

4-8.1.2 Transmit Subsystem. The teletypewriter send equipment, normally either a keyboard or Transmitter-Distributor (TD) generates a RED DC signal which is supplied via the RED DC patch panel to the crypto equipment where it is encrypted. The encrypted BLACK DC signal is patched via the BLACK DC patch panel to the keyer channels of the AN/UCC-1. The keyers convert the DC signal into an audio tone. The resulting output from the AN/UCC-1 is a composite signal consisting of as many as 16 tones. These tones are patched via the transmitter transfer switchboard to the transceiver. The audio tones amplitude modulate the RF signal generated by the transmitter. The amplitude modulated RF signal is routed to the antenna via the antenna coupler/multicoupler.

4-8.1.3 Phasing. Phasing control of the TSEC/KW-7 transmit crypto equipment on each channel is accomplished locally at the TSEC/KW-7 or at a Functional Remote Unit (FRU) consisting of a KWX-8/TSEC located at the teletypewriter positions. These FRUs are either hardwired or patchable through an FRU switchboard. Phasing for the TSEC/KG-84 is automatic and does not require operator intervention.

4-8.2 Verification of System Quality. Prior to net activation the system configuration must be tested using QMS procedures. Refer to Table 4-16.

TABLE 4-15
LIST OF TYPICAL EQUIPMENT FOR THE UHF "P" SYSTEM

ANTENNA	ANTENNA COUPLER
AS-390/SRC AT-150/SRC AS-1018/URC AS-2877/SRC AS-1735/SRC	AN/SRA-33
TRANSCEIVERS	**SWITCHBOARDS**
URC-9 (FAMILY) RT-1107(V)WSC-3	SB-863/SRT SB-973/SRR SB-988/SRT SB-2727()/SRR
TELEGRAPH TERMINAL KEYER/CONVERTER	**TELETYPE PATCH PANELS**
AN/UCC-1()(V)	SB-1203A/UG SB-1210A/UGQ SB-4034/UG SB-4035/UG
SECURITY DEVICES (See Note)	**TELETYPEWRITER EQUIPMENT**
TSEC/KG-84 TSEC/KW-7 KWX-8/TSEC	Automatic Send/Rcv (ASR) Keyboard Send/Rcv (KSR) PP (RO) RECEIVE ONLY TT (RO)

NOTE: FOR DETAILED TTY DESCRIPTIONS REFER TO NAVELEX EE161-BE-IDX-010/W110-TTY

TABLE 4-16. TESTS FOR THE UHF "P" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameters
TP-1 and 2	Teletype Signal Analysis	
	a. Signal Level	
	1. High Level	58 to 62 ma
	2. Low Level	+5 to +7 VDC (MARK) -5 to +7 VDC (SPACE)
	b. Signal Shaping	Observe oscilloscope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. % Speed Error	2% Maximum
	d. Distortion	5% Maximum
TP-3	Audio Signal Analysis	
	a. Send Signal Level	In accordance with Table 5-8, page 5-36.
TP-4	RF Signal Analysis	
	a. Frequency	
	1. RT-1107(V)/WSC-3	±1 Hz
	2. URC-9 (Family)	±10 Hz

TABLE 4-16 TEST FOR THE UHF "P" SYSTEM (continued)

INITIAL SET-UP

Test Point No.	Test	Parameter
TP-4 (continued)	b. Harmonic Products	Not less than 35 dB down from two-tone signal peak.
TP-5	RF Signal Analysis	
	a. Frequency	
	1. RT-1107(V)/WSC-3	±1 Hz
	2. URC-9 (Family)	±10 Hz
TP-6	Audio Signal Analysis	
	a. Signal Level	Not less than -10 dBm and not more than 0 dBm.
TP-7 and 8	Teletype Signal Analysis	
	a. Distortion	15% Maximum

ON-LINE

Test Point No.	Test	Parameters
TP-1 and 2	Teletype Signal Analysis	
	a. Send Signal Level	
	1. High Level	58 to 62 ma.
	2. Low Level	+5 to +7 VDC (MARK) -5 to -7 VDC (SPACE)

TABLE 4-16 TEST FOR THE UHF "P" SYSTEM (continued)

ON-LINE

Test Point No.	Test	Parameter
TP-1 & 2 (continued)	b. Signal Shaping	Observe oscilloscope display for undesirable signal shaping, broken bauds, intermittent signal or interference.
	c. Distortion	5% Maximum.
TP-3	Audio Signal Analysis	
	a. Send Signal Level	In accordance with Table 5-8, page 5-36.
TP-4	RF Signal Analysis	
	a. Frequency	
	1. RT-1107(V)/WSC-3	±1 Hz
	2. URC-9 (Family)	±10 Hz
TP-5	RF Signal Analysis	
	a. Frequency	
	1. RT-1107(V)/WSC-3	±1 Hz
	2. URC-9 (Family)	±10 Hz
TP-6	Audio Signal Analysis	
	a. Signal Level	Not less than -10 dBm and not more than 0 dBm.
TP-7 and 8	Teletype Signal Analysis	
	a. Distortion	15% Maximum

CHAPTER IV
SYSTEMS DESCRIPTION

SECTION 9
AM/FM WIDEBAND SECURE VOICE SYSTEMS
VHF/UHF TYPE "R" SYSTEM

4-9 System Description. The "R" system is the primary means of secure voice communications between units within Line-of-sight. Several stations can operate on the same frequency (simplex) providing netted operation. Figure 4-12 (for SAS equipped ships) and Figure 4-13 (for Non-SAS ships) provide a block diagram of the "R" system. Equipment configurations vary, but normally consist of the VHF/UHF antenna connected through a coupler or multicoupler to a transceiver transfer switchboard to the crypto equipment which is patched via the Remote Switching Control Unit or Single Audio System (SAS). Refer to Table 4-17 for the nomenclature of above listed types of equipment typical of this system.

4-9.1 System Signal Flow. Refer to Figure 4-12 (SAS Equipped); Refer to Figure 4-13 (Non-SAS).

4-9.1.1 Transmit Subsystem. When the operator depresses the Push-to-Talk (PTT) button and speaks into the microphone of the handset at the secure voice remote phone unit, he produces a keyline closure and an audio voice signal. This keyline closure and audio signal are patched to the crypto equipment via the Remote Switching Control Unit or the Single Audio System (SAS) and the Impedance Matching Network. The crypto equipment functions to key the associated transceiver when the operator presses the PTT button and commences to transmit a phasing signal (SYNC preamble) for a short duration. Upon completion of the SYNC preamble, the crypto then changes the audio (analog) signal to a digital signal and encrypts this digital signal, producing a high-speed digital keystream. The keyline closure and the high-speed digital keystream are applied to the transceiver via the Interconnecting Box, the transmitter transfer switchboard, and the Transceiver Switching Unit, respectively. Depending on the type of transceiver selected (AM or FM), the high-speed digital keystream either amplitude or frequency modulates the RF carrier generated by the transceiver which is routed to the antenna via the antenna coupler/multicoupler.

4-9.1.2 Receive Subsystem. The RF signal is received by the antenna system and fed via the antenna coupler/multicoupler to the transceiver where it is demodulated by the receiver portion of the transceiver. The output signal of the transceiver is an encrypted high-speed digital signal which is applied to the crypto equipment via the Transceiver Switching Unit, the receiver audio switchboard, and the Interconnection Box respectively. Once the crypto equipment synchronizes to the transmitted SYNC preamble, the high-speed digital keystream is decrypted and further changed into an audio (analog) signal. The audio signal from the crypto equipment is fed through the Impedance Matching Network to the Remote Switching Control Unit or the Single Audio System (SAS) where it is patched to the remote secure voice phone unit.

4-9.1.3 Phasing. The phasing (synchronization) of this system is accomplished when the push-to-talk button on the handset is depressed; however, the operator must wait (approximately 1 to 2 seconds) until the crypto equipment has transmitted a phasing signal (SYNC preamble) before talking. An indication to the user of when the crypto equipment has completed transmitting the SYNC preamble is the presence of an audible "beep" tone at the handset produced by the crypto equipment.

4-9.2 Verification of System Quality. Prior to net activation the system configuration must be tested using QMS procedures. Refer to Table 4-18.

TABLE 4-17
LIST OF TYPICAL EQUIPMENT FOR THE "R" SYSTEM

ANTENNA	ANTENNA COUPLER
AS-390/SRC AS-1018/URC AS-1735/SRC AS-2877/SRC AT-150/SRC	AN/SRA-33
TRANSCEIVERS	SWITCHBOARDS
URC-9 (FAMILY) RT-1107(V)WSC-3	SB-863/SRT SB-863/SRTC SB-988/SRT SB-2727()/SRR SA-2112(V) C-7594B/U
SECURITY DEVICES	REMOTES
TSEC/KY-8 TSEC/KY58	TA-390/U TA-840A/U C-10276/SSC C-9351/WSC-3 AM-3729/SR LS-474/U NT-49546

TABLE 4-18. TESTS FOR THE "R" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameters
TP-1	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm
TP-2 (SEND)	R.F. Signal Analysis	Refer to Section 3, paragraph 3-3.9, QM test #3H.
TP-2 (RECEIVE)	R.F. Signal Analysis	Refer to Section 3, paragraph 3-3.9, QM test #3H.
TP-3	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.

ON-LINE

Test Point No.	Test	Parameters
TP-1	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.
TP-2 (SEND)	R.F. Signal Analysis	Refer to Section 3, paragraph 3-3.9, QM test #3H.

TABLE 4-18 TEST FOR THE "R" SYSTEM (continued)

INITIAL SET-UP

Test Point No.	Test	Parameter
TP-2 (RECEIVE)	R.F. Signal Analysis	Refer to Section 3, paragraph 3-3.9, QM test #3H.
TP-3	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.

via the receiver audio switchboard. Once the receive crypto equipment synchronizes to the transmitted SYNC preamble, the high-speed digital keystream is decrypted and changed into a RED audio (analog) signal. The RED audio signal from the crypto equipment is fed through the remote Switching Control or Single Audio System (SAS) where it is patched to the RED remote secure voice phone unit.

4-10.1.3 Phasing. The phasing (synchronization) of this system is accomplished when the push-to-talk button on the handset is depressed; however, the operator must wait (approximately 1 to 2 seconds) until the crypto equipment has transmitted a phasing signal (SYNC preamble) before talking. An indication to the user of when the crypto equipment has completed transmitting the SYNC preamble is the presence of an audible "beep" tone produced by the crypto equipment.

4-10.2 Verification of System Quality. Prior to net activation the system configuration must be tested using QMS procedures. Refer to Table 4-20.

TABLE 4-19
LIST OF TYPICAL EQUIPMENT FOR THE "S" SYSTEM

ANTENNA	ANTENNA COUPLER
AS-2537A/SR	AN/SRA-12
AS-2802/SRC	AN/SRA-49
AS-2865/SRC	AN/SRA-56
AS-2803/SRC	AN/SRA-57
AS-2866/SRC	AN/SRA-58
	AN/URA-38
TRANSMITTERS	**RECEIVERS**
AN/URT-23( )	R-1051( )/URR
AN/URT-24	R-1903/UR
T-1322/SRC	
SWITCHBOARDS	**REMOTES**
SB-863/SRT	TA-390/U
SB-973/SRR	TA-840A/U
SB-988/SRT	AM-3729/SR
SB-2727( )SRR	LS-474/U
SA-2112(V)	NT-49546
C-7594B/U	
SECURITY DEVICES	
TSEC/KY-75	

TABLE 4-20. TESTS FOR THE "S" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameters
TP-1	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.
TP-2	R.F. Analysis	
	a. Frequency	±1 Hz
	b. Harmonic Products	Not less than 35 dB down from two-tone signal peak.
	c. Carrier Suppression	Not less than 40 dB down from two-tone signal peak.
TP-3	R.F. Signal Analysis	
	a. Frequency	±1Hz
	b. Signal/Noise	15 dBm minimum signal above noise.
TP-4	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.

TABLE 4-20 TEST FOR THE "S" SYSTEM (continued)

ON-LINE

Test Point No.	Test	Parameter
TP-1	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.
TP-2	R.F. Signal Analysis	
	a. Frequency	±1 Hz
TP-3	R.F. Signal Analysis	
	a. Frequency	±1 Hz
TP-4	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.

CHAPTER 4

SYSTEMS DESCRIPTIONS

SECTION 11
AM/FM NON-SECURE VOICE SYSTEM
VHF/UHF TYPE "U" SYSTEM

4-11 System Description. The "U" system provides a non-secure voice system employing VHF or UHF amplitude or frequency modulation. Figure 4-16 provides a block diagram of the "U" system. A typical non-secure voice system consists of one or more Radiotelephone Remote Units (RRUs) and/or speaker-amplifiers patched to transmitting and receiving equipment (or transceivers) via the transmitter transfer switchboard and receiver audio switchboard. If remote channel selection is required, the remote channel selector may be hardwired to its associated transmitter/transceiver or patched via a separate switch panel. Refer to Table 4-21 for the nomenclature of above listed types of equipment typical to this system.

4-11.1 System Signal Flow. Refer to Figure 4-16.

4-11.1.1 Receive Subsystem. The RF signal is received by the antenna and fed via the coupler or multicoupler to the receiver where demodulation is accomplished resulting in an audio signal output. This audio signal output from the receiver is patched via the receiver audio switchboard to the remote Radiotelephone Unit (RRU) and/or amplifier-loudspeaker. The audio signal is changed from electrical energy to mechanical energy by headphones, handsets or speakers.

4-11.1.2 Transmit Subsystem. The mechanical energy, generated by the operator's voice, is changed to electrical energy in the handset. The push-to-talk button on the handset closes the DC keying circuit to the transmitter placing the transmitter on the air. The audio and DC signals from the handset are patched via the transmitter transfer switchboard to the transmitter or transceiver. The audio signal provides either amplitude or frequency modulation to the RF signal generated by the transmitter. The modulated RF signal is then routed to the antenna via the coupler or multicoupler.

4-11.2 Verification of System Quality. Prior to net activation the system configuration must be tested using QMS procedures. Refer to Table 4-22.

only the remaining sideband being transmitted (Compatible AM).

4-13.2 Verification of System Quality. Prior to net activation and during on-line operation, the system configuration must be tested using QMS procedures. Refer to Table 4-26.

TABLE 4-25

LIST OF TYPICAL EQUIPMENT FOR THE "Y" SYSTEM

ANTENNA	ANTENNA COUPLER
AS-2537A/SR AS-2802/SRC AS-2865/SRC AS-2803/SRC AS-2866/SRC	AN/SRA-12 AN/SRA-49 AN/SRA-56 AN/SRA-57 AN/SRA-58 AN/URA-38
TRANSMITTERS	RECEIVERS
AN/URT-23() AN/URT-24 R-1903/UR T-1322/SRC	R-1051()/URR
SWITCHBOARDS	REMOTES
SB-863/SRT SB-973/SRR SB-988/SRT SB-2727()/SRR	C-1138B/UR AM-3729/SR LS-474/U NT-49546 H-169/U

TABLE 4-26. TESTS FOR THE "Y" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameters
TP-1	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.
TP-2	R.F. Signal Analysis	
	a. Frequency	±1 Hz
	b. Harmonic Products	Not less than 35 dB down from two-tone signal peak.
	c. Carrier Suppression	Not less than 40 dB down from two-tone signal peak.
TP-3	R.F. Signal Analysis	
	a. Frequency	±1 Hz
	b. Signal/Noise	15 dBm (Minimum) Signal above noise.
TP-4	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.

TABLE 4-26 TEST FOR THE "Y" SYSTEM (continued)

ON-LINE TEST

Test Point No.	Test	Parameters
TP-1	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.
TP-2	R.F. Signal Analysis	
	a. Frequency	±1 Hz
TP-3	R.F. Signal Analysis	
	a. Frequency	±1 Hz
TP-4	Audio Signal Analysis	
	a. Signal Level	Peaks to 0 dBm ±5 dBm.

CHAPTER 4
SYSTEMS DESCRIPTIONS

SECTION 14
FACSIMILE RECEIVING SYSTEM

4-1 System Description. The facsimile receiving system is installed on certain afloat commands and is generally used to receive maps transmitted by certain shore-based facilities. Figure 4-19 provides a block diagram of the "Fax" system. The system consists of the receiving antenna system, an HF receiver, a facsimile converter and the facsimile recorder. Diversity reception is not employed in this system. Refer to Table 4-27 for the nomenclature of above listed types of equipment typical to this system.

4-1.1 System Signal Flow. Refer to Figure 4-19.

4-1.1.1 Receive Subsystem. The RF Carrier Shifted signal is received at the antenna and coupled to the receiver, which may be "normalled-through" or patched to a facsimile converter. The receiver is tuned to the radio frequency and demodulates the RF carrier shifted signal. If the converter used is a CV-2979/U, the required audio frequency for the converter are 1500 Hz for a "black" signal and 2300 Hz for a "white" signal. The other type of converter (CV-1066/U) requires 2300 Hz for a "black" signal and 3100 Hz for the "white" signal. This audio signal is normalled-through or patched via the receiver audio switchboard to the facsimile converter. The converter changes the audio frequency signal to an amplitude modulated audio signal. The amplitude modulated signal from the converter is normally "hardwired" to the facsimile recorder where the amplitude variations cause the recorder to "print" (reproduce) a picture which duplicates the transmitted picture.

4-1.1.2 Transmit Subsystem. The transmit subsystem is normally located at a shore station. The figure to be transmitted is placed in a Facsimile transmitter which, utilizing an optical scanner, changes the black and white of the map into Frequency Shifted signals. The RF carrier frequency is shifted 400 Hz above and below the assigned radio frequency for a total shift of 800 Hz. The frequency shifted RF signal is routed to an antenna via the antenna coupler.

4-1.2 Verification of System Quality. Prior to net activation the system configuration must be tested using QMS procedures. Refer to Table 4-28.

TABLE 4-27

LIST OF TYPICAL EQUIPMENT FOR THE "FAX" SYSTEM

ANTENNA	ANTENNA COUPLER
AS-2537A	AN/SRA-12 AN/SRA-49 SB-3332/SR
RECEIVER	SWITCHBOARDS
R-1051()/URR R-1903/UR	SB-863/SRT SB-2727()/SRR
CONVERTER	RECORDER
CV-2979/U CV-1066B/UX	AN/UXH-2B AN/UXH-2C

TABLE 4-28. TESTS FOR THE "FAX" SYSTEM

INITIAL SET-UP

Test Point No.	Test	Parameters
TP-1	RF Analysis	
	a. Frequency	±1 Hz
	b. Signal/Noise	15 dBm (Minimum) Signal above noise.
TP-2	Audio Signal Analysis	
	a. Signal Level	0 dBm

ON-LINE TEST

Test Point No.	Test	Parameters
TP-1	RF Analysis	
	a. Frequency	±1 Hz
	b. Signal/Noise	15 dBm (Minimum) Signal above noise.
TP-2	Audio Signal Analysis	
	a. Signal Level	0 dBm

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

INTRODUCTION

5.0 General. This chapter contains sections with descriptions and nomenclatures for communication equipment typical to the systems described in Chapter 4 of this instruction.

Antennas, Tuners and Multicouplers - Section 1

Shipboard Receivers - Section 2

Switchboards - Section 3

Converters - Section 4

D.C. Patch Panels - Section 5

Teletypewriter Equipment - Section 6

Remote Units - Section 7

Keyers - Section 8

Transmitters - Section 9

Shipboard Transceivers - Section 10

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 1
ANTENNAS, TUNERS AND MULTI-COUPLERS

5-1.0 General.

5-1.0.1 Antenna Types. Shipboard antennas are widely varied in types depending upon the frequency they cover, the application in which they are employed and the environmental limitations to which they are subjected.

5-1.0.2 Antenna Efficiency. Transmitting antenna efficiency is the ratio of power radiated by the antenna to the power delivered by the transmitter. Antenna efficiency and radiated power are determining factors in signal to noise at the receiving antenna.

5-1.0.3 Antenna Tuner. The purpose of an antenna tuner is to add either inductance, capacitance or a combination of both in series or parallel with the antenna to present an acceptable Voltage Standing Wave Ratio (VSWR) to the transmitter. The tuner coupler system is composed of two sections. The tuner, containing capacitors, a variable inductor, switching network and drive motors, is physically co-located with the antenna. The remote control unit, containing control switches or buttons and a meter to indicate a tuned condition, is located at or near the transmitter. The most common shipboard antenna systems are discussed in the following paragraphs.

5-1.1 LF/MF Antenna Systems.

5-1.1.1 AN/SRA-17. The preferred LF/MF receiver antenna system is the AN/SRA-17. This antenna covers a frequency range from 14 to 600 kHz. The AN/SRA-17 utilizes a 10-foot probe which makes it physically small but efficient for use on small craft where long wire antennas are not available or on ships where large, closely spaced antennas would interact. For optimum performance the antenna and the radio frequency tuner must be mounted near the top of a mast, king post, stack or other vertical member of the superstructure. The distance between the radio frequency tuner and its associated receiver should not exceed 150 feet for satisfactory operation. The antenna control unit should be located adjacent to the receiver for ease in adjusting the system.

5-1.1.2 CU-2007/SRR. The RF COMBINER-MULTICOUPLER CU-2007/SRR permits the use of 2-30 MHz antennas with receivers operating on frequencies below 2 MHz. It separates incoming signals above and below a crossover frequency of 1.85-MHz into a low band (10-kHz to 1.85-MHz) and a high band (1.85-MHz to 30 MHz). The low band RF is utilized by the LF receivers connected to the CU-2007.

5-1.2 MF/HF Antenna Systems.

5-1.2.1 Transmit Whip Antennas and Tuners. Examples of transmitting antenna tuner couplers presently in use are the AN/URA-38 and CU-937/UR. These tuners are generally used with a 35-foot whip. The AN/URA-38 (used with the AN/URT-23) and the CU-937 (used with the AN/URT-24) are automatic, single channel antenna tuning systems. The operating range is 2 - 30 MHz and will handle up to 1 kw of average or peak envelope power (PEP). The AN/URA-38 can be operated in any one of three modes: Automatic, Manual or Silent Tuning.

5-1.2.2 Broadband Antennas.

a. The number of communications circuits required to satisfy the operational commitments of shipboard communications systems have increased to a degree that it is not possible to install tuned antennas for each circuit. This is due to lack of shipboard space and the effects of the interaction between closely spaced antennas that tend to degrade their efficiency. Broadband antennas are capable of operation with multi-couplers and several circuits may be operated with a single antenna. Therefore, the total number of antennas for an individual system is reduced, and the possibility of pattern distortion and mutual coupling impedance effects are diminished due to the greater separation possible with few antennas.

b. Typical broadband antennas used for shipboard installations are: multiple element (trussed) whips, discone/cages, and fans.

(1) Cage and Trussed Whips. Vertical antennas are made broadband by the use of the multiple wires running from a ring, arms or other support structure at the center or bottom of the antenna to the top, or to the top and bottom. The frequency range within 2 to 30 MHz is dependent on the size of the antenna and number of wires.

(2) Discone/Cages. This structure consists of two truncated wire rope cones constructed base-to-base and supported by a central mast. The lower portion of the structure functions as a cage monopole for the 4 to 12 MHz frequency range. The upper portion operates as a discone radiator in the 10 to 30 MHz frequency range.

(3) Fans. A fan antenna is essentially a long wire antenna and is broadband by the use of 3 to 8 wires arranged in a fan shape. It is designed to cover various segments of the frequency range from 2 to 30 MHz depending on its length and number of elements.

5-1.2.3 Transmitting Multi-Couplers. Transmitting multi-couplers are used with broadband antennas to provide coupling and matching between the transmitter and antenna at a VSWR between 3:1 and 4:1. They also allow up to four (4) transmitters to feed a single antenna. Manually tuned multi-couplers are the AN/SRA-56, AN/SRA-57 and AN/SRA-58 which cover segments of the frequency range from 2 to 30 MHz. The AN/SRC-16 and AN/SRC-23 transceivers used with NTDS have integral antenna multi-couplers which provide automatic antenna matching for themselves and several other transmitters simultaneously. Although the broadband antennas used with each of these couplers usually cover the frequency range of the coupler, there are some cases where they do not. Attempting to tune a frequency outside the range of the antenna will result in high VSWR and possible damage to the equipment. Installations with limited antenna frequency range are so identified on the antenna coupler.

5-1.2.4 Receive Antenna Systems.

a. Whip Antennas and Multi-Couplers. The most common receiving antenna found aboard ship is the 35-foot whip. This antenna is untuned and is used with the AN/SRA-12 filter multi-coupler which provides the capability to operate a number of receivers from the same antenna. The AN/SRA-12 employs plug-in low-pass/high-pass filter sub-assemblies to cover the frequency spectrum between 14 kHz and 32 MHz. Within this spectrum, a maximum of seven bands of frequencies are available by employing combinations of six different filter sub-assemblies. Each band of the AN/SRA-12 has four jacks, the top three decoupled by 300 ohm isolation resistors. The lower jack will provide the strongest signal and should be used for the most difficult or important circuit. Filter assemblies should be arranged in decreasing frequencies from left to right as viewed from front panel. A red circled jack indicates that this jack is connected directly to the antenna through the sub-assembly.

An unpainted output jack indicates that this jack is decoupled from direct input by a 300 ohm resistor. Locally transmitted signals in the pass band of the individual AN/SRA-12 filters are attenuated only 2 dB by the filter.

b. Tunable Receiving Whips. There are two tunable receiving whips available, the AN/SRA-43 for 2 to 8 MHz and the AN/SRA-51 for 2 to 15 MHz. These antennas consist of a tuner with a five foot probe and remote control capability. The limiting factor of these antennas is that they can only be used with one receiver at a time.

c. Broadband Receiving Antennas. Broadband receiving antennas generally take the same form as the broadband transmitting antennas. The FAN is not used for receiving. Since VSWR requirements for receiving antenna systems are not usually as stringent as for transmitting systems, they normally cover a broader frequency range than would the equivalent transmitting antenna. As a result, fewer receiving antennas, each covering a broader frequency range, are usually installed aboard ship. The AN/SRA-49, with its tunable filters, covers the frequency range from 2 to 30 MHz. These filters minimize EMI and protect the receiver from locally generated high power signals. Do not tune more than one filter to a single frequency; doing so will result in a reduction in signal strength caused by interaction between the filters.

d. Precautions. Under no circumstances should a receiving antenna be used without a filter/multi-coupler. Voltages in excess of 100 volts can appear on the antenna, and without the filter, damage to the receiver may result. Unless designed for multi-purpose use, e.g., CU-937/UR, when used with associated transceivers, transmitting antennas should not be used for receiving. Very high RF voltages are developed on these antennas from surrounding transmitter antennas and damage to filter coupler or receivers could result.

5-1.2.5 MF/HF Antenna Location. For best performance, the MF/HF antenna should be located as close to the water line as possible and free from surrounding structures. Using this criteria, the best transmitting antenna for the 6 MHz or above frequency range would be a DISCONE/CAGE antenna located as far forward as possible. For a receiving antenna, a trussed whip, or twin whip antenna located on the superstructure should receive signals 2 to 30 MHz with excellent results. Antennas should be assigned to prevent adjacent transmitting and receiving antennas from operating on frequencies separated by less than ten percent.

5-1.3 VHF/UHF Antennas and Multi-Couplers.

5-1.3.1 VHF/UHF Antennas. VHF/UHF antennas are usually either a dipole or ground-plane vertical antenna. These antennas have a wide bandwidth to cover the frequency range of VHF and UHF equipment. Because of physical location, polarization and height, each antenna will present different directional characteristics which must be taken into consideration when selecting an antenna for a particular function. Most VHF/UHF antennas are fed by multi-couplers permitting more than one transceiver to use the same antenna.

5-1.3.2 AN/SRA-60. The AN/SRA-60 is a VHF system of four couplers capable of operating simultaneously into a single broadband antenna covering a frequency range of 30 to 76 MHz. A single cabinet, supplied with the basic system, is capable of housing either one or two of the 4 channel coupler groups. Interlock control circuits are provided to shut down the associated 100 watt transmitter when coupler VSWR is greater than 4:1. Excessive temperature rise in the coupler operates a thermostat which also opens the interlock circuit.

5-1.3.3 AN/SRA-33. The UHF unit most commonly used is the AN/SRA-33. The AN/SRA-33 is used with the AN/URC-9 family and AN/WSC-3 transceivers and provides automatic antenna tuning in response to channel selection of the transceiver.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 2
SHIPBOARD RECEIVERS

5-2.0 General. In this section general capabilities for common shipboard receivers are covered.

5-2.1 LF RECEIVERS.

5-2.1.1 AN/SRR-19. This receiver operates in the 30-300 kHz frequency range, tunable in four selective bands. Operating modes are CW, MCW, AM and SSB. Of the receivers capable of LF reception, only the SRR-19 has sufficient frequency stability to satisfactorily copy the SSB Multichannel Fleet Broadcast. The AN/URQ-10 or 23 should be used as an external standard in lieu of the internal standard when possible.

5-2.1.2 AN/WRR-3. This receiver operates in the 14-600 kHz frequency range, tunable in five selective bands. Operating modes are CW, MCW and FSK. The receiver can be calibrated every 10 kHz using the front panel "CAL" controls. This receiver is not synthesized and therefore not normally used to copy the Multichannel Fleet Broadcast. It has no provisions for use of an external frequency standard. This receiver normally utilizes the AN/URA-17 for signal conversion.

5-2.2 MF/HF Receivers.

5-2.2.1 R-390. This receiver operates in the .5 to 32 MHz frequency range. Operating modes are CW, MCW, Voice and FSK. The receiver can be calibrated every 100 kHz using front panel controls. It has no provisions for use of an external frequency standard.

5-2.2.2 R-1051/URR. This receiver operates in the 2 to 30 MHz frequency range. The R-1051A is tunable in 500 Hz increments while subsequent series are tunable in 100 Hz increments. Continuous tuning within each 1 kHz increment is available by using the VERNIER. Operating modes are CW, MCW, FSK, AM, SSB and FAX. The AN/URQ-10 or 23 should be used as an external standard in lieu of the internal standard when possible.

5-2.2.3 R-1903/UR. The R-1903/UR is an independent sideband receiver which operates on one of 280,000 channels in the HF range of 2 to 29.9999 MHz. The receiver is capable of receiving CW, FSK, Voice or DATA signals in one of nine modes of operation.

5-2.3 VHF/UHF Receivers.

5-2.3.1 AN/GRR-23. The GRR-23 is a single-channel, solid state, super-heterodyne VHF receiver that operates in the AM mode. It is capable of receiving radiotelephone and modulated CW signals in the 116 to 150 MHz frequency range. The GRR-23 is capable of only plain (narrow-band) voice reception. A primary function of the GRT-21/GRR-23 combination is to guard the aircraft emergency distress frequency (121.5 MHz). To accomplish this function, the VHF GRR-23 is used in conjunction with the GRT-21 to provide the transmit subsystem. The GRT-21 utilizes the same antenna as the GRR-23.

5-2.3.2 AN/SSR-1. The SSR-1, which is used for copying Fleet Broadcast (FLTBCST), is a six-channel, preselector-tuned receiving system capable of receiving FM and PSK satellite communications signals in the VHF band. The receiving system contains two major units: the Combiner-Demodulator and the Demultiplexer.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 3
SWITCHBOARDS

5-3.0 General. Switchboards are divided into two categories: 1) Receiver Audio Switchboards; and 2) Transmitter Transfer Switchboards.

5.3.1 Receiver Audio Switchboards. After receivers are tuned for an optimum audio signal, the signal must be applied to a converter, crypto device or remote operating position. This is accomplished through audio transfer switchboards. The most common models are briefly described below.

5-3.1.1 SB-973/SRR. The SB-973/SRR transfers the audio output of radio receivers to remote locations. It provides for switching five receiver outputs to as many as ten remote locations through 7-position rotary switches. Each switch represents a remote location, five of the seven positions represent receiver audio outputs.

5-3.1.2 SB-2727B/URR. The SB-2727B/URR contains twenty, 25-position rotary switches which are capable of transferring the audio outputs of 23 radio receivers to any or all of 20 remote locations. Each knob represents a particular remote control station. Position 24 of each knob provides continuity between switches controlling the same remote control station. This capability is provided when more than 24 radio receivers are available to any remote audio signals from that particular remote control station.

5-3.2 Transmitter Transfer Switchboards. Transmitter transfer switchboards provide for connection of remote radiophone and remote radio control units to the ship's transmitters. They provide for switching audio, start-stop control and indicator, keying, 12 volt DC microphone, carrier control and carrier indicator.

5-3.2.1 SB-863/SRT. The SB-863/SRT has ten, 20-position rotary selector switches in two vertical columns. Each rotary switch corresponds to a remote control station, and each switch position (1 through 19) corresponds to a controlled transmitter. Thus, switching control is provided for up to 10 remote control stations and 19 transmitters. When more than 10 remote stations or 19 transmitters are to be connected, additional transfer switchboards may be installed.

Position 20 of each rotary switch is provided for connections to an additional transfer switchboard to control extra transmitters. The switches consist of 12 wafers that connect the keying, 12 volt DC microphone, carrier control, and carrier indicator circuits for the various transmitters. Any of the remote single stations may be connected to control any of the transmitters in the system, however, a single remote cannot be patched to more than one transmitter.

5-3.2.2 SB-988/SRT. Transmitter transfer Switchboard, Type SB-988/SRT functions in a like manner to the SB-863/SRT mentioned above with the exception that it is designed to control only six transmitters. It is to be utilized where less than 10 transmitters are required.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 4
CONVERTERS

5-4.0 General. Many shipboard communication systems require conversion of the output of the receiver to a different form, suitable for reproduction. The receiver audio output, for example, must be converted to DC MARKS or SPACES in the case of radio teletypewriter systems. In the case of facsimile systems, the receiver audio output must be converted to DC at varying levels to permit reproduction of the facsimile photo. An exception is the case of non-secure voice systems. In these systems the audio output can be applied to speaker amplifiers without further signal conversion. In the following paragraphs the most commonly employed types of signal converters will be discussed.

5-4.1 Frequency Shift Keyed (FSK) RATT Converter/Comparator (AN/URA-17).

5-4.1.1 FSK RATT Description. One of the most common methods of Ship/Ship and Ship/Shore/Ship teletypewriter communications is frequency shift keyed (FSK) radio teletypewriter (RATT). In this type system the DC MARKS and SPACES from the send teletypewriter and associated crypto equipment at the sending station cause that station's radio transmitter to shift frequency by pre-designated amounts. The most commonly used frequency shifts are 850 Hz for MF/HF (above 2 MHz), and 170 Hz for LF/MF (below 2 MHz). In terms of AN/URA-17 operation, 850 Hz is considered wide shift and 170 Hz is considered narrow. Almost all Navy applications are wide shift operations. There are no longer any FSK transmitters below 2 MHz on board Navy ships. The following paragraphs discuss FSK operations.

5-4.1.2 MF/HF Using Wide Shift. Assume the distant end transmitter is utilizing an ASSIGNED frequency of 5935 kHz. The presence of a SPACE from the crypto equipment adds 425 Hz to this for a resultant frequency of 5935.425 kHz as follows:

ASSIGNED Frequency	5,935.000 kHz	(Not Transmitted)
SPACE Frequency	+.425 kHz	
	5,935.425 kHz	(Transmitted Frequency)

5-4.1.3 Effect of MARK. When a MARK from the crypto equipment is applied to the transmitter, the output frequency is decreased 425 Hz from the ASSIGNED frequency for a resultant output frequency of 5934.575 kHz as follows:

ASSIGNED Frequency	5,935.000 kHz	(Not Transmitted)
MARK Frequency	-.425 kHz	
	5,934.575 kHz	(Transmitted Frequency)

5-4.1.4 Total Shift. This provides a total 850 Hz shift, 425 Hz above the assigned frequency and 425 Hz below the ASSIGNED frequency.

5-4.1.5 Received FSK Signal Processing. To process the received FSK signal the audio output of the receiver is applied to the AN/URA-17 converter to transform the received frequency shifted signals back into current/no-current (MARK or SPACE) form. Remember that the "spread" or total shift between MARK and SPACE was shown to be 850 Hz.

5-4.1.6 MARK and SPACE SIGNAL Recreation. The following describes the way in which a receiver and the AN/URA-17 converter operate together to recreate the MARK and SPACE signals transmitted from a distant station.

a. The AN/URA-17 converter normally uses a CENTER frequency (or reference frequency) of 2000 Hz for communications in the MF/HF band (above 2 MHz). The 850 Hz spread centered about the 2000 Hz frequency results in a SPACE frequency of 2425 Hz (2000 plus 425) and a 1575 Hz MARK frequency (2000 minus 425).

b. The receiver converts the received RF signals to two separate audio tones (1575 Hz for a MARK, and 2425 Hz for a SPACE). The converters have internal circuitry which produces current/no current DC signals in accordance with the received signals. These alternate current and no current pulses correspond to the MARK and SPACE pulses that were originally generated at the distant end. The receiver tuning controls are adjusted to supply the proper frequencies to the converter.

c. Some receivers use multiple conversion stages before the audio output. Since some of the stages use subtractive mixers and others use additive mixers, it is possible to shift the sense of the MARK and SPACE signals. If the MARK and SPACE frequencies are reversed in the mixer stages of the receiver, the audio output frequencies will be 2425 Hz for a MARK and 1575 Hz for a SPACE. Should this be the case, they can be easily changed to the proper sense by shifting the normal/reverse switch on the AN/URA-17 converter to the "normal" position. This reverses the audio signals in the converter itself and produces the proper MARK and SPACE outputs to the DC Loop.

5-4.2 Tone Modulated Radio Teletypewriter Converter (CV-2460/SGC).

5-4.2.1 Tone Modulated Circuit Description. Tone modulated teletypewriter circuits are ideally suited for UHF ORESTES circuits. These circuits are reliable and can be netted, that is, employed by more than two ships. The CV-2460/SGC is the converter employed for tone modulated radio teletypewriter circuits. The equipment converts DC to audio in the transmit mode. They receive a DC signal from the crypto equipment and convert this DC signal into audio tone shift frequencies for further transmission by a radio transmitter. The audio tone for a teletypewriter MARK is 700 Hz and the SPACE frequency is 500 Hz. In the receive mode, the equipment is audio-to-DC converters. Audio from the receiver is applied to the converter. When a 700 Hz tone is received, the equipment converts this to a teletypewriter MARK (current); when a 500 Hz tone is received, it is converted into a teletypewriter SPACE (no current).

5-4.2.2 CV-2460/SGC. The CV-2460/SGC is completely solid-state requiring little space. The CV-2460/SGC has a mode selector switch that can place the equipment in either HALF DUPLEX (send or receive only), SIMPLEX (send and receive, but not simultaneously), FULL-DUPLEX (send and receive simultaneously) and a send/receive back-to-back position for adjustment and maintenance purposes. The equipment has two frequency shift options: narrow shift (OPTION A.) operates at a 600 Hz CENTER frequency with shifts of 100 Hz either side. This yields shifted frequencies of 500 Hz (SPACE) and 700 Hz (MARK). Wide shift (OPTION B.) operates at a 2000 Hz CENTER frequency with shifts of 425 Hz either side for resultant frequencies of 1575 Hz (MARK) and 2425 Hz (SPACE).

5-4.3 Facsimile Converters (FAX).

5-4.3.1 FAX Description. Facsimile is a low data rate method for transmitting pictorial and graphic information (images) by wire and reproducing it in its original form at the receiving station. The images, called pictures or copy in facsimile terminology, may be weather maps, photographs, sketches, typewritten or printed text, or handwriting. The most common afloat application of facsimile by the Navy is transmission of fully plotted and analyzed weather charts.

5-4.3.2 FAX Operations. The still image serving as the facsimile copy or picture cannot be transmitted instantly in its entirely. Three distinct operations are performed:

(1) Scanning.

(2) Transmitting.

(3) Recording.

All three can be accomplished simultaneously.

5-4.3.3 FAX Scanning. The scanning operation sub-divides the picture in an orderly manner into a large number of segments. This process is accomplished in the facsimile transmitter by a scanning drum and photocell.

5-4.3.4 FAX Scanning Drum. The picture to be transmitted is mounted on a cylindrical drum, which revolves at a speed of two revolutions per second and travels along a lead screw at the rate of 12.5 inches in 10 minutes. Light from an exciter lamp illuminates a small segment of the moving picture and is reflected by the picture through an aperture to a photocell. During the transmission of a complete picture, the light traverses every segment of the picture as the amount of light reflected back to the photocell is a measure of the lightness or darkness of the tiny segment of the picture that is being scanned. The photocell transforms the varying amounts of light into varying electrical signals.

5-4.3.5 FAX Transmission Equipments. Various equipments are available for FAX transmission and all operate basically in the same manner. Two radio FAX transmission systems are available, AFS (Audio Frequency Shift) and CFS (Carrier Frequency Shift). Worldwide facsimile transmitting stations can be found in Publication HO 119 which lists time of transmission, frequencies and contents. To receive radio facsimile signals of either CFS transmission or AFS transmission, conventional super-heterodyne receivers may be used. With either system, the signal output of the radio receiver is an AFS signal in which a low frequency represents the black signal and a high frequency represents the white signal output from the FAX transmitter at the sending terminal.

5-4.3.6 AFS Signal Conversion. In order to convert the AFS signal output of the radio receiver into an AM (amplitude modulated) signal suitable for operation of a FAX recorder or transceiver, an additional unit must be interposed between the receiver and the recorder. This unit may be frequency shift converters CV-2979/U or CV-1066B/UX.

5-4.3.7 Frequency Shift Conversion. Frequency shift converter CV-2979/U is used to convert 1500 to 2300 Hz facsimile signals received from a radio receiver to AM signals suitable for operating a FAX recorder. The CV-1066B/UX is used to convert 2300 to 3100 Hz signals. The converter contains provision for audible monitoring of the incoming signal and for visual checking of the frequency limits.

5-4.3.8 Frequency Shift Examples. For example, the input signal to the CV-2979/U from the radio receiver is an AFS signal in which 1500 Hz represents black and 2300 Hz represents white. (Frequencies between 1500-2300 Hz represent various shades of gray.) Tuning aids are provided on the converter panel. When a 1500 Hz signal is being received, the "1500" tuning eye will close or nearly so and the output will be maximum signal level for the FAX recorder. Also, when a 2300 Hz signal is being received, the "2300" tuning eye will close and the output will be minimum signal level for the FAX recorder. The same principle applies to the CV-1066B/UX with 2300 Hz being black and 3100 Hz being white.

5-4.3.9 Tuning Eye Frequencies. When the radio receiving equipment is properly adjusted for the CV-2979/U, the tuning eye indicators will show 1500 and 2300 Hz signals are being fed to the input of the frequency shift converter. For the CV-1066B/UX, 2300 and 3100 Hz apply.

5-4.3.10 FAX Output. The output of frequency shift converters CV-2979/U or CV-1066B/UX may be connected to one of various facsimile recorders available. Recorders available to the fleet are the AN/UXH-2B and AN/UXH-2C.

5-4.3.11 Standard Fleet FAX Units. FAX recorder set AN/UXH-2B and AN/UXH-2C are the standard units available to the fleet. These are continuous page recorders designed to make direct recordings transmitted over land wires or radio. These sets are designed to operate at 60, 90, or 120 scans per minute. When receiving from a transmitter with the proper signals, these units will automatically phase and start recording at the beginning of a transmission. They will stop when the transmission is complete as well as compensate for changes in signal level during the recording. When this automatic operation is utilized, these sets may be left unattended. Manual operation is recommended as the signal varies from picture to picture resulting in varying degrees of contrast. Refer to appropriate operator manuals for proper system adjustments.

5-4.4 Multichannel RATT Demultiplexer/Converter (AN/UCC-1) Equipment.

5-4.4.1 Demultiplexing. Multichannel teletypewriter systems are designed to receive a multiple number of teletypewriter circuits over a single communications link or radio path. This is possible through use of demultiplex equipment such as the AN/UCC-1( ).

5-4.4.2 Transmission. At the transmitting station, signals from several teletypewriters are multiplexed or combined into one composite or multichannel signal for transmission. At the receiving station, the composite signal is demultiplexed or separated into individual signals and converted into DC which is distributed to crypto equipment as required. The individual signal streams, which were combined to form the composite signals, are designated as channels. The basic number of channels is 16 in Navy frequency division multiplex. Individual systems may be configured for fewer channels based on requirements for traffic volume and reliability.

5-4.4.3 Center Frequencies. Each channel within the composite tone package of the broadcast or termination is assigned a CENTER frequency. The lowest CENTER frequency is 425 Hz and the highest CENTER frequency is 2975 Hz. CENTER frequencies are 170 Hz apart; e.g. 425, 595, 765, etc. This provides a capability for sixteen separate channels of intelligence, when required (See Figure 5-1).

5-4.4.4 Receive. Two inputs to the AN/UCC-1( ) will appear on the audio switchboard and will normally be marked as UCC-1 RCVR "A" and UCC-1 RCVR "B". This connects the receivers to the "A" and "B" inputs of the AN/UCC-1( ).

5-4.4.5 Terminations.

a. Four (Quad) Diversity: This technique may only be used on full-period multichannel Ship/Shore/Ship terminations and then only when "twinning" is employed. The diversity switch is set to the "four" position and drawers inserted in the AN/UCC-1( ) as shown in Figure 5-2. With four diversity, two receivers are utilized with one connected to the RCVR "A" and other to the RCVR "B" tone inputs of the AN/UCC-1( ). Ensure the receiver selector switch on top of each drawer is to RCVR "A" or RCVR "B" as appropriate. The converter circuitry combines the signals appearing at the converter drawers and provides a single output at the BLACK DC patch panel for each respective traffic channel. No signal will appear in the alternate position at the BLACK DC patch panel. If any drawer is pulled out, either a constant MARK or SPACE will appear at the BLACK DC patch panel.

b. Two Diversity (Out of Band). The diversity switch is set to the "two" position when twinning is being employed (Figure 5-3). A separate receiver is connected for each input to the AN/UCC-1( ). The "A" tone input is connected to converter drawers 1, 3, 5 and 7 of the AN/UCC-1( ) cabinet. The "B" tone input is connected to converter drawers 2, 4, 6 and 8 of the same AN/UCC-1( ) cabinet. Outputs will appear at the normal position of the BLACK DC patch panel for each diversity group. Ensure the receiver selector switch on top of each converter drawer is set to RCVR "A" or RCVR "B" as appropriate. If any drawer is pulled out on either RCVR "A" or RCVR "B" segment, no keying will appear at the BLACK DC patch panel. This method also provides a constant back-up, in the event on of the incoming signals goes bad.

c. One Diversity. The diversity selector switch on the front of each converter drawer of the AN/UCC-1( ) should be set to the "one" position when copying "untwinned" multichannel signals. It is recommended that the AN/UCC-1( ) drawers be arranged as shown in Figure 5-4. Using this configuration DC keying will appear in the normal loops of the BLACK DC patch panel. Ensure the receiver selector switch is set to appropriate position.

DRAWER CENTER FREQUENCY (DCF)	SUPPRESSED CARRIER
	382.5
D-C-F	425 Hz
	467.5
	552.5
D-C-F	595 Hz
	637.5
	722.5
D-C-F	765 Hz
	807.5
	892.5
D-C-F	925 Hz
	977.5
	1062.5
D-C-F	1105 Hz
	1147.5
	1232.5
D-C-F	1275 Hz
	1317.5
	1402.5
D-C-F	1445 Hz
	1447.5
	1572.5
D-C-F	1615 Hz
	1657.5
	1742.5
D-C-F	1785 Hz
	1827.5
	1912.5
D-C-F	1955 Hz
	1997.5
	2082.5
D-C-F	2125 Hz
	2167.5
	2252.5
D-C-F	2295 Hz
	2337.5
	2422.5
D-C-F	2465 Hz
	2507.5
	2592.5
D-C-F	2635 Hz
	2677.5
	2762.5
D-C-F	2805 Hz
	2847.5
	2932.5
D-C-F	2975 Hz
	3017.5

Figure 5-1. AN/UCC-1 Multichannel Broadcast

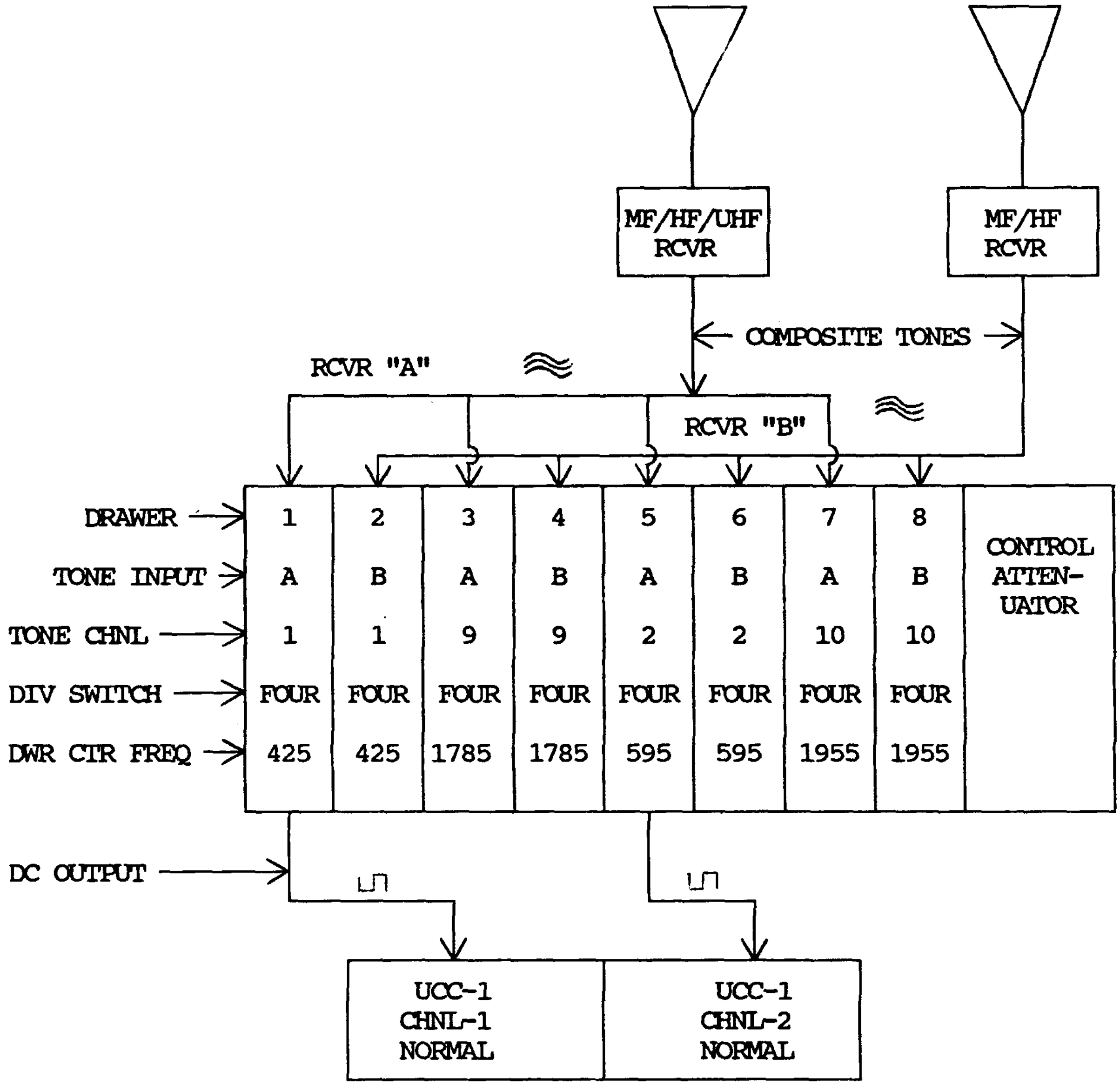


Figure 5-2. Equipment Configuration for Receive "P" System (Twinned Operation) Quad Diversity.

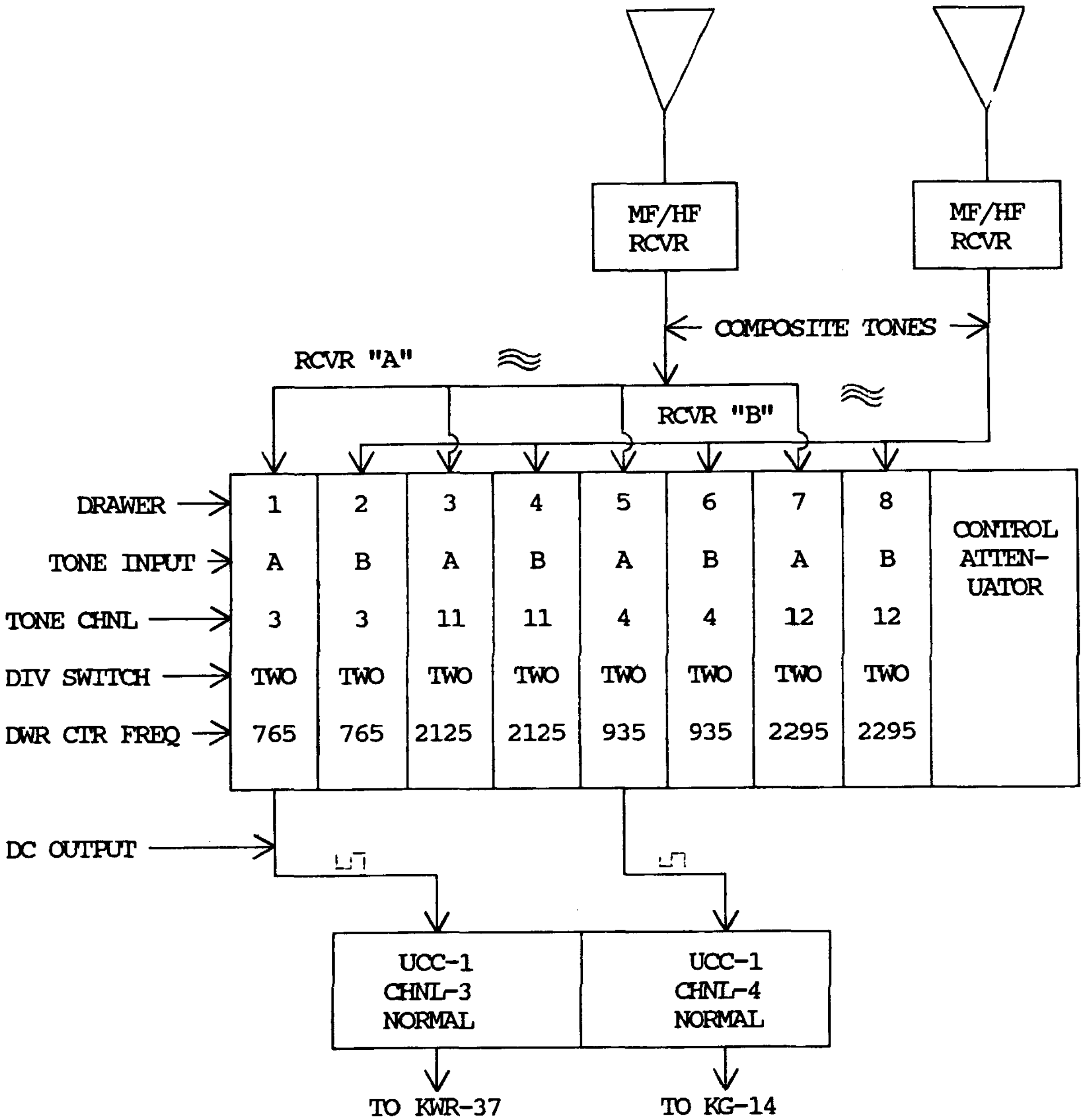


Figure 5-3. Equipment Configuration for MF/HF of "Two" OutBand Diversity Operation.

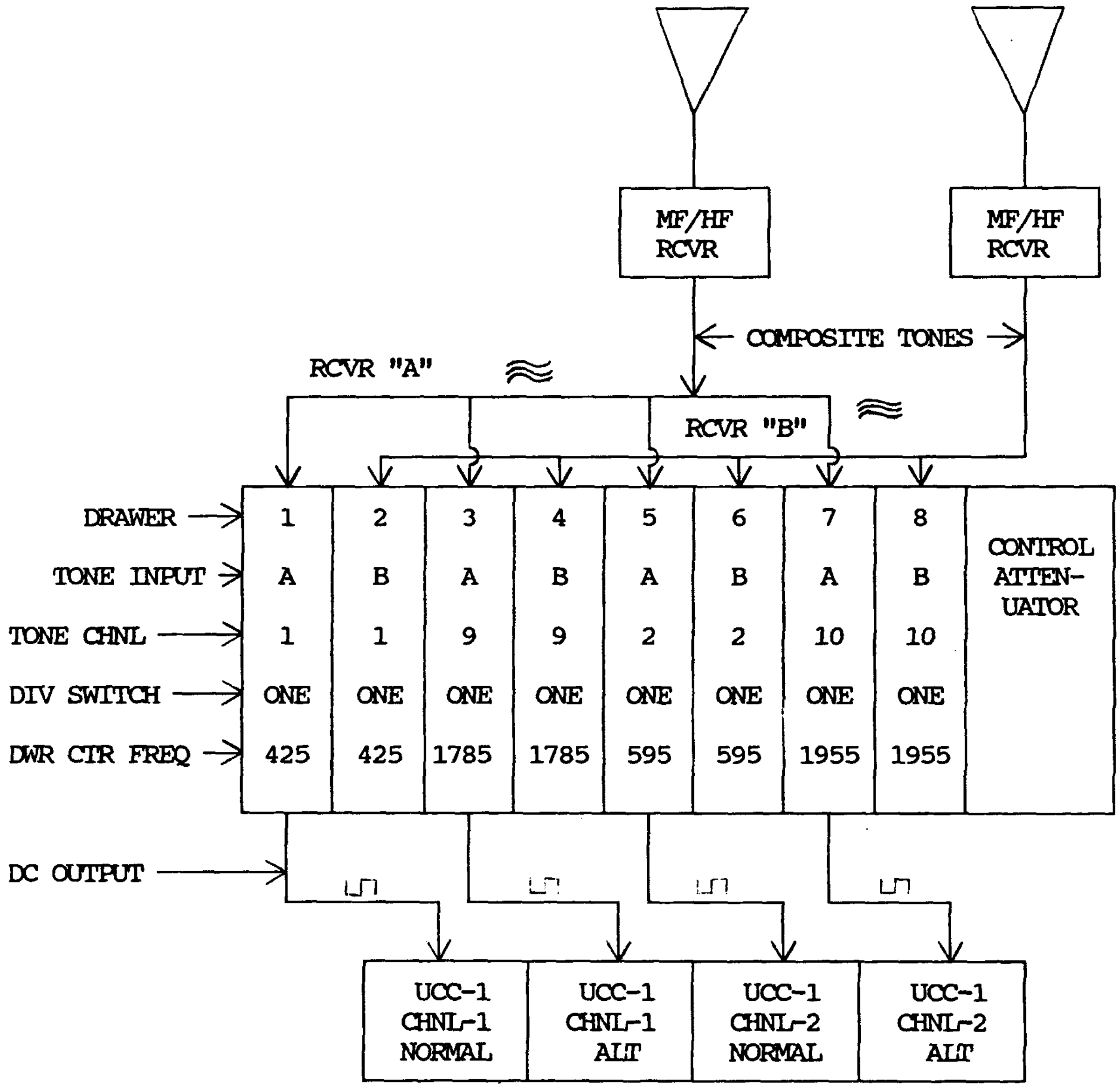


Figure 5-4. Equipment Configuration Receive "P" System (Untwinned Operation) One Diversity.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 5
DC PATCH PANELS

5-5.0 General. The DC inputs and outputs of converters, MODEMS, teletypewriters and crypto devices are wired to DC patch panels. These patch panels consist of a jack field divided into DC looping groups. Each group generally consists of looping jacks, set-jacks, miscellaneous jacks, and a rheostat for adjusting loop current. The loop jacks are connected in series with a source of DC loop current and each set-jack is connected in series with terminal equipment, FSK trunk lines, or crypto equipment. Within the patch panel, the looping jacks are connected in series with the set-jacks and rheostats for adjusting loop current. Equipment may be wired in series with looping jacks, or wired to miscellaneous jacks. The local arrangement must be determined by examination.

5-5.1 Patching.

5-5.1.1 DC Patch Panel Operation. The DC patch panel provides for "normal-through" operation or patching capability. "Normal-through" operation involves wiring certain equipment to one of the set-jacks of a looping group so that when the loop is keyed, the keying is applied directly to the ancillary equipment without the use of a patch cord. It is generally preferred to employ as much "normal-through" wiring as possible to alleviate the necessity of using physical patches. Equipment on any set-jack can be patched to any looping jack by use of a patch cord. Insertion of the patch cord removes the "normal-through" loop and substitutes a new loop.

5-5.1.2 Patching Methods. Patching is accomplished by inserting patch cords from one type of jack (looping, set or miscellaneous) to another. Looping jacks are never patched together, nor are set-jacks. When patching to looping jacks, the set or miscellaneous is patched first, then the other end of the patch cord is placed in the looping jack.

5-5.2 Loop Current.

5-5.2.1 High-Level. DC loop current is normally controlled at the patch panel. Loop current should be set for 60 ma (milliamperes) with all the equipment in the loop in a MARK condition. DC equipment is designed to operate at 60 ma MARK, and an increase or decrease in the loop current is generally indicative of system trouble. The DC milliammeter, permanently installed on all types of DC panels, is very helpful in system trouble-shooting.

5-5.2.2 Low-Level. Crypto and teletypewriter terminal equipment must be modified to employ low-level keying. Low-level keying reduces radiation inherent to 60 ma high-level keying. Polar type voltage keying is employed in which a zero reference voltage is used. A MARK keys a plus-6 volt signal while a SPACE keys a minus-6 volt signal. Current is approximately 70 to 100 microamperes. The signal pulses are shaped to prevent the steep or rapid rise and fall of the signal. This shaping, combined with reduced signal amplitude, reduces radiation. Significant differences between low and high-level systems are:

a. Patch panel jacks are wired in parallel instead of series.

b. Keying voltages are provided by signal sources. That is, on the send side voltages are provided by the teletypewriter equipment while, on the receive side, voltages are provided by the crypto equipment.

c. The keying voltage to teletypewriter equipment is applied to a selector magnet driver (amplifier) which converts the low-level, polar, voltage keying to the high-level, neutral, current required to drive the selector magnet.

5-5.2.3 Signal Distortion. Reduction in radiation through low-level systems is not achieved without penalty. Mutual interference, dirty or high impedance connections, readily distort the signal.

5-5.3 Types.

5-5.3.1 High Level Black. Black DC patching panels commonly used are the SB-1203A/UG and SB-4034/UG. On both panels, signal battery is provided by a common power supply. The primary difference between the SB-4034/UG and the SB-1203A/UG is the number of looping/set-jacks and the total number of loops (circuits) on the board. The meter circuits also differ. The meter circuit on the SB-1203A/UG is controlled by a switch which is used to select the loop to be read; however, on the SB-4034/UG, a patch must be made from the METER jack to each individual looping jack.

5-5.3.2 High Level Red. The standard high-level RED patch panel is the SB-1210A/UGQ. This unit is used to provide the inter-connection between cryptographic devices and teletypewriter equipment. Each field consists of looping jacks, set-jacks, miscellaneous jacks and a rheostat for adjusting loop current. Each panel includes a meter and rotary selector switch for measuring line current in any loop. Each loop is normally operated at 60 ma. Electrical operation and patching is the same as in the SB-1203A/UG Black patch panel previously described.

5-5.3.3 Low-Level Red. The SB-4035/UG is the standard low level (RED) patch panel. This unit is designed to facilitate interconnecting and transfer of crypto equipment outputs to teletypewriters. It is comprised of 24 loop circuits, each consists of 2 looping jacks, 2 set jacks and 1 miscellaneous jack, and 1 loop current rheostat.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 6
TELETYPEWRITER EQUIPMENT

5-6.0 General. Because of the increasing variety of teletypewriter equipment installed aboard ship, it is impractical to describe every piece of equipment likely to be encountered. The equipment listed in Tables 5-1 through 5-7 is representative of the types commonly employed in shipboard installations. In some instances installed equipment may be designated by nomenclature different from that shown in the tables; in most of these instances, this variance in nomenclature merely indicates a modification to the basic equipment described herein.

5-6.1 Teletypewriter Equipment. The function of the teletypewriter is to provide a record copy of message traffic (Page Printers), tape for transmission purposes (perforators and reperforators), and message transmission equipment (Transmitter Distributors, Keyboards).

TABLE 5-1

AUTOMATIC SEND-RECEIVE PAGE PRINTER SETS

Nomenclature	Description
AN/UGC-5()	Console type (high-level) keyboard, page printer, typing reperforator, transmitter distributor. 7.42 unit code.
AN/UGC-6()	Console type (high-level) keyboard, page printer, typing reperforator, transmitter distributor. 7.42 unit code.
AN/UGC-13()	Console type (high-level) keyboard, printer, typing reperforator, transmitter distributor, NTDS use with special computer interface electronics. 7.00 unit code.
AN/UGC-48()	Console type (low-level version of AN/UGC-6). 7.42 unit code.
AN/UGC-49()	Console type (low-level version of AN/UGC-13). 7.00 unit code.
AN/UGC-59()	Console type (high-level) keyboard, page printer, keyboard non-typing reperforator, type reader. 11.0 unit 8 level code.

TABLE 5-2

KEYBOARD SEND-RECEIVE PAGE PRINTER SETS

Nomenclature	Description
AN/UGC-20()	Compact cabinet (high-level) keyboard, page printer. 7.42 unit code.
AN/UGC-47()	Floor console type (low-level version of TT-47) keyboard, page printer. 7.00 unit code.
AN/UGC-60()	Floor console (low-level) keyboard, page printer, similar to TT-47/UG. 7.42 unit code.
AN/UGC-77()	Compact cabinet type (low-level version of AN/UGC-20) keyboard, page printer. 7.42 unit code.
AN/UGC-79()	Floor console type (high-level) keyboard, page printer. 11.0 unit 8-level code. Model 35 modified for computer interface with missile and weapons control systems consoles.
TT-47()/UG	Floor console type (high-level) keyboard, page printer. 7.42 unit code.
TT-69()/UG	Cabinet type (high-level) keyboard, page printer. 7.42 unit code.
TT-70()/UG	Cabinet type (high-level) keyboard, page printer, series governed motor. 7.42 unit code.
TT-176()/UG	Rack mount type (high-level) keyboard, page printer.

TABLE 5-3

RECEIVE ONLY PAGE PRINTER SETS

Nomenclature	Description
AN/UGC-25()	Compact cabinet type (high-level) page printer. 7.42 unit code.
AN/UGR-9()	Compact cabinet type (low-level version of AN/UGC-25) page printer. 7.00 unit code.
TT-624(V)/UG	Teleprinter. Eight-bit ASCII (bit parallel, character serial). 3600WPM.

TABLE 5-4

MULTIPLE PAGE PRINTER CONSOLE SETS

Nomenclature	Description
AN/FGC-79()	Floor console type (high-level) 3-page printers, Keyboard. 7.42 unit code.
AN/FGC-100()	Floor console type (high-level) 4-page printers, no keyboard. 7.00 unit code.
AN/UGC-61	Floor console type (low-level version of AN/FGC-79()) 3-page printers, keyboard. 7.42 unit code.
AN/UGC-61(A)	Same as AN/UGC-61 with structurally reinforced cabinet for shipboard use.
AN/UGR-10()	Floor console type (low-level version of AN/FGC-100) 4-page printers, no keyboard. 7.00 unit code.
AN/UGR-10(A)	Same as AN/UGR-10 with structurally reinforced cabinet for shipboard use.

TABLE 5-5

SEND-RECEIVE TYPING REPERFORATOR

Nomenclature	Description
TT-253()/UG	Cabinet type (high-level) keyboard, typing reperforator. 7.42 unit code.
AN/UGC-78()	Cabinet type (low-level version of TT-253()/UG) keyboard, typing reperforator. 7.42 unit code.

TABLE 5-6

RECEIVE ONLY TYPING REPERFORATORS

Nomenclature	Description
TT-192()/UG	Compact cabinet type (high-level) no keyboard, typing reperforator. 7.00 unit code.
TT-571()/UG	Cabinet type (low-level version of TT-192()/UG) no keyboard, typing reperforator. 7.00 unit code.
TT-605()/UG	Compact cabinet type (low-level version of TT-192/UG) no keyboard, typing reperforator. 7.00 unit code.

TABLE 5-7

TAPE TRANSMITTER DISTRIBUTOR SETS

Nomenclature	Description
TT-187()/UG	Standard cabinet (high-level) 7.42 unit code.
TT-570()/UG	Compact cabinet (low-level version of TT-187()/UG). 7.00 unit code.
TT-603()/UG	Miniaturized cabinet (low-level) 7.42 unit code.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 7
REMOTE UNITS

5-7.0 General. Voice communication normally requires both transmit and receive capabilities. Radio signals, received and converted by the ship's radio receivers to audio frequencies, are passed through the audio transfer switchboards to various remote stations in the ship. Speaker amplifiers are normally provided at the remote locations for reproduction of received audio at the proper level. Transmit voice signals are converted by a handset at a remote position to audio signals to either be encrypted and/or transmitted.

5-7.1 Control Indicator. C-10276 is located near its associated telephone set TA-970A/U and provides remote channel request capability for the telephone set.

5-7.2 Loudspeakers.

a. LS-474/U is a permanent magnet loudspeaker, containing matching transformers to match the input impedance of the loudspeaker to the 600-ohm impedance of the audio line. It is designed primarily for interior use.

b. NT-49546 is the same as the LS-474 except it is designed for exterior use.

5-7.3 Audio Frequency Amplifier. AM-3729/SR is a transistorized three-stage audio frequency amplifier capable of accepting one of two operator-selectable 600-ohm balanced audio inputs.

5-7.4 Telephone Set.

a. TA-970/U is a PTT device that permits two-way radio telephone voice communications via the SA-2112 and connected crypto/radio equipment. It has front panel controls for user selection of transmitting mode (CIPHER/PLAIN) and for associated loudspeaker muting (OFF, HOOKSWITCH, PTT).

b. TA-840A/U consists of a handset, associated circuits, and controls mounted on a single ferrous metal case.

5-7.5 Radio Control Set. The C-1138B/UR provides the capability to remotely control radio-phone transmitter functions and the output of a radio receiver. Incorporated into the circuitry is the means to voice modulate a shipboard transmitter, to key a URT-23 in the CW mode, and to monitor and control the output from any shipboard radio receiver.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 8
KEYERS

5-8.0 General.

5-8.0.1 Outgoing DC Signals. For radio teletypewriter operation, the outgoing digital DC signals, whether encrypted or non-encrypted, will appear on the non-secure (BLACK) DC Patch Panel. In the case of applying this intelligence to a transmitter operated in the AM, SSB or ISB modes, this DC signal must be patched from the BLACK DC Patch Panel to an adapter or keyer which converts the DC signal to audio signals in order to modulate a transmitter.

5-8.0.2 FSK Keyer. In the case of FSK, the transmitter normally has a self-contained FSK generator (keyer) that requires DC signals to shift the output of the generator between its two discrete frequencies. The DC signal input to the transmitter's internal FSK generator normally appears at the BLACK DC Patch Panel or at an FSK switchboard.

5-8.1 Multichannel Radio Teletypewriter Transmissions.

5-8.1.1 "P" System Terminations. For Multichannel Radio Teletypewriter transmission, certain ships of larger classes have equipment installations that give them the capabilities for multiplexing their various teletypewriter circuits into one composite audio signal for transmission via an RF path ("P" System terminations). For this type of transmission, the keyer drawers of the AN/UCC-1() are utilized. The DC signal for each of the individual outgoing teletypewriter channels appears at the BLACK DC Patch Panel which is either passed through or patched to a particular keyer drawer of the AN/UCC-1. Each keyer converts the incoming DC signal into an audio signal centered about a particular center frequency (refer to Figure 5-1). The audio output of each keyer utilized is normally applied to a common line within the AN/UCC-1 cabinet which applies all the different audio frequencies (composite tone signal) to a constant level amplifier within the Control Attenuator drawer of the AN/UCC-1. The Control Attenuator drawer primarily functions to hold the composite tone output of the AN/UCC-1 at a nominal constant level. This output appears at the transmitter transfer switchboard.

5-8.1.2 Diversity Options. The diversity options that maybe employed with the keyers depends on several circumstances, such as whether terminating the circuit over an RF path or into a landline at the pier, the demands of the distant end of the termination, the reliability of the circuit, etc.

a. One type of keyer diversity that may be used is the "one diversity" (non-diversity) mode. In this mode of operation up to sixteen (16) different channels of intelligence can be multiplexed into a composite tone package. Each individual outgoing teletypewriter channel is converted to a particular tone frequency by the keyer. This diversity mode may be used in certain circumstances on RF circuits or primarily when terminating into a landline at the pier.

b. The other type of keyer diversity that may be used is the "two diversity" mode (also called "twinned" or "in-band diversity"). In this mode of operation, up to eight (8) different channels of intelligence can be transmitted, with each teletypewriter channel keying two different drawers, utilizing up to sixteen tone frequencies. For each intelligence channel, the two different drawer frequencies are separated by 1360 Hz, such as drawer frequencies 425 Hz and 1785 Hz for information channel one, 595 Hz and 1955 Hz for information channel two, etc. (Refer to Figure 5-5.) This mode of operation is generally used or desired when transmitting over long haul RF paths in the HF range.

5-8.1.3 Number of Keyers. The number of keyers required will be determined by the diversity mode utilized and the circuit requirements. Any time keyer drawers are not actually being used for passing traffic, they should be turned off (also termed as "blocking" or "idling out") so that more of the transmitter power will be distributed among the channels in use, and not wasted in the unused channels. Any time the number of keyer channels are changed, it is extremely important that the composite audio level is checked to ensure proper level is maintained to the transmitter(s) input. These composite tone levels must be set with the AN/UCC-1's output terminated into the transmitter(s) for a load. Ensure the transmitter is in remote prior to making the composite tone level adjustment. Generally all common shipboard transmitters require a composite tone input level of -10 dBm. Refer to Table 5-8 for the correct composite tone levels for each type of transmitter used. It is also just as important that the individual keyer tone levels are correctly adjusted to their proper levels and that each tone channel should be within 1-1/2 dB of each other. Refer to Table 5-9 for keyer tone levels for the number of keyers installed in the system. Once the keyer tone levels are adjusted for their proper values as indicated in Table 5-9, only the control attenuator's output level must be adjusted to ensure the correct level to the transmitter whenever the number of channels or tones are changed. All AN/UCC-1 tone level measurements should be done with a HP400() since the Test Set to the AN/UCC-1 does not have the required dB range on its front panel meter. The related AN/UCC-1 maintenance manuals should not be referred to for making the individual keyer and composite tone level adjustments since this information is incorrect for proper modulation of shipboard transmitters. For more specific details and information on tone multiplexing of shipboard transmitters, refer to EIB 822.

5-8.2 Tone Modulated Radio Teletypewriter Transmissions.

5-8.2.1 CV-2460/SGC Usage. For tone modulated radio teletypewriter operation, the CV-2460/SGC tone shift keyer/converter is used. The CV-2460/SGC (when operated in the Low Band frequency shift) is commonly used for "Line of Sight" VHF/UHF communications.

5-8.2.2 CV-2460/SGC Functional Operation. The CV-2460/SGC equipment, when functioning as a keyer, converts the incoming DC signal from the BLACK DC Patch Panel into audio tones of 700 Hz for a MARK and 500 Hz for a SPACE (600 Hz center frequency). These audio frequencies are used to modulate the transmitter. It has mode capabilities of operating HALF-DUPLEX (Send or Receive only), SIMPLEX (Send and Receive, but not simultaneously) and FULL-DUPLEX (Send and Receive simultaneously), depending on the selection by the operator. This equipment also has two frequency shift band options (FREQUENCY OPTION switch). One of the selections is Low Band frequency shift, allowing the converter/keyer to operate at a 600 Hz center frequency with shifts of 100 Hz either side of the center frequency for 700 Hz and 500 Hz tones. The other selection is a High Band frequency shift, allowing the converter/keyer to operate at a 2000 Hz center frequency with shifts of 425 Hz either side of this center frequency for 2425 Hz and 1575 Hz tones. The CV-2460/SGC also features a signal sense switch (KEYING switch) which allows operation with normal and/or reverse signal sense for both the send and receive sections of the equipment. The output level of this equipment must be adjusted for 0 dBm with the output terminated into a transmitter and the transmitter in remote.

5-8.3 Facsimile (FAX). Refer to Chapter 4, Section 14 for discussion of the Facsimile keyers and transmission methods.

Table 5-8. AN/UCC-1 Composite Tone Setting for Shipboard Transmitters.

AN/URT-23(V)

TONES	AN/UCC-1() INPUT LEVEL	POWER METER LEVEL (PEP)	POWER/TONES
2	-10dBm	1000 W	= 250 W
4	-10dBm	1000 W	= 75 W
6	-10dBm	1000 W	= 60 W
8 (TR1)	-10dBm	1000 W	= 36 W
10 (TR4)	-10dBm	1000 W	= 36 W
10 (TR6)	-10dBm	1000 W	= 36 W
12 (TR8)	-10dBm	1000 W	= 32 W
16 (TR14)	-10dBm	1000 W	= 19 W

AN/URT-24

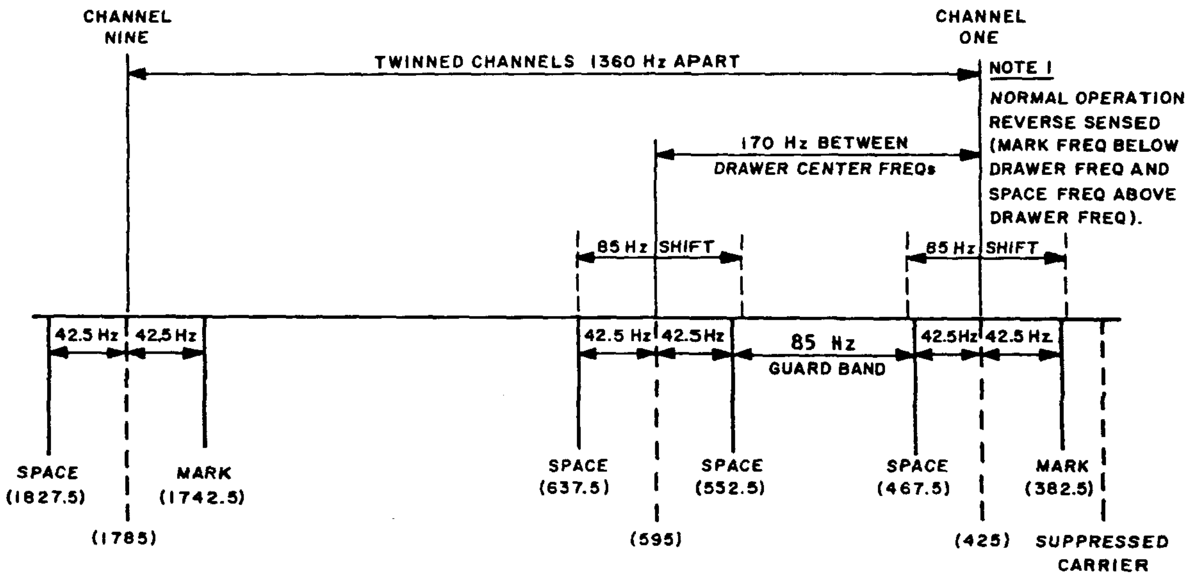
TONES	AN/UCC-1() INPUT LEVEL	POWER METER LEVEL (AP)	POWER/TONES
2	-10dBm	40 to 60 W	= 25 W
4	-10dBm	25 to 40 W	= 10 W
6	-10dBm	25 to 40 W	= 8 W
8 (TR1)	-10dBm	25 to 40 W	= 4 W
10 (TR4)	-10dBm	15 to 40 W	= 4 W
10 (TR6)	-10dBm	15 to 40 W	= 4 W
12 (TR8)	-10dBm	10 to 40 W	= 3 W
16 (TR14)	-10dBm	10 to 40 W	= 1 W

Table 5-9. AN/UCC-1 Keyer Tone Level Adjustment.

SYSTEM	NO. OF CHANNELS	MAX NO. OF TONES IN SYSTEM (NOTE 1)	LEVEL PER TONE (NOTE 2)
AN/UCC-1() - TR1	4	8	- 9 dBm
AN/UCC-1() - TR4	5	10	- 10 dBm
AN/UCC-1() - TR6	5	10	- 10 dBm
AN/UCC-1() - TR8	6	12	- 11 dBm
AN/UCC-1() - TR14	8	16	- 12 dBm

NOTE: 1. The individual keyer tone levels must be equal and adjusted to the value in column 4 as determined by the maximum number of tones to be transmitted.

2. All keyer level adjustments must be made with the loops in a MARK condition.



The UCC-1 operates under the frequency division multiplex technique, and the channels share space in a 3 kHz slot. Figure 5-1 shows that we actually key audio frequencies from 382.5 Hz to 3017.5 Hz. Drawers one (drawer center freq of 425 Hz, never radiated) utilizing reverse sensing keys a MARK freq at 382.5 Hz and a SPACE freq at 467.5 Hz for a total 85 Hz shift. Drawer two has a center freq of 595 Hz (not required and is 170 Hz above drawer one (center freq)). Drawer two keys a MARK freq at 552.5 Hz and a SPACE freq at 637.5 Hz. Note that there is an 85 Hz guard band between channel one SPACE freq and channel two MARK freq. Channel one when operated in a "twinned" mode uses drawer one and drawer nine, channel two uses drawer two and drawer ten. These twinned drawer center freqs are 1360 Hz apart as illustrated above.

Figure 5-5. Mark and Space Frequencies and Twinning in the AN/UCC-1.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 9
TRANSMITTERS

5-9.0 General. Several types of transmitters are in widespread use aboard ships. In the following paragraphs the most common types are discussed briefly. It is recommended that radio supervisors and quality control operators refer to the instruction manuals for transmitters on their ship in order to gain more detailed knowledge.

5-9.1 HF Transmitters.

5-9.1.1 AN/URT-23(). The AN/URT-23() is a one-KW single sideband radio transmitting set. The equipment operates in the 2 to 30 MHz frequency range, tuning in 100 Hz increments. Modes of operation are USB, LSB, ISB, CW, FSK and compatible AM. The radio transmitting set is essentially automatic tuning with frequency selection by digital controls. Stability of the internal frequency standard is 1 part in 10^8 per day. Operation with an external standard is required when possible.

5-9.1.2 AN/URT-24(). The AN/URT-24() is a 100-watt single sideband radio transmitting set. The equipment has a frequency range of 2 to 30 MHz tunable in 100 Hz increments with emissions of USB, LSB, ISB, CW, FSK and compatible AM. The set is automatic with frequency selection by digital controls. Stability of the internal frequency standard is 1 part in 10^8 per day. Operation with an external standard is required when possible.

5-9.1.3 T-1322/SRC. The T-1322/SRC is an independent sideband exciter which operates on one of 280,000 channels in the HF frequency range of 2 to 29.999 MHz with a maximum power output of 250 MW. The exciter drives a 1-KW Linear Power Amplifier in one of nine modes of operation.

5-9.2 VHF Transmitters.

AN/GRT-21. The GRT-21, operating between 116.00 and 149.95 MHz in the VHF frequency band, is capable of both AM and modulated CW modes of operation. The GRT-21 is used for non-secure LOS, ship-to-ship, and ship-to-aircraft voice transmissions. A primary function of the GRT-21/GRR-23 combination is to guard the aircraft emergency distress frequency (121.5 MHz). To accomplish this function, the VHF GRR-23 is used in conjunction with the GRT-21 to provide the receiver subsystem. The GRT-21 utilitizes the same antenna as the GRR-23.

CHAPTER 5
TYPICAL SHIPBOARD COMMUNICATION EQUIPMENT

SECTION 10
SHIPBOARD TRANSCEIVERS

5-10.0 General. In this section general capabilities for common shipboard transceivers are covered.

5-10.1 MF/HF Transceivers. AN/SRC-16 is a shipboard, single-sideband communications system with a frequency range of 2-30 MHz. In addition to the normal voice, CW, and FSK communications, the system provides high-frequency reception and transmission for terminal equipment such as the NTDS (Navy Tactical Data System). The system uses dual single-sideband equipment and both sidebands are available for use independently for either voice or multitone signals. The system operates on four independent channels, each channel consisting of a single-side-band receiver, a single-sideband transmitter (exciter) and a 500-watt PEP linear power amplifier. Two 5-kilowatt PEP linear power amplifiers, which can be substituted for the 500 watt PEP linear power amplifiers, provide for high-power operation on two channels. The receiver and transmitter frequency of each channel can be independently set in 1-kHz increments. The frequency of each receiver and transmitter is phase-locked to a system primary frequency standard.

5-10.2 VHF/UHF Transceivers.

5-10.2.1 AN/VRC-46. AN/VRC-46 is an FM transceiver operating from 30 to 75.9 MHz in two bands, with a 920 channel capability. It has a nominal power output of 35 watts. The AN/VRC-46 is used primarily by ground elements and supporting amphibious units.

5-10.2.2 AN/URC-9. AN/URC-9 is composed of Receiver-Transmitter RT-581/URC-9, power supply PP-2702/URC-9 and Receiver-Transmitter case CY-2959/URC-9. The unit functions as a triple conversion receiver during non-transmitting conditions. When the microphone push-to-talk switch is actuated, a series of T/R (Transmit-Receive) relays convert the unit to a transmitter. The AN/URC-9 operates either AM or MCW mode with approximately 16-30 watts output power. The frequency range is 225 to 400 MHz, which is covered in 0.1-Hz steps by 1750 crystal-controlled channels. Frequency selection is determined by the position of the Chan Sel switch, which has 19 preset channel frequencies that can be preset to any one of the 1750 available channels on a memory drum, accessible through a door in the front panel. When the Chan-Sel switch is in the Manual position any one of 1750 channels can be selected using the Manual Frequency Tens, Units and Tenths controls on the front panel of the AN/URC-9.

5-10.2.3 AN/SRC-21. AN/SRC-21 is composed of the AN/URC-9 and Radio Set Control C-3866/SRC. Complete control including the selection of any one of the 19 preset channels of the AN/URC-9 can be exercised from up to a maximum of 4 remote-control points. To provide this control and selection of preset channels from the remote control points, the system requires remote control units Radio Set Control C-1138/UR or C-1207/UR and indicator Control C-3868/SRC.

5-10.2.4 AN/SRC-20. AN/SRC-20 is composed of the AN/URC-9, Radio Set Control C-3866/SRC and Radio Frequency Amplifier AM-1565/URC (which is a 100-watt UHF linear power amplifier). The AN/SRC-20 has all the capabilities of the AN/SRC-21 plus an increase of 100 watts output power. For remote control and selection at remote points the system requires all components listed for the AN/SRC-21.

5-10.2.5 AN/WSC-3. AN/WSC-3 is a Line of Sight (LOS) or Satellite Communication (SATCOM) simplex set consisting of radio transmitter R/T 1107/WSC-3 and control indicator C-9351/WSC-3 (remote control unit). It operates in narrowband AM/FM, wideband AM, 75 BPS FSK, 75, 300, 1200, 2400, 4800 and 9600 BPS PSK. It also has a 70 MHz external MODEM provision. Power output in FM is adjustable from 1 to 100 watts across the band, in AM it is fixed 30 watts across the band. The frequency range is 225 to 399.975 MHz, the equipment can be preset for 20 separate channels. The SATCOM mode requires the use of a special Satellite antenna and antenna pre-amplifier. The transmit (Uplink) and the receive (Downlink) frequencies are different. The radio set incorporates circuitry to automatically eliminate the physical operation of changing frequencies during SATCOM operation.

CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATIONS

INTRODUCTION

6.0 Factors. This chapter contains information on different factors affecting the quality of communications. Each section is devoted to describing particular factors and their effect/s and sources as applicable.

Frequency Selection - Section 1

Frequency Accuracy - Section 2

Electromagnetic Interference - Section 3

Diversity Reception - Section 4

Modulation Techniques - Section 5

D.C. Distortion - Section 6

Landline Communications - Section 7

CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATIONS

SECTION 1
FREQUENCY SELECTION

6-1.0 General. In all RF communication systems proper frequency selection is an important key to successful communications. Knowing what frequency band to employ for a particular time of day and for particular locations is essential to maintenance of circuit continuity. Non-systematic frequency selection is not sufficient to maintain effective communication. AN/TRQ-35 (Ionospheric sounder) data, NTP-6 SUPP-1 predictions, special computer-generated frequency predictions from area NAVCAMS FTOC, WWV alphanumeric transmissions, careful monitoring of broadcast frequencies and use of common sense are principal tools for intelligent frequency selection.

6-1.1 USE OF NTP-6 SUPP-1.

6-1.1.1 Frequency Selection Graphs. One of the best guides for optimum frequency selection is a graph prepared from NPT-6 SUPP-1. Such graphs have been used successfully by Fleet units. These graphs are relatively simple to prepare and, when used in conjunction with "usable broadcast frequency bands", will greatly enhance selection of proper frequency.

6-1.1.2 Frequency Forecasts. NTP-6 SUPP-1 is a forecast of frequency trends. The predictions are available on a quarterly basis in a yearly format. To eliminate the "look-up" process, NTP-6 SUPP-1 information should be extracted ahead of time and made into graphic form. The graphs present a picture which clearly shows the upper and lower limits within which to work, how the boundaries behave, and when to expect trouble. Preparing the graph requires only a few minutes time.

6-1.1.3 Frequency Graph Examples. Simple illustrations of NTP-6 SUPP-1 prediction graphs are contained in Figures 6-1 and 6-2. The graph is laid out with frequency plotted vertically and time plotted horizontally. Two curves are drawn: one for MUF (Maximum Usable Frequency) and one for FOT (Frequency of Optimum Traffic). The resulting graph presents a predicted operating frequency envelope. Frequencies selected should be within plus or minus 10% of the FOT.

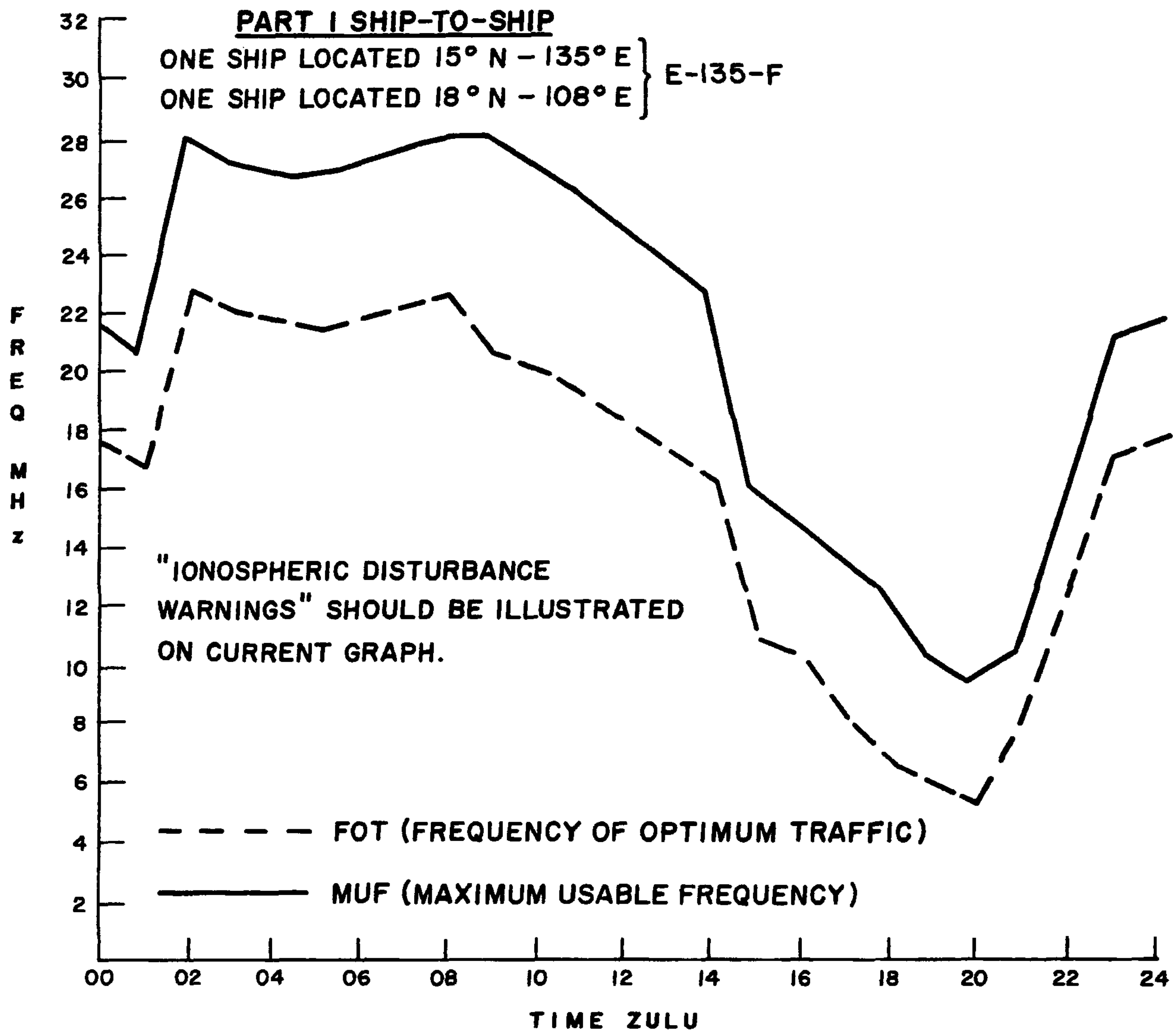


Figure 6-1. Ship to Ship Forecast of Frequency Trends.

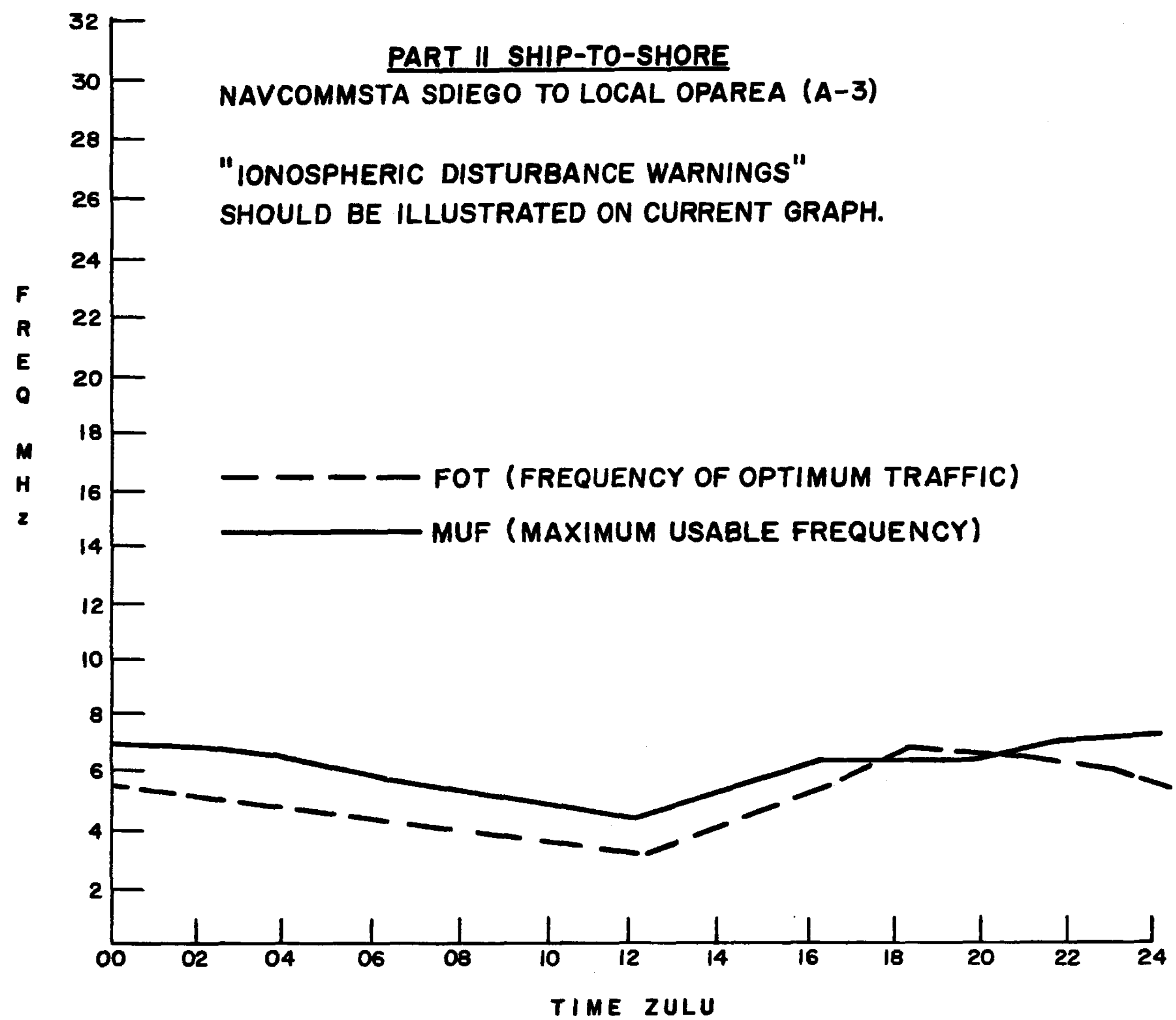


Figure 6-2. Ship to Shore Forecast of Frequency Trends.

a. To utilize Section 1 of NTP-6 SUPP-1 (Ship-to- Ship), select the correct table by plotting each ship's position on a graph provided in the front section of NTP-6 SUPP-1. Detailed directions and examples are provided for table selection.

b. Once the correct table has been selected, plot the points of MUF for each hour of the day at the point where frequency and time intersect. Connect the points with a continuous line. Repeat for the FOT. Figure 6-1 is an example of the finished graph for Section 1.

c. To utilize Section II (Ship-to-Shore), area maps are provided for each communication station in the world. Obtain your own ship's position and apply to the appropriate map for the NAVCOMMSTA with whom you are terminated or whose broadcast is desired. This application of ship's position will determine the correct table for the desired NAVCOMMSTA. After selection of the correct table, repeat the plotting procedures described in paragraph 6-1.1.3. Figure 6-2 is an example of a finished chart for Section II.

6-1.2 <u>AN/TRQ-35 (Ionospheric Sounder).</u> Some NAVCOMMSTA's and some larger ships are equipped with the AN/TRQ-35 (Ionospheric Sounder). The AN/TRQ-35 provides current direct read-out, audio and CRT presentation of the ionosphere, indicating multi-path interference and frequency change and/or fading. Ships so equipped should utilize the AN/TRQ-35 information to provide frequency predictions to ships in company.

6-1.3 <u>Broadcast Frequency Selection.</u>

6-1.3.1 <u>Broadcast Reception.</u> For broadcast reception, primary consideration should be to the LF component because of its advantages over HF. Within the area of LF ground wave coverage, the signal is usually more reliable than HF. In many areas the LF spectrum is not heavily used, thus adjacent channel interference is negligible. Except in occasional instances, shipboard transmitters do not operate in the LF band; accordingly, the LF spectrum is relatively free of intermodulation and harmonic distortion which plague reception of HF aboard ship.

6-1.3.2 <u>LF Range Limitation.</u> The LF broadcast is, however, limited in range. The reliable range of the LF broadcast depends on atmospheric noise levels which vary with geographical location, time of year and time of day. The LF broadcast will often prove reliable to a range of 1,000 miles and usually provides solid copy out to 500 miles from the transmitter.

6-1.3.3 HF Limitations. The HF component of the broadcast is capable of being transmitted over long distances with considerably less power than used with LF broadcast. However, this ability to cover great distances also subjects the broadcast to severe interference problems from distant stations and ships transmitting on the same or on nearby frequencies.

6-1.3.4 Summary. In summary, when selecting a frequency:

a. Use the LF component of the broadcast if feasible.

b. Use NTP-6 SUPP-1 as a guide in selecting high frequencies.

c. If available, utilize an Ionospheric Sounder for frequency selection.

d. When NTP-6 SUPP-1 or an Ionospheric sounder indicates use of a frequency range covered by interference, select a slightly higher frequency. Lower frequencies will in general be subject to higher noise levels.

CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATIONS

SECTION 2
FREQUENCY ACCURACY

6-2.0 General. The requirement for frequency accuracy has become critical since the advent of SSB Multichannel Broadcast and Ship/Shore communications. Frequency accuracy of receivers and multichannel radio teletypewriter equipment is particularly important for Multichannel Broadcast and Ship/Shore circuits. A normal radio path can usually be expected to introduce distortion to teletypewriter signals often on the order of 10 to 15%, Additional distortion is introduced by equipment operating at less than peak performance.

6-2.1 Distortion Effects.

6-2.1.1 Teletypewriter Distortion. Figure 6-3 illustrates an approximate relationship between teletypewriter distortion and frequency error for a typical channel of the multichannel broadcast. Note that each of the first five hertz of frequency error generates approximately one percent average bias distortion. Each of the next five hertz contributes approximately two percent. It has been found that when average bias distortion reaches a level of about twenty-five percent that the peaks of the distortion measure in excess of forty percent, causing printing errors on the circuit. On many occasions frequency availability and other factors prevent reducing bias distortion on radio teletypewriter circuits to below ten or fifteen percent, indicating that the margin for additional distortion is only about ten percent. Based on a ten-percent allowable margin of distortion it would appear that there is still a cushion of approximately plus or minus eight Hz of frequency error. This cushion, however must be shared among four pieces of equipment: the transmitter, the receiver, and the transmit and receive multiplex terminals. By the time the multiplex terminals take their allocated share of this tolerance, only four Hertz remain to be shared between the transmitter and receiver.

6-2.1.2 Other Circuits. The frequency tolerance of some other types of communications are not as critical as the systems mentioned above. On Amplitude Modulated (AM) circuits, errors of khz have been noted and stations far off were still able to communicate. However, frequency errors contribute greatly to quality degradation and do not permit optimum circuit efficiency; e.g., if a ship tries to communicate on a

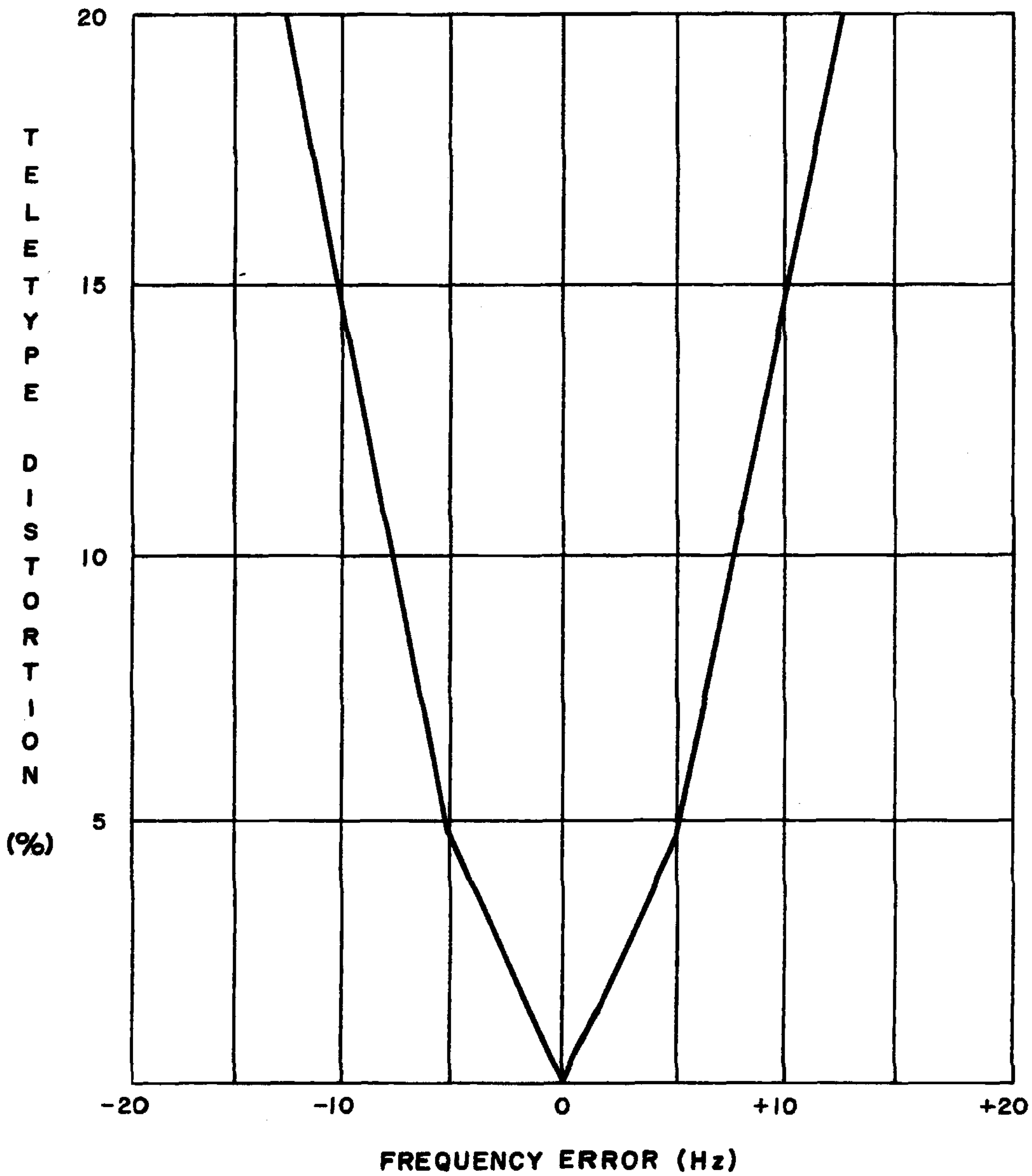


Figure 6-3. Distortion Versus Frequency Error.

voice net, any ship 2 kHz off would require operation of receivers in a broader bandwidth mode (16 vice 8 kHz in the R-390/URR) resulting in more noise or a lower signal/noise ratio. If nearby frequencies are in use by other stations, these signals could interfere greatly with more important voice circuits.

6-2.1.3 RATT Circuits. On single channel RATT circuits such as the Primary Fleet Ship/Shore, the effects are similar to those on AM circuits. Off-frequency operation on this type of circuit requires receiver re-tuning and more often than not, converter adjustments, all of which contribute to excessive delays in the transmission of messages.

6-2.1.4 UHF SATCOM. For UHF SATCOM receivers and transceivers, frequencies are electronically stabilized and frequency error should not be a problem.

6-2.2 Reference Standard and Internal Reference Oscillators.

6-2.2.1 Frequency Standards. Frequency error is one of the principal causes of communication circuit degradation. To ensure frequency accuracy, reference standards or oscillators have been distributed throughout the fleet. These reference oscillators (AN/URQ-10 or AN/URQ-23) must be corrected by Navy calibration laboratories on a periodic basis.

6-2.2.2 Internal Oscillators. There are few communications equipment aboard ships which do not depend upon an internal reference oscillator for their accuracy and, consequently, performance. The reference oscillator is the only method widely available at present to determine the correct alignment of these internal oscillators. Ships do not have the capability of determining the correct frequencies to the tolerance required by utilizing WWV.

6-2.2.3 External Standards. Use of the AN/URQ-10 or AN/URQ-23 as an external standard in lieu of the internal standard in synthesized equipment, such as the R-1051 and AN/URT-23, is required. (Refer to EIBs 712 and 721)

6-2.2.4 Frequency Counters. If the ship uses continuous tune transmitters, a calibrated frequency counter may be used to check transmitter accuracy. The preferred method of checking for frequency accuracy is described in detail in Chapter 3, Section 3.

6-2.2.5 Frequency Error Checks. Net control stations should check the transmitted frequencies of all ships on the net with quality monitoring procedures on a periodic basis. The exact amount of frequency error may be determined using the procedures outlined in Chapter 3, Section 3 of this manual.

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CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATIONS

SECTION 3
ELECTROMAGNETIC INTERFERENCE

6-3.0 General. Electromagnetic Interference (EMI) is an electromagnetic or electrostatic disturbance which degrades or causes a malfunction to electronic systems. EMI has grown from a comparatively small problem in the past to become a dangerous threat to present and future ability to communication efficiency.

6-3.1 Types of EMI. There are two types of EMI, narrowband interference and broadband interference. Narrowband interference consists of a single frequency or a narrow band of frequencies that occupies little space in the receiver bandpass. Broadband interference is not of a discrete frequency; i.e., it occupies a relatively large part of the radio frequency spectrum. This type of interference is usually caused by arching or corona and it is misleading in that it is sometimes misinterpreted by inexperienced operators as high background noise caused by atmospheric conditions.

6-3.2 Sources.

6-3.2.1 RF Interference. Sources of radio frequency interference can be broadly categorized as follows:

a. Natural Interference: Radio interference caused by natural phenomena, such as electrical storms, aurora borealis, aurora australis, sun spots, snowstorms, rain particles, and interstellar radiation, are commonly termed atmospheric noise or static. This interference is characterized by the following types of noises heard in the earphones:

(1) Impulses of high intensity, occurring intermittently, caused by local thunderstorms.

(2) A steady rattling or crackling produced by distant thunderstorms.

(3) A continuous noise caused by the impact of charged particles against the antenna, known as precipitation static.

(4) A steady hiss type of static observed at high frequencies, apparently having an interstellar origin.

b. Inherent Interference: Interference is inherent in the design of receiving equipments. Random motion of free electrons in a conductor causes small potential differences to be developed across the terminals of the conductor. This action, called thermal agitation, is a common source of receiver background noise.

c. Vacuum Tubes: Vacuum tubes are noise sources because of the variations in the movements of electrons to the anode. This causes a noise commonly called "shot" effect. Shot effect is created by electrons being emitted from the cathode in a random way so any current resulting from such emission has a random variation.

d. Modern Receiving Equipment: Modern receiving equipment is designed in such fashion as to minimize inherent receiver noise and permit usable signal-to-noise ratios at extremely small signal input levels. As an example the R-1051 receiver will produce a standard 0 dBm output with signal to noise ratio of 10 dB at an input signal level of 1 microvolt. As in the case of natural interference, the key to minimizing the effect of inherent receiver noise is proper frequency selection to ensure that the received signal is strong enough to overcome inherent noise.

6-3.3 <u>Other Electrical or Electronic Components and Equipment.</u> Other electrical or electronic components and equipments are the most troublesome sources of radio frequency interference. This type of interference may enter radio receivers in two ways:

a. RADIATED INTERFERENCE: Any undesirable Radio Frequency (RF) signal which reaches a receiver through direct radiation and degrades its performance. This may be caused by poorly shielded radar modulators, RF energy escaping from waveguide flange couplings, commutators, relays or co-channel or adjacent channel transmitter outputs.

b. CONDUCTED INTERFERENCE: Any undesired signal which reaches a receiver direct, inductive, or capacitive coupling through the antenna lead-in cable, power leads, signal leads or control circuits.

6-3.4 <u>Hull Generated Intermodulation.</u> The shipboard environment possesses all the necessary elements required to produce a harmonic generation and mixing system. The elements are present in the complex ship structures, appendages, and other objects that are found in the topside areas in which intense RF fields are present. The RF signal produces standing waves on portions of the structures, and, if a corroded joint or oxidized fastening exists, rectification occurs to some extent. Intermodulation products created by the non-linear junctions existing in the ship structures are commonly called the "rusty bolt" effect. Frequencies that can result from interaction of up to 10 transmitters are shown in Figure 6-4, a graph prepared by the Naval Electronics Laboratory Center San Diego. Frequencies generated from this interaction are radiated by the rusty bolt effect to receiving antennas. By examination of this graph, it should become clear that a major factor in generating interfering frequencies is the ship's own transmitters. The most effective way to reduce interference generated by shipboard transmitters is to reduce on-the-air transmitters to the absolute minimum consistent with valid communication requirements. The "rusty bolt" effect can be reduced considerably by a combination of good design and maintenance practices.

6-3.5 Spectrum Analysis of RF Spectrum. A TS-1379Z/U or equivalent Spectrum Analyzer can be a helpful tool in determining cause of EMI and localizing the source. If a transmitter is suspected of emitting unwanted radiations, its output can be checked utilizing a spectrum analyzer. If the transmitter is radiating other than the desired signal it will be observed on the scope. Operators should become familiar with the operation and capabilities of the spectrum analyzer. The TS-1379Z/U is covered in another section of this manual.

NO. OF TRANSMITTERS	3rd ORDER	5th ORDER	7th ORDER	9th ORDER	11th ORDER	13th ORDER
1	1	1	1	1	1	1
2	6	10	14	18	22	26
3	19	51	99	163	243	339
4	44	180	476	996	1804	2964
5	85	501	1765	4645	10165	19605
6	146	1182	5418	17718	46530	104910
7	231	2471	14407	57799	180775	474215
8	344	4712	34232	166344	614680	1866280
9	489	8361	74313	432073	1871145	6539625
10	670	14002	149830	1930490	5188590	20758530

Figure 6-4. Order of Harmonics.

CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATIONS

SECTION 4
DIVERSITY RECEPTION

6-4.0 General. Reception of RF signals can be improved by the use of "Diversity" techniques. Such techniques are used to improve communications quality and reliability and combat poor ionospheric conditions and frequency transition periods. Diversity operation implies a "difference of operations". There are several diversity techniques in common use.

6-4.1 Space Diversity. One of the first high frequency diversity techniques used was "Space Diversity". In this system two or more antennas are spaced some distance from one another and are each connected to a separate receiver. A signal fading badly at one antenna might not be fading at the same instant at another. This technique can be utilized effectively on ships with 50 feet or more of antenna spacing. The least gain in space diversity improvement is in the initial 300 feet of spacing, which accounts for approximately 25% of the attainable gain. Optimum spacing is 600 feet or greater.

6-4.2 Frequency Diversity. Frequency Diversity requires an information channel that is radiated by two or more transmitters at a particular station. The receiving station will select two of the radiated frequencies, ensuring a separation of no less than 2 MHz, and no more than 5 MHz. The two frequencies must be patched to a converter/comparator which will select and provide the strongest signal. In broadcast systems such as the Fleet Multichannel Broadcast network, several geographically separated transmitting stations retransmit information channels initiated by the broadcast keying station. These retransmitted signals will arrive at the ship's receivers at different times due to signal paths and regenerative equipment at the various transmitting stations. Due to this difference in arrival time at the ship's receivers, these signals are not compatible with one another and may not be employed using the frequency diversity technique. The LF portion of the fleet broadcast is not normally compatible with the HF portion and the two should not be utilized in frequency diversity.

6-4.3 Polarization Diversity. A third technique is known as "Polarization Diversity". Radio waves reflected off the Ionosphere come back to earth in both horizontally and vertically polarized state. If a single antenna either horizontally or vertically polarized is used at the receiving station, very deep fades can be experienced if the received signal is polarized differently from the antenna. When two antennas, one horizontally polarized and one vertically polarized, are used with two receivers, a considerable advantage can accrue.

6-4.4 Tone or In-Band Diversity. All of the above techniques are primarily concerned with antenna/frequency/receiver configurations. (Two receivers are used in each.) Another technique of equal importance for multichannel tone transmission is "Tone" or "In-Band" diversity. In-band diversity is a technique in which each information channel appears at two places in the transmission bandwidth. This method of diversity, also called "Twinning", is used exclusively with full period ship/shore/ship multichannel terminations. At the transmit station, the DC output from each cryptographic device is used to key two of the tone channels. Hence, four information channels would be transmitted as eight tone channels. In twinned operation, the information transmitted on tone channel 1 is also transmitted on tone channel 9. Channels 2 and 10, 3 and 11, etc., are similarly twinned. At the receive terminal the twinned channels are separated and compared, and the stronger signal of each pair is selected for further processing. Twinning or In-band diversity helps to reduce the effects of frequency selective fading by providing approximately 1300 Hz separation between twinned channels. Twinning is employed on MF, HF, and UHF.

6-4.5 Quad Diversity. When "Tone" or "In-band" diversity is combined with Frequency, Space or Polarization diversity, the result is commonly termed "Quad Diversity".

6-4.6 Order of Preference. Through extensive tests and evaluations documented by Naval Electronic Systems Engineering Center San Diego, the following order of preference for diversity reception has been established:

a. Multichannel:

(1) Polarization - Quad Diversity
(2) Space - Quad Diversity
(3) Frequency - Quad Diversity

b. Single Channel:

(1) Polarization
(2) Space
(3) Frequency

CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATION SYSTEMS

SECTION 5
MODULATION TECHNIQUES

6-5.0 General.

6-5.0.1 Modulation. Although the basic principles of modulation are widely known, a few facts are provided here for a short review. Modulation is the process by which some property of a radio frequency signal, called the carrier, is controlled by a message to be transmitted. Modulation is needed in radio telecommunications because the message to be transmitted is not generally in a form suitable for direct propagation. There are three chief methods of modulation:

a. Amplitude Modulation

b. Angle Modulation (Frequency and Phase)

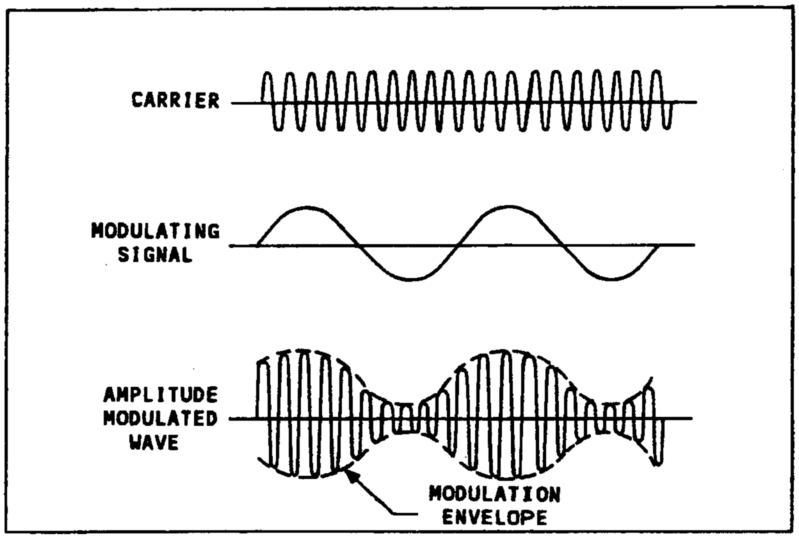
c. Pulse Modulation

6-5.0.2 Applied Variations. Variations and combinations of these basic methods are applied in different ways in afloat communications. Amplitude Modulation (AM) includes conventional AM and Single-Sideband (SSB) techniques. Angle modulation includes frequency modulation and phase modulation techniques. An example of pulse modulation is radar.

6-5.1 Amplitude Modulation. In amplitude modulation, as the name suggests, the amplitude of a Radio Frequency (RF) signal is controlled by the message to be sent. The waveform of the RF signal, the carrier, is generally desired to be a SINE wave. Although the modulating signal is seldom a pure SINE wave in actual practice, a SINE wave is convenient to illustrate the concepts of Amplitude Modulation. Figure 6-5 illustrates the waveforms of an RF carrier, an audio modulating signal and the resulting amplitude modulated wave. Note that the outline of the modulated wave (dotted line) resembles the wave shape of the modulating signal. This outline is usually called the modulation envelope. Examples of effects of changing frequency and amplitude of the modulating signal are shown in Figure 6-6.

6-5.1.1 Percentage of Modulation.

a. There are limitations as to the strength of the modulating signal. To produce an AM wave having maximum modulation (100%) without distortion, the negative peak of the modulating signal should decrease



Figures 6-5. Amplitude Modulation.

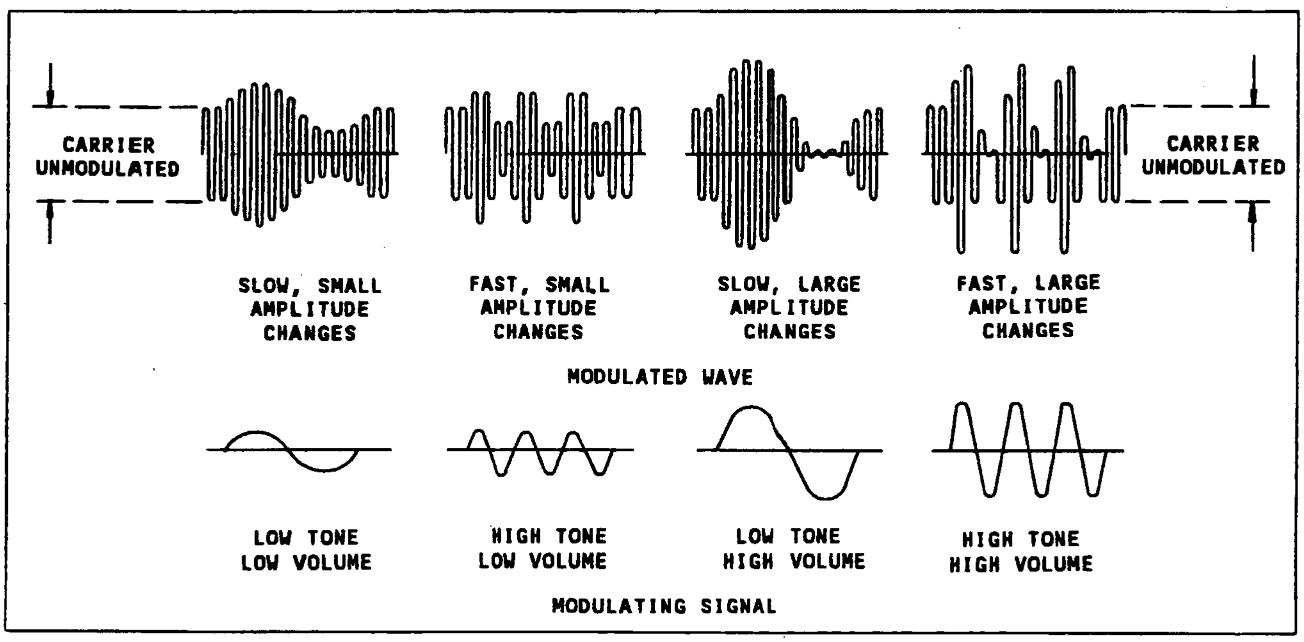


Figure 6-6. AM Waveforms.

the amplitude of the carrier wave to zero, and the plus peak should raise the carrier amplitude to twice its normal value. The degree of modulation is the ratio of the difference of the peak amplitude of modulated wave (Y) and the peak amplitude of the unmodulated carrier wave (X) to the peak amplitude of the unmodulated carrier wave. When the degree of modulation is multiplied by 100, it is called the percentage of modulation. Mathematically:

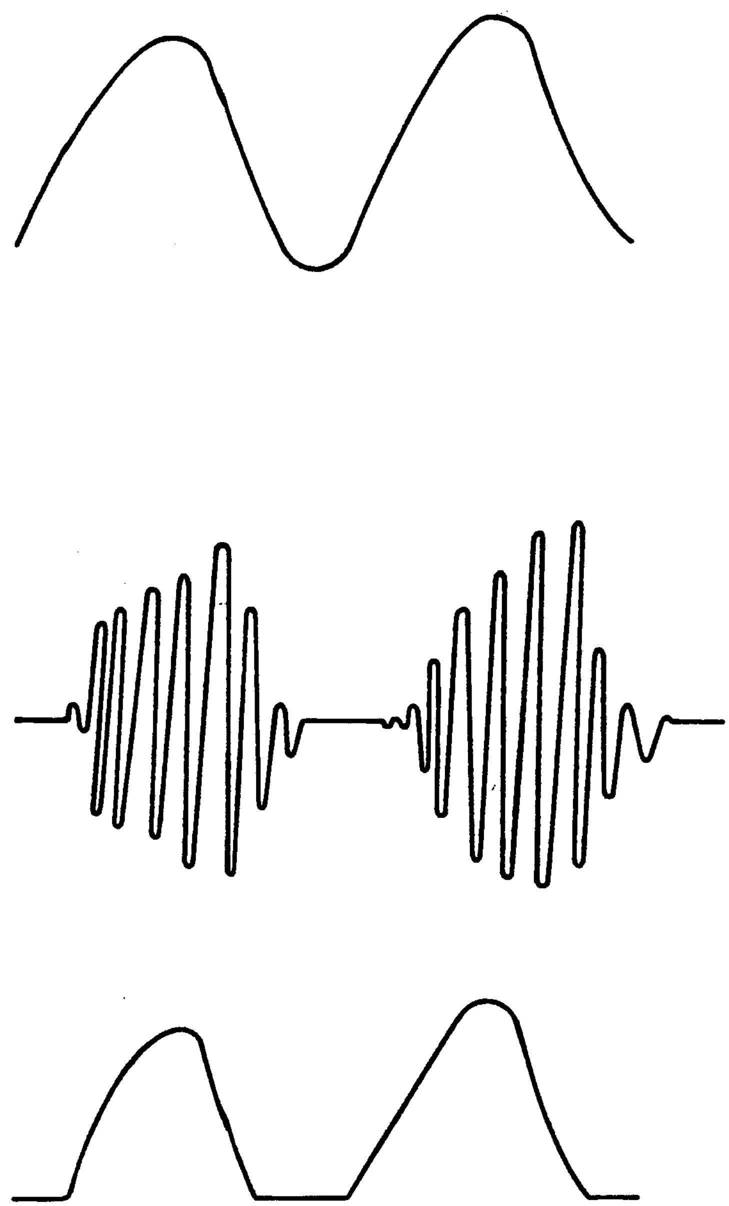
$$\% \text{ MODULATION} = \frac{Y - X}{X} \times 100\%$$

b. If the peak power is greater than twice the "no modulation" power, or if the carrier power falls to zero before the modulating waveform does, the transmitter is said to be "over-modulated". In the case of over-modulation, the carrier power actually disappears. This is shown in Figure 6-7. Note that the demodulated waveform is not a reproduction of the original modulating waveform.

c. In addition to signal degradation or loss of intelligence, over-modulation causes other severe problems. Over-modulation of an RF carrier causes "spillage" or generation of frequencies outside the authorized band. As a result, over-modulated systems cause noise and severe interference over a wide portion of the spectrum. Often it can contribute to other communication circuits being "wiped out" by interference.

d. As stated earlier, 100% modulation enables maximum efficiency of a system to be achieved. If pure audio tones (such as from an audio oscillator) are to be transmitted, it is feasible to adjust the modulation circuits to almost 100%. Transmission of the human voice does not lend itself to this practice, since no two human voices are exactly alike. This means that each voice has its own "fingerprints" or characteristics. Some frequencies tend to be generated at high levels. These individual frequencies can cause over-modulation peaks and result in distortion while other frequencies are transmitted without distortion. For voice transmission it is standard practice to adjust the transmitter modulation controls for some value between 60% and 90%. This compensates somewhat for individualities in voices and also allows for carrier "fading".

e. The uninitiated may assume that under-modulation would be desirable, since the possibility of loss of intelligence or interference is lessened. Remember, however, that sideband power (which really carries the intelligence) is reduced when modulation levels decrease. So the best



A. Modulating Waveform

B. Over Modulated Carrier

C. Detected Audio

Figure 6-7. Effects of Over Modulation.

rule to follow when setting up a transmitter is to consult the operating instructions in the equipment manual. If there are no instructions, the 60% to 90% factor should be used.

6-5.1.2 Sidebands.

a. The modulated signal occupies a definite amount of space (bandwidth) in the frequency spectrum. The bandwidth is twice the modulation frequency centered about the carrier. In other words, with a 1000 Hz tone modulating a 4100 kHz carrier, the frequencies in the modulating envelope are the difference between the two frequencies (4,100,000 minus 1000) and the sum (4,100,000 plus 1000). The sum and difference frequencies are called sidebands. The actual existence of sidebands can be seen on a spectrum analyzer. Analysis of the waveform of the 4100 kHz signal modulated by a 1000 Hz audio tone on the spectrum analyzer would be similar to the diagram of Figure 6-8. The lower sideband appears on one side of the carrier, and the upper sideband on the other.

b. In amplitude modulation systems, the carrier power and sideband power are distributed in such a manner that the carrier power is twice the total sideband power. In other words the power in one of the sidebands is only 1/6 of the total power emitted.

6-5.1.3 Advantages of Double Sideband Amplitude Modulation.

a. Simplicity. AM systems have the advantage of being easy to operate, adjust and maintain. The circuitry is basically uncomplicated.

b. Frequency Control. Since the carrier is transmitted and is employed in detection and demodulation or extraction of the intelligence, there are no stringent frequency requirements. An example of what is meant here can be observed by tuning a commercial broadcast receiver midway between two stations in the broadcast band. As long as the carrier frequencies and sidebands are within the bandpass characteristics of the receiver it is possible to hear both stations at the same time. An AM signal can be tuned in several hundred Hz off frequency and still be intelligible.

6-5.1.4 Disadvantages of Double Sideband Amplitude Modulation.

a. Wasted Power. From previous discussion it was learned that the sideband power is only a portion of the radiated power. A single sideband contains all of the intelligence, but only 1/6 of the total power emitted.

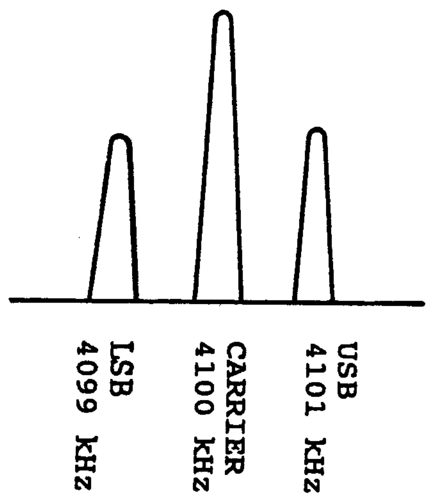


Figure 6-8. Carrier and Sidebands.

b. Excess Bandwidth. Since the same intelligence is contained in both sidebands and both are transmitted, it is obvious that the portion of the spectrum used in an AM signal is twice as wide as that required to convey the intelligence.

c. Fading. When atmospheric conditions are such that signals are fading, an AM signal is very susceptible to distortion. Selective fading causes a phase shift between the carrier and the sidebands that results in a loss of strength in either or both sidebands and/or the carrier. Proper demodulation can only occur when the received carrier power is as strong as the sum of the power in the sidebands. Any deviation from the original waveforms causes degradation of intelligence.

6-5.2 Single Sideband Systems.

6-5.2.1 System Description. In double sideband amplitude modulated systems the RF carrier with upper and lower sidebands is radiated from the antenna. In single sideband suppressed carrier operation, only one sideband is radiated. Both the carrier and one sideband are suppressed at least 40 db below the level of the radiated sideband. Other types of single sideband operation include single sideband reduced carrier (carrier suppressed 10 db or 20 db); however, single sideband suppressed carrier is the only single sideband technique used in afloat communications. It is usually referred to simply as Single Sideband (SSB). It should be understood that single sideband are simply special types of Amplitude Modulated systems. For example, a single sideband system in which the carrier is not suppressed may be operated with "AM" (double sideband) receivers and this is called Compatible AM.

6-5.2.2 SSB Transmission. Figure 6-9 is a block diagram of a typical SSB transmitter. For purposes of illustration, let us assume that a 500 Hz audio tone is to be transmitted. This tone is inserted at the AF input and is then amplified by one or more stages of amplification. The output of the AF amplifier is then fed into the "balanced modulator" stage where it is mixed with the 300 kHz (300,000 Hz) "IF Oscillator" signal. A balanced modulator is a specialized type of mixer circuit which in this case gives us the sum and difference of the two inputs, but allows neither of the original frequencies to pass. In this example, the two output frequencies of the balanced modulator are:

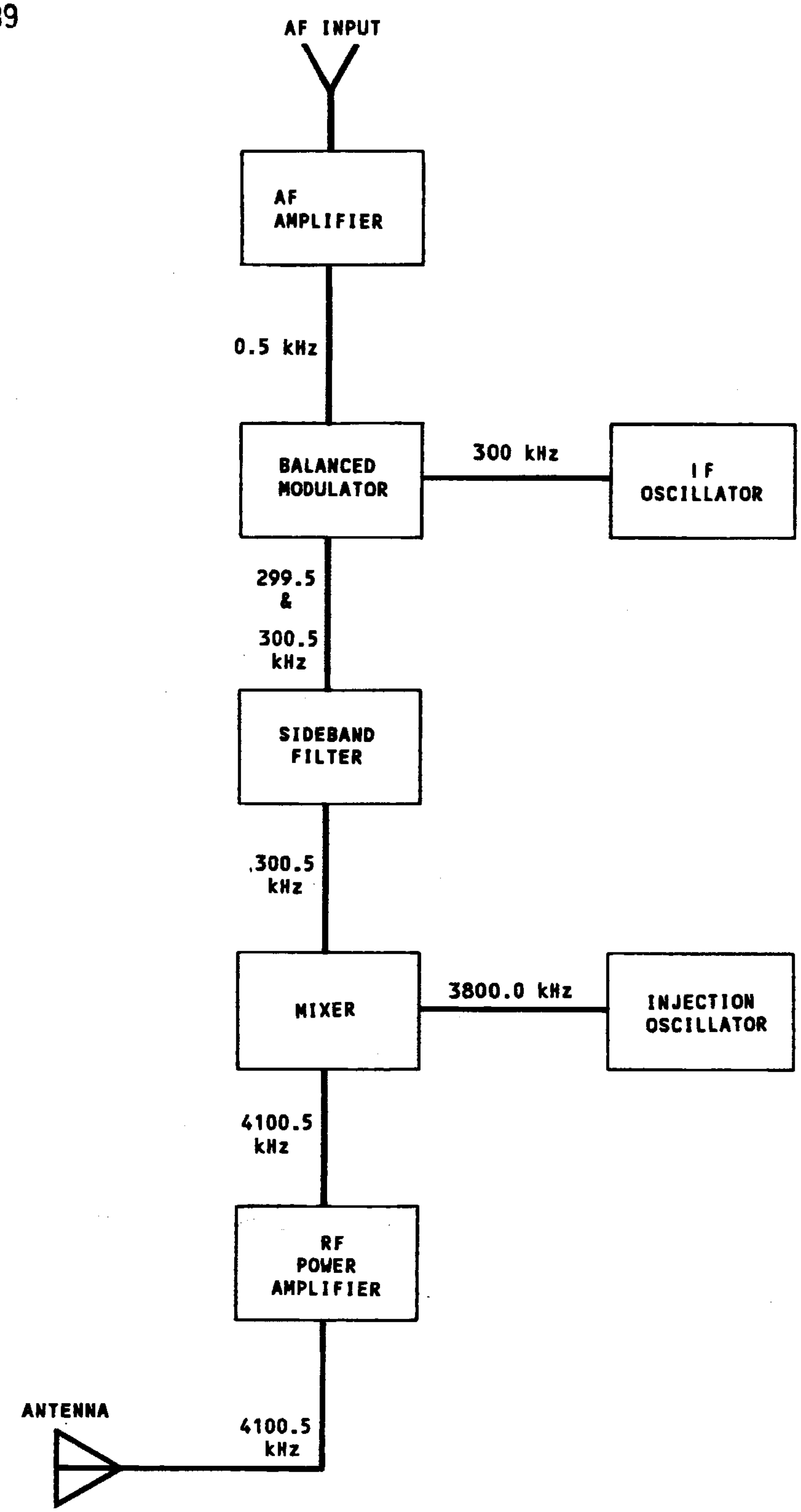


Figure 6-9. SSB Transmitter Block Diagram

SUM		DIFFERENCE
300,000 Hz	Intermediate Frequency	300,000 Hz
+ 500 Hz	Audio Frequency	- 500 Hz
300,500 Hz	Resultant Frequency	299,500 Hz
or		or
300.5 kHz		299.5 kHz

6-5.2.3 SSB Filtering. The two output frequencies of the balanced modulator are fed to the sideband filter which selects either the high frequency if USB transmission is desired, or the lower frequency if LSB transmission is desired. The block diagram is of a USB transmitter, so its filter will select the upper frequency, 300.5 kHz.

6-5.2.4 Signal Translation. The signal must now be translated to the operating frequency chosen. The 300.5 kHz USB signal is fed into a mixer stage where it is added to an "injection oscillator" frequency of 3800.0 kHz. This is done as follows:

3,800,000 Hz	Injection Oscillator Frequency
+ 300,500 Hz	Intermediate Frequency USB Signal
4,100,500 Hz	Resultant Frequency

6-5.2.5 Signal Amplification. This resultant frequency is the desired operating frequency, but is still at a very low power level. The USB signal is then fed through as many stages of power amplification as necessary to bring its level to the power required.

6-5.2.6 USB Transmission. What has just been described is a USB transmitter, modulated by a 500 Hz tone, operating on an assigned frequency of 4100 kHz (4,100,000 Hz). It can be seen that the only frequency being generated by the transmitter is 4100.5 kHz (4,100.500 Hz). Comparing this to the spectrum of an AM emission on the same frequency as discussed in paragraph 6-5.1, it is found that effective elimination of both the lower sideband and the carrier frequency has been accomplished. See Figure 6-10.

6-5.2.7 LSB Transmission. It is easy to change the transmitter from USB to LSB simply by changing the "sideband filter" so that it will select the difference frequency instead of the sum. This difference frequency when translated becomes the lower sideband signal shown in Figure 6-10.

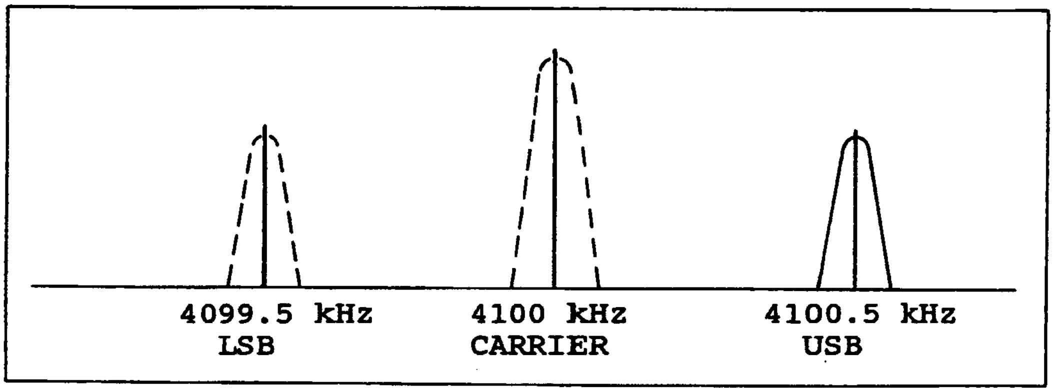


Figure 6-10. Carrier and Sidebands, USB Transmission.

3,800,000 Hz	Injection Frequency
+ 299,500 Hz	Intermediate Frequency LSB Signal
4,099,500 Hz	Resultant Frequency

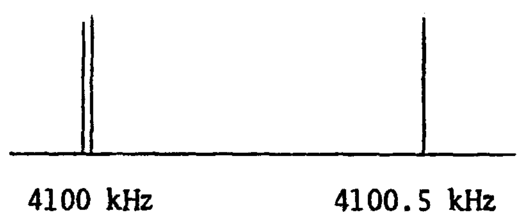
6-5.2.8 Switching. Switching the intelligence from USB to LSB in sideband transmitters is normally done by switching sideband filters.

6-5.2.9 SSB vs. AM. As indicated in Figure 6-9, in a USB transmitter, to transmit an audio tone of 500 Hz on an assigned frequency of 4100 kHz, the only frequency transmitted is a single RF frequency of 4100.5 kHz. In contrast, transmission of a 500 Hz audio tone in the AM (6A3) mode of operation would result in a carrier frequency of 4100 kHz, and sidebands of 4099.5 and 4100.5 kHz. This is one of the major advantages of SSB: all of the transmitted power is concentrated in transmitting the intelligence.

6-5.2.10 Frequency Constraints. SSB operation demands absolute frequency accuracy and stability. Successful demodulation of an SSB signal requires the reinsertion (at the receive end) of a discrete frequency which has the same relationship to the desired modulating signal that the suppressed carrier has in the transmitter.

6-5.2.11 Dual Conversion Receiver. To clarify the above, assume that a dual conversion receiver is used to receive and process SSB signals. The basic stages of this receiver are shown in Figure 6-11. Although the block diagram does not represent a particular receiver, the theory of operation is similar to Navy equipment. A thorough knowledge of theory of operation of the block diagram will enable understanding of the actual processing of an SSB signal.

6-5.2.12 Assigned Frequency. It was previously assumed that a 500 Hz audio tone was being transmitted in an SSB mode at an assigned frequency of 4100 kHz. It was determined that the actual frequency radiated was 4100.5 kHz (4,100,500 Hz). The receiver selects this 4100.5 kHz when the receiver is adjusted to 4100 kHz. The following figure shows the relative position of the desired signal in relation to the assigned frequency.



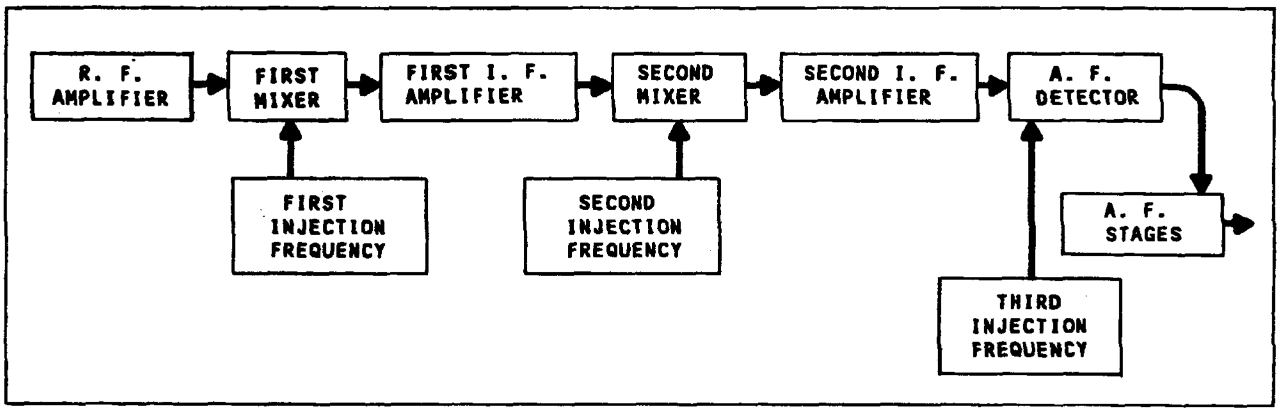


Figure 6-11. Typical SSB Receiver.

6-5.2.13 First Mixer Stage. In the first mixer stage, the received signal is combined with the first injection frequency to produce the first IF signal. The frequency of the first IF in Figure 6-11 is 220 kHz. The first injection frequency is tunable in such a manner that it is always 220 kHz higher than the assigned frequency. The difference between the incoming signal and the first injection is thus within the bandpass of the 220 kHz amplifier.

4,320,000 Hz	Injection Frequency
-4,100,500 Hz	Incoming Frequency
219,500 Hz	Resultant Frequency

6-5.2.14 Translated Frequency. The illustration below shows the intelligence frequency (which has been "translated") in reference to the first IF frequency. Note that during the translation process the position of the intelligence frequency has been reversed in relation to the reference frequency.

6-5.2.15 Relative Position to IF. Although the position of the intelligence in reference to the IF has been reversed, it is still a USB signal. During translation processes in both transmitters and receivers the intelligence frequency may change position. The ultimate determination of whether a given SSB signal is USB or LSB is determined by its position in reference to the assigned frequency.

6-5.2.16 Second Mixer. The intelligence frequency is now present in the first IF amplifier at a frequency of 219,500 Hz. Here it is amplified and applied to the second mixer where it is combined with the second injection frequency. In a typical receiver, the second IF is a fixed frequency of 80 kHz (80,000 Hz). Regardless of the incoming frequency, the second injection frequency is fixed at 140 kHz, which is 80 kHz lower than the first IF. Thus, any signal present in the first IF amplifier is again translated to fall with the bandpass limits of the second IF amplifier.

219,500 Hz		Output Frequency of First IF
-140,000 Hz		Second Injection Frequency
79,500 Hz		Resultant Frequency

6-5.2.17 Second IF Amplification. In the second IF amplifier, the intelligence bearing signal is below the second IF which is similar to its position in the first IF amplifier. Here it is amplified still further and is applied to the AF detector, where it is mixed with the third injection frequency. The third injection frequency is the same as the second IF frequency. It is at this stage that the "injected" carrier is mixed with the "single sideband" signal to reproduce the original intelligence frequency.

6-5.2.18 Third Mixer. When 79.5 kHz second IF signal is mixed with the 80 kHz third injection frequency, the difference between these two is found to be a 500 Hz tone. The transmitted frequency has been faithfully reproduced in the output.

6-5.3 Independent Sideband.

6-5.3.1 Simultaneous Broadcasts. The basic receiver in Figure 6-11 can be used successfully to copy either a USB or an LSB signal. Maximum utilization of the spectrum available for Naval Communications will soon require the use of both USB and LSB communication on the same assigned frequency. This means that it is possible to transmit simultaneously two completely different information channels. Equipment presently installed on many ships has the capability to accomplish this.

6-5.3.2 Modified Receiver. A modification to the basic receiver illustrated in Figure 6-11 is shown in Figure 6-12. This modification permits independent sideband operation.

6-5.3.3 Added Modules. The modules added to the basic receiver are the USB and LSB detector amplifiers. Quite similar to an AF detector amplifier, they perform a similar function. The basic difference lies in the tuned circuits which are an integral part of each.

6-5.3.4 AF Detector. A typical AF detector stage will have tuned circuits which will pass frequencies several kHz above and below the IF frequency. Representative frequencies of the AF detector of Figure 6-11 would range from 74 kHz to 86 kHz. In many receivers, a front panel switch permits selection of IF bandwidth.

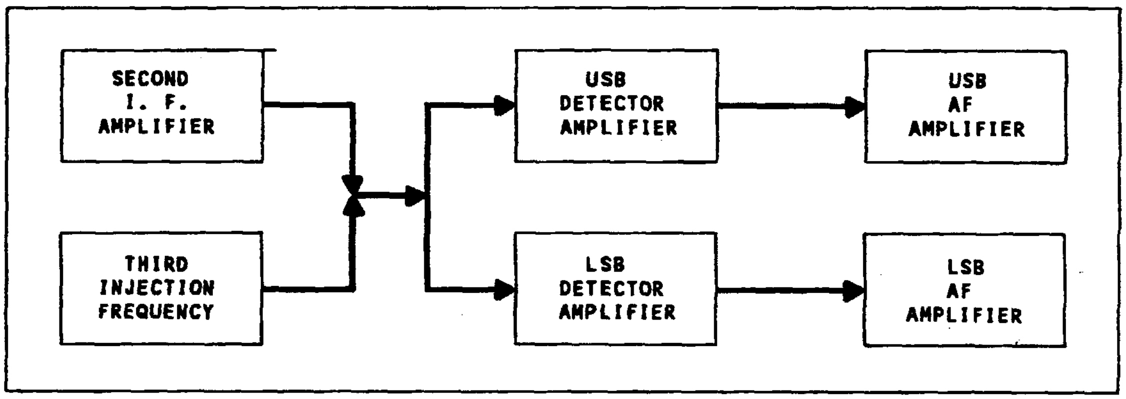


Figure 6-12. Audio Stages of ISB (Independent Sideband) Receiver.

6-5.3.5 USB/LSB Detector Differences. The USB and LSB detector/amplifiers possess slightly different properties. Each will pass only a relatively narrowband of frequencies, approximately 4 kHz wide, either above or below the IF frequency. The USB and LSB detector/amplifier frequencies, of Figure 6-12, are as follows:

USB DETECTOR AMPLIFIER		LSB DETECTOR AMPLIFIER
80 kHz ± 5 kHz	Signal Input Frequency	80 kHz ± 5 kHz
80 kHz	Injection Frequency	80 kHz
76.0 to 79.7 kHz	Input Signal Response	80.3 to 84 kHz
300 to 4000 Hz	Audio Output	300 to 4000 Hz

6-5.3.6 Module Output. The output of both USB and LSB modules are audio frequencies. If one of the single sideband inputs is multichannel RATT, and the other single sideband input is a voice communications channel, it is possible to transmit sixteen 100 wpm teletypewriter signals and a voice channel simultaneously, with no interference from each other, on the same assigned frequency. And all of this is accomplished within the same spectral bandwidth as an AM channel.

6-5.3.7 Receiver Tuning. Some Navy SSB receivers are capable of either "continuous" tuning, or "incremental" tuning. Continuous tuned receivers, as the name implies, are capable of being continuously turned over the entire operating range. This mode of operation, however, requires the use of a variable frequency oscillator. It has the disadvantage of being unstable in relation to an incrementally tuned receiver, but has the advantage of being able to compensate for a frequency error in the transmitted signal.

6-5.3.8 Incremental Tuning. Incrementally tuned receivers are capable of being operated in "steps". Some receivers tune in steps of 1 kHz 0.5 kHz and 0.1 kHz steps.

6-5.3.9 Synthesized Receivers. Synthesized receivers (R-1051, R-1903, AN/SRR-19) are inherently more accurate than the older generation of receivers since frequency control is obtained from a very stable oscillator. Operation of these receivers in the continuous mode is accomplished by substituting a variable frequency for one of the fixed injection frequencies resulting in non-synthesized operation.

6-5.3.10 Frequency Control. The importance of absolute frequency control and accuracy in transmit and receive terminals cannot be overemphasized. Any deviation between the transmitter frequency and the receive frequency causes distortion. The effects of this distortion are most pronounced on Multichannel RATT circuits. A frequency difference of 5 Hz causes sufficient distortion to cause degradation of copy. Beyond 10 Hz difference, the demodulated signal is so highly distorted that the copy may be rendered useless.

6-5.3.11 Optimum Operation. For the reasons listed above, optimum operation of SSB equipment is achieved when the reference oscillators are adjusted to, or "slaved" to a frequency standard, such as the AN/URQ-10 or AN/URQ-23. The equipment should be operated in a synthesized mode. It is in this mode that all injection frequencies are direct derivatives of the reference oscillator. In the "continuous" mode, one of the injection oscillators is variable, and therefore is subject to error and drift.

6-5.4 Advantages of Single Sideband Suppressed Carrier and Sideband Operation.

6-5.4.1 Comparison to AM. Generally speaking, comparisons between various modes and methods of operation are relative. Although nonstringent frequency control is listed as an advantage for AM, present day technology has permitted design of equipment which is more than adequate in both frequency accuracy and stability.

6-5.4.2 Advantages over AM. The following are generally considered as advantages in relation to AM:

a. Spectrum Conservation. SSB requires only half as much bandwidth as AM. Additionally, the stringent frequency accuracy reduces guard band requirements.

b. Power Conservation. An SSB transmitter with radiated power equal to the power in one sideband of an AM transmitter will operate with equal effectiveness.

c. Physical Size. Since it is possible to radiate intelligence in equal amounts with approximately 1/6 the total power rating, it follows that SSB transmitters are physically smaller than AM transmitters.

d. General. There are many other considerations in comparing AM with SSB. Included among these are selective fading of AM signals, or other propagation irregularities. The advantages of SSB over AM are most pronounced under less-than-optimum conditions.

6-5.5 Angle Modulation.

6-5.5.1 Angle Modulation Types. Two methods of modulation differing from amplitude modulation, but closely resembling each other, are Frequency Modulation (FM) and Phase Modulation (PM); both are forms of Angle Modulation. Angle Modulation differs from amplitude modulation in that the amplitude of the RF carrier is held constant while the carrier frequency and carrier phase are varied in accordance with the modulating signal. Frequency and phase modulation are not independent since the frequency cannot be varied without also varying the phase and vice versa. The difference is mainly a matter of definition.

6-5.5.2 Effectiveness. The effectiveness of FM and PM for communication purposes depends almost entirely on the receiving methods. If the receiver will respond to frequency and phase changes but not to amplitude changes, it will discriminate against most types of noise such as electrically generated static.

6-5.6 Frequency Modulation (FM).

6-5.6.1 Modulation Technique. In FM when a modulating signal is applied, the carrier frequency is increased during one half cycle of the modulating signal and decreased during the half cycle of opposite polarity. The change above or below the carrier frequency (frequency deviation) is proportional to the instantaneous amplitude of the modulating signal. Refer to Figure 6-13. The total frequency variation is called the carrier swing.

6-5.6.2 Center Frequency. The assigned carrier frequency of an FM transmitter is the "resting" frequency, or center frequency. The center frequency corresponds to the unmodulated carrier frequency of an AM transmitter.

6-5.6.3 Sideband Frequencies. The sideband frequencies present in FM systems result from the amplitude of the modulating signal. However, the rate of change of the sideband distribution and the separation between the individual sidebands depends on the frequency of the modulating signal. Although the number of sidebands produced is theoretically infinite, there is a practical limit to the number of usable sidebands. Those sidebands beyond the practical limit contain so little power they cannot be detected by the receiver.

6-5.7 Phase Modulation (PM). If the phase of the current in circuit is changed, there is a corresponding instantaneous change in frequency.

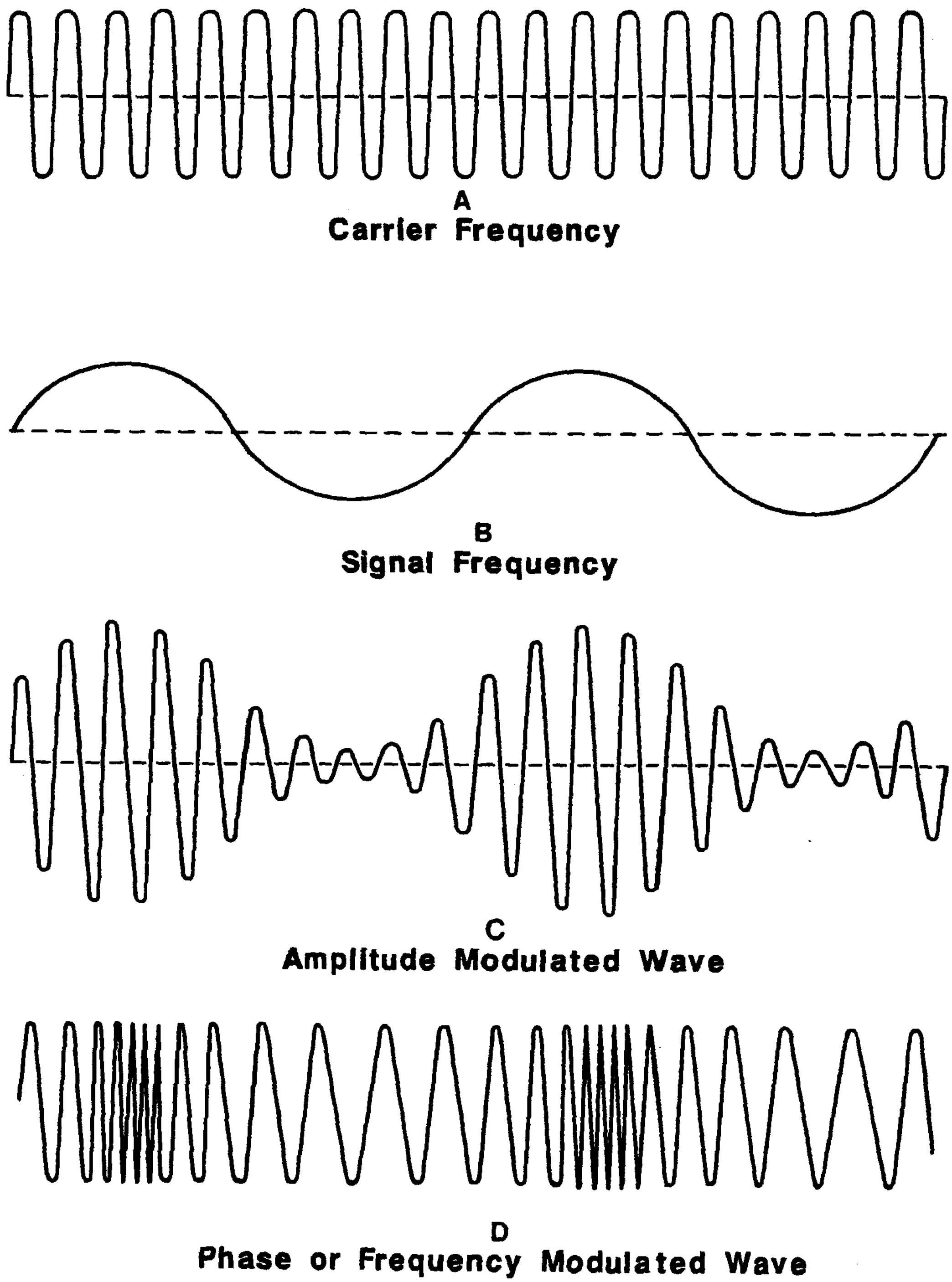


Figure 6-13. Waveshapes, Amplitude, Phase and Frequency Modulated Carrier

The amount of frequency deviation depends on how rapidly the phase shift is accomplished and on the total amount of the phase shift. The frequency deviation in PM is proportional to both the amplitude and frequency of the modulating signal; while in FM, the frequency deviation is proportional to only the amplitude of the modulating signal. However, PM and FM will appear the same in the spectrum as indicated by Figure 6-13.

6-5.8 Modulation Index.

6-5.8.1 Definition. Since the amplitude of the carrier in an FM system remains constant, degree of modulation is expressed in terms of the "deviation ratio" or "modulation index". The modulation index is the ratio of the maximum deviation of the center frequency (frequency deviation) to the maximum modulating frequency causing the deviation. Mathematically it is:

$$\text{Modulation Index} = \frac{\text{Maximum Frequency Deviation}}{\text{Maximum Modulating Frequency}}$$

6-5.8.2 Commercial Application. The maximum frequency deviation in commercial applications is 75 kHz.

6-5.8.3 Military Application. In military applications the maximum deviation is limited to 40 kHz and is classed as Narrowband FM.

6-5.9 Frequency Shift Keying (FSK).

6-5.9.1 Definition. One of the most common methods of shipboard radio-teletypewriter communications is by the use of FSK. TTY signals are produced using "MARK" and "SPACE" elements. A "MARK" causes current to flow in a TTY loop. A "SPACE" causes no current in a TTY loop. In FSK, a discrete frequency is radiated for a MARK element and another discrete frequency is radiated for a SPACE element.

6-5.9.2 Single Channel RATT. Single channel RATT (FSK) may involve frequency shifts of:

a. 200 Hz: CV-2460/SGC with 500 Hz SPACE and 700 Hz MARK modulating a single sideband suppressed carrier transmitter or a UHF transmitter.

b. 850 Hz: AN/WRT-2 with 425 Hz below (MARK) and 425 Hz above (SPACE) the assigned frequency.

c. 850 Hz: AN/URT-23, AN/URT-24, AN/URC-32, AN/SRC-23, AN/WRC-1 AND T-1322 which produce 1575 Hz (MARK) and 2425 Hz (SPACE) above the suppressed carrier frequency. (425 Hz above and below the assigned frequency.)

6-5.10 Phase Shift Keying (PSK) and Differential Phase Shift Keying (DPSK).

6-5.10.1 PSK Definition. PSK and DPSK are methods of phase modulation. Phase shift keying (PSK) is similar to FSK, except that the phase of the RF carrier is shifted by some angle each time the carrier is keyed. In its simplest form, PSK operates with phase reversals (that is, shifts 180 degrees each time a "MARK" or "one" is received and no phase reversal each time a "SPACE" or "zero" is received). One way to produce a PSK signal is illustrated in Figure 6-14. A MODEM may be used to shift the phase of an audio frequency signal in accordance with a DC teletypewriter loop signal. The sharp changes in the audio frequency signal generate other audio frequencies, some of which are filtered out to reduce the bandwidth. The resulting audio frequency signal may be used to amplitude modulate an RF carrier (single sideband, suppressed carrier) to produce a PSK emission. In the resulting process a band of frequencies is produced, but the intelligence is carried in the phase shift.

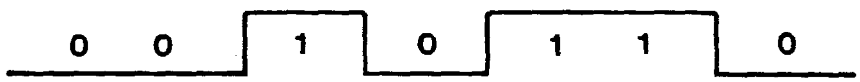
6-5.10.2 DPSK Definition. Differential Phase Shift Keying (DPSK) is very similar to PSK except that the phase shift is made only when a change (from MARK to SPACE or from SPACE to MARK) occurs in the keying DC signal. That is, the interpretation of each signal element depends on the immediately preceding signal element. Referring to Figure 6-15, the DC signal changes from 0 to 1 and from 1 to 0 causing phase reversals. However the DC Signal elements which remain at "0" or "1" state cause no phase reversals. The receiver must therefore compare each signal element with the one immediately preceding it for proper interpretation of the original message.

6-5.10.3 Variations. The techniques described above are presented to illustrate the concepts of PSK and DPSK. Variation of these techniques are used with the AN/WSC-5, AN/WSC-3 transceivers and the AN/SSR-1 Satellite Fleet Broadcast Receiver.

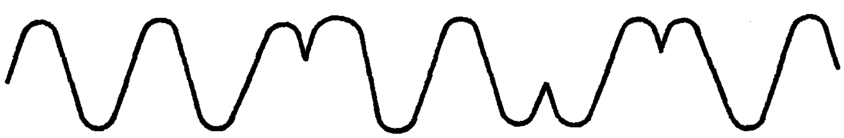
6.5.11 Tone Modulated Radio-teletypewriter.

6-5.11.1 Usage. This method of radio teletypewriter communications is normally used in intra-task force and inter-ship UHF communications. Tone modulated telegraphy is employed in UHF-HF relay operations and

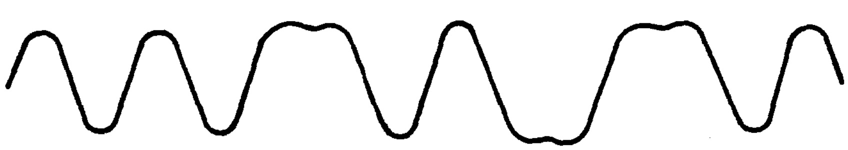
(a) Unmodulated Carrier



(b) Modulation Signal - Data Elements



(c) Modulated Carrier



(d) Modulated Carrier After Filtering

Figure 6-14. Phase Shift Keying

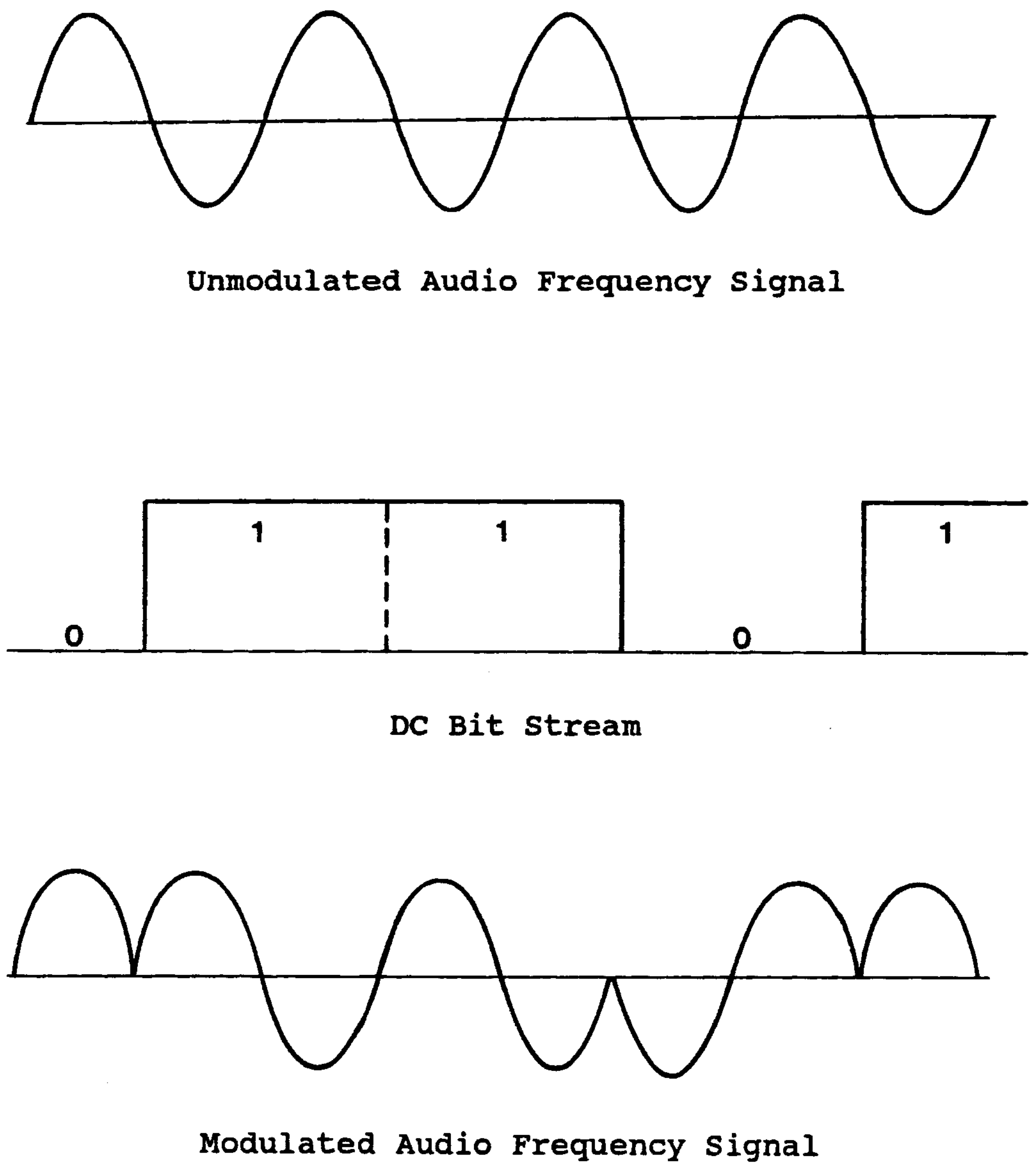


Figure 6-15. Differential Phase-Shift Keying.

occasionally in port when emission below 100 MHz is not permitted due to HERO restrictions.

6-5.11.2 Advantages. Tone modulated radio teletypewriter is used most advantageously for line-of-sight transmission. Relatively secure task force communications can be achieved by employment of UHF, since detection beyond line-of-sight is difficult. In line-of-sight UHF communications, the most satisfactory mode for RATT is tone modulation. A UHF tone modulated signal can be several hundred hertz off frequency and still be intelligible since the carrier is present in the modulation "package", and reinsertion is unnecessary.

6-5.11.3 Description of Technique. A detailed discussion of tone modulated RATT techniques and equipment is contained in Chapter 5, Section 4.

6-5.12 Multichannel Radio Teletypewriter.

6-5.12.1 Description. The purpose of this mode of transmission is to increase communication capabilities (provide more channels) by transmitting up to sixteen 100 WPM teletypewriter channels in a nominal 3 kHz bandwidth utilizing one transmitter. Each of the sixteen channels is assigned a reference or "center" frequency. This center frequency is not transmitted. For example, the center frequency (reference) for channel one is 425 Hz. The total shift is 85 Hz centered on the reference frequency. For channel one, the MARK frequency is 382.5 Hz and the SPACE frequency is 467.5 Hz. When this particular channel is being keyed, these two frequencies will be transmitted in accordance with the MARKS and SPACES generated by the associated crypto equipment. See below.

CHANNEL	MARK FREQ (HZ)	CENTER FREQ (HZ)	SPACE FREQ (HZ)
ONE	382.5	425	467.5
TWO	552.5	595	637.5
THREE	722.5	765	807.5
FOUR	892.5	935	977.5
FIVE	1062.5	1105	1147.5
SIX	1232.5	1275	1317.5
SEVEN	1402.5	1445	1487.5
EIGHT	1572.5	1615	1657.5
NINE	1742.5	1785	1827.5
TEN	1912.5	1955	1997.5
ELEVEN	2082.5	2125	2167.5
TWELVE	2252.5	2295	2337.5
THIRTEEN	2422.5	2465	2507.5

CHANNEL	MARK FREQ (Hz)	CENTER FREQ (Hz)	SPACE FREQ (Hz)
FOURTEEN	2592.5	2635	2677.5
FIFTEEN	2762.5	2805	2847.5
SIXTEEN	2932.5	2975	3017.5

6-5.12.2 "In-band" Diversity Operation. For "In-band" Diversity Operation, two channels contain identical information. For example, the 425 Hz channel (1) is operated simultaneously or "twinned" with the 1785 Hz channel (9). This method provides in-band diversity within a nominal 3 kHz bandwidth. For Fleet Multichannel Broadcast "N" System, in-band diversity is no longer used and the AN/UCC-1 IS OPERATED "UNTWINNED".

6-5.12.3 "P" System Operation. For Fleet Primary Multichannel Ship/Shore "P" System use, in-band diversity is prescribed. Channels of the AN/UCC-1 terminal equipment are twinned as follows:

CHANNEL	CENTER FREQUENCY		CHANNEL	CENTER FREQUENCY
1	425 HZ	TWINNED WITH	9	1785 HZ
2	595 HZ	TWINNED WITH	10	1955 HZ
3	765 HZ	TWINNED WITH	11	2125 HZ
4	935 HZ	TWINNED WITH	12	2295 HZ
5	1105 HZ	TWINNED WITH	13	2465 HZ
6	1275 HZ	TWINNED WITH	14	2635 HZ
7	1445 HZ	TWINNED WITH	15	2975 HZ
8	1615 HZ	TWINNED WITH	16	2975 HZ

6-5.12.4 Keying. Each of the twinned pairs is keyed simultaneously. These twinned pairs produce a composite tone group which is used to modulate a transmitter. To provide security, each teletypewriter channel is covered.

6-5.12.5 AN/UCC-1 Description. A detailed discussion of the AN/UCC-1 is provided in Chapter 5, Sections 4 and 10.

CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATIONS

SECTION 6
DC DISTORTION

6-6.1 Start-Stop Mode.

6-6.1.1 Teletypewriter Signals. If a teletypewriter signal could be drawn on paper, it would resemble Figure 6-16. Shaded areas show intervals during which the circuit is closed (MARKING). Blank areas show the intervals during which the circuit is open (SPACING). In the code most frequently used in Navy teletypewriter communications, 7.42 units represent one teletypewriter character. The start element precedes the first code element and is always a SPACE signal. Its purpose is to start the receiving machine. The stop element follows the last code element and is always a MARK signal. Its purpose is to stop the receiving machine in preparation for receiving the next character. The start element is always equal in duration to the code elements. The stop element must be equal in duration to at least one element of the Code. The most common mode uses a stop element 1.42 times the length of one element. It is common practice to refer to a code element as a unit and the duration of a unit as the unit interval. The code just described is technically referred to as a "five-unit code, start-stop, with a 1.42 unit stop". This code is more commonly referred to as 7.42 unit code.

6-6.1.2 Start-Stop Method. The method of teletypewriter communication described above is called the start-stop method and gets its name from the start-stop units. The start-stop method keeps teletypewriter machines and signals in synchronization with each other. With this method the selecting mechanism in the receiving machine comes to a complete stop after each character.

6-6.1.3 Characters. Different characters are transmitted from the keyboard by an automatic process that selects various combinations of MARKING and SPACING in the five intelligence units (Figure 6-17). When reading tape, holes in the tape represent MARKS and solid areas represent SPACES. The reason is that holes in the tape allow the transmitter-distributor pins to rise, sending a current pulse. No holes in the tape prevent sensing pins from rising, thereby preventing current pulses. Thus we have spacing intervals. The machine, without benefit of tape perforations, automatically generates the start and stop elements.

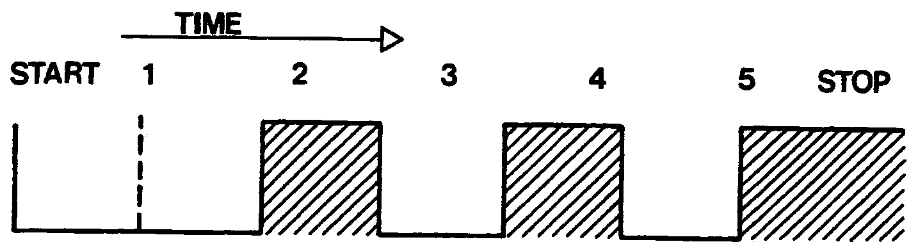


Figure 6-16. Mark and Space Teletype Signals.
(Character R)

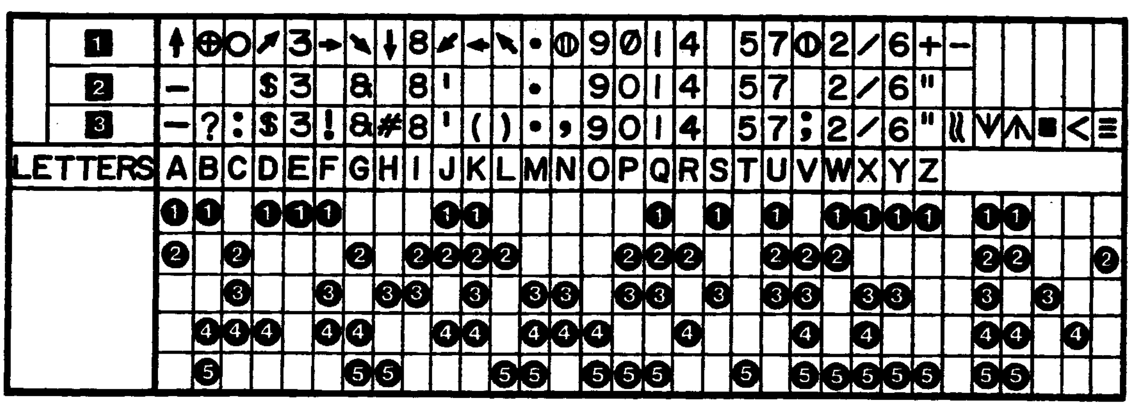


Figure 6-17. Five Level Teletype Code Chart.

6-6.1.4 Cases. A total of 32 combinations can be obtained from the five intelligence units, but by using uppercase and lowercase, the number of characters obtainable is greatly increased. When a teletypewriter printing mechanism is shifted to uppercase as a result of receiving a FIGS shift character, all succeeding characters received before a LTRS shift character, print in uppercase as numerals and punctuation marks. The machine does not, however, make such double use of all 32 possible combinations, because six are used for the functions of carriage return, line feed, figures shift, letters shift, space, and for one normally unused blank key. This leaves 26 of the 32 that can be employed in both uppercase and lowercase. When the six special functions are added, the total is 58 characters and functions that can be sent from a teletypewriter keyboard.

6-6.1.5 Transitions. Examine Figure 6-16 once more. Theoretically, this diagram represents a perfect signal. The quality of each element remains the same during its transmission, and the shift from MARKING to SPACING (and vice versa) is instantaneous. These changes are called transitions. They occur at the beginning and end of each of the solid blocks. Some are MARK-TO-SPACE transitions, and others are SPACE-TO-MARK transitions. For some other character combination a transition may occur between "start" and intelligence units, but in any transmitted character there can be only 2, 4, or 6 transitions.

6-6.1.6 Unit Length. As previously discussed the first 6 units of the signal are the same length, but the 7th (stop) unit is longer. Each of the first 6 units requires 13.5 milliseconds of the circuit time for transmission. This timing is based on a transmission speed of 100 words per minute. The stop unit requires 19.0 milliseconds. If a value of 1 is assigned to each of the first 6 units, then the stop unit has a value of 1.42. The total number of units in letter R is 7.42, requiring a transmission time of 100 milliseconds. No allowance is made for transition time, because a transition has negligible time duration. See Figure 6-18.

6-6.1.7 Transmitter Contacts. Transmitter contacts are actually a set of mechanically controlled switches that can produce a different combination of the 7.42 unit signal for any letter or function lever depressed. The selector magnet of the receiving teletypewriter mechanically releases a start lever when the start pulse is received, thus allowing the selector cam clutch to rotate through one revolution. During this revolution, five selector levers in the selector unit are positioned by the operation or release (MARKING or SPACING) of the

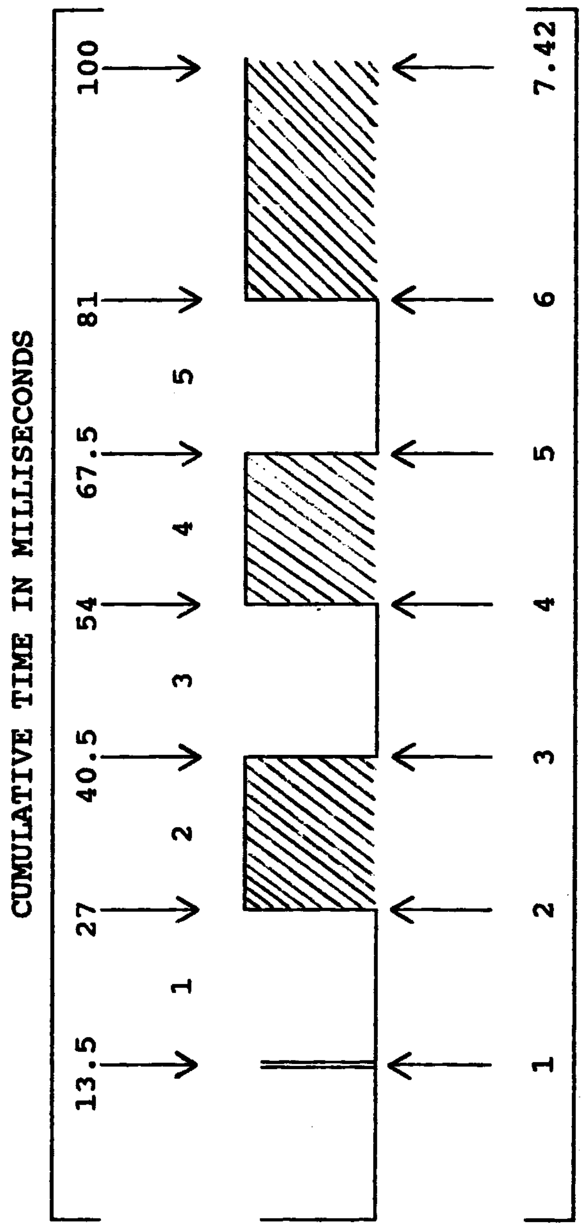


Figure 6-18. The 7.42-Unit Teletype Signal

selector magnet armature as determined by each intelligence pulse received. The time required to position each selector lever is approximately 20 percent of the time of one intelligence pulse, or 2.7 milliseconds. This time, again, is based on a teletypewriter running at 100 WPM. Cams on the selector cam-clutch are so located that the time between each selector lever operation is fixed at 13.5 milliseconds.

6-6.1.8 Selector Levers. During 2.7 milliseconds of the first pulse the first selector lever is positioned; during 2.7 milliseconds of the second pulse the second selector lever is positioned, and so forth until all 5 selector levers are positioned. See Figure 6-19. These selector levers control the internal mechanism of the teletypewriter so as to select and at the proper time print the correct character.

6-6.1.9 Receiving. In the start-stop mode, the receiving machine is allowed to run for only one character and is then stopped to await the reception of a start signal indicating that the next character is about to start. In this manner any difference in speed between the transmitting and receiving machines can accumulate only during the duration of one character. There is a penalty to pay for this advantage. The length of each character must be increased to include an element to start the receiving machine and another added to stop it. Also, the receiver must be slightly faster than the transmitter to ensure that the receiver will complete its cycle and be ready to receive another character before the transmitter sends it. Thus, speed of transmission and operating margins are sacrificed for synchronization.

6-6.2 Synchronous Mode. Synchronous teletypewriter operation, as opposed to start-stop operation, does not in all cases have to rely upon elements of the transmitter character to maintain proper position in relation to the receiving device. External timing signals may be used, allowing the start and stop elements to be discarded. Then only the elements necessary to convey a character, and in some cases a reference element, need to be transmitted. This results in more information being passed in a given period of time and all elements are of equal length. Synchronous operation is employed in AUTODIN Digital Subscriber Terminal Equipments (DSTEs) and in most forms of digital data transmission other than teletypewriter. Due to its current limited use in ships, it will not be discussed in detail.

a. Maladjusted relays can cause bias distortion due to the armature's remaining longer on one contact than it does on the other. Bias distortion can also be caused by an improper balance between line and bias currents in a netural relay.

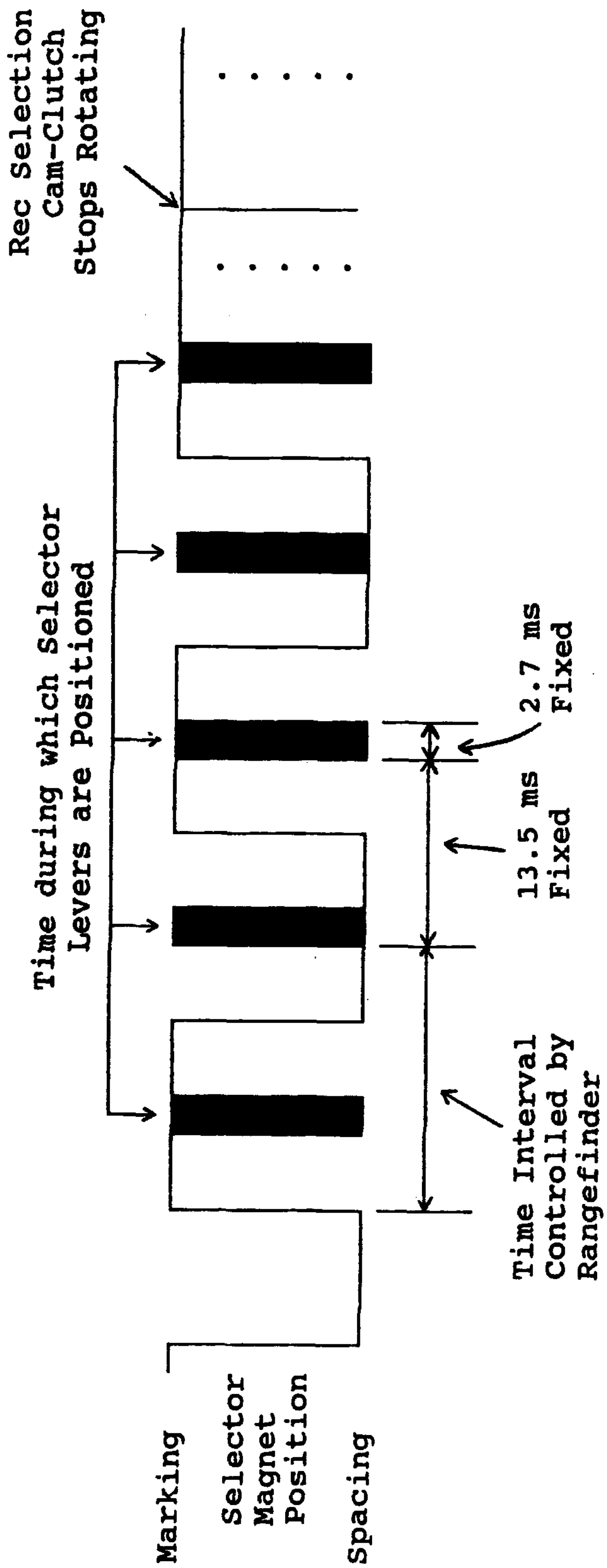


Figure 6-19. Selecting Intervals for Letter Y

b. FSK (Frequency Shift Keyed) equipment will cause bias distortion when the time required to change from MARK-to-SPACE and the time required to change from SPACE-to-MARK are not identical, even though the MARK and SPACE frequencies are correct. This can usually be eliminated by proper setting of the center frequency while transmitting unbiased reversals (alternate MARKS and SPACES of equal length).

c. In certain FSK equipment, improper receiver tuning or transmitter drifting will cause bias. This equipment uses some type of balanced FM (Frequency Modulated) discriminator. When the MARK and SPACE frequencies are equally centered on the discriminator response slope, and equipment is is properly tuned and aligned, the result is a signal without bias.

d. Bias distortion may be introduced into DC circuits by monitor printers inserted in series with the circuit for checking purposes. This is true on neutral circuits where the added monitor printer inductance changes the shape of the wave form. The use of monitor printers that are not equipped with line relays to isolate the selector magnet will cause more bias than those equipped with relays. High impedance shunt monitor devices should be used where possible to reduce the effects normally encountered with series monitoring.

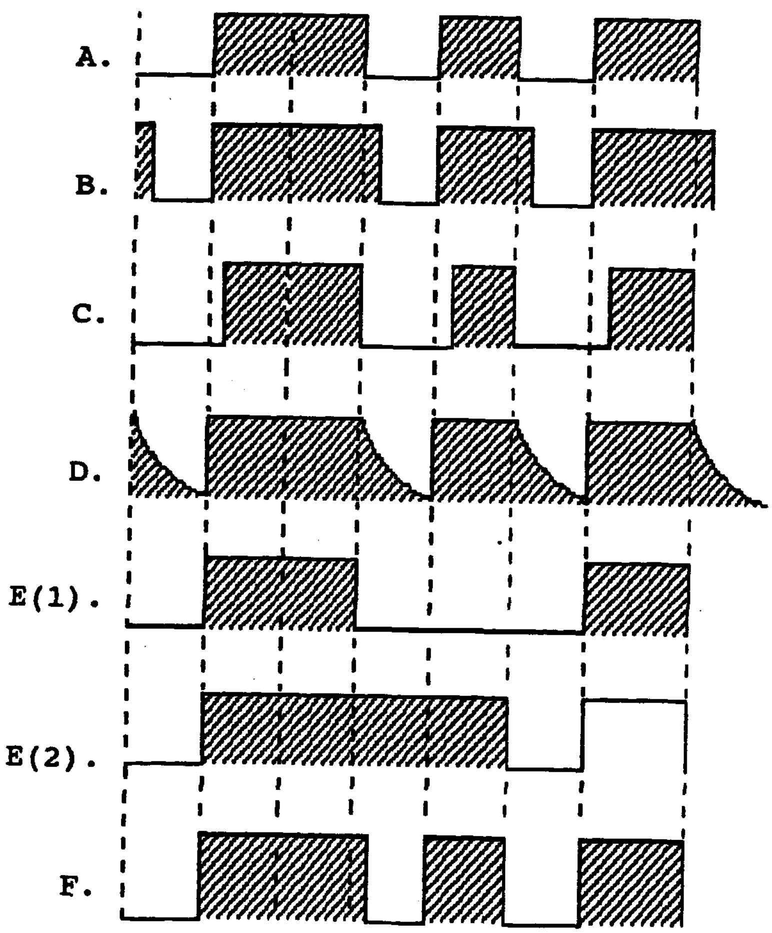
e. Differences in speed between the transmitting and receiving devices will appear as signal distortion to the receiver. An analyzing device capable of sensing each signal element will show a proportional increase in distortion with each element sampled if the speed error is in the transmitter.

6-6.2.2 Fortuitous Distortion. Fortuitous distortion is the random displacement, splitting, or breaking up of the MARK and SPACE elements. It is caused by things such as cross talk interference between circuits, atmospheric noise, power line induction, poorly soldered connections, lightning storms, and dirty keying contracts. See Figure 6-20, comment F.

a. On radio circuits, fortuitous distortion is caused by noise, interference, and multipath conditions. The results vary from an occasional hit to a complete disruption of the signal.

b. Interchannel or adjacent channel interference on multichannel radio or carrier equipment may cause fortuitous distortion.

TELETYPEWRITER DISTORION



A. Perfect signal, 7.42 unit interval, 74.2 BAUD (character "J")

B. Marking Bias - approx. 25%

C. Spacing Bias - approx. 25%

D. End distortion

E. (1) Characteristic Distortion. 4th intelligence unit stays on space. Effect is to make letter "J" print as letter "A".

(2) Characteristic Distortion. 3rd intelligence unit stays on a mark. Effect is to make letter "J" print as letter "K".

F. Fortuitous Distortion.

Figure 6-20. Teletypewriter Distortion.

c. Any minor breaks in signal elements are properly called fortuitous distortion, but the duration or length of such breaks may be so short as to go unnoticed except in some sensitive distortion measuring devices. If a break of 1 millisecond occurs at the instant of sampling, and the receiving device has a sampling interval of 4 milliseconds, then the loss will not be noticed. If the same conditions exist but the sampling interval is only one-half millisecond, then the element may be completely lost. To properly interpret the effect of fortuitous distortion on a traffic circuit, extensive knowledge of the receiving devices and distortion measuring equipment characteristics is required.

6-6.2.3 End Distortion. End distortion is the uniform displacement of MARK-to-SPACE signal transitions with no significant effect on SPACE-to-MARK transitions. It is caused by the combination of resistance, inductance, and capacitance in the circuit. See Figure 6-20, comment D.

6-6.2.4 Characteristic Distortion. Characteristic distortion is a repetitive displacement or disruption peculiar to specific portions of the signal. It normally is caused by mechanical maladjustment or broken parts of the sending equipment. It differs from fortuitous distortion in that it is repetitive instead of random. An example would be the repeated splitting of the third code element of a teletypewriter signal, resulting in the transmission of a MARK vice a SPACE. See Figure 6-20, comment E.

6-6.2.5 Distortion Measurements. Proper analysis of signals depends on the skill of the individual, understanding of the nature of the receiving devices and the distortion measuring devices used. The two modes of transmission, start-stop and synchronous, use different methods of establishing a reference point from which to have a sampling interval. Therefore, distortion measuring equipment should be capable of "sensing" the received signal in the same manner the receiving device uses on the circuit. The term "maximum distortion", used in a table of allowable distortion, is a percentage calculated from the ratio of the difference between an observed unit interval and an ideal unit interval. For example, if the correct unit interval is 22 milliseconds and the maximum displacement, early or late, of a transition is 8 milliseconds, the ratio of maximum distortion is 8:22, or approximately 36 percent.

a. The degree of distortion present on start-stop signals is the same as the maximum distortion explained above except that the time (which establishes the relationship or ratio between the observed signal and the ideal signal) is based upon the beginning of the start element in the signal being measured. The ideal signal timing is established internally within the distortion measuring device, and is triggered by the beginning of the start impulse.

b. Distortion measurements of synchronous signals can be made with distortion measuring devices set to the start-stop mode. This method of measurement uses the MARK-to-SPACE transition as the reference point from which to establish an ideal and compare the deviation of the transitions. It also counts a block of elements equivalent to the unit code setting of the measuring device. The next MARK-to-SPACE transition which occurs is used as the reference point for the next block of elements. Distortion test procedures are outlined in Chapter 3, Section 1.

CHAPTER 6
FACTORS AFFECTING QUALITY OF COMMUNICATIONS

SECTION 7
LANDLINE COMMUNICATIONS

6-7.0 General. In many ports, landlines are provided at the pier for telephone and teletypewriter communications. To facilitate maintenance, conserve the RF spectrum and lessen the workload on shipboard communicators, full-period terminations are shifted to landline when possible. Both audio and DC methods are employed.

6-7.1 Audio. In this mode of operation the DC signals from the send crypto equipment are converted to audio tones by utilizing audio tone equipment such as the AN/UCC-1. The audio tones are operated into the landline through audio filters. If the AN/UCC-1 is used, single or "untwinned" operation is employed. Only those tones from drawers which are actually being keyed should appear in the output as one multiplexed signal. The remainder of the drawers should be turned off or "idled out". Many times, to conserve shore lines, the serving NAVCOMMSTA may utilize one common landline for more than one ship. This is made possible by one ship keying a group of drawers within a certain audio frequency band, such as 425 to 1615 Hz, and another ship keying another group of drawers in another audio frequency band, such as 1785 to 2975 Hz. For this reason extreme care must be exercised to ensure that each ship and shore station key only those drawers which have been designated by the NAVCOMMSTA, and that the transmit audio levels are set as directed by the NAVCOMMSTA.

6-7.2 DC Keying. For single channel terminations, either simplex or duplex operation, the signal for crypto equipment may be sent via DC landline. The NAVCOMMSTA will provide battery for the DC loop, however, when crypto equipment is utilized, the keying must be filtered prior to leaving the ship. A DC isolation filter is used to fulfill this requirement. When the DC isolation filter is utilized the ship must provide DC battery to the ship side of the filter and the shore facility provides DC battery to the off-ship side of the filter. Permission must be obtained from higher authority prior to keying crypto equipment into landlines without the use of these filters.

6-7.3 Problems. Many problems may be encountered when a ship attempts communication via landline. Most problems can be avoided or easily solved by:

a. A complete understanding of a signal flow from the ship's patch panel to the shipboards

APPENDIX A

Basic Quality Monitoring System

A-1 General. This appendix contains information necessary for the fabrication, installation and operation of a Basic Quality Monitoring System (QMS). Figures A-1 and A-2 show typical relations between a Basic QMS and an Radio Communication System (RCS). Paragraph A-2 is an outline giving functional capabilities of the Basic QMS. Figure A-3 is a pictorial of the two cabinets showing a typical shipboard communications quality monitoring console. Figures A-4 and A-5 are the cabinet wiring diagrams necessary for fabrication of a Basic QMS. Tables A-1 and A-2 list the equipment and parts necessary for fabricating the Basic QMS. Figures A-6 through A-9 provide details for fabrication of various assemblies. Paragraph A-3 and Figures A-10 through A-17 provide information, parts lists and drawings to aid in accomplishing the required modifications of the R-1051B/URR receiver for utilization in the Basic Quality Monitoring System. Figure A-18 gives the procedures and Table A-3 gives the parts necessary for the fabrication of the DC Test Patch Cord.

A-2 Basic Quality Monitoring System Function and Capabilities. The Basic QMS is a multifunction equipment group used as a master monitor for a Radio Communication System (RCS). The QMS permits evaluations of equipment performance both on-line and off-line to facilitate failure prediction, identification of interference origins, and equipment fault isolation through manual monitoring of RCS systems. Monitoring and fault isolation functions are accomplished on LF, MF, HF,VHF and UHF communications circuits within the Radio Frequency Range of 9KHz to 400 MHz employing several modulation techniques. Signals can be monitored in the DC, Audio and RF sections of these circuits. The Basic QMS also enables the QMS operator to conduct limited signal analysis on On-Line Communications circuits. The QMS consists of two equipment racks, various test devices, one UHF dedicated antenna, a 2-32 MHz antenna access and distortion analyzer. The equipment racks house the equipment listed in Table A-1.

The Basic QMS can accomplish the following QM tests as outlined in Chapter 3.

1. Teletype/Data signal analysis
    a. Signal Level (off-line only)
    b. Signal Shaping

c. % Speed Error
d. Distortion

2. Audio Signal Analysis
   a. Signal Level
   b. Aural Monitoring (Send Audio only, Off-line only)
   c. Audio Line Balance (Send Audio only, Off-line only)

3. R.F. Signal Analysis
   a. Frequency (HF AM, HF Composite Tones)(HF SSB Voice, off-line only) (MF/HF above 2 MHz FSK AFTS Single Channel, off-line only)
   b. Signal above Noise
   c. Linearity of HF Multichannel/Ratt Tones (off-line only)
   d. Harmonic/Inter-Modulation Distortion (off-line only)
   e. Carrier Suppression (HF, SSB and FSK) (off-line only)
   f. Non-Secure/Secure VHF/UHF Spectrum Analysis

A-3 R-1051/URR Modifications for Quality Monitoring Systems.

a. The necessary modifications require tapping off the 500 kHz IF stage and the VERNIER oscillator output, and extending these signals to two BNC connector jacks at the rear of the receiver's cabinet via two separate coaxial (RG-174/U) cables. The 500 kHz IF signal from the receiver is connected to the Spectrum Analyzer (500 kHz input) in the Quality Monitoring System for utilization in spectrum analysis of off-the-air signals. The VERNIER oscillator output signal from the receiver is connected to the Frequency Counter input in the Quality Monitoring System for utilization in frequency measurements of off-the-air signals.

b. Included in this Appendix is one other modification that changes the present R-1051B/URR VERNIER control (with 360 degree rotation) to a 10-turn (3600 degree rotation) dial and potentiometer. This modification is not absolutely necessary for the Quality Monitoring receiver, but will allow the operator to more precisely tune the VERNIER control for a lissajous pattern when making frequency measurements. The present 360 degree VERNIER control presents a problem of being too critical when used for fine tuning, especially when "cutting" individual MARK/SPACE frequencies of a Multichannel tone package.

A-3.1 Installation of Rear Cabinet BNC Connectors.

a. Figure A-10 is a drawing, indicating the location and measurements for installing the VERNIER OUT and IF OUT BNC connector jacks at the rear of the R-1051B/URR receiver cabinet.

A-3.2 500 kHz IF Output.

a. The IF signal is taken from the REC IF OUT-TP-8 of the RF TRANSLATOR unit (A2A6A6) and extended via RG-174/U cable to the rear cabinet BNC connector.

b. Figure A-11 represents the detail of how the end of the RG-174/U cable should be dressed. A center connector pin, obtained from a snap-on type RF Coaxial connector as used on RF patch cords for the AN/SRA-12 or equivalent, is soldered to the center conductor of the RF-174/U cable. The braided shield (outer conductor) of this cable should be dressed long enough and with a terminal lug so that it may be attached to ground at the fastening screw of the IF AUDIO AMPL module unit. Bend the end of the cable, where the center connector pin is attached, 90 degrees so that it will fit into TP-8 at the top of the RF TRANSLATOR module unit. Ensure that the end of this cable is fixed so that no portion of the center conductor will short to ground after installation of the cable.

A-3.3 Vernier Output.

a. The VERNIER oscillator output signal is taken from TP-3 of the 100 CPS SYNTHESIZER unit (A2A6A4) and extended via RG-174/U cable to the rear cabinet BNC connector.

b. Figure A-11 represents in detail how the end of the RG-174/U cable should be dressed. A center connector pin, obtained from a snap-on type RF coaxial connector as used on RF patch cords for the AN/SRA-12 or equivalent, is soldered to the center conductor of the RG-174/U cable. The braided shield (outer-conductor) of this cable should be dressed long enough and with a terminal lug so that it may be attached to ground at the fastening screw to the right of TP-3 on the 100 CPS SYNTHESIZER module. Bend the end of the cable, where the center connector pin is attached, 90 degrees so that it will fit into TP-3 at the top of the 100 CPS SYNTHESIZER module. Ensure that the end of this cable is fixed so that no portion of the center conductor will short to ground after installation of the cable.

A-3.4 RG-174/U Installation. Figure A-12 shows the top portion of the R-1051B/URR (cut away view) and how the RG-174/U cables are installed and run from the necessary Test Points (TP) to the back of the chassis. Ensure the cables are stuffed down in between the modules so that when closing and opening the receiver chassis, the cables are not caught on the top of the cabinet. At the back of the chassis, run the cables down to the main cable harness and extend along this harness to the newly installed BNC connectors. These RG-174/U cables should be taped to the main cable harness with black electrical plastic tape. Cut, dress and solder these cables to their respective BNC connectors at the inside rear of the cabinet.

A-3.5 Vernier Control Replacement.

a. For installation of this modification, a new CPS switch knob must be manufactured as drawn in Figure A-13. This knob should be manufactured from stock aluminum. Precise measurements, drillings and treadings are required in the manufacture of this knob.

b. The precision potentiometer required for this modification may be "open purchased" as indicated in the Parts List (Table C-1) until a modification kit is available in the Navy Supply System. The shaft on this potentiometer must be at least 2 inches in length and 1/8 (.128) inch diameter. For installation, remove the present CPS and VERNIER knobs as indicated in Figure A-14. Unsolder the leads from the present VERNIER potentiometer (A2R7) and remove the potentiometer. Install the new potentiometer and solder the leads electrically, identical to the way they were on the old potentiometer (refer to Figure A-15). Install the new CPS knob and Revodex (planitary) dial as indicated in Figures A-16 and A-17. Calibrate the Revodex primary and secondary dials (inner and outer dials respectively) at 00 with the 10-turn potentiometer set fully counter-clockwise and tighten the set-screw (installation instructions are included with the Revodex Dial).

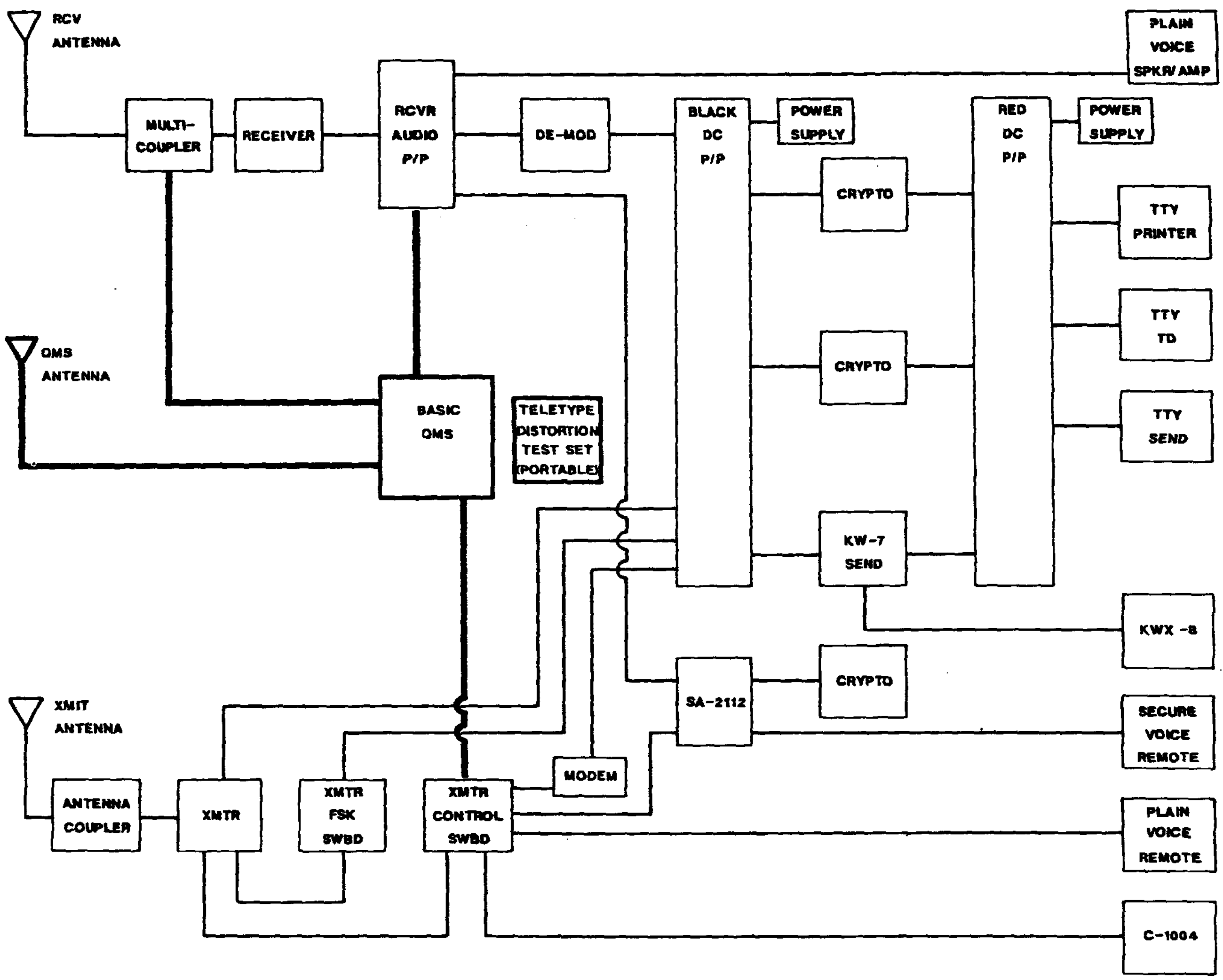


Figure A-1. Basic Quality Monitoring System Block Diagram For Radio Communication Systems Testing.

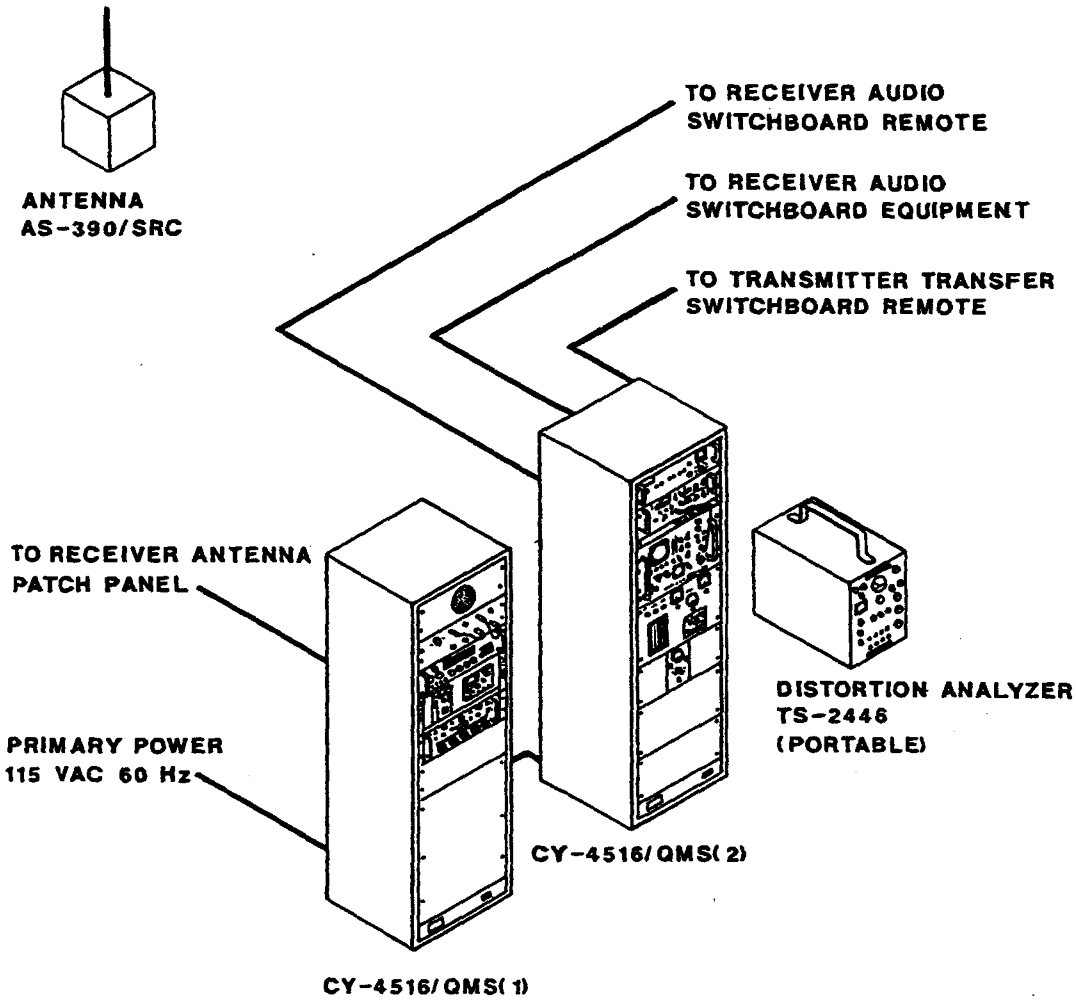


Figure A-2. Basic Quality Monitoring Subsystem.

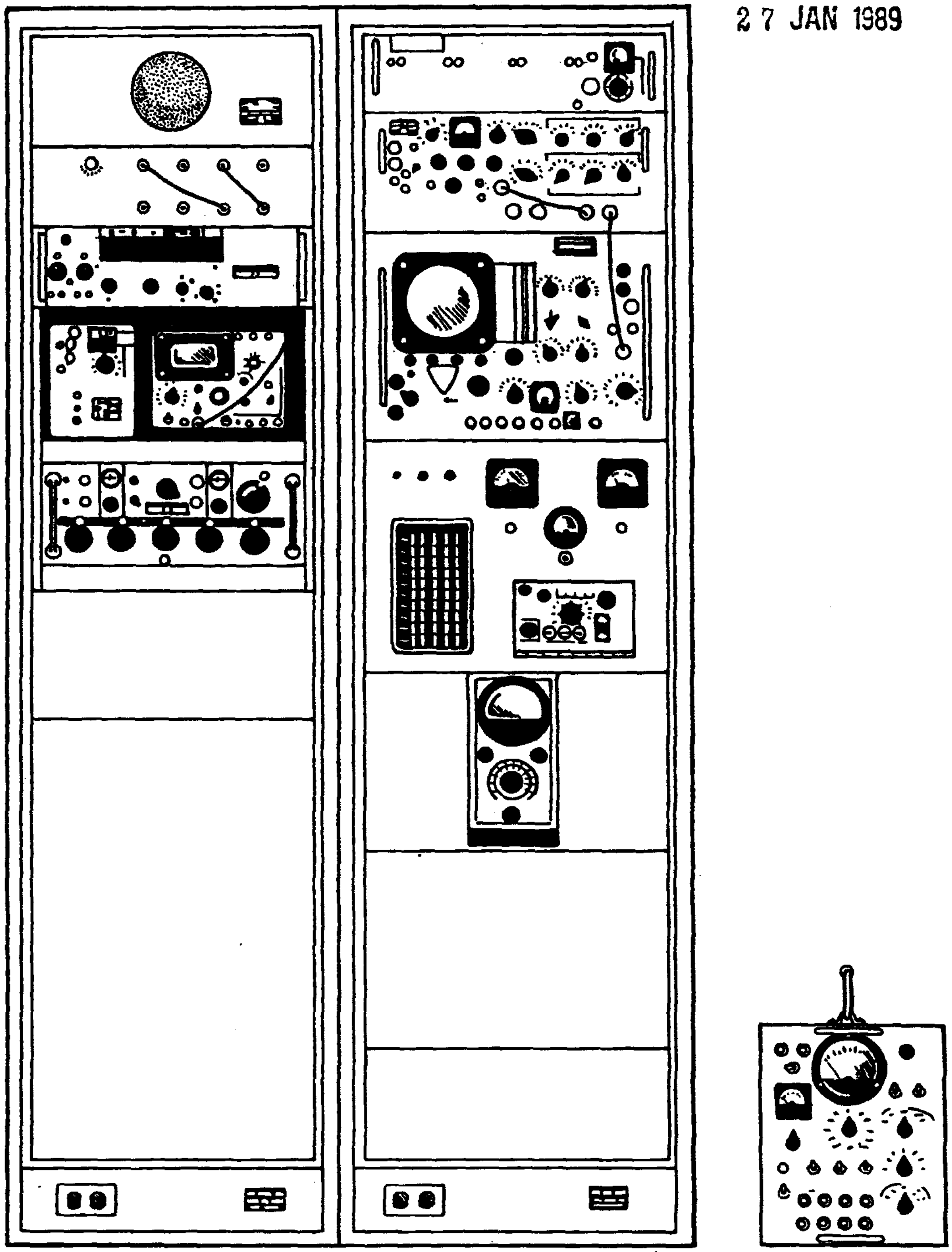


Figure A-3. Basic Quality Monitoring System Pictorial.

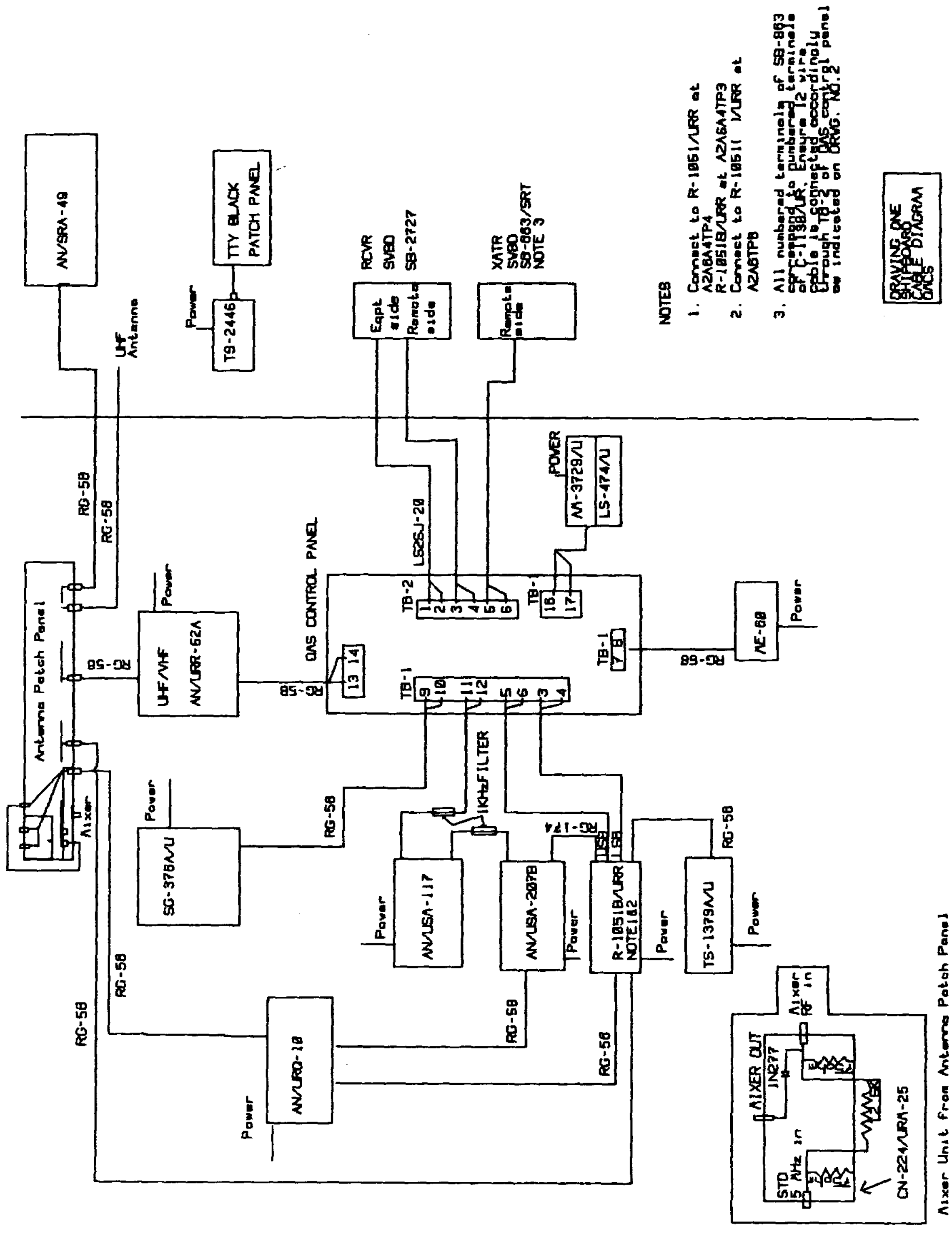


Figure A-4. Basic Quality Monitoring System Wiring Diagram.

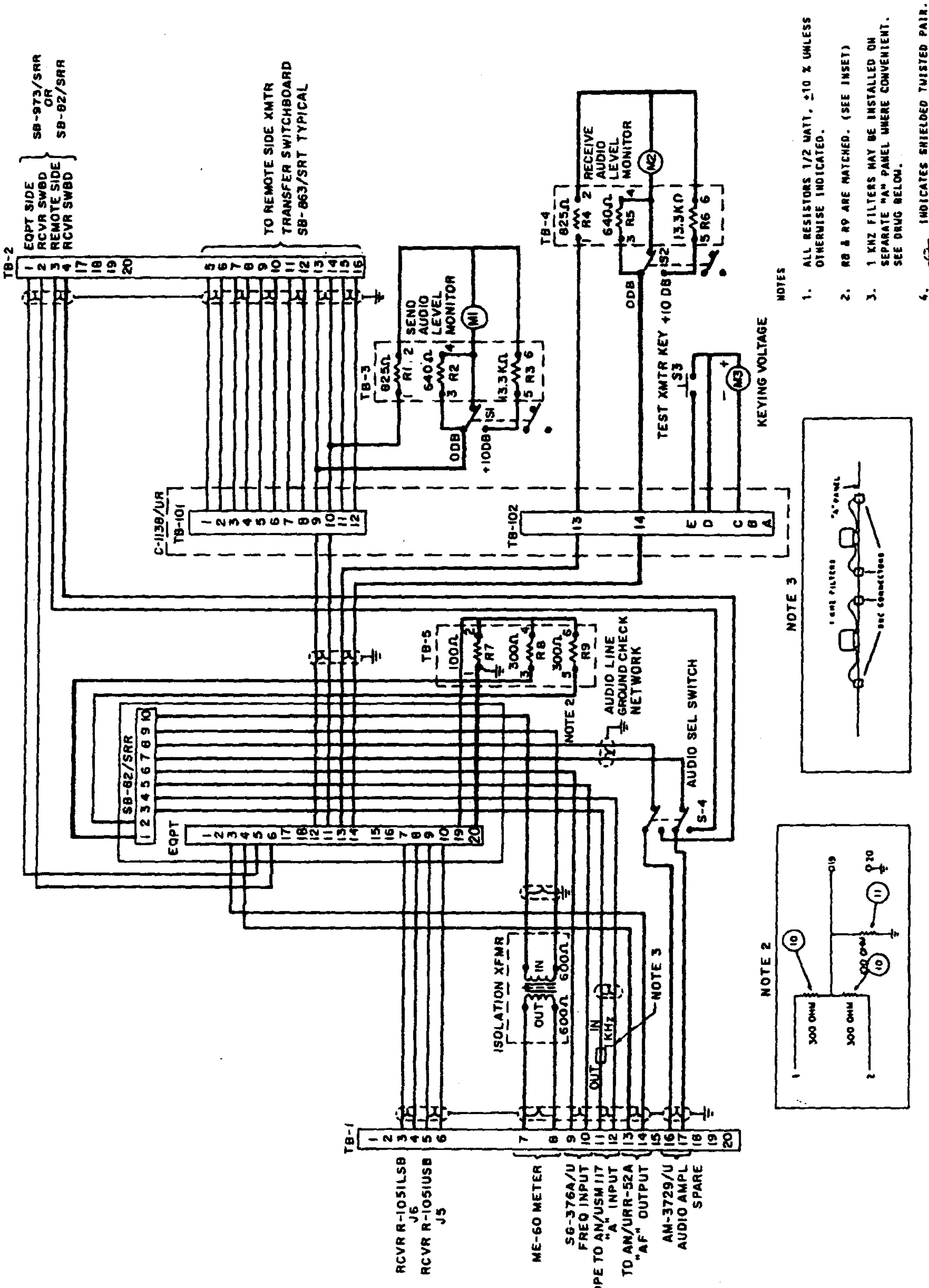


Figure A-5. Basic Quality Monitoring System Cabinet Wiring Diagram.

TABLE A-1
LIST OF RECOMMENDED EQUIPMENT FOR QUALITY MONITORING CONSOLE

COMPONENTS	QTY	FSN	ITEM NO.	REMARKS
R-1051B/URR HF Receiver	1	2Z 5820-00-948-3408		NOTE 1
AN/URR-52A VHF/UHF Receiver	1	5820-00-999-8022		NOTE 2
AN/USM-117C Oscilloscope	1	6G 6625-00-998-0356		
AN/USM-207B Frequency Counter	1	6G 6625-00-150-6484		
TS-2616 Distortion Analyzer	1	4G 6625-00-857-4351		
TS-2446 Distortion Analyzer	1	6G 6625-00-999-7415		
TS-1379A/U Spectrum Analyzer	1	6G 6625-00-489-0576		
SG-376A/U Two Tone Sig Gen	1	6G 6625-00-880-1569		
Mode 300H-U7 dB Meter	1	6G 6625-00-839-8012		
AM-3729/U Amplifier	1	1N 5820-00-999-2591		
LS-474/U Speaker	1			
SB-82/SRR Audio Patch Panel	1	4G 5820-00-508-7802	1	
C-1138/U Transmitter Remote	1	1N 5820-00-681-8038	15	
CN-1128/U 0-120 Attenuator	1	9N 5985-00-957-1860	2	
1 kHz Audio Filter	2	9N 5915-00-503-4624	19	
VU Meter	2	1N 6625-00-678-5478		
DC Volt Meter	1	1N 6625-00-649-4825		
1:1 600 OHM Isolation Transformer	1	9N 5950-00-645-1943	6	
3 Position Toggle Switch	2	9N 5930-00-548-7855		
2 Position Toggle Switch	2	9N 5930-00-615-9376	8	
Push Button Switch	1	9N 5930-00-660-7004	9	
2.5 KOHM Potentiometer	1	9N 5905-00-581-1393	7	
300 OHM Resistor 1/2W	2	9N 5905-00-229-1965	10	
100 OHM Resistor 1/2W	1	9N 5905-00-106-9344	11	
6490 OHM Resistor 1/2W	2	9N 5905-00-583-5207	12	
825 OHM Resistor 1/2W	2	9N 5905-00-577-7372	13	
13.3 KOHM Resistor 1/2W	2	9N 5905-00-581-1019	14	
Germanium Diode 1N277	1	9N 5961-00-669-6884	16	
CN-224/URM-25 Fixed Attenuator	1	9N 5905-00-644-7676	3	
BNC Connector	8	9N 5935-00-823-0308	17	
BNC Connector	1	9N 5935-00-665-7171	18	
10 Terminal - Terminal Board	4	9G 5940-00-983-6051	20	
CY-4516 A/S	2	5975-00-908-9159		
"D" PANEL BLANKING (AS REQ'D)		5975-00-665-1012		
"F" PANEL BLANKING (AS REQ'D)		5975-00-253-9743		
SCREW NO. 10-32X3/4 DELBERT BLINN	(AS REQ'D)			
CUP WASHERS MCW-10 RAIL/EQUIP MTG	(AS REQ'D)			
NYLON FILLER WASHERS NW-15-10 RAIL/EQUIP MTG		(AS REQ'D)		

NOTE 1: Modified for Quality Monitoring use as outlined in PARAGRAPH A-3.

NOTE 2: Air Force Stock Number, no COG, coded FFZ. Carrying point is:
Sacramento Air Material Area
McClellan AFB, California 95652

TABLE A-2

PARTS LIST FOR R-1051B/URR MODIFICATIONS FOR QUALITY MONITORING SYSTEM

ITEM	QUANTITY REQUIRED	NOMENCLATURE OR DESCRIPTION	REMARKS
1	1 ea.	Potentiometer, SPECTROL Model #534-295, Linearity 50527, 30 KOHM	Spectrol Electronics Co. 17070 E. Gale Avenue City of Industry, Ca. 91745
2	2 ea.	Set screw, Hex Socket #6-32 x 3/16" Long	Set screws for CPS switch knob.
3	1 ea.	Dial, 10-turn, REVODEX #RD-422	For 10-turn potentiometer (VERNIER CONTROL).
4	1 ea.	Knob, CPS switch	Manufactured as outlined in Appendix C, Para 6.
5	2 ea.	Connector, BNC coaxial AMPHENOL #31-318	For mounting at rear of R-1051B/URR cabinet.
6	10 ft.	Cable, coaxial RG-174/U	Cut to required lengths for IF & VERNIER OUTPUT cable runs.

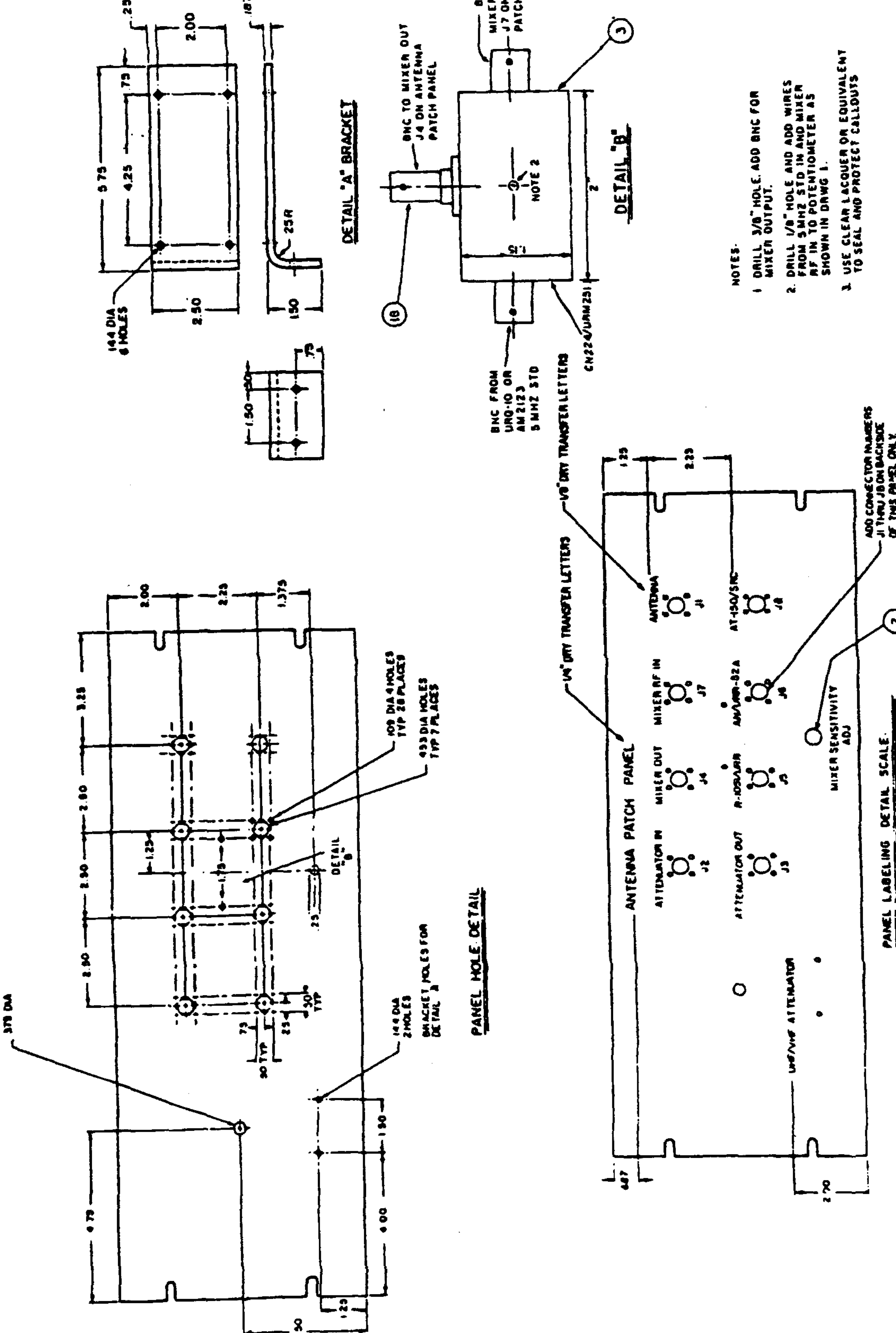
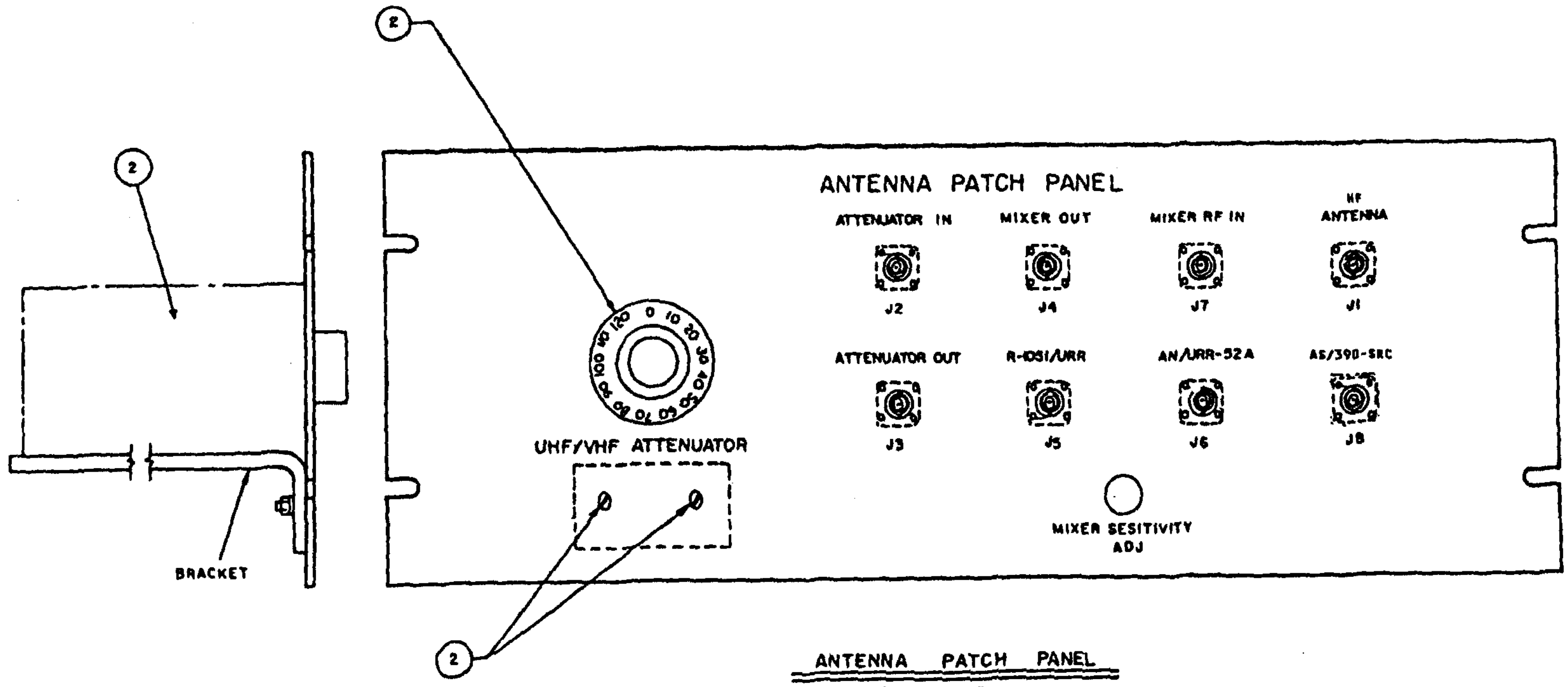


Figure A-6. Antenna Patch Panel Detail Drawing.

LEGEND:
O - ITEM #



NOTE

1. FINISH-IRIDITE NO. 14 PER MIL-C-5541, PAINT PER MIL-E-15090 ENAMEL.

LEGEND:
O - ITEM #

Figure A-7. Antenna Patch Panel Pictorial.

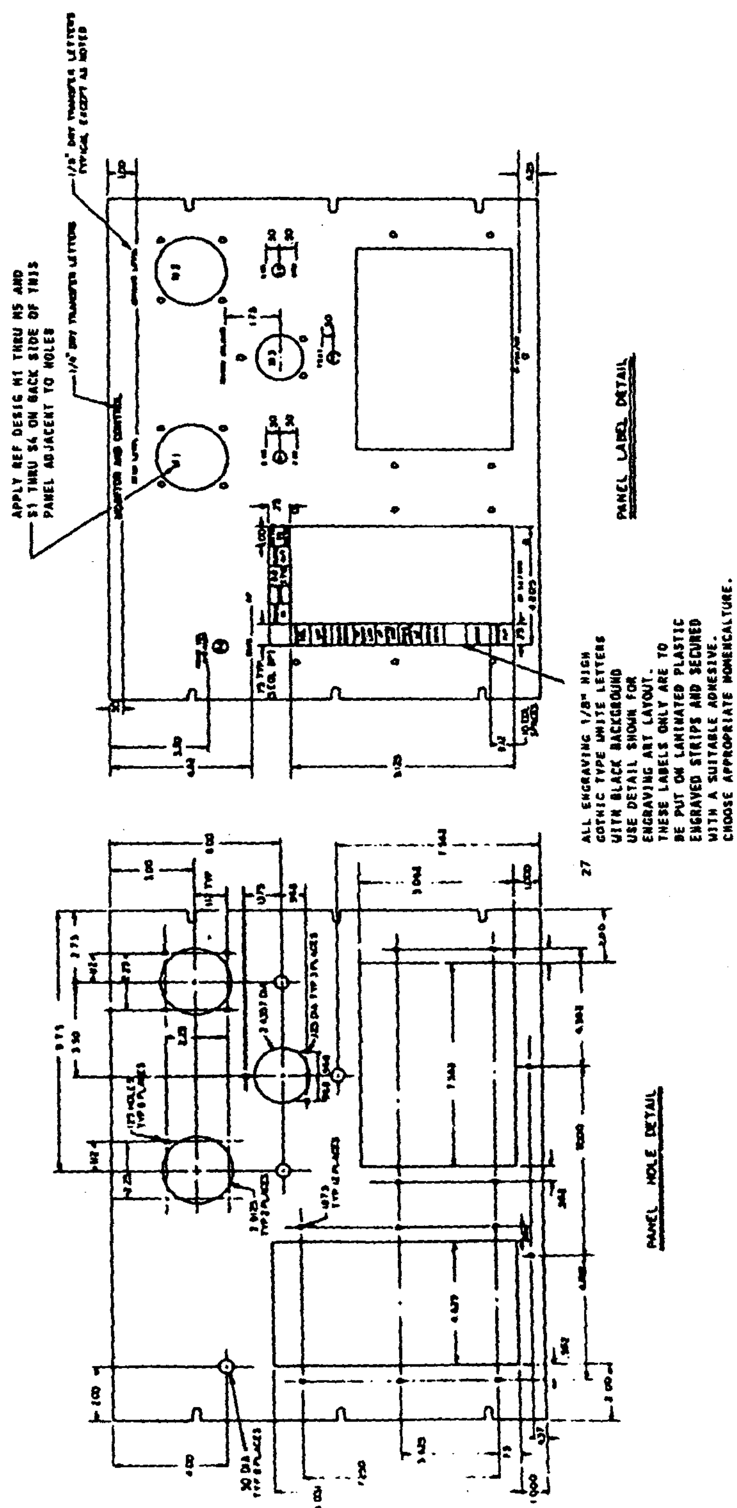
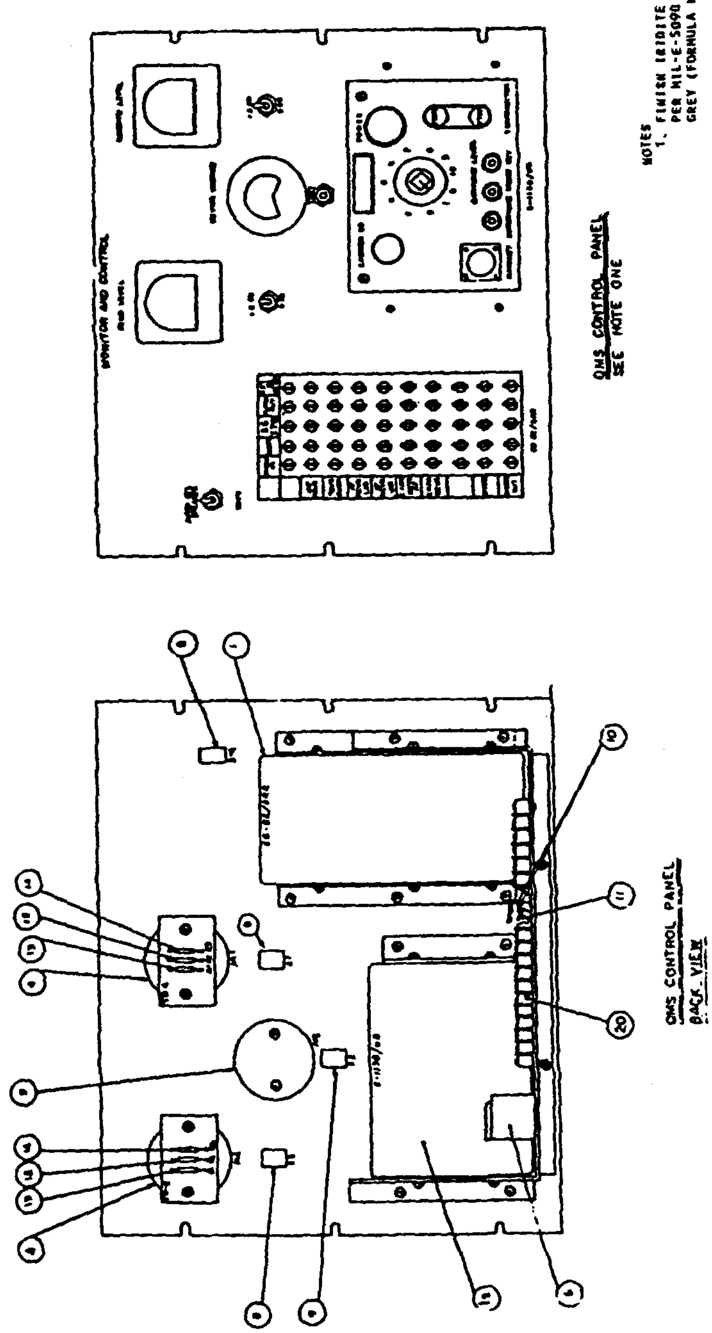


Figure A-8. QMS Control Panel Detail Drawing.

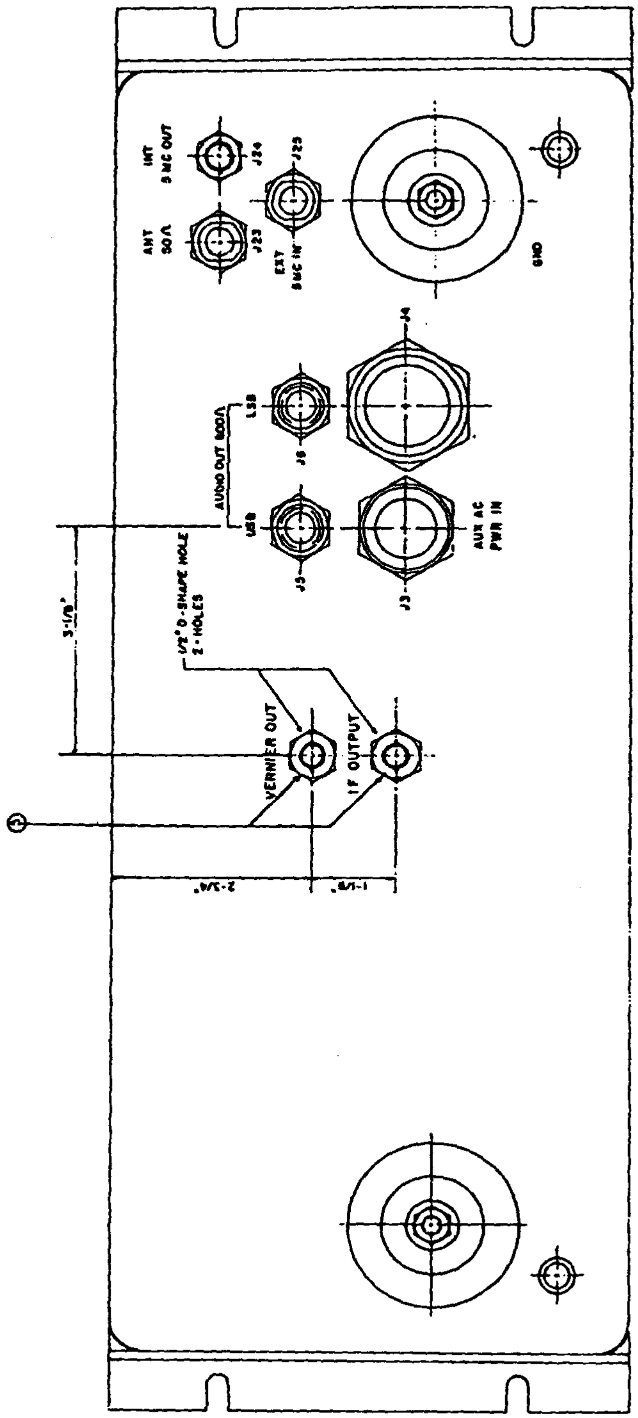
NOTES
1. FINISH IRIDITE NO. 14 PER MIL-C-5541 PAINT PER MIL-E-5090 ENAMEL EQUIPMENT LIGHT GREY (FORMULA NO. 11).
2. SEE TECHNICAL MANUAL FOR C-1138/U TRANSMITTER REMOTE FOR DETAILS.

(SEE TABLE A-1).



LEGEND:
O - ITEM #

Figure A-9. QMS Control Panel Layout.



REAR VIEW OF R-1051B/URR CABINET SHOWING DETAILED LOCATION AND MEASUREMENTS FOR INSTALLATION OF VERNIER OUT AND IF OUTPUT OF BNC CONNECTOR JACKS

LEGEND:
O - Item #

Figure A-10. R-1051B/URR Rear View Detail Drawing.

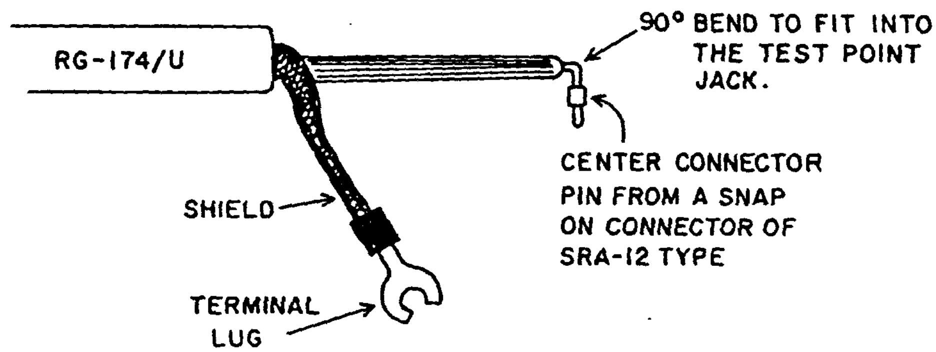


Figure A-11. Vernier/IF Output Cable Detail Drawing.

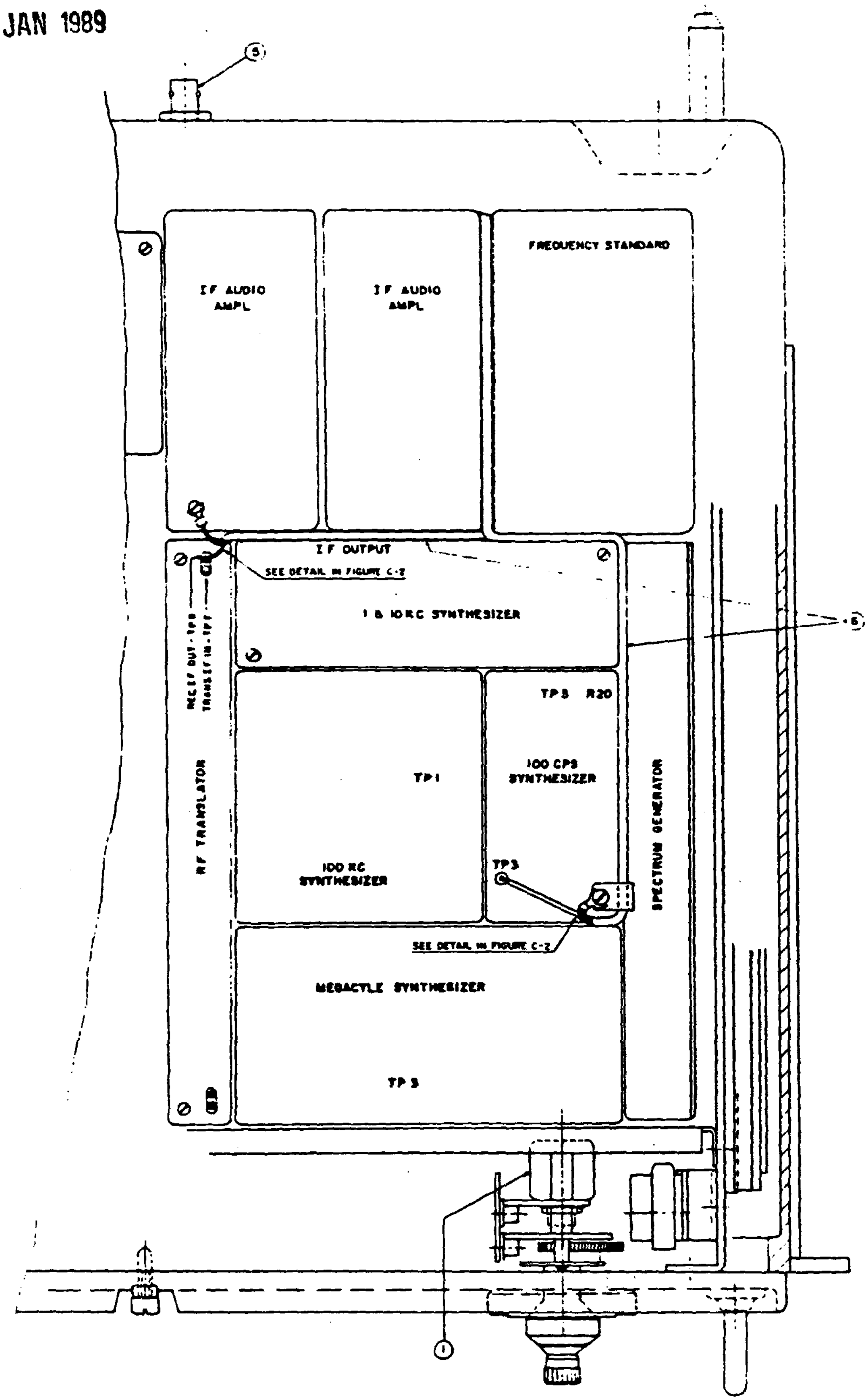
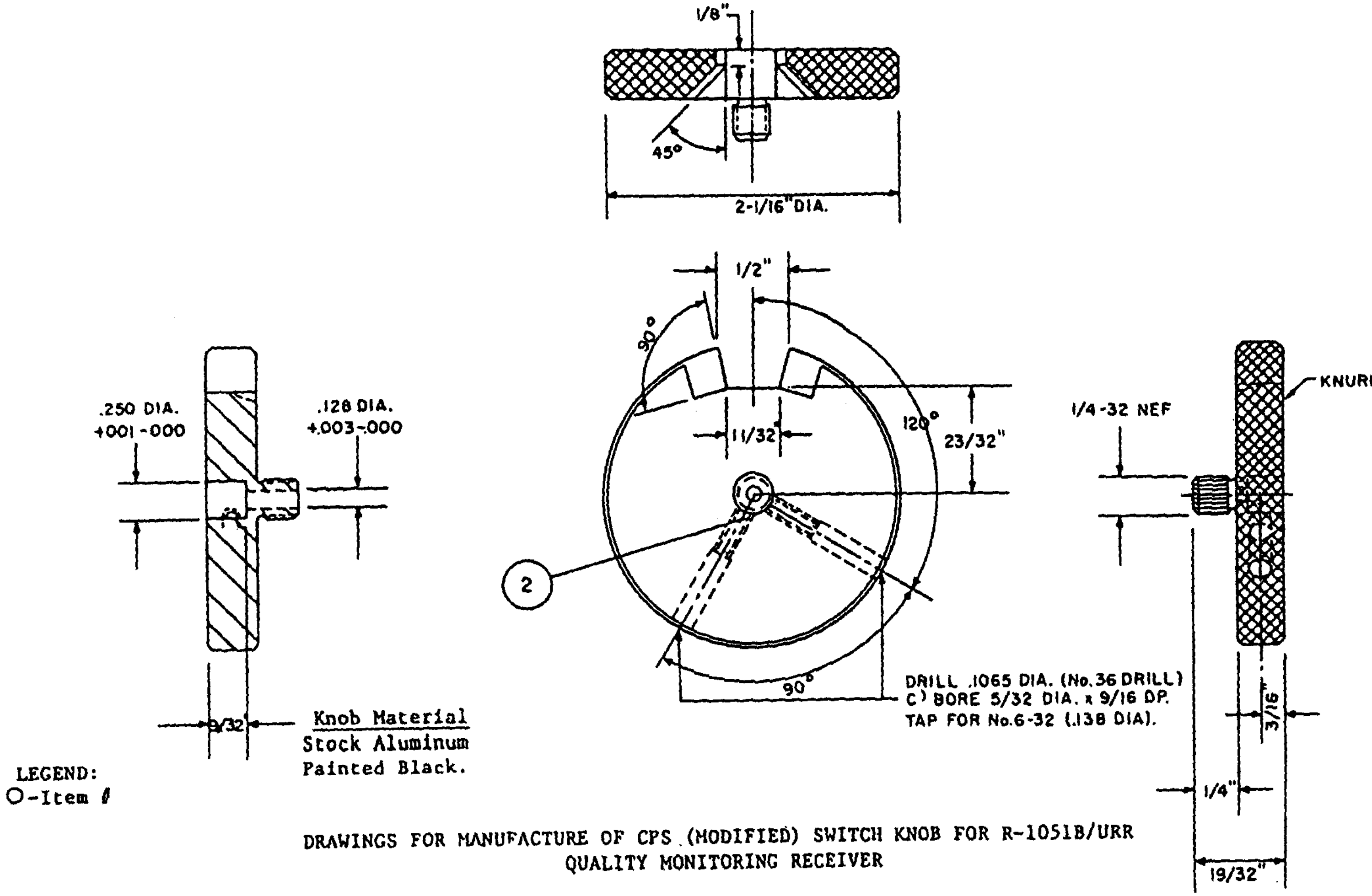


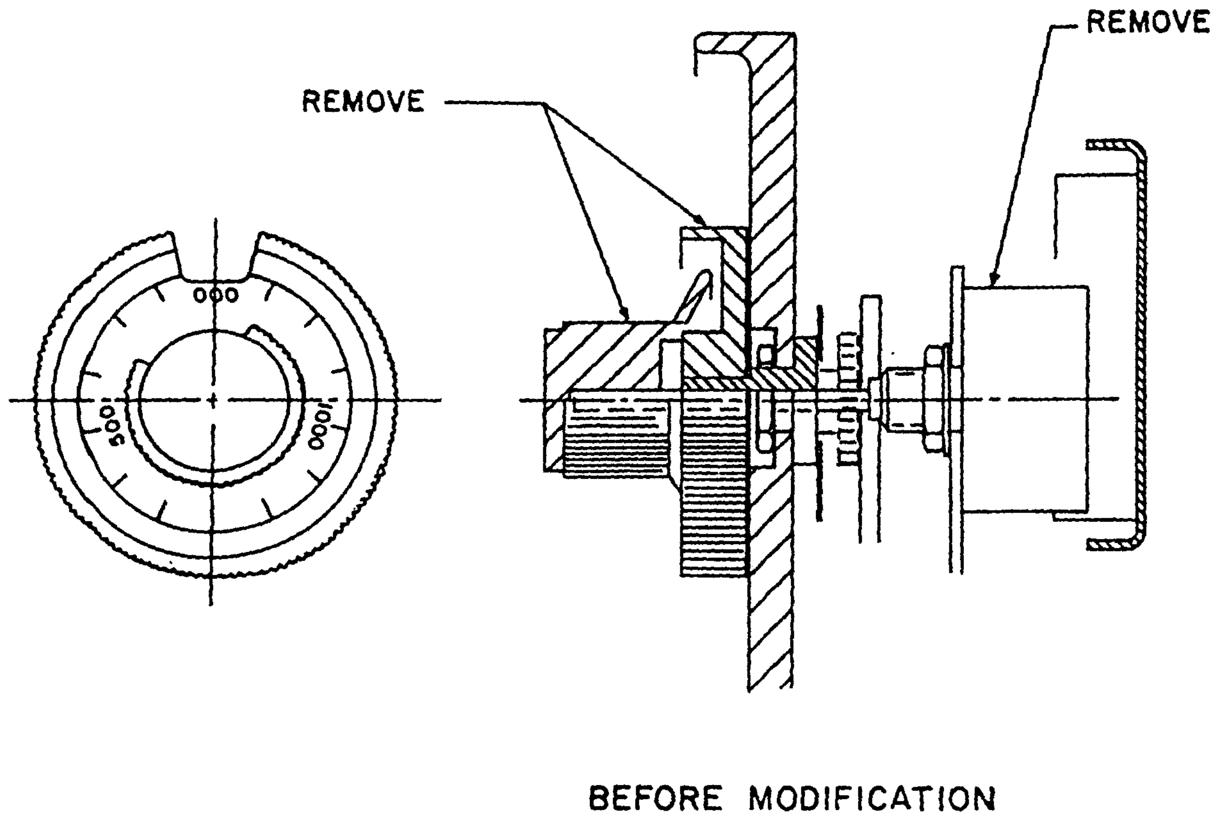
Figure A-12. R-1051B/URR, Top View Recommended RG-174 Cable Routing.

LEGEND:
O - Item #



DRAWINGS FOR MANUFACTURE OF CPS (MODIFIED) SWITCH KNOB FOR R-1051B/URR
QUALITY MONITORING RECEIVER

Figure A-13. R-1051B/URR, CPS Knob Detail Drawing.



SIDE VIEW OF R-1051B/URR VERNIER CONTROL,

POTENTIOMETER AND CPS SWITCH KNOB PRIOR TO MODIFICATION

Figure A-14. R-1051B/URR, Potentiometer and CPS Knob Prior To Modification.

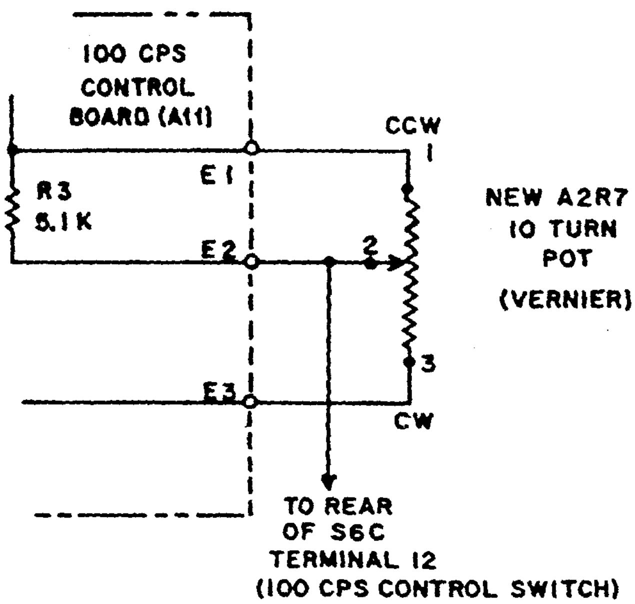
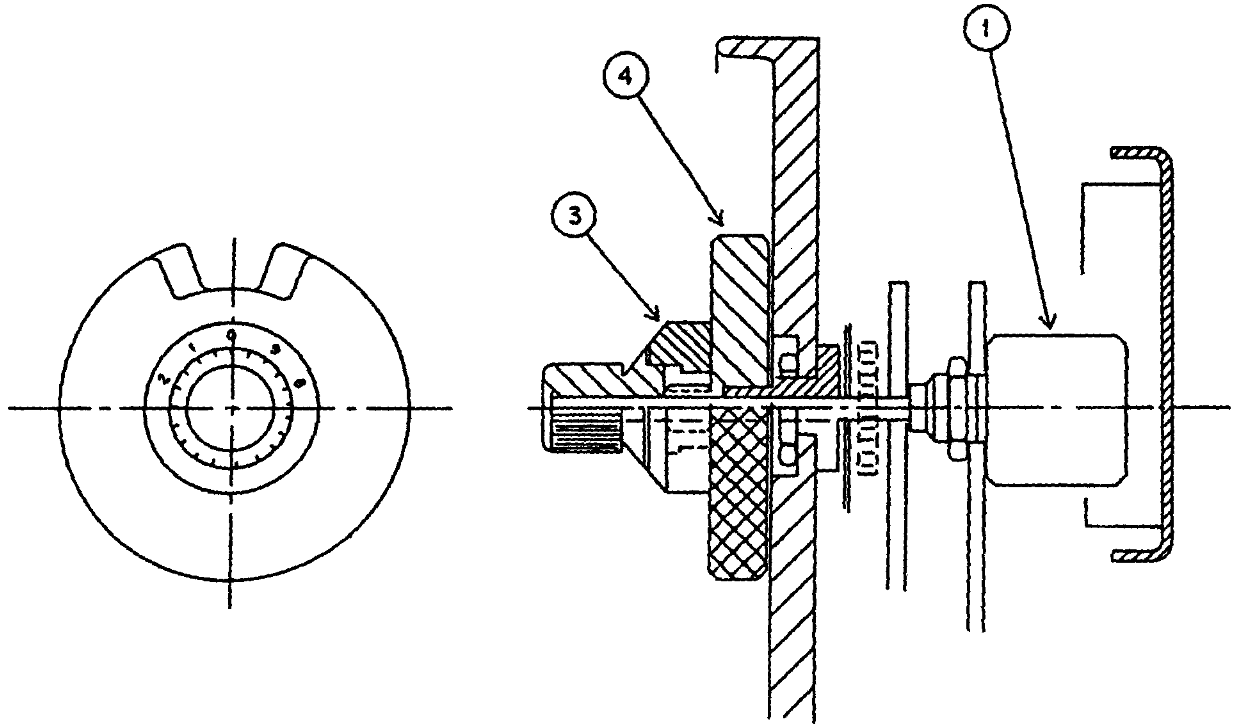


Figure A-15. R-1051B/URR, CPS Schematic Diagram.



AFTER MODIFICATION

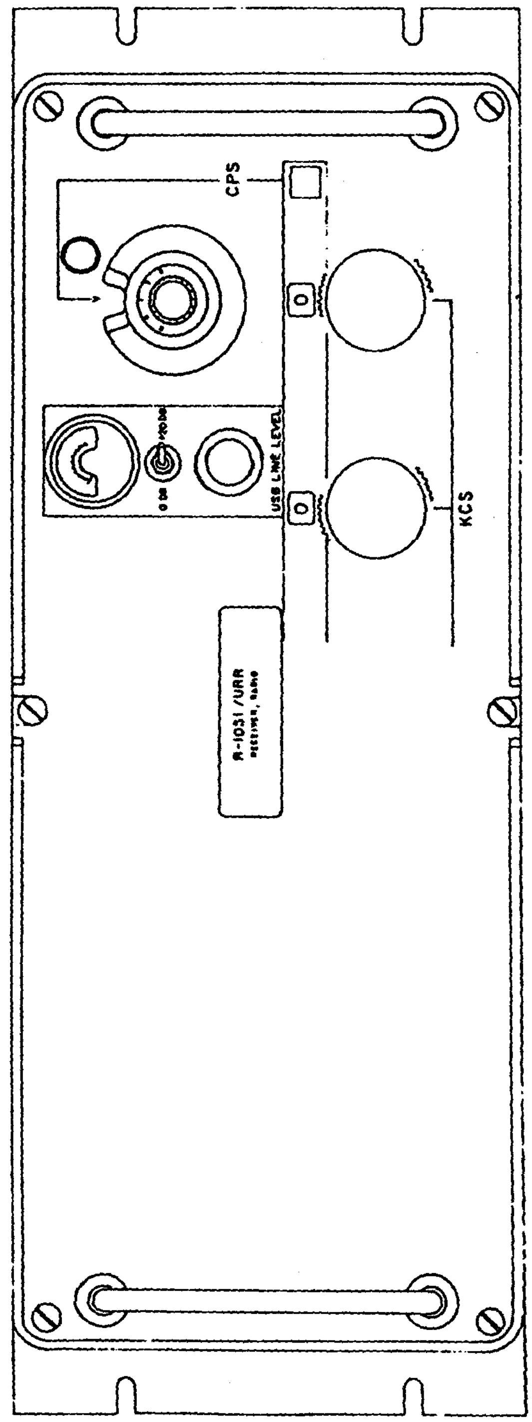
LEGEND:

O - Item #

SIDE VIEW OF R-1051B/URR VERNIER CONTROL POTENTIOMETER

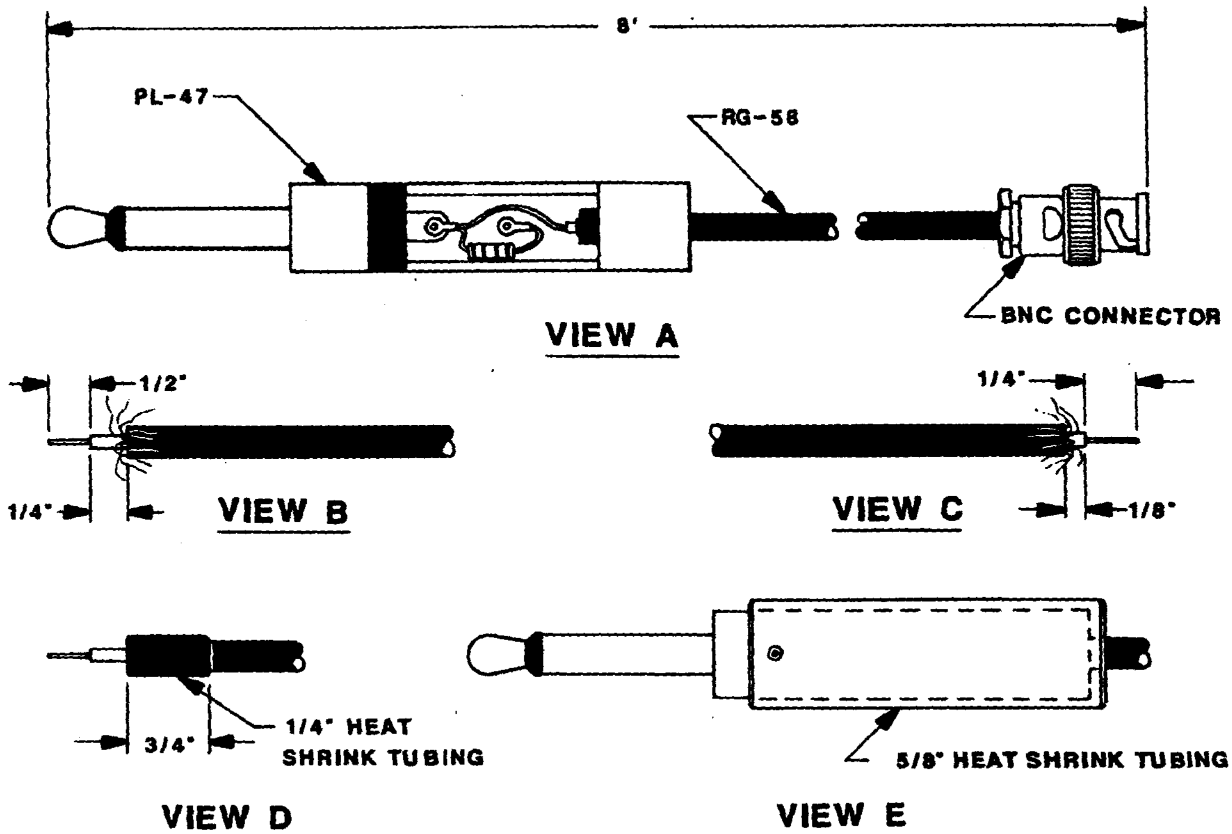
AND CPS SWITCH KNOB AFTER MODIFICATION AND INSTALLATION

Figure A-16. R-1051B/URR, Potentiometer and CPS Knob After Modification.



R-1051B/URR FRONT PANEL VIEW OF COMPLETED VERNIER CONTROL AND CPS SWITCH KNOB MODIFICATIONS

Figure A-17. R-1051B/URR Front Panel View Of Completed Vernier Control and CPS Knob Modification.



1. Prepare an 8-foot patchcord using RG-58 cable in accordance with View A.

2. Dress both ends of the 8-foot cable, one end in accordance with View B, the other in accordance with View C.

3. Clip shield on the View B end of the 8-foot cable and seal with 1/4" diameter Heat-Shrink-Tubing to cover the exposed shield. See View D.

4. Connect the center conductor of the RG-58 (end with the Heat-Shrink) to the "TIP" lug of the PL-47 Plug. See View A.

5. Solder an 18-OHM resistor between the "TIP" lug and the "SLEEVE" lug of the PL-47 Plug. See View A.

6. Connect a BNC connector to the free end of the 8-foot RG-58 cable. See View A.

7. Cover the PL-47 plug with 5/8" diameter Heat-Shrink-Tubing in accordance with View E.

Figure A-18. D.C. Test Patch Cord Detail Drawing.

TABLE A-3

PARTS FOR PATCH CORD CONFIGURATION
FOR DC TEST

QUANTITY REQUIRED	NOMENCLATURE OR DESCRIPTION
8 ft.	RG-58
1 ea.	Telephone Plug (PL-47)
1 ea.	Resistor 18 OHM 1/4W
1 ea.	Connector BNC
6"	Heatshrink tubing 1/4"
6"	Heatshrink tubing 5/8"

APPENDIX B

AN/SSQ-88/88A

B-1 General. The AN/SSQ-88 Quality Monitoring Set (QMS) is a multifunction equipment group used as a master monitor for a Radio Communication System (RCS). The QMS permits evaluations of equipment performance to facilitate failure predictions, identification of interference origins, and equipment fault isolation through manual monitoring of RCS Systems. Monitoring and fault isolation functions are accomplished on LF, MF, HF, VHF, and UHF communications circuits within the frequency range of 9KHz to 400 MHz and employing several modulation techniques. Signals can be monitored in the DC audio and RF sections of these circuits. The QMS also enables the QMS operator to conduct signal analysis on all circuits. The QMS consists of one equipment rack, one UHF dedicated antenna, and one dedicated HF antenna, or 2-32 MHz antenna access. The equipment rack houses ten electrical assemblies.

a. The QMS is subdivided into three functional areas:

1. Measurement and Display. This function provides all devices required to measure and display DC, AF, and RF signals.

2. Generating and Modulating. This function provides a means to generate and/or modulate signals up to 400 MHz.

3. Ancillary Equipment. This function permits miscellaneous controlling of the measurement and display, and the generating and modulating functions.

b. Collectively, the three functions provide the following capabilities:

1. Measurement of DC, AF, or RF voltage levels.

2. Measurement of audio DB levels.

3. Amplifying selected audio signals for local monitoring.

4. Generating modulated or unmodulated RF test signals.

5. Frequency measurements of RF and AF signals, signal-to-noise ratio.

6. Measurement and displaying channel spectrum.

7. Generating teletype test signals.

8. Analyzing teletype signals.

c. Technical manuals with the operating procedures for different types of QMS systems are:

QMS System	Technical Manual
AN/SSQ-92(V)1	EE169-DA-MMO-020
AN/SSQ-92(V)2	EE169-DB-OM1-020/E110-SSQ92V2
AN/SSQ-92(V)3	EE169-DC-MMA-020
AN/SSQ-88/88A	ET822-AA-OMP-010/P630 SSQ88/88A
OD-164/SRC	EE120-AA-OM1-030/E110 OD164SRC
OD-164B/SRC	EE120-AA-OM1-030/E110 OD164SRC
OD-164C/SRC	EE120-AA-OM1-030/E110 OD164SRC

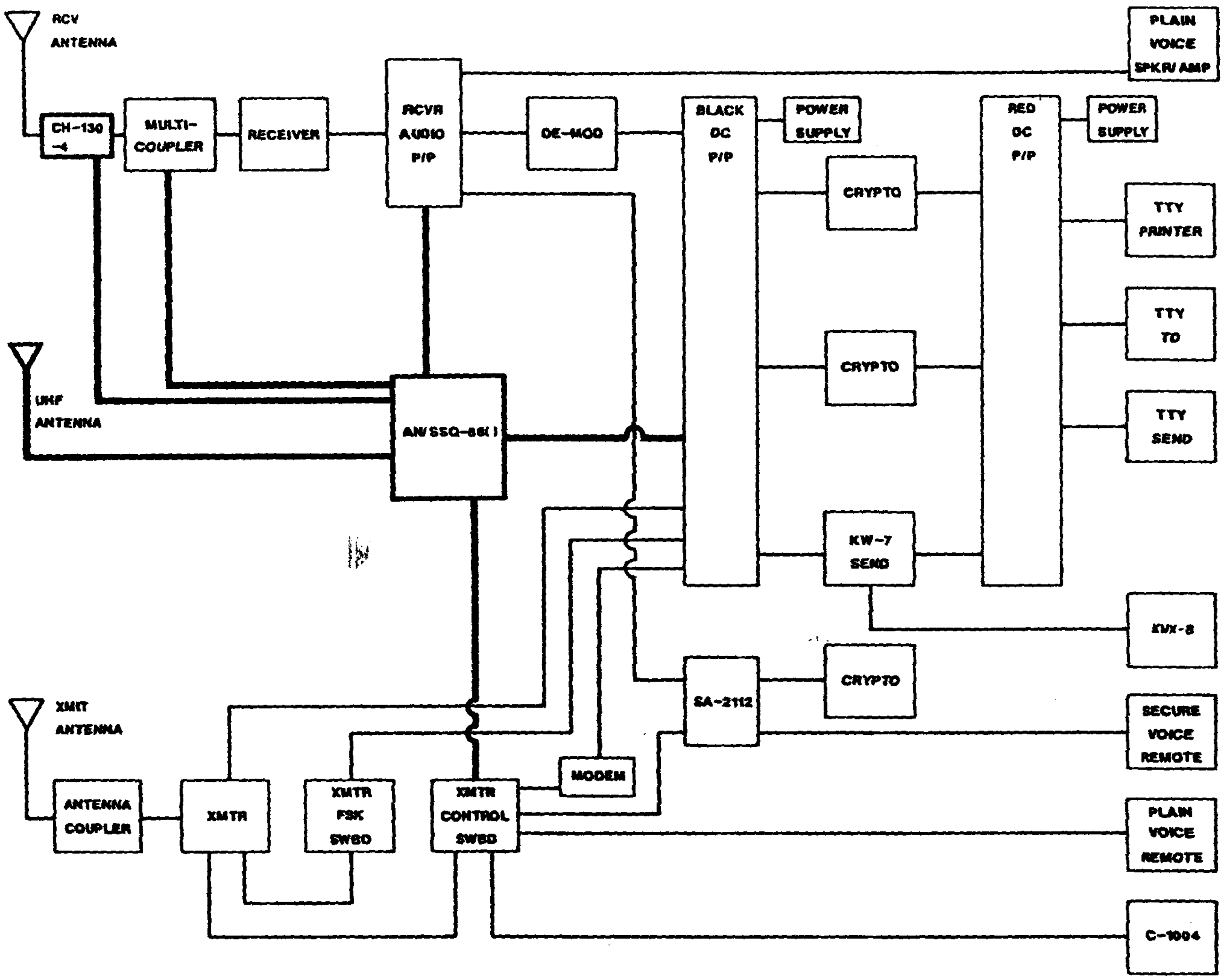


Figure B-1. AN/SSQ-88/88A Quality Monitoring System Block Diagram For Radio Communication Systems Testing.

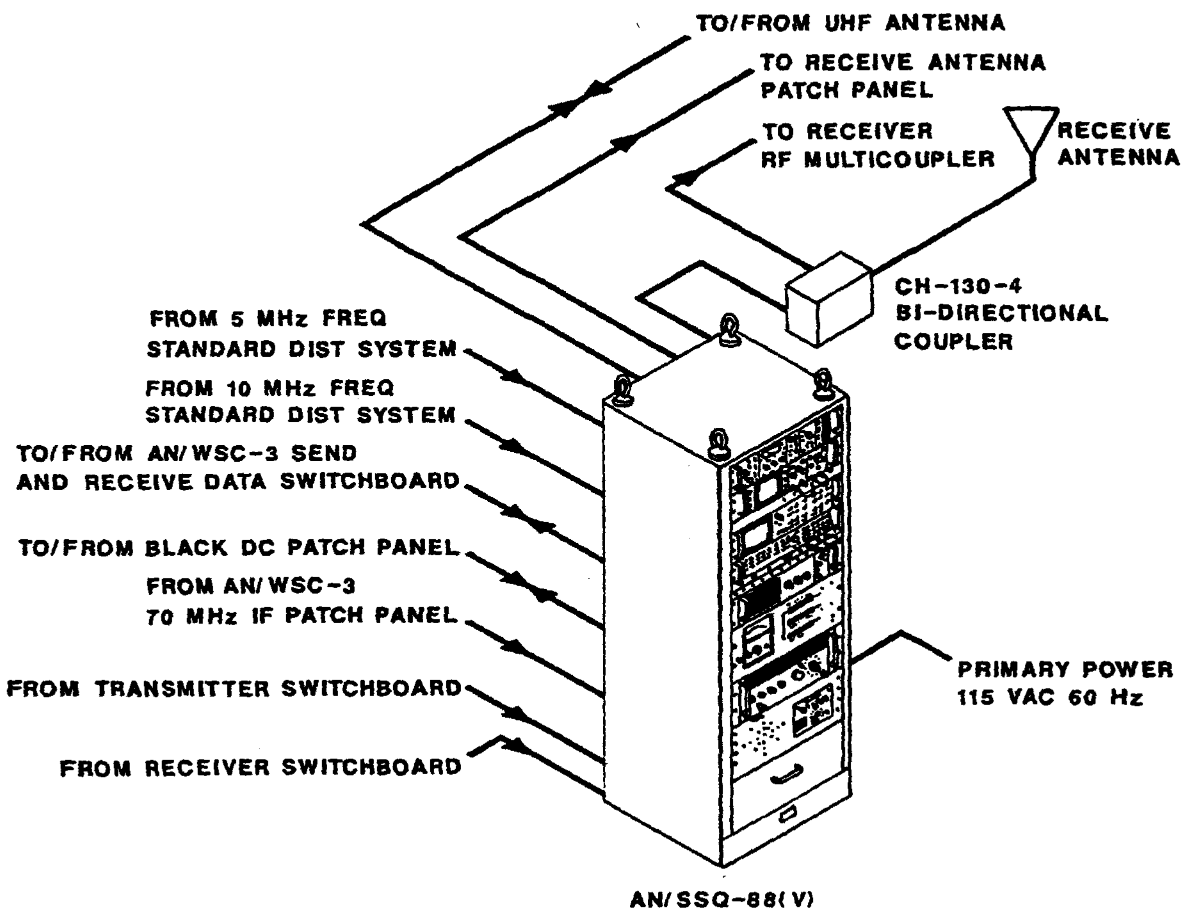


Figure B-2. AN/SSQ-88/88A Quality Monitoring Subsystem

APPENDIX C

AN/SSQ-92(V)1

C-1 Genereal. The AN/SSQ-92(V)1 Multifunction Equipment Group is used as a master monitoring, surveillance, and remote control station for RCS. It provides command and control functions for RCS to aid in maintaining effective communications. This is accomplished through automatic and manual monitoring of RCS equipment. Monitoring and fault isolation functions are accomplished on LF, MF, HF, VHF and UHF communications circuits operating within the radio frequency range of 9KHz to 400MHz employing any of several modulation techniques. Signals are monitored in the DC, audio and RF sections of these circuits. The Monitor-Control Subsystem consists of three groups (units 1, 2 and 3) of cabinet-mounted equipment, and 9 remotely-located units (units 5 through 12 and 30A4). There are three major functions performed by the MCS: Automatic Data Analysis Function (ADAF), Manual Signal Analysis Function (MSAF) and Control and Display Function (CDF).

a. ADAF provides automatic, simultaneous monitoring of transmit and receive RCS channels, provides a visual status of LF, MF, HF, VHF and UHF equipments and generates alarm signals. With the exception of the operator-adjusted alarm thresholds and transmitter output power reference levels, this function is fully automatic and is not disturbed or interrupted by other MCS monitoring and test functions.

1. Provides on-line summary/detail displays of abnormal audio, output, and keyline activity status of 20 transmitters.

2. Controls the summary/detail mode of the status displays.

3. Controls the output power reference levels of 8 transmitters.

4. Provides on-line, summary/detail displays of abnormal audio and inactivity of LF, MF, VHF, and UHF receivers.

5. Provides on-line summary/detail displays of receiver multicoupler faults.

6. Provides summary/detail displays of HF cabinet cooling.

7. Provides display of miscellaneous MCS and RCS faults.

8. Provides on-line, summary/detail displays of teletypewriter line monitoring.

b. MSAF enables the measurement and display of selected operational parameters for transmitter and receiver RCS subsystems. This function permits measurement, display and analysis of equipment operation with minimal interruption of an active communications channel.

1. Selects one of 20 radio transmitter audio inputs for manual signal analysis at electrical patchboard 2A6, and audible monitoring at generator-controller 2A5.

2. Displays level of selected transmitter audio input on control-indicator 2A4 meter.

3. Selects one of 27 radio receiver audio outputs for manual signal analysis at electrical patchboard 2A6, and audible monitoring at generator-controller 2A5.

4. Displays level of selected receiver audio output on control-indicator 2A4 meter.

5. Selects one of 20 radio transmitter RF outputs for manual signal analysis at electrical patchboard 2A6.

6. Selects RF input channel to one of 27 radio receivers for insertion of manually controlled RF test signal from generator-controller 2A5.

7. Electrical patchboard 2A6 provides patchcord configured interfaces between MCS test and signal generation equipment, and RCS patch panels and switchboards.

c. CDF permits local or remote selection and control of RCS HF transmitter operation, remote control of UHF transmitter channel selection and manual recording and display of control link configurations.

1. The control function is performed by transmitter control units 3A2A1 through 3A2A3, 3A3A1 through 3A3A3, and 3A4A2. The control function is used to control RCS functions, and its purpose in the MCS is to facilitate MASF operation.

2. The display function is performed by display panel Unit 8. The display panel is used to manually record the various link configurations.

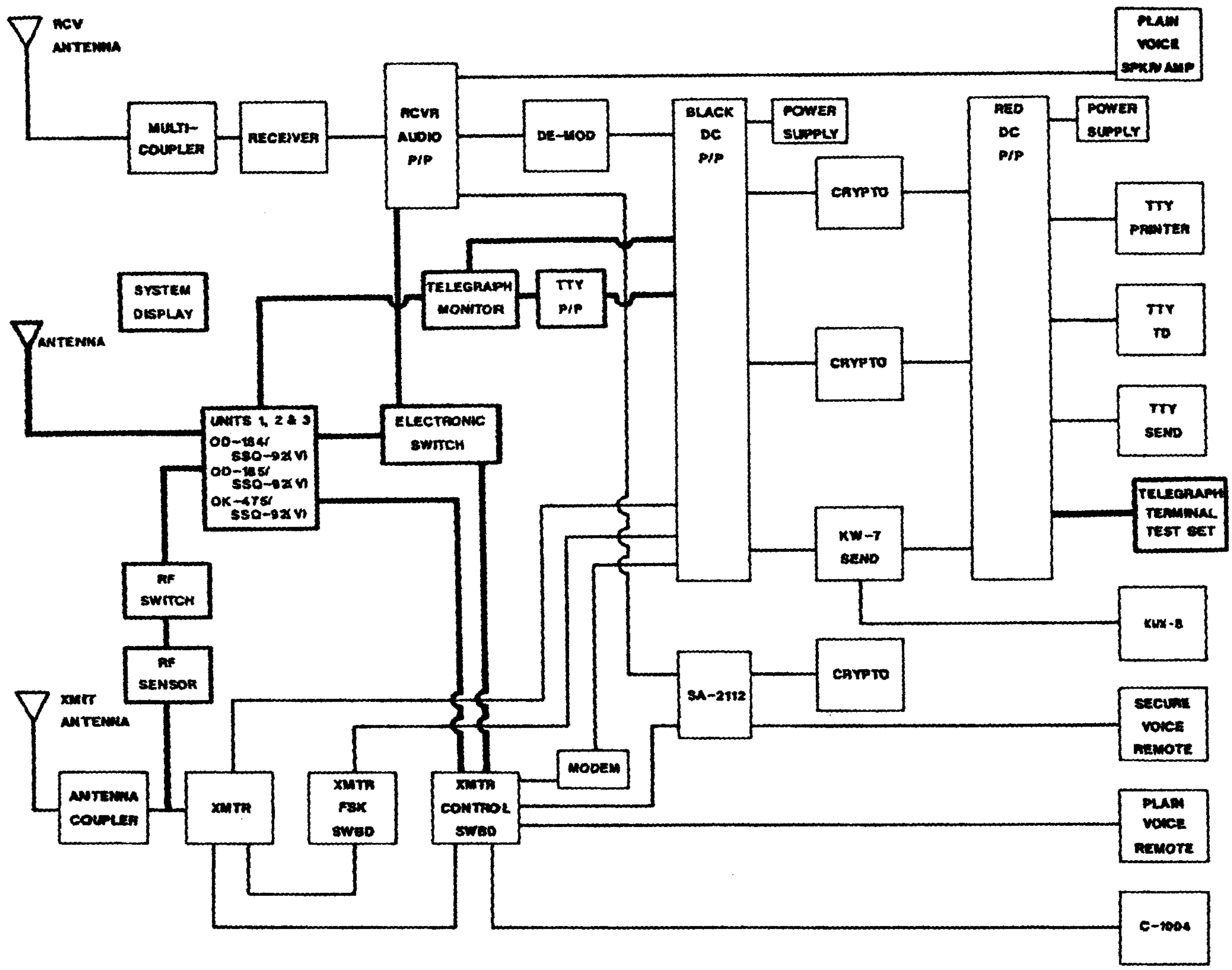


Figure C-1. AN/SSQ-92(V)1 Quality Monitoring System Block Diagram For Radio Communication Systems Testing.

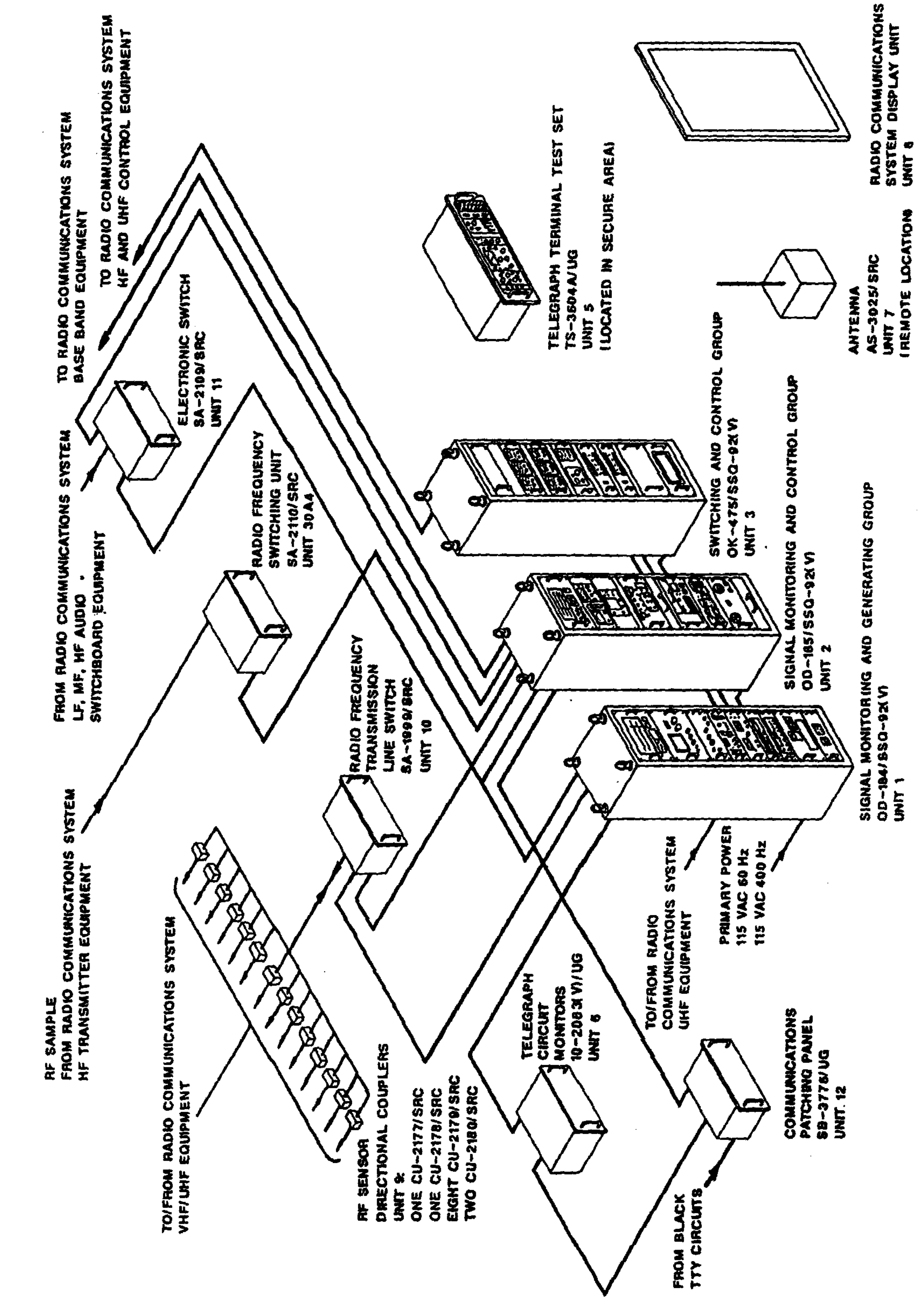


Figure C-2. AN/SSQ-92(V)1 Quality Monitoring Subsystem.

APPENDIX D

AN/SSQ-92(V)2

The AN/SSQ-92(V)2 Multifunction Equipment Group is used as a master monitoring, surveillance, and remote control station for a RCS. It provides command and control functions for RCS to aid in maintaining effective communications. This is accomplished through automatic and manual monitoring of RCS equipment. Monitoring and fault isolation functions are accomplished on LF, MF, HF, VHF and UHF communications circuits operating within the radio frequency range of 9 KHz to 400 MHz employing any of several modulation techniques. Signals are monitored in the DC, audio and RF sections of these circuits. The Monitor-Control Subsystem (MCS) consists of three groups (units 1, 2 and 3) of cabinet-mounted equipment, and 13 remotely-located units (units 5, 7 through 11, 13 through 18 and 29A2). There are three major functions performed by the MCS: Automatic Data Analysis Function (ADAF), Manual Signal Analysis Function (MSAF) and Control and Display Function (CDF).

a. ADAF provides automatic, simultaneous monitoring of transmit and receive RCS channels, provides a visual status of LF, MF, HF, VHF and UHF equipments and generates alarm signals. With the exception of the operator-adjusted alarm thresholds and transmitter output power reference levels, this function is fully automatic and is not disturbed or interrupted by other MCS monitoring and test functions.

1. Provides on-line summary/detail displays of abnormal audio, output power, and keyline activity status of 28 transmitters.

2. Controls the summary/detail mode of the status displays.

3. Controls the output power reference levels of 8 transmitters.

4. Provides on-line, summary/detail displays of abnormal audio and inactivity of LF, MF, VHF, AND UHF receivers.

5. Provides on-line summary/detail displays of receiver multicoupler faults.

6. Provides summary/detail displays of HF cabinet cooling.

7. Provides display of miscellaneous MCS and RCS faults.

b. MSAF is divided into three functional areas: the measurement and display function, the generating and modulating function, and the ancillary function. The measurement and display function provides for all equipment required to measure and display DC, AF, and RF signals. The generating and modulating function provides a means to generate and/or modulate signals up to 400 MHz. The ancillary function permits miscellaneous control of the measurement, display, generation, and modulating functions. Collectively, these three functions provide the following MSAF capabilities:

1. Measures AF and RF voltage levels

2. Measures audio DB levels

3. Amplifies selected audio signals for local monitoring

4. Generates modulated/unmodulated RF test signals

5. Measures frequency of RF signals

6. Measures and displays channel spectrum

7. Generates teletype test signals

8. Analyzes teletype signals (DC or AF)

9. Selects transmitter and/or receiver for manual testing

10. Provides patching facilities for access to selected test points, test equipment, trunks, and AF/RF terminations; allows signal grouping (baseband and RF) and signal dividing/combining (RF only).

c. CDF permits local or remote selection and control of RCS HF transmitter operation, remote control of UHF transmitter channel selection and manual recording and display of control link configurations.

1. The control function is performed by transmitter control units 3A2A1 through 3A2A3, 3A4A1 through

3A4A3, 3A5A2 and 3A5A3, and by LRI control panel. The control function is used to control RCS functions, and its purpose in the MCS is to facilitate MSAF operation.

2. The display function is performed by display panel Unit 8. The display panel is used to manually record the various link configurations.

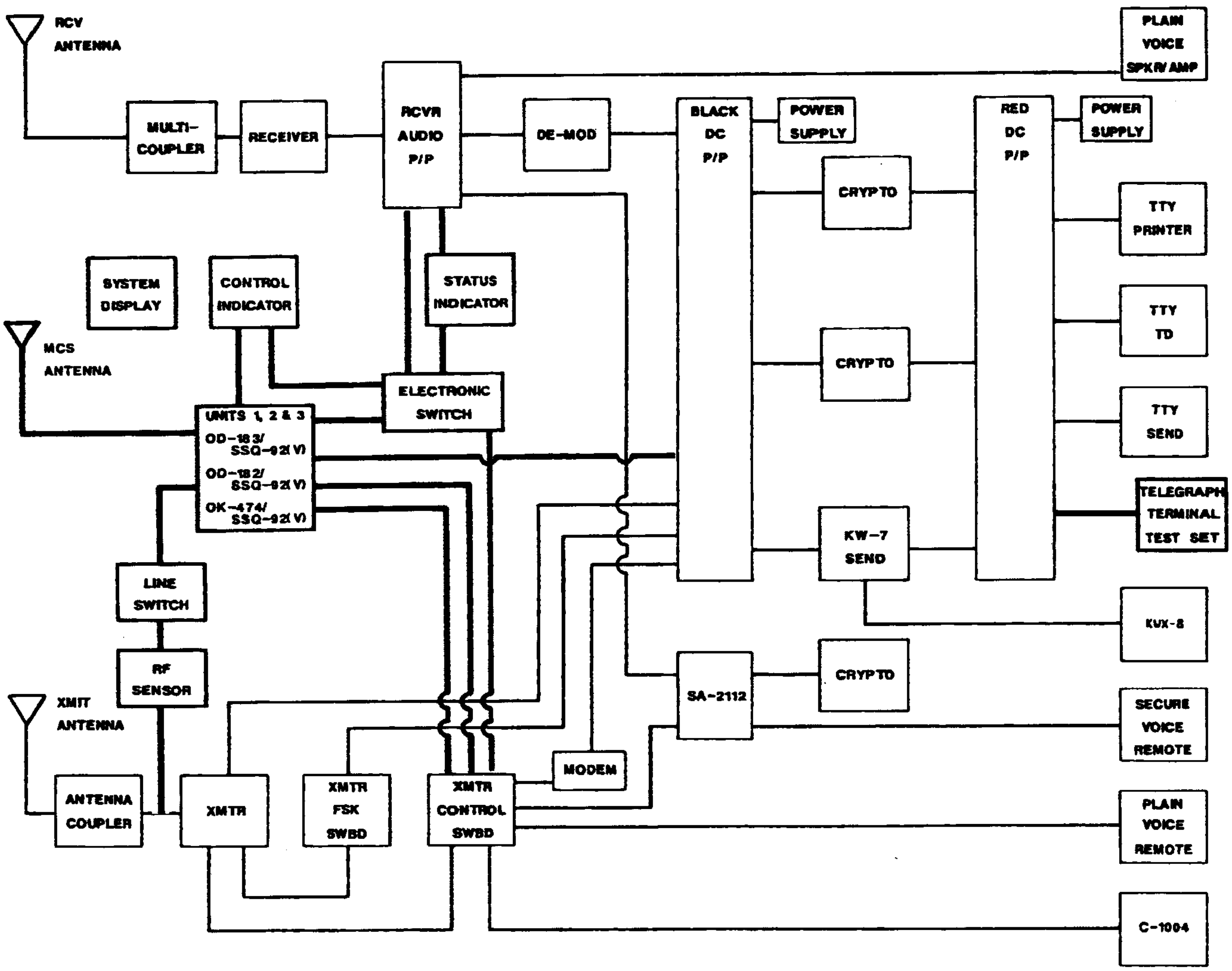


Figure D-1. AN/SSQ-92(V)2 Quality Monitoring System Block Diagram For Radio Communication Systems Testing.

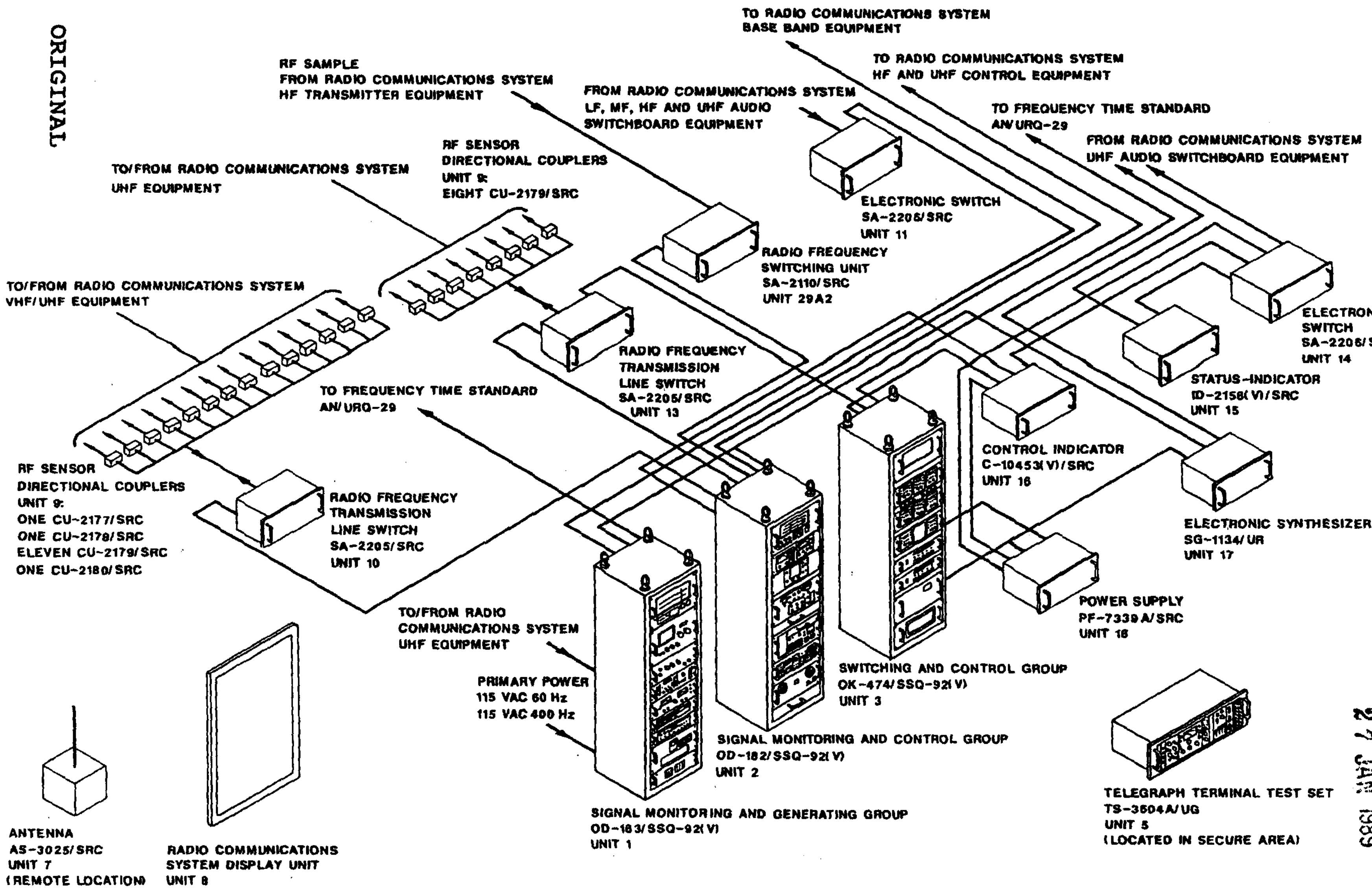


Figure D-2. AN/SSQ-92(V)2 Quality Monitoring Subsystem.

APPENDIX E

AN/SSQ-92(V)3

E-1 General. The AN/SSQ-92(V)3 Multifunction Equipment Group is used as a master monitoring, surveillance, and remote control station for RCS. It provides command and control functions for RCS to aid in maintaining effective communications. This is accomplished through automatic and manual monitoring of RCS equipment. Monitoring and fault isolation functions are accomplished on LF, MF, HF, VHF and UHF communications circuits operating within the radio frequency range of 9 KHz to 400 MHz employing any of several modulation techniques. Signals are monitored in the DC, audio and RF sections of these circuits. The Monitor-Control Subsystem (MCS) consists of three groups (units 1, 2 and 3) of cabinet-mounted equipment, and 6 remotely-located units (units 5, 7 through 11, and 29A2). There are three major functions performed by the MCS: Automatic Data Analysis Function (ADAF), Manual Signal Analysis Function (MSAF) and Control and Display Function (CDF).

a. ADAF provides automatic, simultaneous monitoring of transmit and receive RCS channels, provides a visual status of LF, MF, HF, VHF and UHF equipments and generates alarm signals. With the exception of the operator-adjusted alarm thresholds and transmitter output power reference levels, this function is fully automatic and is not disturbed or interrupted by other MCS monitoring and test functions.

1. Provides on-line summary/detail displays of abnormal audio, output power, and keyline activity status of 18 transmitters.

2. Controls the summary/detail mode of the status displays.

3. Controls the output power reference levels of 7 transmitters.

4. Provides on-line, summary/detail displays of abnormal audio and inactivity of LF, MF, VHF, AND UHF receivers.

5. Provides on-line summary/detail displays of receiver multicoupler faults.

6. Provides summary/detail displays of HF cabinet cooling.

7. Provides display of miscellaneous MCS and RCS faults.

b. MSAF is divided into three functional areas: the measurement and display function, the generating and modulating function, and the ancillary function. The measurement and display function provides all equipment required to measure and display DC, AF, and RF signals. The generating and modulating function provides a means to generate and/or modulate signals up to 400 MHz. The ancillary function permits miscellaneous control of the measurement, display, generation, and modulating functions. Collectively, these three functions provide the following MSAF capabilities:

1. Measures AF and RF voltage levels

2. Measures audio DB levels

3. Amplifies selected audio signals for local monitoring

4. Generates modulated/unmodulated RF test signals

5. Measures frequency of RF signals

6. Measures and displays channel spectrum

7. Generates teletype test signals

8. Analyzes teletype signals (DC or AF)

9. Selects transmitter and/or receiver for manual testing

10. Provides patching facilities for access to selected test points, test equipment, trunks, and AF/RF terminations; allows signal grouping (baseband and RF) and signal dividing/combining (RF only).

c. CDF permits local or remote selection and control of RCS HF transmitter operation, remote control of UHF transmitter channel selection and manual recording and display of control link configurations.

1. The control function is performed by transmitter control units 3A2A1 through 3A2A3, 3A4A1 through 3A4A3, 3A5A2 and by LRI control panel 3A3. The control function is used to control RCS functions, and its

purpose in the MCS is to facilitate MSAF operation.

2. The display function is performed by display panel Unit 8. The display panel is used to manually record the various link configurations.

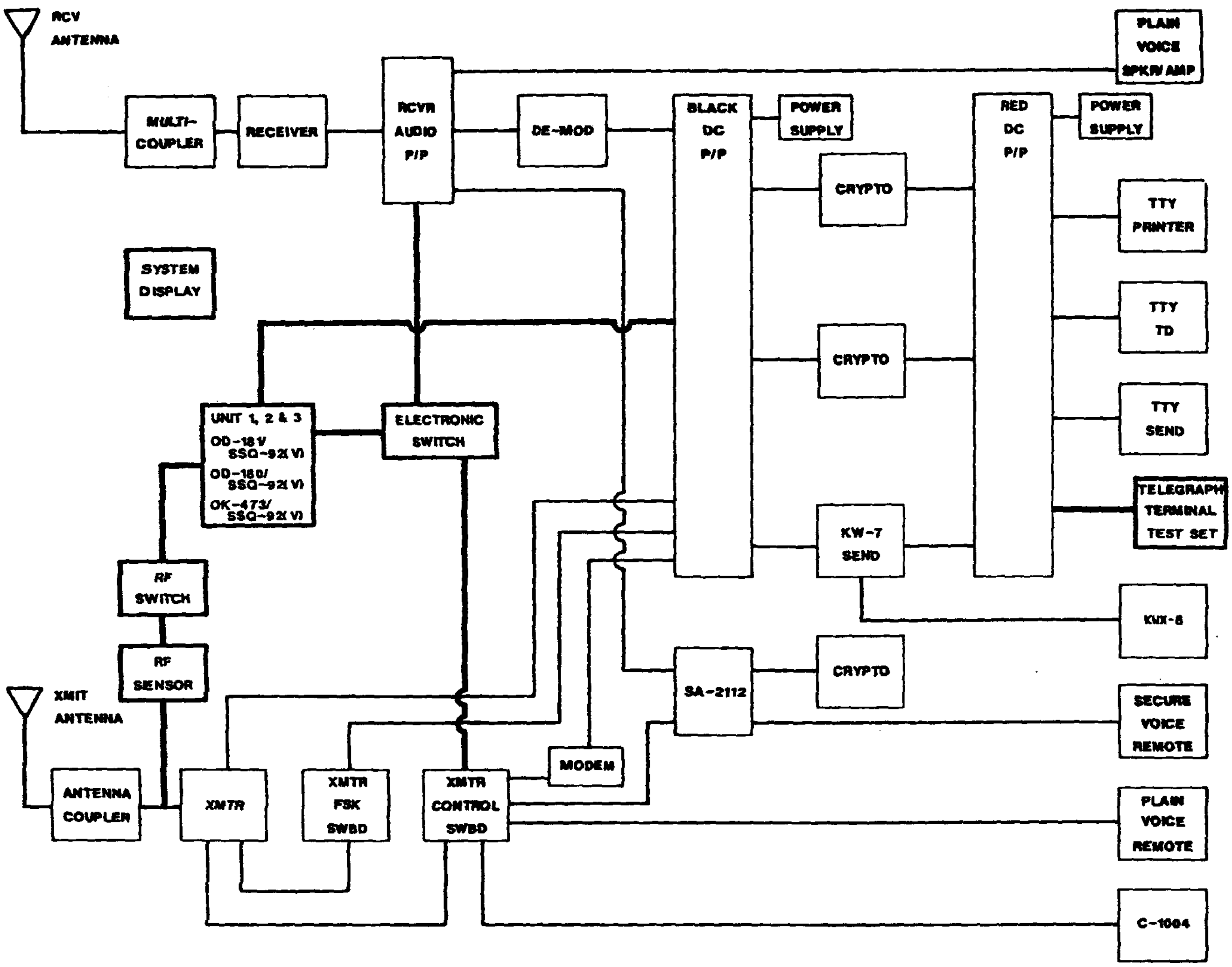


Figure E-1. AN/SSQ-92(V)3 Quality Monitoring System Block Diagram For Radio Communication Systems Testing.

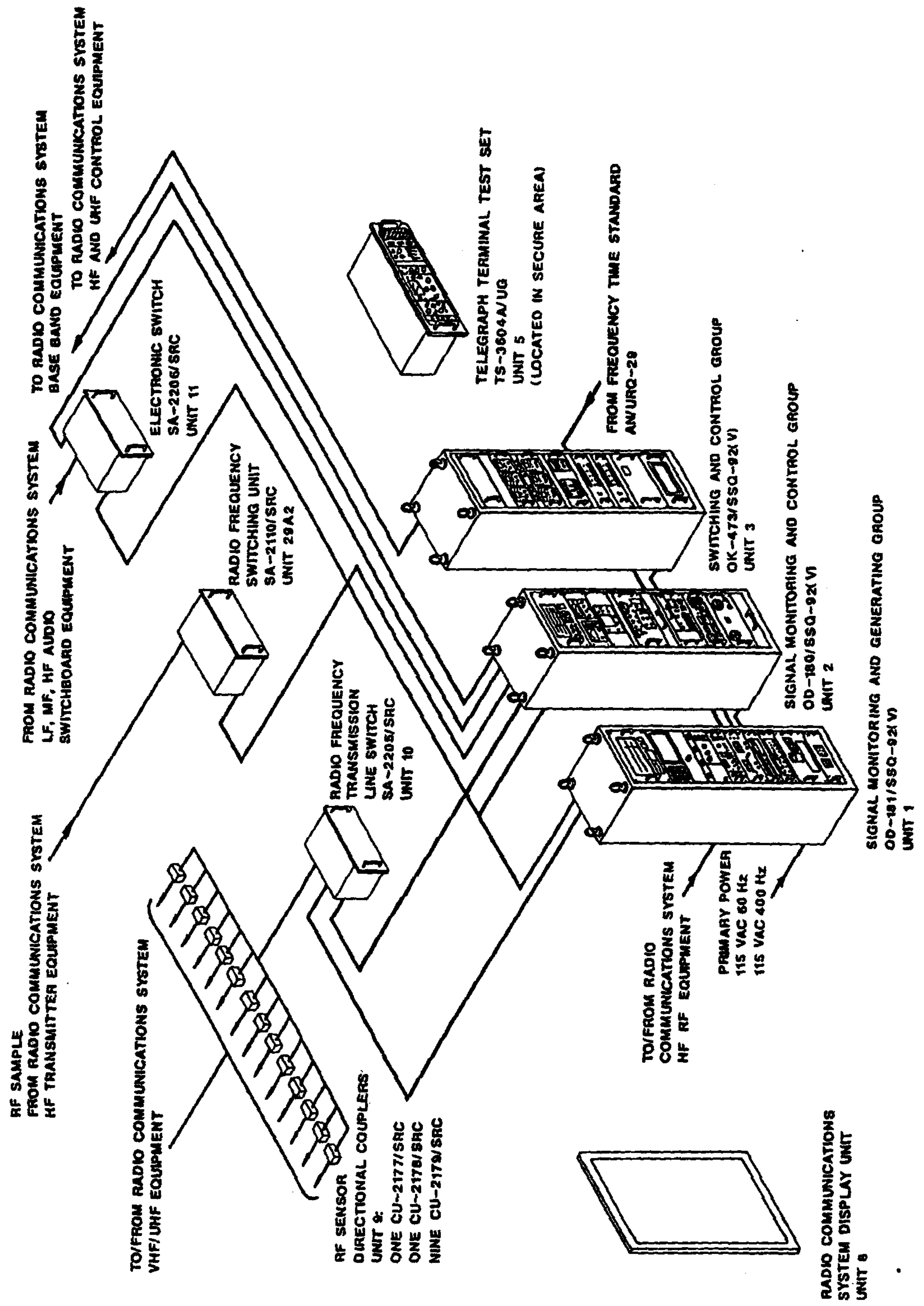


Figure E-2. AN/SSQ-92(V)3 Quality Monitoring Subsystem.

APPENDIX F

OD-164/SRC

F-1 General. The OD-164/SRC Monitor-Control Group (MCG) is a multifunction equipment group used as a master monitoring, surveillance, and remote control station for RCS. It provides command and control functions for RCS to aid in maintaining effective communications. This is accomplished through automatic and manual monitoring of RCS equipment. Monitoring and fault isolation functions are accomplished on LF, MF, HF, VHF and UHF communications circuits operating within the radio frequency range of 9 KHz to 400 MHz employing any of several modulation techniques. Signals are monitored in the DC, audio and RF sections of these circuits. The Monitor-Control Group (MCGG) consists of three equipment racks, units 1, 2 and 3, designated QM-1, QM-2 and QM-3 respectively and 8 remotely-located units designated unit 5, unit 6, units 8 through 12 and 29A2. There are three major functional groups in the MCG: Automatic Data Analysis Group (ADAG), Manual Signal Analysis Group (MSAG) and Control and Display Group (CDG).

a. ADAG provides automatic, simultaneous monitoring of transmit and receive RCS channels, provides a visual status of LF, MF, HF, VHF and UHF equipments and generates alarm signals. The ADAG monitors the RCS for transmitter and receiver operability, teletype signal distortion, and faults and provides a continuous summary and/or detailed visual display of RCS operability. With the exception of the operator-adjusted alarm thresholds and transmitter output power reference levels, this function is fully automatic and is not disturbed or interrupted by other MCS monitoring and test functions. The ADAG is subdivided into three functional areas: the control area, the display area, and the monitor equipment area. The control area contains all functions that are used to control the ADAG monitoring and display capabilities. The display area function provides appropriate visual and aural indications of detected transmitter and receiver status and faults. The monitor equipment area contains functions that perform actual monitoring of transmitters and receivers at predetermined points. Collectively, these functional areas provide the following monitoring and display capabilities:

1. Transmitter output power

2. Transmitter audio

3. UHF transmitter modulation

4. Transmitter keyline activity

5. Receiver activity

6. SRA-34 multicoupler faults

7. Cabinet cooling

8. Miscellaneous faults, e.g. excessive operating temperature.

b. MSAG enables the measurement and display of selected operational parameters for transmitter and receiver RCS subsystems. The group has access to both baseband and RF signals which are sampled at strategic points within the transmitter and receiver subsystems to permit measurement, display, and analysis of equipment operation with minimal interruption of an active communications channel. The MSAG is subdivided into three functional areas: the measurement and display equipment, the generating and modulating equipment, and the ancillary equipment. The measurement and display function provides for all equipment required to measure and display DC, AFV, and RF signals. The generating and modulating function provides a means to generate and/or modulate signals up to 400 MHz. The ancillary equipment function permits miscellaneous controlling of the measurement and display and generating and modulating functions. Collectively, the three functions provide the following MSAG capabilities:

1. Measure RF voltage levels.

2. Measure audio DB levels.

3. Amplifies selected audio signal for local monitoring.

4. Generates modulated or unmodulated RF test signals.

5. Measure frequency of RF signals.

6. Measure and display channel spectrum.

7. Generates teletype test signals (DC).

8. Analyzes teletype signals (DC or AF).

9. Selects transmitter and/or receiver for manual testing.

10. Provides patching facilities for access to selected test points, test equipment and trunks, AF and RF terminations, and allows signal grouping (baseband and RF) and signal dividing/combining (RF only).

c. CDG permits remote control of RCS HF transmitter operation, and remote control of UHF transmitter channel selection. The control and display group is divided into two groups: the control group and the display panel. The control group permits remote control of HF transmitters and UHF channel selection. The control group is primarily used to control RCS functions and is part of the MCG to facilitate MSAG operation. The display panel is a panel used to manually record various link configurations.

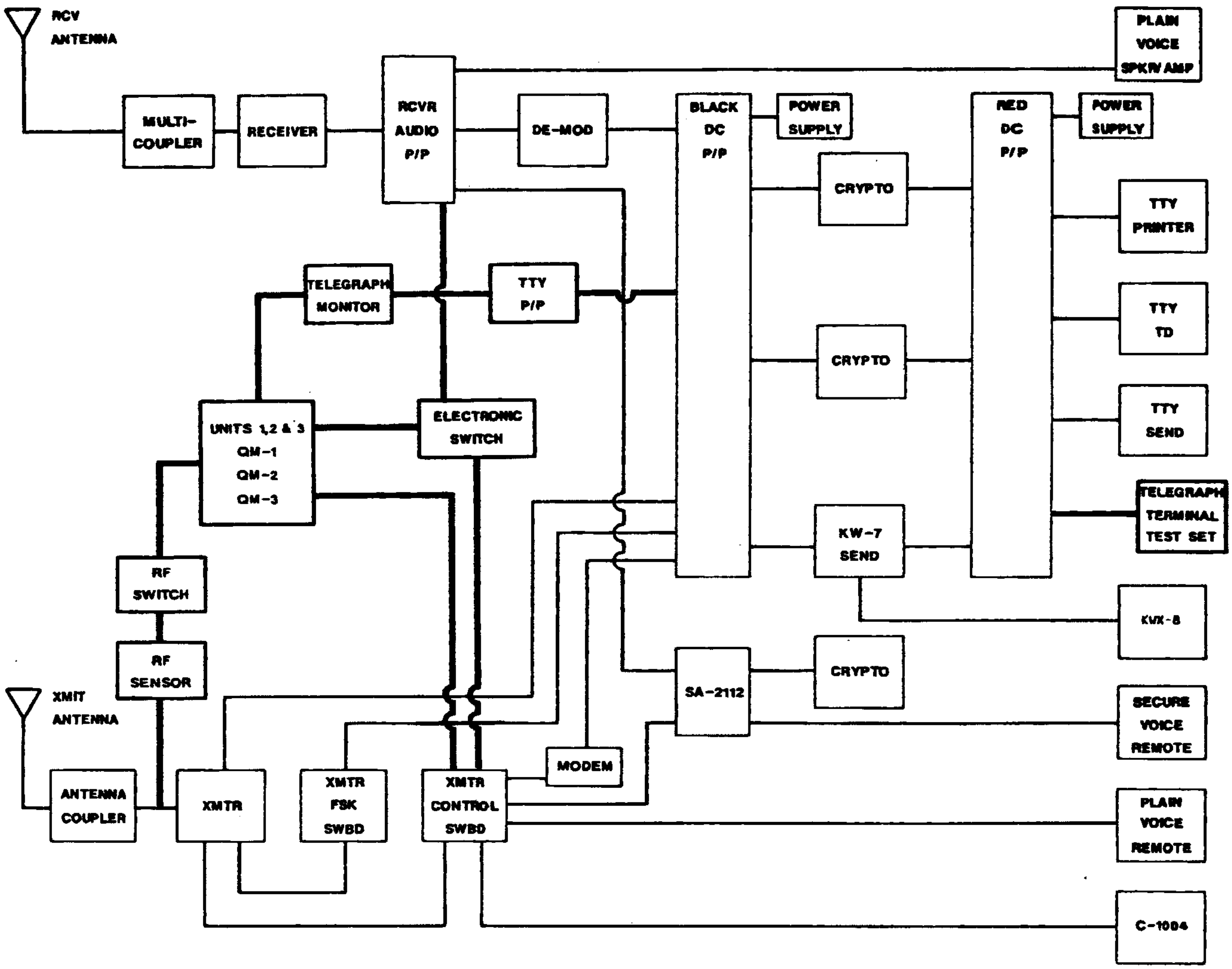


Figure F-1. OD-164/SRC Quality Monitoring System Block Diagram For Radio Communication Systems Testing.

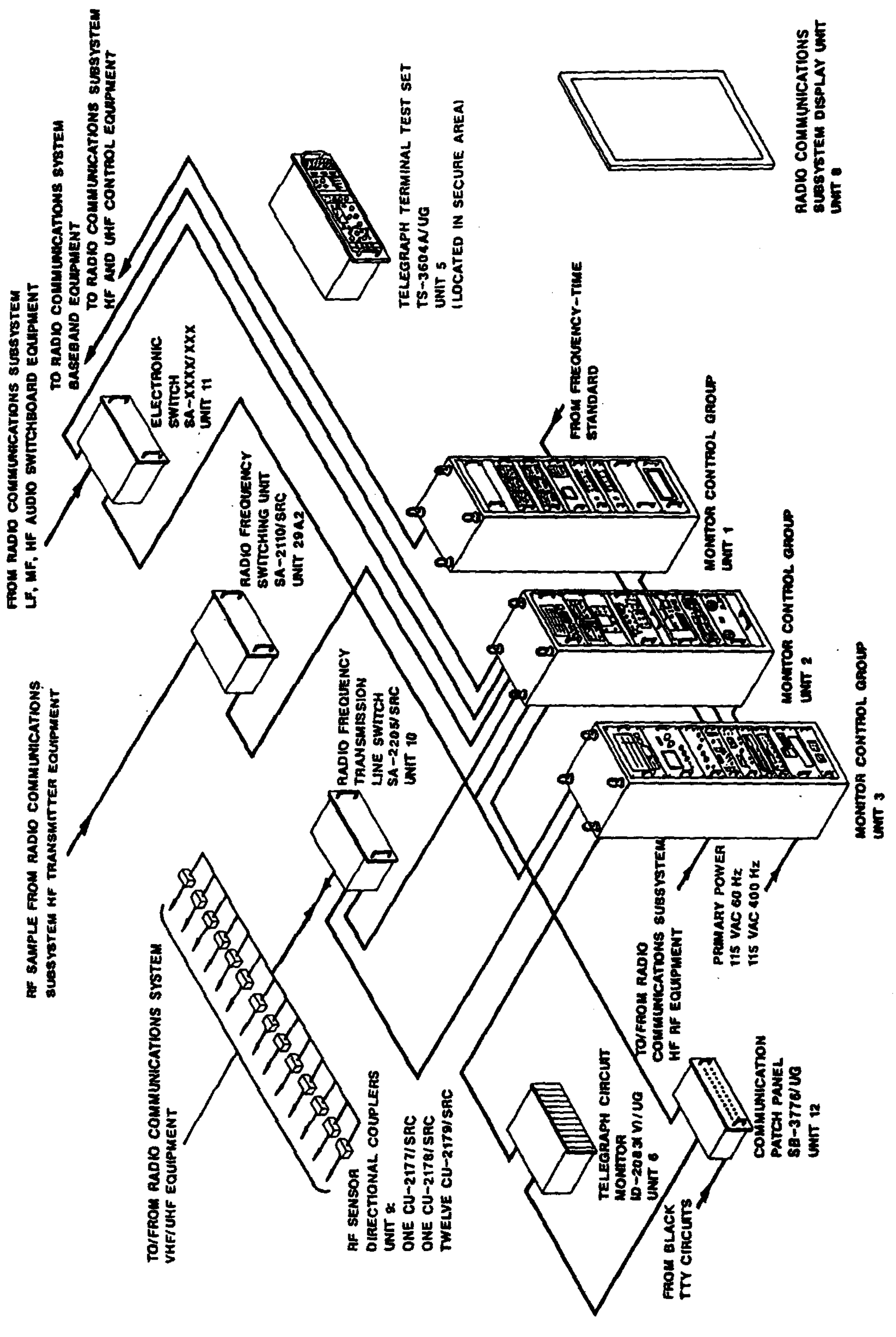


Figure F-2. OD-164/SRC Quality Monitoring Subsystem.

APPENDIX G

GLOSSARY OF TERMS

-A-

AMPLITUDE MODULATION	The process by which the amplitude of the RF carrier wave is varied by combining the carrier and modulation signal.
ANGLE OF RADIATION	The angle between the surface of the earth and the center of the beam of energy radiated upward into the sky from a transmitting antenna.
ANTENNA	A device for radiating electromagnetic waves into space, or for receiving these waves.
ANTENNA HALF-WAVE	An antenna whose electrical length is approximately equal to one-half the wavelength being transmitted or received.
ANTENNA, OMNIDIRECTIONAL	An antenna having an essentially nondirectional pattern in azimuth and a directional pattern in elevation.
ANTENNA, QUARTER WAVE	An antenna which has an electrical length equal to one-fourth the wavelength of the signal to be transmitted or received.
ANTENNA, TUNED	An antenna designed to provide resonance at the desired operating frequency by means of its own inductance and capacitance.

ASSIGNED FREQUENCY	A frequency assigned by International agreement for use by the U. S. Armed Forces. The assigned frequency is located at the center of the radiated intelligence.
ASYNCHRONOUS	More commonly referred to as *START-STOP operation.* The transmitted information has start and stop pulses in each character to independently synchronize receiving device with transmitter.
ATTENUATION	A general term used to denote a decrease in magnitude of current, voltage, or power of a signal in transmission from one point to another.
AUDIO FREQUENCY	A frequency which can be detected by the human ear. The range of audio; frequencies extends from approximately 20 to 20,000 Hz.
AUDIO FREQUENCY TONE SHIFT	A term referring to that *transmission in which* teletypewriter pulses are converted into corresponding audio tones which are used to amplitude modulate the transmitter. (See VFCT)
AZIMUTH	A direction expressed as a horizontal angle from a reference direction, usually expressed in degrees or miles and measured clockwise from North. Azimuth can be true azimuth, grid azimuth, or magnetic azimuth depending upon which North is used.

-B-

BALANCED AUDIO LINES	A pair of audio lines where both wires are terminated to an output transformer which provides equal impedance to both wires. Neither wire is physically grounded.
BANDWIDTH	The difference between the highest and the lowest emission frequencies of a transmitter, in the region of the carrier or principal carrier frequency.
BASEBAND	In the process of modulation, the frequency band occupied by the aggregate of the transmitted signals when first used to modulate a carrier.
BAUD	The unit of modulation rate. One baud corresponds to a rate of one unit interval per second. The modulation rate is expressed as the reciprocal of the duration in seconds of the unit interval.
BIAS DISTORTION	In a teletypewriter system it is the uniform lengthening or shortening of the MARK or SPACE elements, one at the expense of the other.
BINARY DIGIT	A unit of information content; one element or bit of a Binary or two element code.

BLACK	The BLACK designation is applied to all conductors and equipment involved in handling or processing unclassified PLAIN LANGUAGE and/or encrypted INFORMATION in electrical form. It is also applied to all facilities and circuits which are not designated RED
BLACKOUT	Interruption of radio communication due to excess absorption caused by solar flares. During severe blackouts, all frequencies above approximately 1500 KHz are absorbed excessively in the daylight zone.
BROADBAND	A type of communication where the radiated modulation occupies a bandwidth of 40 to 80 KHz. Used primarily on VHF/UHF circuits.

-C-

CARRIER	The frequency of the unmodulated emission.
CARRIER FREQUENCY	The frequency which is generated at the sending end of a communication circuit and which has one or more of its characteristics varied by modulating it with the intelligence frequency(s).
CENTER FREQUENCY	Also referred to as Reference Frequency. The center frequency is NOT radiated and refers to the exact center of the radiated intelligence.

CHANNEL — A limited band of frequencies, or a separate circuit, for conveying a signal so as to be isolated from other signals in the same system or frequency range.

CHARACTERISTIC DISTORTION — The repetitive displacement or disruption peculiar to specific portions of the signal.

CIRCUIT — An electrical path between two or more points capable of providing one or more channels for the transmission of intelligence.

COMPATIBLE AM — A single-sideband transmission in which the lower sideband is suppressed and a full carrier is transmitted. Transmission can be copied with any receiver capable of AM reception.

COMPOSITE TONES — A group of radio channels combined together for transmission.

CONVERTER — An electronic device designed to convert received audio signals to DC, and transmitted DC pulses to audio.

CORONA — An effect of the sun causing the ionosphere to dissipate, resulting in extremely marginal long-haul radio communications. Corona is also referred to in communications as the illuminous discharge appearing at the surface or between the terminals of an electrical conductor under high voltage, i.e., arcing.

CROSSTALK — The phenomenon in which a signal transmitted on one circuit or channel of a transmission system is detectable in another circuit or channel.

CRYPTO — A device used to decrypt/encrypt received-transmitted signals.

-D-

D LAYER — The first ionized layer existing during daylight hours only and extends from 25 to 50 miles in height. *At times will completely* absorb low and medium frequency waves.

DATA — Material transmitted or processed to provide information or to control a process.

DECIBEL (db) — One tenth of a bel. A unit for measuring transmission gain or loss. A relationship that can be used to compare voltages across, or currents through, equal impedances by calculating 20 log of the voltage or current ratio, or 10 log of the power ratio. The standard unit of comparison between two quantities of electrical or acoustical power.

dbm — Decibels relative to one milliwatt. The absolute value is 0.775 volts across 600 ohms.

DEMODULATION — The process by which intelligence is recovered from a modulated wave.

DEMULTIPLEX — A process of separating a multiplexed signal into individual signals.

DEVIATION RATIO — A term used in frequency modulation to indicate the amount by which the carrier or rest frequency increases or decreases when modulated.

DIGITAL SIGNAL — A nominally discontinuous electrical signal that changes from one state to another in discrete steps. The electrical signal could change its amplitude or polarity, for instance, in response to outputs from computers, teletypewriters, etc.

DISCRIMINATOR — A circuit which transforms a frequency modulated signal into an amplitude modulated wave.

DISTORTION — An undesired change in wave form. The principal sources of distortion are: A nonlinear relation between input and output at a given frequency; non-uniform transmission at different frequencies; and phase shift not proportional to frequency.

DIVERSITY — The method of transmission and/or reception whereby in order to reduce the effects of fading, a single received information signal is derived from a combination of, or selection from, a plurality of signals containing the same information.

DOWNLINK — A term used in satellite communications to denote the receive leg to the terminal from the satellite.

DUPLEX (FDX) — *DUPLEX (FULL DUPLEX)* is that type of operation which provides two channels or frequencies linking two different stations, allowing the simultaneous exchange of information.

-E-

E LAYER — One of the regular ionospheric layers with an average height of about 1000 kilometers. This layer occurs during daylight hours and its ionization is dependent on the sun's angle.

ELECTRONAGNETIC INTERFERENCE (EMI) — An undesired disturbance in reception, or that which causes the undesired disturbances. The interference may be caused by a disturbance in the transmitter, transmission medium, ship generated, and/or the receiver. Formerly known as "RFI".

END DISTORTION — In start-stop teletypewriter signals, it is the shifting of the end of all marking pulses from their proper positions in relation to the beginning of the start pulse. Affects the "trailing edge" of the teletype signal.

ERROR RATE — A ratio of the number of bits, elements, characters, or blacks incorrectly received to the total number of bits, elements, characters or blocks sent.

-F-

F LAYER — The stratified layer of ionized gases which exists during the hours of darkness at a height of approximately 200 miles from the earth.

F1 LAYER — One of the regular ionospheric layers at an average height of about 225 kilometers which occurs during the daylight hours and follows the sun closely.

F2 LAYER — The most useful of the ionospheric layers for radio wave propagation. It is the most highly ionized and highest of the layers, having an average night height of 225 kilometers and a mid-day height of about 300 kilometers. This layer is ionized throughout the day. Its ionization is least just before dawn and maximum early in the afternoon.

FADING — The fluctuation in intensity and relative phase of any or all frequency components of a received radio signal due to changes in the characteristics of the propagation path.

FAN (WIRE ROPE) — A type of antenna consisting of 3 to 8 wires arranged in a fan shape. Usually designed to cover a frequency range of 2 to 30 MHz.

FREQUENCY — The number of complete cycles per unit of time. When the unit of time is one second, the measurement unit is given in Hertz (cycles per second).

FREQUENCY DIVERSITY — Any method of transmission and/or reception wherein the same information signal is transmitted and received simultaneously on two or more distinct frequencies.

FREQUENCY DIVISION MULTIPLEX (FDM) — The process of transmitting two or more signals simultaneously over a single path by means of assigning a portion of the assigned bandwidth to each of the signals.

FREQUENCY SHIFT KEYING — A process of modulating the transmitter with discrete frequencies corresponding usually to current and no current pulses; referring normally to a single channel teletypewriter circuit.

-G-

GROUND WAVE — In propagation, that portion of the transmitted radio wave that travels near the surface of the earth.

GUARD BAND — A frequency band between two channels which gives a margin of safety against mutual interference.

-H-

HARMONIC — A sinusoidal quantity having a frequency which is an integral multiple of the fundamental frequency of a periodic quantity to which it is related. For example, a wave the frequency of which is twice the fundamental frequency is called a second harmonic.

HERO — Hazards of Electromagnetic Radiation to Ordnance.

HERTZ — The international unit of frequency, equal to one cycle per second.

HIGH FREQUENCY — Frequency range from 3 to 30 MHz.

-I-

INDEPENDENT SIDEBAND — That method of communication in which the frequencies on the opposite sides of the carrier, produced by the process of modulation, are not related to each other but are related separately to two sets of modulating signals. The carrier frequency may be transmitted, suppressed or partially suppressed.

IONOSPHERE	That part of the earth's outer atmosphere where ions and free electrons are normally present in quantities sufficient to affect the propagation of radio waves.
IONOSPHERIC DISTURBANCE	A variation in the state of ionization of the ionosphere beyond the normally observed random day-to-day variations.
IONOSPHERIC SOUNDER	A receiver designed to periodically tune to various signals within the 2 to 32 MHz range to determine propagation at that time within the ionosphere.
I ZONE	One of the three zones into which the earth is divided to take into consideration the variations of the F2 layer with reference to longitude when making frequency predictions. This zone roughly covers the intermediate area between the western and eastern hemispheres: Africa, Europe and Greenland on one side of the world; Hawaiian Islands, Alaska and a portion of Canada on the other side.

-L-

LIMITER
A device which reduces the power of an electrical signal when it exceeds a specified value. The amount of reduction or compression increases with increase of the input power.

LINE-OF-SIGHT
The straight line distance *from transmitter to the* horizon. Represents the radio and radar VHF/UHF transmission range limits under normal conditions.

LINK
Used with satellites - a communications path formed between two stations transmitting and receiving radio communications traffic via a satellite.

-M-

MEDIUM FREQUENCY
300 KHz to 3 MHz.

MEGAHERTZ (MHz)
10 to the sixth power, Hertz. (1 MHz = 1,000.000 Hz).

MODEM
A contraction of two words, *Modulator-demodulator*, identifying equipment circuitry of a carrier terminal normally mounted together on a single panel and having common elements. Functionally, a MODEM converts the digital signal into analog signals for transfer via voice frequency band in a carrier system, and back to digital at the receiving end.

MODULATION	The process of varying some characteristics of the carrier wave in accordance with the instantaneous value, or samples of the intelligence to be transmitted.
MODULATION RATE	Reciprocal of the unit interval measured in seconds. Expressed in bauds.
MULTICOUPLER	A device used to minimize the reception or radiation of unwanted signals and connect several transmitters or receivers to a single antenna.
MULTIPATH	The propagation of identical electromagnetic signals via diverse paths; i.e., single hop and double hop, to a particular receiver location.

-N-

-O-

-P-

PEAK ENVELOPE POWER	The power supplied to the antenna transmission line by a transmitter during one radio frequency cycle at the highest crest of the modulation envelope, taken under conditions of normal operation.
PROPAGATION	In electrical practice, the travel of waves through or along a medium or transmission path.

PULSE — A signal characterized by the rise and decay in time of a quantity whose value is normally constant.

-Q-

QUADRUPLE DIVERSITY — Referred to as "QUAD". The simultaneous combining of four (4) signals and their detection through the use of space, frequency, polarization characteristics or combinations thereof.

-R-

RADIATION HAZARD (RADHAZ) — A situation in which transmitting equipment can generate an electromagnetic field of sufficient intensity to: (1) Induce or otherwise couple currents and/or voltages of sufficient magnitude to active ordnance, electro-explosive devices. (2) Cause harmful or injurious effects to personnel. (3) Create sparks having sufficient magnitude to ignite flammable mixtures or materials which must be handled in an area that is susceptible to RF hazard.

RADIO FREQUENCY CARRIER SHIFT (RFCS) — A discontinued term. Replaced by FSK of single channel RATT.

RED — That portion of a communication system where all signals are considered classified or unencrypted.

-S-

SELECTIVITY	That characteristic of a radio receiver which determines the extent and degree to which the receiver is capable of differentiating between the desired signal and signals of interference at other frequencies.
SELECTIVE FADING	Fading which affects the different frequencies within a specified band unequally.
SENSITIVITY	The minimum input signal required in a radio receiver to produce a specified output signal having a specified signal-to noise ratio.
SIDEBAND	The bands of frequencies on each side of the carrier frequency produced by modulation.
SIGNAL-TO-NOISE	The ratio of the amplitude of the desired signal to that of the noise products, usually expressed in DB.
SIMPLEX	A method of telecommunication employing only one direction of transmission at any one time.
SINGLE SIDEBAND (SSB)	An amplitude modulated signal in which one sideband and the carrier (usually) are suppressed at the transmitter.

SPACE DIVERSITY	A method of transmission and/or reception which employs antennas having considerable physical separation and connected to separate receivers.
SUPPRESSED CARRIER	A single-sideband signal in which the carrier is completely suppressed at the transmitter a level at least 40 db below the peak sideband power level.
SYNCHRONOUS	A system in which the sending and receiving instruments are operating continuously at substanially the same frequency and are maintained by means of correction if necessary, in a desired phase relationship.

-T-

TERMINATION (FULL PERIOD)	A circuit which is maintained full time (24 hours) to provide record communication between an afloat command and those ashore.
TOTAL DISTORTION	The total of all forms of signal distortion is cumulative and is known as the total distortion of the digital signal.
TRANSITION PERIODS	Periods of unspecified duration at dawn and dusk when propagation conditions may be varying rapidly.
TWINNED	Two multiplex channels separated in frequency containing the same intelligence.

-U-

ULTRA HIGH FREQUENCY (UHF)	300 to 3000 MHz.
UPLINK	A term used in satellite communications to denote the transmit leg to the satellite.
USER	Any individual or organization authorized to use service provided by a communication system.

-V-

VERY HIGH FREQUENCY (VHF)	30 to 300 MHz.
VERY LOW FREQUENCY (VLF)	3 to 30 KHz.
VOCODER	A device for converting voice or voice frequency signals to digital form.
VOICE FREQUENCY CARRIER TELEGRAPH (VFCT)	Equipment which enables transmission of 16 or more telegraph channels over one voice grade channel. The composite signals from the VFCT form a group of tones that can be transmitted over a 3 KHz (normally) bandwidth channel of voice frequency carrier multiplex.
VOICE FREQUENCY TONE GROUP (VFTG)	A discontinued term referring to a system employing a number of tone channels slightly displaced in frequency. See VFCT.

VOLTAGE STANDING-WAVE RATIO (VSWR) — The ratio of the amplitude of the electric field or voltage at a voltage maximum to that at an adjacent minimum in a stationary-wave system, as in a wave guide, coaxial cable or other transmission line

VOLUME UNIT (VU) — The unit of measurement for electrical speech power in communication work as measured by VU meter in the prescribed manner. Zero VU equals zero dbm in measurement of sine wave test tone power.

-W-

WAVEFORM — The graphical representation of the shape of a wave, showing variations in amplitude versus time.

WAVELENGTH — The distance in meters traveled by a wave during the time interval of one complete cycle. It is equal to the velocity divided by the frequency.

WIDEBAND — Transmission facilities having a frequency bandpass of 20 KHz or greater.

WINDOW FREQUENCY — Refers to dial frequency. (Normally same as suppressed carrier.)

-XYZ-

APPENDIX H

LIST OF ABBREVIATIONS

ADAF	Automatic Data Analysis Function
ADAG	Automatic Data Analysis Group
AF	Audio Frequency
AFS	Audio Frequency Shift
AFTS	Audio Frequency Tone Shift
AFV	Audio Frequency Voice
AM	Amplitude Modulated
BFO	Beat Frequency Oscillator
BNC	Bayonet Neck Connector
CDF	Control Display Functions
CFS	Carrier Frequency Shift
CPS	Cycles Per Second
CW	Continuous Wave
DA	Distortion Analyzer
db	deci bell
DC	Direct Current
DSPK	Differential Phase Shift Keying
DSTE	Digital Subscriber Terminal Equipment
EIB	Electronic Information Bulletin
EMI	Electromagnetic Interference
FAX	Facsimile
FLTBCST	Fleet broadcast
FM	Frequency Modulated
FOT	Frequency of Optimum Traffic
FRU	Functional Remote Unit
FSK	Frequency Shift Keying
FTS	Frequency Tone Shift
HB	High Band
HF	High Frequency
Hz	Hertz
IF	Intermediate Frequency
ISB	Independent Side Band
KHz	Kilo Hertz
LB	Low Band
LF	Low Frequency
LOP	Local Operating Position
LRI	Long Range Intercept
LSB	Lower Side Band
MCG	Monitor-Control Group
MCS	Monitor-Control System
MCW	Modulated Continuous Wave
MF	Medium Frequency
MHz	Mega Hertz
MSAF	Manual Signal Analysis Function
MSAG	Manual Signal Analysis Group
MUF	Maximum Usable Frequency

NTDS	Navy Tactical Data System
PEP	Peak Envelope Power
PM	Phase Modulated
PSK	Phase-Shift-Keyed
PTT	Push-to-Talk
QM	Quality Monitoring
QMS	Quality Monitoring System
RATT	Radio Teletypewriter
RCS	Radio Communications Systems
RF	Radio Frequency
RRU	Radiotelephone Remote Units
SAS	Single Audio System
SATCO	Satellite Communication
SSB	Single Sideband
TD	Transmitter Distributor
TP	Test Point
TTY	Teletypewriter
UHF	Ultra High Frequency
USB	Upper Side Band
VHF	Very High Frequency
VSWR	Voltage Standing Wave Ratio