MIL-STD-188-342

29 FEBRUARY 1972

MILITARY STANDARD

STANDARDS FOR LONG-HAUL COMMUNICATIONS

EQUIPMENT TECHNICAL DESIGN STANDARDS FOR VOICE FREQUENCY CARRIER TELEGRAPH (FSK)

SLH

DEPARTMENT OF DEFENSE
WASHINGTON, D.C. 20305

Equipment Technical Design Standards for
Voice Frequency Carrier Telegraph (FSK)

MIL-STD-188-342

1. This Military Standard is mandatory for use by all departments and Agencies of the Department of Defense.

2. Recommended corrections, additions, or deletions should be reported to the future Preparing Activity, Rome Air Development Center (RADC). (See Defense Standardization Directory (SD-1) for mailing address).

FOREWORD

This standard supersedes paragraphs 3.2.4.2 through 3.2.4.2.9 and 5.2.9.5.1 through 5.2.9.5.4 of DCAC 330-175-1, DCS Engineering Installation Standards Manual.

CONTENTS

CONTENTS

FIGURES

CONTENTS

1. SCOPE

1.1 PURPOSE. The purpose of this standard is to provide technical design standards for voice frequency carrier telegraph (VFCT) terminals for use in long-haul communications. The standards are intended to be used in the design and installation of new VFCT equipment and also in the upgrading of existing equipment.

1.2 APPLICATION. This standard applies to multi-channel, frequency shift keyed, VFCT terminals operating at rates not exceeding 75 bits per second.

1.3 OBJECTIVE. The objective of this standard is to provide the electrical performance parameters required in long-haul communications to enable design, engineering, and installation of that portion of the Defense Communications System (DCS) concerned with VFCT terminals.

2. REFERENCED DOCUMENTS.

a. MIL-STD-188-100, Tactical and Long-Haul Common Standards.

b. MIL-STD-188-300, Long-Haul Communications System Design Standards Applicable to the DCS.

c. MIL-STD-188-311, Equipment Technical Design Standards for Multiplexers.

d. MIL-STD-188-317, Subsystem Design/Engineering and Equipment Technical Design Standards for High Frequency Radio.

e. MIL-HDBK-411, Facility Design for Long-Haul Communications (DCS) Power and Environmental Control for Physical Plant.

f. MIL-STD-461, Electromagnetic Interference Characterisitcs Requirements for Equipment Subsystem and System.

3. TERMS AND DEFINITIONS.

3.1 Telegraph Distortion. The shifting of the transition points of the signal pulses from their proper positions relative to the beginning of the start pulse. The magnitude of the distortion is expressed in percent of a perfect unit pulse length.

3.2 Tone Diversity. A method of Voice Frequency Carrier Telegraph (VFCT) transmission wherein two channels of a 16 channel VFCT carry the same information. This is commonly achieved by twinning the channels of a 16 channel VFCT to provide 8 channels with dual diversity.

3.3 Standard/Specific Telegraph Level (STL). The power per individual telegraph channel required to yield the standard composite data level. For example, for a composite data level of -13 dBm at a 0 dBm transmission level point (TLP), the STL would be -25.0 dBm for a 16 channel VFCT terminal from the relation:

$$STL = -13 \text{ dBm} - 10 \log t$$

where t is the number of telegraph channels.

4. SUBSYSTEM INTERFACE STANDARDS.

4.1 Equipment described herein must interface with the appropriate equipments as described in MIL-STD-188-100, MIL-STD-188-311, and MIL-STD-188-317.

5. DESIGN AND ENGINEERING STANDARDS.

5.1 Frequency Shift Keying (FSK) Voice Frequency Carrier Telegraph (VFCT). This section covers standards for the terminals of a multichannel FSK voice frequency carrier telegraph system of 75 bits per second (b/s) maximum operating speed per channel. Figure 1 shows the system arrangement. VFCT terminals shall be configured in the following ways:

a. Sixteen channel dual diversity terminal for use on high frequency radio systems.

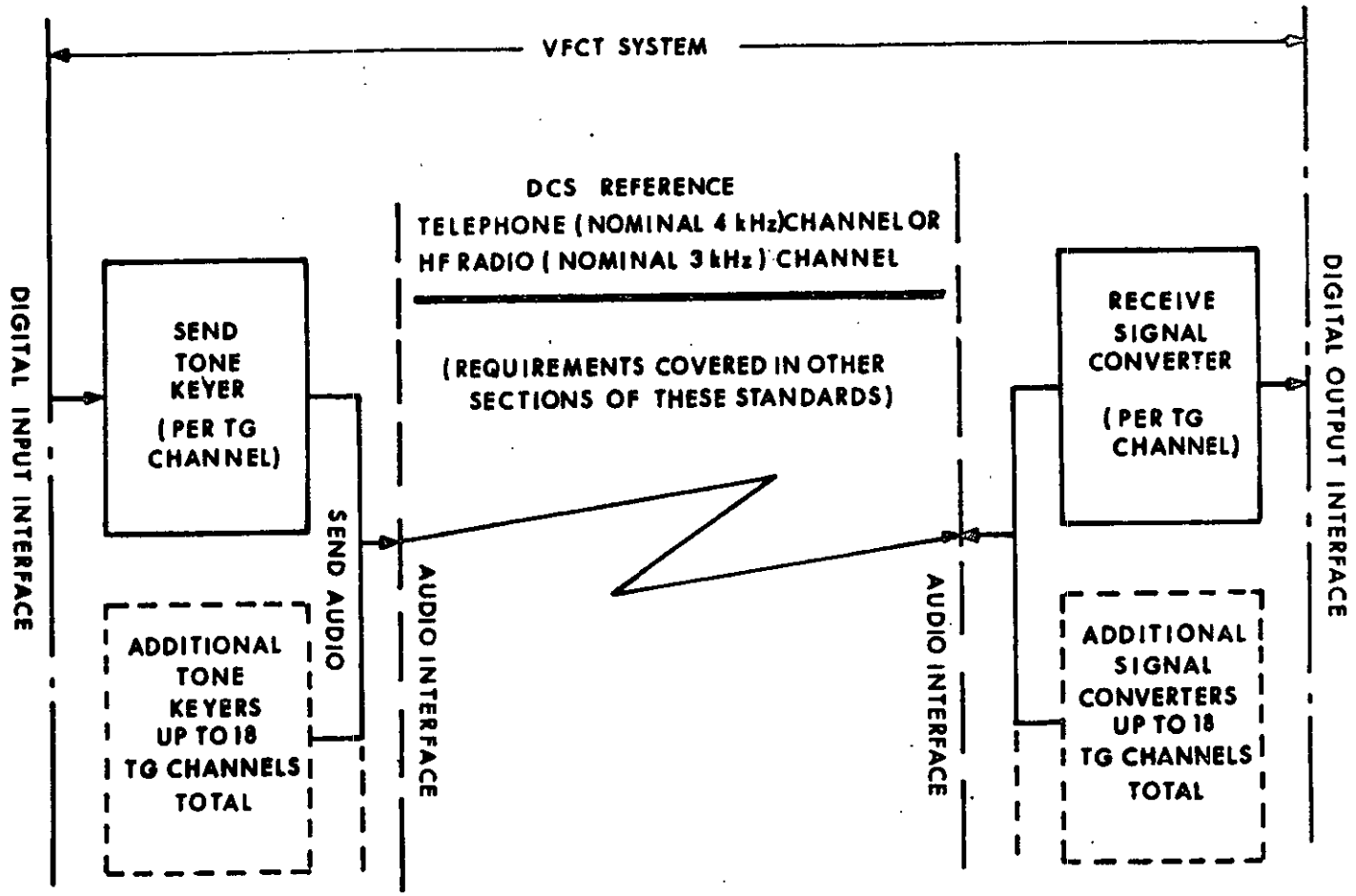


FIGURE 1. VOICE FREQUENCY CARRIER TELEGRAPH (VFCT) SYSTEM CONFIGURATION

b. Sixteen channel nondiversity terminal for use on other type systems, with an option for two additional channels (17 and 18) directly above channel 16. The 16 channel diversity terminal shall incorporate a built-in switching arrangement to permit operation as 16 channel dual diversity through transmission media, 8 channel tone diversity, or 8 channel quadruple diversity using media and tone diversity. Flexibility shall be provided to implement from 1 to 18 channels on nondiversity systems, or from 1 to 16 channels on diversity systems.

5.2 Digital Interface Characteristics.

5.2.1 Standard Digital Interface. The standard digital interface is described in MIL-STD-188-100 and MIL-STD-188-300.

5.2.2 Digital Input/Output Grounding. The digital input and output shall be floating and shall permit connection to a power supply of either polarity or signal ground as required. With any type of connection used, the total peak telegraph distortion shall not exceed the limits specified in paragraph 5.3.14.

5.2.3 Signaling Sense. In polar signaling, "mark" condition shall be represented by a positive voltage between line and signal ground, and "space" condition shall be represented by a negative voltage between line and signal ground. The transmitting and receiving terminals shall be equipped with a switch to reverse the polar signaling sense for nonstandard applications. In neutral operation, the mark condition shall correspond to current ON and the space condition shall correspond to current OFF, regardless of polarity.

5.2.4 Ballast. Ballast lamps, or other approved protective devices, shall be incorporated in each loop power supply lead to limit the signaling current to a safe maximum value in the event the circuit is grounded or improperly patched to another circuit. The protective device shall normally be provided as part of the central office power supply distribution system. Where the VFCT terminal provides its own loop power supply, the protective device shall be incorporated in the terminal power supply distribution.

5.2.5 Modulation Rate. The maximum operating modulating rate of the channels comprising the system shall be 75 baud.

5.2.6 Output Bias Adjustment. Bias adjustment shall be provided in each Receive Signal Converter to reduce the distortion in the output signal. The range of bias adjustment shall be at least ±10% of the normal interval.

5.3 Audio Frequency Characteristics. The audio frequency characteristics of the receiving and transmitting terminals shall be in accordance with the following paragraphs. (Paragraphs 5.3.1 through 5.3.14).

5.3.1 Tone Carrier Frequencies. The nominal center frequencies of the tone channels shall be spaced 170 Hz apart. The frequency of the mark is (f_c -42.5 Hz) and that of the space is (f_c +42.5 Hz) where f_c = the center frequency. Channel designation, center frequency and mark/space frequencies for nondiversity and diversity systems shall be in accordance with tables 1 and 2.

5.3.2 Tone Carrier Frequency Tolerance and Stability. The mark and space transmitted frequencies in each channel shall be within 0.1 Hz of the specified values with stability such that deviation from the specified frequencies shall be no greater than ±0.5 Hz over a six months period.

5.3.3 Tone Carrier Levels. Multichannel VFCT carrier operating levels are defined in terms of the Specific Telegraph Level (STL). At a 0 dBm reference test tone level point, the STL shall be -25.0 dBm for 16 channel VFCT system operating over most voice frequency channels. The total power of 16 channels at this point will be -13.0 dBm. The levels for diversity and nondiversity systems shall be based on the STL's listed in table 3. The power level of each mark and space tone shall be continuously adjustable to any specified level between -30 and 0 dBm and shall maintain this set level within 0.5 dB for 30 days without readjustment.

5.3.4 Noise. The total noise at the audio transmitting jacks between 300 and 3400 Hz shall not exceed 27 dBrnCo (-65 dBm0 flat weighting.) This measurement shall be made with the transmitting terminal set up for normal operation and all tone oscillators or generators turned off.

TABLE 1. NON-DIVERSITY

Channel Designation	Mark Frequency (Hz)	Center Frequency (Hz)	Space Frequency (Hz)
1	382.5	425	467.5
2	552.5	595	637.5
3	722.5	765	807.5
4	892.5	935	977.5
5	1062.5	1105	1147.5
6	1232.5	1275	1317.5
7	1402.5	1445	1487.5
8	1572.5	1615	1657.5
9	1742.5	1785	1827.5
10	1912.5	1955	1997.5
11	2082.5	2125	2167.5
12	2252.5	2295	2337.5
13	2422.5	2465	2507.5
14	2592.5	2635	2677.5
15	2762.5	2805	2847.5
16*	2932.5	2975	3017.5
17**	3012.5	3145	3187.5
18**	3272.5	3315	3357.5

*Marginal over HF (nominal 3 kHz) channels
**Not usable over HF channels

TABLE 2. DIVERSITY

Pair 1(9), 2(10), 3(11), 4(12), 5(13), 6(14), 7(15), and 8(16)
NOTE: Connect loop to lower numbered channel of each pair.

5.3.5 Transmit/Receive Filter Characteristics. Over the range of ±55 Hz from the center frequency, the attenuation shall not exceed the minimum attenuation in the channel by more than 6 dB. The difference between attenuations at the mark and space frequencies shall not exceed 1.5 dB.

5.3.5.1 Attenuation at the Stop Band. The attenuation at the mark and space frequencies of all other channels shall be at least 55 dB with respect to the mean attenuation at the mark and space frequencies of any one channel when referred to equal level points.

5.3.6 Level Attenuators. Attenuators in the combined input and output lines of the carrier terminal shall be adjustable over a range of 0 to 35 dB either continuously or in steps not greater than 0.5 dB. The attenuators shall be balanced or located in the circuit where the input or output line balance is not affected.

5.3.7 Input and Output Impedance. The output impedance or the transmitting terminal and the input impedance of the receiving terminal shall be 600 ohms ±10% resistive and balanced over the frequency range 370 to 3400 Hz. The electrical balance shall be sufficient to suppress the longitudinal currents at least 40 dB below any reference level input.

5.3.8 Harmonic Distortion. At the output of the VFCT transmitting terminal, the second and higher order harmonics of each channel carrier shall be suppressed at least 60 dB below channel signal level.

5.3.9 Dynamic Range. On each individual VFCT channel, sufficient amplification and automatic gain control shall be incorporated to accomodate a normal range of input signals in addition to the specified fade margins. The tone converter shall accept

a normal signal of -25 dBm per channel at the line side of the combined terminal input. The regulated amplifier of a VFCT shall be capable of accepting a fade of at least 32 dB below -25 dBm (i.e., -57 dBm). As a design objective (DO), the regulated amplifier of a VFCT with diversity capability shall accept a fade of at least 45 dB (i.e., -70 dBm).

TABLE 3. STANDARD/SPECIFIC TELEGRAPH LEVELS (STL) FOR SYSTEMS OF 1 TO 18 CHANNELS*

Number of Channels	Standard/Specific Telegraph Levels	Total Composite Power Level at the 0 Reference Level Point
1	-13.0 dBm	-13.0 dBm
2	-16.0 dBm	-13.0 dBm
4	-19.0 dBm	-13.0 dBm
8	-22.0 dBm	-13.0 dBm
12	-23.8 dBm	-13.0 dBm
14	-24.5 dBm	-13.0 dBm
16	-25.0 dBm	-13.0 dBm
18	-25.6 dBm	-13.0 dBm

*Standard/specific telegraph levels for other multiple channels are determined as follows:

$$STL = -13 \text{ dBm} - 10 \log_{10} t$$

where t = number of telegraph channels

5.3.10 Diversity Combiner. A diversity combiner shall be provided when the VFCT is used on HF radio channels. The diversity mode shall provide 2 to 3 dB improvement over the nondiversity mode.

5.3.11 Differential Delay. With the transmitting and receiving terminals connected back-to-back, the differential delay between any two channels shall be adjustable to within 500 microseconds. Each receive tone converter shall be provided with a time delay capability, adjustable continuously from 0 to at least 7 but not more than 13 milliseconds.

5.3.12 Interchannel Interference. With all 16 tone keyers synchronously keyed from the same source with random mark and space signals, and any output attenuated 30 dB below the level of the others, the total telegraphic distortion of that channel shall not exceed 40 percent.

5.3.13 Transmitting Bias. With the send tone keyer keyed with undistorted mark and space reversals at the 75 baud rate; the time duration of the mark and space tones shall be equal within 2 percent.

5.3.14 Telegraph Distortion. With the transmit and receive terminals connected back-to-back, the telegraph distortion on each channel shall not exceed the maximum telegraph distortion limits shown in table 4 with all channels continuously keyed with random information, for example, "Fox" tests, unsynchronized. Each channel shall meet these criteria when adjusted for any delay (see paragraph 5.3.11) between 0 and 7 milliseconds.

5.4 Integral Test Facilities.

5.4.1 Metering. Suitable metering shall be provided to measure delay, levels, current, and voltage.

5.4.2 Jack Panel. Each channel unit shall be provided with test jacks. The jacks shall be arranged for testing and patching the DC and audio lines. The jacks shall be single circuit tip/ring/sleeve (TRS) type jacks. Figure 2 shows a simplified schematic of the DC and audio jack connections.

TABLE 4. MAXIMUM TELEGRAPH DISTORTION

Modulation Rate In Baud	Transmit Level of Each Channel	Total Peak Telegraph Distortion
90*	-25.0 dBm	5.0%
90*	-57.0 dBm	7.5%
90**	-70.0 dBm	7.5%
75	-25.0 dBm	4.0%

*It is not the intent that 90 baud modulation rate be used for other than test purposes.
**Design objective (DO) for VFCT equipped with diversity capability for use on HF radio channels.

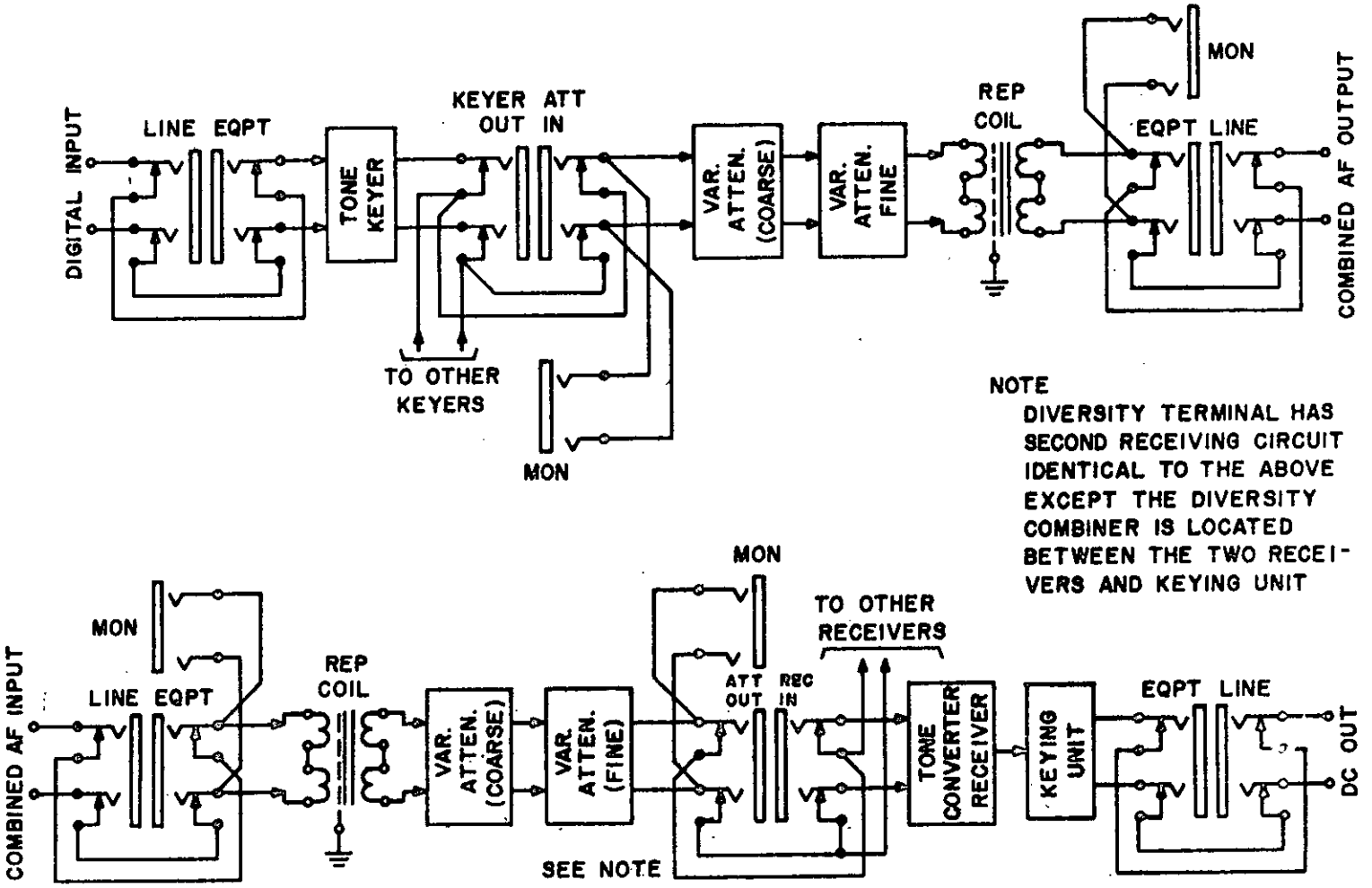


FIGURE 2. TYPICAL DC AND AUDIO JACK CONNECTIONS

6. TEST METHODS

6.1 General. This section includes the procedures for testing subsystem and equipment parameters specified in section 5. The methods presented are to be used as guidlines for testing. Table 5 is a listing of the test methods.

TABLE 5. VFCT TEST METHOD LIST

NUMBER	SUBJECT
5101	Digital Input Sensitivity
5102	Digital Input Impedance
5103	Digital Output Resistance
5104	Digital Input/Output Grounding
5105	Signaling Sense
5106	Power Supply
5107	Carrier Frequency Stability
5108	Tone Carrier Levels
5109	Noise
5110	Filter Characteristics
5111	Level Attenuators
5112	Input/Output Impedance-Voice Frequency Line
5113	Harmonic Distortion
5114	Dynamic Range and Telegraph Distortion
5115	Diversity Combiners
5116	Differential Delay
5117	Interchannel Interference

6.2 Description of Test Methods. The methods provide step-by-step procedures to be followed for the testing of VFCT equipment characteristics. Test setups are given and the required testing apparatus is assigned a reference item number. The Test Equipment List in Appendix 1, following the last test method, specifies test apparatus operating features correlated to the specified reference number. In general, the test methods do not repeat the standard values specified in section 5. However, these values are repeated where necessary in order to clarify a step. Reference should be made to the section 5 paragraphs referenced in the test method.

6.3 Standard-To-Test Method Cross-Reference. Table 5 cross-references the standard paragraph numbers in section 5 to the applicable test method.

TABLE 6. STANDARD-TO-TEST METHOD CROSS-REFERENCE

PARAGRAPH	SUBJECT	TEST METHOD
	Overall Performance	
5.3.14	Telegraph Distortion	5114
	Digital Interface Characteristics	
5.2.1	Input Sensitivity	5101
5.2.1	Input Impedance	5102
5.2.1	Output Resistance	5103
5.2.2	Input/Output Grounding	5104
5.2.3	Signaling Sense	5105
5.2.1	Loop Battery Supply	5106
	Voice Frequency Characteristics	
5.3.1	Carrier Frequencies	5107
5.3.2	Carrier Frequency Stability	5107
5.3.3	Tone Carrier Levels	5108
5.3.4	Noise	5109
5.3.5	Filter Characteristics	5110
5.3.6	Level Attenuators	5111
5.3.7	Input and Output Impedance	5112
5.3.8	Harmonic Distortion	5113
5.3.9	Dynamic Range	5114
5.3.10	Diversity Combiner	5115
5.3.11	Differential Delay	5116
5.3.12	Interchannel Interference	5117

METHOD 5101

DIGITAL INPUT SENSITIVITY

1. SCOPE. This method is used to determine the digital input sensitivity and bias correction capability of voice frequency carrier telegraph (VFCT) transmitting terminals.

2. APPLICABILITY. Parameters shall conform to the applicable portions of the standard digital interface found in MIL-STD-188-300.

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

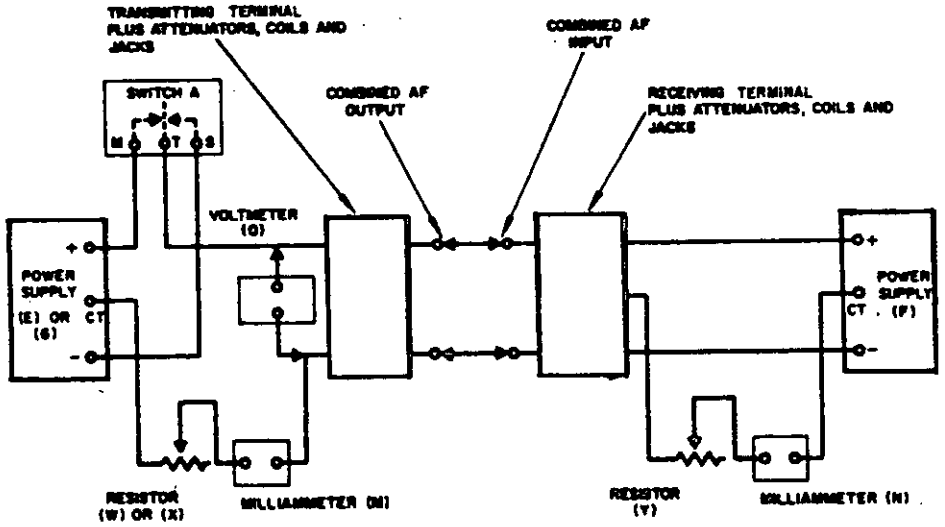
Test Unit	Schematic Reference	Item No. in Appendix 1
Switch	A	950
Power Supply*	E,F	568
Power Supply*	G	569
Milliammeter	M,N	50
Voltmeter	O	51
Resistor Variable	W,Y	441
Resistor Variable	X	442

*Power supplies listed are required only when loop power supplies have not been supplied as part of the VFCT Terminal.

4. PROCEDURES.

4.1 INPUT SENSITIVITY OF POLAR VFCT TRANSMITTING TERMINALS.

Step 1. Connect equipment as shown in figure 5101 (high level signal).



	TEST CURRENT mA	TEST VOLTAGE VOLTS	POWER SUPPLY	MILLI-AMMETER	VOLTMETER	RESISTORS
HIGH LEVEL SIGNALING	2	—	E–F	M–N	—	W–Y
LOW LEVEL SIGNALING	0.1	0.5	G–F	M–N	G	X–Y

FIGURE 5101. ARRANGEMENT FOR TESTING THE INPUT SENSITIVITY OF VFCT TRANSMITTING TERMINALS (POLAR 60 V, 20 mA, OR 6 V, 1 mA)

Step 2. Label switch A so that position connecting positive battery is designated mark and position connecting negative battery is designated space.

Step 3. Set switch A to mark.

Step 4. Arrange tone keyer and tone converter for polar, 20 mA operation.

Step 5. Adjust resistor W so that milliammeter M reads +20 mA and resistor Y so that milliammeter N also reads +20 mA.

Step 6. Readjust resistor W so that milliammeter M reads +2 mA. Milliammeter N should still read +20 mA.

Step 7. Set switch A to space. Milliammeter M should read -2 mA (±2 percent) and milliammeter N should read -20 mA (±2 percent).

Step 8. Operate switch A back and forth between mark and space. Milliammeter N should follow, i.e., when switch A is on mark, milliammeter N should read +20 mA; and when switch is on space, milliammeter N should read -20 mA.

Step 9. Connect equipment for low level signaling with switch A on mark.

Step 10. Arrange tone keyer for polar, 6 V, 1 mA operation. (The tone converter is arranged for 60 V, 20 mA operation as before).

Step 11. Adjust resistor X so that voltmeter O reads +6 volts. (Milliammeter N will read +20 mA).

Step 12. Set switch A to space. (Milliammeter N should read -20 mA, ±2 percent).

Step 13. Set switch A to mark and readjust resistor X so that voltmeter O reads +0.5 volts. (Milliammeter N should read +20 mA).

Step 14. Set switch A to space. (Voltmeter O should read -0.5 volts and milliammeter N should read -20 mA, ±2 percent).

Step 15. Operate switch A back and forth between mark and space. Milliammeter N should follow as it did in step 8.

METHOD 5102

DIGITAL INPUT IMPEDANCE

1. SCOPE. This method is used to determine the digital input impedance of polar or neutral voice frequency carrier telegraph (VFCT) transmitting terminals.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Reference
Digital Input Impedance	MIL-STD-188-100 MIL-STD-188-300

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. in Appendix 1
Ohmmeter or	A	52
Wheatstone Bridge	B	951
Impedance Bridge or	C	952
Capacity Bridge	D	953
Audio Frequency Oscillator	E	180
Null Detector	F	254

4. PROCEDURES.

4.1 DIGITAL INPUT RESISTANCE OF VFCT TRANSMITTERS.

Step 1. Connect equipment as shown in figure 5102-a.

NOTE

Remove any existing connections to the points indicated as battery or ground in figures 5102-a and 5102-b before starting test. Any internal connections of battery to these points must also be removed.

Step 2. Turn all current control resistors on tone keyer under test to zero or strap them out of circuit, as appropriate.

Step 3. Arrange tone keyer under test for neutral 130 V, 60 mA operation and measure resistance, using ohmmeter A or wheatstone bridge B.

Step 4. Arrange tone keyer under test for neutral 130 V, 20 mA operation and measure resistance as in step 3.

Step 5. Arrange tone keyer under test for polar 60 V, 20 mA operation and measure resistance as in step 3.

Step 6. Arrange tone keyer under test for polar 6 V, 1 mA operation and measure resistance as in step 3.

4.2 DIGITAL INPUT SHUNT CAPACITANCE OF A VFCT TRANSMITTER.

Step 1. Connect equipment as shown in figure 5102-b.

Step 2. Turn all current control resistors on tone keyer under test to zero or strap them out of circuit, as appropriate.

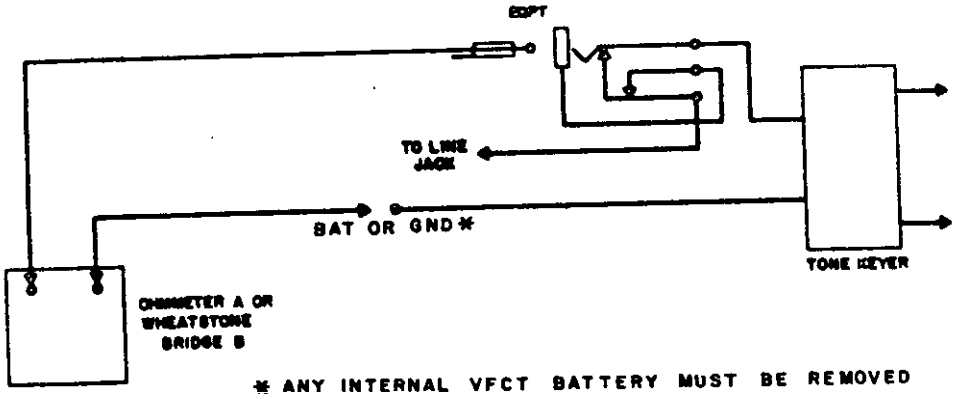


FIGURE 5102-a. ARRANGEMENT FOR MEASURING THE DIGITAL INPUT RESISTANCE OF A VFCT TRANSMITTING TERMINAL POLAR 60 V, 20mA; OR 6 V, 1 mA)

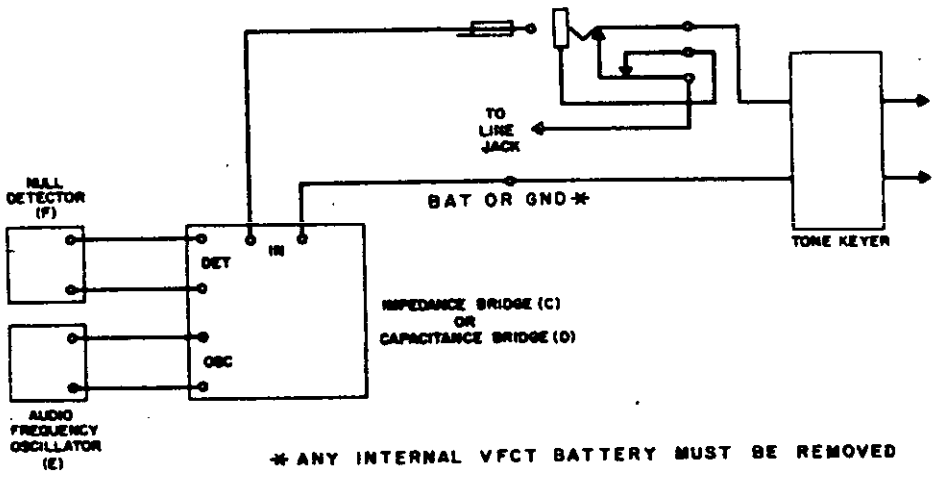


FIGURE 5102-b. ARRANGEMENT FOR MEASURING THE DIGITAL INPUT SHUNT CAPACITANCE OF A VFCT TRANSMITTING TERMINAL (POLAR 6 V, 1 mA)

Step 3. Arrange tone keyer under test for polar 6 V, 1 mA operation and measure capacitance, using impedance bridge C or capacity bridge D. In either case, use AF oscillator E and null detector F.

NOTE

Set AF oscillator at 50 Hz and for sufficient output power to get a satisfactory reading on null detector, when tuned to 50 Hz. It may be necessary to reduce output of AF oscillator or to reduce the amplification of null detector (or both) to keep meter reading of null detector on scale.

METHOD 5103

DIGITAL OUTPUT RESISTANCE

1. SCOPE. This method is used to determine the digital output resistance of VFCT receiving channel terminals.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Reference
Digital Output Resistance	MIL-STD-188-100 MIL-STD-188-300

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Milliammeter	A	48
Milliammeter	B	49
Battery	C	573
Battery	D	570
Resistor (Variable)	E	457
Voltmeter (VTVM)	F	53
Switch	G	946
Power Supply	H	567

4. PROCEDURES.

4.1 NEUTRAL 20 OR 60 mA (MODE A).

Step 1. Connect equipment for back-to-back operation as shown in figure 5103. Battery C and milliammeter A should be used. Both stepped variable attenuators (associated respectively with the transmitting and receiving VFCT terminals) must be set for 0 dB.

Step 2. Adjust loop current to 20 or 60 mA, as appropriate.

Step 3. Adjust individual channel terminal outputs to -25.0 dBm.

Step 4. Arrange receiving terminal for neutral operation.

Step 5. Close switch G and adjust current in milliammeter A to 90 mA.

Step 6. Record voltage across points A and B (marking contact and tongue, respectively, of relaying device).

Step 7. Open switch G and again record voltage across points A and B. Voltage should be approximately that of battery C.

Step 8. See paragraph 4.4.

4.2 POLAR 20 mA (MODE B).

Step 1. Perform steps 1 through 7 of paragraph 4.1, except arrange receiving terminal for polar operation.

Step 2. With switch G still open, transfer test connection from A to C.

Step 3. Adjust current in milliammeter A to 90 mA and record voltage across B and C.

Step 4. Close switch G and again record voltage across B and C. With switch G closed this voltage should be approximately that of battery C.

Step 5. See paragraph 4.4.

4.3 POLAR 6 V (MODE C).

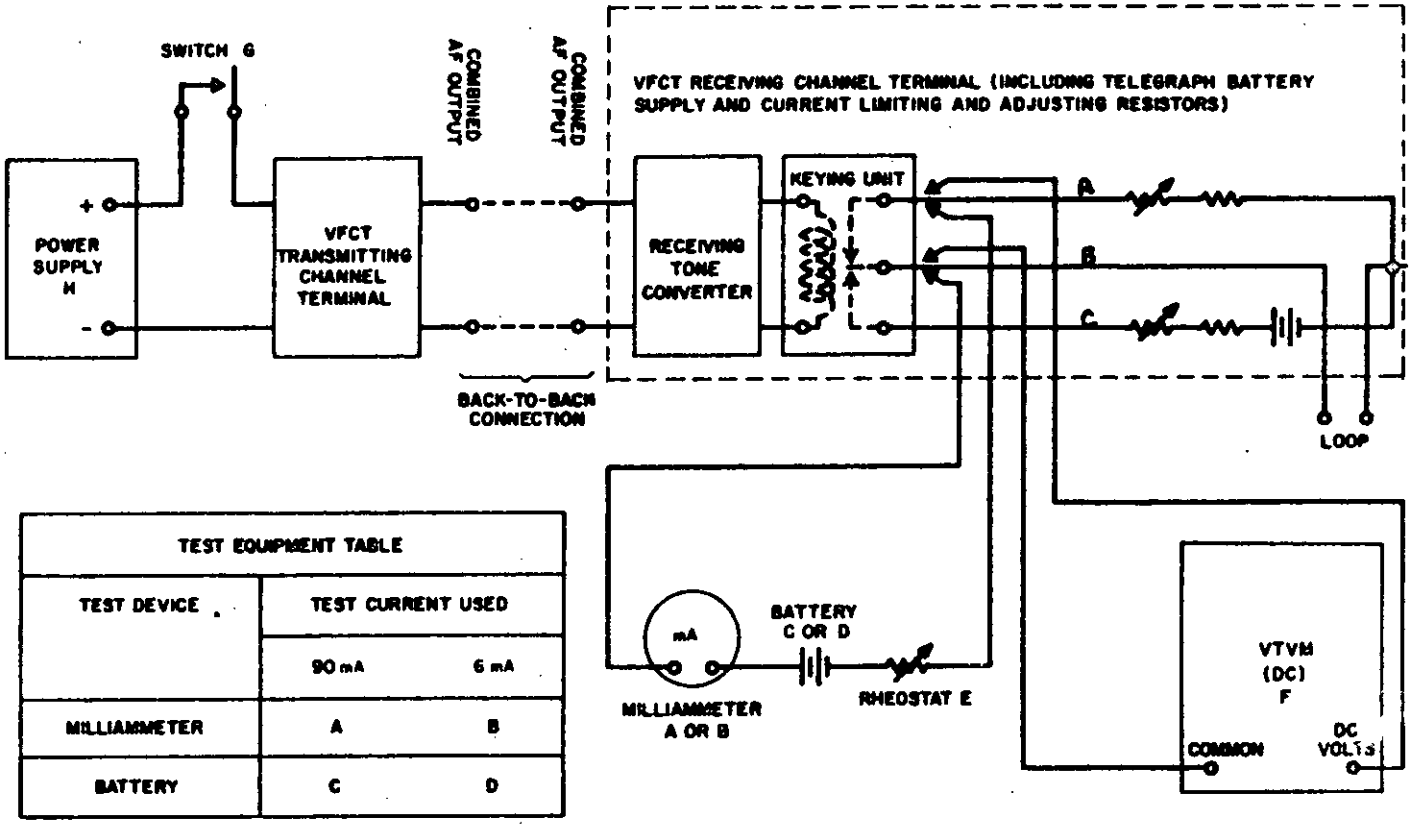
Step 1. Connect equipment for back-to-back operation as shown in figure 5103. Battery D and milliammeter B should be used. Both stepped variable attenuators (associated respectively with the transmitting and receiving VFCT terminals) must be set for 0 dB.

Step 2. Adjust individual channel terminal outputs to -25.0 dBm.

Step 3. Close switch G and adjust current in milliammeter B to 6 mA.

Step 4. Record voltage across A and B.

Step 5. Open switch and again record voltage across A and B. With switch C open, this voltage should be approximately that of battery D.



TEST EQUIPMENT TABLE		
TEST DEVICE	TEST CURRENT USED	
	90 mA	6 mA
MILLIAMMETER	A	B
BATTERY	C	D

FIGURE 5103. ARRANGEMENT FOR MEASURING THE RESISTANCE OF THE DIGITAL OUTPUT OF VFCT RECEIVING CHANNEL TERMINALS

Step 6. With switch G still open, transfer test connections from A to C.

Step 7. Adjust current in milliammeter B to 6 mA and record voltage across B and C.

Step 8. Close switch G and again record voltage across B and C. With switch G closed, this voltage should be approximately that of battery C.

Step 9. See paragraph 4.4.

4.4 RESISTANCE CALCULATION. Calculate contact resistance as follows:

Let: V = Voltage in volts measured across the relaying device contacts by voltmeter F.

I = Current in milliamperes as measured by milliammeter A or B as appropriate.

R = Contact resistance in ohms.

Then: $R = \frac{1000\ V}{I}$

METHOD 5104

DIGITAL INPUT/OUTPUT GROUNDING

1. SCOPE. This method is used to detect unwanted grounds at digital inputs and outputs of voice frequency carrier telegraph (VFCT) equipment.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Digital Input/Output Grounding	5.2.2

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix
Ohmmeter	A	52

4. PROCEDURES.

NOTE

Before starting this test, all connections external to the VFCT terminal must be removed from the battery or ground terminals shown in

figure 5104-a, and from terminals 1 and 2 shown in figure 5104-b. Any internal connection of battery to these points must also be removed.

4.1 DETECTION OF UNWANTED GROUNDS AT DIGITAL INPUT OF A VFCT TRANSMITTING TERMINAL.

Step 1. Connect equipment as shown in figure 5104-a.

Step 2. Connect ungrounded ohmmeter terminal first to tip of equipment jack and then to point designated battery or ground.

Step 3. At each point measured resistance-to-ground should exceed 1 megohm.

4.2 DETECTION OF UNWANTED GROUNDS AT DIGITAL OUTPUT OF A VFCT RECEIVING TERMINAL.

Step 1. Connect equipment as shwon in figure 5104-b.

Step 2. Connect ungrounded ohmmeter terminal first to tip of equipment jack and then to points designated 1 and 2.

Step 3. At each point measured resistance-to-ground should exceed 1 megohm.

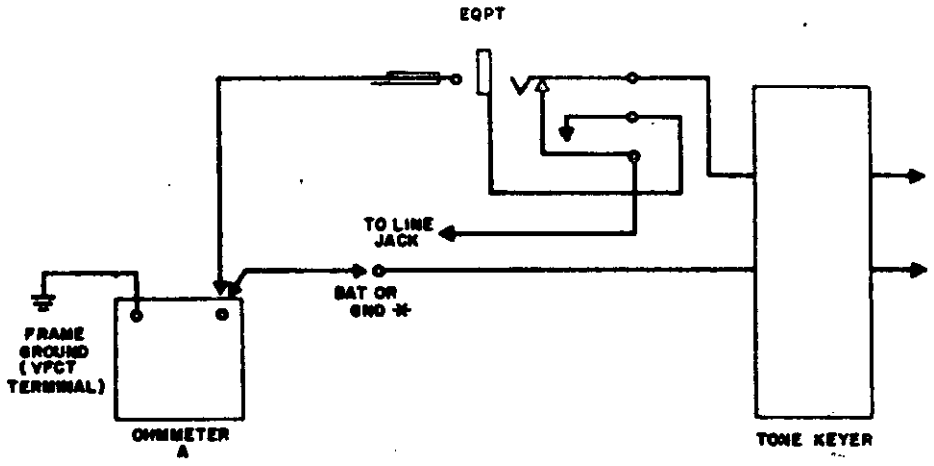
METHOD 5105

SIGNALING SENSE

1. SCOPE. This method is used to determine the signaling sense of input (transmitting) and output (receiving) units of voice frequency carrier telegraph (VFCT) equipment.

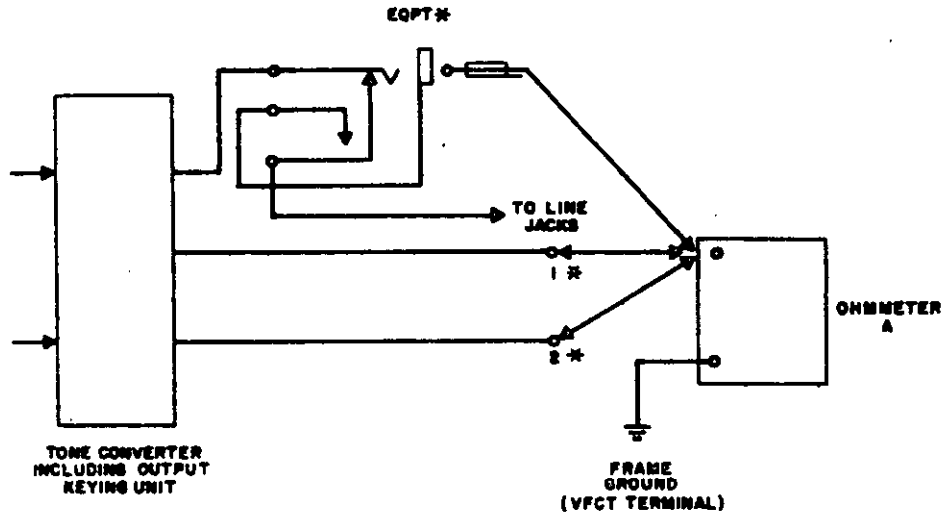
2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Signaling Sense	5.2.3



*ANY INTERNAL VFCT BATTERY MUST BE REMOVED

FIGURE 5104-a. ARRANGEMENT FOR DETECTION OF UNWANTED GROUNDS AT DIGITAL INPUT OF VFCT TRANSMITTING TERMINALS



* ANY INTERNAL VFCT BATTERY MUST BE REMOVED

FIGURE 5104-b. ARRANGEMENT FOR DETECTION OF UNWANTED GROUNDS AT DIGITAL OUTPUT OF VFCT RECEIVING TERMINALS

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Telegraph Signal Generator	A	179
Power Supply	B,C	567
Power Supply	J,L	568
Power Supply	K,M	569
Milliammeter	D,E	48
Milliammeter	N,O	50
Resistor Variable	F,H	443
Resistor Variable	G,I	444
Resistor Variable	P,R	445
Resistor Variable	Q,S	446
Switches	T,U	947

4. PROCEDURES.

4.1 SIGNALING SENSE OF VFCT TRANSMITTING OR RECEIVING TERMINALS (NEUTRAL, 130 V, 60 OR 20 mA).

Step 1. Connect equipment as shown in figure 5105-a, high level signaling.

NOTE

This setup requires the VFCT terminal to be arranged for back-to-back operation as shown in figure 5105-a. It also requires that the transmitting terminal has been checked for the correspondence of mark and space tones to the DC input. The individual tone keyer outputs must be adjusted to -25.0 dBm and both of the stepped variable attenuators set to 0 dB. When double scale meters are used, the proper scale must be selected to avoid damage to the meter.

Step 2. Set telegraph signal generator A to steady mark.

Step 3. Arrange both tone keyer and tone converter for neutral, 130 V, 60 mA operation.

Step 4. Adjust resistors F and H so that milliammeters D and E, respectively, will read 60 mA.

Step 5. Set telegraph signal generator A for steady space.

Step 6. Check that both milliammeters show zero current.

Step 7. Reverse connections to power supply B by operating switch T.

Step 8. Check that both milliammeters still indicate zero current.

Step 9. Set telegraph signal generator to steady mark.

Step 10. Check that both milliammeters show 60 mA, although milliammeter D will indicate current in opposite direction from indication it gave in step 4.

Step 11. Reverse connections to power supply C by operating switch U.

Step 12. Check that both milliammeter now read 60 mA but in a direction opposite to that shown in step 4.

Step 13. Set telegraph signal generator to steady space. (Both milliammeters should read zero).

Step 14. Set telegraph signal generator on steady mark.

Step 15. Replace resistors F and H with resistors G and I and adjust them so that both milliammeters read 20 mA.

Step 16. Put both current supply connections back to normal by operating switches T and U. (Steps

51 and 16 establish conditions for low level signaling).

Step 17. Repeat steps 5 through 13, except that milliammeters read 20 mA rather than 60 mA whenever a mark is being transmitted.

4.2 SIGNALING SENSE OF VFCT TRANSMITTING OR RECEIVING TERMINALS (POLAR 60 V, 20 mA OR 6 V, 1 mA).

Step 1. Connect equipment as shown in figure 5105-b, high level signaling.

NOTE

Review note given in paragraph 4.1, step 1.

Step 2. Set telegraph signal generator A to steady mark.

Step 3. Arrange both tone keyer and tone converter for polar, 60 V, 20 mA operation.

Step 4. Adjust resistors P and R so that milliammeters N and O read 20 mA. (Both should read in the same direction, i.e., positive).

Step 5. Set telegraph signal generator A for steady space.

Step 6. Check that milliammeters N and O read 20 mA in opposite direction, i.e., negative.

Step 7. Reverse positive and negative connections to power supply J by operating switch T.

Step 8. Check that milliammeters N and O read 20 mA positive.

Step 9. Operate control on tone keyer under test in reverse signaling sense. Both milliammeters should read 20 mA negative.

Step 10. Reverse positive and negative connections to power supply L by operating switch U.

Step 11. Check that both milliammeters read 20 mA, but that milliammeter N is negative and milliammeter O is positive.

Step 12. Operate control on tone converter under test to reverse signaling sense. Both milliammeters should read 20 mA negative.

Step 13. Set telegraph signal generator for steady mark. Both milliammeters should read 20 mA positive.

Step 14. Replace power supplies J and L with K and M, and resistors P and R with Q and S.

Step 15. Restore switches T and U to normal.

Step 16. Arrange tone keyer and tone converter for 6 V, 1 mA operation.

Step 17. Adjust resistors Q and S so that milliammeters N and O read 1 mA. (Both should read in the same direction, i.e., positive).

Step 18. Repeat steps 5 through 13, except that the milliammeters read 1 mA rather than 20 mA.

METHOD 5106

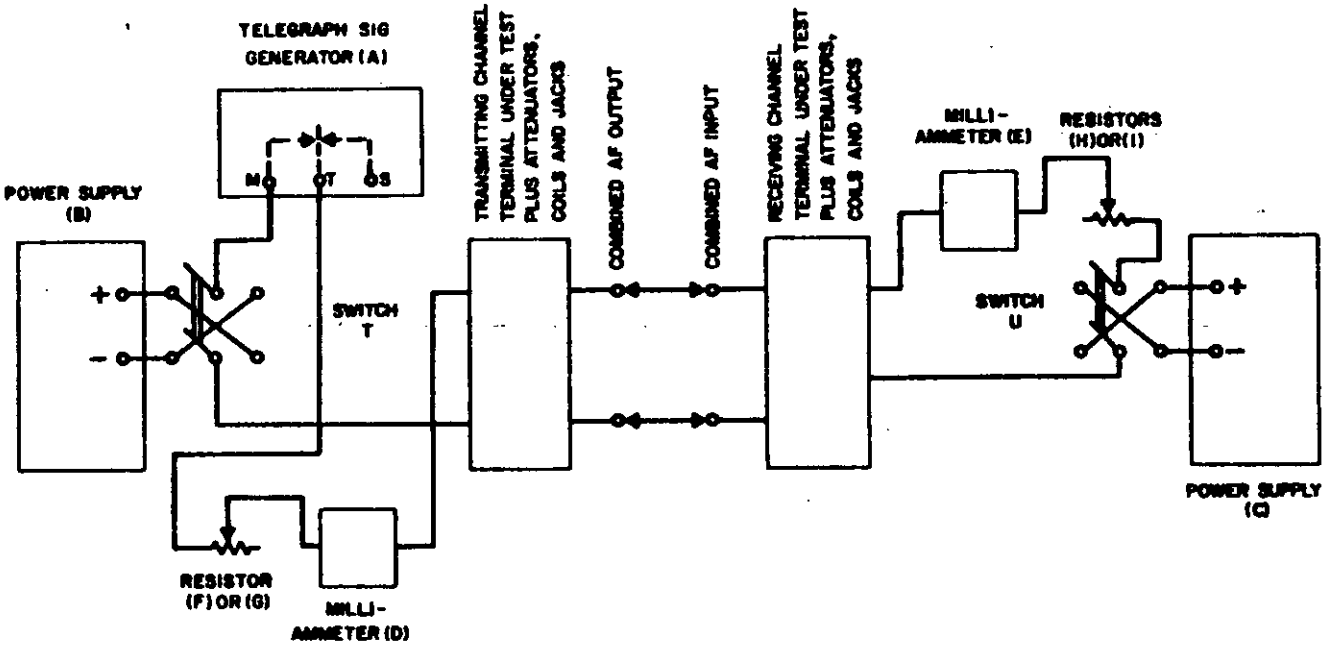
POWER SUPPLY

1. SCOPE. This method describes tests for 60 mA neutral, 20 mA polar, and 6 V polar loop power supplies.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

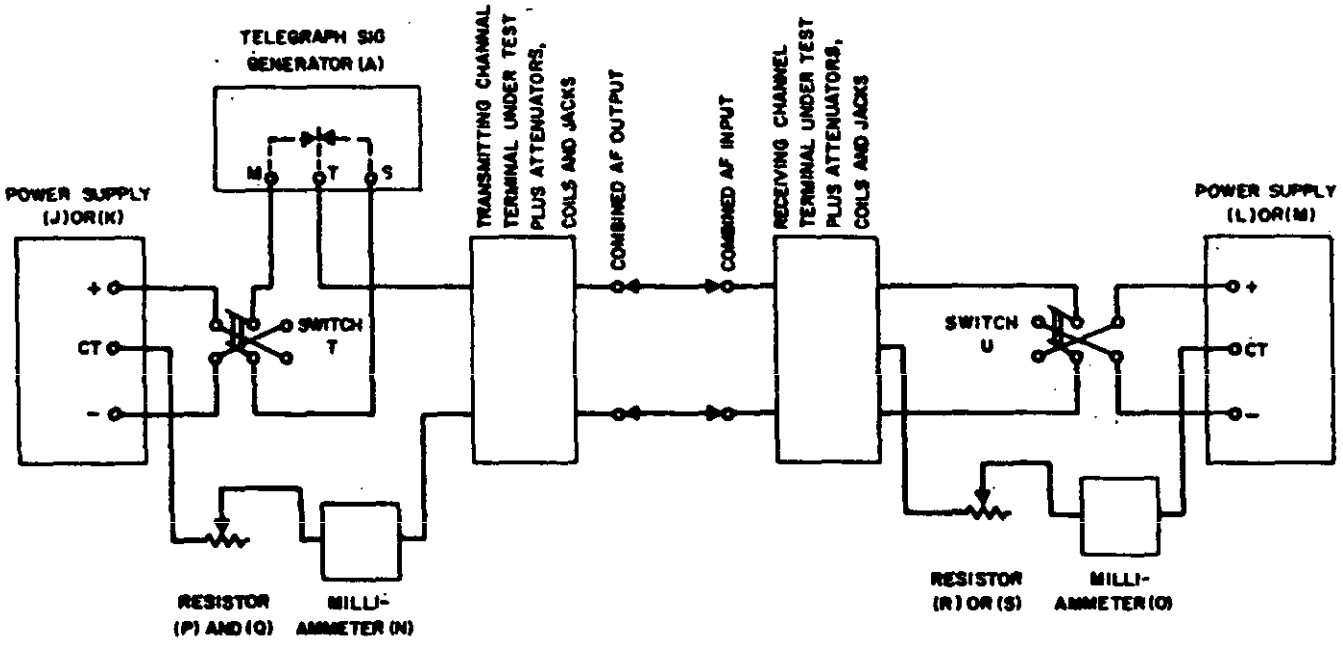
Item	Reference
Loop Battery Supply	MIL-STD-188-100 or MIL-STD-188-300
Dynamic Output Impedance	

3. APPARATUS. Required test equipment is listed in table 1.



	POWER SUPPLY VOLTAGE	LOOP CURRENT mA	POWER SUPPLY	MILLI-AMMETER	RESISTORS
HIGH LEVEL SIGNALING	130	60	B-C	D-E	F-H
LOW LEVEL SIGNALING	130	20	B-C	D-E	G-I

FIGURE 5105-e . ARRANGEMENT FOR DETERMINATION OF SIGNALING SENSE OF VFCT TRANSMITTING OR RECEIVING TERMINALS (NEUTRAL 130 V, 60 OR 20 mA)



	POWER SUPPLY VOLTAGE	LOOP CURRENT mA	POWER SUPPLY	MILLI-AMMETER	RESISTORS
HIGH LEVEL SIGNALING	±60	20	J-L	N-O	P-R
LOW LEVEL SIGNALING	±6	1	K-M	N-O	Q-S

FIGURE 5105-b. ARRANGEMENT FOR DETERMINATION OF SIGNALING SENSE OF VFCT TRANSMITTING OR RECEIVING TERMINALS (POLAR 60 V, 20 mA OR 6 V, 1 mA)

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Voltmeter	A	54
Voltmeter	B	55
Potentiometer	C	452
Electronic Counter	D	255
Voltmeter	E	56
Ammeter	F	57
Variable Autotransformer	G	670
Voltmeter	H	58
Switches	S1, S2	946

4. PROCEDURES.

4.1 LOOP BATTERY SUPPLY VOLTAGE ADJUSTMENT.

NOTE

This adjustment is to be made only when loop power supply constitutes a part of the VFCT terminal.

Step 1. Connect equipment as shown in figure 5106-a.

NOTE

Arrangement (1) is for use on the loop power supply used for 130 V, 60 or 20 mA neutral operation, (2) is for 60 V, 20 mA polar operation and (3) is for 6 V, 1 mA polar operation.

The load resistors shown (R1 through R6) simulate the load of the send and receive loops of 19 VFCT channels.

Step 2. Adjust output voltage to nominal level. For polar operation at 60 or 6 V, plus and minus voltages should be balanced within requirements.

4.2 SWITCHING OF LOOP OR EQUIPMENT POWER SUPPLIES.

NOTE

Power supplies are furnished in duplicate with one supplying the load and the other in standby condition. Failure of the working supply should result in an automatic switch to the standby supply.

Step 1. Connect equipment as shown in figure 5106-b.

Step 2. Adjust potentiometer C for satisfactory operation of triggers to counter. It may not be required on power supplies having output voltages of less than 100 V.

NOTE

The counter is set up to measure "time interval", the interval to be measured being that between failure of the working power supply and the picking up of the load by the standby supply. If the switch is mechanical, this time interval will be a few milliseconds, probably between 1 and 5, but if it is electronic, it may be short, of the order of a few microseconds.

Step 3. Close switches S1 and S2 and determine which power supply is working and which is standby. This determination may be made by inspection of the switching relays or from manufacturers' specifications.

Step 4. Open switch S1 (or S2) that controls AC supply to working power supply.

Step 5. Adjust trigger circuit of counter to start counting when load voltage drops 10 percent from its nominal value. It should stop counting when load voltage has recovered to 90 percent of its nominal value. Interval indicated by count should be less than 5 milliseconds.

4.3 MEASUREMENT OF DC OUTPUT IMPEDANCE OF LOOP POWER SUPPLIES.

NOTE

This measurement is to be made only when the loop power supply constitutes part of the VFCT terminal.

Step 1. Connect equipment as shown in figure 5106-c.

Step 2. Set current limit adjustment of power supply to its maximum value. Failure to observe this precaution may result in output voltage dropping at full load due to current limiting action.

Step 3. Adjust autotransformer G to minimum allowable supply voltage (e.g., 115 V minus 10% = 104 V, or 230 V minus 10% = 207 V).

Step 4. Record DC voltage at power supply output with switch S1 open (no load) and closed (full load).

Step 5. Record full load current as indicated on ammeter F.

Step 6. Adjust autotransformer G to maximum allowable supply voltage (115 V plus 10% = 127 V, or 230 V plus 10% = 253 V).

Step 7. Record DC voltage at the power supply output with switch S1 open and closed.

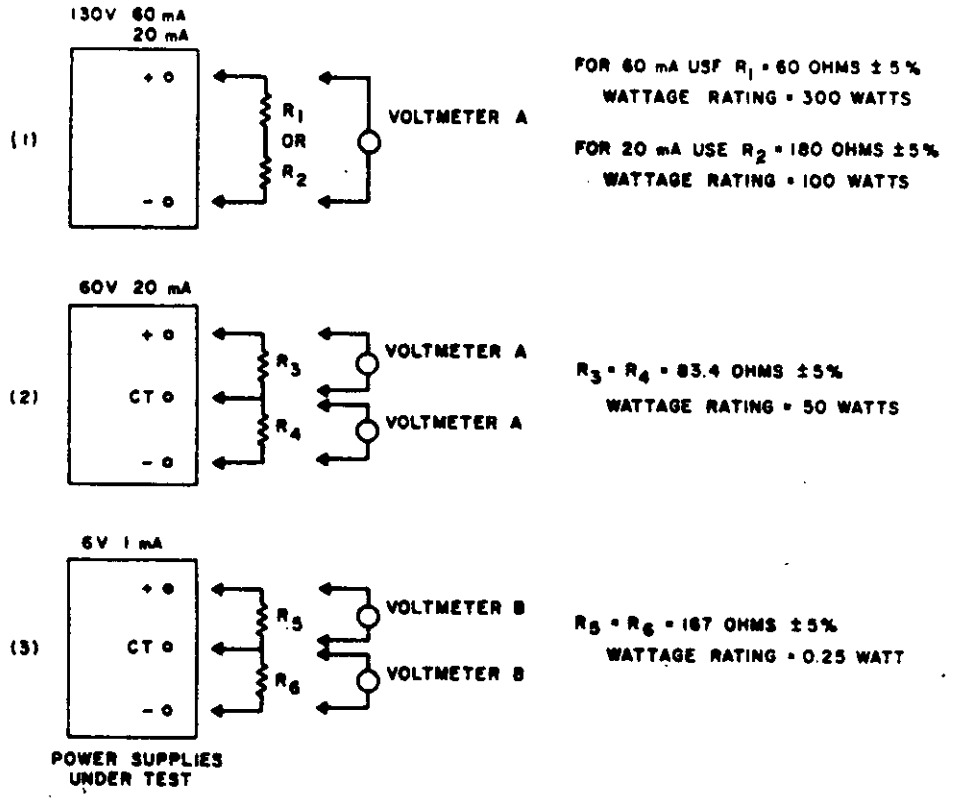


FIGURE 5106-a. ARRANGEMENT FOR ADJUSTING THE VOLTAGE OF LOOP BATTERY SUPPLIES

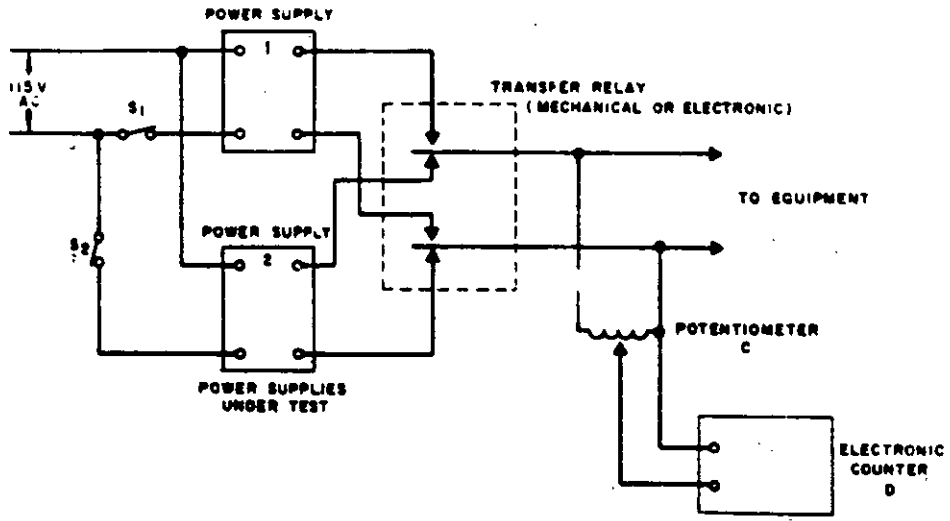


FIGURE 5106-b. ARRANGEMENT FOR CHECKING THE AUTOMATIC CHANGE-OVER OF LOOP OR EQUIPMENT POWER SUPPLIES

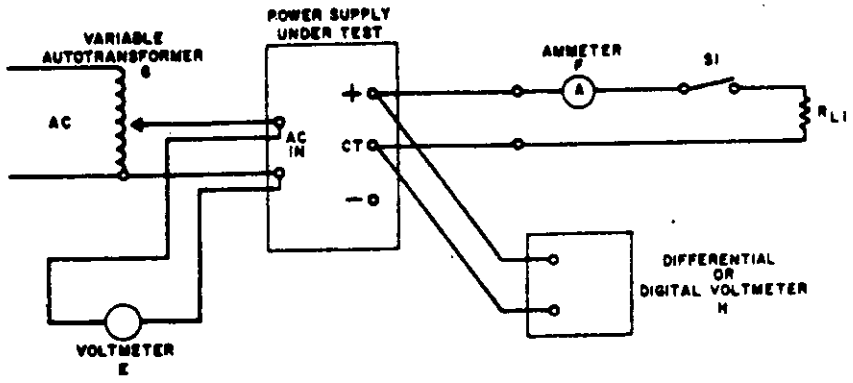


FIGURE 5106-c. CONNECTIONS FOR MEASUREMENT OF OUTPUT IMPEDANCE-DC

Step 8. Record full load current as indicated on ammeter F.

Step 9. Calculate DC output impedance as follows:

$$R = (V1 - V2)/I$$

where V1 is no-load voltage, V2 is full-load voltage, and I is full-load current in amperes.

METHOD 5107

CARRIER FREQUENCY STABILITY

1. SCOPE. This method is used to determine mark and space carrier frequency stability of voice frequency carrier telegraph (VFCT) equipment. This method is also used to measure mark and space frequencies and the adjustment of them to required values and tolerances specified in the standard.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Carrier Frequencies	5.3.1
Carrier Frequency Stability	5.3.2

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Frequency Counter	A	255
Switch	B	946
Resistor	C	410
Power Supply	D	567
Voltmeter	E	56
Thermometer	F	59

4. PROCEDURES.

4.1 MEASUREMENT OF MARK AND SPACE FREQUENCIES.

Step 1. Connect equipment as shown in figure 5107.

Step 2. Arrange tone keyer under test for neutral, 20 or 60 mA operation and VFCT terminal for non-diversity operation.

Step 3. Adjust per channel output to about -25.0 dBm.

Step 4. Measure and record AC supply voltage and air temperature in vicinity of VFCT equipment bays.

Step 5. Adjust current in transmitting loop to 20 or 60 mA as chosen with switch B closed using current meter and current adjusting resistors which are part of the channel terminal.

Step 6. Channel under test will now be transmitting its mark frequency. Measure and record this frequency.

Step 7. Operate switch B to open loop, thus transmitting space frequency of channel under test.

Step 8. Measure and record this frequency.

Step 9. If either mark or space frequencies differ from values specified in table 2 by more than $\pm$0.1 Hz, adjust them in accordance with instruction manual of manufacturer and record final frequencies.

Step 10. Repeat steps 2 through 9 for all channels.

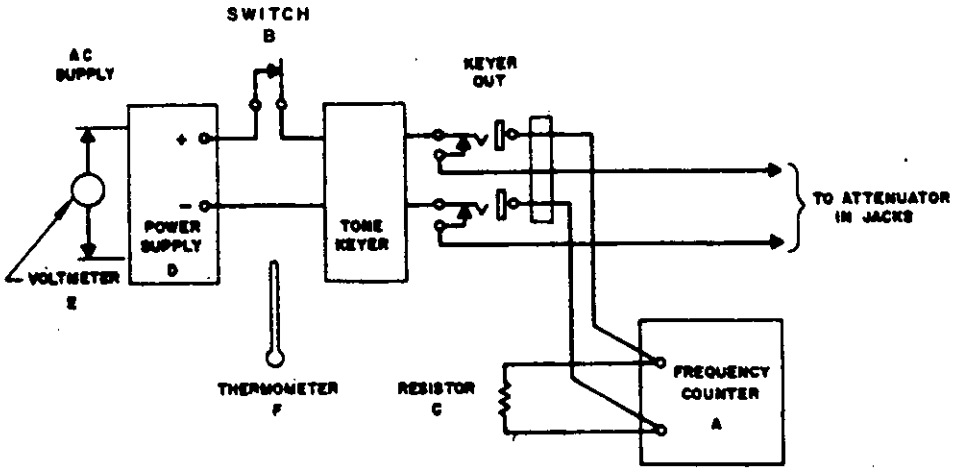


FIGURE 5107. ARRANGEMENT FOR MEASURING AND ADJUSTING MARK AND SPACE FREQUENCIES OF VFCT TRANSMITTING TERMINALS

TABLE 2. MARK AND SPACE CARRIER FREQUENCIES OF A VFCT TRANSMITTING TERMINAL, NONDIVERSITY

Channel Designation	Specified Carrier Frequencies - Hz	
	Mark	Space
1	382.5	467.5
2	552.5	637.5
3	722.5	807.5
4	892.5	977.5
5	1062.5	1147.5
6	1232.5	1317.5
7	1402.5	1487.5
8	1572.5	1657.5
9	1742.5	1827.5
10	1912.5	1997.5
11	2082.5	2167.5
12	2252.5	2337.5
13	2422.5	2507.5
14	2592.5	2677.5
15	2762.5	2847.5
16	2932.5	3017.5
17	3102.5	3187.5
18	3272.5	3357.5

NOTE: On some equipment the mark and space frequencies are independently adjustable. On such equipment, adjust each frequency as necessary to meet the specified values. On other types, only one of the two (either mark or space) is adjustable and the other is determined by a fixed frequency shift, which would be 85.0 Hz. However, this frequency shift may not be exactly 85.0 Hz. In such a case, set the adjustable frequency so that both mark and space frequencies are as close as practicable to the specified values.

4.2 STABILITY OF MARK AND SPACE FREQUENCIES.

Under consideration.

METHOD 5108

TONE CARRIER LEVELS

1. SCOPE. This method is used for the measurement of mark and space tone carrier levels at the output of voice frequency carrier telegraph (VFCT) transmitting terminals.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Tone Carrier Levels	5.3.3

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Transmission Measuring Set	A	345
Power Supply	B	567
Switch	C	946
Voltmeter	D	56
Thermometer	F	59

4. PROCEDURES.

4.1 MEASUREMENT OF TONE CARRIER LEVELS.

NOTE

It is the purpose of the tests described in this section to: (1) measure the maximum and minimum

output available at mark and space frequencies of each transmitting channel terminal at the tone keyer out jacks; (2) determine the accuracy with which the output can be adjusted; (3) determine the difference in the level of the mark and space frequencies of each channel; and (4) determine the stability with time of the tone levels of each channel. All tests described in this section use the arrangement of figure 5108. Neutral, 130 V, 20 mA operation is specified and the current in each loop is adjusted to 20 mA, but, if more convenient, any of the DC signaling modes specified in the standard may be used for this test. Use the integral current meter and the current adjusting resistors which are part of the terminal equipment for adjusting the loop currents.

Step 1. Connect equipment as shown in figure 5108.

Step 2. Turn off all transmitting channel terminals except one under test.

Step 3. With output control potentiometer of channel terminal under test on its maximum level setting, and switch C closed, measure and record level at keyer-out jacks, using transmission measuring set A in the 600 ohm or terminating condition.

Step 4. Keeping output control potentiometer of channel under test on maximum, open switch C and again measure and record output level at keyer-out jacks.

Step 5. Turn output control potentiometer of channel terminal under test to its minimum level setting and measure and record output level at the keyer-out jacks with switch C closed and open.

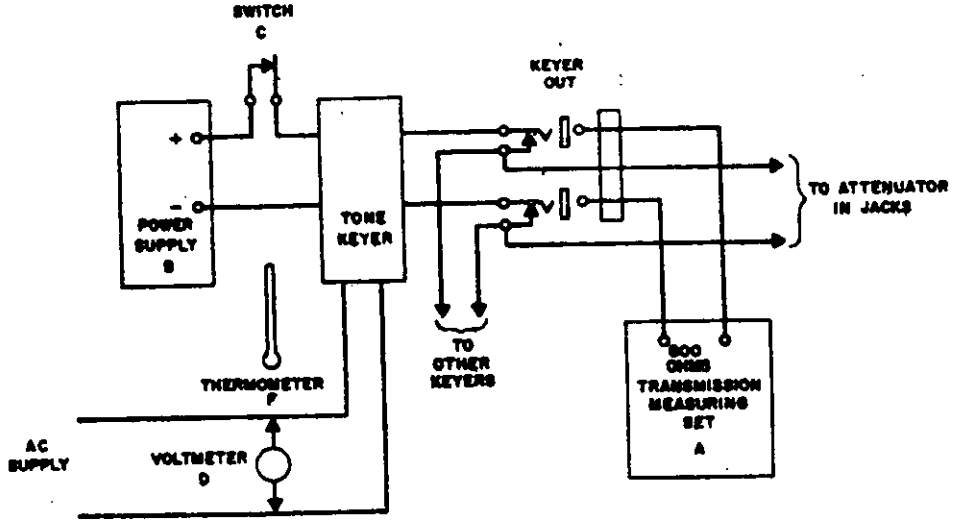


FIGURE 5108. ARRANGEMENT FOR MEASURING AND ADJUSTING TONE CARRIER LEVELS

NOTE

If levels of minimum setting of output control potentiometer are below -50 dBm, do not attempt to measure them accurately nor attempt to compare mark and space levels, since it is possible that carrier tone is being obscured by noise.

Step 6. Using output control potentiometer, adjust level (with switch C closed) as closely as practicable to -25.0 dBm. Record actual measured level.

Step 7. Open switch C and measure and record level without adjustment.

Step 8. Repeat steps 2 through 7 for all terminal channels.

NOTE

The channels should be left energized, i.e., oscillators turned on, power connected to channel terminal equipment, and outputs set according to step 6 so that stability tests described in paragraph 4.2 can be made.

Step 9. Measure and record air temperature in vicinity of equipment bays and AC supply voltage to transmitting channel terminals.

4.2 STABILITY OF TONE CARRIER LEVELS.

NOTE

In determining the stability of the carrier levels over a period of time, the irrelevant variables must be eliminated, insofar as possible, so that the effects of aging will be isolated as the only factor causing a variation of levels. In order that this may be accomplished, it is necessary to reproduce (as nearly as practicable at the time the subsequent series of tests are made) the conditions which existed when the first

series of tests were made. The most important conditions are the AC supply voltage and the ambient temperature. It should be noted that, for the purpose of these tests, the air temperature in the vicinity of the equipment is assumed to be a measure of the actual temperature of the circuit components, since this "actual temperature" is very difficult to measure. This assumption is valid, however, only if the equipment has been energized continuously for a period of a day or more, and if the air temperature is relatively stable. It is not valid, for instance, in the winter (in a cold climate) in a room where the heat is turned off during the night. Since the standard specifies stability over a 30 day period, elaborate arrangements may be necessary to control the temperature. Insofar as AC supply voltage is concerned, a variac or a tapped transformer should be used to adjust this voltage to the value which existed at the time the original tests were made. The stability test results will not be valid unless the equipment under test has been energized for the entire period.

Step 1. Measure and record outputs of each channel at mark and space frequencies with switch C closed and open, at weekly intervals, for a period of 6 weeks.

METHOD 5109

NOISE

1. SCOPE. This method is used to measure the noise existing at the output of a voice frequency carrier telegraph (VFCT) transmitting terminal.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Noise	5.3.4

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Noise Measuring Set	A	344

4. PROCEDURES.

4.1 NOISE EXISTING AT OUTPUT OF VFCT TRANSMITTING TERMINAL.

Step 1. Connect equipment as shown in figure 5109.

Step 2. Set all tone keyers under test for normal operation.

Step 3. Turn all carrier oscillators or generators off.

Step 4. Set stepped variable attenuators to 0 dB.

Step 5. Set noise measuring set for C message weighting and read and record average noise and average of peaks, if any are noted. (The meter of the noise measuring set should be watched for at least five minutes to determine these two averages).

NOTE

From circuit layout cards or other information, determine test tone level (referred to a 0 dBm reference test tone level point, commonly referred to a 0 TLP) at the line jacks. These jacks may be in a VF telegraph line board or a four-wire patching jack bay or repeater bay. In any event, the specified test tone level at the line jacks must be known. Assume that the test tone level at the line jacks is -5 referred to 0 TLP. Then, the corrected noise at the equip-

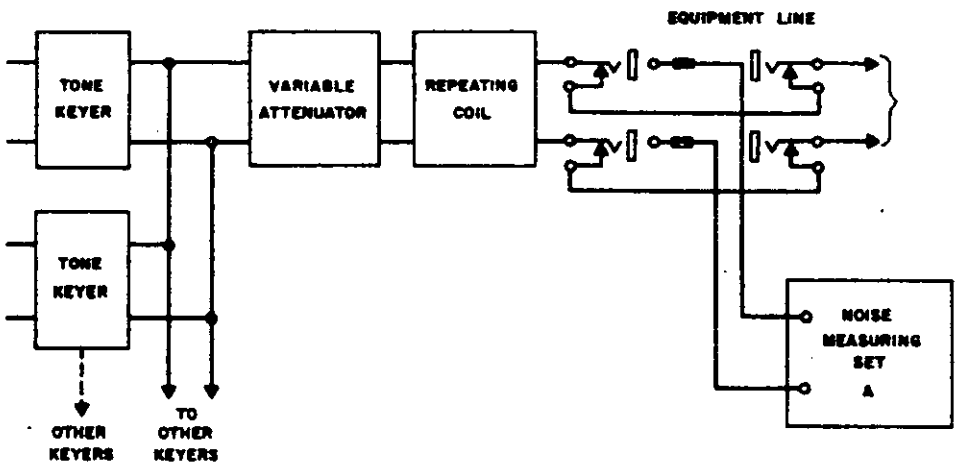


FIGURE 5109 • ARRANGEMENT FOR MEASURING THE NOISE EXISTING AT OUTPUT OF A VFCT TRANSMITTING TERMINAL

ment jacks is measured noise dBrnC minus line jack level referred to 0 TLP. Or in the case assumed, if the measurement was 20 dBrnC, the corrected noise would be 20 - (-5) = 25 dBrnC at 0 TLP.

METHOD 5110

FILTER CHARACTERISTICS

1. SCOPE. This method is used to determine the attenuation characteristics of voice frequency carrier telegraph (VFCT) transmitting and receiving filters.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Transmitting/Receiving Filter Characteristics	5.3.5

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Audio Frequency Oscillator	A	180
Transmission Measuring Set	B	345
Impedance Matching Coil	C	665
Terminating Resistors*	D	460
Impedance Matching Coil	E	666
Terminating Resistors**	F	461
Frequency Counter	G	255
Phase Meter	H	60
Amplifier	I	514
Amplifier	J	514
Resistor	K	410

*One terminating resistor may be required for each transmitting filter (see note 1 on figures 5110-a and 5110-c).
**One terminating resistor may be required for each receiving filter (see note 1 on figure 5110-b.

4. PROCEDURES.

NOTE

All of the filters of the terminal under test (transmitting or receiving) must be paralleled in the normal manner in all four of the test arrangements. Missing or nonconnected filters may affect the impedance, attenuation and envelope delay of the filter under test. When testing one filter, or a bank of filters, all of the other filters in the bank must be terminated. In most cases, the equipment normally connected to the filters may be used as a termination by leaving all of the filters, except the one under test, normally connected. If this cannot be done, resistors equalling the passband impedance of the filter must be used for terminations.

In some cases, the input and output impedances of VFCT filters are not the same. The impedance on the side that is paralleled with the other filters in the bank is usually 600 ohms, but the impedance of the other side may match that of the equipment to which it is connected. Thus, the input impedance of transmitting VFCT filters and the output impedance of receiving VFCT filters must be determined from the specifications of the manufacturer. Filters are frequently unbalanced-to-ground is connected to such filters, precautions must be taken to connect the ungrounded sides together.

4.1 LOSS-FREQUENCY CHARACTERISTICS OF VFCT TRANSMITTING FILTERS.

Step 1. Connect equipment as shown in figure 5110-a, starting with channel 1.

Step 2. Set transmission measuring set used for measuring oscillator output on high (bridging) impedance and set used for measuring loss on 600 ohm (terminating) impedance.

Step 3. Adjust oscillator frequency to within ±0.5 Hz of nominal midfrequency of filter under test.

Step 4. Adjust output level of oscillator to approximately 0 dBm.

Step 5. Measure loss on transmission measuring set patched into keyer aout jacks and record data on form similar to form shown in figure 5110-b, (column A) opposite number of channel being tested.

NOTE

The channel numbers and frequencies of a non-diversity arrangement are used on the form but all possible filter frequencies are included.

Step 6. Adjust audio frequency oscillator to mark (lower) frequency of channel under test (±0.5 Hz,

Step 7. Adjust output to same value used in step 4.

Step 8. Measure loss and record it in column B of figure 5110-b.

Step 9. Adjust audio frequency oscillator to space (upper) frequency of channel under test (±0.5 Hz)

Step 10. Adjust output to same value used in step 4.

Step 11. Measure loss and record it in column C of figure 5110-b.

Step 12. Adjust audio frequency oscillator to center frequency +55 Hz ±0.5 Hz.

Step 13. Adjust output to same value used in step 4.

Step 14. Measure loss and record it in column D of figure 5110-b.

Step 15. Adjust audio frequency oscillator to center frequency -55 ±0.5 Hz.

Step 16. Adjust output to same value used in step 4.

Step 17. Measure loss and record it in column E of figure 5110-b.

Step 18. Adjust audio frequency oscillator, in turn, to mark and space frequencies of all other channels of terminal, using frequency counter to adjust oscillator frequency to ±0.5 Hz of specified frequency of each channel.

Step 19. In each case, adjust oscillator output to value used in step 4, measure loss as described above and record it in appropriate space on form shown in figure 5110-b (i.e., the measurement of loss of channel 1 filter at channel 2 marking frequency will be entered in column H).

Step 20. Repeat steps 2 through 19 for all other channels, i.e., channels 2 through 18.

4.2 LOSS FREQUENCY CHARACTERISTICS OF VFCT RECEIVING FILTERS.

Step 1. Connect equipment as shown in figure 5110-c.

Step 2. Repeat steps 3 through 20 of paragraph 4.1 for all filters.

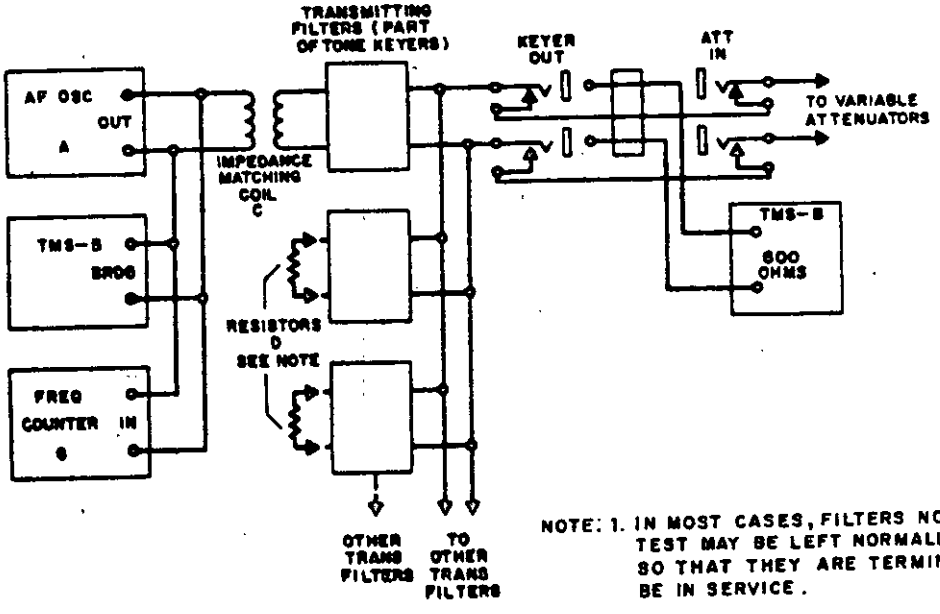


FIGURE 5110-a. ARRANGEMENT FOR MEASURING THE LOSS-FREQUENCY CHARACTERISTICS OF VFCT TRANSMITTING FILTERS

	Frequencies Hz			Attenua-tion in dbs of Passband at own Channel Fre-quencies					Attenuation in dBm of Stop Band at other Channel Frequencies																																			
	Mark	Center	Space	Center a	Mark b	Space c	C+55 d	C-55 e	1 M f	1 S g	2 M h	2 S i	3 M j	3 S k	4 M l	4 S m	5 M n	5 S o	6 M p	6 S q	7 M r	7 S s	8 M t	8 S u	9 M v	9 S w	10 M x	10 S y	11 M z	11 S aa	12 M ab	12 S ac	13 M ad	13 S ae	14 M af	14 S ag	15 M ah	15 S ai	16 M aj	16 S ak	17 M al	17 S am	18 M an	18 S ao
1	382.5	425	467.5						-	-																																		
2	552.5	595	637.5								-	-																																
3	722.5	765	807.5										-	-																														
4	892.5	935	977.5												-	-																												
5	1062.5	1105	1147.5														-	-																										
6	1232.5	1275	1317.5																-	-																								
7	1402.5	1445	1487.5																		-	-																						
8	1572.5	1615	1657.5																				-	-																				
9	1742.5	1785	1827.5																						-	-																		
10	1912.5	1955	1997.5																								-	-																
11	2082.5	2125	2167.5																										-	-														
12	2252.5	2295	2337.5																												-	-												
13	2422.5	2465	2507.5																														-	-										
14	2592.5	2635	2677.5																																-	-								
15	2762.5	2805	2547.5																																		-	-						
16	2932.5	2975	3017.5																																				-	-				
17	3102.5	3145	3187.5																																						-	-		
18	3272.5	3315	3357.5																																								-	-

FIGURE 5110-b. FORM FOR RECORDING MEASUREMENTS OF VFCT TRANSMITTING OR RECEIVING FILTER LOSS-FREQUENCY CHARACTERISTICS

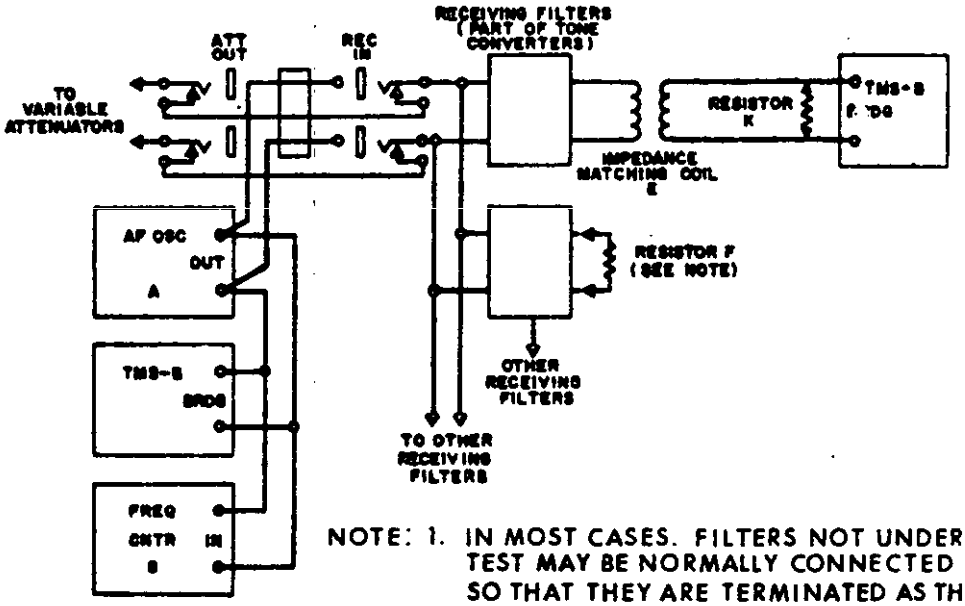


FIGURE 5110-c. ARRANGEMENT FOR MEASURING THE LOSS-FREQUENCY CHARACTERISTICS OF VFCT RECEIVING FILTERS

METHOD 5111

LEVEL ATTENUATORS

1. SCOPE. This method is used to determine attenuation range and size of incremental attenuation in dB of level attenuators associated with voice frequency carrier telegraph (VFCT) equipment.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Level Attenuators	5.3.6

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Audio Frequency Oscillator	A	180
Transmission Measuring Set	B,C	345

4. PROCEDURES.

4.1 ATTENUATION OF LEVEL ATTENUATORS IN COMBINED INPUT LINE OF A VFCT TERMINAL.

Step 1. Connect equipment as shown in figure 5111.

NOTE

For this test connect audio frequency oscillator A and transmission measuring set B to attenuator out jacks and transmission measuring set C to indicated point of receiving terminal under test.

Step 2. Set transmission measuring set B for high (bridging) impedance.

Step 3. Set transmission measuring set C for 600 ohm (terminating) impedance.

Step 4. Set audio frequency oscillator to 1000 Hz and 1 mW output (0 dBm).

Step 5. Set variable attenuators for 0 dB.

Step 6. Record loss as indicated by transmission measuring set C.

Step 7. Increase loss in fine attenuator by one increment. Transmission measuring set C will indicate loss measured under step 6 above plus dB value of one increment of fine attenuator ±0.1 dB. Record loss.

Step 8. Increase loss in fine attenuator one increment at a time, measuring and recording loss at each increment.

Step 9. Return fine attenuator to 0 dB and increase loss in coarse attenuator by one increment. Transmission measuring set C will now indicate the nominal dB loss of one increment of this attenuator, plus loss measured in step 6 above. Record this loss.

Step 10. Increase coarse attenuator one increment at a time, measuring and recording loss at each increment.

4.2 ATTENUATION OF LEVEL ATTENUATORS IN COMBINED OUTPUT LINE OF A VFCT TERMINAL.

Step 1. Connect equipment as shown in figure 5111.

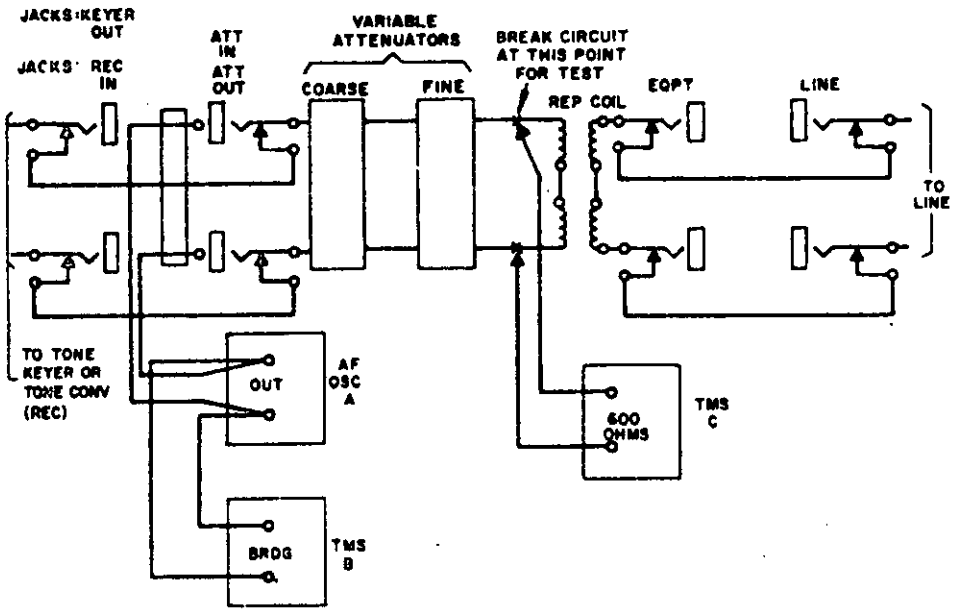


FIGURE 5111. ARRANGEMENT FOR MEASURING ALTENUATORS IN COMBINED INPUT AND OUTPUT LINES OF VFCT TERMINALS

NOTE

For this test connect audio frequency oscillator A and transmission measuring set B to attenuator in jacks and transmission measuring set C to indicated point of transmitting terminal under test.

Step 2. Repeat steps 2 throuhg 10 of paragraph 4.1.

METHOD 5112

INPUT/OUTPUT IMPEDANCE-VOICE FREQUENCY LINE

1. SCOPE. This method is used for the measurement of input/output impedances and electrical balance of voice frequency lines associated with voice frequency carrier telegraph (VFCT) equipment.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Input and Output Impedance-Voice Frequency Line	5.3.7

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
AF Oscillator	A	180
Transmission Measuring Set	B,H	345
Hybrid Coil or	C	667
Alternate Hybrid Coil	E	668
Resistor	D	410
Vacuum Tube Voltmeter	F,G	53
Resistors	R1,R2	447
Resistor	R3	448
Transformer	1	669

4. PROCEDURES.

4.1 IMPEDANCE (RETURN LOSS) OF OUTPUT OF TRANSMITTING VFCT TERMINALS OR OF INPUT OF RECEIVING VFCT TERMINALS.

Step 1. Connect equipment as shown in figure 5112-a.

NOTE

When measuring the impedance of transmitting terminals, the equipment jacks shown in this figure are at the output of the transmitting terminal and when measuring the impedance of receiving terminals, these jacks are at the input of the receiving terminal. Either of the hybrid coil arrangements shown may be used.

Step 2. Make measurements as described in step 4 below at following frequencies: 370, 400, 600, 800, 1000, 2000, 2500, 2800, 3000, 3200, 3300, and 3400 Hz. Calibration must also be performed at each of these frequencies.

NOTE

Calibration: Open terminals 1 and 2 and short terminals 3 and 4 of hybrid coil. Adjust audio frequency oscillator to frequency desired and adjust output to 1 mW (0 dBm) measuring output on transmission measuring set H, which is used on high impedance (bridging). Measure loss on transmission measuring set B, using the 600 ohm input, which is insertion loss of hybrid coil. It will usually be in the neighborhood of 3 to 4 dB.

Step 3. Set variable attenuators associated with transmitting terminal to 0 dB.

Step 4. Adjust frequency of audio frequency oscillator to desired frequency and its output to 1 mW (0 dBm). Measure loss. Return loss at this frequency is then: measured loss minus calibra-

tion loss. The impedance can be determined from curves of figure 5112-b.

NOTE

These curves assume the impedance to be a pure resistance, i.e., any reactive component is disregarded and, therefore, the curves apply at any frequency. In using these curves the actual value of resistor D (ZN) should be determined as accurately as practicable by measurement of it, using a wheatstone bridge.

Step 5. Set variable attenuators associated with transmitting terminal to their maximum value and repeat step 4.

Step 6. Repeat steps 3, 4, and 5 for the receiving terminal setting the variable attenuator associated with this terminal first at 0 dB and then at maximum value.

4.2 ELECTRICAL BALANCE TO GROUND OF OUTPUT OF A VFCT TRANSMITTING TERMINAL.

Step 1. Connect equipment as shown in figure 5112-c, with channel oscillators or carrier generators of all channel terminals turned off.

Step 2. Set variable attenuators associated with transmitting terminal to 0 dB.

Step 3. Turn on channel oscillator or carrier generator associated with channel 1 and adjust its output at equipment jack to as near to 1 mW (0 dBm) as can be attained. Either mark or space frequency of channel may be used. Since these frequencies differ by only 42.5 Hz, they are essentially the same for purposes of this test.

Step 4. Record voltage indicated by vacuum tube voltmeter F designating this V1.

Step 5. Record the much lower voltage indicated by vacuum tube voltmeter G.

Step 6. Interchange resistors R1 and R2 and again read the voltage indicated by vacuum voltmeter G. Designate the mean of these two readings as V2.

Step 7. The balance to ground is then: 20 $\log_{10}$ V1/V2 dB.

Step 8. Repeat steps 3 through 7 above for channels 5, 10, 15, 16, 17, and 18 or as many of these as exist in terminal concerned.

Step 9. The balance to ground must be 40 dB or greater for each of the channel frequencies measured.

Step 10. Repeat steps 3 through 9 above with variable attenuators set for maximum value.

4.3 ELECTRICAL BALANCE TO GROUND OF INPUT OF A VFCT RECEIVING TERMINAL.

Step 1. Connect equipment as shown in figure 5112-d.

Step 2. Adjust variable attenuators associated with receiving terminal to 0 dB.

Step 3. Adjust audio frequency oscillator to lowest frequency given in the following list: 500, 1000, 2000, 2800, 3000, 3400 Hz and adjust output to about 1 mW (0 dBm).

Step 4. Record voltages indicated by vacuum tube voltmeters F and G designating them V1 and V2, respectively.

NOTE

As in paragraph 4.2, step 5, above, V2 is the mean of the two readings of vacuum tube voltmeter G with resistors R1 and R2 interchanged.

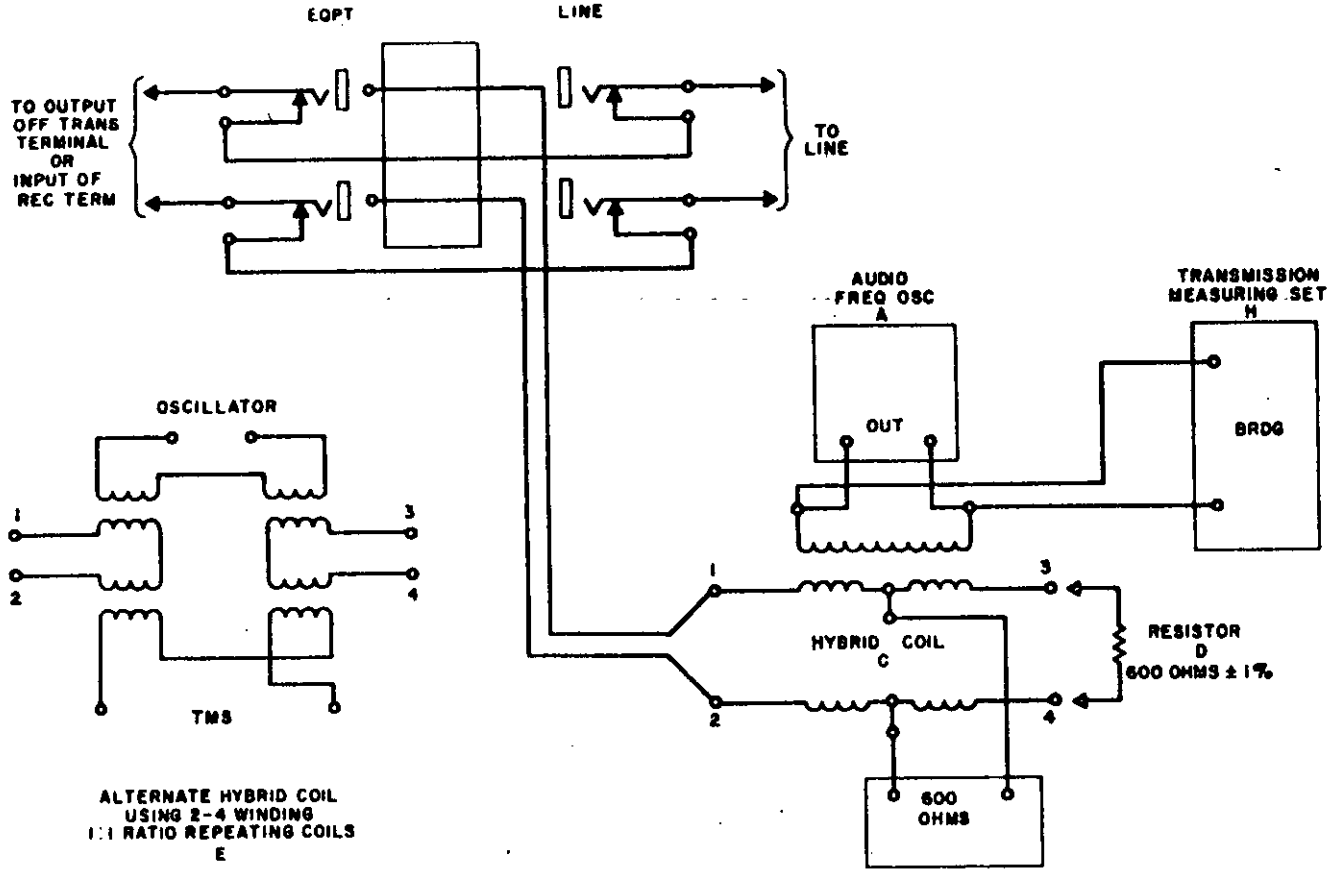


FIGURE 5112-a. ARRANGEMENT FOR MEASURING IMPEDANCE (RETURN LOSS) OF OUTPUT OF A TRANSMITTING VFCT TERMINAL OR INPUT OF A RECEIVING VFCT TERMINAL

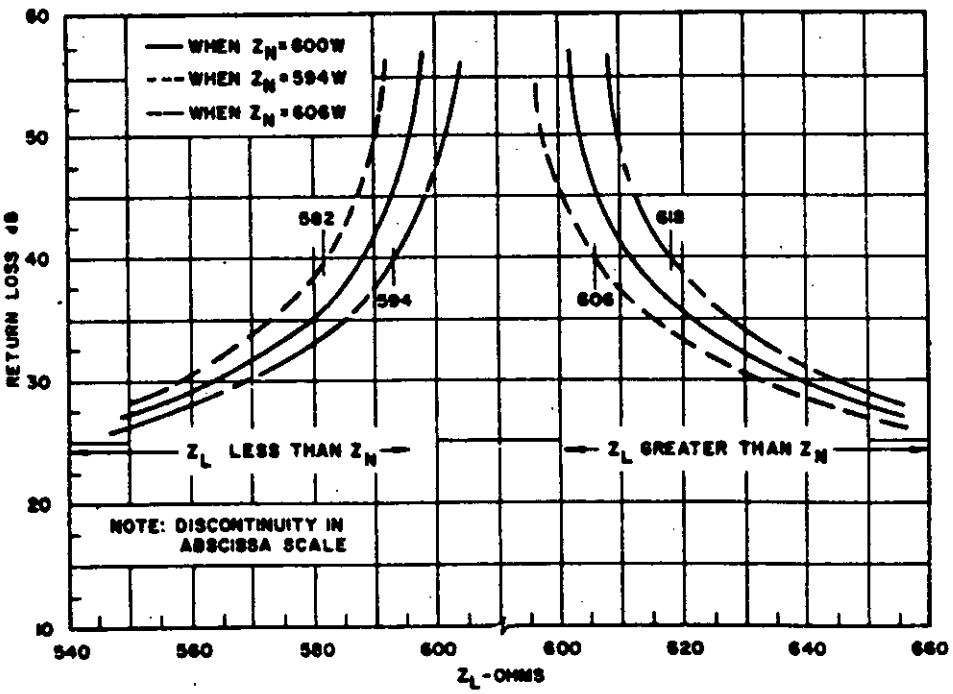


FIGURE 5112-b. RETURN LOSS (dB) Vs Z_L (ohms)

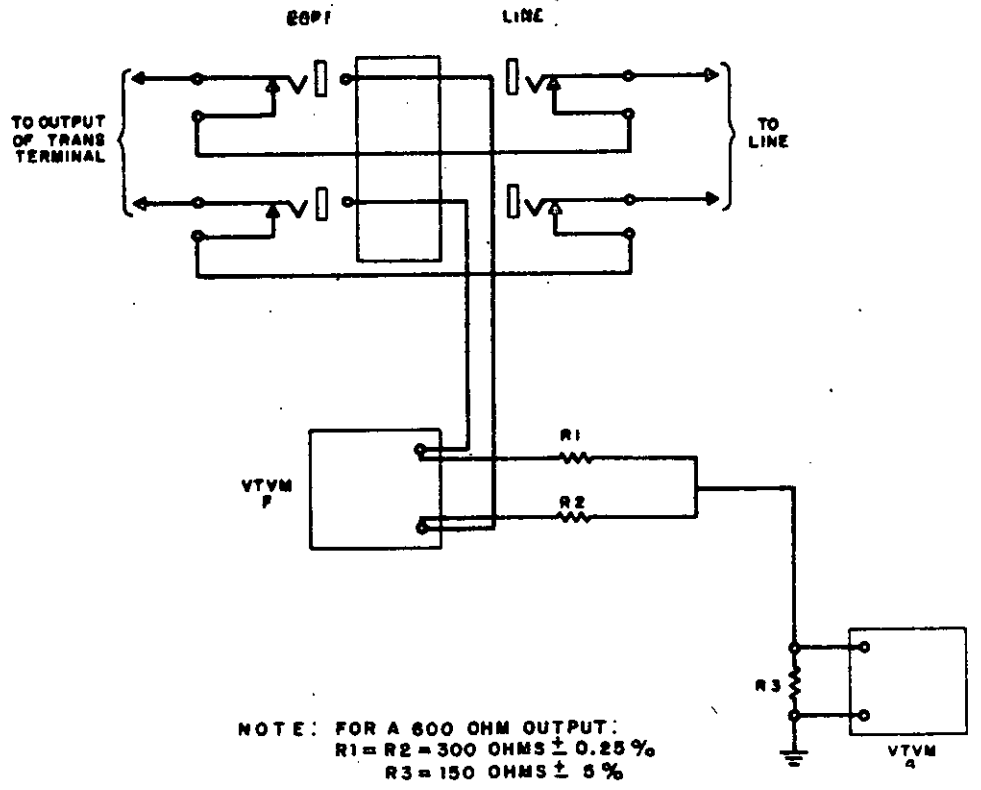


FIGURE 5112-c. ARRANGEMENT FOR MEASURING ELECTRICAL BALANCE-TO-GROUND OF OUTPUT OF A VFCT TRANSMITTING TERMINAL

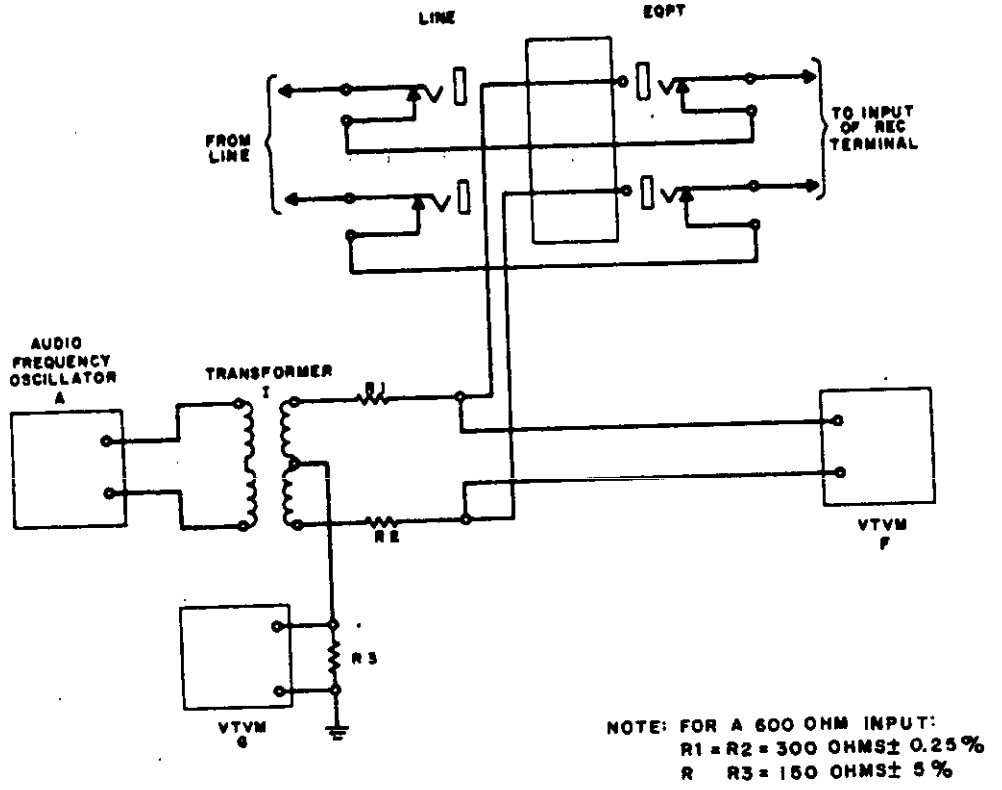


FIGURE 5112-d. ARRANGEMENT FOR MEASURING ELECTRICAL BALANCE-TO-GROUND OF INPUT OF A VFCT RECEIVING TERMINAL

Step 5. Balance to ground is then: 20 $\log_{10}$ V1/V2 dB.

Step 6. Repeat step 4 for each frequency listed in step 3.

Step 7. The balance to ground shall be 40 dB or greater for each frequency listed.

Step 8. Repeat steps 3 through 7 above with variable attenuators set for maximum value.

METHOD 5113

HARMONIC DISTORTION

1. SCOPE. This method is used for measurement of the level of second and higher order harmonics of carrier frequencies associated with voice frequency carrier telegraph (VFCT) transmitting terminals.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Harmonic Distortion	5.3.8

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Wave Analyzer	A	346
Telegraph Signal Generator	B	179
Power Supply	C	567
Transmission Measuring Set	D	345
Resistor	E	410

4. PROCEDURES.

4.1 LEVELS OF CARRIER HARMONICS.

Step 1. Connect equipment as shown in figure 5113.

NOTE

All tone keyers of VFCT terminal under test should be arranged for neutral, 130 V, 60 mA operation. The output of each tone keyer should be adjusted to -13.0 dBm as measured with transmission measuring set D at equipment jacks, and variable attenuators associated with terminal should be set to 0 dB. Since only harmonics falling within the band of 350 to 3400 Hz are of interest, the carriers of channels 1 to 8 (table 2) will be tested. The table also shows frequencies of harmonics to which wave analyzer will be tuned.

Step 2. With power supply and telegraph signal generator connected to channel 1, set latter to steady mark and adjust loop current to 60 mA adjusting resistors which are associated with tone keyer.

Step 3. Turn off tone generators of all other channels. This leaves marking frequency of channel 1 (382.5 Hz) as the only frequency being transmitted.

Step 4. Tune wave analyzer to frequency of second harmonic (table 2), and measure level, if possible. (It may be too low for the instrument to measure) Vary tuning of wave analyzer a few Hz above and below indicated frequency to be sure of optimum response.

Step 5. Tune wave analyzer successively to frequencies of third to eighth harmonics and, if possible, measure level of each.

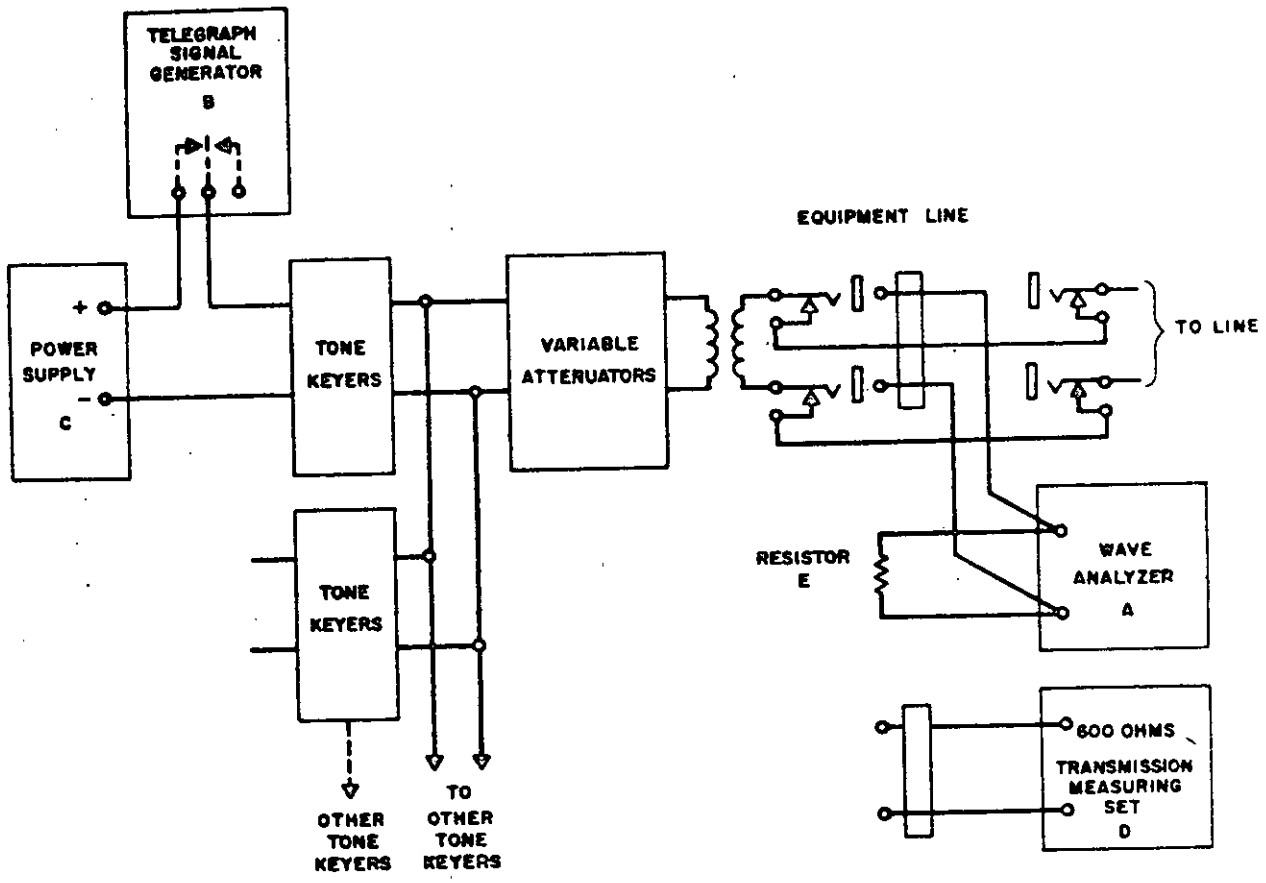


FIGURE 5113. ARRANGEMENT FOR MEASUREMENT OF HARMONICS OF CHANNEL CARRIERS AT OUTPUT OF VFCT TRANSMITTING TERMINALS

Step 6. Set telegraph signal generator to steady space and measure second to seventh harmonics.

Step 7. Repeat steps 2 through 6 for channels 2 through 8 (or as many of these as are present in the terminal being tested), measuring harmonics of each mark and space frequency shown in table 2.

TABLE 2. MARK AND SPACE CARRIER FREQUENCIES OF A VFCT TERMINAL AND HARMONICS OF THESE FREQUENCIES TO BE MEASURED (FREQUENCIES IN Hz)

		Carrier Freq.	2nd	3rd	4th	5th	6th	7th	8th	9th
1	M	382.5	765.0	1147.5	1530.0	1912.5	2295.0	2677.5	3060.0	
	S	467.5	935.0	1402.5	1870.0	2337.5	2805.0	3372.5		
2	M	552.5	1105.0	1657.5	2210.0	2762.5	3315.0			
	S	637.5	1275.0	1912.5	2550.0	3187.5				
3	M	722.5	1445.0	2167.5	2890.0					
	S	807.5	1615.0	2422.5	3230.0					
4	M	892.5	1785.0	2677.5						
	S	977.5	1955.0	2732.5						
5	M	1062.5	2135.0	3187.5						
	S	1147.5	2295.0							
6	M	1232.5	2465.0							
	S	1317.5	2635.0							
7	M	1402.5	2805.0							
	S	1487.5	2975.0							
8	M	1572.5	3145.0							
	S	1657.5	3315.0							
9	M	1742.5	Second and higher harmonics of these channels fall above 3400 Hz and consequently are not of concern							
	S	1827.5								
10	M	1912.5								
	S	1997.5								
11	M	2082.5								
	S	2167.5								
12	M	2252.5								
	S	2337.5								
13	M	2422.5								
	S	2507.5								
14	M	2592.5								
	S	2677.5								
15	M	2762.5								
	S	2847.5								
16	M	2932.5								
	S	3017.5								
17	M	3102.5								
	S	3187.5								
18	M	3272.5								
	S	3387.5								

METHOD 5114

DYNAMIC RANGE AND TELEGRAPH DISTORTION

1. SCOPE. This method is used to determine overall peak distortion and dynamic range of VFCT transmitting and receiving terminals (when connected back-to-back) at normal and fading levels.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Dynamic Range	5.3.9
Telegraph Distortion	5.3.14

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Tape Transmitter Distributor (for each channel)	A,B	182
Tape Transmitter Distributor (for each channel)	A1,B1	183
Telegraph Distortion Measuring Set	C	343
Test Attenuator	D	615
Switch	E	949
Power Supply	F,G	567

4. PROCEDURES.

4.1 DYNAMIC RANGE AND TELEGRAPH DISTORTION.

NOTE

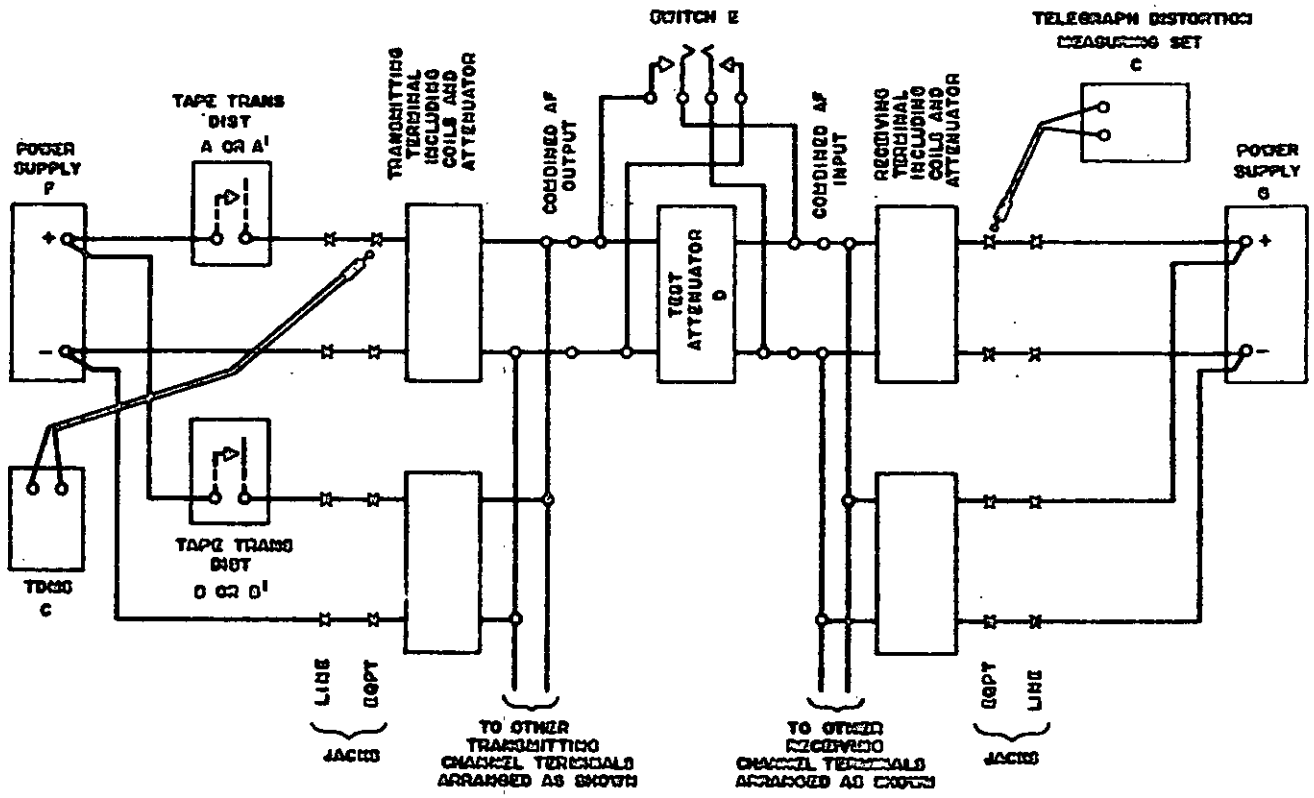
In the procedures described in this section, the power supplies may be those furnished with the VFCT terminals or, if the power supplies have not been selected, separate power supplies will be necessary. In this event, care must be taken to run the wiring for each loop back to the power supply (i.e., there should be no common wiring outside of the power supply). All tests in this section require the arrangement shown in figure 5114, assuming:

(a) the VFCT terminal is connected back-to-back through test attenuator D (figure 5114 with output of each channel of transmitting terminals adjusted to -25.0 dBm and total of stepped variable attenuators (part of VFCT terminals) set to 0 dB);

(b) all terminals are arranged for neutral, 130 V, 20 or 60 mA operation;

(c) all loop currents are adjusted to 20 or 60 mA as selected, using integral current meter and current adjusting resistors, which are part of terminal, for this purpose; and

(d) that every transmitting loop includes a tape transmitter distributor as indicated for two channels shown in figure 5114. (Each of these distributors should be equipped with a tape loop carrying the "FOX" message. These tape loops should be prepared locally. The purpose of this arrangement is to key each channel with a miscellaneous type of signal with transitions on various channels occuring at random times with respect to one another).



TABLE

SPEED		TAPE TRANSMITTER DISTRIBUTOR	TAPE LOOP
BAUDS	RPM		
00	120	A – D	FOX – S LEVEL
75	100	A' – D'	FOX – S LEVEL

FIGURE 5114 ARRANGEMENT FOR MEASUREMENT OF DYNAMIC RANGE AND TELEGRAPH DISTORTION OF VFCT TERMINALS

Step 1. With switch E open and test attenuator D set for 0 dB, start all distributors at random times. Distributors should operate at 90 bauds.

Step 2. Calibrate telegraph distortion measuring set, adjust it for a speed of 90 bauds, and set to indicate total peak distortion.

Step 3. Measure and record distortion of input signal to each channel by inserting, in turn, tip-sleeve cord of telegraph distortion measuring set into equipment jack associated with each tone keyer.

Step 4. Each input should be observed for at least two minutes and highest peak indication of telegraph distortion measuring set recorded.

Step 5. Measure and record total peak telegraph distortion on each channel output by inserting, in turn, tip-sleeve cord of the telegraph distortion measuring set into equipment jack of each tone converter.

Step 6. Each channel should be observed for at least two minutes and highest peak indication of telegraph distortion measuring set recorded.

Step 7. With switch E open, increase setting of test attenuator to 30 dB (50 dB for diversity terminals) and again measure and record peak distortion of each channel as described in steps 5 and 6.

Step 8. With telegraph distortion measuring set connected to lowest numbered channel of the system, and test attenuator set at 30 dB or 50 dB, operate switch E several times at rate of about once every 30 seconds.

Step 9. When switch opens and closes, record telegraph distortion measuring set indication. (After each operation of switch E, telegraph distortion measuring set should be reset to zero indication).

Step 10. Repeat steps 8 and 9 for all channels of the system.

Step 11. Change tape transmitter-distributors to those operating at a speed of 75 baud, and adjust test attenuator to 0 dB.

Step 12. Calibrate telegraph distortion measuring set, adjust it for a speed of 75 bauds, and set to indicate total peak distortion.

Step 13. Repeat steps 3 through 12 at this modulation rate.

Step 14. Repeat steps 1 through 13 but with channels arranged for polar, 60 V, 20 mA operation.

Step 15. Repeat steps 1 through 13 but with channels arranged for polar, 6 V, 1 mA operation.

METHOD 5115

DIVERSITY COMBINERS

1. SCOPE. This method is used to determine the characteristics of diversity combiners as used in voice frequency carrier telegraph (VFCT) systems.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Diversity Combiner	5.3.10

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Power Supply	A,B	567
Telegraph Signal Generator	C	179
Telegraph Distortion Measuring Set	D	343
Random Noise Generator	E	184
Low Pass Filter	F	723
Vacuum Tube Voltmeter	G	53
Hybrid Coil	H	667 or 668
Switch	I,J	947
Resistor	R1	410
Resistor	R2,R4	459
Resistor	R3,R5	458

4. PROCEDURES.

4.1 EFFECT OF NOISE ON NON-DIVERSITY SYSTEMS.

NOTE

This test is made to establish a base from which the benefit obtained by means of diversity may be determined, when the received diversity signals are of approximately the same magnitude.

Step 1. Connect equipment as shown in figure 5115-a. this assumes the following:

(a) The transmitting and receiving terminals are connected back-to-back.

(b) The per channel output levels are adjusted to -25.0 dBm at keyer out jacks.

(c) The transmitting stepped variable attenuator is set to 0 dB and receiving stepped variable attenuator is set to 10 dB.

(d) The channel terminals are arranged for 130 V, 20 mA neutral operation and loop currents are adjusted to 20 mA, using current adjusting resistors which are part of channel terminals and integral current meter. If more convenient, any DC signaling modes specified in the standards may be used for this test.

(e) The power supplies shown, A and B, may be part of system terminals, but if loop power supplies have not been chosen, they will be separate test power supplies as listed under paragraph 3.

Step 2. Set telegraph signal generator C for the "FOX" sentence, 75 bauds, 0 distortion and connect it to channel under test.

Step 3. Measure output distortion by inserting tip-sleeve cord of telegraph distortion measuring set in the equipment jack associated with the sending loop. The transmission distortion measuring set should be set for miscellaneous signals, 75 bauds, total distortion and calibrated.

Step 4. The output distortion should not exceed 1 percent. If it exceeds this, adjust, using bias adjustment on transmission channel terminal (tone keyer), to as near 0 as can be read on meter of transmission distortion measuring set.

Step 5. Measure received total distortion by inserting tip-sleeve cord on transmission distortion measuring set into equipment jack associated with receiving channel terminal.

Step 6. The total distortion so measured should not exceed 2 percent. If it does exceed this, reduce it by adjustment of the bias adjustment associated with receiving channel terminal, tone converter, to as nearly zero as practicable.

Step 7. Repeat steps 2 through 6 on all channels with which terminal is equipped.

Step 8. Add noise to system by connecting random noise generator E and low pass filter F to monitoring jacks as shown in figure 5115-a.

Step 9. With all channels turned off, the noise over the 3.5 kHz band may be measured with vacuum tube voltmeter G.

NOTE

It is suggested that a signal/noise ratio of about 35 dB be used to start. Since signal level (per channel) at point of measurement is -25.0 dBm or .0436 V, 35 dB below this would be -60.0 dBm or 0.000775 V. The dB scale on vacuum tube voltmeter G may be used to measure the noise level in dBm if this scale is 0 referenced to 1 mW, since flat noise is being used.

Step 10. Having established a noise level of 35 dB below transmitting level, connect telegraph signal generator C to channel under test and set it to transmit "FOX" at 75 bauds and 0 distortion.

Step 11. With transmission distortion measuring set measuring overall (received) total peak distortion gradually increase noise level until overall (received) peak distortion is 10 percent.

Step 12. Turn off all channels and measure and record noise level. The difference between this reading and 0 dBm is signal to noise ratio causing 10 percent distortion.

NOTE

"White" or "Gaussian" noise is being used for this test and such noise has a peak factor that, even at a signal to noise ratio of 35 dB, statistically will cause an occasional distortion peak of 10 percent or more. However, when the frequent distortion peaks equal 10 percent, the overall peak distortion is said to be 10 percent. Under this circumstance occasional peaks will exceed 10 percent, with rare peaks exceeding 10 percent by a considerable amount. For this purpose "frequent" means about 1 in 5 to 10 seconds, "occasional" means 1 in 5 to 10 minutes, and "rare" means 1 in 30 minutes to 1 hour.

Step 13. Repeat steps 8 through 12 on all channels with which terminal is equipped.

4.2 CHARACTERISTICS OF DIVERSITY COMBINERS-DUAL FREQUENCY DIVERSITY.

Step 1. Connect equipment as shown in figure 5115-b.

NOTE

Here again the assumptions stated in paragraph 4.1, step 1 are made. It should be noted that with this arrangement, two VFCT channels are keyed simultaneously with the same signal.

Step 2. Send "FOX" sentence at 75 bauds, 0 distortion and measure overall total telegraph distortion. This should not exceed 2 percent.

Step 3. Using random noise generator E, low pass filter F and vacuum tube voltmeter G, add noise at an initial level of -35 dB below transmitting signal level.

Step 4. Increase noise level gradually until overall total peak telegraph distortion reaches 10 percent. (See not under step 12, above.) The signal to noise ratio should be 2 to 3 dB less, i.e., the noise level 2 to 3 dB higher, than that measured under paragraph 4.1, step 12.

Step 5. Repeat steps 3 and 4, above, on all channels with which terminal is equipped.

Step 6. Disconnect random noise generator E, but leave telegraph signal generator C and transmission distortion measuring set connected.

Step 7. Repeatedly turn off and on one of two channels of diversity pair while observing transmission distortion measuring set indication. (The channel should be turned off and on about 30 times at intervals of about 5 to 10 seconds.) The total peak distortion should not exceed 10 percent.

Step 8. Repeat step 7 on second channel of diversity pair, with first channel turned on. The results (total peak distortion) should not exceed 10 percent.

Step 9. Repeat steps 7 and 8 on all channel pairs with which terminal is equipped.

Step 10. Reconnect random noise generator E, low pass filter F and vacuum tube voltmeter G.

Step 11. Adjust noise level 5 dB below value which caused 10 percent distortion in paragraph 4.1, steps 8 through 13. Repeat steps 6, 7, and 8 above, on all channels. The total peak distortion should not exceed 10 percent.

Step 12. Reduce transmitted tone level by 30 dB by setting variable attenuator associated with transmitting terminal to a value of 30 dB.

Step 13. Disconnect random noise generator E, and repeat steps 6, 7, and 8 above, on all channel pairs with which terminal is equipped. The total peak distortion should not exceed 10 percent in any case.

4.3 CHARACTERISTICS OF DIVERSITY LIMITERS-DUAL SPACE DIVERSITY.

Step 1. Connect equipment as shown in figure 5115-c.

NOTE

Here again the assumptions stated in paragraph 4.1, step 1 are made except that settings of stepped variable attenuators associated with receiving terminal are reduced from 10 dB by insertion loss of hybrid coil H. This is best done by turning off all except one tone keyer (mid frequency channel) and measuring received level of this channel tone at attenuator out jacks (now shown in figure 5115-c). This level should be adjusted to -25.0 dBm by adjustment of appropriate receiving stepped variable attenuator. Resistor R1 serves to terminate hybrid coil H so that trans-hybrid losses will be high. The L pads consisting of resistors R2, R3, R4, and R5 will cause 50 dB loss when cut into circuit by switches I or J. Since dual diversity principle is based on only one transmission path being degraded at a time, only one of two pads will be cut in at a time, simulating a 50 dB fade in that path. The hybrid coil H is used to simulate conditions which exist when a single radio transmitter is being received by two radio receivers.

Step 2. Send "FOX" sentence at 75 bauds, zero distortion and measure overall total telegraph distortion. It should not exceed 2 percent.

Step 3. Using random noise generator E, low pass filter F and vacuum tube voltmeter G, add noise at an initial level of -35 dB below transmitted signal level, making connections as shown in figure 5115-

Step 4. Increase noise level gradually until overall total peak telegraph distortion reaches 10 percent. (See note under 4.1. step 12.) The signal to noise ratio should be 2 to 3 dB less, i.e., the noise level should be 2 to 3 dB higher, than that measured under paragraph 4.1, step 12.

Step 5. Repeat steps 3 and 4 on all channels with which terminal is equipped.

Step 6. Disconnect random noise generator E, but leave telegraph signal generator C and transmission distortion measuring set connected.

Step 7. Operate switch I, to cut the pad consisting of resistors R2 and R3 in and out of the circuit, repeatedly. The switch should be operated through at least 30 cycles (a cycle consisting of pad-in-pad-out) at intervals of 5 or 10 seconds. The total peak distortion should not exceed 10 percent.

Step 8. Repeat steps 6 and 7, but operating switch J instead of switch I. Again the total peak telegraph distortion should not exceed 10 percent.

Step 9. Repeat steps 6, 7, and 8 on all channels with which terminal is equipped.

Step 10. Reconnect random noise generator E, low pass filter F and vacuum tube voltmeter G.

Step 11. Adjust noise level to 5 dB below value which caused 10 percent distortion in paragraph 4.1, steps 8 through 13.

Step 12. Repeat steps 6, 7, and 8 above, on all channels. The total peak distortion should not exceed 10 percent.

Step 13. Reduce transmitted tone level by 30 dB by setting transmitting variable attenuator to a value of 30 dB.

Step 14. Disconnect noise source and repeat steps 6, 7, and 8 above, on all channels. The total peak telegraph distortion should not exceed 10 percent in any case.

Step 15. Connect random noise generator E and low pass filter F to monitoring jacks associated with receiving line jacks of path A.

Step 16. Connect vacuum tube voltmeter G to monitoring jacks associated with attenuator out jacks of path A.

NOTE

This connection places receiving variable attenuator between noise source and vacuum tube voltmeter G. Therefore, in order to determine true noise level, setting of variable attenuator in dB must be added to reading of vacuum tube voltmeter G in dB. Adjust noise level to 10 dB above the value that gave 10 percent distortion in steps 3 through 5, above. The total peak telegraph distortion should now not exceed 5 percent.

Step 17. Repeat steps 15 and 16 above, but add noise at monitoring jacks associated with line jacks of path B. With same noise level, total peak telegraph distortion should not exceed 5 percent.

Step 18. Repeat steps 15 through 17, above, in all channel pairs with which terminal is equipped.

4.4 CHARACTERISTICS OF DIVERSITY COMBINERS-QUADRUPLE AND FREQUENCY DIVERISTY.

Step 1. Connect equipment as shown in figure 5115-d.

NOTE

Here two tone keyers are keyed simultaneously with same signal to provide frequency diversity

and hybrid coil H is used to simulate two radio paths of space diversity, the whole arrangement simulating quadruple diversity. The assumptions of paragraph 4.1, step 1 are again made and the variable attenuator adjustments, described in note of paragraph 4.3, step 1 to correct for the insertion loss of the hybrid coil are also required.

Step 2. Send "FOX" sentence at 75 bauds, zero distortion and measure overall total telegraph distortion. It should not exceed 2 percent.

Step 3. Using random noise generator E, low pass filter F and vacuum tube voltmeter G, add noise at an initial level of -35 dB below transmitting signal level, making connections as shown in figure 5115-d.

Step 4. Increase noise level gradually until overall total peak telegraph distortion reaches 10 percent. (See note under 4.1, step 12.) The signal to noise ratio should be 2 to 3 dB lower, i.e., the noise level should be 2 to 3 dB higher, than that measured under paragraph 4.1, step 12.

Step 5. Repeat steps 3 and 4, above, on all channel pairs with which terminal is equipped.

Step 6. Disconnect random noise generator E, but leave telegraph signal generator and transmission distortion measuring set connected.

Step 7. Operate switch I, to cut pad consisting of resistors R1 to R3 and out of circuit repeatedly. The switch should be operated through at least 30 cycles (a cycle consisting of pad-in-pad-out) at intervals of 5 to 10 seconds. The total peak telegraph distortion should not exceed 10 percent.

Step 8. Repeat steps 6 and 7, above, but operating switch J instead of switch I. Again the total peak telegraph distortion should not exceed 10 percent.

Step 9. Repeat steps 6, 7, and 8 on all twin channel pairs with which terminal is equipped.

Step 10. Reconnect random noise generator E, low pass filter F and vacuum tube voltmeter G.

Step 11. Adjust noise level to 5 dB below value which caused 10 percent distortion in paragraph 4.1, steps 8 through 13.

Step 12. Repeat steps 6 through 8, above, on all twin channel pairs with which terminal is equipped. The total peak distortion should not exceed 10 percent.

Step 13. Disconnect random noise generator E.

Step 14. Reduce transmitted level by 30 dB by setting transmitting variable attenuator to a value of 30 dB.

Step 15. Repeat steps 6 through 8, above, on all twin channel pairs with which terminal is equipped. The total peak telegraph distortion should not exceed 10 percent in any case.

Step 16. Connect random noise generator E and low pass filter F to monitoring jacks associated with receiving line jacks of path A.

Step 17. Connect vacuum tube voltmeter G to monitoring jacks associated with attenuator out jacks of path A. (The note appended to paragraph 4.3, step 16 should be observed).

Step 18. Adjust noise level to 10 dB above value which gave 10 percent distortion in steps 3 through 5, above. The total peak telegraph distortion should not now exceed 5 percent.

Step 19. With noise on path A repeatedly turn off and on (at least 30 times at intervals of 5 to 10 seconds) one of the two associated channel tone keyers of frequency diversity pair. The total peak telegraph distortion should not exceed 10 percent.

Step 20. With noise still on path A, repeatedly turn off and on other of two associated channel tone keyers of frequency diversity pair. The total peak distortion should not exceed 10 percent.

Step 21. Repeat steps 16 through 20, above, but with noise on path B. The total peak telegraph distortion should not exceed 10 percent in any case.

Step 22. Repeat steps 16 through 21, above, on all channel pairs with which terminal is equipped. The total peak telegraph distortion should not exceed 10 percent in any case.

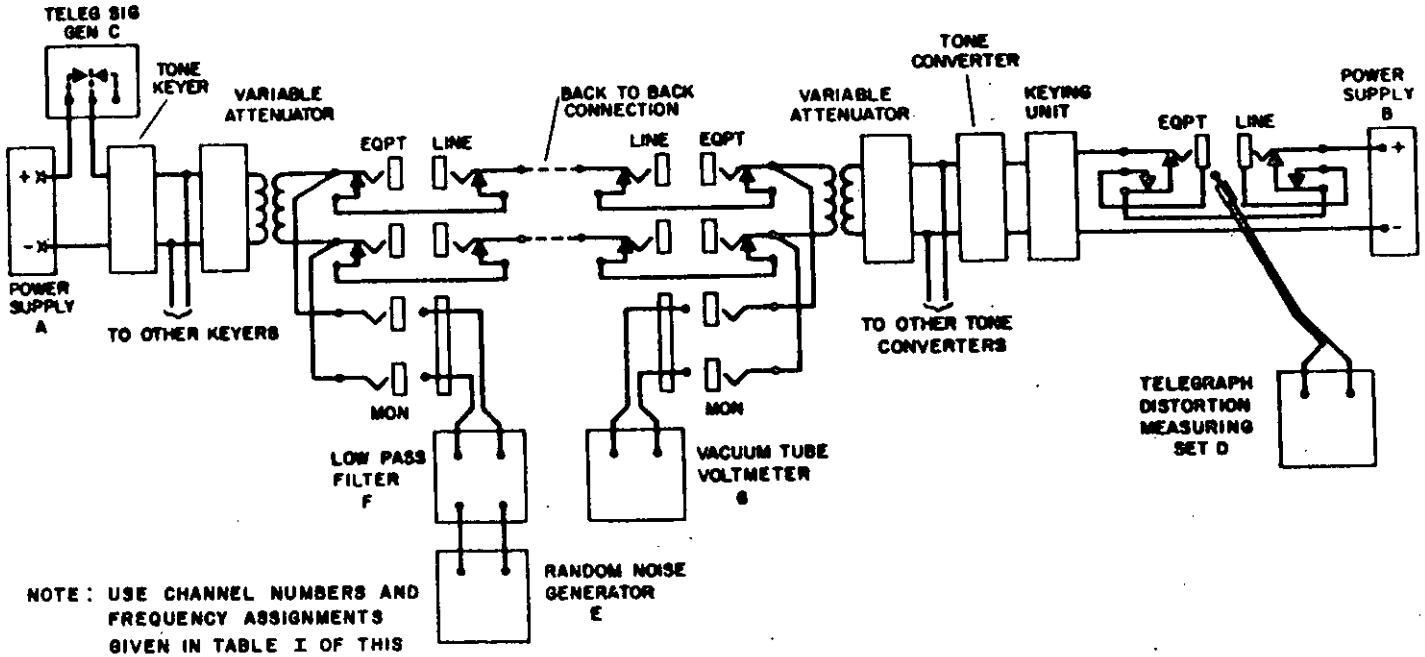


FIGURE 5115-e. ARRANGEMENT FOR MEASURING EFFECT OF NOISE ON NON-DIVERSITY SYSTEMS

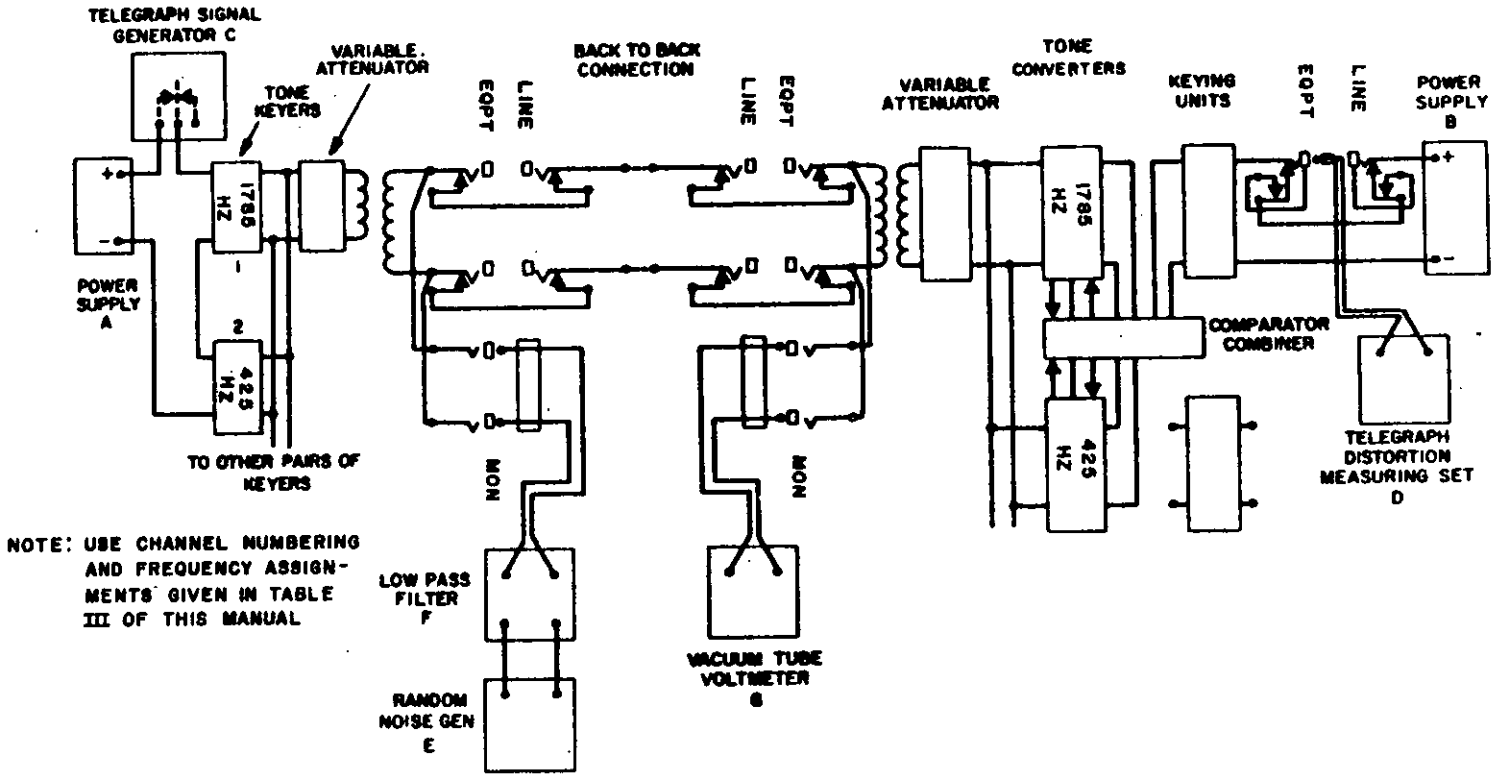


FIGURE 5115-b. ARRANGEMENT FOR MEASURING CHARACTERISTICS OF COMBINERS FOR DUAL FREQUENCY DIVERSITY

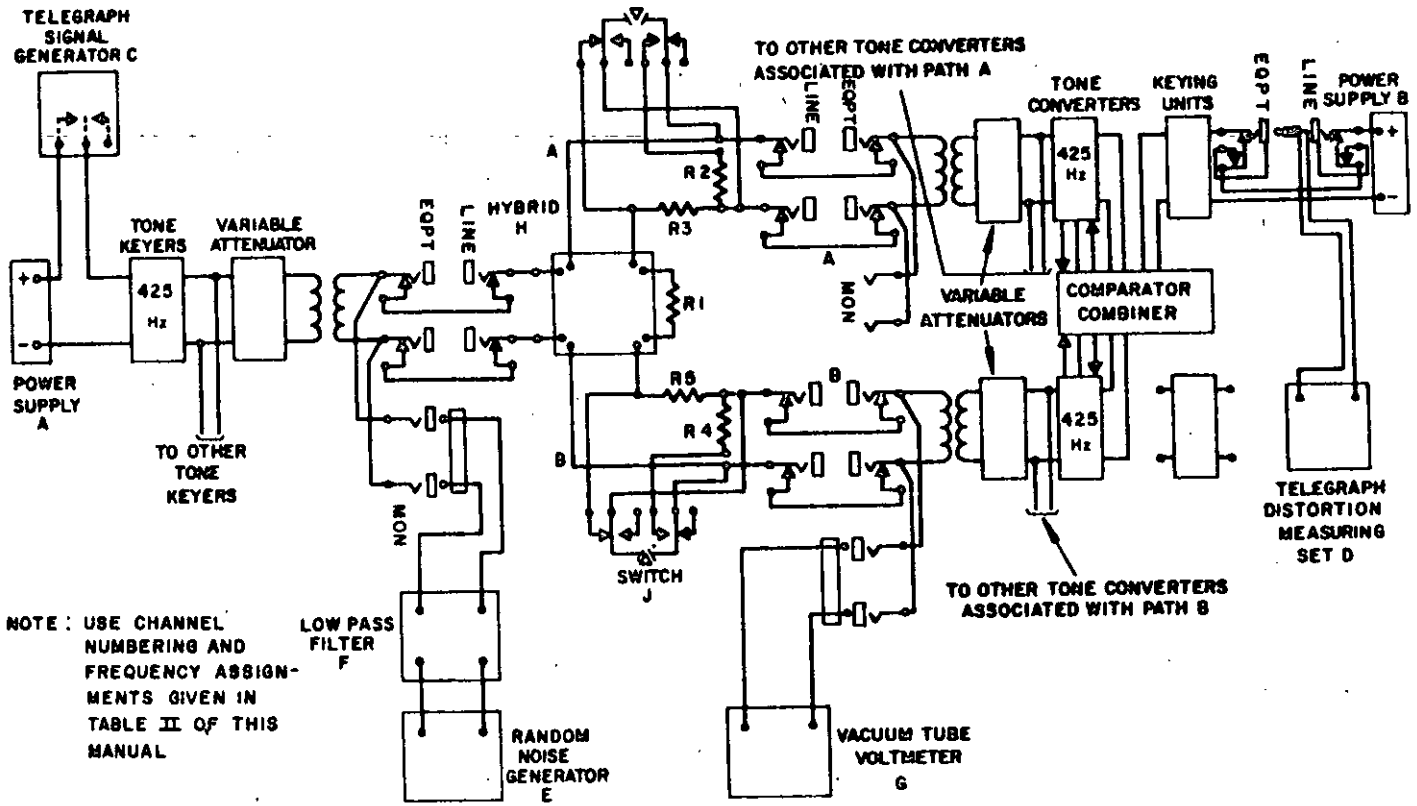


FIGURE 5115-c. ARRANGEMENT FOR MEASURING CHARACTRRISTIC OF COMBINERS FOR DUAL SPACE DIVERSITY

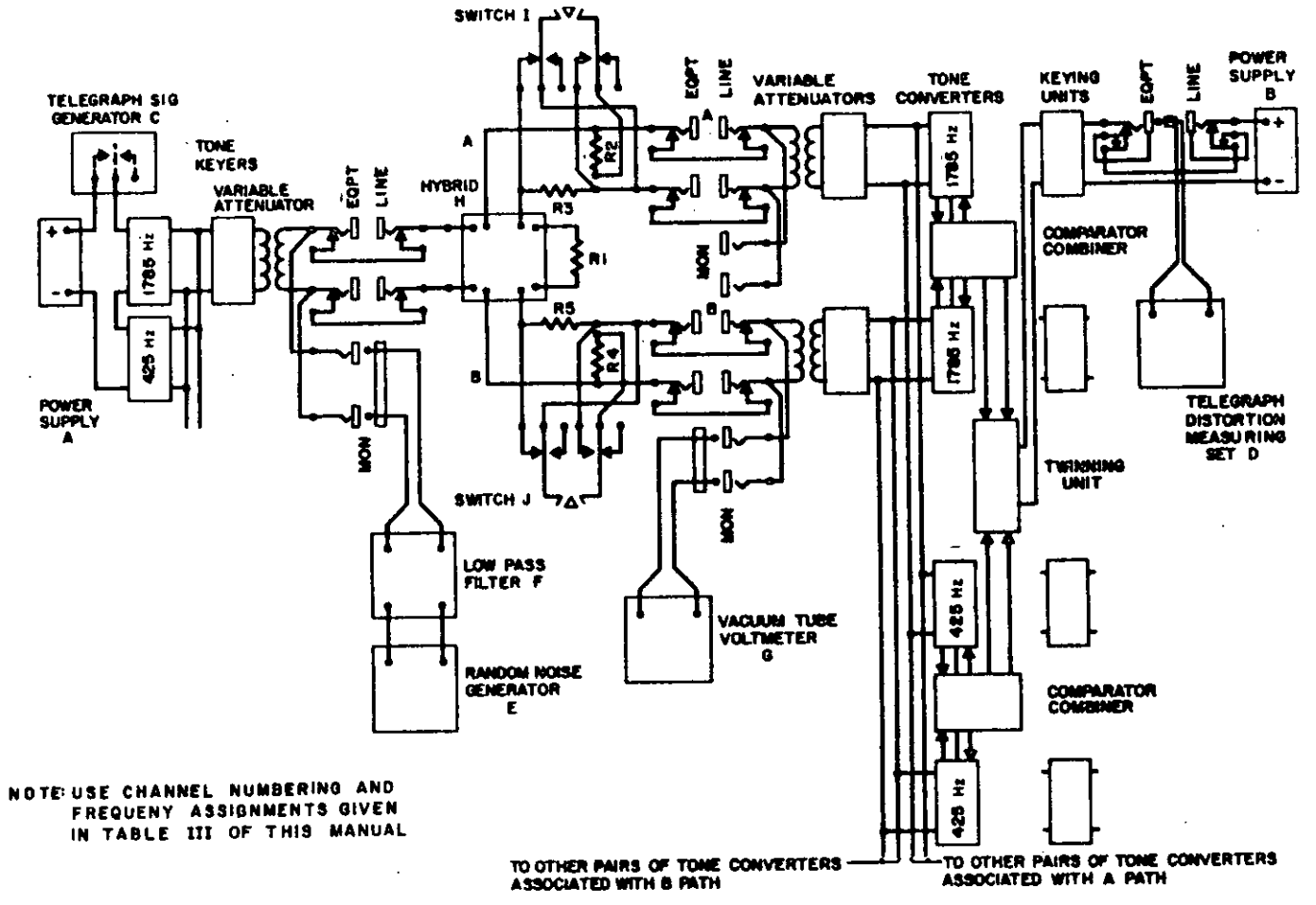


FIGURE 5115-d. ARRANGEMENT FOR MEASURING CHARACTERISTICS OF COMBINERS FOR QUADRUPLE SPACE AND FREQUENCY DIVERSITY

METHOD 5116

DIFFERENTIAL DELAY

1. SCOPE. This method is used for the measurement of delay adjustment of voice frequency carrier telegraph (VFCT) receiving terminals.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Delay Adjustment	5.3.11

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Telegraph Signal Generator	A	179
Power Supply	B,C	567
Oscilloscope	D	256
Relay	E,F	948
Resistor	G	438
Milliammeter	H	49

4. PROCEDURES.

NOTE

The two procedures described in this section require that the VFCT terminal be arranged for back-to-back operation, that channel output and input levels be adjusted to specified values; and that terminals be arranged for neutral, 130 V, 20 mA operation. (If more convenient, any of the other DC signaling modes specified in the standard may be used).

4.1 DELAY ADJUSTMENT FEATURE OF VFCT RECEIVING TERMINALS.

Step 1. Connect equipment as shown in figure 5116-a.

Step 2. Adjust loop currents to 20 mA, using meter furnished with terminals and adjustable resistors that are part of terminals.

Step 3. Set delay adjustment on channel under test to minimum delay.

Step 4. Set telegraph signal generator A to send 1:1 reversals at speed of 75 baud.

Step 5. Connect positive side of DC input of channel under test to trigger input (+ AC, external) of oscilloscope.

Step 6. Connect positive side of DC input of channel under test to vertical trace input of oscilloscope.

Step 7. Use sweep speed that will bring both beginning of trace and positive (leading) edge of signal within graticule of the oscilloscope.

Step 8. Measure absolute delay channel under test. (Since positive leading edge of input marking signal triggers oscilloscope sweep, it is the distance (in centimeters) from start of trace

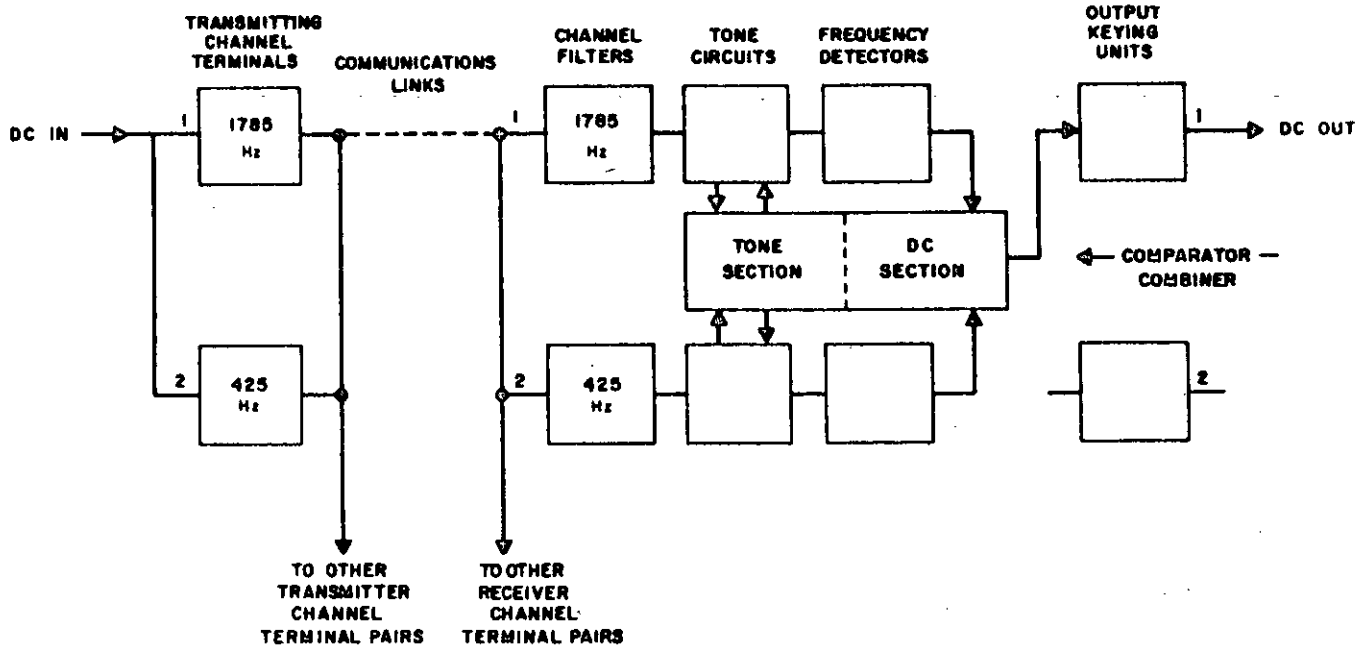


FIGURE 5116-a. ARRANGEMENT FOR CHECKING DELAY ADJUSTMENT FEATURE AT VFCT RECEIVING TERMINALS

is following, multiplied by the sweep speed in micro-or millisecond per centimeter).

Step 9. Set delay adjustment on channel under test to maximum delay.

Step 10. Repeat steps 4 through 8.

4.2 DIFFERENTIAL DELAY BETWEEN TWO VFCT RECEIVING TERMINALS.

Step 1. Connect equipment as shown in figure 5116-b.

Step 2. Adjust loop currents to 20 mA, using milliammeter and adjustable resistors which are part of terminals.

Step 3. Adjust current in circuit containing driving windings of relay E and relay F and output contacts of telegraph signal generator to 20 mA (indicated on milliammeter H by adjusting resistor G).

Step 4. Each battery supply lead (for two sending loops and relay circuit) should be returned individually to power supply as shown. The same precautions apply to power supplies for the two receiving loops.

Step 5. Set delay adjusting circuits of two channels under test for minimum delay.

Step 6. Connect oscilloscope as shown; i.e., with positive side of receiving loop of channel A to oscilloscope trigger input (+ AC external) and positive side of receiving loop of channel B to vertical trace input of the oscilloscope.

Step 7. Set oscilloscope for sweep speed of 100 microseconds per centimeter.

Step 8. Measure difference in delay between the two channels. (Since trace is being triggered by positive (leading) edge of signal in one

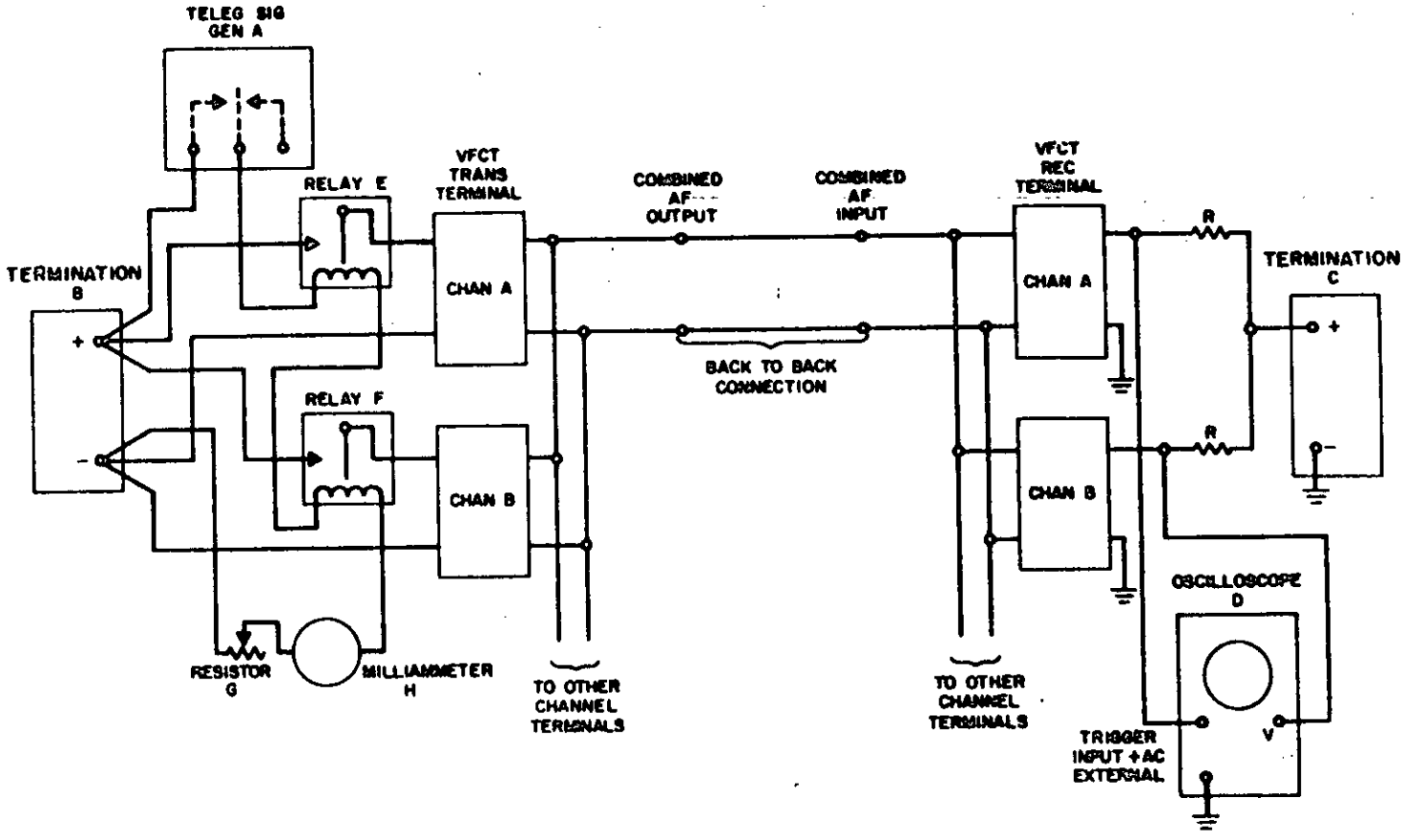


FIGURE 5118-b. ARRANGEMENT FOR CHECKING DIFFERENTIAL DELAY BETWEEN TWO VFCT RECEIVING TERMINALS CONNECTED BACK-TO-BACK

channel, and is following signal in other channel. this differential delay (in microseconds) is the length (in centimeters) of trace to positive (leading) edge of signal, multipled by sweep speed in microseconds per centimeter, in this case 100 microseconds. This assumes that channel B has more delay than channel A. If length of sweep is zero, interchange connections of the two channels to the oscilloscope).

METHOD 5117

INTERCHANNEL INTERFERENCE

1. SCOPE. This method is used for the measurement of interchannel interference of voice frequency carrier telegraph (VFCT) transmitting and receiving terminals.

2. APPLICABILITY. Parameters tested shall conform to the following applicable requirements specified.

Item	Paragraph
Interchannel Interference	5.3.12

3. APPARATUS. Required test equipment is listed in table 1.

TABLE 1. REQUIRED TEST EQUIPMENT

Test Unit	Schematic Reference	Item No. In Appendix 1
Telegraph Signal Generator	A	179
Telegraph Distortion Measuring Set	B	343
Relays	C,D, etc.	948
Variable Resistor	E	457
Power Supplies	F,G	567
Milliammeter	H	48
Transmission Measuring Set	I	345

4. PROCEDURES.

4.1 INTERCHANNEL INTERFERENCE.

NOTE

In test procedures covered in this section the arrangement shown in figure 5117 is intended to key all channels (terminals back-to-back) with random mark and space signals (FOX) but with transitions on all channels at the sending end occuring simultaneously. A telegraph signal generator drives a number of relays (one for each channel) having their windings in series with the contact of the output relay of the sig- n: generator and battery. The contacts of these relays are then used to key the VFCT channels. All tests under this section are made with the terminals connected back-to-back and using 130 V, 20 mA neutral operation.

Step 1. Connect equipment as shown in figure 5117.

Step 2. Adjust output of each channel to -25.0 dBm.

Step 3. Adjust all loop currents to 20 mA.

Step 4. Set variable attenuators associated with channel terminals for total loss of 0 dB.

Step 5. Using variable resistor E and milliammeter H adjust current in relay driving loop to 20 mA.

Step 6. Set telegraph signal generator to send "FOX" sentence (5 level) at speed of 75 bauds, 0 distortion.

Step 7. Adjust telegraph distortion measuring set B to speed of 75 bauds, set it for total peak distortion and calibrate it.

Step 8. Measure and record input telegraph distortion of each channel by inserting tip-sleeve cord of

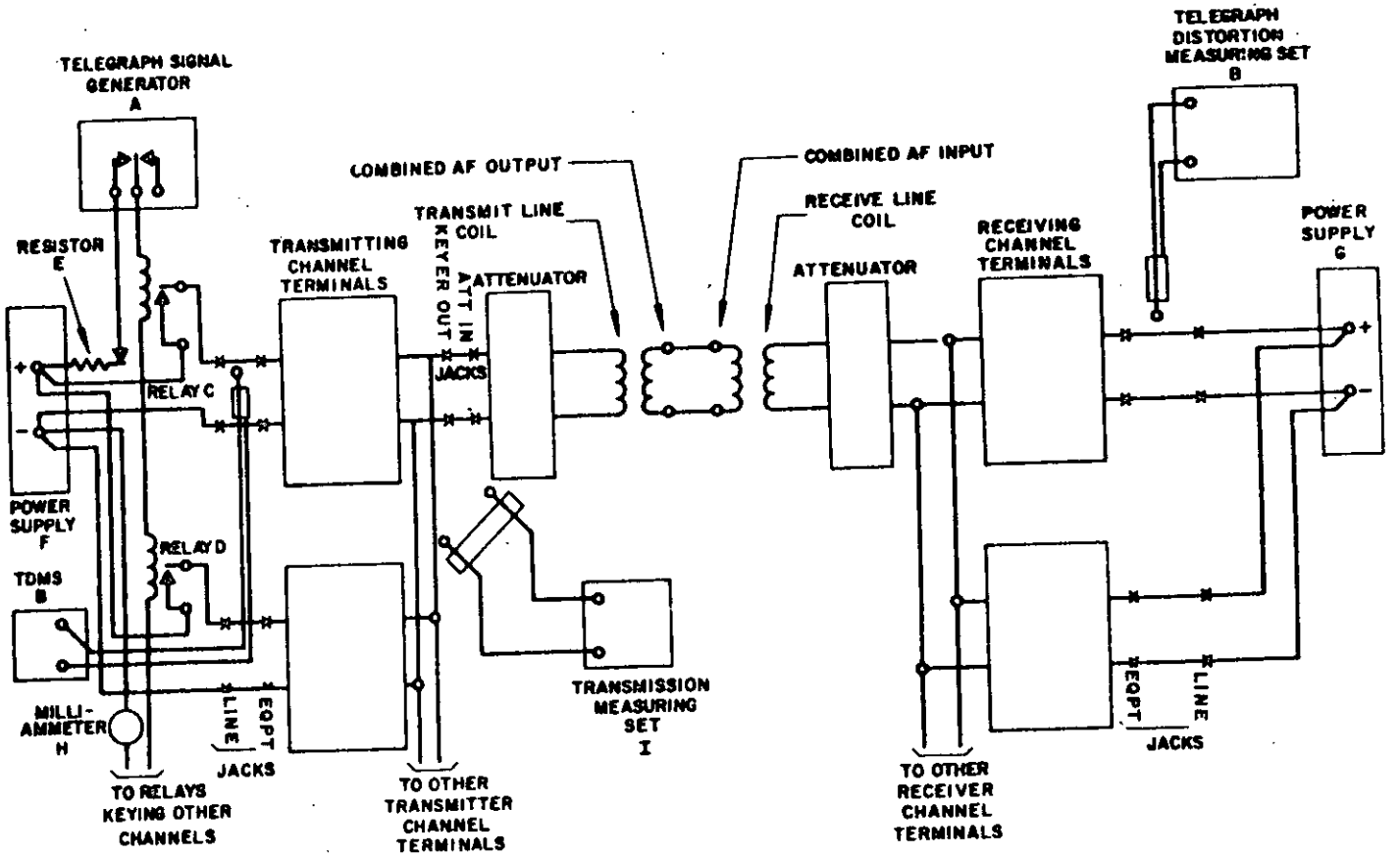


FIGURE 5.117. ARRANGEMENT FOR MEASURING INTERCHANNEL INTERFERENCE OF VFCT TRANSMITTING AND RECEIVING TERMINALS WHEN CONNECTED BACK-TO-BACK

telegraph distortion measuring set B in equipment jack associated with transmitting channel terminal (tone keyer).

Step 9. Measure and record received telegraph distortion by inserting tip-sleeve cord on telegraph distortion measuring set B in equipment jack associated with receiving channel terminal (tone converter).

Step 10. Reduce output level of channel under test by 30 dB. This is accomplished as follows:

(a) Turn off all transmitting channel terminals except one under test.

(b) Insert tip-tip cord on transmission measuring set I in keyer-out jacks, using 600 ohm (terminating) impedance on transmission measuring set I.

(c) Adjust level of channel under test to -55 dBm, using output control on transmitting channel terminal.

(d) Turn on all transmitting channel terminals.

Step 11. Measure input and output total peak distortion of channel under test. The difference between these is a total peak distortion of channel under test.

Step 12. Restore channel under test to its normal level as follows:

(a) Turn off all transmitting channel terminals except channel under test.

(b) Insert tip-tip cord on transmission measuring set I in keyer-out jacks using 600 ohm (terminating) impedance on transmission measuring set I.

(c) Adjust output (transmitting) level of channel under test to 0 dBm, using output control on transmitting channel terminal.

(d) Turn on all transmitting channel terminals

Step 13. Repeat steps 10 through 12 on all channels with which VFCT terminal is equipped.

Step 14. Turn off transmitting channel terminal of channel under test, leaving remainder of channel terminals turned on.

Step 15. Insert tip-sleeve cord of telegraph distortion measuring set B in equipment jack associated with receiving channel terminal (tone converter) of channel under test.

Step 16. Observe indication of telegraph distortion measuring set B for at least two minutes. It should indicate that channel is open, i.e., that no interfering signal strong enough to operate the tone converter is being received.

Step 17. Repeat steps 14 through 16 on all channels of VFCT terminal.

CUSTODIANS:

ARMY - SC
NAVY - EC
AIR FORCE - 17

REVIEW ACTIVITIES:

ARMY - SC, EL, CE, ME
NAVY - AS, OS, YD, MC, CG, SH
AIR FORCE - 1, 11, 13, 71, 80, 89

PREPARING ACTIVITY:

DCA - DC

USER ACTIVITIES:

ARMY
NAVY - MC, YD, SH
AIR FORCE

OTHER INTEREST:

JCS-J6
NSA-NS

Project SLHC 0005

Blank

APPENDIX 1

TEST EQUIPMENT LIST

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
48	Milliammeter	DC-Dual Range	0 - 100 mA 0 - 50 mA
		Accuracy	±1%
49	Milliammeter	DC-Dual Range	0 - 20 mA 0 - 5 mA
		Accuracy	±1%
50	Milliammeter	DC-Center Zero-Dual Range	20- 0 - 20 mA 1 - 0 - 1 mA
		Accuracy	±1%
51	Voltmeter	DC-Center Zero	10- 0 -10 V
		Accuracy	±1%
52	Ohmmeter	Resistance Range	1 ohm to 50 megohms
		Test Voltage	Not more than 6 V
		Accuracy	±2%
53	Vacuum Tube Voltmeter	Voltage Range	1.0 mV to 100 V full scale
		Accuracy	±1%
56	Voltmeter	AC	0 - 150 V
		Accuracy	±1% in range 105V - 125V
57	Ammeter	DC	0.5 A
		Accuracy	±1%

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
58	Differential Voltmeter or Digital Voltmeter	DC Resolution	0 150 V 1 mV or better
		DC Resolution Operating Current Speed Distortion	0 - 150 V 1 mV or better 20 mA At least 100 baud Not more than 1%
59	Thermometer	Type Range Accuracy	Air temperature measurement Mercury column 0 - 120 deg F ±1% deg
60	Phase Meter	Frequency Range Phase Range Accuracy Input Voltage Min. Input Voltage Max. Max. Input Signal Ratio Input Impedance	100 - 5,000 Hz 0 - 360 deg ±0.3 deg 0.05 V rms 50 V rms 40 dB 3 megohms shunted by 20 pF
179	Telegraph Signal Generator	Modulation Rate Character Length Modes of Operation Output Distortion Range	75 and 90 Baud 5 and 8 unit Plus: Start unit 1 bit Stop unit 1 bit 1.5 bit 2.0 bit Start-Stop Synchronous Neutral 130 V - 60 or 20 mA Polar +60 V - 20 mA + 6 V - 1 mA 0 - 50% in 1% steps

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
179 (Cont'd)		Distortion Accuracy	1%
		Distortion Types	Mark or Space Bias Mark or Space End Switched Bias, Early or Late
		Types of Test Signals	1:1 Reversals Continuous Mark Continuous Space Test Sentence 80 Characters Repetitive Single Character
180	Audio Frequency Oscillator	Range Accuracy Output Hum Output Impedance Distortion	20 - 20,000 Hz ±3% Maximum +15 dBm Down 60 dB 600 ohms Less than 1%
181	Audio Frequency Oscillator and Power Amplifier	Range Maximum Output Load Impedance Harmonic Distortion Hum	20 - 300 Hz 200 W 8 - 80 ohms 2% Down 50 dB
182	Tape Transmitter (Tape Reader)	5 Level (7.42 Unit Code) (121 WPM)	Capable of operating at 90 Baud
183	Tape Transmitter (Tape Reader)	5 Level (7.42 Unit Code) (100 WPM)	Capable of operating at 75 Baud
184	Random Noise Generator	Frequency Range Output	200 - 3500 Hz 3 V min ±1 dB 200 - 3500 Hz

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
225	Strip Chart Recorder	Chart Speed	1, 2, 4, 8 inches per min 1, 2, 4, 8 inches per hour 25, 5, 10, 20 cm per min 25, 5, 10, 20 cm per hour Up to 60 inches per min available
		Spans	5 mV - 120 V in 10 spans
		Accuracy	Better than 0.2% of full scale with 0.1% of full scale resettability
		Input Resistance	20,000 ohms per V for first 8 ranges; 2 megohms on all higher ranges
254	Null Detector	Frequency Range	20 - 200,000 Hz
		Sensitivity	0.3 mV
		Selectivity	5% of bandwidth
		Noise Level	Below 1 mV
		Input Impedance	About 50 kilohms
255	Frequency Counter	Frequency Range	10 Hz - 120 kHz
		Accuracy	+1 count
		Gate Time	0.1 and 1 sec min
		Time Interval	1 μs - 1 sec
		Gating Voltage Max.	-100 to +100
		Sensitivity	0.3 V peak-to-peak 0.25 V rms for sine waves
		Separate start-stop channels, each with trigger level controls	
256	Oscilloscope	Tube Diameter	Not less than 5 in.
		Function	General purpose
		Frequency Range	DC - 10 kHz min.
		Vertical Sensitivity	1 mV/cm
		Sweep Rate	At least 100 ms/cm
343	Telegraph Distortion	Modulation Rate	75 and 90 bauds
		Character Lengths	5 and 8 units

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
343 (Cont'd)	Measuring Set		Plus: Start unit-1 bit Stop unit-1 bit 1.42 bit 1.5 bit
		Modes of Operation	Start-Stop and Synchronous
		Distortion Ranges	±50% and ±5%
		Accuracy	±2% on 50% Range ±1% on 5% Range
		Input	Neutral 130 V, 60 or 20 mA Polar ±60 V, 20 mA ± 6 V, 1 mA
		Display Unit	1. CRO with start-stop time base to display: (a) Amount and type of distortion (b) Signal wave shape as applied to the Measuring Unit 2. Meter for Direct Reading of Distortion
344	Noise Measuring Set	Range-Noise Level	To -85 dBm
		Frequency Range	50 - 5000 Hz
		Impedance	600 ohms balanced and high impedance bridging
		Weighting	Flat and C-Message
345	Transmission Measuring Set	Frequency Range	30 Hz - 10 kHz
		Measuring Range	+10 dBm to -75 dBm terminated or bridged
		Impedance	Terminated 600 ohms balanced Bridged more than 10,000 ohms

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
346	Wave Analyzer	Frequency Range	50 - 3400 Hz min.
		Measurement Accuracy	±5% full scale
		Measurement Range	Down to -70 dBm
		Input Impedance	1 megohm
352	Slotted Line Coax	Frequency Range	300 MHz - 4500 MHz
		Characteristic Impedance	50.0 ohms
		Residual VSWR	1.010:1
		Slope	1.005
		Input Connector	Type N
		Output Connector	Universal 1 in coax plus matched or compensated reducers to the line size required
353	Slotted Line Waveguide	Frequency Range	Waveguide operating band
		Residual VSWR	1.010:1
		Slope	1.005
		Flanges	Waveguide cover flanges
410	Resistor	Type	Fixed
		Resistance	600 ohms ±1%
		Wattage Rating	1 W or more

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
438	Resistor	Type Resistance Dissipation	Variable 0 - 7500 ohms ±5% 7.5 W
439	Resistor	Type Resistance Dissipation	Variable 0 - 20,000 ohms ±5% 1.5 W
440	Resistor	Type Resistance Dissipation	Variable 0 - 75,000 ohms ±5% 0.25 W
441	Resistor	Type Resistance Dissipation	Variable 0 - 35,000 ohms ±5% 1/8 W
442	Resistor	Type Resistance Dissipation	Variable 0 - 60,000 ohms ±5% 1/8 W
443	Resistor	Type Resistance Dissipation	Variable 0 - 2500 ohms ±5% 10 W
444	Resistor	Type Resistance Dissipation	Variable 0 - 10,000 ohms 5 W
445	Resistor	Type Resistance Dissipation	Variable 0 - 3000 ohms 2 W
446	Resistor	Type Resistance Dissipation	Variable 0 - 7500 ohms 1/8 W

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
447	Resistor	Type Resistance Dissipation	Fixed 300 ohms ±0.25% 0.25 W
448	Resistor	Type Resistance Dissipation	Fixed 150 ohms ±5% 0.25 W
449	Resistor	Type Resistance Dissipation	Fixed 60 ohms +5% or 180 ohms ±5% 300 W 100 W
450	Resistor	Type Resistance Dissipation	Fixed 84 ohms ±5% 50 W
451	Resistor	Type Resistance Dissipation	Fixed 167 ohms ±5% 0.25 W
452	Resistor	Type Resistance Dissipation	Variable - 3 terminal 100 kilohms ±5% 2 W
453	Capacitor	Type Capacitance WVDC	Electrolytic 1000 µF 200
454	Resistor	Type Resistance Dissipation	Variable 0 - 30 ohms 5 W
455	Resistor	Type Resistance Dissipation	Variable 0 - 75 ohms 5 W

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
456	Resistor	Type Resistance Dissipation	Variable 0 - 1000 ohms 5 W
457	Resistor	Type Resistance Dissipation	Variable 0 - 4000 ohms 5 W
458	Resistor	Type Resistance Dissipation	Fixed 1192 ohms ±1% 1/2 W
459	Resistor	Type Resistance Dissipation	Fixed 3.8 ohms ±1% 1/2 W
460	Resistor	Type Resistance	Fixed Equal to input impedance of transmitting filters ±1% (see manufacturers specifications).
461	Resistor	Type Resistance	Fixed Equal to output impedance of receiving filters ±1% (see manufacturers specifications).
514	Pre-Amplifier	Frequency Response Gain Input Resistance Output Impedance Distortion	-3 dB bandwidth 100 - 5000 Hz 40 dB 15,000 ohms 5000 ohms 1% or less

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
514 (Cont'd)		Max. Input Signal	40 mV rms
		Max. Phase Shift Difference between two Amplifiers of a Matched Pair	1 deg
567	Power Supply	Frequency	DC
		Voltage	130 V - floating
		Current Rating	2.5 A
		Impedance	Less than 1 ohm 0 - 300 Hz
		Regulation	±1% No load to full load
568	Power Supply	Frequency	DC
		Voltage	+60, -60, Common
		Current Rating	1.0 A
		Impedance	Less than 1 ohm 0 - 300 Hz
		Regulation	±1% No load to full load
569	Power Supply	Frequency	DC
		Voltage	+6, -6, Common
		Current Rating	0.5 A
		Impedance	Less than 1 ohm, 0 - 300 Hz
		Regulation	±1% No load to full load
570	Battery	Voltage	1.5 V
		Max. Current	75 mA
571	Frequency Converter	Input Frequency	60 Hz
		Output Frequency	45 - 400 Hz
		Output Power	1000 vA
		Output Voltage	0 - 130 V
		Input	208 V - 3 phase

TEST EQUIPMENT LIST

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
573	Battery	Voltage Max. Current	22.5 V 100 mA
615	Attenuator	Impedance Accuracy Dissipation Range Min. Step	600/600 ±1% for each step 0.6 W (+28 dBm input) 0 - 110 dB 0.1 dB
665	Transformer	Frequency Range Impedance Ratio	200 - 3500 Hz 600: Input impedance of transmitting filters (see manufacturers specifications)
666	Transformer	Frequency Range Impedance Ratio	200 - 3500 Hz 600: Output impedance of filters (see manufacturers specifications)
667	Hybrid Coil	Frequency Range Impedances	200 - 3500 Hz 600:600:600:600
668	Alternate Hybrid Coil (2 Transformers)	Frequency Range Impedance Ratio Coil Arrangement	200 - 3500 Hz 600:600 4 equal coils
669	Transformer	Frequency Range Impedance Ratio Coils	200 - 3500 Hz 600:600 Center tapped
670	Variable Auto-Transformer	Input Output Rated Current	120 V - 60 Hz 0 - 140 V - 60 Hz 10 A

ITEM	EQUIPMENT	MINIMUM PERFORMANCE REQUIREMENT	
723	Low Pass Filter	Type Cut off Impedance	Loss Pass 3.5 kHz 600 ohms input and output
946	Switch	Type Voltage Amperage	SPST - Locking 125 V 6 A
947	Switch	Type Voltage Amperage	DPDT - Locking 125 V 1 A
948	Relay	Type	Telegraph - Neutral Solid-State
949	Switch	Type Voltage Amperage	DPST - Locking 125 V 1 A
950	Switch	Type Voltage Amperage	SPDT - Locking 125 V 1 A
951	Wheatstone Bridge (Including Galvanometer)	Range of Resistance Test Voltage Accuracy	1 - 10,000 ohms Not more than 6 V $\pm$1%
952	Impedance Bridge	Range of Resistance Range of Capacitance Range of Inductance Accuracy Frequency Range	10 - 10,000 ohms 100 pF - 1 µF 1 mH - 1 H $\pm$1% for R, C, and L 50 to 10,000 Hz
953	Capacitance Bridge	Range of Capacitance Accuracy Capable of operating down to 50 Hz	100 pF - 1 µF $\pm$1%

Blank

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