NILECJ-STD-0209.00
DECEMBER 1978

LAW ENFORCEMENT STANDARDS PROGRAM

PERSONAL FM TRANSCEIVERS

U.S. DEPARTMENT OF JUSTICE
Law Enforcement Assistance Administration
National Institute of Law Enforcement and Criminal Justice

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NILECJ STANDARD FOR PERSONAL FM TRANSCEIVERS

A Voluntary National Standard Promulgated by the National Institute of Law Enforcement and Criminal Justice.

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This standard was formulated by the Law Enforcement Standards Laboratory of the National Bureau of Standards under the direction of Marshall J. Treado, Program Manager for Communications Systems, and Jacob J. Diamond, Chief of LESL. NBS Electromagnetics Division staff members responsible for the preparation of the standard were Harold E. Taggart, project leader, John F. Shafer, Leon F. Saulsbery, and John L. Workman. Acknowledgment is given to previous work in this field by the Associated Public-Safety Communications Officers, Inc.; the Electronic Industries Association; the American National Standards Institute; and the International Electrotechnical Commission. This standard has been reviewed and approved by the National Advisory Committee for Law Enforcement Equipment and Technology of the International Association of Chiefs of Police and adopted by them as an IACP Standard.

NILECJ STANDARD
FOR
PERSONAL FM TRANSCEIVERS

CONTENTS

FOREWORD

Following a Congressional mandate[1] to develop new and improved techniques, systems, and equipment to strengthen law enforcement and criminal justice, the National Institute of Law Enforcement and Criminal Justice (NILECJ) has established the Law Enforcement Standards Laboratory (LESL) at the National Bureau of Standards. LESL's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

In response to priorities established by NILECJ, LESL is (1) subjecting existing equipment to laboratory testing and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guidelines, state-of-the-art surveys and other reports.

This document, NILECJ-STD-0209.00, Personal FM Transceivers, is a law enforcement equipment standard developed by LESL and approved and issued by NILECJ. Additional standards as well as other documents are being issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles and clothing.

This equipment standard is a technical document consisting of performance and other requirements together with a description of test methods. Equipment which can meet these requirements is of superior quality and is suited to the needs of law enforcement agencies. Purchasers can use the test methods described in this standard to determine firsthand whether a particular equipment item meets the requirements of the standard, or they may have the tests conducted on their behalf by a qualified testing laboratory. Law enforcement personnel may also reference this standard in purchase documents and require that any equipment offered for purchase meet its requirements and that this compliance be either guaranteed by the vendor or attested to by an independent testing laboratory.

The necessarily technical nature of this NILECJ standard, and its special focus as a procurement aid, make it of limited use to those who seek general guidance concerning personal FM transceivers. The NILECJ Guideline Series is designed to fill that need. We plan to issue guidelines to this as well as other law enforcement equipment as soon as possible, within the constraints of available funding and the overall NILECJ program.

The guideline documents being issued are highly readable and tutorial in nature in contrast to the standards, which are highly technical and intended for laboratory use by technical personnel. The guidelines provide, in non-technical language, information for purchasing agents and other interested persons concerning the capabilities of equipment currently available. They may then select equipment appropriate to the performance required by their agency. Recommendations for the development of particular guidelines should be sent to us.

NILECJ standards are subjected to continuing review. Technical comments and recommended revisions are invited from all interested parties. Suggestions should be addressed to the Program Manager for Standards, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C. 20531.

Lester D. Shubin,
Program Manager for Standards
National Institute of Law
Enforcement and Criminal Justice

[1] Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended.

NILECJ STANDARD FOR PERSONAL FM TRANSCEIVERS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for frequency modulated personal transceivers and their associated antennas and power sources. This standard applies to transceivers which either do not have special subsystems such as selective signaling or voice privacy, or in which such subsystems are bypassed or disabled during testing for compliance with this standard. This standard supersedes NILECJ-STD-0203.00, Personal/Portable FM Transmitters, and NILECJ-STD-0208.00, Personal/Portable FM Receivers.

2. CLASSIFICATION

For the purposes of this standard, personal FM transceivers are classified by their operating frequencies.

2.1 Type I

Transceivers which operate in the 25–50 MHz band with a receiver channel spacing of 20 kHz.

2.2 Type II

Transceivers which operate in the 150–174 MHz band with a receiver channel spacing of 30 kHz.

2.3 Type III

Transceivers which operate in the 400–512 MHz band with a receiver channel spacing of 25 kHz.

3. DEFINITIONS

The principal terms used in this document are defined in this section. Additional definitions relating to law enforcement communications are given in LESP-RPT-0203.00, Technical Terms and Definitions Used with Law Enforcement Communications Equipment [17].

3.1 Adjacent-Channel Selectivity and Desensitization

The ability of a receiver to discriminate against a signal at the frequency of an adjacent channel.

3.2 AM Hum and Noise

The amplitude modulation present on an unmodulated carrier.

3.3 Antenna Power Rating

The maximum continuous wave power which can be applied to an antenna in accordance with the standard duty cycle without degrading its performance beyond specified limits.

3.4 Audiofrequency Harmonic Distortion

Nonlinear distortion characterized by the appearance in the output of integral multiples of an audiofrequency input signal.

3.5 Audiofrequency Response of a Receiver

The variation in the output of a receiver as a function of frequency within a specified bandwidth.

3.6 Audiofrequency Response of a Transmitter

The degree of precision with which the frequency deviation of a transmitter responds to a designated audiofrequency signal level.

3.7 Audio Hum and Noise Power

The average audiofrequency power dissipated in a load across the output terminals of a receiver having an unmodulated radiofrequency signal input.

3.8 Audio Noise Output Power

The average audiofrequency power dissipated in a load across the output terminals of an unsquelched receiver having no radiofrequency signal input.

3.9 Audio Output Power

The audiofrequency power dissipated in a load across the receiver output terminals of an unsquelched receiver having a modulated radiofrequency signal input.

3.10 Authorized Bandwidth

The maximum width of the band of frequencies specified by the Federal Communications Commission to be occupied by an emission, i.e., 20 kHz for public safety agencies. [13]

3.11 Carrier Attack Time

The time required for a transmitter to produce 50 percent of the rated carrier output power after the carrier control switch is activated.

3.12 Carrier Output Power

For a transmitter, the radiofrequency power available at the antenna terminal when no modulating signal is present.

3.13 FM Hum and Noise

The frequency modulation present on an unmodulated carrier.

3.14 Frequency Deviation

In frequency modulation, the difference between the instantaneous frequency of the modulated carrier and the unmodulated carrier frequency.

3.15 Frequency Stability

The ability of a transmitter to maintain an assigned carrier frequency.

3.16 Intermodulation Attenuation

The ratio, expressed in decibles, of (1) the level of specified signals that produces an intermodulation response under specified conditions to (2) the receiver's SINAD sensitivity.

3.17 Intermodulation Response

The response resulting from the mixing of two or more frequencies, in the nonlinear elements of a receiver, in which a resultant frequency is generated that falls within the range of frequencies passed by the receiver.

3.18 Modulation Limiting

That action, performed within an FM transmitter, which intentionally restricts the signal to the required spectral limits.

3.19 Noise Quieting

The reduction of audio noise output caused by an rf signal.

3.20 Nominal Value

The numerical value of a device characteristic as specified by the manufacturer.

3.21 Occupied Bandwidth

The width of the frequency band containing those frequencies at which a total of 99 percent of the radiated power appears, extended to include any discrete frequency at which the power is at least 0.25 percent of the total radiated power.

3.22 Radiation Efficiency

The ratio of the effective radiated power of a transmitter-antenna system to the transmitter output power into a 50 ohm load.

3.23 Rated Capacity, Battery

A designation by the battery manufacturer which indicates the approximate capacity, in ampere-hours or milliampere-hours, at typical discharge rates.

3.24 Rated System Deviation

The maximum carrier frequency deviation permitted by the FCC, for law enforcement communications systems it is ± 5 kHz.

3.25 Sampler

A series device which couples energy over a broad frequency range from a transmission line into a third port. The attenuated output signal from the third port has the same waveform as the original signal.

3.26 Selectivity

The extent to which a receiver is capable of differentiating between the desired signal and signals at other frequencies.

3.27 Service Life

The length of time that a primary cell (or battery) or a fully charged secondary cell (or battery) will provide satisfactory service for a transceiver under specified conditions.

3.28 Sideband Spectrum

The emissions generated by a modulated transmitter that are within 250 percent of the authorized bandwidth, i.e., ± 25 kHz.

3.29 SINAD Ratio

The ratio, expressed in decibels, of (1) signal plus noise plus distortion to (2) noise plus distortion produced at the output of a receiver; from SIgnal Noise And Distortion Ratio.

3.30 SINAD Sensitivity

The minimum modulated rf signal input level required to produce a specified SINAD ratio at a specified audio output power level.

3.31 Spurious Emission

Any part of the radiofrequency output that is not a component of the theoretical output or exceeds the authorized bandwidth.

3.32 Spurious Response

The output of a receiver caused by a signal at a frequency other than that to which the receiver is tuned.

3.33 Squelch

A circuit function for preventing a receiver from producing audio output power in the absence of an rf input signal.

3.34 Squelch Attack Time

The time required to produce a designated audio output power level upon application of a specified rf input signal, when the squelch control is in the threshold squelch position.

3.35 Squelch Block

A squelched condition resulting from excessive frequency deviation due to a specified rf input signal.

3.36 Squelch Release Time

The time required to reduce a specified audio output power to a designated level upon removal of the rf input signal, when the squelch control is in the threshold squelch position.

3.37 Standby Mode

The condition of a transceiver when it is energized but not receiving or transmitting.

3.38 Standing Wave Ratio (SWR)

The ratio of the maximum to the minimum amplitudes of the voltage or current appearing along a transmission line.

3.39 Threshold Squelch Position

The adjustment of the squelch control, starting from the maximum unsquelched position, that first reduces the audio noise output power by a specified amount.

3.40 Threshold Squelch Sensitivity

The minimum standard modulated rf signal input level required to unsquelch a receiver when the squelch control is in the threshold squelch position.

3.41 Tight-Squelch Sensitivity

The minimum standard modulated rf signal input level required to unsquelch a receiver when the squelch control is in the maximum squelch position.

3.42 Transceiver

The combination of radio transmitting and receiving equipment in a common housing, usually for portable or mobile use.

3.43 Usable Bandwidth

The frequency deviation of an input signal which is 6 dB above the 12 dB SINAD sensitivity voltage and which produces a 12 dB SINAD ratio.

4. REQUIREMENTS

4.1 Minimum Performance

The transceiver performance shall meet or exceed the requirement for each characteristic as given below and in tables 1 through 4. The performance requirements listed in tables 1 and 2 meet or exceed those given in the Rules and Regulations published by the Federal Communications Commission.

4.2 User Information

A nominal value for each of the characteristics listed in tables 1 through 4 shall be included in the information supplied to the purchaser by the manufacturer or distributor. In addition, he shall provide the range of temperatures within which the transceiver is designed to be operated, the transmitter and receiver operating frequencies and nominal values for the transmitter carrier output power, the receiver audio output impedance, the battery voltage and the current drains in the transmit, receive and standby modes. The manufacturer shall also indicate the magnitude of the audio input signal necessary for rated system deviation and provide sufficient audio input impedance information to enable test personnel to design an impedance matching network for use between the audio generator and transmitter audio input circuits. The manufacturer or distributor shall label each battery with the nominal voltage, battery type and model, rated capacity, indication of polarity, recharge rate (if rechargeable) and month and year of manufacture.

4.3 Performance at Environmental Extremes

The ability of the transceiver to operate in environmental extremes shall be determined using the test methods described in paragraph 5.3. These tests shall be performed before the transceiver is tested for compliance with the requirements of paragraphs 4.4 through 4.7.

4.3.1 Temperature Stability

Low temperature tests shall be conducted at −30° C (−22° F) or the lowest temperature at which the manufacturer states (paragraph 4.2) that his unit will operate properly, whichever is lower, and high temperature tests shall be conducted at 60° C (140° F) or the highest temperature at which the manufacturer states that his unit will operate properly, whichever is higher.

When the transceiver is operated at low and high temperatures, as defined above, its performance shall not vary, with respect to the appropriate values in table 1 (items A through T), more than items U through AA, for the characteristics listed. In addition, the receiver audio distortion at an audio output power of 500 mW (item M, table 1) shall be less than 18 percent (item AB, table 1) for an rf signal with standard modulation. The transmitter rf output power shall be within 3 dB (item BN, table 2) of the nominal value, its FM hum and noise level shall be attenuated a minimum of 34 dB (item BO, table 2), the carrier frequency shall be within (item BP, table 2) of the assigned value and the audio-frequency harmonic distortion shall be a maximum of 9 percent (item BQ, table 2).

The transceiver primary or fully charged secondary batteries shall operate the transceiver for (item DB or DC, table 4, as appropriate) before the nominal transmitter output power decreases 3 dB.

4.3.2 Humidity Stability

After the transceiver has been maintained at 50° C (122° F) and 90 percent relative humidity or greater for at least eight hours, its performance shall not vary, with respect to the appropriate values in table 1 (items A through T), more than items AC through AI, for the characteristics listed. In addition, the receiver audio distortion at an audio output power of 500 mW (item M, table 1) shall be less than 18 percent (item AJ, table 1) for an rf signal with standard modulation. The transceiver rf output power shall be within 3 dB (item BR, table 2) of the nominal value, its FM hum and noise level shall be attenuated a minimum of 34 dB (item BS, table 2) and the carrier frequency shall be within (item BT, table 2) of the assigned value.

4.3.3 Vibration Stability

No fixed part of the transceiver shall come loose, nor movable part be shifted in position or adjustment, as a result of this test. During the test, the FM hum and noise level shall be attenuated a minimum of 25 dB (item BU, table 2) and the carrier frequency shall be within (item BV, table 2) of the assigned value.

4.3.4 Shock Stability

The transceiver shall suffer no more than superficial damage as a result of this test. No fixed part shall come loose, nor movable part be shifted in position.

4.4 Receiver Performance

4.4.1 SINAD Sensitivity

When measured in accordance with paragraph 5.4.1, the SINAD sensitivity of the receiver shall be 0.5 μV (item A) or less at a SINAD ratio of 12 dB and an audio output power of at least 50 percent of 500 mW (Item M), i.e., 250 mW. When the standard power supply voltage is varied +10 percent and −20 percent, the SINAD sensitivity shall be 0.7 μV (item B) or less.

4.4.2 Selectivity Characteristics

The selectivity characteristics of usable bandwidth, adjacent channel selectivity and desensitization, spurious response attenuation and intermodulation attenuation shall be measured in accordance with paragraph 5.4.2.

4.4.2.1 Usable Bandwidth

The usable bandwidth of the receiver shall be no less than 5 kHz (item C) for an applied rf signal 6 dB above the measured 12 dB SINAD sensitivity value.

4.4.2.2 Adjacent Channel Selectivity and Desensitization

The adjacent channel selectivity and desensitization of the receiver shall be (item D) or more for a degradation of an on-channel signal from 12 dB SINAD ratio to 6 dB SINAD ratio caused by an adjacent channel signal.

4.4.2.3 Spurious Response Attenuation

The spurious response attenuation of the receiver shall be (item E) or more as compared to the on-channel 20 dB noise quieting signal voltage for responses of the receiver between the lowest intermediate frequency of the receiver and 1000 MHz.

TABLE 1. *Minimum Performance Requirements for Receivers Used in Personal FM Transceivers*

Receiver Characteristic		Minimum Requirement Frequency Band (MHz) 25–50	150–174	400–512
Sensitivity Characteristics				
A.	SINAD Sensitivity	0.5 μV	0.5 μV	0.5 μV
B.	SINAD Sensitivity Variance (Supply Voltage Varied + 10% and −20%)	0.7 μV	0.7 μV	0.7 μV
Selectivity Characteristics				
C.	Usable Bandwidth	5 kHz	5 kHz	5 kHz
D.	Adjacent Channel Selectivity and Desensitization	60 dB	70 dB	60 dB
E.	Spurious Response Attenuation	70 dB	60 dB	60 dB
F.	Intermodulation Attentuation	70 dB	60 dB	60 dB
Squelch Characteristics				
G.	Threshold Squelch Sensitivity	0.3 μV	0.4 μV	0.4 μV
H.	Tight Squelch Sensitivity	3.0 μV	4.0 μV	4.0 μV
I.	Threshold Squelch Sensitivity Variance (Supply Voltage Varied + 10% and −20%)	0.45 μV	0.6 μV	0.6 μV
J.	Squelch Block	±5 kHz	±5 kHz	±5 kHz
K.	Squelch Attack Time	150 ms	150 ms	150 ms
L.	Squelch Release Time	250 ms	250 ms	250 ms
Audiofrequency Characteristics				
M.	Audio Output Power (Loudspeaker)	500 mW	500 mW	500 mW
N.	Audio Output Power (Earphones)	3–12 mW	3–12 mW	3–12 mW
O.	Audio Output Power Variance (Supply Voltage Varied + 10% and −20%)	3 dB	3 dB	3 dB
P.	Audio Distortion	10%	10%	10%
Q.	Audiofrequency Response (Loudspeaker)	−10, +2 dB	−10, +2 dB	−10, +2 dB
R.	Audiofrequency Response (Earphones)	−10, +2 dB	−10, +2 dB	−10, +2 dB
S.	Audio Hum and Noise (Unsquelched)	40 dB	40 dB	40 dB
T.	Audio Hum and Noise (Squelched)	50 dB	50 dB	50 dB
Temperature Stability				
U.	SINAD Sensitivity	6 dB	6 dB	6 dB
V.	Usable Bandwidth	20%	20%	20%
W.	Adjacent Channel Selectivity and Desensitization	12 dB	12 dB	12 dB
X.	Tight Squelch Sensitivity	6 dB	6 dB	6 dB
Y.	Threshold Squelch Sensitivity	6 dB	6 dB	6 dB
Z.	Audio Output Power	6 dB	6 dB	6 dB
AA.	Audio Hum and Noise	10 dB	10 dB	10 dB
AB.	Audio Distortion	18%	18%	18%
Humidity Stability				
AC.	SINAD Sensitivity	10 dB	10 dB	10 dB
AD.	Usable Bandwidth	20%	20%	20%
AE.	Adjacent Channel Selectivity and Desensitization	12 dB	12 dB	12 dB
AF.	Tight Squelch Sensitivity	10 dB	10 dB	10 dB
AG.	Threshold Squelch Sensitivity	10 dB	10 dB	10 dB
AH.	Audio Output Power	3 dB	3 dB	3 dB
AI.	Audio Hum and Noise	10 dB	10 dB	10 dB
AJ.	Audio Distortion	18%	18%	18%

4.4.2.4 Intermodulation Attenuation

The intermodulation attenuation of the receiver shall be (item F) or more for a degradation of an on-channel signal from 12 dB SINAD ratio to 6 dB SINAD ratio by two relatively strong signals located at one- and two-channel spacings, respectively, from the receiver frequency, both signals being at frequencies either above or below the on-channel signal.

4.4.3 Squelch Characteristics

The squelch characteristics of sensitivity, block, attack time and release time shall be measured in accordance with paragraph 5.4.3.

4.4.3.1 Squelch Sensitivity

The threshold squelch sensitivity of the receiver shall be (item G) or less. The tight squelch sensitivity shall be (item H) or less. When the standard power supply voltage is varied +10 percent and −20 percent, the threshold squelch sensitivity shall be (item I) or less.

4.4.3.2 Squelch Block

The receiver shall not squelch for modulation frequencies of 0.3 to 3 kHz when the squelch control is adjusted to the maximum squelch position and the frequency deviation of the input signal is ±5 kHz (item J) or less.

4.4.3.3 Squelch Attack Time

The squelch attack time for the receiver to produce an audio output power of 90 percent of 500 mW (item M), i.e., 450 mW, shall be 150 milliseconds (item K) or less.

4.4.3.4 Squelch Release Time

The squelch release time for the audio output power of the receiver to decrease to 10 percent of 500 mW (item M), i.e., 50 mW, shall be 250 milliseconds (item L) or less.

4.4.4 Audiofrequency Characteristics

The audiofrequency characteristics of output power, distortion, frequency response, and hum and noise shall be measured in accordance with paragraph 5.4.4.

4.4.4.1 Audio Output Power

The audio output power of the receiver shall be at least 500 mW (item M) if a loudspeaker is used at the receiver output and at least 3 mW (item N) but not greater than 12 mW if earphones are used. When the standard supply voltage is varied +10 percent and −20 percent, the audio output power shall not be reduced more than 3 dB (item O) below 500 mW (item M).

4.4.4.2 Audio Distortion

Audio distortions at audio output powers of (item M and N) shall be less than 10 percent (item P) for an rf input signal with standard modulation.

4.4.4.3 Audiofrequency Response

The audiofrequency response of the receiver, when used with a loudspeaker, shall be within −10, +2 dB (item Q) of an ideal 6 dB per octave de-emphasis curve with constant frequency deviation at frequencies between 0.3 and 3 kHz. When used with earphones, the audiofrequency response of the receiver shall also be within −10, +2 dB (item R) of the same curve at frequencies between 0.3 and 3 kHz.

4.4.4.4 Audio Hum and Noise

The audio hum and noise output power from the receiver in the unsquelched condition shall be 40 dB (item S) or more, and in the maximum squelched condition shall be 50 dB (item T) or more below an audio output power of 500 mW (item M).

4.5 Transmitter Performance

4.5.1 Radio Frequency Characteristics

The radio frequency carrier characteristics of output power, frequency stability, AM hum and noise level and carrier attack time shall be measured in accordance with paragraph 5.5.1.

4.5.1.1 Output Power

Transmitter output power is specified by the FCC [13]. The carrier output power delivered to a standard output load shall be within −0.3, +1.0 dB (item BA) of the nominal value at all times during the transceiver test duty cycle that the transceiver is in the transmit mode, except for the initial second after the transceiver has been switched from the standby mode to the transmit mode. When the standard supply voltage is varied plus and minus 10 percent, the output power shall not vary more than ±3 dB (item BB). When the standard supply voltage is reduced by 20 percent, the output power shall not vary more than −6, +3 dB (item BC).

TABLE 2. *Minimum Performance Requirements for Transmitters Used in Personal FM Transceivers*

Transmitter Characteristic	Minimum Requirement Frequency Band (MHz) 25–50	150–174	400–512
Radio Frequency Carrier Characteristics			
BA. Carrier Output Power Variance	−0.3, +1.0 dB	−0.3, +1.0 dB	−0.3, +1.0 dB
BB. Output Power Variance (supply voltage varied ±10%)	±3 dB	±3 dB	±3 dB
BC. Output Power Variance (supply voltage varied −20%)	−6, +3 dB	−6, +3 dB	−6, +3 dB
BD. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%
BE. Frequency Stability (supply voltage varied ±15%)	0.002%	0.0005%	0.0005%
BF. AM Hum and Noise Level	34 dB	34 dB	34 dB
BG. Carrier Attack Time	100 ms	100 ms	100 ms
Audiofrequency Modulation Characteristics			
BH. Audiofrequency Harmonic Distortion	5%	5%	5%
BI. FM Hum and Noise Level	40 dB	40 dB	40 dB
BJ. Frequency Deviation	5%	5%	5%
Electromagnetic Compatibility Characteristics			
BK. Radiated Spurious Emissions	43 dB	43 dB	43 dB
BL. Sideband Spectrum (±10 kHz frequency separation)	25 dB	30 dB	30 dB
BM. Sideband Spectrum (±20 kHz frequency separation)	50 dB	60 dB	60 dB
Temperature Stability			
BN. Output Power	±3 dB	±3 dB	±3 dB
BO. FM Hum and Noise Level	34 dB	34 dB	34 dB
BP. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%
BQ. Audiofrequency Harmonic Distortion	9%	9%	9%
Humidity Stability			
BR. Output Power	±3 dB	±3 dB	±3 dB
BS. FM Hum and Noise Level	34 dB	34 dB	34 dB
BT. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%
Vibration Stability			
BU. FM Hum and Noise Level	25 dB	25 dB	25 dB
BV. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%

3. *Minimum Performance Requirements for Personal Transceiver Antennas*

Antenna Characteristic	Minimum Requirement Frequency Band (MHz) 25–50	150–174	400–512
CA. Radiation Efficiency	NA	30%	50%
CB. Power Test Degradation	2 dB	1 dB	1 dB

4. *Minimum Performance Requirements for Personal Transceiver Batteries*

Battery Characteristic	Minimum Requirement Ni-Cad	Mercury	Alkaline	Carbon-Zinc
DA. Service Life: 20 to 30° C	8 hrs.	40 hrs.	20 hrs.	4 hrs.
DB. Service Life: −30° C	2 hrs.	NA	NA	NA
DC. Service Life: +60° C	7 hrs.	40 hrs.	24 hrs.	5 hrs.

4.5.1.2 Frequency Stability

The carrier frequency shall be within (item BD) of the assigned value at all times during the transceiver test duty cycle that the transceiver is in the transmit mode, except for the initial second after the transceiver has been switched from the standby mode to the transmit mode. When the standard supply voltage is varied plus and minus 15 percent, the frequency stability shall be (item BE).

4.5.1.3 AM Hum and Noise Level

The AM hum and noise level shall be attenuated a minimum of 34 dB (item BF) below the unmodulated nominal carrier output power level.

4.5.1.4 Carrier Attack Time

The carrier output power shall increase to 50 percent of its nominal value in less than 100 milliseconds (item BG).

4.5.2 Audiofrequency Modulation Characteristics

The audiofrequency modulation characteristics of harmonic distortion, FM hum and noise level, audiofrequency response, frequency deviation and modulation limiting shall be measured in accordance with paragraph 5.5.2.

4.5.2.1 Audiofrequency Harmonic Distortion

The audiofrequency harmonic distortion shall be a maximum of 5 percent (item BH).

4.5.2.2 FM Hum and Noise Level

The FM hum and noise level shall be attenuated a minimum of 40 dB (item BI).

4.5.2.3 Audiofrequency Response

The audiofrequency response shall not vary more than +1, −3 dB from a true 6 dB per octve pre-emphasis characteristic from 0.3 to 3 kHz as referred to the 1 kHz level, as shown in figure 1, with the exception that a 6 dB per octave roll-off from 2.5 to 3 kHz may be present.

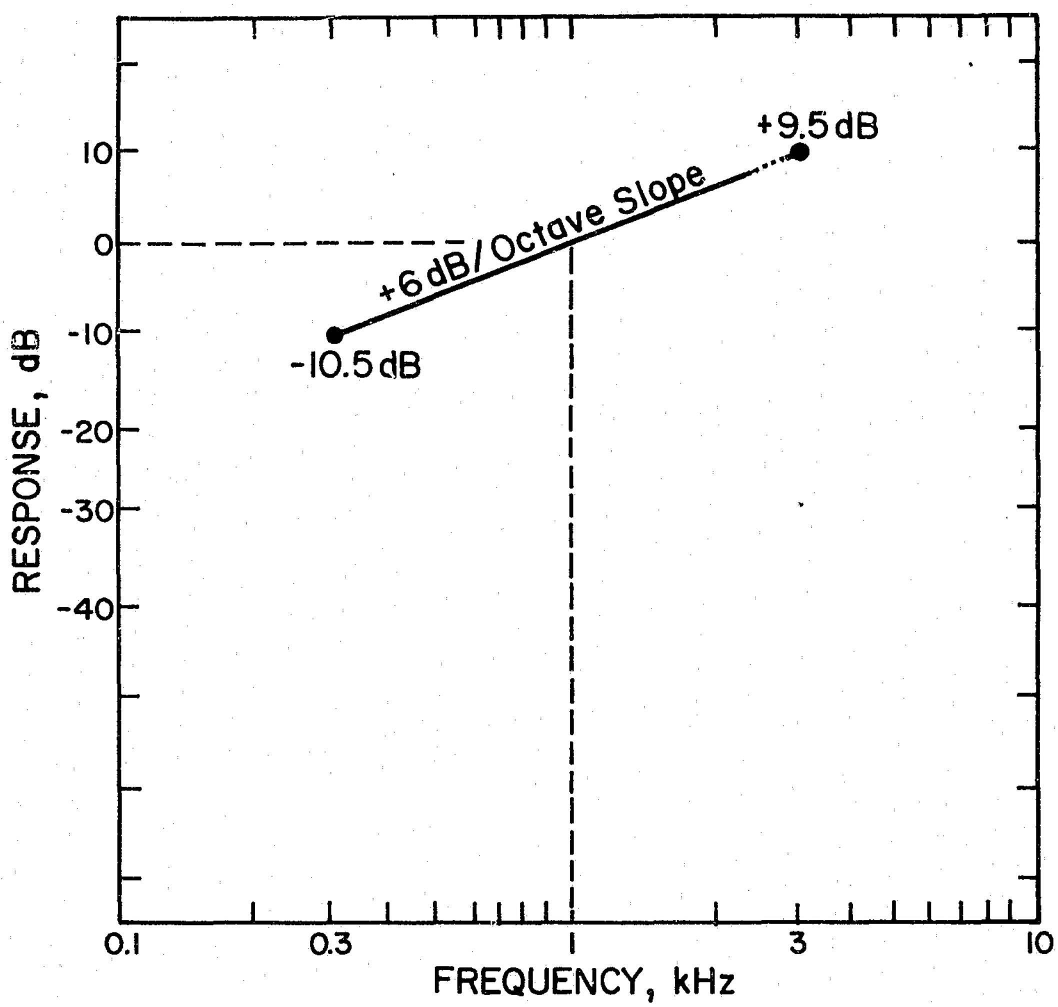

FIGURE 1. Audiofrequency response characteristics of personal FM transmitters.

4.5.2.4 Frequency Deviation

The maximum frequency deviation shall be within 5 percent (item BJ) of ±4.75 kHz.

4.5.2.5 Modulation Limiting

The instantaneous peak and the steady state frequency deviation shall not exceed the maximum value of rated system deviation (±5 kHz) with a 20 dB increase in audio above the nominal audio input level.

4.5.3 Electromagnetic Compatibility Characteristics

The electromagnetic compatibility characteristics of radiated spurious emissions and sideband spectrum shall be measured in accordance with paragraph 5.5.3.

4.5.3.1 Radiated Spurious Emissions

Each radiated spurious emission shall be attenuated a minimum of 43 dB (item BK) + 10 $\log_{10}$ (output power in watts) decibels below the field strength of the carrier.

4.5.3.2 Sideband Spectrum

Each spurious sideband emission shall be attenuated greater than (item BL) when the frequency is separated from the assigned carrier by plus and minus 10 kHz, and shall be attenuated greater than (item BM) when the frequency is separated from the assigned carrier by plus and minus 20 kHz.

4.6 Antenna Performance

4.6.1 Radiation Efficiency

When measured in accordance with paragraph 5.6.1, the radiation efficiency shall be (item CA) or greater.

4.6.2 Antenna Power Stability

When operated for 30 minutes at nominal carrier output power using the test method described in 5.6.2, the antenna radiated field strength shall not decrease more than (item CB).

4.7 Battery Service Life

When tested in accordance with paragraph 5.7, each primary or fully charged secondary battery shall operate the transceiver for (item DA, table 4) before the nominal transmitter output power decreases 3 dB. See also the high and low temperature service life requirements given in paragraph 4.3.1.1.

5. TEST METHODS

5.1 Standard Test Conditions

Allow all measurement equipment to warm up until the system has achieved sufficient stability to perform the measurement. Unless otherwise specified, perform all measurements under standard test conditions.

5.1.1 Standard Temperature

Standard ambient temperature shall be between 20° C (68° F) and 30° C (86° F).

5.1.2 Standard Relative Humidity

Standard ambient relative humidity shall be between 10 percent and 85 percent.

5.1.3 Standard Supply Voltage

The standard supply voltage shall be the nominal battery voltage as specified by the manufacturer in accordance with paragraph 4.2. Tests shall be performed using either a battery of the same type as normally used in the equipment or a well-filtered electronic dc supply. In the latter case, it shall be adjusted to within 1 percent of the voltage required.

5.1.4 Standard Test Frequencies

The standard test frequencies shall be the transmitter and receiver operating frequencies.

5.1.5 Standard Test Modulations

5.1.5.1 Audiofrequency Test Modulation

Audiofrequency test modulation shall be 1 kHz (from a source with distortion less than one percent) at the level required to produce 60 percent of rated system deviation (i.e., ±3 kHz).

5.1.5.2 Electromagnetic Compatibility Test Modulation

Electromagnetic compatibility test modulation shall be a 2.5 kHz sine wave at an input level 16 decibels greater than that required to produce 50 percent of rated system deviation at 1 kHz.

5.1.6 Rated System Deviation

Rated system deviation shall be ±5 kHz.

5.1.7 Standard Squelch Adjustment

The squelch control shall be adjusted to the maximum unsquelch position for all receiver measurements except where otherwise specified.

5.1.8 Battery Test Duty Cycle

The battery test duty cycle will be 6 seconds in the transmit mode, 6 seconds in the receive mode and 48 seconds in the standby mode.

5.1.9 Standard Radiation Test Site

The standard radiation test site shall be located on level ground which has uniform electrical characteristics (i.e., ground constants). Reflecting objects (especially large metal objects), trees, buildings, and other objects which would perturb the electromagnetic fields to be measured should not be located closer than 90 m (295 ft) from any test equipment or equipment under test. All utility lines and any control circuits between test positions should be buried underground. The ambient electrical noise level shall be as low as possible and shall be carefully monitored to insure that it does not interfere with the test being performed. Preferably, the test site should be equipped with a remotely controlled turntable located at ground level.

5.1.10 Standard Charge

Prior to testing, each secondary battery shall be discharged to a voltage of 1 volt per cell at a current of C or less, where C is numerically equal to the battery rated capacity in ampere-hours or milliampere-hours. Slow-charge batteries shall then be recharged at a rate of 0.1 C for 14 to 16 hours. Fast-charge batteries shall be fully recharged in accordance with the manufacturer's instructions.

5.2 Test Equipment

The test equipment discussed in this section is limited to that equipment which is the most critical in making the measurements discussed in this standard. All other test equipment shall be of comparable quality.

5.2.1 FM Signal Generator

The FM signal generator shall have a 50 ohm output impedance, a maximum standing-wave ratio of 1.2, and a calibrated variable output level accurate to ± 2 dB when terminated in a 50 ohm load. The generator should include a digital frequency counter having an uncertainty no greater than one part in 10^6, and a deviation monitor or calibrated control for determining the peak frequency deviation with an uncertainty of no greater than 5 percent. If an integral frequency counter is not included, a separate frequency counter having the required accuracy shall be provided.

5.2.2 CW Signal Generator

The CW signal generator shall have the same characteristics as described in paragraph 5.2.1 except that the FM capability is not required.

5.2.3 Standard RF Input Load (Receiver)

The standard rf input load shall consist of a shielded 50 ohm resistor whose standing wave ratio is less than 1.05.

5.2.4 Standard Audio Output Load (Receiver)

The standard audio output load shall be a resistor having a resistance equal to the nominal output impedance of the transceiver receiver and a power rating equal to or exceeding the nominal audio output power of the transceiver receiver. A filter network shall not be used between the audio output terminals and the audio output load. If an external monitor speaker is used, a matching network to maintain the standard output load impedance at the audio output terminals shall be provided.

5.2.5 Standard Audio Input Load (Transmitter)

The standard audio input load shall consist of a low-noise resistor whose resistance is equal to the specified input impedance of the transceiver transmitter.

5.2.6 Standard RF Output Load (Transmitter)

The standard rf output load shall be a 50 ohm resistive termination having a standing wave ratio (SWR) of 1.1 or less at the standard test frequencies. If connectors and cables are used to attach the standard output load to the transmitter, the combined SWR, including the load, shall be 1.1 or less.

5.2.7 Audiofrequency Voltmeter

The audiofrequency voltmeter shall measure rms voltage rather than average or peak voltage. Its measurement uncertainty shall be 1 percent or less.

5.2.8 Signal Combiner

A signal combiner shall be used when two or more signal generators are connected to the receiver under test. Its amplitude imbalance shall be no greater than 0.2 dB, its standing wave ratio shall be no greater than 1.3 and the isolation between input terminals shall be a minimum of 30 dB. A variety of multiport devices may be used as signal combiners including power dividers, directional couplers, and hybrid junctions.

5.2.9 Test Receiver

The test receiver shall include a standard audio output load as specified by the manufacturer of the test receiver (paragraph 5.2.9.6) and shall have the characteristics specified in the following paragraphs.

5.2.9.1 Audio Response

The audio response characteristics shall not vary more than 1 dB from a 750 microsecond de-emphasis characteristic when the system deviation is held constant and the modulation frequency is varied between 0.05 and 3 kHz.

5.2.9.2 Harmonic Distortion

The audiofrequency harmonic distortion shall be less than 1 percent at standard test modulation. The harmonic distortion at 1 kHz (for larger than rated system deviation) shall be less than 3 percent. The harmonic distortion shall be measured when the test receiver is tuned to a nominal 1 millivolt rf source which is modulated by a sine wave at a level which produces a system deviation 50 percent greater than rated system deviation (i.e., ±7.5 kHz).

5.2.9.3 Audio Hum and Noise Level

The unsquelched audio hum and noise level shall be at least 55 dB below the audio output power when measured with a 1 millivolt input signal.

5.2.9.4 Adjacent Channel Interference

The test receiver shall differentiate by 85 dB or more between a desired modulated signal and a modulated adjacent channel signal 30 kHz on either side, when the adjacent channel interference degrades the desired signal from 12 dB SINAD to 6 dB SINAD.

5.2.9.5 Selectivity

The test receiver shall have a bandwidth of 24 to 30 kHz at the —80 dB points.

5.2.9.6 Standard Audio Output Load

The standard audio output load shall consist of a resistor whose resistance is equal to the load impedance into which the test receiver normally operates.

5.2.10 Deviation Meter

The deviation meter shall be capable of measuring the peak deviation of a modulating waveform with an uncertainty no greater than 5 percent of the deviation being monitored.

5.2.11 Environmental Chamber

The environmental chamber shall produce air temperatures from −30°C to 60°C (−22 to 140°F) and relative humidities in the range of 90 to 95 percent. The test item shall be shielded from air currents blowing directly from heating or cooling elements in the chamber. The temperature of the test item shall be measured with a thermometer separate from the sensor used to control the chamber air temperature. Likewise, humidity shall be measured with a hygrometer separate from the sensor used to control humidity.

5.2.12 Field Strength Meter

The field strength meter, consisting of an antenna and a well-shielded calibrated receiver which operate at the standard test frequencies, shall have a resolution of at least 0.2 dB. The receiver should be located near the receiving antenna to keep the length of the cable between them as short as possible.

5.3 Transceiver Environmental Tests

Conduct these tests on the complete transceiver including the antenna and battery. Where indicated, operate the transceiver on a standard duty cycle of 2 minutes in the transmit mode and 3 minutes in the standby mode.

5.3.1 Temperature Test

Place the transceiver, with power turned off, in the environmental chamber. Adjust the chamber to the required low temperature ±2°C (±3.6°F). Allow the transceiver to reach temperature equilibrium and maintain it at this temperature for 30 minutes. Connect the transceiver to the standard power supply and operate it at the transceiver standard duty cycle. Fifteen minutes after turn-on, test the transceiver to determine whether it meets the requirements of paragraph 4.3.1. Repeat the above procedure at the required high temperature ±2°C (±3.6°F).

5.3.2 Humidity Test

Place the transceiver, with power turned off, in the environmental chamber. Adjust the relative humidity to a minimum of 90 percent at 50°C (122°F) or more and maintain the transceiver at these conditions for at least 8 hours. With the transceiver still in this environment, turn on the transceiver power, operate it at the transceiver standard duty cycle for 15 minutes, and then test the transceiver to determine whether it meets the requirements of paragraph 4.3.2.

5.3.3 Vibration Test

Perform a two part test for a total of 30 minutes in each of three mutually perpendicular directions, one of which is the vertical.

First subject the transceiver to 3 five-minute cycles of simple harmonic motion having an amplitude of 0.38 mm (0.015 inch) [total excursion of 0.76 mm (0.03 inch)] applied initially at a frequency of 10 Hz and increased at a uniform rate to 30 Hz in 2½ minutes, then decreased at a uniform rate to 10 Hz in 2½ minutes.

Then subject the transceiver to 3 five-minute cycles of simple harmonic motion having an amplitude of 0.19 mm (0.0075 inch) [total excursion of 0.38 mm (0.015)] applied initially at a frequency of 30 Hz and increased at a uniform rate to 60 Hz in 2½ minutes, then decreased at a uniform rate to 30 Hz in 2½ minutes.

Repeat for each of the other two directions.

5.3.4 Shock Test

Drop the transceiver once on each of four or more sides (all sides not having a protrusion or antenna connection), from a height of 1 m (3.28 ft) onto a smooth concrete floor. Turn off the transceiver power during the test, and use guides to insure contact with the floor by the correct equipment surface.

5.4 Receiver Tests

5.4.1 SINAD Sensitivity Test

Interconnect the transceiver receiver and test equipment as shown in figure 2. Set the squelch control to the standard squelch adjustment. Adjust the FM signal generator to the standard test frequency with standard audiofrequency test modulation. Set the generator for 1 millivolt output and the receiver volume control for audio output power (item M, table 1). Do not readjust the volume control for the remainder of the measurement. Decrease the output level of the generator until the SINAD ratio of the receiver is 12 dB, as determined with the distortion analyzer. Measure the audio output power to make certain it is at least 50 percent of item M and record the generator output voltage for convenience in re-setting to a 12 dB SINAD ratio, as required by some of the following tests. Repeat the above using plus 10 percent and minus 20 percent changes in standard power supply voltage.

5.4.2 Selectivity Tests

5.4.2.1 Usable Bandwidth Test

Interconnect the transceiver receiver and test equipment as shown in figure 2. Adjust the receiver and FM signal generator in accordance with paragraph 5.4.1 until a 12 dB SINAD ratio is reached. With the generator still set for standard audiofrequency test modulation, increase the generator rf output by 6 dB. Adjust the frequency of the generator

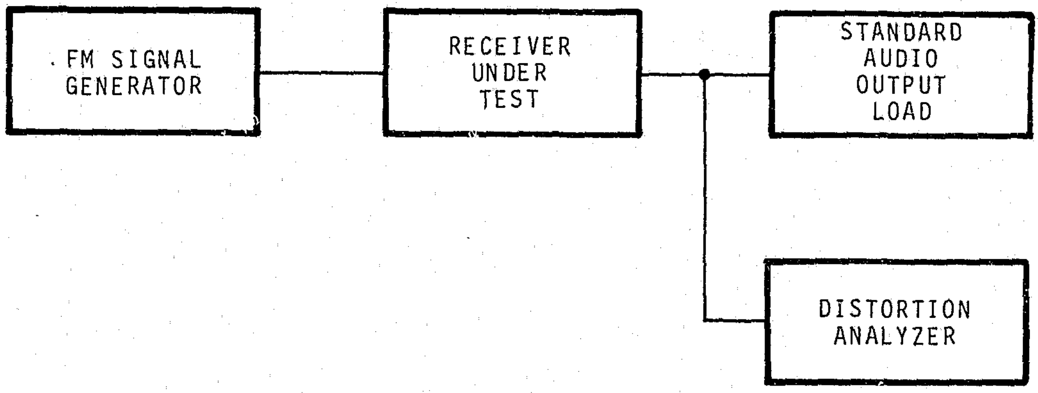

FIGURE 2. Block diagram for SINAD sensitivity, usable bandwidth, squelch sensitivity, squelch block and audio distortion measurements.

above the test frequency until the 12 dB SINAD signal ratio is again obtained. Record the generator frequency. Repeat this measurement by adjusting the generator frequency below the test frequency and record the generator frequency. The smaller displacement from the test frequency plus 3 kHz (standard test modulation) is the receiver bandwidth.

5.4.2.2 Adjacent Channel Selectivity and Desensitization Test

Interconnect the transceiver receiver and test equipment as shown in figure 3. With the output of generator #2 set to zero, adjust the receiver and signal generator #1 in accordance with paragraph 5.4.1 until a 12 dB SINAD ratio is reached. Adjust signal generator #2 for 3 kHz frequency deviation at 400 Hz, and set it to a frequency corresponding to the center of the next higher adjacent channel. Then adjust the output of signal generator #2 to produce a 6 dB SINAD ratio with both signals present. The ratio, expressed in decibels, of the output voltage of signal generator #2 to that of signal generator #1 is the adjacent channel selectivity for the upper channel. Repeat the above procedure for the next lower adjacent channel. The smaller of the two ratios is the required measurement.

5.4.2.3. Spurious Response Attenuation Test

Interconnect the transceiver receiver and test equipment as shown in figure 4. Adjust the unmodulated (CW) signal generator to the standard test frequency. With the generator adjusted for zero output, adjust the receiver volume control to produce 25 percent of item M. This output power is entirely noise power. Do not readjust the volume control for the remainder of the measurement. Increase the output of the generator until the audio noise

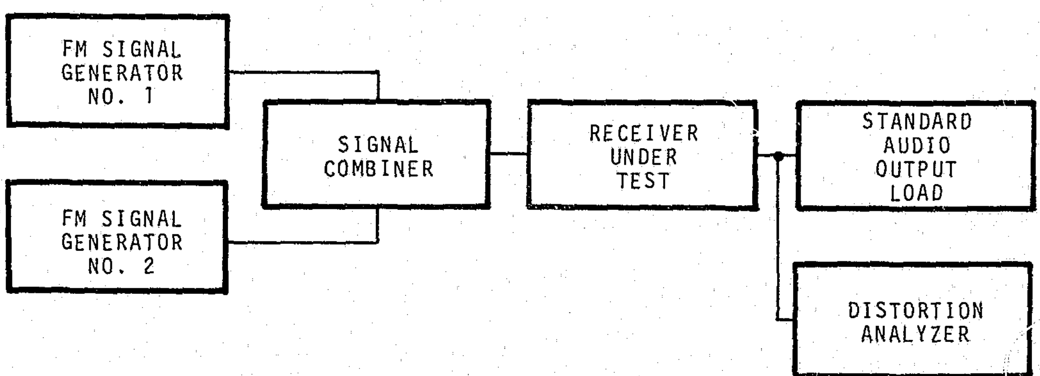

FIGURE 3. Block diagram for adjacent channel selectivity and desensitization measurement.

output power of the receiver is decreased by 20 dB, i.e., 20 dB of noise quieting. Note the generator output in decibels above one microvolt (dBμV) at this frequency. Then increase the output of the generator to approximately 0.1 volt, and slowly vary the generator frequency continuously from just below the lowest intermediate frequency of the receiver to 1,000 MHz. Note each frequency that produces a receiver response as indicated by noise quieting in the receiver's audio output. Ignore harmonic frequencies of the generator that fall within the channel to which the receiver is tuned. For each response, adjust the generator output to produce 20 dB of noise quieting. Record the generator output in dBμV. The generator output at the spurious response frequency minus the generator output at the standard test frequency is the spurious response attenuation. Repeat for all spurious responses. The smallest attenuation is the value sought.

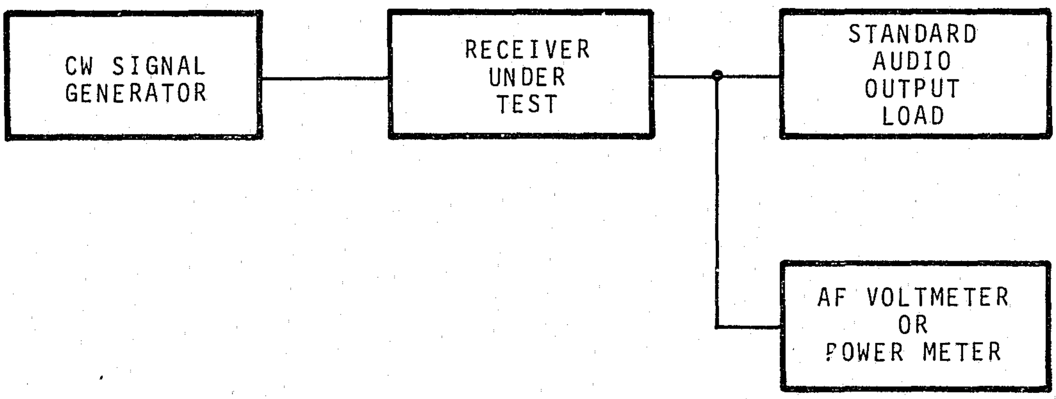

FIGURE 4. Block diagram for spurious response attenuation measurement.

5.4.2.4. Intermodulation Attenuation Test

Interconnect the transceiver receiver and test equipment as shown in figure 5. With the output levels of signal generators #2 and #3 set to zero, adjust the receiver and FM signal generator #1 in accordance with paragraph 5.4.1 until a 12 dB SINAD ratio is reached. Adjust the unmodulated generator #2 to the center frequency of the next higher adjacent channel. Adjust generator #3 for 3 kHz frequency deviation at 400 Hz, and set it to the

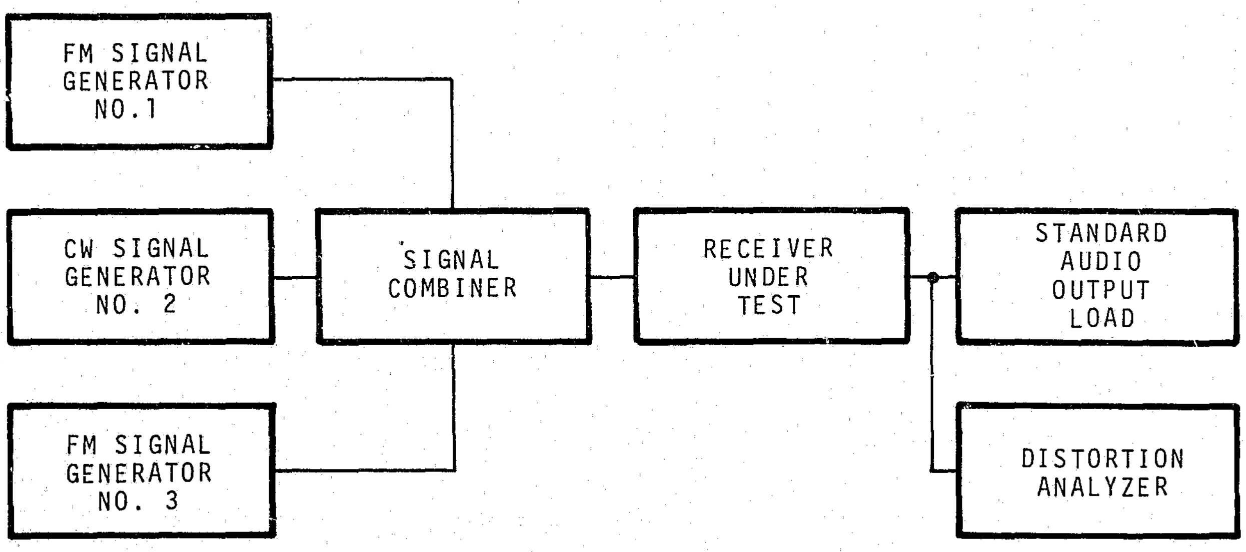

FIGURE 5. Block diagram for intermodulation attenuation measurement.

center frequency of the second higher adjacent channel, i.e., two channels above the standard test frequency. Then adjust the output levels of generators #2 and #3 to produce a 6 dB SINAD ratio with all three signals present. Maintain generators #2 and #3 at equal output voltages throughout the measurement. Adjust slightly the frequency of generator #3 to obtain the 6 dB SINAD ratio with the minimum signal levels from generators #2 and #3. The ratio, expressed in decibels, of the output voltage of generator #2 (or #3) to that of generator #1 is the intermodulation attenuation for the upper channels. Repeat the above procedure for the lower two adjacent channels, with generator #3 set to the lowest channel. The smaller of the two ratios is the value sought.

5.4.3 Squelch Tests

5.4.3.1 Squelch Sensitivity Tests

Interconnect the transceiver receiver and test equipment as shown in figure 2. Adjust the receiver and FM signal generator in accordance with paragraph 5.4.1 until a 12 dB SINAD ratio is reached. Set the output level of the generator to zero, and measure the audio noise output power. Slowly adjust the squelch control until the audio noise output power drops abruptly (40 dB or more). Do not adjust the squelch control and further. This is the threshold squelch position. Increase the output level of the signal generator until the measured audio output power is within 10 dB of the audio output power (item M). The signal generator output voltage is the value for threshold squelch sensitivity. Repeat using plus 10 percent and minus 20 percent standard power supply voltages.

Repeat the above procedure with the squelch control in the maximum squelch position. The resultant signal generator output voltage is the value for tight squelch sensitivity.

5.4.3.2 Squelch Block Test

Interconnect the transceiver receiver and test equipment as shown in figure 2. Adjust the receiver and FM signal generator in accordance with paragraph 5.4.1 until a 12 dB SINAD ratio is reached. Set the output level of the signal generator to zero, and measure the audio noise output power. Then set the squelch control to the maximum squelch position. Adjust the output level of the generator to 12 dB above the measured value of the receiver's tight squelch sensitivity voltage. Then increase the frequency deviation of the generator until the audio output power drops abruptly (40 dB or more). Repeat the above procedure with modulation frequencies of 0.3, 0.5, 2.5, and 3 kHz. The frequency deviations of the signal generator modulation are the values for squelch block.

5.4.3.3 Squelch Attack Time Test

Interconnect the transceiver receiver and test equipment as shown in figure 6a. With the SPST switch closed, adjust the receiver and FM signal generator in accordance with paragraph 5.4.1 until a 12 dB SINAD ratio is reached. Set the output level of the signal generator to zero, and measure the audio noise output power. Slowly adjust the squelch control until the audio output power drops abruptly (40 dB or more). Do not adjust the squelch control any further. Adjust the generator output level to 12 dB above the measured value of the receiver's threshold squelch sensitivity voltage. Adjust the volume control for audio output power (item M). Adjust the oscilloscope vertical controls for full scale deflection. Adjust the oscilloscope trigger controls to start the trace upon switch closure. Then close the SPST switch, and adjust the oscilloscope horizontal sweep controls so that the change in audio output level can be easily determined as a function of time. Open and close the SPST switch and photograph the trace. The time between the start of the oscilloscope trace and the time at which the audio level reached 90 percent of audio output power (item M) is the value for squelch attack time.

Note that relay pull-in and drop-out times are usually more than one-tenth the squelch attack and release times. It will generally be necessary, therefore, to measure the time differential between the two sets of contacts shown in figure 6a, and to correct the measured squelch attach and release times accordingly. Connect the equipment as shown in figure 6b and adjust the oscilloscope as in the previous paragraph. Close the SPST switch and photograph the trace. Subtract the relay pull-in time determined in accordance with the photograph from the time determined in accordance with the previous paragraph to obtain the squelch attack time.

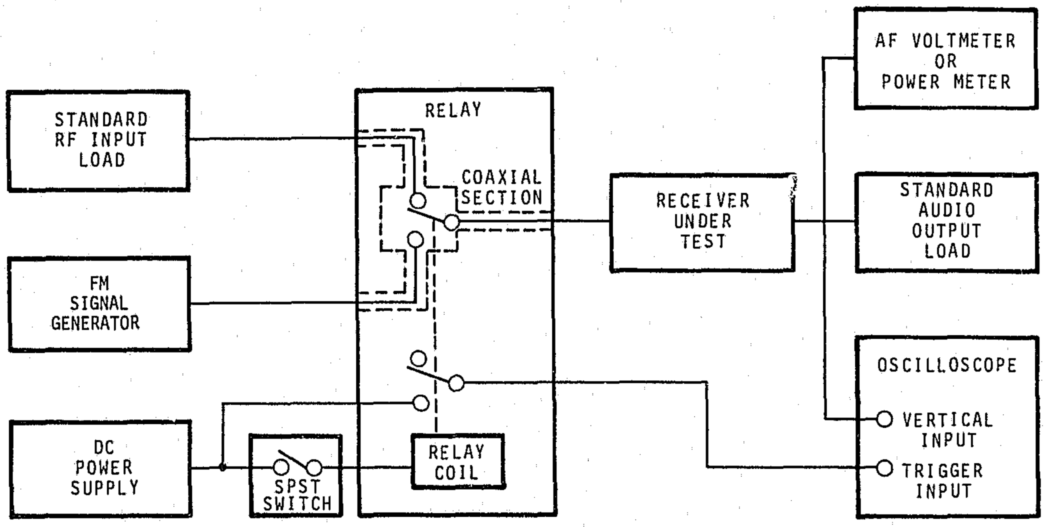

FIGURE 6a. Block diagram for squelch attack time and squelch release time measurements.

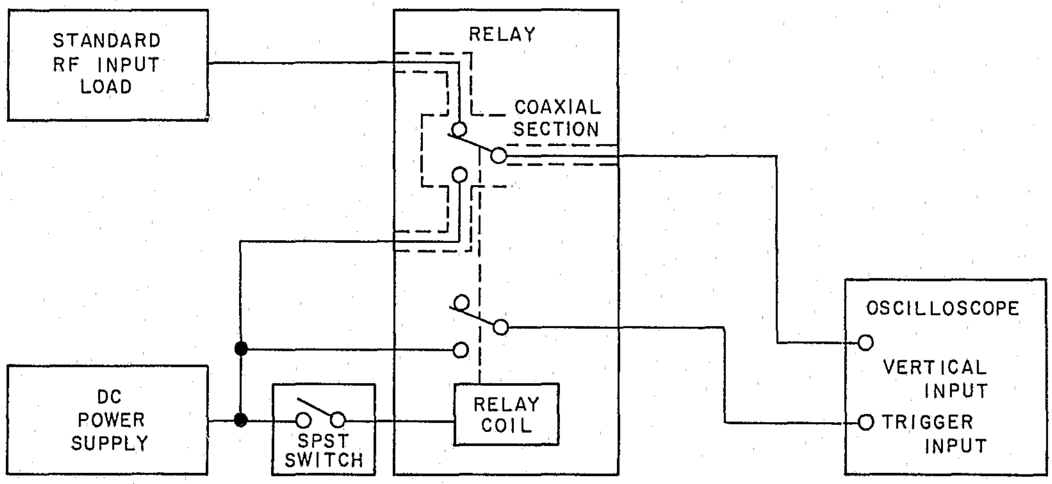

FIGURE 6b. Block diagram for relay pull-in and drop-out time measurements.

5.4.3.4 Squelch Release Time Test

Interconnect the transceiver receiver and test equipment as shown in figure 6a. Adjust all equipment in accordance with paragraph 5.4.3.3. Then adjust the oscilloscope trigger controls to start the trace when the SPST switch is opened. Open the switch and photograph the display. The time between the start of the oscilloscope trace and the time at which the audio level falls to 10 percent of the audio output power (item M) is the value of squelch release time.

Correct the reading, as in the second paragraph of 5.4.3.3, by subtracting the relay drop-out time observed in the photograph from the time determined in accordance with the previous paragraph to obtain the squelch release time.

5.4.4 Audio frequency Tests

5.4.4.1 Audio Output Power Test

Interconnect the transceiver receiver and test equipment as shown in figure 7. Modulate the FM signal generator with standard audiofrequency test modulation and set it to the standard test frequency. With the signal generator adjusted for 1 millivolt output, set the receiver volume control to the maximum position, and measure the audio output power. Repeat using plus 10 percent and minus 20 percent standard power supply voltages.

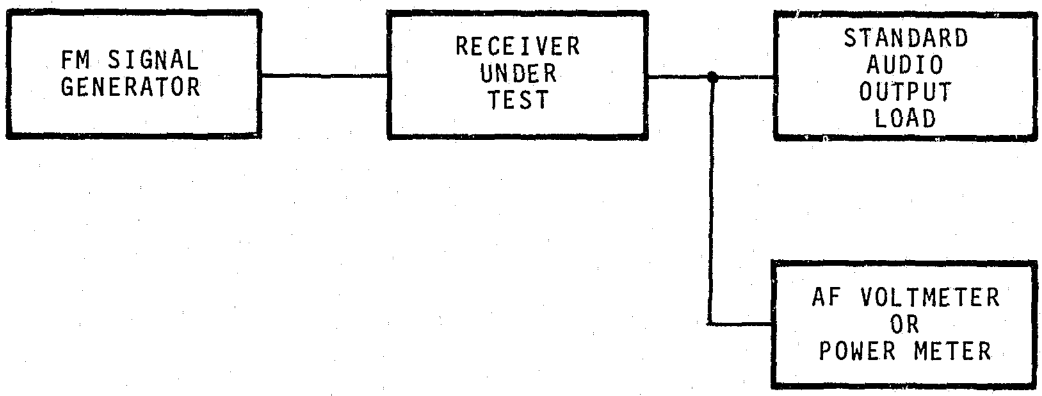

FIGURE 7. Block diagram for audio output power, audiofrequency response, and audio hum and noise measurements.

5.4.4.2 Audio Distortion Test

Interconnect the transceiver receiver and test equipment as shown in figure 2. Modulate the FM signal generator with standard audiofrequency test modulation and set it to the standard test frequency. With the signal generator adjusted for 1 millivolt output, adjust the receiver volume control for an audio output power of (item M) and measure the audio distortion. Repeat at an audio output power of (item N).

5.4.4.3 Audiofrequency Response Test

Interconnect the transceiver receiver and test equipment as shown in figure 7. Modulate the FM signal generator with standard audiofrequency test modulation and set it to the standard test frequency. With the signal generator adjusted for 1 millivolt output, adjust the receiver volume control to 50 percent of audio output power (item M). Do not readjust the volume control for the remainder of the measurement. Reduce the generator frequency deviation to 1 kHz, and measure the audio output power. Repeat for modulating frequencies of 0.3, 0.5, 2 and 3 kHz. Compute the ratio, expressed in decibels, of each of these latter power levels to the output power at 1 kHz.

5.4.4.4 Audio Hum and Noise Tests

Interconnect the transceiver receiver and test equipment as shown in figure 7. Modulate the FM signal generator with standard audiofrequency test modulation and set it to the standard test frequency. With the signal generator adjusted for 1 millivolt output, adjust the receiver volume control for audio output power (item M). Do not readjust the volume control for the remainder of the measurement. Remove the modulation from the signal generator and measure the audio hum and noise output power. Compute the ratio, expressed in decibels, of the audio output power (item M) to the hum and noise output power. This is the value for audio hum and noise (unsquelched).

Set the squelch control to its maximum squelch position. Set the output level of the generator to zero and measure the audio hum and noise output power. Calculate the ratio in decibels of the audio output power (item M) to the hum and noise output power. This is the value for audio hum and noise (squelched).

5.5 Transmitter Tests

5.5.1 Radio Frequency Carrier Tests

5.5.1.1 Output Power Test

Operate the transceiver transmitter without modulation. Measure the output power as shown in figure 8, using standard supply voltage and a power meter accurate to 5 percent. Change the standard supply voltage plus 10 percent, allow it to stabilize at least 5 seconds, and determine the output power. Repeat this for changes in standard supply voltage of minus 10 percent and minus 20 percent.

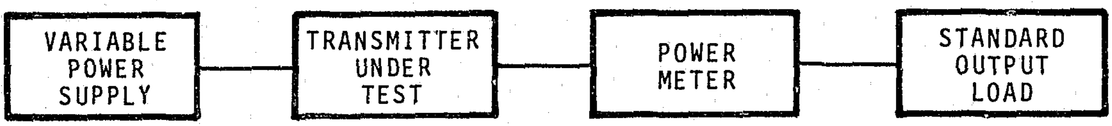

FIGURE 8. Block diagram for output power measurement.

5.5.1.2 Frequency Stability Test

Operate the transceiver transmitter without modulation. Measure the frequency as shown in figure 9, using standard supply voltage. Change the standard supply voltage plus 15 percent, allow it to stabilize for 5 seconds, and determine the change in frequency. Repeat this for a change in standard supply voltage of minus 15 percent.

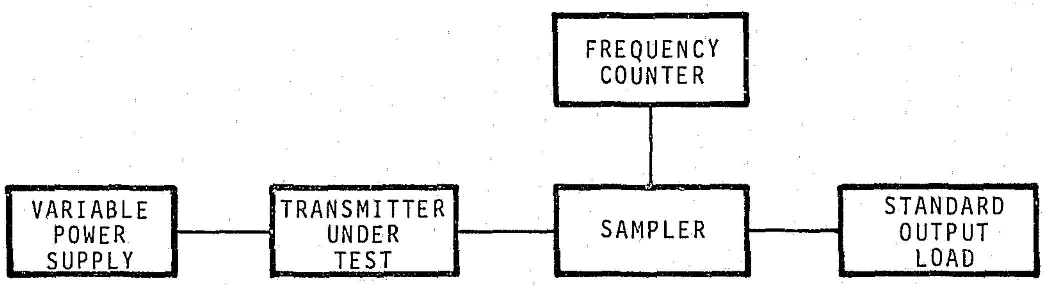

FIGURE 9. Block diagram for frequency stability measurement.

5.5.1.3 AM Hum and Noise Level Test

Interconnect the transceiver transmitter and test equipment as shown in figure 10. Use a linear peak-carrier responsive AM detector to detect the sampled output of the transmitter. With the transmitter operating at rated power with no modulation, measure the dc voltage across the detector load resistor with the high impedance dc voltmeter. Without adjusting the transmitter, measure the peak ac voltage with the oscilloscope. Calculate the AM hum and noise level as 20 $\log_{10} (V_p/V_{dc})$, where V_p is the peak ac voltage and V_{dc} is the dc voltage.

5.5.1.4 Carrier Attack Time Test

Although carrier attack time is defined in terms of rated carrier output power, the test method described herein uses a voltage measurement technique to determine the value of this characteristic. Make the measurement using a calibrated oscilloscope and peak detector connected as shown in figure 11. The peak detector should have a short time constant (less than 10 milliseconds) and provide a linear response with amplitude. Close the trigger circuit of the oscilloscope through the transmitter control switch to start the time interval. The peak director, sampling the rf carrier, provides a voltage to the oscilloscope vertical input. Measure the time required for the trace to reach 71 percent of the peak detector maximum output.

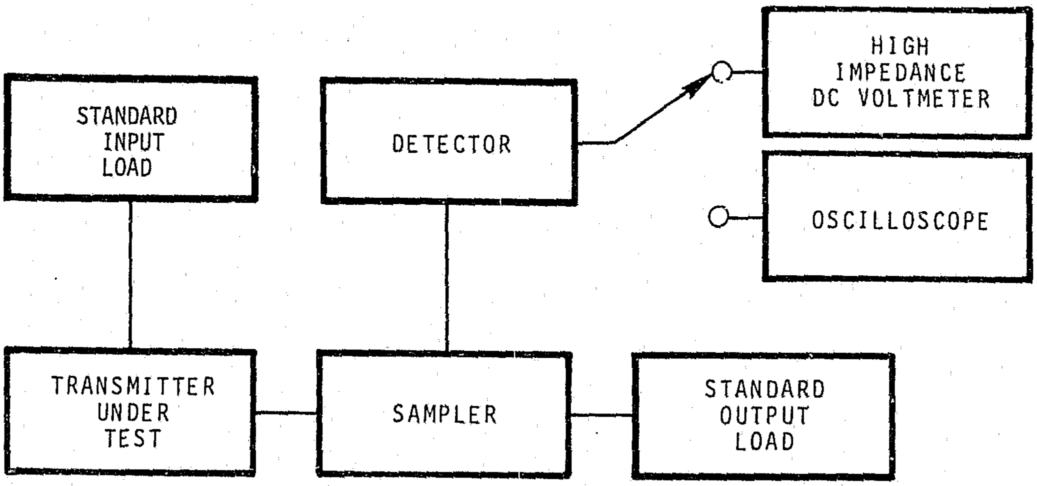

FIGURE 10. Block diagram for AM hum and noise measurement.

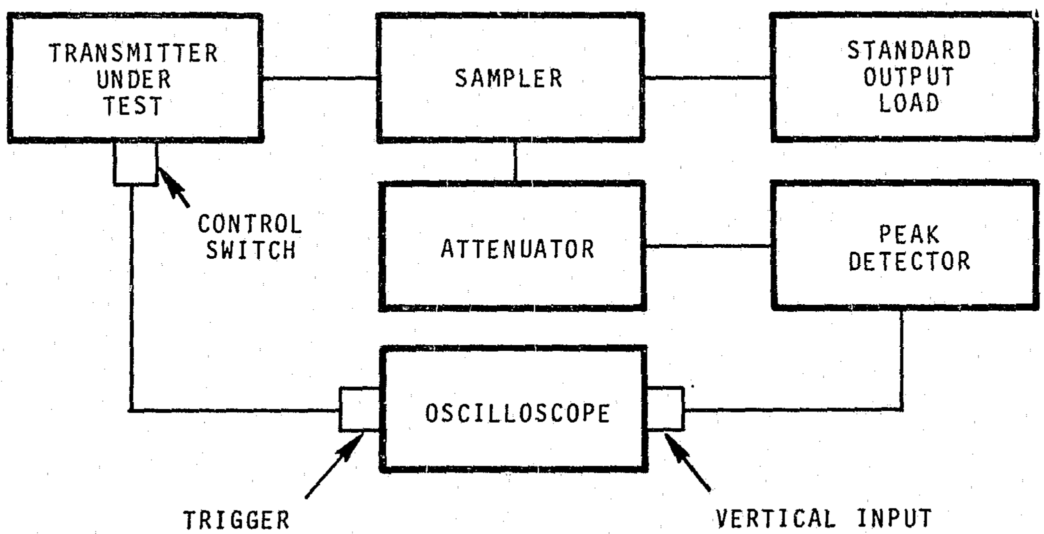

FIGURE 11. Block diagram for carrier attack time measurement.

5.5.2 Audiofrequency Modulation Tests

5.5.2.1 Harmonic Distortion Test

Interconnect the transceiver transmitter and test equipment as shown in figure 12. Operate the transmitter at nominal carrier output power and adjust the audio oscillator for audiofrequency test modulation, except that the 1 kHz modulating signal shall have a total distortion of 0.5 percent or less. Process the sampled transmitter output with the test receiver (paragraph 5.2.9). Use the distortion analyzer, across the standard audio output load, to remove the 1 kHz tone and measure the signal, which is a combination of all the noise and harmonic components.

5.5.2.2 FM Hum Noise Level Test

Interconnect the transceiver transmitter and test equipment as shown in figure 12. Operate the transmitter at nominal carrier output power and adjust the audio oscillator for audiofrequency test modulation. Measure the audio output voltage, V_1, of the test receiver (paragraph 5.2.9) using the distortion analyzer as a voltmeter. Remove the modulation by disconnecting the audio oscillator and connecting the standard audio input load and measure the resulting audio voltage, V_2, at the distortion analyzer. Calculate the FM hum and noise level as $20 \log_{10} (V_1/V_2)$. The method provides reliable measurements up to 50 dB.

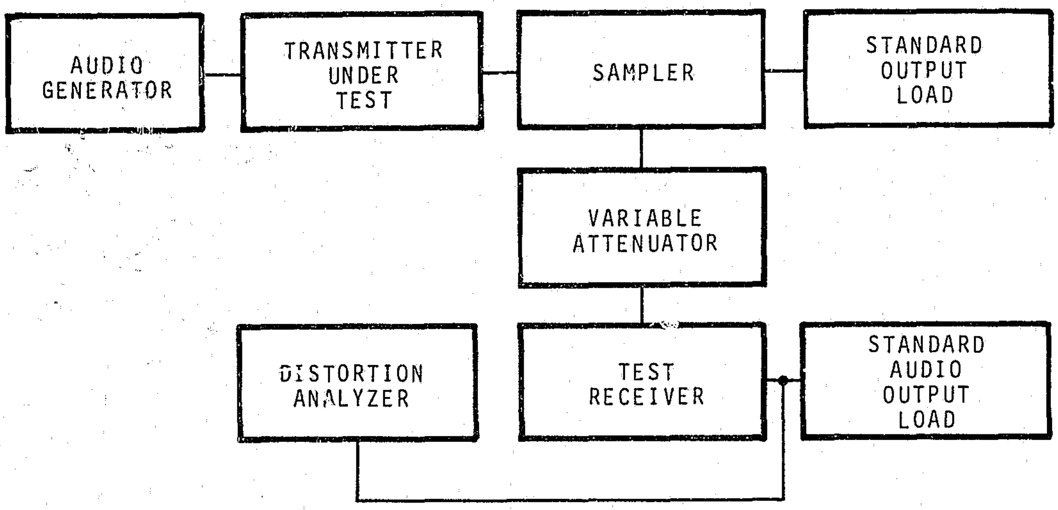

FIGURE 12. Block diagram for harmonic distortion and FM hum and noise measurements.

5.5.2.3 Audiofrequency Response Test

Interconnect the transceiver transmitter and test equipment as shown in figure 13. The matching network is a broadband network which matches the audio generator output impedance to the transmitter audio input impedance.

Apply selected audio frequences from 0.3 to 3 kHz to the transmitter, and maintain the audio input level at a constant 30 percent of rated system deviation (i.e., 1.5 kHz) as observed with the deviation meter. Determine the audio voltmeter reading in decibels relative to the voltmeter reading at 1 kHz, for each test frequency, and draw a graph similar to that shown in figure 1.

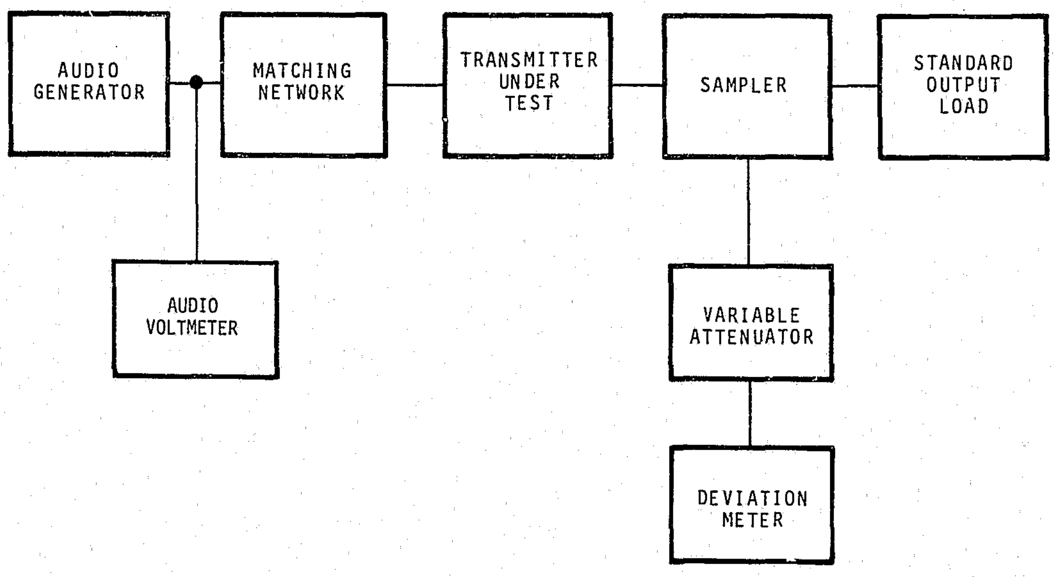

FIGURE 13. Block diagram for audiofrequency response measurement.

5.5.2.4 Frequency Deviation Test

Interconnect the transceiver transmitter and test equipment as shown in figure 14 and adjust the transmitter controls for normal operation. Adjust the audio input for audiofrequency test modulation, and increase the audio input level until maximum frequency deviation is observed. Measure the frequency deviation with the deviation meter.

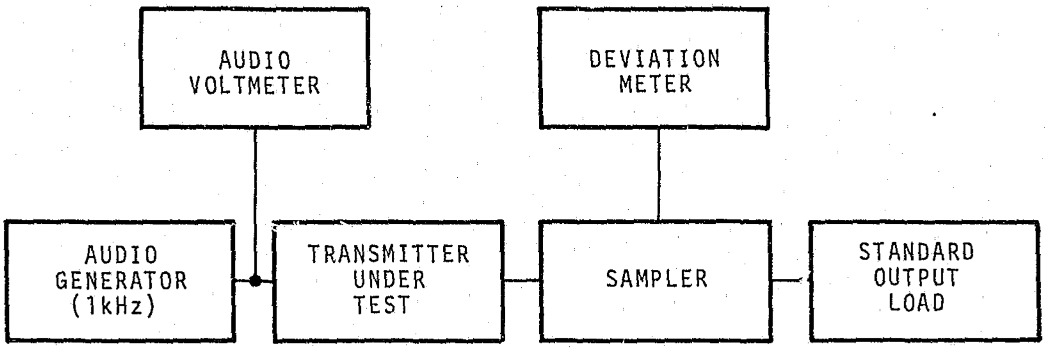

FIGURE 14. Block diagram for frequency deviation and modulation limiting measurements.

5.5.2.5 Modulation Limiting Test

Interconnect the transceiver transmitter and test equipment as shown in figure 14 and adjust the transmitter controls for normal operation. Adjust the audio input for audiofrequency test modulation. Increase the audio input level 20 dB. Hold the audio input level constant, vary the frequency from 0.3 to 3 kHz and measure the frequency deviation with the deviation meter.

5.5.3 Electromagnetic Compatibility Tests

5.5.3.1 Radiated Spurious Emissions Test

Perform the test at a site that meets the requirements of paragraph 5.1.9. Set up the test as shown in figure 15. Have a person stand facing the receiving dipole antenna holding the transceiver with the antenna attached 15 cm (6 in) from his body, with the base of the antenna 1.7 m (68 in) above the earth. Place the vertical receiving dipole antenna 30 m (98.4 ft) from the transceiver and 3.0 m (9.8 ft) above the earth. Turn on the transmitter and measure the field strength of the unmodulated carrier frequency in decibels above one

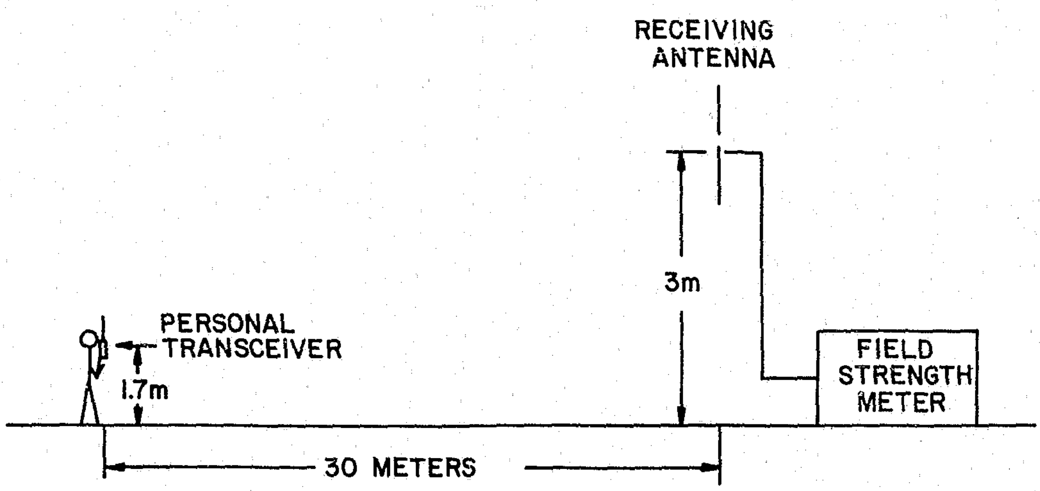

FIGURE 15. Block diagram for radiated spurious emission and radiation efficiency measurements.

microvolt per meter (dBμV/m) using the technique described in the following paragraph. Then measure the field strength in dBμV/m of any radiated spurious emissions, from the lowest radio frequency generated in the transmitter to the tenth harmonic of the carrier. Adjust the receiving antenna to a half-wavelength for each frequency measured.

For the carrier and each spurious frequency, position the horizontally-polarized receiving antenna a quarter wavelength in any direction to obtain a maximum reading on the field strength meter. Rotate the transmitter to further increase this maximum reading. Repeat this procedure of raising and lowering the receiving antenna and rotating the transmitter until the largest signal has been obtained and recorded. Then place the receiving antenna in a vertical position and repeat the procedure for each spurious signal.

The attenuation of each radiated spurious emission is the field strength in dBμV/m of the carrier frequency minus the maximum field strength in dBμV/m of the radiated spurious emission.

5.5.3.2 Sideband Spectrum Test

Interconnect the transceiver transmitter and test equipment as shown in figure 16. Using the variable attenuator, adjust the unmodulated carrier signal for a full-scale signal of at least 60 dB above the noise as displayed on the spectrum analyzer. Apply electromagnetic compatibility test modulation and measure the average envelope of the resulting spectrum at both plus and minus 10 kHz and plus and minus 20 kHz from the center frequency. Adjust the spectrum analyzer controls so that approximately 50 kHz of transmitter spectrum is centered on the display. The image on the cathode ray tube of the spectrum analyzer should be similar to that shown in figure 17.

Record the sideband spectrum attenuations as the differences between the center frequency amplitude and the amplitudes of the sidebands located at ± 10 kHz and ± 20 kHz from the center frequency.

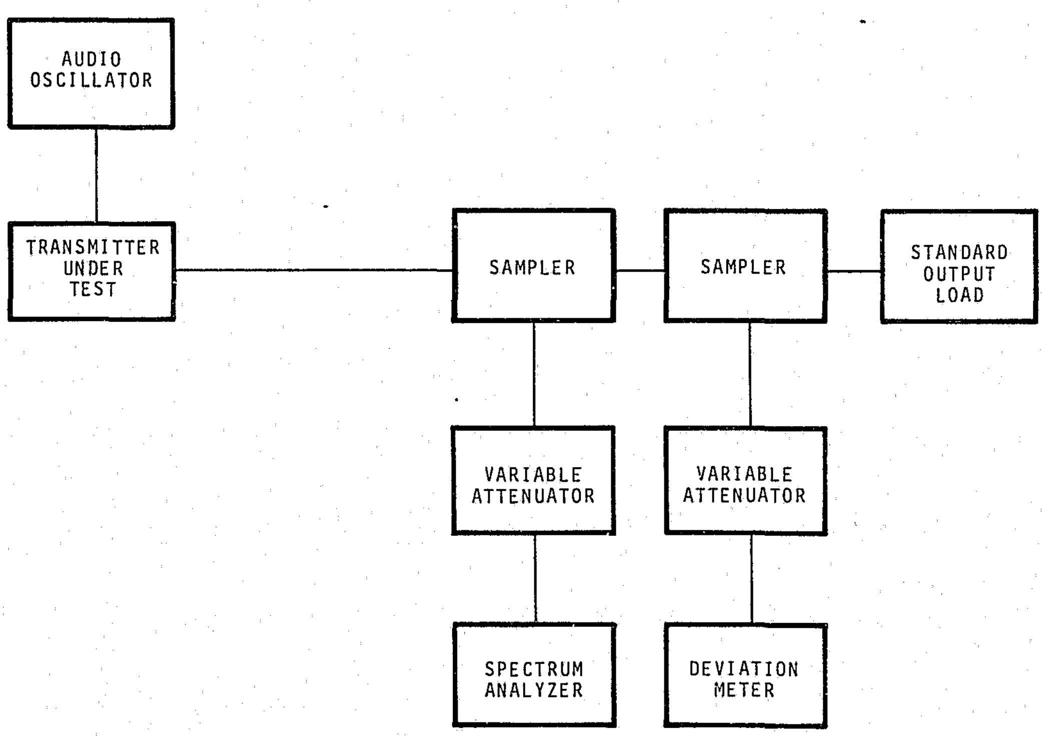

FIGURE 16. Block diagram for sideband spectrum measurement.

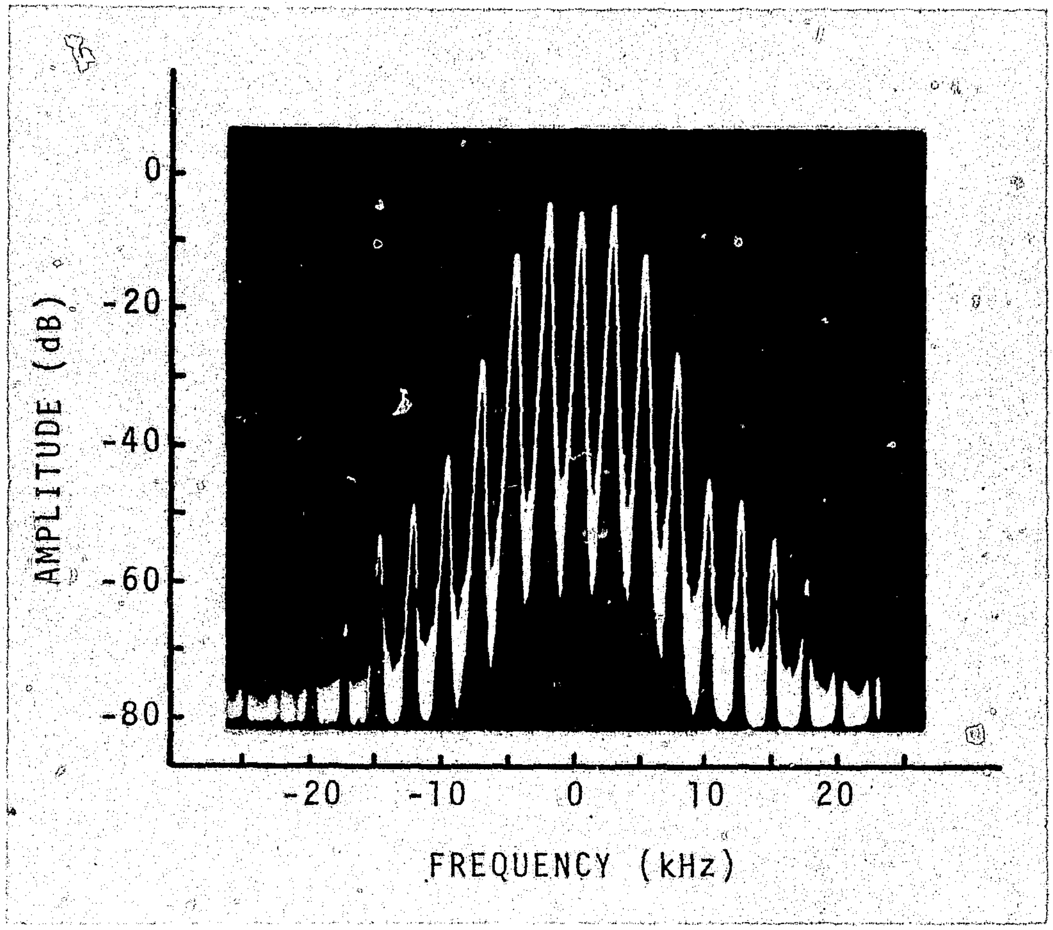

FIGURE 17. Typical sideband spectrum of a transmitter using a 2.5 kHz tone 16 dB greater than that required to produce ±2.5 kHz deviation at 1.0 kHz.

5.6 Antenna Tests

5.6.1 Radiation Efficiency Test

Perform the test at a site that meets the requirements of paragraph 5.1.9. Set up the test as illustrated in figure 15. Have a person stand facing the receiving dipole antenna holding the transceiver, with the antenna attached, 15 cm (6 in) from his body, with the base of the antenna 1.7 m (68 in) above the earth. Place the vertical receiving dipole antenna 30 m (98.4 ft) from the transceiver and 3.0 m (9.8 ft) above the earth. Turn on the transmitter. Move the receiving antenna a quarter wavelength in any direction to obtain a maximum reading on the field strength meter. Rotate the transceiver to further increase this maximum reading. Repeat this procedure of raising and lowering the antenna and rotating the transceiver until the largest signal has been obtained and recorded. Measure the field strength of the unmodulated carrier frequency in volts per meter. Calculate the radiation efficiency using the equation $30\ E^2/P$, where E is the measured field strength in volts per meter and P is the measured transmitter output power in watts (paragraph 5.5.1.1) when terminated in a 50 ohm load.

5.6.2 Power Test

Perform this test in a shielded room or at a site that meets the requirements of paragraphs 5.1.9. Disconnect the antenna from the transceiver and mount it on a circular ground plane 30 cm (12 in) in diameter. Connect the power source and test equipment as shown in figure 18, with the receiving antenna at a convenient height. Apply nominal power to the test antenna, using a matching network if necessary. Record the field strength meter voltage in decibels above one microvolt. Continue to apply nominal power; after 30 minutes, again record the field strength meter voltage. Subtract the two readings.

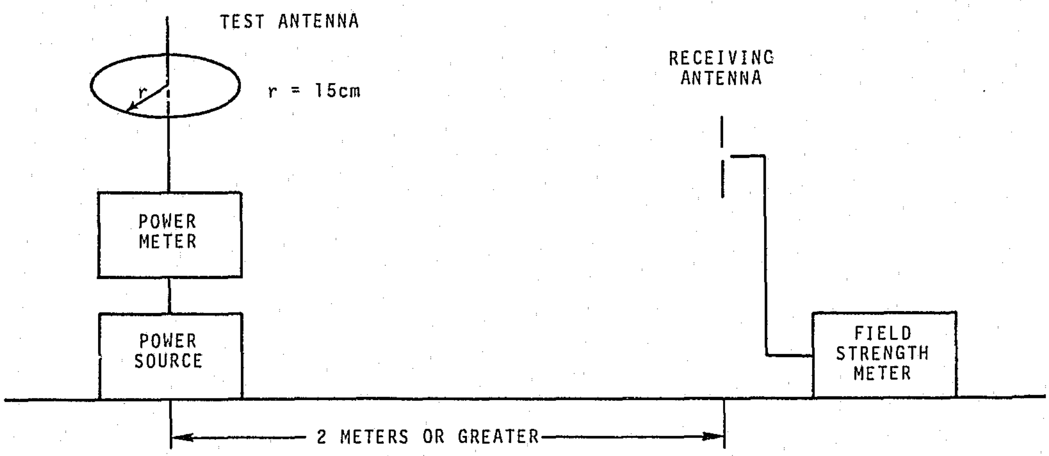

FIGURE 18. Block diagram for antenna power rating measurements.

5.7 Battery Service Life Test

Interconnect the transceiver and test equipment as shown in figure 19. Adjust the transceiver for 500 mW audio output power (item M). Use the signal generator to provide a 1 millivolt signal to the transceiver receiver. Start the test, and use an interval timer to operate the transceiver in accordance with the battery test standard duty cycle (5.1.8). Measure he time required for the transmitter output power to decrease by 3 dB.

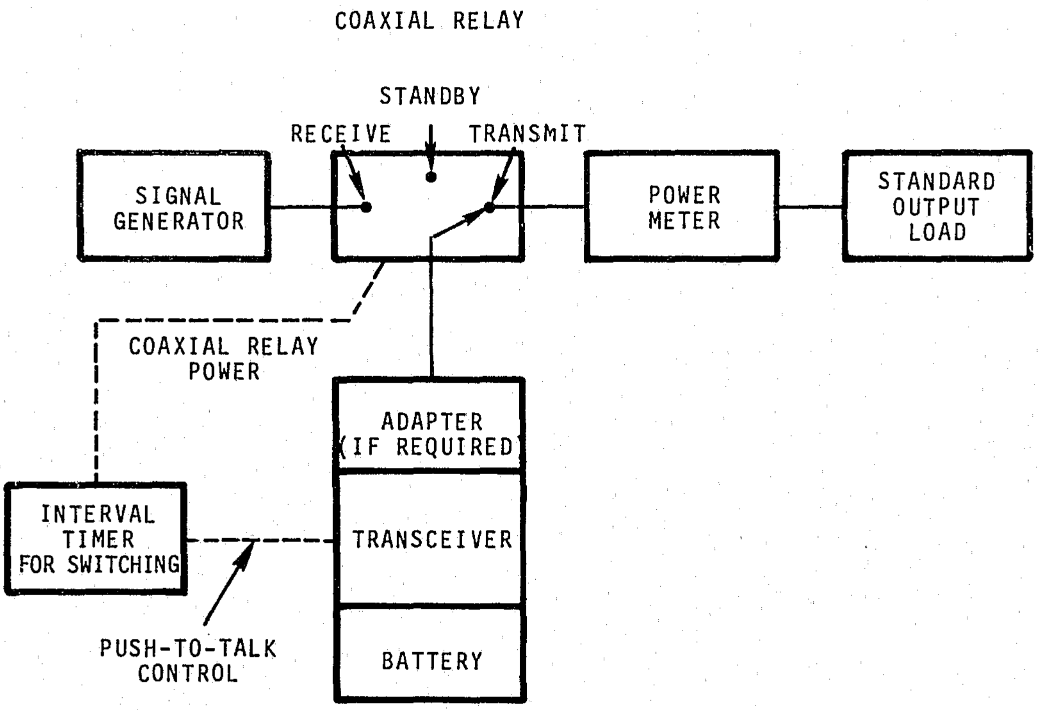

FIGURE 19. Block diagram for battery service life measurements.

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