NILECJ-STD-0202.00
OCTOBER 1974

LAW ENFORCEMENT STANDARDS PROGRAM

MOBILE FM TRANSMITTERS

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

Library of Congress Cataloging in Publication Data

National Institute of Law Enforcement and Criminal Justice.
NILECJ standard for mobile FM transmitters.

At head of title: Law Enforcement Standards Program.
"NILECJ-STD-0202.00."
Bibliography: p.
1. Radio frequency modulation—Transmitters and transmission—Standards—United States. I. Title.
II. Title: Law Enforcement Standards Program.
TK6562.F2N37 1975 621.3841'52'0973 74-28372

LAW ENFORCEMENT STANDARDS PROGRAM

NILECJ STANDARD FOR

MOBILE FM TRANSMITTERS

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

OCTOBER 1974

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

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 70 cents
Stock Number 2700-00287

LAW ENFORCEMENT ASSISTANCE ADMINISTRATION

Richard W. Velde, *Administrator*
Charles R. Work, *Deputy Administrator*

NATIONAL INSTITUTE OF LAW ENFORCEMENT AND CRIMINAL JUSTICE

Gerald M. Caplan, *Director*

ACKNOWLEDGMENTS

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. Acknowledgment is given to previous work in this field by the Associated Public-Safety Communications Officers, Inc.; the Institute of Electrical and Electronics Engineers, Inc.; the Electronic Industries Association; the American National Standards Institute; and the International Electrotechnical Commission.

NILECJ STANDARD FOR MOBILE FM TRANSMITTERS

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-0202.00, Mobile FM Transmitters, is a law enforcement equipment standard developed by LESL and approved and issued by NILECJ. Additional standards as well as other documents will be 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. Purchasing agents 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 mobile FM transmitters. 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.

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

The guideline documents to be 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 will 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, *Manager,*
Standards Program
National Institute of Law
Enforcement and Criminal Justice

NILECJ STANDARD FOR MOBILE FM TRANSMITTERS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for frequency modulated mobile and vehicular transmitters used by law enforcement agencies. This standard applies to transmitters which either do not have special subsystems such as selective signaling or voice privacy, or in which such subsystems are by-passed or disabled during testing for compliance with this standard.

2. CLASSIFICATION

For the purposes of this standard, mobile FM transmitters are classified by their operating frequencies.

2.1 Type I

Transmitters which operate in the 400–512 MHz band.

2.2 Type II

Transmitters which operate in the 150–174 MHz band.

2.3 Type III

Transmitters which operate in the 25–50 MHz band.

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 (Radio Antennas, Transmitters, and Receivers).

3.1 AM Hum and Noise

A measure of the amplitude modulation present on an unmodulated carrier.

3.2 Audiofrequency Response

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

3.3 Authorized Bandwidth

The maximum width of the band of frequencies specified by the Federal Communications Commission which may be occupied by an emission.

3.4 Carrier Attack Time

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

3.5 Carrier Power Output

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

3.6 Conducted Spurious Emission

Any spurious emission conducted over a tangible transmission path. Power lines, control cables, and radio frequency transmission lines are all considered as tangible paths.

3.7 FM Hum and Noise

A measure of the frequency modulation present on an unmodulated carrier.

3.8 Frequency Deviation

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

3.9 Frequency Stability

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

3.10 Harmonic Distortion

Nonlinear distortion of a system or transducer characterized by the appearance in the output of harmonics, in addition to the fundamental component, when the input wave is sinusoidal.

3.11 Modulation Limiting

That action, performed within the modulator, which intentionally restricts the signal to the required spectral and power limitations.

3.12 Occupied Bandwidth (By an Emission)

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

3.13 Radiated Spurious Emission

Any spurious emission other than a conducted spurious emission.

3.14 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.

3.15 Sideband Spectrum

The emissions generated by a modulated transmitter which are within 250 percent of the authorized bandwidth.

3.16 SINAD Ratio

A measure of the audio output of a receiver, expressed in decibels, equal to the ratio of (1) signal plus noise plus distortion to (2) noise plus distortion; from *SI*gnal *N*oise *A*nd *D*istortion *Ratio.*

3.17 Spurious Emission

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

3.18 Standby Mode

The condition in a transmitting and/or receiving system when the system is energized, but not receiving or transmitting.

4. REQUIREMENTS

4.1 Minimum Performance Requirements

The requirement for each transmitter characteristic shall be the value listed in

appendix A. These performance requirements are in agreement with those given in the Rules and Regulations published by the Federal Communications Commission (FCC). In addition to the requirements listed, all of the licensing and operating requirements of the FCC Rules and Regulations shall apply.

4.2 User Information

A nominal value for carrier output power, carrier frequency and each transmitter characteristic listed in appendix A shall be included in the information supplied to the user by the manufacturer or distributor. The manufacturer shall specify the power supply voltage, indicate 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.

4.3 Test Sequence

Each transmitter shall be subjected to the environmental tests before being tested for conformance with paragraphs 4.5, 4.6 and 4.7.

4.4 Environmental Characteristics

The ability of the transmitter to operate in environmental extremes shall be determined using the test methods described in paragraph 5.3.

4.4.1 Temperature Range

When the transmitter is operated at temperatures of −30°C (−22°F) and 60°C (140°F), its performance shall not vary, with respect to the nominal value, more than (Item O, appendix A) for power output, (Item Q) for carrier frequency tolerance and (Item R) for audiofrequency harmonic distortion. In addition, the FM hum and noise level shall be attenuated a minimum of (Item P).

4.4.2 Humidity Range

After the transmitter has been maintained at 50°C (122°F) and 90 percent relative humidity for eight hours or more, its performance shall not vary, with respect to the nominal value, more than (Item S) for power output, and (Item U) for carrier frequency tolerance. In addition, the FM hum and noise level shall be attenuated a minimum of (Item T).

4.4.3 Vibration Stability

No fixed part of the transmitter shall come loose, nor movable part be shifted in position or adjustment, as a result of this test. During vibration the transmitter shall meet the carrier frequency tolerance requirement (Item D) and the FM hum and noise level shall be attenuated 25 dB or more.

4.4.4 Shock Stability

No fixed part of the transmitter shall come loose, nor movable part be shifted in position or adjustment, as a result of this test.

4.5 Radio Frequency Carrier Characteristics

The radio frequency carrier characteristics of power output, frequency stability, AM hum and noise level and carrier attack time shall be measured in accordance with paragraph 5.4.

4.5.1 Power Output

Transmitter input power is specified by the FCC [2]. The carrier power output delivered to a standard output load shall be within (Item A) of the specified value at all times during the standard duty cycle except for the initial two seconds after applying power when the equipment is operating in a standby mode. When the standard supply voltage is varied plus and minus 10 percent, the power output shall not vary more than

(Item B). When the standard supply voltage is reduced by 20 percent, the power output shall not vary more than (Item C).

4.5.2 Frequency Stability

The carrier frequency shall be within (Item D) of the assigned value at all times during the standard duty cycle except for the initial two seconds after applying power when the equipment has been operating in a standby mode. When the standard supply voltage is varied plus and minus 15 percent, the frequency stability shall be (Item E).

4.5.3 AM Hum and Noise Level

The AM hum and noise level shall be attenuated a minumum of (Item F).

4.5.4 Carrier Attack Time

The carrier power output shall increase to 50 percent of its specified value in less than (Item G).

4.6 Audiofrequency Modulation Characteristics

The audiofrequency modulation characteristics of harmonic distortion, FM hum and noise level, modulation limiting, audiofrequency response, and frequency deviation shall be measured in accordance with the procedures of paragraph 5.5.

4.6.1 Audiofrequency Harmonic Distortion

The maximum allowable distortion shall be (Item H).

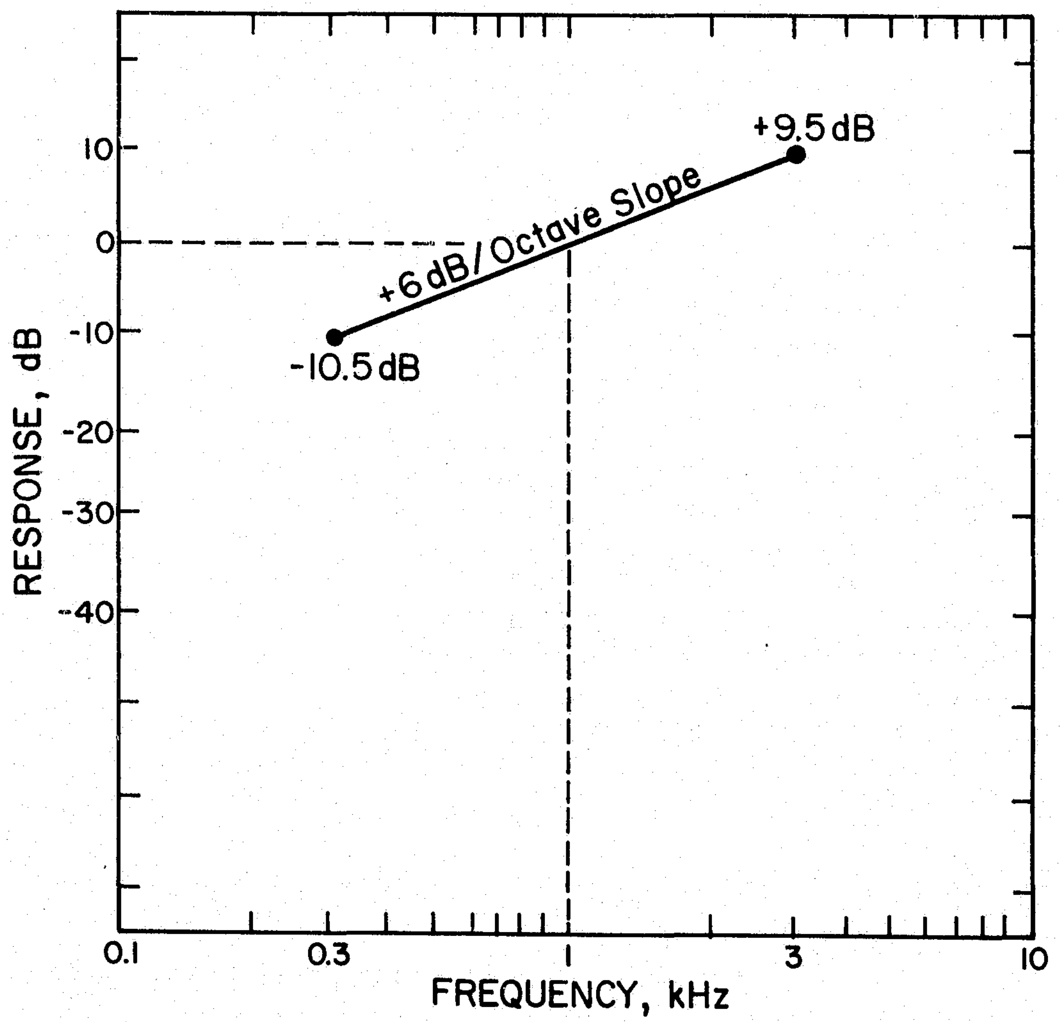

FIGURE 1. *Audiofrequency response characteristics of mobile FM transmitters.*

4.6.2 FM Hum and Noise Level

The FM hum and noise level shall be attenuated a minimum of (Item I).

4.6.3 Audiofrequency Response

The audiofrequency response shall not vary more than +1, −3 dB from a true 6 dB per octave pre-emphasis characteristic from .3 to 3 kHz as referred to the 1kHz level with the exception of a permissible 6 dB per octave roll-off from 2.5 to 3 kHz. See figure 1.

4.6.4 Frequency Deviation

The measured frequency deviation shall be within (Item J) of 4.75 kHz.

4.6.5 Modulation Limiting

The instantaneous peak and steady state frequency deviation shall not exceed 4.75 kHz with a 20 dB increase in audio above the rated input audio level.

4.7 Electromagnetic Compatibility Characteristics

The electromagnetic compatibility characteristics of conducted spurious emissions, radiated spurious emissions and spectrum sideband shall be measured in accordance with paragraph 5.6.

4.7.1 Conducted Spurious Emissions

Each conducted spurious emission shall be attentuated a minimum of (Item K) + 10 $\log_{10}$ (power output in watts) decibels below the level of the transmitter output power.

4.7.2 Radiated Spurious Emissions

Each radiated spurious emission shall be attenuated a minimum of (Item L) + 10 $\log_{10}$ (power output in watts) decibels below the level of the transmitter output power.

4.7.3 Sideband Spectrum

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

5. TEST METHODS

5.1 Standard Test Conditions

All measurement equipment shall be allowed to warm up until the system has achieved sufficient stability to perform the measurement. All measurements, unless otherwise specified, shall be performed 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 Power Supply Voltage

In a nominal 12 volt system, the standard supply voltage shall be determined from the equation $V = 13.8 - 0.02\ I$ where I is the current (in amperes) delivered to the mobile unit. For example, if the current while transmitting is 12 amperes, the standard supply voltage should be approximately 13.6 volts. Appropriate factors shall be used for other voltage supply systems. A well filtered electronic power source should be used in place of a battery for safety and convenience. The standard supply voltage shall be applied to the input terminals of the dc supply cables (including all connectors and circuit protectors) furnished by the manufacturer and adjusted to within 1 percent of the value calculated above.

5.1.4 Rated System Deviation

Rated system deviation shall be ± 5 kHz.

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 dB greater than that required to produce 50 percent of rated system deviation at 1 kHz.

5.1.6 Standard Output Load

The standard rf output load for testing purposes shall be a 50-ohm resistive termination having a Voltage Standing Wave Ratio (VSWR) of 1.1 or less at the frequencies being tested. If coaxial connectors and cables are used with the standard output load, the combined VSWR shall be 1.1 or less.

5.1.7 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 meters (295 feet) 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.

5.1.8 Standard Duty Cycle

The standard duty cycle shall be 2 minutes in the transmit mode followed by 3 minutes in the standby mode.

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 Test Receiver

The test receiver used to determine transmitter audiofrequency distortion and audio response characteristics shall include a standard audio output load specified by the manufacturer (paragraph 5.2.1.6) and shall have the characteristics specified in the following paragraphs.

5.2.1.1 Audio Response

The audio response characteristics shall not vary more than one dB from a 750 microsecond de-emphasis characteristic when the system deviation is held constant and the modulation is varied between .05 and 3 kHz.

5.2.1.2 Harmonic Distortion

The audiofrequency distortion shall be less than one percent at standard modulation. The harmonic distortion at 1 kHz (for larger than rated system deviation) shall be less than three 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).

5.2.1.3 AM Hum and Noise Ratio

The unsquelched AM hum and noise ratio shall be at least 55 dB when measured with a 1000 microvolt input signal.

5.2.1.4 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.

5.2.1.5 Selectivity

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

5.2.1.6 Standard Audio Output Load

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

5.2.2 Deviation Monitor

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

5.2.3 Standard Audio Input Load

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

5.2.4 Band Rejection Filter

The band rejection filter shall have a minimum insertion loss of 40 dB at ±0.01% of the carrier frequency.

5.3 Environmental Tests

The environmental tests shall be performed using standard supply voltage and the measurement techniques described in paragraphs 5.4, 5.5 and 5.6.

5.3.1 Temperature Test

The transmitter shall be placed in an environmental chamber whose temperature is maintained at −30±2°C (−22±3.6°F). The outer cases shall be in place and air currents from heating or cooling elements shall not be allowed to blow directly on the transmitter. The transmitter shall not require adjustment of internal controls to meet the minimum requirements. Further, the unenergized transmitter shall be allowed to reach temperature equilibrium with its surroundings after each temperature change. The transmitter shall be kept at the desired temperature for 30 minutes before energizing. After energizing, wait 2 minutes before operating the transmitter. The transmitter shall meet the designated performance requirements after fifteen minutes of operation at the standard duty cycle. This test shall be repeated at a temperature of 60±2°C (140±3.6°F).

5.3.2 Humidity Test

The unenergized transmitter shall be kept for eight hours in a humidity chamber at a temperature of 50°C (122°F) or more and a relative humidity of at least 90 percent. All covers and shields shall be in place and air currents from heating elements shall not be allowed to blow directly on the transmitter. While still in the humidity chamber, the transmitter shall be placed in the standby mode for 2 minutes, operated at the standard duty cycle for 15 minutes and then tested for the designated performance requirements. The transmitter shall not require adjustments of any controls during this test.

5.3.3 Vibration Test

A two-part test shall be applied for a total of 30 minutes in each of three directions, namely the directions parallel to both axes of the base and perpendicular to the plane of the base.

The unit shall complete three 5-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.

The unit shall next complete three 5-minute cycles of simple harmonic motion having an amplitude of 0.19 mm (0.0075 inch) [total excursion 0.38 mm (0.015 inch)] applied initially at a frequency of 30 Hz and increasing at a uniform rate to 60 Hz in 2½ minutes, then decreased at a uniform rate to 30 Hz in 2½ minutes.

5.3.4 Shock Test

The transmitter shall be subjected to a series of ten impacts in each of three directions (paragraph 5.3.3). Each impact shall consist of a half sine wave acceleration of 20 g peak amplitude and 11 milliseconds duration. This acceleration shall be applied to the transmitter mounting facilities and measured with an accelerometer. The transmitter shall be in the transmit mode during one-half the impacts in each direction and in the standby mode during the other half.

5.4 Radio Frequency Carrier Tests

5.4.1 Power Output Test

The transmitter shall be operated without modulation. The power output shall be measured as shown in figure 2 using the standard supply voltage. The standard supply voltage shall then be changed plus 10 percent, allowed to stabilize at least 15 seconds, and the power output recorded. Repeat the above using minus 10 percent and minus 20 percent changes in standard supply voltage.

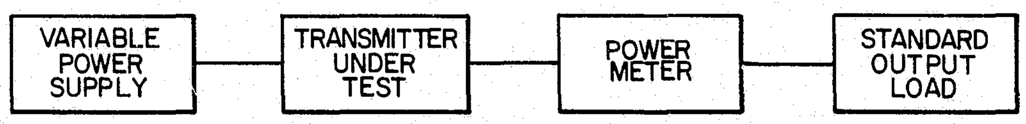

FIGURE 2. *Block diagram for power output measurement.*

5.4.2 Frequency Stability Test

The transmitter shall be operated without modulation. The frequency shall be measured as shown in figure 3 using standard supply voltage. Change the standard supply voltage plus 15 percent, allow it to stabilize for 15 seconds, and record the change in frequency. Repeat this for a change in standard supply voltage of minus 15 percent.

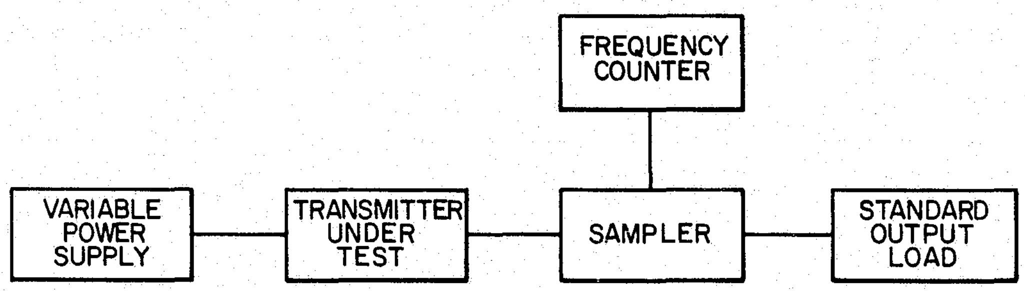

FIGURE 3. *Block diagram for frequency stability measurement.*

5.4.3 AM Hum and Noise Level Test

Connect the equipment as shown in figure 4. In addition, connect the standard audio input load to the transmitter audio input. The linear peak-carrier responsive AM detector is used to detect the sample output of the transmitter. Adjust the transmitter for rated power with no modulation and 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. Modulation of FM transmitters is usually not a critical factor to AM hum and noise level when the transmitter frequency deviation is 10 kHz or less.

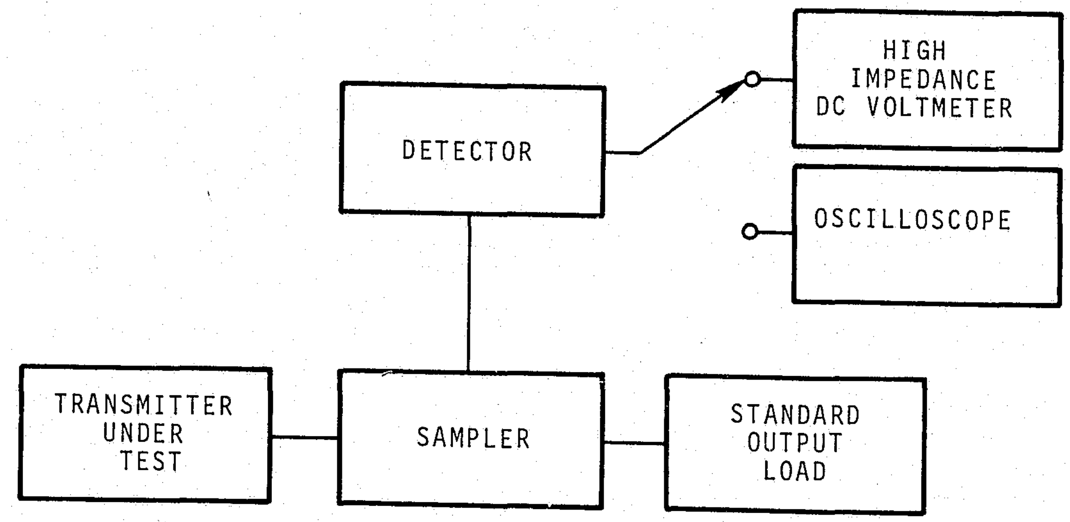

FIGURE 4. *Block diagram for AM hum and noise measurement.*

5.4.4 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. This measurement shall be made using a calibrated oscilloscope and peak detector connected as shown in figure 5. The trigger circuit of the oscilloscope shall be closed through the transmitter control switch to start the time interval. The peak detector, sampling the rf carrier, provides a voltage to the oscilloscope vertical input. The peak detector should have a short time constant (less than 10 milliseconds) and provide a linear response with amplitude. The time required for the trace to reach 71 percent of peak detector maximum output shall be measured.

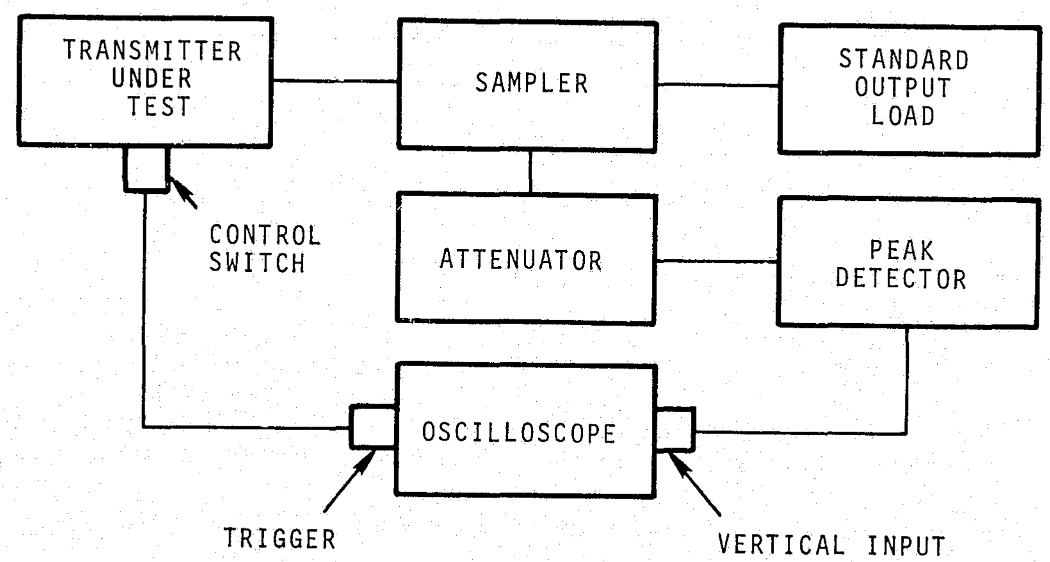

FIGURE 5. *Block diagram for carrier attack time measurement.*

5.5 Audiofrequency Modulation Tests

5.5.1 Harmonic Distortion Test

The transmitter shall be terminated in a standard output load and the audio oscillator adjusted for audiofrequency test modulation except that the 1 kHz modulating signal shall have a total distortion of 0.5 percent or less. The test receiver (paragraph 5.2.1) shall be connected so the transmitter output can be sampled (figure 6).

A distortion analyzer connected across a standard audio output load removes the 1 kHz tone and measures the signal which is a combination of all the noise and harmonic components.

5.5.2 FM Hum and Noise Level Test

The transmitter shall be terminated in a standard output load and the audio oscillator adjusted for audiofrequency test modulation (figure 6). Connect the test receiver and sample the transmitter output. Connect the standard audio output load to the test receiver audio output and measure the audio voltage, V_1, 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.

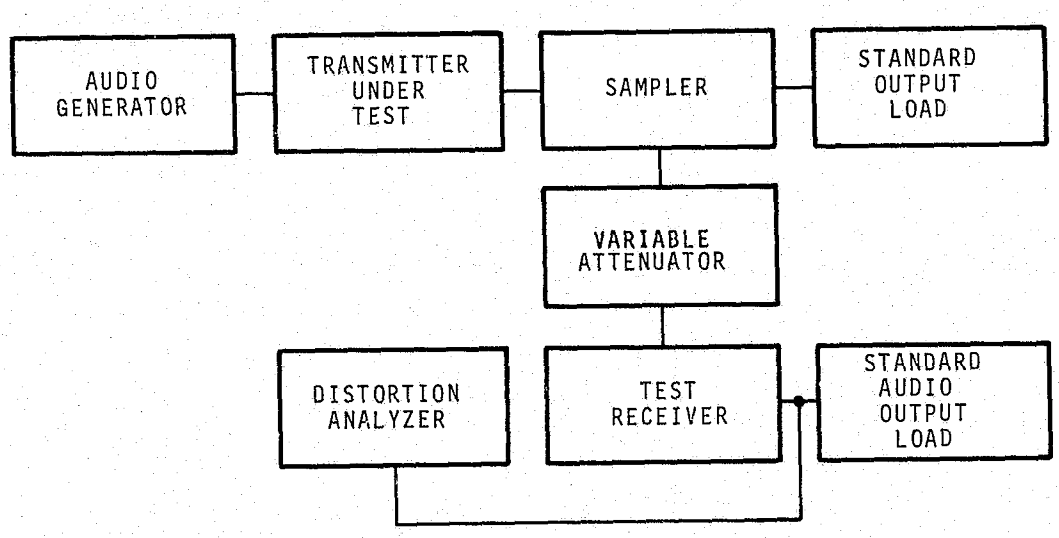

FIGURE 6. *Block diagram for harmonic distortion and FM hum and noise measurements.*

5.5.3 Audiofrequency Response Test

Figure 7 illustrates the equipment connections for performing audiofrequency response measurements. The matching network is a broadband network which matches the audio generator output impedance to the transmitter audio input impedance.

To determine the audio response of the transmitter below 3 kHz, selected audio frequencies from .3 to 3 kHz shall be applied to the transmitter, while adjusting the input audio level for a constant 30 percent of rated system deviation (i.e., 1.5 kHz) using a deviation meter. The audio voltmeter reading in decibels shall be determined for each test frequency and a graph similar to figure 1 shall be drawn.

5.5.4 Frequency Deviation Test

In order to measure frequency deviation, the audio input signal must be changed in amplitude level with the transmitter controls adjusted for normal operation. Follow the block diagram of figure 8. The audio input shall be adjusted for audiofrequency test modulation, and the audio input level increased until maximum frequency deviation is observed. The frequency deviation shall then be measured with the deviation meter.

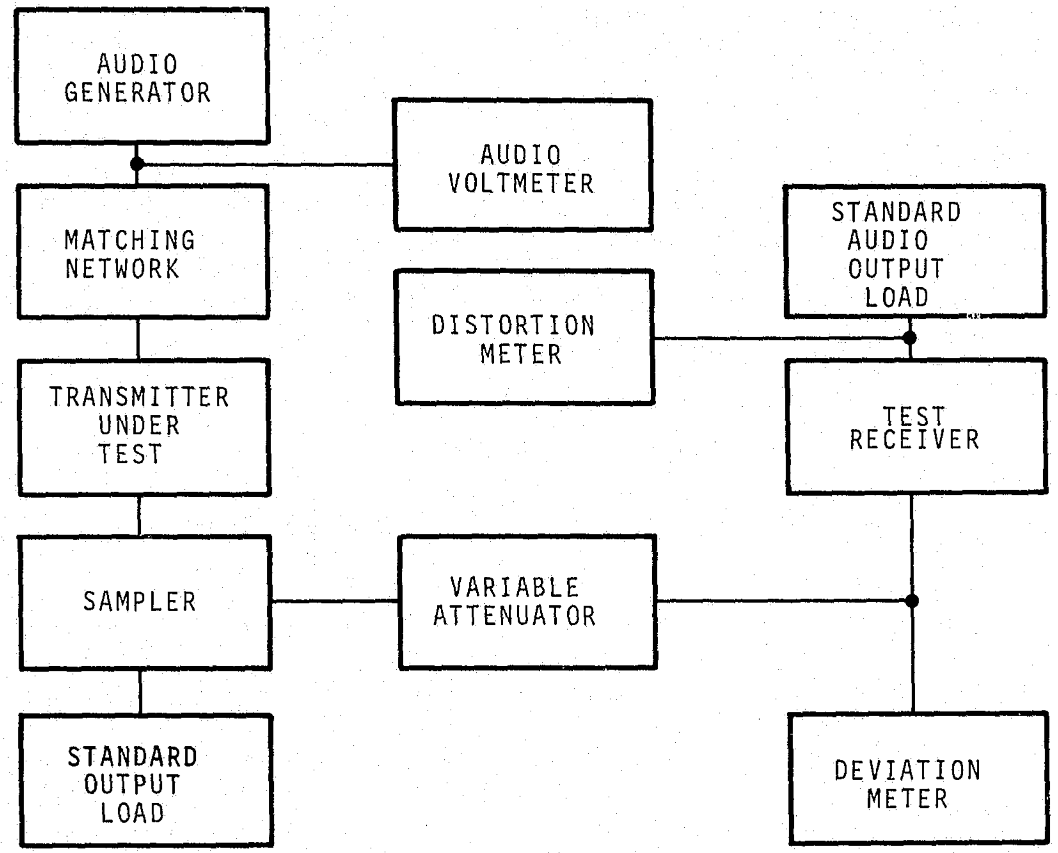

FIGURE 7. *Block diagram for audiofrequency response measurement.*

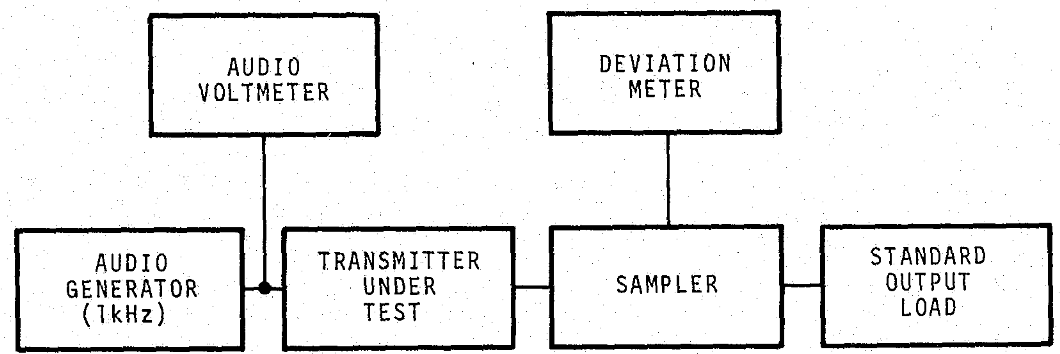

FIGURE 8. *Block diagram for frequency deviation and modulation limiting measurements.*

5.5.5 Modulation Limiting Test

For this measurement, use figure 8 and adjust the transmitter controls for normal operation. Adjust the audio input for audiofrequency test modulation and increase the audio input level approximately 20 dB. Measure the frequency deviation with the deviation meter. Hold the audio input level constant, vary the frequency from 0.3 to 3 kHz and measure the frequency deviation.

5.6 Electromagnetic Compatibility Tests

5.6.1 Test for Conducted Spurious Emissions at the Antenna Terminals

A block diagram for this measurement is illustrated in figure 9. Use a signal generator with a calibrated output. The selective rf voltmeter or spectrum analyzer shall be capable of measuring signals at least 80 dB below the carrier level. This method requires that the transmitter be modulated with the electromagnetic compatibility test modulation.

Measure the rated transmitter output power in decibels above 1 milliwatt (dBm) (step 1). Record the spurious emissions from the transmitter using the selective voltmeter or spectrum analyzer. Disconnect the power meter, transmitter and audio oscillator from the circuit and connect the signal generator as shown in step 2. Adjust the signal generator to obtain the same frequencies and magnitudes of spurious signals as were recorded above, and record the corresponding outputs of the signal generator in dBm. The transmitter output power in dBm minus the signal generator output in dBm is the value sought.

Measure all frequencies from the lowest frequency generated within the transmitter to the tenth harmonic of the carrier.

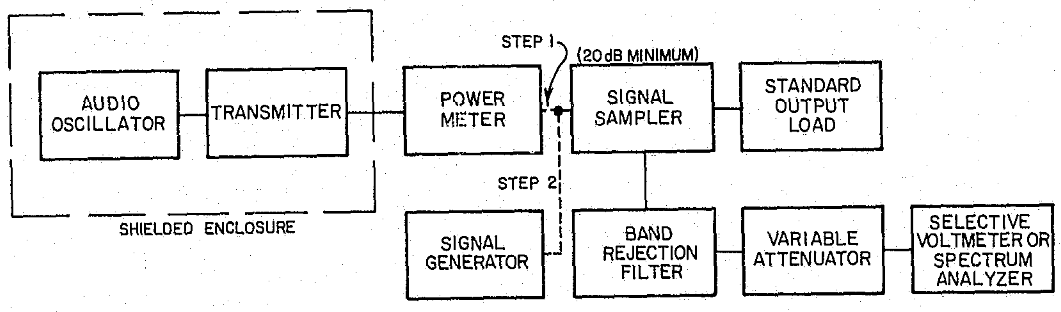

FIGURE 9. *Block diagram for conducted spurious emissions at the antenna terminals.*

5.6.2 Radiated Spurious Emissions Test

The test site shall meet the requirements of paragraph 5.1.7. The equipment shall be connected as illustrated in figure 10. The transmitter (step 1) shall be adjusted for rated output power and modulated with the electromagnetic compatibility test modulation. Record the transmitter power in watts. The spurious emissions shall be measured with the receiving antenna 30 meters (98.4 feet) from the transmitter. The selective voltmeter shall be tuned from the lowest radio frequency generated in the equipment up to the tenth harmonic of the carrier.

For each spurious frequency, the receiving antenna shall be raised and lowered in a horizontal position to obtain a maximum reading on the spectrum analyzer or selective voltmeter. The transmitter shall be rotated to further increase this maximum reading. This procedure of raising and lowering the antenna and rotating the transmitter shall be repeated until the largest signal has been obtained and recorded. The antenna shall be then placed in a vertical position and the procedure repeated for each spurious signal.

Remove the transmitter and substitute a signal generator and a dipole antenna (step 2). The antenna shall be placed in a horizontal position and the frequency of the generator adjusted to each of the spurious frequencies previously measured. With the transmitting antenna fixed, the horizontally positioned receiving antenna shall be raised and lowered to obtain a maximum reading on the selective voltmeter. The output of the signal generator shall be adjusted until the received signal strength is the same as the previously recorded maximum readings for each of the spurious frequencies. This procedure shall then be repeated for each spurious frequency with both antennas vertically positioned.

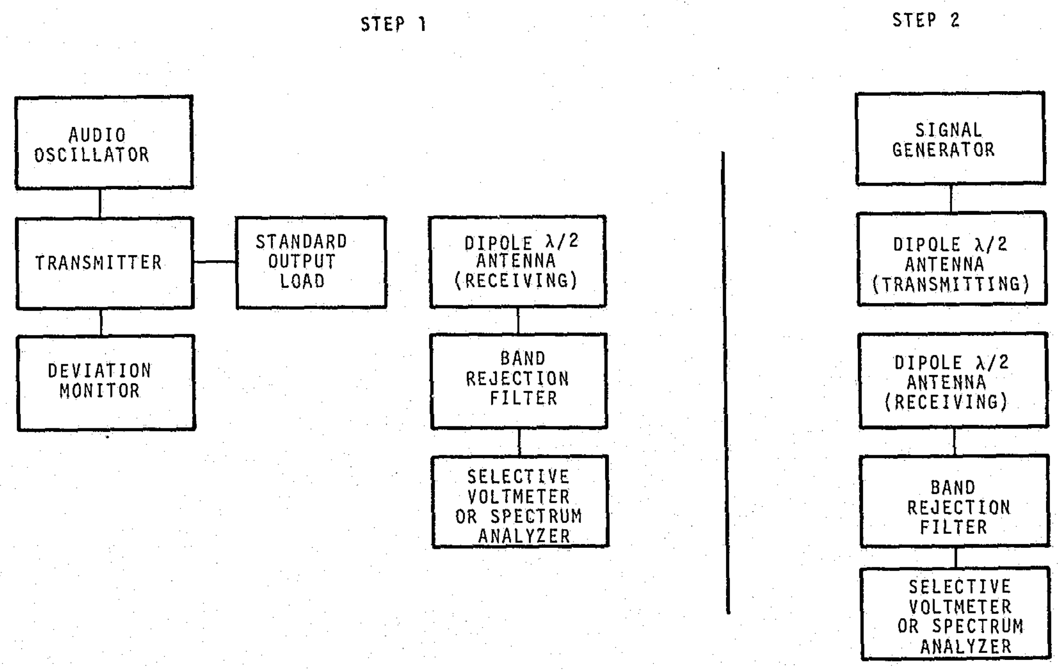

FIGURE 10. *Block diagram for radiated spurious emission measurements.*

The spurious power, in watts, delivered to the transmitting half-wavelength dipole antenna shall be calculated from the antenna and generator impedances and the signal power from the generator. The attenuation of the spurious emission is calculated as 10 $\log_{10}$ of the ratio of the transmitter power to the spurious power.

5.6.3 Sideband Spectrum Test

The method described herein uses a spectrum analyzer to measure transmitter sidebands within several tens of kilohertz of the center frequency. The equipment shall be connected as shown in figure 11. 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. For this measurement, the electromagnetic compatibility test modulation shall be applied and the average envelope of the resulting spectrum measured at both plus and minus 10 kHz and plus and minus 20 kHz from the center frequency. The spectrum analyzer controls shall be adjusted 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 figure 12.

The sideband spectrum is then recorded as the difference between the center frequency amplitude and sideband amplitudes located at ±10 kHz and ±20 kHz from the center frequency.

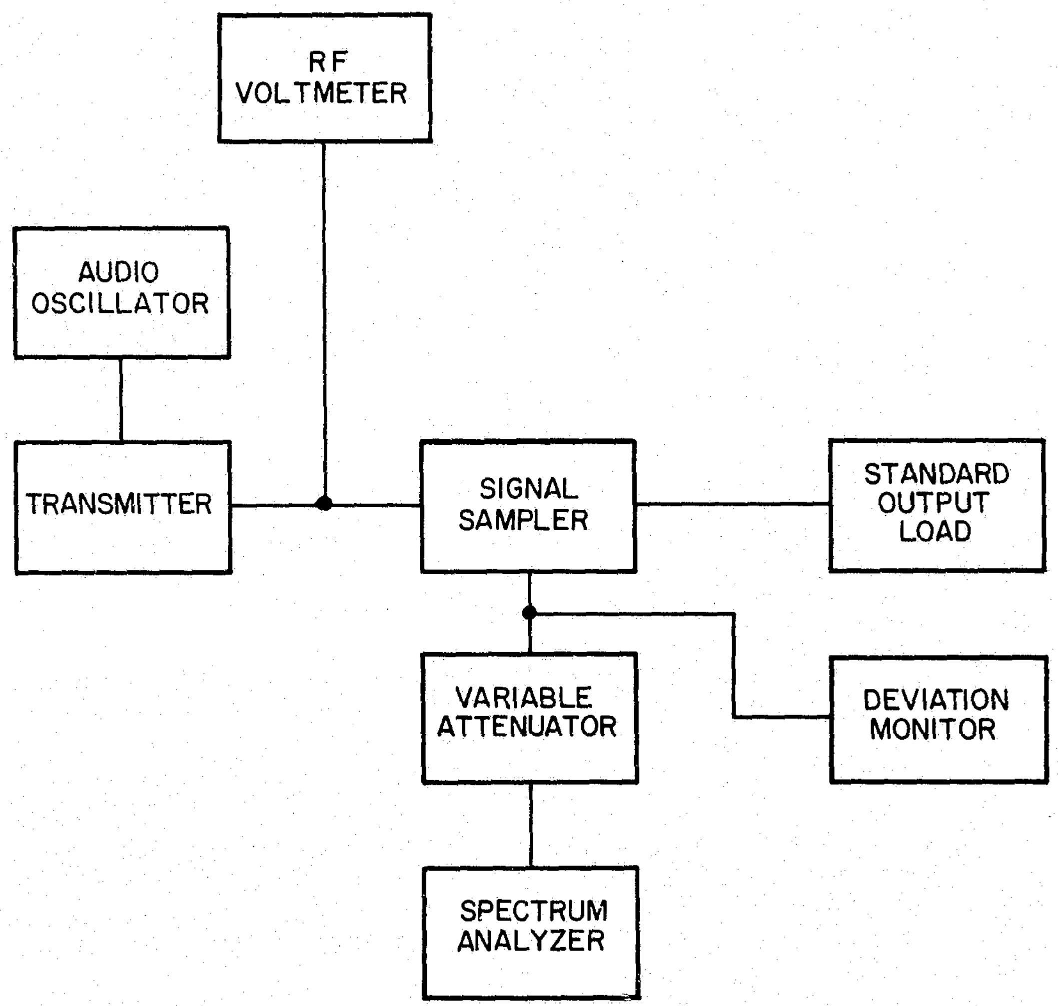

FIGURE 11. *Block diagram for sideband spectrum measurement.*

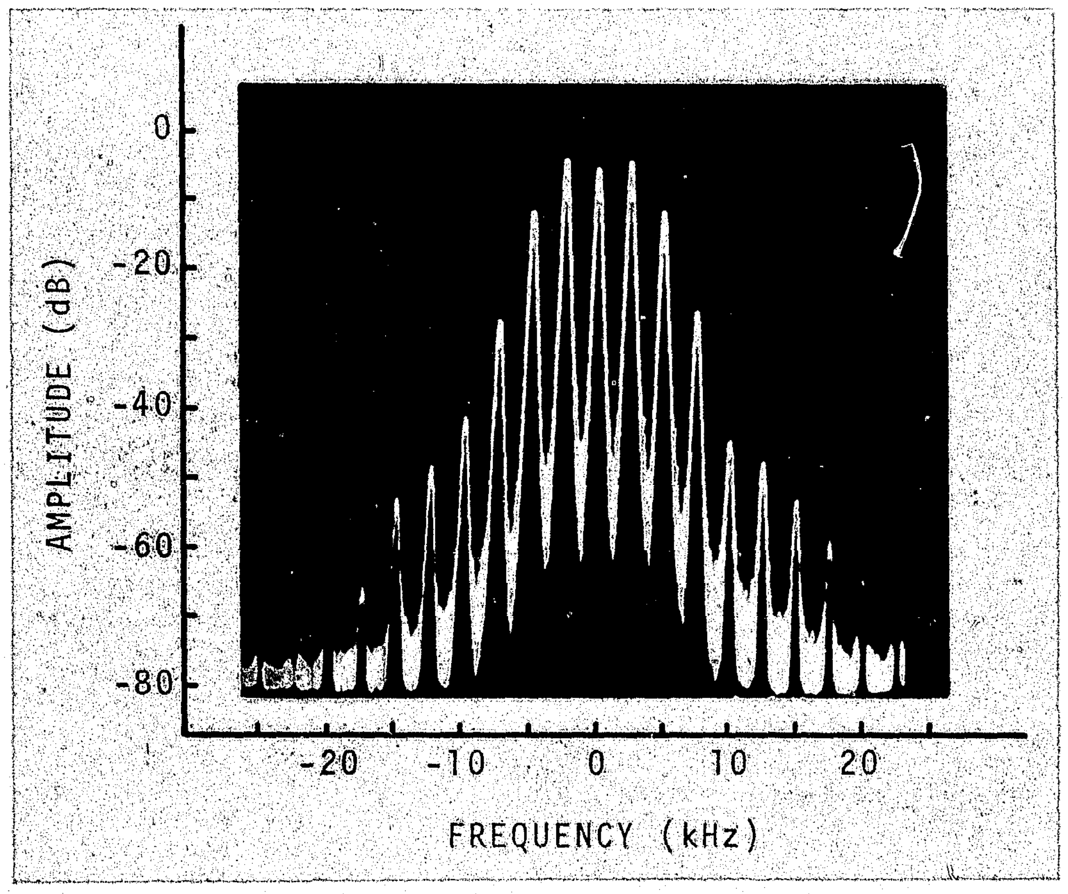

FIGURE 12. *Typical sideband spectrum on a tube-type transmitter using a 2.5 kHz tone 16 dB greater than that required to produce ±2.5 kHz deviation at 1.0 kHz.*

APPENDIX A

Minimum Performance Requirements for Mobile FM Transmitters

Transmitter Characteristic	Requirements Frequency Band (MHz)		
	25–50	150–174	400–512
Radio Frequency Carrier Characteristics			
A. Carrier Power Output Variance	−5, +10%	−5, +10%	−5, +10%
B. Power Output Variance (supply voltage varied ±10%)	−3, +0.5 dB	−3, +0.5 dB	−3, +0.5 dB
C. Power Output Variance (supply voltage varied −20%)	−6, +0.5 dB	−6, +0.5 dB	−6, +0.5 dB
D. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%
E. Frequency Stability (supply voltage varied ±15%)	0.002%	0.0005%	0.0005%
F. AM Hum and Noise Level	34 dB	34 dB	34 dB
G. Carrier Attack Time	100 ms	100 ms	100 ms
Audiofrequency Modulation Characteristics			
H. Audiofrequency Harmonic Distortion	5%	5%	5%
I. FM Hum and Noise Level	40 dB	40 dB	40 dB
J. Frequency Deviation	5%	5%	5%
Electromagnetic Compatibility Characteristics			
K. Conducted Spurious Emissions	55 dB	55 dB	55 dB
L. Radiated Spurious Emissions	55 dB	55 dB	55 dB
M. Sideband Spectrum (±10 kHz frequency separation)	25 dB	30 dB	30 dB
N. Sideband Spectrum (±20 kHz frequency separation)	50 dB	60 dB	60 dB
Environmental Temperature Characteristics			
O. Power Output	−3, +0.5 dB	−3, +0.5 dB	−3, +0.5 dB
P. FM Hum and Noise Level	34 dB	34 dB	34 dB
Q. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%
R. Audiofrequency Harmonic Distortion	9%	9%	9%
Humidity Characteristics			
S. Power Output	−3, +0.5 dB	−3, +0.5 dB	−3, +0.5 dB
T. FM Hum and Noise Level	34 dB	34 dB	34 dB
U. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%

BIBLIOGRAPHY

1. "Minimum Standards for Land Mobile Communication FM or PM transmitters, 25–470 MHz," EIA Standard RS–152–B. (February 1970).
2. Federal Communications Commission, Rules and Regulations, Vol. 5, Part 89, Public Safety Radio Services (January 1970) plus transmittals through No. 8.
3. "Society of Automotive Engineers, Inc., Capacitor, 10 MFD for EMI Measurements," Aerospace Recommended Practice, ARP 936, (May 31, 1968).
4. Battery Council International Newsletter, Number 8–72, (March 17, 1972).
5. American National Standard Specification for Dry Cells and Batteries, ANSI C 18.1–1969, (1970).
6. White, D. R. J., "A Handbook on Electrical Noise and Electromagnetic Interference Specifications," Vol. 1, (Don White Consultants, Germantown, Maryland, 1971).
7. Rumfeld, A. Y., and Elwell, L. B., "Radio Frequency Power Measurements," Proceedings of the IEEE, Vol. 55, No. 6, 837–850 (June 1967).
8. Larsen, N. T., and Clague, F. R., "The NBS Type II Power Measurements," ISA–70 Meeting, Philadelphia, Pa., October 26–29, 1970, paper 712–70.
9. Gerber, E. A., and Sykes, R. A., "Quartz Frequency Standards," Proceedings of the IEEE, Vol. 55, No. 6, 783–791, (June 1967).
10. Tary, J. J., and Livingston, T. L., "A Peak FM Deviation Calibrator Graph," ESSA Tech. Memorandum, ERLTM–ITS 229 (April 1970).
11. Shepard, N. H., and Smith, J. S., "The Gaussian Curve-transmitter Noise Limits Spectrum Utilization," IRE Trans. on V. C., PGVC-10, 27–32, (April 1958).
12. Jarett, D., and Rudoff, A., "A New Technique for Measuring Mobile Transmitter Noise Spectra," IEEE Trans. on Vehicular Communications, Vol. VC–15, No. 2, 48–55 (October 1966).
13. "Minimum Standard for Test Conditions Common to FM Land-Mobile Communications Equipment, 25–470 MHz," EIA Standard RS–388, (January 1971).

U.S. GOVERNMENT PRINTING OFFICE : 1975 OL–566–726

END