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*Technology Assessment  
Program*

# Mobile FM Transceivers

NIJ Standard-0210.00

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**James K. Stewart, Director**  
National Institute of Justice

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## FOREWORD

This document, NIJ Standard-0210.00, Mobile FM Transceivers, is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Bureau of Standards. It is produced as part of the Technology Assessment Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment should meet to satisfy the needs of criminal justice agencies for high quality service. Purchasers can use the test methods described in this standard to determine whether a particular piece of equipment meets the essential requirements, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements. Compliance with the requirements of the standard may be attested to by an independent laboratory or guaranteed by the vendor.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. For those who seek general guidance concerning the selection and application of law enforcement equipment, user guides have also been published. The guides explain in nontechnical language how to select equipment capable of the performance required by an agency.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Program Manager for Standards, National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to: Chief, Law Enforcement Standards Laboratory, National Bureau of Standards, Gaithersburg, MD 20899.

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# NIJ STANDARD FOR MOBILE FM TRANSCEIVERS

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## COMMONLY USED SYMBOLS AND ABBREVIATIONS

A	ampere	H	henry	nm	nanometer
ac	alternating current	h	hour	No.	number
AM	amplitude modulation	hf	high frequency	o.d.	outside diameter
cd	candela	Hz	hertz (c/s)	$\Omega$	ohm
cm	centimeter	i.d.	inside diameter	p.	page
CP	chemically pure	in	inch	Pa	pascal
c/s	cycle per second	ir	infrared	pe	probable error
d	day	J	joule	pp.	pages
dB	decibel	L	lambert	ppm	part per million
dc	direct current	L	liter	qt	quart
$^{\circ}$ C	degree Celsius	lb	pound	rad	radian
$^{\circ}$ F	deg. ee Fahrenheit	lbf	pound-force	rf	radio frequency
diam	diameter	lbf-in	pound-force inch	rh	relative humidity
emf	electromotive force	lm	lumen	s	second
eq	equation	ln	logarithm (natural)	SD	standard deviation
F	farad	log	logarithm (common)	sec.	section
fc	footcandle	<i>M</i>	molar	SWR	standing wave ratio
fig.	figure	m	meter	uhf	ultrahigh frequency
FM	frequency modulation	min	minute	uv	ultraviolet
ft	foot	mm	millimeter	V	volt
ft/s	foot per second	mph	mile per hour	vhf	very high frequency
<i>g</i>	acceleration	m/s	meter per second	W	watt
g	gram	N	newton	$\lambda$	wavelength
gr	grain	N-m	newton meter	wt	weight

area=unit<sup>2</sup> (e.g., ft<sup>2</sup>, in<sup>2</sup>, etc.); volume=unit<sup>3</sup> (e.g., ft<sup>3</sup>, m<sup>3</sup>, etc.)

### PREFIXES

d	deci (10 <sup>-1</sup> )	da	deka (10)
c	centi (10 <sup>-2</sup> )	h	hecto (10 <sup>2</sup> )
m	milli (10 <sup>-3</sup> )	k	kilo (10 <sup>3</sup> )
$\mu$	micro (10 <sup>-6</sup> )	M	mega (10 <sup>6</sup> )
n	nano (10 <sup>-9</sup> )	G	giga (10 <sup>9</sup> )
p	pico (10 <sup>-12</sup> )	T	tera (10 <sup>12</sup> )

### COMMON CONVERSIONS

(See ASTM E380)

ft/s $\times$ 0.3048000 = m/s	lb $\times$ 0.4535924 = kg
ft $\times$ 0.3048 = m	lbf $\times$ 4.448222 = N
ft-lbf $\times$ 1.355818 = J	lbf/ft $\times$ 14.59390 = N/m
gr $\times$ 0.06479891 = g	lbf-in $\times$ 0.1129848 = N-m
in $\times$ 2.54 = cm	lbf/in <sup>2</sup> $\times$ 6894.757 = Pa
kWh $\times$ 3 600 000 = J	mph $\times$ 1.609344 = km/h
	qt $\times$ 0.9463529 = L

Temperature:  $(T_F - 32) \times 5/9 = T_C$

Temperature:  $(T_C \times 9/5) + 32 = T_F$

# NIJ STANDARD FOR MOBILE FM TRANSCEIVERS

## 1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for non-trunked, frequency modulated (FM) mobile transceivers. 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-0202.00, Mobile FM Transmitters and NILECJ-STD-0207.00, Mobile FM Receivers.

## 2. CLASSIFICATION

For the purpose of this standard, mobile 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.

### 2.4 Type IV

Transceivers which operate in the 806-866 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 [1]<sup>1</sup>.

### 3.1 Adjacent-Channel Selectivity and Desensitization

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

<sup>1</sup> Numbers in brackets refer to references in appendix A.



### **3.2 AM Hum and Noise**

The residual amplitude modulation present on an unmodulated carrier.

### **3.3 Audio Harmonic Distortion**

Nonlinear distortion characterized by the appearance in the output of integral multiples of an audio-frequency input signal.

### **3.4 Audio Hum and Noise Power**

The average audiofrequency power dissipated in a load across the output terminals of a receiver having an unmodulated radio frequency (rf) signal input.

### **3.5 Audio Noise Output Power**

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

### **3.6 Audio Output Power**

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

### **3.7 Audio Response of a Receiver**

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

### **3.8 Audio Response of a Transmitter**

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

### **3.9 Authorized Bandwidth**

The maximum width of the band of frequencies specified by the Federal Communications Commission (FCC) to be occupied by an emission, i.e., 20 kHz for public-safety agencies [2].

### **3.10 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.

### **3.11 Carrier Output Power**

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

### **3.12 FM Hum and Noise**

The frequency modulation present on an unmodulated carrier.

### **3.13 Frequency Deviation**

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

### **3.14 Frequency Stability**

The maximum permissible departure by the center frequency of the frequency band occupied by an emission from the assigned frequency.

### **3.15 Intermodulation Attenuation**

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

### **3.16 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 receiver pass band.

### **3.17 Minimum Usable Bandwidth**

The frequency displacement from the unmodulated carrier frequency, +3 kHz, of an input test signal which is 6 dB above the 12-dB SINAD sensitivity voltage and which produces a 12-dB SINAD ratio.

### **3.18 Modulation Limiting**

That action, performed by an FM transmitter, which intentionally restricts the signal to the required spectral limits by restricting the total deviation of the emission.

### **3.19 Noise Quieting**

The reduction of receiver audio noise output caused by the presence of an incoming 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 Rated System Deviation**

The maximum carrier frequency deviation permitted by the FCC. For law enforcement communications systems, it is  $\pm 5$  kHz.

### **3.23 Receiver 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.

### **3.24 Receiver Closing 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.

### **3.25 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, some of which may differ only slightly from the desired signal.

### **3.27 Sideband Spectrum**

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

### **3.28 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*.

### **3.29 SINAD Sensitivity**

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

### **3.30 Spurious Emission**

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

### **3.31 Spurious and Harmonic Response**

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

### **3.32 Squelch**

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

### **3.33 Squelch Block**

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

### **3.34 Standby Mode**

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

### **3.35 Standing Wave Ratio (SWR)**

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

### **3.36 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.

### **3.37 Threshold Squelch Sensitivity**

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

### **3.38 Tight Squelch Sensitivity**

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

### 3.39 Transceiver

The combination of radio transmitting and receiving equipment in a common housing.

## 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 and 2. These performance requirements meet or exceed those given in the Rules and Regulations published by the FCC [2].

### 4.2 User Information

A nominal value for each of the characteristics listed in tables 1 and 2 shall be included in the information supplied to the purchaser by the manufacturer or distributor. In addition, the manufacturer 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 transmitter carrier output power, receiver audio output impedance, and standard supply voltage. 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.

### 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 section 5.3. It is suggested that these tests be performed before the transceiver is tested for compliance with the requirements of sections 4.4 and 4.5.

#### 4.3.1 Temperature Stability

Low temperature tests shall be conducted at  $-30^{\circ}\text{C}$  ( $-22^{\circ}\text{F}$ ), or the lowest temperature at which the manufacturer states that the unit will operate properly (sec. 4.2), whichever is lower. High temperature tests shall be conducted at  $60^{\circ}\text{C}$  ( $140^{\circ}\text{F}$ ) or the highest temperature at which the manufacturer states that the 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 R), more than items U through AA, for the characteristics listed. In addition, the receiver audio distortion at an audio output power of 5 W (item M, table 1) shall be less than 9 percent (item AB) for an rf signal with standard modulation. The transmitter rf output power shall not be less than 3 dB (item BQ, table 2) below the nominal value, its FM hum and noise level shall be attenuated a minimum of 34 dB (item BR), the carrier shall be within (item BS) of the assigned value and the audio harmonic distortion shall be a maximum of 9 percent (item BT).

#### 4.3.2 Humidity Stability

After the transceiver has been maintained at  $50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ) and 90 percent relative humidity or greater for at least 8 h, its performance shall not vary, with respect to the appropriate values in table 1 (items A through R), more than items AC through AI, for the characteristics listed. In addition, the receiver audio distortion at an audio output power of 5 W shall be less than 9 percent (item AJ) for an rf signal with standard modulation. The transceiver rf output power shall not be less than 3 dB (item BU) below the nominal value, its FM hum and noise level shall be attenuated a minimum of 34 dB (item BV) and the carrier frequency shall be within (item BW) 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 BX) and the carrier frequency shall be within (item BY) 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.

TABLE 1. Minimum performance requirements for receivers used in mobile FM transceivers.

Receiver characteristic	Minimum requirement Frequency band (MHz)			
	25-50	150-174	400-512	806-866
<b>Sensitivity Characteristics</b>				
A. SINAD Sensitivity	6.4 $\mu$ V	0.4 $\mu$ V	0.4 $\mu$ V	0.4 $\mu$ V
B. SINAD Sensitivity Variance (Supply Voltage Varied +10% and -20%)	0.7 $\mu$ V	0.7 $\mu$ V	0.7 $\mu$ V	0.7 $\mu$ V
<b>Selectivity Characteristics</b>				
C. Minimum Usable Bandwidth	5 kHz	5 kHz	5 kHz	5 kHz
D. Adjacent-Channel Selectivity and Desensitization	80 dB	80 dB	80 dB	80 dB
E. Spurious and Harmonic Response Attenuation	95 dB	95 dB	95 dB	95 dB
F. Intermodulation Attenuation	65 dB	75 dB	75 dB	75 dB
<b>Squelch Characteristics</b>				
G. Threshold Squelch	0.3 $\mu$ V	0.3 $\mu$ V	0.3 $\mu$ V	0.3 $\mu$ V
H. Tight Squelch Sensitivity	2.5 $\mu$ V	2.5 $\mu$ V	2.5 $\mu$ V	2.5 $\mu$ V
I. Threshold Squelch Sensitivity Variance (Supply Voltage Varied +10% and -20%)	0.3 $\mu$ V	0.4 $\mu$ V	0.4 mV	0.4 mV
J. Squelch Block	$\pm 5$ kHz	$\pm 5$ kHz	$\pm 5$ kHz	$\pm 5$ kHz
K. Receiver Attack Time	150 ms	150 ms	150 ms	150 ms
L. Receiver Closing Time	250 ms	250 ms	250 ms	250 ms
<b>Audio Characteristics</b>				
M. Audio Output Power	5 W	5 W	5 W	5 W
N. Audio Output Power Variance (Supply Voltage Varied +10% and -20%)	2 dB	2 dB	2 dB	2 dB
O. Audio Distortion	5%	5%	5%	5%
P. Audio Response	-8, +2 dB	-8, +2 dB	-8, +2 dB	-8, +2 dB
Q. Audio Hum and Noise (Unsquelled)	45 dB	45 dB	45 dB	45 dB
R. Audio Hum and Noise (Squelled)	60 dB	60 dB	60 dB	60 dB
<b>Temperature Stability</b>				
U. SINAD Sensitivity	6 dB	6 dB	6 dB	6 dB
V. Minimum Usable Bandwidth	20%	20%	20%	20%
W. Adjacent-Channel Selectivity and Desensitization	12 dB	12 dB	12 dB	12 dB
X. Tight Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
Y. Threshold Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
Z. Audio Output Power	6 dB	6 dB	6 dB	6 dB
AA. Audio Hum and Noise	10 dB	10 dB	10 dB	10 dB
AB. Audio Distortion	9%	9%	9%	9%
<b>Humidity Stability</b>				
AC. SINAD Sensitivity	6 dB	6 dB	6 dB	6 dB
AD. Minimum Usable Bandwidth	20%	20%	20%	20%
AE. Adjacent-Channel Selectivity and Desensitization	12 dB	12 dB	12 dB	12 dB
AF. Tight Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
AG. Threshold Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
AH. Audio Output Power	3 dB	3 dB	3 dB	3 dB
AI. Audio Hum and Noise	10 dB	10 dB	10 dB	10 dB
AJ. Audio Distortion	9%	9%	9%	9%

TABLE 2. Minimum performance requirements for transmitters used in mobile FM transceivers.

Transmitter characteristic	Minimum requirement Frequency band (MHz)			
	25-50	150-174	400-512	806-866
<b>Radio Frequency Carrier Characteristics</b>				
BA. Carrier Output Power Variance	-0.3 dB	-0.3 dB	-0.3 dB	-0.3 dB
BB. Output Power Variance (Supply Voltage Varied $\pm 10\%$ )	-3 dB	-3 dB	-3 dB	-3 dB
BC. Output Power Variance (Supply Voltage Varied $-20\%$ )	-6 dB	-6 dB	-6 dB	-6 dB
BD. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%	0.00025%
BE. Frequency Stability (Supply Voltage Varied $\pm 15\%$ )	0.002%	0.0005%	0.0005%	0.00025%
BF. AM Hum and Noise Level	34 dB	34 dB	34 dB	34 dB
BG. Carrier Attack Time	100 ms	100 ms	100 ms	100 ms
<b>Audio Modulation Characteristics</b>				
BH. Audio Harmonic Distortion	5%	5%	5%	5%
BI. FM Hum and Noise Level	40 dB	40 dB	40 dB	40 dB
BJ. Audio Response	+1,-3 dB	+1,-3 dB	+1,-3 dB	+1,-3 dB
BK. Frequency Deviation	5%	5%	5%	5%
BL. Modulation Limiting	$\pm 5$ kHz	$\pm 5$ kHz	$\pm 5$ kHz	$\pm 5$ kHz
<b>Electromagnetic Compatibility Characteristics</b>				
BM. Conducted Spurious Emissions	55 dB	55 dB	55 dB	55 dB
BN. Radiated Spurious Emissions	1.65 mV/m	1.65 mV/m	16.5 mV/m	16.5 mV/m
BO. Sideband Spectrum ( $\pm 10$ kHz Frequency Separation)	25 dB	30 dB	30 dB	30 dB
BP. Sideband Spectrum ( $\pm 20$ kHz Frequency Separation)	50 dB	60 dB	60 dB	60 dB
<b>Temperature Stability</b>				
BQ. Output Power	-3 dB	-3 dB	-3 dB	-3 dB
BR. FM Hum and Noise Level	34 dB	34 dB	34 dB	34 dB
BS. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%	0.00025%
BT. Audio Harmonic Distortion	9%	9%	9%	9%
<b>Humidity Stability</b>				
BU. Output Power	-3 dB	-3 dB	-3 dB	-3 dB
BV. FM Hum and Noise Level	34 dB	34 dB	34 dB	34 dB
BW. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%	0.00025%
<b>Vibration Stability</b>				
BX. FM Hum and Noise Level	25 dB	25 dB	25 dB	25 dB
BY. Carrier Frequency Tolerance	0.002%	0.0005%	0.0005%	0.00025%

## 4.4 Receiver Performance

### 4.4.1 SINAD Sensitivity

When measured in accordance with section 5.4.1, the SINAD sensitivity of the receiver shall be  $0.4 \mu\text{V}$  (item A) or less at a SINAD ratio of 12 dB and an audio output power of at least 50 percent of 5 W, i.e., 2.5 W. When the standard power supply voltage is varied +10 percent and -20 percent, the SINAD sensitivity shall be  $0.7 \mu\text{V}$  (item B) or less.

### 4.4.2 Selectivity Characteristics

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

#### 4.4.2.1 *Minimum Usable Bandwidth*

The minimum 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 80 dB (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 and Harmonic Response Attenuation*

The spurious and harmonic response attenuation of the receiver shall be 95 dB (item E) or more as compared with the on-channel 20-dB noise-quieting signal voltage for receiver responses in the region between the lowest intermediate frequency of the receiver and at least twice the receiver operating frequency, or 1000 MHz, whichever is higher.

#### 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, receiver attack time, and receiver closing time shall be measured in accordance with section 5.4.3.

#### 4.4.3.1 *Squelch Sensitivity*

The threshold squelch sensitivity of the receiver shall be 0.3  $\mu\text{V}$  (item G) or less. The tight squelch sensitivity shall be 2.5  $\mu\text{V}$  (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  $\pm 5$  kHz (item J) or less.

#### 4.4.3.3 *Receiver Attack Time*

The time for the receiver to produce an audio output power of 90 percent of 5 W, i.e., 4.5 W, shall be 150 ms (item K) or less.

#### 4.4.3.4 *Receiver Closing Time*

The time for the audio output power of the receiver to decrease to 10 percent of 5 W, i.e., 0.5 W, shall be 250 ms (item L) or less.

### 4.4.4 **Audio Characteristics**

The audio characteristics of output power, distortion, response, and hum and noise shall be measured in accordance with section 5.4.4.

#### 4.4.4.1 Audio Output Power

The audio output power of the receiver shall be at least 5 W (item M) if a loudspeaker is used at the receiver output. When the standard supply voltage is varied +10 percent and -20 percent, the audio output power shall not be reduced more than 2 dB (item N) below 5 W.

#### 4.4.4.2 Audio Distortion

Audio distortion of the loudspeaker at an audio output power of 5 W shall be less than 5 percent (item O) for an rf input signal with standard modulation.

#### 4.4.4.3 Audio Response

The audio response of the receiver, when used with a loudspeaker, shall be within -8, +2 dB (item P) of an ideal 6 dB per octave de-emphasis curve with constant frequency deviation at frequencies between 0.3 and 3 kHz, with the exception that a 6 dB per octave roll-off from 600 to 300 Hz may be present.

#### 4.4.4.4 Audio Hum and Noise

The audio hum and noise output power from the receiver in the unsquelched condition shall be 45 dB (item Q) or more, and, in the maximum squelched condition, shall be 60 dB (item R) or more below an audio output power of 5 W.

### 4.5 Transmitter Performance

#### 4.5.1 Radio Frequency Characteristics

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

##### 4.5.1.1 Output Power

Transmitter output power is specified by the FCC [2]. When the transceiver is in the transmit mode, the carrier output power delivered to a standard output load shall not decrease more than 0.3 dB (item BA) from the nominal value at any time during the standard test duty cycle, 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  $\pm 10$  percent, the output power shall not decrease by more than 3 dB (item BB). When the standard supply voltage is reduced by 20 percent, the output power shall not decrease by more than 6 dB (item BC).

##### 4.5.1.2 Frequency Stability

The carrier frequency shall be within (item BD) of the assigned value at all times during the standard 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  $\pm 15$  percent, the carrier frequency shall be maintained within (item BE) of the assigned value.

##### 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 ms (item BG).

#### 4.5.2 Audio Modulation Characteristics

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



#### 4.5.2.1 Audio Harmonic Distortion

The audio 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 Audio Response

The audio response of the transmitter shall not vary more than +1, -3 dB from a true 6 dB per octave 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 600 to 300 Hz and from 2.5 to 3 kHz may be present.

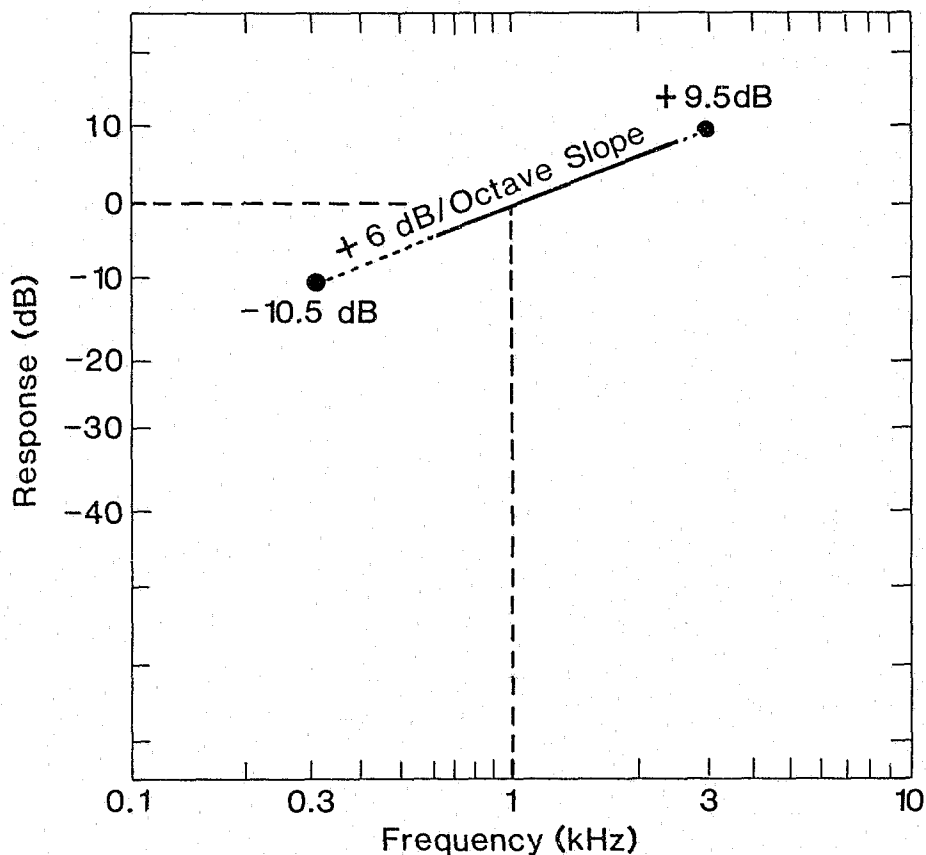


FIGURE 1. Audio response characteristic of mobile FM transmitters.

#### 4.5.2.4 Frequency Deviation

The maximum frequency deviation shall be within 5 percent (item BK) of  $\pm 4.75$  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 of  $\pm 5$  kHz (item BL) with a 20 dB increase in audio above the nominal input level.

#### 4.5.3 Electromagnetic Compatibility Characteristics

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

#### 4.5.3.1 *Conducted Spurious Emissions*

Each conducted spurious emission shall be attenuated a minimum of [55 (item BM) + 10 log<sub>10</sub> (output power in watts)] dB below the level of the transmitter output power.

#### 4.5.3.2 *Radiated Spurious Emissions*

Each radiated spurious emission shall be no larger than 1.65 mV/m (item BN) at 30 m for type I and II transceivers, or 16.5 mV/m (item BN) at 3 m for type III and IV transceivers; i.e., each radiated spurious emission shall be less than 50 μW.

#### 4.5.3.3 *Sideband Spectrum*

Each spurious sideband emission shall be attenuated greater than (item BO) when the frequency is separated from the assigned carrier by ±10 kHz, and shall be attenuated greater than (item BP) when the frequency is separated from the assigned carrier by ±20 kHz.

## 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 and 30 °C (68 and 86 °F).

#### 5.1.2 Standard Relative Humidity

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

#### 5.1.3 Standard Supply Voltage

In a nominal 12-V dc 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 A, the standard supply voltage should be approximately 13.6 V. 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 Standard Test Frequencies

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

#### 5.1.5 Standard Test Modulation

##### 5.1.5.1 *Audio Test Modulation*

Audio test modulation shall be a 1-kHz signal (from a source with distortion less than 1%) 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 Rated System Deviation

Rated system deviation shall be  $\pm 5$  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 Standard Radiation Test Site

#### 5.1.8.1 Type I and II Transceivers

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 ensure that it does not interfere with the test being performed. Preferably, the test site should be equipped with a turntable located at ground level.

#### 5.1.8.2 Type III and IV Transceivers

In addition to the requirements described in 5.1.8.1, the standard radiation test site shall have microwave absorbing material placed on the ground between the transceiver and the receiving antenna to restrict standing waves, produced by reflections from the ground, to no larger than  $\pm 1$  dB. If available, an anechoic chamber may be used instead (sec. 5.2.18). Preferably, the test site should be equipped with a turntable located 1 m above ground level supported by nonreflective material.

### 5.1.9 Standard Test Duty Cycle

The standard test duty cycle shall be 2 min in the transmit mode followed by 3 min 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 Environmental Chamber(s)

The environmental chamber(s) shall produce air temperatures from  $-30$  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.

### 5.2.2 Vibration Tester

The vibration tester shall be adjustable in frequency from 10 to 60 Hz in a linear-sweep mode, and it shall be servo-controlled with a reference signal derived from a suitable calibrated accelerometer or other calibrated sensor. It shall also provide an adjustable simple harmonic motion in at least one plane for a total excursion of 0.04 in (1 mm).

### 5.2.3 FM Signal Generator

The FM signal generator shall have a 50- $\Omega$  output impedance, a maximum SWR of 1.2 and a calibrated variable output level accurate to  $\pm 2$  dB when terminated in a 50- $\Omega$  load. It shall also have a single sideband 1-Hz bandwidth phase noise less than  $-135$  dB below the carrier at 25-kHz separation for carrier frequencies of 500 MHz and lower ( $-130$  dB at 900 MHz). 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. Three of these are required.

#### **5.2.4 CW Sweep Signal Generator**

The CW sweep signal generator shall have the same characteristics as the FM signal generator except that the FM capability and the low phase noise capability are not required. The sweep generator should have some means of slowly, automatically sweeping the frequency band, especially for the higher frequencies.

#### **5.2.5 Distortion Analyzer**

The distortion analyzer shall have a required input level of between 1 and 5 V rms, an input impedance of at least 50,000  $\Omega$  shunted by less than 100 pF, and an accuracy of at least  $\pm 1$  dB. It shall have the capability to measure both audio distortion and the rms voltage of audio signals to within  $\pm 3$  percent. The analyzer shall incorporate a 1000-Hz band elimination filter for the audio distortion measurements.

#### **5.2.6 Isolation Transformer**

The isolation transformer shall have a turns ratio of 1 to 1, an impedance of 600  $\Omega$ , a frequency response within  $\pm 0.1$  dB from at least 300 to 3000 Hz, and a power handling capability of 20 dBm. The isolation transformer is needed when the receiver audio output does not have an isolating circuit such as an output transformer or capacitor, and the following measuring instrument (e.g., distortion analyzer) has a single ended input.

#### **5.2.7 Standard Audio Output Load (Receiver)**

The standard audio output load shall either be the actual speaker or an impedance equivalent to the nominal impedance of the transceiver speaker 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.

#### **5.2.8 Standard RF Input Load (Receiver)**

The standard rf input load shall consist of a shielded 50- $\Omega$  resistor whose SWR is less than 1.05.

#### **5.2.9 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 SWR 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.

#### **5.2.10 Audio Voltmeter**

The audio voltmeter shall measure rms voltage with an uncertainty of 1 percent or less.

#### **5.2.11 Chart Recorder**

The chart recorder shall have sufficient speed of response to record spurious receiver responses when the signal generator is swept slowly.

#### **5.2.12 Standard Audio Input Load (Transmitter)**

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

### 5.2.13 Standard RF Output Load (Transmitter)

The standard rf output load shall be a 50- $\Omega$  resistive termination having an 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.

### 5.2.14 Test Receiver

The test receiver shall include a standard audio output load as specified by the manufacturer of the test receiver (sec. 5.2.14.6) and shall have the characteristics specified in the following sections.

#### 5.2.14.1 Audio Response

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

#### 5.2.14.2 Harmonic Distortion

The audio harmonic distortion shall be less than 1 percent at standard audio 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-mV 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.,  $\pm 7.5$  kHz).

#### 5.2.14.3 Audio Hum and Noise Level

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

#### 5.2.14.4 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.

#### 5.2.14.5 Selectivity

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

#### 5.2.14.6 Standard Audio Output Load

The standard audio output load shall provide an impedance equal to the load impedance into which the test receiver normally operates.

### 5.2.15 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.

### 5.2.16 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 measurement uncertainty of  $\pm 2$  dB or less. It shall be calibrated to accurately measure field strengths from 0.1 to 1 mV/m over the frequency range of interest. When testing type IV transceivers, field strength measurements are required at frequencies up to 3 GHz. The receiver should be located near the receiving antenna to keep the length of the cable between them as short as possible.

### 5.2.17 Microwave Absorber

The microwave absorber shall attenuate the reflected energy at least 20 dB at 400 MHz at an incidence angle of  $56^\circ$ .

### 5.2.18 Anechoic Chamber

The anechoic chamber shall be a room covered on the inside surfaces with microwave absorber such that standing waves produced by imperfect absorption are no larger than  $\pm 1$  dB.

## 5.3 Transceiver Environmental Tests

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

### 5.3.1 Temperature Test

Place the transceiver, with the power turned off and all covers in place, in the environmental chamber. Adjust the chamber to the required low temperature  $\pm 2$  °C ( $\pm 3.6$  °F). Allow the transceiver to reach temperature equilibrium and maintain it at this temperature for 30 min. With the transceiver still in this environment, connect it to the standard supply voltage and operate it at the standard test duty cycle. Fifteen minutes after turn-on, test the transceiver to determine whether it meets the requirements of section 4.3.1. Repeat the above procedure at the required high temperature  $\pm 2$  °C ( $\pm 3.6$  °F).

### 5.3.2 Humidity Test

Place the transceiver, with power turned off and all covers in place, 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 h. With the transceiver still in this environment, connect it to the standard supply voltage and operate it at the standard test duty cycle. Fifteen minutes after turn-on, test the transceiver to determine whether it meets the requirements of section 4.3.2.

### 5.3.3 Vibration Test

Fasten the transceiver to the vibration tester using a rigid mounting fixture. Perform a two-part test for a total of 30 min in each of three mutually-perpendicular directions, one of which is the vertical.

First subject the transceiver to three 5-min cycles of simple harmonic motion having an amplitude of 0.38 mm (0.015 in) [total excursion of 0.76 mm (0.03 in)] applied initially at a frequency of 10 Hz and increased at a uniform rate to 30 Hz in 2-1/2 min, then decreased at a uniform rate to 10 Hz in 2-1/2 min.

Then subject the transceiver to three 5-min cycles of simple harmonic motion having an amplitude of 0.19 mm (0.0075 in) [total excursion of 0.38 mm (0.015 in)] applied initially at a frequency of 30 Hz and increased at a uniform rate to 60 Hz in 2-1/2 min, then decreased at a uniform rate to 30 Hz in 2-1/2 min.

Repeat for each of the other two directions.

### 5.3.4 Shock Test

Subject the transceiver to a series of 10 impacts in each of three mutually-perpendicular directions (sec. 5.3.3), each impact to consist of a half sinewave acceleration of 20-g peak amplitude and 11-ms duration. Apply this acceleration to the transceiver mounting facilities and measure it with an accelerometer. The transmitter portion of the unit 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 Receiver Tests

### 5.4.1 SINAD Sensitivity Test

Connect the transceiver receiver and test equipment as shown in figure 2 for those transceivers with a balanced receiver audio output. For those transceivers with an unbalanced receiver audio output, the isolation transformer is not required. Set the squelch control to the standard squelch adjustment. Adjust the FM signal generator to the standard test frequency with standard audio test modulation. Set the generator for 1-mV output and the receiver volume control for an audio output power of 5 W. 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 2.5 W and record the generator output voltage for convenience in resetting to a 12-dB SINAD ratio,

as required by some of the following tests. Repeat for changes in standard supply voltage of +10 percent and -10 percent.



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

## 5.4.2 Selectivity Tests

### 5.4.2.1 Minimum Usable Bandwidth Test

Connect the transceiver receiver and test equipment as shown in figure 2, with or without the isolation transformer, as necessary. Adjust the receiver and FM signal generator in accordance with section 5.4.1 until a 12-dB SINAD ratio is reached. With the generator still set for standard audio test modulation, increase the generator rf output by 6 dB. Adjust the frequency of the generator above the test frequency until the 12-dB SINAD signal ratio is obtained again. 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 +3 kHz (standard test modulation deviation) is the receiver bandwidth.

### 5.4.2.2 Adjacent-Channel Selectivity and Desensitization Test

Connect the transceiver receiver and test equipment as shown in figure 3. With the output of FM signal generator No. 2 set to zero, adjust the receiver and FM signal generator No. 1 in accordance with section 5.4.1 until a 12-dB SINAD ratio is reached. Adjust signal generator No. 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 No. 2 to produce a 6-dB SINAD ratio with both signals present. The ratio, in decibels, of the output voltage of signal generator No. 2 to that of signal generator No. 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.

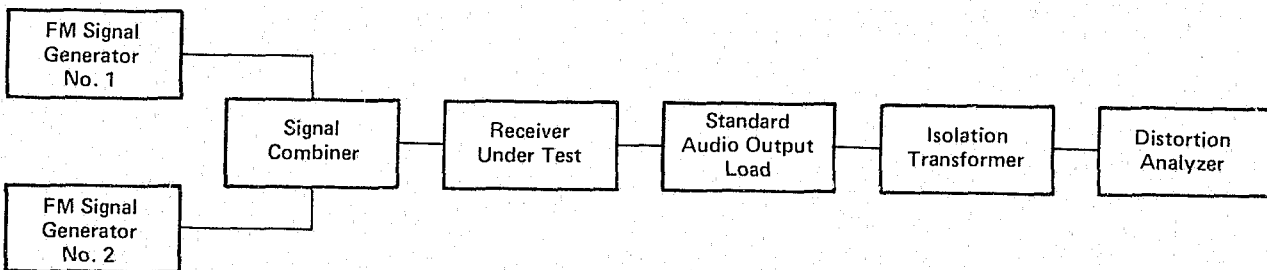


FIGURE 3. Block diagram for adjacent-channel selectivity and desensitization measurement.

### 5.4.2.3 Spurious and Harmonic Response Attenuation Test

Connect the transceiver receiver and test equipment as shown in figure 4. Adjust the CW sweep signal generator to the standard test frequency without modulation. With the generator adjusted for zero output, adjust the receiver volume control to produce 1.25 W. The 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 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 (dB $\mu$ V) at this frequency. Then increase the output of the generator to approximately 0.1 V, and slowly vary the generator frequency continuously from just below the lowest intermediate frequency of the receiver to at least twice the receiver operating frequency or 1000 MHz,

whichever is higher. Synthesized receivers preclude easy prediction of spurious response frequencies. 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 large frequency bandwidths covered, use a signal generator that can be swept automatically and a chart recorder or similar automatic means of recording frequencies of receiver response, as this sweep may take many hours. Then go back and measure the response at each frequency recorded. For each response, adjust the generator output to produce 20 dB of noise quieting. Record the generator output in dB  $\mu$ V. 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.

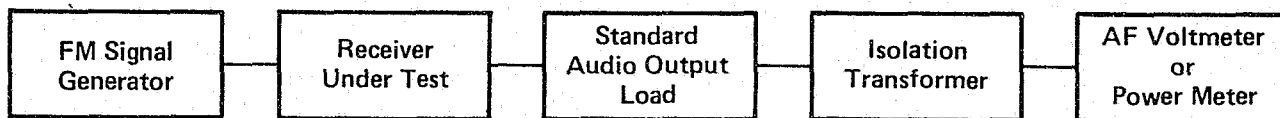


FIGURE 4. Block diagram for spurious and harmonic response attenuation measurement.

#### 5.4.2.4 Intermodulation Attenuation Test

Connect the transceiver receiver and test equipment as shown in figure 5. With the output levels of FM signal generator Nos. 2 and 3 set to zero, adjust the receiver and FM signal generator No. 1 in accordance with section 5.4.1 until a 12-dB SINAD ratio is reached. Adjust generator No. 2, without modulation, to the center frequency of the next higher adjacent channel. Adjust generator No. 3 for 3-kHz frequency deviation at 400 Hz, and set it to the center frequency of the second higher adjacent channel, i.e., two channels above the standard test frequency. Then adjust the output levels of generator Nos. 2 and 3 to produce a 6-dB SINAD ratio with all three signals present. Maintain generator Nos. 2 and 3 at equal output voltages throughout the measurement. Adjust slightly the frequency of generator No. 3 to obtain the 6-dB SINAD ratio with the minimum signal levels from generator Nos. 2 and 3. The ratio, in decibels, of the output voltage of generator No. 2 (or 3) to that of generator No. 1 is the intermodulation attenuation for the upper channels. Repeat the above procedure for the lower two adjacent channels, with generator No. 3 set to the lowest channel. The smaller of the two ratios is the value sought.

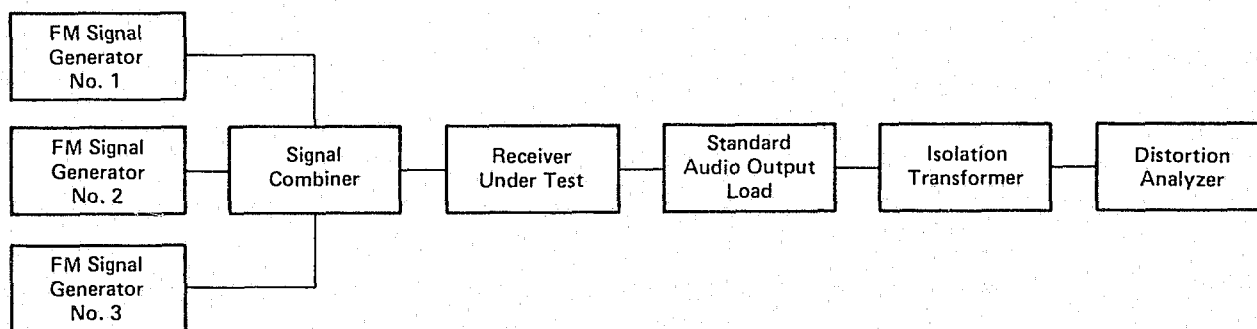


FIGURE 5. Block diagram for intermodulation attenuation measurement.

### 5.4.3 Squelch Tests

#### 5.4.3.1 Squelch Sensitivity Tests

Connect the transceiver receiver and test equipment as shown in figure 2, with or without the isolation transformer, as necessary. Adjust the receiver and FM signal generator in accordance with section 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 any 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 5 W. The signal generator output voltage is the value for threshold squelch sensitivity. Repeat for changes in standard supply voltage of +10 percent and -20 percent.

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

Connect the transceiver receiver and test equipment as shown in figure 2, with or without the isolation transformer, as necessary. Adjust the receiver and FM signal generator in accordance with section 5.4.1 to give 5 W of audio output power. 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 Receiver Attack Time Test

Connect the equipment as shown in figure 6a. Open and close the SPST switch to trigger the oscilloscope trace. Connect the dc output of the coaxial diode detector to the vertical input of the oscilloscope and adjust the horizontal centering controls so that the start of the detector output begins at the left graticule of the oscilloscope screen. Do not adjust the oscilloscope trigger or centering controls any further.

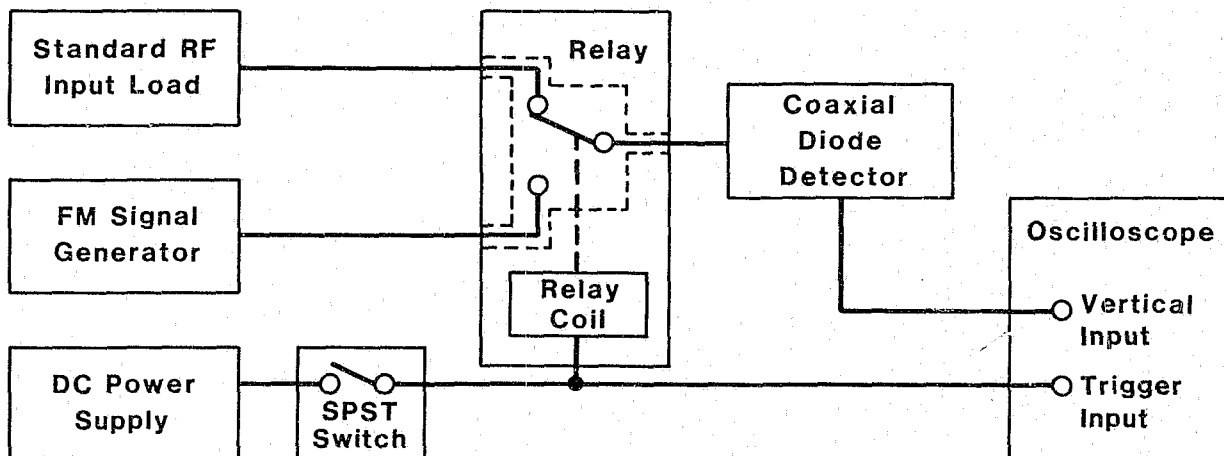


FIGURE 6a. Block diagram for setting oscilloscope trigger.

Connect the transceiver receiver and test equipment as shown in figure 6b. With the SPST switch closed, adjust the FM signal generator in accordance with section 5.4.1 until a 12-dB SINAD ratio is reached. Set 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 any further. Adjust the generator output level to 12 dB above the measured value of the receiver threshold squelch sensitivity voltage. With the oscilloscope on recurrent sweep, adjust the oscilloscope vertical controls for full-scale deflection. Do not adjust the trigger. Return the oscilloscope to external trigger and open and then close the SPST switch and photograph the trace. The time required for the sweep to travel from the left side of the oscilloscope graticule until the audio output power level reaches 4.5 W is the value of receiver attack time.

#### 5.4.3.4 Receiver Closing Time Test

Connect the equipment as shown in figure 6a. Adjust the oscilloscope so the output from the coaxial diode detector stops at the left graticule of the oscilloscope when the SPST switch is opened. Connect the receiver and test equipment as shown in figure 6b. Adjust all equipment as in section 5.4.3.3. Open the SPST switch and photograph the display. The time required for the sweep to travel from the left graticule of the oscilloscope until the audio output power level falls to 500 mW is the value of receiver closing time.

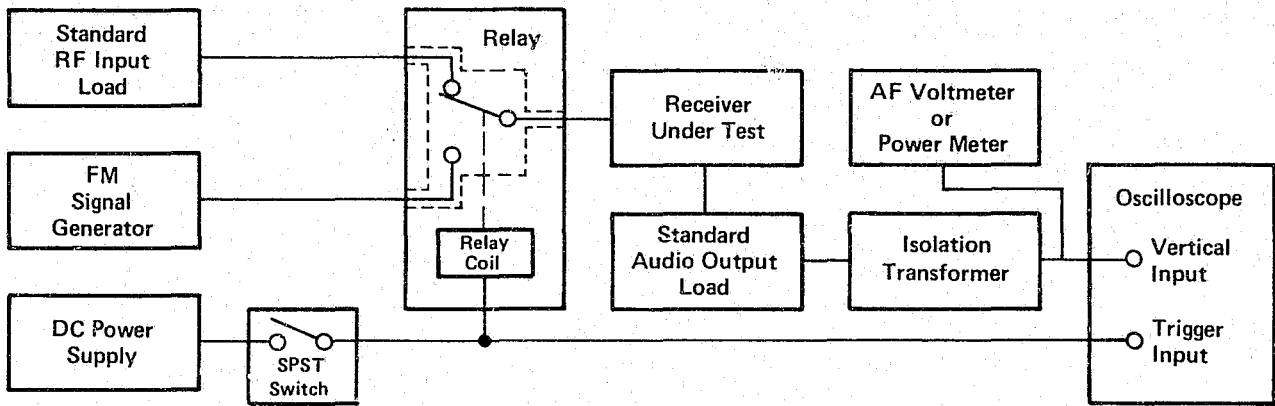


FIGURE 6b. Block diagram for receiver attack time and receiver closing time measurements.

## 5.4.4 Audio Tests

### 5.4.4.1 Audio Output Power Test

Connect the transceiver receiver and test equipment as shown in figure 7. Modulate the FM signal generator with standard audio test modulation and set it to the standard test frequency. With the signal generator adjusted for 1-mV output, set the receiver volume control to the maximum position, and measure the audio output power. Repeat for changes in standard supply voltage of +10 percent and -10 percent.

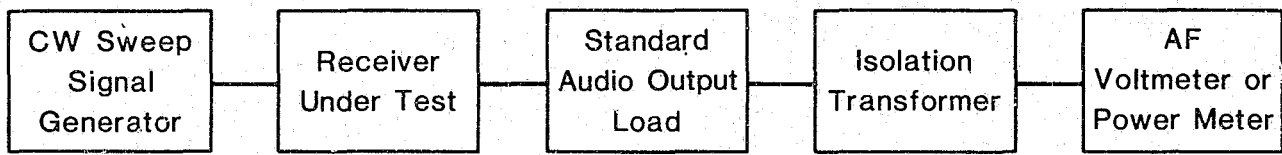


FIGURE 7. Block diagram for audio output power, audio response, and audio hum and noise measurements.

### 5.4.4.2 Audio Distortion Test

Connect the transceiver receiver and test equipment as shown in figure 2, with or without the isolation transformer, as necessary. Modulate the FM signal generator with standard audio test modulation and set it to the standard test frequency. With the signal generator adjusted for 1-mV output, adjust the receiver volume control for an audio output power of 5 W and measure the audio distortion.

### 5.4.4.3 Audio Response Test

Connect the transceiver receiver and test equipment as shown in figure 7. Modulate the FM signal generator with standard audio test modulation and set it to the standard test frequency. With the signal generator adjusted for 1-mV output, adjust the receiver volume control for an audio output power of 5 W. 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, in decibels, of each of these latter power levels relative to the output power at 1-kHz modulation.

### 5.4.4.4 Audio Hum and Noise Tests

Connect the transceiver receiver and test equipment as shown in figure 7. Modulate the FM signal generator with standard audio test modulation and set it to the standard test frequency. With the signal generator adjusted for 1-mV output, adjust the receiver volume control for an audio output power of 5 W. 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, in decibels, of the audio

output power to the audio hum and noise output power. This is the value for audio hum and noise (unscelched).

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 to the audio 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 +10 percent, allow it to stabilize at least 5 s, and determine the output power. Repeat for changes in standard supply voltage of -10 percent and -20 percent.

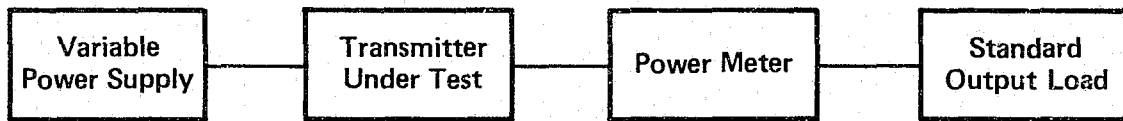


FIGURE 8. Block diagram for output power measurement.

#### 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 +15 percent, allow it to stabilize for 5 s, and determine the change in frequency. Repeat for a change in standard supply voltage of -15 percent.

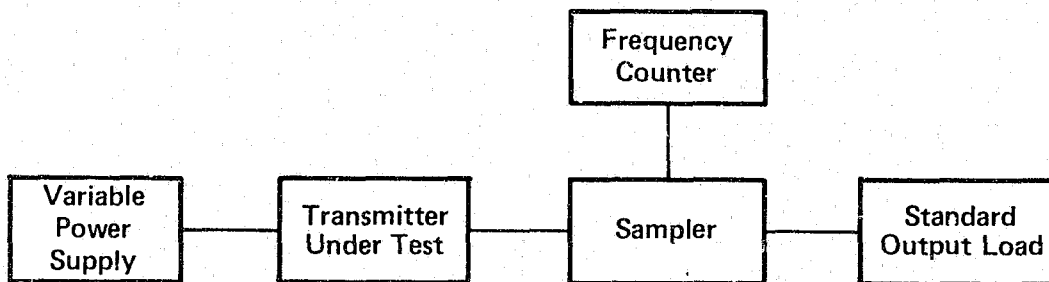


FIGURE 9. Block diagram for frequency stability measurement.

#### 5.5.1.3 AM Hum and Noise Level Test

Connect 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 nominal output 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.

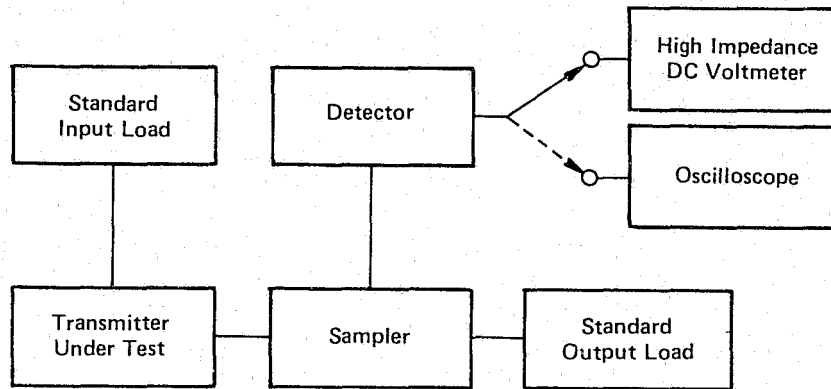


FIGURE 10. Block diagram for AM hum and noise measurement.

#### 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 ( $< 10$  ms) 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 detector, 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.

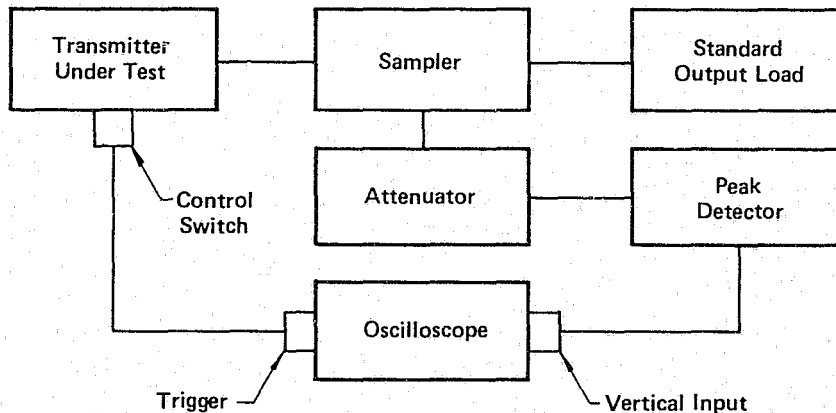


FIGURE 11. Block diagram for carrier attack time measurement.

## 5.5.2 Audio Modulation Tests

### 5.5.2.1 Harmonic Distortion Test

Connect the transceiver transmitter and test equipment as shown in figure 12. Operate the transmitter at nominal carrier output power and adjust the audio input for standard audio test modulation. Ensure that the 1-kHz modulating signal has a total distortion of 0.5 percent or less. Process the sampled transmitter output using the test receiver. Connect the distortion analyzer across the standard audio output load to remove the 1-kHz tone and measure the remaining signal, which is a combination of all the noise and harmonic components.

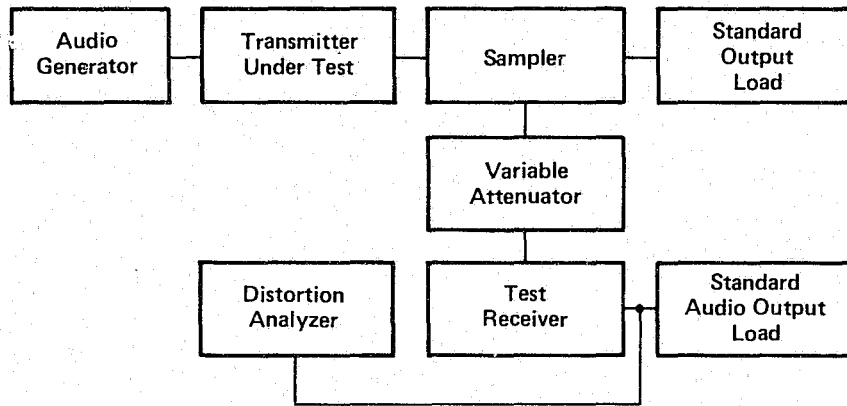


FIGURE 12. Block diagram for harmonic distortion and FM hum and noise measurements.

### 5.5.2.2 FM Hum and Noise Level Test

Connect the transceiver transmitter and test equipment as shown in figure 12. Operate the transmitter at nominal carrier output power and adjust the audio input for standard audio test modulation. Measure the audio output voltage,  $V_1$ , of the test receiver using the distortion analyzer as a voltmeter. Remove the modulation by disconnecting the audio generator and replacing it with the standard audio input load (sec. 5.2.8). 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.

### 5.5.2.3 Audio Response Test

Connect the transceiver transmitter and test equipment as shown in figure 13, using a broadband matching network (sec. 4.2) to match the audio generator output impedance to the transmitter audio input load.

Apply selected audio frequencies 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.

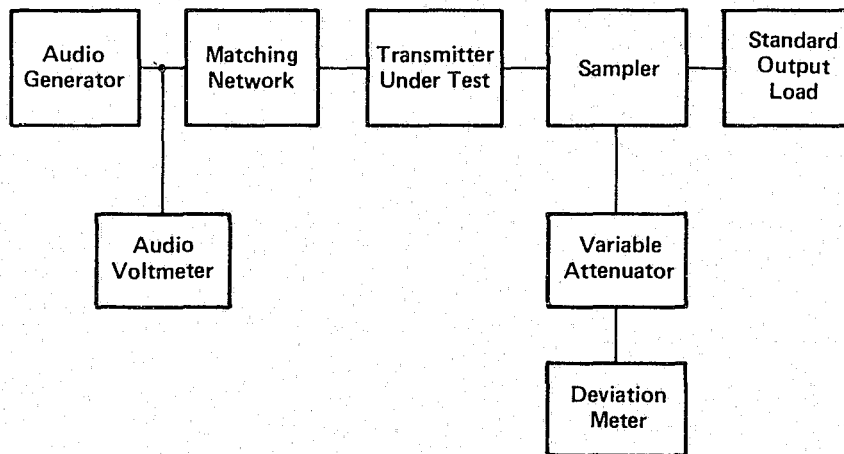


FIGURE 13. Block diagram for audio response measurement.

### 5.5.2.4 Frequency Deviation Test

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

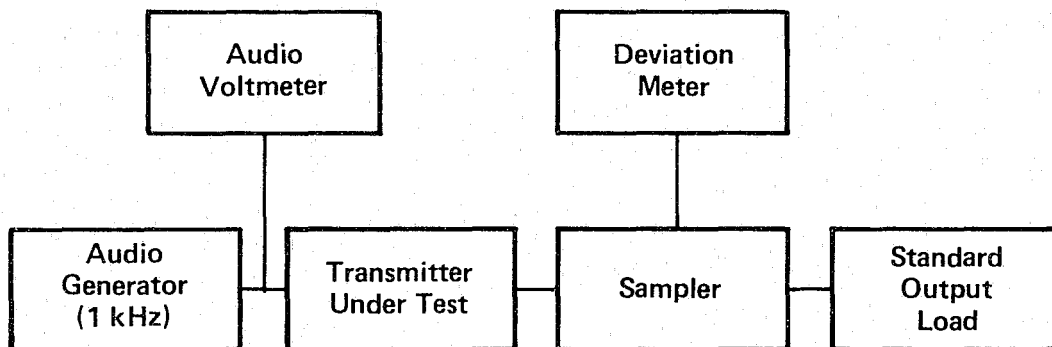


FIGURE 14. Block diagram for frequency deviation and modulation limiting measurements.

### 5.5.2.5 Modulation Limiting Test

Connect the transceiver transmitter and test equipment as shown in figure 14 and adjust the transmitter controls for normal operation. Adjust the audio input for standard audio test modulation and increase the audio output 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 Conducted Spurious Emissions Test

Connect the transceiver transmitter and test equipment as shown in step 1, figure 15. The selective rf voltmeter or spectrum analyzer shall be capable of measuring signals at least 80 dB below the carrier level. Modulate the transmitter with electromagnetic compatibility test modulation and measure the rated transmitter output power in decibels above one milliwatt (dBm). 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. Use a signal generator with a calibrated output. 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 10th harmonic of the carrier, or 3 GHz, whichever is lower.

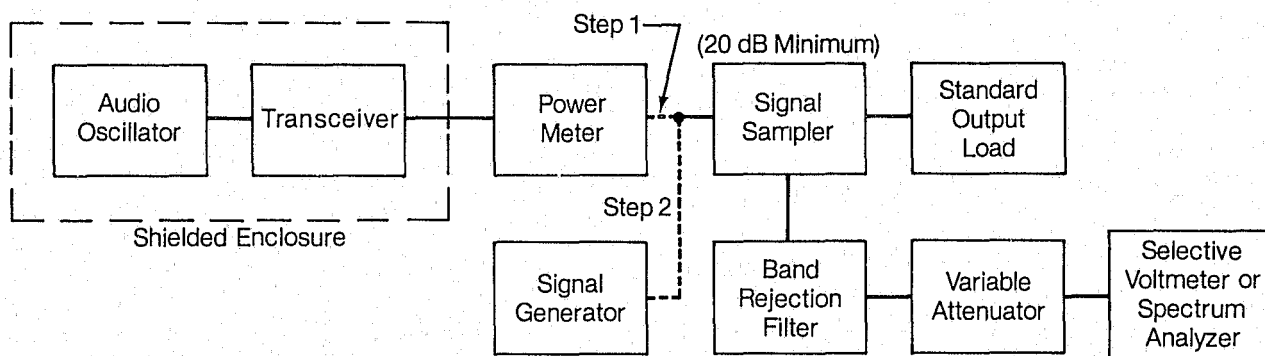


FIGURE 15. Block diagram for measuring conducted spurious emissions at the antenna terminals.

### 5.5.3.2 Radiated Spurious Emissions Test (Type I and II Transceivers)

Set up the mobile transceiver and the test equipment as shown in figure 16 at a site that meets the requirements of section 5.1.8.1. Connect the transmitter to the standard output load and adjust it to produce nominal output power. Measure the spurious emissions with the receiving antenna 30 m (98.4 ft) from the transmitter and 3 m (9.8 ft) above the earth. Tune the field strength meter from the lowest radio frequency generated in the mobile transmission equipment up to the 10th harmonic of the carrier or 1000 MHz, whichever is lower. Note each spurious emission.

For each spurious frequency noted, raise and lower the receiving antenna with a horizontal polarization to obtain a maximum reading on the field strength receiver. Rotate the transmitter to further maximize this reading. Repeat this procedure of raising and lowering the antenna and rotating the transmitter until the largest signal has been obtained and recorded. Then orient the antenna for vertical polarization and repeat the procedure for each spurious signal. Record the maximum field strength of the spurious frequencies.

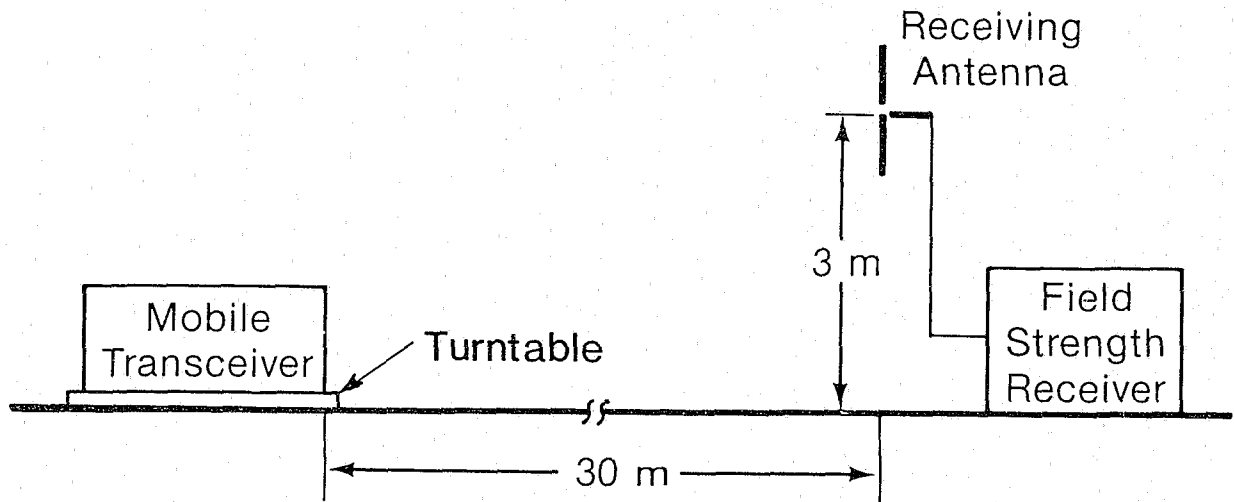


FIGURE 16. Block diagram for radiated spurious emission measurement for type I and II transceivers.

### 5.5.3.3 Radiated Spurious Emissions Test (Type III and IV Transceivers)

Set up the mobile transceiver and the test equipment as shown in figure 17 at a site that meets the requirements of section 5.1.8.2. Place the microwave absorber, at least 1.8 m (6 ft) wide, on the ground between the mobile transceiver and the receiving antenna, as shown. Connect the transmitter to the standard output load and adjust it to produce nominal output power. Measure the spurious emissions with both the receiving antenna and the transmitter 1 m (3.3 ft) above the earth and the horizontally-polarized receiving antenna 3 m (9.8 ft) from the transmitter. Tune the field strength meter from the lowest radio frequency generated in the equipment up to 3 GHz. Note each spurious emission.

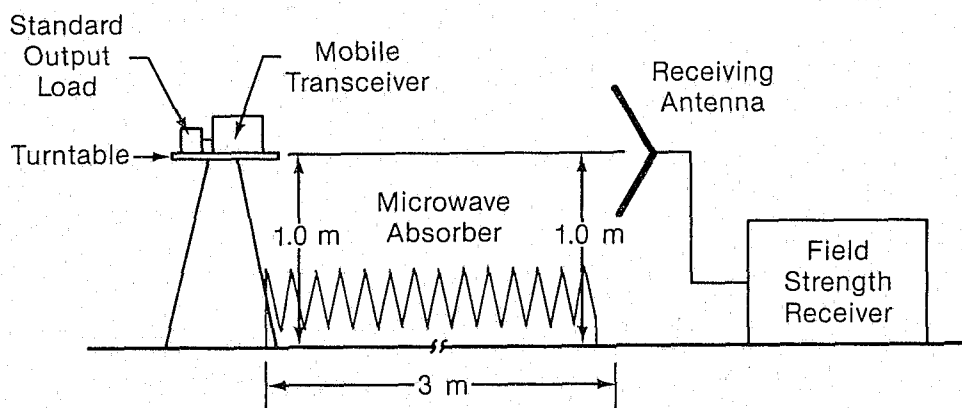


FIGURE 17. Block diagram for radiated spurious emission measurement for type III and IV transceivers.

For each spurious frequency noted, raise and lower the receiving antenna with a horizontal polarization to obtain a maximum reading on the field strength receiver. Rotate the transmitter to further maximize this reading. Repeat this procedure of raising and lowering the antenna and rotating the transmitter until the largest signal has been obtained and recorded. Then orient the antenna for vertical polarization and repeat the procedure for each spurious signal. Record the maximum field strength of the spurious frequencies.

#### 5.5.3.4 Sideband Spectrum Test

Connect the transceiver transmitter and test equipment as shown in figure 18. Using the variable attenuator, adjust the unmodulated carrier signal for a full-scale signal 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  $\pm 10$  kHz and  $\pm 20$  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 19.

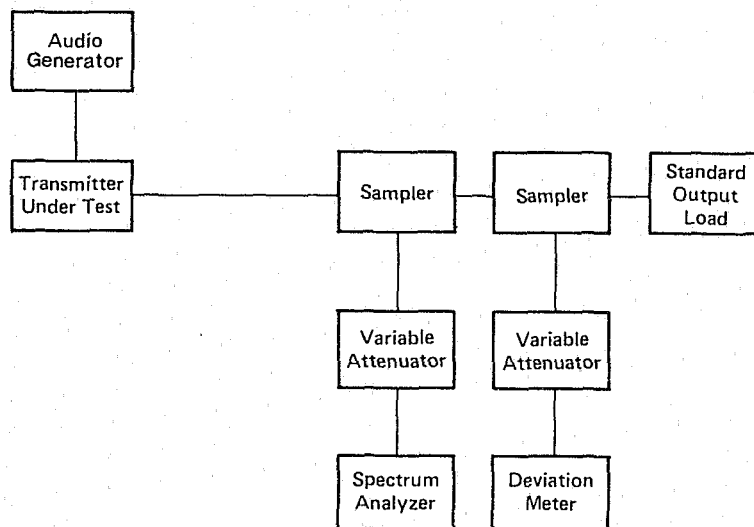


FIGURE 18. Block diagram for sideband spectrum measurement.

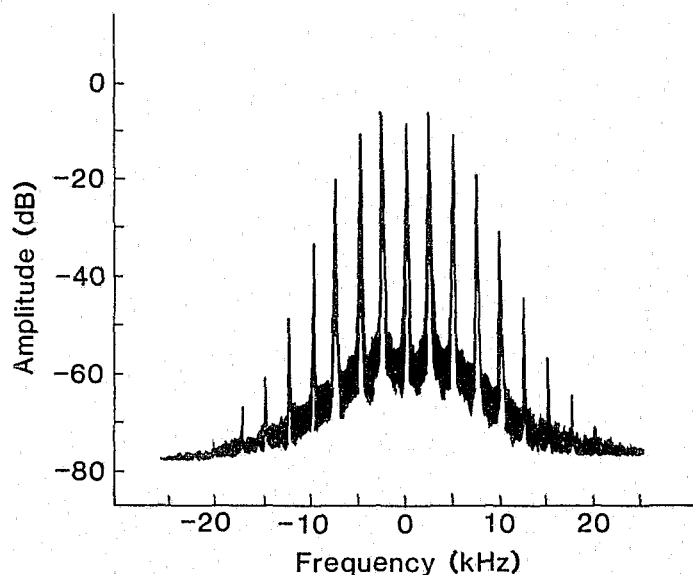


FIGURE 19. Typical sideband spectrum of a transmitter using a 2.5 kHz tone 16 dB greater than that required to produce  $\pm 2.5$  kHz deviation at 1.0 kHz.

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



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