U.S. Department of Justice
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National Institute of Justice / *Technology Assessment*

TECHNOLOGY ASSESSMENT PROGRAM

Fixed and Base Station FM Receivers

NIJ Standard–0206.01

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James K. Stewart, Director
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Fixed and Base Station FM Receivers

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Supersedes NILECJ-STD-0206.00 dated September 1975

July 1988

U.S. DEPARTMENT OF JUSTICE
National Institute of Justice

James K. Stewart, Director

Supersedes NILECJ-STD-0206.00 dated September 1975.

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FOREWORD

This document, NIJ Standard-0206.01, Fixed and Base Station FM Receivers, 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 (NIJ). 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.

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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.

Lester D. Shubin
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National Institute of Justice

NIJ STANDARD FOR FIXED AND BASE STATION FM RECEIVERS

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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)	Ω	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
°C	degree Celsius	lb	pound	rad	radian
°F	degree 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	*M*	molar	SWR	standing wave radio
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
g	acceleration	m/s	meter per second	W	watt
g	gram	N	newton	λ	wavelength
gr	grain	N·m	newton meter	wt	weight

area = unit^2 (e.g., ft^2, in^2, etc.); volume = unit^3 (e.g., ft^3, m^3, etc.)

PREFIXES

d	deci (10^{-1})	da	deka (10)
c	centi (10^{-2})	h	hecto (10^2)
m	milli (10^{-3})	k	kilo (10^3)
μ	micro (10^{-6})	M	mega (10^6)
n	nano (10^{-9})	G	giga (10^9)
p	pico (10^{-12})	T	tera (10^{12})

COMMON CONVERSIONS
(See ASTM E380)

ft/s × 0.3048000 = m/s	lb × 0.4535924 = kg
ft × 0.3048 = m	lbf × 4.448222 = N
ft·lbf × 1.355818 = J	lbf/ft × 14.59390 = N/m
gr × 0.06479891 = g	lbf·in × 0.1129848 = N·m
in × 2.54 = cm	lbf/in^2 × 6894.757 = Pa
kWh × 3 600 000 = J	mph × 1.609344 = km/h
	qt × 0.9463529 = L

Temperature: $(T_{°F} - 32) \times 5/9 = T_{°C}$

Temperature: $(T_{°C} \times 9/5) + 32 = T_{°F}$

NIJ STANDARD FOR FIXED AND BASE STATION FM RECEIVERS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for non-trunked, frequency modulated (FM) fixed and base station receivers used by law enforcement agencies. This standard applies to voice-modulated nonmultiplex receivers 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-0206.00, Fixed and Base Station FM Receivers, dated September 1975. This revision has been written to include receivers operating in the 806–866 MHz frequency band and it also provides modified requirements for receiver sensitivity, audio response and closing time. The tests have been revised to accommodate receivers with a balanced audio output and updated to incorporate improved tests of spurious and harmonic response attenuation and intermodulation attenuation.

2. CLASSIFICATION

For the purpose of this standard, fixed and base station FM receivers are classified by their operating frequencies.

2.1 Type 1

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

2.2 Type II

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

2.3 Type III

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

2.4 Type IV

Receivers 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][1].

3.1 Adjacent-Channel Selectivity and Desensitization

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

[1] Numbers in brackets refer to the 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 audiofrequency 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 unsquelched 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 unsquelched receiver having a modulated rf signal input.

3.7 Audio Response

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

3.8 Authorized Bandwidth

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

3.9 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.

3.10 Intermodulation Response

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

3.11 Maximum Squelch Position

The adjustment of the squelch control of a receiver to the least sensitive condition.

3.12 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.

3.13 Noise Quieting

The reduction of receiver audio noise output caused by the presence of an incoming rf signal.

3.14 Nominal Value

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

3.15 Rated System Deviation

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

3.16 Receive Mode

The condition of a receiver when unsquelched and receiving information.

3.17 Receiver Attack Time

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

3.18 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.

3.19 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.

3.20 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.

3.21 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 *SI*gnal *N*oise *A*nd *D*istortion *R*atio.

3.22 SINAD Sensitivity

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

3.23 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.

3.24 Squelch

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

3.25 Squelch Block

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

3.26 Standing Wave Ratio (SWR)

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

3.27 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.

3.28 Threshold Squelch Sensitivity

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

3.29 Tight Squelch Sensitivity

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

4. REQUIREMENTS

4.1 Minimum Performance

The receiver performance shall meet or exceed the requirement for each characteristic as given below and in table 1. The 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 table 1 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 receiver is designed to be operated, the receiver operating frequencies, the receiver audio output impedance, and the standard supply voltage.

4.3 Performance at Environmental Extremes

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

4.3.1 Temperature Stability

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

When the receiver 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 U), more than items V through AB, 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 AC) for an rf signal with standard modulation.

4.3.2 Humidity Stability

After the receiver has been maintained at 50 °C (122 °F) and 90 percent relative humidity or greater for at least 8 hours, its performance shall not vary, with respect to the appropriate values in table 1 (items A through U), more than items AD through AJ, 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 AK) for an rf signal with standard modulation.

4.4 SINAD Sensitivity

When measured in accordance with paragraph 5.4, the SINAD sensitivity of the receiver shall be 0.4 μV (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.,

TABLE 1. *Minimum performance requirements for fixed and base station FM receivers.*

Receiver Characteristic	*Minimum requirement frequency band*			
	25–50	*150–174*	*400–512*	*806-866*
Sensitivity Characteristics				
A. SINAD Sensitivity	0.4 μV	0.4 μV	0.4 μV	0.4 μV
B. SINAD Sensitivity Variance (Supply Voltage Varied ±10%)	0.4 μV	0.4 μV	0.4 μV	0.4 μV
Selectivity Characteristics				
C. Minimum Usable Bandwidth	±5 kHz	±5 kHz	±5 kHz	±5 kHz
D. Adjacent-Channel Selectivity and Desensitization	85 dB	85 dB	85 dB	80 dB
E. Spurious and Harmonic Response Attenuation	95 dB	95 dB	95 dB	85 dB
F. Intermodulation Attenuation	70 dB	75 dB	80 dB	65 dB
Squelch Characteristics				
G. Threshold Squelch Sensitivity	0.2 μV	0.3 μV	0.3 μV	0.3 μV
H. Tight Squelch Sensitivity	2.5 μV	2.5 μV	2.5 μV	2.5 μV
I. Threshold Squelch Sensitivity Variance (Supply Voltage Varied ±10%)	0.2 μV	0.3 μV	0.3 μV	0.3 μV
J. Squelch Block	±5 kHz	±5 kHz	±5 kHz	±5 kHz
K. Receiver Attack Time	150 ms	150 ms	150 ms	150 ms
L. Receiver Closing Time	150 ms	150 ms	150 ms	150 ms
Audio Characteristics				
M. Audio Output Power (Loudspeaker)	5 W	5 W	5 W	5 W
N. Audio Output Power (Earphones)	3 mW	3 mW	3 mW	3 mW
O. Audio Output Power (Telephone Line)	12 mW	12 mW	12 mW	12 mW
P. Audio Output Power Variance (Supply Voltage Varied ±10%)	0.1 dB	0.1 dB	0.1 dB	0.1 dB
Q. Audio Distortion	5%	5%	5%	5%
R. Audio Response (Loudspeaker)	−8, +2 dB	−8, +2 dB	−8, +2 dB	−8, +2 dB
S. Audio Response (Earphones and Telephone Line)	−3, +1 dB	−3, +1 dB	−3, +1 dB	−3, +1 dB
T. Audio Hum and Noise (Unsquelched)	45 dB	45 dB	45 dB	45 dB
U. Audio Hum and Noise (Squelched)	60 dB	60 dB	60 dB	60 dB
Temperature Stability				
V. SINAD Sensitivity	6 dB	6 dB	6 dB	6 dB
W. Minimum Usable Bandwidth	20%	20%	20%	20%
X. Adjacent-Channel Selectivity and Desensitization	12 dB	12 dB	12 dB	12 dB
Y. Tight Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
Z. Threshold Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
AA. Audio Output Power	6 dB	6 dB	6 dB	6 dB
AB. Audio Hum and Noise	10 dB	10 dB	10 dB	10 dB
AC. Audio Distortion	9%	9%	9%	9%
Humidity Stability				
AD. SINAD Sensitivity	6 dB	6 dB	6 dB	6 dB
AE. Minimum Usable Bandwidth	20%	20%	20%	20%
AF. Adjacent-Channel Selectivity and Desensitization	12 dB	12 dB	12 dB	12 dB
AG. Tight Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
AH. Threshold Squelch Sensitivity	6 dB	6 dB	6 dB	6 dB
AI. Audio Output Power	3 dB	3 dB	3 dB	3 dB
AJ. Audio Hum and Noise	10 dB	10 dB	10 dB	10 dB
AK. Audio Distortion	9%	9%	9%	9%

2.5 W. When the standard power supply voltage is varied ±10 percent, the SINAD sensitivity shall be 0.4 μV (item B) or less.

4.5 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 paragraph 5.5.

4.5.1 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.

4.5.2 Adjacent-Channel Selectivity and Desensitization

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

4.5.3 Spurious and Harmonic Response Attenuation

The spurious and harmonic response attenuation of type I, II and III receivers shall be 95 dB (item E) or more as compared to the on-channel 20-dB noise-quieting signal voltage for responses of the receiver between the lowest intermediate frequency of the receiver and at least twice the receiver operating frequency, or 1000 MHz, whichever is higher. For type IV receivers, the spurious and harmonic response shall be 85 dB (item E) or more as compared to the standard SINAD signal voltage for responses of the receiver between the lowest intermediate frequency of the receiver and at least twice the receiver operating frequency.

4.5.4 Intermodulation Attenuation

The intermodulation attenuation of type I, II and III receivers 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. For type IV receivers, the intermodulation attenuation shall be 65 dB (item F) or more for a degradation of an on-channel signal from the 12-dB SINAD ratio plus 3 dB excess to the 12-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.

4.6 Squelch Characteristics

The squelch characteristics of sensitivity, block, receiver attack time and receiver release time shall be measured in accordance with paragraph 5.6.

4.6.1 Squelch Sensitivity

The threshold squelch sensitivity of the receiver shall be item G or less. The tight squelch sensitivity shall be 2.5 μV (item H) or less. When the standard power supply voltage is varied +10 percent and −10 percent, the threshold squelch sensitivity shall be item I or less.

4.6.2 Squelch Block

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

4.6.3 Receiver Attack Time

The receiver attack 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.

4.6.4 Receiver Closing Time

The receiver closing time for the audio output power of the receiver to decrease to 10 percent of 5 W, i.e., 0.5 W, shall be 150 ms (item L) or less.

4.7 Audio Characteristics

The audio characteristics of output power, distortion, response, and hum and noise shall be measured in accordance with paragraph 5.7.

4.7.1 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, at least 3 mW (item N) if earphones are used, and 12 mW (item O) if a telephone line is used. When the standard supply voltage is varied +10 percent and −10 percent, the audio output power shall not be reduced more than 0.1 dB (item P) below 5 W.

4.7.2 Audio Distortion

Audio distortion at audio output powers of 5 W and 3 mW shall be less than 5 percent (item Q) for an rf input signal with standard modulation.

4.7.3 Audio Response

The audio response of the receiver, when used with a loudspeaker, shall be within −8, +2 dB (item R) of an ideal 6 dB per octave deemphasis curve with constant frequency deviation at frequencies between 0.3 and 3 kHz, with the exception that an additional 6 dB per octave roll-off may be present from 600 to 300 Hz. When used with earphones or telephone line, the audio response of the receiver shall also be within −3, +1 dB (item S) of the same curve 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.

4.7.4 Audio Hum and Noise

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

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 Power Supply Voltage

The standard supply voltage shall be 120 V, 60 Hz, unless otherwise stated by the manufacturer. Variable auto transformers or tapped transformers may be used to adjust the supply voltage to the required value, which should be measured at the receiver power supply input terminals, if practicable, and adjusted to within 1 percent of the nominal value.

5.1.4 Standard Test Frequencies

The standard receiver test frequency shall be the receiver operating frequencies specified in section 4.2.

5.1.5 Standard Audio Test Modulation

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

5.1.6 Standard Squelch Adjustment

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

5.1.7 Standard Duty Cycle

The standard duty cycle shall be continuous operation in the receive 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 FM Signal Generator

The FM signal generator shall have a 50-Ω output impedance, a maximum SWR of 1.2 and a calibrated variable output level accurate to ±2 dB when terminated in a 50-Ω 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 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 such generators are required.

5.2.2 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.

5.2.3 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 Ω shunted by less than 100 pF and an accuracy of at least ±1 dB. It shall have the capability to measure both audio distortion and the rms voltage of audio signals to within ±3 percent. The analyzer shall incorporate a 1000-Hz band elimination filter for the audio distortion measurements.

5.2.4 Isolation Transformer

The isolation transformer shall have a turns ratio of 1 to 1, an impedance of 600 Ω, a frequency response within ±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.

5.2.5 Standard Audio Output Load

The standard audio output load shall be either the actual speaker or an impedance equivalent to the nominal impedance of the receiver speaker with a power rating equal to or exceeding the nominal audio output power of the 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.

5.2.6 Standard RF Input Load

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

5.2.7 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.

5.2.8 Audio Voltmeter

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

5.2.9 Chart Recorder

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

5.2.10 Deviation Meter

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

5.2.11 Environmental Chamber

The environmental chamber shall produce air temperatures from −30 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.

5.3 Environmental Tests

The environmental tests shall be performed using standard supply voltage and the measurement techniques described in sections 5.4 through 5.7.

5.3.1 Temperature Test

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

5.3.2 Humidity Test

Place the receiver, 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 receiver at these conditions for at least 8 hours. With the receiver still in this environment, connect it to the standard supply voltage and operate it at the receiver standard duty cycle. Fifteen minutes after turn-on, test the receiver to determine whether it meets the requirements of section 4.3.2.

5.4 SINAD Sensitivity Test

Connect the receiver and test equipment as shown in figure 1 for those receivers with a balanced audio output. For those receivers with an unbalanced 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.

5.5 Selectivity Tests

5.5.1 Minimum Usable Bandwidth Test

Connect the receiver and test equipment as shown in figure 1, with or without the isolation transformer, as necessary. Adjust the receiver and FM signal generator in accordance with section 5.4 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 again obtained. Record the generator frequency. Repeat this measurement by adjusting the generator frequency below the test frequency and record the generator frequency. The smaller displacement from the test frequency +3 kHz (standard test modulation deviation) is the receiver bandwidth.

FIGURE 1. *Block diagram for SINAD sensitivity, minimum usable bandwidth, squelch sensitivity, squelch block, and audio distortion measurements.*

5.5.2 Adjacent-Channel Selectivity and Desensitization Test

Connect the receiver and test equipment as shown in figure 2. With the output of generator No. 2 set to zero, adjust the receiver and signal generator No. 1 in accordance with section 5.4 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.

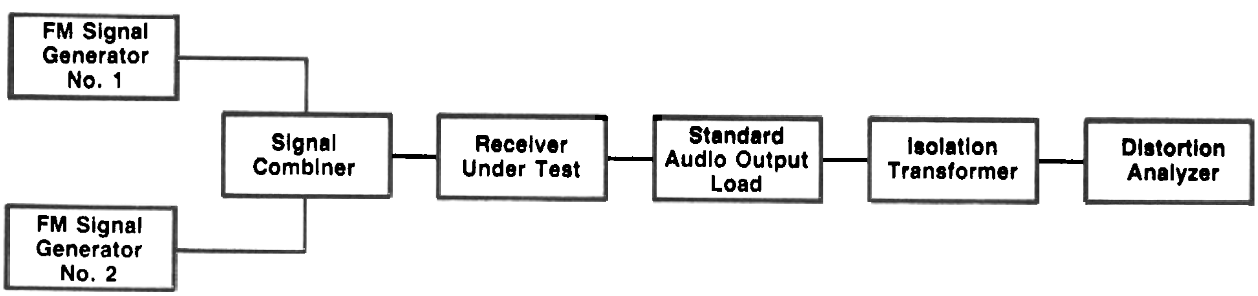

FIGURE 2. *Block diagram for adjacent-channel selectivity and desensitization, and spurious and harmonic response attenuation measurements for type IV receivers.*

5.5.3 Spurious and Harmonic Response Attentuation Tests

5.5.3.1 Type I, II, and III Receivers

Connect the receiver and test equipment as shown in figure 3. Adjust the CW signal generator to the standard test frequency. 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 (dBμV) 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, use a signal generator that can be swept automatically and a chart recorder or voltmeter as an automatic means of recording receiver response as a function of frequency, 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 dBμV. The generator output at the spurious response frequency minus the generator output at the standard test frequency is the spurious response attenuation. Repeat for all spurious responses. The smallest attenuation is the value sought.

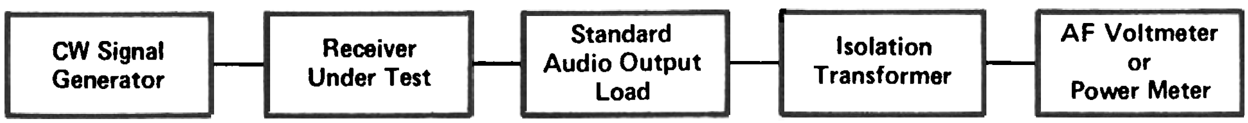

FIGURE 3. *Block diagram for spurious and harmonic response attenuation measurement for type I, II and III receivers.*

5.5.3.2 Type IV Receivers

Connect the receiver and test equipment as shown in figure 2. With the output of FM signal generator No. 2 set to zero, adjust the receiver and signal generator No. 1 in accordance with section 5.4 until a 12-dB SINAD ratio is reached. Note the generator output in dBμV. Increase the signal level of signal generator No. 1 by 3 dB. Adjust signal generator No. 2 for 3 kHz frequency deviation at 400 Hz. Then increase the output of signal generator No. 2 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. For large frequency bandwidths, use a signal generator that can be swept automatically and a chart recorder or voltmeter as an automatic means of recording receiver response as a function of frequency, as this sweep may take many hours. Then go back and measure the response at each frequency recorded. At the frequency of each spurious response, change the level of signal generator No. 2 until the standard SINAD is obtained at the receiver output terminals. Record the frequency of the unwanted input signal along with its dBμV level at the input of the receiver. The ratio, in decibels, of the output voltage of signal generator No. 2 to that of signal generator No. 1 at the 12-dB SINAD ratio is the value sought. Repeat for all spurious responses. The smallest attenuation is the value sought.

5.5.4 Intermodulation Attenuation Tests

5.5.4.1 Type I, II, and III Receivers

Connect the receiver and test equipment as shown in figure 4. With the output levels of signal generators Nos. 2 and 3 set to zero, adjust the receiver and FM signal generator No. 1 in accordance with section 5.4 until a 12-dB SINAD ratio is reached. Adjust unmodulated generator No. 2 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 generators Nos. 2 and 3 to produce a 6-dB SINAD ratio with all three signals present. Maintain generators 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 the generators 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.

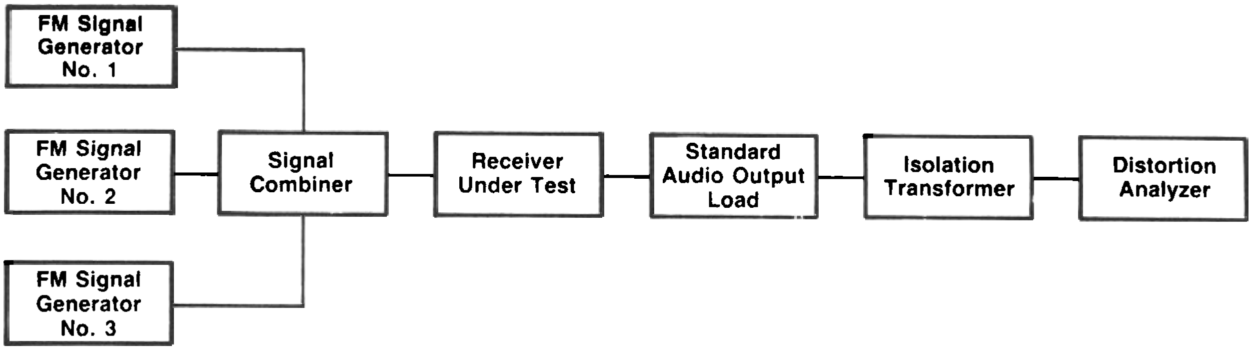

FIGURE 4. *Block diagram for intermodulation attenuation measurement.*

5.5.4.2 Type IV Receivers

Connect the receiver and test equipment as shown in figure 4. With the output levels of FM signal generators Nos. 2 and 3 set to zero, adjust the receiver and FM signal generator No. 1 in accordance with section 5.4 until a 12-dB SINAD ratio is reached. Increase the signal level of signal generator No. 1 by 3 dB. Adjust unmodulated generator No. 2 to the center frequency of the next higher adjacent channel. Adjust unmodulated generator No. 3 to the center frequency of the second higher adjacent channel, i.e., two channels above the standard test frequency. Incrementally increase the levels of signal generators Nos. 2 and 3 until the SINAD of the receiver under test is degraded to the 12-dB SINAD ratio. Maximize this degradation by adjusting the frequency of either signal generator No. 2 or No. 3. Maintain generator Nos. 2 and 3 at equal output voltages throughout the measurement. The ratio, in decibels, of the output voltage of generator No. 2 (or 3) to that of the 12-dB SINAD ratio of the receiver 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.

5.6 Squelch Tests

5.6.1 Squelch Sensitivity Tests

Connect the receiver and test equipment as shown in figure 1 with or without the isolation transformer, as necessary. Adjust the receiver and FM signal generator in accordance with section 5.4 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 using +10 percent and −10 percent standard supply voltages.

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

5.6.2 Squelch Block Test

Connect the receiver and test equipment as shown in figure 1. Adjust the receiver and FM signal generator in accordance with section 5.4 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.

5.6.3 Receiver Attack Time Test

Connect the equipment as shown in figure 5a. 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.

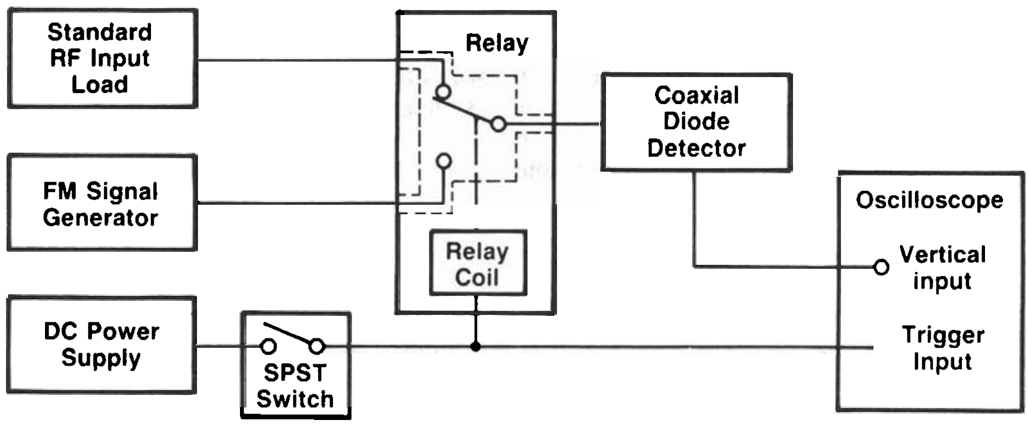

FIGURE 5a. *Block diagram for setting oscilloscope trigger.*

Connect the receiver and test equipment as shown in figure 5b. With the SPST switch closed, adjust the FM signal generator in accordance with section 5.4 until the 12-dB SINAD ratio is reached with an output of 5 W. 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 for receiver attack time.

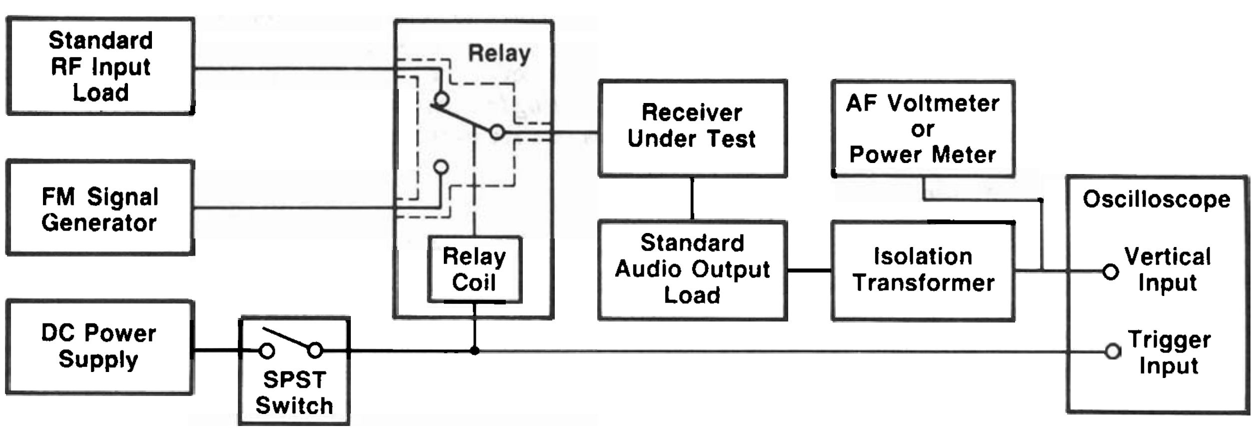

FIGURE 5b. *Block diagram for receiver attack time and receiver closing time measurements.*

5.6.4 Receiver Closing Time Test

Connect equipment as shown in figure 5a. Adjust the oscilloscope so the output from the diode coaxial detector stops at the left graticule of the oscilloscope when the SPST switch is opened. Interconnect the receiver and test equipment as shown in figure 5b. Adjust all equipment as in 5.6.3. 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.

5.7 Audio Tests

5.7.1 Audio Output Power Test

Connect the receiver and test equipment as shown in figure 6 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, set the receiver volume control to the maximum position, and measure the audio output power. Repeat using +10 percent and −10 percent standard supply voltages.

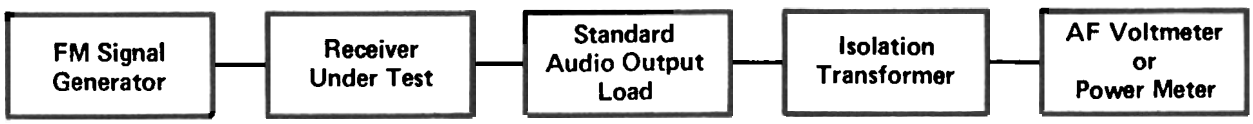

FIGURE 6. *Block diagram for audio output power, audio response, and audio hum and noise measurements.*

5.7.2 Audio Distortion Test

Connect the receiver and test equipment as shown in figure 1. 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. Repeat at an audio output power of 3 mW for earphones and 12 mW for telephone lines.

5.7.3 Audio Response Test

Connect the receiver and test equipment as shown in figure 6. 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.

5.7.4 Audio Hum and Noise Tests

Connect the receiver and test equipment as shown in figure 6. 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 (unsquelched).

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

APPENDIX A—REFERENCES

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