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JUNE 1975

LAW ENFORCEMENT STANDARDS PROGRAM

MOBILE FM RECEIVERS

STANDARD

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NILECJ STANDARD FOR MOBILE FM RECEIVERS

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

JUNE 1975

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This standard was formulated by the Law Enforcement Standards Laboratory of the National Bureau of Standards under the direction of Marshall J. Treado, Program Manager for Communications Systems, and Jacob J. Diamond, Chief of LESL. NBS Electromagnetics Division staff members responsible for the preparation of the standard were Harold E. Taggart, project manager, M. Gerald Arthur, Leon F. Saulsbery, Winston W. Scott, Jr., and John F. Shafer. Acknowledgment is given to previous work in this field by the Associated Public-Safety Communications Officers, Inc.; the Institute of Electrical and Electronics Engineers, Inc.; the Electronic Industries Association; the American National Standards Institute; and the International Electrotechnical Commission.

NILECJ STANDARD for MOBILE FM RECEIVERS

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FOREWORD

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

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

This document, NILECJ-STD-0207.00, Mobile FM Receivers, is a law enforcement equipment standard developed by LESL and approved and issued by NILECJ. Additional standards as well as other documents are being issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles and clothing.

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

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

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

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

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

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

NILECJ STANDARD for MOBILE FM RECEIVERS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for frequency modulated mobile and vehicular 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 disabled or by-passed during testing for compliance with this standard.

2. CLASSIFICATION

For the purposes of this standard, mobile FM receivers are classified by their operating frequencies and their channel spacing.

2.1. Type I

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

2.2. Type II

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

2.3. Type III

Receivers which operate in the 25–50 MHz band with a channel spacing of 20 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 (Radio Antennas, Transmitters and Receivers)."

3.1. Adjacent-Channel Selectivity and Desensitization

The ability of a receiver to discriminate between a desired signal and an undesired signal at the frequency of an adjacent channel.

3.2. 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 signal input.

3.3. Audio Noise Output Power

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

3.4. Audio Output Power

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

3.5. Audiofrequency Harmonic Distortion

The generation, in a system, of integral multiples of a single audiofrequency input signal.

3.6. Audiofrequency Response

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

3.7. Intermodulation Attenuation

The ratio, expressed in decibels, of (1) the selected rf signal levels that produce an intermodulation response to (2) the receiver's SINAD sensitivity.

3.8. 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.

3.9. Modulation Acceptance Bandwidth

The maximum frequency deviation of an input signal which has twice the amplitude of the 12 dB sensitivity voltage and which produces a 12 dB SINAD ratio.

3.10. Noise Quieting

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

3.11. Rated System Deviation

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

3.12. Receive Mode

The condition of a receiver when unsquelched and receiving information.

3.13. Selectivity

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

3.14. SINAD Ratio

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

3.15. SINAD Sensitivity

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

3.16. Spurious Response

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

3.17. Squelch Attack Time

The time required to produce a designated audio output power level upon application of an rf input signal.

3.18. Squelch Block

A squelched condition resulting from excessive frequency deviation.

3.19. Squelch

A circuit function for preventing a radio receiver from producing audio output power in the absence of rf signals.

3.20. Squelch Release Time

The time required to reduce audio noise output power to a designated level upon removal of the rf input signal.

3.21. Standby Mode

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

3.22. Threshold Squelch Sensitivity

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

3.23. Threshold Squelched 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.

3.24. Tight-Squelch Sensitivity

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

4. REQUIREMENTS

4.1. Minimum Performance

The requirement for each receiver characteristic shall be the value listed in table 1. These performance requirements meet or exceed those given in the Rules and Regulations published by the Federal Communications Commission. In addition to the requirements listed, all of the licensing and operating requirements of the FCC Rules and Regulations shall apply.

TABLE 1. *Minimum performance requirements for mobile FM receivers*

Receiver characteristic	Minimum requirement frequency band (MHz)		
	25–50	150–174	400–512
Sensitivity characteristic:			
A. SINAD sensitivity	0.5 μV	0.5 μV	0.5 μV
B. SINAD sensitivity variance (supply voltage varied ± 10%)	0.7 μV	0.7 μV	0.7 μV
Selectivity characteristics:			
C. Modulation acceptance bandwidth	±5 kHz	±5 kHz	±5 kHz
D. Adjacent channel selectivity and desensitization	80 dB	80 dB	80 dB
E. Spurious response attenuation	95 dB	95 dB	95 dB
F. Intermodulation attenuation	60 dB	75 dB	80 dB
Squelch characteristics:			
G. Threshold squelch sensitivity	0.2 μV	0.3 μV	0.3 μV
H. Tight squelch sensitivity	2.0 μV	3.0 μV	3.0 μV
I. Threshold squelch sensitivity variance (supply voltage varied ± 10%)	0.3 μV	0.4 μV	0.4 μV
J. Squelch block	±5 kHz	±5 kHz	±5 kHz
K. Squelch attack time	150 ms	150 ms	150 ms
L. Squelch release time	250 ms	250 ms	250 ms
Audiofrequency characteristics:			
M. Audio output power (loudspeaker)	5 W	5 W	5 W
N. Audio output power (earphones)	3 mW	3 mW	3 mW
O. Audio output power variance (supply voltage varied ±10%)	2 dB	2 dB	2 dB

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TABLE 1. *Minimum performance requirements for mobile FM receivers* — Continued

Receiver characteristic	Minimum requirement frequency band (MHz)		
	25–50	150–174	400–512
P. Audio distortion	5%	5%	5%
Q. Audiofrequency response (loudspeaker)	−8, +2 dB	−8, +2 dB	−8, +2 dB
R. Audiofrequency response (earphones)	−3, +1 dB	−3, +1 dB	−3, +1 dB
S. Audio hum and noise (unsquelched)	45 dB	45 dB	45 dB
T. Audio hum and noise (squelched)	60 dB	60 dB	60 dB
Environmental characteristics:			
Temperature stability:			
U. SINAD sensitivity	6 dB	6 dB	6 dB
V. Modulation acceptance bandwidth	20%	20%	20%
W. Adjacent channel selectivity and desensitization	12 dB	12 dB	12 dB
X. Tight squelch sensitivity	6 dB	6 dB	6 dB
Y. Threshold squelch sensitivity	6 dB	6 dB	6 dB
Z. Audio output power	6 dB	6 dB	6 dB
AA. Audio hum and noise	10 dB	10 dB	10 dB
AB. Audio distortion	9%	9%	9%
Humidity stability:			
AC. SINAD sensitivity	6 dB	6 dB	6 dB
AD. Modulation acceptance bandwidth	20%	20%	20%
AE. Adjacent channel selectivity and desensitization	12 dB	12 dB	12 dB
AF. Tight squelch sensitivity	6 dB	6 dB	6 dB
AG. Threshold squelch sensitivity	6 dB	6 dB	6 dB
AH. Audio output power	3 dB	3 dB	3 dB
AI. Audio hum and noise	10 dB	10 dB	10 dB
AJ. Audio distortion	9%	9%	9%

4.2. User Information

The receiver operating frequencies and nominal values for the receiver audio output impedance, the power source current in the receive mode and each receiver characteristic listed in table 1 shall be included in the information supplied to the user by the manufacturer or distributor.

4.3. Test Sequence

The test sequence shall be in the order listed herein. Each receiver shall be subjected to the environmental tests, and then shall be tested for conformance with paragraphs 4.5 through 4.8.

4.4. Environmental Characteristics

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

4.4.1. Temperature Stability

When the receiver is operated at temperatures of −30 °C (−22 °F) and 60 °C (140 °F), its performance shall not be degraded, with respect to the appropriate value in table 1, more than item U through AA, for the characteristics listed. In addition, the audio distortion at an audio output power of (item M) shall be less than (item AB) for an rf signal with standard modulation.

4.4.2. 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 be degraded, with respect to the appropriate value in table 1, more than item AC through AI, for the characteristics listed. In addition, the audio distortion at an audio output power of (item M) shall be less than (item AJ) for an rf signal with standard modulation.

4.4.3. Vibration Stability

No fixed part of the receiver shall come loose, nor movable part be shifted in position or adjustment, as a result of this test. The receiver shall meet the SINAD sensitivity (item A), audio output power (item M) and audio distortion (item P) performance requirements during the vibration test.

4.4.4. Shock Stability

No fixed part of the receiver shall come loose, or movable part be shifted in position or adjustment, as a result of this test.

4.5. SINAD Sensitivity

When measured in accordance with paragraph 5.4, the SINAD sensitivity of the receiver shall be (item A) or less with a SINAD ratio of 12 dB and at least 50 percent of the value of audio output power (item M). When the standard power supply voltage (5.1.3) is varied ±10 percent, the SINAD sensitivity shall be (item B) or less.

4.6. Selectivity Characteristics

The selectivity characteristics of modulation acceptance bandwidth, adjacent channel selectivity and desensitization, spurious response attenuation and intermodulation attenuation shall be measured in accordance with paragraph 5.5.

4.6.1. Modulation Acceptance Bandwidth

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

4.6.2. 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.

4.6.3. Spurious Response Attenuation

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

4.6.4. 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.

4.7. Squelch Characteristics

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

4.7.1. Squelch Sensitivity

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

4.7.2. Squelch Block

The receiver shall not squelch for modulation frequencies from 0.3 to 3.0 kHz when the squelch control is adjusted to the maximum squelch position and the frequency deviation of the input signal is (item J) or less.

4.7.3. Squelch Attack Time

The squelch attack time for the receiver to produce 90 percent of the audio output power (item M) shall be (item K) or less.

4.7.4. Squelch Release Time

The squelch release time for the audio output of the receiver to decrease to 10 percent of the audio output power (item M) shall be (item L) or less.

4.8. Audiofrequency Characteristics

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

4.8.1. Audio Output Power

The audio output power of the receiver shall be at least (item M) if a loudspeaker is used at the receiver output and (item N) if earphones are used. When the standard power supply voltage is varied ± 10 percent, the audio output power shall not be reduced more than (item O) below (item M).

4.8.2. Audio Distortion

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

4.8.3. Audiofrequency Response

The audiofrequency response of the receiver, when used with a loudspeaker, shall be within (item Q) of an ideal 6 dB per octave de-emphasis curve with constant frequency deviation at all frequencies between 0.3 and 3.0 kHz. When used with earphones, the audiofrequency response of the receiver shall be within (item R) of the same curve at all frequencies between 0.3 and 3.0 kHz.

4.8.4. Audio Hum and Noise

The audio hum and noise output power from the receiver in an unsquelched condition shall be (item S) or more, and in a squelched condition shall be (item T) or more below audio output power (item M).

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. Disable or bypass all special subsystems before testing.

5.1.1. Standard Temperature

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

5.1.2. Standard Relative Humidity

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

5.1.3. Standard Power Supply Voltage

In a nominal 12 volt dc system, the standard supply voltage shall be determined by the equation $V = 13.8 - 0.02\ I$, where I is the current (in amperes) drawn by the receiver in the receive mode. For example, if the current while receiving is 5 amperes, the standard supply voltage is 13.7 volts. Appropriate factors shall be used for other voltage supply systems. A well filtered electronic power supply 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 Frequency

The standard receiver test frequency shall be any one of the operating frequencies as specified in paragraph 4.2.

5.1.5. Standard Test Modulation

Standard test modulation shall be a 1 kHz sinusoidal modulating signal having less than 1 percent total distortion at the level required to produce a ±3 kHz frequency deviation.

5.1.6. Standard Squelch Adjustment

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

5.1.7. Standard Duty Cycle

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

5.2. Test Equipment

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

5.2.1. FM Signal Generator

The FM signal generator shall have a 50 ohm output impedance, a maximum standing-wave ratio of 1.2, and an output level accurate to ±2 dB. 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.

5.2.2. CW Signal Generator

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

5.2.3. Standard RF Input Load

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

5.2.4. Standard Audio Output Load

The standard audio output load shall be a resistor having a resistance equal to the output impedance of the receiver and 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.

5.2.5. Audiofrequency Voltmeter

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

5.2.6. Signal Combiner

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

5.2.7. Environmental Chamber

The environmental chamber shall produce air temperatures from −30 to 60 °C (−22 to 140 °F) and relative humidities in excess of 90 percent while shielding the test receiver from heating or cooling air currents blowing directly on it. The temperature of the test receiver 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

5.3.1. Temperature Test

Place the receiver, with outer cases installed and with power turned off, in the environmental chamber. Adjust the temperature to −30±2 °C (−22±3.6 °F). Allow the receiver to reach temperature equilibrium and maintain it at this temperature for 30 minutes. Turn on the receiver power. Fifteen minutes after turn-on, test the receiver to determine whether it meets the requirements of paragraph 4.4.1. Repeat the above procedure at a temperature of 60±2 °C (140±3.6 °F).

5.3.2. Humidity Test

Place the receiver, with power turned off, in the environmental chamber. Adjust the relative humidity to a minimum of 90 percent at 50 °C (122 °F) or more. Maintain the receiver at these conditions for at least 8 hours. With the receiver still in this environment, turn on the receiver power, allow the receiver to operate for 15 minutes, and then test it to determine whether it meets the requirements of paragraph 4.4.2.

5.3.3. Vibration Test

Perform a two part test for a total of 30 minutes in each of three directions, namely the directions parallel to both axes of the base and perpendicular to the plane of the base. During the test, measure the SINAD sensitivity (5.4), audio output power (5.7.1) and audio distortion (5.7.2).

First subject the receiver to three 5-minute cycles of simple harmonic motion having an amplitude of 0.38 mm (0.015 inch) [total excursion of 0.76 mm (0.03 inch)] applied initially at a frequency of 10 Hz and increased at a uniform rate to 30 Hz in 2½ minutes, then decreased at a uniform rate to 10 Hz in 2½ minutes. Repeat for each of the other two directions.

Then subject the receiver to three 5-minute cycles of simple harmonic motion having an amplitude of 0.19 mm (0.0075 inch) [total excursion of 0.38 mm (0.015 inch)] applied initially at a frequency of 30 Hz and increased at a uniform rate to 60 Hz in 2½ minutes, then decreased at a uniform rate to 30 Hz in 2½ minutes. Repeat for each of the other two directions.

5.3.4. Shock Test

Subject the receiver to a series of 10 impacts in each of three mutually perpendicular directions (paragraph 5.3.3), each impact to consist of a half sine wave acceleration of 20 g peak amplitude and 11 milliseconds duration. Apply the impacts to the receiver mounting facilities.

5.4. SINAD Sensitivity Test

Interconnect the receiver and test equipment as shown in figure 1. Modulate the FM signal generator with standard test modulation and adjust the generator to the standard test frequency. Adjust the generator for 1-millivolt output and the receiver volume control for audio output power (item M). Do not readjust the volume control for the remainder of the measurement. Decrease the output level of the generator until the SINAD ratio

of the receiver is 12 dB, as determined with the distortion analyzer. Measure the audio output power to make certain it is at least 50 percent of item M and record the generator output voltage. Repeat the above using plus 10 percent and minus 10 percent changes in standard power supply voltage.

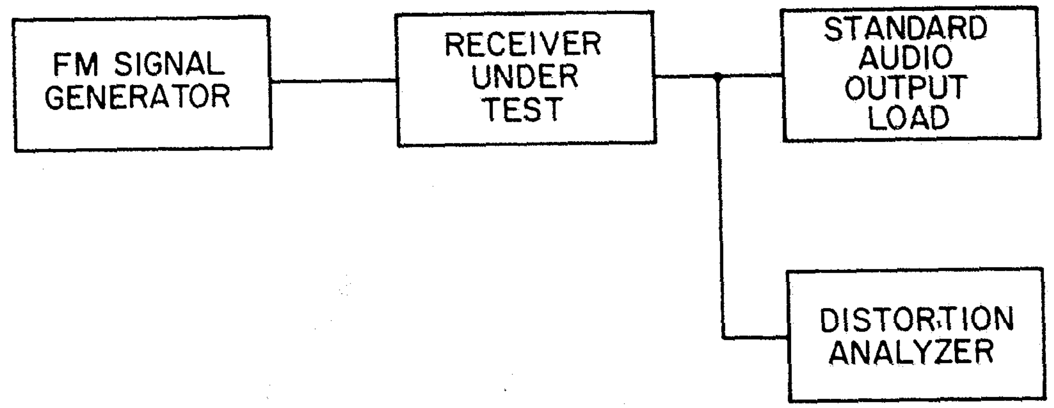

FIGURE 1. Block diagram for SINAD sensitivity, modulation acceptance bandwidth, squelch sensitivity, squelch block and audio distortion measurements.

5.5. Selectivity Tests

5.5.1. Modulation Acceptance Bandwidth Test

Interconnect the receiver and test equipment as shown in figure 1. Adjust the receiver and FM signal generator in accordance with paragraph 5.4 for the 12 dB SINAD signal sensitivity. Increase the output of the generator by 6 dB, and increase the frequency deviation of the generator until the SINAD ratio is again 12 dB. Record the frequency deviation.

5.5.2. Adjacent Channel Selectivity and Desensitization Test

Interconnect the receiver and test equipment as shown in figure 2. With the output of generator #2 set to zero, adjust the receiver and signal generator #1 in accordance with paragraph 5.4 for the 12 dB signal sensitivity. Adjust signal generator #2 for 3 kHz frequency deviation at 400 Hz, and set it to a frequency corresponding to the center of the next higher adjacent channel. Then adjust the output of signal generator #2 to produce a 6 dB SINAD ratio with both signals present. The ratio, expressed in decibels, of the output voltage of signal generator #2 to that of signal generator #1 is the adjacent channel selectivity for the upper channel. Repeat the above procedure for the next lower adjacent channel. The smaller of the two ratios is the required measurement.

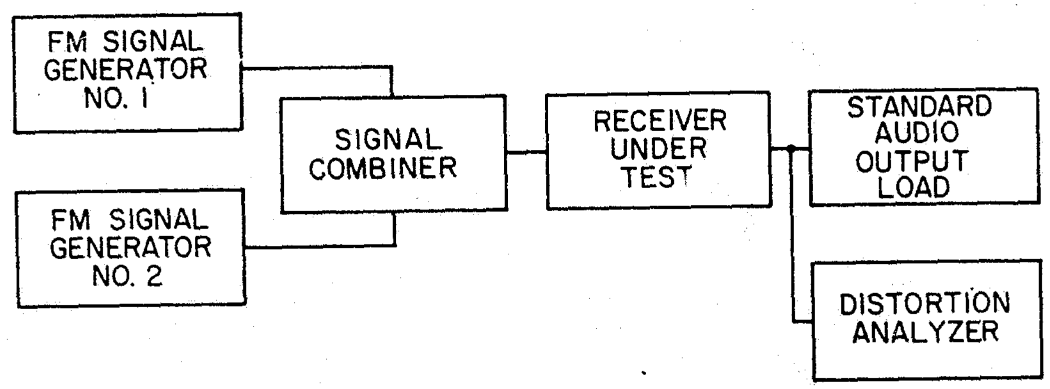

FIGURE 2. Block diagram for adjacent channel selectivity and desensitization measurement.

5.5.3. Spurious Response Attenuation Test

Interconnect the receiver and test equipment as shown in figure 3. Adjust the unmodulated (CW) signal generator to the standard test frequency. With the generator adjusted for zero output, adjust the receiver volume control to produce 25 percent of item M. This output power is entirely noise power. Do not readjust the volume control for the remainder of the measurement. Increase the output of the generator until the audio noise output power of the receiver is decreased by 20 dB, i.e., 20 dB of noise quieting. Note the generator output in decibels at this frequency. Then increase the output of the generator to approximately 0.1 volt, and slowly vary the generator frequency continuously from just below the lowest intermediate frequency of the receiver to 1000 MHz. Note each frequency that produces a receiver response as indicated by noise quieting in the receiver's audio output. Ignore harmonic frequencies of the generator that fall within the channel to which the receiver is tuned. For each response, adjust the generator output to produce 20 dB of noise quieting. Record the generator output in decibles. 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.

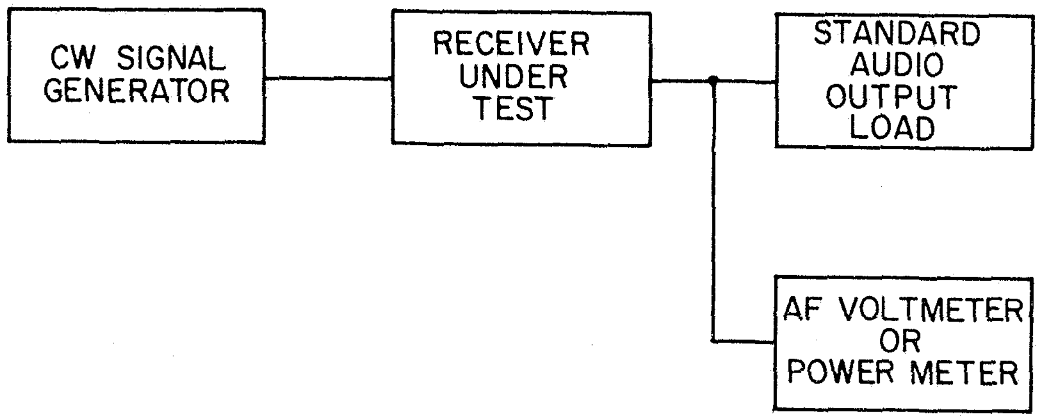

FIGURE 3. Block diagram for spurious response attenuation measurement.

5.5.4. Intermodulation Attenuation Test

Interconnect the receiver and test equipment as shown in figure 4. With the output levels of signal generators #2 and #3 set to zero, adjust the receiver and FM signal generator #1 in accordance with paragraph 5.4 until a 12 dB SINAD ratio is reached.

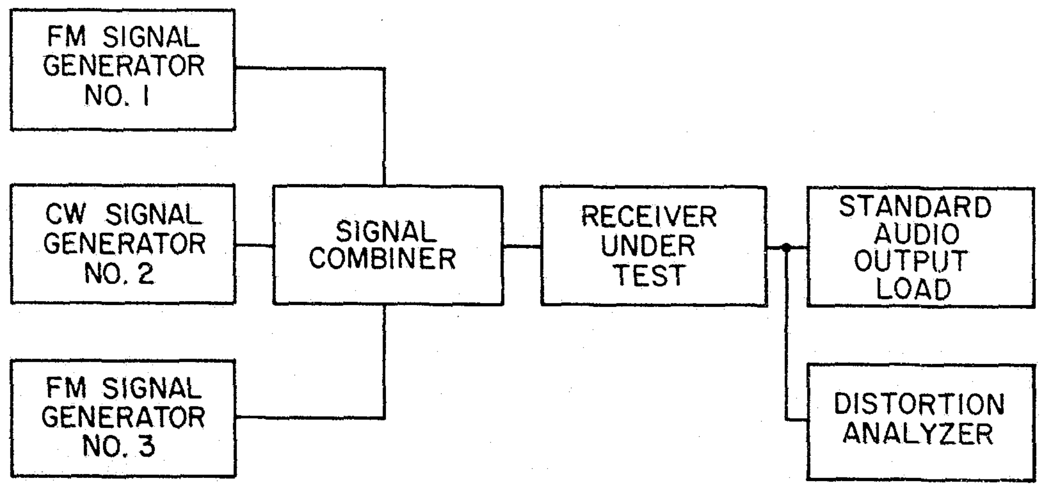

FIGURE 4. Block diagram for intermodulation attenuation measurement.

Adjust the unmodulated generator #2 to the center frequency of the next higher adjacent channel. Adjust generator #3 for 3 kHz frequency deviation at 400 Hz, and set it to the center frequency of the second higher adjacent channel, i.e., two channels above the standard test frequency. Then adjust the output levels of generators #2 and #3 to produce a 6 dB SINAD ratio with all three signals present. Maintain generators #2 and #3 at equal output voltages throughout the measurement. Adjust slightly the frequency of generator #3 to obtain the 6 dB SINAD ratio with the minimum signal levels from generators #2 and #3. The ratio, expressed in decibels, of the output voltage of generator #2 (or #3) to that of generator #1 is the intermodulation attenuation for the upper channels. Repeat the above procedure for the lower two adjacent channels, with generator #3 set to the lowest channel. The smaller of the two ratios is the value sought.

5.6. Sequelch Tests

5.6.1. Squelch Sensitivity Tests

Interconnect the receiver and test equipment as shown in figure 1. Adjust the receiver and FM signal generator in accordance with paragraph 5.4 for the 12 dB signal sensitivity. 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 the audio output power (item M). The signal generator output voltage is the value for threshold squelch sensitivity. Repeat using plus 10 percent and minus 10 percent standard power supply voltage.

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

5.6.2. Squelch Block Test

Interconnect the receiver and test equipment as shown in figure 1. Adjust the receiver and FM signal generator in accordance with Section 5.4 for the 12 dB signal sensitivity. 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 squelched 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 3.0 kHz. The frequency deviations of the signal generator modulation are the values for squelch block.

5.6.3. Squelch Attack Time Test

Interconnect the receiver and test equipment as shown in figure 5a. With the SPST switch closed, adjust the receiver and FM signal generator in accordance with Section 5.4 for the 12 dB signal sensitivity. Set the output level of the signal generator to zero, and measure the audio noise output power. Slowly adjust the squelch control until the audio output power drops abruptly (40 dB or more). Do not adjust the squelch control any further. Adjust the generator output level to 12 dB above the measured value of the receiver's threshold squelch sensitivity voltage. Adjust the volume control for audio output power (item M). Adjust the oscilloscope vertical controls for full scale deflection. Adjust the oscilloscope trigger controls to start the trace upon switch closure. Then close the SPST switch, and adjust the oscilloscope horizontal sweep controls so that the change in audio output level can be easily determined as a function of time. Open and close the SPST switch and photograph the trace. The time between the start of the oscilloscope trace and the time at which the audio level reached 90 percent of audio output power (item M) is the value for squelch attack time.

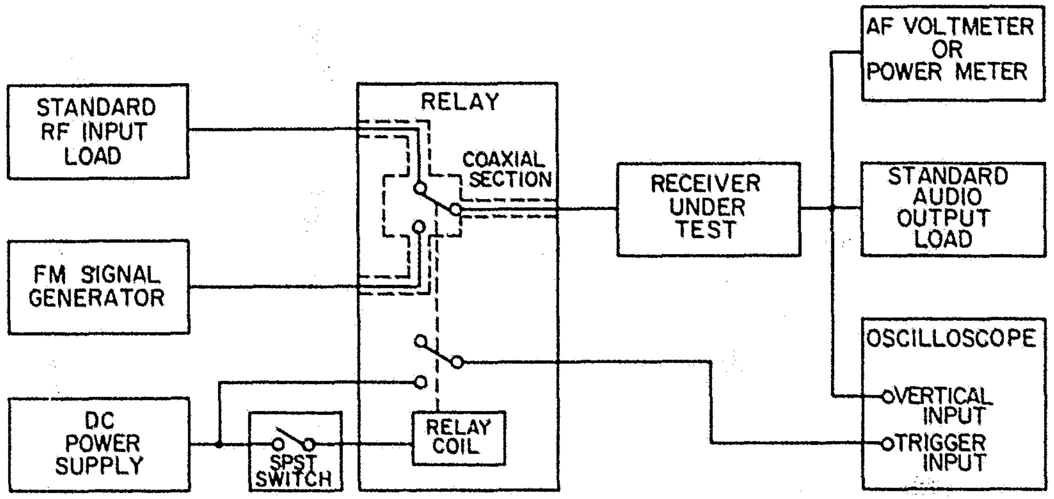

FIGURE 5a. Block diagram for squelch attack time and squelch release time measurements.

Note that relay pull-in and drop-out times are usually more than one-tenth the squelch attack and release times. It will generally be necessary, therefore, to measure the time differential between the two sets of contacts shown in figure 5a, and to correct the measured squelch attack and release times accordingly. Remove the receiver and connect the dc power supply in place of the FM signal generator as shown in figure 5b. Connect the relay to the vertical input of the oscilloscope and adjust the oscilloscope as in the previous paragraph. Close the SPST switch and photograph the trace. Subtract the relay pull-in time determined in accordance with the photograph from the time determined in accordance with the previous paragraph to obtain the squelch attack time.

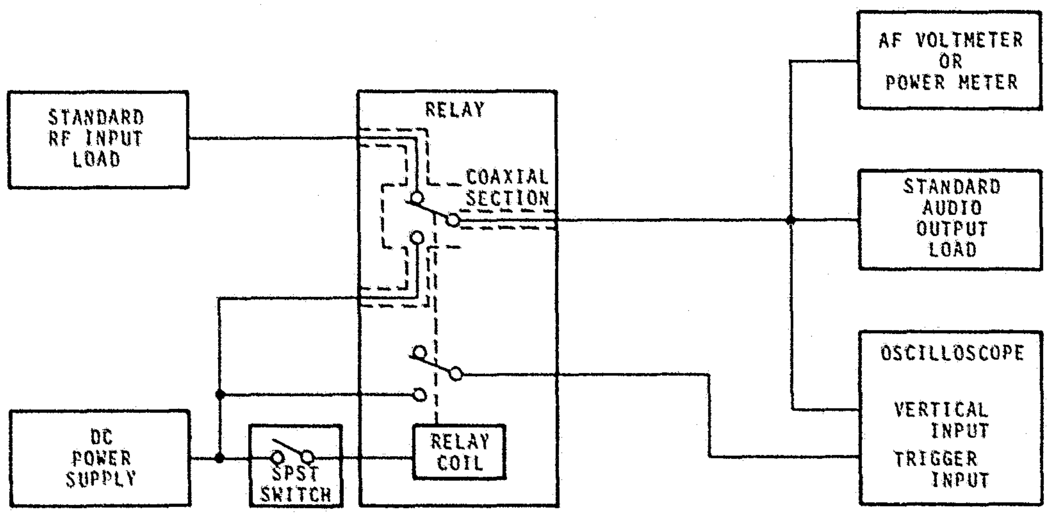

FIGURE 5b. Block diagram for relay pull-in and drop-out time measurements.

5.6.4. Squelch Release Time Test

Interconnect the receiver and test equipment as shown in figure 5a. Adjust all equipment in accordance with Section 5.6.3. Then adjust the oscilloscope trigger controls to start the trace when the SPST switch is opened. Open the switch and photograph the display. The time between the start of the oscilloscope trace and the time at which the audio level falls to 10 percent of the audio output power (item M) is the value of squelch release time. Adjust the reading as in 5.6.3.

5.7. Audiofrequency Tests

5.7.1. Audio Output Power Test

Interconnect the receiver and test equipment as shown in figure 6. Modulate the FM signal generator with standard test modulation and set it to the standard test frequency. With the signal generator adjusted for 1-millivolt output, set the receiver volume control to the maximum position. Measure and record the audio output power. Repeat using plus 10 percent and minust 10 percent standard power supply voltage.

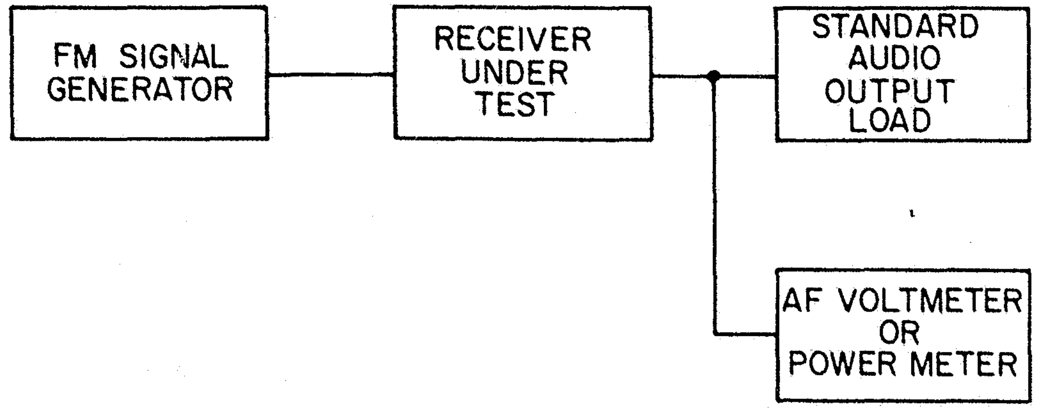

FIGURE 6. Block diagram for audio output power, audiofrequency response and audio hum and noise measurements.

5.7.2. Audio Distortion Test

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

5.7.3. Audiofrequency Response Test

Interconnect the receiver and test equipment as shown in figure 6. Modulate the FM signal generator with standard test modulation and set it to the standard test frequency. With the signal generator adjusted for 1-millivolt output, adjust the receiver volume control to 50 percent of the audio output power (item M). Do not readjust the volume control for the remainder of the measurement. Reduce the generator frequency deviation to 1 kHz, and measure the audio output power for modulating frequencies of 0.3, 0.5, 2.0 and 3.0 kHz. Compute the ratio, expressed in decibels, of each of these latter power levels to the output power at 1 kHz.

5.7.4. Audio Hum and Noise Tests

Interconnect the receiver and test equipment as shown in figure 6. Modulate the FM signal generator with standard test modulation and set it to the standart test frequency. With the signal generator adjusted for 1-millivolt output, adjust the receiver volume control for audio output power (item M). Do not readjust the volume control for the remainder of the measurement. Remove the modulation from the signal generator and measure the audio hum and noise output power. Compute the ratio, expressed in decibels, of the audio output power (item M) to the hum and noise output power. This is the value for audio hum and noise (unsquelched).

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

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