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Amplitude Companded Sideband Transceivers

NIJ Standard–0225.00

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James K. Stewart, Director
National Institute of Justice

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FOREWORD

This document, NIJ Standard-0225.00, Amplitude Companded Sideband Transceivers, is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Institute of Standards and Technology (formerly 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.

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NIJ STANDARD
FOR
AMPLITUDE COMPANDED SIDEBAND TRANSCEIVERS

CONTENTS

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
ft × 0.3048 = m
ft·lbf × 1.355818 = J
gr × 0.06479891 = g
in × 2.54 = cm
kWh × 3 600 000 = J

lb × 0.4535924 = kg
lbf × 4.448222 = N
lbf/ft × 14.59390 = N/m
lbf·in × 0.1129848 = N·m
lbf/in^2 × 6894.757 = Pa
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
AMPLITUDE COMPANDED SIDEBAND TRANSCEIVERS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for amplitude companded sideband (ACSB) mobile transceivers. This standard applies to ACSB mobile 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.

2. CLASSIFICATION

For the purpose of this standard, mobile ACSB transceivers are classified by their operating frequencies. At present, these transceivers operate only in the 150–174 MHz frequency band.

3. DEFINITIONS

The principal terms used in this document are defined in this section. Additional definitions relating to law enforcement communications can be found 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.

3.2 AM Hum and Noise

The residual amplitude modulation present on an ACSB assigned frequency.

3.3 Amplitude Companded Sideband (ACSB)

A type of single sideband amplitude modulation that uses techniques such as compression and expansion to enhance signal transmission and reception in narrowband applications.

3.4 Audio Harmonic Distortion

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

3.5 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.

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[1] Numbers in brackets refer to references in appendix A.

3.6 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.

3.7 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.

3.8 Audio Response of a Receiver

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

3.9 Audio Response of a Transmitter

The variation in the amplitude of the audio component of the rf output of a transmitter as a function of audiofrequency.

3.10 Audio-to-Pilot Ratio

The ratio of the power in a single frequency audio rf component to the power in the pilot rf component. This ratio, in decibels, may be measured in the rf range or in the audiofrequency range.

3.11 Authorized Bandwidth

The maximum width of the band of frequencies specified by the Federal Communications Commission (FCC) to be occupied by an emission.

3.12 Expansion Ratio

The ratio of the logarithm of the output voltage of the expansion process to the logarithm of the input voltage.

3.13 Frequency Stability

The maximum permissible departure by the pilot frequency, usually 1.3 kHz above the assigned frequency, from this expected value.

3.14 Intermodulation Attenuation

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

3.15 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.

3.16 Noise Quieting

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

3.17 Nominal Value

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

3.18 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.

3.19 Peak Envelope Power (PEP)

A transmitter's output power measured over one radial frequency cycle at the peak of the modulation envelope.

3.20 Radio Frequency (RF) Output Power

For a transmitter, the rf power available at the antenna terminal as measured in accordance with section 5.6.1.1.

3.21 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.

3.22 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.

3.23 Receiver Lock Range

The frequency displacement from the assigned frequency of an input test signal at the 12-dB SINAD sensitivity level over which the receiver will suffer no more than a 2-dB degradation of SINAD.

3.24 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.

3.25 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.

3.26 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.

3.27 SINAD Sensitivity

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

3.28 Spurious Emission

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

3.29 Spurious Response

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

3.30 Squelch

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

3.31 Standby Mode

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

3.32 Standing Wave Ratio (SWR)

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

3.33 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.

3.34 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.

3.35 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.

3.36 Transmitted Audiofrequency

The audiofrequency that is produced when an audio signal introduced into the microphone input of an ACSB transmitter produces an ACSB signal with an audio rf component and a pilot rf component. When this signal is demodulated in the receiver, this equivalent transmitted audiofrequency is reproduced.

3.37 Transmitter Attack Time

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

4. REQUIREMENTS

The performance requirements and test methods given in this standard are patterned after those previously developed for the National Institute of Justice (NIJ) and promulgated as NIJ Standard-0210.00, Mobile FM Transceivers [2].

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 FCC Rules and Regulations [3-4].

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 output power, audio output power, receiver audio output impedance, and standard supply voltage. The manufacturer shall 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 and to fabricate a microphone input cable to allow keying of the transmitter and insertion of audio signals from an audio signal generator into the transmitter.

TABLE 1. *Minimum performance requirements for receivers used in ACSB transceivers.*

Receiver characteristic	*Minimum requirement Frequency band (MHz)* 150–174
Sensitivity Characteristics	
A. SINAD Sensitivity	0.4 μV
B. SINAD Sensitivity Variance (Supply Voltage Varied +10% and −20%)	0.7 μV
Selectivity Characteristics	
C. Receiver Lock Range	800 Hz
D. Adjacent-Channel Selectivity and Desensitization	
1. Adjacent ACSB−5 kHz offset	60 dB
2. Adjacent ACSB−10 kHz offset	75 dB
3. Adjacent FM−7.5 kHz offset	45 dB
4. Adjacent FM−12.5 kHz offset	80 dB
E. Spurious and Image Response Attenuation	75 dB
F. Intermodulation Attenuation	80 dB
Squelch Characteristics	
G. Threshold Squelch Sensitivity	0.3 μV
H. Tight Squelch Sensitivity	2.5 μV
I. Threshold Squelch Sensitivity Variance (Supply Voltage Varied +10% and −20%)	0.4 μV
J. Receiver Attack Time	250 ms
K. Receiver Closing Time	250 ms
Audio Characteristics	
L. Audio Output Power	3 W
M. Audio Output Power Variance (Supply Voltage Varied +10% and −20%)	2 dB
N. Audio Distortion	5 %
O. Audio Response	−8, +2 dB
P. Audio Hum and Noise (Unsquelched)	45 dB
Q. Audio Hum and Noise (Squelched)	60 dB
R. Expansion Ratio	3.5 to 4.2
Temperature Stability	
S. SINAD Sensitivity	6 dB
T. Receiver Lock Range	20%
U. Adjacent-Channel Selectivity and Desensitization	12 dB
V. Tight Squelch Sensitivity	6 dB
W. Threshold Squelch Sensitivity	6 dB
X. Audio Output Power	6 dB
Y. Audio Hum and Noise	10 dB
Z. Audio Distortion	9%
Humidity Stability	
AA. SINAD Sensitivity	6 dB
AB. Receiver Lock Range	20%
AC. Adjacent-Channel Selectivity and Desensitization	12 dB
AD. Tight Squelch Sensitivity	6 dB
AE. Threshold Squelch Sensitivity	6 dB
AF. Audio Output Power	3 dB
AG. Audio Hum and Noise	10 dB
AH. Audio Distortion	9%

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 5.4. 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.

TABLE 2. *Minimum performance requirements for transmitters used in ACSB transceivers.*

Transmitter characteristic	*Minimum requirement Frequency band (MHz)* *150–174*
Radio Frequency Characteristics	
BA. Output Power Variance	−1 dB
BB. Output Power Variance (Supply Voltage Varied ±10%)	−3 dB
BC. Output Power Variance (Supply Voltage Varied −20%)	−6 dB
BD. Automatic Level Control	1 dB
BE. Frequency Tolerance	0.0002%
BF. Frequency Stability (Supply Voltage Varied ±15%)	0.0002%
BG. AM Hum and Noise Level	34 dB
BH. Transmitter Attack Time	100 ms
Audio Modulation Characteristics	
BI. Total Audio Harmonic Distortion	5%
BJ. Audio Response	+2, −5 dB
BK. Compression Ratio	3.8 to 4.2
Electromagnetic Compatibility Characteristics	
BL. Conducted Spurious Emissions	50 dB
BM. Radiated Spurious Emissions	1.65 mV/m
Temperature Stability	
BN. Output Power	−3 dB
BO. Frequency Tolerance	0.0002%
BP. Total Audio Harmonic Distortion	9%
Humidity Stability	
BQ. Output Power	−3 dB
BR. Frequency Tolerance	0.0002%
BS. Total Audio Harmonic Distortion	9%
Vibration Stability	
BT. Output Power	−3 dB
BU. Frequency Tolerance	0.0002%
BV. Total Audio Harmonic Distortion	9%

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 that the unit will operate properly (sec. 4.2), whichever is lower. 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 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 S through Z, for the characteristics listed. In addition, the rf output power shall not be less than 3 dB (item BN, table 2) below the nominal value, the pilot frequency shall be within 0.0002 percent (item BO) of the assigned value and the total audio harmonic distortion shall be a maximum of 9 percent (item BP).

4.3.2 Humidity Stability

After the transceiver has been maintained at 50 °C (122 °F) and 90 percent relative humidity or greater for at least 8 h, its performance shall not vary, with respect to the appropriate values in table 1 (items A through R), more than items AA through AH, for the characteristics listed. In addition, the rf output power shall not be less than 3 dB (item BQ) below the nominal value, the pilot frequency shall be within 0.0002 percent (item BR) of the assigned value and the total audio harmonic distortion shall be a maximum of 9 percent (item BS).

4.3.3 Vibration Stability

No fixed part of the transceiver shall come loose, nor movable part be shifted in position, as a result of this test. At all times during this test the rf output power, pilot frequency, and total audio harmonic distortion (items BT through BV) shall be within the assigned value.

4.3.4 Shock Stability

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

4.4 Receiver Performance

4.4.1 SINAD Sensitivity

When measured in accordance with section 5.5.1, the SINAD sensitivity of the receiver shall be 0.4 μV (item A) or less at a SINAD ratio of 12 dB and at the standard audio output power. When the standard supply voltage is varied +10 percent and −20 percent, the SINAD sensitivity shall be 0.7 μV (item B) or less.

4.4.2 Selectivity Characteristics

The selectivity characteristics of receiver lock range, adjacent-channel selectivity and desensitization, spurious and image response attenuation, and intermodulation attenuation shall be measured in accordance with section 5.5.2.

4.4.2.1 Receiver Lock Range

The minimum receiver lock range of the receiver shall be no less than 800 Hz (item C) for a degradation of an on-channel signal from 12-dB SINAD to 10-dB SINAD.

4.4.2.2 Adjacent-Channel Selectivity and Desensitization

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

4.4.2.3 Spurious and Image Response Attenuation

The spurious and image response attenuation of the receiver shall be 75 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 lower 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 80 dB (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 two- and four-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, receiver attack time, and receiver closing time shall be measured in accordance with section 5.5.3.

4.4.3.1 Squelch Sensitivity

The threshold squelch sensitivity of the receiver shall be 0.3 μV (item G) or less. The tight squelch sensitivity shall be 2.5 μV (item H) or less. When the standard supply voltage is varied +10 percent and −20 percent, the threshold squelch sensitivity shall be 0.4 μV (item I) or less.

4.4.3.2 Receiver Attack Time

The time for the receiver to produce an audio output power of 90 percent of the standard audio output power shall be 250 ms (item J) or less.

4.4.3.3 Receiver Closing Time

The time for the audio output power of the receiver to decrease to 10 percent of the standard audio output power shall be 250 ms (item K) or less.

4.4.4 Audio Characteristics

The audio characteristics of output power, distortion, response, hum and noise, and expansion ratio shall be measured in accordance with section 5.5.4.

4.4.4.1 Audio Output Power

The audio output power of the receiver shall be at least the value of the standard audio output power (item L) 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 M) below the value of the standard audio output power.

4.4.4.2 Audio Distortion

Audio distortion of the loudspeaker at an audio output power equal to the standard audio output power shall be less than 5 percent (item N) 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 O) of an ideal 6 dB per octave de-emphasis curve at frequencies between 0.3 and 2.5 kHz, with the exception that an additional 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 power from the receiver in the unsquelched condition shall be 45 dB (item P) or more, and, in the maximum squelched condition, shall be 60 dB (item Q) or more below an audio output power of 3 W.

4.4.4.5 Expansion Ratio

The expansion ratio of a two-stage expander shall be between 3.5 and 4.2 (item R).

4.5 Transmitter Performance

4.5.1 Radio Frequency Characteristics

The radio frequency characteristics of output power, automatic level control, frequency stability, AM hum and noise level, and transmitter attack time shall be measured in accordance with section 5.6.1.

4.5.1.1 Output Power

When the transceiver is in the transmit mode, the peak envelope power (PEP) delivered to a standard output load shall not decrease more than 1 dB (item BA) from the nominal value at any time during the standard test duty cycle, except for the initial 5 s after the transceiver has been switched from the standby mode to the transmit mode. When the standard supply voltage is varied ±10 percent, the PEP shall not decrease by more than 3 dB (item BB). When the standard supply voltage is reduced by 20 percent, the PEP shall not decrease by more than 6 dB (item BC).

4.5.1.2 Automatic Level Control

The rf output power, in PEP, shall be equal to or less than 1 dB greater than the nominal value, for an input that is three times the level that produced rated PEP.

4.5.1.3 Frequency Stability

The pilot frequency shall be within 0.0002% (item BE) of the assigned value at all times during the standard test duty cycle that the transceiver is in the transmit mode. When the standard supply voltage is varied ±15 percent, the pilot frequency shall be maintained within 0.0002% (item BF) of the assigned value.

4.5.1.4 AM Hum and Noise Level

The AM hum and noise level shall be attenuated a minimum of 34 dB (item BG) below the nominal output power level at the assigned frequency.

4.5.1.5 Transmitter Attack Time

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

4.5.2 Audio Modulation Characteristics

The audio modulation characteristics of total harmonic distortion, response, and compression ratio shall be measured in accordance with section 5.6.2.

4.5.2.1 Total Audio Harmonic Distortion

The audio harmonic distortion shall be a maximum of 5 percent (item BI).

4.5.2.2 Audio Response

The audio response of the transmitter shall not vary more than +2, −5 dB (item BJ) from a true 12 dB per octave pre-emphasis characteristic from 0.3 to 2.5 kHz as referred to the 1-kHz level, with the exception that an additional 6 dB per octave roll-off from 600 to 300 Hz may be present.

4.5.2.3 Compression Ratio

The transmitter compression ratio shall be between 3.8 and 4.2 (item BK).

4.5.3 Electromagnetic Compatibility Characteristics

The electromagnetic compatibility characteristics of conducted spurious emissions and radiated spurious emissions shall be measured in accordance with section 5.6.3.

4.5.3.1 Conducted Spurious Emissions

Each conducted spurious emission shall be attenuated a minimum of [50 (item BL) + 10 $\log_{10}$ (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 BM) at 30 m, i.e., each radiated spurious emission shall be less than 50 µW.

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 ACSB Test Signal

The standard ACSB test signal shall be a signal with a transmitted audio frequency of 1 kHz and an audio-to-pilot ratio of 10 dB. The audio rf component is located 800 Hz below and the pilot rf component is located 1.3 kHz above the assigned frequency. See figure 1.

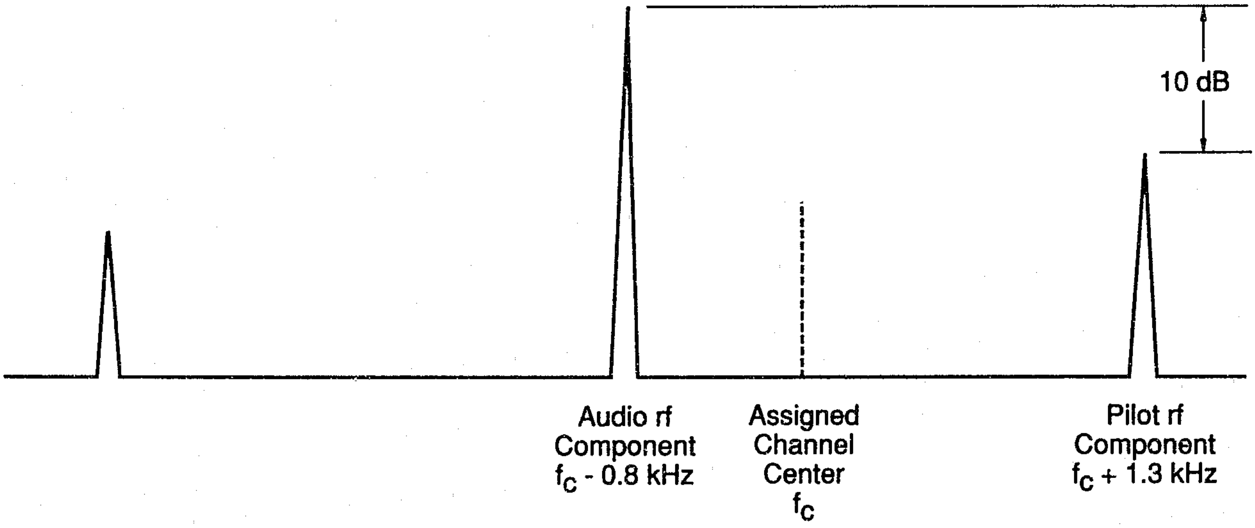

FIGURE 1. *Standard ACSB test signal produced by one rf signal generator operated at $f_c - 0.8$ kHz and 63% modulation at 2.1 kHz. The lower sideband of this signal can be ignored for some measurements.*

5.1.6 Standard Squelch Adjustment

The squelch control shall be adjusted to the maximum unsquelch position, and squelch defeat activated, if required, for all receiver measurements except where otherwise specified.

5.1.7 Standard Audio Output Power

The standard audio output power shall be 3 W or that value supplied by the manufacturer as a nominal value for audio output power in section 4.2, whichever is higher.

5.1.8 Standard Radiation Test Site

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

5.1.9 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 RF Signal Generator

The RF 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 10^7 per hour and shall have an amplitude modulation monitor 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. Five of these are required.

5.2.4 Audiofrequency Signal Generator

The audiofrequency signal generator shall have a frequency range of 300 to 3000 Hz, a continuously adjustable output from 0 to at least 2 V into a 600-Ω impedance, and a total harmonic distortion of less than 0.5 percent over this range. It shall possess an internal or external amplitude modulation capability and, if internal, must have a range of 100 Hz.

5.2.5 SINAD Meter

The SINAD meter shall have an input impedance of at least 50,000 Ω and an error of not more than ±1 dB. It shall incorporate a band elimination filter that will provide at least 40 dB attenuation of the fundamental frequency, relative attenuation of not more than 0.6 dB at one-half or twice the fundamental frequency and, in the presence of a noise signal, shall not cause more than 1 dB of relative attenuation of the total noise output power of a 300 to 3000 Hz flat noise source.

5.2.6 Variable DC Power Supply

The variable dc power supply shall have not more than 0.1 percent change when line or load changes.

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 Frequency Counter

The frequency counter shall be capable of measuring radio frequencies from 150 to 175 MHz with an uncertainty no greater than one part in 10^7 per hour.

5.2.9 Radio Frequency Power Meter

The rf power meter shall have an input impedance of 50 Ω, a maximum SWR of 1.20, and a frequency range which spans both the frequency of the transmitter to be tested and the frequency of any calibration source. It shall provide an internal power reference source with an accuracy traceable to the National Institute of Standards and Technology of ±1 percent for use in internal or external calibrations. After calibration, the meter shall have an error not more than 2 percent of full scale.

5.2.10 Spectrum Analyzer

The spectrum analyzer shall have a 50-Ω input impedance, a frequency range from at least 0.1 to 1000 MHz, and digital storage or a variable persistence storage display. It shall provide a vertical logarithmic display with at least two selectable sensitivities, e.g., 2 dB and 10 dB per division. The display shall be capable of being calibrated to an error not more than 1.5 dB maximum over the 10 dB per division range and 0.5 dB maximum over the 2 dB per division range. It shall accept an input of at least 30 dBm peak and be equipped with a calibrated 10 dB per step attenuator. It shall be able to resolve signals that are 300 Hz apart at 6 dB below the maximum signal amplitude and 1.2 kHz apart at 60 dB below the maximum signal amplitude. It shall provide a means of identifying a specific frequency on the display to an accuracy of at least ±10 MHz with a resolution of at least 1 MHz.

5.2.11 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.

5.2.12 Standard RF Input Load (Receiver)

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

5.2.13 Audio Voltmeter

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

5.2.14 Coaxial Radio Frequency Detector

The coaxial rf detector shall have an input and output impedance of 50-Ω and an input SWR of less than 1.4. It shall either (1) have a maximum input rating sufficiently high to accept the output of the transmitter under test directly, or (2) be preceded by coaxial attenuators to reduce the transmitter voltage to a value that will not damage the detector. The detector shall have a frequency range extending from below 200 kHz to above that of the highest transmitter frequency to be measured.

5.2.15 Oscilloscope

The oscilloscope shall have a calibrated time base, a bandwidth of at least 10 MHz, and a variable persistence storage display.

5.2.16 Standard RF Output Load (Transmitter)

The standard rf output load shall be 50 W or more and have a 50-Ω 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.

5.2.17 Radio Frequency Power Meter

The rf power meter shall be of the thruline type and shall measure peak envelope power directly, allowing insertion of appropriate power level plugs for the measurement being made. At least two plugs, 5 W and 25 W, shall be used. It shall be accurate to at least ±5 percent of full scale.

5.2.18 Distortion Analyzer

The distortion analyzer shall have a required input level of between 1 and 10 V rms, an input impedance of at least 50,000 Ω shunted by less than 100 pF, and an error not more than ±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 have a 1000-Hz band elimination filter for use in audio distortion measurements.

5.2.19 Test Receiver

The test receiver used in transmitter test measurements shall be an ACSB receiver specified by the manufacturer.

5.2.20 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 ±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. The receiver should be located near the receiving antenna to keep the length of the cable between them as short as possible.

5.2.21 Chart Recorder

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

5.2.22 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 ±1 dB.

5.3 Generation of the Standard ACSB Test Signal

The standard ACSB test signal shall be generated using two different techniques. One technique uses a single, amplitude modulated, rf signal generator and the other uses two rf signal generators. The first technique uses the audio modulation frequency to control the frequency difference between the audio rf component and the pilot rf component. Thus the short term stability of the rf signal generator is less critical than when two signal generators are used. Figure 1 illustrates the standard ACSB test signal generated by amplitude modulating an rf signal generator with a 2.1 kHz audiofrequency signal to produce a transmitted audiofrequency of 1 kHz.

5.3.1 Standard ACSB Test Signal #1

Using the equipment configuration shown in figure 2 for procedure 1, set the frequency of the rf signal generator to the frequency of the audio rf component, i.e., 800 Hz below the assigned frequency. Modulate the rf signal generator with a 2.1-kHz tone at 63 percent amplitude modulation to produce the required ACSB test signal.

This test signal should not be used for making measurements of adjacent-channel selectivity, intermodulation attenuation, receiver audio response, audio hum and noise, and expansion ratio.

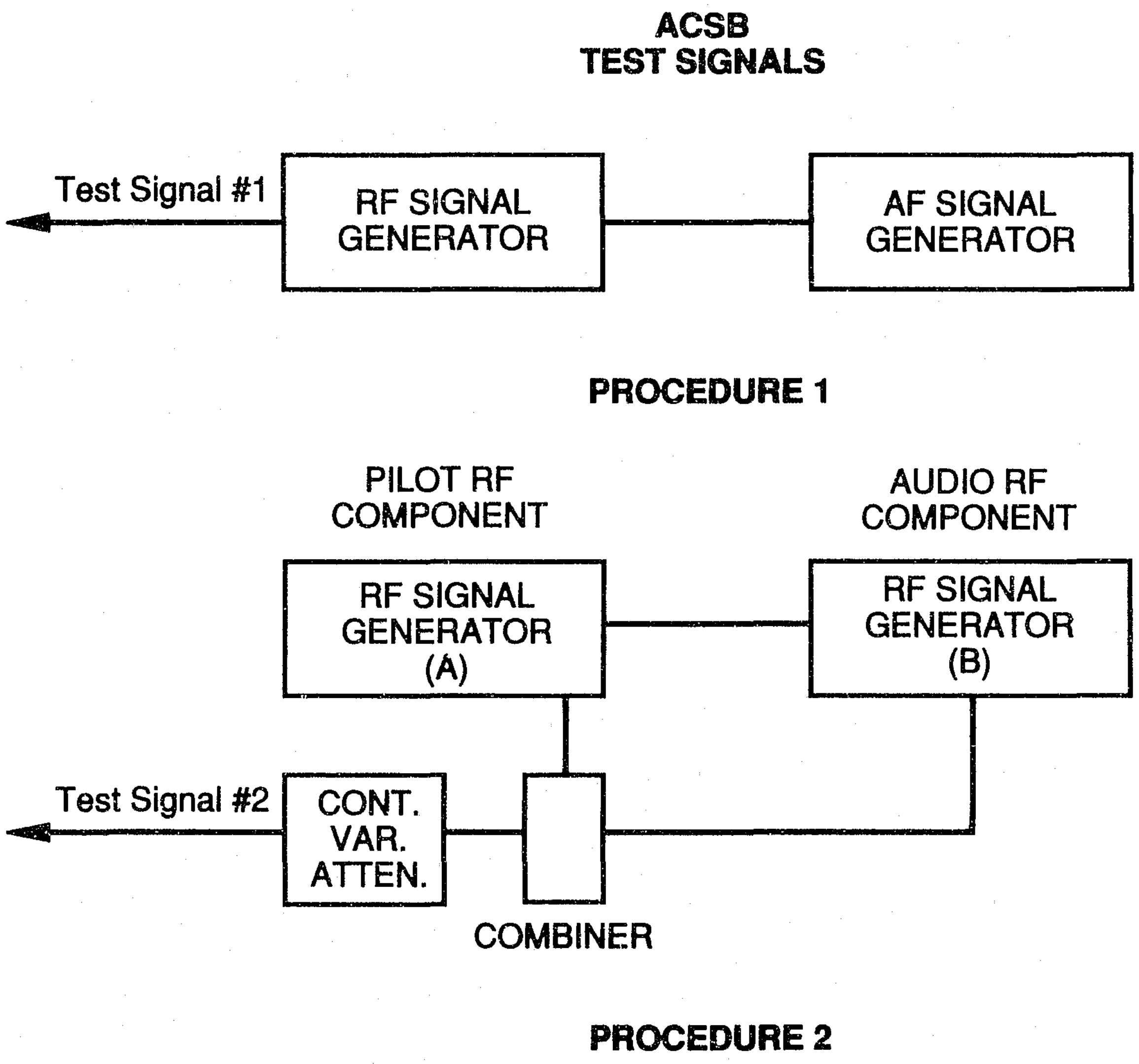

FIGURE 2. *Block diagram of procedures for generating ACSB test signals.*

5.3.2 Standard ACSB Test Signal #2

Using the equipment configuration shown in figure 2 for procedure 2, set the frequency of rf signal generator A to the frequency of the pilot rf component, 1.3 kHz above the assigned frequency. Then set the frequency of rf signal generator B to the frequency of the audio rf component, 800 Hz below the assigned frequency. Using a spectrum analyzer or rf power meter, adjust the output of signal generator A until it is at some convenient reference value in decibels referenced to a mW (dBm) (e.g., -60 dBm). Then adjust the output of signal generator B until it is 10 dB above the level of signal generator A. Connect the outputs of the two signal generators to the input ports of a combiner and a continuously variable attenuator to the output port of the combiner. A step attenuator may be placed between the output of the appropriate signal generator and the combiner if it is desired to incrementally change the level of the audio rf component or the pilot rf component. If other transmitter audio frequencies are desired, signal generator B may be adjusted accordingly.

5.4 Transceiver Environmental Tests

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

5.4.1 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 ±2 °C (±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 ±2 °C (3.6 °F).

5.4.2 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.

5.4.3 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.

5.4.4 Shock Test

Subject the transceiver to a series of 10 impacts in each of three mutually-perpendicular directions (sec. 5.4.3), 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.

5.5 Receiver Tests

5.5.1 SINAD Sensitivity Test

Connect the equipment as in figure 3 and use procedure 1 to produce standard ACSB test signal #1. Set the rf signal generator output to 1 mV and adjust the receiver volume control until it produces the standard audio output power. Decrease the output level of the signal generator until the SINAD meter indicates a SINAD ratio of 12 dB. Record the signal generator output voltage, which is the receiver sensitivity at 12 dB SINAD. Repeat for power supply voltage changes of +10 percent and −10 percent.

5.5.2 Selectivity Tests

5.5.2.1 Receiver Lock Range Test

Connect the equipment as in figure 3 and use procedure 1 to produce standard ACSB test signal #1. Adjust the receiver and the output level of the rf signal generator in accordance with section 5.5.1 until the SINAD meter indicates a SINAD ratio of 12 dB. With the signal generator amplitude modulated 63 percent by a 2.1 kHz tone, decrease the signal generator frequency until a SINAD ratio of 12 dB is reached and record the frequency of the signal generator. Repeat this measurement by increasing the frequency of the signal generator until a 10-dB SINAD ratio is reached and record the signal generator frequency again. When adjusting the signal generator above the original setting, the SINAD may decrease rapidly and it may be difficult to obtain the second value. If this is the case, make the measurement at the point where the SINAD ratio drops rapidly to below 10 dB. The smaller of the two displacements is the value sought.

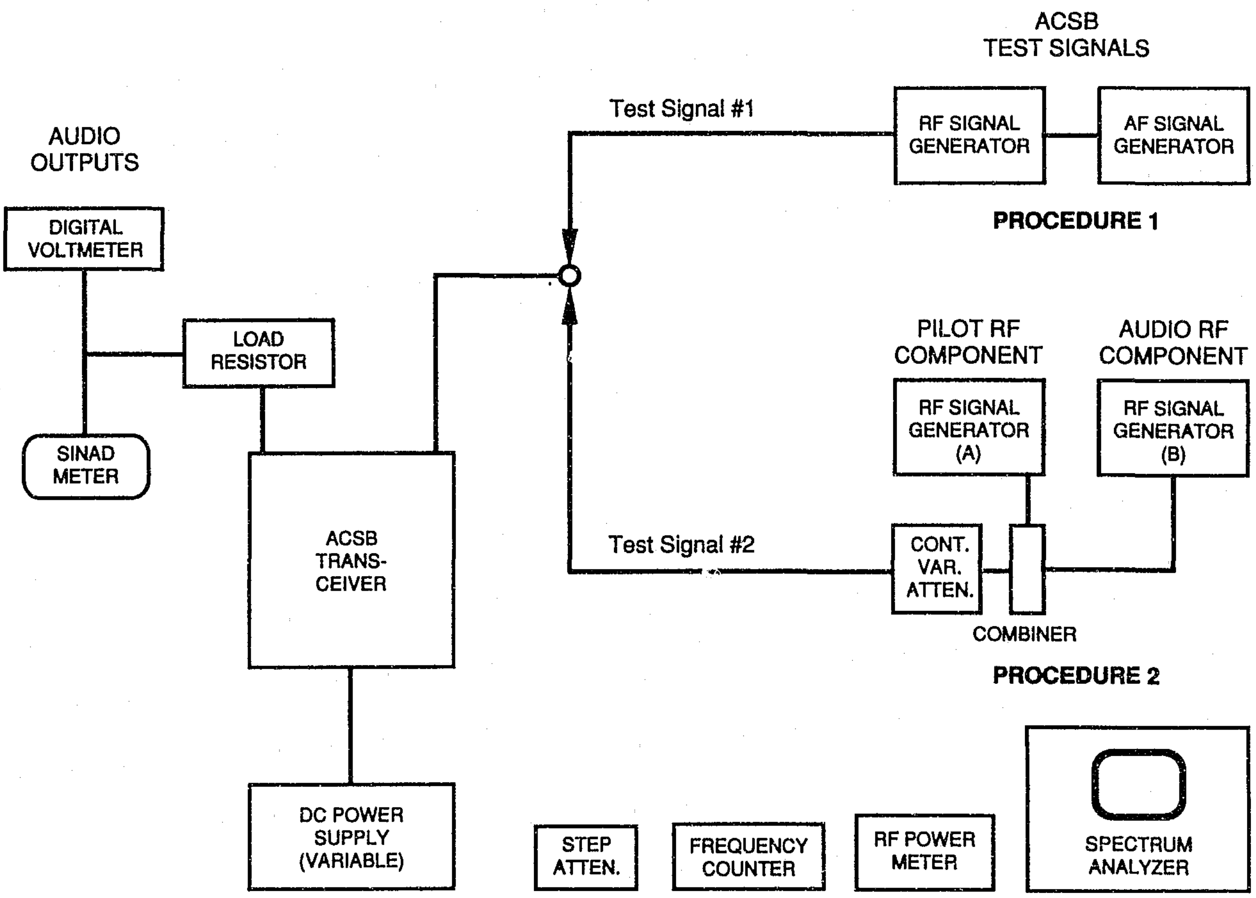

FIGURE 3. *Block diagram of general equipment configuration for making ACSB receiver measurements.*

5.5.2.2 Adjacent-Channel Selectivity and Desensitization Test

Connect the equipment as in figure 4 and use procedure 1 to produce standard ACSB test signal #1. Adjust the receiver output level and the output of rf signal generator A in accordance with section 5.5.1 to obtain a SINAD ratio of 12 dB. Do not readjust the output level of signal generator A for the remainder of the measurement. Remove the modulation from the signal generator and measure its output level, in decibels above 1 milliwatt (dBm), with a spectrum analyzer or rf power meter and record this value (P_{oc}). Reestablish the 63 percent amplitude modulation for signal generator A.

For ACSB adjacent channels, use procedure 2 to produce standard ACSB test signal #2 on the next higher adjacent channel (+5 kHz) with an audio-to-pilot ratio of 10 dB and a transmitted audiofrequency of 1.7 kHz. The output level of rf signal generator C should be about 80 dB above (P_{oc}). Record the level, in dBm, of signal generator C. The output level of rf signal generator B should be 10 dB below rf signal generator C. Connect the output of the continuously variable attenuator, initially set for maximum attenuation, to the combiner (AC). Reduce the attenuation of the continuously variable attenuator until a SINAD ratio of 6 dB is reached and record the setting on the attenuator. The output level, in dBm, of signal generator C (audio rf component of the adjacent channel ACSB signal) minus the setting of the continuously variable attenuator minus P_{oc} is the adjacent channel selectivity for the upper adjacent channel. Repeat the measurement for the next lower adjacent channel (−5 kHz). The smaller of the two measured adjacent channel selectivities is the required value. Repeat the measurement for the second higher and second lower adjacent channel (+10 kHz and −10 kHz).

Adjacent channel tests should be made for FM signals with carriers separated from the ACSB assigned frequency by ±7.5 and ±12.5 kHz. For FM adjacent channels, set rf signal generator D to the frequency of the adjacent FM channel, and modulate it to a deviation of 3 kHz with a 700 Hz audio signal. Adjust signal generator D for zero output and connect it directly to the combiner (AC). Increase the output level of signal generator D until a SINAD ratio of 6 dB is reached. Keep the output of signal generator D at this level, remove its modulation, and record its output level, in dBm, with a spectrum analyzer or rf power meter. The output level, in dBm, of signal generator D minus P_{oc} is the adjacent-channel selectivity.

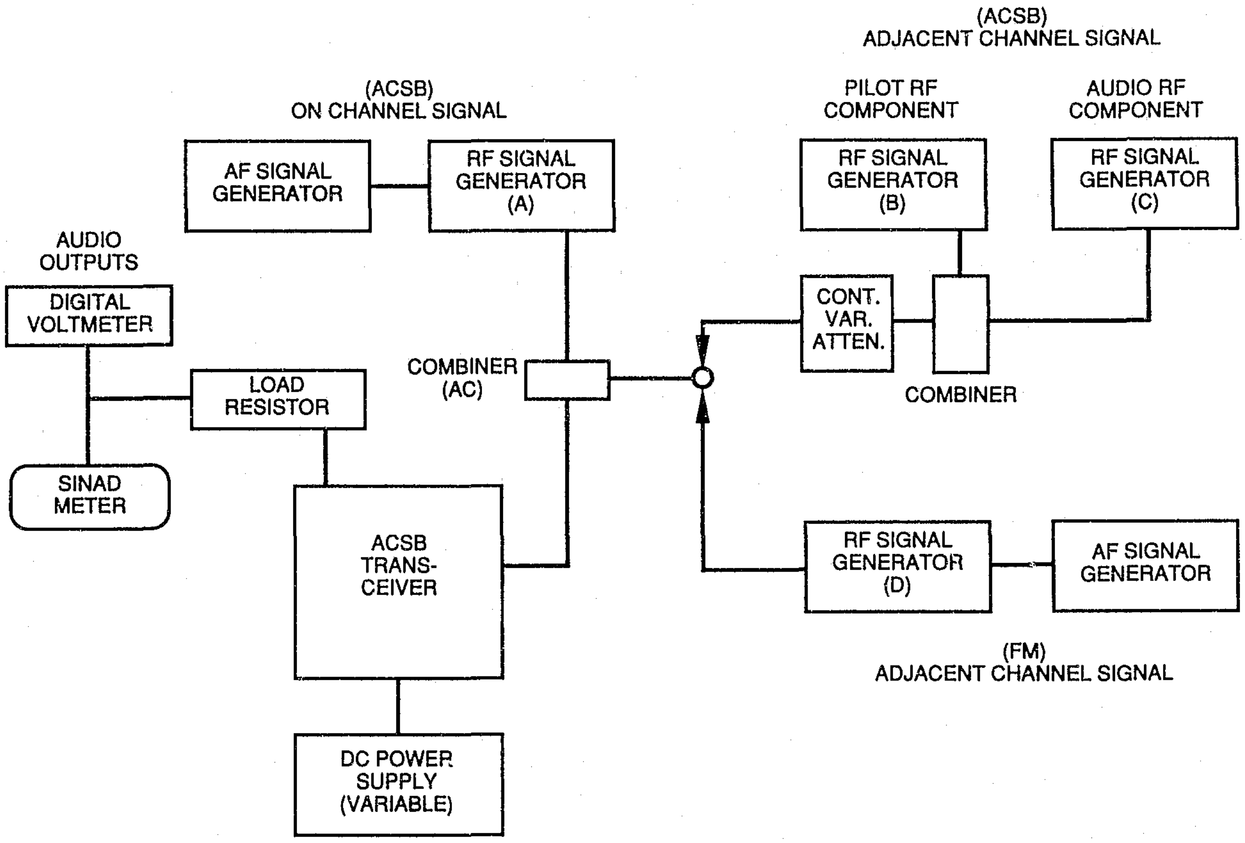

FIGURE 4. *Block diagram for adjacent-channel selectivity and desensitization measurement.*

5.5.2.3 Spurious and Image Response Attenuation Test

Connect the equipment as in figure 3 and use procedure 1 with no modulation for this measurement. Adjust the output frequency of the rf signal generator to the rf pilot frequency, 1.3 kHz above the assigned frequency. The signal generator should then be adjusted for zero output and the receiver volume control adjusted to produce 1.0 W of audio output power—entirely noise power. Do not readjust the volume control for the remainder of the measurement. Increase the output of the signal generator until the audio noise output power of the receiver is reduced by 20 dB. Note the generator output in decibels above 1 microvolt (dBμV) and record this value, Pg. Then, increase the output of the signal generator to approximately 0.1 V, and slowly and continuously vary the generator frequency from just below the lowest intermediate frequency to at least twice the receiver operating frequency or 1000 MHz, whichever is higher. Note each frequency that produces a receiver response as indicated by noise quieting in the receiver's audio output, but ignore harmonic frequencies of the signal generator that fall within the channel to which the receiver is tuned. Since this is a time-consuming measurement, the use of an rf signal generator that can be swept automatically and a chart recorder that can automatically record receiver response is recommended. After the necessary bandwidth has been swept, measure the response at each frequency that produces quieting. For each response, adjust the output of the signal generator until 20 dB of noise quieting is observed. Record the generator output level in dBμV. This level, at the spurious response frequency, minus Pg, is the spurious response attenuation. Repeat the measurement for all spurious response frequencies. The smallest attenuation is the value sought.

5.5.2.4 Intermodulation Attenuation Test

This test procedure requires the generation of three ACSB signals. Connect the equipment as in figure 5 and use procedure 2 to generate standard ACSB test signal #2. With only signal #2 coupled through combiner IM1 into the receiver and with the receiver adjusted to produce standard audio output power, adjust the continuously variable attenuator until a SINAD ratio of 12 dB is reached. Do not readjust this attenuator for the remainder of the measurement. Test signal #3, the pilot rf component of the first higher adjacent channel, is produced using rf signal generator C. Test signal #4 is an ACSB signal on the second higher adjacent channel with a transmitter audio frequency of 1.7 kHz and an audio-to-pilot ratio of 10 dB. Produce signal #4 using procedure 2 with signal levels, before the continuously variable attenuator, at least 80 dB above that required for the 12-dB SINAD sensitivity measurement in section 5.5.1. Set signal generator C to the same level used for the pilot rf component of signal #4. Feed signals #3 and #4 into combiner IM2 and connect the output of this combiner to a continuously variable attenuator, initially set to maximum attenuation. Connect the output of the continuously variable attenuator to the input of combiner IM1. Ensure that the audiofrequency for the on-channel ACSB signal is 1 kHz and the audiofrequency for the second higher adjacent-channel ACSB signal is 1.7 kHz. Adjust the continuously variable attenuator coupling signals #3 and #4 to the receiver until a SINAD ratio of 6 dB is obtained. Slowly adjust the frequency of signal generator C to determine if additional attenuation, using the continuously variable attenuator, will still reduce the SINAD ratio to 6 dB. The level of signal #3 minus the attenuation setting of the continuously variable attenuator minus the level of the pilot rf component of signal #2 plus the attenuation setting of signal #2's continuously variable attenuator is the intermodulation attenuation for the upper channels.

Repeat the above procedure for the lower adjacent channels. Signal #3 will be the pilot rf component of the first lower adjacent channel and signal #4 will be the audio rf component and pilot rf component of the second lower adjacent channel. The smallest attenuation is the value sought.

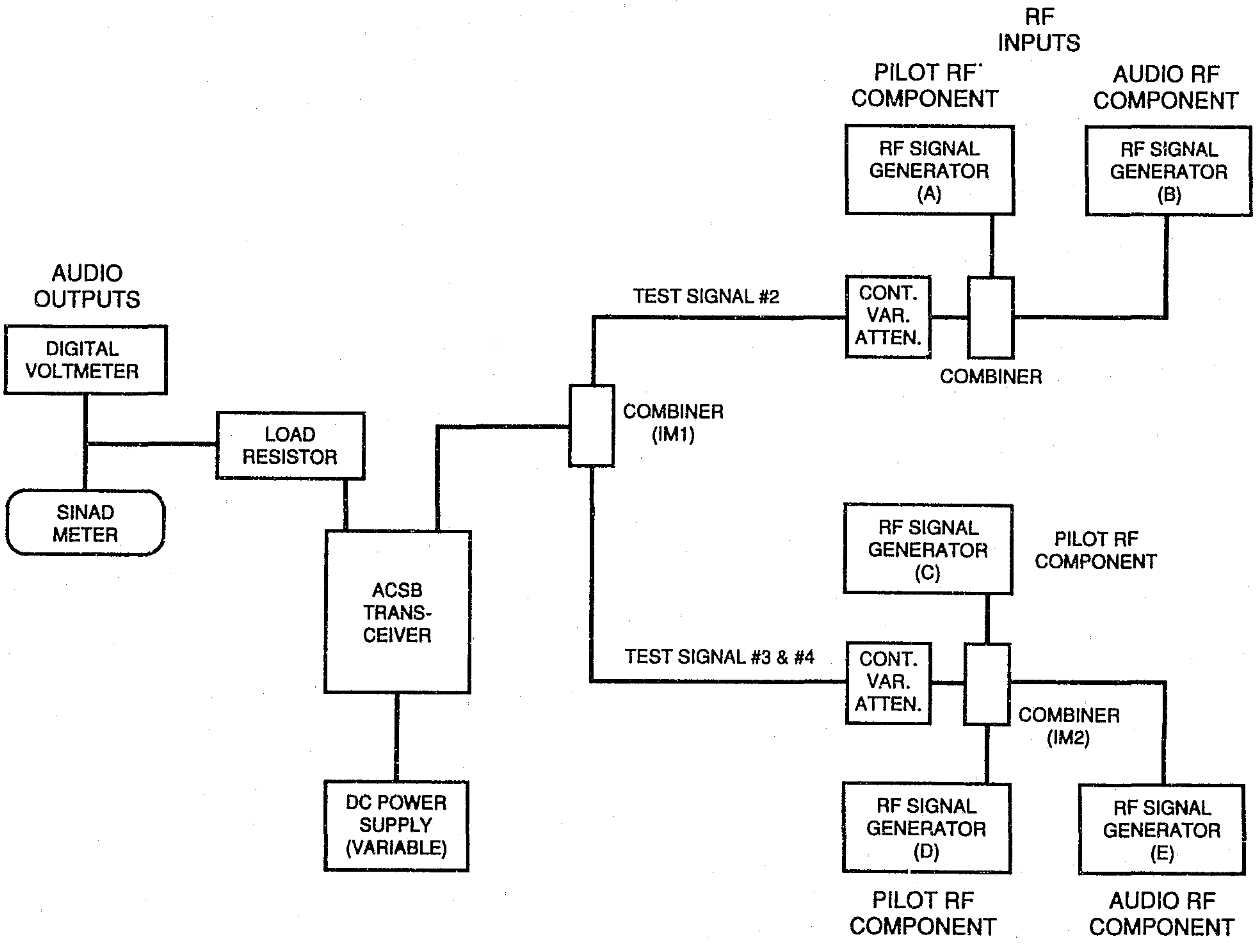

FIGURE 5. *Block diagram for intermodulation attenuation measurement.*

5.5.3 Squelch Tests

5.5.3.1 Squelch Sensitivity Test

Connect the test equipment as in figure 3 and use procedure 1 to produce standard ACSB test signal #1. Adjust the ACSB receiver and the output level of the rf signal generator in accordance with section 5.5.1 to produce standard audio output power. 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 noise output power drops abruptly (40 dB or more) and do not adjust the squelch any further. This is the threshold squelch position. Increase the output level of the signal generator until the audio output is within 10 dB of the standard audio output power. The signal generator output voltage is the value for the threshold squelch sensitivity. Repeat the above procedure for power supply voltage changes of +10 percent and −20 percent.

Repeat the above procedure with the squelch control in the maximum squelch position.

5.5.3.2 Receiver Attack Time Test

Connect the equipment as in figure 6 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.

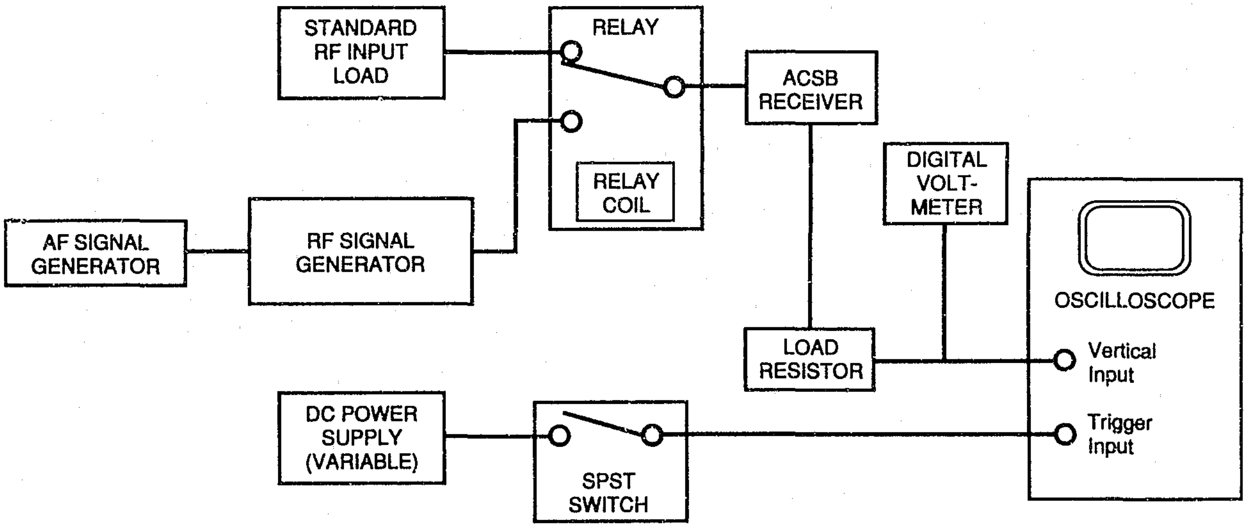

FIGURE 6. *Block diagram for setting oscilloscope trigger.*

Connect the ACSB receiver and test equipment as in figure 7. With the SPST switch closed, adjust the rf signal generator in accordance with section 5.5.1 to obtain a SINAD ratio of 12 dB. Set the signal generator output voltage 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), and do not adjust the squelch any further. Adjust the signal 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 close the SPST switch and photograph the trace. The time required for the sweep to travel from the left oscilloscope graticule to the point where the audio output power reaches 90 percent of the standard audio output power is the receiver attack time.

5.5.3.3 Receiver Closing Time Test

Connect the equipment as in figure 6 and 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. Then connect the ACSB receiver and test equipment as in figure 7 and adjust all equipment as in section 5.5.3.2. Open the SPST switch and photograph the display. The time required for the sweep to travel from the left graticule of the oscilloscope to the point where the audio output power falls to 10 percent of the standard audio output power is the value of receiver closing time.

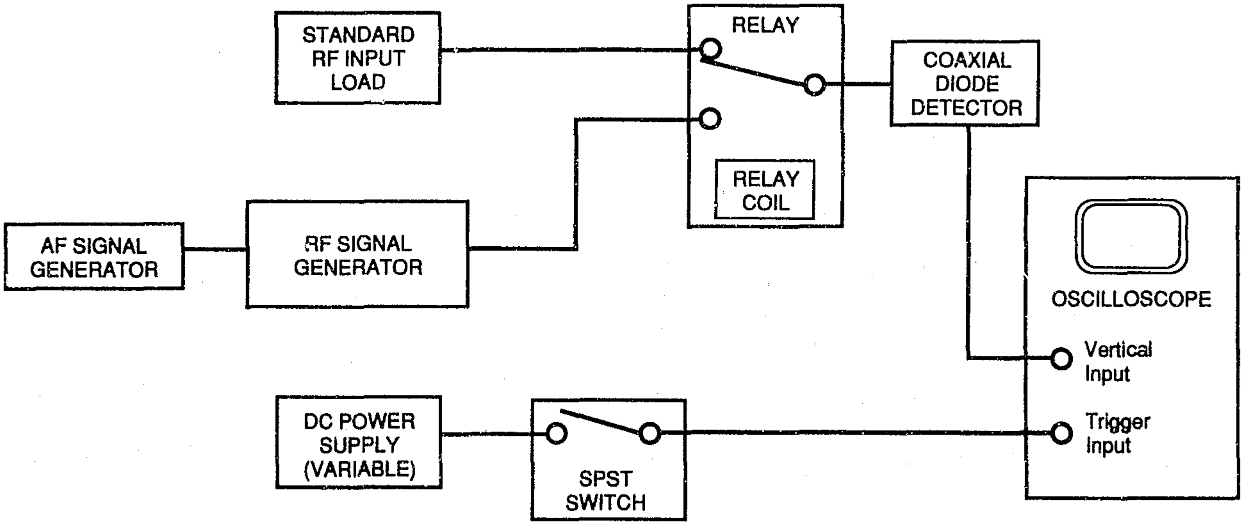

FIGURE 7. *Block diagram for receiver attack time and receiver closing time measurements.*

5.5.4 Audio Tests

5.5.4.1 Audio Output Power Test

Connect the equipment as in figure 3 and use procedure 1 to produce standard ACSB test signal #1. With the rf signal generator set to produce a 1-mV output, adjust the receiver volume control upward to the highest level at which the SINAD is 20 dB or greater. Measure the audio output power. Repeat for power supply voltage changes of ±10 percent.

5.5.4.2 Audio Distortion Test

Connect the equipment as in figure 3 and use procedure 1 to produce standard ACSB test signal #1. Set the rf signal generator for a 1-mV output, adjust the receiver volume control to produce standard audio output power, and measure the audio distortion.

5.5.4.3 Audio Response Test

Connect the equipment as in figure 3 and use procedure 2 to produce standard ACSB test signal #2. Adjust the continuously variable attenuator until the output of the attenuator from rf signal generator B is −50 dBm (the output from the same attenuator for rf signal generator A will be −60 dBm). Measure the power of rf signal generator A and record the value. Set the receiver to produce standard audio output power. Adjust signal generator B to produce transmitted audio frequencies of 0.5, 0.7, 1.4, 1.7, 2.0, and 2.5 kHz. At each of these frequencies, adjust the level of rf signal generator A until the audio output power of the receiver returns to the standard audio output power level. Measure the power of rf signal generator A and record the value at each frequency. If a spectrum analyzer is used to measure the power in rf signal generator A, the measurement should be made with at least the accuracy of the 2-dB scale setting. Compute the ratio, in decibels, of each of these power levels relative to the audio output power for standard ACSB test signal #2. A plot of the power level of rf signal generator A as a function of the audiofrequency shows the audio response of the receiver.

5.5.4.4 Audio Hum and Noise Test

Connect the equipment as in figure 3 and use procedure 2 to produce standard ACSB test signal #2. Adjust the continuously variable attenuator until the output of the attenuator is −50 dBm (the output from the attenuator for rf signal generator A will be −60 dBm). Set the receiver volume control to produce standard audio output power. Do not readjust the volume control for the remainder of the measurement. Set the output level of rf signal generator B to zero and measure the audio hum and noise power. Compute the ratio, in decibels, of the standard audio output power to the audio hum and noise 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 both signal generators to zero and measure the audio hum and noise power. Calculate the ratio, in decibels, of the standard audio output power to the audio hum and noise power. This is the value for audio hum and noise (squelched).

5.5.4.5 Expansion Ratio Test

The expansion ratio of each expander of a two-stage expander may be measured separately. However, in this standard, a combined expansion test is specified.

Connect the equipment as in figure 3 and use procedure 2, with some modifications, to produce an ACSB signal with a transmitted audiofrequency of 1 kHz. Simultaneously increase the pilot rf component and decrease the audio component level as described herein. Set the output of rf signal generator B (audio rf component) to at least −50 dBm and set the output level of rf signal generator A (pilot rf component) to 6 dB below the level of signal generator B. Adjust the continuously variable attenuator until the output from signal generator B is −50 dBm (the output from the attenuator for signal generator A will be −68 dBm). Adjust the volume control to produce standard audio output power and record this voltage (V_p). Using a spectrum analyzer or an rf power meter, increase the output of signal generator A by 3 dB and decrease the output of signal generator B by 3 dB. Measure and record the resulting voltage (V_t) at the speaker terminals. The expansion ratio is $20 \times \log (V_p/V_t)/3$.

5.6 Transmitter Tests

Since ACSB transmitters do not use a carrier, modulation must be applied in order to produce an rf output. For many of the measurements described below, an audio input of either a steady 1-kHz tone or a modulated 1-kHz tone must be used.

5.6.1 Radio Frequency Tests

5.6.1.1 Output Power Test

Connect the equipment as in figure 8 using a wattmeter that measures peak envelope power directly. Key the transmitter with no audio input and wait at least 5 s, then measure and record the pilot power (P_1) indicated on the wattmeter. Ensure that the output of the sampler is at least 10 dB below maximum allowable

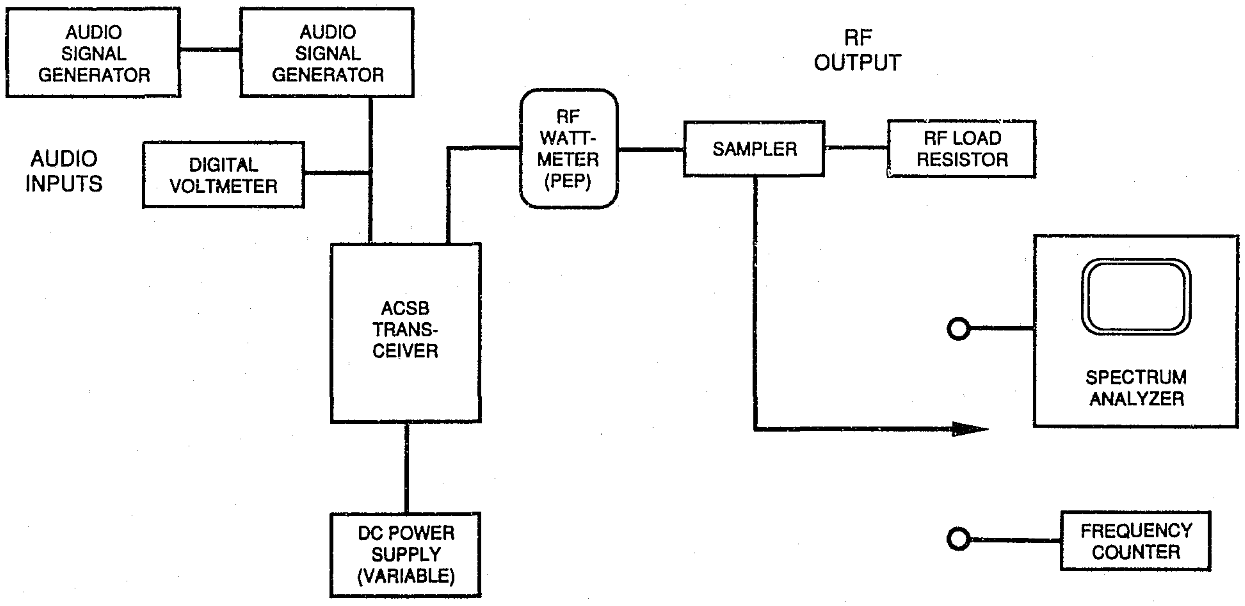

FIGURE 8. *Block diagram of general equipment configuration for making ACSB transmitter measurements.*

input to the spectrum analyzer. If the sampler must be adjusted to achieve this, do not readjust it for the remainder of this measurement. Then, at the output of the sampler, measure and record the pilot (P_2) using the spectrum analyzer. The 25-W reference point is $10 \times \log_{10} (25/P_1)$ dB above this level.

After an interval of at least 5 s, use the audio input of an amplitude modulated, 100 Hz, 75 percent modulation, 1-kHz tone to raise the rf output power above 4 W. Increase the audio input level to the transmitter and observe both the reading on the wattmeter and the sampled transmitter signal on a spectrum analyzer to confirm that distortion products remain at least 32 dB below the 25-W reference point. The most significant distortion product will probably be the intermodulation product located 2.1 kHz below the rf audio component. Rated PEP will be the lesser of 25 W or the transmitter PEP when the highest magnitude distortion product is at least 32 dB below the 25 W reference point.

Adjust the power supply voltage to 10 percent above standard supply voltage, allow 5 s for the transmitter to stabilize, and repeat the measurement. Repeat the measurement for power supply voltage changes of ± 10 and -20 percent.

5.6.1.2 Automatic Level Control Test

Connect the equipment as in figure 8. Increase the level of the audio signal generator (modulated 75% at 100 Hz, if necessary) to raise the transmitter output power to 25 W PEP. Increase the audio input voltage to three times the voltage required to reach 25 W. Record the PEP indication on the rf power meter.

5.6.1.3 Frequency Stability Test

Connect the equipment as in figure 8. Using standard supply voltage, operate the transmitter without modulation and measure and record the frequency. Repeat this procedure for power supply voltage changes of ± 15 percent.

5.6.1.4 AM Hum and Noise Level Test

Connect the equipment as in figure 9. Use a linear peak-carrier responsive AM detector to detect the attenuated output of the transmitter. Using the standard supply voltage, operate the transmitter without modulation between 2 and 4 W. Measure and record the dc voltage, V_{dc}, across the detector load resistor with a high impedance dc voltmeter. Without adjusting the transmitter, measure and record the peak ac voltage, V_p, with the oscilloscope. Calculate the AM hum and noise level in decibels as $20 \log_{10} (V_p/V_{dc})$.

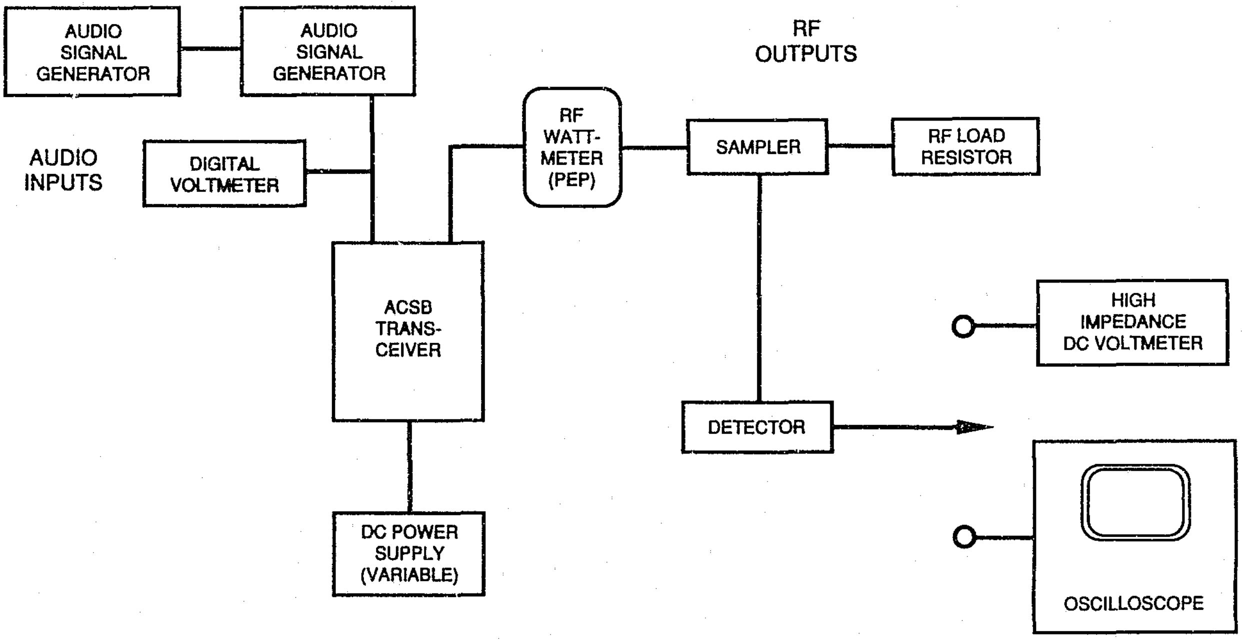

FIGURE 9. *Block diagram for AM hum and noise level measurements.*

5.6.1.5 Transmitter Attack Time Test

If the ACSB transmitter uses a preamble, measure the time it takes the pilot to reach 12.5 W PEP. If there is no preamble, measure the time it takes the pilot to reach 1.25 W PEP. Connect the equipment as in figure 10, and use a peak detector with a short time constant (<10 ms) and a linear amplitude response. Close the trigger circuit of the oscilloscope with the transmitter keying switch to start the time interval. The peak detector, sampling the pilot, provides a voltage to the oscilloscope vertical input. Measure the time required for the trace to reach 71 percent of the maximum output.

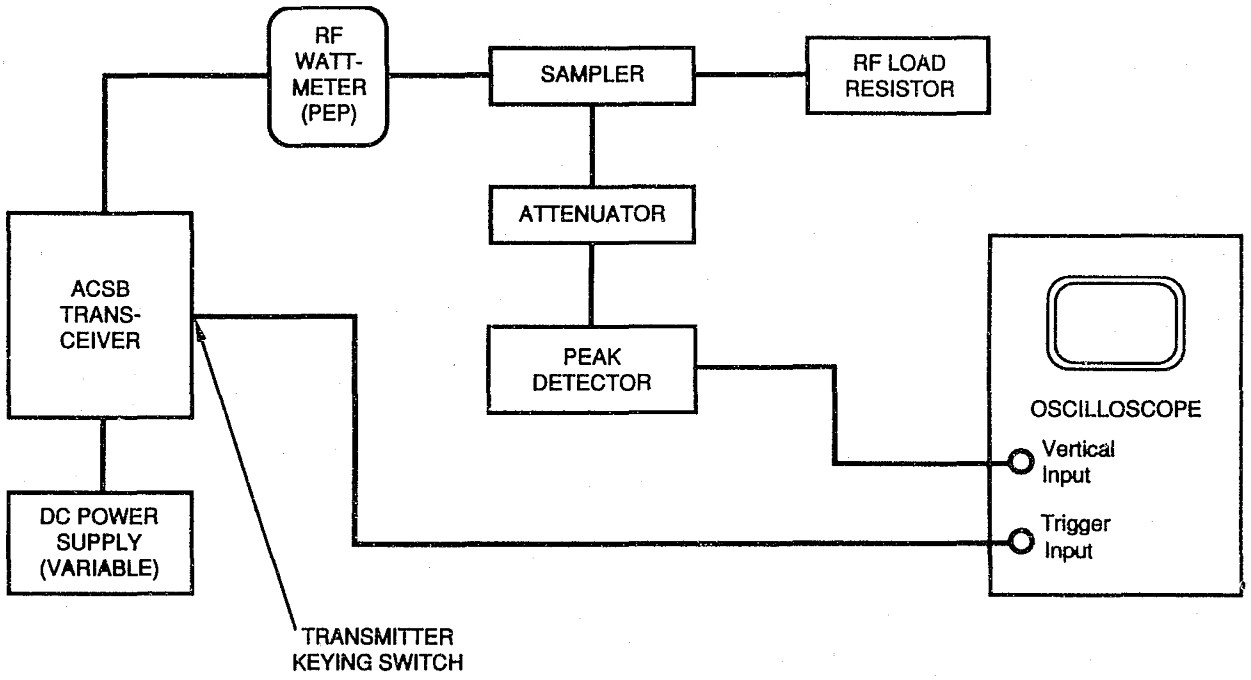

FIGURE 10. *Block diagram for carrier attack time measurements.*

5.6.2 Audio Modulation Tests

5.6.2.1 Total Audio Harmonic Distortion Test

Connect the equipment as in figure 11. Using a 1-kHz tone with a total distortion of 0.5 percent or less, raise the transmitter output power to 10 W PEP. Process the sampled transmitter signal using the test receiver and adjust the sampled transmitter signal level and the audio output level of the receiver for maximum signal-to-noise ratio to minimize the distortion effects of the receiver. This signal-to-noise ratio value is the value of total harmonic distortion for the transmitter.

5.6.2.2 Audio Response Test

Connect the equipment configuration as in figure 8. Raise the rf output power to 10 W PEP using a 1-kHz audio tone and record the voltage of the 1-kHz audio signal. Repeat for 0.5, 0.7, 1.4, 1.7, 2.0, and 2.5 kHz. Measure and record the audio signal voltage at each frequency that will produce an rf output power of 10 W PEP. Plot the audio voltages at each frequency, in decibels, relative to the voltage measured at 1 kHz.

5.6.2.3 Compression Ratio Test

Connect the equipment as in figure 8. Increase the level of the audiofrequency signal generator until the audio-to-pilot ratio observed on the spectrum analyzer is 14 dB. Measure and record the audiofrequency signal generator voltage to the nearest tenth of a millivolt and the level of the audio component (AC1) to the nearest tenth of a dBm on the spectrum analyzer. Reduce the audiofrequency signal generator voltage by

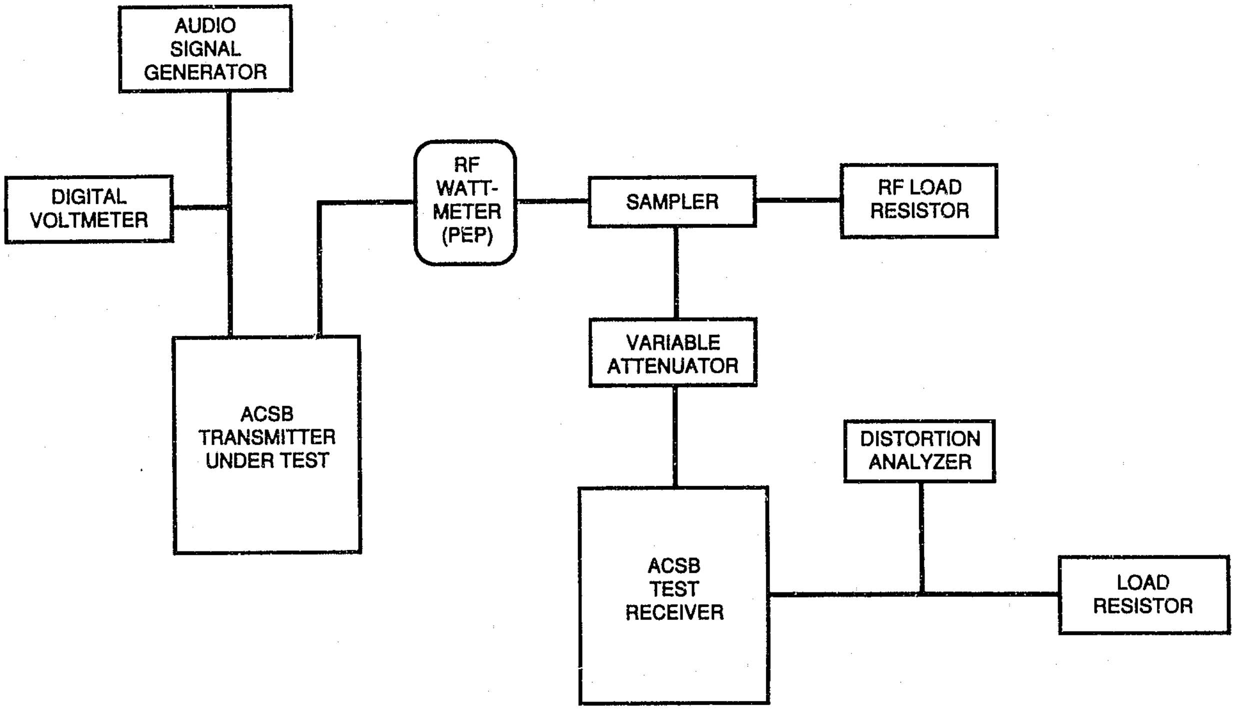

FIGURE 11. *Block diagram for total harmonic distortion measurements.*

12.04 dB (to 1/4 of previous value). Then measure the level of the audio component (AC2) to the nearest tenth of a dBm on the spectrum analyzer. Calculate the compression ratio as

$$\frac{12.04}{AC1-AC2} \cdot$$

5.6.3 Electromagnetic Compatibility Tests

5.6.3.1 Conducted Spurious Emissions Test

Connect the equipment as in figure 8. Use the technique specified in section 5.6.1.1 to determine the 25-W reference point. Using a 1-kHz tone or, if necessary, an amplitude modulated (100 Hz, 75% modulation) 1-kHz tone, raise the rf output power of the transmitter to 25 W PEP. Observe the spurious emissions on the spectrum analyzer. The most significant spurious component will probably be an intermodulation product located 2.1 kHz below the rf audio component. Ignoring those signals that occur within ±250 percent (±9 kHz) of the authorized bandwidth, observe the spurious signal with the highest amplitude and record its power in dBm (P_c). The difference, in decibels, between the 25-W reference point and P_c is the value sought.

5.6.3.2 Radiated Spurious Emissions Test

Connect the equipment as in figure 12. With a 1-kHz tone or, if necessary, an amplitude modulated (100 Hz, 75% modulation) 1-kHz tone, raise the rf output power of the transmitter to 25 W PEP. Measure the spurious emissions with the receiving antenna located 30 m (98 ft) from the transceiver and 3 m (9.8 ft) above the earth. Tune the field strength meter from the lowest radio frequency generated in the transceiver up to 1000 MHz. Note each spurious emission.

For each spurious emission noted, raise and lower the receiving antenna with a horizontal polarization to obtain a maximum reading on the field strength meter. Rotate the transceiver to further maximize this reading. Repeat this procedure of raising and lowering the antenna and rotating the transceiver 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 frequency and maximum field strength of each spurious signal.

The attenuation of each radiated spurious emission is the field strength of the pilot frequency minus the field strength of the radiated spurious emission. The smallest attenuation is the value sought.

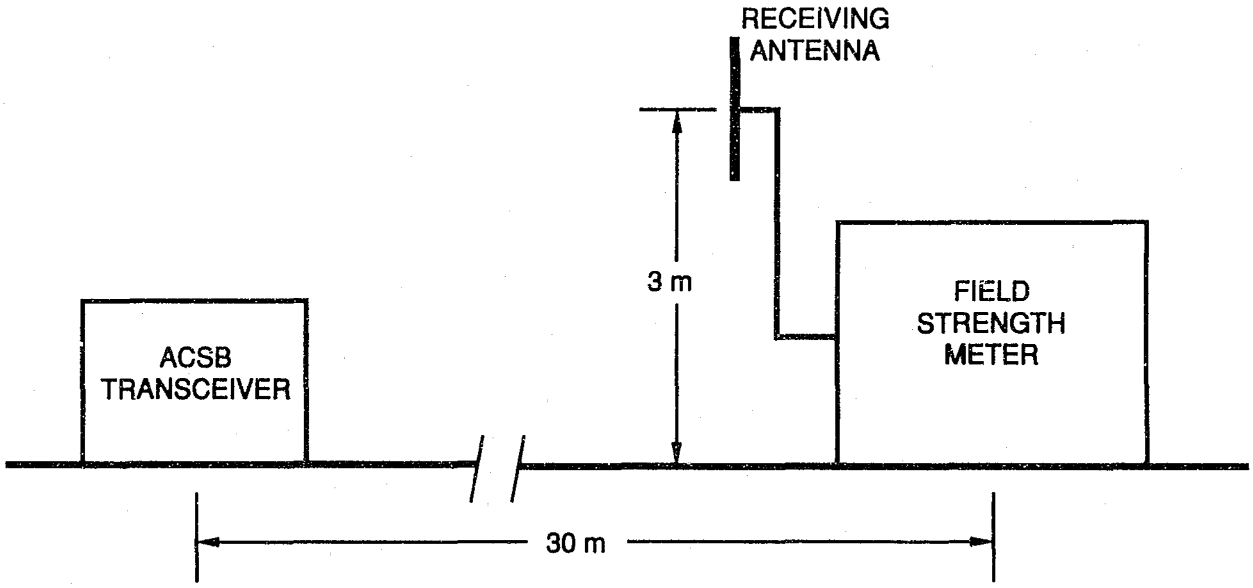

FIGURE 12. *Block diagram for radiated spurious emissions measurements.*

APPENDIX A—REFERENCES

[1] Greene, F. M. Technical terms and definitions used with law enforcement communications equipment. LESP-RPT-0203.00. National Institute of Justice, U.S. Department of Justice, Washington, DC 20531; 1973 June.

[2] Mobile FM transceivers. NIJ Standard-0210.00. U.S. Department of Justice, National Institute of Justice, Washington, DC 20531; 1986 May.

[3] Notice of inquiry and proposed rulemaking. Gen. Docket 85-171. Adopted May 31, 1985, Released June 11, 1985. Federal Communications Commission, 1919 M Street, NW, Washington, DC 20554.

[4] Private land mobile radio services. Rules and Regulations, Vol. 5, Part 90. Federal Communications Commission, 1919 M Street, NW, Washington, DC 20554.

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