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TEST PROCEDURES HANDBOOK FOR SURVEILLANCE RECEIVERS BELOW 100 MHz

M.G. Arthur

Electromagnetic Metrology
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National Bureau of Standards
Boulder, Colorado 80302

October 1973

Prepared for:
U.S. Army Security Test and Evaluation Center
Ft. Huachuca, Arizona

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ABSTRACT

This handbook contains test methods and procedures for radio receivers of advanced design that operate in the frequency range below 100 MHz. Sixty-one methods are given for testing forty receiver characteristics such as sensitivity, selectivity, gain, interference susceptibility, audio characteristics, power supply characteristics and others. Each receiver characteristic is defined. For each method, the following information is given: (a) test equipment required, (b) step by step procedure, (c) data required, and (d) measurement error computation. The handbook also includes a general discussion of standard test conditions, suitable test equipment, and measurement errors.

Key Words: Electronic measurements; electronic test equipment; measurement errors; radio receivers; receiver characteristics; receiver testing.

1.0. INTRODUCTION

Engineers and measurement specialists have provided a variety of methods, techniques, and procedures for testing electronic equipment, and for measuring the various performance parameters that are critical to the proper utilization of electronic systems. This body of knowledge is scattered in various documents so that it is not always convenient to produce upon demand any given procedure that may be needed. Further, because of incompleteness, differences of purpose or outlook, and advances in the state of the art, much of this published measurement knowledge does not satisfy current needs in certain technical areas.

This manual is an attempt to improve upon the current situation by collecting together those procedures that are useful for testing and measuring the performance of surveillance receivers.

1.1. PURPOSE

The specific purpose of this manual is to up-grade the test procedures used by the U.S. Army Security Test and Evaluation Center at Ft. Huachuca, Arizona in its test and evaluation of prototype surveillance receiver equipment in the frequency range below 100 MHz.

1.2. SCOPE AND LIMITATIONS

The test and measurement procedures given are for surveillance and similar types of communications receivers. Long-established procedures are included only if they are still valid. New procedures, that may not yet be widely adopted, are included when they are superior and practicable. Requirements that are not now met by known procedures are identified, and some possible solutions are offered when known.

The procedures given in this manual are written for the knowledgeable engineering technician who has had training and experience in electronic measurements. These are not procedures that can be correctly performed by elementary-level personnel, nor are they such as to require advanced training as may be found only at the primary standards laboratory level.

In some cases, several procedures are given to meet a variety of needs of accuracy, speed, convenience, or equipment inventory limitations.

1.3. SOURCES OF INFORMATION

Principal sources of information are issuances of the IEEE, EIA, IEC, CCIR, and DoD, listed below. Other sources of general information are listed in Section 7.0., Bibliography.

a. IEEE (Institute of Electrical and Electronics Engineers)

1. IEEE Standard Dictionary of Electrical and Electronics Terms, IEEE Std 100 - 1972, Wiley - Interscience, 1972.

2. IRE Standards on Receivers: Definitions of Terms, 1952 (52 IRE 17.S1) (IEEE No. 188).

3. IRE Standards on Radio Receivers: Methods of Testing Amplitude - Modulation Broadcast Receivers, 1948 (48 IRE 17.S1) (IEEE No. 186).

4. IRE Standards on Radio Receivers: Methods of Testing Frequency - Modulation Broadcast Receivers, 1947 (47 IRE 17.S1) (IEEE No. 185).

5. IEEE Test Procedures for Frequency-Modulated Mobile Communications Receivers, IEEE No. 184, April 1969 (Revision of 49 IRE 26.S1).

6. IEEE Standards for Measurement of Radio Noise Generated by Motor Vehicles and Affecting Mobile Communications Receivers in the Frequency Range 25 to 1000 Megacycles per Second, IEEE No. 263, November 1965.

7. IRE Standards on Audio Techniques: Definitions of Terms, 1958 (58 IRE 3.S1).

8. IRE Standards on Audio Systems and Components: Methods of Measurement of Gain, Amplification, Loss Attenuation, and Amplitude-Frequency-Response, 1956 (56 IRE 3.S1).

b. EIA (Electronic Industries Association)

1. Minimum Standards for Land-Mobile Communication FM or PM receivers, EIA RS-204, January 1958.

Also, Standards Proposal No. 1092, a revision of RS-204 October 1970.

2. Minimum Standards for Land-Mobile Communication Systems Using FM or PM in the 25-470 Mc Frequency Spectrum, EIA RS-237, August 1960.

c. IEC (International Electrotechnical Commission)

1. Recommended Methods of Measurement on Receivers for Amplitude-Modulation Broadcast Transmissions, Publication 69, 1954.

2. Recommended Methods of Measurement on Receivers for Frequency-Modulation Broadcast Transmissions, Publication 91, 1958.

3. Recommended Methods of Measurement of Radiation from Receivers for Amplitude-Modulation, Frequency-Modulation and Television Broadcast Transmissions, Publication 106, 1959; and Publication 106A, 1962.

d. CCIR (International Radio Consultative Committee)

1. Noise and Sensitivity of Receivers, Recommendation 331-2, XIIth Plenary Assembly, New Delhi, 1970.

2. Selectivity of Receivers, Recommendation 332-2, XIIth Plenary Assembly, New Delhi, 1970.

3. Bandwidths and Signal-to-Noise Ratios in Complete Systems, Recommendation 339-2, XIIth Plenary Assembly New Delhi, 1970.

4. Amplitude-Modulation Sound Broadcasting, Objective Two-Signal Methods of Measurement of Radio-Frequency Wanted-to-Interfering Signal Ratios, Report 399-1, XIIth Plenary Assembly, New Delhi, 1970.

e. DOD (Department of Defense)

1. Measurement of Radio Frequency Spectrum Characteristics, MIL-STD-449C, 1 March 1965.

2. Electromagnetic Interference Characteristics, Requirements for Equipment, MIL-STD-461A 7 February 1969.

3. Measurement of Electromagnetic Interference Characteristics, MIL-STD-462, 1 August 1968.

4. Electromagnetic Interference Test Requirements and Test Methods, MIL-STD-826, 20 January 1964.

5. Materiel Test Procedure for Receiver-Transmitter, General, MTP 6-2-242, 1 September 1967.

2.0. SURVEILLANCE RECEIVERS

2.1. GENERAL CHARACTERISTICS

The modern surveillance receiver is a high-performance HF and VHF receiver based upon the latest advances in communications technology. Although its operational features are similar to its predecessors, its electrical design and construction bear little resemblance to receivers of a decade ago. Most notable are the characteristics of all solid-state design, modular construction, and digitally controlled heterodyne oscillators. Excellent short- and long-term stability is achieved through the use of automatic frequency control referenced to a precision crystal oscillator. Digital frequency display is common. The small power requirements of solid-state circuits further contribute to stability as well as to compact size and moderate weight. The availability of low-noise, linear transistors results in improved sensitivity and exceptional dynamic range, while at the same time reducing intermodulation and distortion products. The small space and power requirements of modern circuits make feasible the use of independent networks where multipurpose networks had been used; for example, separate detectors for CW, AM, FM, USB, LSB, and AGC, separate AF amplifiers for line and speaker outputs, and separate BFO circuits for CW, USB, and LSB detection.

Modern surveillance receivers are also less susceptible to electromagnetic interference because of improved filtering, shielding, and amplifier linearity. They are designed to work over a wide range of ambient temperature, mechanical shock, and primary power options.

2.2. CRITERIA FOR TEST AND CALIBRATION

The surveillance receiver under test must be in normal operating condition before making any measurements of its electrical parameters. For example, all operating discrepancies must be corrected. All tuned circuits must be aligned and tuned according to the manufacturer's specified procedures. Any malfunctions must be repaired. Power supply voltages must be within the manufacturer's prescribed tolerances.

Although these test procedures can serve to reveal malfunctions and improper operation of the receiver, they are not intended for this purpose. Much time may be saved if the receiver is checked according to the maintenance procedures provided by the manufacturer before starting these tests.

2.3. SPECIFICATIONS OF TYPICAL RECEIVERS

The electrical specifications of surveillance receivers will vary according to the frequency range, application, and operational requirements. Some electrical specifications of typical receivers are listed in Table I. No single receiver will necessarily include all of these parameters, nor will the specified value of a given parameter always fall within the range listed.

The test procedures given in this handbook are designed to measure these parameters within the ranges listed in Table I. In addition, procedures for other parameters are also given.

TABLE I

Selected Electrical Specifications

Of Typical Surveillance Receivers

	Parameter	Units	Range
1.	Sensitivity	Microvolts	0.1 to 3 μv
2.	Noise Factor	Decibels	3 to 15 dB
3.	Gain	Decibels	100 to 150 dB
4.	Dynamic Range	Decibels	
	With AGC		80 to 120 dB
	With MGC		20 to 120 dB
5.	Automatic Gain Control (Levelling Effect)	--	2 to 6 dB levelling for inputs from 1 to 100,000 μV
6.	Automatic Gain Control	Seconds	
	Attack time		0.001 to 0.1 sec.
	Decay time		0.01 to 5 sec.
7.	Bandwidth	Hertz	100 Hz to 25 kHz
8.	Shape Factor	--	1.3:1 to 10:1

Table I (Cont'd)

Parameter	Units	Range
9. Spurious Response Attenuation	Decibels	40 to 100 dB
10. Desensitization	Millivolts	10 to 1000 mV
11. Cross Modulation	Millivolts	10 to 1000 mV
12. Intermodulation Distortion	Decibels	30 to 100 dB
13. Conducted Interference Susceptibility	Millivolts	1 to 1000 mV
14. Radiated Interference Susceptibility	Volts/meter	0.01 to 1 v/V
15. Conducted Emission	Millivolts	1 mV max.
16. Radiated Emission	Millivolts/meter	1 mV/m max.
17. Time Delay	Seconds	0.04 to 20 m sec
18. Frequency Stability (after warm-up)		
Time	Hertz/unit time	Short: 1 to 5 Hz/10 min. Long: 5 to 200 Hz/8 hr.
Temperature	Hertz/° Celcius	1 to 100 Hz/°C
Supply voltage	Hertz/volt	1 to 10 Hz/V

Table I (Cont'd)

	Parameter	Units	Range
19.	Readout Error	Hertz	100 to 1000 Hz
20.	Impedance	Ohms	
	RF/IF		50 to 600 Ω
	AF		3 to 600 Ω
21.	Standing Wave Ratio	--	1:1 to 3:1
22.	Audio Output Power	Watts	0.001 to 10 W
23.	Audio Frequency Response	--	Within ±3 dB from 100 to 5000 Hz
24.	Audio Distortion	Percent	1 to 10%
25.	Audio Hum & Noise (below reference output)	Decibels	-30 dB max.
26.	Squelch Sensitivity	Microvolts	0.05 to 0.5 μV
27.	Input Voltage	Volts	
	AC		100 to 125 VAC
			200 to 250 VAC
			40 to 400 Hz
	DC		22 to 34 VDC

3.0. TEST METHODS AND PROCEDURES

3.1. GENERAL

The test procedures included in this handbook are summarized in Table II. Detailed procedures, including definitions of the parameters measured, purpose of the measurement, general method used, test equipment required, step-by-step procedures, data required, and a discussion of measurement errors, are given in Section 4.0., below.

Table II lists (a) each receiver parameter for which a procedure is given, (b) the sub-section of this handbook in which it is given, (c) the nominal range over which the parameter can be measured, (d) the best and typical measurement accuracies attainable, and (e) the developmental status of the procedure.

The key to the status is as follows:

O -- Old. The procedure, or one similar to it, or the basic principal underlying it, has been established for sufficient time for it to have become known by people who make receiver measurements.

N -- New. The procedure, to our knowledge, has not formally appeared in the open literature.

T -- Tested. The procedure has been used and found suitable for the intended measurement.

P -- Provisional. The procedure, or one similar to it, has been used, but it has not yet been fully tested and verified as suitable for the intended measurement.

U -- Untested. The procedure has been drawn up for this handbook; and although it is expected to be suitable for the intended measurement, it has not been adequately tested and verified.

The reason for the variety of statuses is explained below.

These procedures come from a variety of sources. The principal sources of documented procedures are those listed in Section 1.3, above. Table III shows the extent to which these sources have contributed to this handbook. It can be seen that, although they represent the technical output of the major standardizing organizations (except for DoD) in the area of radio measurements, they fail to provide adequate procedures for a majority of the listed receiver parameters.

When the principal sources provided inadequate or no procedures for certain parameters, new procedures were adapted from information contained in handbooks and textbooks, technical journals and reports, privately published monographs, and from individual metrologists. Most of these ancillary sources do not provide the required detailed information (e.g., step-by-step procedures, equipment requirements, error analysis, etc.). Such information has been newly written specifically for this handbook. Thus, many of the procedures in Section 4.0., below, although based upon sound principles, have not been tested sufficiently to validate that they are entirely practical and without shortcomings in all their particulars. These are identified by the status symbols "N", "P", and "U" in Table II.

TABLE II

Test Procedure Summary

Section	Parameter	Range	Accuracy Best	Accuracy Typical	Status
4.1.1.	Gain-limited Sensitivity (AM)	0.1 µV min.	3%	5% - 20%	O,T
4.1.2.	6 dB SN/N Sensitivity (AM)	0.1 µV min.	3%	5% - 20%	O,T
4.1.3.	12 dB SINAD Sensitivity (AM)	0.1 µV min.	5%	8% - 30%	N,P
4.1.4.	Quieting Sensitivity (FM)	0.1 µV min.	3%	5% - 20%	O,T
4.1.5.	12 dB SINAD Sensitivity (FM)	0.1 µV min.	5%	8% - 30%	O,T
4.1.6.3.	Noise Factor - ANFM Method	1 dB - 15 dB	0.3 dB	0.5 dB - 1.5 dB	O,T
4.1.6.4.	Noise Factor - Y-Factor/Power Meter	1 dB - 15 dB	0.2 dB	0.3 dB - 1 dB	O,T
4.1.6.5.	Noise Factor - Y-Factor/Attenuator	1 dB - 15 dB	0.2 dB	0.3 dB - 1 dB	O,T
4.1.6.6.	Noise Factor - 3 dB Method	1 dB - 15 dB	0.3 dB	0.5 dB - 1.5 dB	O,T
4.2.	Signal-to-Noise Ratio	0 - 60 dB	0.2 dB	0.3 dB - 0.8 dB	O,T
4.3.1.	Power Gain	0 - 120 dB	0.3 dB	0.4 dB - 1.5 dB	O,P
4.3.2.3.	Dynamic Range, MGC	120 dB max.	0.3 dB	0.4 dB - 3 dB	N,U
4.3.2.4.	Dynamic Range, AGC	120 dB max.	0.4 dB	1 dB - 4 dB	N,U
4.3.3.1.	Automatic Gain Control Gain vs. AGC Voltage	120 dB max.gain 10 VDC max.AGC	6%	8% - 40%	O,P
4.3.3.2.	Automatic Gain Control Leveling Effect	120 dB max.	8%	10% - 40%	O,P
4.3.3.3.	Automatic Gain Control Dynamic Characteristics	Attack Time: <0.1 ms. Decay Time: >10 sec.	6%	8% - 40%	O,P
4.4.1.3.	Selectance - Method I	100 dB max.	6%	8% - 40%	O,P
4.4.1.4.	Selectance - Method II	100 dB max.	6%	8% - 40%	O,P
4.4.1.5.	Selectance - Method III	40 dB max.	8%	12% - 40%	O,T
4.4.2.3.	CW Bandwidth - Method I	<100 Hz->25 kHz	3%	6% - 25%	O,P
4.4.2.4.	CW Bandwidth - Method II	<100 Hz->25 kHz	10%	12% - 40%	O,T
4.4.3.	Shape Factor	~1:1 - 20:1	6%	10% - 40%	O,P
4.4.4.	Modulation Acceptance Bandwidth	<2 kHz->25 kHz	10%	15% - 50%	O,T
4.4.5.3.	Spurious Response Attenuation (AM)	0 - 100 dB	0.3 dB	0.4 dB - 1.5 dB	O,P
4.4.5.4.	Spurious Response Attenuation (FM)	0 - 100 dB	0.3 dB	0.4 dB - 1.5 dB	O,P

TABLE II (Cont'd)

Section	Parameter	Range	Accuracy Best	Accuracy Typical	Status
4.4.6.	Noise Bandwidth	<100 Hz->25 kHz	10%	15% - 50%	O,T
4.4.7.	Desensitization	0 - 100 dB	0.4 dB	0.6 dB - 2 dB	N,U
4.4.8.	Cross Modulation	1 V max.	10%	12% - 50%	O,P
4.4.9.	Adjacent Channel Selectivity	0 - 120 dB	0.7 dB	0.9 dB - 2.5 dB	O,T
4.4.10.3.	Intermodulation Distortion Method I	20 - 100 dB	0.5 dB	0.8 dB - 3 dB	N,P
4.4.10.4.	Intermodulation Distortion Method II	1 μV - 1 V	3%	5% - 20%	O,P
4.4.10.5.	Intermodulation Distortion Method III	1 μV - 1 V	3%	5% - 20%	O,P
4.4.10.6.	Intermodulation Distortion Method IV	1 μV - 1 V	5%	8% - 30%	O,P
4.4.11.	Impulse Bandwidth	<100 Hz->25 kHz	8%	10% - 30%	O,P
4.5.1.	Conducted Interference Susceptibility (AM)	1 - 1000 mV	5%	8% - 30%	N,P
4.5.2.	Conducted Interference Susceptibility (FM)	1 - 1000 mV	5%	8% - 30%	N,P
4.5.3.	Radiated Interference Susceptibility (AM)	< 100 V/m	--	100% - 1000%	O,U
4.5.4.	Radiated Interference Susceptibility (FM)	< 100 V/m	--	100% - 1000%	O,U
4.6.1.	Conducted Emission	-130 to 0 dBm	0.3 dB	0.5 dB - 1.5 dB	N,P
4.6.2.	Radiated Emission	0 - 1000 μV/m	--	100% - 1000%	O,U
4.7	Time Delay	10 μ sec - 100 msec	2%	3% - 10%	N,U
4.8.	Frequency Stability	0.1 - 1000 Hz	0.2 Hz	0.2 Hz - 1 Hz	N,P
4.9.	Frequency Readout Error	0 - 10 kHz	--	(Readout resolution)	N,P
4.10.3.	Impedance - Method I	1 - 1000 Ω	4%	5% - 20%	O,T
4.10.4	Impedance - Method II	1 - 1000 Ω	4%	5% - 20%	O,T
4.11	Standing Wave Ratio	1:1 - 10:1	6%	8% - 20%	O,T
4.13.1.	Audio Gain	0 - 60 dB	0.5 dB	0.7 dB - 2 dB	N,P
4.13.2.3.	Audio Frequency Response Method I	10 Hz - 25 kHz	0.5 dB	0.7 dB - 2 dB	O,T
4.13.2.4.	Audio Frequency Response Method II	10 Hz - 25 kHz	0.5 dB	0.7 dB - 2 dB	O,T
4.13.2.5.	Audio Frequency Response Method III	10 Hz - 25 kHz	--	10% - 100%	O,T

TABLE II (Cont'd)

Section	Parameter	Range	Accuracy Best	Accuracy Typical	Status
4.13.2.6.	Audio Frequency Response Method IV	10 Hz - 25 kHz	0.5 dB	0.7 dB - 2 dB	O,P
4.13.3.	Audio Linearity	0 - 60 dB	0.5 dB	0.7 dB - 2 dB	O,T
4.13.4.	Audio Distortion	0.1% - 20%	8%	10% - 50%	O,T
4.13.5.	Hum and Noise	-0 dB to -40 dB below P_o	0.5 dB	0.7 dB - 2 dB	O,P
4.13.6.	Noise Limiter Threshold	0 - 10 V	2%	4% - 15%	N,P
4.13.7.	Squelch Sensitivity	0.01 μV-- 1 μV	5%	8% - 30%	O,P
4.14.1.	Input Power (AC/DC)	1 W - 150 W	2%	4% - 15%	O,T
4.14.2.	Output Voltage (DC)	0 - > ± 300 V	1%	2% - 10%	O,T
4.14.3.3.	Voltage Regulation - Line	0.001% - 10%	2%	4% - 15%	O,T
4.14.3.4.	Voltage Regulation - Load	0.001% - 10%	2%	4% - 15%	O,T
4.14.4.	Ripple and Noise	1 mv - 10 V	1%	2% - 10%	O,T

TABLE III

Sources of Documented Procedures

Parameter	IEEE No. 188	IEEE No. 186	IEEE No. 185	IEEE No. 184	IEEE No. 263	58 IRE 3.S1	56 IRE 3.S1	RS-204	RS-237	Publication 69	Publication 91	Publication 106	Recomm. 331-2	Recomm. 332-2	Recomm. 339-2	Report 399-1	MIL-STD-449C	MIL-STD-461A	MIL-STD-462	MIL-STD-826	MTP 6-2-242
Gain-Limited Sensitivity	S	L	S	*	*	*	*	*	*	S	S	*	U	*	*	*	*	*	*	*	*
6 dB SN/N Sensitivity	*	*	*	*	*	*	*	*	*	S	S	*	U	*	*	*	*	*	*	*	*
12 dB SINAD Sensitivity (AM)	*	*	*	*	*	*	*	*	*	*	*	*	U	*	*	*	*	*	*	*	*
Quieting Sensitivity	S	*	S	S	*	*	*	*	*	*	*	*	*	*	*	*	S	*	*	*	S
12 dB SINAD Sensitivity (FM)	*	*	*	*	S	*	*	S	*	*	*	*	*	*	*	*	*	*	*	*	*
Noise Factor	S	*	*	*	*	*	*	U	*	*	*	*	S	*	*	*	*	*	*	*	*
Signal-to-Noise Ratio	*	U	*	*	*	*	*	*	S	N	N	*	*	*	*	*	*	*	*	*	*
Power Gain	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dynamic Range	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	L	*	*	*	L
Automatic Gain Control	S	S	L	*	*	*	*	*	*	L	L	*	*	*	*	*	*	*	*	*	*
Selectance	L	S	*	*	*	*	*	*	*	S	L	*	*	*	*	*	S	*	*	*	*
CW Bandwidth	L	*	*	*	*	*	*	*	*	*	*	*	*	*	U	*	S	*	*	*	S
Shape Factor	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Modulation Acceptance Bandwidth	*	*	*	S	*	*	*	S	*	*	*	*	*	U	*	*	*	*	*	*	*
Spurious Response Attenuation	*	L	S	S	*	*	*	S	S	S	S	*	*	U	*	*	S	*	*	*	S
Noise Bandwidth	L	*	*	*	*	*	*	*	*	*	*	*	U	*	*	*	*	*	*	*	*
Desensitization	*	S	S	*	*	*	*	*	*	*	*	*	*	U	*	*	N	*	*	*	*
Cross Modulation	*	*	*	S	*	*	*	*	*	S	*	*	*	*	*	S	S	*	*	*	*
Adjacent Channel Selectivity	*	*	S	*	*	*	*	S	S	*	S	*	*	U	*	*	S	*	*	*	*
Intermodulation Distortion	U	S	L	S	*	*	*	S	S	N	N	*	*	*	*	*	S	*	*	*	*
Impulse Bandwidth	L	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	N	*	*	*	*
Conducted Interference Susceptibility (AM)	L	*	*	S	*	*	*	L	*	L	*	*	*	*	*	*	*	S	L	L	*
Conducted Interference Susceptibility (FM)	L	*	*	S	*	*	*	L	*	L	*	*	*	*	*	*	*	S	L	L	*
Radiated Interference Susceptibility (AM)	L	*	L	S	L	*	*	*	*	*	*	*	*	*	*	*	N	S	L	L	*
Radiated Interference Susceptibility (FM)	L	*	L	S	L	*	*	*	*	*	*	*	*	*	*	*	N	S	L	L	*
Conducted Emission	*	L	L	*	*	*	*	L	S	S	L	L	*	*	*	*	L	S	L	L	*
Radiated Emission	*	L	L	*	*	*	*	L	S	S	L	L	*	*	*	*	L	S	L	L	*
Time Delay	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Frequency Stability	*	S	S	*	*	*	*	*	L	L	L	*	*	*	*	*	*	*	*	*	*
Frequency Readout Error	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Impedance	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Standing Wave Ratio	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Detectors	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Audio Gain	*	*	*	*	*	S	S	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Audio Frequency Response	*	S	S	L	*	S	S	N	L	L	L	*	*	*	U	*	S	*	*	*	S
Audio Linearity	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Audio Distortion	U	S	S	*	*	S	*	*	S	S	S	*	*	*	*	*	*	*	*	*	*
Hum and Noise	L	S	S	*	*	S	*	L	*	N	N	*	*	*	*	*	*	*	*	*	*
Noise Limiter Threshold	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Squelch Sensitivity	S	*	*	S	*	*	*	S	*	*	*	*	*	*	*	*	*	*	*	*	*
Input Power	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Output Voltage	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Voltage Regulation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ripple and Noise	L	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Key: * -- No procedure provided
U -- Procedure used as provided
S -- Small Modification
L -- Large Modification
N -- Procedure not used

The procedures in this handbook, therefore, are a mixture (a) of proven methods and (b) of "unproven" methods that are based upon either proven principles or upon the adaptation of similar methods to the requirements at hand. The new, provisional, or untested procedures should be used with technical prudence, but may be expected to yield the desired results without significant modifications.

3.2. STANDARD TEST CONDITIONS

Certain test conditions apply to the majority of these procedures and therefore can be "standardized." Deviations from these standard conditions occur in specific instances, and these are made clear in Section 4.0.

These standard test conditions are recommendations only, and may be modified according to the needs of a particular measurement situation. When this is done, the prevailing test conditions should be recorded with the test data so that proper account can be taken thereof, in the interpretation of the measurement results.

3.2.1. AMBIENT CONDITIONS

3.2.1.1. STANDARD TEMPERATURE

Standard temperature shall be +20°C to + 35°C.

3.2.1.2. STANDARD RELATIVE HUMIDITY

Standard relative humidity shall be as follows:

a. Zero to 90 percent at 20°C to 30°C
b. Zero to 70 percent at 30°C to 35°C

3.2.1.3. STANDARD ATMOSPHERIC PRESSURE

Standard atmospheric pressure shall be the ambient atmospheric pressure at the time of the test.

3.2.2. PRIMARY INPUT POWER SUPPLY VOLTAGE

Standard input power supply voltage shall be within ±5 percent of the mean of the rated operating voltage range of the receiver, as given in the manufacturer's specifications.

3.2.3. ELECTROMAGNETIC COMPATIBILITY CONDITIONS

These tests shall be conducted, as far as practicable, in areas that are sufficiently free from electromagnetic interference fields to allow the measurements to be made without significant adverse effect on the results. Primary input power sources shall be sufficiently filtered to accomplish the same end. Test instrumentation shall be properly shielded, filtered, and grounded so as to minimize erroneous results caused by extraneous signals from these or other sources.

3.2.4. RECEIVER PREPARATION

3.2.4.1. OPERATING CONDITIONS

When important to the test results, the receiver should be situated so that it closely approximates the physical and electrical conditions in which it is intended to operate. All accessories that may affect test results shall be installed and put into operation.

3.2.4.2. RECEIVER CONDITION

Before any measurements are performed, the receiver shall be in proper operating condition as stated in Section 2.2., above.

3.2.4.3. WARM-UP TIME

Sufficient warm-up time, e.g., from one-half to two hours, shall be provided before any measurements are performed to insure adequate stabilization of the receiver parameters.

3.2.5. TEST INSTRUMENTATION PREPARATION

3.2.5.1. OPERATING CONDITIONS

Test instruments shall be operated according to the manufacturer's instructions. Check for proper grounding, proper connections of cables and probes, and proper shielding, filtering, and isolation as required. Sufficient warm-up time shall be provided to insure stable operation.

3.2.5.2. CALIBRATION

All test equipment must meet the manufacturer's specifications on accuracy and other performance parameters. Information on accuracy, frequency response, spectral purity, etc., must be verified and at hand in order to obtain meaningful results from these tests.

3.2.6. TERMINATIONS

All terminations to receiver terminals (ports) shall be of the proper impedance and power rating, as specified by the receiver manufacturer. They shall be adequately shielded to prevent interference to, or from, other parts of the measurement system.

3.2.7. TEST FREQUENCIES

No standard test frequencies are specified in this handbook. Test frequencies are to be determined according to the purposes of the test.

3.2.8. SIGNAL LEVELS

3.2.8.1. INPUT SIGNAL VOLTAGE

No standard input signal level is specified in this handbook. When a specific level is required for a particular test, it is so stated in that test procedure.

R.F. input signal levels are expressed in terms of the open circuit voltage across the output terminals of the source of the input signal. If an impedance matching, filter, or attenuating network is used between the signal generator output terminals and the receiver input terminals, the input signal level is the open circuit voltage across the output terminals of the network. If no such network is used, the input signal is the open circuit voltage across the output terminals of the generator.

3.2.8.2. AUDIO OUTPUT POWER

Reference audio output power shall be established for the receiver as one of the following power levels:

a. 50% of manufacturer's rated audio output power

b. Maximum audio output power having a 12 dB SINAD ratio (6.3% noise and distortion)

c. Manufacturer's rated audio output power

d. Some other power level that is determined by the characteristics of the receiver or the requirements of the test

In this handbook, reference audio output power is taken to be 50% of manufacturer's rated audio output power. Any deviation from this meaning is identified in the text. When the manufacturer has not given a rated audio output power for the receiver under test, establish one using a reasonable criterion, such as the power level at the 10% distortion point.

In all cases, the basis for the reference output power level should be stated in the test report.

3.2.9. MODULATION

3.2.9.1. AMPLITUDE MODULATION

Standard amplitude modulation shall be 30% with a 1000 hertz sinusoid voltage.

3.2.9.2. SINGLE SIDEBAND MODULATION

Standard single sideband suppressed carrier modulation frequencies shall be the two tones of 400 hertz and 2500 hertz. The amplitudes of these two tones shall be equal.

3.2.9.3. FREQUENCY MODULATION

Standard frequency modulation shall be ±60% of rated system deviation with a 1000 hertz sinusoid voltage. Rated system deviation shall be as given by the receiver manufacturer; or, if this is not specified, it may be taken to be the CW bandwidth of the receiver. CAUTION: The CW bandwidth may not be suitable as a basis for determining rated system deviation in some receivers that are not designed correctly for FM reception.

3.3. MEASUREMENT ERRORS

A measurement error is the difference between the true value and the measured value of a quantity.

3.3.1. TYPES OF ERRORS

Measurement errors are of two types: systematic and random. A systematic error is the difference between the true value and the limiting mean of a set of measured values of a quantity. A random error is the error caused by a random process, as contrasted with a systematic or deterministic process.

3.3.2. ORIGINS OF ERRORS

Measurement errors result primarily from uncertainties in the data. They can also result from procedural mistakes; but this source of error can be removed by using care, repeating measurements, cross-checking, and a variety of other procedural methods. Uncertainties in the data come from such sources as (a) uncertainties in the true value of a meter or dial reading, (b) uncertainties in the calibration of an instrument, (c) imprecision in the indicated meter reading due to random fluctuations or poor resolution, (d) variations in the parameter being measured during the measurement interval, and (e) variations caused by human frailties in performing the measurement.

3.3.3. ERROR EQUATION

The total measurement error is obtained by means of an error equation. The error equation comes from an error analysis of the measurement process, and contains terms which represent the individual sources of error.

A thorough error analysis of each measurement procedure is beyond the scope of this handbook. Further, the desired level of precision for these tests does not warrant a highly exhaustive treatment. Therefore, only the principal sources of error have been accounted for in the error equations provided in this handbook.

The total error of a measurement normally consists of both systematic and random errors. In general, the error equation applies separately to both types of errors. Thus, the error equation is used twice, once for systematic errors and once for random errors. The total error is then expressed in two parts, viz., a systematic part and a random part. In some cases, one type may predominate over the other, in which case the total error may be substantially systematic or random.

The error equations given in Section 4.0. are primarily for use with systematic uncertainties, although they can also be used with random uncertainties. For proper use of these equations, refer to Section 3.3.5., below.

3.3.4. REDUNDANCY

Measurements should be made more than once for the following reasons:

a. Gross errors and mistakes may be revealed.

b. The average result usually has a smaller error than each individual result.

c. The spread of the individual results provides an estimate of the measurement error.

Repeating the measurement many times can reduce the random error, but it will not reduce the systematic error. Systematic error is reduced by using test equipment having greater inherent accuracy.

Random error is expressed in terms of the standard deviation, s, of the measurement data. It is common practice to take 3s (three standard deviations) as the random error of the measured value of the parameter.

Standard deviation decreases with the square root of n, the number of measurement results. Significant improvements accrue as n increases from one to two to three, but note that the improvement decreases with increasing n. Seldom is it worthwhile to repeat measurements of the type given in this handbook more than ten times.

3.3.5. POOLING ERRORS

Independent systematic errors are combined algebraically. That is, if one error is positive (+) and the other negative (-), the total of these two errors is their algebraic sum. If a systematic error can be either positive or negative (±) then judgement must be exercised when combining it with other errors. Unless knowledge about an error directs otherwise, the worst-case combination should be used. This normally means that the errors are pooled by adding their absolute values, thus disregarding their algebraic signs. If there is some interdependence (correlation) between individual errors, it may be taken into account to obtain a pooled error that is smaller than their worst-case sum.

Random errors are combined on a root-mean-square basis. That is, the two errors, Δa and Δb, produce a total error, Δc, given by the equation

$$\Delta c = [(\Delta a)^2 + (\Delta b)^2]^{\frac{1}{2}} .$$

When there is a question as to whether an error is systematic or random, usual practice is to pool it with other errors on a worst-case basis.

3.3.6. OBTAINING MEASUREMENT UNCERTAINTIES

In order to estimate a measurement error, it is necessary to obtain quantitative values for the uncertainties in the data. The usual source of information for systematic measurement uncertainties is the manufacturer's accuracy specification for the particular test equipment involved. An alternative, and possibly superior, source is a recent calibration certificate for the instrument, which should include the limits of error on the calibration results. Lacking either of these sources, measurement uncertainties can be obtained by measuring a known quantity with the instrument, and comparing the measurement results with the known value.

Random uncertainties are obtained from a statistical analysis of the data. Refer to standard textbooks on the subject for procedures (see Bibliography).

4.0. DETAILED TEST PROCEDURES

4.1. SENSITIVITY

The sensitivity of a receiver is a measure of its ability to receive weak signals. To express this ability in quantitative terms, sensitivity is broadly defined as the smallest R.F. input signal necessary to produce an acceptable demodulated output signal. Several types of sensitivity are defined to provide for different types of receivers and different receiving requirements. Of these, the following types are described, and measurement methods are given:

1. Sensitivity (Gain-Limited AM receivers)

2. 6 dB SN/N sensitivity (AM receivers)

3. 12 dB SINAD sensitivity (AM and FM receivers)

4. Quieting sensitivity (FM receivers)

5. Noise factor (AM and FM receivers)

4.1.1. SENSITIVITY OF A GAIN-LIMITED AM RECEIVER

4.1.1.1. DEFINITIONS

a. The sensitivity of a gain-limited AM receiver is the open circuit output voltage, in microvolts, from a signal generator amplitude modulated 30% with a 1000 Hz sinusoid, that will produce reference audio output power from the receiver output terminals.

b. A gain-limited receiver is a receiver whose gain and internal noise are such that, when its input termination has a noise temperature of 290K, reference audio output power cannot be produced by amplification of system noise alone.

4.1.1.2. PURPOSE

The purpose of this measurement method is to measure the sensitivity of gain-limited AM receivers. For such receivers, sensitivity is essentially a measure of the total receiver gain. The method ignores the effects of distortion; therefore, for non-linear receivers it does not yield accurate results.

4.1.1.3. METHOD

The method uses an amplitude modulated signal generator and a voltmeter or power meter as shown in figure 4.1.1. The signal generator supplies a known voltage to the receiver at the measurement frequency. The voltmeter or power meter indicates the receiver output signal level.

The generator level is adjusted to the open circuit output voltage that will produce reference audio output power from the receiver. This voltage is the sensitivity of the receiver.

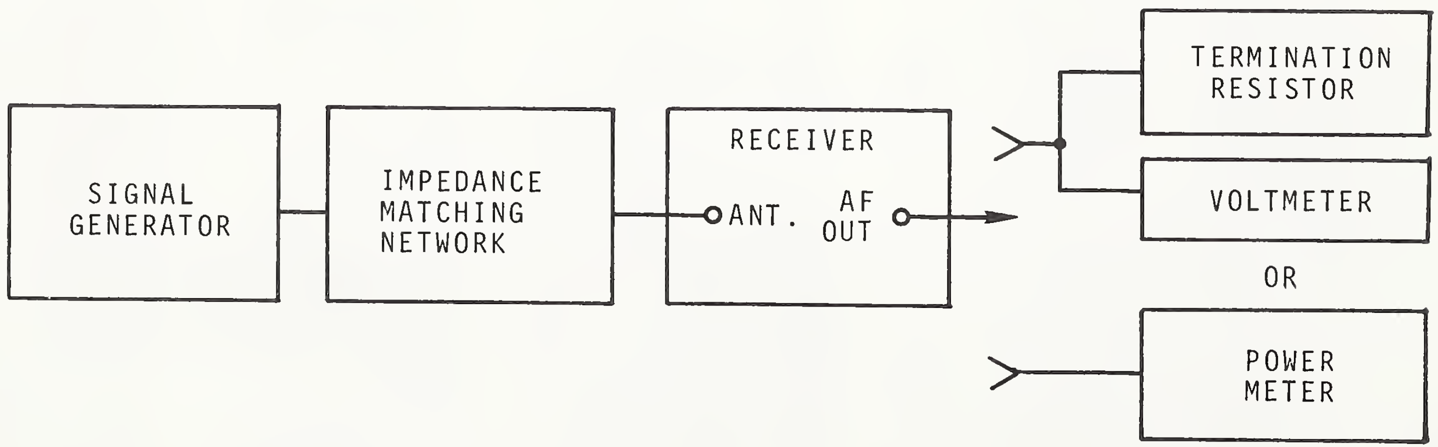

Fig. 4.1.1. Test Set-up for Gain Limited Sensitivity

Measurement uncertainties as small as 3% are possible under best conditions, and range from approximately 5% to 20% under typical conditions. This method uses rudimentary and commonly available test equipment.

4.1.1.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4a. AF power meter

OR,

4b. A.C. voltmeter

4.1.1.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the A.C. VOLTMETER across this resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

OR,

3b. Set the power meter on a range to indicate the reference output power, P_o.

4. Set receiver controls as given in Table IV.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

7. Adjust the output level of the signal generator to give reference audio power output, P_o, from the receiver.

8. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator. This is the SENSITIVITY of the receiver at frequency f_o.

4.1.1.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

TABLE IV

Gain-Limited Sensitivity

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	Maximum
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	Optional

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4a. Record the output voltage, E_o, in volts

OR,

4b. Record the reference output power, P_o, in watts.

5. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator. E_i is the sensitivity of the receiver.

4.1.1.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

2b. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, $\Delta E_i(\%)$, in the receiver sensitivity, E_i, expressed as a percent, is given by the equations

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100\right) + \left(\frac{\Delta E_o}{E_o} \times 100\right),$$

OR

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_o}{P_o} \times 100\right).$$

The uncertainty, ΔE_i, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.1.2. 6 dB SN/N SENSITIVITY OF A NOISE-LIMITED AM RECEIVER

4.1.2.1. DEFINITIONS

a. The 6 dB SN/N sensitivity of a noise-limited AM receiver is the open circuit output voltage, in microvolts, from a signal generator amplitude modulated 30% with a 1000 Hz sinusoid, that will produce a signal-plus-noise-to-noise ratio (SN/N) of 4 (6 dB) at the reference audio output power level from the receiver output terminals.

b. A noise-limited receiver is a receiver whose gain and internal noise are such that, when its input termination has a noise temperature of 290K, reference audio output power can be produced in its output termination by amplification of system noise alone.

4.1.2.2. PURPOSE

The purpose of this measurement method is to measure the 6 dB SN/N sensitivity of noise-limited AM receivers. For such receivers, 6 dB SN/N sensitivity is essentially a measure of the smallest signal that has a usable strength. The method ignores the effects of distortion; therefore, for non-linear receivers it does not yield accurate results.

4.1.2.3. METHOD

The method uses an amplitude modulated signal generator and a power meter or true rms voltmeter as shown in figure 4.1.2. The signal generator supplies a known voltage to the receiver at the measurement frequency. The voltmeter or power meter indicates the receiver output signal level.

The generator level is adjusted to the open circuit output voltage that will produce a 6 dB signal-plus-noise-to-noise ratio at reference audio output power from the receiver. This voltage is the 6 dB SN/N sensitivity of the receiver.

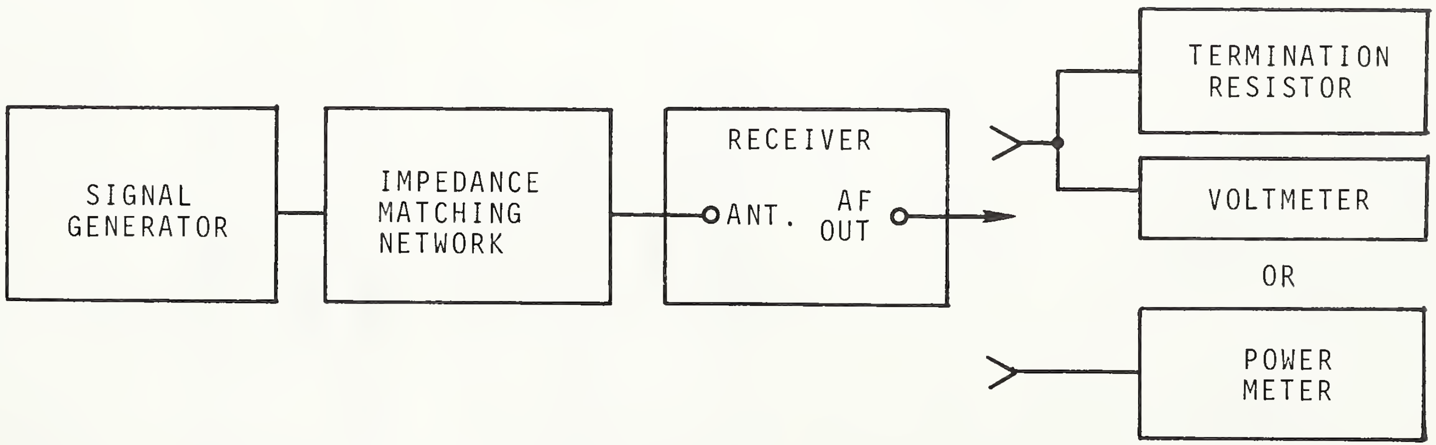

Fig. 4.1.2. Test Set-up for 6 dB SN/N Sensitivity

Measurement uncertainties as small as 3% are possible under best conditions, and range from approximately 5% to 20% under typical conditions. This method uses rudimentary and commonly available test equipment.

4.1.2.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4a. AF power meter

OR,

4b. True rms voltmeter

4.1.2.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell}$$

OR,

3b. Set the power meter on a range to indicate the reference output power, P_o.

4. Set the receiver controls as given in Table V.

Note: Check to make sure the maximum gain setting does not produce signal clipping or compression in the latter IF amplifier stages. If clipping or compression occurs, reduce RF or IF gain.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

7. With the signal generator connected and its output set to zero, adjust the receiver AF gain control to produce 25% of reference audio output power, P_o. This will be noise power only.

8. Adjust the output level of the signal generator to give reference audio output power, P_o. This will be approximately 25% noise power and 75% audio signal power (1000 Hz), and corresponds to a 6 dB signal-plus-noise-to-noise ratio.

9. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator. This is the 6 dB SN/N SENSITIVITY of the receiver at the frequency f_o.

TABLE V

6 dB SN/N Sensitivity

Initial Control Settings

	Control		Setting
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	Optional

4.1.2.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4a. Record the output voltage, E_o, in volts.

OR,

4b. Record the reference output power, P_o, in watts.

5. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator. E_i is the 6 dB SN/N sensitivity of the receiver.

4.1.2.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

2b. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, ΔE_i (%), in the receiver sensitivity, E_i, expressed as a percent, is given by the equations

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100\right) + \left(\frac{\Delta E_o}{E_o} \times 100\right),$$

or

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100\right) + \left(\frac{1}{2}\ \frac{\Delta P_o}{P_o} \times 100\right).$$

The uncertainty, ΔE_i, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.1.3. 12 dB SINAD SENSITIVITY OF A NOISE-LIMITED AM RECEIVER

4.1.3.1. DEFINITIONS

a. SINAD is an acronym for the phrase "signal plus noise plus distortion to noise plus distortion ratio."

$$\text{SINAD} = \frac{S + N + D}{N + D} = \frac{P_{(s+n+d)}}{P_{(n+d)}}$$

b. The 12 dB SINAD sensitivity of a noise-limited AM receiver is the open-circuit output voltage, in microvolts, from a signal generator amplitude modulated 30% with a 1000 Hz sinusoid, that will produce a SINAD of 16 (12 dB) at no less than 50% of the reference audio output power from the receiver output terminals.

c. A noise-limited receiver is a receiver whose gain and internal noise are such that, when its input termination has a noise temperature of 290K, reference audio output power can be produced in its output termination by amplification of system noise alone.

4.1.3.2. PURPOSE

The purpose of this measurement method is to measure the 12 dB SINAD sensitivity of noise-limited AM receivers. For such receivers, SINAD sensitivity is a measure of the smallest typical signal that has usable strength and that produces an audio output signal of acceptable quality. The method takes into account the effects of distortion within the receiver; therefore, it can be a more meaningful measure of sensitivity than 6 dB SN/N sensitivity for real-world receivers.

4.1.3.3. METHOD

The method uses an amplitude modulated signal generator and an audio distortion analyzer as shown in figure 4.1.3. The signal generator supplies a known voltage to the receiver at the measurement frequency. The distortion analyzer measures the power in the audio output from the receiver under two conditions; viz., (a) with the 1000 Hz modulating signal present, and (b) with the 1000 Hz modulating signal filtered from the audio output power. The generator level is adjusted to the open circuit output voltage that causes the ratio of (a) to (b), above, expressed in decibels, to be 12 dB. This voltage is the 12 dB SINAD sensitivity of the receiver.

Measurement uncertainties as small as 5% are possible under best conditions, and range from approximately 8% to 30% under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.1.3.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

4.1.3.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

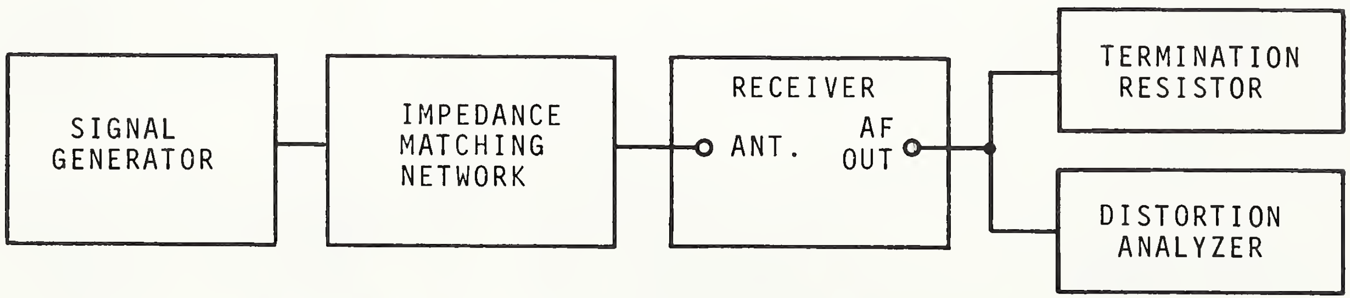

Fig. 4.1.3. Test Set-Up for 12 dB SN/N Sensitivity (AM)

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_{ℓ}, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set the distortion analyzer on a range to indicate the reference output power, P_o.

4. Set receiver controls as given in Table VI.

Note: Check to make sure the maximum gain setting does not produce signal clipping or compression in the latter IF amplifier stages. If clipping or compression occurs, reduce RF or IF gain.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

7. Set the signal generator output level to 1000 microvolts.

8. Adjust the receiver AF gain control to produce reference audio output power, P_o. This is $P_{(s+n+d)}$.

9. Adjust the distortion analyzer so that the 1000 Hz rejection filter tunes out the 1000 Hz modulation from the signal generator.

10. Measure the noise plus distortion output power, $P_{(n+d)}$.

11. Calculate SINAD, in decibels, from the equation

$$\text{SINAD (dB)} = 10 \log \frac{P_o}{P_{(n+d)}} \quad .$$

TABLE VI

12 dB SINAD Sensitivity (AM)

Initial Control Settings

	Control		Setting
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

12. If SINAD calculated in Step 11 is greater (or less) than 12 dB, decrease (or increase) the signal generator output by 3 dB or smaller and repeat Steps 8 through 11. Continue this procedure until 12 dB SINAD is obtained.

Note: If 12 dB SINAD cannot be reached by INCREASING the signal generator output, the receiver is probably distortion-limited. In this case, an alternate reference SINAD such as 6 dB may be used.

13. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator. This is the 12 dB SINAD SENSITIVITY of the receiver at frequency f_o.

4.1.3.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the SINAD ratio in decibels.

6. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network, if used, otherwise, at the output terminals of the generator. E_i is the 12 dB SINAD sensitivity of the receiver.

4.1.3.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2. Uncertainty, ΔP_o, in the measured value of P_o

3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

The total relative uncertainty, $\Delta E_i(\%)$, in the 12 dB SINAD sensitivity, E_i, expressed as a percent, is given by the equation

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100 \right) + \left(\frac{1}{2} \frac{\Delta P_o}{P_o} \times 100 \right) + \left(\frac{1}{2} \frac{\Delta P_{n+d}}{P_{n+d}} \times 100 \right) .$$

The uncertainty, ΔE_i, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.1.4. QUIETING SENSITIVITY OF AN FM RECEIVER WITH ONE OR MORE LIMITERS

4.1.4.1. DEFINITION

The quieting sensitivity of a receiver is the minimum amount of signal from an unmodulated standard input signal source that is required to produce 20 decibels of noise quieting measured at the receiver audio output. (EIA RS-204)

Noise quieting is the reduction of audio noise output power caused by the presence of an input signal to the receiver.

4.1.4.2. PURPOSE

The purpose of this measurement method is to measure the quieting sensitivity of FM receivers containing one or more amplitude limiter stages preceding the FM demodulator circuit. For such receivers, quieting sensitivity is a measure of the degree to which its limiters suppress amplitude fluctuations such as external and internal noise signals. The method ignores the effects of non-linearity in the audio stages; therefore, it may yield slightly inaccurate results.

4.1.4.3. METHOD

The method uses an unmodulated signal generator and a true rms voltmeter or power meter as shown in figure 4.1.4. The signal generator supplies a known voltage to the receiver at the measurement frequency. The voltmeter or power meter indicates the receiver output noise power level.

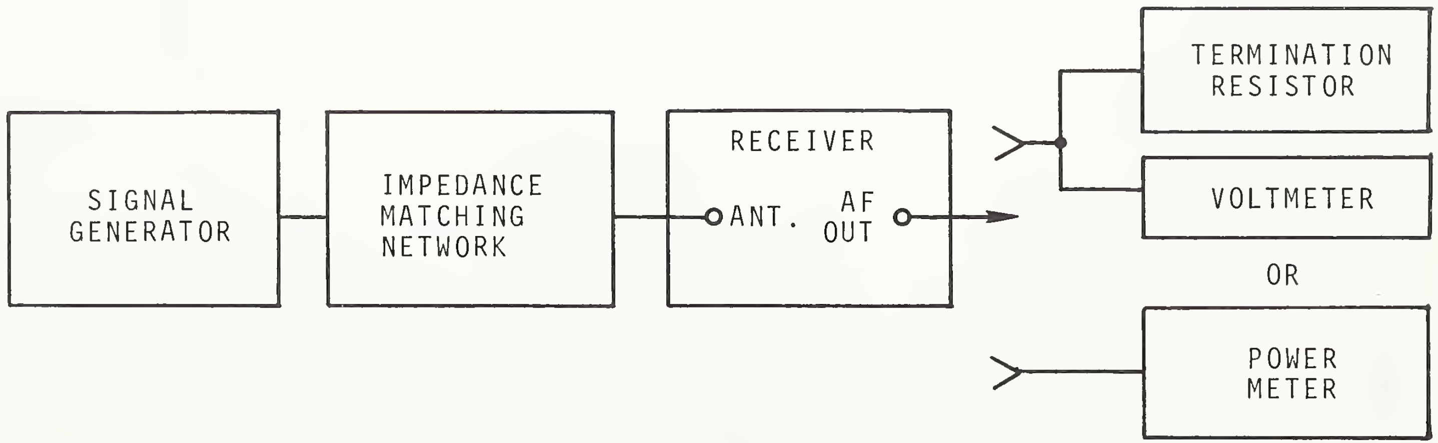

Fig. 4.1.4. Test Set-up for Quieting Sensitivity

The generator level is adjusted to the open circuit output voltage that produces 20 dB of noise quieting as measured with the voltmeter or power meter. This voltage is the quieting sensitivity of the receiver.

Measurement uncertainties as small as 3% are possible under best conditions, and range from approximately 5% to 20% under typical conditions. This method uses rudimentary and commonly available test equipment.

4.1.4.4. TEST EQUIPMENT REQUIRED

1. CW signal generator

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4a. AF power meter

OR,

4b. True rms voltmeter

4.1.4.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across this resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate 25% of the rated output power, P_o. The voltage to be measured is given by the equation

$$E_o = 0.5 \sqrt{P_o R_\ell} \quad .$$

OR,

3b. Set the power meter on a range to indicate 25% of the rated output power, P_o.

4. Set receiver controls as given in Table VII.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the signal generator so that the signal is unmodulated.

7. With the signal generator connected and its output set to zero, adjust the receiver AF gain control to produce 25% of rated audio output power, P_o. This will be noise power only.

TABLE VII

Quieting Sensitivity

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. FM
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

8. Increase the output level of the signal generator until the audio output noise power level is reduced to 0.25% of P_o (0.0025 P_o). This is a reduction to 20 dB below the level indicated in Step 7, above.

Note: If the output noise power level cannot be reduced to 0.25% of P_o, select some other target value such as 2.5% of P_o (reduction of 10 dB).

9. Determine the open circuit signal voltage E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator. This is the 20 dB QUIETING SENSITIVITY of the receiver at the frequency f_o.

4.1.4.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4a. Record the measured output voltage, E_o, in volts, from Step 3a, above.

OR,

4b. Record the measured output power, 0.25 P_o, in watts, from Step 3b, above.

5. Record the measured output voltage, 0.1 E_o, in volts, or the measured output power, 0.0025 P_o, in watts, from Step 8 above.

(If the 10 dB, or other, level of quieting sensitivity is measured, record the measured values of output voltage or power for this criterion.)

6. Record the open circuit signal voltage, E_i in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator. E_i is the quieting sensitivity of the receiver.

4.1.4.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2. Uncertainty, ΔE_o, in the measured value of E_o

3. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, $\Delta E_i(\%)$, in the receiver sensitivity, E_i, expressed as a percent, is given by the equations

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100\right) + \left(\sqrt{2}\,\frac{\Delta E_o}{E_o} \times 100\right) ,$$

or

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100\right) + \left(\frac{\sqrt{2}}{2}\,\frac{\Delta P_o}{P_o} \times 100\right) .$$

The uncertainty, ΔE_i, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.1.5. 12 dB SINAD SENSITIVITY OF AN FM RECEIVER WITH ONE OR MORE LIMITERS

4.1.5.1. DEFINITIONS

a. SINAD is an acronym for the phrase "signal plus noise plus distortion to noise plus distortion ratio."

$$\text{SINAD} = \frac{S + N + D}{N + D} = \frac{P_{(s+n+d)}}{P_{(n+d)}} .$$

b. The 12 dB SINAD sensitivity of an FM receiver with one or more limiters is the open circuit output voltage, in microvolts, from a signal generator frequency modulated ±60% of maximum rated system deviation with a 1000 Hz sinusoid, that will produce a SINAD of 16 (12 dB) at no less than 50% of the reference audio output power from the receiver output terminals.

Note: The rated system deviation, in kilohertz, is found by reference to specifications for the given system. It is typically ±5 kHz to ±25 kHz.

4.1.5.2. PURPOSE

The purpose of this measurement method is to measure the 12 dB SINAD sensitivity of FM receivers containing one or more amplitude limiter stages preceding the FM demodulator circuit. For such receivers, 12 dB SINAD sensitivity is a measure of the smallest typical signal that has usable strength and that produces an audio output signal of acceptable quality. The method takes into account the effects of distortion within the receiver; therefore, it can be a more meaningful measure of sensitivity than Quieting Sensitivity for real-world receivers.

4.1.5.3. METHOD

The method uses a frequency modulated signal generator and an audio distortion analyzer as shown in figure 4.1.5. The signal generator supplies a known input voltage to the receiver at the measurement frequency. The distortion analyzer measures the power in the audio output from the receiver under two conditions; viz., (a) with the 1000 Hz modulating signal present, and (b) with the 1000 Hz modulating signal filtered from the audio output power. The generator level is adjusted to the open circuit output voltage that causes the ratio of (a) to (b), above, expressed in decibels, to be 12 dB. This voltage is the 12 dB SINAD sensitivity of the receiver.

Measurement uncertainties as small as 5% are possible under best conditions, and range from approximately 8% to 30% under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.1.5.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

4.1.5.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

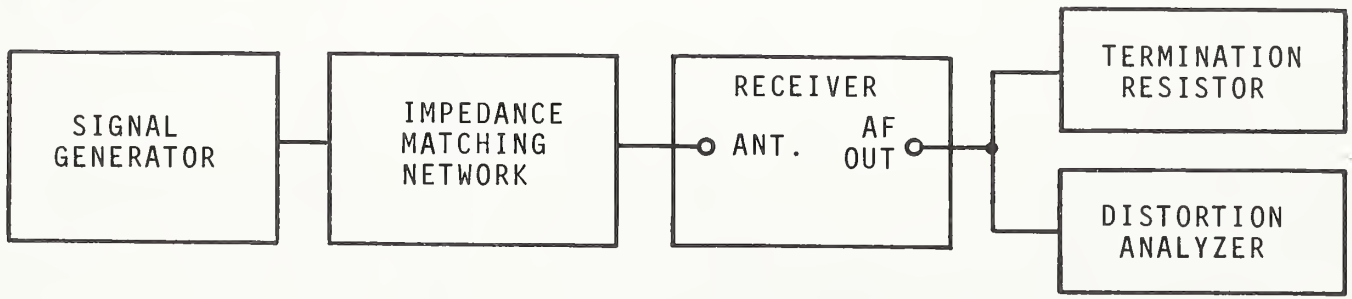

Fig. 4.1.5. Test Set-up for 12 dB SINAD Sensitivity (FM)

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_{ℓ}, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set the distortion analyzer on a range to indicate the reference output power, P_o.

4. Set receiver controls as given in Table VIII.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the frequency modulation in the signal generator to ±60% of rated system deviation at 1000 Hz.

7. Set the signal generator output to 1000 microvolts.

8. Adjust the receiver AF gain control to produce rated audio output power, P_o. This is $P_{(s+n+d)}$.

9. Adjust the distortion analyzer so that the 1000 Hz rejection filter tunes out the 1000 Hz modulation from the signal generator.

10. Measure the noise plus distortion output power, $P_{(n+d)}$.

11. Calculate SINAD, in decibels, from the equation

$$\text{SINAD (dB)} = 10 \log \frac{P_o}{P_{(n+d)}} .$$

12. If SINAD calculated in Step 11 is greater (or less) than 12 dB, decrease (or increase) the signal generator output by 3 dB or smaller and repeat Steps 8 through 11. Continue this procedure until 12 dB SINAD is obtained.

TABLE VIII

12 dB SINAD Sensitivity (FM)

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	FM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

Note: If 12 dB SINAD cannot be reached by INCREASING the signal generator output, the receiver is probably distortion-limited. In this case, an alternate reference SINAD such as 6 dB may be used.

13. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator. This is the 12 dB SINAD SENSITIVITY of the receiver at frequency f_o.

4.1.5.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the SINAD ratio in decibels.

6. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator. E_i is the 12 dB SINAD sensitivity of the receiver.

4.1.5.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i
2. Uncertainty, ΔP_o, in the measured value of P_o
3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

The total relative uncertainty, ΔE_i(%), in the 12 dB SINAD sensitivity, E_i, expressed as a percent, is given by the equation

$$\Delta E_i(\%) = \left(\frac{\Delta E_i}{E_i} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_o}{P_o} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_{n+d}}{P_{n+d}} \times 100\right) .$$

The uncertainty, ΔE_i, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.1.6. NOISE FACTOR

4.1.6.1. DEFINITION

Receiver noise factor (noise figure), F, is the ratio of (a) signal-to-noise power ratio, S_i/N_i, at the antenna terminals to (b) signal-to-noise ratio, S_o/N_o, at the output terminals of the receiver, when the input termination is at standard temperature (290K).

$$F = \frac{S_i/N_i}{S_o/N_o}$$

This definition is an adaptation of the IEEE definition of Average Noise Factor for the particular case of surveillance receivers. Noise factor is usually expressed in decibels; that is,

$$F(\mathrm{dB}) = 10 \log F.$$

4.1.6.2. PURPOSE

The purpose of the following measurement methods is to measure the average noise factor of AM and FM receivers. Noise factor is a measure of the amount of noise power added to a signal by the receiver, thereby degrading the signal quality.

Four methods of measurement are given, and the method used will depend upon the test equipment available, the desired accuracy, and the time available to devote to the measurement. Noise figure is usually measured only for the linear parts of the receiver that precede the demodulator. For CW and AM receivers, this includes the RF and IF stages up to the second detector. For FM receivers, this includes the RF and IF stages up to the first limiter stage. For receivers with a linear demodulator, such as a product detector, noise figure may be measured for the entire receiver from the antenna input terminals to the audio output terminals.

4.1.6.3. METHOD - AUTOMATIC NOISE FIGURE METER

This method uses an automatic noise figure meter (ANFM), which includes a switched random noise generator, as shown in figure 4.1.6.1. The ANFM cyclically switches the noise generator between two output power levels, and automatically computes noise figure from the output signal of the receiver. The measured noise figure is displayed by the panel meter on the ANFM.

Measurement uncertainties as small as 0.3 dB are possible under best conditions, and range from approximately 0.5 dB to 1.5 dB under typical conditions. The method uses equipment that is commonly available for use above 30 MHz, limited availability between 10 and 30 MHz, but unavailable below 10 MHz. It is typically quick and convenient to perform, and is especially convenient when making adjustments to optimize receiver noise figure.

4.1.6.3.1. TEST EQUIPMENT REQUIRED

1. Automatic noise figure meter (ANFM)

2. Noise generator for use with the ANFM

3. Input impedance matching transformer

4.1.6.3.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the NOISE GENERATOR through an IMPEDANCE TRANSFORMER that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the noise generator output impedance equals Z_s, no transformer is needed.

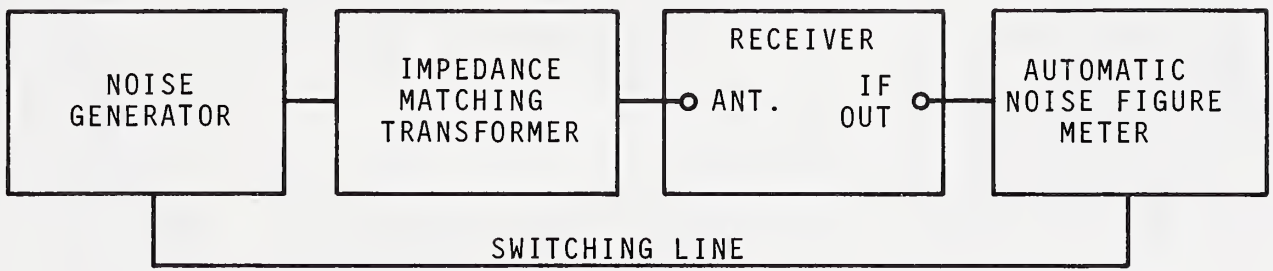

Fig. 4.1.6.1. Test Set-up for Noise Factor, ANFM Method

2. Connect the input port of the ANFM to the output of the last linear IF amplifier stage. Follow the instructions of the manufacturer of the ANFM to make this connection.

3. Set receiver controls as given in Table IX.

Note: For some receivers, maximum RF/IF gain may produce overloading either in the latter IF stages or in the amplifier of the ANFM. In this case, set the RF/IF gain to produce an input level to the ANFM that is from 3 dB to 10 dB greater than the minimum level required by the ANFM.

4. Tune the receiver to the measurement frequency, f_o.

5. Adjust the ANFM according to manufacturer's instructions. This usually includes a calibration adjustment, a mode selection, and selection of scale range.

6. Measure noise factor, F, in decibels, by following the procedure given by the manufacturer.

7. Correct the measured value of F as instructed by the manufacturer. Also correct the results for the effect of the impedance transformer, if used. This is the noise factor, in decibels, of the linear portions of the receiver RF/IF stages when tuned to frequency f_o.

4.1.6.3.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the measured value of F, in decibels.

TABLE IX

Noise Factor, ANFM Method

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	As required
6.	AF Gain	6.	N.A.
7.	Line Gain	7.	N.A.
8.	Detector Mode	8.	N.A.
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	N.A.
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	N.A.
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	N.A.

4. Record the Corrections applied to the measured value of F. These include the following:

a. Noise generator termination temperature

b. VSWR

c. Impedance transformer loss

d. Cable loss

e. Image response

4.1.6.3.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔT_h, in the noise temperature, T_h, of the noise generator

2. Uncertainty, ΔT_a, of the ambient temperature, T_a, of the generator termination

3. Uncertainty, ΔF_z, in F due to the VSWR of the generator impedance

4. Uncertainty, ΔF_i, in F due to image response

5. Uncertainty, ΔF_c, in F due to the uncertainty in the ANFM calibration

The total uncertainty, ΔF, in the measured value of F will vary according to the particular ANFM system used. Refer to the manufacturer's operating manual for the procedure for determining ΔF.

4.1.6.4. METHOD - Y-FACTOR/POWER METER

This method uses a pair of random noise generators and a power meter as shown in figure 4.1.6.2. The hot and cold noise generators supply known input noise powers to the receiver in a band of frequencies which includes that to which the receiver is tuned. The power meter measures the power levels from the last linear IF stage. The ratio of the two power levels corresponding to the two input power levels is the Y-factor. Noise factor is computed from the measured Y-factor and the known power levels of the two generators.

Measurement uncertainties as small as 0.2 dB are possible under best conditions, and range from approximately 0.3 dB to 1 dB under typical conditions. The method uses sophisticated equipment, but it is commonly available.

4.1.6.4.1. TEST EQUIPMENT REQUIRED

1. Hot random noise generator

2. Cold random noise generator

3. Input impedance matching transformer

4. Power meter

4.1.6.4.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the HOT NOISE GENERATOR through an IMPEDANCE TRANSFORMER that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the noise generator output impedance equals Z_s, no transformer is needed.

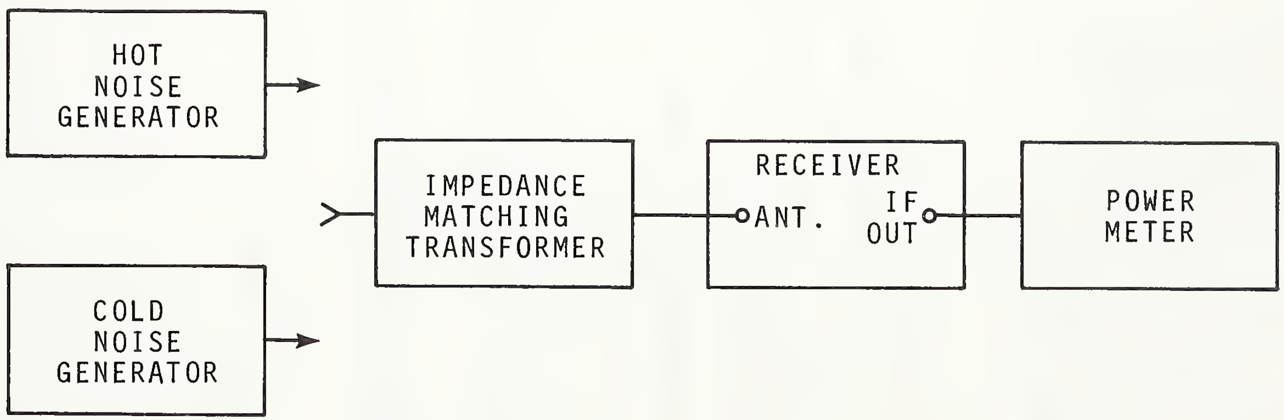

Fig. 4.1.6.2. Test Set-up for Noise Factor, Y-Factor/Power Meter Method

2. Connect the input port of the POWER METER to the output of the last linear IF amplifier stage.

3. Set receiver controls as given in Table X.

Note: For some receivers, maximum RF/IF gain may produce overloading in the latter IF stages. In this case, set the controls to produce maximum RF gain without overload anywhere in the measurement system.

4. Tune the receiver to the measurement frequency, f_o.

5. Measure the output power, P_h, from the last linear IF amplifier stage.

6. Disconnect the hot noise generator and connect the COLD NOISE GENERATOR in its place.

7. Measure the output power, P_c, from the last linear IF amplifier stage.

8. Calculate the Y-factor from the equation

$$Y = \frac{P_h}{P_c} \quad .$$

9. Calculate the noise factor from the equation

$$F = \frac{T_h - YT_c}{290\ (Y-1)} + 1$$

and

$$F\ (dB) = 10 \log F \quad .$$

This is the noise factor, in decibels, of the linear portions of the receiver RF/IF stages when tuned to frequency f_o.

TABLE X

Noise Factor, Y-Factor/Power Meter Method

Initial Control Settings

	Control		Setting
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	As required
6.	AF Gain	6.	N.A.
7.	Line Gain	7.	N.A.
8.	Detector Mode	8.	N.A.
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	N.A.
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	N.A.
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	N.A.

4.1.6.4.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the noise temperature, T_h, in kelvins, of the hot noise generator.

4. Record the noise temperature, T_c, in kelvins, of the cold noise generator.

5. Record the output power, P_h, in milliwatts.

6. Record the output power, P_c, in milliwatts.

7. Record the calculated Y-factor, Y.

8. Record the calculated value of noise factor, F, in decibels.

4.1.6.4.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔT_h, in the noise temperature, T_h, of the hot noise generator

2. Uncertainty, ΔT_c, in the noise temperature, T_c, of the cold noise generator

3. Uncertainty, ΔP_h, in the measured value of P_h

4. Uncertainty, ΔP_c, in the measured value of P_c

The total uncertainty, ΔF, in the calculated value of F is given by the equation

$$\Delta F = C_1 \, \Delta T_h + C_2 \, \Delta T_c + C_3 \, \Delta Y.$$

The uncertainty coefficients C_1, C_2, and C_3 are given by the equations

$$C_1 = \frac{1}{290 \, (Y - 1)} ,$$

$$C_2 = \frac{-Y}{290 \, (Y - 1)} ,$$

and

$$C_3 = \frac{T_c - T_h}{290 \, (Y - 1)^2} .$$

The uncertainties ΔT_h and ΔT_c are obtained from the manufacturer's specifications or from the results of calibrating T_h and T_c. Uncertainty ΔY is given by the relation

$$\Delta Y = \Delta P_h + \Delta P_c ,$$

where ΔP_h and ΔP_c are obtained from the manufacturer's specifications on the power meter.

The relative measurement uncertainty, ΔF(dB), expressed in decibels, is given approximately, for small uncertainties, by the equation

$$\Delta F \text{ (dB)} = 10 \log \left(1 + \frac{\Delta F}{F} \right).$$

4.1.6.5. METHOD - Y-FACTOR/ATTENUATOR

This method uses a pair of random noise generators and a variable attenuator as shown in figure 4.1.6.3. The hot and cold noise generators supply known input powers to the receiver in a band of frequencies which includes that to which the receiver is tuned. The attenuator measures the ratio of the two receiver output power levels corresponding to the two input power levels from the generators. Noise factor is computed from the measured power ratio and the known generator power levels.

Measurement uncertainties as small as 0.2 dB are possible under best conditions, and range from approximately 0.3 dB to 1 dB under typical conditions. The method uses sophisticated equipment, but it is commonly available.

4.1.6.5.1. TEST EQUIPMENT REQUIRED

1. Hot random noise generator

2. Cold random noise generator

3. Input impedance matching transformer

4. Variable attenuator

5. Signal level indicator (voltmeter, power meter, receiver, etc.)

4.1.6.5.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the COLD NOISE GENERATOR through an IMPEDANCE TRANSFORMER that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the noise generator output impedance equals Z_s, no transformer is needed.

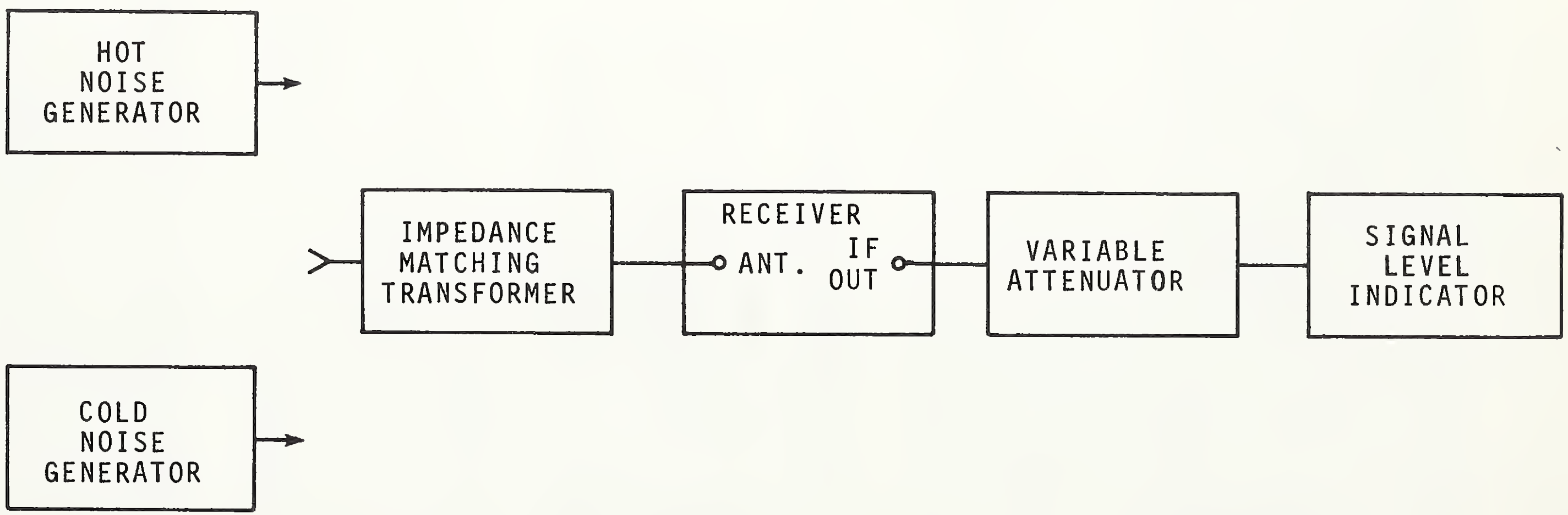

Fig. 4.1.6.3. Test Set-up for Noise Factor, Y-Factor/Attenuator Method

2. Connect the SIGNAL LEVEL INDICATOR to the output of the last linear IF amplifier stage through the VARIABLE ATTENUATOR.

3. Set receiver controls as given in Table XI.

Note: For some receivers, maximum RF/IF gain may produce overloading in the latter IF stages. In this case, set the controls to produce maximum RF gain without overload anywhere in the measurement system.

4. Tune the receiver to the measurement frequency, f_o.

5. Adjust the attenuator and the sensitivity of the signal level indicator to produce a convenient indicator reading near full scale.

6. Record the indicator reading, I_c.

7. Record the attenuator setting, A_c(dB), in decibels.

8. Disconnect the cold noise generator and connect the HOT NOISE GENERATOR in its place.

9. Adjust the attenuator to produce the indicator reading, I_c.

10. Record the new attenuator setting, A_h(dB), in decibels.

11. Compute the Y-factor in decibels from the equation

$$Y(\mathrm{dB}) = A_c(\mathrm{dB}) - A_h(\mathrm{dB}) \ .$$

12. Convert the Y-factor in decibels to Y-factor by the equation

$$Y = \text{antilog}\left(\frac{Y(\mathrm{dB})}{10}\right).$$

TABLE XI

Noise Factor, Y-Factor/Attenuator Method

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	As required
6.	AF Gain	6.	N.A.
7.	Line Gain	7.	N.A.
8.	Detector Mode	8.	N.A.
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	N.A.
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	N.A.
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	N.A.

13. Calculate the noise factor from the equation

$$F = \frac{T_h - YT_c}{290(Y-1)} + 1 ,$$

and

$$F(\text{dB}) = 10 \log F .$$

This is the noise factor, in decibels, of the linear portions of the receiver RF/IF stages when tuned to frequency f_o.

4.1.6.5.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the noise temperature, T_h, in kelvins, of the hot noise generator.

4. Record the noise temperature, T_c, in kelvins, of the cold noise generator.

5. Record the indicator reading, I_c, in millivolts or milliwatts.

6. Record the attenuator setting, A_c (dB), in decibels.

7. Record the attenuator setting, A_h (dB), in decibels.

8. Record the Y-factor, Y(dB), in decibels.

9. Record the numeric Y-factor, Y.

10. Record the calculated value of noise factor, F, in decibels.

4.1.6.5.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔT_h, in the noise temperature, T_h, of the hot noise generator

2. Uncertainty, ΔT_c, in the noise temperature, T_c, of the cold noise generator

3. Uncertainty, ΔA_c, in the measured value of A_c(dB)

4. Uncertainty, ΔA_h, in the measured value of A_h(dB)

The total uncertainty, ΔF, in the calculated value of F is given by the equation

$$\Delta F = C_1 \; \Delta T_h + C_2 \; \Delta T_c + C_3 \; \Delta Y.$$

The uncertainty coefficients C_1, C_2, and C_3 are given by the equations

$$C_1 = \frac{1}{290 \; (Y-1)} \; ,$$

$$C_2 = \frac{-Y}{290 \; (Y-1)} \; ,$$

and

$$C_3 = \frac{T_c - T_h}{290 \; (Y-1)^2} \; .$$

The uncertainties ΔT_h and ΔT_c are obtained from the manufacturer's specifications or from the results of calibrating T_h and T_c. Uncertainty ΔY is given by the relation

$$\Delta Y = \text{antilog} \; \frac{\Delta A_c \text{ (dB)} + \Delta A_h \text{ (dB)}}{10} \; ,$$

where ΔA_c and ΔA_h are obtained from the manufacturer's specifications on the variable attenuator.

The relative measurement uncertainty, $\Delta F(dB)$, expressed in decibels, is given approximately, for small uncertainties, by the equation

$$\Delta F \text{ (dB)} = 10 \log \left(1 + \frac{\Delta F}{F}\right).$$

4.1.6.6. METHOD - 3 DB

This method uses a temperature-limited diode (TLD) noise generator and a 3dB attenuator (hence its name) as shown in figure 4.1.6.4. The TLD noise generator supplies a known but adjustable input power to the receiver in a band of frequencies which includes that to which the receiver is tuned. The signal level indicator is used to indicate a reference level of output power.

With the noise generator output level adjusted to zero, and with the 3dB attenuator out of the system, the receiver output power produces an indication on the signal level indicator. Then the 3 dB attenuator is inserted in the system, and the noise generator output is increased until the same indicator reading is obtained. Noise factor is read directly from the calibrated meter on the TLD noise generator.

Measurement uncertainties as small as 0.3 dB are possible under best conditions, and range from approximately 0.5 dB to 1.5 dB under typical conditions. The method uses commonly available test equipment, and is quick and convenient to perform.

4.1.6.6.1. TEST EQUIPMENT REQUIRED

1. Temperature-limited diode noise generator

2. Input impedance matching transformer

3. 3 dB fixed attenuator

4. Signal level indicator (voltmeter, power meter, receiver, etc.)

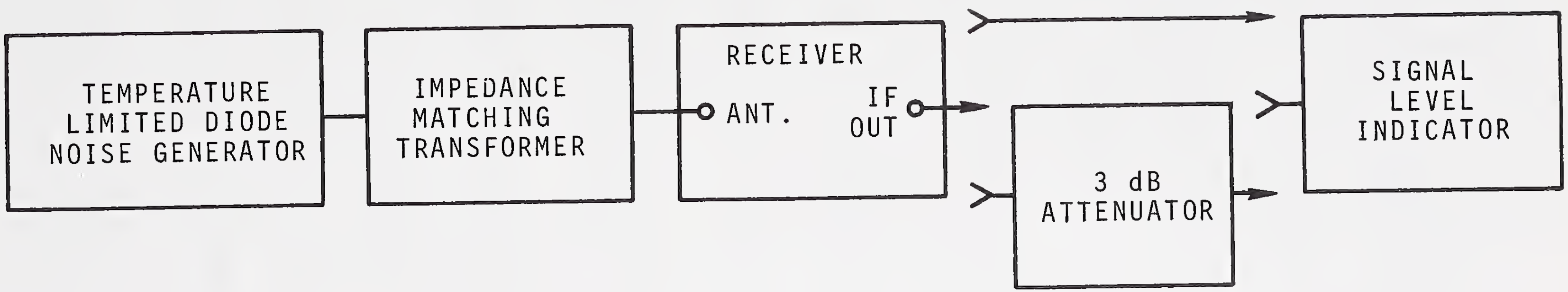

Fig. 4.1.6.4. Test Set-up for Noise Factor, 3 dB Method

4.1.6.6.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the NOISE GENERATOR through an IMPEDANCE TRANSFORMER that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the noise generator output impedance equals Z_s, no transformer is needed.

2. Connect the input port of the SIGNAL LEVEL INDICATOR to the output of the last linear IF amplifier stage.

3. Set receiver controls as given in Table XII.

Note: For some receivers, maximum RF/IF gain may produce overloading in the latter IF stages In this case, set the controls to produce maximum RF gain without overload anywhere in the measurement system.

4. Tune the receiver to the measurement frequency, f_o.

5. Turn the emission current of the TLD noise generator to zero (leave the generator connected to the measurement system).

6. Adjust the sensitivity of the signal level indicator to produce a reading near full scale.

7. Record the indicator reading, I.

8. Disconnect the receiver from the signal level indicator.

9. Insert the 3 dB ATTENUATOR between the receiver and the signal level indicator.

Note: Make certain that the attenuator terminating impedances are proper so that 3 dB of attenuation is obtained.

TABLE XII

Noise Factor, 3 dB Method

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. As required
6. AF Gain	6. N.A.
7. Line Gain	7. N.A.
8. Detector Mode	8. N.A.
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. N.A.
13. Noise Limiter	13. OFF
14. Squelch Level	14. N.A.
15. AGC/MGC Mode Switch	15. MGC
16. Meter Switch	16. N.A.

10. Increase the emission current of the TLD noise generator to produce the indicator reading, I.

11. Record the indicated value of noise factor in decibels as read from the emission current meter on the TLD noise generator.

12. Apply a frequency correction to the indicated value of F(dB), if necessary as described in the manufacturer's operating manual, to provide a corrected value of F(dB). Also, correct F(dB) for the effect of ambient temperature within the noise generator as instructed by the manufacturer. This is the noise factor, in decibels, of the linear portions of the receiver RF/IF stages when tuned to frequency f_o.

4.1.6.6.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the indicator reading, I, in millivolts or milliwatts.

4. Record the indicated value of noise factor, F(dB), in decibels.

5. Record the frequency-corrected and temperature-corrected value of noise factor, F(dB), in decibels.

4.1.6.6.4. MEASUREMENT ERRORS

The principal source of measurement error is the calibration of the TLD noise generator meter. The uncertainty, ΔF(dB), in decibels in the measured value of F will vary according to the particular noise generator used. Refer to the manufacturer's operating manual for the procedure for determining ΔF.

4.2. SIGNAL-TO-NOISE RATIO

4.2.1. DEFINITION

Signal-to-noise ratio is the ratio of the signal power to the noise power in the entire output pass band. This ratio is usually expressed in decibels.

4.2.2. PURPOSE

The purpose of this measurement method is to measure the signal-to-noise ratio of the audio output signal from a surveillance receiver. Signal-to-noise ratio is a measure of the quality of the receiver's output signal. It will vary with the amount of internal noise in the receiver, with the amount of input signal to the receiver, and with the signal-to-noise ratio of the input signal. It may also be a function of receiver sensitivity, selectivity, and distortion.

4.2.3. METHOD

The method uses a power meter or true rms voltmeter as shown in figure 4.2. The power meter or voltmeter measures the output signal level, P_n, when the signal source is turned off (receiver output is noise only), and P_{s+n}, when the signal source is turned on (receiver output is signal plus noise). The signal-to-noise ratio is calculated from these two quantities by the equation

$$S/N = \frac{P_{s+n}}{P_n} - 1 .$$

Measurement uncertainties as small as 0.2 dB are possible under best conditions, and range from approximately 0.3 dB to 0.8 dB under typical conditions. The method uses rudimentary and commonly available test equipment.

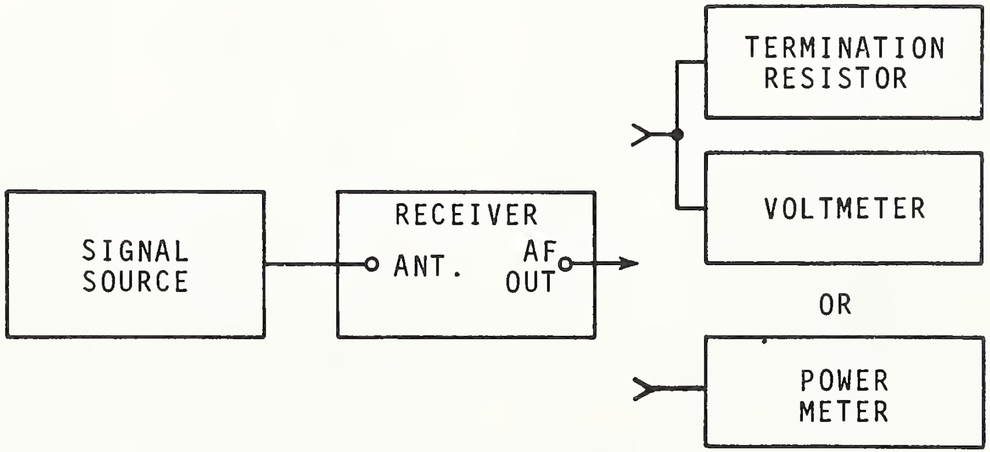

Fig. 4.2. Test Set-up for Signal-to-Noise Ratio

4.2.4. TEST EQUIPMENT REQUIRED

1. Termination resistor for receiver output port

2a. AF power meter

OR,

2b. True RMS voltmeter

4.2.5. PROCEDURE

1. Connect the signal source to the receiver input port. Select whatever matching means that will give the desired operating conditions.

2. Adjust the receiver according to the desired operating conditions (see Table XIII).

3. With the signal source output set to zero, measure the output power, P_n, from the receiver. This will be noise power only.

4. Adjust the output signal from the source according to the desired output level and frequency.

5. Measure the output power, P_{s+n}, from the receiver. This will be both signal and noise power.

6. Calculate the ratio, S/N, by the equation

$$S/N = \frac{P_{s+n}}{P_n} - 1 .$$

This is the signal-to-noise ratio of the receiver output signal under the chosen operating conditions.

TABLE XIII

Signal-to-Noise Ratio

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. As desired
4. RF Gain	4. As desired
5. IF Gain	5. As desired
6. AF Gain	6. As desired
7. Line Gain	7. As desired
8. Detector Mode	8. As desired
9. Beat Frequency Oscillator	9. As desired
10. BFO Frequency	10. As desired
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. As desired
14. Squelch Level	14. As desired
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

4.2.6. DATA REQUIRED

1. Record all receiver operating parameters selected for the test. These include the following:

a. Gain control settings
b. Frequency setting
c. Bandwidth
d. Noise limiter setting
e. AGC mode
g. Settings of any other pertinent controls

2. Record all signal source parameters selected for the test. These include the following:

a. Frequency
b. Output level
c. Modulation type
d. Modulation frequency
e. Modulation percentage/deviation
f. Source impedance
g. Signal level at receiver input port

3. Record P_n, in watts

4. Record P_{s+n}, in watts

5. Record calculated value of S/N

4.2.7. MEASUREMENT ERRORS

The principal source of measurement error is the uncertainty, ΔP, in the reading of the AF power meter, or ΔE in the reading of the true rms voltmeter. The total uncertainty, $\Delta S/N$ (dB), in decibels, in the calculated value of S/N, is given approximately, for small uncertainties, by the equations

$$\Delta S/N \text{ (dB)} = 10 \log \left(1 + \frac{\sqrt{2}\ \Delta P}{P} \right) ,$$

or

$$\Delta S/N \text{ (dB)} = 10 \log \left(1 + \frac{2\ \Delta E}{E} \right) .$$

The uncertainties ΔP and/or ΔE are obtained from the manufacturer's specifications on the power meter or voltmeter, respectively.

4.3. GAIN

Gain is a general term used to denote an increase in signal level in transmission from one point to another. This section provides measurement methods for the following receiver gain parameters:

1. Power Gain

2. Dynamic Range

3. Automatic Gain Control Characteristics

4.3.1. POWER GAIN

4.3.1.1. DEFINITION

The power gain of a receiver is the ratio, in decibels,of (a) the audio power delivered to the receiver's specified output termination at a 12 dB SINAD to (b) the available signal power from the source connected to the receiver's input terminals.

4.3.1.2. PURPOSE

The purpose of this measurement method is to measure the power gain of a receiver. Power gain is a measure of the receiver's ability to convert the power of a small modulated radio frequency signal into a usable audio output signal of acceptable quality.

4.3.1.3. METHOD

The method is as follows (see figure 4.3.1): The 12 dB SINAD sensitivity of the receiver is measured; the signal source impedance is determined; the available input signal power is calculated; then the power gain is calculated as the ratio, in decibels, of (1) the rated audio output power and, (2) the available input signal power.

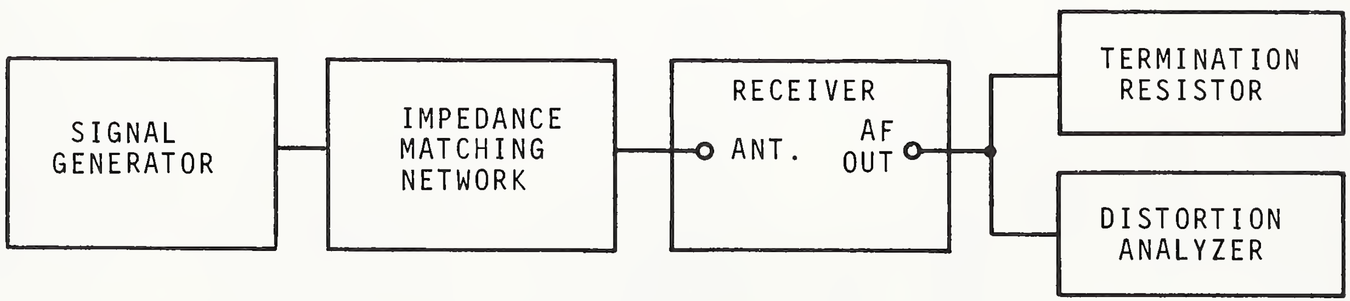

Fig. 4.3.1. Test Set-up for Power Gain

Measurement uncertainties as small as 0.3 dB are possible under best conditions, and range from approximately 0.4 dB to 1.5 dB under typical conditions. The method uses moderately sophisticated but commonly available test equipment.

4.3.1.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

5. Impedance bridge or vector impedance meter

4.3.1.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set receiver controls as given in Table XIV.

TABLE XIV

Power Gain

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. Maximum
7. Line Gain	7. Optional
8. Detector Mode	8. AM, FM as required
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

4. Measure the 12 dB SINAD SENSITIVITY as outlined in Section 4.1.3. for AM receivers, or Section 4.1.5. for FM receivers.

5. Measure the output IMPEDANCE, $Z_s = R_s + j\,X_s$, of the source at the terminals that connect to the input terminals of the receiver. See Section 4.10.

6. Calculate the power, P_a, available from the source, by the equation

$$P_a = \frac{E_i^{\,2}\ R_s}{(R_s^{\,2} + X_s^{\,2})} ,$$

where E_i is the 12 dB SINAD SENSITIVITY.

7. Calculate the power ratio, G, in decibels, by the equation

$$G(\mathrm{dB}) = 10 \log \frac{15\ P_o}{16\ P_a} .$$

The fraction, 15/16, is the fractional part of P_o that is the audio output signal due to the input signal (the remaining 1/16 is noise power). G(dB) is the power gain of the receiver at frequency f_o.

4.3.1.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the SINAD ratio in decibels.

6. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator. E_i is the 12 dB SINAD sensitivity of the receiver.

7. Record the measured value of Z_s, in ohms.

8. Record the calculated value of P_a, in microwatts.

9. Record the calculated value of G, in decibels. G is the gain of the receiver.

4.3.1.7. MEASUREMENT ERRORS

The principal sources of measurement errors are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2. Uncertainty, ΔP_o, in the measured value of P_o

3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

4. Uncertainty, ΔR_s, in the measured value of R_s, and ΔX_s, in the measured value of X_s

The total relative uncertainty, $\Delta G(\mathrm{dB})$, in decibels, in the gain G, is given approximately, for small uncertainties, by the equation

$$\Delta G\ (\mathrm{dB}) = 10 \log \left(1 + \frac{\Delta G}{G}\right)$$

where

$$\frac{\Delta G}{G} = \frac{\Delta P_o}{P_o} + \frac{\Delta P_a}{P_a} ,$$

and

$$G = \frac{15\ P_o}{16\ P_a} .$$

The uncertainty, ΔP_o, is obtained from the manufacturer's specifications on the distortion analyzer. The relative uncertainty, $\Delta P_a/P_a$, in P_a, is obtained from the equation

$$\frac{\Delta P_a}{P_a} = 2 \frac{\Delta E_i}{E_i} + \frac{(R_s^2 - X_s^2)}{(R_s^2 + X_s^2)} \frac{\Delta R_s}{R_s} + \frac{2X_s^2}{(R_s^2 + X_s^2)} \frac{\Delta X_s}{X_s} .$$

The uncertainty ΔE_i is obtained from the manufacturer's specifications on the output level indicator of the signal generator. The uncertainties ΔR_s and ΔX_s are obtained from the manufacturer's specifications on the impedance bridge or meter.

4.3.2. DYNAMIC RANGE

4.3.2.1. DEFINITIONS

a. Dynamic range is the difference, in decibels, between the overload level and the minimum acceptable signal level in a system or transducer. NOTE: The minimum acceptable signal level of a system or transducer is ordinarily fixed by one or more of the following: Noise level, low-level distortion, interference, or resolution level. (IEEE Std 100-1972)

b. Overload level is that level above which operation ceases to be satisfactory as a result of signal distortion, overheating, or damage. (IEEE Std 100-1972)

4.3.2.2. PURPOSE

The purpose of this measurement method is to measure the dynamic range of a receiver. Dynamic range is a measure of the ability of a receiver to receive a signal of arbitrary strength with acceptable quality.

4.3.2.3. METHOD FOR AM RECEIVERS WITHOUT AGC

This method uses an amplitude modulated signal generator, a variable attenuator, and a true RMS voltmeter or power meter as shown in figure 4.3.2.1. The signal generator supplies a known input voltage to the receiver at the measurement frequency. The variable attenuator temporarily replaces the AF gain control, and adjusts the audio output level. The voltmeter or power meter measures the audio output power.

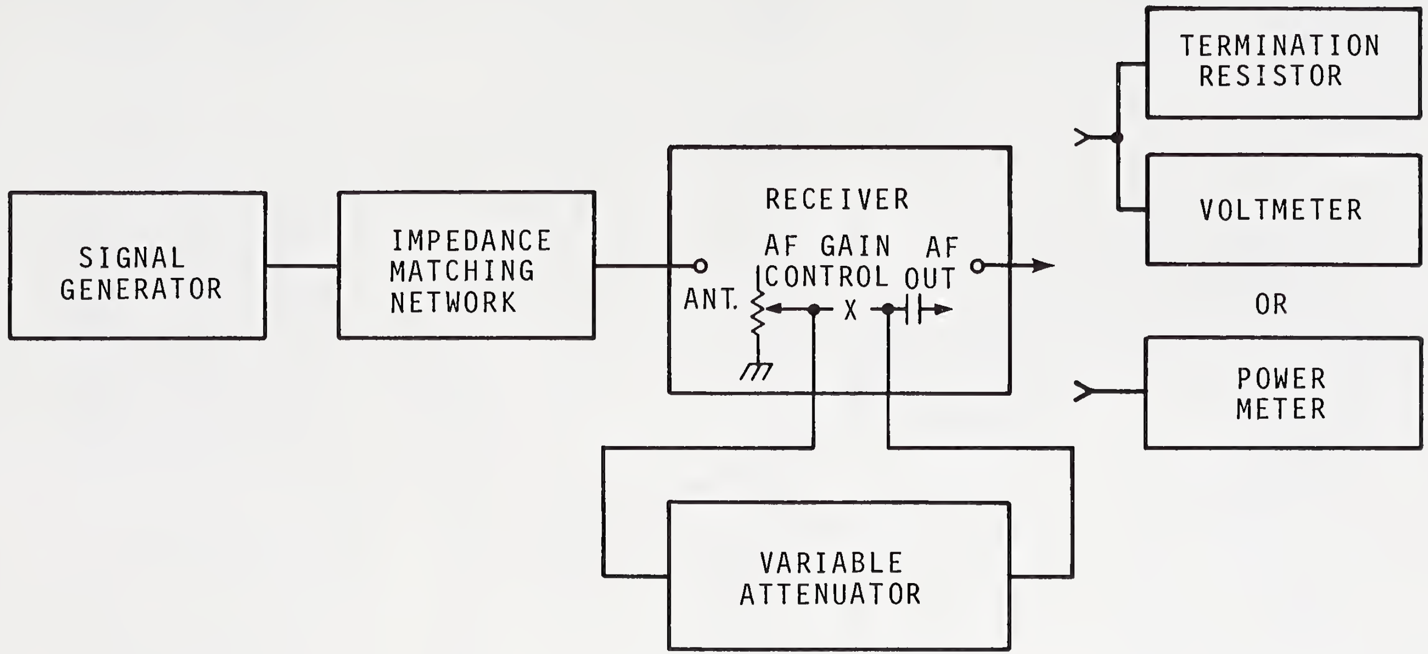

Fig. 4.3.2.1. Test Set-up for Dynamic Range, MGC

The lower end of the dynamic range is obtained by determining the input signal voltage that produces a 6 dB output S/N ratio at the reference output power. The upper end is obtained by determining the signal voltage that produces 1 dB compression at reference output power.

This method does not take into account the distortion produced in the receiver under conditions of large input signal power. It uses conventional and commonly available test equipment. Measurement uncertainties as small as 0.3 dB are possible under best conditions, and range from approximately 0.4 dB to 3 dB under typical conditions.

4.3.2.3.1. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Variable AF attenuator

5a. AF power meter

OR,

5b. True RMS voltmeter

4.3.2.3.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Disconnect the output lead from the receiver AF gain control (slider contact). Insert the variable AF attenuator between the open gain control output terminal and the lead that went to that terminal.

Note: If the resulting input and output terminations to the AF attenuator present a severe mismatch to the attenuator so as to change its calibration, match the attenuator into the circuit with transformers or resistive matching networks.

3a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across this resistor.

OR,

3b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

4a. Set the voltmeter on a range to indicate the rated output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

OR,

4b. Set the power meter on a range to indicate the reference output power, P_o.

5. Set receiver controls as given in Table XV.

6. Tune the signal generator and the receiver to the measurement frequency, f_o.

TABLE XV

Dynamic Range (MGC)

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. Maximum
7. Line Gain	7. Optional
8. Detector Mode	8. AM
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. MGC
16. Meter Switch	16. Optional

7. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

8. With the signal generator output at zero, adjust the variable attenuator to produce 20% of reference output power, P_o. This power is entirely noise.

9. Increase the signal generator output to produce reference output power, P_o. This power is approximately 20% noise and 80% signal, giving a 6 dB S/N ratio.

10. Determine the open circuit signal voltage, E_ℓ, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator. This is the lower voltage level of the dynamic range.

11. Increase the variable attenuator setting by exactly 20 dB. This reduces the output power to approximately 0.01 P_o.

12. Increase the signal generator output to produce reference output power, P_o.

13. Determine the open circuit signal voltage, E_{i1}, at the output terminals of the matching network (or generator).

14. Calculate the quantity R_1, in decibels, where

$$R_1 = 20 \log \frac{E_{i1}}{E_\ell} .$$

15. With the generator set as in Step 12, again increase the variable attenuator setting by exactly 20 dB. This reduces the output power to approximately 0.01 P_o.

16. Again increase the signal generator output to produce reference output power, P_o.

17. Determine the open circuit signal voltage, E_{i2}, at the output terminals of the matching transformer (or generator).

18. Calculate the quantity, R_2, in decibels, where

$$R_2 = 20 \log \frac{E_{i2}}{E_{i1}} .$$

19. Proceed as indicated in Steps 11 through 18, each time changing the variable attenuator setting by 20 dB, and increasing the signal generator output to successively higher levels to produce reference output power, until the computed value of R exceeds 21 dB for the first time. (All preceding values of R are less than 21 dB. 21 dB represents a compression of 1 dB in the gain of the receiver.)

20. Return the variable attenuator setting to the value that immediately preceded the final value reached in Step 19.

21. Decrease the signal generator output to again produce reference output power with the attenuator set as in Step 20.

22. Increase the variable attenuator setting by exactly 10 dB. This reduces the output power to approximately 0.1 P_o.

23. Increase the signal generator output to produce reference output power, P_o.

24. Determine the open circuit signal voltage, E_{j1}, at the output terminals of the matching network (or generator).

25. Reduce the signal generator output by approximately 20 dB.

26. Increase the variable attenuator setting by exactly 20 dB. This may increase the output power to approximately P_o.

27. Adjust the signal generator output to produce reference output power, P_o.

28. Determine the open circuit signal voltage, E_{j_2}, at the output terminals of the matching network (or generator). E_{j_2} corresponds to an attenuator setting that is an increase of 20 dB from the setting in Step 24.

29. Calculate the quantity, R_j, in decibels, where

$$R_j = 20 \log \frac{E_{j_1}}{E_{j_2}} \quad .$$

30a. If R_j is greater than 21 dB, return to Step 20 and proceed through Step 29 except use a smaller attenuation change in Step 22; e.g., use 8 dB instead of 10 dB.

31a. Repeat Step 30a (i.e., Steps 20 through 29) until values for E_{j_1} and E_{j_2} are found for which R_j = 21 dB.

OR,

30b. If R_j in Step 29 is less than 21 dB, return to Step 20 and proceed through Step 29 except use a larger attenuation change in Step 22; e.g., use 12 dB instead of 10 dB.

31b. Repeat Step 30b until values for E_{j_1} and E_{j_2} are found for which R_j = 21 dB.

32. Determine the signal voltage, $E_u = E_{j_1}$, in microvolts. This is the upper voltage level of the dynamic range.

33. Compute the ratio R_d in decibels, where

$$R_d = 20 \log \frac{E_u}{E_\ell} \quad .$$

R_d is the dynamic range, in decibels, for the receiver.

4.3.2.3.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver output terminals.

4a. Record the output voltage, E_o, in volts.

OR,

4b. Record the reference output power, P_o, in watts.

5. Record the open circuit signal voltage, E_ℓ, in microvolts.

6. Record each attenuator setting, in decibels, taken throughout the measurement procedure.

7. Record the open circuit signal voltage, E_i, E_j, or E_u, in microvolts, for each of the attenuator settings of 6, above.

8. Record the ratio R, in decibels, calculated for each pair of voltages, E_i and E_j, of Step 7 above.

9. Record the ratio, R_d, in decibels.

4.3.2.3.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_ℓ, in the measured value of E_ℓ

2. Uncertainty, ΔE_u, in the measured value of E_u

3a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

3b. Uncertainty, ΔP_o, in the measured value of P_o

4. Uncertainty, $\Delta A(\mathrm{dB})$, in the variable attenuator attenuation

The total relative uncertainty, $\Delta E_\ell(\mathrm{dB})$, in decibels, in the lower voltage level, E_ℓ, of the dynamic range, is given approximately, for small uncertainties, by the equations

$$\Delta E_\ell(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_\ell}{E_\ell} + \frac{\Delta E_o}{E_o} \right) ,$$

OR

$$\Delta E_\ell(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_\ell}{E_\ell} + \frac{1}{2} \frac{\Delta P_o}{P_o} \right) .$$

For the upper voltage level, $\Delta E_u(\mathrm{dB})$, in decibels, is given approximately, for small uncertainties, by the equations

$$\Delta E_u(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_u}{E_u} + \frac{\Delta E_o}{E_o} + \frac{1}{2} \frac{\Delta A}{A} \right) ,$$

OR

$$\Delta E_u(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_u}{E_u} + \frac{1}{2} \frac{\Delta P_o}{P_o} + \frac{1}{2} \frac{\Delta A}{A} \right) ,$$

where

$$\frac{\Delta A}{A} \doteq \mathrm{antilog} \frac{\Delta A(\mathrm{dB})}{10} - 1 .$$

The uncertainties ΔE_ℓ and ΔE_u are obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o, ΔP_o, and $\Delta A(\mathrm{dB})$ are obtained from the manufacturer's specifications on the rms voltmeter, AF power meter, and variable attenuator, respectively.

4.3.2.4. METHOD FOR AM RECEIVERS WITH AGC, OR FM RECEIVERS WITH ONE OR MORE LIMITERS

The method uses a modulated signal generator and an audio distortion analyzer as shown in figure 4.3.2.2. The signal generator supplies a known input voltage to the receiver at the measurement frequency. The distortion analyzer measures the power (a) with the 1000 Hz modulating signal present, and (b) with the 1000 Hz modulating signal filtered from the audio output power.

The lower end of the dynamic range is the 12 dB SINAD sensitivity (cf) of the receiver. The upper end of the range is established by determining the lowest of the following three signal levels:

a. The signal voltage that produces a 12 dB SINAD ratio near the receiver's overload level.

b. The signal voltage that fires the receiver's overvoltage protection circuit (if any).

c. The signal voltage that reaches the maximum safe level, above which receiver damage occurs (given as a manufacturer's specification).

The method takes into account the distortion produced in the receiver, and hence provides meaningful information. Measurement uncertainties as small as 0.4 dB are possible under best conditions, and range from approximately 1 dB to 4 dB, depending upon circumstances. The method uses moderately sophisticated but commonly available test equipment.

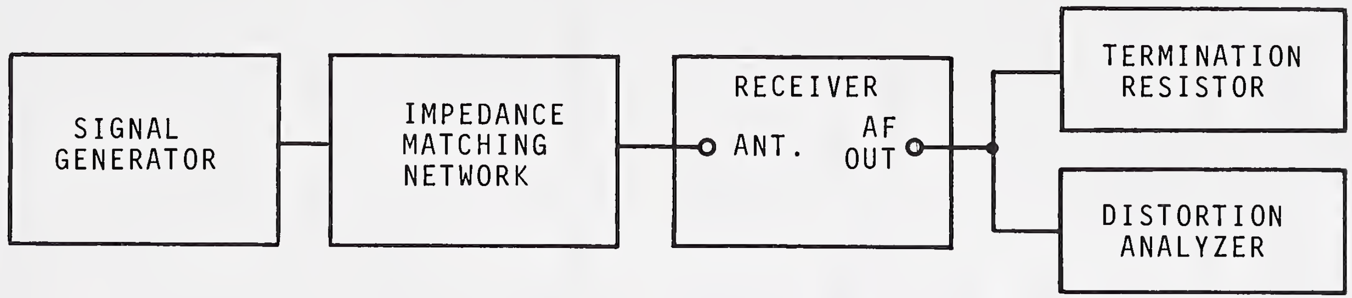

Fig. 4.3.2.2. Test Set-up for Dynamic Range, AGC

4.3.2.4.1. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

4.3.2.4.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set receiver controls as given in Table XVI.

4. Measure the 12 dB SINAD SENSITIVITY as outlined in Section 4.1.3. for AM receivers, or Section 4.1.5. for FM receivers. The 12 dB SINAD SENSITIVITY, in microvolts, is the lower voltage level, E_ℓ, of the dynamic range.

5. Increase the generator output level to the vicinity of the receiver's overload level until one of the following conditions is reached, whichever occurs first:

TABLE XVI

Dynamic Range (AGC)

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. AM, FM, as required
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. AGC as desired
16. Meter Switch	16. Optional

a. 12 dB SINAD ratio is again obtained. The condition sought is a DECREASE of SINAD ratio with an INCREASE of input signal level, and vice versa.

b. The receiver's overvoltage protection circuit is fired.

c. The receiver's specified maximum safe input voltage is reached.

6. Determine the open circuit signal voltage, E_u in microvolts, at the output terminals of the matching transformer (or generator). E_u is the upper voltage level of the dynamic range.

7. Compute the ratio R_d, in decibels, where

$$R_d = 20 \log \frac{E_u}{E_\ell} \quad .$$

R_d is the dynamic range, in decibels, for the receiver.

4.3.2.4.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the output voltage, E_ℓ, in microvolts.

6. Record the signal voltage, E_u, in microvolts.

7. Record the ratio R_d, in decibels.

4.3.2.4.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_ℓ, in the measured value of E_ℓ

2. Uncertainty, ΔE_u, in the measured value of E_u

3. Uncertainty, ΔE_o, in the measured value of E_o

4. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, ΔE_ℓ(dB), in decibels, in the lower voltage level, E_ℓ, of the dynamic range, is given approximately, for small uncertainties, by the equations

$$\Delta E_\ell(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_\ell}{E_\ell} + \frac{\Delta E_o}{E_o}\right) ,$$

OR

$$\Delta E_\ell(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_\ell}{E_\ell} + \frac{1}{2} \frac{\Delta P_o}{P_o}\right) .$$

For the upper voltage level, ΔE_u (dB), in decibels, is given approximately, for small uncertainties, by the equations

$$\Delta E_u(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_u}{E_u} + \frac{\Delta E_o}{E_o}\right) ,$$

OR

$$\Delta E_u(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_u}{E_u} + \frac{1}{2} \frac{\Delta P_o}{P_o}\right) .$$

The uncertainties ΔE_ℓ and ΔE_u are obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o or ΔP_o are obtained from the manufacturer's specifications on the rms voltmeter or AF power meter, respectively.

4.3.3. AUTOMATIC GAIN CONTROL

Automatic gain control (AGC) is a process or means by which GAIN is automatically adjusted in a specified manner as a function of input or other specified parameters (IEEE Std 100-1972). Of importance to receiver performance are the static and dynamic AGC characteristics. The former includes the effect of AGC voltage on system gain and its leveling effect on output power. The latter includes the attack and decay time constants of the AGC system.

4.3.3.1. STATIC AGC CHARACTERISTIC; SYSTEM GAIN VS. AGC VOLTAGE

4.3.3.1.1. DEFINITION

Static AGC characteristic, system gain vs. AGC voltage, is the functional relationship between the gain of the AGC-controlled amplifier system and the AGC control voltage. This characteristic includes all levels of AGC control from a minimum, which may be zero or an offset from zero, to a maximum, which is normally limited by the dynamic range (cf.) of the receiver.

4.3.3.1.2. PURPOSE

The purpose of this measurement method is to measure the static AGC characteristic, in terms of receiver gain as a function of d.c. AGC voltage, for an AM receiver having an AGC system. This characteristic is one measure of the degree to which the AGC system is effective in controlling the gain of the receiver. Effective AGC control usually enhances the dynamic range of the receiver. The method ignores the means by which AGC voltage is obtained.

4.3.3.1.3. METHOD

The method uses an amplitude modulated signal generator, an audio distortion analyzer, and a source of variable d.c. voltage as shown in figure 4.3.3.1. The signal generator supplies a known input voltage to the receiver at the measurement frequency. The variable d.c. voltage source supplies a known AGC voltage that substitutes for the normal internally generated AGC voltage. The distortion analyzer measures the receiver output signal level. Gain, as a function of AGC voltage, is computed from the known input signal level and the measured output signal level.

Measurement uncertainties as small as 6% are possible under best conditions, and range from approximately 8% to 40% under typical conditions. The method uses rudimentary and commonly available test equipment.

4.3.3.1.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

5. Variable, voltage regulated d.c. power supply

6. Impedance bridge or vector impedance meter

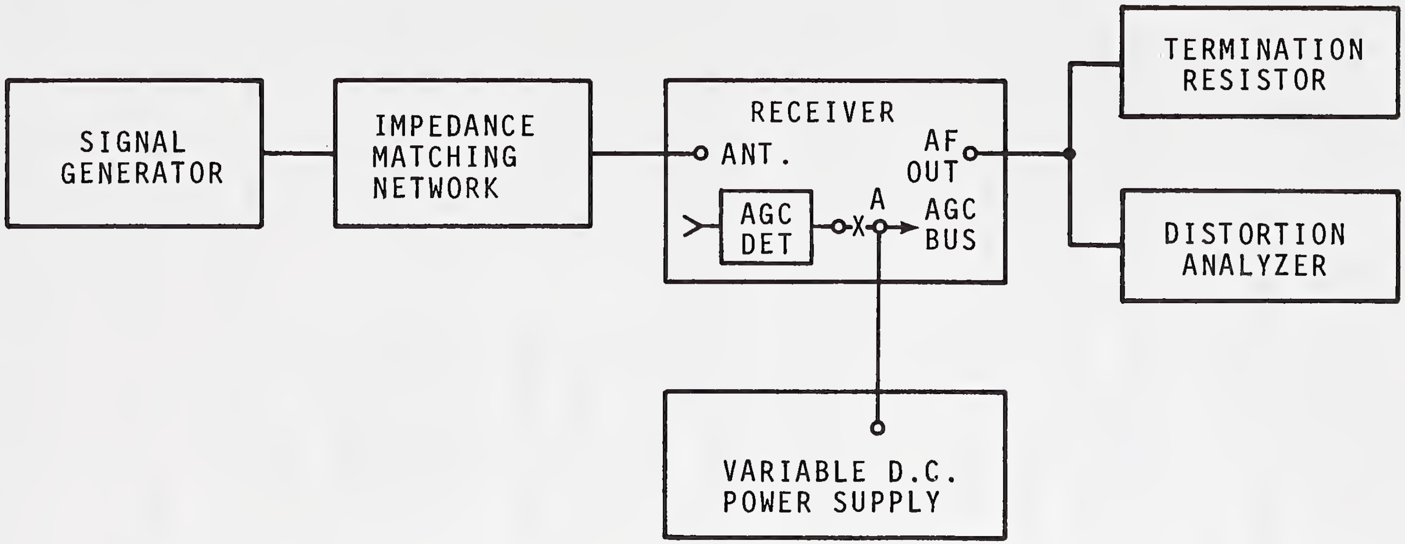

Fig. 4.3.3.1. Test Set-up for Automatic Gain Control; Gain vs. AGC Voltage

4.3.3.1.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Break the line between the output of the AGC rectifier and the AGC line (preceding point A as shown in figure 4.3.3.1.).

Note: If the receiver has delayed AGC, break the line so as not to disrupt this function.

4. Connect the VARIABLE D.C. VOLTAGE SOURCE between point A, figure 4.3.3.1., and ground. Observe correct polarity.

Note: Normally, correct polarity is with the negative voltage applied to the AGC line and positive voltage grounded.

5. Set receiver controls as given in Table XVII.

6. Tune the signal generator and the receiver to the measurement frequency, f_o.

7. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

TABLE XVII

Automatic Gain Control; Gain vs. AGC Voltage

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. AM
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. AGC
16. Meter Switch	16. Optional

8. With the d.c. voltage set to zero, measure the POWER GAIN, G(dB), of the receiver as outlined in Steps 4 through 7, Section 4.3.1.5.

9. Increase the d.c. voltage, $E_{d.c}$, in suitably small steps, e.g., 0.1 volt per step, and measure gain, G(dB), at each step in the following way:

a. With the d.c. voltage at the selected step, adjust the output level of the signal generator to produce reference audio output power, P_o.

b. Measure the gain as in Step 8, above, for each selected d.c. voltage step.

10. Continue as indicated in Step 9, above, until the upper limit, E_u of the dynamic range (cf.) of the receiver is reached.

11. Plot a graph of gain, G(dB), in decibels, vs. AGC voltage, $E_{d.c.}$, in volts, on semi-logarithm paper. This is the static AGC characteristic of the receiver.

4.3.3.1.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to the receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the d.c. AGC voltage, $E_{d.c.}$, in volts, at each step.

6. Record the open circuit signal voltage, E_i, in microvolts, at each step.

7. Record the measured value of Z_s, in ohms.

8. Record the calculated value of P_a, in microwatts.

9. Record the calculated gain, G, in decibels, at each step.

4.3.3.1.7. MEASUREMENT ERRORS

The principal sources of measurement errors are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2. Uncertainty, ΔP_o, in the measured value of P_o

3. Uncertainty, ΔR_s, in the measured value of R_s, and ΔX_s, in the measured value of X_s.

The total relative uncertainty, $\Delta G(\text{dB})$, in decibels, in the gain G, is given approximately, for small uncertainties, by the equation

$$\Delta G(\text{dB}) = 10 \log \left(1 + \frac{\Delta G}{G}\right),$$

where

$$\frac{\Delta G}{G} = \frac{\Delta P_o}{P_o} + \frac{\Delta P_a}{P_a},$$

and

$$G = \frac{15P_o}{16P_a}.$$

The uncertainty, ΔP_o, is obtained from the manufacturer's specifications on the distortion analyzer. The relative uncertainty, $\Delta P_a/P_a$, in P_a, is obtained from the equation

$$\frac{\Delta P_a}{P_a} = 2\,\frac{\Delta E_i}{E_i} + \frac{(R_s^{\,2}-X_s^{\,2})}{(R_s^{\,2}+X_s^{\,2})}\,\frac{\Delta R_s}{R_s} + \frac{2X_s^{\,2}}{(R_s^{\,2}+X_s^{\,2})}\,\frac{\Delta X_s}{X_s} .$$

4.3.3.2. STATIC AGC CHARACTERISTIC; LEVELING EFFECT

4.3.3.2.1. DEFINITION

Static AGC characteristic, leveling effect, is the functional relationship between audio output signal level and receiver input signal level.

4.3.3.2.2. PURPOSE

The purpose of this measurement method is to measure the static AGC characteristic, in terms of its leveling effect on the audio output signal, for an AM receiver having an AGC system. This characteristic is another measure of the degree to which the AGC system is effective in controlling the gain of a receiver. This method accounts for the over-all effect of the amplifier and AGC circuits in the receiver.

4.3.3.2.3. METHOD

The method uses an amplitude modulated signal generator and a true rms voltmeter or power meter as shown in figure 4.3.3.2. The signal generator supplies a known input voltage to the receiver at the measurement frequency. The voltmeter or power meter measures the receiver output signal level. The leveling effect of the AGC system is displayed graphically by a plot cf output signal level vs. input signal level.

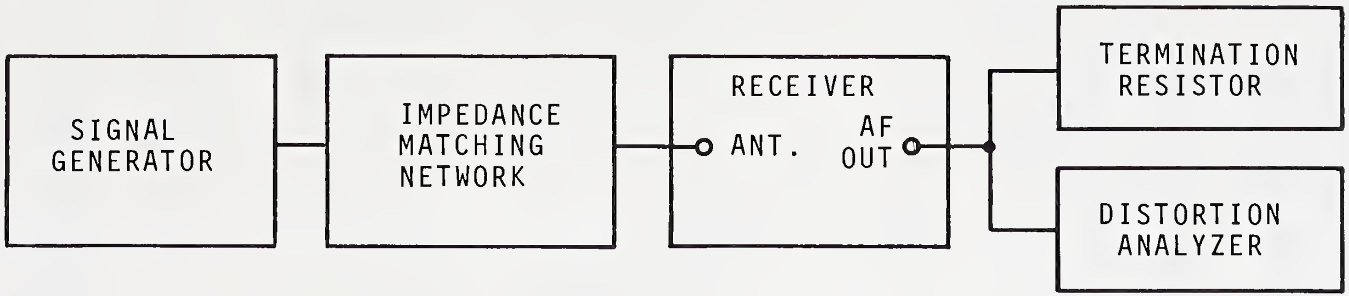

Fig. 4.3.3.2. Test Set-up for Automatic Gain Control; Leveling Effect

Measurement uncertainties as small as 8% are possible under best conditions, and range from approximately 10% to 40% under typical conditions. The method uses moderately sophisticated but commonly available test equipment.

4.3.3.2.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

4.3.3.2.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the output port of the receiver. Connect the audio DISTORTION ANALYZER across the resistor.

3. Set the receiver controls as given in Table XVIII.

4. Tune the signal generator and the receiver to the measurement frequency, f_o.

5. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

TABLE XVIII

Automatic Gain Control; Leveling Effect

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. AM
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. AGC
16. Meter Switch	16. Optional

6. Measure the 12 dB SINAD SENSITIVITY, E_i, as outlined in Section 4.1.3.

7. Increase the output level of the signal generator by 10 dB, i.e., to 3.16 E_i.

8. Measure the audio output power, P_{o1} . This should be slightly greater than the reference audio output power, P_o.

9. Repeat Steps 7 and 8 until the maximum rated output power for the receiver is reached.

Note: Changes of input signal level that are smaller than 10 dB can be made if greater detail of the AGC characteristic is desired.

10. Plot a graph of output power, in watts, vs. open circuit input signal level, in microvolts, on semi-logarithm paper. This is the AGC characteristic, leveling effect, of the receiver.

4.3.3.2.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the open circuit input signal voltage, in microvolts, at each step.

6. Record the output power level, in watts, at each step.

4.3.3.2.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of open circuit input signal voltage, E_i

2. Uncertainty, ΔP_o or ΔP_{o1}, in the measured value of output power, P_o or P_{o1}

The relative uncertainty, $\Delta E_i(\%)$, in the signal voltage, E_i, expressed as a percent, is given by the equation

$$\Delta E_i(\%) = \frac{\Delta E_i}{E_i} \times 100.$$

The relative uncertainty, $\Delta P_o(\%)$, in the output power, P_o (or P_{o1}), expressed as a percent, is given by the equation

$$\Delta P_o(\%) = \frac{\Delta P_o}{P_o} \times 100.$$

The uncertainty, ΔE_i, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainty ΔP_o is obtained from the manufacturer's specifications on the distortion analyzer.

The total relative uncertainty, $\Delta EP(\%)$, in a point on the AGC leveling effect curve is given by the equation

$$\Delta EP(\%) = \Delta E_i(\%) + \Delta P_o(\%) .$$

4.3.3.3. DYNAMIC AGC CHARACTERISTICS

4.3.3.3.1. DEFINITIONS

a. The dynamic AGC characteristics are the attack and decay time constants, in microseconds or milliseconds, of the AGC voltage.

b. For the output of a first-order system forced by a step or an impulse, time constant is the time required to complete 63.2 percent of the total rise or decay. (IEEE Std 100-1972)

4.3.3.3.2. PURPOSE

The purpose of this measurement method is to measure the attack and decay time constants of the AGC system of AM receivers. These time constants are a measure of quickness and holding ability of automatic gain control which determine the uniformity of the receiver's audio output signal.

4.3.3.3.3. METHOD

The method uses an unmodulated signal generator, a SPDT reed relay, and a D.C. oscilloscope as shown in figure 4.3.3.3. The signal generator supplies a known input voltage to the receiver through the reed relay. The oscilloscope displays the change in AGC voltage after the relay is switched. The attack and decay time constants of the AGC circuit are determined from the display, using the scale calibrations of the oscilloscope.

Measurement uncertainties as small as 6% are possible under best conditions, and range from approximately 8% to 40% under typical conditions. The method uses moderately sophisticated but commonly available test equipment.

4.3.3.3.4. TEST EQUIPMENT REQUIRED

1. CW signal generator

2. 30 dB attenuator having a characteristic impedance equal to the specified source impedance, Z_s, for the receiver

3. SPDT reed relay

4. D.C. oscilloscope with delayed internal triggering

5. Oscilloscope camera

4.3.3.3.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the REED RELAY through the 30 dB ATTENUATOR.

2. Connect one of the input ports of the REED RELAY to the output port of the SIGNAL GENERATOR.

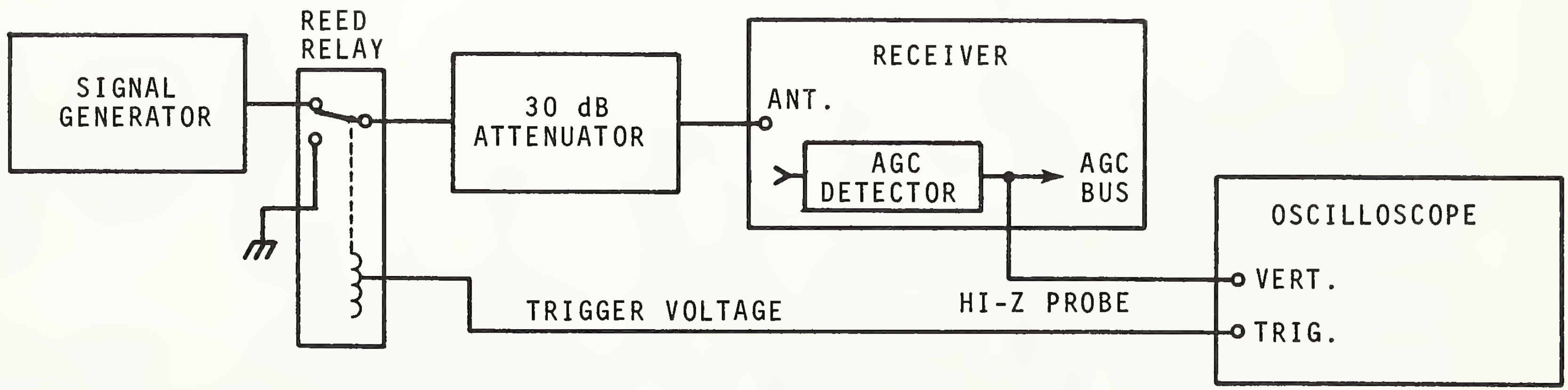

Fig. 4.3.3.3. Test Set-up for Automatic Gain Control; Time Constants

3. Connect the other input port of the REED RELAY to ground.

4. Connect the OSCILLOSCOPE vertical input port to the AGC bus in the receiver, using a high-impedance ($\geqslant 10$ megohm) D.C. probe. Make the connection following the RC networks that establish the time constants of the AGC system.

5. Provide a trigger voltage from the coil circuit of the reed relay to the trigger circuit of the oscilloscope.

6. Set the receiver controls as given in Table XIX.

7. Tune the signal generator and the receiver to the measurement frequency, f_o.

8. Set the output level from the signal generator to approximately 1,000,000 microvolts.

9. Set the reed relay in the OFF position, i.e., with its output port grounded.

10. Adjust the horizontal and vertical controls of the oscilloscope so that when the reed relay is switched to the ON position, the AGC bus voltage change will be displayed throughout from its no-signal value to its full-signal value.

11. Calibrate the vertical scale in volts per centimeter and the horizontal scale in seconds per centimeter.

12. Switch the reed relay to the ON position, and photograph the display of AGC voltage change.

TABLE XIX

Automatic Gain Control; Time Constants

Initial Control Settings

	Control		Setting
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	Optional
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	AGC
16.	Meter Switch	16.	Optional

13. Measure the time constant of the AGC attack time as follows: (a) Determine the starting point of the AGC voltage change; (b) determine the total AGC voltage change; (c) determine the point at which the voltage reached 63.2% of its total change. The attack time constant is the time interval between (a) and (c).

14. Adjust the horizontal controls of the oscilloscope, if required, so that when the reed relay is switched to the OFF position, the AGC bus voltage change will be displayed throughout from its full-signal value to its no-signal value. Recalibrate the horizontal scale as required.

15. Switch the reed relay to the OFF position, and photograph the display of the AGC voltage change.

16. Measure the time constant of the AGC decay time as per Step 13, above. The decay time constant is the time interval between the starting point of the AGC voltage change and the point at which the voltage has reached 63.2% of its final value.

4.3.3.3.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the open circuit voltage at the output terminals of the signal generator.

3. Record the scale calibration factors for the oscilloscope display in volts per centimeter (vertical) and seconds per centimeter (horizontal).

4. Record the measured AVC attack time constant, in microseconds or milliseconds, and the measured AVC decay time constant, in milliseconds or seconds.

4.3.3.3.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, Δt, in the horizontal calibration factor, t/cm, of the oscilloscope

2. Uncertainty, ΔV, in the voltage (vertical) reading, V, of the oscilloscope display

3. Uncertainty, ΔT, in the time (horizontal) reading, T, of the oscilloscope display

The total relative uncertainty, $\Delta\tau(\%)$, expressed in percent in either the attack time constant or the decay time constant, is given by the equation

$$\Delta\tau(\%) = 2\left[\left(\frac{\Delta t}{t/cm} + \frac{\Delta V}{V} + \frac{\Delta T}{T}\right) \times 100\right] .$$

Uncertainty Δt is obtained from the manufacturer's specifications on the voltage and time scale calibrators. Uncertainties ΔV and ΔT are obtained from the reading resolution of oscilloscope display; these are normally estimated from the characteristics of the actual display.

4.4. SELECTIVITY

Selectivity is a measure of the extent to which a receiver is capable of differentiating between a desired signal and disturbances at other frequencies. (IEEE Std 100-1972)

There are various receiver parameters that describe selectivity in different ways, for different conditions, and with differing degrees of adequacy. Selectivity in terms of the response to a single frequency is described by the following parameters:

1. Selectance
2. CW bandwidth
3. Shape factor
4. Modulation acceptance bandwidth
5. Spurious response attenuation

In terms of random signals occupying large regions of spectrum, selectivity is expressed by the parameter,

6. Noise bandwidth.

Parameters explicitly relating to the effects of one or more disturbing signals on the reception of a desired signal are the following:

7. Desensitization
8. Crossmodulation
9. Adjacent channel selectivity
10. Intermodulation

Finally, receiver response to impulsive-type signals is expressed by the parameter,

11. Impulse bandwidth.

Measurement methods for these parameters are given in the following sub-sections.

4.4.1. SELECTANCE

4.4.1.1. DEFINITION

Selectance is a measure of the falling off in the response of a resonant device with departure from resonance. It is expressed as the ratio of the amplitude of response at the resonance frequency, to the response at some frequency differing from it by a specified amount. (IEEE Std 100-1972)

The selectance of a receiver is the voltage response characteristic as a function of frequency around the principal response frequency of the receiver. It normally pertains to a linear receiver. For non-linear receivers, such as those with clipping or AGC, selectance may be a function of signal level.

4.4.1.2. PURPOSE

The purpose of this measurement method is to measure the selectance of a receiver in terms of voltage response as a function of frequency. This characteristic is a measure of the spectrum of frequencies, centered around the principal response frequency, which the receiver will amplify with significant gain. It is not an adequate measure of the receiver's ability to deliver an output signal of acceptable quality in the presence of signals outside of its principal response.

4.4.1.3. METHOD, POINT-BY-POINT - I

The method uses a variable frequency CW generator, an accurate frequency meter, and an R.F. voltmeter as shown in figure 4.4.1.1. The signal generator supplies a known variable input voltage to the receiver at a variety of frequencies within the principal response range of the receiver. The voltmeter measures the I.F. output voltage. The output level of the signal generator is adjusted to maintain a constant output voltage at the voltmeter input terminals.

The voltage gain between the receiver input terminals and the I.F. output terminals is thus measured at the various selected frequencies. Selectance is the graphical plot of (a) the ratio of I.F. output voltage to receiver input voltage versus (b) measurement frequency.

Note: Because of the good signal-to-noise ratio it can provide, this method may give better measurement results at frequencies far removed from the central frequency than the method given in Section 4.4.1.4., below. That method may give better measurement results at frequencies near the central frequency because of better control of overloading. Best results may be obtained by measuring from maximum response to -20 dB or -30 dB down from maximum response by the method of Section 4.4.1.4., and then from there down to the noise limit by the method of this Section.

Measurement uncertainties as small as 6% are possible under best conditions, and range from approximately 8% to 40% under typical conditions. The method uses simple and commonly available test equipment.

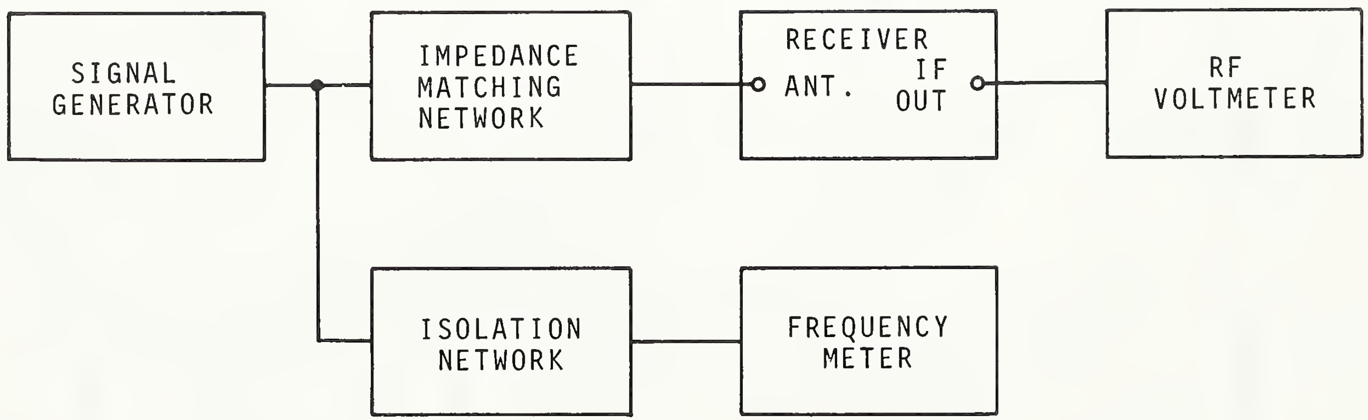

Fig. 4.4.1.1. Test Set-up for Selectance, Point-by-Point Method I

4.4.1.3.1. TEST EQUIPMENT REQUIRED

1. Variable frequency signal generator

2. Input impedance matching network

3. Frequency meter

4. Isolation network

5. R.F. voltmeter

4.4.1.3.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the FREQUENCY METER to the output port of the signal generator through an ISOLATION NETWORK.

3. Connect the R.F. voltmeter across the output terminals of the last I.F. stage.

4. Set receiver controls as given in Table XX.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the output level of the signal generator to a value E_{io}, that is approximately 10 dB below the upper voltage level of the receiver's dynamic range (cf.).

TABLE XX

Selectance, Point-by-Point Method I

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Relatively low
5. IF Gain	5. Medium
6. AF Gain	6. Minimum
7. Line Gain	7. Minimum
8. Detector Mode	8. N.A.
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. N.A.
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. MGC
16. Meter Switch	16. N.A.

7. Determine the open circuit signal voltage E_{io} in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

8. Adjust the sensitivity of the R.F. voltmeter to produce a convenient, near full-scale deflection, E_o.

9. Measure output voltage, E_o, in volts.

10. Compute the voltage ratio, $R(f_o)$, in decibels, as follows:

$$R(f_o) = 20 \log \frac{E_o}{E_{io} \times 10^{-6}} \quad .$$

11. Record $R(f_o)$, in decibels, and the measurement frequency, f_o, in kilohertz or megahertz.

12. Tune the signal generator to a new measurement frequency, f_1, above (or below) f_o. The frequency change, Δf, where

$$\Delta f = f_1 - f_o \ ,$$

is somewhat arbitrary and depends upon the degree of detail with which it is desired to know the selectance.

13. Leave the receiver tuned to frequency f_o.

14. Adjust the output level of the signal generator to a value, E_{i1}, that again produced output voltage E_o.

15. Determine the open circuit signal voltage, E_{i1}, in microvolts as in Step 7, above.

16. Compute the voltage ratio, $R(f_1)$, in decibels, as in Step 10, above.

17. Record $R(f_1)$, in decibels, and the measurement frequency, f_1, in kilohertz or megahertz.

18. Proceed as indicated in Steps 12 through 17, each time changing the frequency in convenient small steps. Continue until the voltage ratio, R, in decibels, is 0 dB or as small as practicable.

19. Plot the voltage ratio, R, in decibels, as a function of measurement frequency, f, on rectilinear graph paper. This plot is the selectance of the receiver.

4.4.1.3.3. DATA REQUIRED

1. Record the measurement frequencies in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the open circuit signal voltages, in microvolts, at the output terminals of the matching network, if used; otherwise, at the ouput terminals of the generator.

4. Record the I.F. output voltage, E_o, in volts.

5. Record the voltage ratios, R(f), in decibels.

4.4.1.3.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured values of E_i

2. Uncertainty, ΔE_o, in the measured value of E_o

3. Uncertainty, Δf, in the measured values of f

The total relative uncertainty, $\Delta R(dB)$, in decibels, in the voltage gain, R, is given approximately, for small uncertainties, by the equation

$$\Delta R(dB) = 20 \log \left(1 + \frac{\Delta R}{R}\right) ,$$

where

$$\frac{\Delta R}{R} = \frac{\Delta E_i}{E_i} + \frac{\Delta E_o}{E_o} .$$

Uncertainties ΔE_i and ΔE_o are obtained from the manufacturer's specfications on the output level indicator of the signal generator and on the R.F. voltmeter, respectively. Uncertainty Δf is obtained from the manufacturer's specifications on the frequency meter.

4.4.1.4. METHOD, POINT-BY-POINT - II

The method uses a variable frequency CW generator and an R.F. voltmeter as shown in figure 4.4.1.2. The signal generator supplies a constant known input voltage to the receiver at a variety of frequencies within the principal response range of the receiver. The voltmeter measures the I.F. output voltage. The voltage gain between the receiver input terminals and the I.F. output terminals is thus measured at the various selected frequencies. Selectance is the graphical plot of (a) the ratio of I.F. output voltage to receiver input voltage versus (b) measurement frequency.

Measurement uncertainties as small as 6% are possible under best conditions, and range from approximately 8% to 40% under typical conditions. The method uses simple and commonly available test equipment. Refer to Note, Section 4.4.1.3.

4.4.1.4.1. TEST EQUIPMENT REQUIRED

1. Variable frequency signal generator

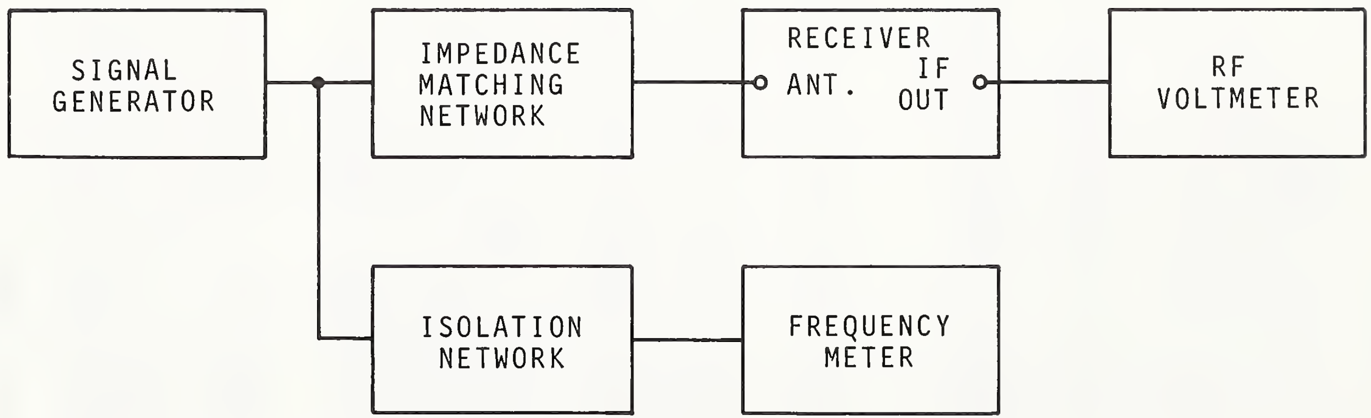

Fig. 4.4.1.2. Test Set-up for Selectance, Point-by-Point Method II

2. Input impedance matching network

3. Frequency meter

4. Isolation network

5. R.F. voltmeter

4.4.1.4.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the FREQUENCY METER to the output port of the signal generator through an ISOLATION NETWORK.

3. Connect the R.F. voltmeter across the output terminals of the last I.F. stage.

4. Set receiver controls as given in Table XX, p. 140.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the output level of the signal generator to a value E_{io}, that is approximately 10 dB below the upper voltage level of the receiver's dynamic range (cf.).

7. Determine the open circuit signal voltage E_{io}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

8. Adjust the sensitivity of the R.F. voltmeter to produce a convenient, near full-scale deflection, E_o.

9. Measure output voltage, E_o, in volts.

10. Compute the voltage ratio, $R(f_o)$, in decibels as follows:

$$R(f_o) = 20 \log \frac{E_o}{E_{io} \times 10^{-6}} \quad .$$

11. Record $R(f_o)$, in decibels, and the measurement frequency, f_o, in kilohertz or megahertz.

12. Tune the signal generator to a new measurement frequency, f_1, above (or below) f_o. The frequency change, Δf, where

$$\Delta f = f_1 - f_o \quad ,$$

is somewhat arbitrary and depends upon the degree of detail with which it is desired to know the selectance. Leave the generator level the same as in Step 7, above.

13. Leave the receiver tuned to frequency f_o.

14. Measure output voltage, E_{o1}, in volts.

15. Compute the voltage ratio, $R(f_1)$, in decibels as follows:

$$R(f_1) = 20 \log \frac{E_{o1}}{E_i \times 10^{-6}} \quad .$$

16. Record $R(f_1)$, in decibels, and the measurement frequency, f_1, in kilohertz or megahertz.

17. Proceed as indicated in Steps 11 through 15, each time changing the frequency in small steps. Continue until the output voltage, E_o, reaches the level produced by the internal noise of the receiver.

18. Plot the voltage ratio, R, in decibels, as a function of measurement frequency, f, on rectilinear graph paper. This plot is the selectance of the receiver.

4.4.1.4.3. DATA REQUIRED

1. Record the measurement frequencies in kilohertz or megahertz.

2. Record the value of source impedance, Z_S, in ohms, connected to the receiver input port.

3. Record the open circuit signal voltage, E_{io}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

4. Record the I.F. output voltages, E_o, in volts.

5. Record the voltage ratios, R(f), in decibels.

4.4.1.4.4. MEASUREMENT ERRORS

1. The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2. Uncertainty, ΔE_o, in the measured values of E_o

3. Uncertainty, Δf, in the measured values of f

The total relative uncertainty, ΔR(dB), in decibels, in the voltage gain, R, is given approximately, for small uncertainties, by the equation

$$\Delta R(\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta R}{R}\right) ,$$

where

$$\frac{\Delta R}{R} = \frac{\Delta E_i}{E_i} + \frac{\Delta E_o}{E_o} .$$

Uncertainties ΔE_i and ΔE_o are obtained from the manufacturer's specifications on the output level indicator of the signal generator and on the R.F. voltmeter, respectively. Uncertainty Δf is obtained from the manufacturer's specifications on the frequency meter.

4.4.1.5. METHOD, SWEPT-FREQUENCY

The method uses a swept-frequency CW signal generator and an oscilloscope as shown in figure 4.4.1.3. The signal generator supplies a swept frequency signal of constant amplitude to the receiver. The oscilloscope displays the detected output voltage from the receiver. Also, the signal generator supplies a linear sweeping voltage for the horizontal deflection circuits of the oscilloscope, and marker signals for calibrating the frequency (horizontal) scale of the display. A camera is used to photograph the oscilloscope display to obtain a permanent record of the selectance.

Measurement uncertainties as small as 8% are possible under best conditions, and range from approximately 12% to 40% under typical conditions. The method uses simple and commonly available test equipment.

4.4.1.5.1. TEST EQUIPMENT REQUIRED

1. Swept-frequency signal generator

2. Input impedance matching network

3. Cathode-ray oscilloscope

4. Oscilloscope camera

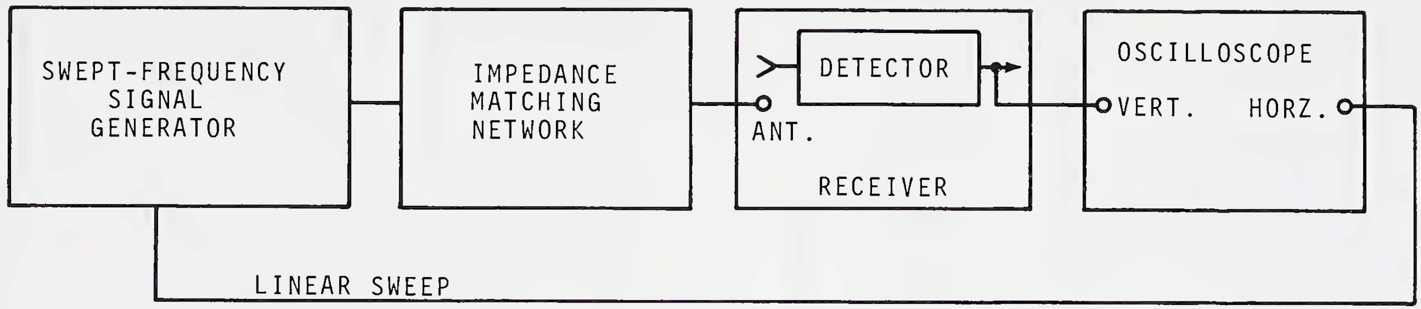

Fig. 4.4.1.3. Test Set-up for Selectance, Swept-Frequency Method

4.4.1.5.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the OSCILLOSCOPE to the detector output as shown in figure 4.4.1.3.

3. Connect the sweeping voltage output from the generator to the horizontal input terminals of the oscilloscope.

4. Set receiver controls as given in Table XXI.

5. Tune the receiver to the measurement frequency, f_o.

6. Adjust the output level of the sweep generator, the sweep width of the sweep generator, and the vertical and horizontal gains of the oscilloscope to produce a display of the detector output voltage having sufficient size to fill the square measurement area of the oscilloscope screen. Use dc coupling in the oscilloscope. If the receiver bandwidth is narrow, use as slow a generator sweep rate as practicable. The output level is adjusted to provide an input signal voltage that is no greater than 10 dB below the upper voltage level of the receiver's dynamic range (cf.). The sweep width is adjusted to display the full range of frequencies of the principal receiver response, and no more.

7. Turn on sufficient marker generators to calibrate the horizontal scale of the display in kilohertz or megahertz.

TABLE XXI

Selectance, Swept-Frequency Method

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Relatively low
5.	IF Gain	5.	Medium
6.	AF Gain	6.	Minimum
7.	Line Gain	7.	Minimum
8.	Detector Mode	8.	AM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	N.A.
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	N.A.

8. Having obtained a suitable display, and with frequency marker pips showing, photograph the display. This is the selectance curve of the receiver.

9. Disconnect the vertical input of the oscilloscope from the receiver detector circuit, and apply a signal from a square-wave calibration source to calibrate the vertical scale of the oscilloscope.

10. Determine the vertical scale factor, in volts per centimeter and record this information on the back of the photograph.

11. Detemine the horizontal scale factor from the marker frequencies, in kilohertz or megahertz per centimeter, and record this information on the back of the photograph.

4.4.1.5.3. DATA REQUIRED

1. Record the measurement frequency, f_o in kilohertz or megahertz.

2. Record the value of source impedance, Z_s in ohms, connected to the receiver input port.

3. Record the open circuit signal voltage, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

4. Record the vertical scale factor, in volts per centimeter.

5. Record the horizontal scale factor, in kilohertz or megahertz per centimeter.

4.4.1.5.4. MEASUREMENT ERRORS

Because this test is primarily qualitative, no error analysis is provided here. An estimate of measurement error can be obtained from the manufacturer's specifications on the various test equipments used.

4.4.2. CW BANDWIDTH

4.4.2.1. DEFINITION

The CW bandwidth of a receiver is the range of frequencies, in kilohertz or megahertz, that lies between the half-power points of the selectance curve (cf.).

To the extent that selectance depends upon the operating conditions of the receiver, CW bandwidth also depends upon these operating conditions.

4.4.2.2. PURPOSE

The purpose of this measurement method is to measure the CW bandwidth of an AM receiver. CW bandwidth is a measure of the spectrum of frequencies, centered around the principal response frequency, which the receiver will amplify with significant gain. It is not an adequate measure of the receiver's ability to deliver an output signal of acceptable quality in the presence of other signals.

CW bandwidth is measured at an arbitrary gain value, i.e., -3 dB from maximum gain. It therefore does not give sufficient information about the frequency response characteristic so that different receivers can be intercompared. It has maximum utility when the frequency response characteristic has a single, Gaussian-like shape. Only when this is the case does CW bandwidth have the qualitative meaning that is assumed in engineering jargon.

4.4.2.3. METHOD, VARIABLE-FREQUENCY GENERATOR

The method uses a variable frequency CW generator, an accurate frequency meter, a 3 dB attenuator, and an R.F. voltmeter as shown in figure 4.4.2.1. The signal generator supplies a known input voltage to the receiver. The R.F. voltmeter measures

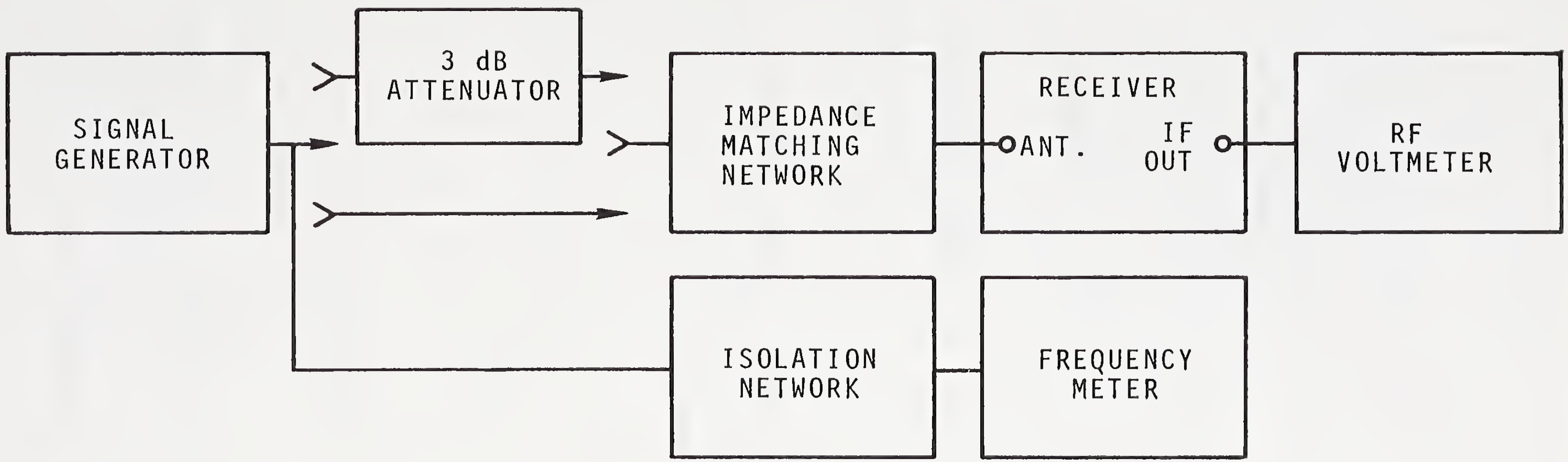

Fig. 4.4.2.1. Test Set-up for CW Bandwidth, Generator Method

the I.F. output voltage, and the frequency meter measures the generator frequency. The 3 dB attenuator is connected between the signal generator and receiver, both of which are tuned to the measurement frequency, f_o. I.F. output voltage, E_o, is noted. Then the 3 dB attenuator is removed and the frequency of the signal generator is adjusted above and below f_o to those frequencies, f_u and f_ℓ, that produce the same output voltage, E_o. CW bandwidth is the frequency difference between f_u and f_ℓ.

Measurement uncertainties as small as 3% are possible under best conditions, and range from approximately 6% to 25% under typical conditions. The method uses simple and commonly available test equipment.

4.4.2.3.1. TEST EQUIPMENT REQUIRED

1. Variable frequency signal generator

2. Input impedance matching network

3. 3 dB attenuator

4. Frequency meter

5. Isolation network

6. R.F. voltmeter

4.4.2.3.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the FREQUENCY METER to the output port of the signal generator through an ISOLATION NETWORK.

3. Connect the R.F. voltmeter across the output terminals of the last I.F. stage.

4. Set receiver controls as given in Table XXII.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. With the 3 dB attenuator connected between the signal generator and the matching transformer, adjust the output level of the generator to a value that is within the linear operating range of the receiver; i.e., at least 10 dB inside the lower and upper voltage levels of the receiver's dynamic range (cf.).

7. Determine the open circuit signal voltage E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

8. Adjust the sensitivity of the R.F. voltmeter to produce a convenient, near full-scale deflection, E_o.

9. Measure output voltage, E_o, in volts.

10. Without changing the output level setting of the generator, remove the 3 dB attenuator and connect the signal generator directly to the matching network.

11. Increase the frequency of the generator above f_o until the I.F. output voltage is again E_o.

12. Readjust the generator output level control, if necessary, to produce the value, E_i, obtained in Step 7, above.

TABLE XXII

CW Bandwidth, Generator Method

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Relatively low
5. IF Gain	5. Medium
6. AF Gain	6. Minimum
7. Line Gain	7. Minimum
8. Detector Mode	8. N. A.
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. N.A.
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. MGC
16. Meter Switch	16. N.A.

13. Repeat Steps 11 and 12 until a frequency above f_o is found that produced E_o when the signal voltage is E_i.

14. Measure this frequency, f_u.

15. Decrease the frequency of the generator below f_o until the detector output voltage is again E_o.

16. Proceed as in Steps 12 and 15 until a frequency below f_o is found that produces E_o when the signal voltage is E_i.

17. Measure this frequency, f_ℓ.

18. Subtract f_ℓ from f_u to give the CW bandwidth B(CW). That is,

$$B(CW) = f_u - f_\ell \ .$$

4.4.2.3.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

4. Record the I.F. output voltage, E_o, in volts.

5. Record the -3dB upper frequency, f_u, in kilohertz or megaherts.

6. Record the -3dB lower frequency, f_ℓ, in kilohertz or megahertz.

7. Record the CW bandwidth, B(CW), in kilohertz or megahertz.

4.4.2.3.4. MEASUREMENT ERRORS

The principal sources of measurement error are the uncertainties, ΔdB, in the attenuation of the 3 dB attenuator, and ΔE_o, in the indicated value of E_o. The uncertainty, Δf, in the measured value of frequency is ordinarily insignificant compared with ΔdB and ΔE_o.

The total relative uncertainty, $\Delta B(\%)$, expressed in percent, in the measured value of bandwidth, B, is given by the equation

$$\Delta B(\%) = \frac{\Delta B}{B} \times 100 \quad ,$$

where the uncertainty, ΔB, is given by the equation

$$\Delta B = (C_\ell + C_u)\ (2.3\ \Delta dB + \Delta E_o) \quad .$$

C_ℓ and C_u are the slopes of the selectance curve, in hertz per volt, at the frequencies f_ℓ and f_u, respectively. They are determined by measuring the change, δE_o, in output voltage, E_o, for a small change, δf, in frequency around f_ℓ or f_u. That is,

$$C_\ell = \left.\frac{\delta f}{\delta E_o}\right|_{f=f_\ell}$$

$$C_u = \left.\frac{\delta f}{\delta E_o}\right|_{f=f_u} \quad .$$

For a symmetrical selectance curve, $|C_\ell| = |C_u|$. Uncertainties ΔdB and ΔE_o are obtained from the manufacturer's specifications on the 3 dB attenuator and R.F. voltmeter, respectively.

4.4.2.4. METHOD, SWEPT-FREQUENCY GENERATOR

The method uses a swept-frequency CW signal generator and an oscilloscope as shown in figure 4.4.2.2. The signal generator supplies a swept frequency signal of constant amplitude to the receiver. The oscilloscope displays the detected output voltage from the receiver. Also, the signal generator supplies a linear sweeping voltage for the horizontal deflection circuits of the oscilloscope, and marker signals for calibrating the frequency (horizontal) scale of the display. A camera is used to obtain a permanent record of the display. The CW bandwidth is found by determining the width of the display at the half power points.

4.4.2.4.1. TEST EQUIPMENT REQUIRED

1. Swept-frequency signal generator

2. Input impedance matching network

3. Cathode-ray oscilloscope

4. Oscilloscope camera

4.4.2.4.2. PROCEDURE

1. Obtain the selectance curve of the receiver as outlined in Section 4.5.1.5.

2. Locate the points on the curve that are 71% of the distance from the base line of the curve to the top of the curve. These are the 71% voltage gain points or 50% power gain (-3dB) points on the curve.

3. Determine the width of the curve, in kilohertz, between these points, using the scale calibration factor in kilohertz per centimeter. This is the CW bandwidth of the receiver.

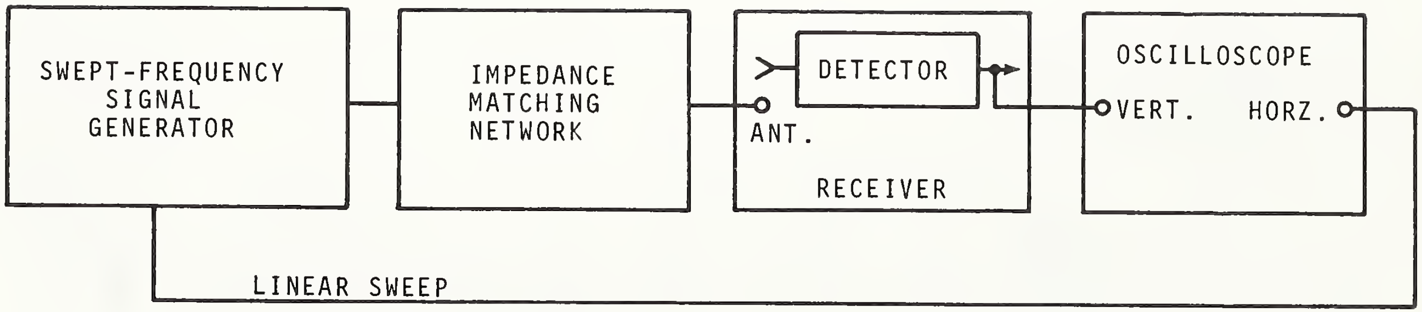

Fig. 4.4.2.2. Test Set-up for CW Bandwidth, Swept-Frequency Method

4.4.2.4.3. DATA REQUIRED

1. Record the measurement frequency, f_o in kilohertz or megahertz.

2. Record the value of source impedance, Z_s in ohms, connected to the receiver input port.

3. Record the open circuit signal voltage, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

4. Record the vertical scale factor, in volts per centimeter.

5. Record the horizontal scale factor, in kilohertz or megahertz per centimeter.

6. Record the frequencies, in kilohertz or megahertz, at the 50% power gain points on the selectance curve.

7. Record the CW bandwidth, B(CW), in kilohertz or megahertz.

4.4.2.4.4. MEASUREMENT ERRORS

Because this test is primarily qualitative, no error analysis is provided here. An estimate of measurement error can be obtained from the manufacturer's specifications on the various test equipments used.

4.4.3. SHAPE FACTOR

4.4.3.1. DEFINITIONS

Shape Factor is the ratio of (a) the selectance bandwidth at -60 dB below the maximum gain point to (b) the selectance bandwidth at -6 dB below the maximum gain point.

Selectance bandwidth is the range of frequencies that lies between two specified points of the selectance curve (c.f.).

Note: When the measurement dynamic range does not permit measurement over a 60 dB range, shape factor may be defined in terms of some other gain points, such as the -40 dB and -6 dB points.

4.4.3.2. PURPOSE

The purpose of this measurement method is to measure the shape factor of the selectance of a receiver. Shape factor is a measure of the slope of the sides of the selectance curve. It has importance as a measure of the ability of a receiver to pass the desired frequency components of an amplitude modulated signal while at the same time rejecting undesired signals adjacent to the desired signal.

4.4.3.3. METHOD

The method uses a variable frequency CW generator, an accurate frequency meter, a 54 dB attenuator, a 60 dB attenuator, and an R.F. voltmeter as shown in figure 4.4.3. The signal generator supplies a known input voltage to the receiver, the R.F. voltmeter measures the I.F. output voltage, and the frequency meter measures the generator frequency. The 54 dB and 60 dB

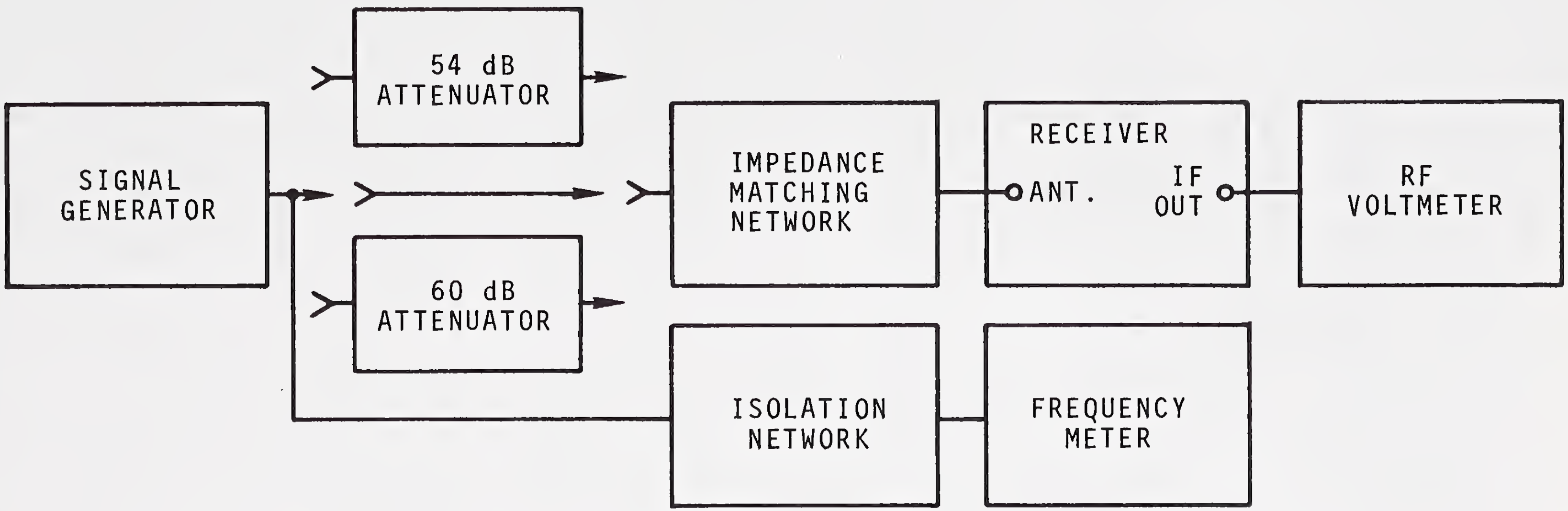

Fig. 4.4.3. Test Set-up for Shape Factor

attenuators are used, in turn, to decrease the input signal to the receiver when measuring the receiver gain at the -6 dB and 0 dB points, respectively, on the selectance curve. The upper and lower frequencies, f_u(-6 dB), f_u(-60 dB), f_ℓ(-6 dB), f_ℓ(-60 dB), are measured and used to calculate the shape factor, S, where

$$S = \frac{f_u(-60\text{dB}) - f_\ell(-60\text{dB})}{f_u(-6\text{dB}) - f_\ell(-6\text{dB})} \quad .$$

This method can be used as given only when the receiver has at least a 60 dB dynamic range. See the Note under Section 4.4.3.1. above.

Measurement uncertainties as small as 6% are possible under best conditions, and range from approximately 10% to 40% under typical conditions. The method uses simple and commonly available test equipment.

4.4.3.4. TEST EQUIPMENT REQUIRED

1. Variable frequency signal generator

2. Input impedance matching network

3. 54 dB attenuator

4. 60 dB attenuator

5. Frequency meter

6. Isolation network

7. R.F. voltmeter

4.4.3.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the FREQUENCY METER to the output port of the signal generator through an ISOLATION NETWORK.

3. Connect the R.F. VOLTMETER across the output terminals of the last I.F. stage.

4. Set the receiver controls as given in Table XXIII.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. With the 60 dB ATTENUATOR connected between the signal generator and the matching transformer, adjust the output level of the signal generator to a value, E_i, that is 10 dB below the upper voltage level of the receiver's dynamic range (cf.).

7. Determine the open circuit signal voltage E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

8. Measure the output voltage, E_o.

9. Without changing the output level setting of the generator, remove the 60 dB attenuator and connect the 54 dB ATTENUATOR between the signal generator and the matching network.

TABLE XXIII

Shape Factor

Initial Control Settings

	Control		Setting
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Relatively low
5.	IF Gain	5.	Medium
6.	AF Gain	6.	Minimum
7.	Line Gain	7.	Minimum
8.	Detector Mode	8.	N.A.
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	N.A.
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	N.A.

10. Increase the frequency of the generator above f_o until the I.F. output voltage is again E_o.

11. Readjust the generator output level control, if necessary, to produce the value, E_i, obtained in Step 7 above.

12. Repeat Steps 10 and 11 until a frequency above f_o is found that produces E_o when the signal voltage is E_i.

13. Measure this frequency, f_u(-6 dB). This is the upper frequency at which the receiver gain is 6 dB below that at f_o.

14. Decrease the frequency of the generator below f_o until the I.F. output voltage is again E_o.

15. Proceed as in Steps 11 and 12 until a frequency below f_o is found that produces E_o when the input voltage is E_i.

16. Measure this frequency, f_ℓ(-6 dB). This is the lower frequency at which the receiver gain is 6 dB below that at f_o.

17. Without changing the output level setting of the generator, remove the 54 dB attenuator and connect the signal generator directly to the matching network.

18. Increase the frequency of the generator above f_o until the I.F. output voltage is again E_o.

19. Readjust the generator output level control, if necessary, to produce the value, E_i, obtained in Step 7 above.

20. Repeat Steps 10 and 11 until a frequency above f_o is found that produces E_o when the signal voltage is E_i.

21. Measure this frequency, f_u(-60 dB). This is the upper frequency at which the receiver gain is 60 dB below that at f_o.

22. Decrease the frequency of the generator below f_o until the I.F. output voltage is again E_o.

23. Proceed as in Steps 11 and 12 until a frequency below f_o is found that produces E_o when the input voltage is E_i.

24. Measure this frequency, f_ℓ(-60 dB). This is the lower frequency at which the receiver gain is 60 dB below that at f_o.

25. Subtract f_ℓ(-6 dB) from f_u(-6 dB) to give the bandwidth at the -6 dB points.

26. Subtract f_ℓ(-60 dB) from f_u(-60 dB) to give the bandwidth at the -60 dB points.

27. Compute the shape factor, S, by the equation

$$S = \frac{f_u(-60\text{dB}) - f_\ell(-60\text{dB})}{f_u(-6\text{dB}) - f_\ell(-6\text{dB})} .$$

4.4.3.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network if used; otherwise, at the output terminals of the generator.

4. Record the I.F. output voltage, E_o, in volts.

5. Record the -6 dB upper frequency, f_u(-6 dB), in kilohertz or megahertz.

6. Record the -6 dB lower frequency, f_ℓ(-6 dB), in kilohertz or megahertz.

7. Record the -60 dB upper frequency, f_u(-60 dB), in kilohertz or megahertz.

8. Record the -60 dB lower frequency, f_ℓ(-60 dB), in kilohertz or megahertz.

9. Record the shape factor, S, as a numeric ratio, usually expressed in the form

$$S = B(-60\ dB) \ /\ B(-6dB) : 1 \quad .$$

4.4.3.7. MEASUREMENT ERRORS

Because this test is primarily qualitative, no error analysis is provided here. An estimate of measurement error can be obtained from the manufacturer's specifications on the various test equipments used.

4.4.4. MODULATION ACCEPTANCE BANDWIDTH

4.4.4.1. DEFINITION

The modulation acceptance bandwidth of an FM receiver is the deviation, in kilohertz, that will produce a 12 dB SINAD ratio at an RF signal level of 6 dB above the 12 dB SINAD SENSITIVITY of the receiver.

Although the basic concept of modulation acceptance bandwidth applies also to an AM receiver, no such receiver parameter has been so defined.

4.4.4.2. PURPOSE

The purpose of this measurement method is to measure the modulation acceptance bandwidth of an FM receiver. Modulation acceptance bandwidth is a measure of the maximum deviation of a frequency modulated carrier that can produce an audio output signal of acceptable quality. The method takes into account the effects of distortion of the desired signal within the receiver. However, it does not take into account the output degradation effects caused by undesired signals.

4.4.4.3. METHOD

The method uses a frequency modulated signal generator and an audio distortion analyzer as shown in figure 4.4.4. First, the 12 dB SINAD sensitivity is measured (cf). Then, the generator output level is increased by 6 dB, and the modulation deviation is increased until a 12 dB SINAD ratio is again obtained. Twice the deviation, in kilohertz, required for this is the modulation acceptance bandwidth of the receiver.

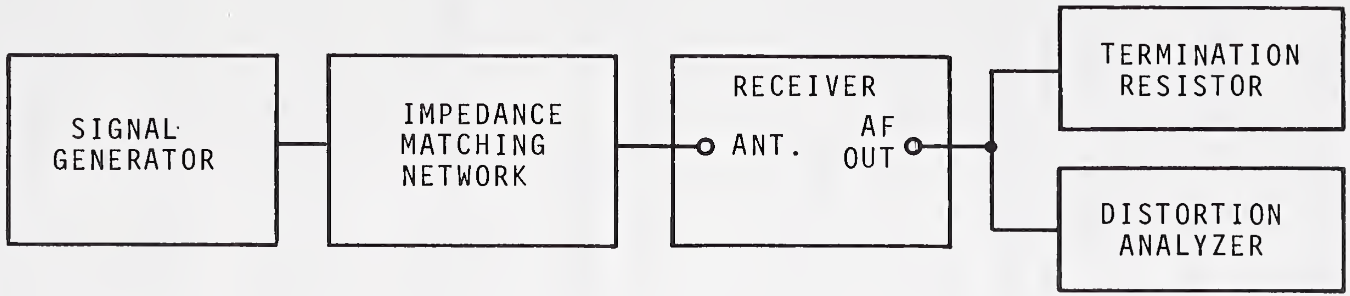

Fig. 4.4.4. Test Set-up for Modulation Acceptance Bandwidth

Measurement uncertainties as small as 10% are possible under best conditions, and range from approximately 15% to 50% under typical conditions. The method uses commonly available test equipment of moderate sophistication.

4.4.4.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver output load

4. Audio distortion analyzer

4.4.4.5. PROCEDURE

1. Measure the 12 dB SINAD SENSITIVITY as outlined in Section 4.1.5. Refer to Table VIII for initial settings of receiver controls.

2. Increase the signal generator output level by exactly 6 dB.

3. Set the distortion analyzer so that the 1000 Hz rejection filter is NOT in the circuit.

4. Adjust the receiver AF gain control to produce reference audio output power, P_o.

5. Adjust the distortion analyzer so that the 1000 Hz rejection filter tunes out the 1000 Hz modulation from the signal generator.

6. Measure the noise plus distortion output power, $P_{(n+d)}$.

7. Calculate SINAD in decibels from the equation

$$\text{SINAD (dB)} = 10 \log \frac{P_o}{P_{(n+d)}} \quad .$$

8. If the SINAD ratio calculated in Step 7 is greater (or less) than 12 dB, increase (or decrease) the deviation percentage and repeat Steps 3 through 7. Continue this procedure until 12 dB SINAD ratio is obtained.

9. Determine the deviation, f_d, in kilohertz, for the conditions obtained in Step 8. Twice f_d ($2f_d$) is the MODULATION ACCEPTANCE BANDWIDTH of the receiver at frequency f_o.

4.4.4.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record 12 dB SINAD sensitivity, in microvolts.

6. Record modulation acceptance bandwidth, $2f_d$, in kilohertz.

4.4.4.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the 12 dB SINAD sensitivity, E_i

2. Uncertainty, Δf_d, in the frequency deviation, f_d

The total relative uncertainty, $\Delta f_d(\%)$, expressed in percent, in the modulation acceptance bandwidth, $2f_d$, is given approximately by the equation

$$\Delta f_d\ (\%) = \Delta E_i\ (\%) + \left(\frac{\Delta f_d}{f_d} \times 100\right) \quad .$$

The relative uncertainty, $\Delta E_i(\%)$, in the 12 dB SINAD sensitivity is obtained as described in Section 4.1.3.7. The uncertainty, Δf_d, is obtained from the manufacturer's specifications on the modulation deviation of the signal generator.

4.4.5. SPURIOUS RESPONSE ATTENUATION

Spurious responses occur when a receiver, due to its circuitry and construction, responds to frequencies other than those in its principal response band. They are considered to be those responses of a receiver to a single input frequency only. Therefore, they are to be distinguished from responses that occur in the presence of two or more simultaneous signals; the latter are described by other terms such as cross modulation (cf.) and intermodulation (cf.).

Spurious responses are usually generated when undesired signals mix with receiver local oscillators or their harmonics in non-linear stages of the receiver. However, faulty receivers having unintended regeneration may produce spurious responses that are not related to local oscillator frequencies.

Spurious responses that consist of families of related responses can often be identified by the following relationships:

For a single conversion receiver:

$$f_s = \frac{pf_{LO} \pm f_{IF}}{q} \quad ;$$

For a dual-conversion receiver:

$$f_s = \frac{p_1 f_{LO1}}{q_1} \pm \frac{p_2 f_{LO2} \pm f_{IF2}}{q_1 q_2} \quad ;$$

For a triple conversion receiver:

$$f_s = \frac{p_1 f_{LO1}}{q_1} \pm \frac{p_2 f_{LO2}}{q_1 q_2} \pm \frac{p_3 f_{LO3} \pm f_{IF3}}{q_1 q_2 q_3} \quad ;$$

where p is an integer or zero denoting the harmonic order of the local oscillator, q is an integer (not zero) denoting the harmonic order of the mixer input signal, f_{LO} and f_{IF} denote the local oscillator and intermediate frequency, respectively, and the subscripts are indicative of the number of mixer stages preceding the signal processing circuitry.

4.4.5.1. DEFINITIONS

a. The spurious response attenuation of a receiver is the ratio, expressed in decibels, of (a) the input voltage required to produce reference audio output power due to a signal at a spurious-response generating frequency, to (b) the input voltage required to produce reference audio output power due to a signal at the frequency to which the receiver is tuned.

b. A spurious response is any response, other than the desired response, of an electric transducer or device. (IEEE Std. 100-1972)

4.4.5.2. PURPOSE

The purpose of this measurement method is to measure the spurious response attenuation of surveillance receivers. Spurious response attenuation is a measure of the spectrum of frequencies, outside of the principal response region, to which the receiver will respond with measurable output power. It is not an adequate measure of the receiver's ability to reject undesired signals, but it does reveal those frequencies where the receiver will be most susceptible to undesired signals.

The test methods given below have general applicability to all receiver spurious responses, including image, I.F. feed-through, local oscillator-related, and extraneously produced responses.

4.4.5.3. METHOD - AM RECEIVERS

The method uses a variable-frequency amplitude modulated signal generator and a power meter or true rms voltmeter as shown in figure 4.4.5.1. The signal generator supplies a known input voltage to the receiver over a range of frequencies. The voltmeter or power meter indicates the receiver output signal level.

Before searching for spurious responses, the 6 dB SN/N SENSITIVITY is measured. Then, with the receiver adjusted for that measurement, the generator output level is increased to a large value and its frequency is slowly adjusted until a spurious response is produced. The input signal level is adjusted at the frequency causing the spurious response to produce reference audio output power. This input level, expressed as a decibel ratio relative to the 6 dB sensitivity, is the spurious response attenuation at that frequency. This process is repeated for the next spurious response.

Measurement uncertainties as small as 0.3 dB are possible under best conditions, and range from approximately 0.4 dB to 1.5 dB under typical conditions. This method uses rudimentary and commonly available test equipment.

4.4.5.3.1. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

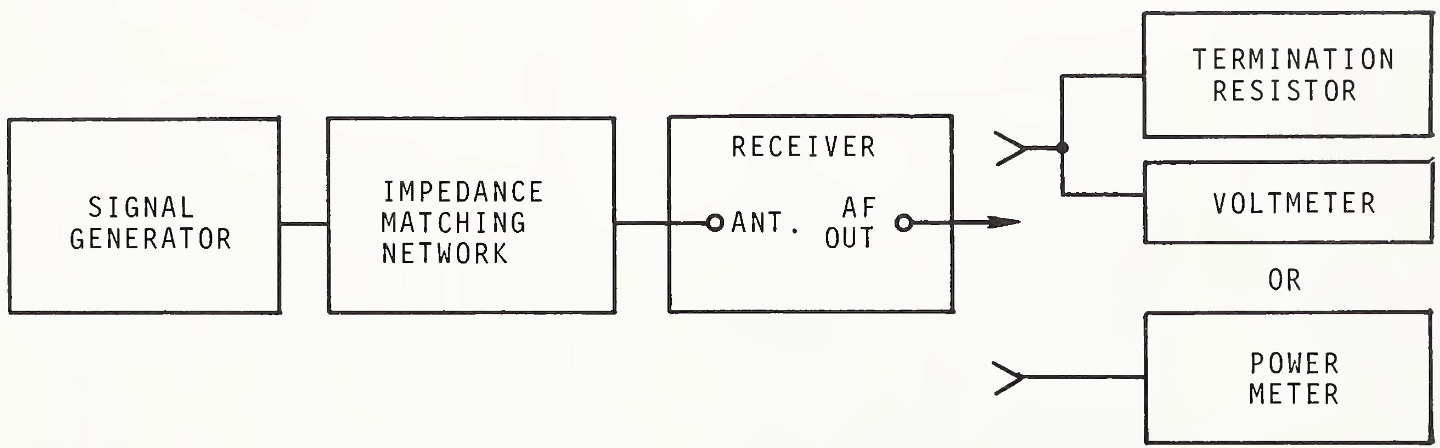

Fig. 4.4.5.1. . Test Set-up for Spurious Response Attenuation (AM)

4a. AF power meter

OR,

4b. True rms voltmeter

4.4.5.3.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3. Measure the 6 dB SN/N SENSITIVITY as outlined in Section 4.1.2.5.

4. Adjust the output level of the signal generator to maximum (e.g., 100,000 to 1,000,000 microvolts).

5. Slowly tune the frequency of the generator away from the principal response region, and search for a response from the receiver's output.

6. When a response is found, reduce the output level of the generator to give reference audio output power, P_o.

7. Determine the frequency, f_s, in kilohertz or megahertz, and the open circuit signal voltage, E_s, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator.

8. Calculate the ratio, R(S), in decibels, given by the following equation:

$$R(S) = 20 \log \frac{E_s}{E_i} .$$

R(S) is the spurious response attenuation of the receiver, referenced to the receiver's 6 dB SN/N sensitivity, at the frequency f_s.

9. Proceed as indicated in Steps 4 through 8, above, until the entire desired frequency range is covered.

4.4.5.3.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz, to which the receiver is tuned.

2. Record the frequencies, f_s, in kilohertz or megahertz, that cause the spurious response.

3. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

4. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

5a. Record the output voltage, E_o, in volts.

OR,

5b. Record the reference output power, P_o, in watts.

6. Record the 6 dB SN/N sensitivity, E_i, in microvolts.

7. Record the open circuit voltages, E_s, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

8. Record the spurious response attenuation, R(S), in decibels, for each spurious response.

4.4.5.3.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2. Uncertainty, ΔE_s, in the measured value of E_s

3a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

3b. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, $\Delta R(\mathrm{dB})$, in decibels, in the spurious response attenuation, R, is given approximately, for small uncertainties, by the equations

$$\Delta R\ (\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_i}{E_i} + \frac{\Delta E_s}{E_s} + \frac{\Delta E_o}{E_o}\right) \quad ,$$

OR,

$$\Delta R\ (\mathrm{dB}) = 20 \log \left(1 + \frac{\Delta E_i}{E_i} + \frac{\Delta E_s}{E_s} + \frac{1}{2}\frac{\Delta P_o}{P_o}\right) \quad .$$

Uncertainties ΔE_i and ΔE_s are obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.4.5.4. METHOD - FM RECEIVERS

The method uses an unmodulated signal generator and a true rms voltmeter or power meter as shown in figure 4.4.5.2. The signal generator supplies a known input voltage to the receiver over a range of frequencies. The voltmeter or power meter indicates the receiver output noise level.

Before searching for spurious responses, the 20 dB QUIETING SENSITIVITY is measured. Then, with the receiver adjusted for that measurement, the generator output level is increased to a large value and its frequency is slowly adjusted until a spurious response is produced. The input signal level is adjusted at the frequency causing the spurious response to produce 20 dB noise quieting. This input level, expressed as a decibel ratio relative to the 20 dB quieting sensitivity, is the spurious response attenuation at that frequency. This process is repeated for the next spurious response.

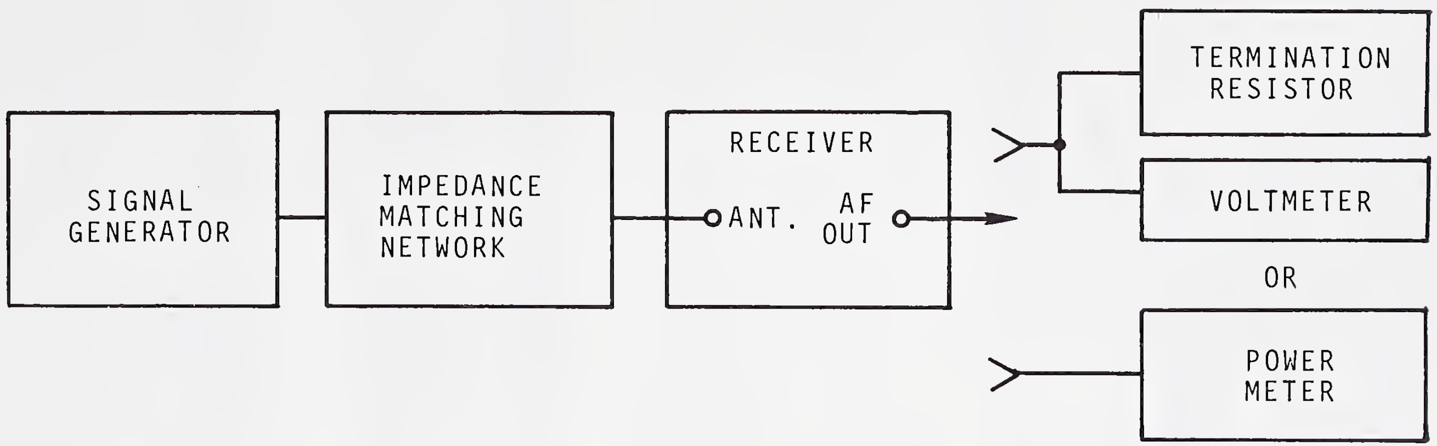

Fig. 4.4.5.2. Test Set-up for Spurious Response Attenuation (FM)

Measurement uncertainties as small as 0.3 dB are possible under best conditions, and range from approximately 0.4 dB to 1.5 dB under typical conditions. This method uses rudimentary and commonly available test equipment.

4.4.5.4.1. TEST EQUIPMENT REQUIRED

1. CW Signal generator

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4a. AF power meter

OR,

4b, True rms voltmeter

4.4.5.4.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across this resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_{ℓ}, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate 25% of the rated output power, P_o. The voltage to be measured is given by the equation

$$E_o = 0.5 \sqrt{P_o R_{\ell}} \ .$$

OR,

3b. Set the power meter on a range to indicate 25% of the rated output power, P_o.

4. Measure the 20 dB QUIETING SENSITIVITY as outlined in Section 4.1.4.5.

5. Adjust the output level of generator No. 2 to maximum (e.g., 100,000 to 1,000,000 microvolts).

6. Slowly tune the frequency of the generator away from the principal response region, and search for a response from the receiver's output.

7. When a response is found, reduce the output of the generator to give 20 dB of noise quieting, measured as outlined in Section 4.1.4.5.

8. Determine the frequency, f_s, in kilohertz or megahertz, and the open circuit signal voltage, E_s, in microvolts, at the OUTPUT TERMINAL of the matching network, if used; otherwise, at the output terminals of the generator.

9. Calculate the ratio, R(S), in decibels, given by the following equation:

$$R(S) = 20 \log \frac{E_s}{E_i} \quad .$$

R(S) is the spurious response attenuation of the receiver, referenced to the receiver's 20 dB quieting sensitivity, at the frequency f_s.

10. Proceed as indicated in Steps 5 through 9, above, until the entire desired frequency range is covered.

4.4.5.4.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz, to which the receiver is tuned.

2. Record the frequencies, f_s, in kilohertz or megahertz, that cause the spurious response.

3. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

4. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

5. Record the measured output voltages, E_o, and 0.1 E_o, in volts.

6. Record the measured output powers, 0.25 P_o and 0.0025 P_o, in watts.

7. Record the 20 dB quieting sensitivity, E_i, in microvolts.

8. Record the open circuit voltages, E_s, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

9. Record the spurious response attenuation, R(S), in decibels, for each spurious response.

4.4.5.4.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured value of E_i

2. Uncertainty, ΔE_s, in the measured value of E_s

3a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

3b. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, ΔR(dB), in decibels, in the spurious response attenuation, R, is given approximately, for small uncertainties, by the equations

$$\Delta R\ (\text{dB}) = 20 \log \left(1 + \frac{\Delta E_i}{E_i} + \frac{\Delta E_s}{E_s} + \frac{\Delta E_o}{E_o} \right) ,$$

OR,

$$\Delta R\ (\text{dB}) = 20 \log \left(1 + \frac{\Delta E_i}{E_i} + \frac{\Delta E_s}{E_s} + \frac{1}{2} \frac{\Delta P_o}{P_o} \right) .$$

Uncertainties ΔE_i and ΔE_s are obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.4.6. NOISE BANDWIDTH

4.4.6.1. DEFINITION

The noise bandwidth of a receiver is the width, in kilohertz or megahertz, of a rectangular selectance curve whose height and area are equal to the maximum height and enclosed area of the receiver's actual selectance curve.

4.4.6.2. PURPOSE

The purpose of this measurement method is to measure the noise bandwidth of surveillance receivers. Noise bandwidth is a partial measure of the amount of random noise power that will be delivered from the output terminals of the receiver. It is a useful quantity for calculating output signal-to-noise ratio. Because it is related only to the average width of the selectance curve, it is not a good measure of the receiver's ability to reject non-random signals.

4.4.6.3. METHOD

The method uses a variable frequency CW generator, an accurate frequency meter, and an R.F. voltmeter as shown in figure 4.4.6. The signal generator supplies a known input voltage to the receiver at a variety of frequencies within the principal response range of the receiver. The voltmeter measures the I.F. output voltage.

The selectance curve is obtained as described in Section 4.4.1. The height and area under the curve are determined, and from these quantities noise bandwidth is calculated.

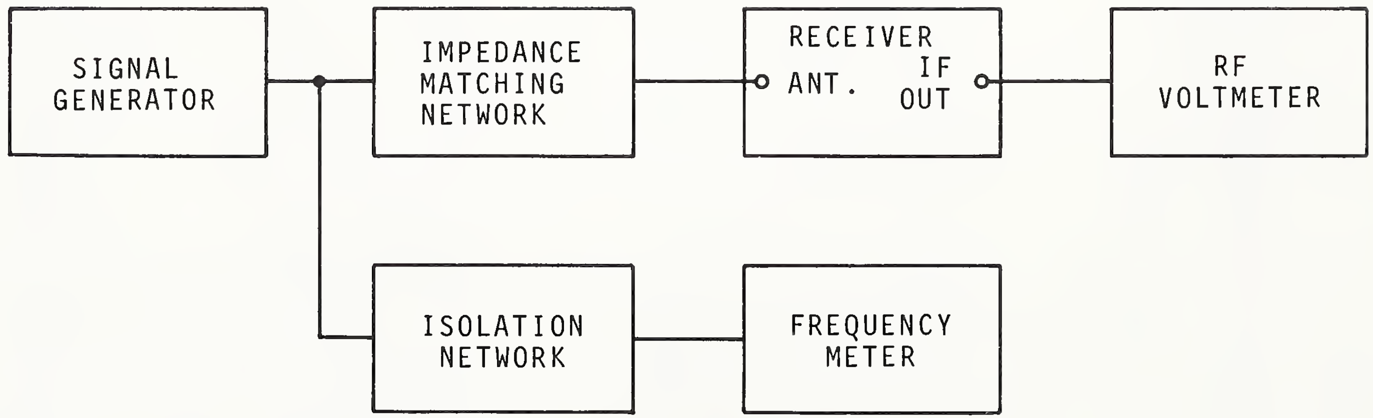

Fig. 4.4.6. Test Set-up for Noise Bandwidth

Measurement uncertainties as small as 10% are possible under best conditions, and range from approximately 15% to 50% under typical conditions. The method uses simple and commonly available test equipment.

4.4.6.4. TEST EQUIPMENT REQUIRED

1. Variable frequency signal generator

2. Input impedance matching transformer

3. Frequency meter

4. Isolation network

5. R.F. voltmeter

4.4.6.5. PROCEDURE

1. Measure the selectance as outlined in Section 4.4.1. However, rather than plotting the selectance curve in terms of voltage gain in decibels versus frequency, plot, on rectilinear graph paper, the voltage ratio, R(f), versus frequency, f.

2. Determine the total area, A, in volts per volt times hertz, enclosed by the selectance curve.

3. Determine the maximum height, h, in volts per volt, of the selectance curve.

4. Determine the width, B(N), in kilohertz or megahertz, of a rectangle whose height is h and whose total area is A. B(N) is the noise bandwidth of the receiver.

4.4.6.6. DATA REQUIRED

1. Record the measurement frequencies in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the open circuit signal voltages, in microvolts, at the output terminals of the matching network, if used; otherwise, at the input terminals of the generator.

4. Record the I.F. output voltages, E_o, in volts.

5. Record the voltage ratios, R(f), as a numeric ratio.

6. Record the area, A, in volts per volt times hertz (v/v)(Hz).

7. Record the height, h, in volts per volt.

8. Record the calculated value of noise bandwidth, B(N), in kilohertz or megahertz.

4.4.6.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_i, in the measured values of E_i

2. Uncertainty, ΔE_o, in the measured values of E_o

3. Uncertainty, Δf, in the measured values of f

The total relative uncertainty, $\Delta B(\%)$, expressed in percent, in the noise bandwidth, $B(N)$, is given by the equation

$$\Delta B\ (\%) = \left(\frac{\Delta A}{A} \times 100 \right) + \left(\frac{\Delta h}{h} \times 100 \right) \quad ,$$

where ΔA is the uncertainty in the area, A, and Δh, is the uncertainty in the height, h. Relative uncertainty $\Delta A/A$ is given by

$$\frac{\Delta A}{A} = 2 \left(\frac{\Delta E_i}{E_i} + \frac{\Delta E_o}{E_o} \right) + \frac{\Delta f}{f} \quad .$$

Relative uncertainty $\Delta h/h$ is given by

$$\frac{\Delta h}{h} = 2 \left(\frac{\Delta E_i}{E_i} + \frac{\Delta E_o}{E_o} \right) .$$

Uncertainties ΔE_i and ΔE_o are obtained from the manufacturer's specifications on the output level indicator of the signal generator and on the R.F. voltmeter, respectively. Uncertainty Δf is obtained from the manufacturer's specifications on the frequency meter.

4.4.7. DESENSITIZATION

4.4.7.1. DEFINITION

The desensitization of an AM receiver is the input voltage level from an undesired signal source which, when present simultaneously with a desired signal source of a selected level that alone produces reference audio output power, produces a reduction of 3 dB in the audio output power as compared with the output in the absence of the undesired signal.

Desensitization in an AM receiver may be a function of desired signal level. It is usually expressed in decibels above the desired signal level at which the measurement is made.

4.4.7.2 PURPOSE

The purpose of this measurement method is to measure the desensitization of AM receivers. Desensitization is a measure of the extent to which receiver gain is reduced by the presence of an adjacent undesired signal.

4.4.7.3. METHOD

The method uses two signal generators and a voltmeter or power meter as shown in figure 4.4.7. The signal generators supply known input voltages at different frequencies to the receiver through a combining network. The voltmeter or power meter measured the receiver output signal level that is produced under the following two conditions:

(1) The first generator is amplitude modulated and adjusted to produce reference audio output power with the second generator turned off.

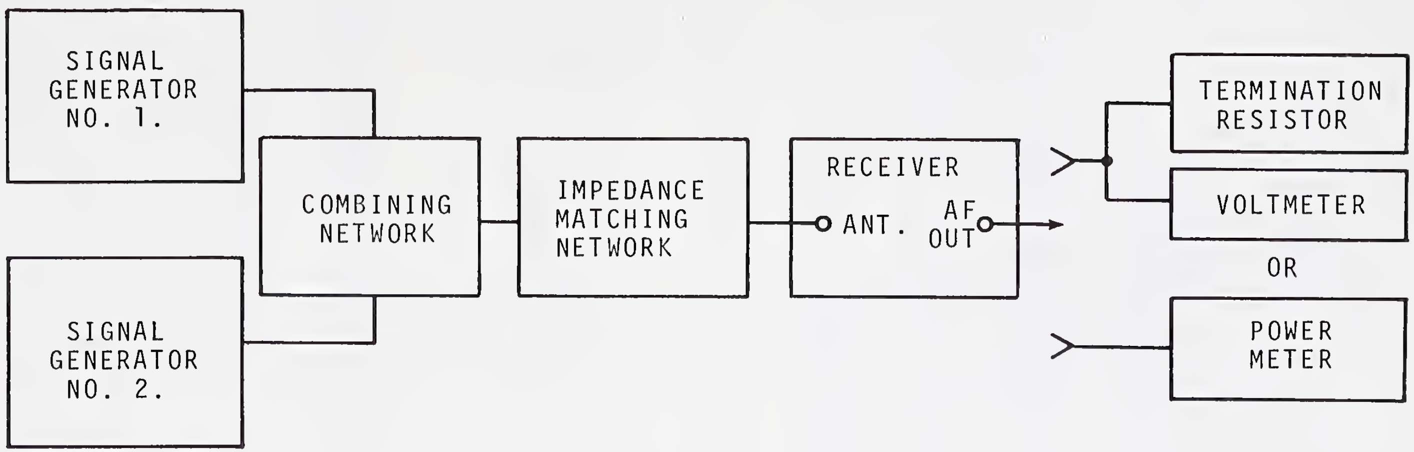

Fig. 4.4.7. Test Set-up for Desensitization

(2) The second generator is unmodulated and tuned to a different frequency. Its output level is adjusted until the audio output power is reduced 3 dB below reference output power.

The signal level ratio, in decibels, of the two generators is the desensitization of the receiver.

Measurement uncertainties as small as 0.4 dB are possible under best conditions, and range from approximately 0.6 dB to 2 dB under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.4.7.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Variable-frequency CW signal generator

3. Three-port combining network

4. Input impedance matching network

5. Termination resistor for receiver audio output port

6a. AF power meter

OR,

6b. A.C. voltmeter

4.4.7.5. PROCEDURE

1. Connect the two SIGNAL GENERATORS to the input port of the receiver through the COMBINING NETWORK and IMPEDANCE MATCHING NETWORK as shown in figure 4.4.7. The matching network is chosen to present the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the output impedance of the combining network, with signal generators connected, equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output level, to the audio output port of the receiver. Connect the A.C. VOLTMETER across this resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell}\,.$$

OR,

3b. Set the power meter on a range to indicate the reference output power, P_o.

4. Set the controls as given in Table XXIV.

5. Tune signal generator No. 1 and the receiver to the measurement frequency, f_o.

TABLE XXIV

Desensitization

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. AM
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. AGC
16. Meter Switch	16. Optional

6. Adjust the amplitude modulation in signal generator No. 1 to 30% at 1000 Hz.

7. Adjust the output level of signal generator No. 1 to give the desired input voltage to the receiver. This will normally lie within the receiver's dynamic range (cf.). A suitable value is 1000 microvolts.

8. Determine the open circuit signal voltage, E_{i1}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the combining network.

9. With the output level of signal generator No. 2 set to zero, adjust the AF gain control to produce reference audio output power, P_o.

10. Tune signal generator No. 2 to the desired interference frequency, f_i.

11. With generator No. 2 unmodulated, and with generator No. 1 set as given above, adjust the output level of generator No. 2 to produce 3 dB reduction in the audio output power obtained in Step 9, above.

12. Determine the open circuit signal voltage, E_{i2}, in microvolts, due to generator No. 2, at the output terminals of the matching network, if used; otherwise, at the output terminals of the combing network.

13. Calculate the ratio, D, in decibels, by the following equation:

$$D(\text{dB}) = 20 \log \frac{E_{i2}}{E_{i1}} .$$

D(dB) is the desensitization of the receiver under conditions of (1) measurement frequency, f_o, (2) interference frequency, f_i, and (3) desired signal level, E_{i1}.

4.4.7.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4a. Record the output voltage, E_o, in volts.

OR,

4b. Record the reference output power, P_o, in watts.

5. Record the open circuit voltages, E_{i1} and E_{i2}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the combining network.

6. Record the desensitization, D(dB), in decibels.

4.4.7.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainties, ΔE_{i1} and ΔE_{i2}, in the measured values of E_{i1} and E_{i2}

2a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

2b. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, $\Delta D(dB)$, in decibels, in the desensitization, D, is given approximately, for small uncertainties, by the equation

$$\Delta D\ (dB) = 20 \log \left(1 + \frac{\Delta D}{D} \right) ,$$

where

$$\frac{\Delta D}{D} = \frac{\Delta E_{i1}}{E_{i1}} + \frac{\Delta E_{i2}}{E_{i2}} + \frac{\Delta E_o}{E_o} \quad ,$$

or

$$\frac{\Delta D}{D} = \frac{\Delta E_{i1}}{E_{i1}} + \frac{\Delta E_{i2}}{E_{i2}} + \frac{1}{2} \frac{\Delta P_o}{P_o} \quad .$$

Uncertainties ΔE_{i1} and ΔE_2 are obtained from the manufacturer's specifications on the output level indicator of the signal generators. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.4.8. CROSS MODULATION

When cross modulation occurs, the modulation components of a large undesired signal are transferred to the carrier of a weak desired signal, and are demodulated along with the desired signal. Cross modulation may occur at any frequency, and no particular relationship among the frequencies of the desired signal, the undesired signal, and the receiver I.F. amplifier need exist.

4.4.8.1. DEFINITIONS

a. Cross modulation is a type of intermodulation due to modulation of the carrier of the desired signal by an undesired signal wave. (IEEE Std 100-1972)

b. Cross modulation is the input voltage level from an undesired signal source which, when present simultaneously with a desired signal source that alone produces reference audio output power, produces 1% of reference audio output power.

4.4.8.2. PURPOSE

The purpose of this measurement method is to measure the cross modulation of an AM receiver. This characteristic is a measure of the ability of a receiver to reject an undesired signal in the presence of, but on a different frequency from, the desired signal.

4.4.8.3. METHOD

The method uses two amplitude modulated signal generators and a voltmeter or power meter as shown in figure 4.4.8. The signal generators supply known input voltages at different

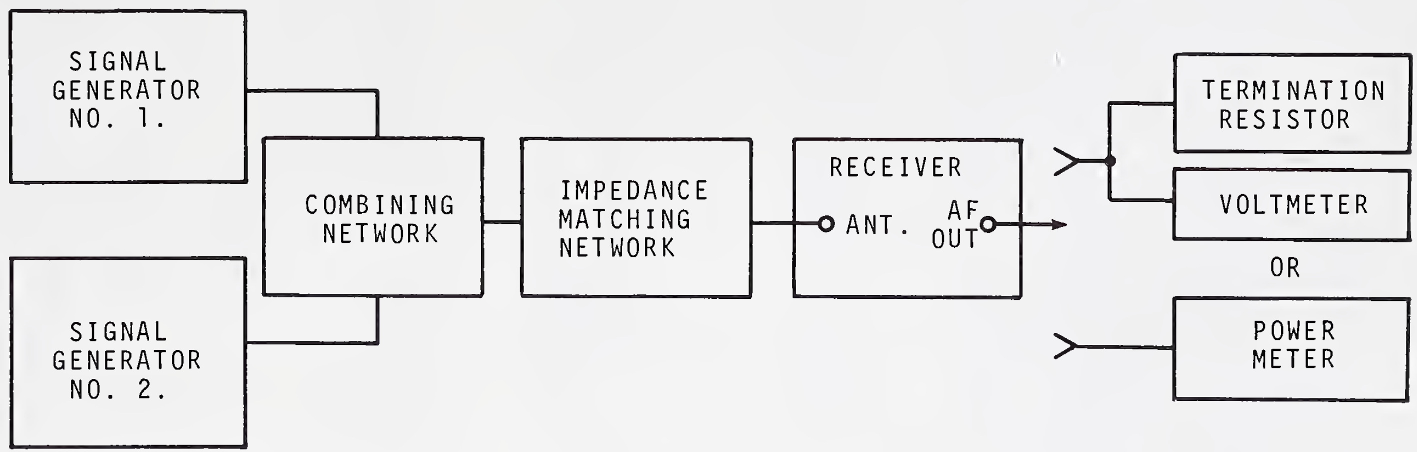

Fig. 4.4.8. Test Set-up for Cross Modulation

frequencies to the receiver through a combining network. The voltmeter or power meter measures the receiver output signal level that is produced under the following two conditions:

(1) The first generator is adjusted to produce reference audio output power with the second generator turned off.

(2) The second generator is tuned to a frequency that produces a response due to cross modulation. Its level is adjusted to produce 1% of rated audio output power in the presence of the first generator's carrier with no modulation on the first generator.

The open circuit voltage, in microvolts, of the second generator is the cross modulation of the receiver.

Measurement uncertainties as small as 10% are possible under best condtions, and range from approximately 12% to 50% under typical conditions. This method uses rudimentary and commonly available test equipment.

4.4.8.4. TEST EQUIPMENT REQUIRED

1. Two amplitude modulated, variable-frequency signal generators

2. Three-port combining network

3. Input impedance matching network

4. Termination resistor for receiver output output port

5a. AF power meter

OR,

5b. A.C. voltmeter

4.4.8.5. PROCEDURE

1. Connect the two SIGNAL GENERATORS to the input port of the receiver through the COMBINING NETWORK and IMPEDANCE MATCHING NETWORK as shown in figure 4.4.8. The matching network is chosen to present the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the output impedance of the combining network, with signal generators connected, equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output level, to the audio output port of the receiver. Connect the A.C. VOLTMETER across this resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3 . Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

OR,

3b. Set the power meter on a range to indicate the reference output power, P_o.

4. Set receiver controls as given in Table XXV.

5. Tune signal generator No. 1 and the receiver to the measurement frequency, f_o.

6. Adjust the amplitude modulation in signal generator No. 1 to 30% at 1000 Hz.

7. Adjust the output level of signal generator No. 1 to give the desired input voltage to the receiver. This will normally lie within the receiver's dynamic range (cf.). A value of 1000 microvolts is suggested.

8. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the combining network.

9. With the output level of signal generator No. 2 set to zero, adjust the AF gain control to produce reference audio output power, P_o.

10. Tune signal generator No. 2 to the desired interference frequency, f_i.

11. Adjust the amplitude modulation of generator No. 2 to 30% at 1000 Hz.

12. Adjust generator No. 1 for zero amplitude modulation (i.e., turn modulation off).

13. With the output level of generator No. 1 still set as in Step 7, above, but unmodulated, adjust the output level of generator No. 2 to produce 1% of reference audio output power, P_o. That is, the output level at this Step, due to generator No. 2, is 20 dB below the output level obtained in Step 9, above, due to generator No. 1.

TABLE XXV

Cross Modulation

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	As desired (normally at maximum)
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

14. Determine the open circuit signal voltage, E_c, in microvolts, due to generator No. 2, at the OUTPUT TERMINALS of the matching network, if used; otherwise at the output terminals of the combining network. E_c is the cross modulation of the receiver under conditions of (1) measurement frequency, f_o, (2) interference frequency, f_i, and (3) desired signal level, E_i.

4.4.8.6. DATA REQUIRED

1. Record the measurement frequency, f_o in kilohertz or megahertz, to which the receiver is tuned.

2. Record the interference frequency, f_i, in kilohertz or megahertz.

3. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

4. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver output terminals.

5a. Record the output voltage, E_o, in volts.

OR,

5b. Record the reference output power, P_o, in watts.

6. Record the open circuit signal voltage, E_i, in microvolts.

7. Record the open circuit signal voltage, E_c, in microvolts.

4.4.8.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_c, in the measured values of E_c

2a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

2b. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, $\Delta E_c(\%)$, in the cross modulation, E_c, expressed as a percent, is given by the equations

$$\Delta E_c\ (\%) = \left(\frac{\Delta E_c}{E_c} \times 100\right) + \left(\frac{\Delta E_o}{E_o} \times 100\right) ,$$

OR

$$\Delta E_c\ (\%) = \left(\frac{\Delta E_c}{E_c} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_o}{P_o} \times 100\right) .$$

The uncertainty, ΔE_c, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.4.9. ADJACENT CHANNEL SELECTIVITY

4.4.9.1. DEFINITION

Adjacent channel selectivity is the input voltage level from a signal source in the adjacent channel of an FM receiver which, when present simultaneously with a signal in the principal channel that alone produces a 12 dB SINAD SENSITIVITY (cf.), degrades the SINAD ratio in the principal channel to 6 dB.

Adjacent channel selectivity is usually expressed in decibels above the level of the signal in the principal channel. It is also called DESENSITIZATION, referring to FM receivers.

4.4.9.2. PURPOSE

The purpose of this measurement method is to measure the adjacent channel selectivity of an FM receiver. This characteristic is a measure of the receiver's ability to deliver an output signal that is degraded a specified amount (6 dB) below the normally accepted quality in the presence of a strong adjacent channel signal.

Although this method is described in terms of degradation caused by an adjacent channel signal, it applies equally well to a second signal located at an arbitrary frequency.

4.4.9.3. METHOD

This method uses two frequency modulated signal generators and an audio distortion analyzer as shown in figure 4.4.9. Generator No. 1 is used to measure the 12 dB SINAD SENSITIVITY (cf.), of the receiver. Then generator No. 2, tuned to an adjacent channel and modulated with a different audio tone (400 Hz), is adjusted to a level sufficient to decrease the SINAD from 12 dB to 6 dB. The signal level ratio, in decibels, of the two generators is the desired adjacent channel selectivity of the receiver.

Measurement uncertainties as small as 0.7 dB are possible under best conditions, and range from approximately 0.9 dB to 2.5 dB under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.4.9.4. TEST EQUIPMENT REQUIRED

1. Two frequency modulated, variable-frequency signal generators

2. Three-port combining network

3. Input impedance matching network

4. Termination resistor for receiver audio output port

5. Audio distortion analyzer

4.4.9.5. PROCEDURE

1. Connect the two SIGNAL GENERATORS to the input port of the receiver through the COMBINING NETWORK and IMPEDANCE MATCHING NETWORK as shown in figure 4.4.9. The matching network is chosen to present the specified source impedance, Z_s, to

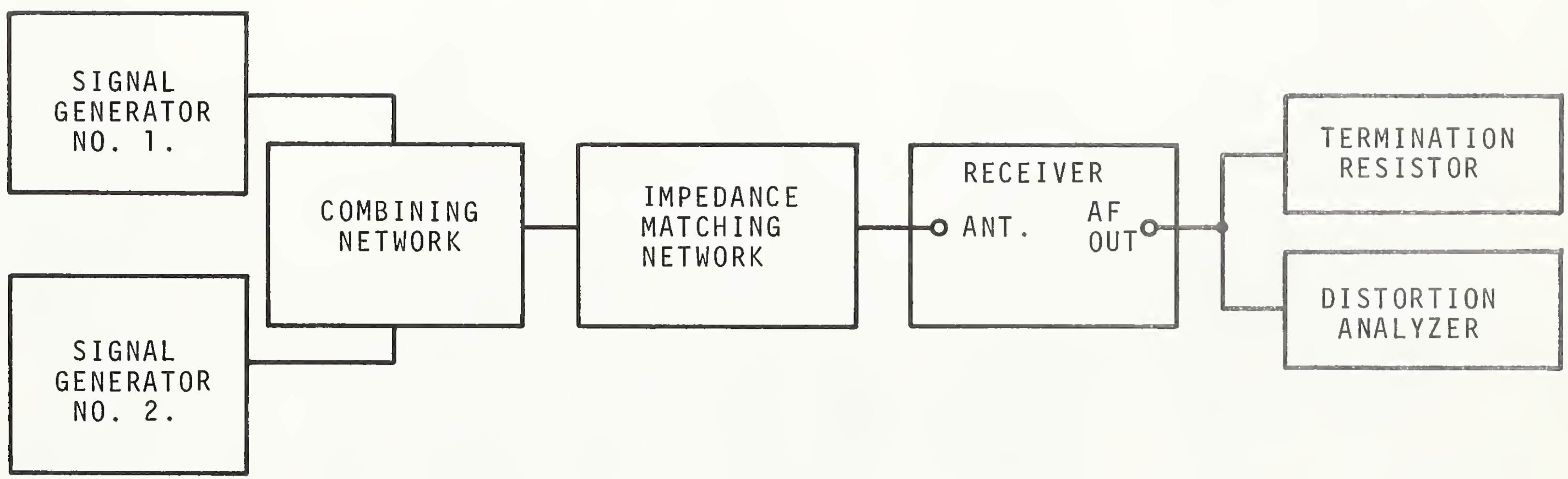

Fig. 4.4.9. Test Set-up for Adjacent Channel Selectivity

the receiver at the measurement frequency, f_o. If the output impedance of the combining network, with signal generators connected, equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Tune the signal generator and the receiver to the measurement frequency, f_o.

4. With generator No. 2 turned off, use generator No. 1 to measure the 12 dB SINAD SENSITIVITY, E_i, as described in Section 4.1.5.5.

5. Tune signal generator No. 2 to the desired adjacent channel or other frequency, f_i.

6. Adjust the frequency modulation of generator No. 2 to ±60% of rated system deviation at (400 Hz). This places the demodulated audio signal away from the 1000 Hz rejection notch of the distortion analyzer.

7. Adjust the output level of generator No. 2 to produce a 6 dB SINAD ratio in the principal channel. Generator No. 1 remains as in Step 2, above, during this time, and the SINAD ratio is measured using the 1000 Hz rejection filter in the distortion analyzer.

8. Determine the open circuit signal voltage, E_a, in microvolts, due to generator No. 2, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the combining network.

9. Calculate the ratio, R_a(dB), in decibels, by the following equation:

$$R_a \text{ (dB)} = 20 \log \frac{E_a}{E_i}$$

R_a(dB) is the adjacent channel selectivity of the receiver under conditions of (1) measurement frequency, f_o, (2) adjacent channel or arbitrary interference frequency, f_i, and (3) desired signal level equal to the 12 dB SINAD SENSITIVITY, E_i.

4.4.9.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the adjacent channel or arbitrary interference frequency, f_i, in kilohertz or megahertz.

3. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

4. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver output terminals.

5. Record the reference output power, P_o, in watts.

6. Record the open circuit signal voltage, E_i, in microvolts.

7. Record the open circuit signal voltage, E_a, in microvolts.

8. Record adjacent channel selectivity, R_a(dB), in decibels.

4.4.9.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_a, in the measured value of E_a

2. Uncertainty, ΔP_o, in the measured value of P_o

3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

The total relative uncertainty, ΔR_a(dB), in decibels, in the adjacent channel selectivity, R_a, is given approximately, for small uncertainties, by the equation

$$\Delta R_a \text{ (dB)} = 20 \log \left(1 + \frac{\Delta E_a}{E_a} + \frac{1}{2} \frac{\Delta P_o}{P_o} + \frac{1}{2} \frac{\Delta P_{n+d}}{P_{n+d}} \right) .$$

The uncertainty, ΔE_a, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.4.10. INTERMODULATION DISTORTION

4.4.10.1. DEFINITION

Intermodulation distortion is non-linear distortion of a system or transducer characterized by the appearance in the output of frequencies equal to the sums and differences of integral multiples of two or more component frequencies present in the input wave. NOTE: Harmonic components also present in the output are usually not included as part of the intermodulation distortion. When harmonics are included, a statement to that effect should be made. (IEEE Std 100-1972)

Intermodulation distortion is usually expressed as the ratio, in decibels, of (a) the signal level of one or more undesired signals to (b) the signal level of the desired signal under conditions necessary to produce a prescribed receiver output signal. These conditions vary with type of equipment and method of measurement, and are specified below.

4.4.10.2 PURPOSE

The purpose of these measurement methods is to measure the intermodulation distortion of surveillance receivers. Intermodulation distortion is a measure of the ability of the receiver to deliver an output signal of acceptable quality in the presence of other undesired input signals.

4.4.10.3. METHOD I - SINGLE-SIGNAL METHOD, AM OR FM RECEIVERS

The single-signal method uses a modulated signal generator, a variable AF band-pass filter, and an A.C. voltmeter, as shown in figure 4.4.10.1. The signal generator is modulated with two audio signals having different frequencies and known amplitudes. The generator supplies a known input voltage to the receiver at the measurement frequency. The variable band-pass filter selects the modulation and distortion frequencies, which are measured with the voltmeter.

In this method, intermodulation distortion is expressed as a voltage ratio, in decibels, of (a) the rms voltage of each of the distortion products to (b) the rms voltage of the higher frequency (reference) audio modulation signal.

Measurement uncertainties as small as 0.5 dB are possible under best conditions, and range from 0.8 dB to 3 dB under typical conditions. This method uses moderately sophisticated but commonly available test equipment. The intermodulation distortion of the signal generator must be small so as not to obscure the intermodulation products generated within the receiver.

4.4.10.3.1. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Two audio frequency generators

3. AF combining network

4. Input impedance matching network

5. Termination resistor for receiver audio output port

6. Variable audio frequency band pass filter

7. A.C. voltmeter

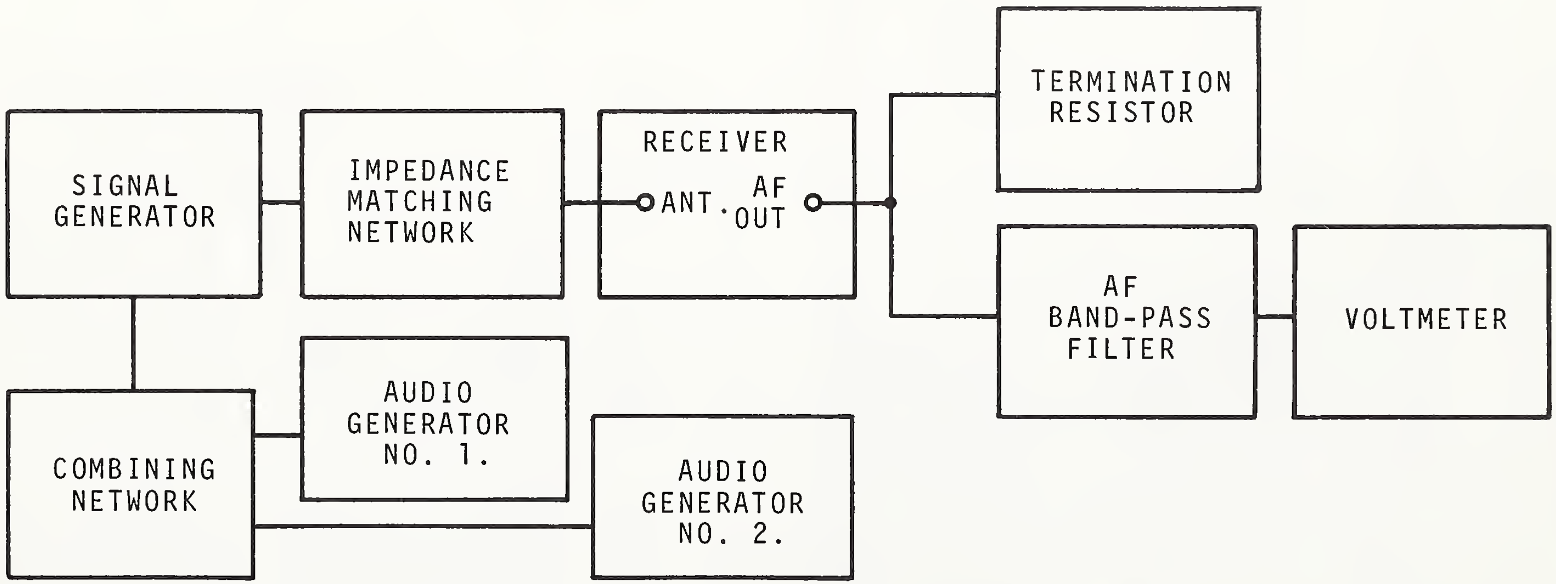

Fig. 4.4.10.1. Test Set-up for Intermodulation Distortion, Method I

4.4.10.3.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver.

3. Connect the input port of the AF BAND PASS FILTER across the termination resistor.

4. Connect the A.C. VOLTMETER to the output port of the band pass filter.

5. Set the voltmeter on a range to indicate reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

6. Set receiver controls as given in Table XXVI.

7. Tune the signal generator and the receiver to the measurement frequency, f_o.

8a. If the measurement is to be made on an AM receiver, adjust AUDIO GENERATOR No. 1 to produce 30% amplitude modulation at 2500 Hz. Note the setting of the output level

TABLE XXVI

Intermodulation Distortion, Method I

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. As desired
5. IF Gain	5. As desired
6. AF Gain	6. As desired
7. Line Gain	7. Optional
8. Detector Mode	8. AM or FM, as desired
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

control on generator No. 1. Then, with audio generator No. 1 turned off, adjust AUDIO GENERATOR No. 2 to produce 30% amplitude modulation at 300 Hz. Note the setting of the output level control on generator No. 2.

OR,

8b. If the measurement is to be made on an FM receiver, adjust audio generator No. 1 to produce frequency modulation of ±60% of rated system deviation at 2500 Hz. Note the setting of the output level control on generator No. 1. Then, with generator No. 1 turned off, adjust audio generator No. 2 to produce frequency modulation at ±60% of rated system deviation at 300 Hz. Note the setting of the output level control on generator No. 2.

9. Turn audio generator No. 1 back on so that the signal generator is modulated with both the 300 and 2500 Hz signals.

10. Adjust the output level of the signal generator to the value at which the measurement is to be made. Normally, this will be within the receiver's dynamic range (cf.).

11. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the generator.

12. With the audio band pass filter tuned to pass the 2500 Hz signal and to attenuate the 300 Hz signal by at least 40 dB, adjust the AF gain control to produce reference output power, P_o. This is indicated by the A.C. voltmeter reading, E_r, which should be E_o times the insertion ratio of the filter at 2500 Hz.

13. Record the voltage reading E_r.

14. Adjust the band pass filter to each of the distortion frequencies, f_n, listed in Table XXVII, in turn, and measure filter output voltage, E_n. Adjust the tuning of the filter to obtain maximum voltage reading at each frequency. It may not be possible to measure the voltage at every frequency because some distortion products may be absent or very weak.

TABLE XXVII

Band Pass Filter Frequency, f_n

Order of IM Product, n	Frequency f_n (Hz)
1	2500
2	2200
3	1900
4	1600
5	1300
6	1000
7	700
8	400
9	100

Note 1: Table XXVII does not include all of the frequencies for all of the orders listed; it includes only those for the first nine orders that fall below the highest modulation frequency.

Note 2: Use care to distinguish the IM distortion products from the harmonic distortion products, which occur at integral multiples of 300 Hz.

15. Calculate the ratio, R(IM) in decibels, between the output voltage E_r at 2500 Hz and at each of the distortion products, E_n, by the following equation:

$$R(IM) = 20 \log \frac{E_r}{E_n} .$$

R(IM) is the intermodulation distortion of the receiver at frequency f_o when the input signal level is E_i microvolts.

4.4.10.3.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to the receiver output terminals.

4. Record the reference output voltage, E_o, in volts.

5. Record the open circuit signal voltage, E_i, in microvolts.

6. Record the intermodulation distortion frequencies, f_n, in hertz, and their corresponding order, n.

7. Record the measured voltages, E_r and E_n, of each of the measured audio frequencies at the output of the audio filter.

8. Record the intermodulation distortion, R(IM), in decibels, for each of the distortion frequencies, f_n.

4.4.10.3.4. MEASUREMENT ERRORS

The principal sources of error are the uncertainties, ΔE_r and ΔE_n, in the measured values of E_r and E_n. The total relative measurement error, $\Delta R(dB)$, in decibels, in the intermodulation distortion, $R(IM)$, is given approximately, for small uncertainties, by the equation

$$\Delta R\ (dB) = 20 \log \left(1 + \frac{\Delta E_r}{E_r} + \frac{\Delta E_n}{E_n} \right) .$$

Uncertainties ΔE_r and ΔE_n are obtained from the manufacturer's specifications on the A.C. voltmeter and band pass filter.

4.4.10.4. METHOD II - TWO-SIGNAL METHOD, AM RECEIVER

This method uses three amplitude modulated signal generators and a voltmeter or power meter as shown in figure 4.4.10.2. Signal generators No. 1 and No. 2 supply known input voltages at a variety of frequencies for the measurement of intermodulation distortion in the receiver. Generator No. 3 is used to adjust and calibrate the receiver prior to the measurement. The voltmeter or power meter indicates the receiver output signal level.

The 6 dB SN/N sensitivity of the receiver is measured at frequency f_o as described in Section 4.1.2. Then, using generators No. 1 and No. 2 simultaneously, distortion products are measured by adjusting the generators, as described below, to the frequencies and signal levels required to produce intermodulation distortion output power equal to the reference output power level. Intermodulation distortion is expressed as the signal levels, in microvolts, required to produce the specified output power.

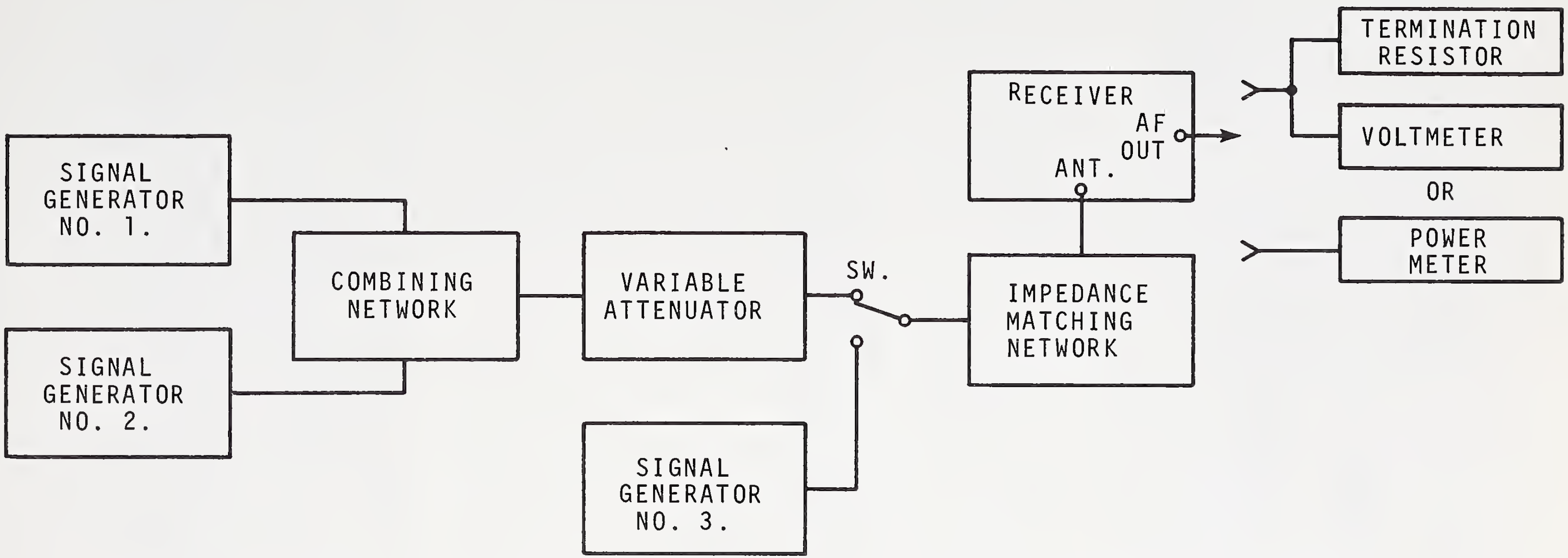

Fig. 4.4.10.2. Test Set-up for Intermodulation Distortion, Method II

Measurement uncertainties as small as 3% are possible under best conditions, and range from approximately 5% to 20% under typical conditions. This method uses rudimentary and commonly available test equipment.

4.4.10.4.1. TEST EQUIPMENT REQUIRED

1. Three signal generators capable of amplitude modulation

2. Signal combining network

3. Coaxial switch

4. Variable step attenuator

5. Input impedance matching network

6. Termination resistor for receiver audio output port

7a. AF power meter

OR,

7b. True rms voltmeter

4.4.10.4.2. PROCEDURE

1. Connect SIGNAL GENERATORS No. 1 and No. 2 to the receiver through the COMBINING NETWORK, VARIABLE STEP ATTENUATOR, COAXIAL SWITCH, and IMPEDANCE MATCHING NETWORK as shown in figure 4.4.10.2. The impedance matching network must provide the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If Z_s is equal to the output impedance actually present at the attenuator output port, no matching network is required.

2. Connect SIGNAL GENERATOR No. 3 to the receiver through the coaxial switch.

3a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

OR,

3b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

4a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

OR,

4b. Set the power meter on a range to indicate the reference output power, P_o.

5. Set receiver controls as given in Table XXVIII.

6. Turn the coaxial switch to connect generator No. 3 to the impedance matching network.

7. With the output level of generators No. 1 and No. 2 set to zero, tune generator No. 3 and the receiver to the measurement frequency, f_o.

TABLE XXVIII

Intermodulation Distortion, Methods II and III

Initial Control Settings

	Control		Setting
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	As desired
5.	IF Gain	5.	As desired
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	MGC
16.	Meter Switch	16.	Optional

8. Adjust the amplitude modulation in generator No. 3 to 30% at 1000 Hz.

9. Set the step attenuator to 10 dB attenuation.

10. With signal generator No. 3 connected and its output set to zero, adjust the receiver AF gain control to produce 25% of rated audio output power, P_o. This will be noise power only.

11. Adjust the output level of the signal generator to give reference audio output power, P_o. This will be approximately 25% noise power and 75% audio signal power (1000 Hz), and corresponds to a 6 dB signal-plus-noise-to-noise ratio.

12. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the variable attenuator.

13. Set the step attenuator to some large value, e.g., 80 dB.

14. Adjust generator No. 3 to zero output.

15. Turn the coaxial switch to connect the attenuator to the combining network.

16. Adjust the modulation on generator No. 1 to 30% at 1000 Hz. Leave generator No. 2 unmodulated.

17. Adjust both generator No. 1 and generator No. 2 to a large output level setting, e.g., 100,000 microvolts. Adjust output levels to produce equal signal levels at the input to

the step attenuator. This can be done as follows: Adjust generator No. 2 to the same frequency and modulation conditions as generator No. 1, and use the receiver to indicate when equal signal levels are obtained. Then turn off the modulation in generator No. 2.

18. Adjust generator No. 1 to frequency f_a that is different from f_o but within the range 0.5 f_o to 2 f_o. Leave the receiver tuned to frequency f_o.

19. Adjust generator No. 2 to frequency f_b, where f_b is given by one of the entries shown in Table XXIX. The choice of f_b is determined by which particular intermodulation distortion product is to be measured. The formula for computing f_b is the general equation,

$$f_o = m\ f_a \pm n\ f_b,$$

where m and n are integers, and the sum, m + n, is the order of the distortion product (e.g., for m = 1, n = 2, the product is of third order).

20. Check to see that the signal levels from the two generators at the attenuator input are equal.

21. Adjust the step attenuator to produce reference audio output power. This step is similar to Step 11, above.

22. Determine the open circuit signal voltage, E_d, in microvolts, of either one of the two signals at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the variable attenuator. This is the intermodulation distortion level of the receiver, due to equal signals at frequencies f_a and f_b, when tuned to frequency f_o.

TABLE XXIX

Frequency f_b, of Generator No. 2

I M Product	Frequency f_b
Second order:	$f_a + f_o$
	$\lvert f_a - f_o \rvert$
Third order:	$2f_a + f_o$
	$\lvert 2f_a - f_o \rvert$
	$\frac{1}{2}(f_a + f_o)$
	$\frac{1}{2}(\lvert f_a - f_o \rvert)$
Fourth order:	$3f_a + f_o$
	$\lvert 3f_a - f_o \rvert$
	$\frac{1}{2}(2f_a + f_o)$
	$\frac{1}{2}(\lvert 2f_a - f_o \rvert)$
	$(f_a + f_o)$
	$\frac{1}{3}(\lvert f_a - f_o \rvert)$
Fifth order:	$4f_a + f_o$
	$\lvert 4f_a - f_o \rvert$
	$\frac{1}{2}(3f_a + f_o)$
	$\frac{1}{2}(\lvert 3f_a - f_o \rvert)$
	$\frac{1}{3}(2f_a + f_o)$
	$\frac{1}{3}(\lvert 2f_a - f_o \rvert)$
	$\frac{1}{4}(f_a + f_o)$
	$\frac{1}{4}(\lvert f_a - f_o \rvert)$

4.4.10.4.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to the receiver output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the open circuit signal voltage, E_i, in microvolts.

6. Record the intermodulation distortion frequencies, f_a and f_b, in kilohertz or megahertz.

7. Record the intermodulation product order, m + n.

8. Record the intermodulation distortion level, E_d, in microvolts.

4.4.10.4.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_d, in the measured value of E_d

2a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

2b. Uncertainty, ΔP_o in the measured value of P_o

The total relative uncertainty, $\Delta E_d(\%)$, in the intermodulation distortion, E_d, expressed as a percent, is given by the equations

$$\Delta E_d\ (\%) = \left(\frac{\Delta E_d}{E_d} \times 100 \right) + \left(\frac{\Delta E_o}{E_o} \times 100 \right) ,$$

OR

$$\Delta E_d\ (\%) = \left(\frac{\Delta E_d}{E_d} \times 100 \right) + \left(\frac{1}{2} \frac{\Delta P_o}{P_o} \times 100 \right) .$$

The uncertainty, ΔE_d, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.4.10.5. METHOD III - THREE-SIGNAL METHOD, AM RECEIVER

This method uses four amplitude-modulated signal generators and a voltmeter or power meter as shown in figure 4.4.10.3. Signal generators No. 1, No. 2 and No. 3, supply known input voltages at a variety of frequencies for the measurement of intermodulation distortion in the receiver. Generator No. 4 is used to adjust and calibrate the receiver prior to the measurement. The voltmeter or power meter indicates the receiver output signal level.

The 6 dB SN/N sensitivity of the receiver is measured at frequency f_o as described in Section 4.1.2. Then, using generators No. 1, No. 2, and No. 3 simultaneously, distortion products are measured by adjusting the generators as described below, to the frequencies and signal levels required to produce

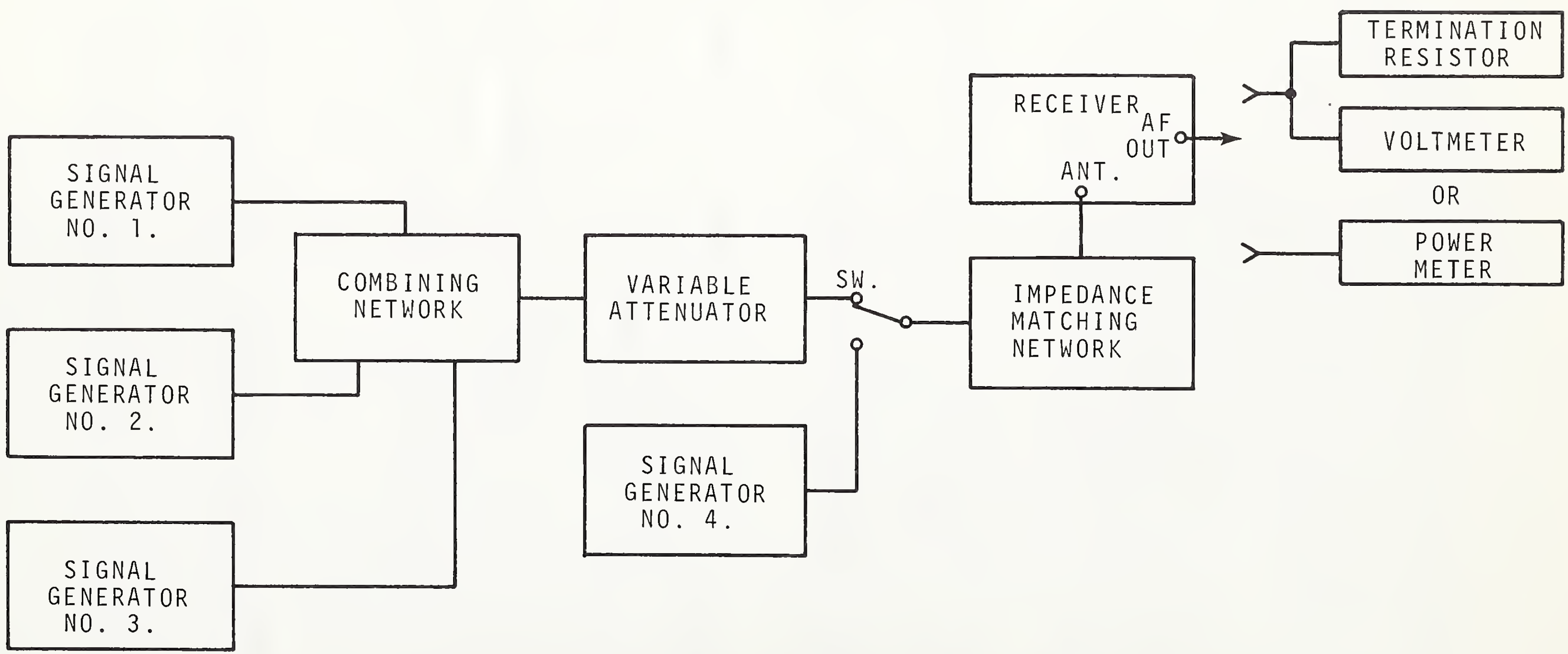

Fig. 4.4.10.3. Test Set-up for Intermodulation Distortion, Method III

intermodulation distortion output power equal to the reference output power level. Intermodulation distortion is expressed as the signal levels, in microvolts, required to produce the specified output power.

Measurement uncertainties as small as 3% are possible under best conditions, and range from approximately 5% to 20% under typical conditions. This method uses simple and commonly available test equipment.

4.4.10.5.1. TEST EQUIPMENT REQUIRED

1. Four signal generators capable of amplitude modulation

2. Signal combining network

3. Coaxial switch

4. Variable step attenuator

5. Input impedance matching network

6. Termination resistor for receiver audio output port

7a. AF power meter

OR,

7b. True rms voltmeter

4.4.10.5.2. PROCEDURE

1. Connect SIGNAL GENERATORS No. 1, No. 2, and No. 3 to the receiver through the COMBINING NETWORK, VARIABLE STEP ATTENUATOR,

COAXIAL SWITCH, and IMPEDANCE MATCHING NETWORK as shown in figure 4.4.10.3. The impedance matching network must provide the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If Z_s is equal to the output impedance actually present at the attenuator output port, no matching network is required.

2. Connect SIGNAL GENERATOR No. 4 to the receiver through the coaxial switch.

3a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

OR,

3b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

4a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

OR,

4b. Set the power meter on a range to indicate the reference output power, P_o.

5. Set receiver controls as given in Table XXVIII, p. 230.

6. Turn the coaxial switch to connect generator No. 4 to the impedance matching network.

7. With the output levels of generators No. 1, No. 2, and No. 3 set to zero, tune generator No. 4 and the receiver to the measurement frequency, f_o.

8. Adjust the amplitude modulation in generator No. 4 to 30% at 1000 Hz.

9. Set the step attenuator to 10 dB attenuation.

10. With the signal generator No. 4 connected and its output set to zero, adjust the receiver AF gain control to produce 25% of rated audio output power, P_o. This will be noise power only.

11. Ajust the output level of generator No. 4 to give reference audio output power, P_o. This will be approximately 25% noise power and 75% audio signal power (1000 Hz), and corresponds to a 6 dB signal-plus-noise-to-noise ratio.

12. Determine the open circuit signal voltage, E_i, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the variable attenuator.

13. Set the step attenuator to some large value, e.g., 80 dB.

14. Adjust generator No. 4 to zero output.

15. Turn the coaxial to connect the attenuator to the combining network.

16. Adjust the modulation on generator No. 1 to 30% at 1000 Hz. Leave generators No. 2 and No. 3 unmodulated.

17. Adjust generators No. 1, No. 2, and No. 3 to a large output level setting, e.g., 100,000 microvolts. Adjust output levels to produce equal signal levels at the input to the step attenuator. This can be done as follows: Adjust generators No. 2 and No. 3 to the same frequency and modulation conditions as generator No. 1, and use the receiver to indicate when equal signal levels are obtained. Then turn off the modulation in generators No. 2 and No. 3.

18. Adjust generator No. 1 to frequency f_a that is different from f_o but within the range 0.5 f_o to 2 f_o. Leave the receiver tuned to frequency f_o.

19. Adjust generator No. 2 to frequency f_b and generator No. 3 to frequency f_c, where f_b and f_c are given by one of the solutions to the general equation

$$f_o = m\,f_a \pm n\,f_b \pm p\,f_c.$$

The factors m, n, and p are integers, and the sum, m + n + p, is the order of the distortion product (e.g., for m = 1, n = 1, and p = 3, the product is of fifth order).

20. Check to see that the signal levels from the three generators at the attenuator input are equal.

21. Adjust the step attenuator to produce reference audio output power. This step is similar to Step 11, above.

22. Determine the open circuit signal voltage, E_d, in microvolts, of any one of the three signals at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the variable attenuator. This is the intermodulation distortion level of the receiver, due to equal signals at frequencies f_a, f_b, and f_c, when tuned to frequency f_o.

4.4.10.5.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to the receiver output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the open circuit signal voltage, E_i, in microvolts.

6. Record the intermodulation distortion frequencies, f_a, f_b, and f_c, in kilohertz or megahertz.

7. Record the intermodulation product order, m + n + p.

8. Record the intermodulation distortion level, E_d, in microvolts.

4.4.10.5.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_d, in the measured value of E_d

2a. Uncertainty, ΔE_o, in the measured value of E_o

OR,

2b. Uncertainty, ΔP_o, in the measured value of P_o

The total relative uncertainty, $\Delta E_d(\%)$, in the intermodulation distortion, E_d, expressed as a percent, is given by the equations

$$\Delta E_d\ (\%) = \left(\frac{\Delta E_d}{E_d} \times 100\right) + \left(\frac{\Delta E_o}{E_o} \times 100\right),$$

OR

$$\Delta E_d\ (\%) = \left(\frac{\Delta E_d}{E_d} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_o}{P_o} \times 100\right).$$

The uncertainty, ΔE_d, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔE_o and/or ΔP_o are obtained from the manufacturer's specifications on the voltmeter and/or power meter, respectively.

4.4.10.6. METHOD IV - THREE-SIGNAL METHOD, FM RECEIVER

This method uses three signal generators and a distortion analyzer as shown in figure 4.4.10.4. One signal generator is frequency modulated; all three supply known input voltages at a variety of selected frequencies. The distortion analyzer measures the output SINAD ratio under various input signal conditions.

The 12 dB SINAD SENSITIVITY of the receiver is measured at frequency f_o as described in Section 4.1.5. Then, using all three generators simultaneously, distortion products are measured by adjusting the generators, as described below, to the frequencies and signal levels required to produce intermodulation distortion products having a 12 dB SINAD ratio. Intermodulation distortion is expressed as the signal levels, in microvolts, required to produce a 12 dB output SINAD ratio.

Measurement uncertainties as small as 5% are possible under best conditions, and range from approximately 8% to 30% under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.4.10.6.1. TEST EQUIPMENT REQUIRED

1. Three signal generators capable of frequency modulation
2. Signal combining network
3. Variable step attenuator
4. Input impedance matching network
5. Termination resistor for receiver audio output port
6. Audio distortion analyzer

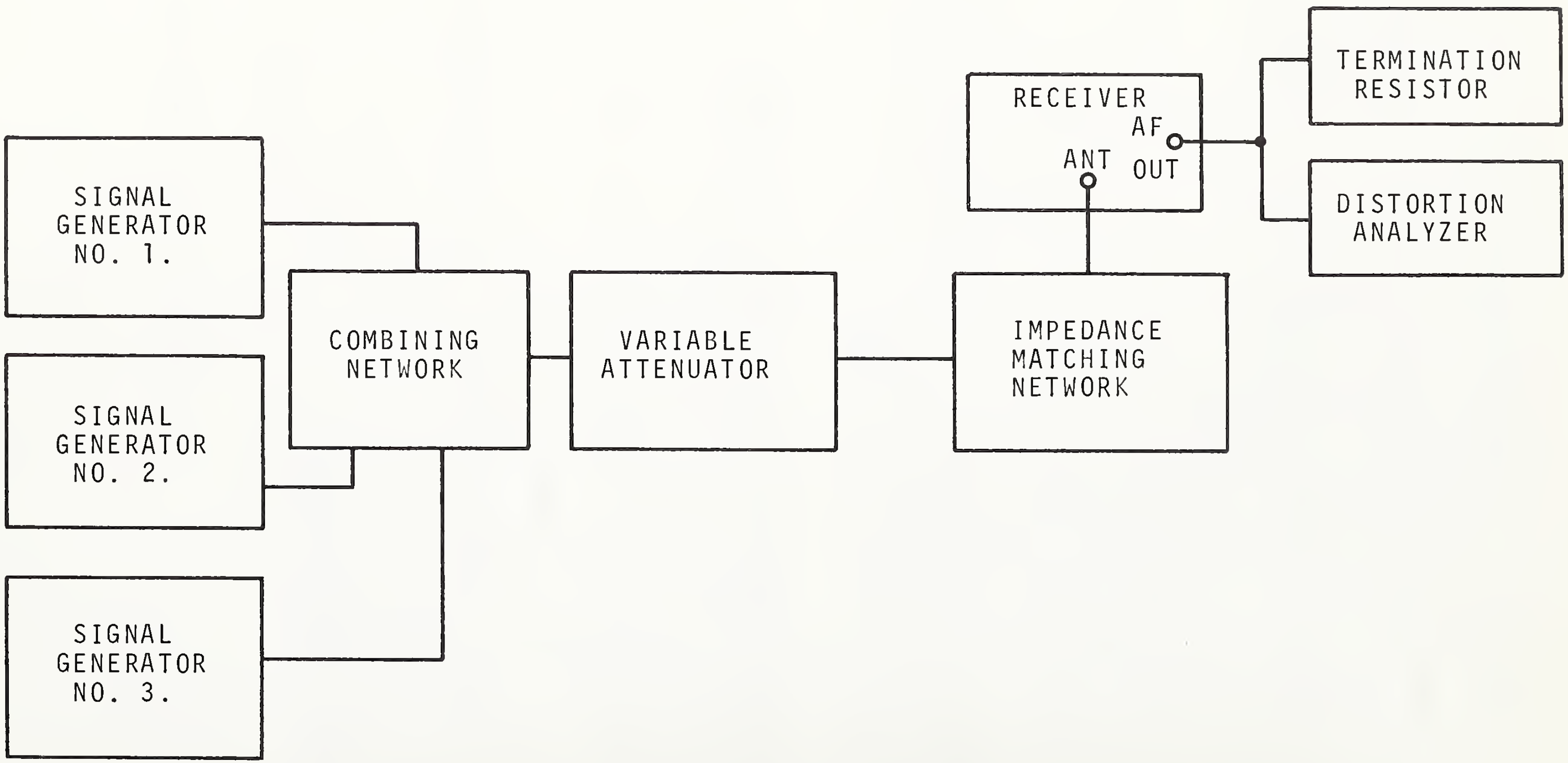

Fig. 4.4.10.4. Test Set-up for Intermodulation Distortion, Method IV

4.4.10.6.2. PROCEDURE

1. Connect SIGNAL GENERATORS No. 1, NO. 2, and No. 3 to the receiver through the COMBINING NETWORK, VARIABLE STEP ATTENUATOR, and IMPEDANCE MATCHING NETWORK as shown in figure 4.4.10.4. The impedance matching network must provide the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If Z_s is equal to the output impedance actually present at the attenuator output port, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set the distortion analyzer on a range to indicate the rated output power, P_o.

4. Set the receiver controls as given in Table XXX.

5. Set the step attenuator to minimum attenuation.

6. With the output levels of generators No. 2 and No. 3 set to zero, tune signal generator No. 1 and the receiver to the measurement frequency, f_o.

7. Adjust the frequency modulation in generator No. 1 to ±60% of rated system deviation at 1000 Hz.

8. Measure the 12 dB SINAD SENSITIVITY, E_i, as outlined in Section 4.1.5.5.

9. Set the step attenuator to some large value, e.g., 80 dB.

TABLE XXX

Intermodulation Distortion, Method IV

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	FM
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

10. Adjust the generators No. 1, No. 2, and No. 3 to a large output level setting, e.g., 100,000 microvolts. Adjust output levels to produce equal signal levels at the input to the step attenuator. This can be done as follows: Adjust generators No. 2 and No. 3 to the same frequency and modulation conditions as generator No. 1, and use the receiver to indicate when equal signal levels are obtained. Then turn off the modulation in generators No. 2 and No. 3.

11. Adjust generator No. 1 to frequency f_a that is different from f_o but within the range 0.5 f_o to 2 f_o. Leave the receiver tuned to frequency f_o.

12. Adjust generator No. 2 to frequency f_b and generator No. 3 to frequency f_c, where f_b and f_c are given by one of the solutions to the general equation

$$f_o = m\, f_a \pm n\, f_b \pm p\, f_c.$$

The factors m, n, and p are integers, and the sum, m + n = p, is the order of the distortion product (e.g., for m = 1, n = 1, and p = 3, the product is of fifth order).

13. Check to see that the signal levels from the three generators at the attenuator input are equal.

14. Adjust the step attenuator to produce 12 dB SINAD ratio.

15. Determine the open circuit signal voltage, E_d, in microvolts, of any one of the three signals at the OUTPUT TERMINALS of the matching network, if used; otherwise, at the output terminals of the variable attenuator. This is the intermodulation distortion level of the receiver, due to equal signals at frequencies f_a, f_b, f_c, when tuned to frequency f_o.

4.4.10.6.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to the receiver output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the open circuit signal voltage, E_i, in microvolts.

6. Record the intermodulation distortion frequencies, f_a, f_b, and f_c, in kilohertz or megahertz.

7. Record the intermodulation product order, $m + n + p$.

8. Record the intermodulation distortion level, E_d, in microvolts.

4.4.10.6.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_d, in the measured value of E_d

2. Uncertainty, ΔP_o, in thy measured value of P_o

3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

The total relative uncertainty, $\Delta E_d(\%)$, in the intermodulation distortion, E_d, expressed as a percent, is given by the equation

$$\Delta E_d\ (\%) = \left(\frac{\Delta E_d}{E_d} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_o}{P_o} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_{n+d}}{P_{n+d}} \times 100\right) .$$

The uncertainty, ΔE_d, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.4.11. IMPULSE BANDWIDTH

4.4.11.1. DEFINITION

The impulse bandwidth of a receiver is the ratio of (a) the peak voltage response, E_p, of the receiver to (b) twice the gain-spectral intensity product, 2GS, where G is the receiver voltage gain from input terminals to demodulator input and S is the spectral intensity of the impulse input signal.

This is an operational definition of impulse bandwidth rather than a descriptive definition. A descriptive definition, based upon fundamental considerations, has not yet been derived. As a consequence, the method of measuring impulse bandwidth does not follow steps that have an obvious relationship to bandwidth.

4.4.11.2. PURPOSE

The purpose of this measurement method is to measure the impulse bandwidth of a receiver. Impulse bandwidth is a measure of the degree of distortion (time dispersion) suffered by an impulsive signal as it passes through the receiver. It is useful in predicting the interference susceptibility of the receiver to impulsive signals.

The method given below is useful only for receivers that have nearly synchronously-tuned tuned circuits with near-Gaussian selectance. Field intensity meters are usually designed this way, whereas other types of receivers often are not. Receivers with sharp filters (e.g., resonant crystal filters), and with rectangular passbands (e.g., mechanical and/or crystal lattice filters) will produce a response to impulses that is unsuitable for calculating impulse bandwidth by this method.

4.4.11.3. METHOD

The method uses an impulse generator and an oscilloscope as shown in figure 4.4.11.1. The impulse generator supplies a periodic train of very narrow pulses to the receiver. The oscilloscope displays the I.F. output voltage response. Impulse bandwidth is determined by (1) dividing the total area enclosed by the envelope of the oscilloscope display by the maximum total height of the display to obtain an effective length of the pattern, (2) converting this effective length to time duration of the response, and (3) taking the reciprocal of this time duration, which is impulse bandwidth.

This method requires that the repetition rate of the impulse generator be no greater than one-fifth of the CW bandwidth of the receiver.

Measurement uncertainties as small as 8% are possible under best conditions, and range from approximately 10% to 30% under typical conditions. The method uses moderately sophisticated but commonly available test equipment.

4.4.11.4. TEST EQUIPMENT REQUIRED

1. Wide-band impulse generator

2. 20 dB attenuator or lossy impedance matching network

3. Cathode-ray oscilloscope (delayed or expandable sweep is helpful)

4. Oscilloscope camera

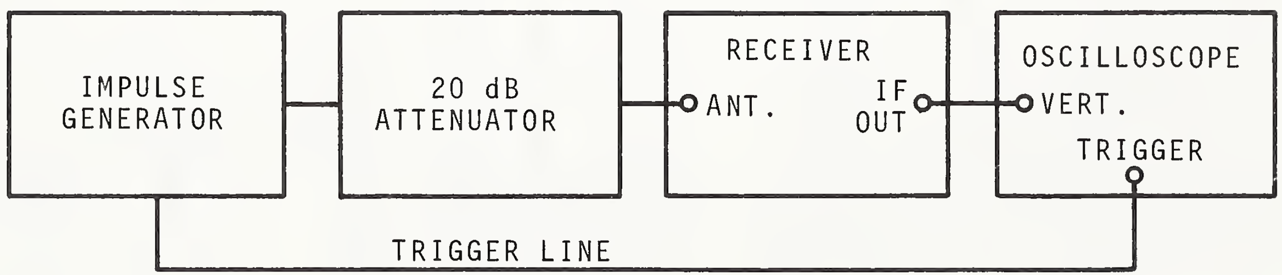

Fig. 4.4.11.1. Test Set-up for Impulse Bandwidths

4.4.11.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the IMPULSE GENERATOR through a 20 dB resistive attenuator whose characteristic impedance equals that of the specified source impedance, Z_s. If the load impedance required by the impulse generator does not equal the characteristic impedance of the attenuator, provide a proper RESISTIVE MATCHING NETWORK between generator and attenuator.

2. Connect the vertical input port of the OSCILLOSCOPE to the output of the last linear I.F. amplifier of the receiver.

3. Set receiver controls as given in Table XXXI.

4. Tune the receiver to the measurement frequency, f_o.

5. Adjust the output level of the generator to 80 dB above 1 microvolt per megahertz.

6. Adjust the repetition rate of the generator, if adjustable, to between 100 and 1000 pulses per second. The repetition rate must be no less than one-fifth the receiver CW bandwidth (cf.).

7. Adjust the oscilloscope to obtain a pattern that fills the calibrated area on the screen. Adjust the horizontal sweep to a convenient, known value. Adjust the trigger circuit to obtain a stable display.

8. Photograph the display, or trace its outline on a sheet of transparent material.

9. Determine the total area, A, in square centimeters, enclosed by the pattern. Use a planimeter, or count squares, or use whatever other means are available.

TABLE XXXI

Impulse Bandwidth

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Medium
5. IF Gain	5. Medium
6. AF Gain	6. Optional
7. Line Gain	7. Optional
8. Detector Mode	8. Optional
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. Optional
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. MGC
16. Meter Switch	16. Optional

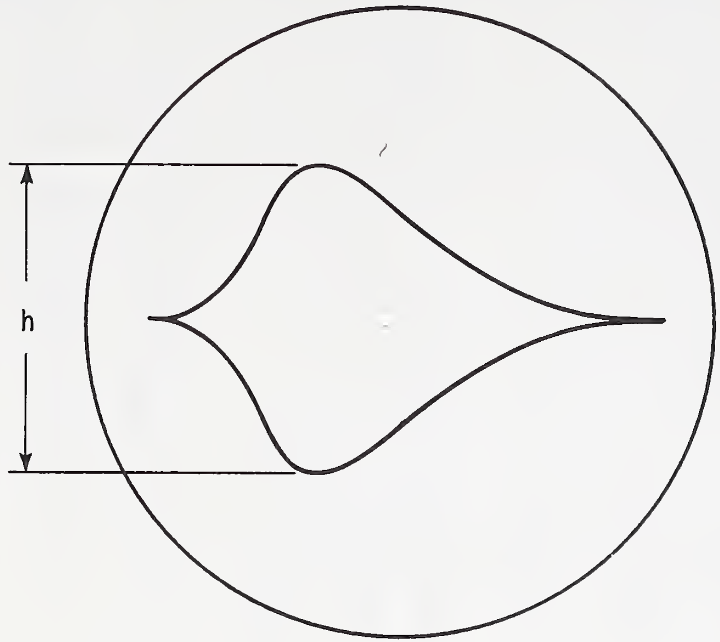

Fig. 4.4.11.2. Impulse Response Pattern

10. Determine the height, h, in centimeters, of the pattern between the points at which the height is maximum (see figure 4.4.11.2.).

11. Determine the horizontal scale factor, T, in seconds per centimeter, from the sweep speed calibration of the oscilloscope.

12. Compute the impulse bandwidth, B(Imp), in kilohertz, by the following equation

$$B(\mathrm{Imp}) = \frac{h\ (\mathrm{cm}) \times 10^{-3}}{A(\mathrm{cm}^2) \times T\ (\mathrm{sec/cm})}.$$

4.4.11.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the output level setting, in decibels above 1 microvolt per megahertz, of the impulse generator.

3. Record the horizontal sweep rate, T, in seconds per centimeter of the oscilloscope.

4. Record the area, A, in square centimeters, and height, h, in centimeters, of the oscilloscope pattern.

5. Record the impulse bandwidth, B(Imp) in hertz or kilohertz.

4.4.11.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔA, in the measured value of area, A

2. Uncertainty, Δh, in the measured value of height, h

3. Uncertainty, ΔT, in the horizontal scale factor, T

The total relative uncertainty, $\Delta B(\%)$, expressed in percent, in the impulse bandwidth, B(Imp), is given by the equation

$$\Delta B\ (\%) = \left(\frac{\Delta A}{A} \times 100\right) + \left(\frac{\Delta h}{h} \times 100\right) + \left(\frac{\Delta T}{T} \times 100\right) .$$

Uncertainties ΔA and Δh are obtained by estimating the reading resolution of the scope display. Uncertainty ΔT is obtained from the manufacturer's specifications on the sweep circuit of the oscilloscope.

4.5. INTERFERENCE SUSCEPTIBILITY

The interference susceptibility of a receiver is a measure of its ability to withstand the effects of undesired signals and noise that tend to interfere with reception of desired signals. To express this ability in quantitative terms, interference susceptibility is broadly defined as the smallest undesired signal level necessary to produce a specified degradation in the desired demodulated signal from the receiver.

Normally, a receiver is susceptible to interfering signals by two mechanisms: conduction and radiation. Measurement methods for conducted interference are generally similar to other methods given in this handbook. However, presently available methods for measuring radiated interference are generally inadequate or worthless because of the large inaccuracies and variations of results that they provide. The meaningful measurement of radiated interference susceptibility requires a knowledge of the electric and magnetic fields at, and in the presence of, the receiver. Present methods for determining such fields throughout the frequency range covered by this handbook have errors that typically range from 100% to 500%, and may reach 1000% or higher, depending upon the circumstances. Measurements in shielded enclosures, as presently practiced, are essentially meaningless because of the large standing waves usually present. Adequate anechoic chambers are not yet developed for frequencies below 100 MHz. Parallel-plate configurations give satisfactory results only at very low frequencies, and coaxial line enclosures are similarly limited. Open-field arrangements are usually not practical because of the space, power, and interference problems. But underlying all of these configuration problems is the lack of basic techniques for determining the strength of perturbed near fields with adequate accuracy.

4.5.1. CONDUCTED INTERFERENCE SUSCEPTIBILITY OF A NOISE-LIMITED AM RECEIVER

4.5.1.1. DEFINITION

Conducted interference susceptibility of an AM receiver is the voltage, in microvolts, of a signal that is amplitude modulated 30% with a 1000 Hz sinusoid, which when applied to a specified pair of receiver terminals, will produce a SINAD ratio of 16 (12 dB) at the reference audio output power from the receiver output terminals.

4.5.1.2. PURPOSE

The purpose of this measurement method is to measure the conducted interference susceptibility of noise-limited AM receivers. For such receivers, conducted interference susceptibility is a measure of the receiver response to signals that are conducted into the receiver by paths other than via the antenna terminals. Such paths include power, audio, and control line connections.

4.5.1.3. METHOD

The method uses an amplitude modulated signal generator, an insertion network and an audio distortion analyzer as shown in figure 4.5.1. A separate measurement is made at each accessible line terminal. The generator supplies a known input voltage to the selected terminal at the measurement frequency through the insertion network. The distortion analyzer measures the audio output power from the receiver under two conditions; viz., (a) with the 1000 Hz modulating signal present, and (b) with the 1000 Hz modulating signal filtered from the audio output power. The generator level is adjusted to the voltage that causes the ratio of (a) to (b), above, expressed in decibels, to be 12 dB. This voltage is the conducted interference susceptibility of the selected terminal of the receiver.

Measurement uncertainties as small as 5% are possible under best conditions, and range from approximately 8% to 30% under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.5.1.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

5. Input termination

6. Insertion network

7. R.F. voltmeter

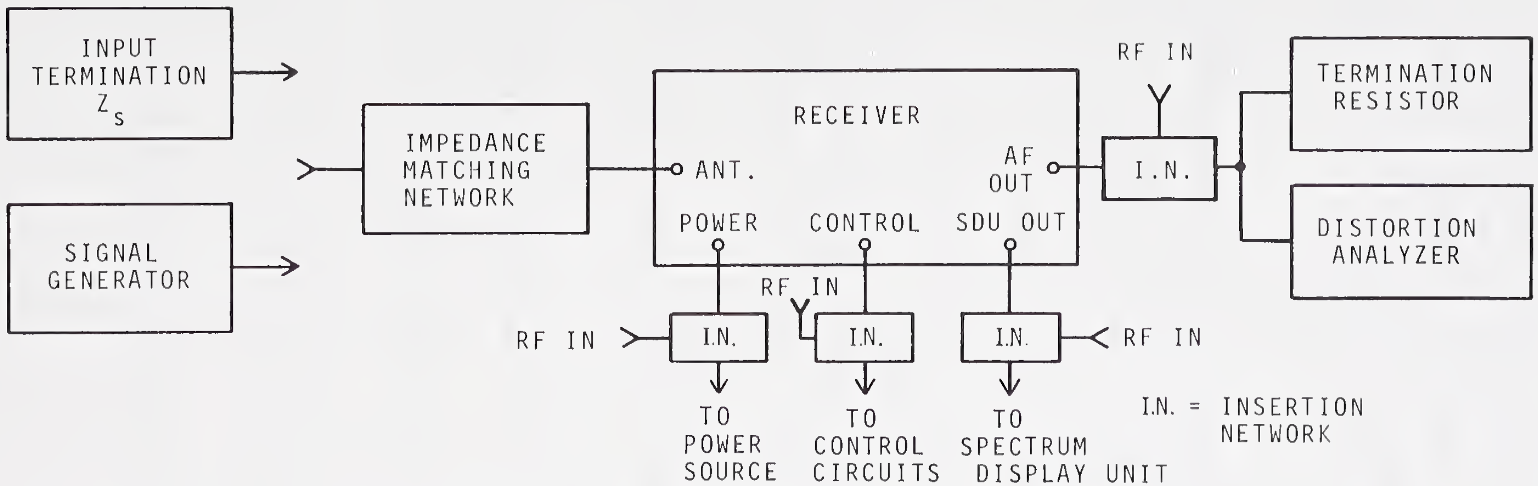

Fig. 4.5.1. Test Set-up for Conducted Interference Susceptibility (AM)

4.5.1.5. PROCEDURE

1. Connect the output port of an INSERTION NETWORK, whose characteristics are suitable for the measurement (see Section 5.2.7.), to the selected receiver terminal at which the measurement is to be made (power line, audio line, control line, AGC line, etc.). Refer to figure 4.5.1. for connection arrangements.

2. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

3. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

4. Set the distortion analyzer on a range to indicate the rated output power, P_o.

5. Set receiver controls as given in Table XXXII.

6. Tune the signal generator and the receiver to the measurement frequency, f_o.

7. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

8. Measure the 12 dB SINAD SENSITIVITY, E_i, as outlined in Section 4.1.3.5.

TABLE XXXII

Conducted and Radiated Interference Susceptibility (AM)

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. AM
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

9. Disconnect the signal generator from the impedance transformer at the receiver input port, and connect the TERMINATION, Z_s, in its place.

10. Connect the signal generator to the input port of the insertion network at the selected receiver terminal.

11. Set the generator output level to maximum (e.g., 100,000 to 1,000,000 microvolts).

12. Vary the generator frequency to cover all frequencies of interest, including f_o and spurious response frequencies (cf.).

13. When a response is produced, adjust the generator output level to produce a 12 dB SINAD ratio at reference audio output power, P_o.

Note: If the generator output level is not large enough to produce a 12 dB SINAD ratio, do one of the following things:

(1) Insert a power amplifier between the generator output port and the insertion network input port. Choose an amplifier with sufficient gain and power capability to produce a 12 dB SINAD ratio.

(2) Adjust the voltage gain of the insertion network as necessary to allow a 12 dB SINAD ratio to be reached.

(3) If (1) or (2) do not work, or if they would produce voltages that would cause equipment failure, stop the procedure at this point.

14. Measure the signal frequency, f_j, in kilohertz or megahertz, and voltage E_j, in microvolts, at the selected receiver terminal with an R.F. VOLTMETER. This voltage is the conducted interference susceptibility of the selected terminal at receiver frequency, f_o, and interference frequency, f_j.

Note: If the test was stopped as per (3) under Step 13, determine the signal voltage, E_m, at the selected terminal and report the results as follows: "The conducted interference susceptibility is in excess of (E_m) microvolts."

4.5.1.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the 12 dB SINAD sensitivity, E_i, in microvolts.

6. Record the interference frequency, f_j, in kilohertz or megahertz.

7. Record the interference susceptibility voltage, E_j or E_m, in microvolts.

8. Record the selected receiver terminal at which f_j and E_j are determined.

4.5.1.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_j, in the measured value of E_j
2. Uncertainty, ΔP_o, in the measured value of P_o
3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

The total relative uncertainty, $\Delta E_j(\%)$, expressed in percent, in the conducted interference susceptibility, E_j, is given by the equation

$$\Delta E_j(\%) = \left(\frac{\Delta E_j}{E_j} \times 100 \right) + \left(\frac{1}{2} \frac{\Delta P_o}{P_o} \times 100 \right) + \left(\frac{1}{2} \frac{\Delta P_{n+d}}{P_{n+d}} \times 100 \right) .$$

The uncertainty, ΔE_j, is obtained from the manufacturer's specifications on the R.F. voltmeter. Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.5.2. CONDUCTED INTERFERENCE SUSCEPTIBILITY OF AN FM RECEIVER WITH ONE OR MORE LIMITERS

4.5.2.1. DEFINITION

Conducted interference susceptibility of an FM receiver is the voltage, in microvolts, of a signal that is frequency modulated ±60% of maximum rated system deviation with a 1000 Hz sinusoid, which, when applied to a specified pair of receiver terminals, will produce a SINAD ratio of 16 (12 dB) at the reference audio output power from the receiver output terminals.

4.5.2.2. PURPOSE

The purpose of this measurement method is to measure the conducted interference susceptibility of FM receivers containing one or more amplitude limiter stages preceding the FM demodulator circuit. For such receivers, conducted interference susceptibility is a measure of the receiver response to signals that are conducted into the receiver by paths other than via the antenna terminals. Such paths include power, audio, and control line connections.

4.5.2.3. METHOD

The method uses a frequency modulated signal generator, an insertion transformer, and an audio distortion analyzer as shown in figure 4.5.2. A separate measurement is made at each accessible line terminal. The generator supplies a known input voltage to the selected terminal at the measurement frequency through the insertion transformer. The distortion analyzer measures the audio output power from the receiver under two conditions; viz., (a) with the 1000 Hz modulating signal present, and (b) with the 1000 Hz modulating signal filtered from the audio output power. The generator level is adjusted to the

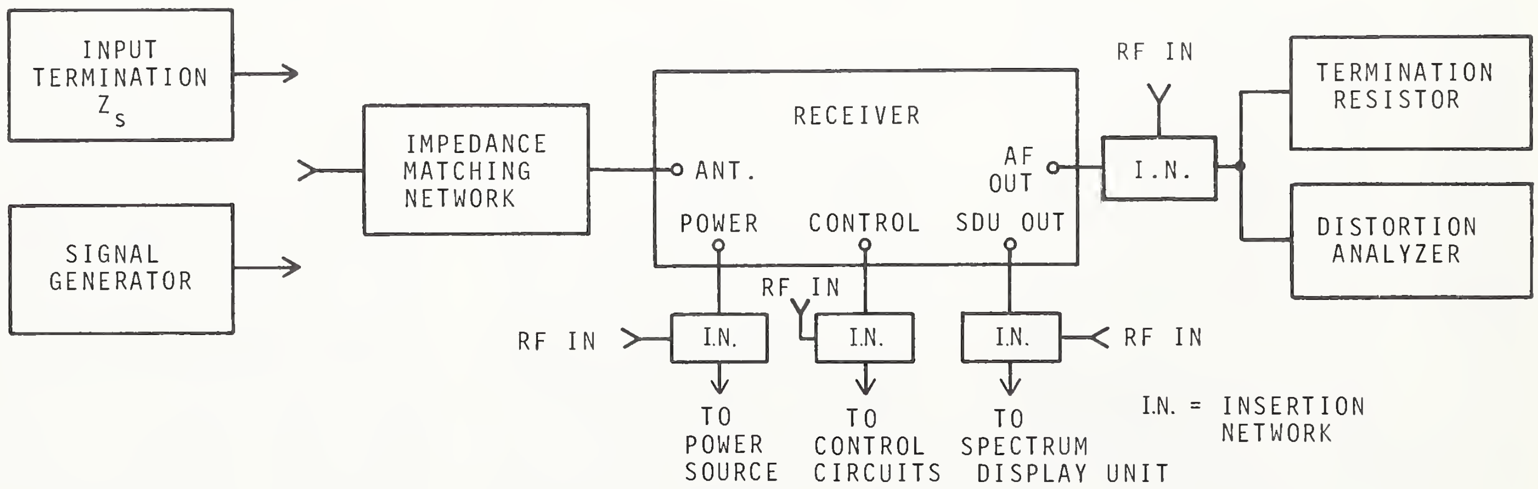

Fig. 4.5.2. Test Set-up for Conducted Interference Susceptibility (FM)

voltage that causes the ratio of (a) to (b), above, expressed in decibels, to be 12 dB. This voltage is the conducted interference susceptibility of the selected terminal of the receiver.

Measurement uncertainties as small as 5% are possible under best conditions, and range from approximately 8% to 30% under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.5.2.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

5. Input termination

6. Insertion network

7. R.F. voltmeter

4.5.2.5. PROCEDURE

1. Connect the output port of an INSERTION NETWORK whose characteristics are suitable for the measurement (see Section 5.2), to the selected receiver terminal at which the measurement is to be made (power line, audio line, control line, AGC line, etc.). Refer to figure 4.5.2. for connection arrangements.

2. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

3. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

4. Set the distortion analyzer on a range to indicate the rated output power, P_o.

5. Set receiver controls as given in Table XXXIII.

6. Tune the signal generator and the receiver to the measurement frequency, f_o.

7. Adjust the frequency modulation in the signal generator to ±60% of rated system deviation at 1000 Hz.

8. Measure the 12 dB SINAD SENSITIVITY, E_i, as outlined in Section 4.1.5.5.

9. Disconnect the signal generator from the impedance transformer at the receiver input port, and connect the TERMINATION, Z_s, in its place.

10. Connect the signal generator level to the input port of the insertion network.

11. Set the generator output level to maximum (e.g., 100,000 to 1,000,000 microvolts).

TABLE XXXIII

Conducted and Radiated Interference Susceptibility (FM)

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. FM
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

12. Vary the generator frequency to cover all frequencies of interest, including f_o and spurious response frequencies (cf.).

13. When a response is produced, adjust the generator output level to produce a 12 dB SINAD ratio at reference audio output power, P_o.

Note: If the generator output level is not large enough to produce a 12 dB SINAD ratio, do one of the following things:

(1) Insert a power amplifier between the generator output port and the insertion network input port. Choose an amplifier with sufficient gain and power capability to produce a 12 dB SINAD ratio.

(2) Adjust the voltage gain of the insertion network as necessary to allow a 12 dB SINAD ratio to be reached.

(3) If (1) or (2) do not work, or if they would produce voltages that would cause equipment failure, stop the procedure at this point.

14. Measure the signal frequency, f_j, in kilohertz or megahertz, and voltage E_j, in microvolts, at the selected receiver terminal with an R.F. VOLTMETER. This voltage is the conducted interference susceptibility of the selected terminal at receiver frequency, f_o, and interference frequency, f_j.

Note: If the test was stopped as per (3) under Step 13, determine the signal voltage, E_m, at the selected terminal and report the results as follows: "The conducted interference susceptibility is in excess of (E_m) microvolts."

4.5.2.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the 12 dB SINAD sensitivity, E_i, in microvolts.

6. Record the interference frequency, f_j, in kilohertz or megahertz.

7. Record the interference susceptibility voltage, E_j or E_m, in microvolts.

8. Record the selected receiver terminal at which f_j and E_j are determined.

4.5.2.7. MEASUREMENT ERRORS

The principal sources of measurement errors are the following:

1. Uncertainty, ΔE_j, in the measured value of E_j

2. Uncertainty, ΔP_o, in the measured value of P_o

3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

The total relative uncertainty, $\Delta E_j(\%)$, expressed in percent, in the conducted interference susceptibility, E_j, is given by the equation

$$\Delta E_j(\%) = \left(\frac{\Delta E_j}{E_j} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_o}{P_o} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_{n+d}}{P_{n+d}} \times 100\right) .$$

The uncertainty, ΔE_j, is obtained from the manufacturer's specifications on the R.F. voltmeter. Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.5.3. RADIATED INTERFERENCE SUSCEPTIBILITY OF A NOISE-LIMITED AM RECEIVER

4.5.3.1. DEFINITION

Radiated interference susceptibility of an AM receiver is the field strength, in volts per meter, of an electromagnetic field that is amplitude modulated 30% with a 1000 Hz sinusoid, which, when incident upon the most receptive region of the receiver, will produce a SINAD ratio of 16 (12 dB) at the rated audio output power from the receiver output terminals.

4.5.3.2. PURPOSE

The purpose of this measurement method is to measure the radiated interference susceptibility of noise-limited AM receivers. For such receivers, radiated interference susceptibility is a measure of the receiver response to radiated electromagnetic fields that produce signals in the receiver by paths other than via the receiver antenna. Such paths include power cords, audio and control lines, and leakage paths through openings in the receiver enclosure.

Note: The method given below is only indicative of the basic principle of measurement. It is not given as a recommended method that will give accurate results. See the discussion given under Section 4.5.

4.5.3.3. METHOD

The method uses an amplitude modulated signal generator, an antenna, and an audio distortion analyzer as shown in figure 4.5.3. The generator and antenna produce a known radiation field strength at the measurement frequency. The distortion analyzer measures the audio output power from the receiver under two conditions; viz., (a) with the 1000 Hz modulating signal present, and (b) with the 1000 Hz modulating signal filtered from the audio output power. The radiated field strength is adjusted to a level that causes the ratio of (a) to (b), above, expressed in decibels, to be 12 dB. This field strength is the radiated interference susceptibility of the receiver.

Measurement uncertainties are seldom less than 200%, and may be as great as 1000% under typical conditions. The method uses commonly available test equipment of moderate sophistication.

4.5.3.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

5. Input termination (shielded)

6. Antenna

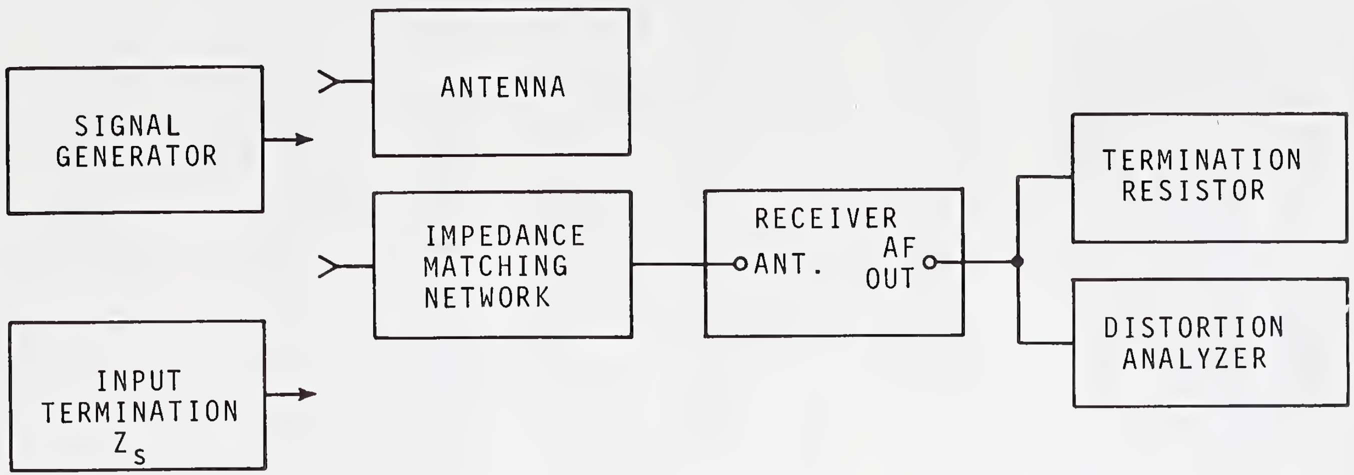

Fig. 4.5.3. Test Set-up for Radiated Interference Susceptibility (AM)

4.5.3.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set the distortion analyzer on a range to indicate the rated output power, P_o.

4. Set receiver controls as given in Table XXXII, p. 263.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

7. Measure the 12 dB SINAD SENSITIVITY, E_i, as outlined in Section 4.1.3.5.

8. Disconnect the signal generator from the impedance transformer at the receiver input port, and connect the SHIELDED TERMINATION, Z_s, in its place.

9. Connect the signal generator to the terminals of the ANTENNA.

10. Set the generator output level to maximum (e.g., 100,000 to 1,000,000 microvolts).

11. With the antenna approximately 30 meters from the receiver, vary the generator frequency to cover all frequencies of interest, including f_o and spurious response frequencies (cf.).

12. When a a response is produced, adjust the orientation of the receiver for maximum response, keeping the antenna 30 meters from the receiver at the closest point.

13. Adjust the generator output level to produce a 12 dB SINAD ratio.

Note: If the radiated field strength is not large enough to produce a 12 dB SINAD ratio, do one of the following things:

(1) Move the antenna closer to receiver.

(2) Insert a power amplifier between the generator output port and the antenna terminals. Choose an amplifier with sufficient gain and power capability to produce a 12 dB SINAD ratio.

14. Determine the signal frequency, f_j, and field strength, E_j, in volts per meter, at the location of the receiver by standard techniques. This field strength is the radiated interference susceptibility of the receiver for receiver frequency, f_o, and interference frequency, f_j.

4.5.3.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the 12 dB SINAD sensitivity, E_i, in microvolts.

6. Record the antenna-to-receiver distance.

7. Record the interference frequency, f_j, in kilohertz or megahertz.

8. Record the radiated interference susceptibility field strength, E_j, in volts per meter.

4.5.3.7. MEASUREMENT ERRORS

Measurement uncertainties depend upon local circumstances and are difficult to predict for the general case. See discussion given under Section 4.5.

4.5.4. RADIATED INTERFERENCE SUSCEPTIBILITY OF AN FM RECEIVER WITH ONE OR MORE LIMITERS

4.5.4.1. DEFINITION

Radiated interference susceptibility of an FM receiver is the field strength, in volts per meter, of an electromagnetic field that is frequency modulated ± 60% of maximum rated system deviation with a 1000 Hz sinusoid, which, when incident upon the most receptive region of the receiver, will produce a SINAD ratio of 16 (12 dB) at the rated output power from the receiver output terminals.

4.5.4.2. PURPOSE

The purpose of this measurement method is to measure the radiated interference susceptibility of FM receivers containing one or more amplitude limiter stages preceding the FM demodulator circuit. For such receivers, radiated interference susceptibility is a measure of the receiver response to radiated electromagnetic fields that produce signals in the receiver by paths other than via the receiver antenna. Such paths include power cords, audio and control lines, and leakage paths through openings in the receiver enclosure.

Note: The method given below is only indicative of the basic principle of measurement. It is not given as a recommended method that will give accurate results. See the discussion given under Section 4.5.

4.5.4.3. METHOD

The method uses a frequency modulated signal generator, an antenna, and an audio distortion analyzer as shown in figure 4.5.4. The generator and antenna produce a known radiation field strength at the measurement frequency. The distortion analyzer measures the audio output power from the receiver under two conditions; viz., (a) with the 1000 Hz modulating signal present, and (b) with the 1000 Hz modulating signal filtered from the audio output power. The radiated field strength is adjusted to a level that causes the ratio of (a) to (b), above, expressed in decibels, to be 12 dB. This field strength is the radiated interference susceptibility of the receiver.

Measurement uncertainties are seldom less than 200%, and may be as great as 1000% under typical conditions. The method uses commonly available test equipment of moderate sophistication.

4.5.4.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

5. Input termination

6. Antenna

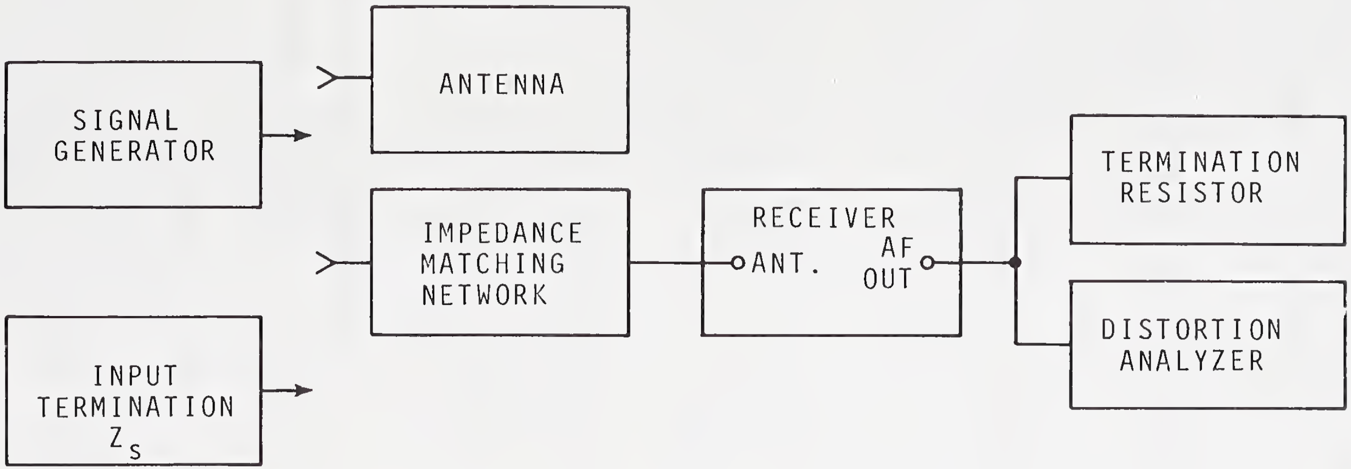

Fig. 4.5.4. Test Set-up for Radiated Interference Susceptibility (FM)

4.5.4.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across the resistor.

3. Set the distortion analyzer on a range to indicate the rated output power, P_o.

4. Set receiver controls as given in Table XXXIII, p. 271.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6. Adjust the receiver modulation in the signal generator to ±60% of rated system deviation at 1000 Hz.

7. Measure the 12 dB SINAD SENSITIVITY, E_i, as outlined in Section 4.1.5.5.

8. Disconnect the signal generator from the impedance transformer at the receiver input port, and connect the SHIELDED TERMINATION, Z_s, in its place.

9. Connect the signal generator to the ANTENNA terminals.

10. Set the generator output level to maximum (e.g., 100,000 to 1,000,000 microvolts).

11. With the antenna approximately 30 meters from the receiver, vary the generator frequency to cover all frequencies of interest, including f_o and spurious response frequencies (cf.).

12. When a response is produced, adjust the orientation of the receiver for maximum response, keeping the antenna 30 meters from the receiver at the closest point.

13. Adjust the generator output level to produce a 12 dB SINAD ratio.

Note: If the radiated field strength is not large enough to produce a 12 dB SINAD ratio, do one of the following things:

(1) Move the antenna closer to receiver.

(2) Insert a power amplifier between the generator output port and the antenna terminals. Choose an amplifier with sufficient gain and power capability to produce a 12 dB SINAD ratio.

14. Determine the signal frequency, f_j, and field strength, E_j, in volts per meter, at the location of the receiver. This field strength is the radiated interference susceptibility of the receiver for receiver frequency, f_o, and interference frequency, f_j.

4.5.4.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the 12 dB SINAD sensitivity, E_i, in microvolts.

6. Record the antenna-to-receiver distance.

7. Record the interference frequency, f_j, in kilohertz or megahertz.

8. Record the radiated interference susceptibility field strength, E_j, in volts per meter.

4.5.4.7. MEASUREMENT ERRORS

Measurement uncertainties depend upon local circumstances and are difficult to predict for the general case. See discussion given under Section 4.5.

4.6. EMISSION

Energy from internal signal sources within a receiver may produce undesired emissions, either conducted or radiated, via the receiver's antenna, power cord, audio cables, and control cables. Potential sources of this energy are (1) oscillators used for frequency conversion, (2) beat frequency oscillators, (3) oscillators used for synchronous detection, (4) converter-type power supplies, and (5) spurious oscillations from unstable circuits.

Measurement methods for conducted emission are generally similar to other methods given in this handbook. However, presently available methods for measuring radiated emission are generally inadequate or worthless because of the large inaccuracies and variations of results that they provide. Errors typically range from 100% to 500%, and may reach 1000% or higher, depending upon the circumstances. Measurements in shielded enclosures, as presently practiced, are essentially meaningless because of the large standing waves usually present. Adequate anechoic chambers are not yet developed for frequencies below 100 MHz. Open-field arrangements are usually not practical because of the space, power, and interference problems. But underlying all of these configuration problems is the lack of basic techniques for determining the strength of perturbed near fields with adequate accuracy.

4.6.1. CONDUCTED EMISSION

4.6.1.1. DEFINITION

Conducted emission is electromagnetic energy that is propagated along a conductor.

Conducted emission is usually expressed as the power, in dBm, available from specified receiver terminals.

4.6.1.2. PURPOSE

The purpose of this measurement method is to measure the radio frequency power that is available at each of the receiver's accessible terminals, and which is generated by sources within the receiver. This power may be radiated or otherwise conveyed from the receiver to other electronic devices, causing undesired interference.

4.6.1.3. METHOD

The method uses a sensitive, tunable, frequency-selective voltmeter and a variable-frequency CW signal generator as shown in figure 4.6.1. The voltmeter measures the signal level of internal sources at the selected receiver terminals. The signal generator is used to calibrate the voltmeter. Conducted emission, in dBm, is computed from the voltmeter reading and the impedance level at the terminals.

Measurement uncertainties as small as 0.3 dB are possible under best conditions, and range from 0.5 dB to 1.5 dB under typical conditions. This method uses commonly available test equipment, but requires some specialized accessories.

4.6.1.4. TEST EQUIPMENT REQUIRED

1. Tunable, frequency-selective voltmeter

2. Variable frequency CW generator

3. Insertion network

4. Line impedance network

4.6.1.5. PROCEDURE

1. Connect the input port of the SELECTIVE VOLTMETER to the selected terminals of the receiver through an INSERTION NETWORK or LINE IMPEDANCE NETWORK as shown in figure 4.6.1. The networks should provide proper terminations for both the selective voltmeter and the receiver.

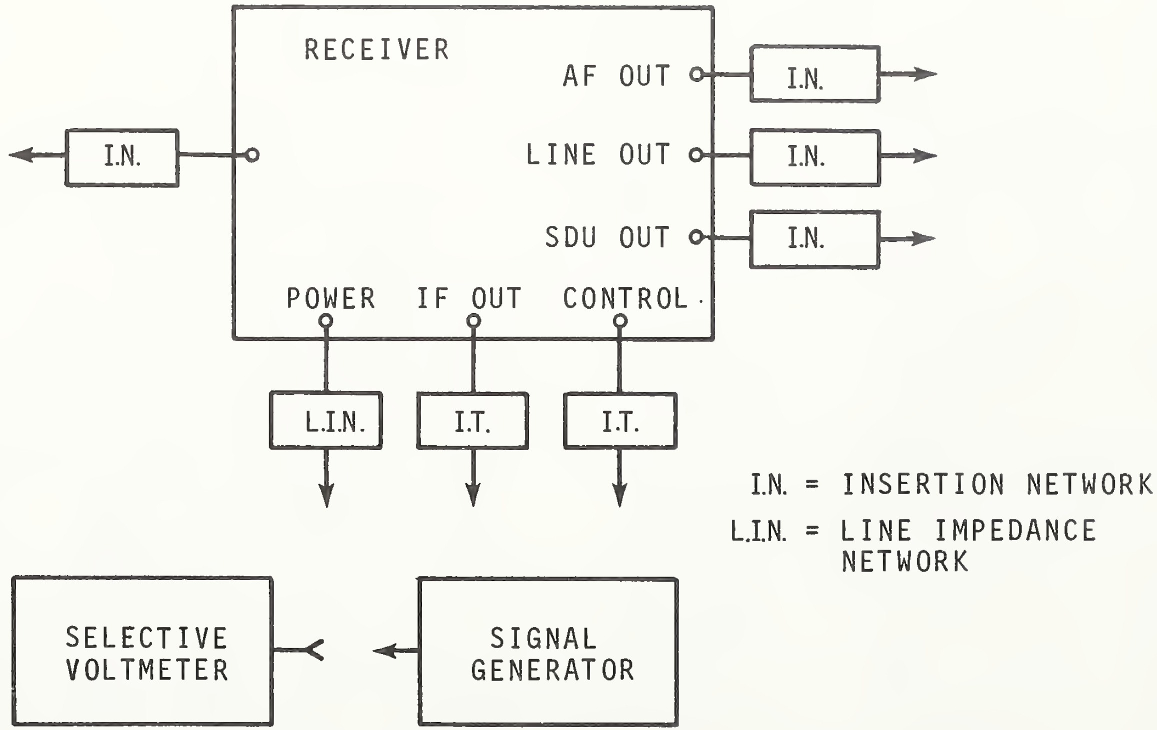

Fig. 4.6.1. Test Set-up for Conducted Emission

2. Set receiver controls as given in Table XXXIV.

3. Set the voltmeter for maximum sensitivity.

4. Tune the voltmeter until it indicates a response to a signal coming from the measurement terminals.

5. Adjust voltmeter sensitivity to indicate the level of the response.

6. Disconnect the voltmeter from the insertion or line impedance network and connect it to the SIGNAL GENERATOR.

7. Tune the generator to the frequency that produced the voltmeter response. Record this frequency, f_r, in kilohertz or megahertz.

8. Adjust the output level of the generator to produce the same response as that produced by the signal from the receiver.

9. Determine the available power, $P_g(f_r)$, in dBm, from the generator in Step 7, above, by determining the generator open circuit voltage, E_g, and generator source impedance, Z_s (see Section 4.10.).

10. Calculate the available power, $P_r(f_r)$, in dBm, from the receiver by ADDING the loss, L, in dB, of the insertion or line impedance network at frequency f_r. $P_r(f_r)$ is the conducted emission, in dBm, of the receiver at frequency f_r.

TABLE XXXIV

Conducted Emission

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As desired
7. Line Gain	7. As desired
8. Detector Mode	8. As desired
9. Beat Frequency Oscillator	9. As desired (normally ON)
10. BFO Frequency	10. As desired
11. IF Bandwidth	11. Optional
12. AF Bandwidth	12. Optional
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

11. Repeat Steps 3 through 10 at other frequencies that produce a voltmeter response. Be sure to include fundamental and harmonic frequencies of known sources with the receiver.

4.6.1.6. DATA REQUIRED

1. Record receiver control settings and operational information.

2. Record frequencies, f_r, of conducted emissions.

3. Record voltmeter readings of conducted emissions.

4. Record the generator power, $P_g(f_r)$, in dBm, available at frequency f_r.

5. Record the loss, in dB, at frequency f_r, of the insertion or line impedance network.

6. Record the conducted emission power, $P_r(f_r)$, in dBm, for each frequency, f_r.

4.6.1.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔP_g, in the measured value of P_g

2. Uncertainty, ΔL, in the measured loss, L, of the insertion or line impedance network

The total relative uncertainty, ΔP_r(dB), in decibels, in the conducted emission, P_r, expressed in dBm, is given approximately, for small uncertainties, by the equation

$$\Delta P_r \text{ (dB)} = 10 \log \left(1 + \frac{\Delta P_g}{P_g} + \frac{\Delta L}{L} \right) .$$

Relative uncertainty $\Delta P_g/P_g$ is given by the equation

$$\frac{\Delta P_g}{P_g} = 2\,\frac{\Delta E_g}{E_g} + \frac{\Delta Z_s}{Z_s} \quad ,$$

where ΔE_g is the uncertainty in the measured value of generator voltage, E_g, and ΔZ_s is the uncertainty in the measured value of source impedance, Z_s.

Uncertainty ΔE_g is obtained from the manufacturer's specifications on the selective voltmeter; ΔZ_s is obtained from the specifications on the impedance meter used to measure Z_s; ΔL is obtained from the specifications on the equipment (power meter, voltmeter, etc.) used to measure insertion loss, L.

4.6.2. RADIATED EMISSION

4.6.2.1. DEFINITION

Radiated emission is the field strength, in volts per meter, produced by radiation from the receiver, due to signal sources within the receiver, at a specified point external to the receiver.

Note: Because the antenna used with the receiver may not be uniquely specified, radiated emission as considered in this Section will not include radiation via the receiver's antenna terminals.

4.6.2.2. PURPOSE

The purpose of this measurement method is to measure the field strength of electromagnetic energy radiated from all parts of the receiver except the antenna terminals. Radiation may come from internal sources via the power, audio, or interconnecting cables, and/or from leakage paths in the receiver's enclosure. Receiver radiation is a measure of the receiver's interference potential to other electronic or communications equipment.

Note: The method given below is only indicative of the basic principle of measurement. It is not given as a recommended method that will give accurate results. See the discussion given under Section 4.6.

4.6.2.3. METHOD

The method uses a field intensity meter (FIM) as shown in figure 4.6.2. The FIM measures the field intensity at a point in space that has a specified relationship to the receiver; this relationship depends upon the measurement frequency, and is given in the procedure below.

Measurement uncertainties are seldom less than 100% and may be as great as 1000% under typical conditions. The method uses commonly available test equipment of moderate sophistication.

4.6.2.4. TEST EQUIPMENT REQUIRED

1. Field intensity meter

2. Shielded termination for receiver's antenna port

3. Power line filter

4.6.2.5. PROCEDURE, ELECTRIC FIELD, 14 KHZ TO 100 MHZ

1. Place the receiver on a ground plane that meets the specifications of MIL-STD-462, paragraph 4.2.1.2.

2. Connect the receiver through the POWER LINE FILTER to the source of primary power. Bond the filter to the ground plane at a point at least 2 meters from the receiver.

3. Attach the SHIELDED TERMINATION to the receiver's antenna port.

4. Adjust the electrical settings of the receiver for the desired operating conditions.

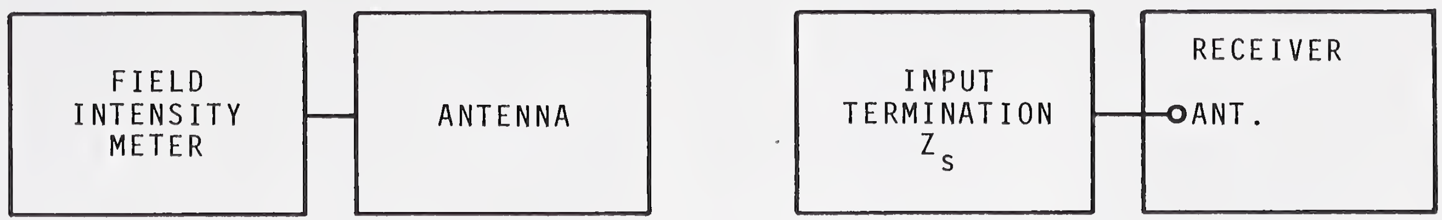

Fig. 4.6.2. Test Set-up for Radiated Emission

5. Tune the FIM to the measurement frequency, or place the FIM in the swept-frequency mode.

6. Scan the receiver with the FIM probe (antenna) to locate the sites of maximum radiation. Orient the FIM probe as required for maximum pick-up.

7. When radiation is detected, position the FIM probe 1 meter from the nearest point to the receiver, and adjust the orientation of the probe and the frequency of the FIM for maximum FIM response.

8. Measure the field intensity with the FIM. This is the receiver radiation, in volts per meter, at the measurement frequency for the selected receiver operating conditions.

9. Repeat Steps 4 through 8, above, until the desired range of frequencies and receiver operating conditions are covered.

4.6.2.6. DATA REQUIRED

1. Record receiver control settings and operating conditions.

2. Record frequency of radiated emissions.

3. Record field intensity of radiated emissions.

4.6.2.7. MEASUREMENT ERRORS

Measurement uncertainties depend upon local circumstances and are difficult to predict for the general case. See discussion given under Section 4.6.

4.7. TIME DELAY

4.7.1. DEFINITION

Time delay is the time interval between the manifestation of a signal at one point and the manifestation or detection of the same signal at another point. (IEEE Std 100-1972)

4.7.2. PURPOSE

The purpose of this measurement method is to measure the time delay of signals passing through surveillance receivers. Time delay is important when combining two or more receivers in multiple-diversity receiving systems, or in position-plotting systems.

4.7.3. METHOD

This method uses a modulated signal generator, a matched pair of detectors, and a cathode-ray oscilloscope as shown in figure 4.7. The generator supplies a modulated signal of known modulation frequency to the receiver. The matched detectors supply demodulated signals to the two vertical input channels of the oscilloscope, which operates in a dual-channel mode. The oscilloscope displays the time displacement between the two demodulated signals, and time delay is measured graphically from this display.

This method is most useful when the time delay is longer than twice the reciprocal bandwidth or, if they are approximately equal, time delay must be approximately proportional to reciprocal bandwidth. Otherwise, accuracy may suffer.

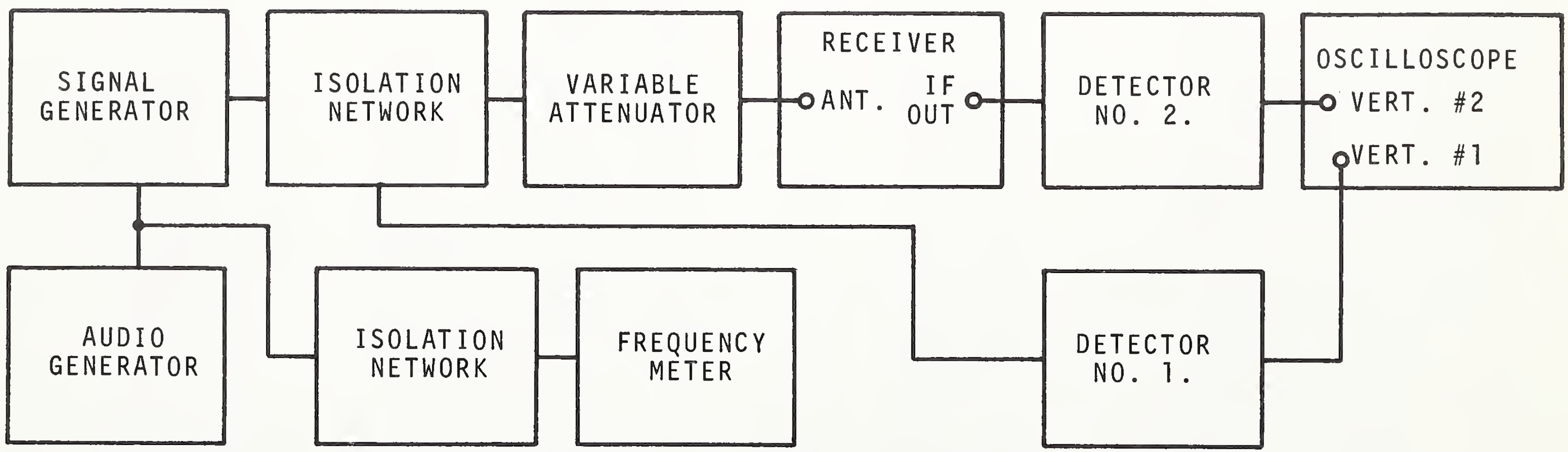

Fig. 4.7. Test Set-up for Time Delay

Measurement uncertainties as small as 2% are possible under best conditions, and range from 3% to 10% under typical conditions. This method uses commonly available test equipment of moderate sophistication.

4.7.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of external amplitude or frequency modulation

2. Audio signal generator

3. Frequency meter

4. Isolation network

5. Variable attenuator

6. Two matched envelope detectors

7. Two matched frequency - modulation detectors

8. Cathode-ray oscilloscope with dual-channel mode of operation

9. Oscilloscope camera

4.7.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through the VARIABLE ATTENUATOR.

2. Connect DETECTOR No. 1 to the junction of the signal generator and the variable attenuator.

3. Connect DETECTOR No. 2 to the output of the last I.F. amplifier stage of the receiver. If detector No. 1 matches the detector built into the receiver, the receiver's detector may be used in place of detector No. 2.

4. Connect each detector output to a vertical input port of the dual channel OSCILLOSCOPE.

5. Connect the output port of the AUDIO GENERATOR to the EXTERNAL MODULATION input port of the signal generator.

6. Connect the FREQUENCY METER through an ISOLATION NETWORK to the junction of the audio generator and the signal generator.

7. Set the receiver controls as given in Table XXXV.

8. Set oscilloscope controls as given in Table XXXVI.

9. Tune the signal generator and the receiver to the measurement frequency, f_o.

10. Adjust the oscilloscope vertical gains to maximum, and approximately equal.

11a. If the measurement is on an AM receiver, adjust the amplitude modulation of the signal generator to 30% at a very low frequency, e.g., 25 hertz.

OR

11b. If the measurement is on an FM receiver, adjust the frequency modulation of the signal generator to ±60% of rated system deviation at a very low frequency, e.g., 25 hertz.

TABLE XXXV

Time Delay

Initial Control Settings

	Control		Setting
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Moderate
5.	IF Gain	5.	Moderate
6.	AF Gain	6.	Optional
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM or FM
9.	Beat Frequency Oscillator	9.	Off
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	Optional
13.	Noise Limiter	13.	Off
14.	Squelch Level	14.	Off
15.	AGC/MGC Mode Switch	15.	Optional
16.	Meter Switch	16.	Optional

TABLE XXXVI

Oscilloscope Control Settings

Control	Setting
1. Mode	1. Chopped
2. Channel 1 Gain	2. As required
3. Channel 2 Gain	3. As required
4. Sweep speed	4. As required
5. Trigger Mode	5. Internal, Channel 1
6. Trigger Phase	6. Zero

12. Adjust the signal generator output to maximum, e.g., approximately 100,000 to 1,000,000 microvolts.

13. Adjust oscilloscope controls to obtain a stable trace from detector No. 1. Display from 5 to 15 cycles of the sinusoid pattern.

14. Adjust the variable attenuator to produce approximately the same output from detector No. 2 as from detector No. 1.

15. Note the time relationship between the traces of the output signals from detectors No. 1 and No. 2. There is usually a small time displacement between the two traces.

16. Increase the frequency of the audio generator. The trace from detector No. 2 should move relative to that of detector No. 1.

17. Determine if the frequency can be increased sufficiently to cause the two traces to be in exact phase alignment, so they can be superimposed, without having the signal from detector No. 2 decrease in amplitude by more than 3 dB. This is a function of receiver CW bandwidth. If this is possible, adjust the audio generator to a frequency, f_a, where the two traces are exactly in phase on the screen.

18. Measure frequency f_a with the frequency meter.

19, Calculate τ by the equation

$$\tau = \frac{1}{f_a} .$$

τ is the time delay of the receiver at frequency f_o.

20. Confirm the value of τ in the following way: Increase the generator to the frequency f_b that causes the two traces to again be exactly in phase, if possible. Under this condition,

$$\tau = \frac{1}{f_b - f_a} .$$

For $\tau = 1/f_a$ as in Step 18, above, then f_b will equal $2f_a$. In general,

$$\tau = \frac{m}{f_1} = \frac{m + 1}{f_2} = \frac{1}{f_2 - f_1} ,$$

where m is an integer.

If the receiver bandwidth prevents obtaining a trace from detector No. 2 with modulation frequency f_b, then τ cannot be checked in this way.

21. If the receiver bandwidth prevents obtaining a trace from detector No. 2 with modulation frequency f_a as in Step 17, above, proceed as follows:

a. Adjust the audio generator to the frequency, f_c, at which the output from detector No. 2. is approximately 3 dB below that of detector No. 1.

b. Measure the time interval, Δt, between a zero crossing point on the output of detector No. 1 and a same zero crossing point of the same slope on the output of detector No. 2. Expand the horizontal scale to facilitate this measurement. Photograph the display, if desired.

c. Determine time delay, τ, by the equation

$$\tau = \Delta t \quad .$$

4.7.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the variable attenuator setting, A, in decibels.

3. Record the modulation/demodulation mode, AM or FM.

4. Record the oscilloscope adjustments; particularly note the horizontal sweep speed.

5. Record the audio generator frequencies, f_a, f_b, or f_c, in hertz.

6. Record the measured value of Δt, in milliseconds.

7. Record the calculated value of time delay, τ, in microseconds or milliseconds.

4.7.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainties, Δf_a, Δf_b, and Δf_c, in the measured values of f_a, f_b, and f_c.

2. Uncertainty, $\Delta(\Delta t)$, in the measured value of Δt.

3. Uncertainty, $\Delta(\Delta t_a)$, in the superposition of the two traces in Step 17, above.

When using Steps 17, 18, and 19 to measure τ, the total relative uncertainty, $\Delta\tau(\%)$, expressed in percent, in τ, is given by the equation

$$\Delta\tau\ (\%) = \left(\frac{\Delta f_a}{f_a} + \frac{\Delta(\Delta t_a)}{T}\right) \times 100 \quad ,$$

where T is the time, in seconds, for the trace to sweep across the screen.

When using Step 20 to measure τ, $\Delta\tau(\%)$ is given by the equation

$$\Delta\tau\ (\%) = \left(\frac{\Delta f_a}{f_a} + \frac{\Delta f_b}{f_b} + \frac{\Delta(\Delta t_a)}{T}\right) \times 100 \quad .$$

When using Step 21 to measure τ, $\Delta\tau(\%)$ is given by the equation

$$\Delta\tau\ (\%) = \frac{\Delta(\Delta t)}{\Delta t} \times 100 \quad .$$

Uncertainties Δf_a, Δf_a, and Δf_c are obtained from the manufacturer's specifications on the frequency meter. Uncertainties $\Delta(\Delta t)$ and $\Delta(\Delta t_a)$ are obtained from the manufacturer's specifications on the horizontal sweep circuits of the oscilloscope.

4.8. FREQUENCY STABILITY

The frequency stability of a receiver may be considered in two different ways. First, the various oscillators within the receiver may change frequency because of electrical or physical changes to which they respond. Second, the various circuits that provide frequency selectivity within the receiver may change their response characteristics for the same reasons. Both of these changes can cause degradation in receiver performance.

Only oscillator stability is discussed in this section. Methods for measuring the stability of frequency sensitive transducers generally are the same as for measuring selectivity (cf.).

The method given in this section applies to frequency fluctuations that occur at a rate that is slower than approximately one hertz per second; there is no limit in principle to the slowness of fluctuation for which this method applies. The method may lose utility for fluctuations faster than one hertz per second because of instrument limitations. However, the method is applicable to most stability problems encountered with surveillance receivers, and no attempt is made here to divide these problems into the two poorly defined categories of short-term stability and long-term stability.

4.8.1. DEFINITION

The frequency stability of a receiver is the change in oscillator frequency per unit change in a frequency-perturbing parameter. Examples of such parameters include (1) time, (2) temperature, (3) voltage, (4) atmospheric pressure, and (5) humidity.

4.8.2. PURPOSE

The purpose of this measurement method is to measure the frequency stability of the oscillators contained within surveillance receivers. Examples of such oscillators are (1) tunable oscillators used for frequency conversion, commonly called local oscillators, (2) beat frequency oscillators used to render keyed CW signals audible, and (3) oscillators used for synchronous detection of suppressed carrier signals. The frequency stability of such oscillators is a measure of the receiver's ability to receive stable signals without drift in spite of changes in power supply and ambient conditions.

4.8.3. METHOD

The method uses a stable CW generator, a precision electronic counter, and a digital printer as shown in figure 4.8. The generator delivers a signal at a known frequency to the receiver. The counter measures the frequency from the IF section for receivers operating in the AM and FM modes, and from the AF section for CW and SSB modes. The printer provides a hard copy record of the counter output.

I.F. output signal frequency is measured under controlled conditions where the frequency-perturbing parameter is changed in a known way. Frequency stability is obtained from a graphical plot of I.F. output frequency versus this parameter.

Measurement uncertainties as small as 0.2 Hz are possible under best conditions, and range from 0.2 Hz to 1 Hz under typical conditions. The method requires sophisticated but commonly available test equipment.

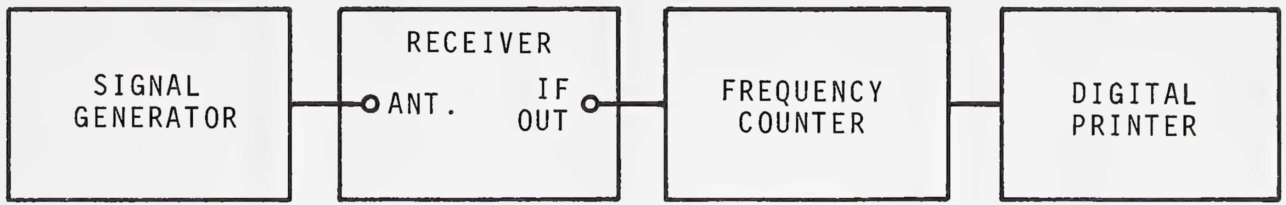

Fig. 4.8. Test Set-up for Frequency Stability

4.8.4. TEST EQUIPMENT REQUIRED

1. Stable CW signal generator

2. Electronic counter

3. Digital printer

4. Equipment as required to produce controlled changes in operating conditions, such as (1) variable autotransformer, (2) environmental chamber.

4.8.5. PROCEDURE

1. Connect the CW SIGNAL GENERATOR to the input port of the receiver.

2. Connect the DIGITAL COUNTER to the output of the IF amplifier, if the measurement is not to include the BFO stability. Otherwise, connect the counter to the output terminals of the audio amplifier.

3. Connect the DIGITAL PRINTER to the counter per manufacturer's instructions.

4. Arrange the receiver as required for the desired test. For example:

a. If the test is to measure frequency as a function of line voltage, connect the receiver line cable to a regulated, adjustable, and metered supply of the proper voltage and frequency.

b. If the test is to measure frequency as a function of environmental conditions, install the receiver in a suitable environmental chamber that provides the required control and metering of the environmental parameter.

c. If the test is to measure frequency as a function of time for special operating conditions, such as those indicated in a and b, above, provide a clock to monitor this parameter. For "average" operating conditions, special auxiliary equipment may not be required.

5. Set receiver controls as given in Table XXXVII.

6. Tune the signal generator and the receiver to the measurement frequency, f_o.

7. Adjust the output level of the generator to produce a clean output signal from the IF or audio sections.

8. Measure the generator frequency, f_o, with the counter.

9. Measure the IF output signal frequency, f_{if}, with the counter.

10. Measure the audio output signal frequency, f_{af}, with the counter (CW and SSB modes only).

11. Repeat Steps 8 through 10, above, according to the desired information. That is, repeat the measurements as often as desired to obtain the stability as a function of time with the desired density of measurement points; repeat as required by changes in test conditions per Step 4, above.

12. Plot, on rectilinear graph paper, the measured frequency as a function of the frequency-perturbing parameter (voltage, temperature, time, etc.).

13. Determine the slope of the curve plotted in Step 12, above, at any point of interest. The slope is the FREQUENCY STABILITY of the oscillator at that particular operating point.

TABLE XXXVII

Frequency Stability

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	As required
5.	IF Gain	5.	As required
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	As desired
9.	Beat Frequency Oscillator	9.	As desired
10.	BFO Frequency	10.	As desired
11.	IF Bandwidth	11.	Optional
12.	AF Bandwidth	12.	Optional
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

4.8.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the IF output signal frequency, f_{if}, in kilohertz or megahertz.

3. Record the audio output signal frequency, f_{af}, in hertz or kilohertz.

4. Record the value of the frequency-perturbing parameter, and correlate it with the measured IF or audio signal frequency.

4.8.7. MEASUREMENT ERRORS

The principal sources of measurement errors are the following:

1. Uncertainty, Δf, in the measured value of each frequency, f

2. Uncertainty, Δf_g, in the frequency of the stable CW generator, due to drift

3. Uncertainty in the value of the frequency-perturbing parameter selected for the test

The total relative uncertainty, $\Delta f_t(\%)$, in percent, in the measured value of frequency, f, is given by the equation

$$\Delta f_t(\%) = \left(\frac{\Delta f}{f} \times 100\right) + \left(\frac{\Delta f_g}{f_g} \times 100\right) .$$

Uncertainties Δf and Δf_g are obtained from the manufacturer's specifications on the signal generator and on the electronic counter.

4.9. FREQUENCY READOUT ERROR

4.9.1. DEFINITION

Frequency readout error is the frequency difference, in hertz or kilohertz, between the receiver's indicated reception frequency and the frequency to which the receiver is tuned.

4.9.2. PURPOSE

The purpose of this measurement method is to measure the frequency readout error of surveillance receivers. Readout error affects the ease with which the receiver can be tuned to receive a signal of a given carrier frequency.

4.9.3. METHOD

The method uses a stable CW generator and a precision electronic counter as shown in figure 4.9. The generator delivers a signal at a known frequency to the receiver. The counter measures the frequency of the I.F. signal. The receiver is tuned until the I.F. signal is at the specified frequency. The difference between the receiver's indicated frequency and the generator frequency is the readout error. The measurement uncertainty is determined primarily by the readout resolution of the receiver's frequency display. The method uses sophisticated but commonly available test equipment.

4.9.4. TEST EQUIPMENT REQUIRED

1. Stable CW signal generator

2. Electronic counter

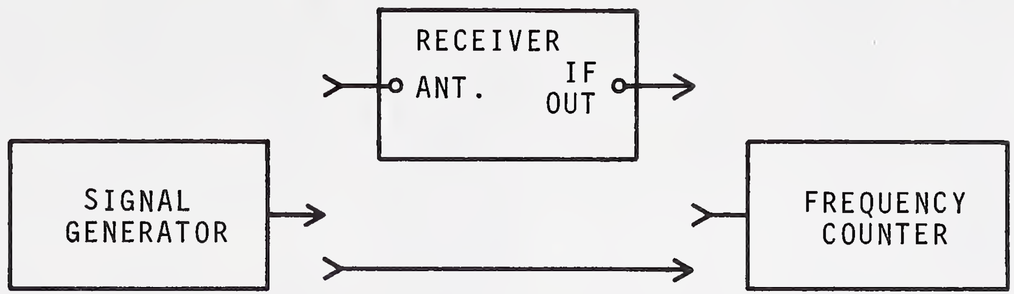

Fig. 4.9. Test Set-up for Frequency Readout Error

4.9.5. PROCEDURE

1. Connect the CW SIGNAL GENERATOR to the input port of the receiver.

2. Set receiver controls as given in Table XXXVIII.

3. Tune the signal generator to the measurement, f_o.

4. Adjust the output level of the generator to produce a clean output signal from the I.F. section of the receiver.

5. Measure the generator frequency, f_o, with the COUNTER.

6. Connect the counter to the output of the I.F. amplifier section.

7. Tune the receiver near f_o, and adjust the tuning to produce an I.F. signal with a frequency equal to the manufacturer's specified intermediate frequency, f_{if}.

8. Read the indicated reception frequency, f_r, on the receiver's frequency readout display.

9. Calculate the frequency difference, Δf_r, in hertz or kilohertz, between f_r and f_o by the equation

$$\Delta f_r = f_r - f_o \quad .$$

TABLE XXXVIII

Frequency Readout Error

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. As required
5. IF Gain	5. As required
6. AF Gain	6. As desired
7. Line Gain	7. Optional
8. Detector Mode	8. AM, FM, as desired
9. Beat Frequency Oscillator	9. Off
10, BFO Frequency	10. N.A.
11. IF Bandwidth	11. Optional
12. AF Bandwidth	12. Optional
13. Noise Limiter	13. Off
14. Squelch Level	14. Off
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

Δf_r is the frequency readout error of the receiver at the indicated reception frequency, f_r. If Δf_r is positive, f_r is greater than f_o; if Δf_r is negative, f_r is less than f_o.

4.9.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the intermediate frequency, f_{if}, in kilohertz or megahertz.

3. Record the indicated reception frequency, f_r, in kilohertz or megahertz.

4. Record the frequency readout error, Δf_r, in hertz or kilohertz.

4.9.7. MEASUREMENT ERRORS

The principal source of measurement error is normally the uncertainty in the receiver's frequency display, which is determined by its readout resolution. In this case, the total measurement uncertainty, $\Delta(\Delta f_r)$, in hertz, in the measured readout error, Δf_r, is the receiver readout resolution. This is obtained from the manufacturer's specifications, or by inspection of the readout indicator.

4.10. IMPEDANCE

The requirements for impedance measurement in surveillance receivers usually pertain to antenna input impedance and IF and/or AF output impedance. Because these impedances involve active components, measurement methods are required that do not significantly alter the impedance whose value is to be measured.

4.10.1. DEFINITIONS

a. Input impedance is the impedance presented by the receiver to the signal source.

b. Output impedance is the impedance presented by the receiver to a termination.

c. Impedance is the ratio, at a given frequency, of (a) the sinusoidal voltage across a pair of terminals to (b) the corresponding sinusoidal current, at the same frequency, passing into and out of the pair of terminals.

4.10.2. PURPOSE

The purpose of these measurement methods is to measure the input and output impedances at the accessible ports of receivers. These impedances determine in large part the ability of a receiver to deliver output signals of acceptable quality at adequate power levels.

Impedance is a function of frequency. Input impedances are normally measured at frequencies in the range to which the receiver is tuned. Output impedances are measured at audio frequencies, and at intermediate frequencies (IF's) when the receiver is provided with a suitable I.F. output network and connector. Further, the input and output impedances of special circuits, such as local oscillator inputs or outputs can be measured by these methods.

Measurement uncertainties as small as 4% are possible under best conditions, and range from 5% to 20% under typical conditions. The method requires sophisticated but commonly available test equipment.

4.10.3. METHOD I - VECTOR IMPEDANCE METER

The method uses a variable frequency vector impedance meter as shown in figure 4.10.1. The impedance meter contains its own signal source, detector networks, and output display. Impedance is read directly from the meter display.

This method is suitable for measuring both input and output impedances. It is particularly suited for impedance measurement when the network under test can tolerate only a very small test signal because of low-level active devices.

4.10.3.1. TEST EQUIPMENT REQUIRED

1. Vector impedance meter

4.10.3.2. PROCEDURE

1. Connect the VECTOR IMPEDANCE METER probe to the terminals of the receiver at which the measurement is to be made.

2. Set receiver controls as given in Table XXXIX.

3. Tune the vector impedance meter to the measurement frequency, f_o.

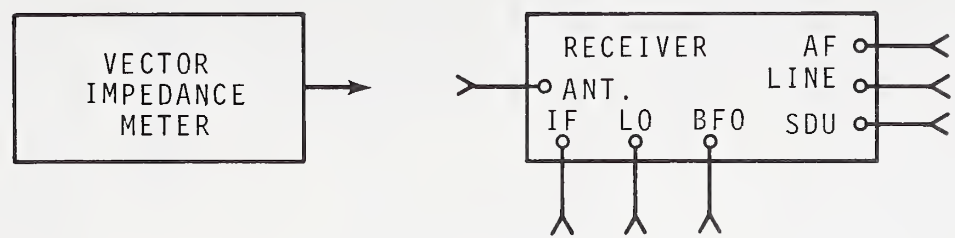

Fig. 4.10.1. Test Set-up for Impedance, Method I

TABLE XXXIX

Impedance, Methods I and II

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	As desired
4.	RF Gain	4.	As desired
5.	IF Gain	5.	As desired
6.	AF Gain	6.	As desired
7.	Line Gain	7.	As desired
8.	Detector Mode	8.	Optional
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

4. Read the impedance indicated by the meter. If the meter indication is in terms of magnitude, $|Z|$, and phase angle, Θ, convert to real, R, and reactive, X, parts by the following equations:

$$Z = R + jX \quad ,$$

where

$$R = |Z| \cos \Theta \quad ,$$

$$X = |Z| \sin \Theta \quad .$$

5. Record the values of R and X as the terminal impedance at frequency f_o.

4.10.3.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Identify the terminals at which the measurement is made.

3. Record the measured values of $|Z|$ and Θ.

4. Record the calculated values of R and X.

4.10.3.4. MEASUREMENT ERRORS

The measurement uncertainty is given by the manufacturer's specifications on the impedance meter.

4.10.4. METHOD II - IMPEDANCE BRIDGE

The method uses a variable frequency signal generator, an impedance bridge, and a signal detector as shown in figure 4.10.2. The generator provides current for the bridge circuit, and the detector indicates the null condition. The bridge is adjusted for a null at the measurement frequency, and impedance is read from the dial settings on the bridge.

This method is suitable for measuring both input and output impedances, but for some receivers it must be used with care when measuring input impedance. The required signal level across the measuring terminals of the bridge is usually greater than for Method I, above, which can produce erroneous results because of nonlinear network components.

Measurement uncertainties as small as 4% are possible under best conditions, and range from 5% to 20% under typical conditions. The method uses moderately sophisticated but commonly available test equipment.

4.10.4.1. TEST EQUIPMENT REQUIRED

1. CW signal generator

2. Impedance bridge

3. Null detector

4.10.4.2. PROCEDURE

1. Connect the SIGNAL GENERATOR, IMPEDANCE BRIDGE, and NULL DETECTOR as shown in figure 4.10.2. Connect the bridge measuring terminals to the terminals of the receiver at which the measurement is to be made. For most situations, use a coaxial cable for this connection.

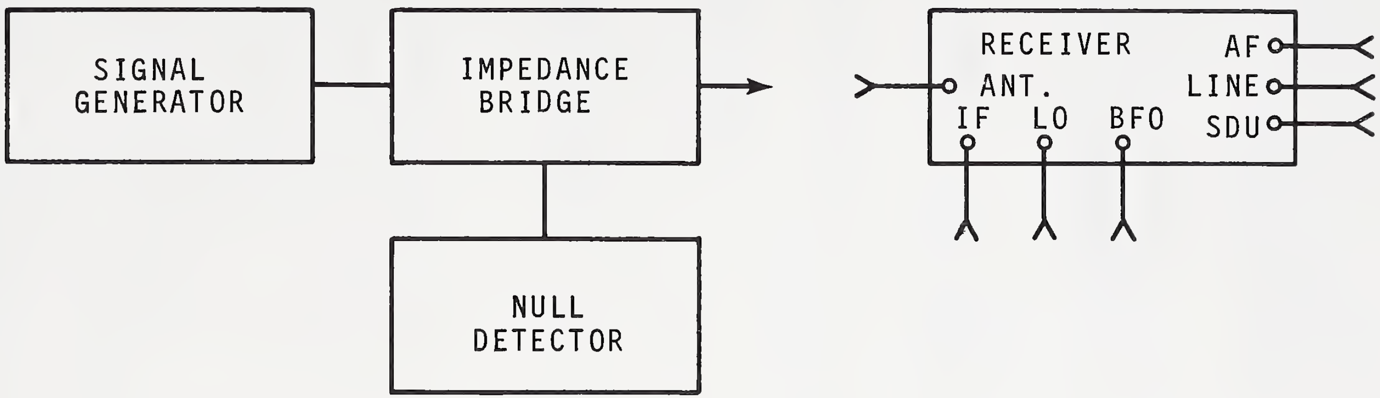

Fig. 4.10.2. Test Set-up for Impedance, Method II

2. Set receiver controls as given in Table XXXVIX, p. 324.

3. Tune the generator to the measurement frequency, f_o.

4. Adjust the generator output level to near maximum (e.g., between 0.1 and 1.0 volt).

5. Adjust the null detector sensitivity to indicate bridge output. If the null detector is tunable, tune it to f_o.

6. Adjust the bridge for an initial balance, following the manufacturer's instructions.

7. Measure the receiver impedance desired, following the manufacturer's instructions.

8. Record the indicated readings of R and X from the bridge dials.

9. Apply frequency corrections to the dial readings, if necessary.

10. Correct the measurement results for the effects of the cable connecting the bridge to the receiver terminals, following the manufacturer's instructions. This usually entails measuring the parameters of the cable, and applying these results by means of formulae or charts supplied by the manufacturer.

11. Record the corrected values of R and X as the terminal impedance at frequency f_o.

12. Reduce the generator output level by 10 dB, and repeat Steps 6 through 11. If the measurement results differ from the original, reduce the generator output further until the results do not change or until they are degraded by noise. The variation

of R and/or X with bridge drive level is an indication of excessive signal at the measurement terminals. The values obtained at the lowest drive level are normally the most nearly correct. If a stable measurement result cannot be obtained because of this cause, use Method I, above.

4.10.4.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Identify the terminals at which the measurement is made.

3. Record the calculated values of R and X.

4.10.4.4. MEASUREMENT ERRORS

The measurement uncertainty is given by the manufacturer's specifications on the impedance meter.

4.11. STANDING WAVE RATIO

The requirements for VSWR measurements on surveillance receivers usually pertain to the antenna input and IF output ports. Because the ports connect to active circuits within the receiver, measurement methods are required that do not significantly alter the VSWR whose value is to be measured.

4.11.1. DEFINITION

a. Standing wave ratio is the ratio of the amplitude of a standing wave at an antinode to the amplitude at a node. (IEEE STD 100-1972)

b. The voltage standing wave ratio, VSWR, at a specified port of a receiver is the ratio of (a) the absolute value of the port's reflection coefficient, $|\Gamma|$, plus unity (1), to (b) unity minus the absolute value of the port's reflection coefficient.

$$\mathrm{VSWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|} .$$

c. The reflection coefficient, Γ, at a port is given by the equation

$$\Gamma = \frac{Z_p - Z_r}{Z_p + Z_r} ,$$

where Z_p = complex impedance looking into the port,

Z_r = reference impedance.

Note: From the above definitions, VSWR can be expressed by the normalized relationship.

$$\mathrm{VSWR} = \frac{Z_p}{Z_r} .$$

When $Z_p < Z_r$, the VSWR at the port is usually expressed by the relationship

$$\mathrm{VSWR} = \frac{Z_r}{Z_p} .$$

4.11.2. PURPOSE

The purpose of this measurement method is to measure the VSWR at the accessible ports of surveillance receivers. VSWR is a measure of the receiver's ability to transfer power to and from the circuits connected to these ports.

4.11.3. METHOD

The method uses a variable frequency vector impedance meter as shown in figure 4.11. The impedance meter contains its own signal source, detector networks, and output display. VSWR is obtained by first measuring the impedance at the port, and then computing VSWR by means of a Z-Θ chart.

Measurement uncertainties as small as 6% are possible under best conditions, and range from approximately 8% to 20% under typical conditions. The method uses sophisticated but commonly available test equipment.

4.11.4. TEST EQUIPMENT REQUIRED

1. Vector impedance meter

2. Z-Θ chart paper (or Smith chart paper)

4.11.5. PROCEDURE

1. Connect the VECTOR IMPEDANCE METER probe to the terminals of the receiver at which the measurement is to be made.

2. Set receiver controls as given in Table XXXX.

3. Tune the vector impedance meter to the measurement frequency, f_o.

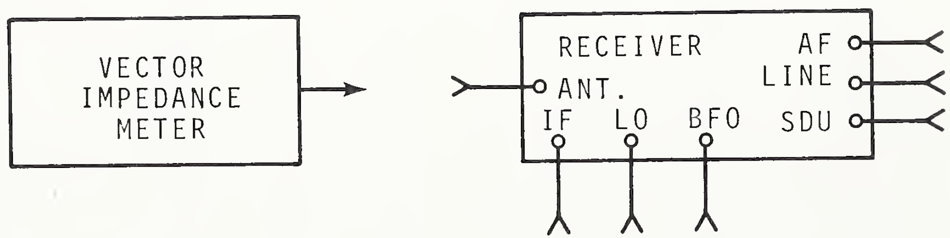

Fig. 4.11. Test Set-up for Standing Wave Ratio

TABLE XXXX

Standing Wave Ratio

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	As desired
4.	RF Gain	4.	As desired
5.	IF Gain	5.	As desired
6.	AF Gain	6.	As desired
7.	Line Gain	7.	As desired
8.	Detector Mode	8.	Optional
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

4. Read the impedance indicated by the meter.

5. Plot $|Z|$ and Θ on Z-Θ CHART PAPER. If the impedance meter gives the real part, R, and imaginary part, X, of Z, normalize these values and plot on a Smith chart.

6. Determine the VSWR circle on the Z-Θ chart (or Smith chart) by constructing a circle whose center is at the origin of the chart and which passes through the point $|Z|$, Θ (or R and X, normalized).

7. With Z-Θ paper, determine the value of VSWR by locating the point of intersection between the Z/Z_r - axis and the circle. Read the value for which $Z/Z_r > 1$. (On the Smith chart, the VSWR is the intersection of the circle and the real axis.) This is the VSWR at the port. Express VSWR as a ratio of this number to unity (e.g., 1.5:1 or 3:1, etc.).

4.11.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Identify the terminals at which the measurement is made.

3. Record the measured values of $|Z|$ and Θ.

4. Record the calculated values of R and X.

5. Record the value of VSWR, determined from Z-Θ chart.

4.11.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, $\Delta|Z|$, in the measured value of $|Z|$

2. Uncertainty, $\Delta\Theta$, in the measured value of Θ

3. Uncertainty, Δ(VSWR), in the reading resolution of the points on the Z-Θ chart

The total relative uncertainty, Δ VSWR (%), in percent, in the VSWR of the specified receiver port, is given by the equation

$$\Delta\text{VSWR}\ (\%) = \left(\frac{\Delta|Z|}{|Z|} \times 100\right) + \left(\frac{\Delta\Theta}{\Theta} \times 100\right) + \left(\frac{\Delta\text{VSWR}}{\text{VSWR}} \times 100\right) .$$

Uncertainties $\Delta|Z|$ and $\Delta\Theta$ are obtained from the manufacturer's specifications on the impedance meter. Uncertainty Δ (VSWR) is estimated from the readability of the plot on the Z-Θ chart.

4.12. DETECTORS

Procedures for testing the characteristics of various types of detectors separately from the receiver as a system are not given in this handbook because they have limited value in the evaluation of receiver performance. Detector performance is an integral part of overall receiver performance. Thus, the procedures given in Sections 4.1 through 4.11 either do, or can, include the effects of the selected detector mode on the measured receiver parameter.

The procedures cited above are given explicitly only for AM and/or FM detector modes. A portion of those procedures also applies to testing done in the CW and SSB detector modes. Specifically, these include the following:

Section 4.1.1. Gain-limited Sensitivity
Section 4.1.2. 6 dB SN/N Sensitivity
Section 4.1.3. 12 dB SINAD Sensitivity
Section 4.3.1. Power Gain
Section 4.3.2. Dynamic Range
Section 4.3.3. Automatic Gain Control
Section 4.4.8. Cross Modulation
Section 4.4.7. Desensitization

To test in the CW or SSB modes, the procedure for the AM mode is followed with the exception of the choice of detector and BFO settings, which are selected as required by the test.

4.13. AUDIO SECTION

Although the audio amplifier portion of a receiver is only one of several sections through which a signal must pass, its characteristics are normally measured separately from other sections. The characteristics of primary interest are gain, frequency response, power output, linearity, distortion, hum, and noise. Methods for measuring these parameters are discussed separately in this section. Also included in this section are measurement methods for noise limiter and squelch circuits.

4.13.1. AUDIO GAIN

4.13.1.1. DEFINITION

Audio gain is the ratio, in decibels, of (a) the power that an audio amplifier delivers to a specified load under specified operating conditions to (b) the available power of a specified source.

4.13.1.2. PURPOSE

The purpose of this measurement method is to measure the gain of the audio section of surveillance receivers. This parameter is a measure of the receiver's ability to amplify a demodulated signal into a usable output signal of acceptable quality.

4.13.1.3. METHOD

The method uses an audio signal generator and a distortion analyzer as shown in figure 4.13.1. The signal generator supplies a known input voltage at the measurement frequency, f_o, to the audio section of the receiver. The distortion analyzer measures the level and distortion percentage of the audio output power.

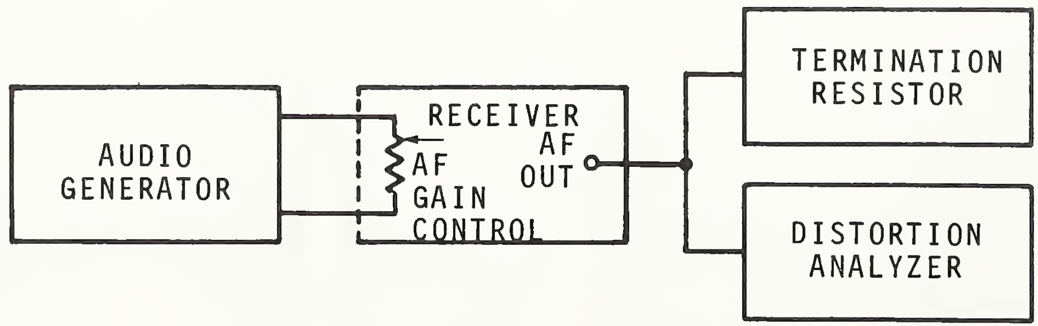

Fig. 4.13.1. Test Set-up for Audio Gain

The generator's available output power is adjusted to a level that produces either rated audio output power or an audio output power that contains 10% distortion. The ratio of receiver output power to generator available power in decibels, is the audio gain of the receiver at this distortion level.

Measurement uncertainties as small as 0.5 dB are possible under best conditions, and range from approximately 0.7 dB to 2 dB under typical conditions. The method uses commonly available test equipment.

4.13.1.4. TEST EQUIPMENT REQUIRED

1. Audio signal generator

2. Termination resistor for receiver audio output port

3. Distortion analyzer

4.13.1.5. PROCEDURE

1. Connect the output port of the SIGNAL GENERATOR through a cable to the receiver's AF gain control. Break the connection between this gain control and the circuit preceding the control.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set the distortion analyzer on a range to indicate the rated output power, P_o.

4. Tune the signal generator to the measurement frequency, f_o. This is normally 1000 Hz.

5. Adjust the AF gain control to maximum gain setting.

6. Adjust the output level of the signal generator to produce either rated audio output power or 10% distortion in the termination resistor as measured with the distortion analyzer.

7. Measure the total audio output power, P_o, (i.e. signal plus noise plus distortion) in the termination resistor, R_ℓ, with the distortion analyzer. Use the equation

$$P_o = \frac{E_o^2}{R_\ell} \quad ,$$

where E_o is the voltage reading of the analyzer.

8. Determine the available power, P_a, from the generator. Use the equation

$$P_a = \frac{E_i^2}{4\ R_g} \quad ,$$

where E_i is the open circuit voltage and R_g is the output impedance of the generator.

9. Calculate the gain, G, in decibels, by the equation

$$G(dB) = 10 \log \frac{P_o}{P_a} \quad .$$

G(dB) is the audio gain of the receiver, at the measurement frequency, f_o, for rated audio output power or 10% distortion in the termination resistor as measured with the distortion analyzer.

4.13.1.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in hertz or kilohertz.

2. Record the total audio output power, P_o, in milliwatts or watts.

3. Record the generator available power, P_a, in milliwatts.

4. Record the audio gain, G, in decibels.

4.13.1.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔP_o, in the measured value of P_o

2. Uncertainty, ΔP_a, in the measured value of P_a

The total relative uncertainty, $\Delta G(dB)$, in decibels, in the gain, G, is given approximately, for small uncertainties, by the equation

$$\Delta G(dB) = 10 \log \left(1 + \frac{\Delta P_o}{P_o} + \frac{\Delta P_a}{P_a}\right) .$$

Uncertainties ΔP_o and ΔP_a are obtained from the manufacturer's specifications on the distortion analyzer and signal generator, respectively.

4.13.2. AUDIO FREQUENCY RESPONSE

4.13.2.1. DEFINITION

Audio frequency response is the gain characteristic as a function of frequency of the audio section of the receiver.

4.13.2.2. PURPOSE

The purpose of these measurement methods is to measure the audio frequency response of surveillance receivers. This characteristic is a measure of the spectrum of audio frequencies which the receiver will amplify with significant gain.

Four methods are discussed. The first three use audio frequency signals, and deal with the audio section alone. The fourth method uses a modulated RF signal, and therefore includes the selectivity effect of the receiver pre-detection stages. The third method uses a swept-frequency technique, whereas the remaining methods use the point-by-point technique.

4.13.2.3. METHOD - AF POINT-BY-POINT - I

This method uses a variable frequency audio signal generator, an accurate frequency meter, and a power meter or true rms voltmeter as shown in figure 4.13.2.1. The signal generator supplies a known input voltage at a variety of frequencies to the audio section of the receiver. The power meter or voltmeter measures the audio output level. The generator output level is adjusted to maintain constant output power from the receiver. The gain of the audio section is measured at various selected frequencies. Audio frequency response is the graphical plot of audio gain versus measurement frequency.

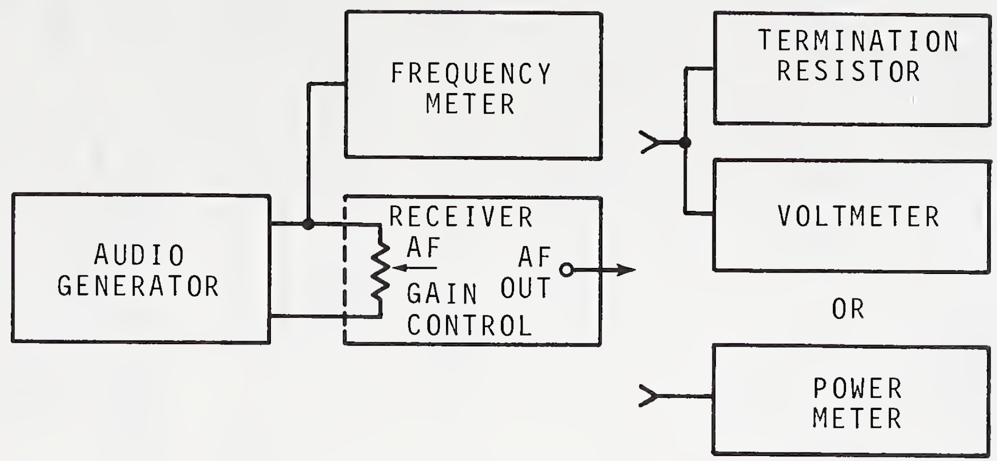

Fig. 4.13.2.1. Test Set-up for Audio Frequency Response, Point-by-Point Method I

Measurement uncertainties as small as 0.5 dB are possible under best conditions, and range from approximately 0.7 dB to 2 dB under typical conditions. The method uses commonly available test equipment.

4.13.2.3.1. TEST EQUIPMENT REQUIRED

1. Audio signal generator

2. Frequency meter

3. Termination resistor for receiver audio output port

4a. AF power meter

OR,

4b. A.C. voltmeter

4.13.2.3.2. PROCEDURE

1. Connect the output port of the SIGNAL GENERATOR through a cable to the receiver's AF gain control. Break the connection between this gain control and the circuit preceding the control.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the A.C. VOLTMETER across this resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \ .$$

OR,

3b. Set the power meter on a range to indicate the reference output power, P_o.

4. Tune the signal generator to a frequency, f_m, near that at which the audio gain is maximum.

5. Adjust the AF gain control to maximum gain setting.

6. Adjust the output level of the signal generator to produce reference audio output power, P_o.

7. Determine the available power, P_a, from the generator. Use the equation

$$P_a = \frac{E_i^2}{4 R_g} \ ,$$

where E_i is the open circuit voltage and R_g is the output impedance of the generator.

8. Calculate the gain, $G(f_m)$, in decibels, at frequency f_m, by the equation

$$G(f_m) = 10 \log \frac{P_o}{P_a} \ .$$

9. Tune the generator to a new measurement frequency above (or below) f_m. The frequency change is somewhat arbitrary and depends upon the degree of detail with which it is desired to know the frequency response.

10. Adjust the generator output level to produce reference audio output power, P_o.

11. Determine the generator available power, P_a, at the new measurement frequency.

12. Calculate the audio gain as in Step 8, above.

13. Proceed as indicated in Steps 9 and 12, above, until the desired audio frequency range is covered, or until the measured audio gain is unity (0 dB).

14. Plot the audio gain, G, in decibels, as a function of measurement frequency on rectilinear graph paper. This plot is the audio frequency response of the receiver.

4.13.2.3.3. DATA REQUIRED

1. Record the measurement frequencies, f, in hertz or kilohertz.

2. Record the reference audio output power, P_o, in milliwatts or watts.

3. Record the generator available powers, P_a, in milliwatts or watts.

4. Record the audio gain, G, in decibels.

4.13.2.3.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔP_o, in the measured value of P_o

2. Uncertainty, ΔP_a, in the measured value of P_a

The total relative uncertainty, ΔG(dB), in decibels, in the gain, G, is given approximately, for small uncertainties, by the equation

$$\Delta G \text{ (dB)} = 10 \log \left(1 + \frac{\Delta P_o}{P_o} + \frac{\Delta P_a}{P_a}\right) .$$

Uncertainties ΔP_o and ΔP_a are obtained from the manufacturer's specifications on the distortion analyzer and signal generator, respectively.

4.13.2.4. METHOD - AF POINT-BY-POINT - II

This method uses a variable frequency audio signal generator, an accurate frequency meter, and a power meter or true rms voltmeter as shown in figure 4.13.2.2. The signal generator supplies a constant known input voltage at a variety of frequencies to the audio section of the receiver. The power meter or voltmeter measures the audio output level. The gain of the audio section is measured at various selected frequencies. Audio frequency response is the graphical plot of audio gain versus measurement frequency.

Measurement uncertainties as small as 0.5 dB are possible under best conditions, and range from approximately 0.7 dB to 2 dB under typical conditions. The method uses commonly available test equipment.

4.13.2.4.1. TEST EQUIPMENT REQUIRED

1. Audio signal generator

2. Frequency meter

3. Termination resistor for receiver audio output port

4a. AF power meter

OR,

4b. A.C. voltmeter

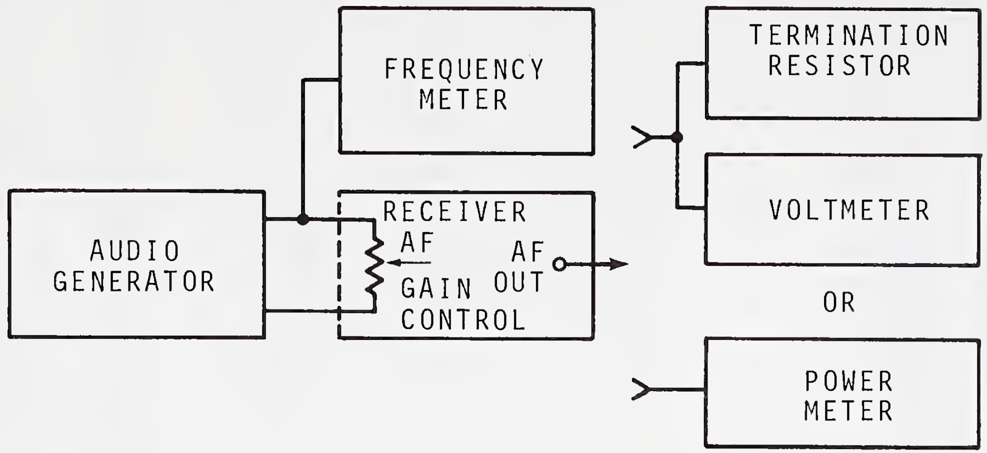

Fig. 4.13.2.2. Test Set-up for Audio Frequency Response, Point-by-Point Method II

4.13.2.4.2. PROCEDURE

1. Connect the output port of the SIGNAL GENERATOR through a cable to the receiver's AF gain control. Break the connection between this gain control and the circuit preceding the control.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the A.C. VOLTMETER across this resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell}\ .$$

OR,

3b. Set the power meter on a range to indicate the reference output power, P_o.

4. Tune the signal generator to a frequency, f_m, near that at which the audio gain is maximum.

5. Adjust the AF gain control to maximum gain setting.

6. Adjust the output level of the signal generator to produce reference audio output power, P_o.

7. Determine the available power, P_a, from the generator. Use the equation

$$P_a = \frac{E_i^2}{4 R_g} ,$$

where E_i is the open circuit voltage and R_g is the output impedance of the generator.

8. Calculate the gain, $G(f_m)$, in decibels at frequency f_m, by the equation

$$G (f_m) = 10 \log \frac{P_o}{P_a} .$$

9. Tune the generator to a new measurement frequency above (or below) f_m. The frequency change is somewhat arbitrary and depends upon the degree of detail with which it is desired to know the frequency response.

10. With the generator available power the same as in Step 7, above, measure the power, P_d, delivered to the termination resistor at the new measurement frequency.

11. Calculate the audio gain by the equation

$$G (f_m) = 10 \log \frac{P_d}{P_a} .$$

12. Proceed as indicated in Steps 9 through 11, above, until the desired audio frequency range is covered, or until the measured audio gain is unity (0 dB).

13. Plot the audio gain, G, in decibels, as a function of measurement frequency on rectilinear graph paper. This plot is the audio frequency response of the receiver.

4.13.2.4.3. DATA REQUIRED

1. Record the measurement frequencies, f, in hertz or kilohertz.

2. Record the delivered audio output power, P_d, in milliwatts or watts.

3. Record the generator available power, P_a, in milliwatts.

4. Record the audio gain, G, in decibels.

4.13.2.4.4. MEASUREMENT ERRORS

The principal sources of measurement area are the following:

1. Uncertainty, ΔP_d, in the measured value of P_d

2. Uncertainty, ΔP_a, in the measured value of P_a

The total relative uncertainty, $\Delta G(\mathrm{dB})$, in decibels, in the gain, G, is given approximately, for small uncertainties, by the equation

$$\Delta G\ (\mathrm{dB}) = 10 \log \left(1 + \frac{\Delta P_d}{P_d} + \frac{\Delta P_a}{P_a} \right) .$$

Uncertainties ΔP_d and ΔP_a are obtained from the manufacturer's specifications on the distortion analyzer and signal generator, respectively.

4.13.2.5. METHOD - AF SWEPT-FREQUENCY

This method uses a swept-frequency audio signal generator and an oscilloscope as shown in figure 4.13.2.3. The generator supplies a swept frequency signal of constant amplitude to the receiver. The oscilloscope displays the receiver's output signal which represents the frequency response of the receiver's audio section. Also, the generator supplies a linear sweeping voltage for the horizontal deflection circuits of the oscilloscope. A camera is used to photograph the oscilloscope display to obtain a permanent record of the audio frequency response characteristic.

This is a qualitative measurement method, and measurement uncertainties may range from 10% to 100%, depending upon circumstances. The method uses equipment that is commercially available, but which may not be included in the average laboratory inventory.

4.13.2.5.1. TEST EQUIPMENT REQUIRED

1. Swept-frequency audio signal generator
2. Termination resistor for receiver audio output port
3. Linear AF detector
4. Cathode-ray oscilloscope
5. Oscilloscope camera

4.13.2.5.2. PROCEDURE

1. Connect the output port of the SWEPT-FREQUENCY GENERATOR through a cable to the receiver's AF gain control. Break the connection between this gain control and the circuit preceding the control.

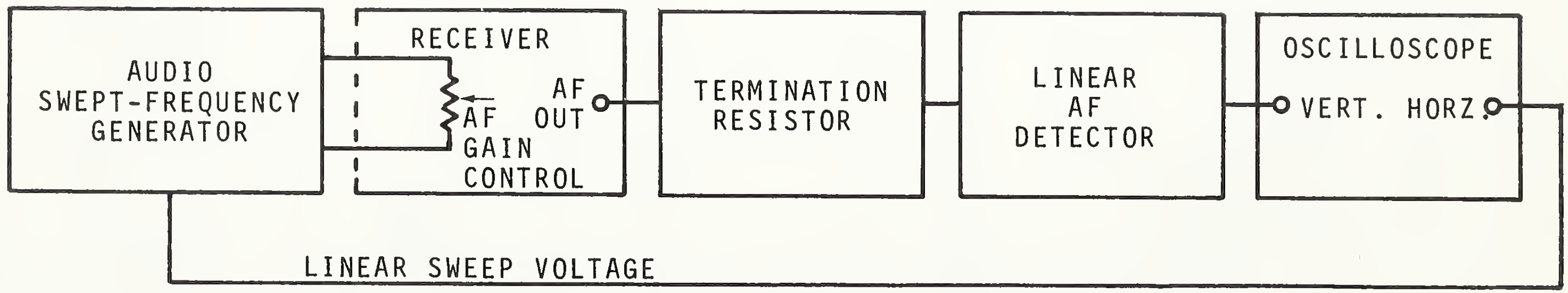

Fig. 4.13.2.3. Test Set-up for Audio Frequency Response, Swept-Frequency Method

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver.

3. Interconnect the receiver output, DETECTOR, and OSCILLOSCOPE as shown in figure 4.13.2.3.

4. Connect the sweeping voltage output from the generator to the horizontal input terminals of the oscilloscope.

5. Adjust the output level of the sweep generator, the sweep width of the sweep generator, and the vertical and horizontal gains of the oscilloscope to produce a display of the detected receiver output signal having sufficient size to fill the square measurement area of the oscilloscope screen. The generator output level is adjusted to provide a convenient or selected input signal voltage, E_g, to the audio section that is within the linear range of the audio amplifier.

6. Having obtained a suitable display, photograph or trace the display. This is the audio frequency response of the receiver.

7. Calibrate the vertical axis, in volts per centimeter, with a signal from a square-wave calibration source. Record this information on the back of the photograph.

8. Calibrate the horizontal axis, in hertz per centimeter, with the marker generators provided in the sweep generator. Record this information on the back of the photograph.

4.13.2.5.3. DATA REQUIRED

1. Record the generator input signal voltage, E_g, in volts.

2. Record the vertical scale factor in volts per centimeter.

3. Record the horizontal scale factor in hertz per centimeter.

4.13.2.5.4. MEASUREMENT ERRORS

Because this is a qualitative measurement method, no error analysis is given. However, the measurement uncertainty may be estimated from the manufacturer's specifications on the test equipment used.

4.13.2.6. METHOD - RF POINT-BY-POINT

This method uses an amplitude or frequency modulated signal generator and a power meter or true rms voltmeter as shown in figure 4.13.2.4. The signal generator supplies a known input voltage to the receiver at the measurement frequency, modulated with a known audio frequency signal. The voltmeter or power meter indicates the receiver output signal level.

The audio modulation frequency is varied while maintaining a constant modulation percentage or deviation, and the receiver output level is measured as a function of this frequency. The relative response of the output signal is the audio frequency response of the overall receiver.

Measurement uncertainties as small as 0.5 dB are possible under best conditions, and range from approximately 0.7 dB to 2 dB under typical conditions. The method uses commonly available test equipment.

4.13.2.6.1. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Audio frequency signal generator

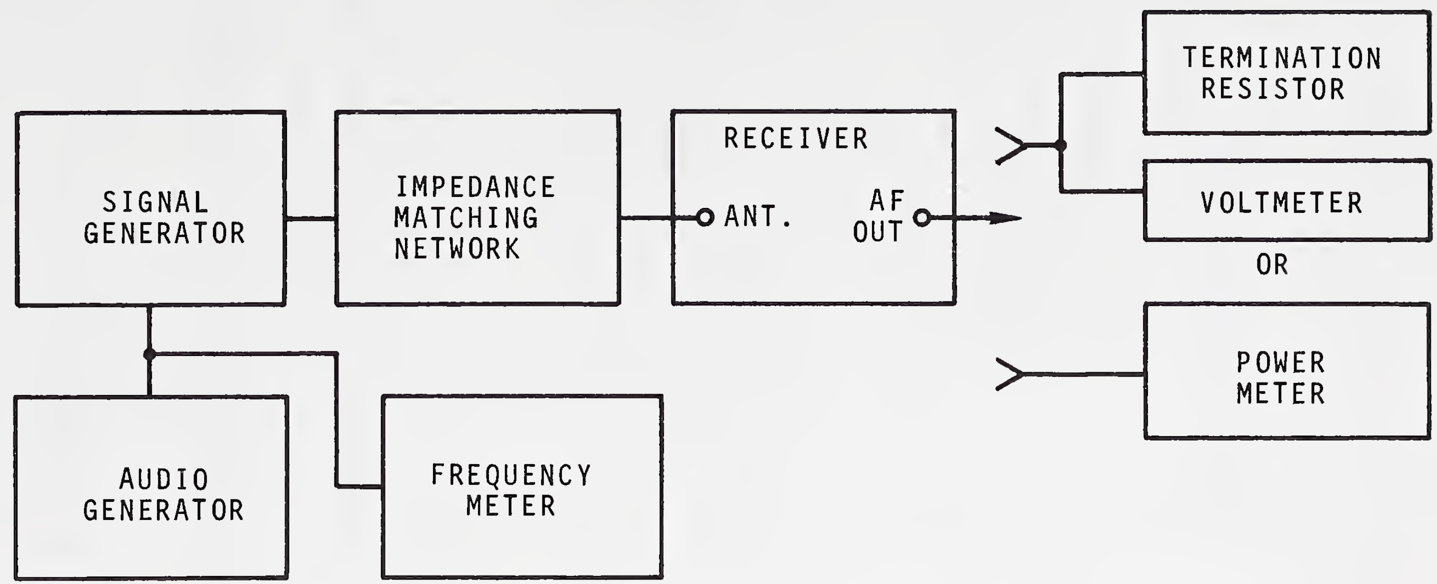

Fig. 4.13.2.4. Test Set-up for Audio Frequency Response, RF Method

3. Frequency meter

4. Input impedance matching network

5. Termination resistor for receiver audio output port

6a. AF power meter

OR,

6b. True rms voltmeter

4.13.2.6.2. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

OR,

3b. Set the power meter on a range to indicate the reference output power, P_o.

4. Set receiver controls as given in Table XXXXI.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6a. If the measurement is to be made on an AM receiver, adjust the amplitude modulation in the signal generator to 30% at 1000 Hz, using the external AUDIO SIGNAL GENERATOR.

OR,

6b. If the measurement is to be made on an FM receiver, adjust the frequency modulation in the signal generator to ± 60% of rated system deviation at 1000 Hz, using the external AUDIO SIGNAL GENERATOR.

7. Adjust the output level of the signal generator to a value within the dynamic range (cf.) of the receiver, and the AF gain control to a value within the linear range of its audio amplifier, to produce reference audio output power, P_o.

8. Tune the audio signal generator to a new measurement frequency, f, above (or below) 1000 Hz. The frequency change is somewhat arbitrary and depends upon the degree of detail with which it is desired to know the frequency response.

9. Measure the power, P_d, delivered to the termination resistor, R_ℓ, at this new modulation frequency.

TABLE XXXXI

Audio Frequency Response, RF Method

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM or FM, as required
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	OFF
15.	AGC/MGC Mode Switch	15.	AGC
16.	Meter Switch	16.	Optional

10. Proceed as indicated in Steps 8 and 9, above, until the desired audio frequency range is covered, or until the measurement results become meaningless because of insufficient signal-to-noise ratio.

11. Calculate the relative output level by selecting the maximum measured delivered power, $P_d(\max)$, and calculating the ratios, $R(f)$, in decibels, of $P_d(\max)$ to each of the other measured levels at audio frequencies, f. Use the equation,

$$R(f) = \frac{P_d(\max)}{P_d(f)} \quad ,$$

where $P_d(f)$ is the measured delivered power at frequency f.

12. Plot the power ratio, R, in decibels, as a function of audio frequency, f, on rectilinear graph paper. This plot is the audio frequency response of the receiver.

4.13.2.6.3. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_ℓ, in ohms, connected to receiver audio output terminals.

4a. Record the output voltage, E_o in volts.

OR,

4b. Record the reference output power, P_o, in watts.

5. Record the open circuit signal voltage, E_i, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

6. Record the audio modulation frequencies, f, in hertz or kilohertz.

7. Record the delivered audio output power, P_d, in milliwatts or watts.

8. Record the ratio, R(f), in decibels, for each modulation frequency, f.

4.13.2.6.4. MEASUREMENT ERRORS

The principal measurement error is the uncertainty, ΔP_d, in the measured value of P_d. The total uncertainty, $\Delta R(dB)$, in decibels, in the ratio, R(f), is given approximately, for small measurement uncertainties, by the equation

$$\Delta R \text{ (dB)} = 10 \log \left(1 + \frac{2\Delta P_d}{P_d} \right) .$$

Uncertainty ΔP_d is obtained from the manufacturer's specifications on the AF power meter or rms voltmeter.

4.13.3. AUDIO LINEARITY

4.13.3.1. DEFINITIONS

a. Linearity of a transducer is the deviation of its transfer function from a constant value as function of one or more signal parameters.

b. Transfer function is a relationship between one system variable and another that enables the second variable to be determined from the first. (57 IRE 26.S2)

This section on audio linearity is concerned with the change of audio gain as a function of audio signal level.

4.13.3.2. PURPOSE

The purpose of this measurement method is to measure the linearity of the audio section of surveillance receivers. This parameter is a measure of the receiver's ability to amplify a demodulated signal into an output signal of acceptable quality.

4.13.3.3. METHOD

The method uses an audio signal generator and a power meter or true rms voltmeter as shown in figure 4.13.3. The signal generator supplies a known input voltage at the measurement frequency, f_o, to the audio section of the receiver. The power meter or voltmeter measures the audio output level.

The audio output power is measured for various levels of input signal. A plot of output versus input power displays the deviation of the transfer function from a constant value.

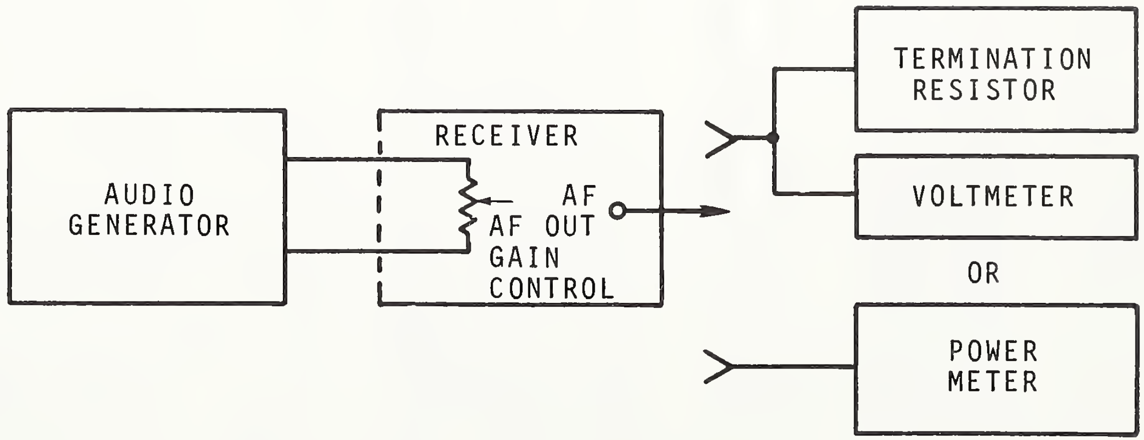

Fig. 4.13.3. Test Set-up for Audio Linearity

This method does not take into account the distortion produced by the audio amplifier as it is operated in the non-linear region of its transfer function.

Measurement uncertainties as small as 0.5 dB are possible under best conditions, and range from approximately 0.7 dB to 2 dB under typical conditions. The method uses commonly available test equipment.

4.13.3.4. TEST EQUIPMENT REQUIRED

1. Audio signal generator

2. Termination resistor for receiver audio output port

3a. AF power meter

OR,

3b. True rms voltmeter

4.13.3.5. PROCEDURE

1. Connect the output port of the SIGNAL GENERATOR through a cable to the receiver's AF gain control. Break the connection between this gain control and the circuit preceding the control.

2a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_{ℓ}, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

OR,

2b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

3. Tune the signal generator to the measurement frequency, f_o. This is normally 1000 Hz.

4. Adjust the AF gain control to maximum gain setting.

5. With the signal generator output set at zero, measure the output power, P_n, from the receiver. This will be entirely noise.

6. Adjust the output level of the generator to produce an audio output power, P_d, that is 100 times (20dB above) P_n.

7. Measure the total audio output power, P_d, (i.e., signal plus noise plus distortion) delivered to the termination resistor, R_ℓ. If P_d is measured with the voltmeter, use the equation

$$E_o = \sqrt{P_d R_\ell},$$

where E_o is the voltage across R_ℓ.

8. Determine the available power, P_a, from the generator. Use the equation

$$P_a = \frac{E_i^2}{4 R_g},$$

where E_i is the open circuit voltage and R_g is the output impedance of the generator.

9. Increase the output level of the generator to produce an audio output level that is a selected amount greater than P_d, Step 6. The amount selected is somewhat arbitrary, and depends upon the degree of detail with which it is desired to know the transfer function.

10. Measure the delivered power, P_d, of Step 9, above, and calculate the corresponding available power, P_a, from the generator.

11. Proceed as indicated in Steps 9 and 10, above, until the desired power range is covered. Suitable stopping points are (1) when the delivered power equals the receiver's rated audio output power, P_o, or (2) when the distortion level of the delivered power reaches a selected value, e.g., 15%.

12. Plot the delivered power, in watts or milliwatts, against the generator available power, in milliwatts or microwatts, on rectilinear or log-log graph paper (not semi-log paper). This plot displays the linearity of the receiver's audio section. A point of reference is the generator available power level at which the plot falls 1 dB below a straight-line extrapolation of the low-level portion of the curve. This input level is usually expressed as voltage across the input terminals of the amplifier.

4.13.3.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in hertz or kilohertz.

2. Record the audio output powers, P_n and P_d, in milliwatts or watts.

3. Record the generator available powers, P_a, in milliwatts or watts.

4.13.3.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainties, ΔP_n and ΔP_d, in the measured value of P_a and P_d

2. Uncertainty, ΔP_a, in the measured value of P_a

The relative uncertainties, ΔP_n (%), ΔP_d (%), and ΔP_a (%) in percent, in the measured values of P_n, P_d, and P_a, respectively, are given by the equations

$$\Delta P_n\ (\%) = \frac{\Delta P_n}{P_n} \times 100 ,$$

$$\Delta P_d\ (\%) = \frac{\Delta P_d}{P_d} \times 100 ,$$

$$\Delta P_a\ (\%) = \frac{\Delta P_a}{P_a} \times 100 .$$

Uncertainties ΔP_n, ΔP_d, and ΔP_a are obtained from the manufacturer's specifications on the instruments used to measure P_n, ΔP_d, and ΔP_a.

4.13.4. AUDIO DISTORTION

4.13.4.1. DEFINITION

Distortion is an undesired change in waveform. (IEEE STD 100-1972)

The types of distortion that can occur in an audio amplifier are the following:

a. Amplitude

b. Amplitude-frequency

c. Delay

d. Harmonic

e. Intermodulation

f. Phase

Types a, d, and e are normally caused by a nonlinearity in the real part of the transfer function. Types b, c, and f are normally caused by nonlinearity in the imaginary part of the transfer function.

Distortion is expressed as a percent, referenced to the level of the audio output power.

4.13.4.2. PURPOSE

The purpose of this measurement method is to measure the audio distortion of surveillance receivers caused by NONLINEARITY IN THE

REAL PART of the transfer function of the receiver's audio section. The types of distortion generated are amplitude, harmonic, and intermodulation. Distortion is a measure of the receiver's ability to amplify a demodulated signal into an output signal of acceptable quality.

4.13.4.3. METHOD

The method uses an audio signal generator and a distortion analyzer as shown in figure 4.13.4. The signal generator supplies a known input voltage at the measurement frequency, f_o, to the audio section of the receiver. The distortion analyzer measures the percentage distortion at rated audio output power.

Measurement uncertainties as small as 8% are possible under best conditions, and range from approximately 10% to 50% under typical conditions. The method uses commonly available test equipment.

4.13.4.4. TEST EQUPMENT REQUIRED

1. Audio signal generator

2. Termination resistor for receiver audio output port

3. Distortion analyzer

4.13.4.5. PROCEDURE

1. Connect the output port of the SIGNAL GENERATOR through a cable to the receiver's AF gain control. Break the connection between this gain control and the circuit preceding the control.

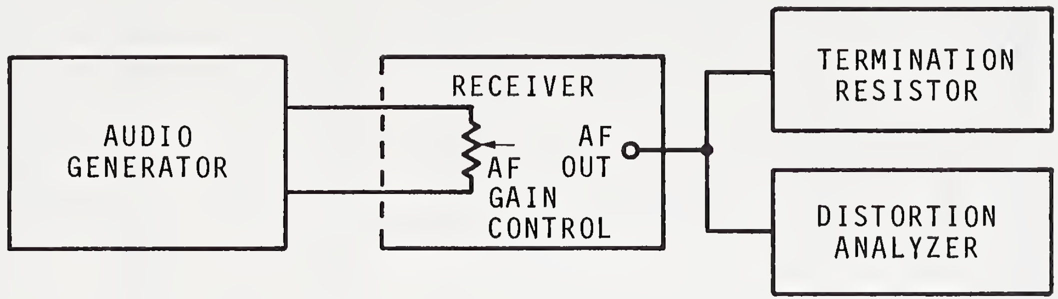

Fig. 4.13.4. Test Set-up for Audio Distortion

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set the distortion analyzer on a range to indicate the rated output power, P_o.

4. Tune the signal generator to the measurement frequency, f_o. This is normally 1000 Hz.

5. Adjust the AF gain control to maximum gain setting.

6. Adjust the output level of the signal generator to produce reference audio output power, P_o.

7. Adjust the distortion analyzer so that the 1000 Hz rejection filter tunes out the 1000 Hz modulation from the signal generator.

8. Measure the noise plus distortion output power, $P_{(n+d)}$.

9. Measure the signal voltage, E_i, in millivolts, across the AF gain control.

10. Calculate the percent distortion, D(%), by the equation

$$D(\%) = \frac{P_{(n+d)}}{P_o} \times 100 \quad .$$

This is the distortion of the amplifier for a signal of amplitude E_i at frequency f_o.

4.13.4.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in hertz or kilohertz.

2. Record the input signal voltage, E_i, in millivolts.

3. Record the total audio output power, P_o, in milliwatts or watts.

4. Record the noise plus distortion output power, P_{n+d}, in milliwatts or watts.

5. Record the percent distortion, D(%).

4.13.4.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔP_o, in the measured value of P_o

2. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}

The total relative uncertainty, $\Delta D(\%)$, expressed as a percent, in the percent distortion, D(%), is given by the equation

$$\Delta D\ (\%) = \left(\frac{\Delta P_o}{P_o} \times 100\right) + \left(\frac{\Delta P_{n+d}}{P_{n+d}} \times 100\right) \quad .$$

Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.13.5. HUM AND NOISE

4.13.5.1. DEFINITION

Hum and noise are the low-pitched composite tone at the receiver output caused by fluctuations in the power supply. Note: Noise is any audible undesired signal present at the output. (IEEE Std 100-1972)

4.13.5.2. PURPOSE

The purpose of this measurement method is to measure the maximum hum and noise power output of surveillance receivers due to sources in the detector, audio, and power supply circuits. Hum and noise power level is expressed as the ratio, in decibels, below the receiver's reference audio output power level, P_o. This method does not include hum and noise from sources in the RF or IF circuits. The amount of hum and noise power is a measure of the receiver's ability to produce an output signal of acceptable quality.

4.13.5.3. METHOD

The method uses a power meter or true rms voltmeter as shown in figure 4.13.5. The receiver gain controls are adjusted for minimum RF/IF gain and maximum AF gain, and the total output power is measured. This is the maximum hum and noise level of the receiver's audio amplifier.

Measurement uncertainties as small as 0.5 dB are possible under best conditions, and range from approximately 0.7 dB to 2 dB under typical conditions. The method uses commonly available test equipment.

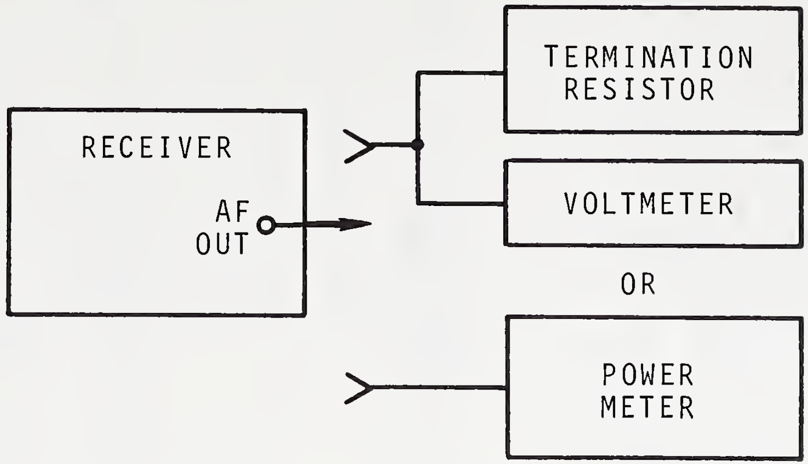

Fig. 4.13.5. Test Set-up for Audio Hum and Noise

4.13.5.4. TEST EQUIPMENT REQUIRED

1. Termination resistor for receiver audio output port

2a. AF power meter

OR,

2b. True RMS voltmeter

4.13.5.5. PROCEDURE

1a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across this resistor.

OR,

1b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

2. Adjust the RF/IF gain controls for minimum gain setting.

3. Adjust the AF gain control for maximum gain setting.

4. Set detector switch in desired position. If CW or SSB mode is selected, set BFO for desired operating conditions.

5. Measure the output power, P_n, from the receiver. If the output level is measured with the voltmeter, compute the output power by the relation

$$P_n = \frac{E_o^{\,2}}{R_\ell} ,$$

where E_o is the true rms output voltage across R_ℓ .

6. Calculate the ratio, R_n(dB), in decibels, of the hum and noise power, P_n, to the reference audio output power, P_o, by the equation

$$R_n \text{ (dB)} = 10 \log \frac{P_n}{P_o} .$$

R_n(dB) is the hum and noise power, relative to the receiver's reference output power level, for the chosen operating conditions.

4.13.5.6. DATA REQUIRED

1. Record the reference audio output power, P_o, in milliwatts or watts.

2. Record the measured hum and noise power, P_n, in milliwatts or watts.

3. Record the power ratio, R_n(dB), in decibels.

4.13.5.7. MEASUREMENT ERRORS

The source of measurement error is the uncertainty, ΔP_n, in the measured value of P_n. The total uncertainty, ΔR_n(dB), in decibels, in the value of R_n(dB), is given approximately, for small uncertainties, by the equation

$$\Delta R_n \text{ (dB)} = 10 \log \left(1 + \frac{\Delta P_n}{P_n} \right) .$$

Uncertainty ΔP_n is obtained from the manufacturer's specifications on the power meter or rms voltmeter.

4.13.6. NOISE LIMITER THRESHOLD

4.13.6.1. DEFINITION

The noise limiter threshold of a receiver is the voltage level, in volts, at which limiting action begins.

4.13.6.2. PURPOSE

The purpose of this measurement method is to measure the clipping threshold of a noise limiter located in the audio section of surveillance receivers. The clipping or noise limiter threshold is a measure of the effectiveness of the receiver's noise limiter to suppress the interference effects of static- and pulse- type noise.

This method is not suitable for testing the performance of pre-demodulator limiter circuits nor circuits having a floating reference point.

4.13.6.3. METHOD

The method uses a modulated signal generator and an oscilloscope as shown in figure 4.13.6. The signal generator supplies a test signal which is clipped by the receiver's noise limiter and displayed on the oscilloscope. The noise limiter threshold is determined from the calibrated oscilloscope display.

Measurement uncertainties as small as 2% are possible under best conditions, and range from approximately 4% to 15% under typical conditions. The method uses commonly available test equipment.

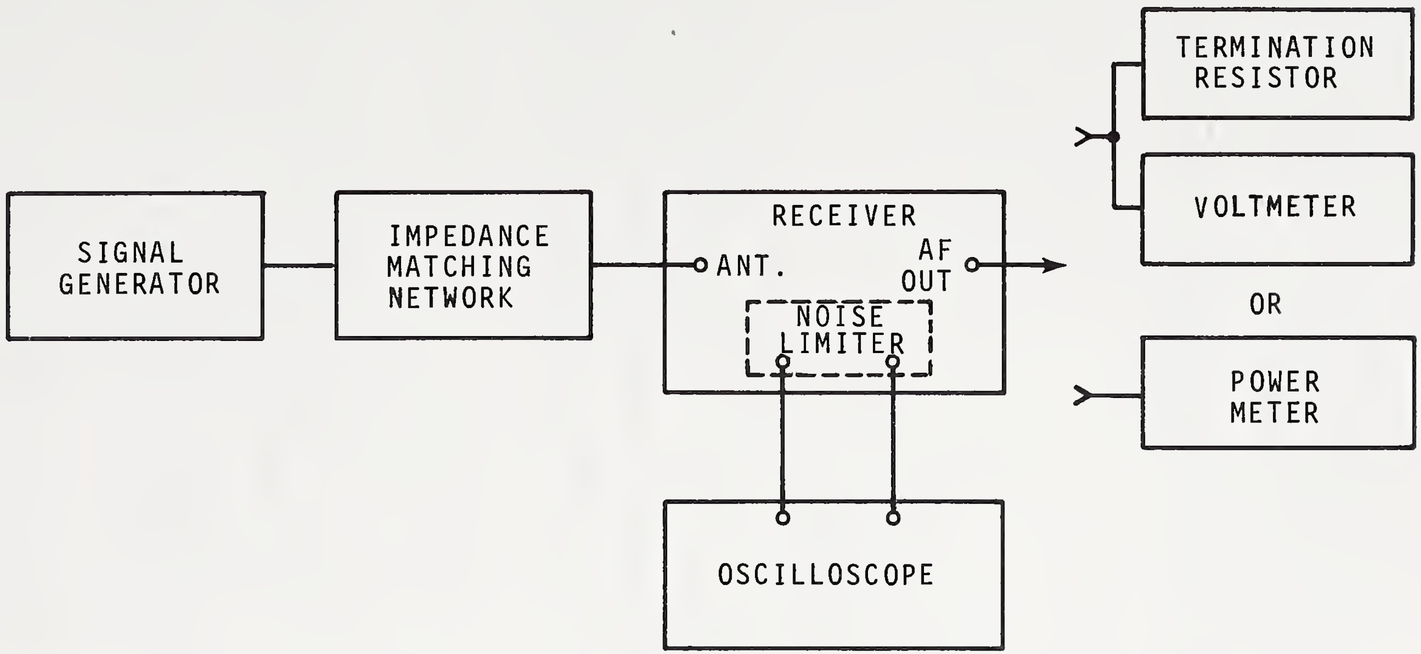

Fig. 4.13.6. Test Set-up for Noise Limiter Threshold

4.13.6.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Input impedance matching network

3. Cathode-ray oscilloscope

4. Terminating resistor for receiver audio output port

5a. AF power meter

OR,

5b. True rms voltmeter

4.13.6.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the OSCILLOSCOPE across the output of the noise limiter circuit in the receiver.

3a. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

OR,

3b. Connect the POWER METER, having an input impedance equal to the specified load resistance, R_ℓ, to the audio output port of the receiver.

4a. Set the voltmeter on a range to indicate the reference output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell}\ .$$

OR,

4b. Set the power meter on a range to indicate the reference output power, P_o.

5. Set receiver controls as given in Table XXXXII.

6. Tune the signal generator and the receiver to a suitable measurement frequency, f_o.

7a. If the measurement is to be made with the receiver in an AM detector mode (or CW, SSB), adjust the generator for amplitude modulation of 30% at 1000 Hz.

OR,

7b. If the measurement is to be made with the receiver in an FM detector mode, adjust the generator for frequency modulation of ±60% of rated system deviation at 1000 Hz.

8. With the generator output level set to zero, adjust the RF, IF, and AF gain controls to their maximum gain settings.

9. Set the noise limiter control to the desired position.

TABLE XXXXII

Noise Limiter Threshold

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As desired
7. Line Gain	7. Optional
8. Detector Mode	8. AM, CW, or SSB
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. As desired
12. AF Bandwidth	12. As desired
13. Noise Limiter	13. ON
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

10. Increase the generator output level until clipping of the 1000 Hz demodulated signal just begins as seen on the oscilloscope display.

11. Note the audio output power from the receiver. If it exceeds twice the reference output power, reduce the AF gain control to produce approximately twice reference output power.

12. Increase the generator output level by 6 dB above that of Step 10 above. This should produce a well-defined clipped 1000 Hz waveform.

13. Determine the positive and negative amplitudes, V_p and V_n, of the clipped 1000 Hz signal, using the calibrated vertical scale of the oscilloscope. V_p and V_n are the positive and negative noise limiter thresholds, respectively, of the receiver for the limiter setting of Step 9, above.

4.13.6.6. DATA REQUIRED

1. Record the operating conditions of the receiver.

2. Record the positive clipping voltage, V_p, in volts.

3. Record the negative clipping voltage, V_n, in volts.

4.13.6.7. MEASUREMENT ERRORS

The principal source of measurement error is the uncertainty, ΔV, in the measured values of V_p and V_n. The uncertainty, ΔV (%), in percent, in V_p and/or V_n, is given by the equation

$$\Delta V\ (\%) = \frac{\Delta V}{V_{p,n}} \times 100 \quad .$$

Uncertainty ΔV is obtained from the manufacturer's specifications on the calibrator used to calibrate the oscilloscope vertical scale.

4.13.7. SQUELCH SENSITIVITY

4.13.7.1. DEFINITION

The audio squelch sensitivity of a receiver is the minimum value of the standard test input signal source, which, when modulated at standard test modulation, will open the receiver squelch. (EIA RS-204)

4.13.7.2. PURPOSE

The purpose of this measurement method is to measure the squelch sensitivity of surveillance receivers. This parameter is a measure of receiver's ability to break squelch on a weak signal.

4.13.7.3. METHOD

The method uses an amplitude or frequency modulated signal generator and an audio distortion analyzer as shown in figure 4.13.7. The signal generator supplies a known input voltage to the receiver at the measurement frequency. The distortion analyzer measures the power in the audio output from the receiver. With the generator output level set to zero, the squelch control is adjusted to reduce the audio noise output power to at least 40 dB below the unsquelched value. Then the generator level is adjusted to the voltage that causes a continuous audio output level that is no less than 10 dB below reference output power. This voltage is the squelch sensitivity of the receiver.

Measurement uncertainties as small as 5% are possible under best conditions, and range from approximately 8% to 30% under typical conditions. This method uses commonly available test equipment of moderate sophistication.

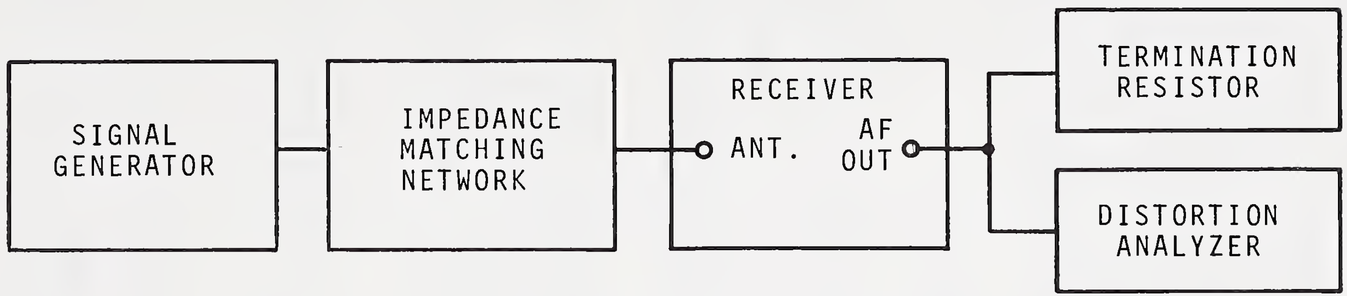

Fig. 4.13.7. Test Set-up for Squelch Sensitivity

4.13.7.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. Audio distortion analyzer

4.13.7.5. PROCEDURE

1. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

2. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the audio DISTORTION ANALYZER across this resistor.

3. Set the distortion analyzer on a range to indicate the rated output power, P_o.

4. Set receiver controls as given in Table XXXXIII.

5. Tune the signal generator and the receiver to the measurement frequency, f_o.

6a. If the measurement is to be made on an AM receiver, adjust the generator for amplitude modulation of 30% at 1000 Hz.

TABLE XXXXIII

Squelch Sensitivity

Initial Control Settings

Control		Setting	
1.	Band Switch	1.	As desired
2.	Frequency Tuning	2.	As desired
3.	Antenna Trimmer	3.	Peak
4.	RF Gain	4.	Maximum
5.	IF Gain	5.	Maximum
6.	AF Gain	6.	As required
7.	Line Gain	7.	Optional
8.	Detector Mode	8.	AM, FM, as desired
9.	Beat Frequency Oscillator	9.	OFF
10.	BFO Frequency	10.	N.A.
11.	IF Bandwidth	11.	As desired
12.	AF Bandwidth	12.	As desired
13.	Noise Limiter	13.	OFF
14.	Squelch Level	14.	As required
15.	AGC/MGC Mode Switch	15.	As desired
16.	Meter Switch	16.	Optional

OR,

6b. If the measurement is to be made on an FM RECEIVER, adjust the generator for frequency modulation of ±60% of rated system deviation at 1000 Hz.

7. Set the squelch control for minimum squelch.

8. Measure the 12 dB SINAD SENSITIVITY, E_i, as outlined in Section 4.1.3. for AM receivers, or Section 4.1.5. for FM receivers.

9. Set the generator output level to zero.

10. Measure the audio output power, P_n. This will be noise only.

11. Adjust the squelch control to reduce the audio output power to at least 0.0001 P_o (40 dB below P_n), or lower if the squelch is a triggered system.

12. Increase the generator output to the first (lowest) level that just produces a continuous audio output power level that is no less than 10 dB below reference output power, P_o.

13. Determine the open circuit signal voltage, E_s, in microvolts, at the OUTPUT TERMINALS of the matching network, if used; otherwise at the output terminals of the generator. This is the SQUELCH SENSITIVITY of the receiver at frequency f_o.

4.13.7.6. DATA REQUIRED

1. Record the measurement frequency, f_o, in kilohertz or megahertz.

2. Record the value of source impedance, Z_s, in ohms, connected to receiver input port.

3. Record the value of termination resistance, R_{ℓ}, in ohms, connected to receiver audio output terminals.

4. Record the reference output power, P_o, in watts.

5. Record the 12 dB SINAD sensitivity, E_i, in microvolts.

6. Record the output noise power, P_n, in milliwatts.

7. Record the squelch sensitivity, E_s, in microvolts.

4.13.7.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔE_s, in the measured value of E_s

2. Uncertainty, ΔP_o, in the measured value of P_o

3. Uncertainty, ΔP_{n+d}, in the measured value of P_{n+d}.

The total relative uncertainty, $\Delta E_s(\%)$, in the squelch sensitivity, E_s, expressed as a percent, is given by the equation

$$\Delta E_s(\%) = \left(\frac{\Delta E_s}{E_s} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_o}{P_o} \times 100\right) + \left(\frac{1}{2}\,\frac{\Delta P_{n+d}}{P_{n+d}} \times 100\right) .$$

The uncertainty, ΔE_s, is obtained from the manufacturer's specifications on the output level indication of the signal generator. Uncertainties ΔP_o and ΔP_{n+d} are obtained from the manufacturer's specifications on the distortion analyzer.

4.14. POWER SUPPLY SECTION

Receiver power supply parameters that are of primary interest are the following:

a. Input power

b. Output voltage

c. Voltage regulation; line and load

d. Ripple and noise

Methods for measuring these parameters are discussed in this section.

The measurement of power supply parameters alone may not be meaningful in predicting overall receiver performance. Receiver parameters that are affected by power supply parameters are best tested by directly measuring those parameters under various power supply conditions. The tests given above may be repeated under conditions of low and high supply voltages to fully assess the receiver's performance characteristics.

4.14.1. INPUT POWER

4.14.1.1. DEFINITION

Input power is the power, in watts, drawn by the receiver through its power cable from the primary source of operating energy. It may be a.c. or d.c., depending upon the design of the receiver power supply circuit.

4.14.1.2. PURPOSE

The purpose of this measurement method is to measure the input power drawn by surveillance receivers during normal operation. Input power is a measure of the energy required to operate the receiver.

4.14.1.3. METHOD

The method uses a signal generator, a true rms voltmeter, and either (a) an a.c. wattmeter for a.c. primary source, or (b) a voltmeter and ammeter for d.c. primary source as shown in figure 4.14.1. The signal generator supplies an input signal to the receiver so as to operate the receiver at maximum rated audio output power, as indicated by the true rms voltmeter. The wattmeter or voltmeter-ammeter pair measure the power drawn from the primary source of energy, such as an a.c. generator or a storage battery.

Measurement uncertainties as small as 2% are possible under best conditions, and range from 4% to 15% under typical conditions. The method uses rudimentary and commonly available test equipment.

4.14.1.4. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. True rms voltmeter

5. A.C. wattmeter

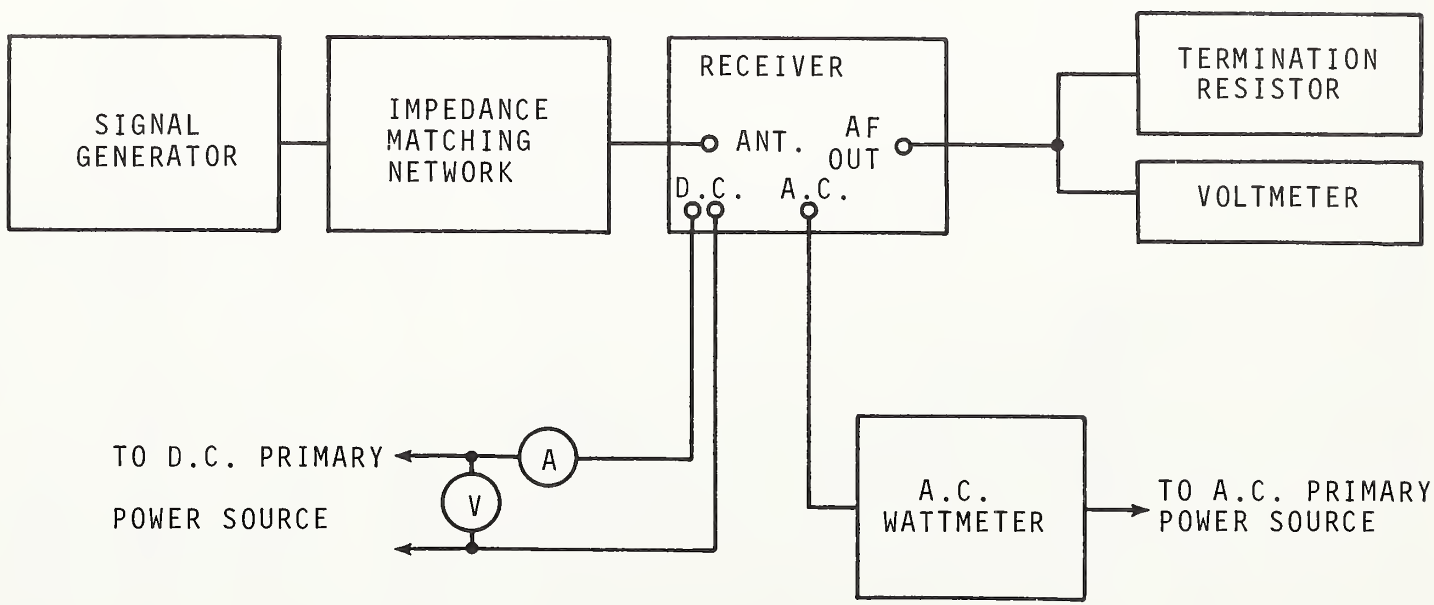

Fig. 4.14.1. Test Set-up for Input Power

6. D. C. voltmeter

7. D.C. ammeter

4.14.1.5. PROCEDURE

1a. For a.c. power source, connect the receiver's power cord through the A.C. WATTMETER to the primary power source.

OR,

1b. For d.c. power source, connect the receiver's hot power cable through the D.C. AMMETER to the primary power source and connect the return power cable to the remaining power source terminal. Connect the D.C. VOLTMETER across the output terminals of the source. Observe correct polarity.

2. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no transformer is required.

3. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

4. Set the voltmeter on a range to indicate the rated output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \quad .$$

5. Set receiver controls as given in Table XXXXIV.

6. Tune the signal generator and the receiver to the measurement frequency, f_o.

7. Adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

8. With the RF, IF, and AF gain controls set to their minimum gain settings, and the function switch set in STANDBY position, record the wattmeter reading, P_{is}, in watts, or the D.C. voltmeter and D.C. ammeter readings, V_{is} and I_{is}, in volts and amperes, respectively.

9. For the d.c. power source, compute the input power, P_{is}, in watts, by the equation

$$P_{is} = V_{is} I_{is} \quad .$$

P_{is} is the input power drawn by the receiver under standby conditions.

10. Adjust the receiver RF/IF gain controls to their maximum gain settings.

11. With the signal generator connected and its output set to zero, adjust the receiver AF gain control to produce 1% rated audio output power, P_o. This will be noise power only.

12. Adjust the output level of the signal generator to give rated audio output power, P_o.

13. Record the wattmeter reading, P_{im}, in watts, or the D.C. voltmeter and D.C. ammeter readings, V_{im} and I_{im}, in volts and amperes, respectively.

TABLE XXXXIV

Input Power

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. As required
5. IF Gain	5. As required
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. AM
9. Beat Frequency Oscillator	9. As desired
10. BFO Frequency	10. Optional
11. IF Bandwidth	11. Optional
12. AF Bandwidth	12. Optional
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. As desired
16. Meter Switch	16. Optional

14. For the d.c. power supply, compute the input power, P_{im}, in watts, by the equation

$$P_{im} = V_{im} I_{im} \quad .$$

P_{im} is the input power drawn by the receiver under conditions of rated audio output power.

4.14.1.6. DATA REQUIRED

1. Record rated audio output power, P_o, in milliwatts or watts.

2. Record standby input power, P_{is}, in watts.

3. Record standby input voltage, V_{is}, in volts.

4. Record standby input current, I_{is}, in amperes.

5. Record maximum input power, P_{im}, in watts.

6. Record maximum input voltage, V_{im}, in volts.

7. Record maximum input current, I_{im}, in amperes.

4.14.1.7. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔP_i, in the measured input power, P_{is} or P_{im}

2. Uncertainty, ΔV_i, in the measured input voltage, V_{is} or V_{im}

3. Uncertainty, ΔI_i, in the measured input current, I_{is} or I_{im}

The relative uncertainty, $\Delta P_i(\%)$, in percent, in the input power, P_i, is given by the equations

$$\Delta P_i \ (\%) = \frac{\Delta P_i}{P_i} \times 100 \quad ,$$

OR

$$\Delta P_i \ (\%) = \left(\frac{\Delta V_i}{V_i} \times 100 \right) + \left(\frac{\Delta I_i}{I_i} \times 100 \right) \quad .$$

Uncertainties ΔP_i, ΔV_i, and ΔI_i are obtained from the manufacturer's specifications on the wattmeter, D.C. voltmeter, and D.C. ammeter, respectively.

4.14.2. OUTPUT VOLTAGE

4.14.2.1. DEFINITION

Output voltage is the voltage, in volts, at the output terminals of the power supply section of the receiver.

4.14.2.2. PURPOSE

The purpose of this measurement method is to measure the output voltages of the power supply section of surveillance receivers. Output voltage is a measure of the ability of the power supply to deliver the energy required by the receiver.

The receiver power supply may provide output voltages of several different levels and current capacities. This method is applicable to each individual voltage level.

4.14.2.3. METHOD

The method uses a D.C. voltmeter as shown in figure 4.14.2. The voltmeter is placed across the selected output terminals in the power supply, and the voltage indication is read.

Measurement uncertainties as small as 1% are possible under best conditions, and range from 2% to 10% under typical conditions. The method uses rudimentary and commonly available test equipment.

4.14.2.4. TEST EQUIPMENT REQUIRED

1. D.C. voltmeter

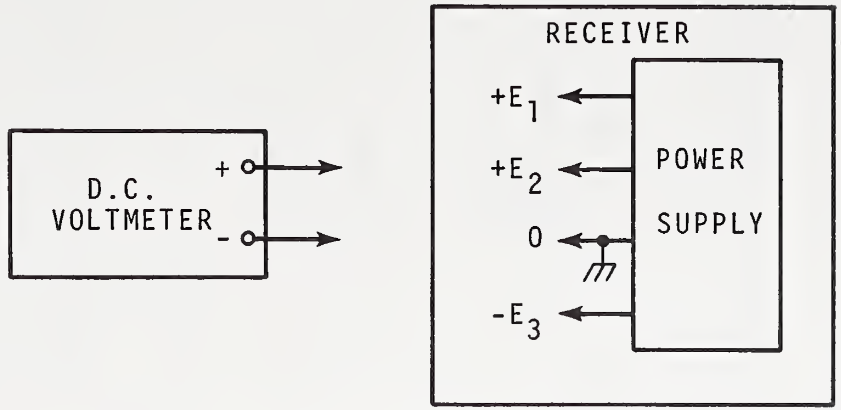

Fig. 4.14.2. Test Set-up for Output Voltage

4.14.2.5. PROCEDURE

1. Adjust the receiver to the desired operating conditions.

2. Set the D.C. VOLTMETER to the highest range setting provided. Make sure this is greater than the maximum D.C. voltage delivered by the power supply, as stated in the receiver's operating manual.

3. Connect the voltmeter to the selected terminals in the power supply circuit. Observe correct polarity.

4. Measure the D.C. voltage, V, at the selected terminals. Adjust the range setting as required to give a meter deflection in the upper two-thirds portion of the scale.

5. Record the measured voltage. This is the output voltage at the selected terminals of the power supply under the operating conditions established in Step 1, above.

4.14.2.6. DATA REQUIRED

1. Record selected operating conditions of the receiver.

2. Record each measured D.C. voltage, V, in millivolts or volts.

4.14.2.7. MEASUREMENT ERRORS

The principal source of measurement error is the uncertainty, ΔV, in the measured D.C. voltage, V. The total measurement uncertainty, $\Delta V(\%)$, in percent, in the measured value of voltage, V, is given by the equation

$$\Delta V\ (\%) = \frac{\Delta V}{V} \times 100.$$

Uncertainty ΔV is obtained from the manufacturer's specifications on the D.C. voltmeter.

4.14.3. VOLTAGE REGULATION

4.14.3.1. DEFINITION

Voltage regulation is the maximum change in output voltage as a result of a specified change in line voltage, output load, temperature, or time.

Voltage regulation is usually expressed in percent of output voltage level.

4.14.3.2. PURPOSE

The purpose of these measurement methods is to measure the voltage regulation of receiver power supplies under variations of line voltage and audio output power. Voltage regulation is a partial measure of the potential stability and output signal quality of the receiver.

4.14.3.3. METHOD - LINE REGULATION

The method uses a signal generator, a true rms voltmeter, a D.C. differential voltmeter, a variable auto-transformer with voltmeter, and a variable D.C. primary power supply with voltmeter as shown in figure 4.14.3.1. The signal generator supplies an input signal to the receiver so as to operate the receiver at a selected audio output power level, as indicated by the true rms voltmeter. The D.C. differential voltmeter measures the receiver's power supply output voltage and the change therein produced by changes in the primary power supply voltage. These latter changes are produced by the variable auto-transformer or the variable D.C. primary power source.

The primary supply line voltage is set to a standard value and the receiver's power supply output voltage, V_o, is measured.

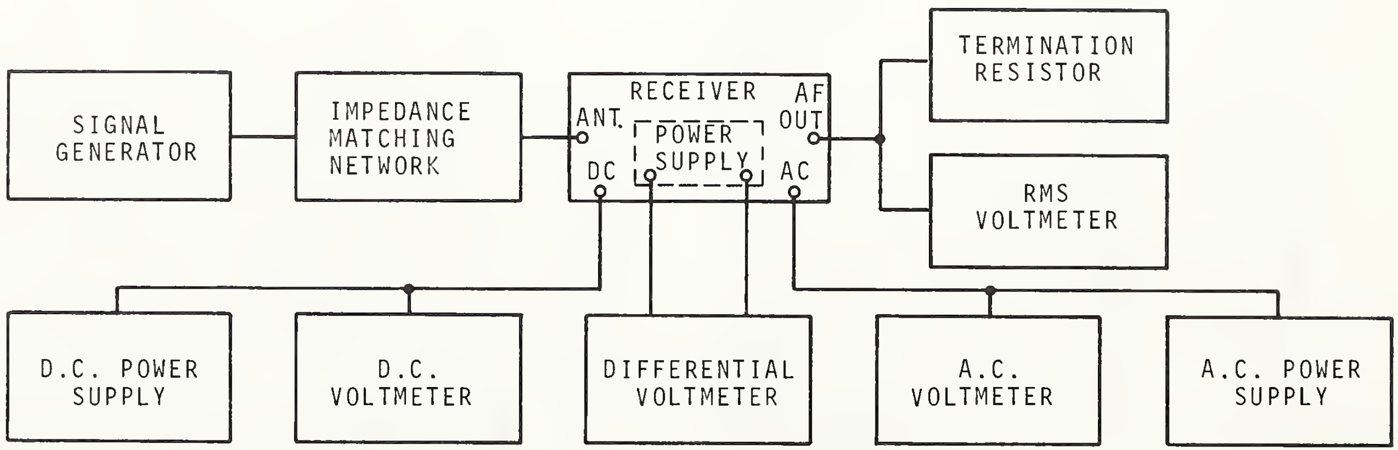

Fig. 4.14.3.1. Test Set-up for Voltage Regulation (Line)

Then the primary supply voltage is changed a prescribed amount and the change in the receiver's power supply output voltage, ΔV_o, is measured. The line regulation is the ratio $\Delta V_o/V_o$, expressed as a percent.

Measurement uncertainties as small as 2% are possible under best conditions, and range from 4% to 15% under typical conditions. The method uses rudimentary and commonly available test equipment.

4.14.3.3.1. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

4. True rms voltmeter

5. D.C. differential voltmeter

6. Variable auto-transmeter, equipped with an output A.C. voltmeter

7. Variable D.C. power supply, equipped with an output D.C. voltmeter.

4.14.3.3.2. PROCEDURE

1a. For A.C. power source, connect the receiver's A.C. power cord to the output socket of the VARIABLE AUTO-TRANSFORMER. Connect the auto-transformer to the primary power source.

OR,

1b. For D.C. power source, connect the receiver's D.C. power cord to the output terminals of the VARIABLE D.C. POWER SUPPLY.

2. Connect the D.C. DIFFERENTIAL VOLTMETER to the selected terminals in the receiver's power supply. Observe correct polarity.

3. Set the differential voltmeter to a range that is higher than the voltage to be measured, as given by the receiver's operating manual.

4. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

5. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

6. Set the voltmeter on a range to indicate the rated audio output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \ .$$

7. Set receiver controls as given in Table XXXXV.

TABLE XXXXV

Voltage Regulation

Initial Control Settings

Control	Setting
1. Band Switch	1. As desired
2. Frequency Tuning	2. As desired
3. Antenna Trimmer	3. Peak
4. RF Gain	4. Maximum
5. IF Gain	5. Maximum
6. AF Gain	6. As required
7. Line Gain	7. Optional
8. Detector Mode	8. AM, FM, as desired
9. Beat Frequency Oscillator	9. OFF
10. BFO Frequency	10. N.A.
11. IF Bandwidth	11. Optional
12. AF Bandwidth	12. Optional
13. Noise Limiter	13. OFF
14. Squelch Level	14. OFF
15. AGC/MGC Mode Switch	15. AGC
16. Meter Switch	16. Optional

8. Tune the signal generator and the receiver to the measurement frequency, f_o.

9a. If the measurement is to be made on an AM receiver, adjust the amplitude modulation in the signal generator to 30% at 1000 Hz.

OR,

9b. If the measurement is to be made on an FM receiver, adjust the frequency modulation in the signal generator for ±60% of rated system deviation at 1000 Hz.

10. Adjust the receiver to the desired operating conditions. This may be (a) on standby, (b) operating with zero audio output power, (c) operating with rated audio output power, (d) operating at some intermediate audio output power, or (e) operating under some special mode of operation.

11a. Adjust the auto-transformer for normal operating supply voltage, V_s, as specfied in the receiver's operating manual. For example, this may be 115 volts A.C.

OR,

11b. Adjust the variable D.C. power supply for normal operating supply voltage, V_s, as specified in the receiver's operating manual. For example, this may be 28 volts D.C.

12. Measure the output voltage, V_o, of the receiver's power supply as selected in Step 2, above, using the differential voltmeter.

13. Reduce the supply voltage applied to the receiver to the lower operating limit specified in the receiver's operating manual. For example, on A.C. this voltage may be 105 volts; on D.C. this voltage may be 24 volts.

14. Measure the change in output voltage, ΔV_{O1}, of the receiver's power supply, using the differential voltmeter.

15. Calculate the relative voltage change, R_1, in percent, by the equation

$$R_1\ (\%) = \frac{\Delta V_{O1}}{V_O} \times 100 \quad .$$

R_1 is the receiver's voltage regulation due to a decrease in line voltage for the operating conditions selected in Step 10, above.

16. Increase the supply voltage applied to the receiver to the upper operating limit specified in the receiver's operating manual. For example, on A.C. this voltage may be 125 volts; on D.C. this voltage may be 32 volts.

17. Measure the change in output voltage, ΔV_{O2}, of the receiver's power supply, from the value V_O obtained in Step 12, above, using the differential voltmeter.

18. Calculate the relative voltage change, R_2, in percent, by the equation

$$R_2\ (\%) = \frac{\Delta V_{O2}}{V_O} \times 100 \quad .$$

R_2 is the receiver's voltage regulation due to an increase in line voltage for the operating conditions selected in Step 10, above.

4.14.3.3.3. DATA REQUIRED

1. Record the selected operating conditions of the receiver.

2. Record the supply voltages, V_s, in volts.

3. Record the receiver's power supply voltage, V_o, in volts.

4. Record the changes in power supply voltage, ΔV_o, in millivolts or volts.

5. Record the calculated line voltage regulation, R, in percent.

4.14.3.3.4. MEASUREMENT ERRORS

The principal sources of measurement error are the following:

1. Uncertainty, ΔV_s, in the supply voltage, V_s

2. Uncertainty, ΔV_o, in the measured value of V_o

3. Uncertainty, $\Delta(\Delta V_o)$, in the measured values of ΔV_o

The total uncertainty, $\Delta R(\%)$, in percent, in the value of R, is given by the equation

$$\Delta R\ (\%) = \left(\frac{\Delta V_s}{V_s} \times 100\right) + \left(\frac{\Delta V_o}{V_o} \times 100\right) + \left(\frac{\Delta(\Delta V_o)}{\Delta V_o} \times 100\right) .$$

Uncertainties ΔV_s, ΔV_o, and $\Delta(\Delta V_o)$ are obtained from the manufacturer's specifications on the several voltmeters used in this method.

4.14.3.4. METHOD - LOAD REGULATION

The method uses a signal generator, a true rms voltmeter, a D.C. differential voltmeter, a variable auto-transformer with voltmeter, and a variable D.C. primary power supply with voltmeter as shown in figure 4.14.3.2. The signal generator supplies an input signal to the receiver so as to operate the receiver at a selected audio output power level, as indicated by the true rms voltmeter. The D.C. differential voltmeter measures the receiver's power supply output voltage, V_o, and the change therein, ΔV_o, produced by the change in the power required by the receiver. This change in power is the difference between the power drawn under no-signal conditions and the power under full signal conditions. The load regulation is the ratio $\Delta V_o/V_o$, expressed as a percent.

The primary supply line voltage is set to a standard value and the receiver's power supply output voltage, V_o, is measured. Then the load on the receiver's power supply is changed a prescribed amount and the change in the output voltage, ΔV_o, is measured. The load regulation is the ratio $\Delta V_o/V_o$.

Measurement uncertainties as small as 2% are possible under best conditions, and range from 4% to 15% under typical conditions. The method uses rudimentary and commonly available test equipment.

4.14.3.4.1. TEST EQUIPMENT REQUIRED

1. Signal generator capable of amplitude or frequency modulation

2. Input impedance matching network

3. Termination resistor for receiver audio output port

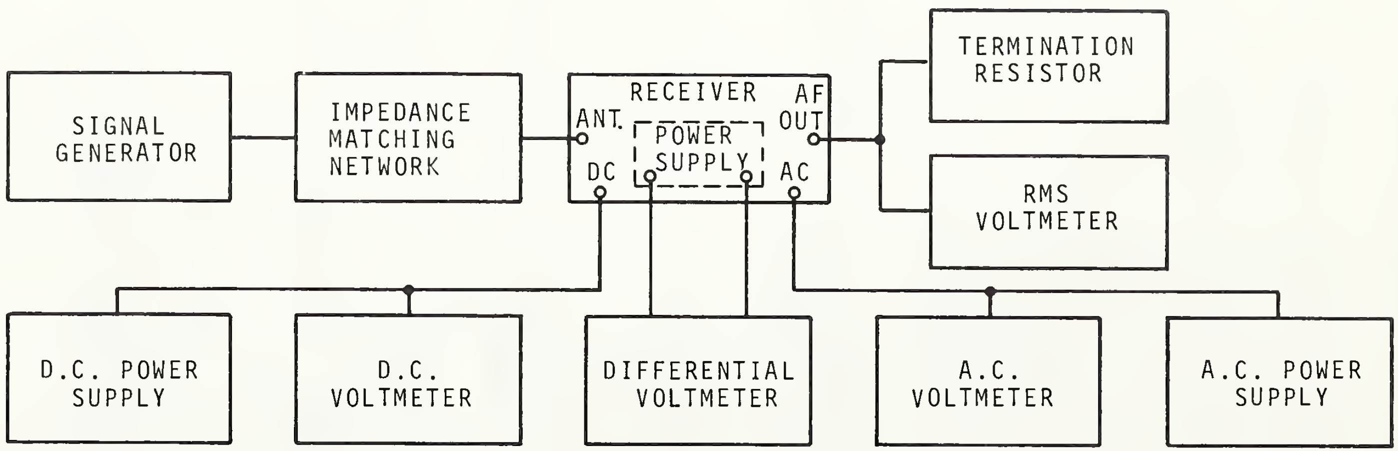

Fig. 4.14.3.2. Test Set-up for Voltage Regulation (Load)

4. True rms voltmeter

5. D.C. differential voltmeter

6. Variable auto-transmeter, equipped with an output A.C. voltmeter

7. Variable D.C. power supply, equipped with an output D.C. voltmeter.

4.14.3.4.2. PROCEDURE

1. Connect the receiver's power cord to either the VARIABLE AUTO-TRANSFORMER (A.C. power cord) or the VARIABLE D.C. POWER SUPPLY (D.C. power cord).

2. Connect the D.C. DIFFERENTIAL VOLTMETER to the selected terminals in the receiver's power supply. Observe correct polarity.

3. Set the differential voltmeter to a range that is higher than the voltage to be measured, as given by the receiver's operating manual.

4. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through an IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

5. Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_ℓ, and a power rating in excess of the receiver's rated audio output power level, to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across the resistor.

6. Set the voltmeter on a range to indicate the rated output power, P_o. The voltage to be measured is given by the equation

$$E_o = \sqrt{P_o R_\ell} \; .$$

7. Set receiver controls as given in Table XXXXV, p. 405.

8. Tune the signal generator and the receiver to the measurement frequency, f_o.

9a. If the measurement is to be made on an AM receiver, adjust the frequency modulation in the signal generator to 30% at 1000 Hz.

OR,

9b. If the measurement is to be made on an FM receiver, adjust the frequency modulation in the signal generator for ±60% of rated system deviation at 1000 Hz.

10. Adjust the A.C. or D.C. supply voltage to the receiver for normal operating supply voltage, V_s, as specified in the receiver's operating manual. For example, on A.C. this may be 115 volts; on D.C. this may be 28 volts.

11. Put the receiver in operating condition, but set the RF, IF, and AF gain controls to their minimum gain settings.

12. Measure the output voltage, V_o, of the receiver's power supply, using the differential voltmeter.

13. Adjust the receiver RF/IF gain controls to their maximum gain settings.

14. With the signal generator connected and its output set to zero, adjust the receiver AF gain control to produce 1% rated audio output power, P_o. This will be noise power only.

15. Adjust the output level of the signal generator to give rated audio output power, P_o.

16. Measure the change in output voltage, ΔV_o, of the receiver's power supply, using the differential voltmeter.

17. Calculate the relative voltage change, R(%), in percent, by the equation

$$R(\%) = \frac{\Delta V_o}{V_o} \times 100 \quad .$$

R_ℓ is the receiver's voltage regulation due to a change in power supply load from minimum to maximum load, for the operating condition selected in Step 11, above.

4.14.3.4.3. DATA REQUIRED

1. Record the selected operating conditions of the receiver.

2. Record the supply voltages, V_s, in volts.

3. Record the receiver's power supply voltage, V_o, in volts.

4. Record the changes in power supply voltage, ΔV_o, in millivolts or volts.

5. Record the calculated load voltage regulation, R, in percent.

4.14.3.4.4. MEASUREMENT ERRORS

The principal sources of measurement errors are the following:

1. Uncertainty, ΔV_s, in the supply voltage, V_s

2. Uncertainty, ΔV_o, in the measured value of V_o

3. Uncertainty, $\Delta(\Delta V_o)$, in the measured values of ΔV_o

The total uncertainty, $\Delta R(\%)$, in percent, in the value of R, is given by the equation

$$\Delta R\ (\%) = \left(\frac{\Delta V_s}{V_s} \times 100\right) + \left(\frac{\Delta V_o}{V_o} \times 100\right) + \left(\frac{\Delta(\Delta V_o)}{\Delta V_o} \times 100\right) .$$

Uncertainties ΔV_s, ΔV_o, and $\Delta(\Delta V_o)$ are obtained from the manufacturer's specifications on the several voltmeters used in this method.

4.14.4. RIPPLE AND NOISE

4.14.4.1. DEFINITION

Power supply ripple and noise is the total rms A.C. voltage that appears superimposed upon the D.C. output voltage.

4.14.4.2. PURPOSE

The purpose of this measurement method is to measure the ripple and noise voltage of receiver power supplies. Ripple and noise voltages are a potential source of hum and noise interference in the receiver, and can reduce the quality of the audio output power.

4.14.4.3. METHOD

The method uses a true rms voltmeter and a cathode-ray oscilloscope as shown in figure 4.14.4. The voltmeter is placed across the selected output terminals in the receiver power supply, and the ripple and noise voltage is read. The oscilloscope displays the A.C. voltage waveform to reveal the presence of deleterious voltage spikes or oscillations.

Measurement uncertainties as small as 1% are possible under best conditions, and range from 2% to 10% under typical conditions. The method uses rudimentary and commonly available test equipment.

4.14.4.4. TEST EQUIPMENT REQUIRED

1. True rms voltmeter

2. Cathode-ray oscilloscope

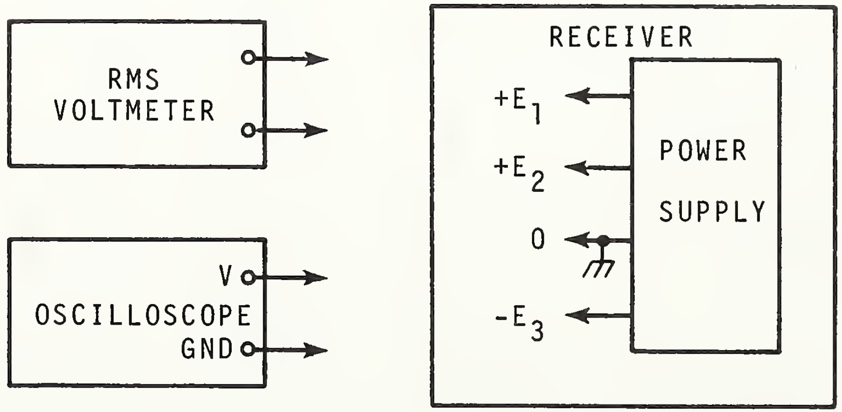

Fig. 4.14.4. Test Set-up for Ripple and Noise

4.14.4.5. PROCEDURE

1. Adjust the receiver to the desired operating conditions.

2. Set the TRUE RMS VOLTMETER to the highest range setting provided. Make sure this is greater than the maximum D.C. voltage delivered by the power supply, as stated in the receiver's operating manual.

3. Connect the voltmeter and the OSCILLOSCOPE, in parallel, to the selected terminals in the power supply circuit.

4. Measure the A.C. voltage, V_r, at the selected terminals. Adjust the range setting as required to give a meter deflection in the upper two-thirds portion of the scale.

5. Record the measured voltage, V_r. This is the rms value of the ripple and noise voltage at the selected terminals of the power supply under the operating conditions established in Step 1, above.

6. The oscilloscope display provides information about the ripple and noise waveform. It can yield the peak value of voltage excursions and the nature of the ripple and noise.

4.14.4.6. DATA REQUIRED

1. Record the operating conditions of the receiver.

2. Record the ripple and noise voltage, V_r, in millivolts or volts.

4.14.4.7. MEASUREMENT ERRORS

The principal source of measurement error is the uncertainty, ΔV_r, in the measured value of V_r. The total uncertainty, $\Delta V_r(\%)$, in percent, in the value of V_r, is given by the equation

$$\Delta V_r\ (\%) = \frac{\Delta V_r}{V_r} \times 100 \quad .$$

Uncertainty ΔV_r is obtained from the manufacturer's specifications on the rms voltmeter.

NOTE: If the frequency range of the rms voltmeter extends to zero frequency (D.C.), connect a D.C. blocking capacitor in series with the voltmeter's ungrounded terminal when measuring V_r.

5.0. TEST EQUIPMENT

5.1. GENERAL REQUIREMENTS

Test equipment of the types required to perform the measurements described in this handbook must measure a variety of quantities over the frequency range of D.C. to 100 MHz or higher. Such equipment has become fairly well standardized, and a wide range of types and quality is available.

Because the quality of a measurement depends ultimately upon the quality of the test apparatus, the highest quality instruments, commensurate with the desired results, should be chosen. Give close attention to such matters as shielding, filtering, mechanical stability, electrical stability, control smoothness, display readability, and operating convenience. Most test methods require interconnecting several pieces of apparatus, and their compatibility and operating ease in a complex measurement system can be an important factor.

5.2. SPECIAL REQUIREMENTS

A listing of all the technical specifications of the relevant test equipment, including the routine as well as the unique requirements, is beyond the scope of this handbook. Most requirements are well known by knowledgeable technicians. This section will cover only those special requirements that are critical to the procedures included in Section 4.0.

5.2.1. RF SIGNAL GENERATORS

5.2.1.1. HARMONIC AND SPURIOUS OUTPUT

Harmonic and spurious output should be at least 30 dB below the desired signal. Certain tests, such as spurious response and intermodulation, require better than this. External filters may be used to obtain the necessary signal purity.

5.2.1.2. LEAKAGE

Low leakage is essential. The generator must have adequate shielding and filtering. Safe leakage levels vary from one test to another, and cannot be specified. However, each test set-up can and should be checked for leakage by observing the receiver response (a) to the generated signal with the output control set to zero, and (b) to changes in the test configuration. If evidence of leakage is found, provide additional shielding (e.g., a shielded box) and filtering (e.g., in the power line and interconnecting cables).

5.2.2. VOLTMETERS

5.2.2.1. TRUE RMS VOLTMETERS

True rms voltmeters are required to measure the rms value of random noise signals and signals comprised of a mixture of random and non-random signals. Conventional voltmeters, which contain an envelope detector, averaging circuits, and whose output is displayed as an equivalent rms value, give inaccurate measurements of random and semi-random signals. Conventional voltmeters may be used to indicate a reference level of random signals, or of semi-random signals when the mix does not vary, but a true rms meter should be used to MEASURE such levels.

5.2.2.2. D.C. DIFFERENTIAL VOLTMETERS

Power supply regulation can best be measured with a differential voltmeter because of its superior resolution. If a differential voltmeter is unavailable, one can be simulated with a stable, variable D.C. voltage source in series with a sensitive, low-range voltmeter.

5.2.3. IMPEDANCE METERS

Conventional RF impedance bridges often give erroneous results when measuring the impedance of an active network. The cause of this is the large signal voltage across the network that is required to obtain adequate bridge detector sensitivity at null. The large voltage may alter the operating point of the active device in the network, and the impedance may then become a function of the bridge voltage. The solution is to decrease the voltage needed across the active network terminals.

The vector impedance meter technique maintains good sensitivity even with small signal levels. It has been found suitable for many applications where an impedance bridge gives variable results.

5.2.4. IMPEDANCE MATCHING NETWORKS

An impedance matching network may consist of (a) an impedance transformer, or (b) a resistive matching network. A transformer has a low insertion loss, but tends to be narrow band. A resistive matching network is generally broad band, and for many measurements its higher insertion loss is of no consequence.

The electrical characteristics of any matching network must be known so that the measurement results can be corrected for its effects in the test set-up.

5.2.5. ISOLATION NETWORKS

An isolation network may be required between a frequency meter and the point of measurement to prevent the input impedance of the frequency meter from affecting the other parts of the measurement system. Suitable networks include the following:

a. Attenuator network
b. Directional coupler
c. High-impedance probe
d. Signal splitter

The network is chosen on the basis of frequency, circuit impedance, and signal level.

5.2.6. COMBINING NETWORKS

Combining networks are required when two or more signal generators are connected into a common circuit. A variety of means can be used to combine sources. These include the following:

a. Resistive summing networks
b. Hybrid multi-port networks
c. Directional couplers
d. Signal splitters (in reverse)
e. Attenuator networks
f. Multi-tap transformers

The particular choice of combining network is selected on the basis of frequency, circuit impedance, signal level, and number of signal sources to be combined.

5.2.7. INSERTION NETWORKS

An insertion network is used to inject a test signal into, or extract a signal from, a receiver via a power, audio, or interconnecting cable. It must provide a known coupling ratio between input and output terminals, and must not adversely disturb the circuit into which it connects. Suitable networks include the following:

a. Transformer
b. R-C coupling network
c. L-C coupling network

The particular choice and design of insertion network is selected on the basis of frequency, circuit impedance, signal level, load current, and cable configuration. The electrical characteristics of the network can be determined by measurement using standard procedures.

5.2.8. LINE IMPEDANCE NETWORKS

A line impedance network is used to extract a signal from a receiver via the power cable for conducted interference measurements. A suitable network for use from 300 kHz to 25 MHz has been described by the IEEE (56 IRE 27.S1), and its schematic is shown in figure 5.2.8. The installation and use of this network is described in the standard cited above.

For frequencies below 300 kHz and above 25 MHz, a similar network with suitable component values may be designed.

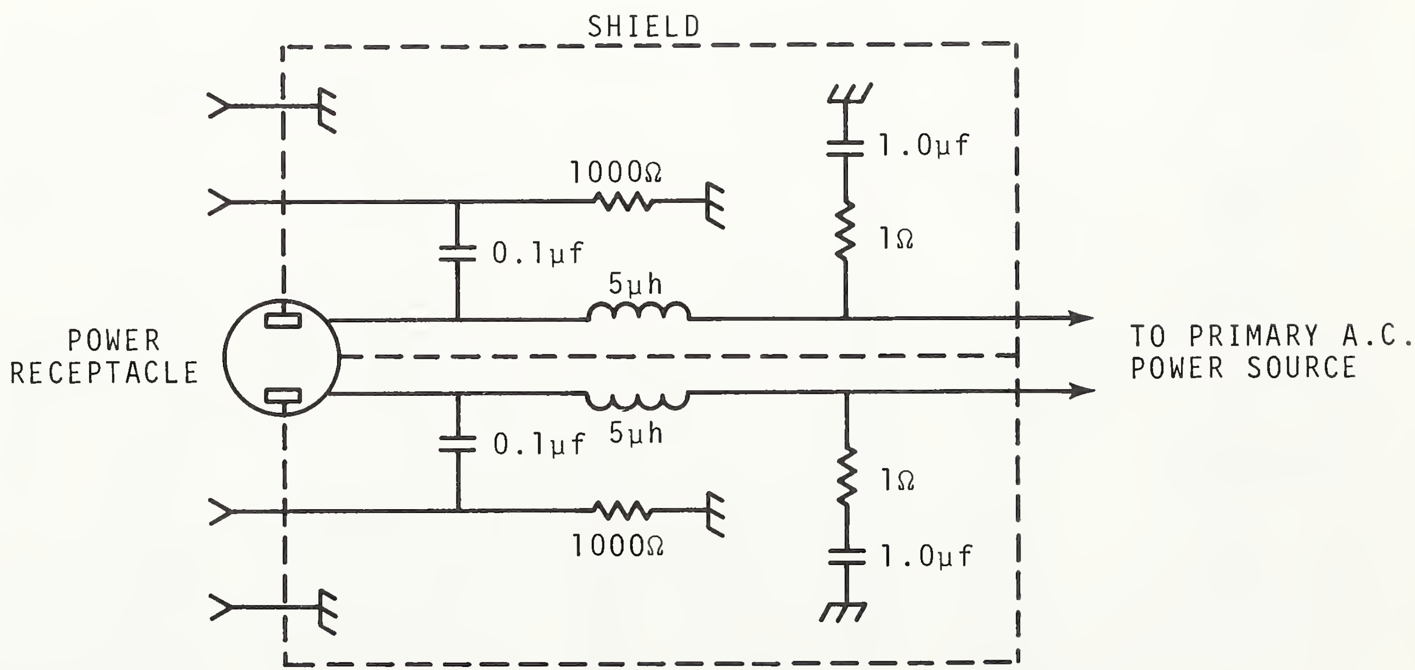

Fig. 5.2.8. Line Impedance Network

5.3. INVENTORY REQUIREMENTS

A complete list of the major equipment required to perform these test procedures is given in Table XXXXVI. Minor items, such as cables, connectors, test leads, probes, etc., are not listed because a qualified technician will know what is required.

5.3.1. EQUIPMENT IN USASATEC INVENTORY

Of the required equipment, those items that are listed in the USASATEC Electronic Equipment Catalog (dated March 1970; updated through August 1, 1972) are identified in Table XXXXVI by "Yes." These items are believed to be suitable for these test procedures, based upon the descriptions given in the catalog.

5.3.2. EQUIPMENT NOT IN USASATEC INVENTORY

Major equipment not listed in the USASATEC catalog are identified in Table XXXXVI by "No." Items marked with an asterisk (*) are not listed in the catalog, but can be readily obtained either by purchase or by building them in the electronics shop. Items marked with a double asterisk (**) are not available in the USASATEC inventory in models sufficient to cover the complete frequency range or level range required by these procedures. All of this equipment is discussed below.

5.3.2.1. DETECTOR, AF

The af detector is used to rectify the audiofrequency signal from the receiver before presentation to the oscilloscope in the swept-frequency method of testing for audiofrequency response. A standard detector circuit is suitable here, e.g., a half-wave rectifier using a semiconductor diode and having an input frequency range of approximately 10 to 10,000 Hz.

TABLE XXXXVI

Test Equipment Requirements

	Type of Equipment	Listed in ASA Catalog
1.	Analyzer, distortion, AF	Yes
2.	Antennas	Yes
3.	Attenuator, fixed, 3, 30, 54, and 60 dB	Yes
4.	Attenuator, variable, AF	Yes
5.	Attenuator, variable, IF	Yes
6.	Attenuator, variable, RF	Yes
7.	Autotransformer, variable, 60 Hz power	Yes
8.	Bridge, RF impedance	Yes
9.	Camera, oscilloscope	Yes
10.	Detector, AF	*
11.	Detector, IF, envelope, 2 ea. matched	*
12.	Detector, IF, FM, 2 ea. matched	*
13.	Detector, null, RF	Yes
14.	Filter, variable band pass, AF	Yes
15.	Filter, power line	*
16.	Generator, audiofrequency	Yes
17.	Generator, noise, hot/cold	**
18.	Generator, noise, temperature-limited diode	No
19.	Generator, signal, RF, AM	Yes
20.	Generator, signal, RF, CW	Yes
21.	Generator, signal, RF, FM	**
22.	Generator, swept-frequency, AF	No
23.	Generator, swept-frequency, RF	**
24.	Indicator, signal level	Yes
25.	Meter, AC voltmeter	Yes
26.	Meter, AC wattmeter	Yes
27.	Meter, AF power	Yes
28.	Meter, automatic noise figure	**

Table XXXXVI (contd.)

Type of Equipment	Listed in ASA Catalog
29. Meter, DC ammeter	Yes
30. Meter, DC differential voltmeter	Yes
31. Meter, DC voltmeter	Yes
32. Meter, field intensity	Yes
33. Meter, frequency counter	Yes
34. Meter, IF power	**
35. Meter, RF voltmeter	Yes
36. Meter, selective RF voltmeter	No
37. Meter, true RMS	Yes
38. Meter, vector impedance	No
39. Network, combining, AF, 3-port	*
40. Network, combining, RF, 3-port	**
41. Network, combining, RF, 4-port	*
42. Network, impedance matching, RF	**
43. Network, line impedance	*
44. Network, insertion	*
45. Network, isolation	*
46. Oscilloscope, DC	Yes
47. Oscilloscope, dual channel	Yes
48. Oscilloscope, wide band	Yes
49. Power supply, variable DC	Yes
50. Printer, digital	No
51. Switch, coaxial	*
52. Termination, resistive, AF load	*
53. Termination, resistive, RF input, shielded	*

5.3.2.2. DETECTOR, IF, ENVELOPE

The test procedure for time delay for an AM receiver requires two matched envelope detectors which operate at the receiver's intermediate frequency. These detectors may be constructed using standard AM detector circuits with components matched to within approximately 5% or less.

5.3.2.3. DETECTOR, IF, FM

The test procedure for time delay for an FM receiver requires two matched FM detectors which operate at the receiver's intermediate frequency. These detectors may be constructed using standard FM detector circuits with components matched to within approximately 5% or less.

5.3.2.4. FILTER, POWER LINE

This filter may be one of many standard radio frequency interference filters designed for this purpose. It should provide at least 40 dB attenuation to rf signals from 10 kHz to 100 MHz, and have a voltage and current rating suitable for the receiver under test.

5.3.2.5. GENERATOR, NOISE, HOT/COLD

Fixed-temperature random noise generators, suitable for these test procedures, are not available at USASATEC for use below 10 MHz. A suitable generator for this range would have the following specifications:

a. Frequency range: 0 Hz to above 100 MHz

b. Hot noise temperature: 373 K ± 1 K

c. Cold noise temperature: 77 K ± 1 K

5.3.2.6. GENERATOR, NOISE, TEMPERATURE-LIMITED DIODE

Commercial temperature-limited diode noise generators, suitable for these test procedures, are available with the following brief specifications:

a. Frequency range: 100 kHz to 500 MHz

b. Noise temperature range: 300 K to 12,000 K

c. Source Impedance: 50 ohms

d. VSWR: <1.05

e. Accuracy: Approximately 3% or better

5.3.2.7. GENERATOR, SIGNAL, RF, FM

The USASATEC catalog does not list any FM signal generators with frequency coverage below approximately 20 MHz. The specifications required to perform these test procedures are generally the same as for FM signal generators on hand, but with coverage extending to the lowest radio frequency of interest.

5.3.2.8. GENERATOR, SWEPT-FREQUENCY AF

A swept-frequency signal generator for testing audio-frequency response by the swept-frequency method will have the following brief specifications:

a. Frequency range: 20 Hz to 20 kHz

b. Sweep width: 0 to 20 kHz

c. Output voltage: 1 volt rms into 50 ohms

d. Horizontal output: 5 volts, peak-to-peak, sawtooth

Such a generator is available from commercial suppliers.

5.3.2.9. GENERATOR, SWEPT-FREQUENCY, RF

The USASATEC catalog does not list any rf swept-frequency generators with frequency coverage below approximately 700 kHz. The specifications required to perform these test procedures are generally the same as for rf swept-frequency generators on hand, but with coverage extending to the lowest radio frequency of interest.

5.3.2.10. METER, AUTOMATIC NOISE FIGURE

The USASATEC catalog does not list any automatic noise figure meters with frequency coverage below 10 MHz. This is the lowest frequency available with commercial meters; therefore, no procurement recommendations are made at this time.

5.3.2.11. METER, IF POWER

The USASATEC catalog does not list any IF power meters for measuring power levels below 10 mw full scale. Commercial power meters are available with adequate sensitivities for use over most of the frequency range required by these test procedures.

5.3.2.12. METER, SELECTIVE RF VOLTMETER

A selective rf voltmeter for measuring conducted emission may consist of a stable radio receiver having an accurate signal level meter calibrated in microvolts. Suitable available instruments include field intensity meters, and selective voltmeters designed for this purpose. Communications receivers are often not suitable for this purpose because of an inaccurate metering system.

5.3.2.13. METER, VECTOR IMPEDANCE

Commercial vector impedance meters, suitable for these test procedures, are available with the following brief specifications:

a. Frequency range: 5 Hz to 100 MHz

b. Impedance range: 1 ohm to 100 K ohms

c. Phase angle range: 0 to ±90 degrees

d. Accuracy: Impedance: ±5% or better
Phase angle: ±6 degrees or better

5.3.2.14. NETWORK, COMBINING

Commercial 3-port and 4-port combining networks are available that cover much of the frequency range used in these test procedures. When commercial networks are unavailable, suitable networks can normally be assembled in the electronics shop using standard circuits. See Section 5.2.6. for a list of suitable networks.

5.3.2.15. NETWORK, IMPEDANCE MATCHING, RF

Commercial impedance matching networks are available for standard line impedances. Non-standard impedances can be matched by building-out the required impedance with resistive networks.

5.3.2.16. NETWORK, LINE IMPEDANCE

A suitable line impedance network is described in Section 5.2.8.

5.3.2.17. NETWORK, INSERTION AND ISOLATION

Insertion and isolation networks are discussed in Sections 5.2.7. and 5.2.5., respectively.

5.3.2.18. PRINTER, DIGITAL

Commercial digital printers are available for printing the readout from the digital frequency counter used in these procedures.

5.3.2.19. SWITCH, COAXIAL

Commercial coaxial switches are available that are suitable for use in these test procedures.

5.3.2.20. TERMINATION, RESISTIVE, AF LOAD

The af output port termination resistor may be any non-inductive resistor having the specified resistance and the power rating, or greater, required by the receiver.

5.3.2.21. TERMINATION, RESISTIVE, RF INPUT

The rf input port termination resistor may be any low-noise, non-inductive, shielded resistor having the specified resistance and a VSWR of 1.05 or less at the measurement frequency. It shall be fitted with a connector that mates with the receiver's input connector.

5.4. CALIBRATION REQUIREMENTS

5.4.1. CALIBRATION SCHEDULE

Test equipment must be calibrated periodically to insure that the expected performance is actually obtained. A regular calibration schedule should be established for each instrument, and followed faithfully. The schedule is based on the type of equipment and the amount of use it gets. Typically, intervals between calibrations range from 30 days to two years. No specific schedules can be given that apply to all laboratories, but schedules for equipment in a given laboratory can be based upon the following considerations:

a. Recalibrate as recommended by the manufacturer of the instrument.

b. Analyze the calibration history of an instrument to determine if and how much it was out of calibration when recalibrated. Base the new schedule on the results of this historical study.

An instrument may be recalibrated at times other than the scheduled periodic calibration for the following reasons:

a. Obviously faulty performance.

b. Recalibration following repairs, readjustments, or replacement of parts.

c. Recalibration prior to a critical measurement.

d. Recalibration following return from being loaned to another group.

5.4.2. CALIBRATION INFORMATION

To be useful, the calibration report must contain the following minimum information:

a. The VALUE of the quantity being measured (voltage, frequency, attenuation, dial correction, scale factor, etc.), expressed in units consistent with the readings on the instrument.

b. The calibration UNCERTAINTY in the value of the quantity being measured. This includes both the systematic uncertainty and the random uncertainty, stated separately, and expressed either in the units of the quantity being measured, in percent, or in decibels.

c. The test conditions prevailing during the measurement.

With this information, the absolute accuracy of the instrument is known, and its behavior can be intelligently evaluated over a period of time.

6.0. RECOMMENDATIONS

6.1. VERIFICATION OF PROCEDURES

Procedures listed in Table II with status symbols "U" or "P" have not been fully tried and tested in all particulars sufficient to verify that they are suitable and without fault for the intended purpose. Steps should be taken to evaluate them; to demonstrate their worth and/or shortcomings.

6.2. PARAMETERS NOT COVERED

The procedures contained in Section 4.0. cover a majority of the receiver parameters that are most commonly measured. However, procedures have not been worked out for other parameters that may be significant in certain applications. Such procedures should be developed as necessary. These parameters include the following:

a. Incidental FM
b. Phase distortion, both RF and AF
c. Reciprocal mixing
d. Response to internally generated spurious signals ("birdies")
e. Sweep-tuning linearity
f. AFC capture bandwidth
g. Noise limiter efficiency
h. Detector linearity
i. Detector efficiency
j. Diversity transfer sensitivity
k. Overload protection threshold
l. Power supply transient recovery
m. Tuning backlash, mechanical and/or electrical

6.3. IMPROVED PROCEDURES

Certain of the procedures listed in Table II are either completely inadequate for the intended purpose (e.g., 4.5.3., 4.5.4., and 4.6.2.) or can be improved upon by applying newly developed principles or techniques. These improvements will require R & D effort on the part of qualified metrologists, and should be carried out according to the need. Parameters for which present procedures are inadequate or which warrant improvement include the following:

a. Radiated interference susceptibility
b. Radiated emission
c. Dynamic range
d. Spurious response attenuation
e. Cross modulation
f. Intermodulation distortion
g. Impulse bandwidth
h. Conducted interference susceptibility
i. Time delay
j. Selectance

Radiated susceptibility and emission measurements are hamstrung by the lack of effective techniques for measuring in the near field and in shielded enclosures. New probes and radically new enclosure designs are needed by many agencies for a wide variety of purposes.

Measurement techniques for parameters involving receiver nonlinearities (cross modulation, intermodulation, etc.) give marginal results because of nonlinearities and distortion products in the test equipment itself. Alternate techniques might be possible; for example, the noise power ratio (NPR) technique shows promise for measuring intermodulation distortion.

Measurements requiring large amounts of time, such as searching for intermodulation products or spurious responses, or which require large amounts of data, such as selectance or AGC leveling effect, can benefit from elementary automation techniques.

The measurement of receiver impulse response, and related parameters such as impulse bandwidth and phase distortion, are hampered by inadequate definitions and standards for pulse quantities. A time-domain description of receiver behavior may have some advantages over the traditional frequency-domain description.

Finally, conducted susceptibility and emission measurements are often meaningless because of line impedance variations and uncertainties. Improved insertion and line impedance network designs are needed, or alternate techniques must be developed.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This handbook contains test methods and procedures for radio receivers of advanced design that operate in the frequency range below 100 MHz. Sixty-one methods are given for testing forty receiver characteristics such as sensitivity, selectivity, gain, interference susceptibility, audio characteristics, power supply characteristics, and others. Each receiver characteristic is defined. For each method, the following information is given: (a) test equipment required, (b) step by step procedure, (c) data required, and (d) measurement error computation. The handbook also includes a general discussion of standard test conditions, suitable test equipment, and measurement errors.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

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