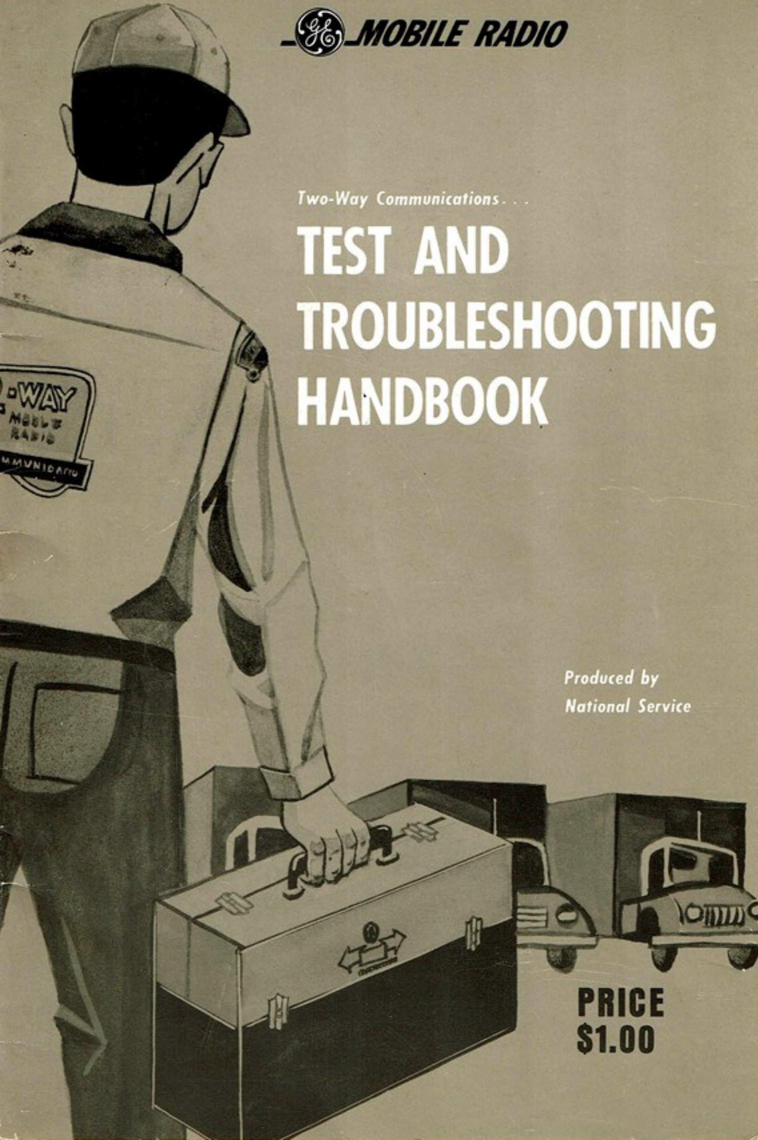
GE MOBILE RADIO

Two-Way Communications . . .

TEST AND TROUBLESHOOTING HANDBOOK



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FORWARD

Any mobile communications service shop has but one commodity to offer its customers - time, the time spent to return a communications unit to service. Behind this commodity must be an adequate facility and experienced personnel, but perhaps the most important of all service supports. is knowledge. of the equipment being serviced, of the test equipment used. and of the methods employed.

This booklet treats in some detail the methods of determining, to the maximum extent practicable in the field, the condition of a mobile or base station transmitter and receiver. The General Electric Company hopes that this booklet will clarify the purpose, the results, and the techniques of proving that the unit meets its stated specifications.

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INTRODUCTION

GENERAL

When a manufactured commodity is purchased in sufficient quantity by the consumer, need usually dictates the formation of a national organization to set standards, offer technical support, promote legislation, and keep all members informed. In mobile communications, there are national organizations which provide some of these services, yet there are certain areas of technical support which are not supplied. As a result, hundreds upon hundreds of locations in the Nation at which mobile communications equipment is installed and maintained follow no common maintenance practices. Although many of these service locations earn their income solely through the installation and maintenance of mobile communications equipment, there is no central organization from which they can seek certain types of assistance. Furthermore, the shortage of qualified reference material on the subject is appalling.

Of all the areas in which confusion exists, one of the most notable is in the area of standard test procedures. Considering the fact that the communications service technician is continually evaluating the condition of mobile units base station equipment, and all associated accessories, the absence of complete but simplified test procedures continues to limit the service facility from producing maximum income.

Purpose of the book:

It is the intent to describe in this book in the simplest terms, those tests which will allow the technician to ascertain the condition of a mobile or base station combination in the shortest possible time.

The tests described here are not all of the tests which can be performed; on the contrary, these tests were chosen for three other reasons:

(1) to provide a series of tests which can be performed quickly, both in the shop and in the field, utilizing test equipment usually employed in communications equipment;

(2) to provide exact information with a minimum of time and effort;

(3) to provide a simplified system of locating failures, utilizing a minimum number of tests.

Use of the Tests:

It should be remembered that design of communications equipment varies widely between manufacturers. However, even though this booklet was first produced for use by General Electric Authorized Service Stations of mobile communications equipment, the principles as stated can apply to all mobile communications equipment, regardless of manufacturer. In most cases, the mechanics of the tests can be directly applied to any combination, regardless of type.

In all cases, the technician must be aware of specifications of the unit under test. He must consult the instruction manual shipped with the equipment to learn of its expected performance. Although some of the stated specifications are difficult to prove in the field because of the complexity of the tests and the need for extensive test equipment, most can be checked quickly and definitely, using common mobile communications test equipment with the procedures described here.

Need for the Tests:

The value of experience in testing and repairing of communications equipment cannot be questioned. As always, however, experience makes its greatest contribution when applied to good procedures and facilities. Consequently, both the experienced and inexperienced technician will benefit more if the procedures outlined here are followed in sequence and in sufficient detail to produce the needed results. To circumvent described procedure could produce erroneous results since every effort has been made to simplify the operations.

Application of the Tests:

The final section of this booklet describes methods of using these tests in troubleshooting. This brief, but most significant section can be the key to fast and accurate bench work in the repair of mobile communications equipment. By isolating problems to the faulty stage needless troubleshooting time can be changed to productive hours.

There will be those who consider this procedure cumbersome and time-consuming at the first review. Those who disregard these procedures on this basis will be rejecting an opportunity to improve their service techniques in three ways.

(1) by increasing their efficiency through faster determination of the unit's performance according to specifications;

(2) by being able to locate failures in a minimum of time; and

(3) by being assured that after repair and proper testing, the unit is, without question, ready for customer use and that a recall for the same problem will not be necessary.

As in the case of any manual operation, first efforts are tedious. It has been proven, however, that with a minimum of practice, all tests described here can be performed in minutes so long as standard test practices are followed.

How to Use This Book:

For those interested in getting the most from this material, no bench work should be started until the book has been read thoroughly, more than once, if necessary, to get the full concept of its purpose and plan. Study the definitions thoroughly; think through the mechanical procedure in performing the tests, and digest the troubleshooting techniques in detail. When an understanding of these things is complete, proceed with each test on the bench on a known good unit with the specifications at hand. Repeat each test until the mechanics are familiar. It will be seen that the entire series of receiver and transmitter tests can be performed in minutes. Next, introduce a typical failure in either unit and follow the troubleshooting procedure in locating the problem. With a minimum of practice, the technician should learn not only the performance of each test, but also the tremendous advantage each can be in determining the location of problems.

It is believed that this book should take a regular place on the communications workbench and in the tool box as an aid toward faster, more accurate communications equipment servicing.

Test Equipment Considerations:

Measurement can be only so accurate as the equipment used is accurate. All test equipment indicated here should be calibrated regularly if good results are to be obtained. It should also be remembered that the person who puts absolute faith in his test equipment without positively knowing of its condition could cause himself hours of unnecessary labor.

The following list of test equipment represents all items described in this booklet. It can be seen that in almost every case, it represents items common to any complete communications service shop. To some, the distortion analyzer may represent an addition; however, after reading the material, it will be seen how valuable this instrument will be.

(1) VOM Meter
(2) AC VTVM
(3) Audio Generator
(4) RF Signal Generator and Attenuation Pad
(5) Deviation Meter
(6) Distortion Analyzer
(7) Frequency Meter
(8) Wattmeter and Dummy Load
(9) DC VTVM

This represents a minimum listing. Although it is possible to perform some service with less equipment, it is impossible to get truly accurate reports which guarantees the performance of the unit without at least that equipment listed above.

DEFINITIONS

The purpose of this section is to give a basic definition and/or practical description of the tests described in this book.

Some of these tests are required to be performed by the FCC and have been in use in the field for years. Even though this is true, it has been found, in many instances, that some communications technicians still lack a basic understanding of the meaning and method of many important tests. This, of course, becomes more evident when new transmitter and receiver tests are introduced to the serviceman.

To guarantee correct performance of each test, these descriptions should be studied carefully.

POWER:

One of the primary specifications of a transmitter is its power output. The power is specified in watts and is directly related to the useable range of a transmitter.

When a transmitter is properly tuned and is working into a proper load, the power as read by a recently calibrated wattmeter should meet the specifications of the transmitter under test.

Besides the ultimate reading in watts, there is one other very important value that must be set when power is checked. This is plate power input.

The FCC states that the plate power input (plate voltage times plate current) to the power amplifier must never exceed the station's licensed value. The plate power input is measured by measuring the voltage at the cathode of the power amplifier. It should be noted that some transmitters are metered in the plate.

The voltage as read across the cathode resistor is the sum of the plate and grid (control and screen if the stage is not a triode) currents times the cathode resistance. The cathode resistor of the power amplifier is fixed; however, the total current flowing in the power amplifier can be changed by: (1) changing its plate voltage; and/or (2) by changing the load on the power amplifier. The plate voltage for a given power amplifier is generated in the power supply and is, like the cathode resistor, a fixed value.

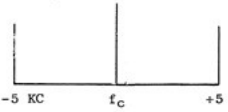
The transmitter will be properly loaded when the antenna transformer is adjusted for a specified plate current or cathode voltage, as the case may be.

If the power amplifier is allowed to draw excessive current, its life will be shortened considerably and the transmitter may not be complying with FCC regulations.

DEVIATION AND SYMMETRY:

Frequency Deviation

The frequency of an FM transmitter without audio modulating signal input is referred to as the "center frequency" and is designated f_c. The value of the center frequency corresponds to the assigned frequency of the transmitter.



When a modulating signal is applied, the change in frequency either above or below the center frequency is called the "frequency deviation" and the total change is called the "carrier swing".

In an "amplitude modulated" (AM) system, the percent of modulation expresses the amount that the modulating signal changes the amplitude of the carrier. With an FM system, the amplitude of the R.F. Signal remains constant so that another means must be used to express the amount of modulation. Because the amplitude of the modulating signal produces a change in center-frequency, the degree of modulation is expressed in terms of "frequency deviation."

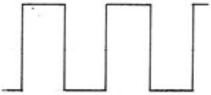
To set properly the deviation of the General Electric Company's mobile equipment, a 1,000 cycle per second tone at a specified output level must be used. The 1,000 cps input will remain constant for all product lines, but the output level will vary from one product line to another.

SYMMETRY:

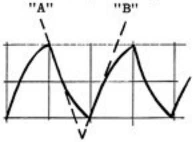
If we assume that the modulating signal that is applied to the modulator is a pure sine wave and the modulator is working properly, the frequency deviation above and below the center frequency will be equal. In this case, the deviation of the transmitter would be symmetrical.

If we assume that the modulating signal to the modulator is anything but a pure sine wave, then the amplitude and the slopes of the modulating signal above and below the base line must be equal in order to produce equal frequency changes above and below the center frequency. It should be pointed out that unequal amplitudes alone at the modulating signal may not result in unsymmetrical modulation.

To further clarify what is meant by amplitude and slope of the modulating signal, assume that the limiters are in limiting and have an output as shown below:



The square wave that is produced by the limiters is sent through a de-emphasis network before it is applied to the modulator. The input to the modulator would appear as shown:



Notice that the positive and negative excursions of the modulating signals are equal but most important, the slopes of the sawtooth shown as "A" and "B", are equal.

TRANSMITTER AUDIO DISTORTION:

The measurement of audio distortion takes into consideration any change to an input audio signal waveform resulting in a measurable degree of waveform change at the output.

This is to infer that such distortion may occur in any part of the unit under test, although the vast majority of such distortion usually occurs in the modulator and audio stages.

TRANSMITTER FREQUENCY:

One of the specific items that the FCC requires to be checked and recorded is the operating frequency of a transmitter. FCC regulations state that the frequency is to be checked when: (1) the transmitter is installed, (2) a change is made in the transmitter which affects the operating frequency, and (3) at regular intervals. The regular intervals must not exceed one month when the transmitter is not crystal-controlled, or six months when the transmitter is crystal-controlled. For some services, the six-month requirement has been changed to one year.

A transmitter will always have a specification as to stability. This stability is generally expressed in a percentage or "parts per million" and refers to the total frequency drift that can occur from the licensed center frequency.

The stability in percentage or "parts per million" is easily converted to cycles once the operating frequency of the transmitter is known. As an example, consider a transmitter operating at 150 megacycles with a stability of .0005%.

.0005% = .000005 = 5 parts per million

That is to say, the frequency may change 5 cycles per megacycle.

At 150 megacycles, the maximum allowable frequency drift is 150 X 5 or 750 cycles.

If the transmitter's stability is .0001%, then the maximum allowable drift is 1 part per million or 150 cycles.

An important fact to remember is that good measurement techniques require that the measuring device should be at least 5 times more accurate than the quantity being measured. A frequency meter with an accuracy of .0005% is not adequate to measure the frequency of a transmitter that has a stability of .0005%.

There will be no attempt made here to outline a procedure for checking and setting a transmitter's frequency due to the variety of frequency meters and counters used. It would simply not be practical to lay out a comprehensive "step-by-step" procedure and cover all types of frequency measuring devices.

SENSITIVITY:

Sensitivity is a measure of the ability of a receiver to reproduce, with satisfactory volume, weak signals received by the antenna. It may further be defined as a measure of the strength of input signal required to provide a readable output at the speaker. It is generally expressed in microvolts across a 50Ω input impedance.

There are two tests of receiver sensitivity which may be performed if the receiver under test is to be completely evaluated. The two tests are 12 db SINAD and 20 db Quieting.

12 db SINAD:

SINAD can be defined as Signal + Noise + Distortion/Noise + Distortion. 12 db SINAD means that the ratio between signal + noise + distortion and noise + distortion is 12 db. This ratio must be obtained at or below a specified minimum input signal measured in microvolts.

20 db Quieting:

The 20 db Quieting sensitivity of a receiver is the minimum amount of signal from an unmodulated input signal source that is required to produce 20 decibels of noise quieting measured at the receiver's audio output.

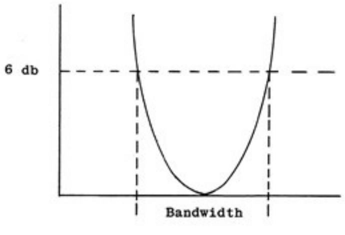
Notice that even though both tests are a check of sensitivity, 12 db SINAD takes receiver distortion into account whereas 20 db Quieting does not.

MODULATION ACCEPTANCE BANDWIDTH:

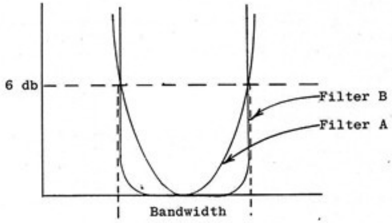
The Modulation Acceptance Bandwidth of a receiver is a measure of the deviation that the receiver will accept at a specified RF signal level above the measured SINAD sensitivity.

It must be understood that the Term "bandwidth" is not the same as Modulation Acceptance Bandwidth.

A low (290 KC) IF filter in a receiver has a specific bandwidth in kilocycles to its 6 db down points as shown below.



If this is to be considered the bandwidth of a filter and if all filters are then measured this way, we must say that the two filters shown below have the same bandwidth.



Notice that filter "A" has a round "nose" and filter "B" has a squared "nose". Because of inherent phase characteristics, filter "B" will not pass without distortion as high a phase modulated signal as filter "A" will.

Modulation Acceptance Bandwidth will tell how much deviation the receiver will pass with a specified amount of distortion.

RECEIVER AUDIO DISTORTION:

The measurement of audio distortion takes into consideration any change to an input audio signal waveform resulting in a measurable degree of waveform change at the output.

This is to infer that such distortion may occur in any part of the unit under test although the vast majority of such distortion usually occurs in the discriminator and audio stages.

SQUELCH SENSITIVITY:

Squelch Sensitivity is a measure of the minimum receiver input signal that allows the receiver to produce a continuous audio output when the squelch control is set to just suppress noise with no RF signal input (threshold setting), or when it is set fully counter-clockwise (maximum setting).

In order to completely evaluate squelch sensitivity, the test must be performed at both critical (threshold) squelch and maximum (tight) squelch.

TEST EQUIPMENT REQUIRED

TRANSMITTER TESTS

(1) Audio Signal Generator:

The Audio Signal Generator will be used in setting deviation and checking symmetry, and audio distortion. Any low distortion (.1% or less) audio signal generator that has an output of 1,000 cycles at variable signal levels can be used. The output impedance of the audio signal generator should be 500 to 600 ohms.

It should be noted that some equipments do not have an input impedance of 500 to 600 ohms. For this reason, an AC VTVM should be placed across the output of the audio signal generator. The signal level output of the audio signal generator should be metered with the AC VTVM and set under load.

(2) AC Vacuum Tube Voltmeter:

The AC VTVM will be used in all tests requiring an audio signal generator. Any standard high input impedance (1 Megohm) AC VTVM will be suitable.

(3) Distortion Analyzer:

The Distortion Analyzer will be used in the audio distortion tests, 12 db SINAD sensitivity and 20 db Quieting sensitivity tests, and Modulation Acceptance Bandwidth test. The Distortion Analyzer must have a 1,000 cycle filter or a filter that can be tuned to 1,000 cycles. The distortion analyzer should also have an AC VTVM that will give full scale deflection for at least 1, 3, and 10 volts. The distortion meter should give a full scale deflection of at least 3, 10, 30, and 100%.

All distortion analyzers perform the same function in a like manner; however; controls on different distortion analyzers have different terminology. Before a distortion analyzer is used in mobile radio testing, the operator should be familiar with its operating instructions.

(4) Wattmeter:

The wattmeter is used to check the power output of the transmitter. The wattmeter should have an input impedance of about 50 ohms so that the transmitter will be properly loaded. A recently calibrated thruline or terminating wattmeter should be used. It is not uncommon to find wattmeters with accuracies of no better than 10 to 15 percent.

(5) DC Voltmeter:

The DC Voltmeter will be used to monitor the power amplifier cathode voltage as well as for transmitter alignment. A 20,000 ohm-per-volt meter with at least a 3 volt DC and 12 volt DC full-scale reading is desirable.

(6) Dummy Load:

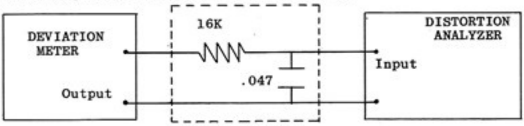
The dummy load is used to provide the transmitter with a load when no other load is being used. For example, a dummy load is used with a thruline wattmeter when power is checked, but would not be used if a terminating wattmeter is used to check power. The dummy load must have a suitable input impedance (50 ohms) and have suitable power handling capabilities.

(7) Deviation Meter:

The deviation meter is used to set maximum rated system deviation of the transmitter under test. It is also used in the check of symmetry, and audio distortion.

The deviation meter must be capable of reading the peak value of a square wave. If the meter reads other than the peak value of a square wave, it must provide for interpolation to a true peak value. The deviation meter must contain a symmetry reversing switch or be capable of being tuned to read deviation on both sides of the center frequency. (Refer to the definition of deviation and symmetry). If the deviation meter is a standard receiver, that is, having an output that is de-emphasized at 6 db per octave (750 microseconds), it can be used in the transmitter audio distortion check.

If the deviation meter has output jacks, but does not have a de-emphasis network built into it, a 750 microsecond network can be added externally providing it does not load the output of the deviation meter excessively.



750 Microsecond
DE - Emphasis Network

(8) A Transmitter Supply Voltage that meets the specifications for the transmitter under test must be provided.

RECEIVER TESTS

(1) RF Signal Generator:

The RF Signal Generator will be used in all receiver tests. The RF Signal Generator must be capable of supplying any frequency used in mobile communications systems. The signal level output at any of these frequencies must be variable and calibrated from .1 microvolt to 100,000 microvolts.

The signal generator must be capable of supplying a signal at the above listed frequencies and levels that have been frequency modulated by a 1,000 cycle audio signal. This 1,000 cycle source may be built into the signal generator or the signal generator must have provisions to accept the 1,000 cycles from an external source.

When the output frequency of the signal generator is being frequency modulated, the amount of peak deviation must be variable from 0 to 16 KC and must be symmetrical and of low distortion.

(2) Attenuation Pad:

The Attenuation Pad will be used on the output of the RF signal generator for all receiver tests. The Attenuation Pad Must have an impedance of 50 ohms. The Attenuation Pad can have an attenuation of 6 db or greater.

(3) Distortion Analyzer:

The Distortion Analyzer will be used in the audio distortion test, the 12 db sensitivity and 20 db sensitivity tests, and the Modulation Acceptance Bandwidth test.

The Distortion Analyzer must have a 1,000 cycle filter or a filter that can be tuned to 1,000 cycles. The distortion analyzer should also have an AC VTVM that will give full scale deflection for at least 1, 3, and 10 volts.

The Distortion Analyzer should give a full-scale deflection of at least 3, 10, 30, and 100%.

All distortion analyzers perform the same function in a like manner; however, controls on different distortion analyzers have different terminology. Before a distortion analyzer is used in mobile radio testing, an operator should be familiar with its operating instructions.

(4) DC Vacuum Tube Voltmeter:

The DC VTVM will be used in all receiver tests.

Any standard high input impedance (10 Megohm) DC VTVM will be suitable. A zero center adjustment is desirable.

(5) A Receiver Supply Voltage that meets the specifications for the receiver under test must be supplied.

NOTE:

When tests are performed on both transmitters and receivers, the end results, as obtained by taking readings from the test equipment, must be properly interpreted. Remember, the accuracy of the final reading is only as accurate as the least accurate piece of test equipment used.

OPERATING TEST CONDITIONS

The purpose of this section is to clarify for the tester, the reason why specific values of frequencies and voltages are setup on the test equipment when the tests are performed.

After the tester understands the definitions and operating test conditions, he should have a greater insight as to what the test is doing and why it is being performed on both the transmitter and receiver.

TRANSMITTER:

In the transmitter deviation test, symmetry test, and audio distortion test, the audio signal generator is set to produce a 1,000 cycle output. This frequency is used because in an operating system, the frequency of the voice centers around 1,000 cycles.

In the deviation and symmetry tests, the level of the 1,000 cycles signal is obtained from the maintenance manual for the transmitter under test. This signal level is selected to place the limiters in 20 db of limiting.

In the deviation test (Mechanics Section), the level of the 1,000 cycles signal is decreased by 25%. If the limiters are in limiting, this decrease in signal level should have little or no effect on rated system deviation.

In step 15 of the symmetry test, (Mechanics Section), the input level of the 1,000 cycles signal is reduced until the deviation meter reads 2KC for narrow band units and 8 KC for wide band units. When the transmitter is so deviating, the limiters should not be limiting.

In the transmitter audio distortion test, the level of the 1,000 cycle modulating signal is set to produce 60% of maximum rated system deviation. A more exact figure would be 2/3 of Maximum rated system deviation; however, because some transmitters are on the verge of limiting at this value and limiting will create distortion, a value of 60% should be used.

RECEIVER:

In the 12 db SINAD test, Modulation Acceptance Bandwidth test, audio distortion test, and squelch sensitivity test, the FM signal generator is producing a carrier frequency that has been modulated with a 1,000 cycle audio signal at 2/3 of maximum rated system deviation.

The 1,000 cycle is used because the average modulating frequency in an operating system is about 1,000 cycles. The deviation of 2/3 of maximum rated system deviation is used because this is the average deviation a receiver would be receiving in an operating system.

In the 12 db SINAD test, the Modulation Acceptance Bandwidth test, 20 db of Quieting test, and audio distortion test, the squelch control is set at minimum. This control is set at minimum so that the squelch circuit does not affect these tests.

In the 12 db SINAD test and the audio distortion test, the output signal level of the RF signal generator is set at 1,000 microvolts. This is to ensure that the receiver will have an input level that is great enough to overcome system noise and place the limiters in deep limiting.

For all receiver tests, the receiver must have a proper load. This load should be a resistor of the proper value in place of a speaker or a 600 ohm resistor if the receiver normally matches to a 600 ohm line. The wattage rating of the resistor must be great enough to accept the output of the receiver under test. The receiver's volume control will be set as designated in each test.

The output of a receiver is expressed in watts across a specified load. This value of watts can be converted to a voltage with the following formula:

$$P = \frac{E^2}{R} \quad \text{or} \quad E = \sqrt{PR}$$

E is the RMS voltage the volume control is set for.

P is the output power of the receiver and is listed on the receiver specification sheet.

R is the load resistance of the receiver.

As an example, assume that the receiver has an output of 1.5 W across 3.5 ohms.

$$E = \sqrt{PR}$$

$$= \sqrt{5.25}$$

$$E = 2.29 \text{ Volts RMS}$$

For full rated power output, the volume control would be set so that 2.29 volts RMS is read with a voltmeter.

If one quarter rated power is desired then:

$$E = \sqrt{\frac{P}{4} R}$$

$$= \sqrt{\frac{1.5}{4} X 3.5}$$

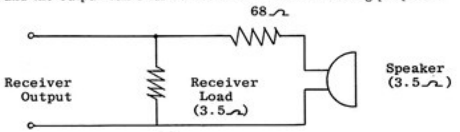
$$= \sqrt{.375 X 3.5}$$

$$= \sqrt{1.31}$$

$$= 1.145$$

The voltage for one-quarter rated power will always be one-half the voltage for full rated power.

When a resistor is used for the receivers load, it will, of course, be impossible to listen to the output of the receiver. The following is a drawing of how the speaker may be connected back into the circuit so that the receiver will maintain a proper load and the output can still be heard for troubleshooting purposes.



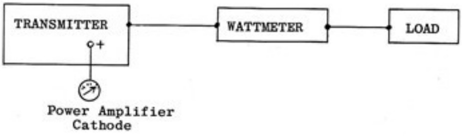
MECHANICS OF TESTS

The following section contains the mechanics, or step-by-step procedure for performing the transmitter and receiver tests.

The recommended procedure for doing any of the tests is first, read the definition and the operating test conditions for the test; second, read and understand the mechanics of the test that is to be performed; third, ensure that the proper test equipment is available and that it is known how to properly operate it.

After the tests have been performed, the results must be interpreted. In any test that a required value is needed for comparison, consult the maintenance manual. An example would be the sensitivity of a receiver in microvolts. A second method for interpreting the results of all tests is described in the last section of the book on basic troubleshooting.

POWER MEASUREMENT



(1) Use a transmitter supply voltage that meets the specifications for the transmitter under test.

(2) Place DC voltmeter in the power amplifier cathode jack, observing meter lead polarity.

(3) Connect a short piece of 50 ohm coaxial cable from the output jack of the transmitter to the input jack of the wattmeter.

(4) Connect a short piece of 50 ohm coaxial cable from the wattmeter output jack to the input jack of the load.

<u>NOTE</u>:

If a terminating type wattmeter is used, the load is not used.

(5) Place the "tune-operate" switch to the "operate" position.

(6) Turn on the equipment and allow at least 5 minutes for warm-up.

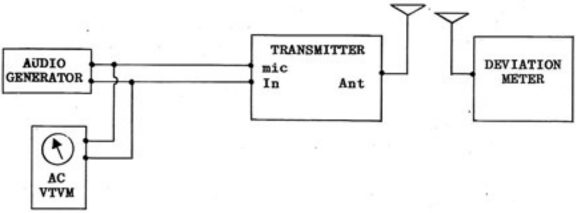
(7) Key the transmitter.

(8) Read the power as indicated on the wattmeter and the power amplifier cathode voltage as indicated on the DC voltmeter.

(9) Refer to the specifications for the transmitter under test to ensure that the cathode voltage does not exceed specifications and that the power output is correct.

(10) If the power is low and the power amplifier cathode voltage is correct or low, refer to troubleshooting section.

DEVIATION



(1) Connect an "audio generator" to the microphone input of the transmitter.

(2) Connect an "AC VTVM" across the output of the audio generator.

(3) Connect an "antenna" or "dummy load" to the antenna jack of the transmitter.

(4) Connect the "deviation meter" as per the manufacturer's instructions.

(5) Apply power to the transmitter and test equipment. Allow for a 20-minute warm-up period.

(6) Key the transmitter and tune the "deviation meter".

(7) Refer to the alignment section in the Maintenance Manual for the transmitter under test and note the signal level of the 1,000 cps needed to set deviation.

(8) Apply a 1,000 cps signal from the audio generator at the correct output level measured on the AC VTVM. (OUTPUT LEVEL NOTED IN STEP 7.) Whistling into the microphone is not satisfactory!

(9) Key the transmitter.

(10) Adjust the modulation control in the transmitter for maximum rated system deviation on the deviation meter. (Narrow Band ± 5 KC - Wide Band ± 15 KC unless otherwise specified). Before rated system deviation is properly set, note that deviation can be adjusted above and below the proper setting.

(11) Reverse the "polarity switch" on the deviation meter.

(12) Key the transmitter.

(13) Read the deviation on the deviation meter. If the reading is below or the same as the reading obtained in step 10, do not change the modulation control in the transmitter. If the reading exceeds the reading obtained in step 10, re-adjust the modulation control in the transmitter for the reading obtained in step 10.

(14) If there is a difference in symmetry of greater than 15%, refer to troubleshooting section (5 KC to 4 KC for Narrow Band and 15 KC to 12.5 KC for Wide Band).

(15) Place the "polarity switch" on the deviation meter in the position that gave maximum rated system deviation. (Leave the polarity switch in this position).

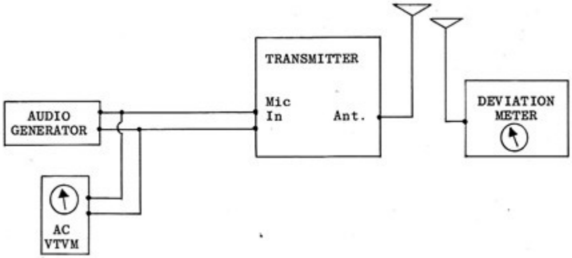
(16) Leave the audio generator at 1,000 cps and decrease its output level measured on the AC VTVM by 25%.

(17) Key the transmitter.

(18) Read the deviation on the deviation meter and note that it does not exceed system rated deviation obtained in step 10.

SYMMETRY

DO NOT PERFORM THIS TEST UNLESS DEVIATION HAS BEEN PROPERLY SET



STEPS 1 - 6 SAME AS FOR DEVIATION TEST

(1) Connect an "audio generator" to the microphone input of the transmitter.

(2) Connect an "AC VTVM" across the output of the audio generator.

(3) Connect an "antenna" or "dummy load" to the antenna jack of the transmitter.

(4) Connect the "deviation meter" as per the manufacturer's instructions.

(5) Apply power to the transmitter and test equipment. Allow for a 20-minute warm-up period.

(6) Key the transmitter and tune the "deviation meter".

(7) Apply a 1,000 cps signal from the audio generator at the correct output level measured on the AC VTVM. This level is found in the Maintenance Manual for the transmitter under test.

(8) The "polarity switch" on the deviation meter should be in the position that gave maximum rated system deviation.

(9) Key the transmitter.

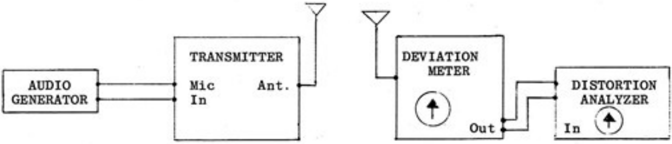
(10) Note the deviation reading on the deviation meter.

(11) Reverse the "polarity switch" on the deviation meter.

(12) Key the transmitter.

(13) Note the deviation reading on the deviation meter.

TRANSMITTER AUDIO DISTORTION



(1) Connect an "audio generator" to the microphone input of the transmitter.

(2) Connect an "antenna" or dummy load to the antenna jack of the transmitter.

(3) Connect the "deviation meter" as per the manufacturer's instructions. (The deviation meter must be a standard receiver as explained in the Test Equipment section).

(4) Connect a "distortion analyzer" to the output jacks of the deviation meter.

(5) Apply power to the transmitter and test equipment. Allow for a 20-minute warm-up period.

NOTE:

The following steps are performed with the Transmitter keyed.

Do not exceed the duty cycle of the transmitter under test.

(6) Tune the deviation meter.

(7) Apply a 1,000 cps signal from the audio generator at an output level to give 60% of rated system deviation as read on the deviation meter. (Narrow Band ±3 KC - Wide Band ± 9 KC).

(8) Set the distortion analyzer to the 100% scale.

NOTE: If full scale deflection cannot be obtained on the 100% scale, reduce the sensitivity scale until full scale deflection is obtained and consider this as 100%.

(9) With the 1,000 cps filter out, adjust the level control for a 100% full scale deflection.

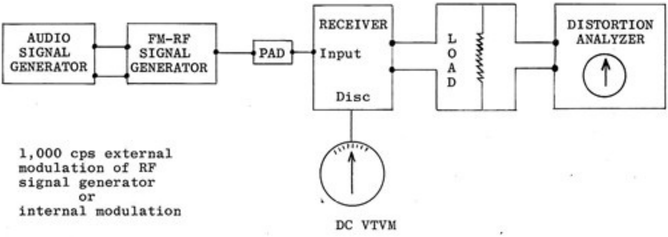
(10) With the 1,000 cps filter in, tune for a minimum reading (null) with the tuning controls.

(11) Reduce the percentage scale (100% to 30%, etc.) until the lowest meter reading is obtained.

(12) Tune for a minimum reading with the tuning controls.

(13) Note what percentage scale the distortion analyzer is set to and read the percentage of distortion from the meter.

12 db SINAD SENSITIVITY TEST



NOTE:

If the RF Signal Generator has the capabilities of internal modulation of 1,000 cps, no audio signal generator is necessary.

(1) Turn on "test equipment" and allow at least a 20-minute warm-up period.

(2) Set the RF signal generator for internal or external 1,000 cps modulation.

(3) Connect the output of the RF signal generator through a 50 ohm pad to the input of the receiver.

(4) Disconnect the receiver's speaker and replace it with the correct resistive load. Note: See page 4 of Operating Test Conditions.

(5) If the receiver under test has a squelch circuit, set the squelch control for minimum squelch. (This position on the General Electric Company's communications equipment is fully clockwise.)

(6) Turn "on" the receiver.

(7) Connect the receiver's resistive load to the input of the distortion analyzer.

(8) Connect the DC-VTVM to the receiver's discriminator test jack.

(9) Apply a 1,000 uv (microvolt) "on-frequency" signal with 2/3 rated system deviation at 1,000 cps from the RF signal generator to the receiver while monitoring for zero discriminator on the DC-VTVM.

(10) Set the controls on the distortion analyzer for use as a VTVM.

(11) Adjust the receiver's volume control for full rated power output as read on the distortion analyzer VTVM. Once this has been set, do not re-adjust the volume control.

(12) Adjust the distortion analyzer so that the signal will couple through the 1,000 cps filter.

(13) Tune the 1,000 cps filter for a null (minimum reading) on the lowest possible meter scale. (100% - 30%, etc.)

(14) Switch the 1,000 cps filter out of the circuit and adjust the level control for a 0 db reading. For best results, set this on a mid-range such as 30%.

(15) Switch the 1,000 cps filter into the circuit. Notice that the meter deflection has moved to the left.

(16) Decrease the output from the signal generator at the same time switching the distortion analyzer's 1,000 cps filter in and out. Continue reducing the RF signal generator's output until there is a 12 db difference reading on the distortion analyzer meter between the filter in and filter out positions.

(17) Set the distortion analyzer's controls to read the output power from the receiver.

(18) The reading on the distortion analyzer VTVM should not be less than 50% of the receiver's full rated output power.

(19) The microvolt setting of the RF signal generator is the 12 db SINAD Sensitivity of the receiver.

(20) Leave all controls as they are for you are ready to perform the Modulation Acceptance Bandwidth test.

MODULATION ACCEPTANCE BANDWIDTH

NOTE:

Before a Modulation Acceptance Bandwidth test can be performed. a 12 db SINAD Sensitivity Measurement must be made.

(1) Increase the output of the RF Signal generator 6 db (twice the microvolt reading obtained for the 12 db SINAD Sensitivity).

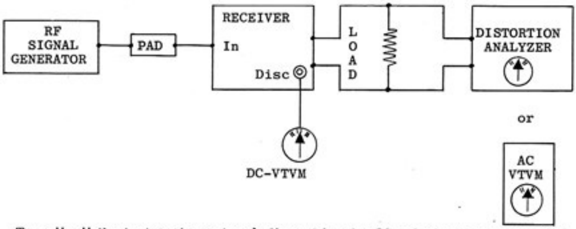
(2) Set the controls of the distortion analyzer so that the 1,000 cps filter is out of the circuit and adjust the level control for a 0 db reading. For best results, set this 0 db reference on a mid-range such as 30%.

(3) Switch the 1,000 cps filter into the circuit. Notice that the meter deflection has moved to the left.

(4) Increase the deviation of the signal at the RF signal generator at the same time switching the distortion analyzer's 1,000 cps filter in and out. Continue increasing the deviation until there is a 12 db difference reading on the distortion analyzer between the filter in and out positions.

(5) The deviation reading on the RF signal generator for the 12 db difference is the Modulation Acceptance Bandwidth of the receiver.

20 db QUIETING SENSITIVITY



(1) Turn "on" the test equipment and allow at least a 20-minute warm-up period.

(2) Connect the output of the RF signal generator through a 50 ohm pad to the input of the receiver.

(3) Disconnect the speaker and replace it with the correct resistive load.

(4) If the receiver under test has a squelch circuit, set the squelch control for minimum squelch. (This position on the General Electric Company's communications equipment is fully clockwise.)

(5) Turn "on" the receiver.

(6) Connect the distortion analyzer or AC VTVM across the receiver's load.

(7) Connect the DC VTVM to the receiver's discriminator test jack.

(8) Apply an unmodulated "on-frequency" signal from the RF signal generator while monitoring for zero discriminator on the DC VTVM.

(9) Set the RF signal generator's attenuation pad to minimum so that no signal is fed to the receiver.

(10) Set the controls on the distortion analyzer for use as a VTVM.

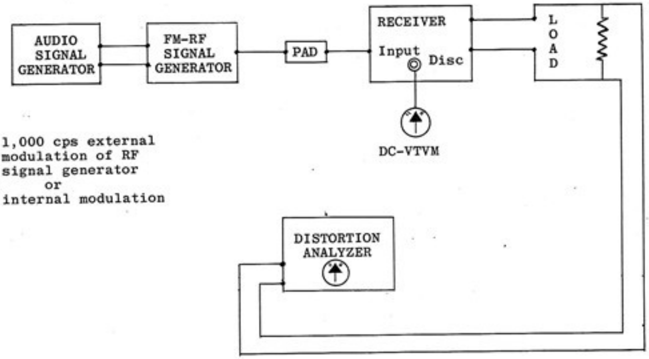
(11) Adjust the receiver's volume control for one-quarter (1/4) full rated power output. Do not touch the setting of the volume control once it has been set.

(12) Set the controls of the distortion analyzer to a db scale (%) and with the filter out of the circuit, adjust the level control for 0 db.

(13) Increase the RF signal generator's output with the attenuation pad until the reading on the distortion analyzer has decreased 20 db.

(14) Read in microvolts the setting of the RF signal generator's attenuation pad. This reading is the 20 db Quieting Sensitivity of the receiver.

AUDIO DISTORTION



NOTE:

If the RF signal generator has the capabilities of internal modulation of 1,000 cps, no audio signal generator is necessary.

(1) Turn "on" test equipment and allow at least a 20-minute warm-up period.

(2) Set the RF signal generator for internal or external 1,000 cps modulation.

(3) Connect the output of the RF signal generator through a 50 ohm pad to the input of the receiver.

(4) Disconnect the receiver's speaker and replace it with the correct resistive load.

(5) If the receiver under test has a squelch circuit, set the squelch control for minimum squelch. (This position on the General Electric Company's communications equipment is fully clockwise.)

(6) Turn "on" the receiver.

(7) Connect the distortion analyzer across the receiver's resistive load.

(8) Connect the DC-VTVM to the receiver's discriminator test jack.

(9) Apply a 1,000 uv (microvolt) "on-frequency" signal with 2/3 rated system deviation at 1,000 cps from the RF signal generator to the receiver while monitoring for zero discriminator on the DC-VTVM.

(10) Set the controls on the distortion analyzer for use as a VTVM.

(11) Adjust the receiver's volume control for full rated power output as read on the distortion analyzer. Once this has been set, do not re-adjust the volume control.

(12) Set the distortion analyzer to the 100% position.

(13) With the 1,000 cps filter out of the circuit, adjust the level control for a 100% full scale deflection.

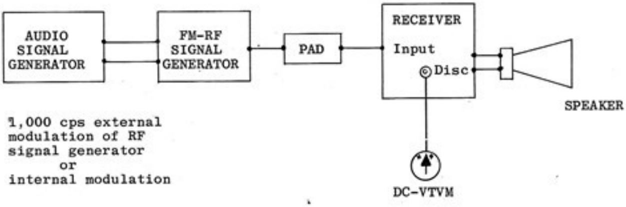
(14) With the 1,000 cps filter in the circuit, tune the distortion analyzer for a null or minimum reading with the tuning controls.

(15) Reduce the percentage scale (100% to 30%, etc.) until the lowest meter reading is obtained.

(16) Tune for a minimum reading with the tuning controls.

(17) Note the percentage scale to which the distortion analyzer is set and read the percentage of distortion from the meter.

SQUELCH SENSITIVITY
(Critical and Maximum)



NOTE:

If the RF signal generator has the capabilities of 1,000 cps internal modulation, no audio signal generator is necessary.

(1) Turn "on" test equipment and allow at least a 20-minute warm-up period.

(2) Set the RF signal generator for internal or external 1,000 cps modulation.

(3) Connect the output of the RF signal generator through a 50 ohm pad to the input of the receiver.

(4) Turn "on" the receiver.

(5) Set the receiver's squelch control for minimum squelch. (This position on the General Electric Company's communications equipment is fully clockwise.)

(6) Apply a 1,000 uv (microvolt) "on-frequency" signal with 2/3 rated system deviation at 1,000 cps from the RF signal generator to the receiver while monitoring for zero discriminator on the DC-VTVM.

(7) Adjust the attenuation pad on the RF signal generator for minimum. (No signal output)

(8) Adjust volume control for normal listening level on noise.

Critical Squelch:

(9) Adjust the receiver's squelch control so that the noise is just squelched.

(10) Increase the RF signal generator until the receiver produces a continuous audio output.

(11) The setting of the RF attenuator in microvolts is the Squelch Sensitivity of the receiver.

Maximum Squelch:

(12) Set the RF attenuator to minimum.

(13) Adjust the squelch control for maximum squelch. (This position on the General Electric Company's Communications equipment is fully counterclockwise.)

(14) Increase the RF attenuator until the receiver produces a continuous audio output.

(15) The setting of the RF attenuator in microvolts is the maximum Squelch Sensitivity of the receiver.

TROUBLESHOOTING

The following section has been written to aid the communications technician in applying and interpreting the foregoing transmitter and receiver tests in troubleshooting.

Troubleshooting mobile equipment by the proper application of tests is not meant to be a cure-all that will isolate a problem to a component. The tests will, however, in many cases, aid the serviceman in isolating a trouble to a section of circuitry in a minimum of time.

It must be recognized that these tests cannot be used on a transmitter or receiver if it is completely inoperative. This type of trouble is not generally the type that the serviceman spends unwarranted amounts of time trying to correct.

As this section is read, it will become obvious that the troubleshooting procedures are not detailed; they are not meant to be. Component troubleshooting of a section of circuitry has been left to the technician's ability and experience.

Basic troubleshooting techniques require that fuses and power supply voltages be checked first when trouble is encountered. It should be realized that if a transmitter or receiver supply voltages are just a little low, power and sensitivity will be low.

TRANSMITTER TROUBLESHOOTING

Power:

As explained in the Test Equipment Section, unless the wattmeter in use has been recently calibrated, you should consider that its accuracy may only be within 10 to 15 percent.

Whenever the power amplifier cathode voltage is lower than or at maximum specifications with the power output greater than or the same as specifications, the transmitter power output is good.

(1) If the correct power output cannot be obtained and the power amplifier cathode voltage is correct as in step 10, make the following checks:

(a) Retune the power amplifier stage. If correct power output still cannot be obtained at the correct cathode voltage, check the drive at the power amplifier grid. If the PA grid drive is not correct, check the drive of all RF stages including the oscillator preceding the power amplifier. (Grid drives that should be obtained will be found in the transmitter alignment section of the Maintenance Manual for the transmitter under test.)

(2) If the correct power is obtained and the PA cathode voltage is high as in Step 11, make the following test:

(a) Check the power amplifier high B+.
(b) Check the PA tube by substituting another in its place.
(c) Check for proper tuning.

Deviation:

(1) If the deviation cannot be adjusted up to rated system deviation in step 10, make the following checks:

(a) The trouble will probably be in the audio stages or the modulator stage. Since the input signal for setting deviation should put the limiter into deep limiting, the use of an oscilloscope will help localize the problem. If the waveform of the signal out of the limiter shows limiting, check the circuits following the limiter. The waveform across the de-emphasis network capacitor should be a sawtooth. If the phase modulator is tuneable, make sure it is tuned properly. If it is tuned properly, or is not a tuneable phase modulator, make resistance and voltage checks as well as checking the tube or transistor.

If the waveform of the signal in the output of the limiter shows that no limiting is taking place, check the limiter and preceding circuits. Remember, the input audio signal from the audio signal generator must be measured under load for the correct output level.

(2) If the deviation cannot be adjusted below the system rated deviation, the problem will most likely be between the output of the limiter and the input of the modulator.

(a) Check the waveform of the signal at the output of the de-emphasis network. If it is not a sawtooth, but a square wave, check the de-emphasis network. In some systems, transistors will be found to be a part of the de-emphasis network). If the output of the de-emphasis network is a sawtooth, check components such as the modulation control.

(3) If there is a difference in symmetry of greater than 15%, perform the second half of the symmetry test. The symmetry test is to be performed as a troubleshooting aid and steps 1 - 15 are the same as the steps so far performed in the deviation test, start with step 15. If the symmetry test was to be performed without first making a deviation test, it would have to be performed in its entirety.

If the readings in step 19 of the Symmetry Test are greater than 10%, check the stages preceding the limiter and the modulator.

If the readings in step 19 are good, check the limiter and modulator.

(4) If the deviation in step 17 of the Deviation Test exceeds rated system deviation, the trouble will most likely be found in the audio amplifiers or the limiter.

Transmitter Audio Distortion:

(1) If the percentage of distortion in step 13 exceeds 10%, the trouble will most likely be in the audio stages and/or the modulator stage. The following methods of troubleshooting can be used.

(a) With an oscilloscope, check the modulating signal for clipping in the audio stages.

(b) Connect the audio signal generator to the input of the modulator. Apply a 1,000 cps signal and increase the output level until 60% of rated system deviation is obtained. Check the distortion of the modulator. Connect the generator to the input of the limiter. Make sure there is no output from the generator when it is first connected. Apply a 1,000 cps signal and increase the output level for 60% of rated system deviation. Check the distortion. With these two readings and the original reading, you have the distortion of each individual stage. If one is much greater than the other two, it may be worthwhile to check this stage by making resistance and voltage checks. If the trouble is not found, check the other stages in the same manner.

RECEIVER TROUBLESHOOTING

Because 12 db SINAD is the first test that should be performed on a receiver, the receiver troubleshooting procedure will start with this test and bring modulation acceptance bandwidth and 20 db of quieting into play.

12 db SINAD Test:

(1) If an on-frequency signal has been coupled to the receiver and zero discriminator cannot be obtained as in Step 9 ----- STOP. This indicates a loss in the RF, high IF, or low IF circuits, or trouble in the discriminator.

Check the limiter metering points for normal operation to ensure that signal is present to the limiters. A normal limiter reading can be found in one of three ways: First, the Maintenance Manual for the Receiver under test; or second, from Maintenance Records being kept on the unit under test; or third, from the past experience with the receiver under test. If the limiters do not act normally on noise and/or signal, check first the receiver's IF circuits. The Receiver's IF circuits can be checked by first injecting the receiver's low IF frequency on the grid of the second mixer and observing the limiter and discriminator for activity. If activity is not observed, the trouble will be between the second mixer and limiter or the discriminator. If activity at the limiter and discriminator are observed, this indicates that the trouble is probably in front of the low IF circuitry. Proceed by injecting the receiver's high IF frequency into the grid of the first mixer and observing the limiters and discriminator for activity. Correct the trouble before 12 db SINAD is attempted again.

(2) If full rated output power (refer to Operating Test Conditions) of the receiver cannot be obtained as in step 11 ---- STOP. Listen to the output first to see if noise or signal is present. If it is not, meter the discriminator and limiters for proper operation to ensure that the signal is present at these points. If it is, proceed to the audio stages and check the output audio amplifier and speaker circuits first. Resistance and voltage readings for these circuits are available in the instruction book for the receiver under test.

(3) After the 12 db ratio is obtained on the distortion analyzer, re-check the output power of the receiver as in Step 18. If at least 50% of full rated power output is not obtained ---- STOP. Check the gain of the IF circuits starting with the limiters. It is possible to have a reasonably good 12 db SINAD ratio and still have a weak IF amplifier or limiter. Step 18 will indicate this. Correct the trouble and repeat the 12 db SINAD Test.

(4) If, when the SINAD Test was performed and none of the above listed troubles occured, but the microvolt reading as obtained in Step 19 did not meet specifications, it indicates a possible trouble in the receiver's front end, low IF filters, or discriminator.

At this point, the Modulation Acceptance Bandwidth Test should be performed. If the results of the Modulation Acceptance Bandwidth Test meet the Receiver's Specifications, the 20 db Quieting Test should be performed. Bad results of this test usually indicates a bad signal-to-noise ratio of the RF and/or high IF circuits in the receiver.

If the results of the Modulation Acceptance Bandwidth Test do not correspond to the receiver's specifications, the trouble will most likely be in the receiver's low IF circuits of discriminator.

The discriminator should be checked by injecting the receiver's low IF frequency in the low IF circuits following the low IF filters, and noting that the discriminator zero's properly and is linear when frequencies above and below the low IF's are injected.

If the discriminator proves good, the trouble will probably be in the low IF filter circuits. Refer to the receiver's low IF alignment procedures, but first double-check the low IF gain stages.

(5) If the 12 db SINAD Test met the receiver's sensitivity specifications, the 20 db Quieting Test and Modulation Acceptance Bandwidth Test need not be performed. This indicates that the receiver's signal-to-noise ratio is good, that there is at least the minimum required gain in the low IF amplifier stages, and that the receiver will pass a properly modulated signal with a minimum of IF Distortion. It is possible that a 12 db SINAD Test can be performed, and be satisfactory in all respects, and the receiver can still have below normal gain in the low IF circuitry. The only way to conclude that there is proper gain in the low IF stages is to first, have a satisfactory 12 db SINAD Test; second, have normal limiter readings as previously described; and third, meet the critical squelch sensitivity specifications.

Audio Distortion Test:

The Audio Distortion Test, like the 12 db SINAD Test, should always be performed on a receiver. It can, however, be performed before the SINAD Test and its step-by-step interpretation has been written on the assumption that SINAD was not performed first.

(1) If an on-frequency signal has been coupled to the receiver and zero discriminator cannot be obtained as in step 9 ---- STOP. This indicates a loss of signal in the RF, high IF, or low IF circuits or trouble in the discriminator.

Check the limiter metering points for normal operation to ensure that signal is present to the limiters. If the limiters do not act normally on noise and/or signal, check first the receiver's oscillator circuits for proper operation, and second, inject the receiver's low and high IF Frequencies to determine if the trouble is in the discriminator or IF circuits.

Correct the trouble before the Audio Distortion Test is attempted.

(2) If the receiver's full rated power output cannot be obtained in step 11, and the limiters and discriminator are acting normally, proceed to the audio stages and check the audio output stage and speaker circuits first.

(3) Read the percent distortion from the Distortion Analyzer in Step 17 and compare this with the receiver's specifications. If the distortion exceeds specifications, the trouble will probably be in the discriminator, audio amplifier circuits, or the switch in the squelch circuit. If the switch in the squelch circuit is not completely open, the audio stages could be operated with improper bias levels which could cause distortion. Before any audio stage troubleshooting procedures are attempted a SINAD Sensitivity and Modulation Acceptance Bandwidth tests should be performed.

(a) The discriminator is checked by injecting the receiver's low IF frequency into the low IF circuits following the low IF filters and metering the discriminator for a proper zero and linearity. If the discriminator proves to be satisfactory, proceed to the audio stages using standard component troubleshooting methods.

A 1,000 cycle signal can be injected on the grid of the first audio amplifier from an external source at a level that produces rated power output. (The volume control has been previously set properly) and audio distortion re-checked. This should confirm that the trouble is in the audio stages.

An audio signal generator and oscilloscope are an aid in localizing audio distortion problems to a stage.

Squelch Sensitivity:

Because the squelch sensitivity of a receiver is somewhat dependent on the receiver's sensitivity, the 12 db SINAD Test must be performed first so that accurate interpretation of the squelch tests can be made.

(1) If, in step 8, no noise is heard from the speaker and the discriminator and limiters indicate noise present, check the audio amplifiers and speaker circuits.

(2) If the receiver noise cannot be squelched in step 9, check the squelch circuit starting with the noise amplifier.

(3) When signal is applied in step 10, and the receiver will not open, check the squelch circuit starting with the noise rectifier.

(4) When the squelch sensitivity in microvolts is obtained from the RF signal generator in Step 11, compare it with the receiver's specifications. If the squelch sensitivity is high, check the squelch circuit starting with the noise rectifiers.

(5) If the receiver will not open or the maximum squelch sensitivity is high in step 15, check the squelch circuit starting with the noise amplifier.

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