MOBILE RADIO SERVICE TRAINING

SEMINAR 1969

TABLE OF CONTENTS

TYPICAL SPECIFICATIONS

TRANSMITTER

Power Output - 80 watts minimum

Modulation - 0 to 15 kHz

Deviation Symmetry - Narrow Band - .5 kHz MAY

Audio Sensitivity - Less than 100 MV

Audio Distortion - Less than 3%

RECEIVER

Sensitivity	
12-db Sinad	0.35 Microvolts
20-db Quieting	.5 Microvolts
Audio Output	5 Watts
Audio Distortion	Less than 5%
Squelch Sensitivity	
Critical	.15 Microvolts
Maximum	Less than 1.5 Microvolts greater than 20db quieting

POWER SUPPLY

Output		
Regulated Receiver	10V	at 70MA
Regulated Transmitter	20V	at 90MA
Bias	-45V	
Low B-Plus	309V	at 110MA
High B-Plus	680V	at 220MA

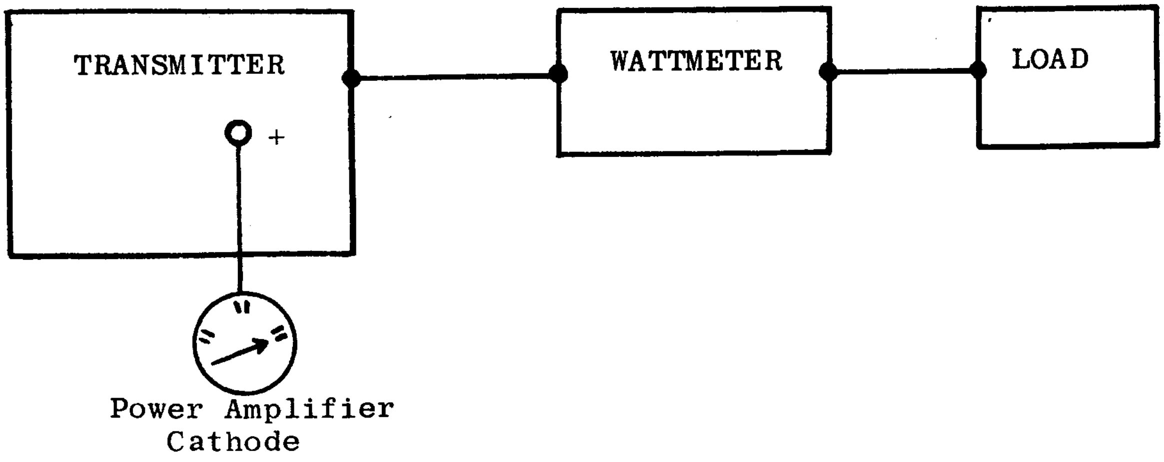
BATTERY DRAIN

Transmit	13.4V	at 21 Amps

RECEIVING

Standby-Squelched	13.8V	at 50MA
Standby Unsquelched	13.8V	at 700MA
Squelched-Transmitter filaments on	13.8V	at 1.3 Amps

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.

NOTE

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.

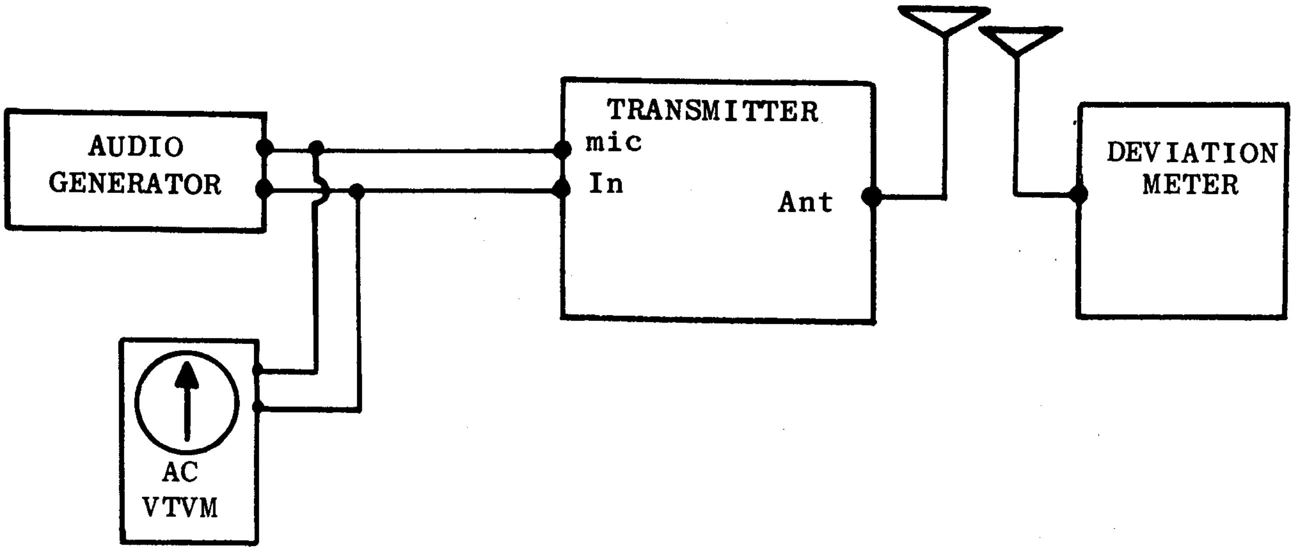
(7) Key the transmitter.

(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" of "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%.

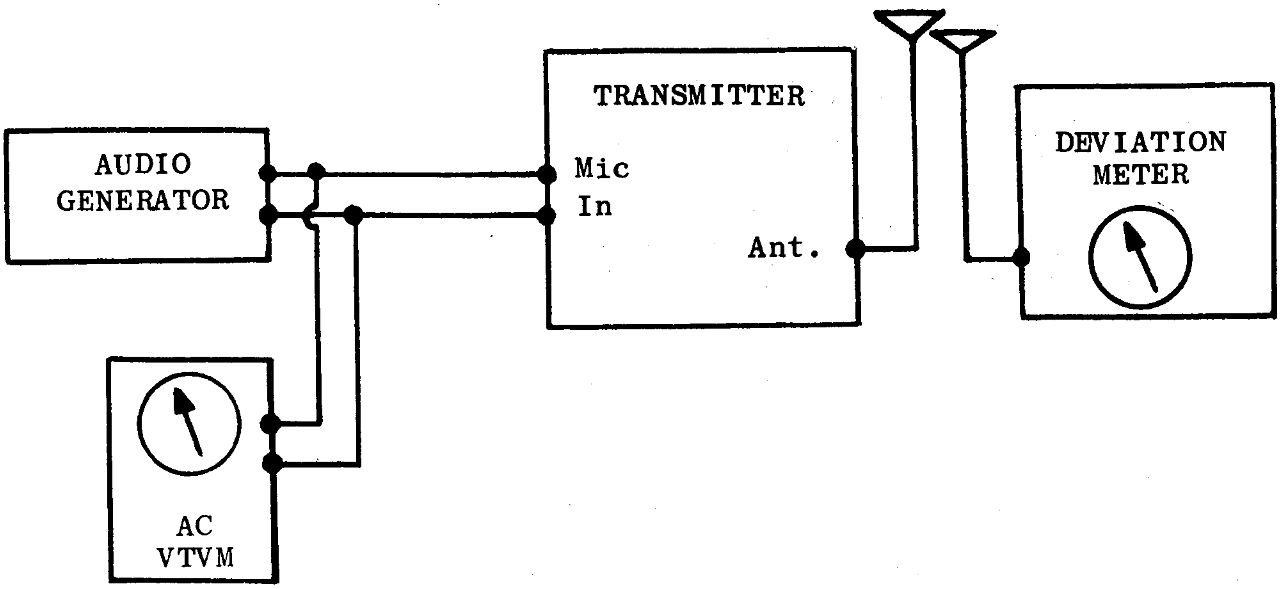
(17) Key the transmitter.

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

(19) Reduce output from audio generator until deviation falls to 2/3 rated system deviation (3.3 kHz in Narrow Band systems or 10 kHz in Wide Band systems). This is Transmitter Audio Sensitivity.

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 manufacturers 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.

(14) Compare the readings of steps 10 and 13. The two readings should be within 15% of each other.
(Narrow Band 5 KC to 4 KC - Wide Band 15 KC to 12.5 KC).

(15) Leave the audio generator at 1,000 cps. With the transmitter keyed, reduce the audio generator's output level for a 2 KC Narrow Band or 8 KC Wide Band deviation reading on the deviation meter.

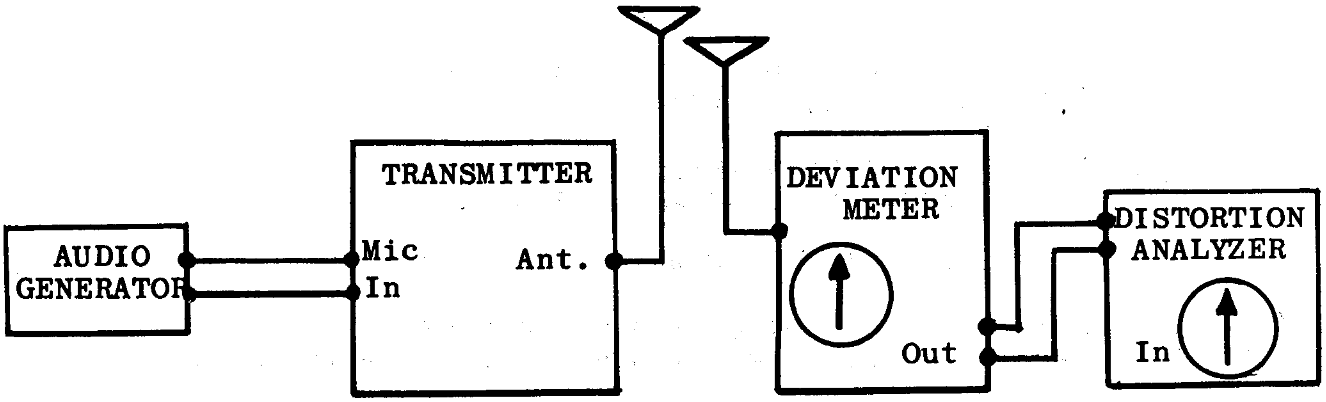
(16) Reverse the polarity switch on the deviation meter.

(17) Key the transmitter.

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

(19) Compare the readings of steps 15 and 18. The two readings should be within 10% of each other.

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.

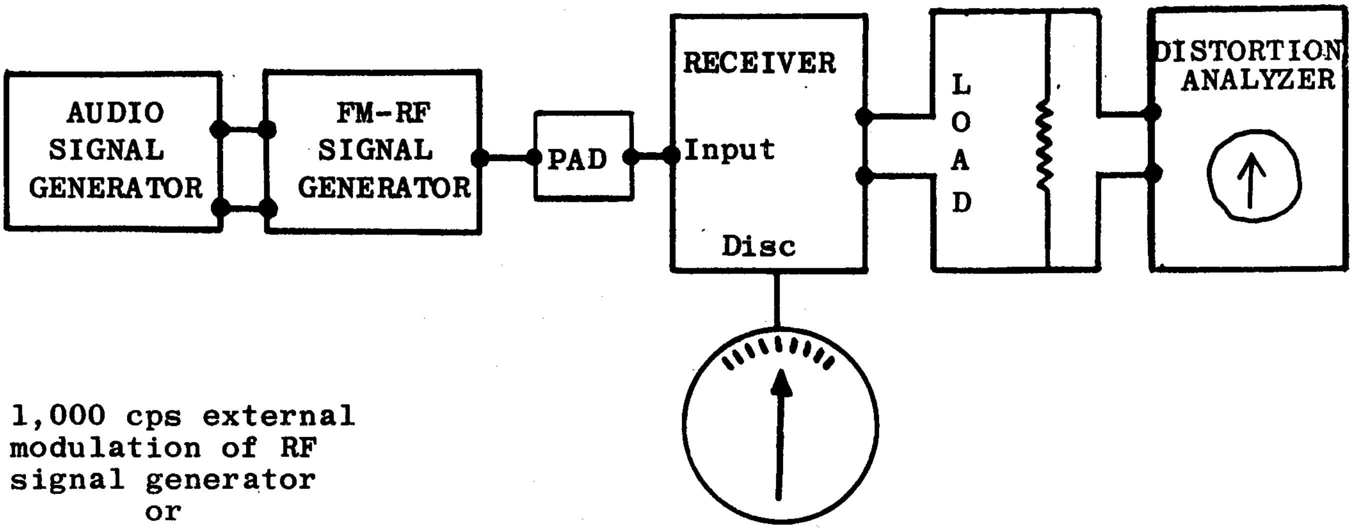
(10) With the 1,000 cps filter in, tune for a minimum reading (null) with the tuning controls.

(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



1,000 cps external
modulation of RF
signal generator
or
internal modulation

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 e uipment" 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).

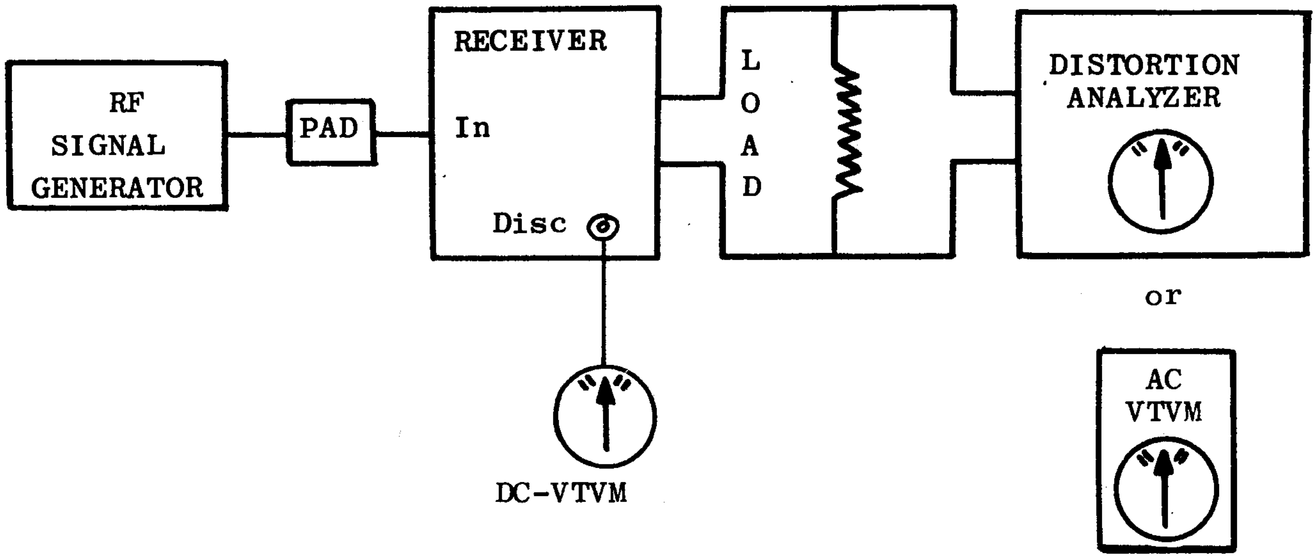
(2) Set the controls of the distortion analyzer so that the 1,000 cps filter is out of the circuit and adjust the level control for a 0 db reading. For best results, set this 0 db reference on a mid-range such as 30%.

(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.

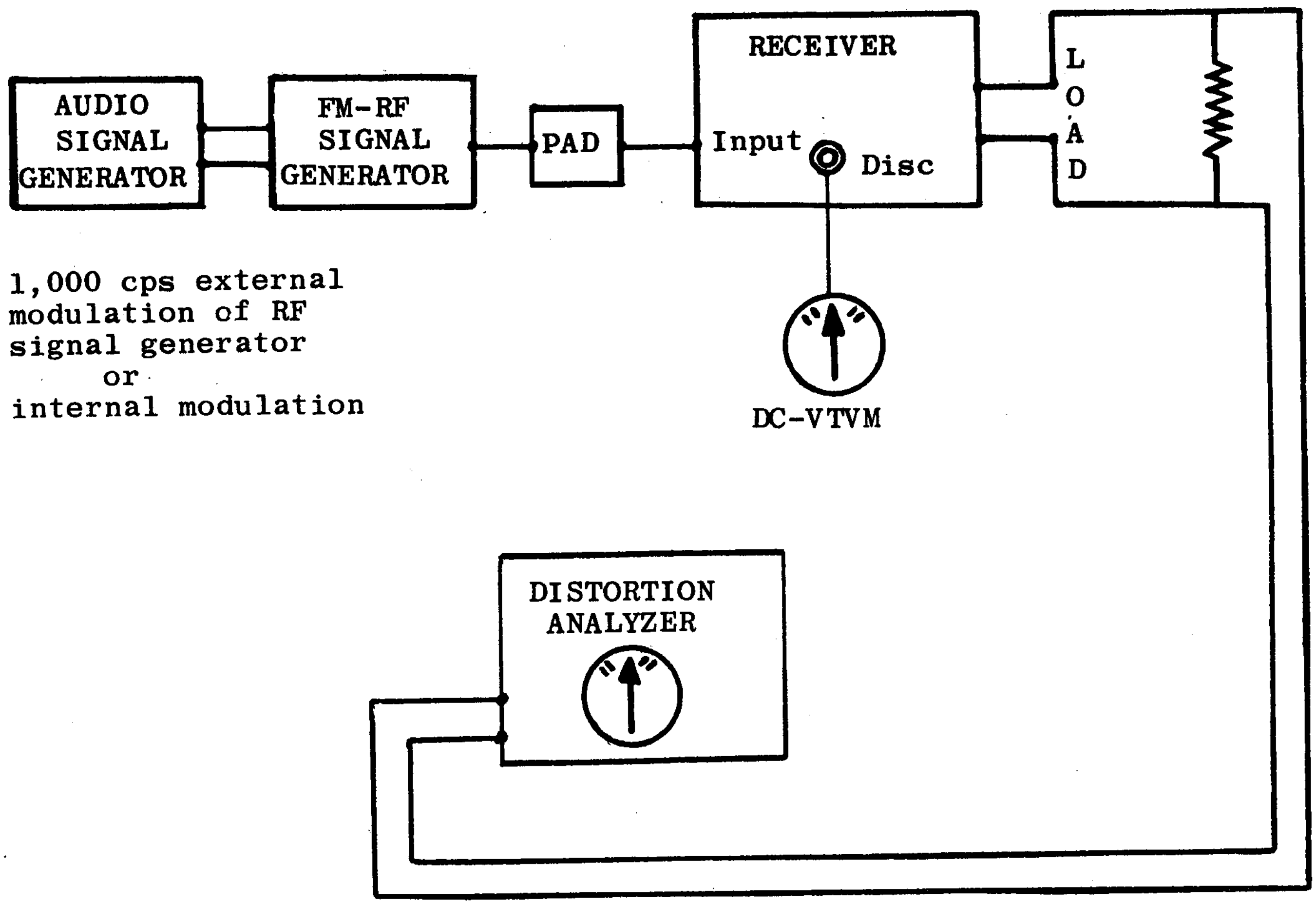
(11) Adjust the receiver's volume control for one-quarter (1/4) full rated power output. Do not touch the setting of the volume control once it has been set.

(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.

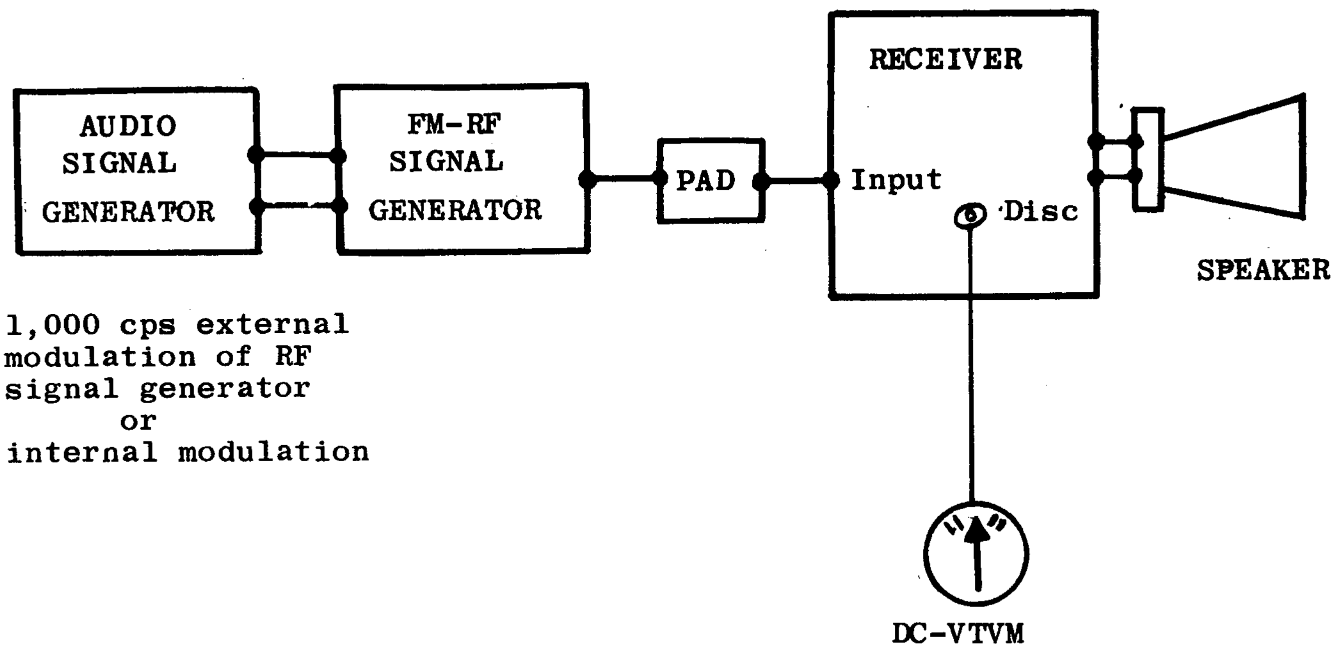
(14) With the 1,000 cps filter in the circuit, tune the distortion analyzer for a null or minimum reading with the tuning controls.

(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.

SQUELCH SENSITIVITY
(Critical and Maximum)

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 clockwise.)

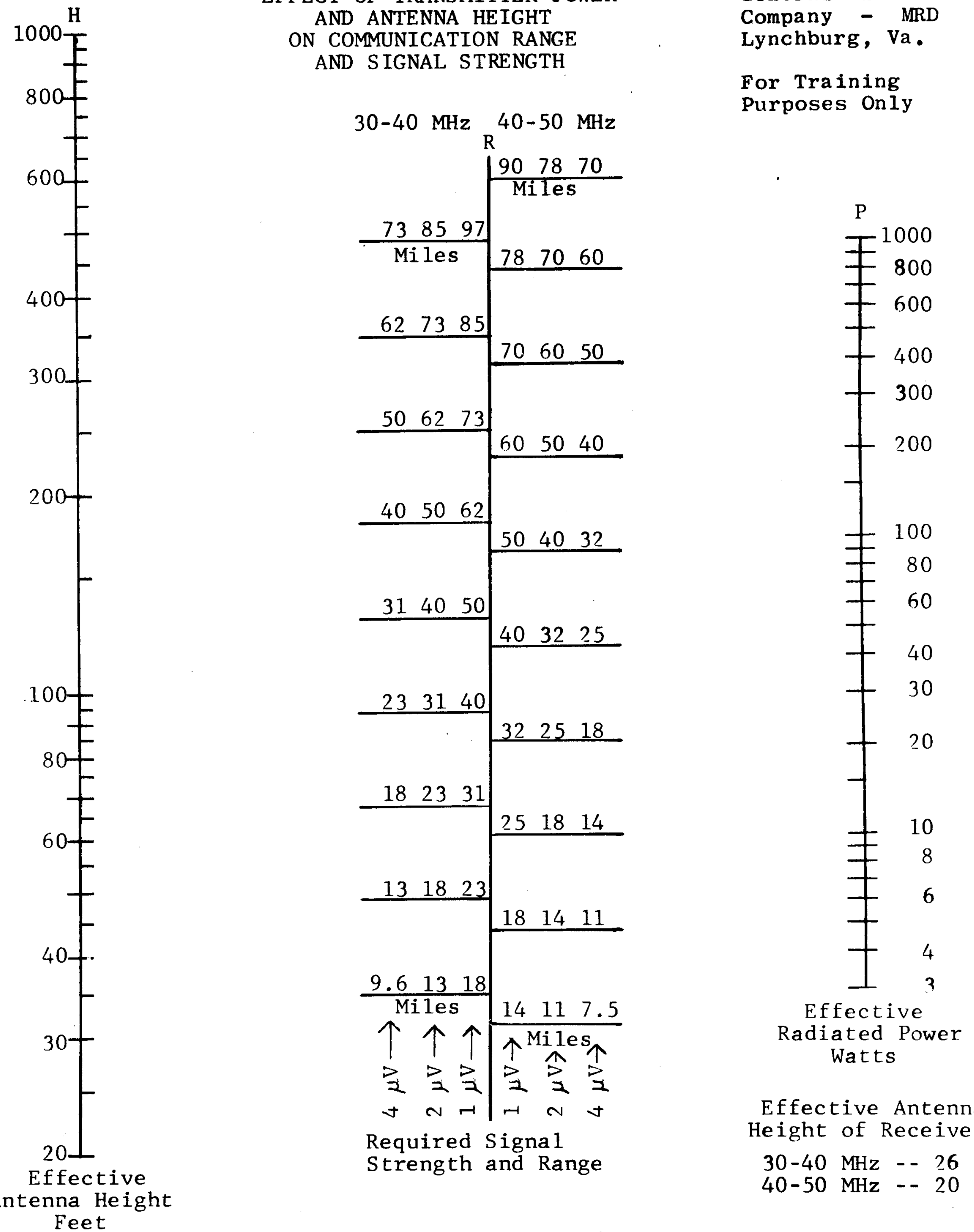
(14) Increase the RF attenuator until the receiver produces a continuous audio output.

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

EFFECT OF TRANSMITTER POWER AND ANTENNA HEIGHT ON COMMUNICATION RANGE AND SIGNAL STRENGTH

General Electric Company - MRD
Lynchburg, Va.

For Training Purposes Only



Effective Antenna Height of Receiver

30-40 MHz -- 26 ft
40-50 MHz -- 20 ft

Draw Line from H to P and Read Range on R Corresponding to Required Signal Strength and Frequency Band

EFFECT OF TRANSMITTER POWER AND ANTENNA HEIGHT ON COMMUNICATION RANGE AND SIGNAL STRENGTH

General Electric Company - MRD
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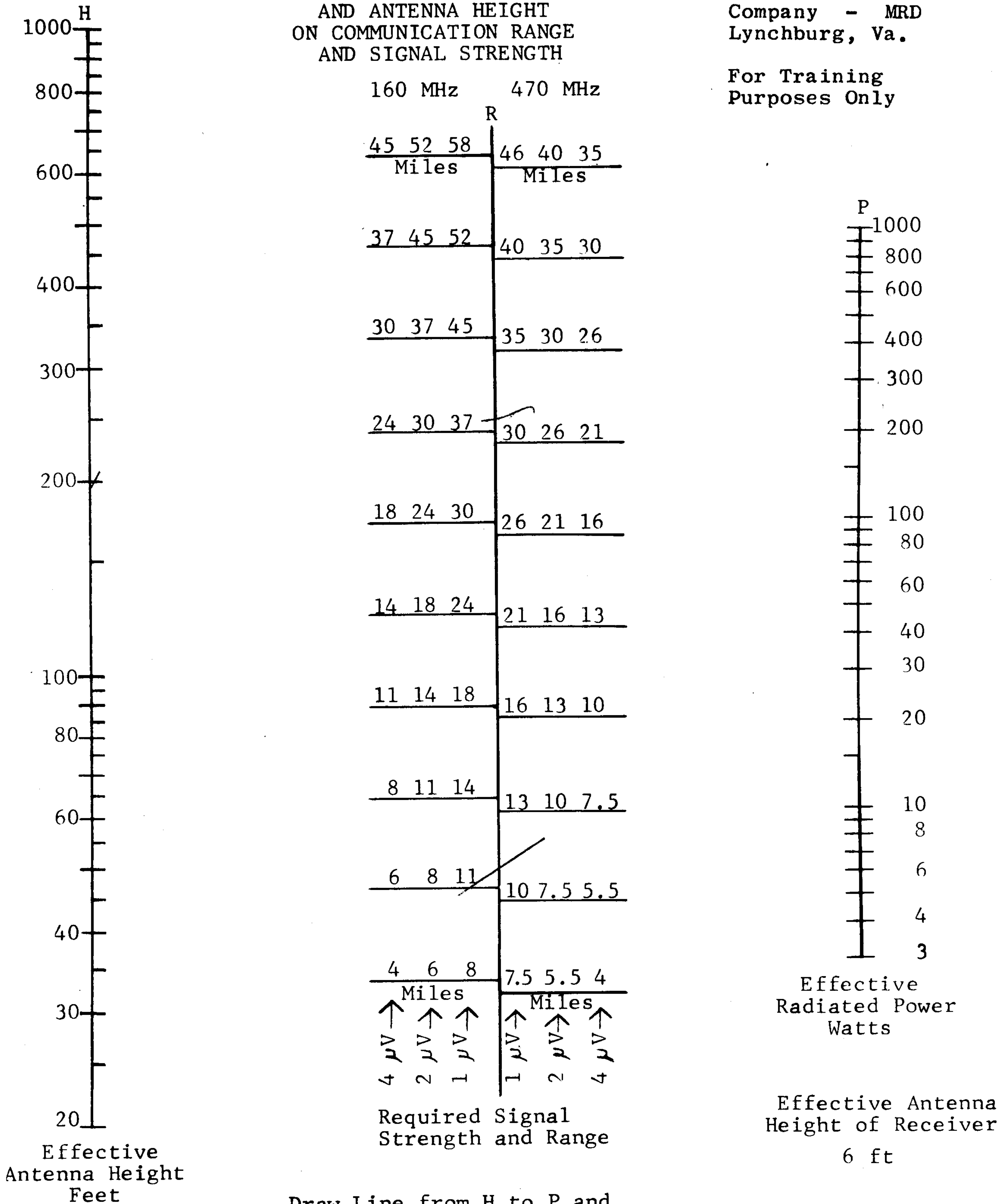
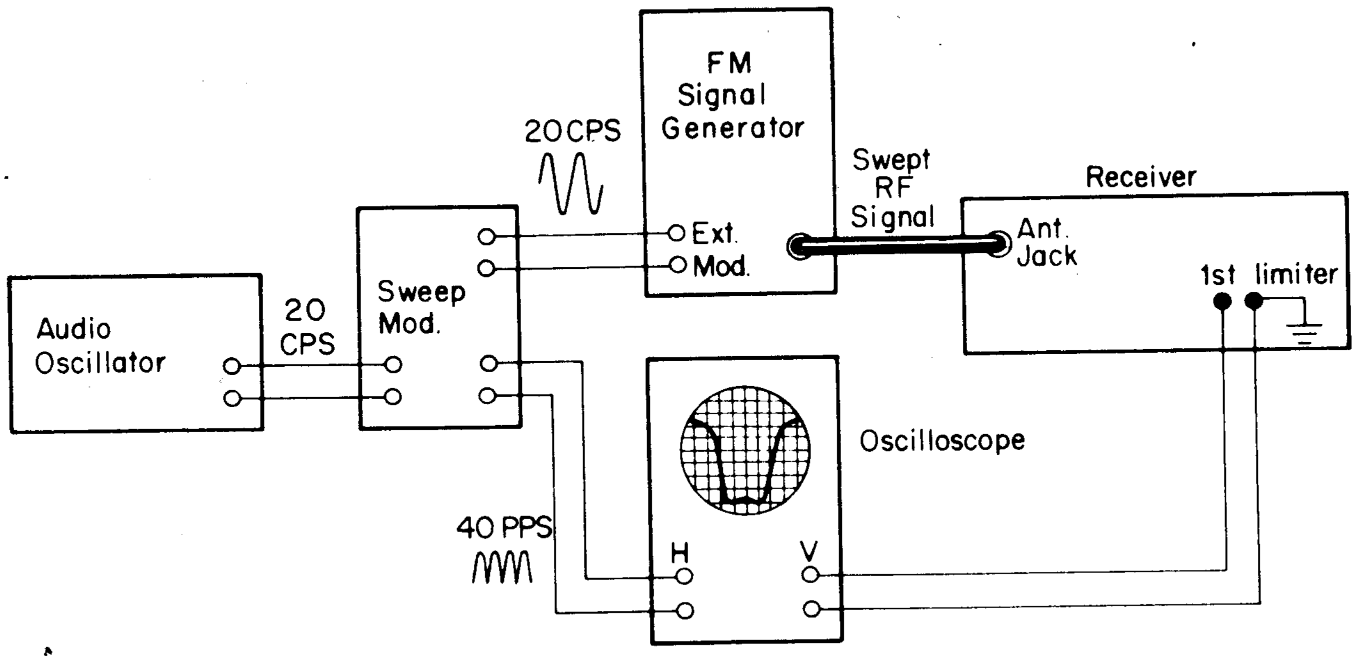
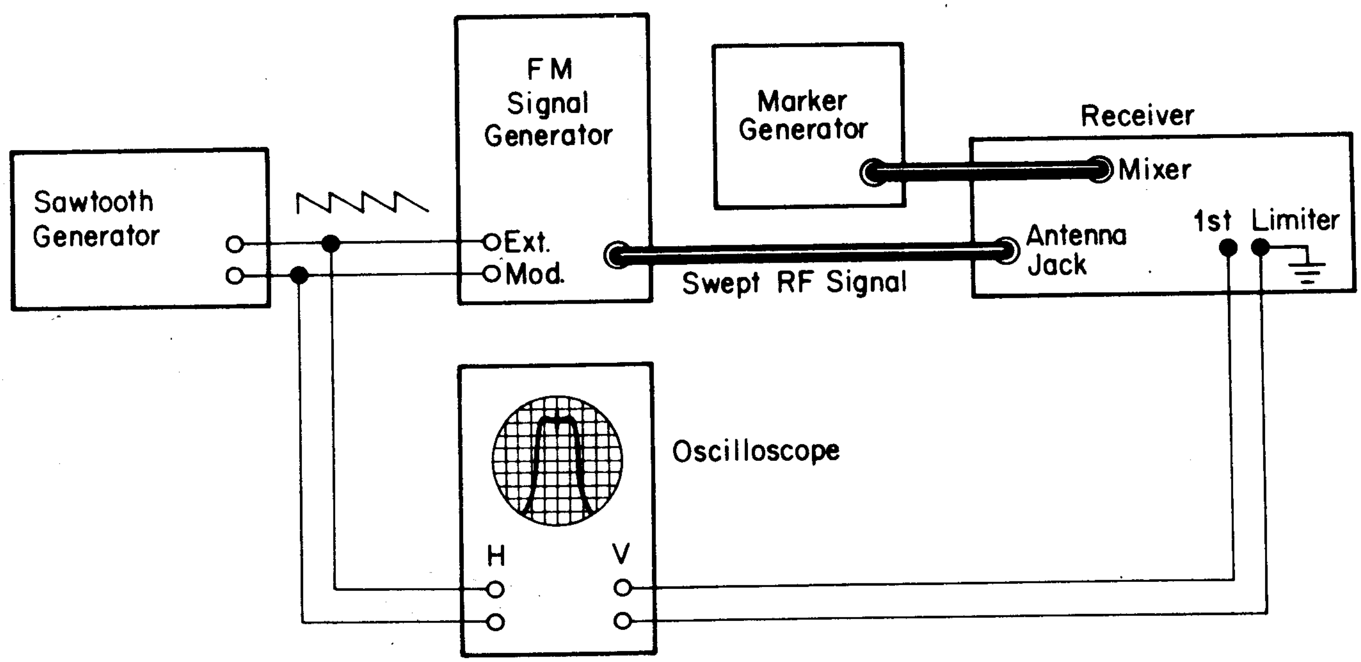


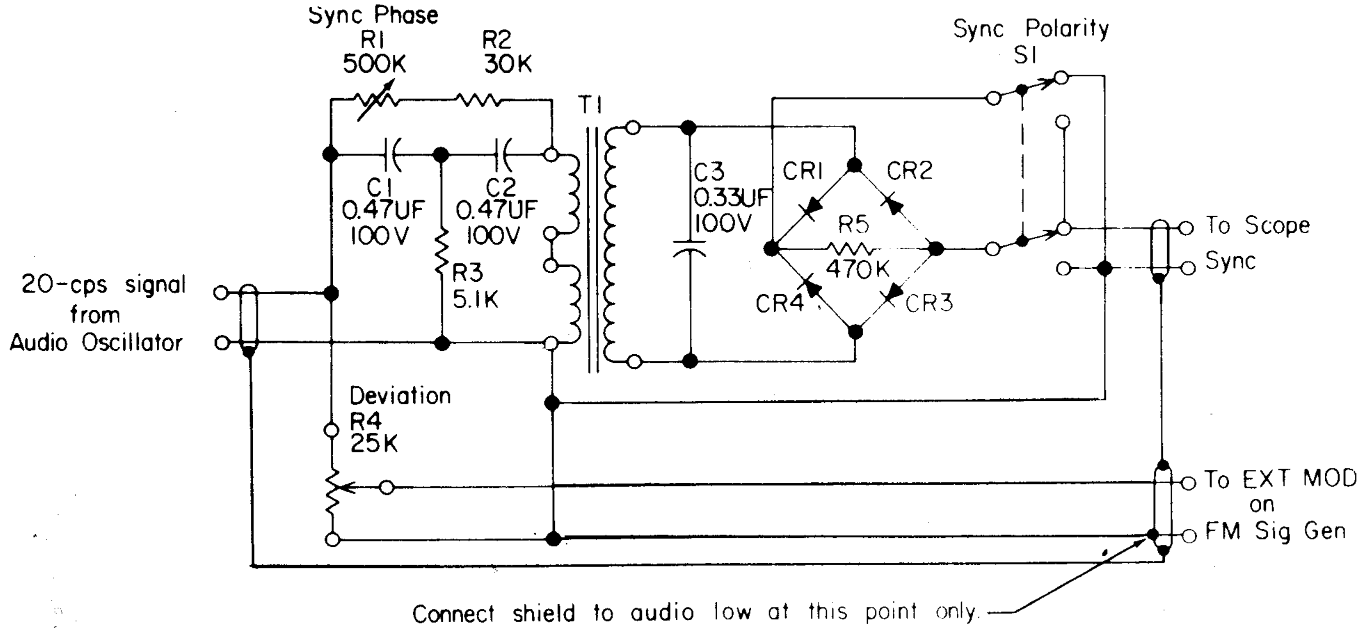
Draw Line from H to P and Read Range on R Corresponding to Required Signal Strength and Frequency Band



Test setup for 20-cps double-trace sweep alignment



Test Setup Used for Single-Trace Sweep Alignment

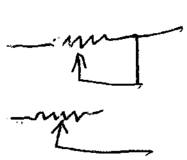


Sweep Modulator Circuit

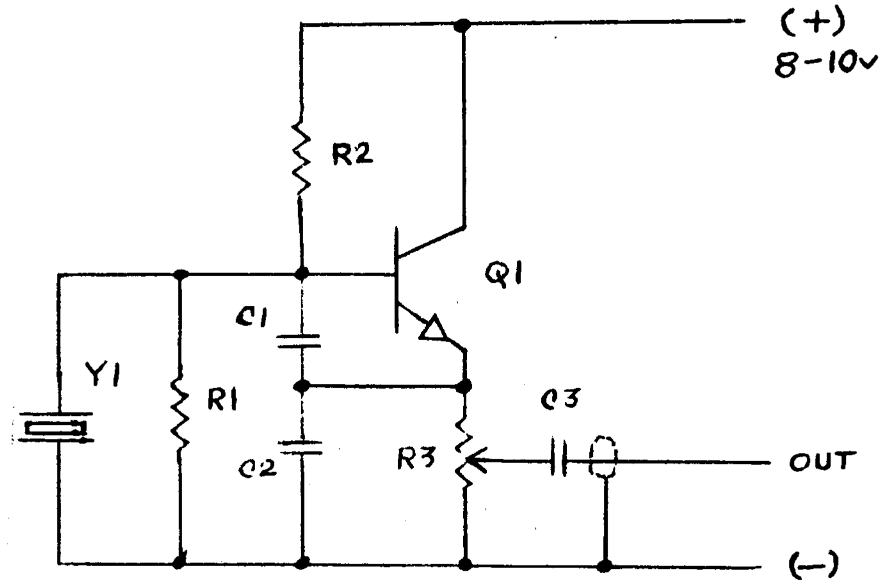
PARTS LIST FOR SPK-218

The following components can be obtained by ordering SPK-218 from Service Parts (price $15.50, subject to change). Chassis, mechanical parts, knobs and wiring are not included.

Symbol Number	GE Part Number	Description
C1 and C2	19A115028-P19	Capacitor, polyester dielectric: 0.47 µf ±20%, 100 VDCW.
C3	19A115028-P17	Capacitor, polyester dielectric: 0.33 µf ±20%, 100 VDCW.
CR1 thru CR4	4037822-P1	Diode, silicon: 200 volts PIV.
R1	5490032-P4	Potentiometer: 500K ohms ±20%, 2.25 watts, mod log taper, sim to Allen-Bradley Type J.
R2	3R77-P303K	Resistor, fixed: 30K ohms ±10%, 1/2 watt.
R3	3R77-P512K	Resistor, fixed: 5.1K ohms ±10%, 1/2 watt.
R4	2R74-P16	Potentiometer: 25K ohms ±20%, 1.13 watts, mod log taper.
R5	3R77-P474K	Resistor, fixed: 470K ohms ±10%, 1/2 watt.
S1	7145098-P1	Switch, slide: DPDT.
T1	5490525-P3	Transformer, audio: printed circuit mounting Primary impedance: 35,000 ohms Secondary No. 1 impedance: 2000 ohms Secondary No. 2 impedance: 2000 ohms



HIGH IF GENERATOR/IF MARKER OSCILLATOR



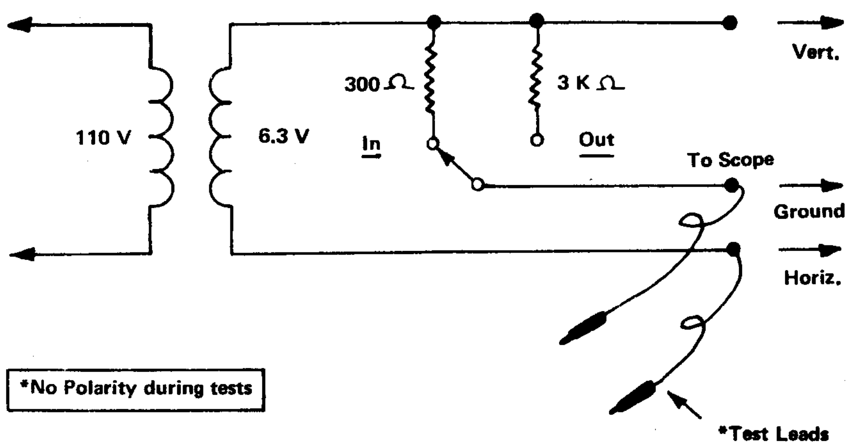
5.3 MHz				10.7 MHz			
R1	10K	C1	220pf	R1	8.2K	C1	47pf
R2	10K	C2	220pf	R2	33K	C2	68pf
R3	5K	C3	33pf	R3	5K	C3	22pf
Y1	5.3Mhz	Q1	19A115889	Y1	10.7MHz	Q1	19A115889

THE CURVE TRACER

Get that 'scope off the bench, dust if off, plug it in and let's check semiconductors--the easy way.

In order to provide a rapid and positive method of servicing transistor products, a "Curve Tracer" has been utilized to provide in-circuit as well as out-of-circuit rapid testing of transistors. See schematic below.

Will work on Junction Field effect
will not work on insulated Gate eff

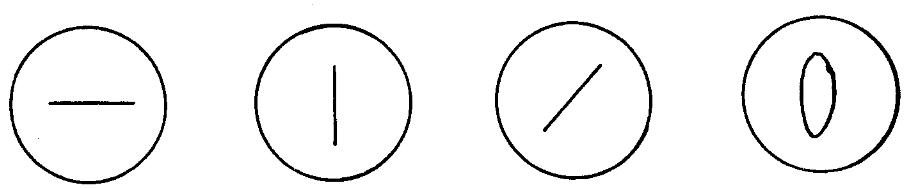


Basically, we sweep the junction of a transistor with 6.3 volts AC so that it may be observed while both conducting and not conducting during alternate plus and minus portions of the AC wave. This display is observed on a regular, low-priced oscilloscope with no power applied to the unit under test.

Before proceeding, adjust the 'scope thusly:

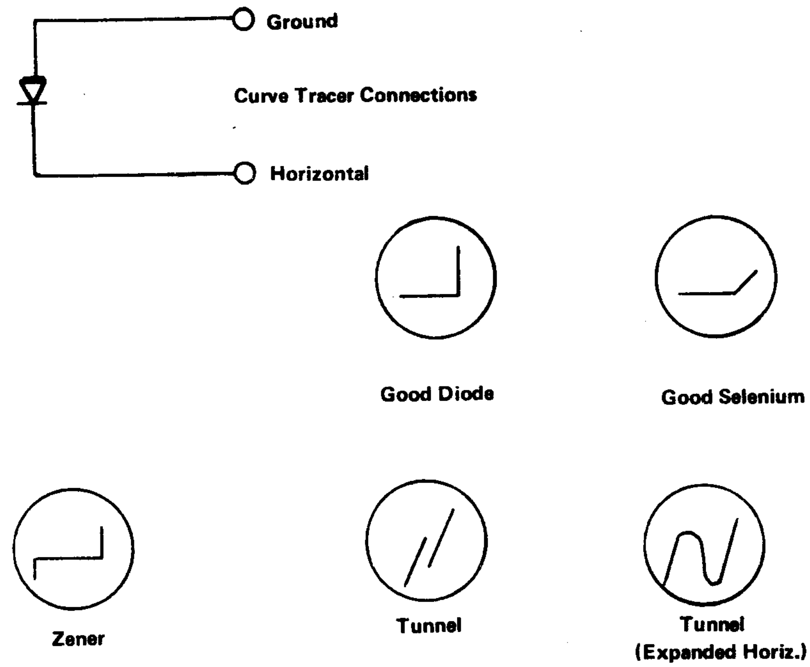
- With no load across the test leads, adjust the 'scope horizontal amplification to scan 2.
- With the test leads shorted, adjust the scope vertical amplification to scan 2.

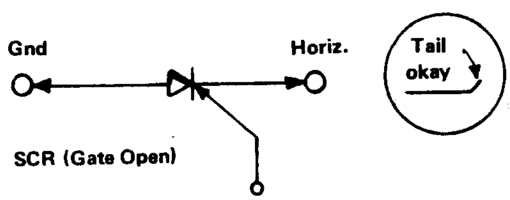
We are not so much interested in the intricacies of the wave form obtained as we are in a "go" or "no-go" type of check. Samples of basic wave forms are shown below.

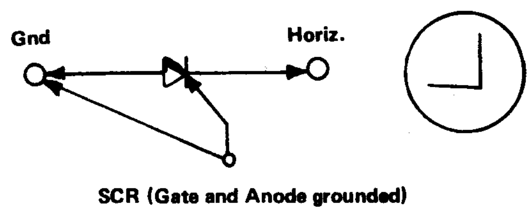


Open Short Resistance Capacitance

Below are examples of typical, good semiconductor wave shapes. Notice the sharp vertex--evidence of conduction.

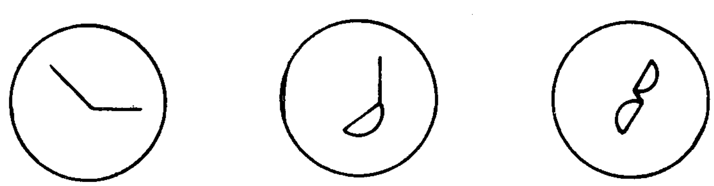






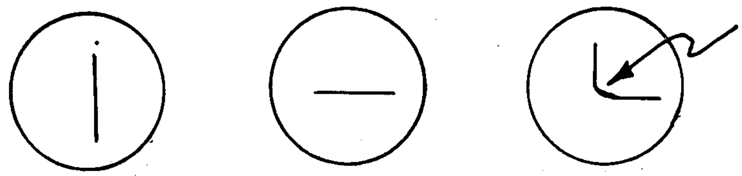
In-Circuit Checks

In-circuit usage will produce a combination of two wave shapes. Capacitance and resistance may mask the response; however, the wave shape of a good transistor there is some evidence of a sharp junction or a current change. This is the key to identify a good transistor from a defective one.



No-Go Condition

A defective transistor can show any of three basic patterns:



To completely check the transistor with a two-lead checker, three checks will have to be made. Polarity of the leads is important so the check can be made very rapidly, checking from: 1) emitter to collector, 2) base to collector, 3) base to emitter. Most of the breakdowns occur from emitter to collector; therefore, time can be saved by always making this test first. Most good tests of base to emitter or collector show a typical diode pattern.

Diodes

When checking a diode, if the vertex of the L-shape is rounded, or if either leg is much shorter than the other, or slanted from the horizontal or vertical, the diode should be discarded. NOTE: It is important to have adjusted the 'scope correctly.

Seleniums

When looking at a selenium rectifier, a typical pattern will have a rounded vertex and a short, slightly slanted vertical leg--indicative of poor transfer characteristics, a high forward voltage drop and some forward resistance. These are typical selenium characteristics and are no cause for concern unless the vertical leg is very short or very slanted.

Tunnels

A good tunnel diode will display two vertical lines with a gap in the center. However, by increasing the 'scope's horizontal gain, you can get the classical tunnel diode curve.

Zeners

The horizontal part of the trace is the Zener voltage and can be calibrated with a known Zener for measuring unknown ones. It's probably worth mentioning that with a 6.3 volt transformer, you are limited to checking Zeners of 9 volts or less. There isn't enough sweep voltage available to show the reverse junction above this value. No real problem here though--if you need to check Zeners above 9 volts, there is no reason why a 12 volt transformer couldn't be used. If this is done, the current limiting resistor should be doubled to limit the current to a couple of mills for safety.

SCR's

Checking SCR's with the Curve Tracer is as simple as ABC since it will conduct during the half-cycle when the anode and gate are positive with respect to the cathode. With the gate open, the SCR will not conduct and the Curve Tracer shows an open circuit.

Capacitors

Capacitors connected between horizontal and ground (without regard to polarity, even with electrolytics), will display an ellipse, with the long axis horizontal for values up to about 0.85 µfd. At about 0.85 µfd, the pattern will be a circle and above this value the major axis is oriented vertically. When testing capacitors, if the major axis of the ellipse is tilted, throw away the capacitor--its leakage is much too high.

Resistors

Resistors between 100 and 100,000 ohms can be checked. The tilt or angle of the trace will be in direct proportion to the resistance of the unit being tested.

Potentiometers can be connected between center tap and either end. When the pot shaft is rotated, the 'scope trace will move from horizontal to vertical--(if the value of the pot is great enough). A jumpy or fuzzy trace indicates a noisy or open unit which should be cleaned or discarded.

Photoconductors

Photoconductors connected between horizontal and ground with the surface exposed to light will display a nearly vertical trace indicating the low resistance of the unit when exposed to light. Now, cover the cell with your hand and watch the line move to the horizontal, indicating the high dark resistance of the cell.

Versatility is the Key

It was interesting to check a number of different devices without any need for adjustment. A great time-saver, it is especially useful as a comparator--the angle for a given resistor is noted, the horizontal and vertical controls set so a capacitor produces a perfect circle and any deviation shows which way the difference lies. About the only common electronic components the curve tracer won't test are quartz crystals and batteries.

In summary, then, the Curve Tracer provides accuracy, speed and simplicity. With a very minimum of equipment, or investment, any serviceman can determine the "go" or "no-go" condition of a semiconductor, in or out of the circuit.

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