101 WAYS

to use your...

SIGNAL GENERATOR

by
ROBERT G. MIDDLETON

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$2.00

101 ways to use your SIGNAL GENERATOR

by ROBERT G. MIDDLETON

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101 ways to use your SIGNAL GENERATOR

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PREFACE

Signal-generator instruction books sometimes have a family resemblance to oscilloscope instruction books. This resemblance is found in such assertions as "the field of application of the instrument is limited only by the knowledge and resourcefulness of the user." This assertion is true.

Experience proves that knowledge and resourcefulness cannot be obtained by reaching out into thin air, but only by "going through the mill" and after many years of practical experience.

Radio and television servicing is a highly competitive business. Technicians cannot afford to spend a twenty- or thirty-year apprenticeship. Today's technician desperately needs immediate access to the knowledge that comes with long experience.

101 Ways to Use Your Signal Generator recognizes this urgent need and offers an all-out effort to meet it.

Bob Middleton

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INTRODUCTION

Signal generators are used in practically all service shops. A signal generator is usually considered to be a limited instrument, useful only for alignment and signal-substitution tests. As a matter of fact, a signal generator is a most versatile instrument, with an unexpectedly wide field of use.

You can use your signal generator to localize intermittents; to check for open bypass capacitors; to check amplifier distortion; to determine the dynamic range of an amplifier; to measure image-rejection ratios; to check high-frequency impedances; to test FM receivers for AM rejection; to modulate broadcast signals, black-and-white TV signals, or color TV signals on another carrier frequency; to localize regeneration; to check for Miller effect; to make over-all audio-fidelity tests; to check for frequency stability of receivers against line-voltage variations; and to make numerous other special tests described in this book.

A service shop should have the best signal generator possible, within the limitations of the budget. A wider range of test work is possible with the more elaborate types of generators. However, if suitable techniques are used, even a simple signal generator can perform a surprisingly large number of useful tests.

The better types of signal generators cover all bands on pure fundamentals. Output is reasonably uniform at all output frequencies. Calibrated attenuators, which provide a known output level in microvolts, add further utility to the instrument. Modulating facilities vary widely among the different types of generators. In the simpler instruments, the oscillator is directly modulated; as a result, spurious frequency modulations occurs, in addition to the desired amplitude modulation. In the better generators, wide-band modulators are provided which operate independently from the oscillator. The more elaborate generators often include crystal-calibrating facilities. The output frequency can be accurately adjusted to the desired value. Frequency drift is controlled closely in the higher-priced instruments. Band-spreading provides less critical adjustment of the tuning dial. Better immunity is provided against frequency change due to line-voltage variations.

The important point is to know your instrument. If you know its capabilities and limitations, you can obtain full service and avoid false conclusions caused by operating the generator beyond its capabilities.

You will find it advisable to have at least two signal generators on hand. An AM generator is suitable primarily for AM and FM receiver tests. On the other hand, the higher frequencies required in TV work are better accommodated by a generator designed for a pure fundamental output over the VHF channels.

Although the title of this book is *101 Ways to Use Your Signal Generator,* there are many other applications in which signal generators can be used together with other test instruments. Interested readers are referred to the companion volumes, *101 Ways to Use Your Sweep Generator, 101 Ways to Use Your Oscilloscope,* and *101 Ways to Use Your VOM and VTVM.*

EQUIPMENT CHECKS

U1

To Check the Frequency Calibration of a Signal Generator

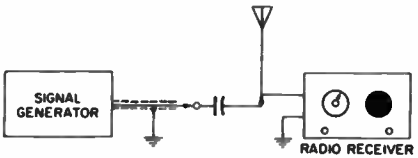
Equipment: Radio receiver with tuning range over the required frequencies.

Connections Required: Couple the signal-generator output to the receiver input terminals with a small capacitance.

Procedure: Tune the radio receiver to various stations of known frequencies. Set signal generator to obtain a zero beat against the station carrier.

Evaluation of Results: At zero beat, the signal generator has an output frequency equal to that of the station carrier frequency.

A signal generator usually has harmonic output. Hence, you will also obtain a heterodyne "squeal" and a zero beat when the generator is tuned to one-half the station frequency, one-third the station frequency, etc. The fundamental "squeal" is the loudest. The harmonic beats are useful because one station of known frequency can be used to calibrate several generator bands. This is also a useful test for determining the frequency stability of the generator over a period of time. If the generator has good thermal stability, the beat note will not vary appreciably when the generator is operated for several minutes. On the other hand, a poor signal generator will show rapid and severe frequency drift.



Test setup.

NOTE 1

Calibration of VHF Signal Generator

A VHF signal can be calibrated in a manner similar to the one in U1. A TV station signal and a TV receiver are used in place of the AM broadcast station and the AM radio. Likewise, an FM or communications receiver can be used to calibrate the generator at other frequencies.

U2

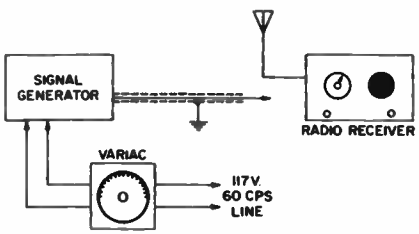
To Check the Frequency Stability of a Signal Generator Against Line-Voltage Variations

Equipment: Radio receiver and Variac.

Connections Required: Connect the Variac between the signal generator and the power line. Lay the output cable from the generator near the antenna lead of the radio receiver.

Procedure: Tune in a station signal on the receiver. Tune signal generator for audible beat against station signal. Adjust input voltage to the generator with the Variac.

Evaluation of Results: The beat tone varies if the signal-generator frequency changes with the line voltage. A good signal generator provides a constant output frequency over a reasonable variation of line voltage, such as from 100 to 115 volts.



Test setup.

To Calibrate a Signal Generator Against a Quartz Crystal Oscillator

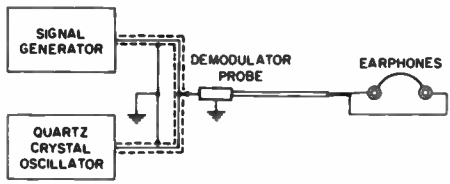
Equipment: Quartz crystal oscillator, demodulator probe, and earphones.

Connections Required: Feed generator and oscillator outputs to the input of the demodulator probe. Connect earphones to probe output.

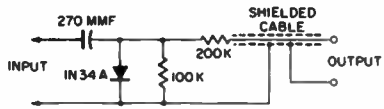
Procedure: Tune signal generator and listen for heterodyne beats in the phones. Zero beat indicates that the fundamental or a harmonic of the generator is at the same frequency as the fundamental or a harmonic of the oscillator.

Evaluation of Results: The strongest heterodyne whistle is obtained when the fundamental of the generator beats with the fundamental of the oscillator. The fundamental vs. harmonic beats are progressively weaker. Hence, a wide range of calibrating points can be obtained from a single 1-mc crystal, for example.

If a 1-mc crystal is used, its harmonics are 2 mc, 3 mc, 4 mc, etc. If the generator is tuned to 100 kc, its tenth harmonic beats against the crystal fundamental. Hence, the generator can be calibrated at frequencies much lower than those of the crystal fundamental.



Test setup.



Demodulator probe circuit.

NOTE 2

Probe Output Can Be Amplified

In the method in U3, an audio amplifier and a speaker may be used in place of the earphones. This gives greater sensitivity and permits checking with higher harmonics from the generator and the oscillator.

NOTE 3

External Calibrating Equipment Not Required With TV Calibrator-type VHF Signal Generator

Some VHF signal generators have complete built-in calibrating facilities. Therefore, no external equipment is required for frequency calibration procedures. This type of signal generator is also called a television calibrator. A typical instrument is provided with 2-mc, 0.25-mc, and 4.5-mc crystals; a modulator; and an audio amplifier with a speaker. The accuracy of the output can be checked at any time by switching the instrument to the Calibrate position. Audible zero beats are then obtained at each 0.25-mc interval along the dial without changing any connections. This type of generator is somewhat easier to use than the simpler types, particularly in critical applications requiring frequent calibration of the output.

U4

To Calibrate a Signal Generator Against WWV Transmissions

Equipment: Radio receiver with suitable tuning range.
Connections Required: Loosely couple generator output cable to antenna lead-in of receiver.
Procedure: Tune in the WWV transmission. Adjust generator for either fundamental or harmonic beat with WWV carrier.
Evaluation of Results: The carrier frequency accuracy of a WWV signal is better than one part in 50,000,000.

WWV maintains eight transmitters near Washington, D.C. Transmissions are continuous, twenty-four hours a day. Frequencies are as follows:

Carrier Frequency, Mc	*Audio Modulation, Cps*
2.5	440
5	440
10	440 and 4000
15	440 and 4000
20	440 and 4000
25	440 and 4000
30	440
35	

U5

To Calibrate a Signal Generator Accurately at 3.579545 Mc

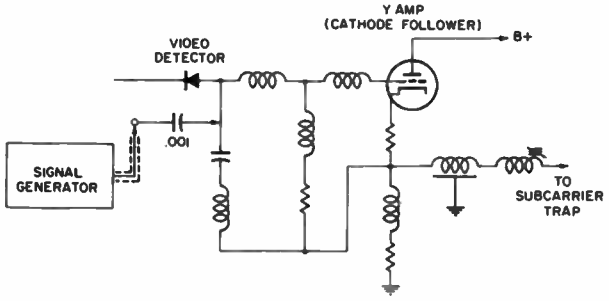
Equipment: Color TV receiver in good operating condition and 0.001-mfd blocking capacitor.

Connections Required: Connect blocking capacitor in series with generator output cable. Apply the generator output to the input of the receiver video amplifier.

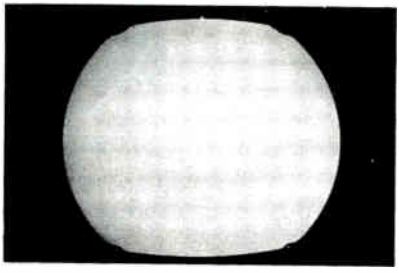
Procedure: Advance generator output to maximum. Tune generator in vicinity of 3.58 mc while watching screen of color picture tube.

Evaluation of Results: Generator is tuned accurately to 3.579545 mc when a solid color field is displayed on the picture-tube screen. The field may fluctuate from red to green to blue, but will remain a solid color when generator is tuned to the exact color-subcarrier oscillator frequency.

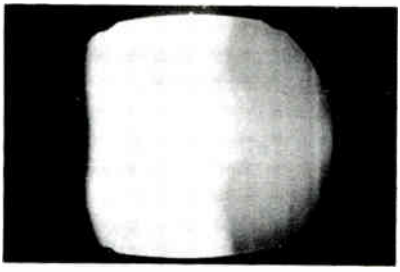
If generator is mistuned to one side of the subcarrier oscillator frequency, moving or stationary rainbows can be seen on the picture-tube screen. A stationary rainbow occurs at each "sidelock" frequency. A sidelock frequency is removed from the color-subcarrier oscillator frequency by an integral number of horizontal scanning intervals. Thus, a single stationary rainbow can be seen if the generator is tuned to 15,750 cycles above or below 3.579545 mc.



Typical picture detector and video-amplifier circuit.



Solid color field.



Rainbow display.

U6

To Make Wavelength Checks of Signal-Generator Output

Equipment: No. 18 bare copper wire, 4" × 4" copper plate, steel measuring tape, VTVM, and high-frequency probe.

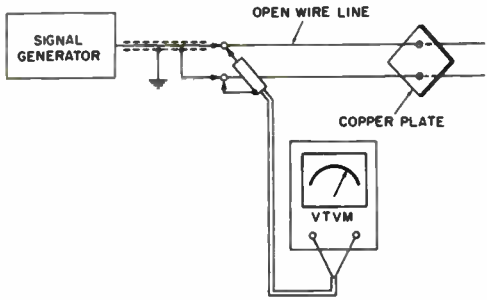
Connections Required: Connect signal-generator output to an open-wire line constructed from the copper wire, as shown in the following illustration. Space the two wires approximately one inch apart. Drill two holes through the copper plate to accommodate the wires. Connect high-frequency probe at input of open-wire line. Feed probe output to VTVM.

Procedure: Slide copper plate along line for a null reading on VTVM. Note this position by marking wire with ink. Next, slide plate farther along wire, passing through a peak read-

ing on the VTVM and along to the next null reading. Mark the second null reading on the wire. Finally, measure the distance between the marks with the measuring tape.

Evaluation of Results: The distance between the marks is a half wavelength. The distance between nulls in inches can be converted to frequency in megacycles by dividing inches into 5905. Thus, mc = 5905/inches. This method is particularly useful over the VHF range. Wavelengths can be measured to an accuracy of approximately 0.5% with this method, provided the measurements are made with exacting care.

If the signal generator does not have appreciable output, or if the VTVM does not have sufficient sensitivity, use a suitable high-frequency amplifier between the generator and the line.



Test setup.

U7

To Check a Signal Generator for Uniformity of Output

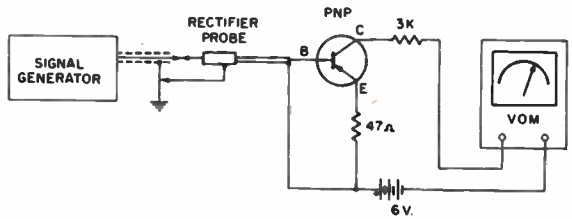
Equipment: Rectifier probe, VOM, transistor, 47-ohm resistor, 3000-ohm resistor, and 6-volt battery.

Connections Required: Connect equipment as shown in the accompanying diagram.

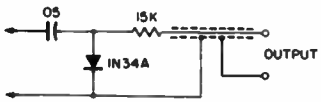
Procedure: Operate VOM on one of its lower DC current ranges. Tune signal generator through its various bands while watching meter indication.

Evaluation of Results: A good signal generator has a very small variation of output signal level over a wide frequency range.

If the signal generator has a high output, the transistor amplifier is not required. However, many signal generators have a low output which will not operate a VOM satisfactorily in this test.



Test setup.



Rectifier probe circuit.

NOTE 4

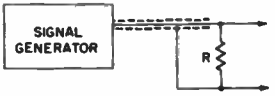
Generator Output Cable Should Be Terminated in Its Own Characteristic Impedance

When the test described in U7 is made, the uniformity of output at high frequencies will be greatly improved by terminating the generator output cable in its own characteristic impedance, as shown in the following. At high frequencies, the physical length of the output cable becomes a substantial fraction of the operating wavelength. Unless the output cable is properly terminated, standing waves will develop in it. The cable will act like a parallel-resonant circuit at some frequencies and like a series-resonant circuit at other frequencies. Correct termination makes the cable purely resistive at all frequencies.

Terminate the output cable with a composition resistor R. The cable impedance is usually 50 or 75 ohms. In the test of U7, best termination is indicated by flattest output from the generator.

Whenever the output cable is to be applied at a circuit point where DC voltage is present, insert a blocking capacitor in series with the "hot" lead of the cable to avoid DC voltage drain-off. This not only avoids impairment of receiver circuit operation, but may also provide immunity from damage to the generator output circuit or the receiver circuit due to heavy DC current flow.

Terminating resistor connected to generator output.



NOTE 5

Terminated Output Cable May Be Any Length

Users of signal generators sometimes wish to use output cables of extended lengths for greater operating convenience. It is sometimes asked whether long output cables change the characteristics of a test signal. If a cable is terminated in its own characteristic impedance, it may be any length without changing the signal characteristics. There is a very slight attenuation of signal through a long cable. However, for cable lengths up to 10 or 15 feet, the attenuation is imperceptible. On the other hand, if a long cable is incorrectly terminated, it will cause severe peaks and dips in the signal output, even at low test frequencies.

U8

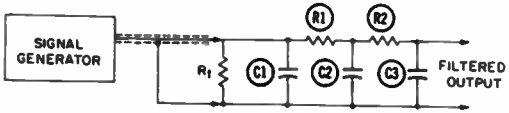
To Minimize the Harmonic Output From a Signal Generator

Equipment: Resistors and capacitors.

Connections Required: Connect the resistors and capacitors into a low-pass filter network, as shown in the following illustration.

Procedure: Use the method in U7 to check output from signal generator. Increase the values of R and C until the generator output drops to approximately 25% of its direct output level. Larger values of R and C are required for low test frequencies.

Evaluation of Results: R_t is a terminating resistor (see Note 4). R1, R2, C1, C2, and C3 form a low-pass filter network for harmonic suppression. When the R and C values of the filter are chosen to attenuate the total output approximately 75%, the harmonics present are attenuated much more than the fundamental. This facilitates tests in which a pure sine-wave output is required from the signal generator.



Filter connected to generotor output.

NOTE 6

Filter Provides No Advantage If Spurious Outputs Are Lower Than the Fundamental Frequency

The beat oscillator principle was used in a few older signal generators to obtain a wide frequency coverage at low cost. Such generators had a large number of spurious outputs. Some of the spurious outputs have a lower frequency than the beat fundamental. Therefore, the filter network shown in U8 is not feasible because it will weaken the fundamental with respect to the lower-frequency spurious outputs. On the other hand, the method shown in Note 24 is applicable.

U9

To Check the Modulated RF Output From a Signal Generator

Equipment: Demodulator probe and audio amplifier.

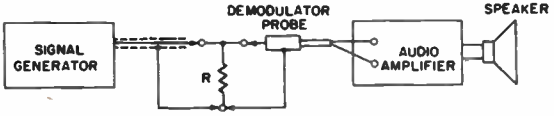
Connections Required: Connect test setup as shown in the following diagram. R is a terminating resistor (see Note 4). See U3 for construction of demodulator probe.

Procedure: Operate signal generator on modulated RF output. Note change in tone and level from amplifier as signal generator is tuned through its various bands.

Evaluation of Results: Most signal generators are arranged for 30% modulation of the RF output voltage. The modulating frequency is usually 400 cycles. If the modulation is uniform over the output frequency range, a constant-level, 400-cycle tone is heard from the audio amplifier as the generator is tuned. Any variation in level of the tone indicates that either the RF output is rising or falling, or the percentage modulation is rising or falling, or both. To determine whether the RF output level is constant, see U7. Any variation in

tone quality as the generator is tuned indicates that the modulation waveform is distorted. A good modulator gives a pure 400-cycle tone at any RF output frequency.

Test setup.



NOTE 7

Percentage of Modulation Is Adjustable in Some Generators

Some signal generators have a control for varying the percentage of modulation. In the usual tests, this control should be set for approximately 30% modulation. However, you may find in U9 that the control requires readjustment because the percentage of modulation changes from one end of an RF band to the other end. Accurate checks of the percentage of modulation must be made with a DC scope, as explained in the companion volume, *101 Ways to Use Your Oscilloscope*. The percentage of modulation can also be measured with a demodulator probe and VTVM, as explained in *101 Ways to Use Your VOM and VTVM*. However, a VTVM check is less informative than a DC scope check, because a VTVM gives no information concerning possible waveform distortion.

NOTE 8

Increasing Maximum Output From a Signal Generator

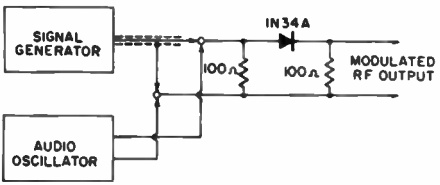
Some signal generators, designed primarily for AM radio receiver alignment, have a relatively low output. The low output prevents overloading of the receiver, because it is customary to align AM receivers at maximum sensitivity. On the other hand, in some applications such as impedance and component tests, it is necessary to have appreciable output from the generator. The high output can be accomplished by eliminating the output attenuating pads or dividers in the generator. Refer to the circuit diagram in the instrument instruction book for the attenuating means employed.

NOTE 9

External Modulator Often Useful in Modulated RF Test Work

When the internal modulator of a signal generator is unsatisfactory, or when modulating frequencies other than 400 cycles are required, the external modulator shown in the following diagram can be used. The

modulator requires suitable levels of signal from both the signal generator and the audio oscillator. The most satisfactory determination is made with a DC scope, as explained in the companion volume, *101 Ways to Use Your Oscilloscope*.

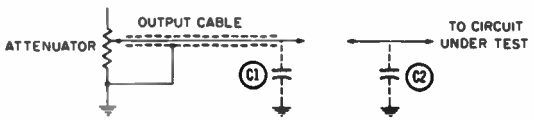


Construction of an external modulator.

NOTE 10

Signal Generator Uses a Low-Resistance Attenuator

Beginners sometimes ask why a low-resistance attenuator (50 or 75 ohms, 300 ohms maximum) is used in a signal generator. The answer is that stray capacitances and input capacitances of the circuits under test would make the generator unusable if a high-resistance attenuator were employed. This is shown in the accompanying illustration. The attenuator is shunted by the total generator output capacitance C1. At higher frequencies, the reactance of the stray capacitance in the generator output system becomes quite low. To realize a workable attenuator, we must lower its resistance to a point where its value is only a fraction of the capacitive reactance in the output system. Likewise, the input capacitance of a circuit under test (C2) shunts the attenuator and tends to bypass the generator signal. The resistance of the attenuator must be low enough that the shunting effect of capacitances C1 and C2 is negligible; otherwise, the attenuator will not function properly.



The shunting effect of the generator output capacitance and the circuit input capacitance.

To Check the Audio Signal Output From a Signal Generator for Sine Waveform

Equipment: Capacitor, resistor, and AC VTVM.

Connections Required: Connect capacitor and resistor (suitable values as determined to give easily readable scale indications) in series across generator output. Connect the VTVM across the resistance as shown in Test 1; then reverse the connections of R and C, and connect the VTVM across the capacitor as shown in Test 2. Finally, measure the generator output voltage as shown in Test 3.

Procedure: Observe voltage reading in each of the three tests.

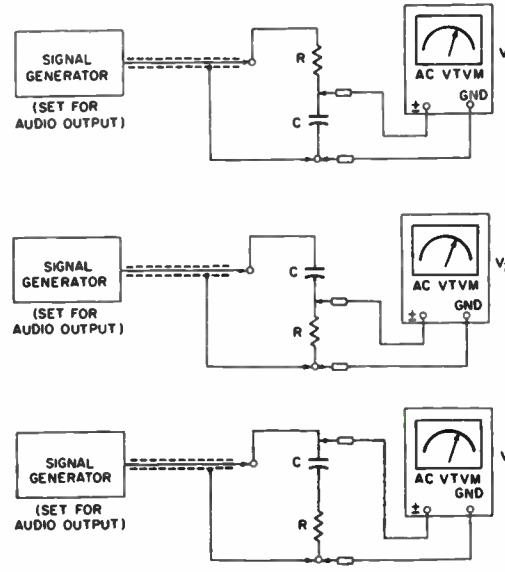
Evaluation of Results: The three voltage readings, represented as line lengths, should fit together as a right-angled triangle. If a right triangle is not formed, the audio output voltage does not have a true sine waveform.

The positions of R and C are reversed in the first two tests, so that the VTVM can operate its ground return at true ground potential. Thus, possible error caused by improper ground return is avoided.

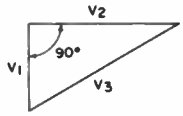
Test 1.

Test 2.

Test 3.



Test setup.



Plot of voltages.

U11

To Check the Frequency of the Audio Signal Output From a Generator

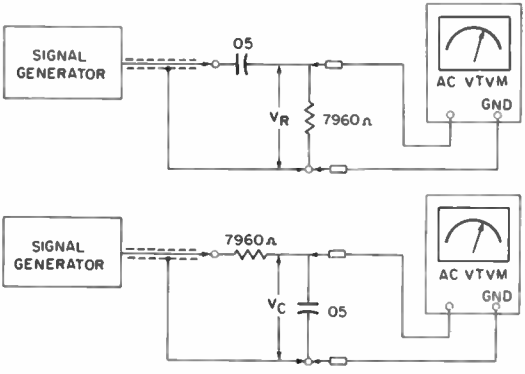
Equipment: 0.05-mfd capacitor, 7960-ohm resistor, and AC VTVM.

Connections Required: Connect equipment as shown in the following diagrams.

Procedure: Operate the signal generator on 400-cycle audio output. Measure the drop across the resistor, as shown in Test 1. Then measure the drop across the capacitor, as shown in Test 2.

Evaluation of Results: If equal voltages are measured in the two tests, the audio output frequency is 400 cycles. On the other hand, if unequal voltages are measured, the frequency is not 400 cycles. The accuracy of this test depends upon the accuracy of the capacitance and resistance values.

If the output frequency is 400 cycles, unequal voltages will be measured if harmonics are present. A test for harmonics is described in U10.



Test 1.

Test 2.

Test setup.

NOTE 11

Check for Frequencies Other Than 400 Cycles

If the audio output frequency from a signal generator is not 400 cycles, the frequency can still be found from the measurements made in U11. Calculate the frequency from the formula:

$$f = 400V_R/V_C$$

where,

V_R is the voltage drop across the resistor,

V_C is the voltage drop across the capacitor.

As previously noted, the output must have a sine waveform; otherwise, the test results will be in error.

U12

To Check Attenuator Action of a Signal Generator

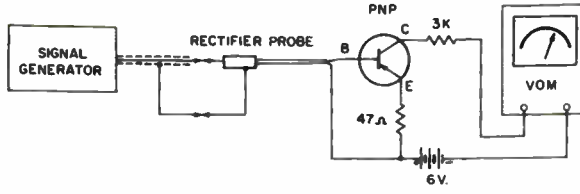
Equipment: Rectifier probe, VOM, transistor, 47-ohm resistor, 3000-ohm resistor, and 6-volt battery.

Connections Required: Connect equipment as shown in the accompanying diagram.

Procedure: Observe meter reading as the attenuator is reduced to progressively lower settings.

Evaluation of Results: The meter reading should decrease as the attenuator setting is reduced. If the reading decreases at first and then increases as the attenuator setting is further reduced, the attenuator is faulty. This is more commonly found at high RF frequencies and is caused by internal RF leakage in the generator, which permits RF voltage to flow around the attenuator to the output cable.

Accessory external attenuators are available for use with signal generators. These attenuators give known values of attenuation at frequencies from zero to 250 mc. The more elaborate attenuators provide a range from zero to 80 db in 1-db steps.

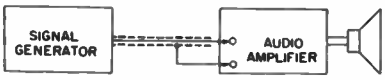


Test setup.

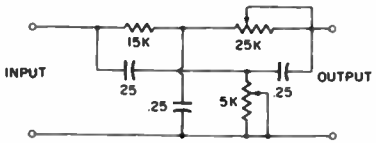
NOTE 12

60-Cycle Hum Voltage in Output of Signal Generator

You will sometimes find 60-cycle hum voltage in the output of a signal generator. You can check for hum voltage by using the test setup shown in the following diagram. To minimize 60-cycle hum voltage, use the parallel-T RC network, as shown. This network provides complete attenuation when correctly adjusted. It is advisable to use two potentiometers (instead of two fixed resistors) in the two branches of the network, for two reasons. First, the tolerances on capacitors and resistors (10% or 20%) make it difficult to select fixed values for all the components. The relative values in the two branches are critical for complete hum rejection. Second, variations in loading of the network output change the required values somewhat. Note that the parallel-T network shown will completely reject 60-cycle hum, but not its harmonics.



Checking for 60-cycle hum voltage.



Parallel-T R-C network.

U13

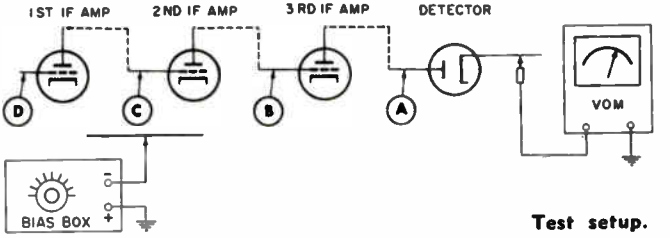
To Calibrate the Attenuator of a Signal Generator (Attenuation in Steps of × 10)

Equipment: IF amplifier, DC bias box, and VOM.

Connections Required: Connect bias box to AGC (or AVC) line, as shown in the following diagram. Connect VOM (or VTVM) at detector output. Connect signal-generator output to point A, and then to point B.

Procedure: Tune signal generator to frequency of IF amplifier. Apply maximum generator output at point A and note meter reading. Next, apply maximum generator output at point B and note stage gain. Adjust bias box for a meter reading ten times higher at B than at A (stage gain of 10 times). Then reduce attenuator setting of generator to obtain same meter reading at B that was obtained at A when maximum generator output was used.

Evaluation of Results: The setting of the attenuator that gives the same meter reading at B is marked × 0.1. This setting gives an output that is 0.1 of maximum. We use an IF amplifier in this test because the VOM or VTVM would not give a readable indication with 0.1 of maximum output from the generator.



Test setup.

NOTE 13

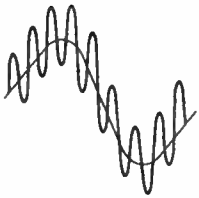
Calibrating × 0.01 and × 0.001 Steps on the Attenuator

The × 0.01 step on the attenuator is determined in the same manner as the × 0.1 step (see U13). With the attenuator set to the × 0.1 position, apply the generator output to point B and note the meter reading. Next shift the generator output to point C. Adjust the DC bias box for a gain of 10 times in the second IF stage. Then, with the generator signal applied at C, reduce the attenuator setting until the meter reading is the same as with a × 0.1 signal applied at B. This reduced setting of the attenuator is the × 0.01 position. We determine the × 0.001 position of the attenuator in the same manner, by level tests at points C and D.

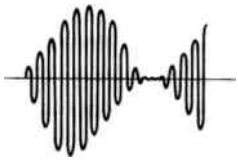
NOTE 14

Modulated Hum Output From Signal Generator

Poor power-supply filtering, heater-cathode leakage in an oscillator tube, and other similar faults cause hum-modulated output from a signal generator. To check for modulated hum, connect the output cable from the signal generator to the antenna-input terminals of a broadcast receiver. Set generator controls for CW output. Tune generator to the operating frequency of the receiver. If modulated hum is present, a 60-cycle or 120-cycle hum will be heard from the speaker. Carefully note the difference between modulated and unmodulated hum in the generator output. *Unmodulated* hum in inaudible when the foregoing check is made. *Modulated* hum passes through the RF and IF sections of the receiver. Unmodulated hum will become audible if the generator output is applied at the audio-amplifier input. On the other hand, modulated hum is not audible when the signal is applied directly at the audio amplifier input.



Unmodulated hum voltage.



Modulated hum voltage.

NOTE 15

Blocking Capacitor Often Needed in Making Tests

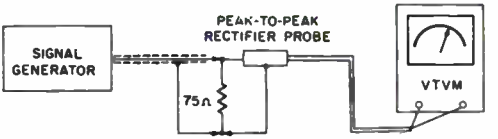
Few signal generators have a blocking capacitor in series with the "hot" lead of the output cable. Hence, such a blocking capacitor may have to be added. If a generator signal is injected into a receiver circuit in which DC voltage is present, a series blocking capacitor will be necessary. Otherwise, the generator output circuit will drain away the DC voltage. This often disturbs the circuit operation, and may damage the circuit components or attenuator in the generator.

U14

To Calibrate the Output From a Signal Generator in Microvolts

Equipment: VTVM with peak-to-peak, high-frequency probe.
Connections Required: Connect output cable from signal generator to input of peak-to-peak probe.
Procedure: Set generator attenuator to × 1 (maximum output) position. Note voltage reading on VTVM scale.
Evaluation of Results: One volt is equal to 1,000,000 microvolts. Hence, the typical maximum output from a signal generator may be 100,000 microvolts. The output on the × 0.1 step would then be 10,000 microvolts; on the × 0.01 step, 1000 microvolts; and on the × 0.001 step, 100 microvolts.

If the generator has a very low output, a low-range VTVM is required to obtain an accurate measurement.



Measuring generator output.

NOTE 16

Calibration of Attenuator in Rms Microvolts

The method discussed in U14 provides calibration of the generator attenuator in peak-to-peak microvolts. If desired, the calibration may be converted to rms microvolts. We divide the peak-to-peak voltage by 2.83 to obtain the rms voltage. For a complete discussion of waveform voltages, see the companion volume, *101 Ways to Use Your VOM and VTVM*.

NOTE 17

Generator Attenuators Are Usually Reactive

Signal generators usually have attenuators which are reactive, particularly at higher frequencies. Consequently, attenuator calibrations at one frequency are generally invalid at other frequencies. For this reason, the generator should be calibrated at the most often-used frequencies, such as 455 kc, 10.7 mc, 23 mc, and 44 mc.

U15

To Calibrate the VHF Output From a Signal Generator

Equipment: Field-strength meter and balun (see Note 18).

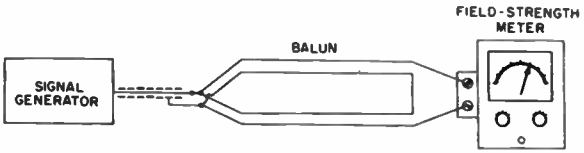
Connections Required: Connect signal-generator output to balun, and connect balun to antenna input terminals of field-strength meter.

Procedure: Tune signal generator and field-strength meter to desired test frequency. Note field-strength meter reading in microvolts as generator attenuator is adjusted to various settings.

Evaluation of Results: The generator output will usually vary widely over the various VHF channels unless the generator

is relatively expensive. Hence, the calibration must be checked on each channel of interest.

The better field-strength meters indicate microvolt levels with reasonable accuracy. On the other hand, relative field-strength meters do not give accurate microvolt readings.

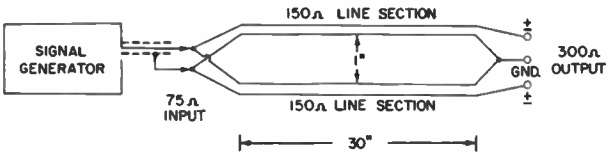


Test setup.

NOTE 18

Balun Is a Voltage-Doubling, Impedance-Matching Device

A balun constructed from line sections is a voltage-doubling, impedance-matching device. A line-section balun suitable for RF tests on all VHF channels is shown in the following illustration. The balun connects the 75-ohm generator impedance to the double-ended, 300-ohm impedance. The impedance is stepped up four times and the voltage is doubled. In other words, we have transformer action. Therefore, a balun is a line-section transformer.

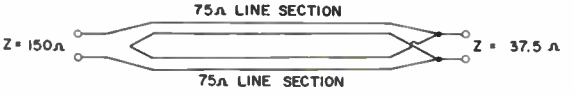


A line-section balun suitable for RF tests on all VHF channels.

NOTE 19

Stepping Down Impedances With Line-Section Baluns

As shown in the following illustration, a line-section balun can be operated in reverse to step a higher impedance down to a lower impedance. The balun gives a 4-to-1 step-down in impedance and a 2-to-1 step-down in voltage. It is essential that a balun always work into a matched load. For the example shown, this load is 37.5 ohms. If a balun works into a bad mismatch, strong standing waves will be present and will make the tests invalid.



A bolun for stepping down impedances.

U16

To Check a Signal Generator for Leakage

Equipment: Radio receiver with a suitable tuning range.
Connections Required: None.
Procedure: Remove output cable from generator. Cap the output connector, so that the output terminal is completely surrounded by grounded metal. Set the signal generator for modulated RF output. Tune generator to same frequency as receiver.
Evaluation of Results: If the signal generator has negligible leakage, no tone will be heard from the speaker of the receiver (even when receiver is operated at high gain). If leakage is evident, try to locate the leak by turning the generator in different directions. If high leakage is apparent when the generator is some distance from the receiver, check to see if external metal components, such as the tuning dial, are properly grounded.

NOTE 20

Line Cord Should Be Well Filtered

High leakage from a signal generator sometimes occurs if the line cord is not well filtered. Filtering prevents the escape of high-frequency voltages, and is accomplished by the use of RF chokes and bypass capacitors. The chokes are connected in series with the line, and the bypass capacitors are shunted from the line to the generator case.

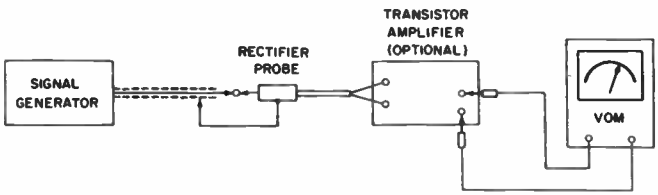
To Measure the Input Capacitance of an RF Rectifier Probe

Equipment: Rectifier probe, calibrated variable capacitor or assortment of small fixed capacitors, transistor amplifier (optional), and VOM.

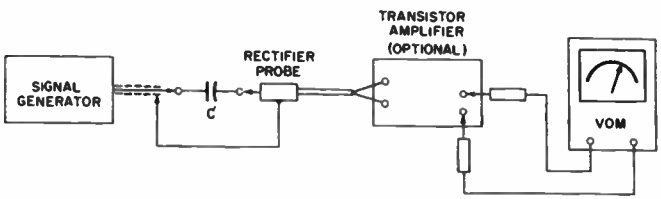
Connections Required: Connect generator output cable directly to rectifier probe input. Feed probe output to transistor amplifier (if used). Apply amplifier output (or probe output) to VOM. For second test, insert capacitor(s) in series with probe input.

Procedure: Operate signal generator on a frequency of 100 kc or higher. Note scale reading on VOM. Next, insert capacitor in series with probe to reduce VOM reading to one-half. The value of the inserted capacitor is equal to the input capacitance of the probe.

If the signal generator has a high output, the transistor amplifier is not required. However, the output of many signal generators is too low for satisfactory indication directly on a VOM.



Test 1.



Test 2.

Test setup.

NOTE 21

Zero-Set Adjustment of a VOM

An accurate determination of one-half maximum indication cannot be obtained from the test in U17 unless the meter is zero-set. It is possible to obtain a very small resting current through the meter by selection of a low-leakage transistor. On the other hand, there is always a small leakage current. This current causes appreciable zero offset on a very low current range, such as 50 microamperes. In such case, you can use the mechanical zero-set adjustment of the VOM to cancel the leakage-current indication.

U18

To Check a VTVM for RF Rejection

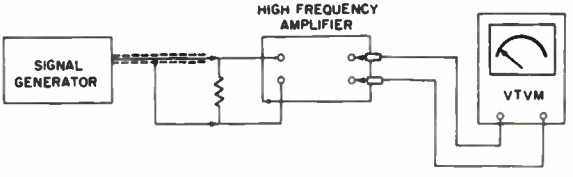
Equipment: VTVM and high-frequency amplifier.

Connections Required: Connect terminated output cable from signal generator to input terminals of high-frequency amplifier. Connect DC probe from VTVM to output terminals of amplifier.

Procedure: Set VTVM to its lowest DC voltage range. Observe meter indication, if any.

Evaluation of Results: A good VTVM does not respond to a high-level RF voltage when operated on its DC voltage function.

An IF amplifier in a radio or TV receiver, or the vertical amplifier in a scope, are convenient high-frequency amplifiers for this test.

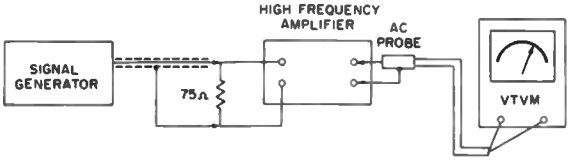


Checking RF rejection of VTVM.

To Check the Frequency Response of a VTVM

Equipment: High-frequency amplifier and VTVM with AC probe.
Connections Required: Connect terminated output cable from signal generator to amplifier input terminals. Feed amplifier output to AC probe of VTVM.
Procedure: Adjust signal-generator output for nearly full-scale deflection on first VTVM range. Then set VTVM for next higher voltage range and note whether the voltage reading changes. Repeat this two-step procedure at increasingly higher frequencies.
Evaluation of Results: The upper useful frequency limit of the VTVM occurs when a different voltage is read as the VTVM is switched to an adjacent range.

The range-switching method of test is used because the output of most service generators is not uniform over a wide range of frequencies. A wide-band scope amplifier is useful, in this test, at frequencies up to 4 or 5 mc. The RF amplifier of communications-type receivers can be used at still higher test frequencies. An amplifier is required because the output voltage available from most generators is inadequate for checking a VTVM.



Test setup.

U20

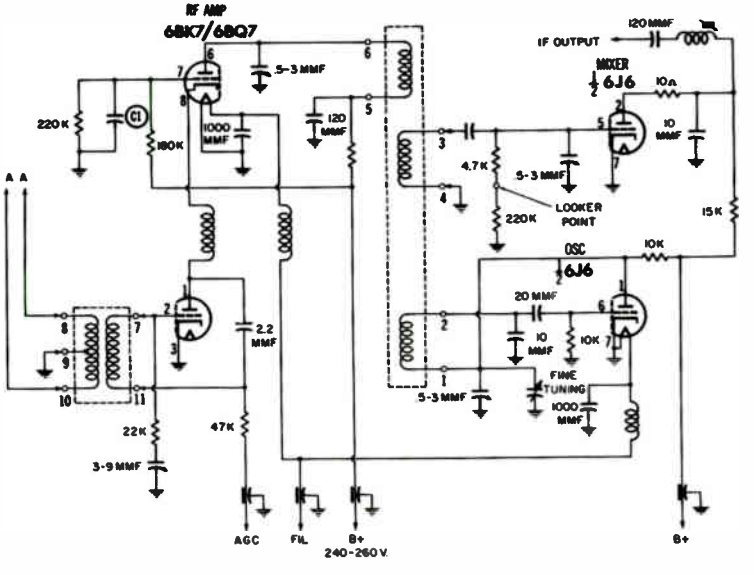
To Align the Front End of a Field-Strength Meter

Equipment: Field-strength meter, balun (see Note 18), VTVM, and bias box.
Connections Required: Connect balun to output cable of signal generator. Feed balun output to antenna input terminals of

field-strength meter. If field-strength meter has AGC, override the AGC bias with −1 volt DC. Connect VTVM to "looker" point on RF tuner.

Procedure: Tune signal generator to picture-carrier frequency of channel under test. Align RF trimmers for peak reading on meter. Tune signal generator to sound-carrier frequency of channel under test. If meter reading decreases, make compromise adjustments of RF trimmers until equal readings are obtained at both the picture-carrier and the sound-carrier frequencies.

Evaluation of Results: Repeat the foregoing procedure on each active channel. Equal meter readings usually cannot be obtained on all VHF channels at picture-carrier and sound-carrier frequencies. Hence, make compromise RF adjustments to equalize response on all channels as much as possible.



Schematic of a typical RF tuner.

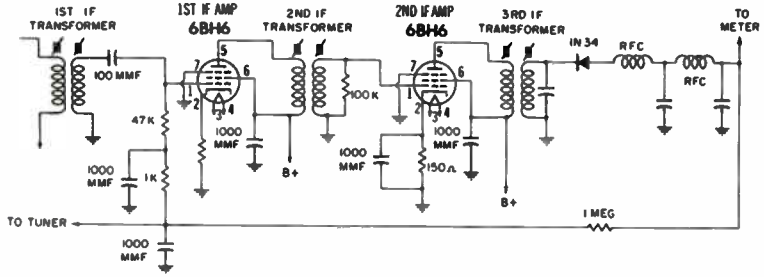
To Align the IF Amplifier in a Field-Strength Meter

Equipment: Field-strength meter, VTVM, and bias box.

Connections Required: Disable local oscillator in RF tuner. Connect output cable from signal generator to floating tube shield over mixer tube. Apply −3 volts of override DC bias to the AGC line (if field-strength meter has AGC). Connect VTVM at output of second detector.

Procedure: Set signal generator to IF frequency of field-strength meter (23 mc or 44 mc). Peak the IF coils for maximum indication on VTVM. (The field-strength meter can be used instead of a VTVM, unless the meter operates from the AGC line.) Finally, make a regeneration-or-oscillation test, as follows: Reduce the override bias to −1 volt, and reduce the generator output to avoid overload. Watch for a sudden jump in the meter indication. A jump to an abnormally high output indicates feedback trouble.

Evaluation of Results: The IF amplifier in a field-strength meter is usually aligned for narrow-band response and maximum gain, unless instability occurs at low AGC bias levels. In such case, the IF coils must be stagger-tuned sufficiently to obtain stable operation at low signal levels.



Typical IF and detector circuits for a field-strength meter.

To Adjust the Range Controls of a Relative Field-Strength Meter

Equipment. Field-strength meter.

Connections Required: Connect output cable from signal generator to antenna input terminals of field-strength meter.

Procedure: Tune signal generator to operating frequency of field-strength meter. Set meter to its lowest sensitivity range. Adjust generator output for 1/10th full-scale indication. Next, switch field-strength meter to R × 10 range. Adjust R × 10 range control for full-scale indication. Then reduce output from signal generator for 1/10th full-scale indication. Switch field-strength meter to R × 100 range. Adjust R × 100 range control for full-scale indication.

Evaluation of Results: This procedure provides relative tracking of the field-strength meter ranges. On the other hand, it does not indicate microvolts. Calibration for field strength in microvolts can be made from a calibrated signal generator only.

U23

To Check the Frequency Response of an Oscilloscope

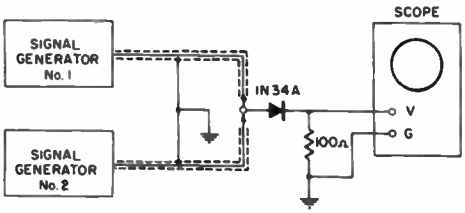
Equipment: Auxiliary signal generator, oscilloscope, crystal diode, and 100-ohm resistor.

Connections Required: Connect equipment as shown in the accompanying diagram.

Procedure: Set the signal generators to a reference frequency, such as 10 mc. Slowly tune one generator from the reference frequency to higher frequencies, such as from 10 to 15 mc. Observe vertical deflection on scope screen.

Evaluation of Results: Useful frequency range of scope extends to point at which the vertical deflection starts to drop off. For example, if one generator is set to 10 mc and the vertical deflection starts to drop off when the auxiliary generator is tuned to 14 mc, the scope has a flat response up to 4 mc.

This method is useful for tests above the audio-frequency range only. Below 50 kc, depending upon the generator construction, the two generators will start to "pull" and "lock." The beat output will then drop to zero.



Test setup.

U24

To Check an Oscilloscope for Modulated High-Frequency Burst Response

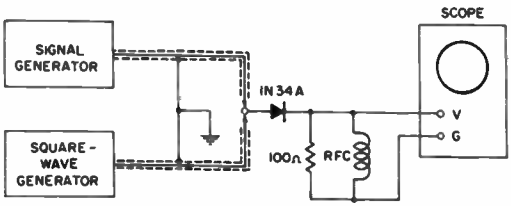
Equipment: Oscilloscope, square-wave generator, crystal diode, 100-ohm resistor, and RF choke.

Connections Required: Connect equipment as shown in the following diagram.

Procedure: Tune signal generator to check frequencies, such as 1 mc, 3 mc, and 5 mc. Set square-wave generator to approximately 15-kc output.

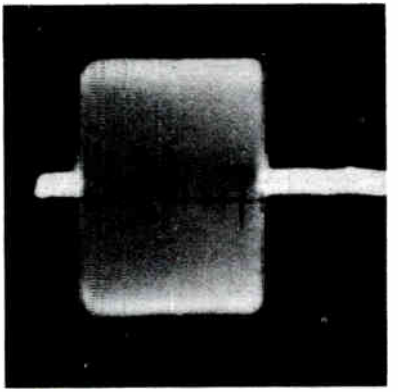
Evaluation of Results: Scope should show good transient response, with flat base line between bursts and with flat tops on bursts.

A scope which displays a good 15-kc modulated, 3-mc burst response is adequate for color TV service. A more severe test can be made by increasing the square-wave frequency to 100 kc.



Test setup.

Example of good transient response.



U25

To Use a Signal Generator as a Heterodyne Frequency Meter

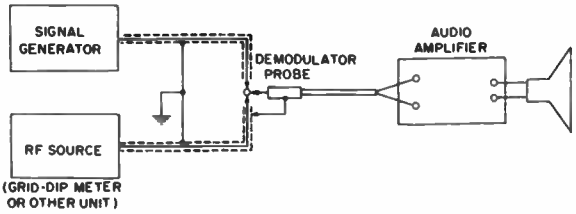
Equipment: High-frequency unit to be checked (such as grid-dip meter), demodulator probe, audio amplifier, and speaker. (A good signal tracer can be used in place of the probe, amplifier, and speaker.)

Connections Required: Connect equipment as shown in the accompanying diagram.

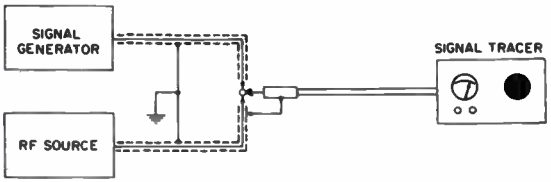
Procedure: Tune signal generator for zero beat from speaker. The frequency indicated by the signal generator is then equal to the frequency of the high-frequency source under test.

Evaluation of Results: The accuracy of frequency determination depends upon the accuracy of the signal generator. Also note that harmonics from the generator and from the unit under test cause additional zero beats. However, the strongest beat is obtained when a fundamental beats against a fundamental.

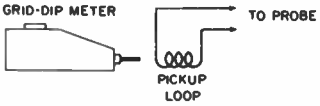
If grid-dip meter is being checked, construct a pickup loop—as shown—to couple the grid-dip meter to the probe. Use as loose a coupling as practical.



Test setup using demodulator probe, audio amplifier and speaker.



Test setup using a signal tracer.



Coupling grid-dip meter to probe.

ANTENNA TESTS

U26

To Determine Whether a TV Antenna Is Matched to a Lead-in

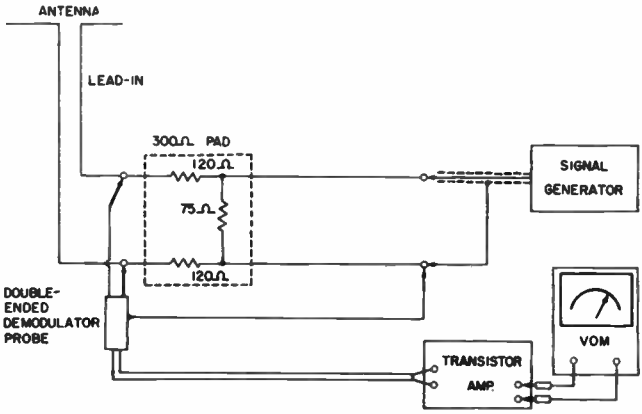
Equipment: 300-ohm resistive pad, double-ended demodulator probe, transistor amplifier (see U7), and VOM.

Connections Required: Connect test setup as shown in the following diagram. Keep all RF leads as short as possible.

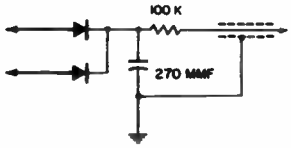
Procedure: Tune signal generator through the TV channel under test (from the picture-carrier frequency to the sound-carrier frequency) and note the meter reading.

Evaluation of Results: The meter reading does not change if the antenna is matched to the lead-in. On the other hand, a bad mismatch causes a wide variation in the meter reading as the generator is tuned from the picture-carrier frequency to the sound-carrier frequency.

This test must be made with an RF signal generator having a relatively low harmonic output. Otherwise, the test results will be invalid. Some signal generators cover the TV channels on second, third, or fourth harmonics, and are unsuitable for this test. Therefore, a generator having pure fundamental output on the VHF channels should be used.



Test setup.



Double-ended demodulator probe circuit.

NOTE 22

How to Take the Generator Characteristic Into Account

The test in U26 is straightforward if the generator has a uniform output over the channel tested. On the other hand, if the generator output is not uniform, the generator characteristic must be taken into account. The generator characteristic is determined as shown in U7. The test in U26 is generally a useful test in checking adjustment of Q bars, distribution systems, and couplers. (Also see the companion volumes, *101 Ways to Use Your Sweep Generator* and *101 Ways to Use Your Oscilloscope*.)

NOTE 23

UHF Output From AM or VHF Generators

AM and VHF signal generators usually have a weak harmonic UHF output, which is generally not useful. Aside from its very low level, this UHF output is uncontrollable by means of the attenuator in the generator. Leakage usually is high, and there is almost as much UHF voltage on the outside as there is on the inside of the output cable. Special UHF signal generators are available, which are suitable for alignment of UHF tuners, converters, etc.

To Measure the Characteristic Impedance of a Sample of Coaxial Cable

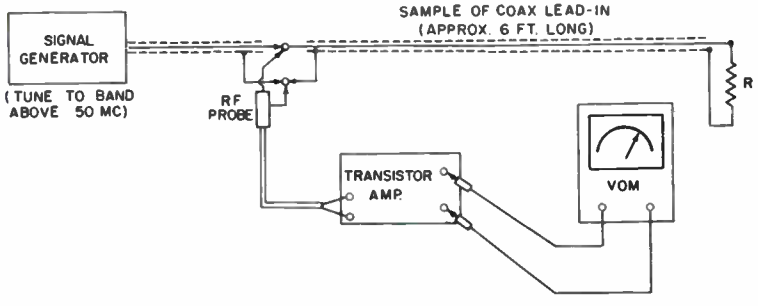
Equipment: Assortment of composition resistors, RF probe, transistor amplifier (see U7), and VOM.

Connections Required: Connect equipment to sample of cable, as shown in the accompanying diagram.

Procedure: Tune RF generator through a band of approximately 15 mc. Observe any change in the meter reading.

Evaluation of Results: When the value of R gives uniform meter indication over the test band (or gives the generator characteristic), this value is equal to the characteristic impedance of the coax cable.

For this test, the generator need not have a pure fundamental output.



Measuring characteristic impedance of coaxial cable.

U28

To Measure the Characteristic Impedance of a Sample of Twin-Lead

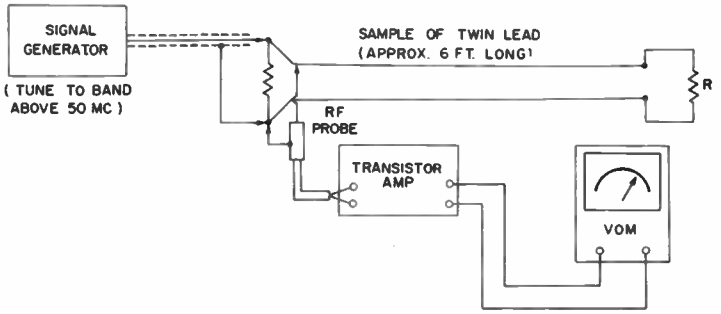
Equipment: Assortment of composition resistors, RF probe, transistor amplifier (see U7), and VOM.

Connections Required: Connect equipment as shown in the accompanying diagram.

Procedure: Tune RF generator through a band of approximately 15 mc. Observe any change in the meter reading.

Evaluation of Results: When the value of R gives uniform meter indication over the test band (or gives the generator characteristic), this value is equal to the characteristic impedance of the twin-lead.

In this test, the generator output impedance is mismatched to the twin-lead impedance. However, a match is not required to the generator, and a simple test setup can be used.



Measuring characteristic impedance of twin lead.

U29

To Check the Efficiency of an Interference Filter

Equipment: TV receiver, interference filter, and balun (see Note 8).

Connections Required: Connect output cable of signal generator to input of balun. Connect output of balun to antenna input terminals of TV receiver. In second part of test, insert interference filter between output of balun and antenna input terminals of receiver.

Procedure: Tune signal generator to the frequency that the filter is to reject. Use modulated RF output. Observe the bar interference on the picture-tube screen. In second part of test, observe screen for reduced or eliminated interference pattern.

Evaluation of Results: If suitable filters are used, it is possible to greatly reduce or eliminate interference at any frequency outside the operating channel. On the other hand, it is impossible to eliminate co-channel interference because the picture will be deteriorated by the same amount that the interference is reduced. However, interference near the high end of the operating channel can often be attenuated considerably without excessive picture degradation.

U30

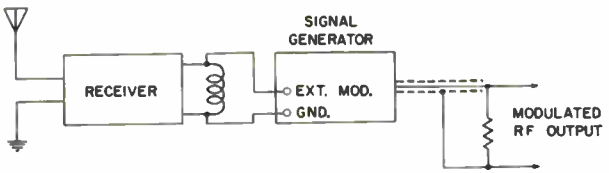
To Modulate a Broadcast Signal on Another Carrier Frequency

Equipment: Broadcast radio receiver.

Connections Required: Connect audio output from receiver to Ext. Mod. terminals of signal generator.

Procedure: Tune receiver to AM broadcast station. Tune signal generator to desired carrier frequency. Adjust receiver volume control for undistorted modulation.

Evaluation of Results: Output from signal generator can be connected to another radio receiver tuned to the generator frequency, in order to check the modulator operation. This application provides wide flexibility in shop work when a limited number of broadcast signals are available from the antenna.



Test setup.

To Modulate a Color TV Signal on Another Carrier Frequency

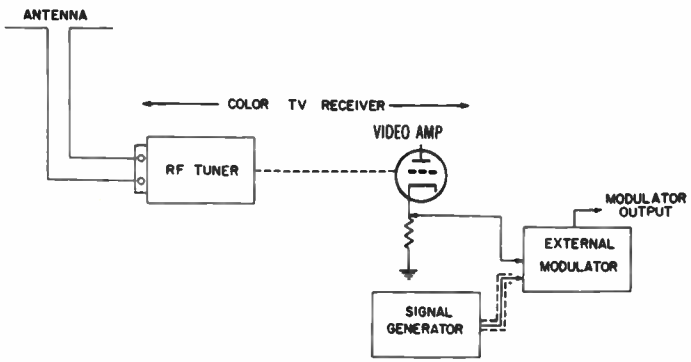
Equipment: Color TV receiver and external modulator (see Note 9).

Connections Required: Connect video signal output from receiver, and RF output from signal generator, to modulator input. The video signal must be taken from a low-impedance point in the receiver circuits (such as an unbypassed video cathode resistor); otherwise, the color burst and chroma signal will be seriously attenuated.

Procedure: Tune in a color TV broadcast. Tune signal generator to desired RF carrier frequency.

Evaluation of Results: Modulator output can be connected to another color receiver input to check the modulator action. Good modulator action requires that suitable chroma and RF signal levels be applied to the modulator diode.

An external modulator is required to "rebroadcast" a color TV signal, because full 4-mc bandwidth is needed. This method can also be used for black-and-white receivers.



Test setup.

To Measure the Resonant Frequency of a Tuned Stub

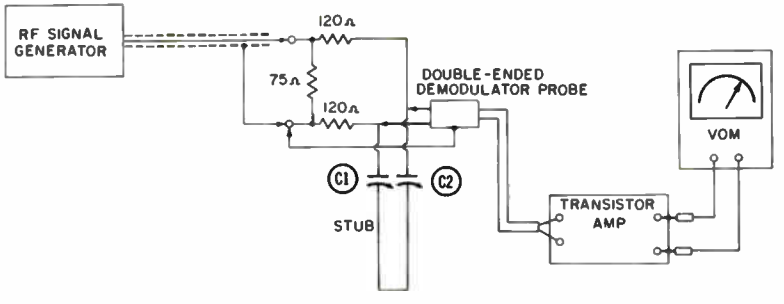
Equipment: Two 120-ohm resistors, one 75-ohm resistor, stub (constructed from 300-ohm line), two trimmer capacitors, double-ended demodulator probe (see U26), transistor amplifier (optional) (see U7), and VOM.

Connections Required: Connect equipment as shown in the following diagram.

Procedure: Tune signal generator while watching meter indication.

Evaluation of Results: The resonant frequency is indicated by a dip to minimum in the meter reading. The stub can be tuned by the two trimmer capacitors C1 and C2. The smaller the value of these capacitors, the sharper the trap response.

This test cannot be made with a generator having strong spurious outputs.

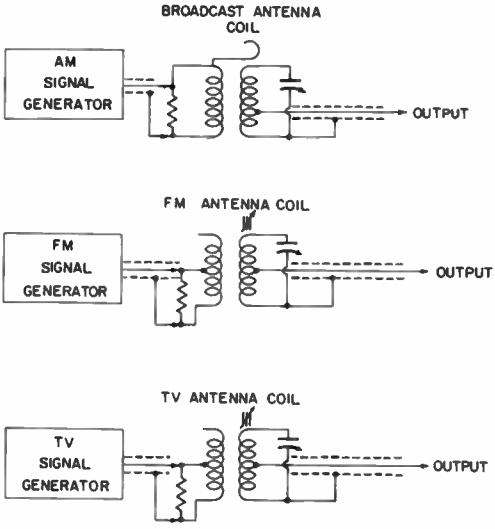


Measuring resonant frequency of tuned stub.

NOTE 24

Resonant Circuit Minimizes Spurious Generator Outputs

Spurious outputs from a signal generator can be minimized by use of a resonant circuit, as shown in the accompanying diagram. A resistor R of approximately 75 ohms is shunted across the generator output cable. The secondary of the antenna coil or transformer is tapped down approximately 90% to match the low impedance of the coax output cable. The disadvantage, in most instances, is that the resonant circuit must be retuned when the generator frequency is changed.



Use of resonant circuits to reduce spurious outputs.

AM-FM RECEIVER TESTS

U33

To Check the Selectance Ratio of a Receiver

Equipment: VTVM or VOM with decibel scale.

Connections Required: Connect signal-generator output cable to antenna input terminals of receiver. Connect voltmeter across voice coil of speaker (or across primary of output transformer, using the Output function of the VOM).

Procedure: Tune receiver to 600 kc. Adjust signal generator to same frequency. Operate generator on modulated RF output. (Avoid overloading receiver.) Note db reading on meter. Next, adjust signal generator 10 kc off frequency (610 or 590 kc). Do not change attenuator setting. Note reduced db indication on meter. Test is customarily repeated at 800, 1000, and 1400 kc.

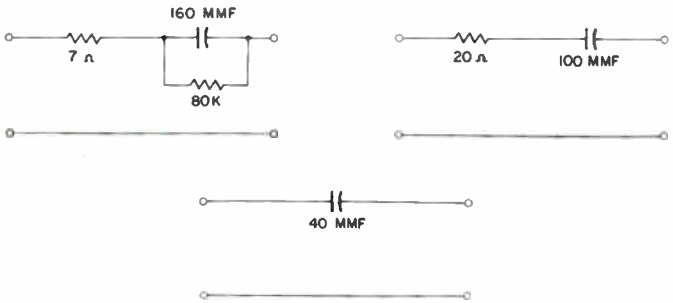
Evaluation of Results: The selectance ratio is the ratio of db readings on-frequency and 10 kc off-frequency.

A poor selectance ratio is caused by misalignment or by an inadequate number of tuned circuits in a receiver. A poor ratio can also be caused by faults which lower the normal Q of the tuned circuits.

NOTE 25

Dummy Antennas for Auto Radio Tests

Dummy antennas for auto radio testing are not as standardized as those for other classes of receivers. It is advisable to consult the receiver service notes. Three typical dummy antennas for audio radio work are shown in the accompanying diagram.



Dummy antennas for auto radio tests.

U34

To Determine the Antenna Detuning Effect

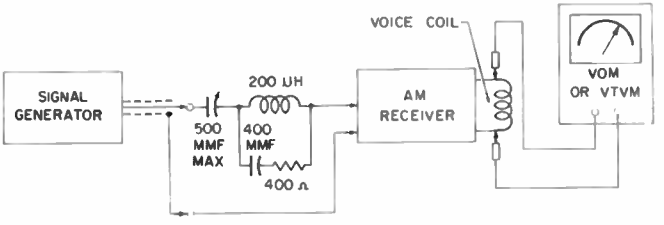
Equipment: 500-mmf variable capacitance, 20-microhenry coil, 400-mmf fixed capacitor, 400-ohm resistor, and VOM (or VTVM).

Connections Required: Connect components to form a dummy antenna, as shown in the following diagram. Connect dummy antenna between output cable of signal generator and antenna input terminals of receiver. Connect voltmeter across speaker voice coil.

Procedure: Operate signal generator on modulated RF output. Set variable capacitor to approximately 200-mmf capacitance (standard dummy antenna value). Tune signal generator for maximum indication on meter. Next, increase the variable capacitance to maximum; retune signal generator to determine whether resonant frequency of receiver has changed.

Repeat test with variable capacitor set to nearly minimum capacitance. Finally, repeat test with variable capacitor shorted.

Evaluation of Results: Resonant frequency of receiver should not change in any of the three tests. If it does change, the converter circuit is not adequately decoupled from the antenna input coil.



Test setup.

U35

To Track a Replacement Ferrite Antenna

Equipment: VTVM.

Connections Required: Connect VTVM to AVC line in receiver. Place signal-generator cable near ferrite antenna unit (or use several turns of wire to loop-couple the generator output).

Procedure: Tune the generator to approximately 1,300 kc, and adjust trimmer on antenna tuning capacitor for maximum meter reading. Next, tune the generator to approximately 600 kc, and adjust slug in ferrite antenna unit for maximum meter reading. Finally, repeat the procedure to eliminate possible interaction errors between trimmer and slug.

Evaluation of Results: The ferrite antenna unit is properly tracked when no further improvement in output can be obtained by repeating the foregoing procedure.

As in all alignment applications, the test signal must be kept well below the overload point to insure accurate adjustments. Overload causes a broad and indefinite resonance indication.

To Measure the Sensitivity of an AM Broadcast Receiver

Equipment: AM signal generator with microvolt-calibrated attenuator, resistor with a value equal to voice-coil impedance, and AC VTVM.

Connections Required: Connect output cable from signal generator, through standard dummy antenna, to antenna-input terminals of receiver (see U34). Connect resistor to receiver output in place of the speaker voice coil. Connect VTVM across resistor.

Procedure: Operate the signal generator on 30% modulated RF output. Tune signal generator and receiver to desired test frequency. Observe meter reading and microvolt output from generator.

Evaluation of Results: The power in the resistor is given by E^2/R, where E is the voltage across the resistor. The sensitivity of the receiver is given by the number of microvolts' input required to obtain 0.5 watt of power in the load resistor.

U37

To Inject a Signal Into the Loop Antenna of a Transistor Radio

Equipment: Five feet of No. 26 insulated wire.

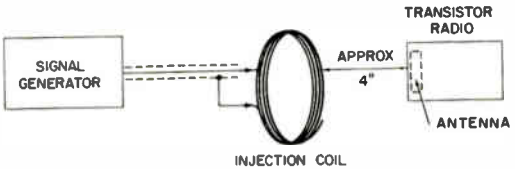
Connections Required: Wind wire into a coil approximately 1½ inches in diameter. Connect ends of coil to output cable of generator.

Procedure: Couple coil to loop in receiver, as shown in the following diagram. Use modulated RF output from generator.

Evaluation of Results: If hand capacitance is troublesome while you are adjusting the receiver trimmers, move the coil farther away from receiver. If signal is too weak, move coil closer to receiver.

A VTVM can be connected across the volume control as a convenient output indicator.

Test setup.



U38

To Check the Tracking of the Preselector Circuits

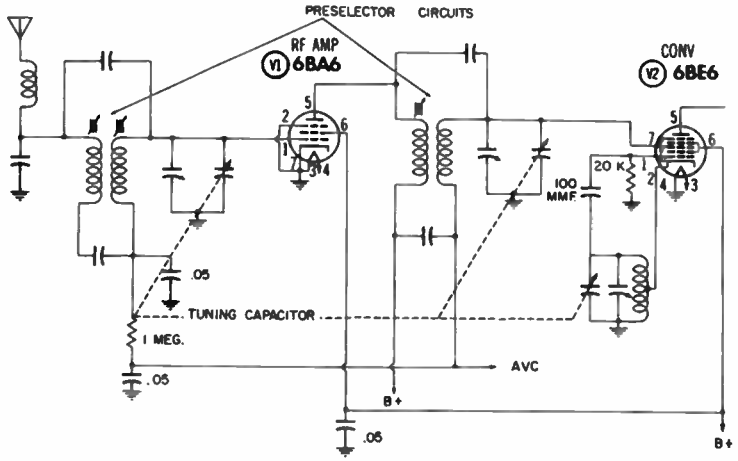
Equipment: Tuning wand and VTVM.

Connections Required: Connect output cable from signal generator through standard dummy antenna (see U34). Connect VTVM across speaker voice coil.

Procedure: Operate signal generator on modulated RF output. Operate VTVM on AC voltage function. Tune signal generator and receiver to several RF frequencies within the range of 550 to 1,500 kc. Observe change in meter indication as powdered-iron end and as brass end of tuning wand are brought, in turn, into the field of the preselector coils.

Evaluation of Results: If the meter reading decreases when either the powdered-iron end or the brass end of the tuning wand is inserted into a preselector coil, the receiver is tracking exactly. On the other hand, if the meter reading increases, there is a tracking error. If the increase occurs for the brass end of the wand, the preselector resonance is too low; if the increase occurs for the powdered-iron end, the preselector resonant frequency is too high.

There will usually be a small tracking error at some frequencies over the tuning range. Therefore, compromise tracking edjustments must be made, to minimize the over-all tracking error.



Preselector circuits in a typical receiver.

U39

To Determine the Image-Rejection Ratio of an AM Receiver

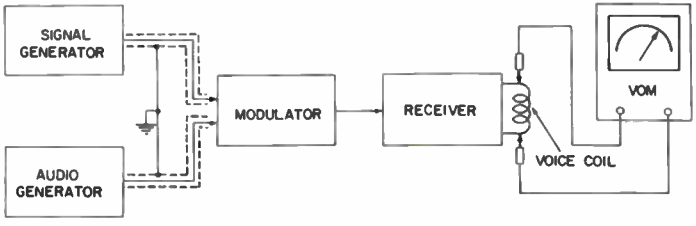
Equipment: Audio oscillator, external modulator (see Note 9), and VOM.

Connections Required: Connect equipment as shown in the following diagram.

Procedure: Tune signal generator to operating frequency of receiver, and note voltmeter reading. Then tune signal generator to image frequency, and note the lower voltmeter reading.

Evaluation of Results: The ratio of the two meter readings is the image-rejection ratio of the receiver.

The image frequency in an AM broadcast receiver is usually the operating frequency ±910 kc, because the IF amplifier usually operates at 455 kc. Both sum and difference frequencies are generated in the converter, which makes it possible for the image frequency to cause interference. The better the preselection in a receiver, the higher the image-rejection ratio.



Test setup.

U40

To Check the Image-Rejection Ratio of an FM Receiver

Equipment: VOM and audio oscillator (optional).

Connections Required: Connect output cable of signal generator to antenna input terminals of receiver. Connect VOM across speaker voice coil. If signal generator does not have appreciable spurious FM modulation, connect audio-oscillator output leads to Ext. Mod. terminals of signal generator.

Procedure: Operate signal generator on modulated RF output. Tune signal generator to operating frequency of FM receiver. Operate VOM on AC voltage or on Output function. If a substantial reading is not obtained on VOM, use audio-oscillator signal to Ext. Mod. terminals of signal generator. Advance audio-oscillator output until substantial spurious frequency modulation occurs, as shown by the VOM. Then tune the signal generator to the image frequency of the FM receiver. Again note the VOM reading.

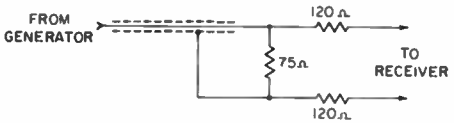
Evaluation of Results: The ratio of the two VOM readings is the image-rejection ratio of the receiver.

The image frequencies in an FM receiver result from the fact that the converter and mixer generate both sum and difference frequencies. The local oscillator operates at 10.7 mc above or below the signal frequency. Thus, the image frequency is 21.4 mc from the desired frequency. The image-rejection ratio is poorest in receivers with little or no preselection.

NOTE 26

Dummy Antenna for Testing FM Receivers

Most modern FM receivers have a 300-ohm balanced input and are driven from 300-ohm twin-lead. A suitable dummy antenna consists of a resistive pad like the one in the accompanying illustration. A line-section balun, as described in Note 18, can also be used.



Dummy antenna for FM receivers.

NOTE 27

Alignment and Signal-Substitution Tests

A signal generator is widely used for alignment and signal-substitution tests in FM receivers. For a discussion of these topics, see the companion volume, *101 Ways to Use Your VOM and VTVM*. Alignment is most conveniently made with an FM sweep generator. A signal generator is used to mark the response curve. These methods are explained in the companion volume, *101 Ways to Use Your Sweep Generator*.

NOTE 28

Service-type Signal Generators Unsatisfactory for Testing Communications Equipment

Modern communications equipment, such as police and taxicab radio receivers requires the use of laboratory-type signal generators, because service generators do not have sufficient stability and accuracy to give valid tests.

U41

To Check the Input Impedance of an FM Receiver

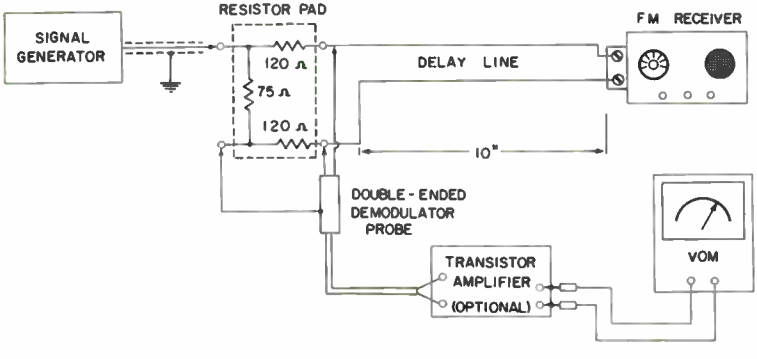
Equipment: Delay line, resistor pad, double-ended demodulator probe (see U26), transistor amplifier (optional), and VOM.
Connections Required: Connect test setup as shown in the following diagram. A 75- to 300-ohm balun may be substituted

for the resistor pad (see Note 18). The balun doubles the signal voltage instead of introducing a loss. The transistor amplifier is not required if the output from the generator is high.

Procedure: Operate the signal generator on unmodulated RF output. Tune generator over the operating channel of the receiver. Observe meter indication.

Evaluation of Results: The meter reading should be constant as the generator frequency is varied through the operating channel. Otherwise, a mismatch will be present. When the lead-in is mismatched to the receiver input, receiver sensitivity will be impaired. The impedance match is adjusted by proper coupling of the primary and secondary coils in the antenna transformer.

The signal generator in this test must have a pure sine-wave output without strong harmonics or other spurious frequencies. An antenna transformer is always mismatched at any frequencies that differ widely from the operating frequency. Hence, spurious frequencies from the signal generator make this test invalid.



Test setup.

NOTE 29

"FM Signal Generator" Is An FM Sweep Generator

Technicians often refer to an FM sweep generator as an "FM signal generator." Actually, there is a wide difference between a true FM signal generator and the bench-type "FM signal generator." A true FM signal generator is not a sweep generator, although it provides an adjustable

frequency-modulated signal. The frequency of modulation and the deviation can be adjusted in a true FM signal generator. On the other hand, an FM sweep generator is greatly limited. It has only one modulating frequency—60 cycles. Also, the output from a service FM sweep generator is usually a beat fundamental and contains a spectrum of spurious frequencies. Note that it is *not* possible to determine the *over-all frequency response* of an FM receiver with an *FM sweep generator*. For a discussion of the characteristics of typical FM sweep generators, see the companion volume, *101 Ways to Use Your Sweep Generator*.

NOTE 30

External Modulation of FM Sweep Generator

Beginners sometimes suppose than an FM sweep generator can be used as a complete FM signal generator by external modulation of the deviation device in the generator. For example, if a loudspeaker-capacitor system is used in the generator to obtain FM sweep, it is thought that the output from an audio oscillator can be used to energize the system. In fact, some FM sweep generators provide for use of an external modulating voltage. Even though a limited range of output can be obtained in this manner, the following limitations will be encountered:

1. Although a loudspeaker-capacitor type of modulator operates satisfactorily at low frequencies, such as at 60 cycles, it is almost impossible to obtain appreciable deviation at higher audio frequencies.
2. The deviation obtained is unknown unless, at each frequency of modulation, a special test set-up is used to measure the deviation.
3. The stability of the center frequency is much less in a beat-frequency generator than in a true FM signal generator.

U42

To Track the Head-End Circuits in a Multiband Receiver

Equipment: VTVM, tuning wand, and dummy antenna.

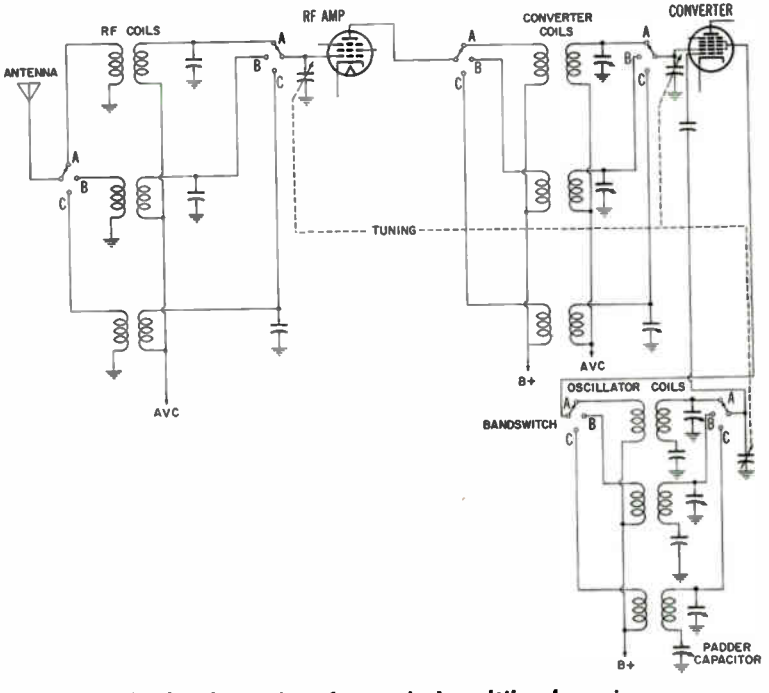
Connections Required: Connect output from signal generator to dummy antenna. Connect output from dummy antenna to antenna input terminals of receiver. Connect VTVM across AVC line in receiver.

Procedure: Tune generator to operating frequency of receiver. Set generator to unmodulated RF output. Align front-end circuits in the usual manner, except *do not bend rotor plates*

of tuning capacitor to improve the tracking. Insert tuning wand in RF-amplifier and converter coils to determine whether tracking is satisfactory. (Make tracking tests at low, medium, and high ends of tuning range on band.) If the RF coil tracking needs adjustment, adjust the inductance by squeezing the turns together or spreading them apart. If the converter coil tracking needs adjustment, adjust the coil inductance in combination with the converter trimmer for best tracking. Repeat for each band. When working on a band having a series oscillator-coil padder (as shown for band C in the following diagram), also adjust the padder for best tracking.

Evaluation of Results: The head end is properly tracked when the tuning wand reduces the VTVM reading of each test frequency on each band.

Perfect tracking is not possible in commercial receivers. Hence, compromise adjustments are made for optimum tracking at low-, medium-, and high-band responses.



Head-end circuits of a typical multiband receiver.

To Check a Receiver for Whistle Modulation

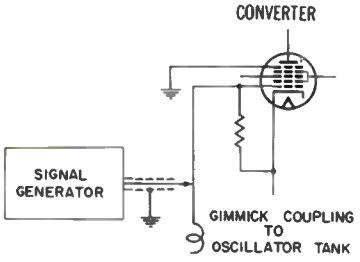
Equipment: None.
Connections Required: Connect output cable from signal generator to antenna input terminals of receiver.
Procedure: Tune signal generator to twice the intermediate frequency of the receiver (usually 910 kc). Vary the generator frequency ±30 kc from 910 kc while rocking the receiver tuning dial. Listen for a whistle from the speaker.
Evaluation of Results: If the receiver has good converter operation, little or no whistle modulation will be heard.

When whistle modulation is abnormally high, check operating voltages of converter tube.

U44

To Substitute a Generator Signal for a Dead Local Oscillator

Equipment: None.
Connections Required: Connect generator output cable to oscillator input lead of converter.
Procedure: Use a maximum output from generator. Tune generator to required oscillator frequency.
Evaluation of Results: The generator output is usually less than the normal injection voltage to the converter. Nevertheless, the condition of the receiver can be determined with this test.



Substituting signal generator for local oscillator signal.

U45

To Track the Oscillator in a Transistor Radio

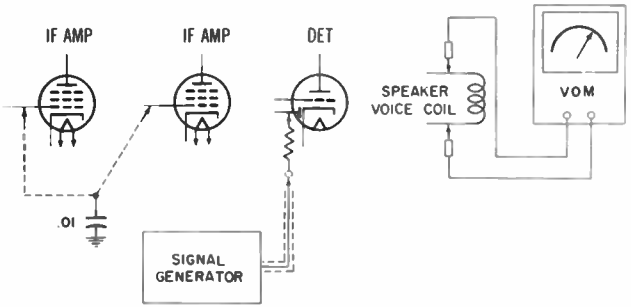
Equipment: Five feet of No. 26 insulated wire, and VTVM.
Connections Required: Wind wire into a coil approximately 1½ inches in diameter. Connect ends of coil to output cable of generator. Connect VTVM across volume control.
Procedure: Adjust oscillator trimmer for maximum meter reading with generator and receiver tuned to 1,500 kc. Adjust oscillator coil for maximum meter reading with generator and receiver tuned to 600 kc.
Evaluation of Results: Oscillator trimmer and coil should be adjusted back and forth several times to obtain best tracking.

Some AM signal generators have preset frequencies of 262, 455, 456, 600, and 1,400 kc. When using this type of generator, substitute 1,400 kc in the 1,500-kc test just explained.

U46

To Check an IF Amplifier for Regeneration

Equipment: Isolating resistor, 0.01-mfd capacitor, and VOM.
Connections Required: Connect generator output in series with isolating resistor (as large a resistance as possible) to input of the second detector. Connect VOM across voice-coil terminals.
Procedure: Tune signal generator for maximum reading on VOM. Operate VOM on AC volts or on Output function. Use modulated RF output from generator. If VOM reading is undesirably low, use a smaller value of isolating resistance. Shunt the 0.01-mfd capacitor, in turn, from the grid of each IF tube to chassis while watching for any change in the meter reading.
Evaluation of Results: Any change in meter reading when the grid of an IF tube is bypassed indicates that regenerative feedback voltage is present at the test point. In this manner, a regenerative loop can be localized.



Test setup.

NOTE 31

Regenerative Feedback Loops Often Start At Detector

The test described in *U46* is made by injecting the signal voltage at the second detector, because most regeneration starts at the detector. The detector is a nonlinear device that generates strong harmonics of the IF frequency. In some instances these harmonics find a path back to the receiver input, and form tunable birdies or tweets. In other instances the high-level IF input to the second detector finds its way back, in part, to an earlier IF stage. We start looking for sources of regeneration in high-level, high-frequency circuits first.

U47

To Check for Miller Effect in the IF Amplifier

Equipment: DC bias box and VOM (or VTVM).

Connections Required: Apply a negative DC bias of 3 volts from box to AVC line. Connect AC voltmeter across voice coil. Apply modulated IF signal from generator to grid of converter tube. Disable local oscillator.

Procedure: Tune signal generator for maximum meter reading. Reduce AVC override bias to a low value (such as one-half volt). Attenuate generator output to avoid overloading IF amplifier. Again tune signal generator for maximum meter reading.

Evaluation of Results: A maximum meter reading that requires another setting of the generator tuning dial when the bias

is reduced, indicates that Miller effect is present in the IF amplifier. Stabilize amplifier operation by separating the grid and plate leads. Then check the bypass capacitors.

NOTE 32

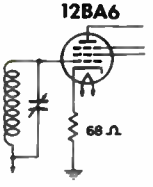
DC Bias Box Required for Certain Types of Tests Only

Although a DC bias box is needed in signal-circuit tests requiring controlled bias (such as for Miller effect), the override bias is not always necessary or even desirable in other tests. For example, aligning RF and IF circuits, making selectance and image-rejection checks, and testing for IF rejection require that normal AVC action be present before a valid test can be made. The reason is that AVC action broadens the apparent selectivity of a tuned amplifier. As a test signal is tuned down the side of the response curve, the AVC bias decreases and, in turn, increases the stage gain. Thus, if override bias is used in alignment, the measured bandwidth is less than the operating bandwidth. Again, when rejection tests are made, the desired evaluation is in terms of receiver operation under normal AVC control conditions.

NOTE 33

Miller Effect Is Caused by Grid-Plate Capacitance

The Miller effect in an amplifier is caused by grid-plate capacitance. Excessive grid-plate capacitance can be caused by a faulty screen-bypass capacitor, which reduces the shielding effect of the screen grid. It can also be caused by dressing grid and plate leads too close together. The Miller effect causes the plate-load reactance to be partly reflected into the grid circuit. The value of the reflected reactance varies with the stage gain. This variation detunes the grid circuit when the grid bias changes, and causes "walking" frequency-response curves. Note that the Miller effect is a positive feedback. Even in a well-designed IF amplifier, there is often a residual Miller effect, which is offset by a suitable value of negative feedback. The following illustration shows the cathode circuit of a typical IF amplifier. The negative feedback is obtained by use of a 68-ohm unbypassed cathode resistor. If the resistor should change in value, the instability caused by the Miller effect may become noticeable.



Cathode circuit of a typical IF amplifier.

To Check for Open IF Screen Capacitors

Equipment: High-frequency rectifier probe, transistor amplifier, and VOM.

Connections Required: Connect probe and transistor amplifier as shown in U7. Feed probe output to VOM. Connect generator output cable to receiver input terminals. Test with probe at each screen bypass capacitor.

Procedure: Tune signal generator to operating frequency of receiver. Observe meter reading as probe is connected across each screen-bypass capacitor.

Evaluation of Results: Any voltage indication on meter when probe is applied across bypass capacitor indicates the capacitor is faulty.

NOTE 34

Alignment and Signal-Injection Applications of AM Signal Generators

AM signal generators are widely used for alignment and in signal-substitution tests. For a discussion of such tests, see the companion volume, *101 Ways to Use Your VOM and VTVM.*

U49

Quick Test for Nonlinear IF Amplifier Operation

Equipment: VOM or VTVM.

Connections Required: Connect generator output cable to antenna input terminals of receiver. Connect voltmeter from plate to ground of suspected IF tube.

Procedure: Tune signal generator to operating frequency of receiver. Advance generator output while watching meter reading.

Evaluation of Results: When the stage starts nonlinear operation, the meter reading will change. In a Class-A amplifier, the presence of a signal causes only a slight change in the DC plate-voltage reading.

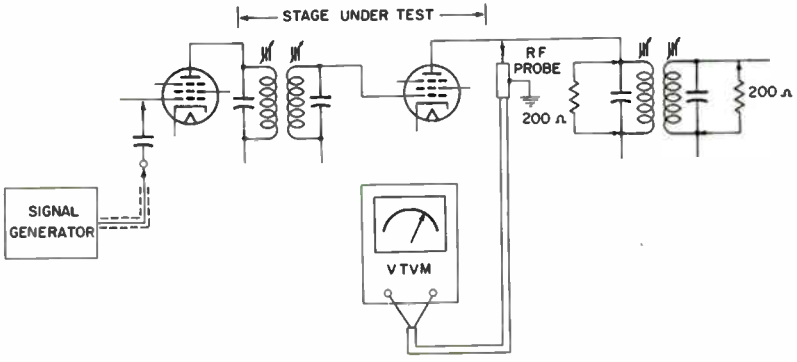
To Determine the Q of a Single IF Stage

Equipment: VTVM and RF probe, two 200-ohm resistors, and a blocking capacitor.

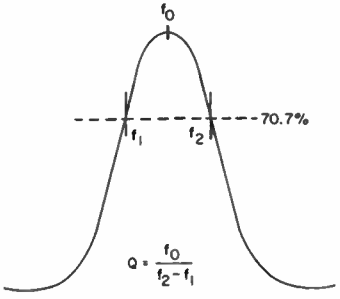
Connections Required: Connect output cable of generator, through blocking capacitor, to grid of tube preceding the stage under test. Connect the 200-ohm resistors across primary and secondary of IF transformer following stage under test. Connect RF probe and VTVM at plate of the stage under test (see the following illustration).

Procedure: Tune signal generator for maximum VTVM reading. Then tune signal generator below resonance for 0.707 of peak reading on VTVM. Note generator frequency. Finally, tune signal generator above resonance for 0.707 of peak reading. Again note generator frequency.

Evaluation of Results. The difference between the frequencies at 0.707 output, divided into the resonant frequency, is the Q of the circuit. Example: The resonant frequency is 465 kc; the frequencies of 70.7% output are 460 and 470 kc; divide 10 into 465 to find that Q equals 46.5.



Test setup.



Response curve.

To Check for Regeneration and Oscillation in Transistor Radios (Neutralizing Adjustments)

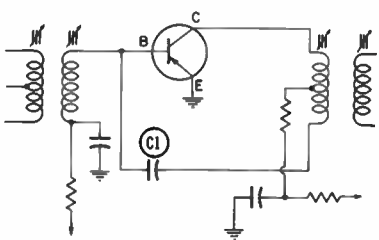
Equipment: Five feet of No. 26 insulated wire, and VTVM.

Connections Required: Wind wire into a coil approximately 1½ inches in diameter. Connect ends of coil to output cable of generator. Connect VTVM across volume control.

Procedure: Tune signal generator slowly through the passband with the receiver tuned to approximately 600 kc. Watch meter for sudden "kick" at a critical frequency. Vary neutralizing capacitors for stable operation. Repeat test with receiver tuned to approximately 1,500 kc.

Evaluation of Results: Regeneration causes sharp high peaks in the frequency response, which result in sudden meter "kicks." Oscillation paralyzes the receiver, so that no signal can be passed by the IF amplifier. Transistors are triodes and have base-to-collector electrode capacitance, just as triode tubes have grid-plate capacitance. The principle of neutralizing is the same whether tube or transistor amplifiers are involved. The neutralizing capacitor (C1 in the following illustration) may be fixed or variable. If fixed (typical value, 10 mmf), its value sometimes must be increased if a high-gain "hot" transistor is used in the IF amplifier circuit.

Neutralizing capacitance values which are correct for one transistor are not always correct for replacement transistors. Remember also that such circuit faults as off-value resistors or defective capacitors sometimes cause regenerative symptoms. In reception of broadcast stations, the customer's complaint is either "poor quality," "poor quality and whistles," or "no reception on some stations."



IF amplifier stage of a transistor radio.

NOTE 35

Signal Injection in Transistor Radios

Signal-injection methods can be used to locate dead stages in transistor radios, in the same general manner as in tube radios. An 0.1-mfd series blocking capacitor should be used in the "hot" output lead from the generator. If the generator provides a high output voltage (e.g., on the 400-cycle audio function), remember that transistors are subject to damage from overload. A low signal level is also desirable to avoid "feed-through" on a dead stage, with consequent false conclusions. Inject the signal at the base of the transistors, working backward from the speaker. Use audio output from the generator to check the AF amplifier. Use modulated RF output at IF frequency to check the IF amplifier. The 400-cycle tone signal becomes noticeably distorted when the signal is injected into a stage having appreciable amplitude nonlinearity.

U52

To Check the Quieting Level of an FM Receiver

Equipment: Signal generator with calibrated attenuator.

Connections Required: Connect output from signal generator to antenna input terminals of receiver.

Procedure: Advance volume control until the noise level is clearly audible. Tune signal generator to the same frequency as that of the receiver. Advance generator output while listening to receiver noise output.

Evaluation of Results: The quieting level (limiter threshold point) is reached when the noise chokes off to a minimum level that remains unchanged as the generator output is further increased. Note the number of microvolts of input required for quieting action. The level can be compared with another receiver of the same type known to be in good operating condition.

To Check an FM Receiver for AM Rejection

Equipment: AM signal generator and VOM or VTVM.
Connections Required: Connect generator output cable to antenna input terminals of receiver. Connect voltmeter across voice-coil terminals.
Procedure: Operate signal generator on modulated RF output. Tune generator to operating frequency of receiver. Operate voltmeter on AC voltage or on Output function. Switch modulation on and off in AM generator while watching for a change in meter reading.
Evaluation of Results: If receiver has good AM rejection, the meter reading will not rise when the generator signal is AM-modulated.

NOTE 36

Service AM Generator May Have Spurious Frequency Modulation

Some service AM generators will have spurious frequency modulation when set for modulated RF output (amplitude-modulated output). Spurious frequency modulation is usually caused by amplitude modulation of the oscillator in the generator. Amplitude modulation will vary the plate voltage of the oscillator tube cyclically. In turn, this causes frequency modulation of the output signal. To test for spurious FM in the output of an AM generator, make the test in U53 with an FM receiver known to be in good operating condition. Note that, when spurious frequency modulation is troublesome, you can use an external modulator and audio oscillator to advantage. The oscillator in an AM generator is usually isolated to some degree from the output circuit. Sometimes electron coupling is used. Or the output may be taken from a low-impedance circuit point in the oscillator. In such case, an external AM modulator introduces less spurious frequency modulation into the signal (see Note 9).

U54

To Make an Over-all Audio Fidelity Test of an AM Radio

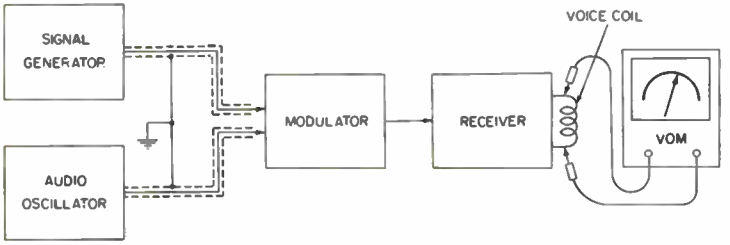
Equipment: Audio oscillator, external modulator (see Note 9), and VOM.

Connections Required: Connect equipment as shown in the following diagram.

Procedure: Tune signal generator to operating frequency of receiver. Operate VOM on AC volts or on Output function. Tune audio oscillator through the audio-frequency range while watching the meter indication.

Evaluation of Results: A good receiver will have a reasonably flat response over an audio range from 100 to 10,000 cycles. The over-all audio fidelity depends upon the bandwidth and alignment of the signal circuits, as well as upon the frequency response of the audio section.

The audio oscillator should have a reasonably uniform output over the audio range. Otherwise, its characteristic should be taken into account. To eliminate sound output from a receiver under test, disconnect the voice coil and substitute a resistor with a value equal to the impedance of the voice coil. The voice-coil impedance is *not* equal to its DC resistance—check with manufacturer's specifications.



Test setup.

NOTE 37

Audio-Fidelity Test for Receiver With Tone Control

In receivers having a tone control, the over-all audio fidelity depends upon the setting of this control. Hence, a comprehensive test requires checks at low, midrange, and high settings of the tone control. A receiver with a top audio response of 10,000 cycles at maximum setting of the tone control may have a top response of only 1,500 cycles at the minimum setting. Also note that the more elaborate receivers often have two controls, one for bass boost and the other for treble boost. The bass-boost control affects response principally at low audio frequencies; the treble-boost control affects response principally at high audio frequencies.

NOTE 38

Over-all Audio-Fidelity Test of FM Receiver Cannot Be Made With Usual Shop Test Equipment

An over-all audio-fidelity test of an FM receiver requires an FM signal generator that can be modulated by an audio oscillator. This type of signal generator generally is not found in service shops. An FM sweep generator cannot be used in this test because it can be modulated at 60 cycles only. Section-by-section tests which practically insure good over-all audio fidelity can be made. These sectional tests are as follows:

1. Proper alignment of the RF and IF amplifiers.
2. Correct limiter operation.
3. Proper discriminator alignment.
4. Accurate de-emphasis characteristic.
5. Flat audio-amplifier response.

U55

To Check the Frequency Stability of a Receiver Against Line-Voltage Variations

Equipment: Variac or equivalent, audio oscillator, external modulator (see Note 9), and VOM.

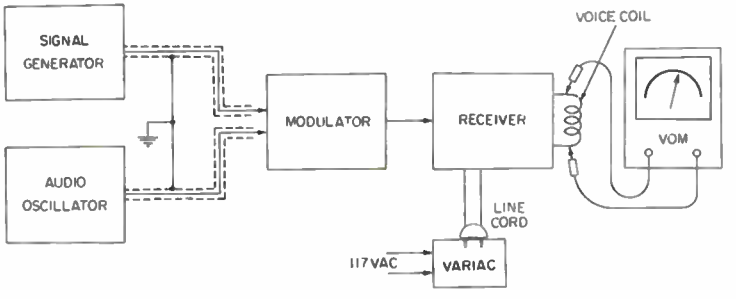
Connections Required: Connect equipment as shown in the following diagram.

Procedure: Use modulated RF output from signal generator. Tune generator for maximum reading on meter. Adjust Variac over line-voltage test range. When line voltage is changed, retune signal generator while watching the meter reading.

Evaluation of Results: If the generator must be retuned to obtain maximum meter indication, the local oscillator in the receiver is shifting frequency and is responsive to changes in the plate-supply voltage.

With constant Variac voltage, also check for weak and strong output signals from the signal generator. When the AVC voltage in the receiver changes, the plate-current demand will also change. This shifts the local-oscillator frequency when power-supply regulation is poor. The signal generator must be retuned for maximum meter indication. This frequency shift is sometimes

confused with Miller effect (see U47). To distinguish between the two, check with the IF signal applied to the IF amplifier input.



Test setup.

U56

To Check an FM Receiver for Immunity to Line Pickup

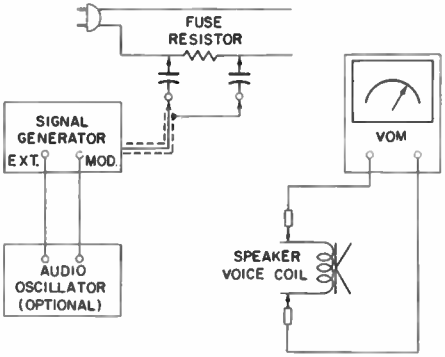
Equipment: Two 0.1-mfd capacitors.

Connections Required: Connect the capacitors in series with the generator output leads. Apply signal across fuse resistor in chassis. (If there is no fuse resistor in the receiver, insert a 4.7-ohm resistor in series with the line.)

Procedure: Operate the generator on modulated RF output. Apply maximum output from generator across fuse resistor. Advance receiver volume control.

Evaluation of Results: If audio tone is heard from speaker, the receiver is not immune to line pickup. Line pickup can be eliminated by suitable low-pass filtering in the line.

If signal generator does not have substantial spurious FM output, use an audio oscillator for high-percentage modulation from the Ext. Mod. terminals of the generator. This generates substantial spurious FM.



Test setup.

NOTE 39

Receivers in Which Power Line Is Used As Antenna

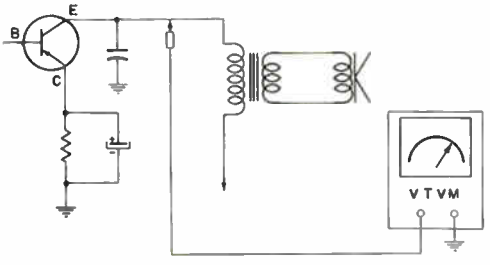
In some FM receivers the power line is used as an alternate antenna. The line is permanently coupled to the receiver input circuit, and the coupling point from the line is followed by an RF filter. The consideration here is immunity to line pickup past the RF filter. Hence, in this type of receiver, the 4.7-ohm test resistor should be inserted between the RF filter and the power supply.

U57

To Check the Maximum Undistorted Output of a Transistor Radio

Equipment: Signal generator, VTVM, and signal-injection loop.
Connections Required: Couple output from signal generator to input of receiver. Connect VTVM from collector terminal of output transistor to ground.
Procedure: Operate generator on modulated RF output. Operate VTVM on DC voltage function. Increase output from generator while observing meter reading.
Evaluation of Results: Maximum undistorted output is reached when the VTVM reading starts to change.

Test setup.



U58

To Check the Thermal Stability of a Transistor Radio

Equipment: VTVM and heat lamp.

Connections Required: Connect output from generator to a signal-injection loop. Couple loop to antenna of receiver. Connect VTVM to voice coil or output transformer.

Procedure: Operate signal generator on modulated RF output. Operate VTVM on AC voltage function. Tune for normal receiver output, and note meter reading. Then warm the chassis moderately with the heat lamp. (Do not heat the chassis excessively because the transistors will be damaged.) Note any change in meter reading. Retune the signal generator to see whether the oscillator has shifted frequency.

Evaluation of Results: Practically no change in output or in operating frequency will occur if the stabilizing resistors in the receiver circuits are of the correct values. On the other hand, incorrect values of stabilizing resistors will change the circuit characteristics widely as the temperature changes.

In the conventional grounded-emitter circuit, the resistor between the emitter and ground is the thermal stabilizing component.

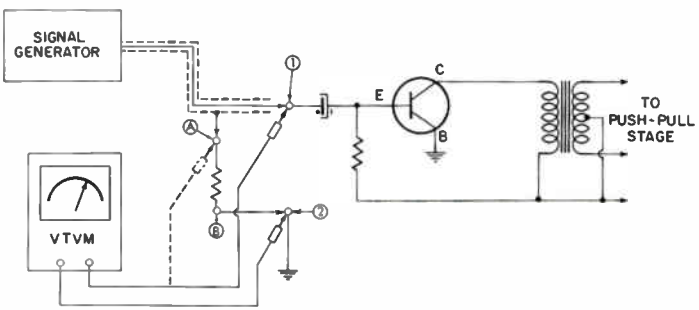
To Measure the Input Impedance of a Transistor Audio Amplifier

Equipment: VTVM and 1,000-ohm resistor.

Connections Required: Connect equipment as shown in the following diagram.

Procedure: Operate signal generator on 400-cycle, audio-output function. Operate VTVM on AC voltage function. Apply normal operating signal to receiver. (Do not overload receiver because transistors may be damaged.) Measure voltage across points A and B. Then measure voltage across points 1 and 2.

Evaluation of Results: The input impedance is equal to the voltage divided by the current. The voltage across points 1 and 2 is the input voltage to the amplifier. The voltage across points A and B is proportional to the input current to the amplifier. There is 1 milliampere of input current for each volt across points A and B. Thus, if we measure 1 volt across points 1 and 2, and 1 volt across points A and B, the input impedance will equal 1/0.001, or 1,000 ohms.



Test setup.

TV RECEIVER TESTS

U60

To Make Signal-Injection Tests in a TV Receiver

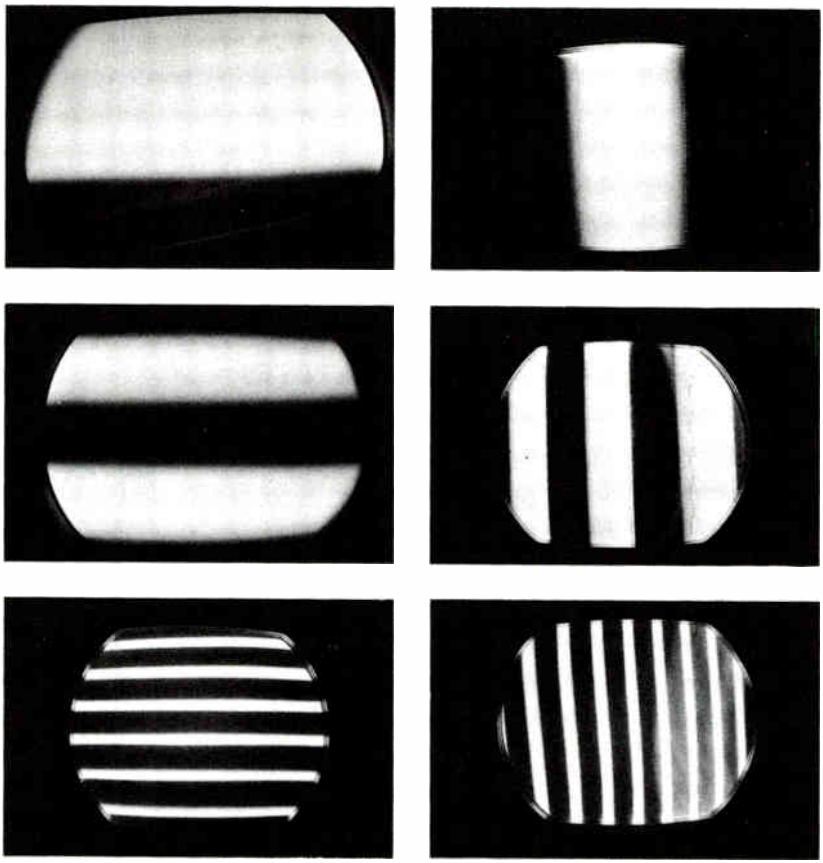
Equipment: None. (Audio oscillator, optional.)

Connections Required: Connect output cable from signal generator between grid of tube and ground, at point of signal injection. Use blocking capacitor in series with "hot" lead of cable if there is DC at the injection point.

Procedure: Use audio output from generator to inject signal into video-amplifier circuits. Use modulated IF output for tests in video IF amplifier. Use modulated RF output for tests in RF section. The optional audio oscillator can be used to externally modulate the signal generator. This gives the bar patterns shown in the following illustration.

Evaluation of Results: If signal flows through the circuits from the point of injection to the picture tube, a bar pattern will appear on the screen. No pattern indicates a dead signal circuit in the path of signal flow. When an audio oscillator is used to modulate the signal generator, any desired number of vertical or horizontal bars can be displayed for linearity checks.

If the signal generator is modulated by a square-wave generator, the edges of the bars will be sharper.



Typical bar patterns displayed on picture-tube screen when signal generator is modulated by audio oscillator.

U61

To Use an AM Generator as a Signal Source in Signal-Tracing Tests

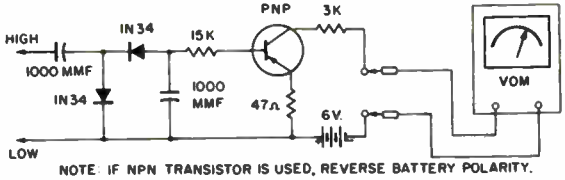
Equipment: Signal-tracing probe (or transistorized signal-tracing probe with VOM). If a conventional signal-tracing probe is used, a VTVM is a more sensitive indicator.

Connections Required: Connect generator output cable to antenna input terminals of receiver. Connect probe to voltmeter. Apply probe successively to grids and plates of IF stages. Probe can also be applied in video amplifier.

Procedure: Operate the signal generator on modulated RF output, and tune generator to operating channel of receiver. Avoid excessive signal input to receiver because feed-through may give a false indication.

Evaluation of Results: A dead stage results in no meter reading. Readings increase as probe is applied in later stages.

A signal-tracing probe can detune an IF stage in such a manner that the probe will cause oscillation. The meter reading will then jump to an excessively high value. If oscillation occurs when the grid of a tube is being tested, shift the probe to the plate. If oscillation occurs when a plate of a tube is being tested, shift the probe to the grid of the tube.



Voltage-doubler, signal-tracing probe with transistor amplifier.

U62

To Check the Adjacent-Channel Selectivity of a TV Receiver

Equipment: AC VTVM.

Connections Required: Connect output cable from signal generator to antenna input terminals of receiver. Connect VTVM from output of video amplifier to ground.

Procedure: Tune signal generator to picture-carrier frequency of channel to which receiver is set. Use modulated RF output from generator. Adjust output from generator to obtain nor-

mal output level from video amplifier (typically, 100 volts peak-to-peak). Next, tune generator in turn to picture-carrier and sound-carrier frequencies of the adjacent channels. Note meter reading in each test.

Evaluation of Results: A receiver with good adjacent-channel selectivity will show no meter reading above noise level on an adjacent-channel test. On the other hand, receivers with poor adjacent-channel selectivity will show large meter readings. Adjacent-channel selectivity is best evaluated in terms of decibels. (See the companion volume, *101 Ways to Use Your VOM and VTVM).*

U63

To Check the Image-Frequency Rejection of a TV Receiver

Equipment: VTVM and rectifier probe.

Connections Required: Connect output cable from signal generator to antenna input terminals of receiver. Connect probe to video amplifier output. Feed probe output to VTVM.

Procedure: Tune signal generator to picture-carrier frequency of receiver channel. Use modulated RF output from generator. Adjust output from generator for normal receiver output. Next, detune the generator by twice the IF frequency: if local oscillator operates above the RF frequency, tune the generator above the original setting; If local oscillator operates below the RF frequency, tune the generator below the original setting. Note the meter reading.

Evaluation of Results: No reading above noise level is caused by application of the image frequency if rejection is complete.

NOTE 40

Checking for Second-Image Rejection

The first image signal (U63) is more likely to cause interference in reception than the second image signal. However, the second image signal can also cause interference. This interference results from a beat between the second harmonic of the local oscillator and an interfering signal that differs from the picture-carrier frequency by three times the

IF frequency. A check for second-image rejection can be made in the same manner as the check described in U63, except the generator is tuned to a frequency removed from the operating frequency by three times the IF frequency.

U64

To Check the Frequency of a Local Oscillator

Equipment: Signal generator of the heterodyne frequency meter type (television calibrator).

Connections Required: Run test lead from RF test post of generator to shield over oscillator-mixer tube.

Procedure: Tune generator for zero beat in speaker.

Evaluation of Results: Local-oscillator frequency is equal to the dial indication of the generator. For more accurate measurement, calibrate the generator against internal quartz crystals.

If the open test lead from the generator picks up objectionable local AM broadcasts (generator "plays music"), shunt a 100K resistor from the test lead to chassis ground. Also note that oscillator and generator harmonics will both give additional zero-beat indications. However, the strongest beat will be fundamental vs. fundamental.

U65

To Check the IF Rejection of a TV Receiver

Equipment: AC VTVM.

Connections Required: Connect output cable from signal generator to antenna input terminals of receiver. Connect VTVM from output of video amplifier to ground.

Procedure: Tune signal generator to IF frequency for the receiver under test (either 23 mc or 44 mc). Use modulated IF output from generator. Adjust output from generator to obtain normal output level from video amplifier (typically, 100 volts peak-to-peak).

Evaluation of Result: A receiver with good IF rejection will show no meter reading above the noise level. On the other hand, receivers with poor IF rejection will show large meter readings.

IF rejection tests can be made in the same general manner for any AM, FM, or communications receiver.

NOTE 41

Required Values of IF and Image Rejection

For satisfactory operation in medium- and weak-signal areas, a TV receiver should provide a rejection of at least 60 db for IF or image frequencies applied at the antenna input terminals. The number of decibels of rejection can be determined from the db scales of a VOM or VTVM, which is used in usual alignment procedures. First, tune the signal generator to the picture-carrier frequency of the channel to which the receiver is set, and note the reading on the db scale. Then tune the generator to the IF frequency and again note the db reading. A similar test is made by tuning the generator to the image frequency. The difference in db readings gives the amount of rejection. Note that this test can be misleading unless the signal generator has a reasonably uniform output over the range of test frequencies.

U66

To Peak-Align an IF Amplifier

Equipment: VTVM and bias box.

Connections Required: Connect bias box to apply negative DC voltage on AGC bus. Connect output cable from signal generator to floating tube shield over mixer tube. Connect VTVM at output of picture detector.

Procedure: Disable local oscillator. Operate generator on unmodulated RF output. Operate VTVM on DC voltage function. Tune signal generator to IF peaking frequencies, as specified in receiver service literature. Adjust IF coil slug associated with the given peaking frequency while watching meter indication.

Evaluation of Results: The IF stage is peak-aligned when maximum meter indication is obtained.

Peak alignment does not usually give the best possible picture quality. It is preferable to follow up a peak alignment by a sweep-frequency test and a modulated square-wave test. Compromise adjustments are made on the basis of these tests to obtain the best over-all response. For details of these tests, see the companion volumes, *101 Ways to Use Your Sweep Generator* and *101 Ways to Use Your Oscilloscope.*

NOTE 42

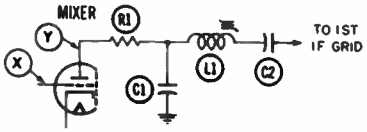
Stabilization of IF-Amplifier Frequency Response

When an IF amplifier is peak-aligned, the peaking frequency sometimes will change considerably when the override bias is reduced from —3 volts, for example, to —1 volt. This is caused by regeneration (positive feedback). Difficulty results from unsuitable replacement of screen bypass capacitors (particularly in 40-mc IF amplifiers). In some capacitors the inductance is low enough that no special precautions are required. Other bypass capacitors require critical lengths of connecting leads in order to resonate the capacitor at the IF frequency. Difficulty can also result from changed values of unbypassed cathode resistors in both 23-mc and 40-mc IF amplifiers. Grounding points of all replacement parts in 40-mc IF amplifiers should be made to original locations, so that feedback due to common ground impedances is avoided.

NOTE 43

Test Signal Can Be Injected at Mixer Grid, But Not at Mixer Plate

Instead of injecting an IF test signal by means of a floating tube shield over the mixer tube, some technicians prefer to inject the signal at the mixer grid (point X in the accompanying illustration). This is a satisfactory method and is helpful when the output from the generator is quite weak. On the other hand, beginners sometimes make the mistake of trying to inject the IF test signal at the mixer plate, as shown at point Y. This is not a satisfactory signal-injection point for alignment purposes because the frequency response of the receiver will be seriously distorted. This distortion occurs because the mixer plate load is designed to work out of the plate resistance of the mixer tube. When the generator output cable is applied at Y, the mixer plate load works out of a very low resistance—approximately 75 ohms. Hence, C1, L1, and C2 no longer develop a normal resonant response. Instead, the resonant response is largely "swamped out" by the low source resistance of the generator.



Mixer plate circuit.

NOTE 44

Adjacent-Sound Trap Should Give 40-Db Rejection

Receivers used in medium- and weak-signal areas must have adjacent-sound traps to obtain interference-free reception. Adjacent-sound traps are aligned for minimum response at the adjacent-sound frequency. The rejection provided should be at least 40 db if the trap is operating properly. The number of decibels of rejection can be observed from the VOM or VTVM used in alignment procedures. In other words, observe the reading on the decibel scale when the generator is tuned to the picture-carrier frequency. Then observe the reading on the decibel scale when the generator is tuned to the adjacent-sound frequency. There should be a difference of at least 40 db between the two readings. For a further discussion of decibels and scale factors, see the companion volume, *101 Ways to Use Your VOM and VTVM.*

U67

To Locate an Intermittent by Using Noise-Modulated Carrier Method (RF and IF Amplifiers)

Equipment: Earphones and blocking capacitor.

Connections Required: Connect earphones in series with blocking capacitor across video amplifier output. Connect generator output cable to antenna input terminals of receiver.

Procedure: Operate signal generator on unmodulated RF output. Tap suspected components in IF and RF sections, and listen for a microphonic modulation of the noise signal in the earphones.

Evaluation of Results: A potential intermittent that does not open or short during the test is sometimes microphonic. Even a small contact-resistance variation causes the noise modulation on the CW signal to change considerably. This is heard in the earphones when the potential intermittent is vibrated by tapping.

The audio section of the TV receiver is not too useful in this test because small amplitude variations are rejected by the ratio detector.

U68

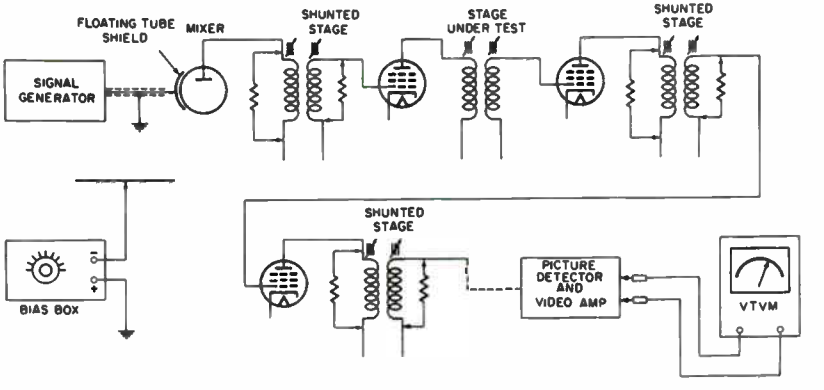
To Make Single-Stage IF Tests (Shunt-Resistance Method)

Equipment: 200-ohm resistors, AGC bias box, and VTVM.

Connections Required: Connect a 200-ohm resistor across each IF coil winding except the stage under test. (Resistors can be provided with test clips for easy connection and disconnection.) Connect bias box between AGC line and ground to apply negative DC bias to line. Connect generator output cable to floating tube shield over mixer tube. Disable local oscillator. Connect VTVM at output of video amplifier.

Procedure: Operate generator on modulated RF output. Operate VTVM on AC voltage function. Tune generator for maximum meter reading and for one-half maximum readings on either side of resonance.

Evaluation of Results: The resistors flatten the response of the shunted stages and reduce the stage gain to approximately unity. The generator indicates the peaking frequency of the stage under test at maximum meter indication. The bandwidth of the single stage is given by the frequency separation of the half-voltage points.



Test setup.

To Check the Frequency Response of a Video Amplifier (Two-Generator Method)

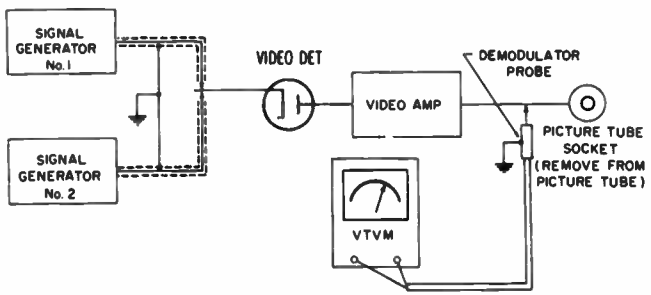
Equipment: Two signal generators, VTVM, and demodulator probe (see U3).

Connections Required: Connect equipment as shown in the following illustration.

Procedure: Set one signal generator to the IF frequency (such as 23 mc). Slowly tune the other signal generator over a 5-mc range (such as 23 to 28 mc). Observe meter reading over the video passband.

Evaluation of Results: The two signal-generator outputs beat in the picture detector to form a video frequency signal. The generator, which is tuned over the 5-mc bandwidth, should have a reasonably uniform output over the band. The video amplifier response should be reasonably flat from zero frequency (both generators tuned to 23 mc) to 3.5 or 4 mc. Serious peaks or dips in the response are caused by such circuit faults as off-value load resistors, defective bypass capacitors, or faulty peaking coils.

The socket should be removed from the picture tube, so that the input capacitance of the probe substitutes for the input capacitance of the picture tube. Likewise, a VTVM with an external probe is preferred, instead of a VTVM with a built-in high-frequency rectifier. The external probe minimizes the capacitance shunted across the output of the video amplifier.



Test setup.

To Determine the Dynamic Range of a Video Amplifier

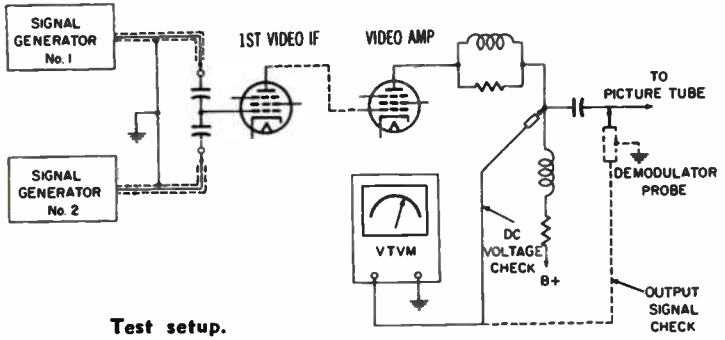
Equipment: Two signal generators, VTVM, and demodulator probe (see U3).

Connections Required: Inject generator signals at grid of first IF amplifier (as shown in the following illustration), to obtain a high-level, video-frequency test signal. Connect DC voltmeter from plate of video amplifier tube to ground.

Procedure: Tune signal generators approximately 2 mc apart but within the IF passband. Advance generator outputs until DC voltmeter reading starts to change. Then connect demodulator probe to VTVM and measure the signal output voltage from the video amplifier.

Evaluation of Results: Two IF frequencies 2 mc apart are beat through the picture detector to form a high-level, video-frequency signal. The video amplifier shows DC plate-voltage change at onset of amplitude distortion. Corresponding video-signal voltage is measured with a high-frequency probe and a VTVM. The dynamic range of the video amplifier (range of undistorted output) is from zero volts to the peak voltage measured at the picture tube in this test. The peak-to-peak dynamic range is twice the peak-voltage range. The dynamic range determines the picture contrast that can be obtained without distortion. (See picture-tube manual for video driving voltages required for full picture contrast.)

The accuracy of the peak-voltage reading in this test depends upon the response of the probe. Since the characteristics of crystal diodes vary considerably, it is desirable to check the calibration of the probe-and-meter arrangement by using a known source of RF or IF sine-wave voltage.



Test setup.

NOTE 45

Increasing the Dynamic Range of a Video Amplifier

The dynamic range of a video amplifier can be increased by raising the plate and screen voltages on the tube and by adjusting the grid bias to the best operating point. On the other hand, the plate and screen dissipation ratings for the tube must not be exceeded because the tube life will be shortened. A tube with higher g_m provides a greater dynamic range at a given plate voltage. For measurements of plate and screen dissipation values, see the companion volume, *101 Ways to Use Your VOM and VTVM.*

U71

To Check for Even-Harmonic Distortion in a Video Amplifier

Equipment: Two signal generators, VTVM, and special high-frequency probe.

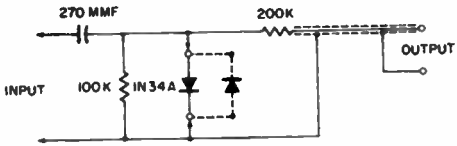
Connections Required: Inject generator signals at grid of first IF amplifier. Construct probe as shown in the following diagram. Mount diode in a snap holder so that its polarity can be easily reversed. Connect probe from plate of video amplifier to ground.

Procedure: Measure output voltage from video amplifier with the high-frequency probe and the VTVM. Then reverse the crystal diode in the probe and repeat the measurement.

Evaluation of Results: Any difference between the two meter readings indicates even-harmonic distortion. Even harmonics cause the positive and negative half-cycles of a reproduced sine wave to have different peak voltages. To distinguish between distortion in the IF amplifier and distortion in the video amplifier, also make the test at the picture-detector output. If even-harmonic distortion is found here, the most usual cause is overloading of the last IF stage.

The probe cannot simply be turned over in this test, because a VTVM has an extensive ground system which would seriously load the video amplifier output and cause a highly inaccurate measurement. Hence, we reverse the crystal diode in the probe.

High-frequency, rectifier-probe circuit.



NOTE 46

Elimination of Cross-Talk Voltages in Receiver Tests

When signal-generator tests are made in TV receiver circuits, an output from the amplifier will sometimes be observed, even when the generator output is reduced to zero. Spurious outputs are usually caused by cross talk of the horizontal and vertical sweep circuits into the signal circuits. Cross talk can be eliminated by pulling the horizontal- and vertical-output tubes during signal-circuit tests. Note that it is not good practice to pull the horizontal-oscillator tube because the horizontal-output tube often depends upon signal-developed grid bias—the tube can draw excessive screen and plate current in some instances when the drive is removed. With the sweep circuits disabled, a voltmeter will still indicate a small output from high-gain circuits because of noise voltages.

U72

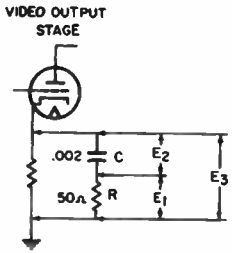
To Check a Video Amplifier for Odd-Harmonic Distortion

Equipment: 50-ohm resistor, 0.002-mfd capacitor, two signal generators, VTVM, and rectifier probe (see U3).

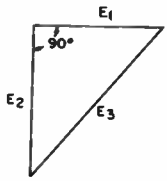
Connections Required: Connect capacitor and resistor in series. Shunt the R-C combination across an unbypassed cathode resistor in the video output stage. Connect generator outputs to grid of first IF amplifier. Connect probe and VTVM across R, then across C, then across the combination. (See the following.)

Procedure: Tune signal generators approximately 2 mc apart, but within the IF passband. Advance outputs to obtain desired output from video amplifier. Then observe the meter readings obtained in the foregoing three tests.

Evaluation of Results: The three voltage readings, represented as line lengths, will form a right-angled triangle if there is no harmonic distortion. If harmonic distortion is present, a right-angled triangle will not be formed.



Test setup.



Plot of voltages.

NOTE 47

Odd-Harmonic Check When Video Amplifier Has No Unbypassed Cathode Resistor

When the video amplifier does not have an unbypassed cathode resistor, no low-impedance signal check point is available. Meter tests are not practical in the plate circuit because of the circuit loading imposed by the necessary R-C test arrangement. Therefore, other means of testing will be required. A useful method drives the video amplifier with a differentiated square wave, and indicates the reproduced waveform on a scope screen. (See *101 Ways to Use Your Oscilloscope.*)

U73

To Check for Parasitic Oscillation in a Video Amplifier

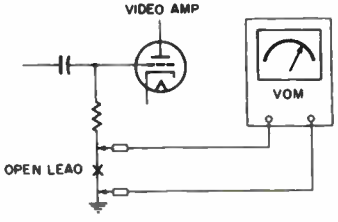
Equipment: Two signal generators and VOM.

Connections Required: Connect output cables from signal generators (through blocking capacitors) to the grid of the first IF tube. Open the grid-leak return in the video amplifier circuit and insert the DC microammeter, as shown in the following diagram.

Procedure: Tune signal generators within IF passband but to frequencies approximately 2 mc apart. Advance outputs from generators until full output is obtained from video amplifier, and note microammeter reading.

Evaluation of Results: As full video amplifier output is approached, noticeable grid-current flow can be observed. However, grid-current flow should remain small and should

increase slowly as the generator signal level is increased. A sudden jump in grid-current flow indicates that there is parasitic oscillation in the stage. Parasitic oscillation causes additional picture distortion, over and above the compressed grays resulting from nonlinear distortion.



Measuring video amplifier grid current.

U74

To Check for Open Screen and Cathode Bypass Capacitors in a Video Amplifier

Equipment: Two signal generators, high-frequency probe, and VTVM.

Connections Required: Apply outputs from signal generators to grid of first IF tube, with blocking capacitors in series with the "hot" generator leads. Connect high-frequency rectifier probe across bypass capacitor under test. Feed probe output to VTVM.

Procedure: Tune both signal generators to frequencies within the IF passband but with a 3-mc frequency separation. Advance generator outputs for normal video amplifier output. Observe meter reading (if any) when probe is applied across bypass capacitor under test.

Evaluation of Results: An appreciable voltage indication on the VTVM indicates a faulty bypass capacitor.

Video-amplifier cathode resistors are sometimes partially bypassed so that a high-frequency boost can be obtained. The amplifier becomes progressively degenerative at lower video frequencies. Hence, we make the test at a relatively high video frequency of 3 mc.

To Locate an Intermittent in a Video Amplifier

Equipment: VTVM, Variac, and heat lamp.

Connections Required: Connect generator output cable to antenna input terminals of receiver. Connect VTVM at output of video amplifier.

Procedure: Operate the signal generator on modulated RF output, and tune the generator to the operating channel of the receiver. Operate the VTVM on its AC function. Power the receiver from the Variac. Adjust Variac for maximum line voltage to receiver, as specified in receiver service literature. Make the following tests while watching the VTVM indication:

1. Tap each component in the video amplifier sharply.
2. Move each connecting wire slightly.
3. Jar and rap the chassis moderately.
4. Shine a heat lamp on the various components.
5. Turn the receiver off and on several times in succession.

Next, adjust Variac for minimum line voltage, as specified in receiver service literature; and repeat the preceding five tests.

Evaluation of Results: An intermittent is indicated by a sudden change in the meter reading.

This method is also useful for locating intermittents elsewhere in the signal circuits, such as in the IF and RF sections.

U76

To Locate an Intermittent by Using the Noise-Modulated Method (Video Amplifier)

Equipment: Demodulator probe, earphones, and blocking capacitor.

Connections Required: Connect output cable (use blocking capacitor) from signal generator to picture-detector output lead. Apply demodulator probe across video amplifier output. Connect output cable from demodulator probe to earphones.

Procedure: Tune signal generator to approximately 3 mc. Operate signal generator at maximum output. Tap suspected components in video amplifier circuit, and listen for microphonic modulation in the earphones.

Evaluation of Results: A potential intermittent that does not open or short during the test is sometimes microphonic. Even a small contact-resistance variation causes the noise modulation on the CW signal to change considerably. This is heard in the earphones when the potential intermittent is vibrated by tapping.

The foregoing method of locating a potential intermittent can also be applied to radio receivers.

U77

To Make an Over-all Frequency-Response Test of a TV Receiver

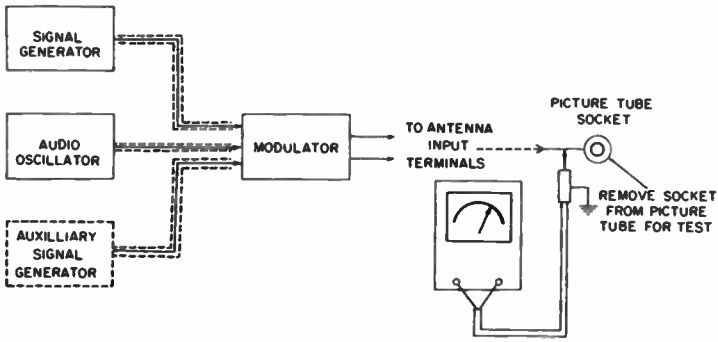
Equipment: Audio oscillator, external modulator, auxiliary AM signal generator, and VOM with rectifier probe.

Connections Required: Connect equipment as shown in the accompanying diagram.

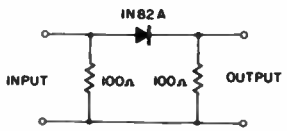
Procedure: Tune signal generator to picture-carrier frequency of receiver. Set audio oscillator to 60 cycles and observe the meter reading. Next, gradually increase the audio-oscillator frequency to its top frequency while watching for a changed reading on the meter. Finally, disconnect the audio oscillator from the modulator input and substitute the auxiliary AM signal generator. Observe meter readings as the generator frequency is gradually increased to 4 mc. (The results can be plotted on graph paper, if desired.)

Evaluation of Results: The frequency response obtained in this test is the combined response of the RF, IF, and video sections. It is the response that is basically associated with picture quality. For best picture quality, the over-all response should be reasonably flat from 60 cycles to 4 mc.

If the outputs from the audio oscillator and auxiliary signal generator are not uniform, the generator characteristics must be taken into account before a valid test can be obtained.



Test setup.



Modulator circuit.

U78

To Make an Over-all Signal-Channel Test For Transient Ringing

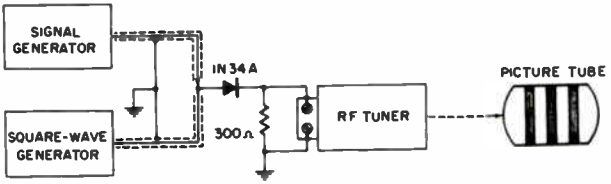
Equipment: Square-wave generator, crystal diode, and 300-ohm resistor.

Connections Required: Connect equipment as shown in the accompanying diagram.

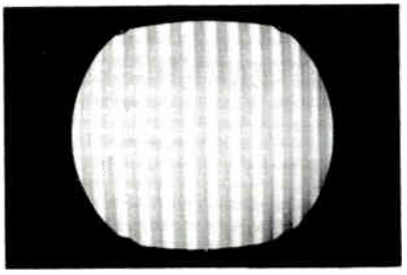
Procedure: Tune signal generator to picture-carrier frequency. Set square-wave generator to successive test frequencies, such as 10, 50, 100, or 500 kc. Observe pattern on screen of picture tube.

Evaluation of Results: If there is no ringing in the signal circuits, the edges of the bar pattern will be clean and sharp. On the other hand, when ringing occurs, the edges will either be blurred or will consist of a series of black and white border lines. Ringing is minimized by good alignment of the RF

and IF amplifiers and by proper adjustment of the video amplifier circuits.



Test setup.



Typical bar pattern.

U79

To Align a Split-Sound System in a TV Receiver

Equipment: VTVM.

Connections Required: Connect output cable from signal generator to floating tube shield over mixer tube. Connect VTVM across grid-load resistor of sound limiter.

Procedure: Tune signal generator to sound IF frequency of receiver. Adjust slugs in the sound IF transformers (or coils) for maximum meter readings.

Evalaution of Results: Proper alignment is obtained when all sound IF circuits are peaked for maximum output.

Unless the signal generator is crystal-calibrated, do not change the generator tuning until all of the sound IF traps have been adjusted. This is a common mistake made by beginners because of the difficulty in resetting the generator to exactly the original frequency. Hence, disconnect the VTVM from the limiter

and connect it to the picture-detector output. Adjust the sound IF traps for minimum meter reading. This insures that the sound IF circuits and traps are aligned to the *same* frequency, even if the generator is not set to exactly the specified frequency.

U80

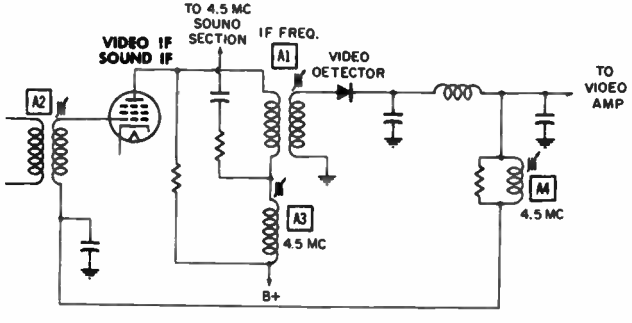
To Align a Reflexed Sound IF Amplifier

Equipment: VTVM and generator with a 4.5-mc crystal.

Connections Required: Connect output cable from signal generator to floating tube shield over mixer tube. Connect VTVM to limiter grid, to permit checking input to FM detector. Connect VTVM to picture-detector output, to permit checking input to video amplifier.

Procedure: Tune signal generator to specified peaking frequencies for IF circuits (A1 and A2). With VTVM connected at picture-detector output, peak A1 and A2 for maximum output at required peaking frequency. Next, tune signal generator to picture-carrier IF frequency, and switch the 4.5-mc crystal on. With VTVM connected to check FM detector input, peak A3 and A4 for maximum output.

Evaluation of Results: Adjustments A1 and A2 are independent from A3 and A4 unless the circuits are too far out of alignment. For most accurate alignment, the foregoing procedure should be repeated.



Reflexed video IF and sound IF amplifier circuit.

To Align a Delta Sound Circuit

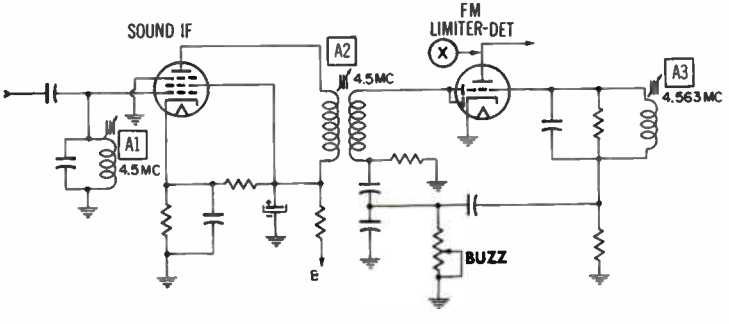
Equipment: VTVM and signal generator with crystal-calibrating facilities.

Connections Required: Apply generator output signal to grid of video amplifier tube in receiver. Disable local oscillator. Connect VTVM at plate of FM limiter-detector tube (point X in accompanying diagram).

Procedure: Operate VTVM on DC voltage function. Tune signal generator accurately to 4.5 mc. Peak adjustments A1 and A2 for maximum meter reading. Next, tune signal generator accurately to 4.563 mc. Peak adjustment A3 for maximum meter reading.

Evaluation of Results: Note meter reading when signal generator is tuned accurately to 4.475 mc. Then note meter reading when generator is tuned accurately to 4.5 mc. Finally, note meter reading when generator is tuned accurately to 4.563 mc. The output should increase uniformly between these limits—that is, the reading at 4.5 mc should fall halfway between the readings at the limit frequencies. Make compromise adjustments, if necessary.

The delta sound circuit is a slope detector and also provides limiting action. The buzz control is set to minimize sync buzz on a TV station transmission.



The Delta sound detector circuit.

To Check the AGC Action of a TV Receiver

Equipment: VTVM.

Connections Required: Connect output cable from signal generator to antenna input terminals of TV receiver. Connect VTVM between AGC line and ground.

Procedure: Tune signal generator to channel operating frequency of receiver. Advance output from generator while watching the meter indication.

Evaluation of Results: AGC voltage should increase steadily as the generator output is increased.

The front-end of a TV receiver usually has clamped AGC. Clamped AGC does not respond at very low input signal levels. The IF AGC bias rises before the front-end AGC bias starts to rise. After a threshold input level is reached, the front-end AGC bias starts to rise with increasing signal input. The IF AGC bias continues to rise after the threshold is passed.

U83

To Check the Over-all Chroma-Channel Response

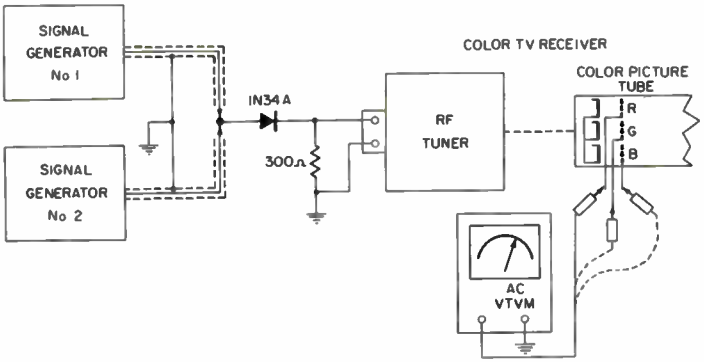
Equipment: Auxiliary signal generator, crystal diode, 300-ohm resistor, and VTVM.

Connections Required: Connect equipment as shown in the following diagram.

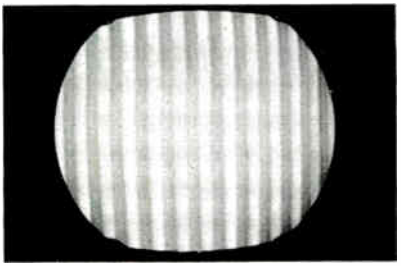
Procedure: Tune generator No. 1 to the picture-carrier frequency of the channel under test. Tune generator No. 2 to 3.58 mc and observe meter reading. Then tune generator No. 2 above and below 3.58 mc until meter reading drops to 71% of the reading at 3.58 mc. Repeat the test for all three chroma channels (R, G, and B).

Evaluation of Results: The distance between the 71% points is the over-all chroma-channel bandwidth. Good color reproduction requires that the chroma channels have a reasonably flat response for at least 0.5 mc on either side of the color-subcarrier frequency. Each time the generator No. 2 frequency is offset another 15,750 cycles, another vertical

rainbow appears on the picture-tube screen. A bandwidth test frequency of 0.5 mc corresponds to a display of 21 vertical rainbows on the picture-tube screen.



Test setup.



Picture tube pattern.

U84

To Adjust a Color-Subcarrier Trap

Equipment: AC VTVM and 0.01-mfd blocking capacitor.

Connections Required: Connect output cable from signal generator through blocking capacitor to picture-detector output lead. Connect VTVM to output of Y amplifier (cathodes of color picture tube).

Procedure: Tune signal generator accurately to 3.58 mc. Adjust slug in subcarrier trap coil while observing the meter reading.

Evaluation of Results: Trap is correctly adjusted when VTVM reading is minimum.

Some signal generators provide a 3.58-mc crystal output. This output is accurate and convenient for subcarrier trap adjustments.

U85

To Check the Y-Amplifier Frequency Response

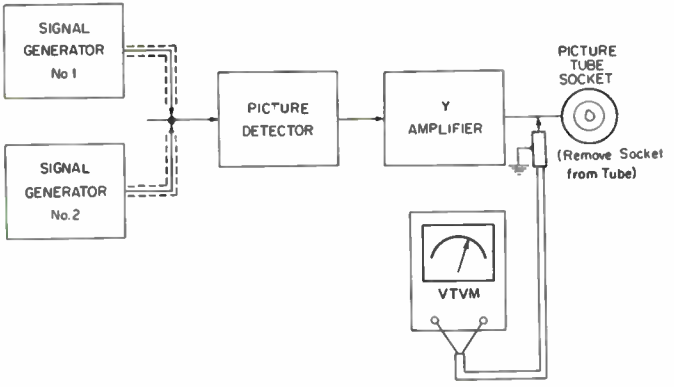
Equipment: Auxiliary signal generator, VTVM, and rectifier probe.

Connections Required: Apply signal-generator outputs in parallel at input of picture detector. Remove socket from color picture tube. Connect rectifier probe between Y-amplifier output lead and chassis ground. Feed probe output to VTVM.

Procedure: Tune both signal generators to a reference frequency, such as 40 mc. Then tune one generator from the reference frequency, through a frequency range of approximately 5 mc (such as 40 to 45 mc), while observing the meter.

Evaluation of Results: The Y amplifier should have a reasonably flat response up to approximately 3 mc (second generator tuned to 43 mc). A deep dip in response occurs at 3.58 mc (second generator tuned to 43.58 mc) if the color-subcarrier trap is correctly tuned. Some receivers have appreciable response past 3.58 mc. Others have negligible response between 3.58 and 4.5 mc. Y-amplifier response tests can be made more rapidly with a sweep-frequency test, as described in the companion volume, *101 Ways to Use Your Sweep Generator.*

The picture-tube socket is removed so that the input capacitance of the rectifier probe substitutes for the input capacitance of the picture tube. This permits a more accurate check of the high video-frequency response. In some receivers, a better check is obtained by disconnecting the lead from the last IF transformer to the picture detector diode. This avoids the possibility of the IF transformer characteristics' impairing the flatness of the applied test signal.



Test setup.

NOTE 48

Avoiding Spurious Noise and Cross-Talk Voltages in Y-Amplifier Tests

When a test signal is injected at the output of the picture detector, there are, at the picture tube, two possible sources of spurious voltages which may mask the test voltage. Noise voltages can feed through from the RF and IF amplifiers. To eliminate the noise voltages, bias off the IF amplifier or pull the last IF tube. Cross talk from the horizontal- and vertical-sweep circuits can be troublesome. To eliminate the cross talk, pull the output tubes. (It is seldom necessary to also "kill" the horizontal and vertical oscillators.) If the B voltage rises objectionably when the output tubes are pulled, use suitable power resistors to bleed the B supply. Also note that some receivers have blanking pulses applied to the Y amplifier from the sweep circuits — these pulses are also eliminated by pulling the output tubes. If you are working on one of the rare color chassis having series heaters, dummy tubes must be inserted to maintain heater continuity.

U86

To Substitute a Generator Signal for a Dead Color-Subcarrier Oscillator

Equipment: None.

Connections Required: Connect output cable from signal generator, across terminals of 3.579545-mc crystal socket.

Procedure: Tune generator accurately to 3.579545 mc. Use maximum generator output.

Evaluation of Results: The output from most generators is a small fraction of the normal crystal output. Nevertheless, the test will show the operability of the receiver. The color picture or pattern will not remain in color sync, but can be freewheeled through sync by careful adjustment of the generator.

U87

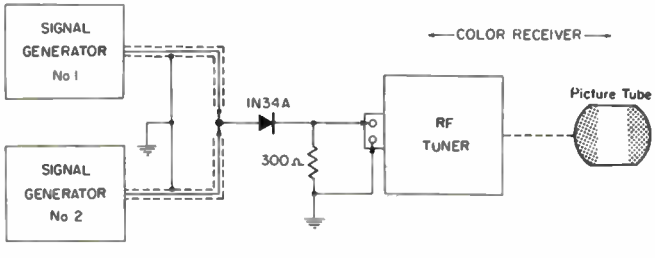
To Check Stability of Color Sync Lock

Equipment: Auxiliary signal generator, crystal diode, and 300-ohm resistor.

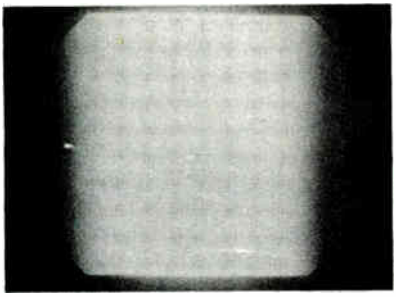
Connections Required: Connect equipment as shown in the following illustration.

Procedure: Tune in a single rainbow pattern on the screen. Then rock the dial of generator No. 2 back and forth, and observe how the rainbow pattern pulls left and right on the screen before color sync breaks.

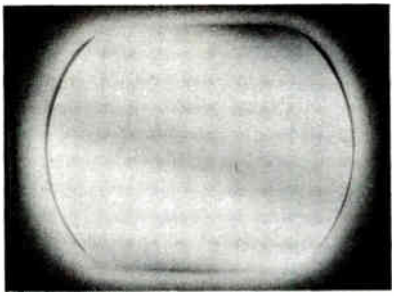
Evaluation of Results: The pattern should pull substantially to the left as the generator is tuned off-frequency in one direction, and then should pull substantially to the right as the generator is tuned off-frequency in the other direction. If the rainbow pattern breaks sync easily in one direction, the color-AFC balance control requires adjustment. If the pattern breaks sync quickly in both directions, check the burst-amplifier and reactance-tube circuits.



Test setup.



Rainbow pattern in sync.



Loss of color sync.

COMPONENT TESTS

U88

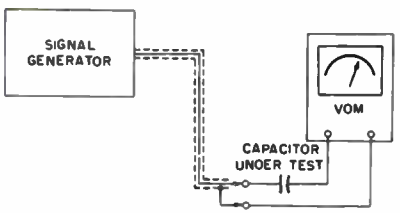
To Measure the Value of a Capacitor

Equipment: VOM.

Connections Required: Connect capacitor under test in series with the generator and VOM, as shown in the following diagram.

Procedure: Operate the signal generator on 400-cycle audio output. Advance output to maximum. Operate VOM on its AC voltage function and on a suitable range. Observe meter reading.

Evaluation of Results: The test setup must be calibrated by using known close-tolerance capacitors as standards. Prepare a graph of voltage vs. capacitance, for easy interpolation of odd values. Compare meter reading with graph data to find the capacitance of the unknown capacitor.



Test setup.

To Measure the Value of a Small Capacitor

Equipment: Radio receiver, terminating resistor, 100-mmf capacitor, VTVM, and bias box.

Connections Required: Shunt the 100-mmf capacitor across the antenna input terminals of receiver. Connect terminated output cable from signal generator, across 100-mmf capacitor. Connect bias box to AVC line in receiver. In final test, connect the small, unknown capacitor in series with the "hot" lead from the signal generator.

Procedure: Operate the signal generator on modulated RF output. Operate the VTVM on its AC voltage function. Tune the signal generator for a reference reading on the VTVM. Then insert the small, unknown capacitor in series with the "hot" generator lead, and again note the VTVM reading.

Evaluation of Results: The value of the small capacitor is given by:

$$C = \frac{(E_2 - E_1)\ 100 \times 10^{-12}}{E_1}$$

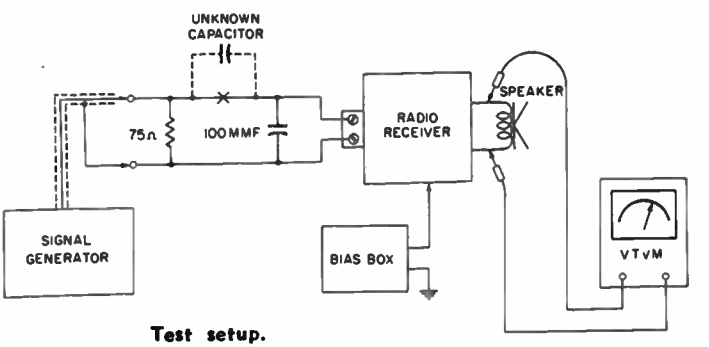
where,

C is the value in mmf of the small, unknown capacitor,

E_1 is the VTVM reading with the unknown capacitor inserted,

E_2 is the VTVM reading without the capacitor inserted.

Shunting the 100-mmf capacitor across the receiver input terminals makes its input impedance essentially capacitive. Hence, the test setup operates as a simple capacitive voltage divider when the small, unknown capacitor is inserted. The result will be in error to the extent that the receiver does not have a purely resistive input impedance.



Test setup.

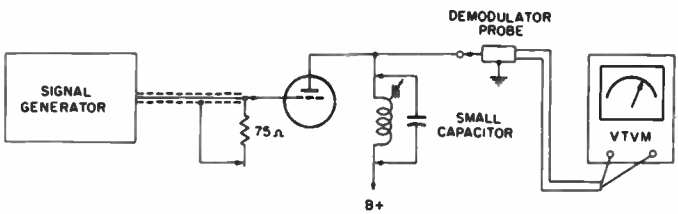
To Measure the Distributed Capacitance of a Coil

Equipment: Terminating resistor, at least two small fixed capacitors with accurately rated values, VTVM, and demodulator probe.

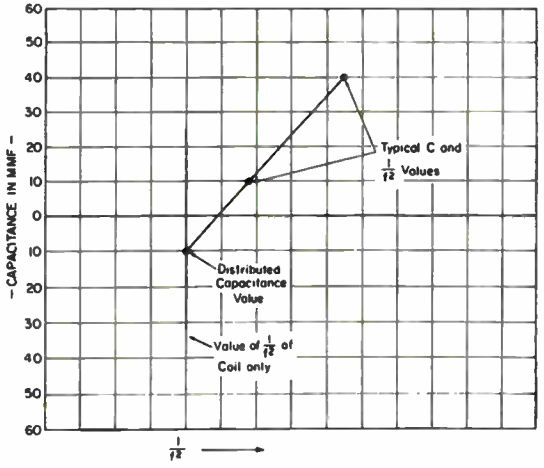
Connections Required: Connect terminated output cable from signal generator to grid of tube preceding coil. Connect demodulator probe across coil. Feed probe output to VTVM input. Connect fixed capacitors, in turn, across coil.

Procedure: With no shunt capacitor across the coil, tune the signal generator for a peak VTVM reading. Then connect a small fixed capacitor across the coil, and again tune the generator for a peak VTVM reading. Repeat the procedure with at least one more fixed capacitor having a different value.

Evaluation of Results: Note the frequency of resonance (peak reading) in each of the foregoing tests. Calculate the value of $1/f^2$ in each test. Plot the capacitor values along the vertical axis of the graph paper (both above and below the zero point). Then let each division along the horizontal axis equal a given value for $1/f^2$. (The value assigned will depend upon the values obtained for $1/f^2$.) Draw a vertical line from the point where the $1/f^2$ value falls for the coil without a shunting capacitor. Then plot the value of each shunting capacitor against its $1/f^2$ value. Draw a line between these points and extend it until it intersects the vertical line from the $1/f^2$ value for the coil without shunting capacitor. The point where the lines intersect is the distributed capacitance of the coil.



Test setup.



Plot of values.

U91

To Check the Characteristics of a Tuned Transformer

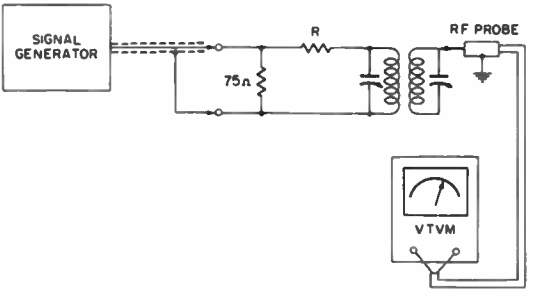
Equipment: VTVM, RF probe, terminating resistor, and series resistor (for value, see below).

Connections Required: Connect terminated output cable from generator through resistor R to primary of transformer, as shown in the following diagram. Connect RF probe across secondary. Feed probe output to DC input of VTVM.

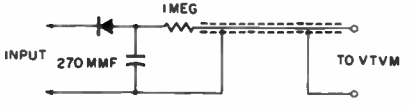
Procedure: Tune signal generator and observe VTVM reading. Use maximum output.

Evaluation of Results: The peak indication on the VTVM gives the resonant frequency of the transformer. There will be two peak indications if the transformer is overcoupled or stagger-tuned, or both. The transformer selectivity is given by the number of cycles between the two 0.070-of-peak readings. The tuned-circuit gain can be found by tuning the generator for peak reading, and then transferring the probe to the primary terminals. The ratio of the readings across the primary and secondary is the gain of the transformer.

The most common error made by beginners in this type of test is to omit series resistor R. The signal generator has a very low output impedance. The primary of the transformer cannot tune normally unless a series resistor R having approximately the same resistance as the plate resistance of the tube to be used with the transformer is used. Tube manuals give plate-resistance value. For example, a 6SK7 tube has a plate resistance of 120,000 ohms, and a 6J5 has a plate resistance of 7,000 ohms.



Test setup.



Low capacitance RF probe circuit.

U92

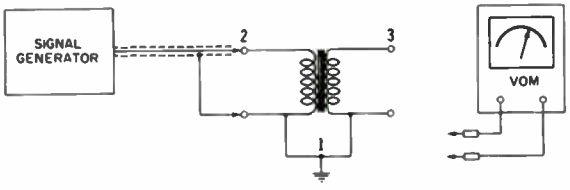
To Test for the Polarity of the Transformer Windings (In-phase or Out-of-phase Output)

Equipment: Transformer and VOM.

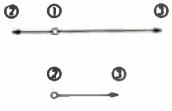
Connections Required: Connect output cable from signal generator to one winding of the transformer. Ground (or connect together) one end of each transformer winding. Connect VOM across one winding (between points 1 and 2), then across the other winding (between points 1 and 3), and finally across the "hot" terminals of both windings (between points 2 and 3).

Procedure: Operate VOM on its AC voltage function. Operate signal generator on its 400-cycle audio output. Note the meter readings in each of the three tests.

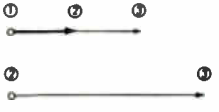
Evaluation of Results: As shown in the following illustration, the primary and secondary voltages subtract in the third test if the "hot" terminals have opposite polarity (are out of phase). On the other hand, the primary and secondary voltages add in the third test if the "hot" terminals have the same polarity (are in phase).



Test setup.



Plot of voltages for out-of-phase condition.



Plot of voltages for in-phase condition.

U93

To Meosure the Impedonce of o Voice Coil

Equipment: 3-ohm precision resistor and VTVM.

Connections Required: Connect resistor and voice coil terminals to generator output cable, as shown in the following diagram. Connect VTVM, in turn, across the resistor and across the voice coil.

Procedure: Operate generator on 400-cycle audio output. Operate VTVM on AC voltage function. Observe voltage readings in the foregoing two tests.

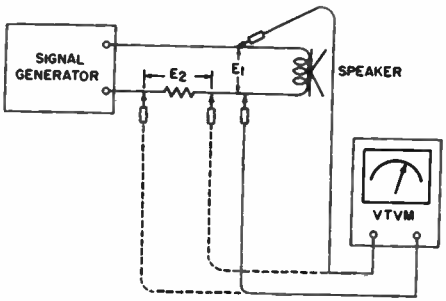
Evaluation of Results: The impedance of the voice coil is calculated by the formula:

$$Z_{vc} = \frac{E_1}{E_2} \times 3$$

where,

Z_{vc} is the voice coil impedance,
E_1 is the voltage drop across the voice coil,
E_2 is the voltage drop across the resistor.

The impedance value measured in this test is the 400-cycle impedance. The voice coil has other impedance values at other frequencies. However, 400 cycles is a standard reference frequency for the test.



Test setup.

U94

To Determine the Impedance Ratio of an Audio-Output Transformer

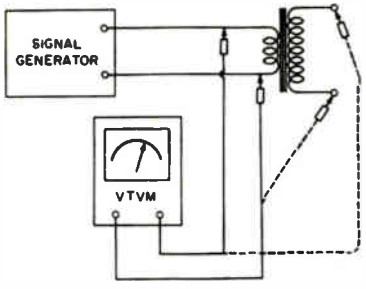
Equipment: VTVM.

Connections Required: Connect generator output cable to secondary of output transformer. Connect VTVM to the secondary terminals of the transformer, and then to the primary terminals.

Procedure: Operate signal generator on 400-cycle audio-output function. Note voltage readings across primary and secondary.

Evaluation of Results: Divide the secondary voltage by the primary voltage. Square this value to find the impedance ratio of the transformer. For example, if one volt is measured

across the primary and 50 volts across the secondary, the voltage ratio is 50:1 and the impedance ratio is 2500:1.

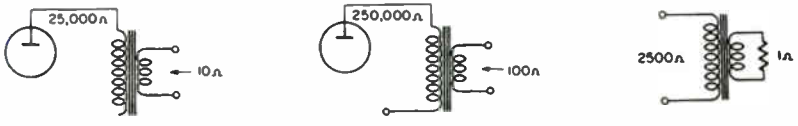


Test setup.

NOTE 49

Reflection of Impedance by Transformer

The impedance *ratio* of a transformer is determined by its winding ratio. If the winding ratio is 50-to-1, the impedance ratio is the square of the winding ratio, or 2500-to-1. The impedance *ratio* means that any value of impedance connected across one winding is *reflected* into the other winding by the impedance ratio. This is shown in the following illustration.



Effect of impedance ratio on reflected impedance.

NOTE 50

Need for Matching Impedances

Impedances must be matched to obtain maximum power transfer. The following illustrations show the effect of mismatched impedances. The transformer, in both instances, has an impedance ratio of 2500:1. Also, a 10-ohm load is connected across the secondary of each transformer. In illustration A, a tube with a plate impedance of 25,000 ohms is connected to the primary; therefore, the impedances are matched, and greatest circuit efficiency is obtained. In illustration B, a tube with a 50,000-ohm plate impedance is connected to the primary, and the impedances are mismatched.

(A) Matched impedances. (B) Mismatched impedances.

Matched and mismatched impedances.

U95

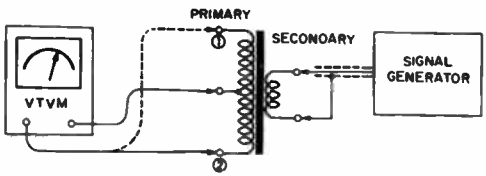
To Check a Push-Pull Audio-Output Transformer for Balance

Equipment: VTVM.

Connections Required: Connect output cable from signal generator across secondary of output transformer. Connect VTVM, in turn, betwen primary center tap and each primary terminal.

Procedure: Operate VTVM on AC voltage function. Operate generator on 400-cycle audio-output function. Observe meter reading in each of the two measurements.

Evaluation of Results: The primary winding is balanced if equal meter readings are obtained across each half of the primary. Unbalance can result from shorted turns, manufacturing tolerances or errors, or leakage from coil to coil or from coil to core.

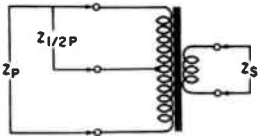


Test setup.

NOTE 51

Impedance of a Center-Tapped Transformer

A push-pull stage works into a center-tapped primary. The impedance ratio of half the primary to the secondary is only *one-fourth* the impedance of the complete primary to the secondary. To illustrate this fact, consider the transformer in the accompanying diagram. The transformer has 1000 turns on the complete primary (tapped at 500 turns) and 10 turns on the secondary. The winding ratio of the complete primary to the secondary is 100-to-1. The impedance ratio of the complete primary to the secondary is 10,000-to-1 ($Z_p/Z_s = 10{,}000$). The winding ratio of half the primary to the secondary is 50-to-1; therefore, the impedance ratio of half the primary to the secondary is only 2500-to-1. ($Z_{1/2p}/Z_s = 2500$). How can this be? Actually, it results from the mutual inductance between the two halves of the primary winding. The center-tapped winding is itself a transformer (an autotransformer). If we start with the inductance of half the primary, the inductance of the complete primary will then be $2L+2L_m$, where L_m is the mutual inductance between windings. The coupling is is maximum (unity), which makes $L_m = L$. In other words, the total inductance of the center-tapped primary is four times the inductance of half the primary. Impedance is directly proportional to inductance, since $Z = IX_L$. It is essential to keep these facts in mind when selecting an output transformer to match a push-pull stage to a speaker.



A center-tapped output transformer.

U96

To Measure the Input Impedance of an Audio Amplifier

Equipment: VTVM and 100-ohm resistor.

Connections Required: Connect equipment as shown in the following diagram.

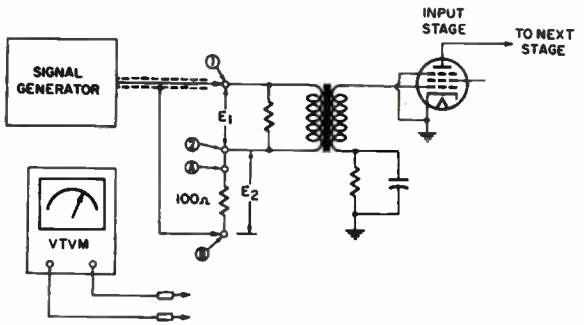
Procedure: Operate signal generator on 400-cycle audio-output function. Operate VTVM on AC voltage function. Measure voltage E_1 across amplifier input terminals 1 and 2. Then measure the voltage E_2 across the 100-ohm resistor, at terminals A and B.

Evaluation of Results: The input impedance of the amplifier is calculated by the formula:

$$Z_{input} = \frac{100\ E_1}{E_2}$$

where,

E_1 is the voltage measured across the input transformer,
E_2 is the voltage measured across the 100-ohm resistor in series with the input transformer.



Test setup.

U97

To Measure the Phase Shift Between the Input and Output of an Audio Amplifier

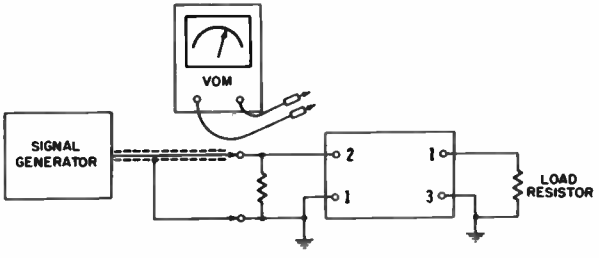
Equipment: Audio amplifier, terminating resistor, load resistor, and VOM.

Connections Required: Connect equipment as shown in the following illustration.

Procedure: Operate signal generator on its 400-cycle audio output. Operate VOM on its AC voltage function. Measure voltage from points 1 to 2, from points 1 to 3, and from points 2 to 3.

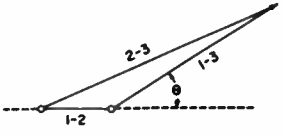
Evaluation of Results: Represent the voltages as line lengths, and fit the three lengths together in a triangle, as shown. The phase shift between input and output is the angle θ.

The 400-cycle waveform from the generator must be sinusoidal; otherwise, the test will be invalid. If the amplifier distorts the wavefrom appreciably, the test will be invalid, also.



Test setup.

Plot of voltages.



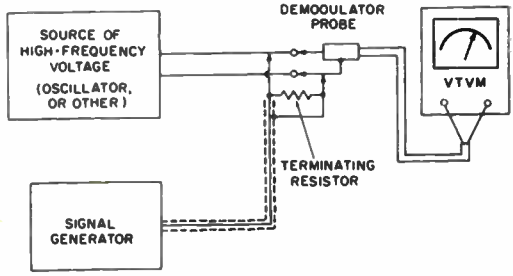
MISCELLANEOUS APPLICATIONS

U98

To Make a Search-Voltage Check for Harmonics in a High-Frequency Waveform

Equipment: Terminating resistor, demodulator probe, and VTVM.
Connections Required: Connect outputs, from source of high-frequency voltage and from signal generator, to input of demodulator probe. Feed probe output to VTVM input.
Procedure: Tune signal generator and watch for a "jump" in the VTVM reading. A rise and dip in indication will be observed at the fundamental frequency and at the harmonic frequencies in the source voltage. The largest change in reading occurs as the signal-generator frequency is tuned through the fundamental. The limitation in identification of harmonics occurs when the harmonic voltage is too small a percentage of the total voltage for a readable pointer movement to be obtained.

The signal generator used in the search-voltage test must have a good sine-wave output, because generator harmonics will cause spurious meter indications.



Test setup.

U99

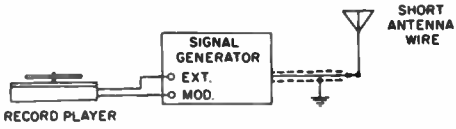
To Use a Signal Generator as a Wireless Record Player

Equipment: Several feet of wire and a record player.

Connections Required: Connect audio output from record player to Ext. Mod. terminals of signal generator. Connect a few feet of wire as a short antenna to the "hot" lead of the generator output cable. Connect output cable braid to ground.

Procedure: Set signal generator for maximum output. Tune signal generator to vacant spot on broadcast range. Adjust volume control of record player for best modulated output from generator.

Evaluation of Results: Ext. Mod. input level is correct when best reproduction is obtained on a nearby radio receiver. (An AM receiver must be used; FM and TV receivers are not suitable.) The distance over which the arrangement can be used depends upon the available output from the generator and the length of the antenna wire connected to the generator output cable.



Using signal generator as wireless record player.

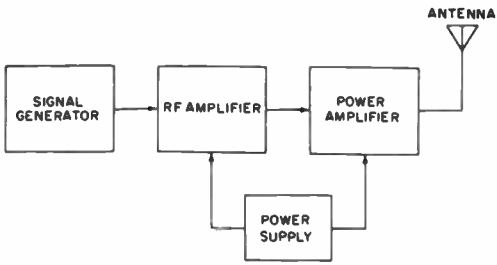
To Use a Signal Generator as a VFO

Equipment: None.

Connections Required: Connect output from signal generator to input of RF amplifier in transmitter.

Procedure: Tune signal generator to desired frequency. If the transmiter has doubler amplifiers, tune the generator to a suitable subharmonic of the desired transmission frequency.

Evaluation of Results: The generator operates as a stable VFO, and permits rapid and accurate shift to another operating frequency. It is desirable to occasionally calibrate the generator against a crystal oscillator, and to keep a calibration chart at hand.



Using signal generator as VFO.

U101

To Use a Signal Generator as an Audio Oscillator

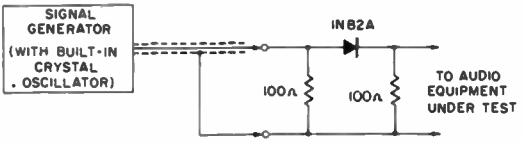
Equipment: Signal generator with built-in crystal oscillator, two 100-ohm resistors, and 1N82A crystal diode.

Connections Required: Connect equipment as shown in the accompanying diagram.

Procedure: Switch crystal oscillator on. Tune signal generator the desired number of cycles or kilocycles away from the crystal frequency.

Evaluation of Results: Output from modulator contains the difference frequency between the generator and crystal frequencies. The output is at a low level and, hence, is suitable for checking fairly high-gain audio devices only.

The modulator output also contains RF frequencies and the RF sum frequency of the inputs. However, these RF frequencies are normally filtered out at the input of the audio device.



Using signal generator as audio oscillotor.

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BOB MIDDLETON was born in Watsonville, Calif., in 1908. He spent his early years on a farm in the Bay region. Becoming interested in wireless in 1919, he operated a "bootleg" spark transmitter until he was old enough to become a licensed operator. In 1921, he held the state record for long-distance reception on a cats-whisker detector. Bob operated his own radio service business for a number of years and later entered design engineering. In 1948, he moved into field engineering and technical lecturing. He has become well known also for his writing on service problems and instrumentation. Bob is a senior member in the I. R. E., and his biography appears in "Who's Who in the Midwest." He has written three previous companion volumes —*101 Ways to Use Your Sweep Generator, 101 Ways to Use Your Oscilloscope,* and *101 Ways to Use Your VOM and VTVM.*

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