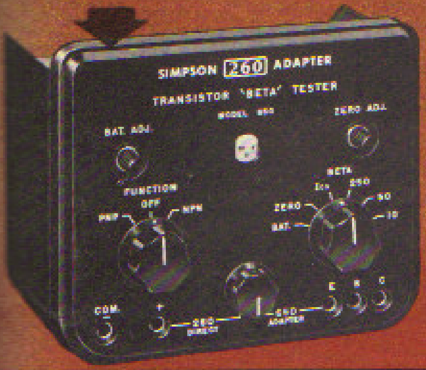
PRICE $1.00

1,001 USES FOR THE 260®

VOLT-OHM-MILLIAMMETER

Simpson

Simpson's Exclusive
Add-A-Tester Adapters
expand the 260's
Measurement Capability



SIMPSON ELECTRIC COMPANY, 5200 West Kinzie St., Chicago, Illinois 60644, (312) 379-1121

With the warmest of sentiments, I dedicate this new edition of the "1001 VOM Tests" manual to the thousands of engineers, technicians, servicemen, students, and hobbyists, who rely on Simpson's 260® Volt-Ohm-Milliammeter.

Thirty years ago, we pioneered the concept of a multitester. Into the early models went our total design and manufacturing ingenuity. And this is still true today . . . many refinements later. As a result, the 260 series of VOMs has earned an enviable position of preference. During this year, my 60th in the instrument industry, we will have supplied two million 260 VOMs to users all over the world.

All of us at Simpson Electric Company hope this new edition of our VOM manual will be helpful to you as a refresher course . . . as a training aid . . . as a way to make your testing faster and more efficient.

Sincerely,

Ray Simpson

Ray R. Simpson
Board Chairman-Consultant
Simpson Electric Company

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

PREFACE

For many years, the 260® has been a "must" for every serviceman, the standard VOM for industrial application and the right hand of most lab technicians. The chief reason for this popularity is the amazing versatility, dependability and ruggedness of this VOM.

Surprisingly though, few people know just how many uses there are for the 260 or how to make many checks that are often thought impossible without expensive and complicated equipment.

The purpose of this book is to show a cross-section of the many applications of the 260, ranging from the basic measurements to some of the more unusual applications.

The present 260, shown in Figure A on next page, is a VOM having a basic DC sensitivity of 20,000 ohms per volts and a basic sensitivity of 5,000 ohms per volts.

The voltage ranges on DC are from 250 millivolts through 5,000 volts, on AC from 2.5 volts through 5,000 volts. Accuracy on DC is 2% and on AC is 3% with the exception of the two 5,000 volt ranges. On the 5,000 volt ranges the DC accuracy is 3% and AC is 4%.

Three resistance ranges are incorporated, R x 1, R x 100 and R x 10,000. The center scale value is 12 ohms.

Current ranges of 50 microamperes, 1 milliampere, 10 milliamperes, 100 milliamperes, 500 milliamperes, and 10 amps DC are provided.

Provision is made for output voltage measurements through 400 volts through a blocking capacitor connected to an output jack.

Figure A

260 VOM FAMILY

The Simpson 260 has become the world's most popular VOM since its introduction in 1937. Keeping pace with improvements in available materials and techniques plus meeting the needs of our changing technology, five progressively improved versions of the 260 have been produced; the first unit was the 260-1. Table 1 shows the features of the various models, Figure B shows these VOM's.

The 260-2 was the first version of the 260 VOM to have the present type of case with a molded front panel. Its lowest current range was 100 microamperes. (This was the same as the original 260—for subsequent models the lowest current range became 50 microamperes.) Series 260-2 was also the first version to incorporate a 10-amp. DC range. Both Series 260-1 and 260-2 had accuracies of 3% on DC and 5% on AC.

Series 260-3 was the first version to use a printed circuit board. It also incorporated banana jacks which featured lower test lead contact resistance and improved reliability. A rectifier circuit improvement extended the frequency response and boosted AC accuracy to 3%, the same as the DC ranges. Current overload protection was provided by a pigtail fuse.

A modification of 260-3 (260-3A) featured a new self-shielding meter movement and the spring-loaded jewels which are now standard on 260's. Since only about one thousand 260-3A's were produced before the more advanced 260-4 the instrument has become a "collector's item".

Series 260-4 added an improved printed circuit board and a calibration circuit that increased the meter's DC accuracy 2%.

Series 260-5 is the current model. It has all the features of the 260-4, plus a printed circuit board capable of withstanding higher voltages and a special varistor to prevent electrical damage to the meter movement. The varistor provides protection against overloads of 5,000 times normal. This is a real boon to those who occasionally connect their 260 across the 110-volt line while they're on the Rx1 range. Varistor protection can be added to older model 260's if desired. See page 30.

260-5P is the most recent modification. It is known as the "Goof-Proof 260" because it reduces the probability of accidental damage to almost zero. 260-5P senses overloads electronically and opens a relay which disconnects one side of the meter from the circuit. This feature is especially valuable when the meter must be used by untrained personnel in schools or industry.

Add-A-Tester Adapters can be used on all series 2-5 260's made by Simpson.

Series 1 Series 2 Series 3

Series 4 Series 5 Series 5P

Figure B

TABLE 1. 260 EVOLUTION

Series	1*	2*	3*	4*	5	5P
50μA meter, 250 MV F.S.	x	x	x	x	x	x
10A Range	—	x	x	x	x	x
50μA Range	—	—	x	x	x	x
100μA Range	x	x	—	—	—	—
1 ma Range	—	—	x	x	x	x
Polarity Reversing Switch	—	—	x	x	x	x
5 Kc Response	x	x	—	—	—	—
500 Kc Response	—	—	x	x	x	x
Pin Jacks	x	x	—	—	—	—
Banana Jacks	—	—	x	x	x	x
Shelf-Shielding Annular Movement	—	—	—	x	x	x
Spring-Loaded Jewels	—	—	x	x	x	x
Fuse Protection	—	—	x	x	x	x
Overload Relay	—	—	—	—	—	x
% Accuracy, AC Scales	5	5	3	3	3	3
% Accuracy, DC Scales	3	3	3	2	2	2
Movement Protection†	—	—	—	—	x	x

* Obsoleted by improved 260 series. Older 260's can be up-dated by adding features. See page 81.

† Can be added to earlier 260's. See page 30.

260 RANGES

The 260 can measure DC voltage, AC voltage, AF voltage, Decibels, Current and Resistance as shown in Table 2 below.

TABLE 2. 260-5 RANGES

MEASURMENT RANGES

D.C. VOLTAGE	Accuracy in % of Full Scale
Sensitivity;	
20,000 ohms-per-volt	
0 - 250 millivolts	±2%
0 - 2.5 volts	±2%
0 - 10 volts	±2%
0 - 50 volts	±2%
0 - 250 volts	±2%
0 - 1000 volts	±2%
0 - 5000 volts	±3%

DIRECT CURRENT	
0 - 50 microamperes	±1.5%
0 - 1 milliampere	±2%
0 - 10 milliamperes	±2%
0 - 100 milliamperes	±2%
0 - 500 milliamperes	±2%
0 - 10 amperes	±2%

D.C. RESISTANCE	Accuracy in degrees of Arc
R x 1 for 0-2000 ohms (12 ohms center)	2.5°
R x 100 for 0-200,000 ohms (1200 ohms center)	2.0°
R x 10,000 for 0-20 megohms (120,000 ohms center)	2.0°

A.C. VOLTAGE	Accuracy in % of Full Scale
Sensitivity;	
5,000 ohms-per volt	
0 - 2.5 volts	±3%
0 - 10 volts	±3%
0 - 50 volts	±3%
0 - 250 volts	±3%
0 - 1000 volts	±3%
0 - 5000 volts	±4%

A. F. OUTPUT VOLTAGE

With 0.1 μf internal series capacitor

0 - 2.5 volts
0 - 10 volts
0 - 50 volts
0 - 250 volts

VOLUME LEVEL IN DECIBELS

With zero DB equal to
1 milliwatt across a 600 ohm line

– 20 to +10 DB
– 8 to +22 DB
+6 to +36 DB
+20 to +50 DB

DC Voltage

For measurements of DC voltages on the 0-250 millivolt range, the leads are connected as in Figure C. For the 0-2.5, 0-10, 0-50, 0-250 and 0-1000 volt ranges, the connections are as shown in Figure D. For the 0 to 5,000 volts DC scale the connections are changed as shown in Figure E. For measuring DC voltages, except the 250 MV range, the function switch can be in either the —DC or +DC position. This avoids the necessity of switching lead connections in the event of reversed readings. The polarity switch is not connected in the 50μa, 250 MV range.

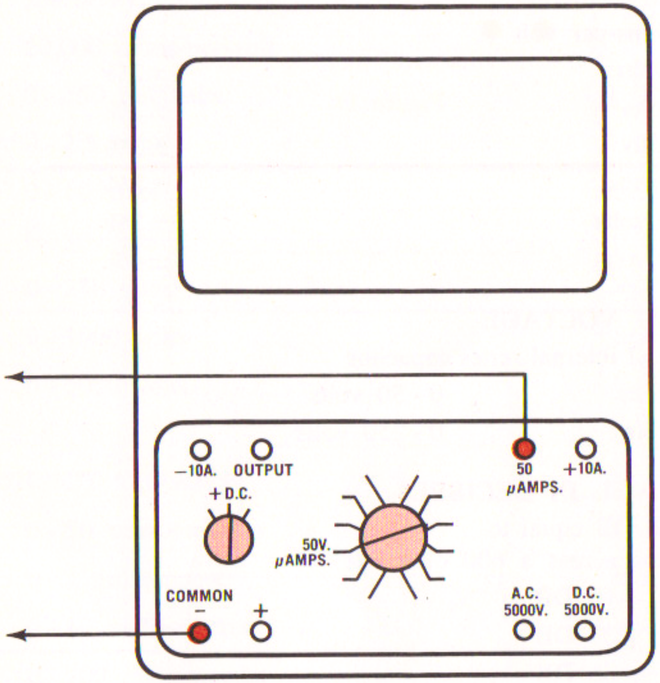


Figure C

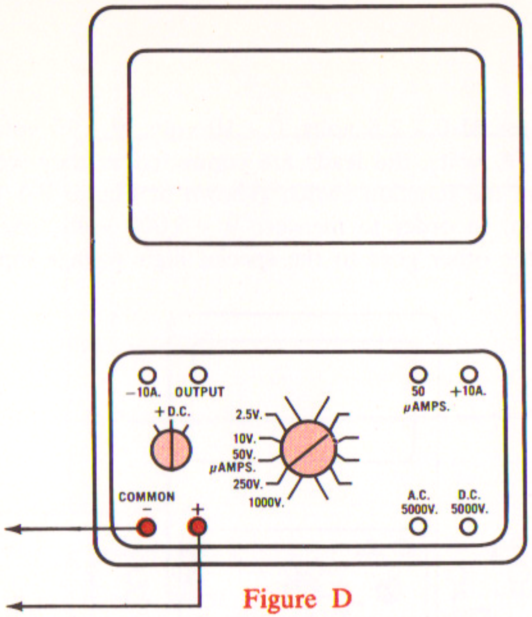


Figure D

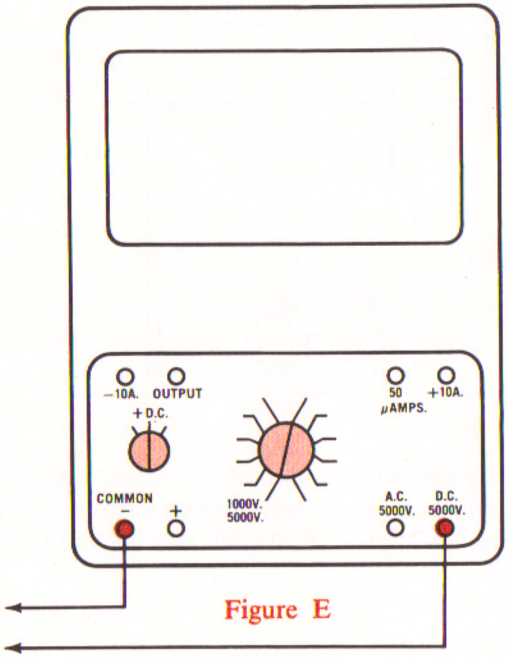


Figure E

AC Voltage

For AC voltages of 0 - 2.5 volts, 0 - 10 volts, 0 - 50 volts, 0 - 250 volts, and 0 - 1,000 volts, the leads are connected as they were for DC voltage except that the function switch (shown in Figure F-1.) is turned to the AC position. In order to measure 0 - 5,000 volts, one lead goes to common and the other goes to the special high voltage input for AC as in Figure F-2.

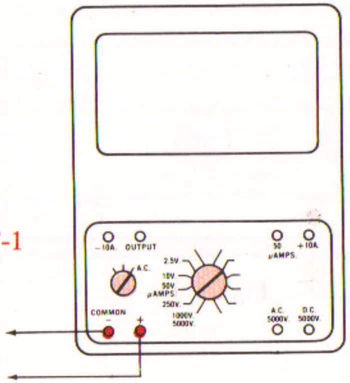


Figure F-1

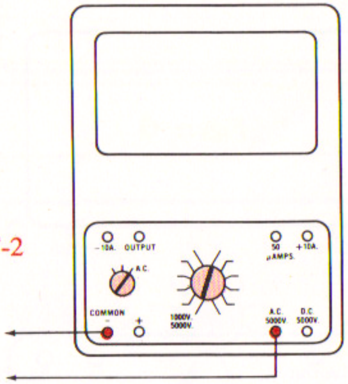


Figure F-2

AF Volts

Provision is made for using the 260 as an output meter where one lead is connected to common and the other connected to the Output jack as in Figure G. Scales are 0 - 2.5, 0 - 10, 0 - 50, and 0 - 250 volts.

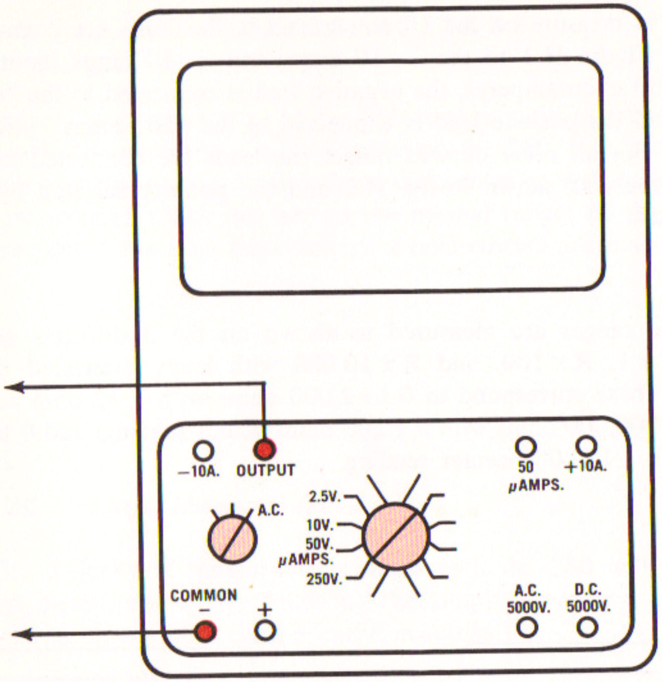


Figure G

Decibels

DB scales of −20 to +10, −8 to +22, +6 to +36, and +20 to +50 are available for a standard reference level of 1 milliwatt with a 600 ohm load with leads connected as in Figure D. The range switch is set to 2.5, 10, 50 or 250 respectively.

DC Current

Current readings are from 0 - 50 microamperes, 0 - 1 milliampere, 0 - 10 milliamperes, 0 - 100 milliamperes, 0 - 500 milliamperes, and 0 - 10 amperes.

In order to measure on the 10 ampere scale, the leads are connected as shown in Figure H-1 to the — 10 amps and + 10 amps input. To measure 0 - 50 microamperes, the negative lead is connected to the "common" jack and the positive lead is connected to the "50 μamps" jack, as in Figure C. For all other current ranges the leads are connected to the + and — inputs as shown in fig. H-2 and the polarity selected by the function switch.

Resistance

Resistance ranges are measured as shown on the 3 different scales which are R x 1, R x 100, and R x 10,000 with leads connected as in Figure H-2. These correspond to 0 to 2,000 ohms with a 12 ohm center reading, 0 to 200,000 ohms with a 1,200 ohms center reading, and 0 to 20 megohms with a 120,000 center reading.

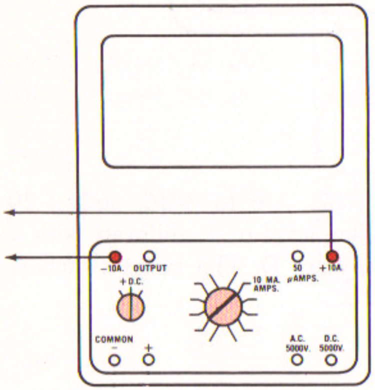


Figure H-1

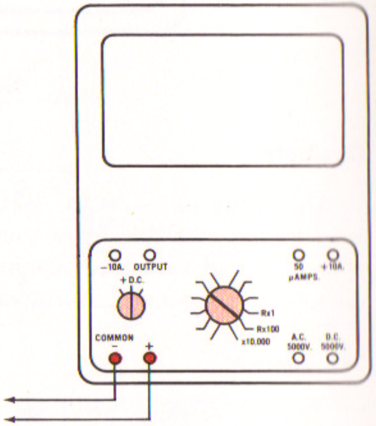


Figure H-2

1.0 MEASURING VOLTAGE

One of the primary uses of the 260 is as a multi-range voltmeter. In addition to the normally available scales on the 260, it is possible to use this unit to measure very small voltage differences as well as high voltages and low voltages which are not on the normal ranges of the instrument. This section shows how these voltage measurements are made.

1.1 DC Voltage Measurements

The majority of measurements made with the 260 will probably be voltage measurements. By following the simple procedures given below, you will be certain of making accurate readings.

There are three different arrangements for measuring DC voltage; one for the 250 MV range, one for the 5,000 volt range, and one for all other ranges from 2.5 volts to 1,000 volts.

For the 0 to 250 MV range:

1. Connect the tester as shown in Figure C.
2. Turn the range switch to 50 μA position.
3. Turn the function switch to "+DC".
4. Connect the test leads to the circuit to be measured and turn the power "on."

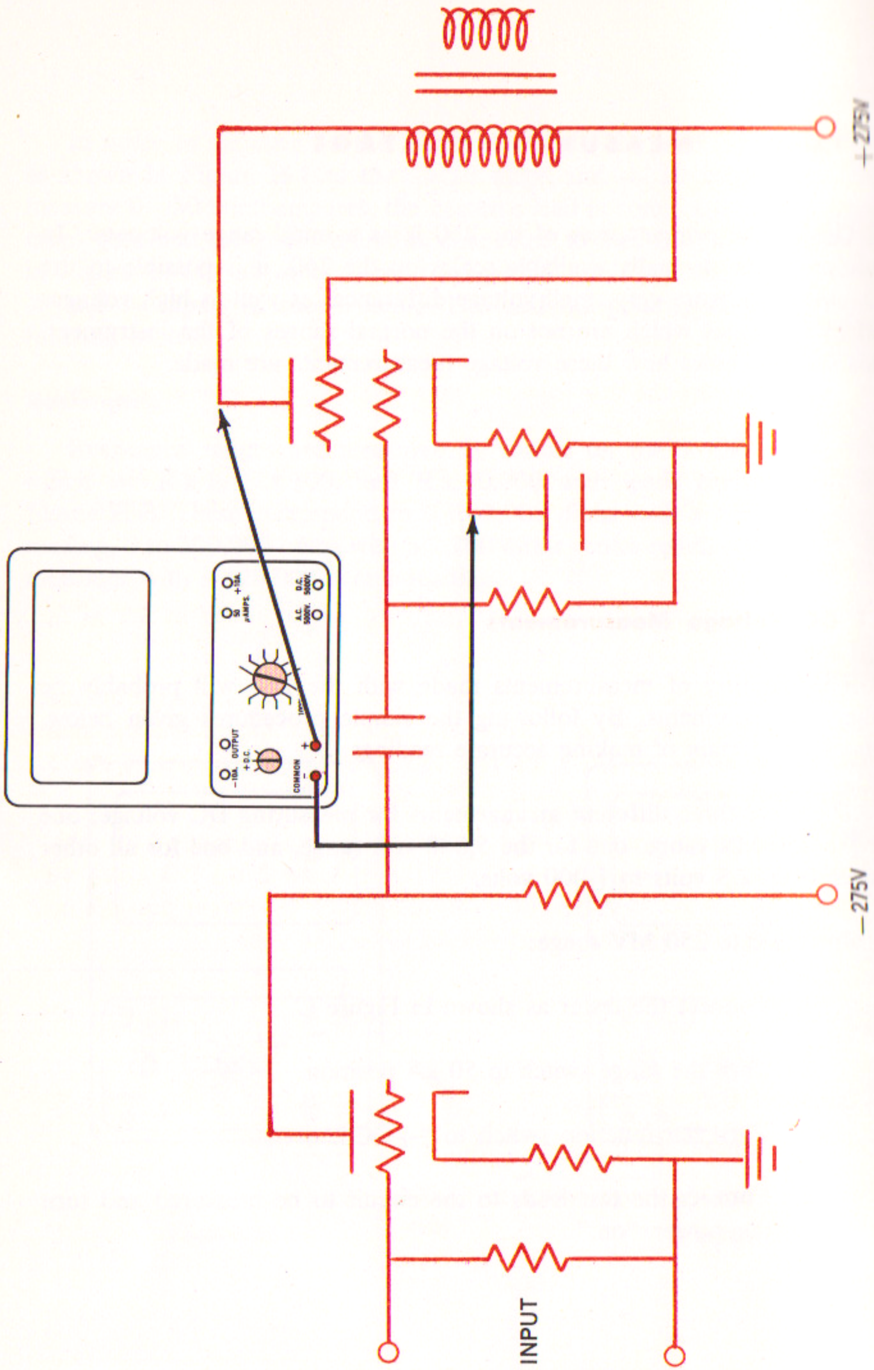


Figure 1.1

For ranges from 2.5 volts through 1000 volts:

1. Connect the test leads as shown in Figure D.
2. Turn the range switch to a range known to be higher than the voltage to be measured.
3. Turn the function switch to "+DC" (or "—DC" if the leads are reversed).
4. Connect the test leads to the circuit to be measured and turn the power "on."
5. If the meter reading is below the next lower range, switch to that range. This will increase the accuracy of the reading.

Example:

Suppose that you want to measure the plate voltage of V3 as in Figure 1.1.

Since the voltage indicated is higher than the 250 volt range on the 260, the range switch would be set on the 1,000 volt range. The function switch would be on "+DC", the red lead would be connected to Pin 3 and the black lead would connect to Pin 2.

When the power is turned on, the meter reads approximately 245 volts. Since this voltage is lower than next lower range on the 260 (250 volts) we turn the range switch to 250 volts. With the greater resolution possible on the lower range, we find the actual voltage to be 248 volts.

For the 5,000 volt range:

1. Connect the meter as shown in Figure E.
2. Turn the range switch to 1,000v
   5,000v

3. Turn the function switch to "+DC" (or "−DC" if the leads are reversed).

4. Connect the test leads to the circuit to be measured and turn the power "on."

1.2 Small Voltage Differences

It is possible to measure very small voltage differences on the 260 by using the technique of a suppressed zero scale. A suppressed zero scale is one where voltages below a certain value cause no up-scale indication. (Meters of this type are commonly called "segmental" voltmeters). By "suppressing" the unnecessary portion of the scale, the critical range can be spread out over the entire scale length. This technique can be used to measure and detect exceedingly small variations in a voltage source.

For example, suppose that it were necessary to measure a variation in a 24 volt dc source. It is possible, of course, to measure this on the 50 volt range but the variations in the reading might be exceedingly small and hard to read. A supplemental source, say of 22.5 volts, can be used as shown in Figure 1.2, with the supplemental source arranged to "buck" or oppose the voltage to be measured.

The meter is then turned to the 2.5 volt range instead of the 50 volt range. The meter will indicate the difference between the fixed 22.5 volts and the 24 volts to be measured. Using this technique it is possible to observe very small changes in the 24 volt source that would not be noted if a larger scale reading were used.

NOTE

This technique does not increase the accuracy of the reading unless a precisely known bucking voltage is used. It merely makes possible detection of exceedingly small changes and does increase the comparative accuracy of the readings.

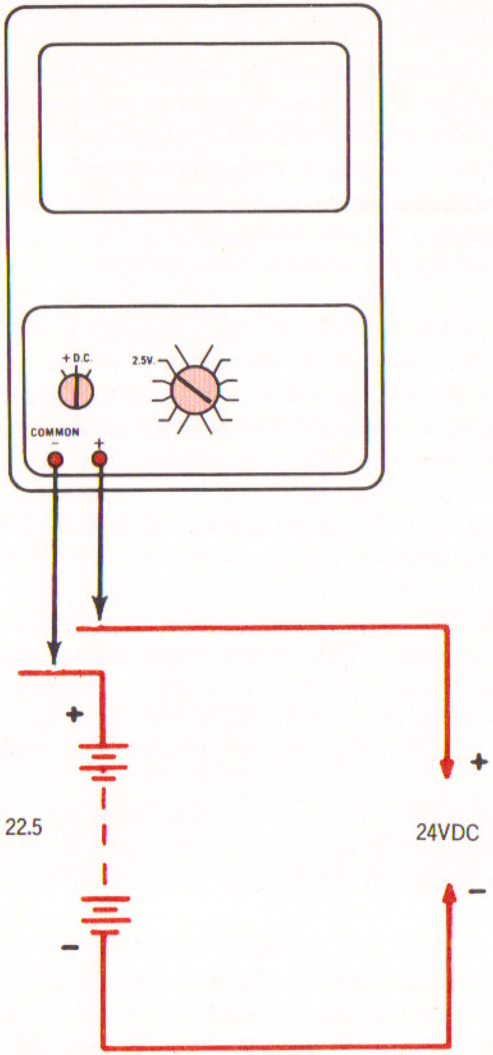


Figure 1.2

1.3 High Voltage

There are often requirements for measuring a high voltage beyond the normal VOM range. These high voltages occur in radio transmitter, television receivers and high voltage power supplies used in other equipment such as oscilloscopes or certain industrial electronic equipment. There are high voltage probes that are available to extend the VOM voltage measuring capability but it is possible to construct a voltage multiplier that can be used for high voltage if a probe is not available.

The basic principle is that a high resistance is placed in series with the meter and the voltage to be measured. A portion of this high voltage is "dropped" by the resistance while the balance appears across the meter. The meter reading is then calibrated in terms of the entire high voltage to be measured.

The value of the external resistance will depend on the voltage to be measured and the sensitivity of the meter movement involved.

In the basic 260 meter movement, the meter has a DC sensitivity of 20,000 ohms per volt. (The current sensitivity of almost all VOMs is rated in terms of the number of ohms necessary to cause a voltage drop of 1 volt). The voltage to be measured is multiplied by the ohms per volt sensitivity; the answer is the value of the multiplier resistor in ohms.

When using either commercial or homemade high voltage multipliers, the 260 is normally set on the 2.5 DC volt range*. At any voltage in excess of the available ranges on the 260, the resistance of this voltage range can be ignored.

**Multipliers were designed for the series 1, 2 and 3, 260's for use with the testers switched to the 1000 volt range. These multipliers were replaced in 1957 by today's design.*

Thus, if a 10,000 volt DC multiplier were required, the resistance would be:

10,000 (volts) x 20,000 (ohms per volt) = 200,000,000 ohms or 200 megohms.

If a 10,000 volt *AC* multiplier were required, its resistance would be:

10,000 (volts) x 5,000 (ohms per volt) = 50,000,000 ohms or 50 megohms.

These resistances that are external to the meter are normally used in probes. In practice they are made up of a number of individual resistors, not a single unit. The resistors that are used depend upon the available practical values and the necessary combination of these to produce the total series resistance. These resistors should be measured to produce the value as close as possible to that required or, if available, precision resistors can be used.

However, there is more to producing a high voltage network in a probe than just choosing the proper values of resistors and connecting them. It is important to consider the voltage handling capability of the resistors since there is a possibility of voltage breakdown from end to end, depending upon the physical size of the resistors. Also the wattage ratings of the resistors must be great enough to dissipate the power applied to them.

Using a probe, it is important to remember that most of the voltage to be measured will be dropped across the resistances contained in the probe. Because of this, special probes are used with precautions against arc over that can endanger the user. Most of these probes have a rib or series of ribs to prevent arc over. In addition, a grounded shield is provided between the resistors and the handle of the probe. (See Figure 1.3B) In the event of a breakdown, arcing will take place inside the probe, thus protecting the user. It is important to remember these considerations in constructing a probe; the figure shows the probe construction.

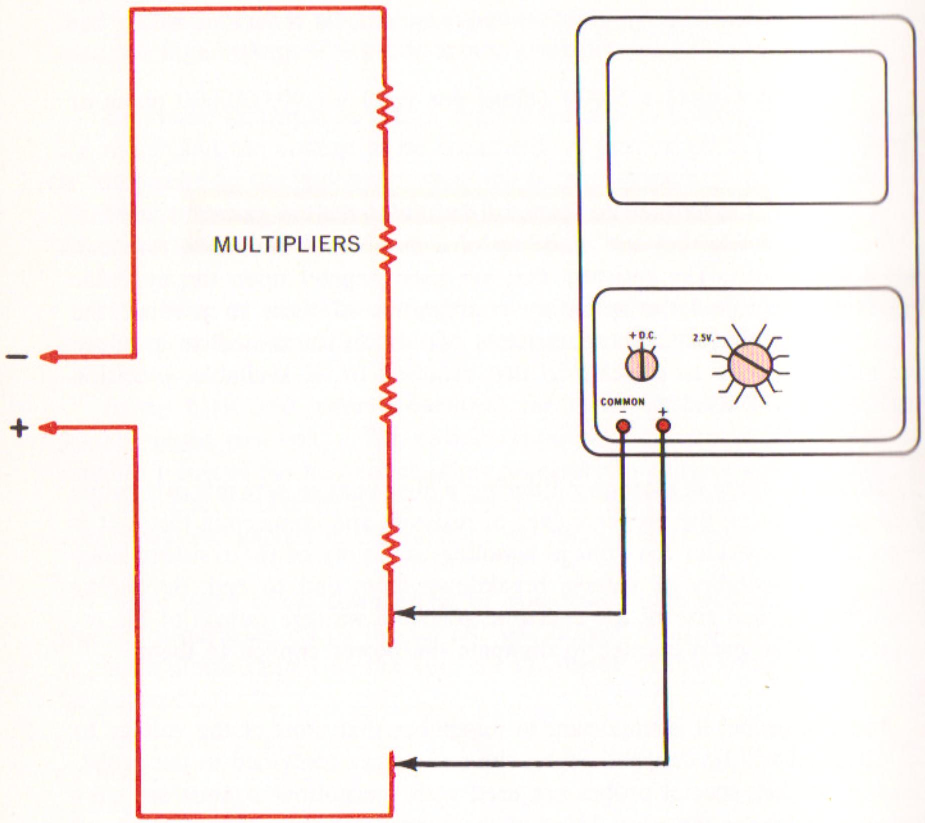


Figure 1.3A

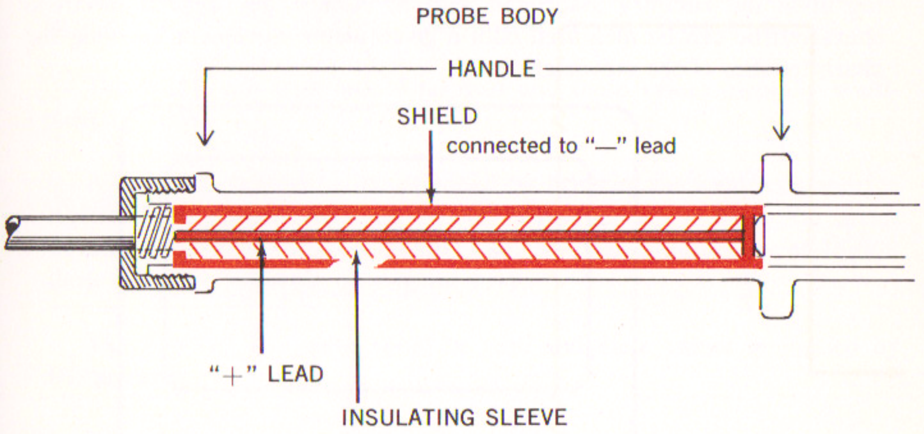


Figure 1.3B

If a standard high voltage probe is not available or if the case from a standard high voltage probe cannot be used to obtain the high voltage network for these high voltage measurements the best practice is to connect the series network and the meter into the circuit before turning the circuit on. After the probe is connected and the circuit is turned on the reading should be taken without touching the probe or the circuit to prevent any possible danger to the operator. These precautions are necessary in measuring high voltage and should always be followed.

1.4 Low Voltage

The 260 can measure DC voltages well below the lowest normal voltage range indicated on the meter. To understand how this can be done it is necessary to know something about the basic meter movement in a VOM. This meter movement is a current sensitive device whose indication can be made proportional to current, voltage or resistance depending upon the circuitry associated with it. Almost any desired electrical characteristic can be measured with a given meter movement knowing the characteristics of the movement itself.

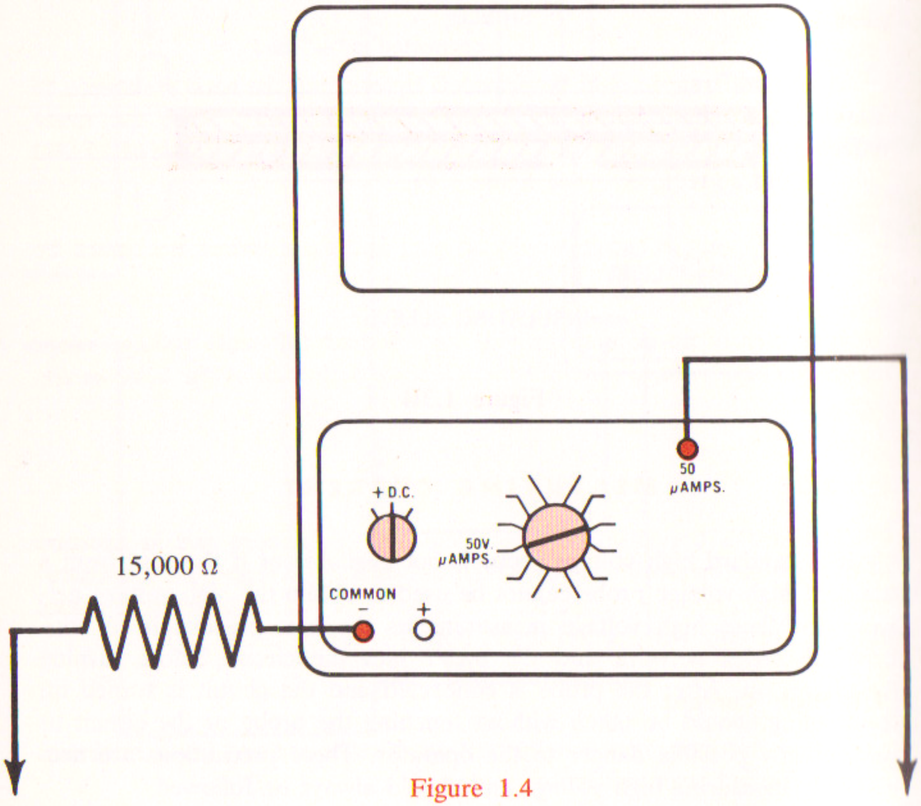


Figure 1.4

Consider a typical VOM meter movement, the 260, which has an internal resistance of 5,000 ohms and which requires 50 microamperes of current to provide a full scale deflection. Obviously from Ohm's law a potential of 250 millivolts would have to be applied to cause a full-scale deflection (F. S. D. or F. S.).

It is possible then by connecting the leads directly to the meter to have a 0 to 250 millivolt range. (See instructions in "Ranges" section.)

The 0-250 volt scale would be read and these values mentally multiplied by .001.

A one volt range could be provided by bringing the total resistance to 20,000 ohms (basic sensitivity 20,000 ohms per volt). Since the meter movement has a resistance of 5,000 ohms, an external resistance of 15,000 ohms would be required. (See figure 1.4).

The 100 volt DC scale would be read and these values multiplied by .01 mentally.

It is clearly possible to provide any desired full scale voltage range *higher than the voltage required for full scale deflection of the basic meter.*

2.0 MEASURING CURRENT

The 260 is basically a current measuring instrument and in addition to the current measuring scales which are directly available on the instrument it is also possible to use the 260 to measure other high-current values and AC current. This section shows how this can be done.

2.1 High Current

Any meter movement is a current sensitive device and has a minimum current for full scale deflection.

We have already seen how it is possible to provide non-standard ranges or ranges higher than those provided for voltage measurement by using external resistors. The same can be done for current measurement by using a shunt. The purpose of the shunt is to carry all of the extra current above and beyond that required for full scale deflection while the meter reading indicates the total current flow to the shunt and to the meter itself.

Currents up to 10 amperes can be measured directly on the 260. Current values in excess of this can be measured only if external shunts are used to carry the majority of the current. The value of the shunt resistor can readily be calculated by using the formula:

$$R_s = \frac{E_m}{I_t - I_m}$$

R_s = Resistance of the shunt

E_m = Voltage drop of the basic movement

I_t = Current to be measured

I_m = Current in the basic meter circuit

In the 260, the millivolt drop of the meter movements is 250 millivolts. (The current in the basic 260 meter circuit in the Series 1 and Series 2 units is 100 microamperes and in the Series 3 through 5 units it is 50 microamperes.) Since the meter currents are so small as compared with the currents that would require the use of external shunts, they generally can be ignored so that the formula merely becomes:

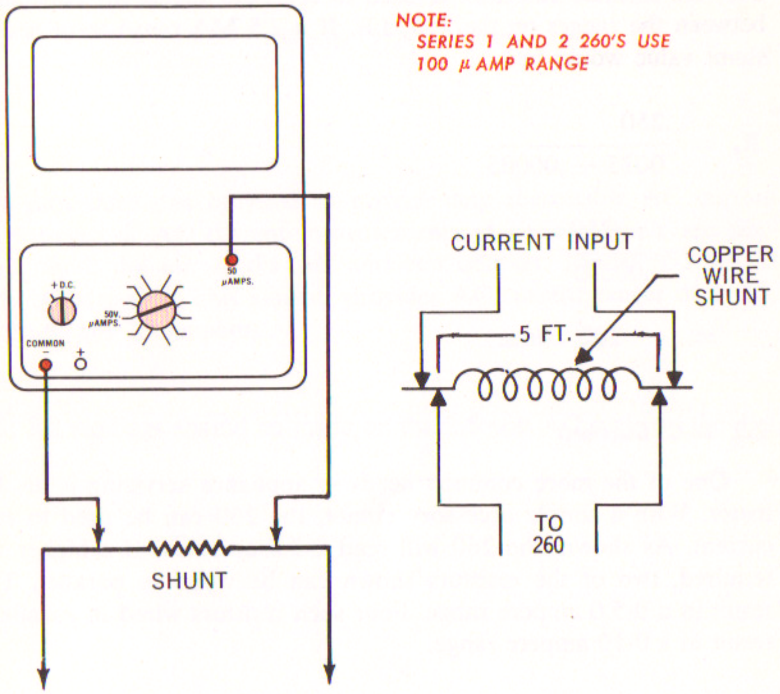
$$R_s = \frac{E_m}{I_t}$$

For example, let's assume that it's necessary to measure a 20 amp current with the 260. The formula becomes R_s is equal to:

$$R_s = \frac{.250}{20} \text{ or } .0125 \text{ ohm.}$$

This would be equal to approximately 5 feet of #14 copper wire.

If only an approximate reading unit were desired, the shunt could be constructed from copper wire as shown. Notice that the connections for the current input and for the tapoff of the millivolt output are not at the same place. This prevents possible errors due to contact resistance at the connections.



NOTE:
SERIES 1 AND 2 260'S USE
100 µ AMP RANGE

Figure 2.1

Obviously, this shunt will only give approximate readings unless it is accurately calibrated. This would require that its exact resistance be established at .0125 ohm. This could be done through the use of a Kelvin double bridge, measuring with the milliohmmeter, or by substituting a known current input and adjusting the taps for the proper voltage drop.

Even such a calibration procedure, however, would not guarantee accurate measurements under all conditions. Using copper as the shunt material would result in errors if the temperature of the wire did not remain constant. The nominal resistance of copper wire changes by approximately .22% per degree Fahrenheit. For this reason it is suggested that Manganin, Karma, Evenohm or some other low temperature coefficient material be used in making up special shunts.

In addition to providing current ranges above the maximum on the 260, the formula can also be used to calculate shunts for currents falling between the ranges on the 260. I.E. If a 2.5 MA range were needed, the shunt value would be:

$$R_s = \frac{.250}{.0025 - .00005}$$

$$= \frac{.250}{.00245}$$

$$= 102 \text{ ohms.}$$

2.2 A-C Current

One of the more common needs in appliance servicing is an AC ammeter. With a simple accessory circuit, the 260 can be used to read AC current. As shown, the 260 will read 0-2.5 amperes. If a higher range is required, two of the resistors shown can be wired in parallel. This will result in a 0-5.0 ampere range. Four such resistors wired in parallel would result in a 0-10 ampere range.

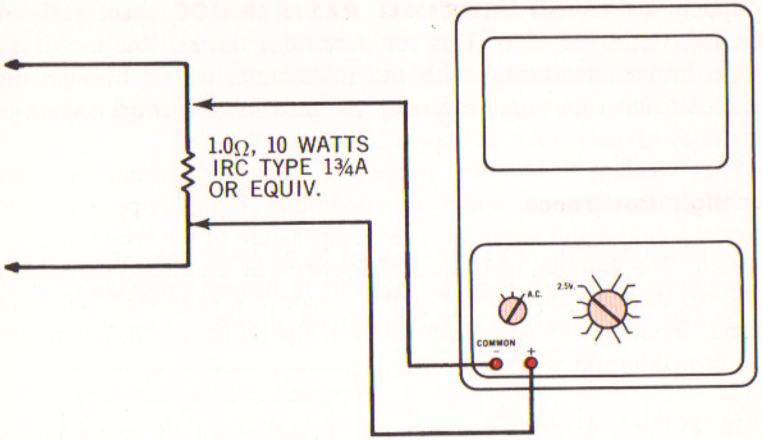


Figure 2.2

This procedure can be used to provide any reasonable AC current range. However, if AC current measurements at various levels are normally required, the use of the AC ammeter adapter, Model 653 would probably be advisable. This adapter provides AC current ranges of 0-.25, 1, 2.5, 12.5, and 25 amperes.

NOTE: All readings should be made on the 2.5 volt AC scale on the dial.

3.0 MEASURING RESISTANCE

The 260 can be used directly as an ohmmeter with the ranges supplied. It can also have its range extended to measure very high values or very low values of resistance as shown in this section.

3.1 High Resistance

As purchased, the 260 can be used to measure resistance values up to 20 megohms. However, it is also possible to measure resistances above this (up to 200 megohms) by using the circuit shown.

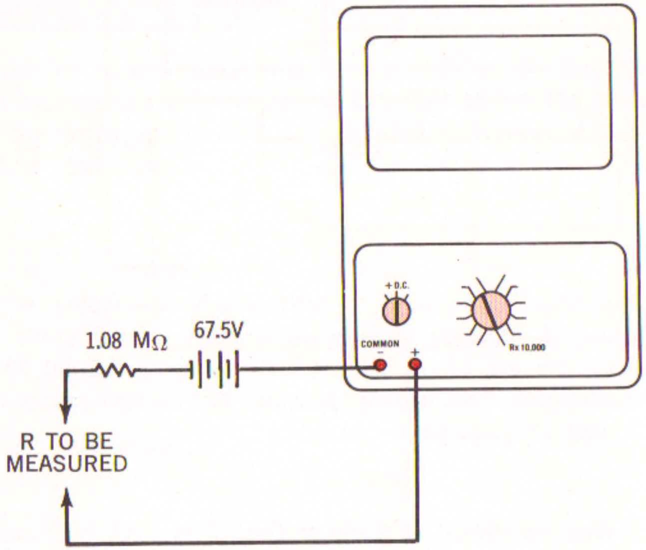


Figure 3.1

An external 67.5 volt battery is used in series with a 1.08 megohm resistor. The 260 is used on the R x 10,000 range. This circuit changes the range to R x 100,000, a 10 times multiplication.

3.2 Low Resistance

Increasing use of power transistors has made low resistance measurements more important. As shown in the typical output circuit, Figure 3.2A, R1 is 0.25 ohm, R2 is 1.0 ohm.

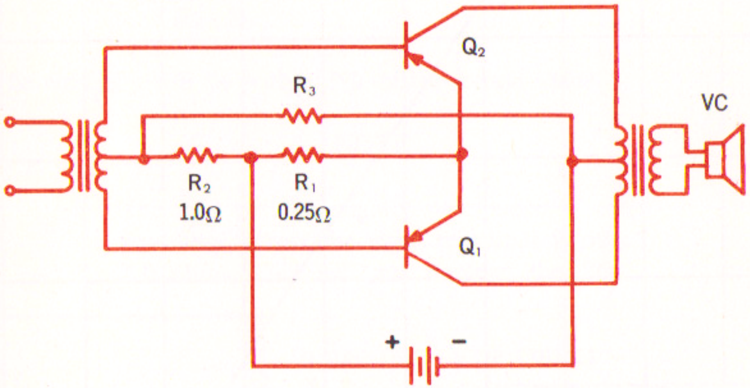


Figure 3.2A

Since the emitter bias determines the operating point of the transistor, these resistor values are important to minimize distortion. Unfortunately, the standard resistance ranges don't give much accuracy at these values.

The 260 can be used for these low resistance measurements. The R x 1 scale can be used for readings to about 2 ohms. For less than 2 ohms down to about 0.10 ohm the following technique can be used.

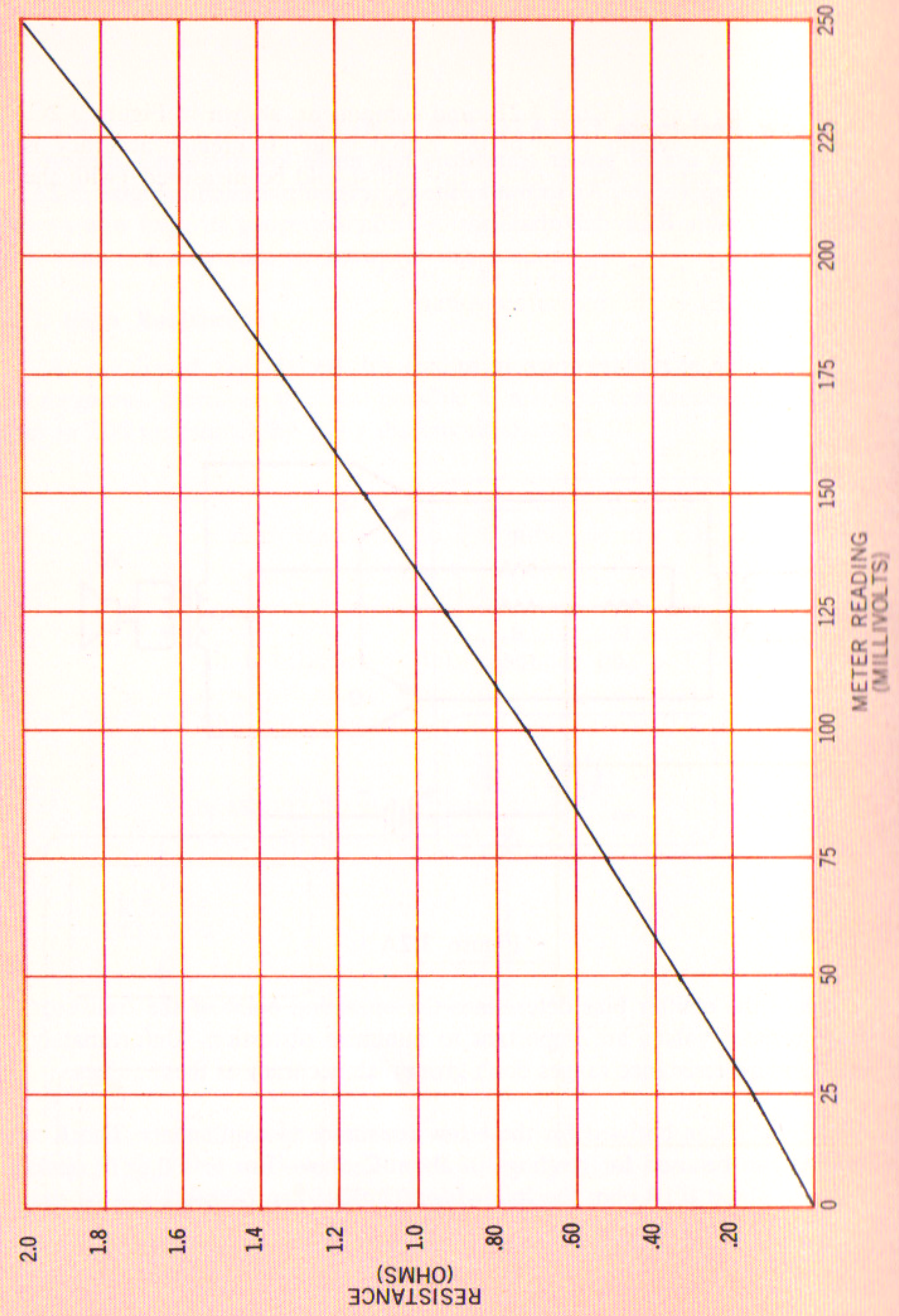


Figure 3.2B

Using the graph, Figure 3.2B, and components shown in Figure 3.2C, the accuracy is within 10% of the actual value. If greater accuracy is required, the actual voltage of the dry cell should be measured (with the terminals to the unknown resistance shorted).

Where: E_1 is the dry cell (1.5 volts)
E_2 is the measured voltage

The value of the unknown resistance will be:

$$R_x = \frac{10\,E_2}{E_1 - E_2}$$

The accuracy will be within 3% of the actual value.

NOTE

The 260 will be slightly overloaded if the resistance across the input terminals is over 2.0 ohms. This will not damage the 260.

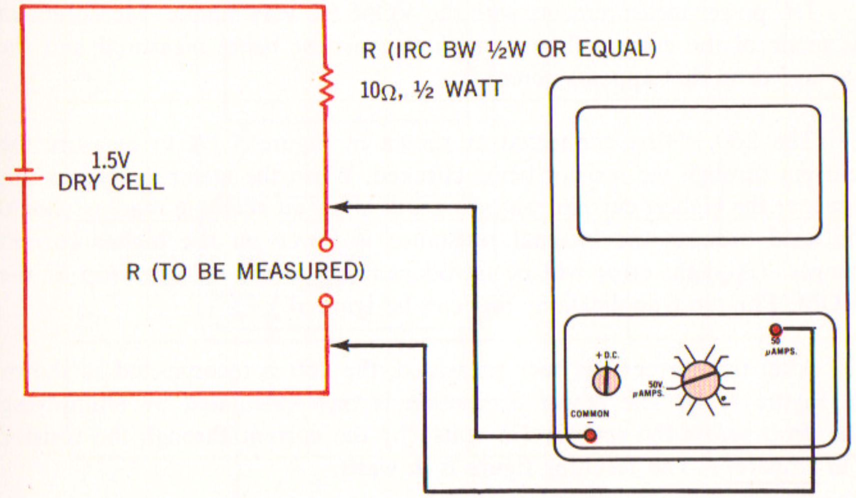


Figure 3.2C

The milliohmmeter adapter, Model 657, can be used with the 260 to measure resistance values as low as 0.001 ohms. (See pages 77-78) Use of this adapter with the 260 allows accurate resistance measurements of low resistance windings in motors, generators, and transformers and in other specialized applications such as, an accurate determination of the resistance of ammeter shunts. The milliohmmeter can also be used to determine the contact resistance of switches and relays which is normally very low.

4.0 MEASURING POWER

4.1 D.C. Power

DC power measurements with the VOM are very simple. Measurement is made of the current flow through the resistor being measured and the voltage drop that appears across it.

The 260 is first connected as shown in Figure 4.1A to measure the current through the resistor being checked. When the meter is used in this manner the highest current range that will allow an accurate reading should be used because the internal resistance is lower on the higher current ranges. (A slight error will be introduced due to the voltage drop of the VOM. For most applications this can be ignored.)

After the current has been measured, the 260 is reconnected as shown in Figure 4.1B. The power dissipation is then calculated by multiplying the drop across the resistor (in volts) by the current through the resistor (in amperes). The resulting figure is in watts.

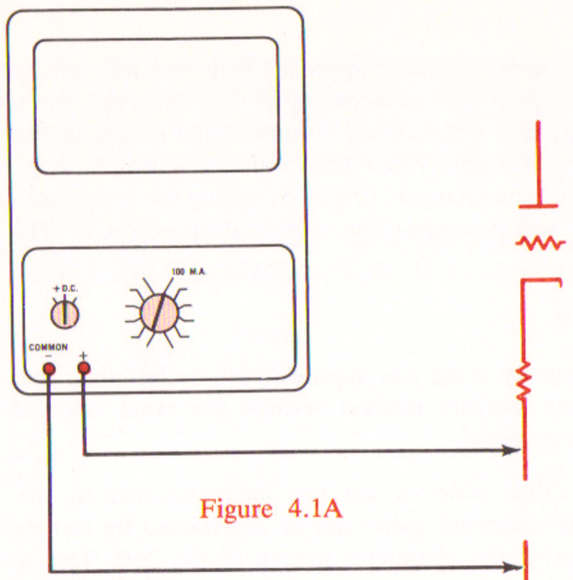


Figure 4.1A

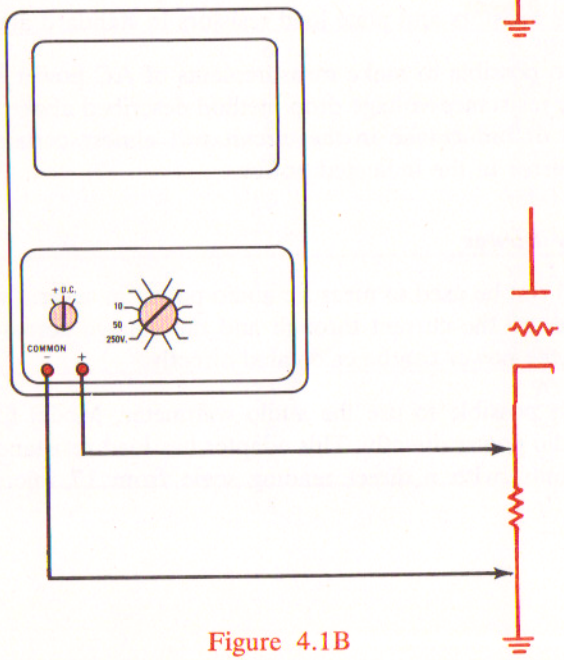


Figure 4.1B

This voltmeter-ammeter approach to power measurement generally results in a reading with an accuracy of 5% or better. However, it has the disadvantage that a lead must be unsoldered or cut in order to make the current measurement. When this is not practical, it is possible to make approximate measurements simply by noting the resistance of the circuit or component and measuring the voltage drop across it. The power is then equal to $\frac{E^2}{R}$

The accuracy using this approach will be less than that achieved from the voltmeter-ammeter method because the exact value of resistance has not been determined.

Where other resistors are not interconnected to the resistor being checked, the resistance value can be determined by turning off the equipment and using the ohmmeter section of the 260. This will improve the accuracy of the measurement.

Such a resistance measurement would be practical in the case of most cathode bias resistors and plate load resistors in standard amplifier circuits.

It is also possible to make measurements of AC power in *resistive* circuits via the resistance-voltage drop method described above. However, any capacitance or inductance in the circuit will almost certainly result in a substantial error in the indicated power.

4.2 Audio Power

The 260 can be used to measure audio power in several ways. It is possible to measure the current through and the voltage across the resistance from which the power can be calculated directly.

It is also possible to use the audio wattmeter, Model 654 adapter, to measure audio power directly. This adapter has load resistances of 4, 8, 16, and 600 ohms, with a direct reading scale from 17 microwatts to 100 watts.

The output power from an audio amplifier system can be determined by using the Model 654 together with the 260 and by connecting the proper resistive load to the amplifier. The reading will be given directly in watts. Table 3 shows the conversion from watts to decibels.

TABLE 3. DECIBELS ABOVE AND BELOW 1 MW REF LEVEL EXPRESSED IN WATTS

Watts	Power Level (DB)	Watts
	− +	
6.00 x 10^{-3}	0	6.00 x 10^{-3}
4.77 x 10^{-3}	1	7.55 x 10^{-3}
3.87 x 10^{-3}	2	9.51 x 10^{-3}
3.01 x 10^{-3}	3	1.20 x 10^{-2}
2.39 x 10^{-3}	4	1.51 x 10^{-2}
1.90 x 10^{-3}	5	1.90 x 10^{-2}
1.51 x 10^{-3}	6	2.39 x 10^{-2}
1.20 x 10^{-3}	7	3.01 x 10^{-2}
9.51 x 10^{-4}	8	3.87 x 10^{-2}
7.55 x 10^{-4}	9	4.77 x 10^{-2}
6.00 x 10^{-4}	10	6.00 x 10^{-2}
4.77 x 10^{-4}	11	7.55 x 10^{-2}
3.87 x 10^{-4}	12	9.51 x 10^{-2}
3.01 x 10^{-4}	13	1.20 x 10^{-1}
2.39 x 10^{-4}	14	1.51 x 10^{-1}
1.90 x 10^{-4}	15	1.90 x 10^{-1}
1.51 x 10^{-4}	16	2.39 x 10^{-1}
1.20 x 10^{-4}	17	3.01 x 10^{-1}
9.51 x 10^{-5}	18	3.87 x 10^{-1}

Watts	Power Level (DB)	Watts
—		+
7.55 x 10^{-5}	19	4.77 x 10^{-1}
6.00 x 10^{-5}	20	6.00 x 10^{-1}
1.90 x 10^{-5}	25	1.90
6.00 x 10^{-6}	30	6.00
1.90 x 10^{-6}	35	1.90 x 10
6.00 x 10^{-7}	40	6.00 x 10
1.90 x 10^{-7}	45	1.90 x 10^{2}
6.00 x 10^{-8}	50	6.00 x 10^{2}
6.00 x 10^{-9}	60	6.00 x 10^{3}
6.00 x 10^{-10}	70	6.00 x 10^{4}
6.00 x 10^{-11}	80	6.00 x 10^{5}

4.3 Power Ratios

The 260 can be used to measure power ratios in several different ways.

The 260 has decibel scales of —20 to +10 db, —8 to +22 db, +6 to +36 db, and +20 to +50 db. For all of these scales, the zero reference is one milliwatt into 600 ohms as a standard load.* Since decibel readings are power ratios, they must have some zero reference level. On the 260, this is the standard reference level as used in the broadcast and telephone industries. It is thus possible to use the VOM directly to obtain a decibel reading with reference to this standard load.

It is also possible to obtain answers in decibels to a direct voltage or power ratio as shown in figure 4.3. Using this graph you measure first one voltage and then the other. These are divided and knowing the voltage ratio the reading in decibels can be obtained directly.

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* Series 1 and 2 260 are 6 MW across 500 ohm reference level. See page 36.

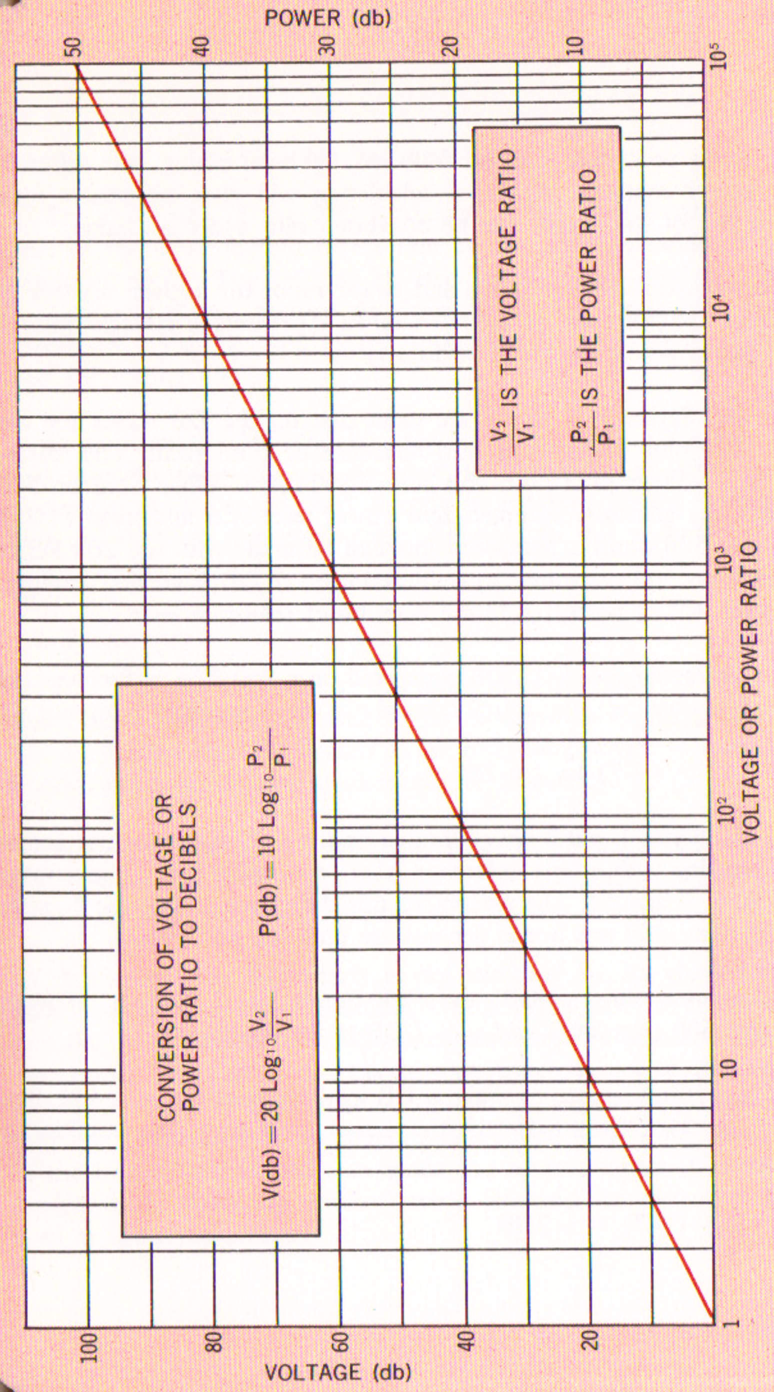


Figure 4.3

The same procedure can be followed by determining two different specific power readings. Again, a calculation will give the power ratio which by use of the graph, can be converted into a decibel value.

Remember that *voltage* ratios and *power* ratios for a given number of DB change are different. A 20 DB change represents a *voltage* ratio of 10 to 1 but a *power* ratio of 100 to 1.

The 260 Series 3, 4 and 5 are calibrated on the DB scales for use across a 600 ohm line with a zero reference of 1 milliwatt. This corresponds to a voltage of 0.7746 volt across 600 ohms. When used on *500* ohm lines, the generally accepted zero power level is 6 milliwatts (1.732 volts across 500 ohms). Measurements can be made with the 260 Series 3, 4 and 5 on 500 ohm lines by subtracting + 7 DB from the readings. The answer will be corrected to the 6 milliwatt reference level.

I.E. If a reading of + 13 DB were read on a 260-3, 4 or 5 connected across a 500 ohm line, the actual level above the 6 milliwatt reference is:

$$+13 - (+7) = +6 \text{ DB.}$$

The 260 Series 1 and 2 are calibrated on the D.B. scales for use across a 500 ohm line with a zero reference level of 6 milliwatts. (The reverse of the 260-3, 4 and 5). The reason for this difference is that the 1 milliwatt, 600 ohm level was not in general use until the mid 1940's.

To convert readings of DB's on a 260 Series 1 or 2 to the 1 milliwatt level across 600 ohm lines, *add* a + 7 DB to the readings.

I.E. If a 260-2 is used to make a DB measurement across a 600 ohm line and the 260 reads —9 DB, the actual level from the 1 milliwatt level is:

$$-9 + (+7) = -2\text{DB}$$

5.0 OTHER MEASUREMENTS

The versatility of the 260 is shown in this section which describes some of the other measurements that can be made in addition to those mentioned so far. The 260 can be used to determine wavelength and (by conversion) the frequency of the signal, it can be used to test transistors directly or it can be used to test transistors in a circuit, and it can be used for testing diodes.

In addition the 260 can be used as a microvolt attenuator or as a field strength meter. It can be used to determine an unknown value of capacity or it can be used directly to measure battery voltage under load. All of these applications are discussed in this section.

5.1 Frequency

The 260 can be used to determine the frequency of many signals which are normally considered to be far beyond its range. Actually in this application the 260 is used as an indicating device to measure wave lengths which are in turn converted into frequency.

A Lecher line is used with the meter as shown; a Lecher line is a transmission line section that is used as a wave meter; a clamp is used as the shorting bar which is necessary for the operation of the line.

A transmission line which is not matched by its characteristic impedance will always have standing waves. This short circuited transmission line will, because it is deliberately not properly matched, have standing waves. The end of the Lecher line which is not at the end of the moveable short is moved near the circuit whose frequency is to be measured. Sometimes loose coupling is required to produce enough energy in the Lecher line in order to make the measurements. Normally, however, a close proximity of the Lecher line and the circuit to be measured is usually sufficient.

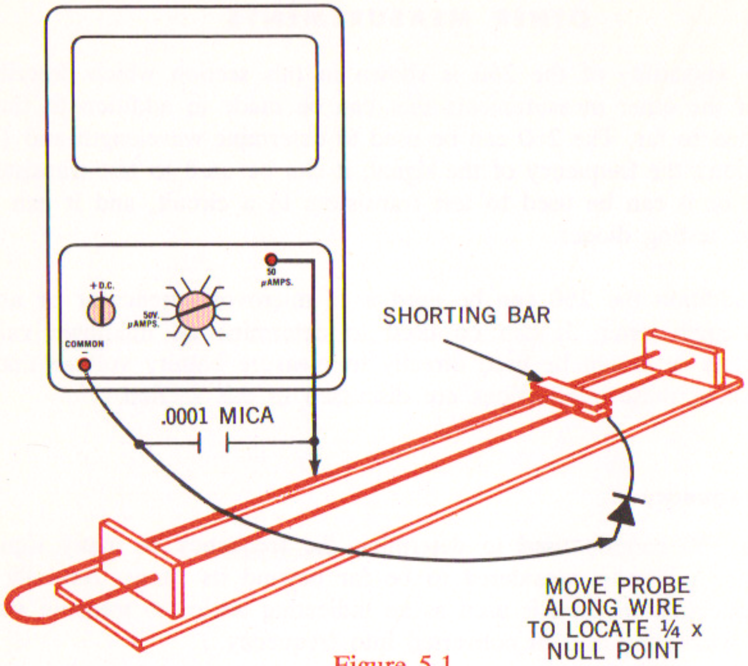


Figure 5.1

The 260 is used on a low current scale and a high frequency rectifier diode is used to convert the high frequency AC into DC current. The standing waves created will produce a voltage minimum at the short circuit and a voltage maximum 1/4 wave length away from the shorted point. By carefully moving the test lead along the Lecher line it is possible to determine a point of current maximum which would be 1/4 wave length from the voltage minimum. From this it is possible to calculate the operating frequency.

It might be necessary to move the shorting bar several times until a sharp indication is given on the meter. Readings can be taken at various positions of the shorting bar since it is possible to obtain a different number of multiples of 1/4 wave length on a particular Lecher line.

Consider a case where the 1/4 wave length is measured as 25 centimeters. Thus for frequency in megacycles:

$$\text{wavelength in meter } (\lambda) = \frac{300}{\text{Freq. in MC (f)}}$$

$$\tfrac{1}{4}\ \lambda = 25 \text{ cm}$$

Freq. in Mc (f)

$$\lambda = 100 \text{ cm} = 1 \text{ m}$$

$$f = \frac{300}{1} = 300 \text{ Mc}$$

5.2 Transistor Tester

The 260 VOM can be used to make certain tests on a transistor to determine whether or not it can be used in a circuit application. In order to measure the transistor when it is used as an amplifier, it is necessary to measure the base current and the collector current.

As shown, a transistor is used with 3 resistors, a switch and the 260. The meter is used on the low resistance range which, in effect, allows the internal battery of the 260 to check the transistor, with the base of the transistor connected to the 220 k ohm resistor the current to the base is zero except for leakage of the emitter-to-base junction. With the switch in position 2, the amount of current to the transistor base circuit depends on the 10,000 ohm resistor. The collector current will now be greater than it was before. These are the two important readings which will determine how the transistor can be used as an amplifier.

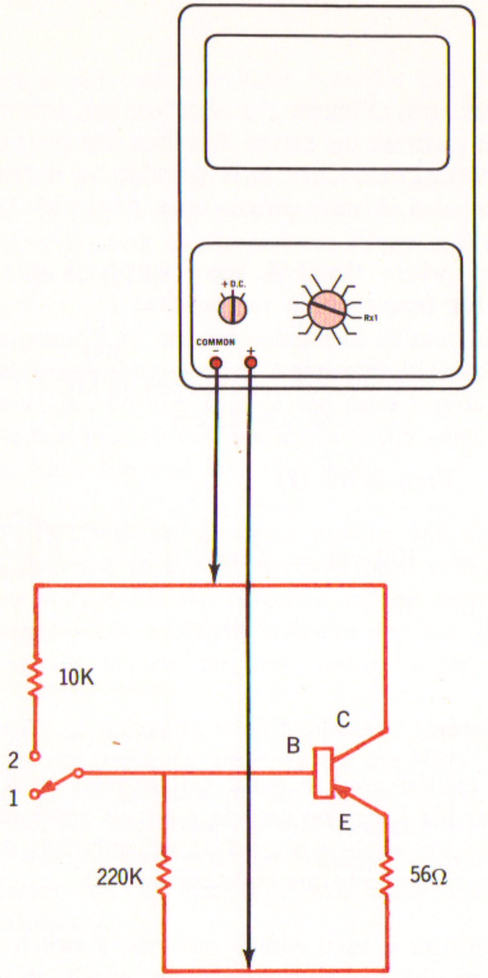


Figure 5.2

This is almost the equivalent of measuring the current amplification of the transistor. For an audio amplifier there should be at least 8 to 1 difference in the readings. If both of the readings are high, the transistor may almost be shorted and if both the readings are low the transistor may have too great a resistance in the forward direction.

5.3 Transistor In-Circuit Testing

The 260 can be used to test transistors in the circuit. Although the transistor is a current operated device, as opposed to the voltage operation of a vacuum tube, it is possible to transfer much knowledge about vacuum tube operation to understanding transistors and their measurements.

The basic PNP transistor circuit is shown in Figure 5.3A. The collector voltage will normally be negative, while the emitter voltage will normally be positive. Ordinarily, the base of the transistor will be slightly negative with respect to the emitter and slightly positive with respect to the collector. For the NPN transistor, the voltage polarities will be reversed.

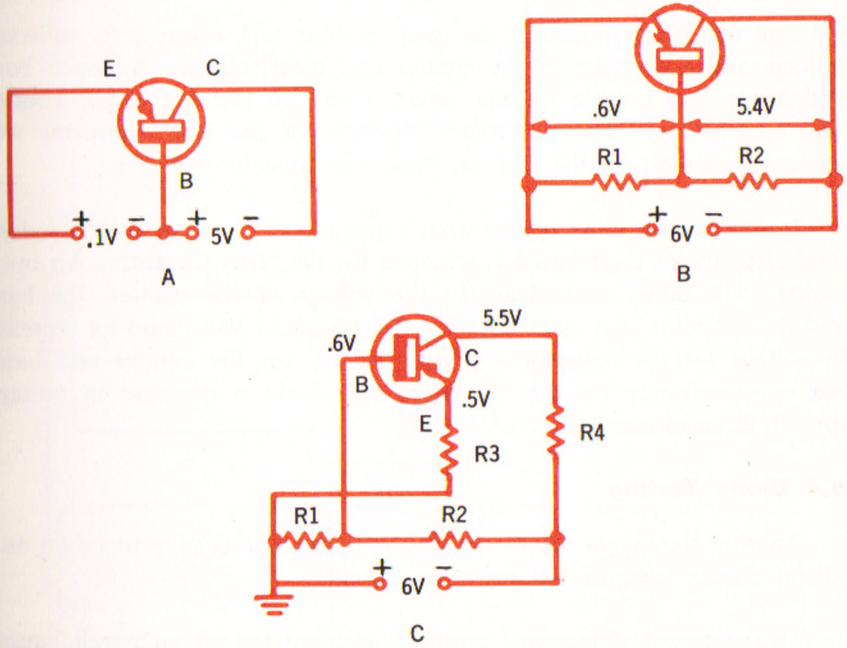


Figure 5.3

The circuit shows two individual batteries but the same thing can be accomplished using one battery and a voltage divider as shown in B of the figure. Here the collector is tied to one end of the battery while the emitter is tied to the other end. The voltage divider network is arranged to provide the proper polarity for the base so that the base is forward biased in relation to the emitter. Either end of the battery may be grounded depending upon the circuit.

Since it is possible to ground either end of the battery power supply it is important to recognize which end is grounded for a given circuit. Figure 5.3 shows the positive side of the battery grounded with an PNP transistor. Note that the collector voltage is —5.5 volts, the emitter voltage is —0.5 volts, while the base is —0.6 volts.

For the PNP transistor, an open emitter will cause zero collector voltage and a decrease in the emitter and base voltages. An open base will cause zero voltage for the collector and an increase in the emitter and base voltages while an open collector for the PNP transistor will cause an increase in the emitter, base and collector voltages.

It is important to recognize what happens to the voltages when individual elements of the transistor are open for the NPN transistor. An open emitter will cause an increase in the voltage of the emitter, the base and the collector. An open base for this transistor will cause an increase in voltage for the collector and zero voltage for the emitter and base. An open collector for this transistor will cause a decrease in voltage for all three elements.

5.4 Diode Testing

Another significant use of the 260 is in the testing of germanium and silicon diodes used in electronic equipment.

Two types of diodes are normally encountered in industrial equipment and in radio/TV equipment. Each has special characteristics which make it suitable for a particular type of service.

The first of these types is the germanium or silicon rectifiers that are commonly found in the power supply section to convert the AC input current to DC for use in the equipment as in Figure 5.4A. These units are comparatively rugged. No particular care is necessary in making measurements on them with the 260.

The diode to be tested would have one end disconnected and the 260 would be switched to R x 1 range. The readings would be checked in both the forward and reverse directions as shown in Figures 5.4B and C.

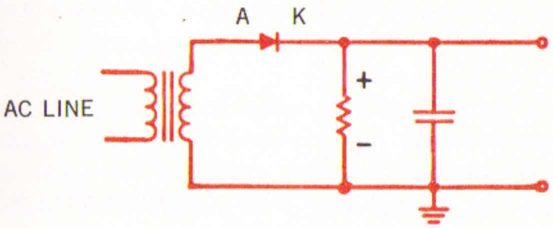


Figure 5.4 A

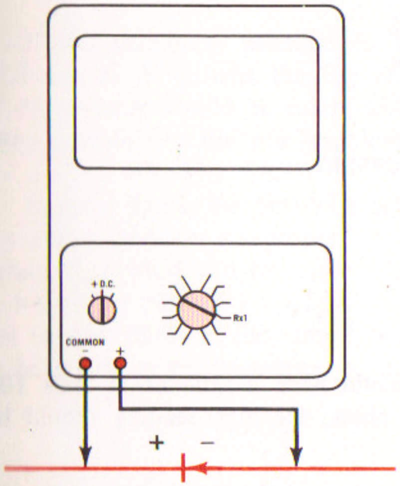


Figure 5.4 B

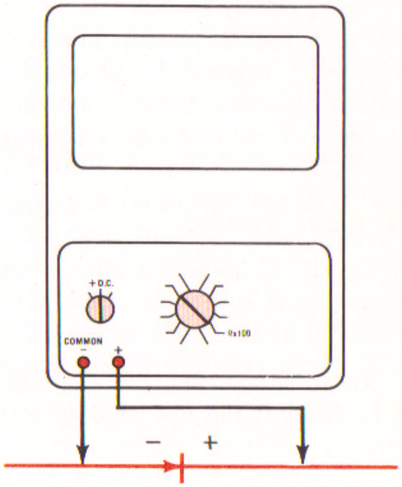


Figure 5.4 C

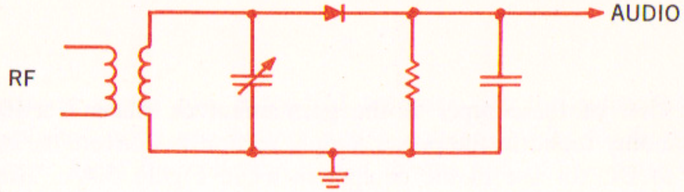


Figure 5.4 D

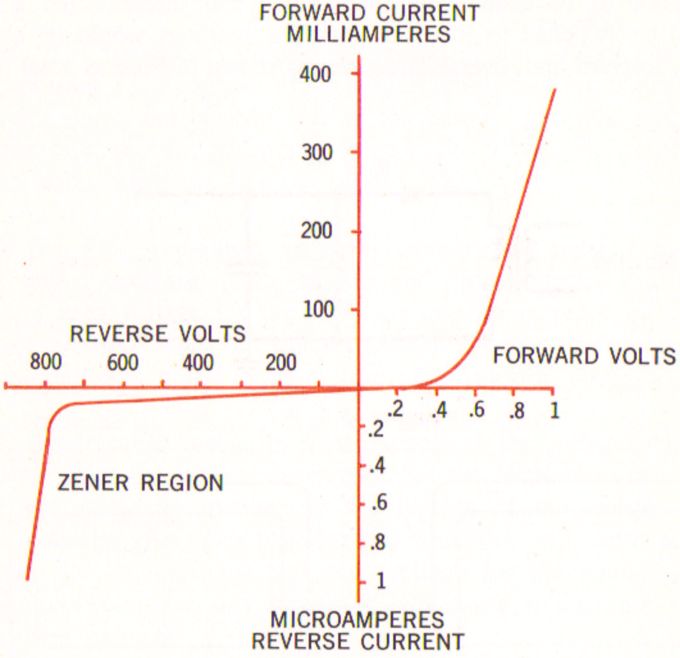


Figure 5.4 E

To be acceptable, the readings should have a ratio of at least 100 to 1. Thus, if the low reading is 15 ohms, the high reading should be at least 1500 ohms. (It may be necessary to switch to the R x 100 range to check the high reading.)

The second type of diode that will be encountered is the detector diode, such as would be found in the video detector of a television set or the second detector of a standard mixer superhet radio receiver. (Figure 5.4D.)

Figure 5.4E shows typical diode characteristics. When a small signal diode is to be checked, the characteristics of the diode should first be determined by examining the data sheet. In rare cases, the detector diodes are extremely low power units and can be damaged by simply connecting a conventional ohmmeter to them.

In measuring power rectification diodes such as are used in power supply rectifiers, there is no problem with the ohmmeter causing excessive current flow. However, when measuring a signal diode in this manner it is possible that the current flow provided from the internal resistance of the VOM battery may be sufficient to cause excessive current flow for the diode. In testing diodes of this type it is necessary to know maximum current flow that can be obtained from the meter under these conditions.

If the maximum permissable DC output current is less than 50 milliamperes, a current limiting resistor should be inserted (the value of this resistor should be subtracted from the forward resistance reading when establishing the minimum resistance for the 100 to 1 ratio).

In some cases, the 100 to 1 ratio may not mean that the diode will necessarily perform its proper circuit function. In some cases, specific values of forward and reverse characteristics are necessary for the diode to work in a particular application. If the diode under test is suspected, test another diode of the same type. If the second diode tested is known to be good, its readings may be compared to the previous diode.

Also, when the forward resistance is relatively high so that the R x 10,000 range must be used to determine if the reverse resistance is sufficiently high, the diode characteristics should be checked to be certain that the 7.5 volts that appears at the ends of the leads on the 260 Series 1 through 5 and the 16.5 volts that appears on the Series 5P units will not cause damage.

Polarity Checks

The 260 can also be used to determine the polarity of an unmarked diode. With the function switch in the Plus DC position, the black test lead in the common jack and the red lead in the plus jack, and with the range switch on the R x 100 position, measurements of the diode resistance are made in both directions. When the connections to the diode result in the lowest reading, the red test lead is connected to the anode (minus) and the black test lead is connected to the cathode (plus) lead. The R x 100 range is used to minimize the possibility of damage to the small signal diodes.

5.5 Capacity

There are two relatively simple methods of determining the value of an unknown capacitor. The first involves the use of a known capacitor and the measurement of the voltage across it as shown in Figure 5.5A.

The 260 can be used to measure the capacity of an unknown capacitor by the very simple circuit that is shown. The unknown capacitor and a known capacitor are connected in series across AC voltage. This AC voltage can be the line AC directly or it can be a voltage obtained from the line across a voltage divider network if necessary. In either case, the voltage can be determined by accurately measuring it on the VOM AC scale.

The voltages that appear across the two capacitors are proportional to their relative reactances. The value of the unknown capacitor can be determined by using the formula:

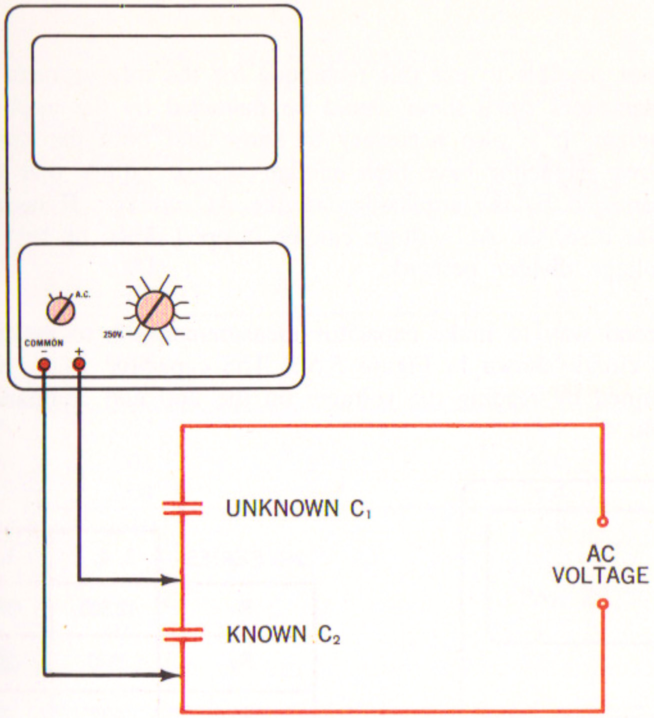


Figure 5.5A

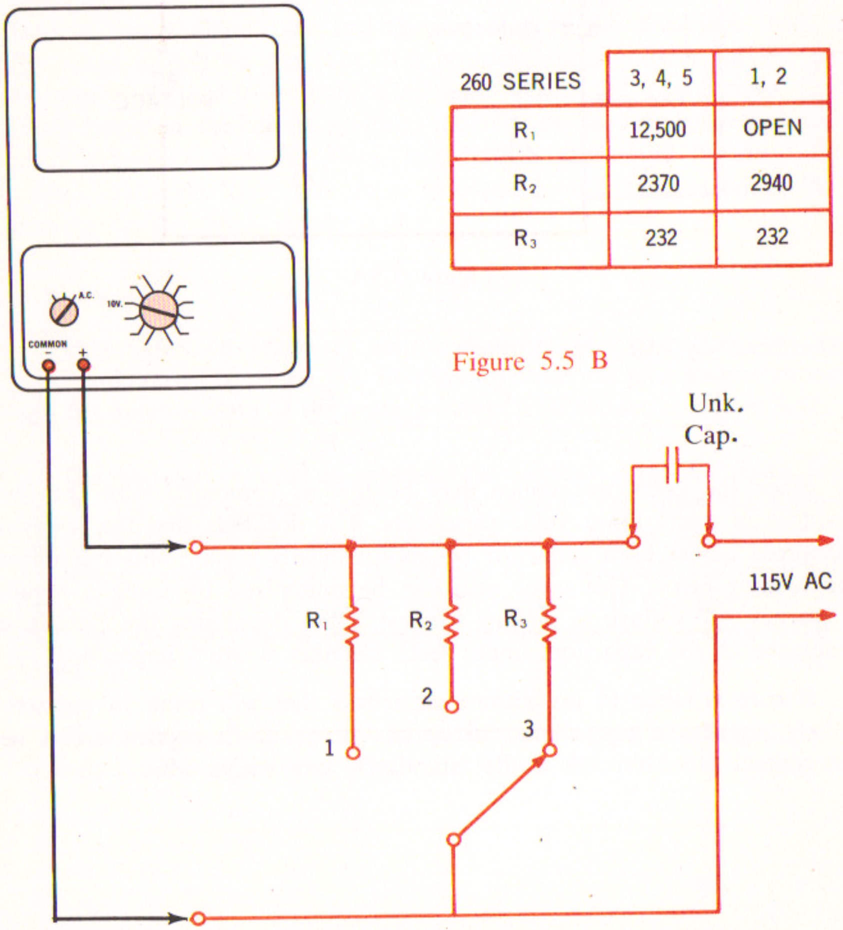
$$\frac{C_1}{C_2} = \frac{E_2}{E_1}$$

Since the 260's impedance may be low as compared with the impedance of many lower value capacitors, it is desirable that the voltages measured across each capacitor be approximately equal. This minimizes the loading error. This error also can be minimized by using a higher frequency AC voltage in making the test, (thus decreasing the capacitive reactance of the capacitors under test) but this is often impractical.

If care is taken to use known capacitors that will result in approximately equal readings, the accuracy of the unknown capacitor can be determined to within 5% if the "standards" are within 1%.

It is not possible to use this technique for the measurement of electrolytic capacitors since these would be damaged by the applied alternating current. It is also necessary to know that both the known and the unknown capacitor have high enough voltage ratings that they will not be damaged by the application of the AC voltage. If necessary in a particular case, the AC voltage can be stepped down by the use of a simple voltage divider network.

A second way to make capacitor measurements is to make up the accessory circuit shown in Figure 5.5B. The capacitor values will then be determined by reading the voltages on the 260 and comparing them with Table 4.



260 SERIES	3, 4, 5	1, 2
R_1	12,500	OPEN
R_2	2370	2940
R_3	232	232

Figure 5.5 B

TABLE 4. CAPACITOR TEST

Unknown Capacitor Mfd.	Approximate Pos. 1 Reading A. C. Volts
.001	0.6
.002	1.1
.003	1.5
.004	1.9
.005	2.5
.006	3.0
.007	3.6
.008	4.0
.009	4.4
.010	4.8
	Pos. 2
.01	1
.02	2
.03	3
.04	4
.05	5
.06	6
.07	7
.08	8
.09	9
.1	10
	Pos. 3
.1	1
.2	2
.3	3
.4	4
.5	5
.6	6
.7	7
.8	8
.9	9
1.0	10

5.6 Microvolt Attenuation

The 260 VOM can be used with precision voltage divider networks to produce a very low calibrated voltage for many applications in audio and D-C circuits.

Checking choppers or measuring amplifier performance are typical examples. The circuit of Fig. 5.6 can provide accurate, low impedance signal sources for these applications. R1 and R2 should be 1% or better units to provide maximum accuracy. When R1 is 1000 ohms, a 1000 to 1 attenuation is achieved.

If an AC signal were desired, E_{UNK} could be taken from a filament XFMR or a signal generator. With the 260 on the 2.5 volt AC range, the attenuator would provide voltages of 0 - 2.5 *millivolts* as the 260 read 0 - 2.5 *volts*. If still lower output levels were desired, R1 can be increased. If R1 were 10,000 ohms, the output would be 0 - 250 *Micro* volts and if R1 is 1 megohm, the output becomes 0 - 2.5 microvolts.

Correspondingly accurately measured very low level DC signals can be produced simply by substituting a DC source (2 dry cells) at the input and using the 2.5 volt DC range.

If these low level voltage needs occur frequently or vary greatly in value, it may be desirable to buy a microvolt attenuator adapter, Model 655, for your 260. (See Page 75.)

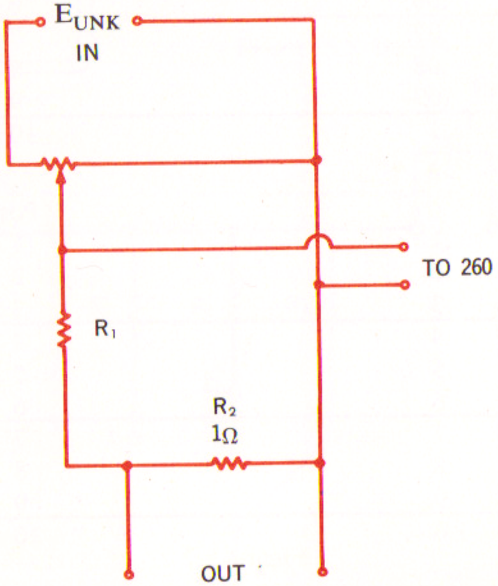


Figure 5.6

5.7 Batteries

The 260, of course, can be used to test the condition of a battery but it is important to recognize that a battery in most cases is more than just a voltage source. Because it must deliver power it is necessary to test the voltage under its normal operating conditions.

To properly test the battery then, the battery must have the proper load resistance, corresponding to the "in use" value. For example, a standard "D" cell such as the Eveready 950 is normally rated at 150 milliamps. To properly test such a cell, a 10 ohm resistor should be placed across the cell as shown. Under these conditions the cell is loaded as it normally would be in the circuit. The voltage appearing at the terminals would provide an accurate indication of the cell condi-

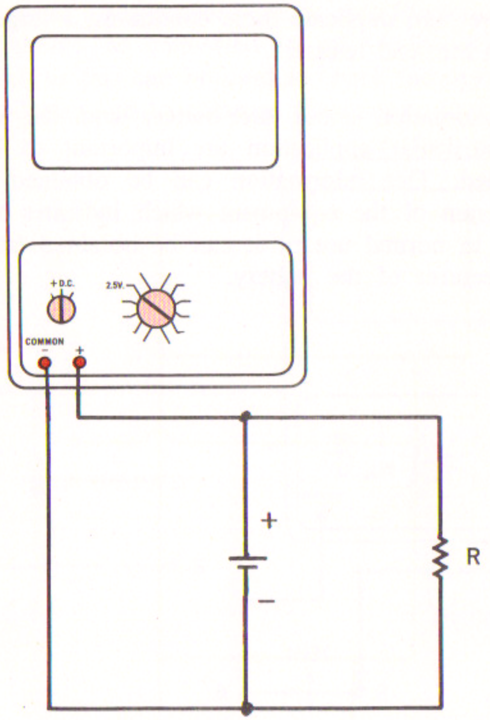


Figure 5.7

tion. Usually it is considered that when the battery voltage falls below about 80% of its rated voltage it should not be used for electronic equipment. (As in any voltage measurement the 260 range used should be the one which gives the highest "on scale" deflection.)

The Battery Tester Adapter (Model 656) can be used to convert the 260 for checking all radio and hearing-aid batteries up to 90 volts, at recommended load or with an external load.

The use for a battery in a particular circuit, of course, varies with the type of equipment. Where the battery is to provide a certain amount of current such as in a transistor radio, the battery cannot effectively function if it cannot deliver this current. There are however, cases as in a bias supply where the battery has a very small current drain. In cases of this sort the battery is not called upon to deliver any significant amount of power. To duplicate these conditions, a large resistance value will be used in the load resistor.

Specific information about the battery and the suggested current drain in its particular application are important to know before the battery is tested. This information can be obtained either from the schematic diagram of the equipment which indicates the current drain of the battery in normal use or it can be obtained from data supplied by the manufacturer of the battery.

5.8 Field Strength

It is possible to use the 260 as a Field Strength Meter to make comparative measurements of field strength. The calibration of such a device would have to be done against an actual field strength meter on a calibrated scale.

A very simple type of field strength meter can be made by connecting a diode rectifier such as a 1N34 across the terminals of the VOM, using the 50 microampere scale. (Fig. 5.8B) This will only work up to VHF frequencies because the leads are too long to make an effective circuit at UHF. Used in this way the 260 will give a comparative reading of the relative field strength provided that the field is reasonably strong.

A field strength meter which is more elaborate and more effective can be made using a tuned circuit and antenna. (Fig. 5.8A) The size of the coil and the capacitor, of course, is a function of the frequency to be measured. If this meter arrangement is to be used for actual field strength measurement, it should be calibrated in microvolts. However, a field strength meter such as this can be used to check the operation of signal generators or oscillators and to compare the relative strength of the two signals.

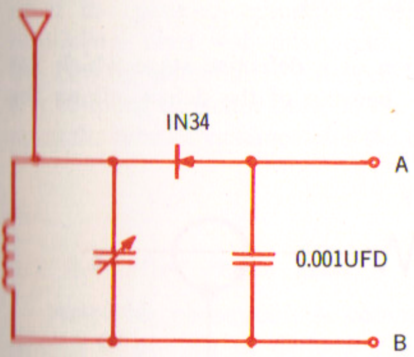


Figure 5.8A

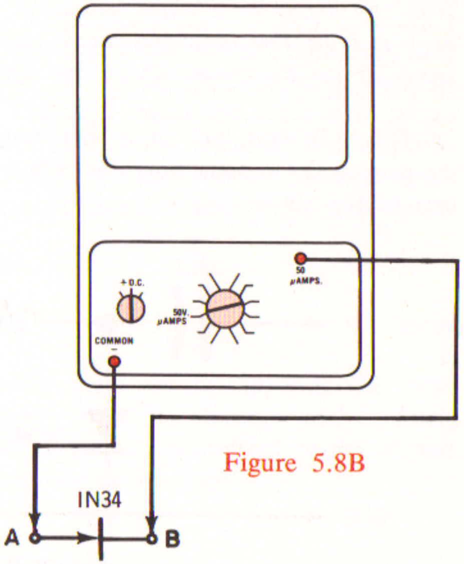


Figure 5.8B

6.0 RECEIVERS

One of the basic functions of the 260 is in receiver troubleshooting, testing, and alignment. Since the basic purpose of the meter is to measure current, voltage or resistance it can be used directly in troubleshooting receivers of all types including radio, television, and communication equipment.

This section shows three of the more unusual servicing uses of the 260; it can be used as a signal tracer, it can be used to measure amplifier phase shift, and it can be used to balance push-pull amplifiers.

6.1 RF Signal Tracing

Signal Tracing is an important part of radio and television servicing and it is possible to use the 260 as a signal tracer to follow a signal in the receiver.

The tester is used on a low DC voltage range and the probe in 6.1A of the figure is used to explore the location of a signal, using either a broadcast signal or a signal generator as a signal source. The signal can be traced to the radio-frequency amplifier and intermediate frequency amplifiers to determine where the signal is lost.

This technique will allow the location of a defective stage which has the proper D-C connections but which, because of the defect, allows the loss of the signal.

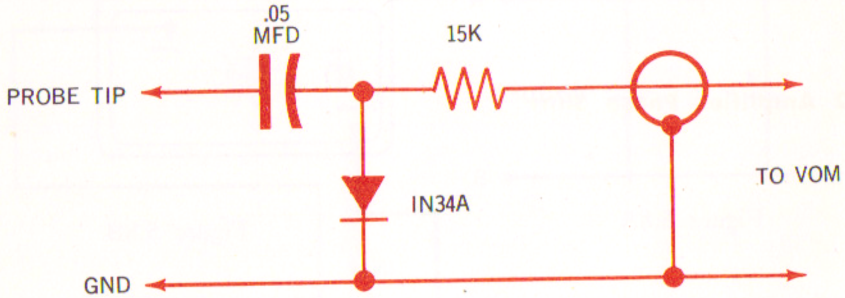


Figure 6.1A

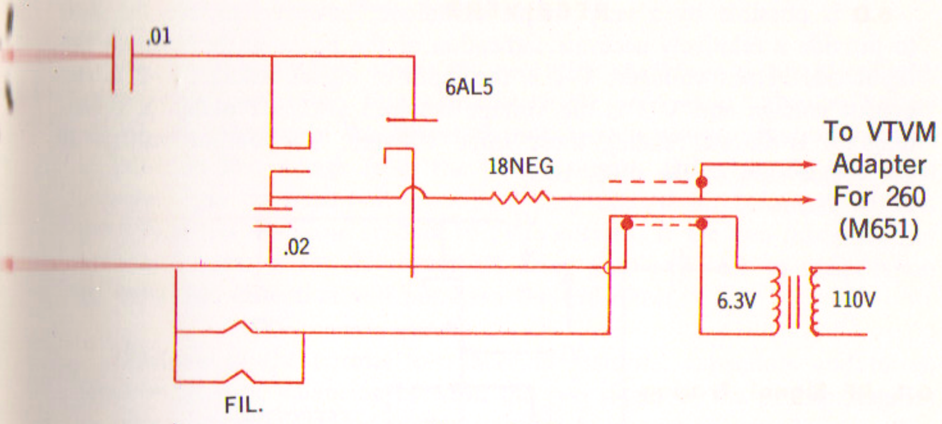


Figure 6.1B

For use with a vacuum-tube voltmeter adapter for the 260, an RF probe as in Figure 6.1B can be used. This circuit uses the diode rectifier to reduce the input capacitance when using the VOM on a-c voltage measurements.

When a probe such as this is used the input voltage rating depends upon the plate-to-cathode rating of the diode, because there are no multipliers used with this circuit. This is a half-wave rectifier in which the contact potential is balanced out. The input capacitor of the probe is a coupling capacitor only, so the input capacitance of the probe depends upon the tube capacitance plus the capacitance that might exist in the leads.

6.2 Amplifier Phase Shift

Amplifier phase shift is commonly measured by applying the input voltage to one set of deflection plates on an oscilloscope and applying the output voltage to the other set of plates. Specialized pieces of test equipment to make this measurement are also available.

It is possible by a very simple technique, however, to use the 260 to provide a relatively accurate indication of the phase angle between the input and output voltages. V-1 is the input or signal voltage, V-2 is the output voltage and V-3 is the voltage between grid and plate. A vector diagram is shown relating these three voltages. The output voltage is the vector sum of the other two.

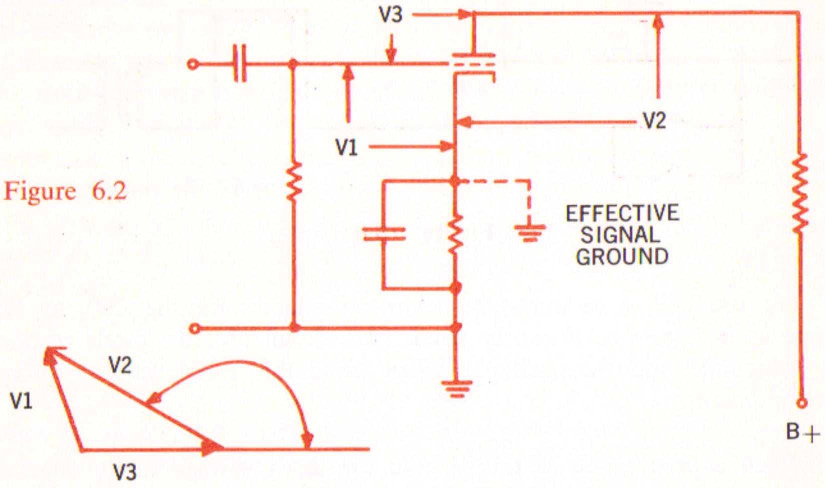


Figure 6.2

To make the test, a fixed input signal is applied to the amplifier. Measurements are then made at the three points shown in the diagram of the AC signal component. The 260 function switch would be in the AC position and the Output jack would be used.

The three voltages would be plotted as shown with their lengths being proportional to the voltage. When this has been done, the phase shift can be measured with a protractor.

Because the low frequency response of the 260 in the "output" function falls off sharply below 100 cps, it is recommended that this test be made only at 100 cps or higher. Relatively good accuracy can be expected at any frequency from 100 cps through 20,000 cps.

6.3 Balancing Push Pull Amplifiers

Push-pull amplifiers, where the two grids are driven out-of-phase with each other, are often found in electronic equipment. This technique allows an increase in the power output, over a single tube, without an increase in the voltage from the power supply. However, for the most effective use of push-pull amplifiers they should be balanced so that each tube has the same amount of plate current. If the two tubes are not balanced, some of the advantages of using push-pull such as cancellation of harmonic distortion will not have the full effect.

Because of the normal tolerances of resistors, capacitors and tubes, some method of balancing between the two stages of the push-pull tubes is almost always included in the circuits. As shown in the diagram (Fig. 6.3; Page 58) this balance control R varies the cathode bias to obtain balance between the tubes. Other methods for obtaining balancing include variation in the drive for each of these grids. In any case, balance can be obtained by measuring the signal voltage at each plate and comparing the two. The drawing shows a much simpler and more direct method. The 260 is connected from the V-1 plate to the V-2 plate and it is used on a DC scale. The DC scale chosen should be at least equal to the B+ voltage for each tube.

When the tubes are exactly in balance, the DC voltage at each plate will be exactly the same, hence the balance control is adjusted until approximate balance is obtained on the 250 V. DC scale and the meter is then switched to a lower DC scale. Balancing then continues until the meter is switched to the 2.5 volt DC scale and the balance control adjusted until zero reading is obtained. At this point, both tubes are conducting exactly the same amount and a perfect balance is obtained.

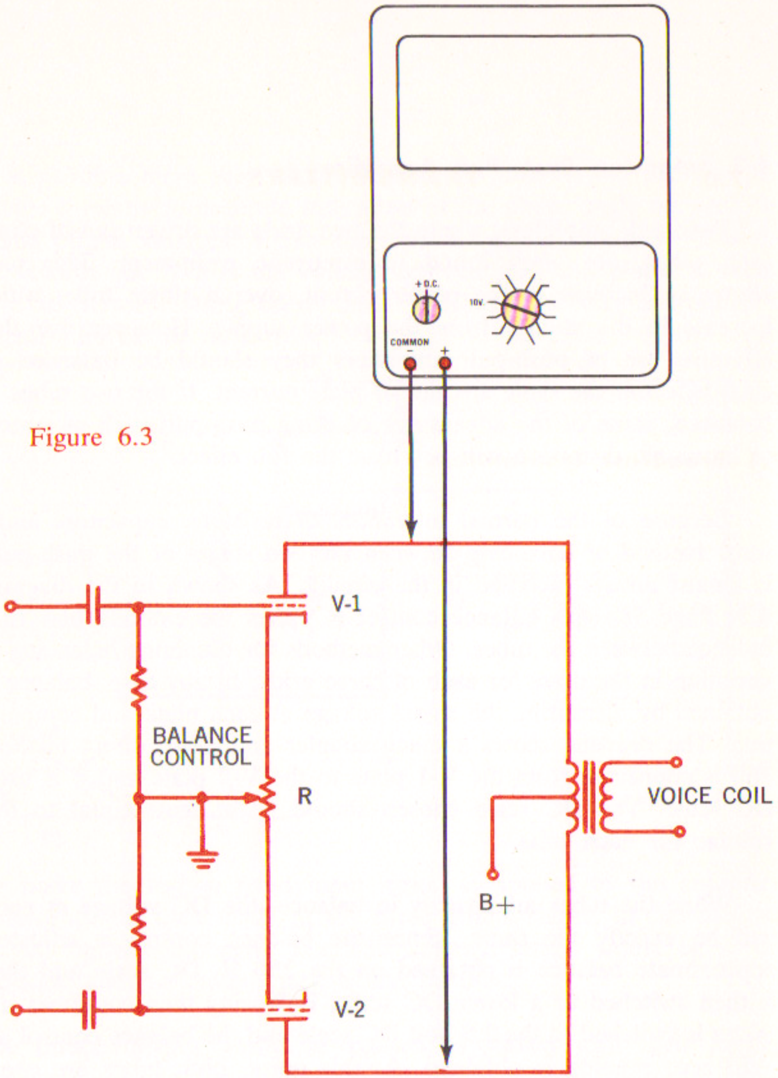


Figure 6.3

It is occasionally necessary to rebalance push-pull tubes since changes in resistance values or tube characteristics are apt to occur with time. Rebalancing should be quite simple since the unbalance will probably be only a small amount. This technique will work for any push-pull amplifier regardless of the frequency of operation or the type of tube operation. However, *no signal should be applied while balancing* since the AC or RF signal could cause damage to the 260 on the low voltage ranges even though no meter reading would be present.

7.0 TRANSMITTERS

Large commercial transmitters have built-in meters to monitor their normal operation while mobile transmitters normally do not. However, for all types a VOM is required for troubleshooting. The 260 can be used on all types of radio and television transmitters both as a troubleshooting instrument and as a check on the built-in meters if the transmitting equipment has such meters.

7.1 Broadcast Transmitters

Commercial broadcast transmitters are designed with panel meters for taking readings of significant parameters. These readings are used to check on the normal operating conditions of the equipment and information from some of these readings is necessary for the station log as required by the FCC.

Because stations are limited to a specific power, for example, it is necessary to measure the plate current and plate voltage in the final stage so that the maximum power of the station will not be exceeded. It is also customary to make close check on the filament voltage of transmitting tubes since a voltage which is higher or lower than normal will reduce the life of the tubes.

In addition to the panel meters that are a part of the equipment, it is necessary to use an accurate VOM such as the 260 on commercial broadcast equipment for two reasons. First, it is good practice to use a multimeter known to be accurate to check on the panel meters; in this way, reliance can be placed on the readings obtained from these built-in meters. The second important use of a multimeter is for a means of preventive maintenance and troubleshooting. Each individual stage will have a number of test points that can be used for this purpose.

An example of a transmitter stage is the low-powered single-ended final radio frequency amplifier shown in Figure 7.1. Six individual tests may be made with the 260 to determine the proper operation of this stage.

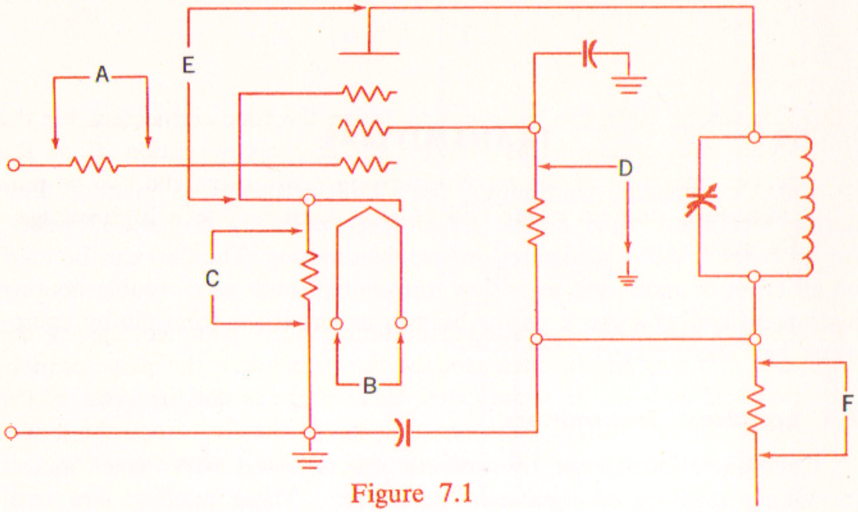


Figure 7.1

Each of these tests is shown in the figure and given below:

A. The grid leak bias voltage can be measured as shown. Because of the high resistance of this grid leak, the VTVM Adapter Model 651 with its high input impedance is suggested for accurate readings. The amount of the bias depends upon the type of operation of the stage and for example, in a Class A stage, there should be no self-bias across the grid leak resistor. In a Class B or Class C stage (which would have to be used in push-pull), the amount of bias obtained, is a function of the amount of the drive signal on the grid.

B. Filament voltage can be measured with the 260 at the two tube pins as shown in B, in order to determine the actual voltage at this point. As indicated above, the tube life depends upon having the filament voltage very close to the design center rating of the tube.

C. A cathode resistor is used as a form of tube self-protection; this resistor which is part of the bias network for the tube will provide a certain amount of bias even if there is no excitation on the tube. Because of this resistor, the plate current of the tube will be limited to safe values even if there is no other form of bias. The voltage across this resistor can be measured, as shown, on a low-voltage DC scale.

D. The screen voltage is measured between the tube connection for the screen and ground. This voltage will give an indication as to the proper operation of the screen-dropping resistor and the two by-pass capacitors, one on either end of this resistor. Use a high-voltage DC scale.

E. One of the basic operating conditions is the plate voltage of the tube and this can be measured as shown between the plate connection and cathode. In some cases, this voltage is not the same as the power supply voltage because of drops in the line from the power supply to the tube and the voltage drop in the cathode resistor.

F. To determine the power in this stage, the plate voltage and plate current are both required. It is possible to measure the plate current by breaking the plate lead and inserting a milliammeter. Another way of measuring the plate current is to determine the drop across a resistance in the plate circuit as shown. From this reading the plate current can be calculated. Note that the plate current is not the same as the cathode current because of the current flow from the cathode to the other elements of the tube.

One of the best troubleshooting techniques is to make a tabular list of the normal or nominal operating voltages using the 260 as shown in the figure. This is done for a stage known to be in its peak operating condition. When trouble occurs with the stage, it is possible to measure the individual readings and compare these to the normal readings in the chart. In this way, quite often it is possible to quickly localize the trouble to a defective part of the circuit or even to a defective component.

There are other supplemental uses of a multimeter in locating the defective part in a stage such as this. These other applications include measuring the continuity of resistors, measuring a capacitor for a possible short circuit and measuring the continuity and resistance of a coil.

7.2 Transmitting Tubes

Operation of transmitter tubes can be tested with the 260 knowing the tubes' ratings and class of service. There are various types of ratings for power tubes depending upon the service in which the tube will be used. Three of these ratings are: Continuous Commercial Service, Intermittent Commercial and Amateur Service, and Intermittent Mobile Service.

Continuous Commercial Service (CCS) is that rating applied to a tube where the basic considerations are long tube life and maximum dependability. Because of this, tube ratings tend to be lower in this service than in the other types of service. In this application a tube is assumed to be used continuously.

In the Intermittent Commercial and Amateur Service (ICAS) the primary consideration is the output power from the tube and the long tube life is a secondary consideration. Intermittent Commercial Service normally applies to tubes that are used where the "on" or active period for the tube usually does not exceed five minutes and is followed by a stand by or "off" period of at least the same duration. Clearly it is possible to have a higher rating for a tube in this type of service than with Continuous Commercial Service. In Amateur Service, which is a part of the same rating, the tubes are considered to be used on an infrequent basis or used in amateur transmitters where, by the nature of the service, the tube is only "on" an intermittent basis. Usually the ICAS ratings are much higher than the CCS ratings. From an overall view point an increased power output required of the tube usually means a reduction in the tube life. However, in general, it is possible that a small tube operating in ICAS service will give the same life as a larger tube operating in CCS service.

The third type of service is Intermittent Mobile Service (IMS) where this tube application requires a high power output for a short time. Because the equipment is mobile the smallest tubes that will do the job are required. In this service the ratings are based upon a transmitter "on" period not to exceed fifteen seconds followed by an "off" or standby period of at least sixty seconds.

Consider the type 6146 as in tables 5 & 6. Plate input power is the total power supply to the plate and is the product of the D-C plate voltage (E_b) and the direct current in the plate circuit (I_b).

Plate dissipation is the power loss in the tube. This is power in the form of heat resulting from the electron flow to the plate and is the difference between the power provided to the plate of the tube or the tube input and the power that the tube delivers to the load circuit.

Tube power output or the power output obtained from the tube is the plate input less the plate dissipation. Useful power output is the power output as measured at the load of the output circuit.

Grid excitation or grid driving power is the signal power input to the control grid to which must be added the power which is lost in the bias supply for the grid. Grid driving power is equal to grid signal voltage multiplied by the grid current.

Grid input for the screen grid is the D-C power which is provided to the grid two. This is the product of the screen voltage and screen current. Power lost in the screen grid circuit is the power dissipated as heat caused by electron bombardment.

The 6146 beam power transmitting tube is designed for use with full ratings at 60 Mc; it has a maximum plate dissipation of 20 watts in CCS service and 25 watts in ICAS service. The maximum ratings for this tube are shown in Table 5, typical operation is shown in Table 6.

Measuring the operating conditions in a specific class of service, will allow a direct comparison to the tube's ratings.

TABLE 5. MAXIMUM RATINGS — TUBE TYPE 6146

Maximum Ratings:	CCS	ICAS	
DC Plate Voltage	600 max	750 max	volts
DC Grid-No. 2 Voltage	250 max	250 max	volts
DC Grid-No. 1 Voltage	−150 max	−150 max	volts
DC Plate Current	140 max	150 max	ma
DC Grid-No. 1 Current	3.5 max	4.0 max	ma
Plate Input	67.5 max	90 max	watts
Grid-No. 2 Input	3 max	3 max	watts
Plate Dissipation	20 max	25 max	watts
Peak Heater-Cathode Voltage:			
Heater negative with respect to cathode	135 max	135 max	volts
Heater positive with respect to cathode	135 max	135 max	volts
Bulb Temperature (At hottest point)	220 max	220 max	°C

TABLE 6. TYPICAL OPERATION — TUBE TYPE 6146

Typical Operation as Amplifier up to 60 Mc:	CCS		ICAS		
DC Plate Voltage	500	600	600	750	volts
DC Grid-No. 2 Voltage	170	150	180	160	volts
From series resistor of	36000	51000	43000	56000	ohms
DC Grid-No. 1 Voltage	−66	−58	−71	−62	volts
From grid-No. 1 resistor of	27000	20000	24000	20000	ohms
From cathode resistor of	470	470	430	470	ohms
Peak RF Grid-No. 1 Voltage	84	73	91	79	volts
DC Plate Current	135	112	150	120	ma
DC Grid-No. 2 Current	9	9	10	11	ma
DC Grid-No. 1 Current (Approx.)	2.5	2.8	2.8	3.1	ma
Driving Power (Approx.)	0.2	0.2	0.3	0.2	watt
Power Output (Approx.)	48	52	66	70	watts

8.0 INDUSTRIAL

The 260 is a basic industrial tool for measuring and testing industrial electronics of all types. This section shows how the 260 can be used to measure power tubes including the ignitron and thyratron, to test motors and generators, and, with auxilliary equipment, to measure temperature.

8.1 Power Tubes

The 260 has direct application to industrial power tube testing. Two special tube types used in heavy industrial equipment as rectifiers are thyratrons and ignitrons. The thyratron is essentially a gas filled triode, although in many types of thyratrons there are auxilliary tube elements as well.

A thyratron, when not conducting, is essentially an open circuit and the voltage drop across the tube should indicate this. When a thyratron is conducting, it is essentially a very low resistance, hence the anode voltage should be very close to the cathode voltage. Because of the large currents conducted by these tubes, the voltage drop measurement technique is recommended for testing the operation of a tube in a circuit rather than using the 260 as an ammeter.

The ignitron is essentially a large power diode in which the cathode is a pool of mercury. In operation this mercury is vaporized so that there is conduction from the cathode to the anode. Large ignitrons can carry thousands of amperes. These tubes are very expensive and have a long life under normal conditions.

It is possible to use the 260 to test the operation of an ignitron. The ignitor of this tube is the element that starts the tube conduction and, in a tube that does not operate properly, the problem is often the ignitor circuit.

The tube's ignitor can be tested. After the tube is removed from the equipment, using the 260 as an ohmmeter, connected between the ignitor lead and the cathode bus, readings will usually indicate if there is trouble in the ignitor circuit.

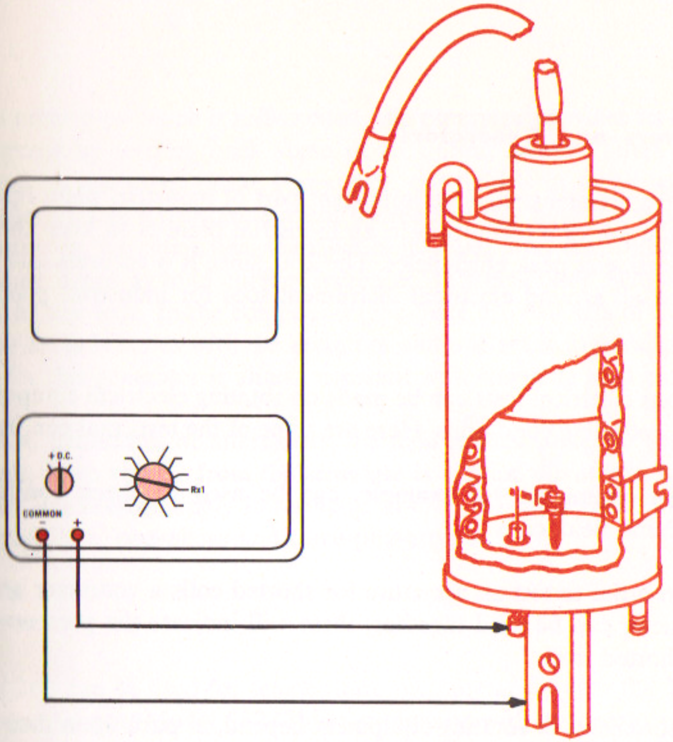


Figure 8.1

The ignitor dips into the mercury cathode in order to start conduction. For testing, connect the 260 as shown in figure 8.1. Slowly tilt the tube toward the ignitor stud about 15 degrees and then tilt it about 15 degrees in the opposite direction. In a tube with no defects the resistance will vary smoothly up and down.

If the resistance is below 10 ohms, or above about 200 ohms, there is probably a defect in the tube. If the resistance change is erratic, or if the resistance shows sudden change, the ignitor is either broken or wetted so that it does not make the proper contact with the mercury pool. Either of these readings mean a defective tube. If the ohmmeter reading is either zero or infinity it means that the ignitor has been destroyed and the tube can no longer be used.

8.2 Motors and Generators

Preventive maintenance is an important part of industrial plant operations because the job of a technician in an industrial plant is to keep the equipment operating at peak efficiencies. The 260, since it is accurate and reliable is the best all around electrical instrument tool for industrial plant maintenance.

Various electrical tests can be made on rotating electrical equipment to check all operating conditions. Here are some of the tests that can be made.

1. An ohmmeter, for example, can be used to check continuity of shunt field coils.
2. In order to test an armature for shorted coils a voltmeter and millimeter can be used together; these will indicate the presence of any shorted coils.

Measurements of rotating equipment depend, in part, upon their operating characteristics. D-C motors for example can be series, shunt and combination series-shunt or compound. In the series type where the field winding is in series with armature, the field strength changes with armature current and starting torque is high. An increased load reduces the speed and the torque increases. In the shunt type, the field winding is in parallel with armature and the field strength does not vary with armature current. Starting torque is lower and speed varies little with load changes. In the compound type of motor, there are two sets of field windings, one set in parallel with the armature while the other set is in series. Characteristics of the compound motor for both speed and load can be varied by relations of the two sets of windings.

D-C generators can be divided into two classes depending on the source of excitation for the field. In the separately-excited type there is an outside source of D-C current for field which is separate from the motor itself.

The other type which is self-excited, the generator provides its own D-C field current by feeding back some of its output power. Three different arrangements are used. In the series type, the field is in series with armature; it operates as a constant-current source and this field has few turns of heavy wire. In the shunt type the field is in shunt with the armature; output voltage drops as load current increases, this generator field has many turns of lighter wire. In the compound type there are two sets of field windings; one set is in series with the armature and one set is in parallel. Output voltage for this generator is almost constant with changing load current.

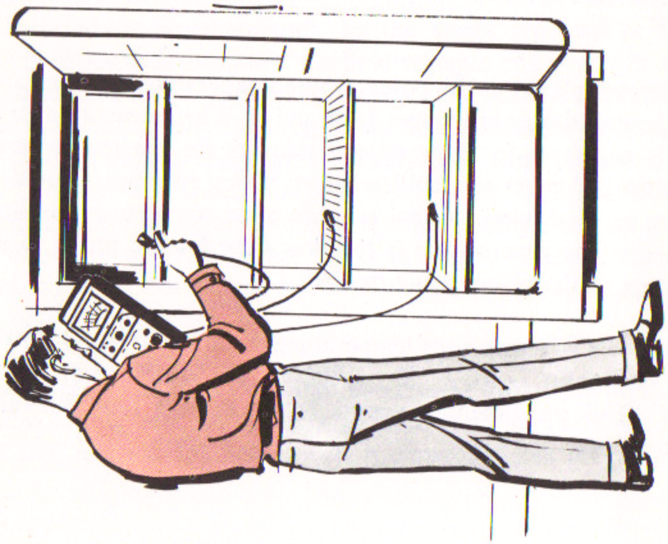
In A-C generators or alternators, the field rotates while the armature is stationary. High voltage from the armature is applied directly to load while slip rings and brushes apply low-voltage D-C to the rotor field. Alternators are single-phase, two-phase and three-phase types.

8.3 Temperature

The 260 can be used for temperature measurements with the Temperature Tester Adapter Model 652. This combination with temperature-sensitive probes, provides accurate temperature indications with scales calibrated in degrees F or C.

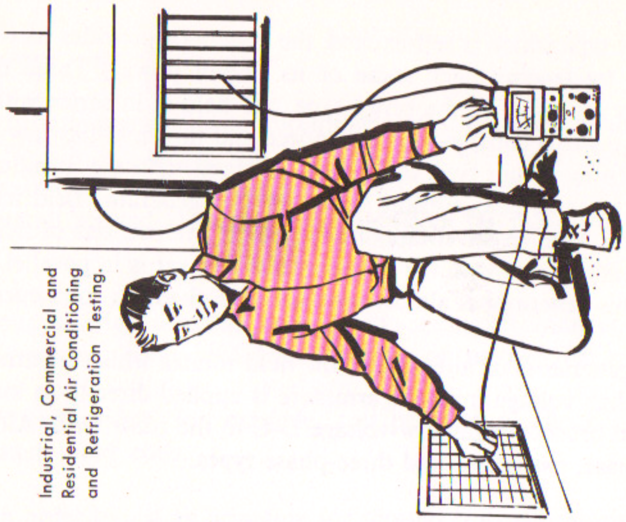
Probes are placed at the points where temperature readings are desired as with the unit shown in Figures 8.3A and B. When measuring air temperature, it is necessary to allow several minutes for the temperature of the probe sensing element to stabilize before taking readings. Liquid temperatures can be read within a few seconds after complete immersion of the probe body. The general rule is to allow time for the probe to attain the temperature of the object being measured.

The Model 652 measures temperatures from —50° to +250°F in two ranges, one from —50°F to +100°F, the other from +100°F to +250°F. This instrument is supplied with one 15 foot general purpose thermistor lead.



Industrial, Commercial and Residential Refrigeration Testing.

Figure 8.3A



Industrial, Commercial and Residential Air Conditioning and Refrigeration Testing.

Figure 8.3B

It will also accommodate two additional leads. Accuracy is within 3°F for any scale reading. Near center scale, the accuracy is within 2°F.

(0° to 250°F) Typical applications include these:

1. Solid-state circuit testing—Because of problems of temperature sensitivity many circuits require testing at various ambients.
2. Grain storage—Long probes are inserted into stored grain in silos to read the temperature rise.
3. Weather indicators—Both wet-bulb and dry-bulb readings are possible with electronic systems.
4. Motor and generator testers—Rise in operating temperatures are often the first sign of motor or generator failure.
5. Freezer and cold storage units—Normal in-use temperature checks are necessary for routine maintenance.

9.0 AUTOMOTIVE

The 260 can be used for automotive testing but it does not replace more specialized equipment used for and designed for this purpose.

The 260 can make four different types of automotive tests. These are:

Quick-Check Tests

Battery Testing

Voltage Drops

Ignition Coil

9.1 Quick-Test Checks

The 260 can be used to make a quick check of battery, starter, and starter circuit. This is done by connecting one voltmeter lead to the starter relay (Figure 9.1A) and the other to a good ground on the chassis or engine. Depress the starter switch or button and, while the starter is cranking the engine, note the voltmeter reading. The reading should be at least 4.8 volts or more for a 6-volt system or 9.6 volts for a 12-volt system.

If readings less than this are obtained, there is probably a defect somewhere in the electrical system and the battery starter switch and the cables should be checked. This will give, at a quick glance, an overall measure of the effectiveness of the starter electrical system.

If the voltage is low, the trouble can usually be located quickly by checking the individual parts. (See Fig. 9.1B)

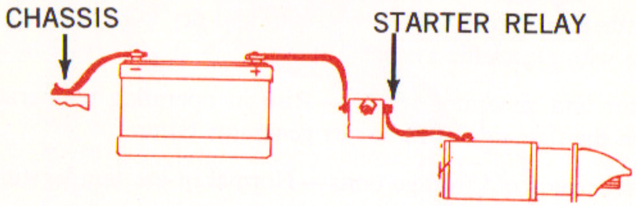


Figure 9.1A

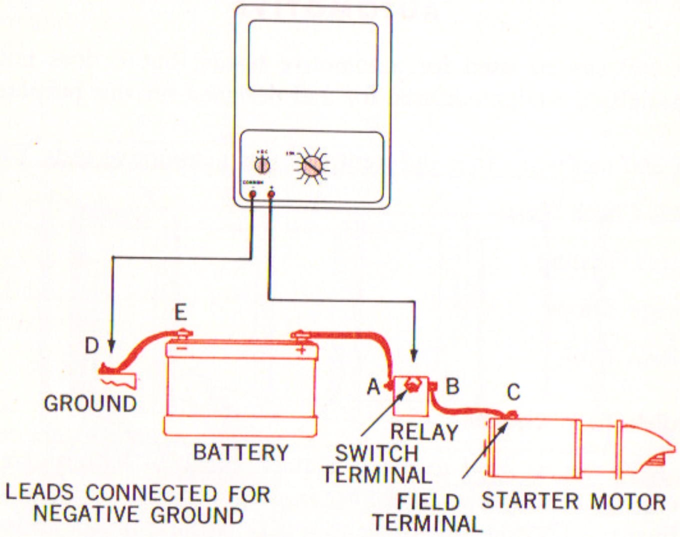


Figure 9.1B

All readings below are for 12 volt systems. For six volt systems, all readings should be ½ the indicated value.

To prevent the engine from starting during cranking tests, disconnect the center lead from the distributor cap.

Connect the 260, on the 2.5 volt range, across points A & B. (The pointer will move beyond full scale but no damage to the tester will occur). Crank the engine. While cranking, the 260 should read almost "0". A reading of more than 3 divisions (.075 volt) generally indicates a faulty starter relay.

Next, connect to points B & C. When cranking the engine, the reading should not exceed .3 volts. Higher readings indicate a bad cable or a loose connection. Connect the 260 to points D & E. Crank engine. Reading should be .1 volt (4 divisions) or less. Higher readings indicate a bad cable or loose connection.

Finally, turn the 260 to the 10 volt range and connect across points C & D. (The pointer will move beyond full scale but no damage to the tester will occur). Crank the engine. Readings of *less* than 10.0 volts indicate a "low" battery, (partialy discharged), a faulty battery or loose battery cables.

The regulator can be quickly checked for high voltage setting by grounding the generator field lead with a jumper and connecting the voltmeter between chassis ground and the "bat" lead on the voltage regulator. The motor is started and the throttle is set for a maximum charging rate (about 1800 rpm). Under these conditions the voltmeter reading should not be greater than 8 volts for the 6 volt system or greater than 16 volts for the 12 volt system.

It is possible, in the same manner to run a quick check on the distributor points by connecting the voltmeter leads to the distributor terminal and a good ground. The ignition is turned on and the points should be held open by the cam or with a wedge. The voltage as measured across the points should be the same as the battery voltage. With the points closed, the reading on the voltmeter should be 0.1 volt or less for a 6 volt system and 0.2 volt or less for a 12 volt system.

NOTE *Do not attempt to measure starting current in an automotive system with the 260 VOM.*

9.2 Battery Testing

In order to test the battery, the 260 VOM should be connected as a voltmeter across the battery terminals. With the ignition switch off, the starter should be engaged and the voltmeter should be read while the engine is turning. With normal starting current and with a fully charged battery, the battery voltage should read 5.1 volts or higher for the 6 volt system and 10.2 volts or higher for the 12 volt system.

Voltage for individual cells, under the conditions given above, will be between 1.7 and 2 volts for a specific gravity reading of about 1.275. With a load applied, the voltage should remain constant for about 30 seconds and the cells should read within 0.2 volts of each other. With a specific gravity reading of between 1.240 and 1.255 for a partly discharged battery the cell voltage should be between 1.5 and 1.7 volts.

If the battery has a weak cell or, for a discharged battery, the voltage for each cell will be below 1.5 volts and the specific gravity reading will be from about 1.200 to 1.225. Where this is measured, the battery should first be charged and then re-tested.

Where the voltage varies more than 0.2 volts between individual cells on a battery under load after it has been charged, there is a clear indication of a defective cell. The cells which measure lower than normal are the defective ones.

Current leakage or a continual discharges of the battery that tends to discharge the battery, can be tested by disconnecting a battery terminal and connecting the 260 in series as an ammeter. This may be done by connecting the ammeter using an alligator clip between the terminal and the cable that has been removed. No attempt to start the engine should ever be made while the ammeter is connected in this manner.

With the ammeter connected above, the reading should be zero. If there is a reading, each individual circuit, in turn, should be disconnected, including the stoplight, radio, heater, dome light, parking light, or any other item that draws current, to see if there is a zero reading.

If the ammeter shows zero, when a particular circuit has been disconnected or removed, this indicates that there is leakage in that particular circuit.

9.3 Voltage Drops

Voltage drop in the ignition system can also be measured using the 260. The voltage drop is very significant in the starter circuit, for example, since the starting current is extremely high. Tests should be made while the starter is cranking the engine and for a battery with full charge, the battery voltage should be 5.1 or more for a 6 volt system and 10.2 volts or more for a 12 volt system. This should be about 0.3 volts less at the starter terminals for a 6 volt system and about 0.6 volts less at the starter terminals for a 12 volt system.

In any 12 volt ignition system a ballast resistor will be found in the primary circuit. This is either a separate resistance or it is built into the wire itself. The purpose of the resistor is to limit the primary current flow through the coil and distributor points to a maximum safe value.

In many systems, this resistor is removed from the circuit during cranking. The ignition coil is then directly connected to the battery through the points. This maintains the ignition voltage as high as possible during the cranking period. When conducting cranking voltage tests for a system of this type it is necessary to attach the voltmeter leads to the primary terminals of the coils in order to obtain proper readings.

9.4 Ignition Coil Testing

The 260 can be used as an ohmmeter in testing ignition systems for possible troubles. The high tension lead is removed from the center of the distributor cap. With the 260 used as an ohmmeter, the primary and secondary windings of the ignition coil are measured for continuity. Where the breaker points are located between the low end of the primary and ground, these points must be closed to provide a complete circuit.

Exact values of resistance cannot be given for either the primary or secondary of the coil since it depends upon the manufacturer's specification; however, the 260 can be used to check for continuity and it is a very simple matter to determine if either the primary or the secondary circuit is open.

10.0 260 ADD-A-TESTER ADAPTERS

Various applications showing the Simpson 260 add-a-testers are described elsewhere in the text. A brief description and illustration are shown here.

Transistor Tester, Model 650

Used to check low and medium power transistors of the junction type. Checks Beta and Ico with an accuracy heretofore found only in laboratory type instruments.

DC VTVM, Model 651

High sensitivity with laboratory type DC coverage (10 ranges) offers higher accuracy of reading. Ideal for general VTVM applications, transistorized circuitry (design and servicing).

Temperature Tester, Model 652

Three lead hook-up, ideal for production and engineering spot temperature measurements, servicing of heating and refrigeration devices, and for general type measurements. Normally supplied with °F scale; can be supplied with °C scale.

AC Ammeter, Model 653

Wide frequency range 50 to 3,000 cps. Ideal for government engineering and testing, commercial engineering and testing, industrial applications, general servicing, electrical installations and servicing.

Battery Tester, Model 656

Checks all radio and hearing aid batteries up to 90 volts at the manufacturer's recommended load, or any external load.

Microvolt Attenuator, Model 655

Calibrated output from 2.5 microvolts to 250,000 microvolts from DC or audio frequency power sources. Applications include audio circuitry, DC circuitry (choppers, low level DC systems) design and servicing; and industrial control systems.

Audio Wattmeter, Model 654

Can be used as a dummy load in some DC systems. Ideal for service and installation of high fidelity and general type audio systems, telephone and intercoms, and public address systems.

Milliohmmeter, Model 657

Measures resistance values as low as .001 ohm. Ideal for accurate measurements of low resistance windings in motors, generators, and transformers; accurate measurement of ammeter and milliammeter shunts; and accurate measurement of contact resistance in switches and relays.

DC Ammeter, Model 661

Multi-range, excellent accuracy of reading. Applications: Automotive accessories (servicing), automotive electrical system, DC supplies, industrial (DC control systems — welding, heavy current rectifiers, etc.)

260 ADD-A-TESTER ADAPTERS

TRANSISTOR TESTER
MODEL 650

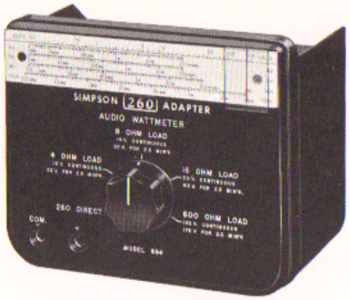
DC VTVM
MODEL 651

TEMPERATURE TESTER
MODEL 652

AC AMMETER
MODEL 653

BATTERY TESTER
MODEL 656

MICROVOLT ATTENUATOR
MODEL 655



AUDIO WATTMETER
MODEL 654

MILLIOHMMETER
MODEL 657

DC AMMETER
MODEL 661

Updating older 260's

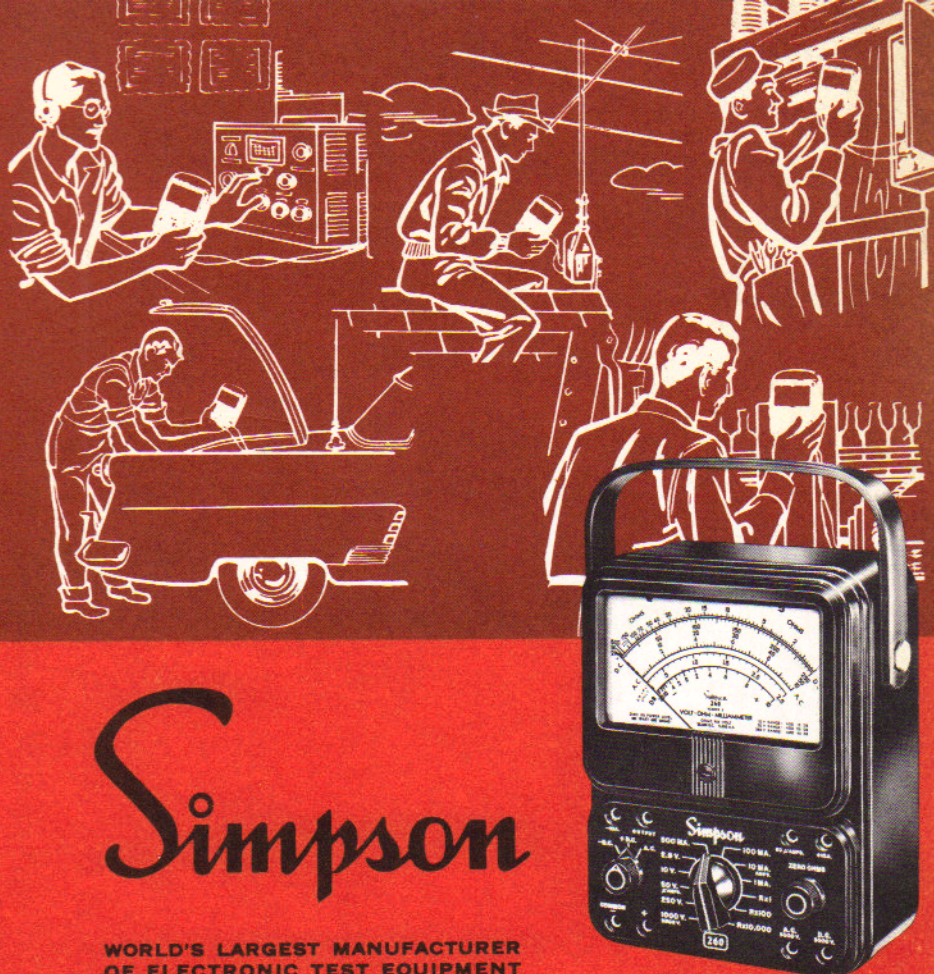
While it is impractical to "convert" older 260's to duplicate the present version, some features can be added.

Series 1 and 2 units did not have fuse protection. As a result, replacement of the 11.5 ohm bobbin on the RX1 range is frequently necessary.

The fuse can be added to these units cutting out the lead between the "–" or common jack and soldering in the pigtail fuse, part #1-117702 that is available from any Simpson parts station. Since the fuse resistance is part of the RX1 circuit, the 11.5 ohm bobbin should be replaced at the same time with part #10-805073, 11.2 ohms. If this is not done, a slight error will be added to the RX1 range. The movement overload varistor can be added to Series 1, 2, 3 and 4 260's. Order part #12612. Full instructions are included with each unit.

This book shows a few of the thousands of applications of the 260 with details on those that we felt would be of special interest to you. If you have a question about using your 260, why not write to us about it? We'll be glad to try to help you.

NOTES


Simpson
260
VOLT-OHM-MILLIAMMETER
ZERO OHMS
100 MA.
10 MA.
1 MA.
Rx1
Rx100
Rx10,000
2.5 V.
10 V.
50 V.
250 V.
1000 V.