



The Science of Measurements

Voltmeters (Digital & Analog)

By Hal Silverman WB6WXO
SOARA Education Director

I am in the process of putting together a technical seminar, a part of which will cover “hands on” electronic measurements. Why is this important and why this subject, you ask? In a previous life I was a calibration technician and later on in my career I managed a secondary standards lab. So, maybe that is what is driving me to write this. The other thing is there is never too much knowledge when it comes to learning the electronics business.

Some day you may want to dabble in older used equipment and there will be a need to “tune up” an older piece of equipment. The first instrument you will need is a meter. Over the past 40+ years I have been in the electronic business and for almost all of that time, I have been a ham. The instrument of choice when I broke into the electronic business was the Simpson model 260 analog multimeter. For its time and place it was a workhorse of the industry.

In the early 1960s, digital technology started to show up on the electronic production floor as well as in the secondary standards labs. Today for all practicable usage the 3 ½ digital multimeter has become the standard tool in the electronic and electrical industries. What’s the difference you ask? The digital meter has a 1999 count display and most of the professional meters have auto-ranging. That is they will change scales without moving a range selection knob. The accuracy of the standard 3 ½ digit multimeter is about $\pm 0.5\%$ of the reading ± 1 count. That means that reading may fluctuate in the last digit (i.e. ± 1 count). There are other digital multimeters available for bench use that operate from 110VAC power.

The instruments discussed in this article also have an AC function. There are limitations on making AC measurements with these instruments. The frequency response is usually limited to 400Hz. For ham radio equipment, this might be useful for checking 110Vac or 220Vac at the input of a rig or the input of a power supply.



Figure 2 Fluke 27

Let’s see how to make a simple DC voltage measurement. All voltage measurements are made with respect to ground as shown in figure 3. If I wish to measure the voltage across R2, then measure the voltage from point “A” to ground and then measure the voltage from point “B” to ground. If you then subtract the voltage at point “B” from the voltage at point “A,” you obtain the voltage across R2. To measure current, an ammeter is inserted in series with the circuit. For practical purposes, it is difficult at best to do this. Sometimes one would have to float an ammeter at high voltage. To calculate the current through R2, use ohm’s law. $[I = (V_A - V_B)/R_2]$

What about the variations in the measurement? If the resistors are $\pm 5\%$, then the total resistance of the circuit ($R_1 + R_2 + R_3$) can vary from 8400Ω down to 7600Ω ($8K\Omega \pm 5\%$). The current in the circuit could vary from 23.8mA to

Figure 2 shows my Fluke 27 digital multimeter. It is set on “DC volts” and will auto range from less than 1 volt to 1000VDC. It also has settings for mV DC, V AC, mA DC, μA DC, A AC, mA AC and Ω . Note that there are separate input jacks for current measurements. This type of meter will cover about 90% of the measurements you will have to make.



Figure 1 Triplet 630

My Triplet 630 analog VOM (Volt - Ohm Milliammeter). Designed in 1949, this meter was the workhorse of the industry in the 50s and early 60s. The “630” is still made by Triplet. Today, it can be used to tune circuits for a maximum or minimum, where you want to see a needle move. There is also a feature of a separate input for a high voltage measurement to 5000Vdc or 5000Vac. A meter like this is great for troubleshooting a tube-type linear amplifier. As an example, the plate voltage on a Heathkit SB200 amplifier is about 2200Vdc.

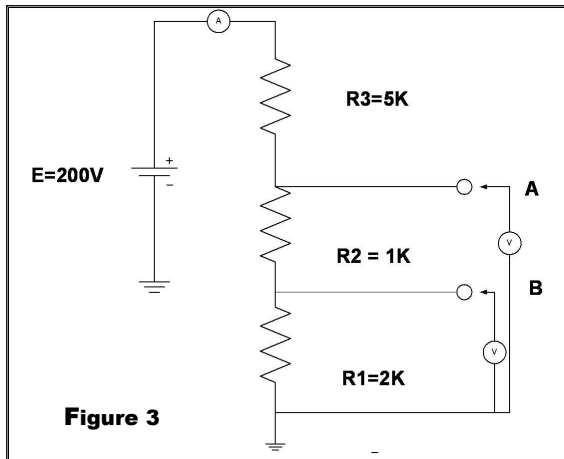


Figure 3

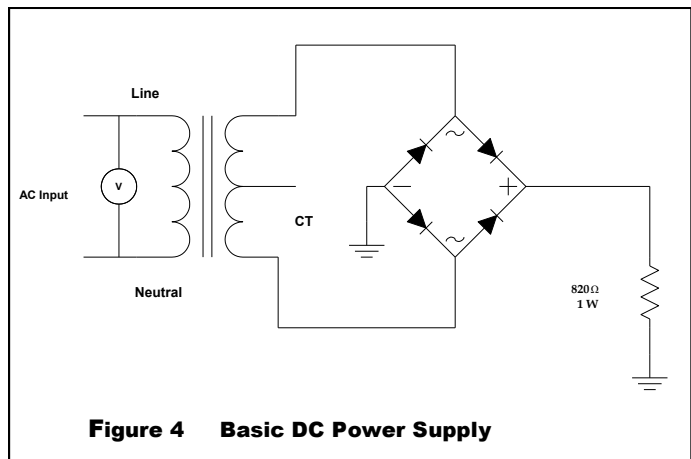


Figure 4 Basic DC Power Supply

26.3mA. This assumes that the voltage is set to 200Vdc with a tolerance of much less than the $\pm 5\%$ variation in the resistors.

We can also use our multimeter to measure AC voltage and current. The AC voltage measured with the multimeter is the root mean square or RMS voltage. This voltage is $.707 * V_{pk}$. Another way of looking at it is that the peak voltage is $1.414 * V_{rms}$. Usually the accuracy of the AC multimeter is somewhat less than that of a DC multimeter. Normally the AC line can vary as supplied by the Edison Company from 105Vac to 125Vac. So, if you are checking the primary side of the transformer for an input voltage, an exact value is not expected. However, the measured value should be in the range of 105 to 125VAC.

Figure 4 is a simplified linear power supply. The AC voltmeter is placed across the primary side of the transformer to measure the incoming line voltage. The voltmeter could be used to measure the secondary side of the transformer. This could be the full secondary or from the center tap to one side of the secondary. The voltage on the secondary side of the transformer will be either stepped up for a higher voltage or stepped down to a lower voltage than what is supplied by the power line.

In the next example, figure #5, we can make use of the multimeter using both the AC and DC functions. Some capacitive filtering has been added to our simplified power supply. The capacitor will smooth out much of the AC ripple on the DC output. The multimeter is set on the AC range to read the secondary of the transformer and on DC to measure the rectified and filtered voltage.

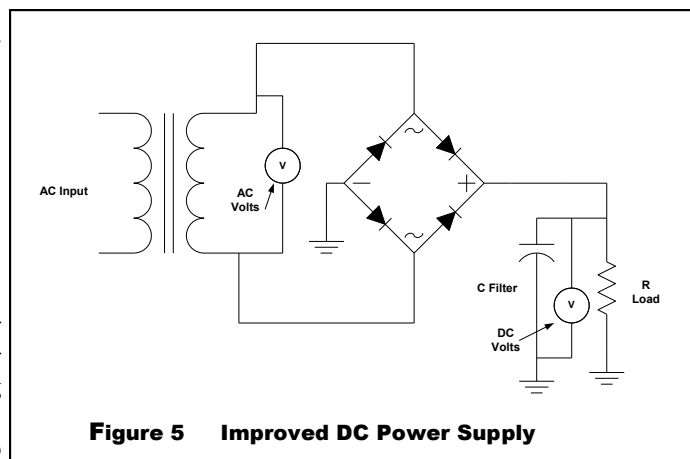


Figure 5 Improved DC Power Supply

As an example, if the secondary of the transformer is rated at 24VAC RMS, then when the multimeter is set to measure the DC output voltage a reading of approximately 34V DC ($24 * 1.414$) is obtained. Remember that the capacitor will charge to the peak AC voltage. In this example I have idealized the diodes and have not included any voltage drop from them. A silicon diode will normally drop about 0.6 V in the forward direction.

To further analyze this simplified power supply, an oscilloscope is needed. That will be discussed in the August issue of the propagator.

Next month I will discuss oscilloscopes and counters.

If there are any questions, please contact me at WB6WXO@soara.org