

ELECTRICAL MEASUREMENTS**2.1. INTRODUCTION**

A variety of instruments are available for the measurement of the different electrical variables. The used principles include the electromechanical meter movement, electromagnetic induction, thermocouples, and electronic meters.

The permanent magnet moving coil instruments are based on the galvanometer invented by Arsene d'Arsonval. This device possesses a stationary permanent magnet, a moving coil, a spring, and a pointer attached to the coil. Figure 2.1 illustrates the way the equipment works. When a current flows through the coil, there is an induced force on it due to the created electromagnetic field, and the coil rotates around its central axis until the induced torque is equal and opposite to the spring torque. The rotation torque, and consequently the angle the pointer rotates is proportional to the current. The rotation angle is measured on a calibrated scale, and the amount of current flowing through the meter can be measured. The d'Arsonval movement is used basically to measure average or DC currents and voltages.

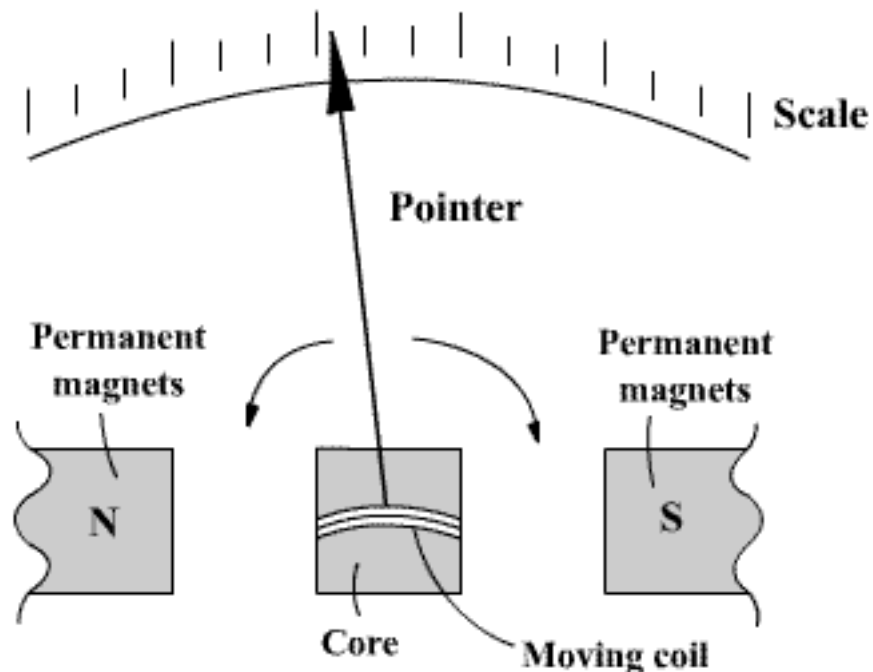


Figure 2.1. d'Arsonval Meter Movement

2.2. –VOLTAGE, CURRENT, AND RESISTANCE MEASUREMENTS

Figure 2.2 shows a device based on the d'Arsonval movement, which is frequently used for measuring different electrical quantities. This equipment is known as analog multimeter. By locating the range switch and the function switch in the proper position, the desired variable may be measured in the selected scale.



Figure 2.2. Analog Multimeter

Current Measurement

This type of devices is used to measure currents typically up to 1 Amp.

- 1) The first step is to locate the range and function switches in the proper position, observing that the function switch be in the AC or DC current position, and the range switch selecting a range with maximum value higher than the expected current value.

2) The meter is connected, using its leads, in series with the element where the current is going to be measured, as can be seen in figure 2.3.

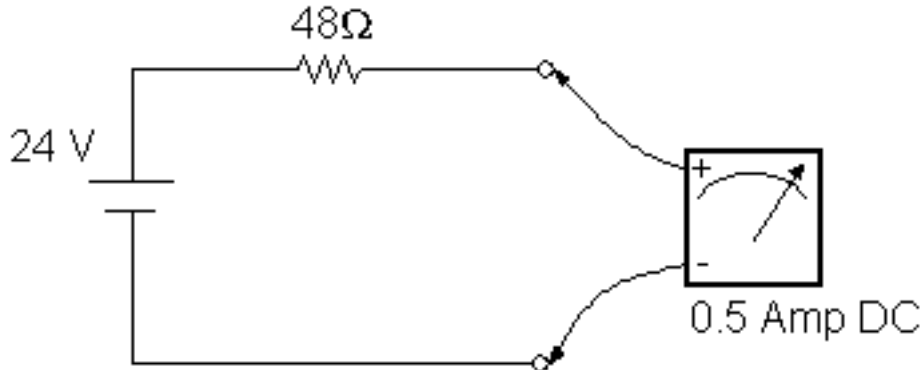


Figure 2.3. Current Measurement

Voltage Measurement

- 1) Select the AC or DC voltage position, depending on the characteristics of the measured voltage, and select also the correct scale.
- 2) Connect the meter in the way shown in Figure 2.4.

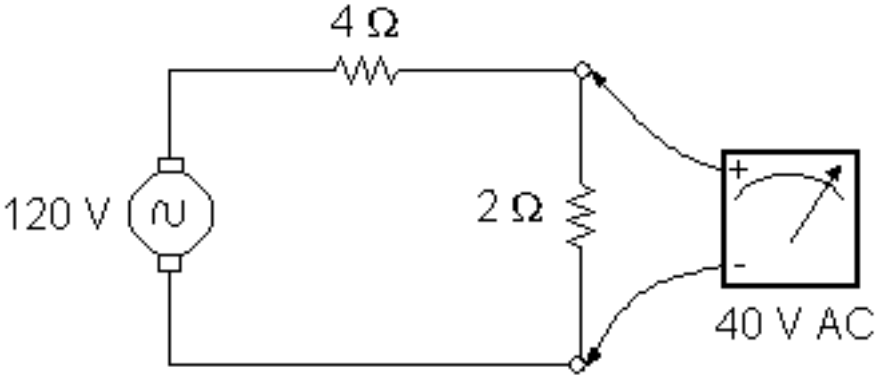


Figure 2.4. Voltage Measurement

Resistance Measurement

- 1) Select the resistance (Ohm) position
- 2) Connect the meter leads to the terminals of the measured device.

It is important to be awarded of the fact that the device resistance never shall be measured if it is connected to the energy source or to other devices. For measuring the resistance, the device will be isolated from the rest of the circuit.

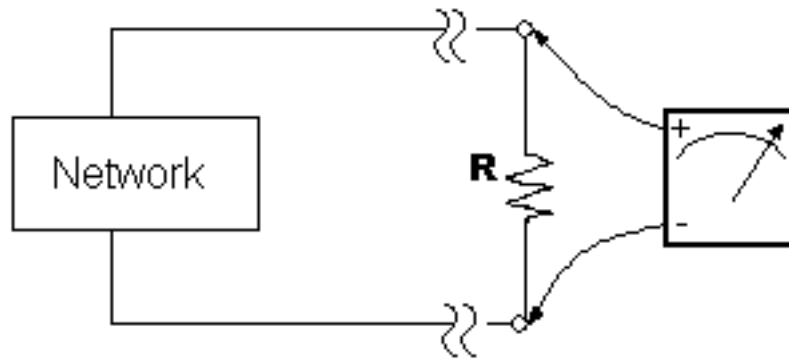


Figure 2.5 Resistance Measurement

The resistance measurement may be used also to check if there is a closed circuit between two terminals of a passive network as can be seen in Figure 2.6.

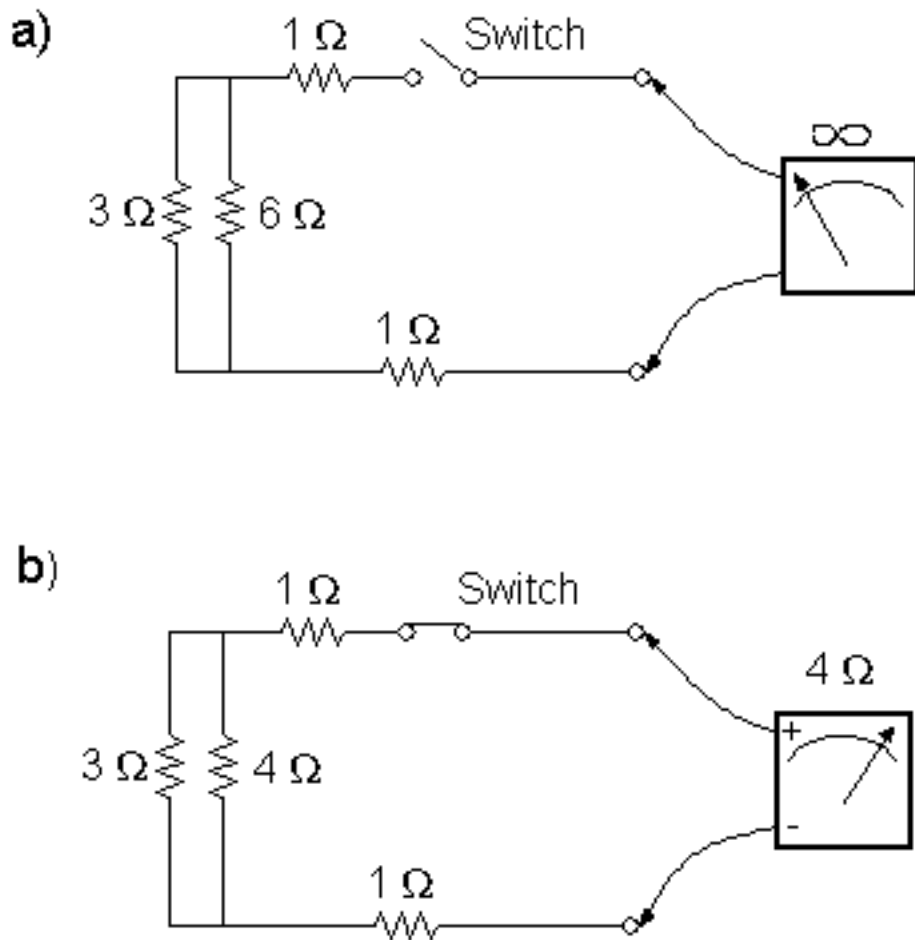


Figure 2.6. Continuity Measurement in circuits

The digital multimeter uses electronic principles for making the measures. It is shown in Figure 2.7. Some of its advantages are:

- 1) Better accuracy
- 2) More functions can be incorporated with one meter.
- 3) Auto-ranging as well as automatic polarity indication is possible.

The mode the digital multimeter is connected to the circuit is the same as for the analog multimeter.



Figure 2.7. Digital Multimeter

For measuring voltage, select AC or DC. Select the range for the V scale, and connect test leads in parallel with the load. To avoid shock hazard or meter damage, do not apply more than 1000 V DC or 750 V AC. For measuring current, select AC or DC. Select the range for the A scale, and connect test leads in series with the circuit. For measuring resistance, select (Ohms) function and connect the leads to the load. For continuity detection, select, if there is continuity in the circuit when connecting the leads a beep will be heard.

High Current Measurements

When measuring AC currents at levels greater than one Ampere, the clamp-on meter is frequently used. These meters use the principle of electromagnetic field induction and clamp over the wire, do not breaking the insulation as shown in Figure 2.8. when using this method, be sure to measure only one conductor at a time.



Figure 2.8. Clamp-on Ammeter

2.3. –POWER MEASUREMENTS

For measuring power in pure resistive circuits it is possible to use an ammeter and a voltmeter and calculate the power using the formula $p = v i$. In place of doing this, a power-measuring meter called a wattmeter can be used. Using the wattmeter the following advantages are obtained:

- 1) Simplify the measurement, due to the use of one device only.
- 2) If the circuit has inductors and capacitors, the use of ammeter and voltmeter gives the apparent power in place of the real power.
- 3) Voltmeters and ammeters consume power. Therefore, very accurate power measurements can not be made by measuring voltage and current and then calculating the power.

A wattmeter has two internal coils, namely, a voltage coil and a current coil. The voltage coil is connected in parallel to the circuit, where the power is to be measured, and the current coil is connected in series with the circuit. The wattmeter gives a direct indication of the real (average) power of the circuit.

2.4. –INSULATION MEASUREMENTS

When several millions of Ohms are going to be measured, an ordinary ohmmeter can not be used. This

situation occurs for example, in conductor insulation or transformer winding measurements. The used device in these cases is called megohmmeter or megger. The meter is similar to a moving-coil meter, except that it has two windings. There are three types of meggers, depending on the way they receive the energy: hand, battery and electric.

Newer meggers instead of having a scaled meter movement, present the value of resistance in a digital readout display. The digital readout makes reading much easier and helps to eliminate errors. Figure 2.9. shows a digital megger.



Figure 2.9. Digital Megger

Besides the enumerated measurements, frequently other electrical variables are measured, for example: frequency, power factor, capacitance, inductance, etc.

2.5. –VOLTAGE TESTERS

The basic component of this instrument is a solenoid. When a current flows across the coil, a magnetic field is produced. The magnetic field intensity is proportional to the current and consequently to the applied voltage. Due to the magnetic field, a force is induced pulling a plunger down to a spring (Figure 2.10). As the current increases, the plunger moves farther. A pointer on the plunger indicates the

potential difference on a scale. The instrument also indicates whether the circuit is AC or DC by vibrating on alternating current.



Figure 2.10. Voltage Tester

Another very useful device for the electrician is the neon-glow lamp tester, shown in figure 2.11. It consist of a very small neon lamp in series with a 200,000 Ohms protective resistance enclosed in a molded case. The tester works satisfactorily in circuits from 60 V ac to 500 V ac. With the test tips connected to the circuit, if a voltage exist between the indicated limits, the lamp will glows. Higher voltage corresponds to higher glow. If both electrodes in the lamp glow, the voltage is alternating. On dc, only one electrode glows.



Figure 2.11. Neon-glow lamp tester