

Fundamentals of measurement theory

Review

- Classification of electrical measuring instruments
 - Deprez type instruments
 - Digital type instruments (DMM)
- Measurement range, accuracy
- Voltage measurement
- Current measurement
- Resistance measurement
- Special instruments

What can we measure with multimeter?

- Most basic instruments are suitable for:
 - measuring resistance (Ω);
 - measure voltage (direct current (DC) and alternating current (AC));
 - measure current (direct current (DC) and alternating current (AC)).
- They may also be suitable for:
 - continuity testing;
 - semiconductor testing;
 - capacitance measurement;
 - temperature measurement;
 - frequency measurement;
 - measurement data collection, etc.

Classification of electrical measuring instruments*

Analog (moving coil) or
Deprez instrument



DMM with automatic measurement
range

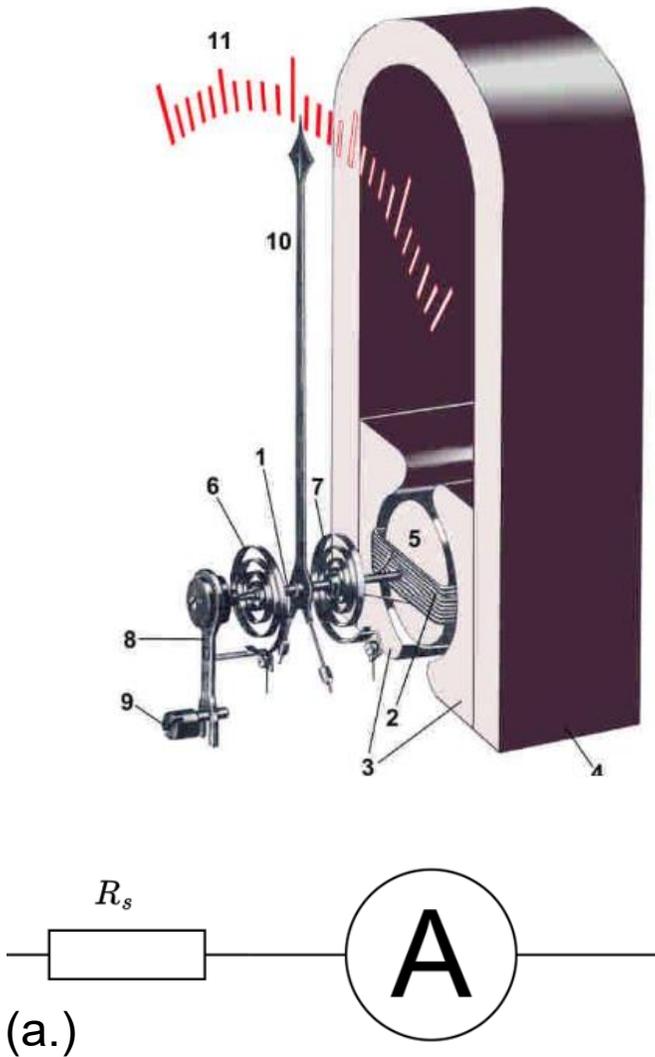


DMM with manual measurement
range

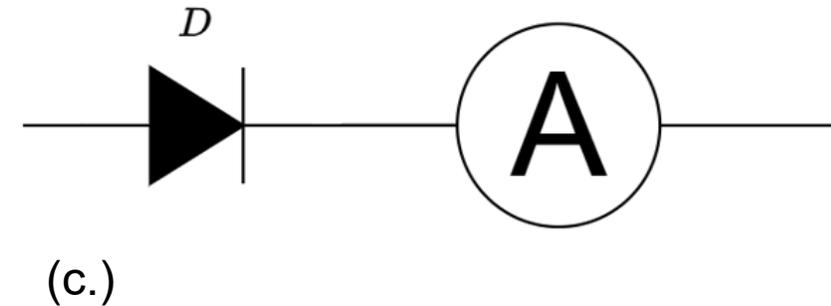
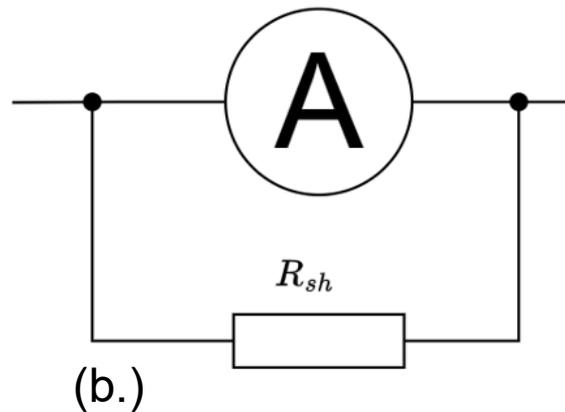


*not completely

Deprez (soft iron) meter



- Its working principle is based on the Lorentz force (see experiment)
- The basic instrument can only measure current, but if we add additional components:
- (a.) Series resistor – for voltage measurement :in order to measure voltage with it, it must be modified so that the current flowing through the coil is proportional to the voltage being measured.
- (b.) Shunt resistor – for higher current measurement: extending the measuring range with shunt resistors is a standard procedure. An ammeter with multiple measuring ranges has several shunt resistors that can be selected using a rotary switch.
- (c.) Diode – for AC measurement: With the help of the diode, the AC quantity can be rectified for the basic instrument.



DMM



Measurement range

- The digital multimeter shown on the previous slide has a manual measurement range selector, so it is the responsibility of the user to select the correct measurement range;
- There are multimeters that select the measurement range automatically; in this case, only the quantity to be measured needs to be selected (and the test leads connected correctly);
- But what is a measurement range? It is the maximum value that the instrument can measure (in the case of analog instruments, the value corresponding to full scale).
- If the measured value is unknown, the highest measurement range must be selected. If the measurement range is too high, remove the test leads and then reduce the measurement range. This must be repeated until the correct measurement range is found.
- The correct measurement range is as close as possible to the value to be measured. For example, I can measure 10mA in several measurement ranges. This is where measurement accuracy comes into play.
- The measuring instrument has different accuracies at different measurement limits. This is usually given as a percentage. It matters which measurement limit we choose, because the measurement accuracy differs!

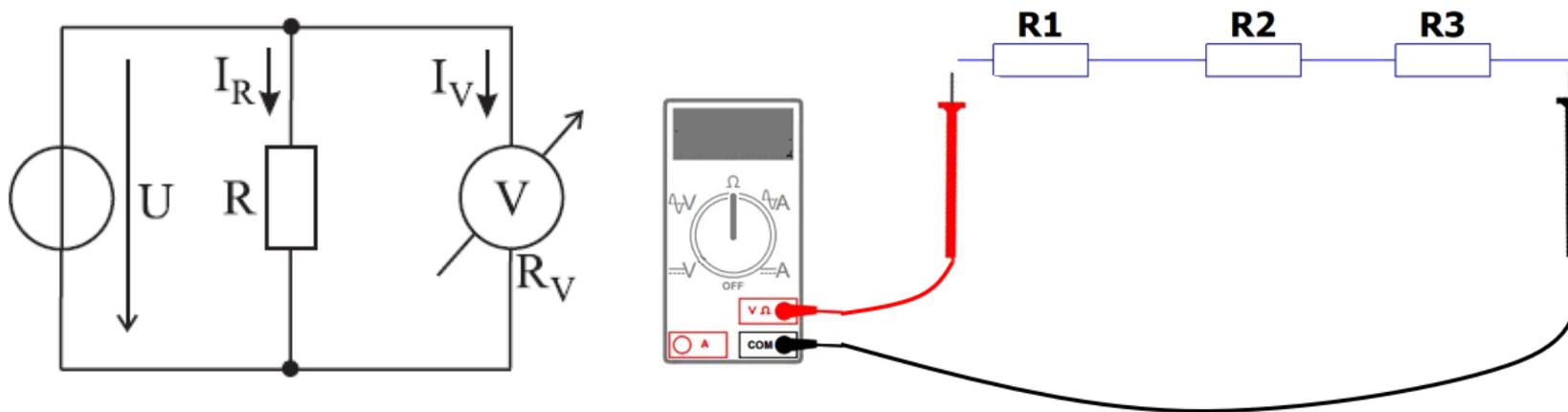


MY-64 DMM current measurement accuracy

MÉRÉSHATÁR	FELBONTÁS	FESZÜLTSGESÉS	PONTOSSÁG (18-28 °C)
2 mA	1 μ A	110 mV / mA	$\pm 0,8\% \pm 1$ dg.
20 mA	10 μ A	15 mV / mA	$\pm 0,8\% \pm 1$ dg.
200 mA	100 μ A	5 mV / mA	$\pm 1,5\% \pm 1$ dg.
10 A	10 mA	30 mV / A	$\pm 2,0\% \pm 5$ dg.

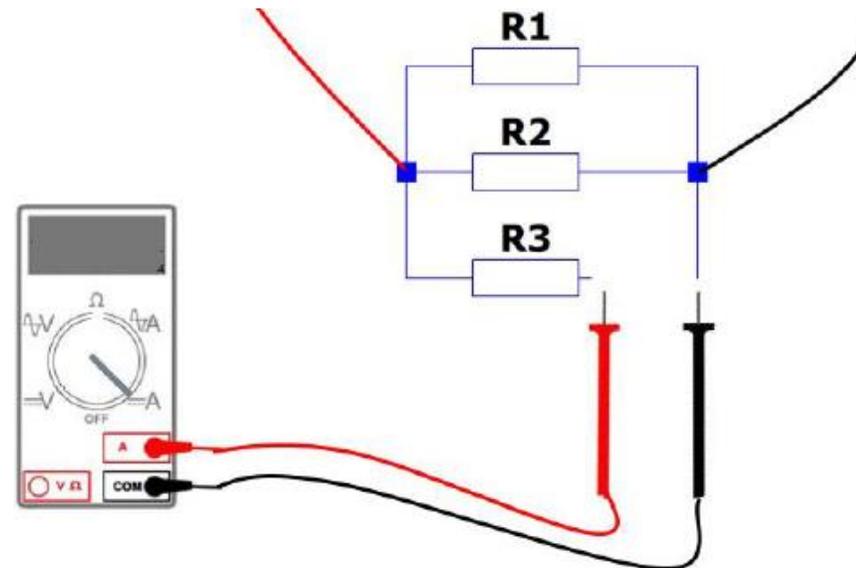
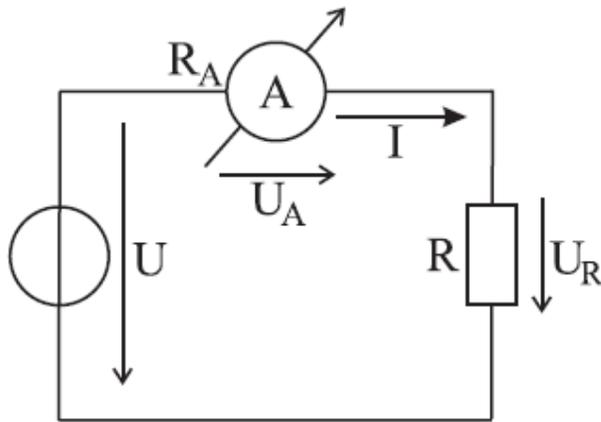
Voltage measurement

- A voltmeter is used to measure the voltage of a circuit element.
- Based on the previous definition, voltage is the potential difference between two points: this means that the voltmeter is always connected in parallel to the network element under test.
- Like all electrical devices, voltmeters have internal resistance. Ideally, this is infinitely large, but in practice it is a few M/GΩ.
- The goal is to keep the current I_V flowing through the instrument as low as possible so that it affects the measured value as little as possible.
- The greater the ratio of the measured resistance to the internal resistance of the instrument, the more accurate the measurement.



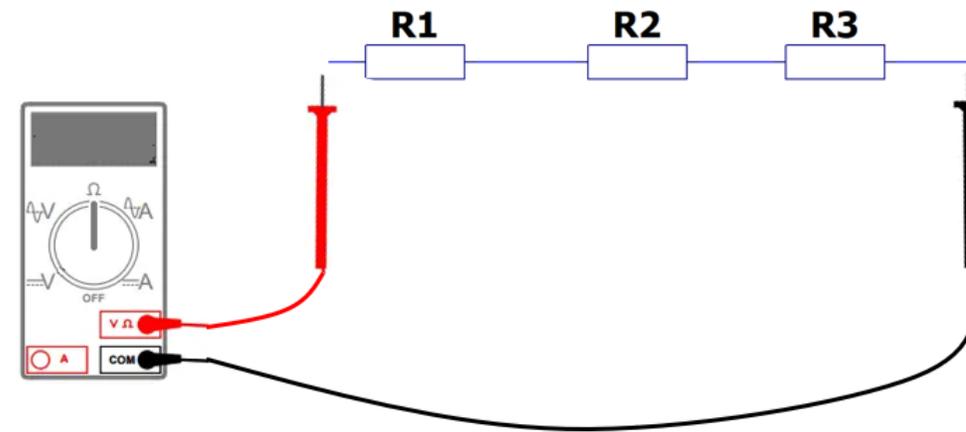
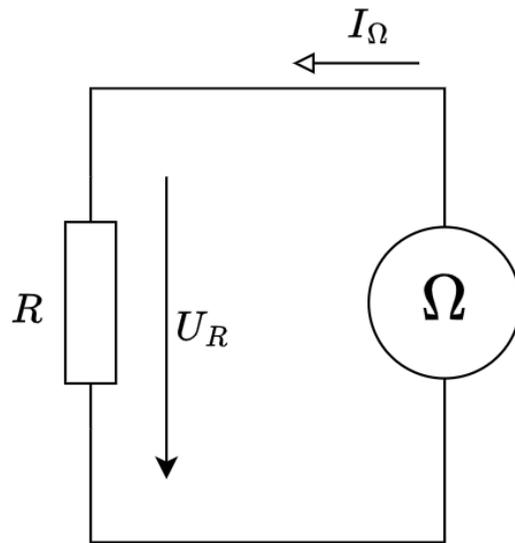
Current measurement

- An ammeter can be used to measure the current in a network component;
- Since the current is the same in series-connected components, the ammeter must always be connected in series with the network component to be measured. This means that the circuit must be interrupted at the appropriate point and the measuring instrument must be inserted into the circuit (there are so-called clamp meters that can measure current without contact (based on the electromagnetic principle));
- Based on the above, the internal resistance of the measuring instrument must be as low as possible in order to minimize the voltage drop across it (think of Ohm's law!);
- Ideally, the internal resistance of the measuring instrument is 0Ω , but in reality it is a few Ω .
- The lower the internal resistance of the instrument compared to the measured value, the more accurate the measurement.



Resistance measurement

- Resistance measurement is performed in a similar way to voltage measurement (resistance is measured between two points)
- The difference is that in the case of resistance measurement, the circuit/equipment must be de-energized. Why?
- The resistance meter passes a small current through the resistance to be measured and examines the voltage drop across it. If the circuit/equipment is energized, the measuring instrument will be destroyed.



Special measuring instruments

- Clamp-meter
- 4 point resistance meter
- HV Insulation tester

