Metrology

Laboratory

THEME:

DC CURRENT MEASUREMENT

OBJECTIVES:
- to learn how to measure DC currents;
- to learn how to use an analogue ammeter and a digital multimeter properly and what are their parameters;
- to learn how to calculate measurement errors and what are their sources.

EQUIPMENT:
- Analogue Ammeter
- Digital Multimeter
- Resistance Standard
- Decade Resistor
- DC Power Supply

BACKGROUND:

Electric current is a flow of electric charges and it is measured using an ammeter (realising a direct method of measurement). The meter must be connected in series (in-line) to the circuit under the test. An ideal ammeter has zero internal resistance, so there is no voltage drop across it and power is not taken by such an instrument. Real ammeters have nonzero resistances, so they have impact on a circuit under the test, specifically on measured current.

The situation during current measurement is very similar to voltage measurement. A connection diagram for such a measurement task is shown in Fig. 1. It is too general to be analysed precisely.

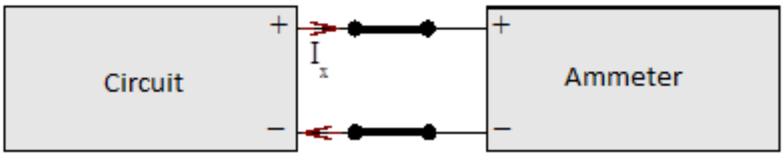

Fig. 1. Connection diagram of current measurement with a direct method.

Using the Thevenin equivalent for the circuit under the test (a current source) and the equivalent circuit of a real ammeter, a more detailed circuit (Fig. 2.), consisting of ideal components presenting the measured value (I_x), a meter (A) and parameters influencing measurement (Rc – internal or equivalent circuit resistance and R_A – internal ammeter resistance), can be obtained.

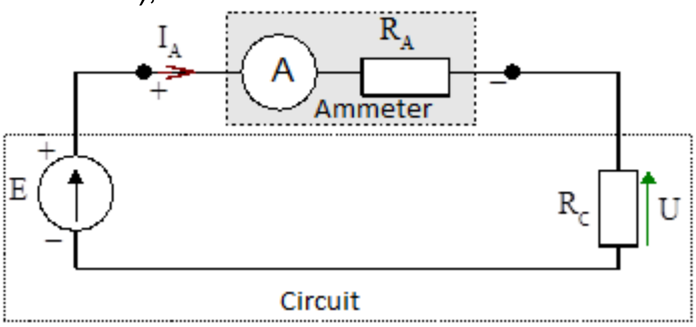

Fig. 2. An equivalent circuit for direct current measurement with components influencing measurement.

For the above circuit it is easy to write down the following expressions:

$$I_x = \frac{E}{R_C}, \qquad I_A = \frac{E}{R_C+R_A}, \qquad I_x \neq I_A$$

The inequality of the true value of current I_x (the value of current before connecting a meter) and the current value measured by ammeter I_A, indicates the existing error of the method. This is a systematic error and its value can be calculated using the definition of a measurement error

$$\Delta_m I = I_A - I_x = -I_x \cdot \frac{R_A}{R_A + R_C} = -I_A \cdot \frac{R_A}{R_C}$$

$$\delta_m I = \frac{I_A - I_x}{I_x} = -\frac{R_A}{R_A + R_C}$$

As one can see, it can be calculated without knowing the true value I_x. What is needed are only: ammeter indication, ammeter internal resistance (an ammeter's parameter) and tested circuit's resistance. Knowing about existence of the method error, one has to calculate the correction factor:

$$c = -\Delta_m I$$

and then to include it in the final measurement result in the following way:

$$I_c \pm \Delta I_A, \qquad I_c = I_A + c$$

where ΔI_A is the limiting error (uncertainty).

It is important to know that for multi-range instruments, the internal resistance varies when the instrument is switched to different ranges.

PROCEDURE:

1. Direct method of current measurement

Set the power supply unit to 2 V. Calculate the theoretical values of current for the load resistance of values 10Ω, 100Ω, 1kΩ, 10kΩ connected to the unit. Connect the measurement circuit shown in Figure 3. Set the decade resistor to: 10Ω, 100Ω, 1kΩ, 10kΩ and measure current Ix, using all the given ammeters. For each measurement record also ammeter's resistance.

Calculate the errors for each measurement and compare them. Write down properly the results of measurements.

2. Indirect method of current measurement

Connect the measurement circuit shown in Figure 4. For each value of the decade resistor given in point 1, measure values of voltage on the resistance standard, using all the given voltmeters.

Calculate the errors for each measurement and compare them. Write down properly the results of measurements.

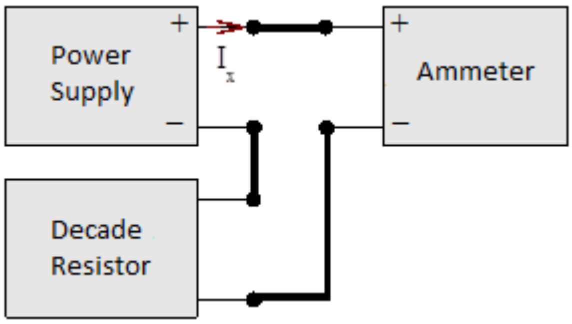

Fig. 3.

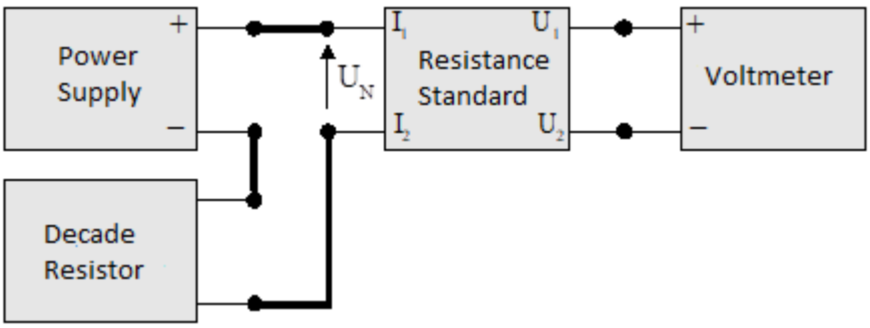

Fig. 4.