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INVESTIGATE THE BEHAVIOR OF CAPACITOR IN DC AND AC CIRCUIT

Measurement practice III.

FOR VEHICLE ENGINEER STUDENTS

Version: 1.1

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1. Introduction

The capacitor is an important building block of electronic circuits, it is found in almost every circuit, so it is very important to know it. The lesson aims to study the behavior of capacitors in DC and AC circuits. To do this, it is essential to learn how to use an oscilloscope and an AC signal generator.

1.1 Objectives

- Knowledge of electrical wiring diagram;
- Studying the behavior of capacitors in AC circuits;
- Studying the behavior of capacitors in DC circuits;
- Using of oscilloscope and AC signal generator.

1.2 Required instruments and components

- AC signal generator (see Fig. 1.);
- DC voltage supply (see Fig. 2.);
- resistor table (see Fig. 3.);
- capacitor table (see Fig. 4.);
- digital oscilloscope (see Fig. 5.);
- BNC to banana plug adapter (see Fig. 6.);
- measuring cable.

Fig.1. AC signal generator (HM8150)

Fig.2. Power supply (TP-2303)

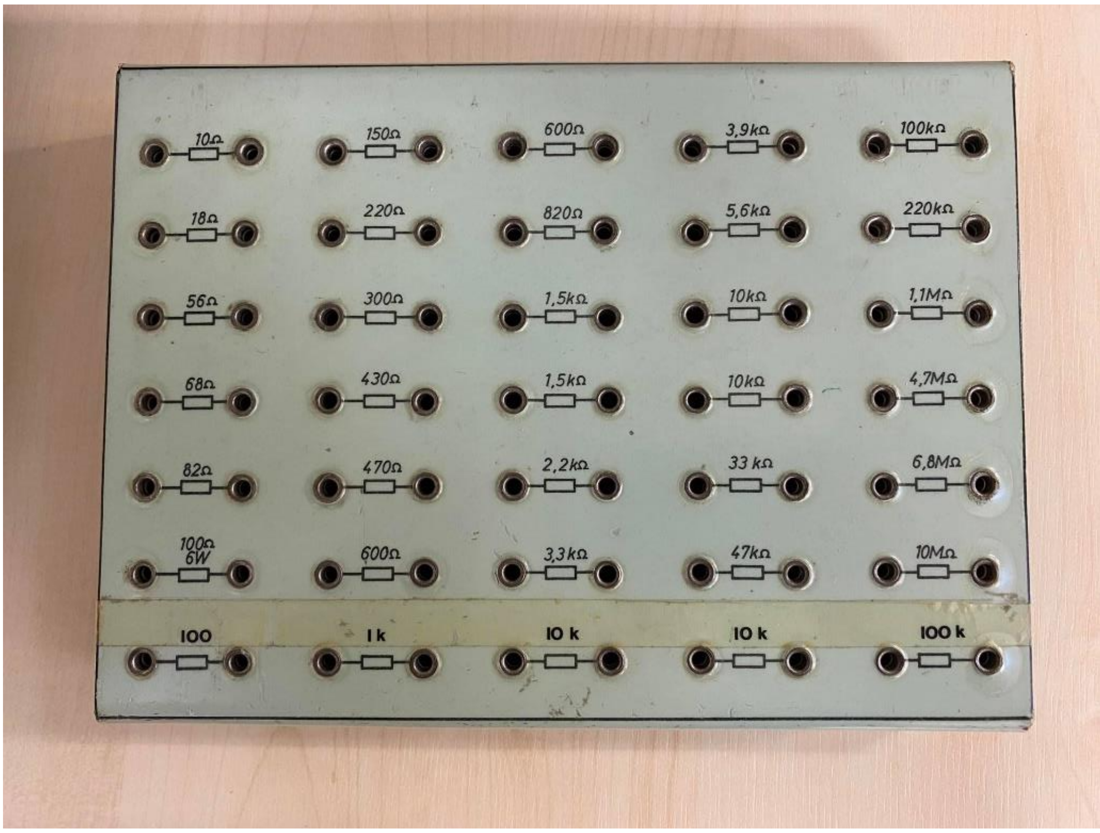

Fig.3. Resistor table

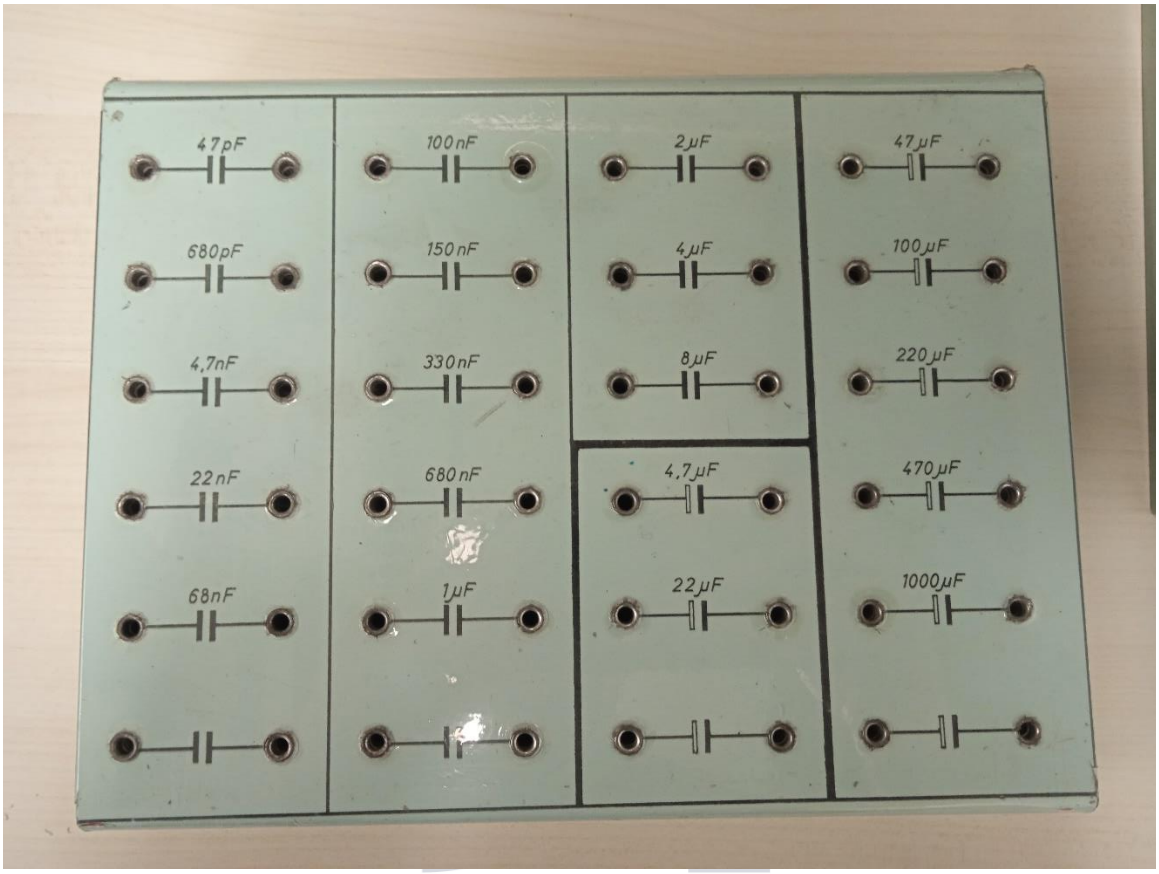

Fig.4. Capacitor table

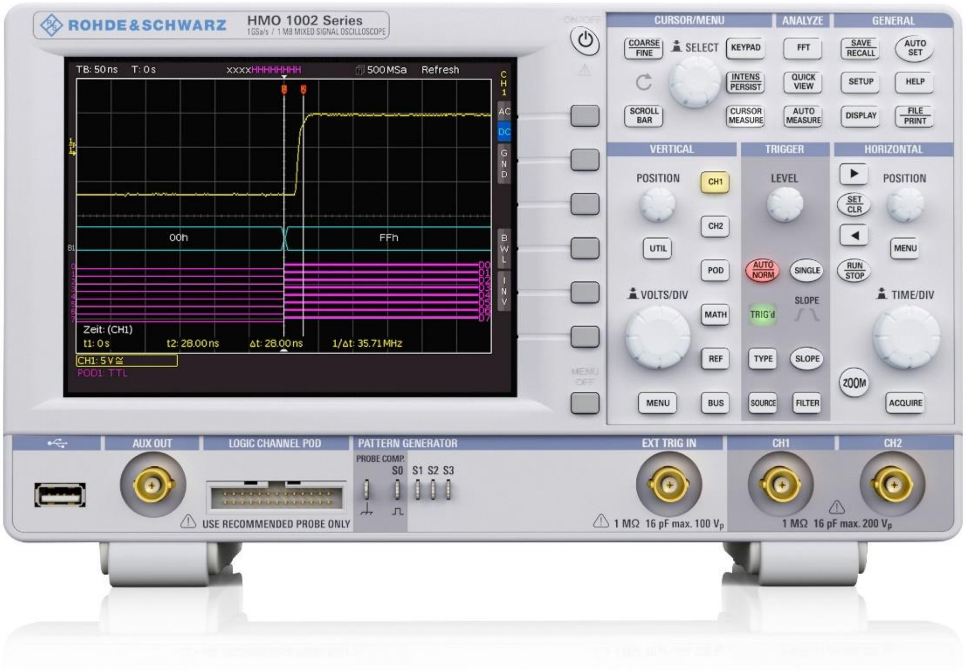

Fig.5. Digital oscilloscope

Fig.6. BNC to banana plug adapter

3. Measurement exercises

3.1 Measure charge and discharge of capacitor (AC measurement)

The measurement setup used to charge and discharge the capacitor is shown in Fig. 7. The system is excited by a periodically alternating square wave (AC signal). During the measurement, the capacitor voltage is measured using an oscilloscope.

The steps of measurement:

1. Prepare the necessary tools and instruments.
2. Build the circuit with a 100nF capacitor and 1.5kΩ value resistor!
3. On the AC signal generator, select a square wave output and set the frequency to 1kHz and the voltage to 10Vpp. Check the set value on each channel of the oscilloscope.
4. If the set value is correct, connect the signal to the input of the circuit and the same time to the first channel of the oscilloscope, the output (capacitance voltage) to the second channel.
5. Adjust the oscilloscope so that the two signals are visible below each other on the display. Use the correct knobs!
6. Save the signal to your flash drive! Make a note of the Volts/Div and Time/Div settings.
7. Change the value of capacitance (22nF) and repeat the measurement!
8. Calculate the time constant of the system (see chapter 5.1!).

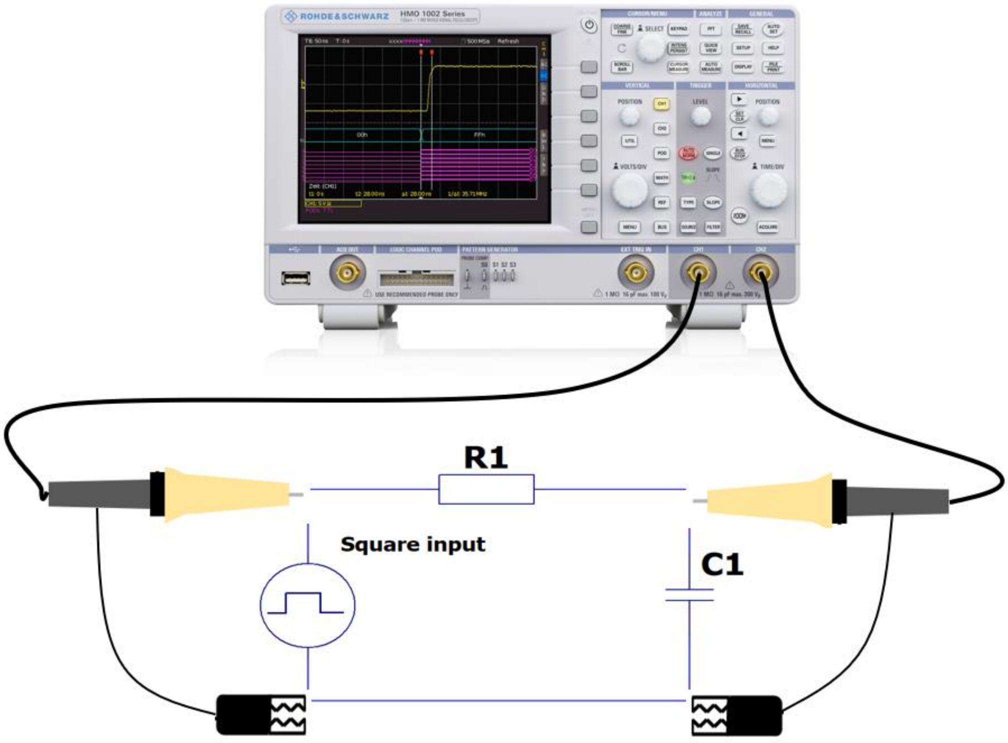

Fig.7. Measuring of circuit resistance

3.2 Measure the behavior of capacitance in DC circuit

In this measurement, the behavior of a capacitor in a DC circuit is investigated using two measurement setups.

The steps of the first measurement:

1. Prepare the necessary tools and instruments.
2. Build the circuit with the following resistors and capacitor: R1 = 1,5kΩ; R2 = 3,9kΩ; R3 = 100kΩ and C = 1000μF!
3. Set up the DC power supply to produce a 12V(DC)! Adjust the current limit to 0.5A!
4. Check the set voltage with a digital multimeter. Make sure that the multimeter is set to the correct measuring volume (voltage) and that the test leads are connected correctly.
5. Switch off the output voltage of the power supply and connect the circuit to it. Make sure the polarity of the power supply is correct, as the capacitor is polarity-dependent (ELKO)!
6. Measure the voltage of resistor R3. What do you observe?
7. Note the measured value!

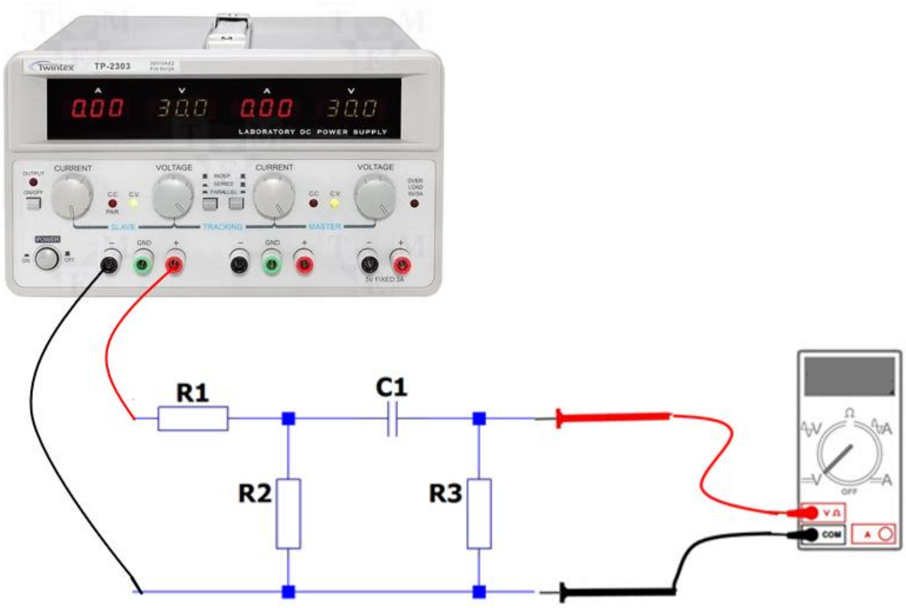

Fig.8. Voltage measurement on resistor R3

The steps of the second measurement:

1. Prepare the necessary tools and instruments.
2. Build the circuit with the same resistors and capacitor:
3. Set up the DC power supply to produce a 12V(DC)! Adjust the current limit to 0.5A!
4. Check the set voltage with a digital multimeter. Make sure that the multimeter is set to the correct measuring volume (voltage) and that the test leads are connected correctly.
5. Switch off the output voltage of the power supply and connect the circuit to it. Make sure the polarity of the power supply is correct, as the capacitor is polarity-dependent (ELKO)!
6. Measure the voltage of resistor R3. What do you observe?
7. Note the measured value!

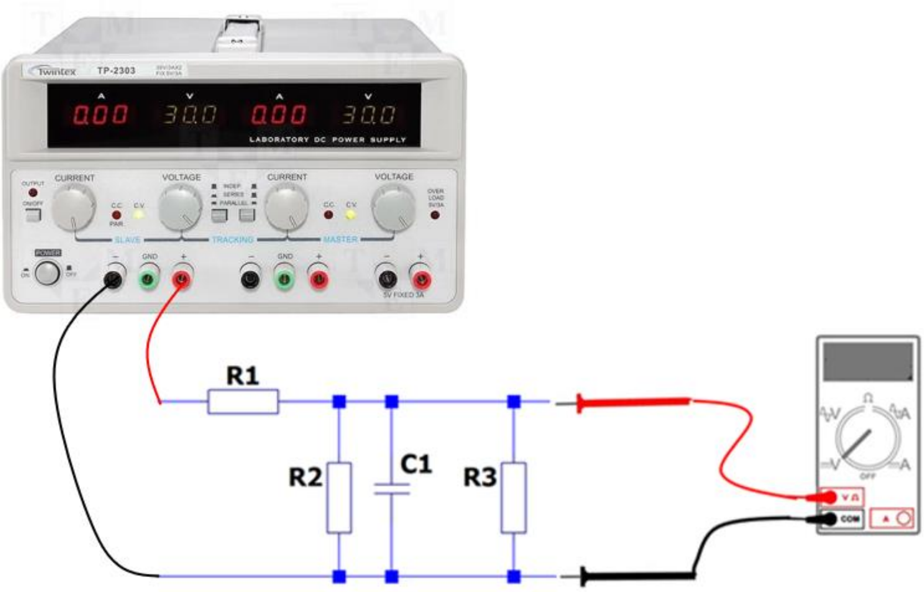

Fig.9. Voltage measurement on resistor R3

4. Measurement results

The output waveform of the first measurement (C=100nF):
Volt/Div:
Time/Div:

The output waveform of the first measurement (C=22nF):
Volt/Div:
Time/Div:

Voltage on R3 (first measurement):
Voltage on R3 (second measurement):

5.1 Necessary equation

$$\tau = RC \tag{1}$$

$$u_c = U_{in}\left(1 - e^{-t/RC}\right) \tag{2}$$

$$i_c = -\frac{U_{in}}{R}\left(1 - e^{-t/RC}\right) \quad (2)$$

5. Conclusions

What is the time constant of the system?
How does the time constant of the system depend on the value of the capacitor?
How does the time constant of the system depend on the value of the resistor?
How does the current of a capacitor depend on time? Why?
How does the capacitor behave when it is switched on?
How does capacitance behave in a series DC circuit?
How does capacitance behave in a parallel DC circuit?

6. Homework

You need to include to the measurement report:

- The schematic of the measurement.
- Simulated form with Ltspice:
    - first measurement: transient simulation (voltage on the capacitor);
    - second and third measurement: operating point simulation.
- Measurement results
    - First measurement results (saved oscilloscope diagrams and oscilloscope set-up);
    - Second and third measurements (measured voltage on R3).