

DEPARTMENT OF ELECTRONICS AGH UST

LABORATORY
OF
ELECTRONIC ELEMENTS

INVESTIGATION OF
RLC ELEMENTS

REV. 1.0

1. THE GOAL OF THE EXERCISE

- introduction to the NI Educational Laboratory Virtual Instrumentation Suite (NI ELVIS II),
- introduction to the basic measurement techniques,
- measurements of basic RLC element's parameters.

2. THE UTILIZED MODELS AND ELEMENTS

During the exercise following components will be used:

- NI ELVIS Prototyping Board (ELVIS) connected with PC,
- Virtual measurement devices Virtual Instruments (VI):
 - Digital Multimeter (DMM),
 - Impedance Analyzer (Imped),
 - Function Generator (FGEN),
 - Oscilloscope (Scope),
 - Bode Analyzer (Bode),
 - Two-Wire Voltage Analyzer (2-Wire),
 - Variable Power Supply (VPS).
- Set of electronics elements: resistors, inductors and capacitors.

3. PREPARING THE DRAFT

3.1. For the series RLC one-port network from Fig. 3.1 draw the vectors of voltage and currents for the case, when alternating supply voltage (sinusoidal) is utilized. Formulate a formula for resonant frequency.

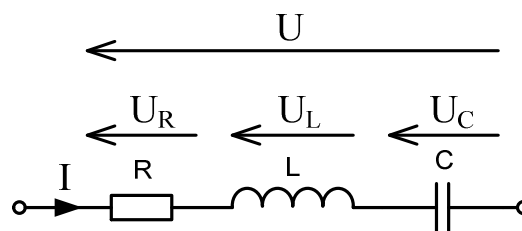


Fig. 3.1. RLC one-port network

3.2. For the voltage divider from Fig. 3.2. formulate a formula for a division ratio.

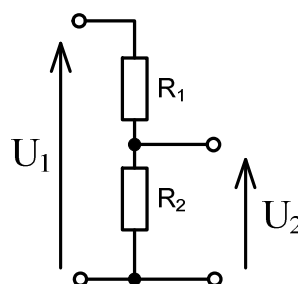


Fig. 3.2. Voltage divider

4. THE COURSE OF THE EXERCISE

In this exercise the measurements will be performed with the use of virtual instruments. At first start NI ELVISmx Instrument Launcher from Start menu or with the use of icon:



. This opens following GUI:



To launch an instrument, click the button corresponding to the desired instruments.

AN INVESTIGATION OF RESISTORS

4.1. Resistance measurement with the use of DMM multimeter.

With the use of multimeter, measure the resistance of following three resistors: wirewound, layered and bulk (Fig. 4.1). The measurement setup is presented in Fig 4.2. The measurement results should be listed in the table.

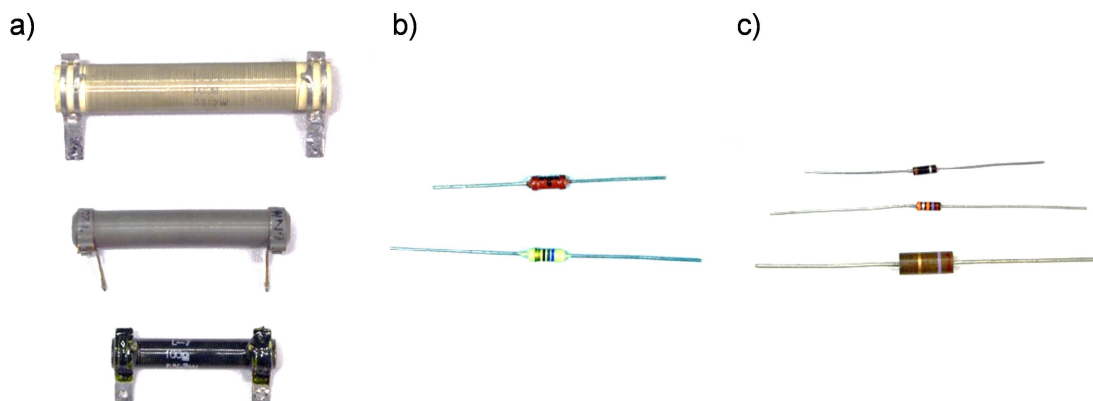


Fig. 4.1.: a) wirewound resistors, b) layered resistors, c) bulk resistors.

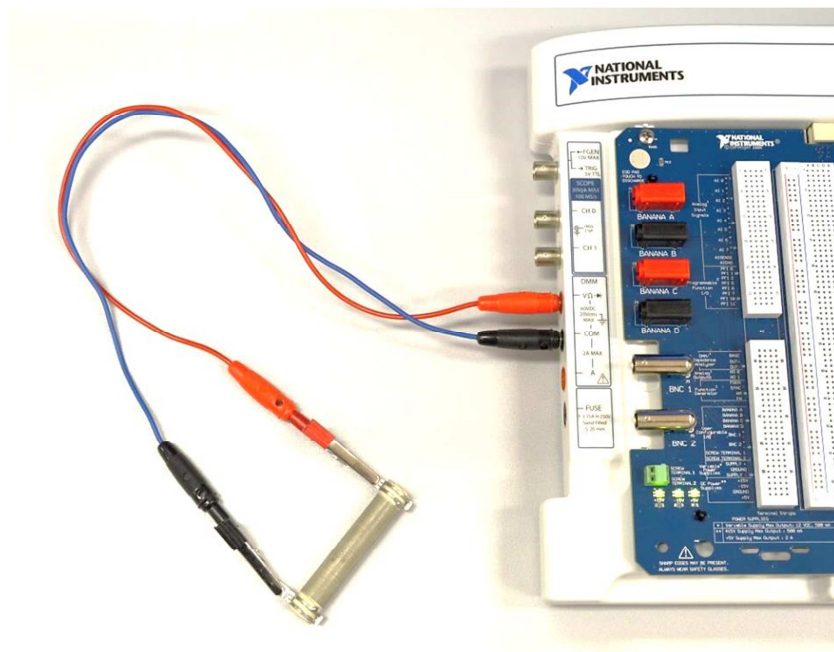


Fig. 4.2. The measurement setup (measurements with the use of multimeter).

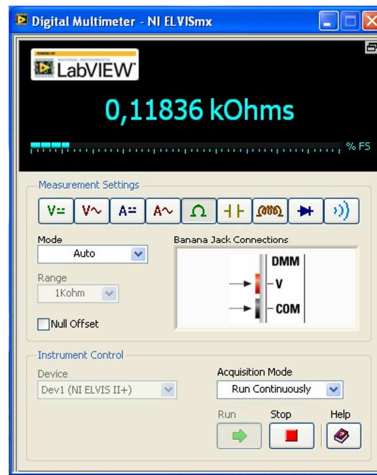
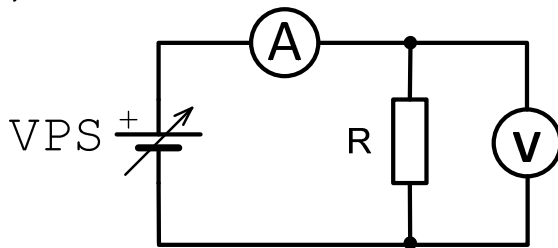


Fig. 4.3. Multimeter window.

4.2. Resistance measurement basing on the Ohm's Law.

Construct the circuit from Fig. 4.4.a or 4.4.b (teacher decides which circuit will to be used). For one of the chosen resistors measure the current passing through the resistor. The measurements need to be performed with the use of power supply and DMM multimeter. Measure the current several times for the different supply voltages (Fig. 4.5). The measurement results should be listed in the table. Basing on the obtained measurements draw the graph. The measurement setup together with power supply and multimeter GUI are presented in Fig. 4.5 and Fig. 4.6.

a)



b)

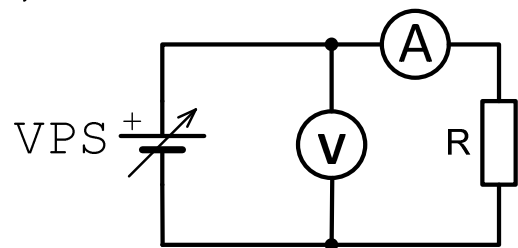


Fig. 4.4. Circuits utilized to measure the resistance basing on the Ohm's Law: a) precise measurement of voltage. b) precise measurement of current.

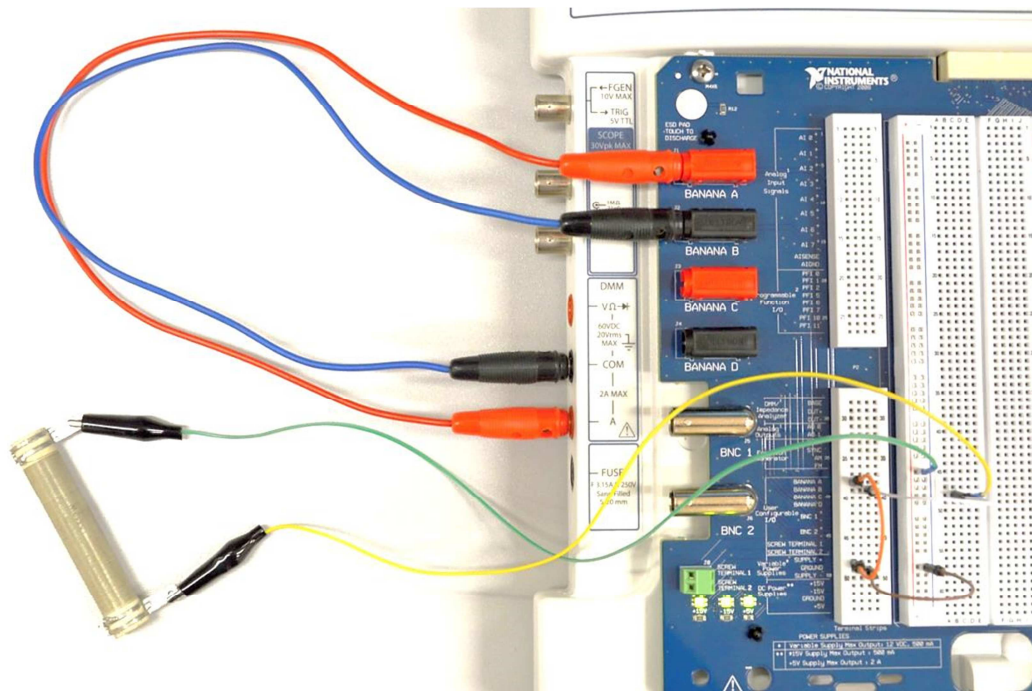


Fig. 4.5. The measurement setup (precise measurement of voltage).

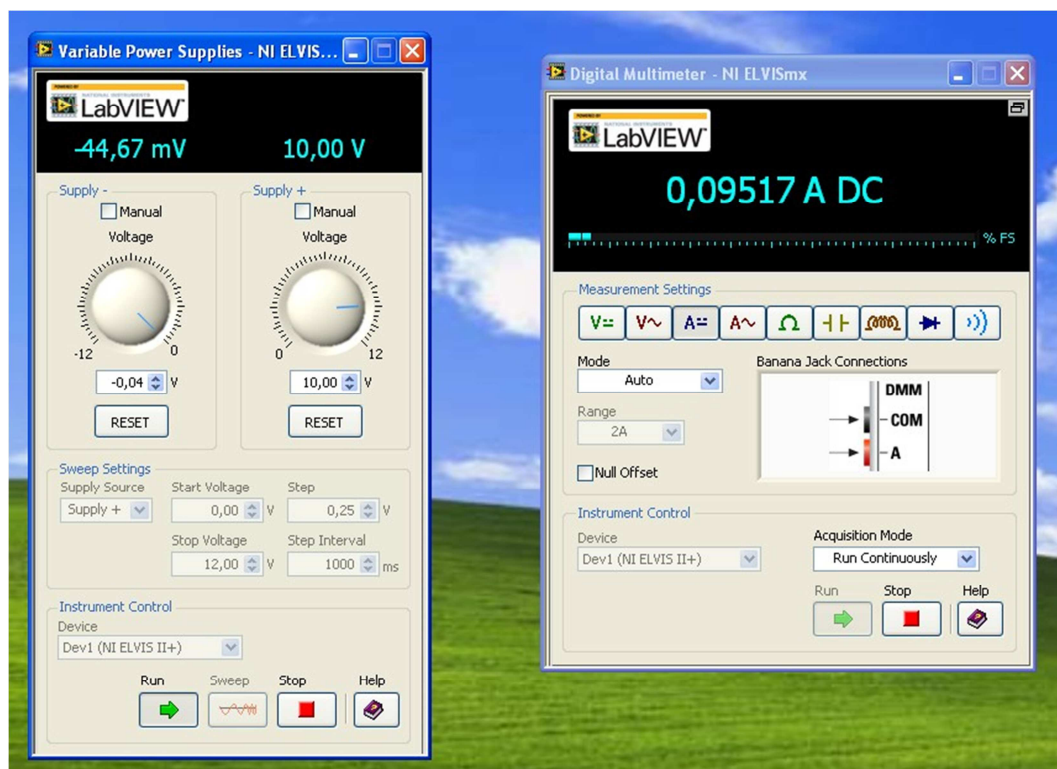


Fig. 4.6. Power supply and multimeter GUI.

- 4.3. Determine current-voltage characteristics of the resistor with the use of 2-Wire analyzer. Previously measured resistor needs to be connected between DUT+ and DUT- (Fig. 4.7), start 2-Wire analyzer, set the input voltage range from 0 to 5V and draw the characteristic. Copy the obtained graph to the report.

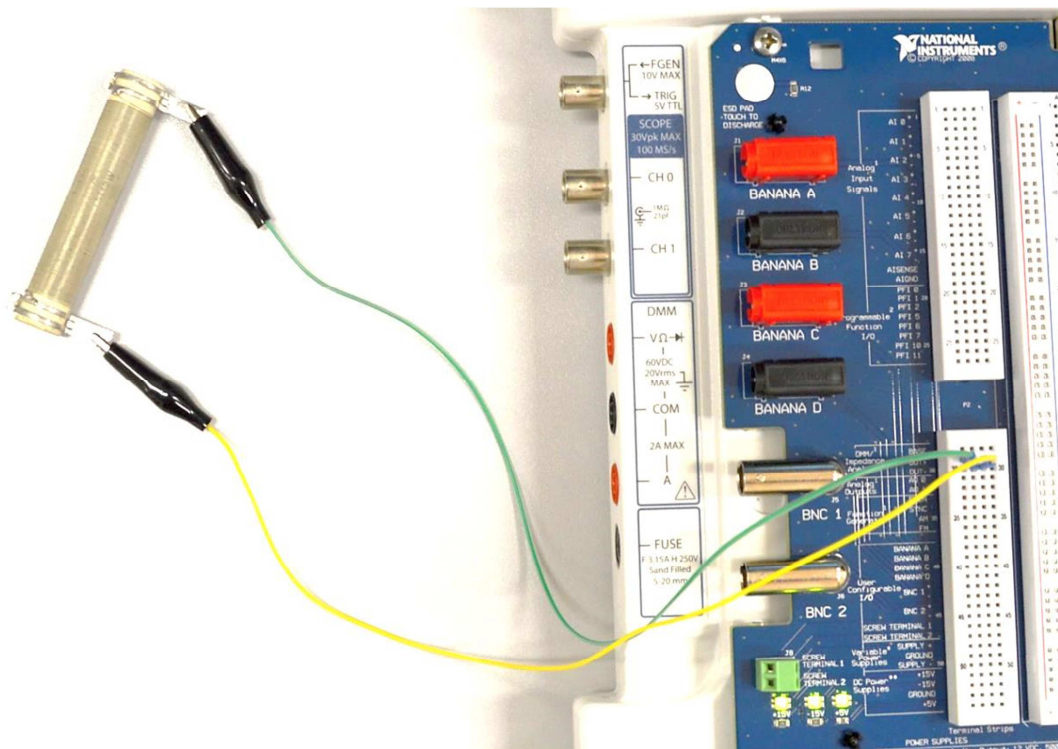


Fig. 4.7. The measurement setup (measurement of current-voltage characteristics).

4.4. Measurement of resistors with the use of impedance analyzer Imped.

Connect previously measured resistors to DUT+ and DUT- and measure their parameters with the use of impedance analyzer for several frequencies (for example: 1 kHz, 10 kHz, 20 kHz). The result of measurements i.e. real and imaginary part of impedance should be listed in the table. Note the imaginary part of impedance. Impedance analyzer GUI is presented in Fig. 4.8.

Compare and discuss measurement results obtained with the use of different methods.

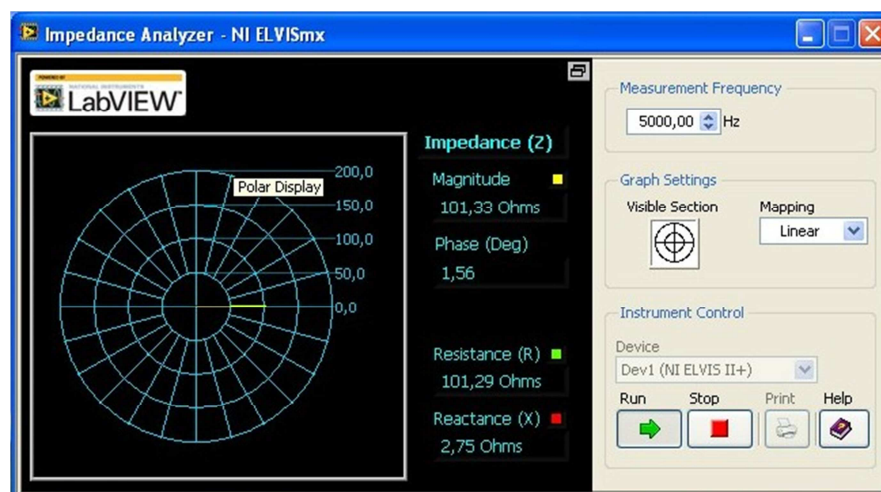


Fig. 4.8. Impedance analyzer GUI.

AN INVESTIGATION OF INDUCTORS

4.5. Measurement of inductors with the use of impedance analyzer Imped and DMM multimeter.

Connect the inductor (Fig. 4.9) between DUT+ and DUT- and measure their parameters for several frequencies (for example: 1 kHz, 10 kHz, 20 kHz) with the use of impedance analyzer. Put into the table the real and imaginary parts of impedance of the measured inductors.

Calculate the inductance value for the appropriate frequencies.

For comparison, measure the inductance and resistance of the inductors with the use of DMM multimeter. The obtained measurement results should also be listed in the table.

Compare and discuss the obtained calculated and measured results.



Fig. 4.9. Inductors.

AN INVESTIGATION OF CAPACITORS

4.6. Measurements of capacitors with the use of impedance Imped and DMM multimeter.

Perform the measurements for several types of capacitors presented in Fig. 4.10 (having the same values of capacitance for example 1 μF) with the use of impedance analyzer. The capacitors should be connected between DUT+ and DUT-. Perform the measurements for several frequencies (for example: 1 kHz, 10 kHz, 20 kHz). **ATTENTION: „-“ of electrolytic capacitor (shorter ending) needs to be connected to DUT-.**

Put into the table real and imaginary part of the measured impedances. Calculate values of capacitances for appropriate frequencies.

For the comparison, measure the capacitances with the use of DMM multimeter. The obtained measurement results should also be listed in the table. Compare and discuss the obtained calculated and measured results.

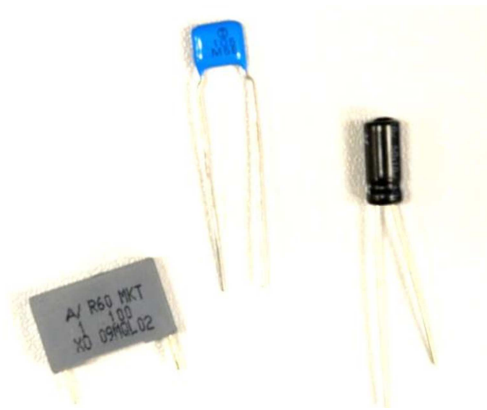


Fig. 4.10. Capacitors.

AN INVESTIGATION OF SERIES RLC ONE-PORT NETWORK

4.7. Measurements of series RLC circuit with the use of oscilloscope Scope.

Connect series RLC circuit with the use of available elements. Signal generator needs to be connected to the network input. Voltages will be observed on oscilloscope through analogue inputs operating in differential mode (default). The connection should be performed as it has been shown in Fig. 4.11.

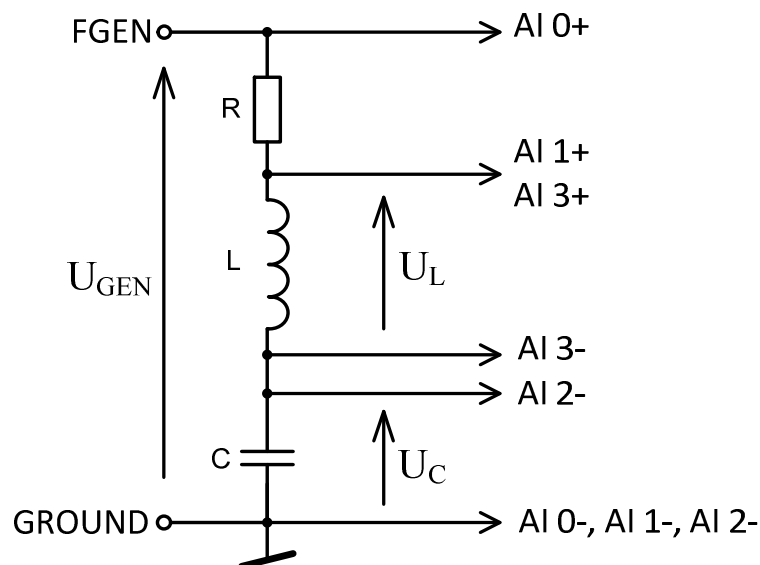


Fig. 4.11. Series RLC one-port network

Open the generator FGGEN and oscilloscope Scope (Fig. 4.12). Set the amplitude of generator as 5V. In the oscilloscope choose AI 0 and AI 1 as the signal sources of channels 0 and 1, respectively. Set the trigger type as edge and as the source channel 0. Turn on the equipment and change the frequency until the voltage on the inductor and capacitor ($U_L + U_C$) achieve the lowest value. Put found frequency into the report. Using the formula for resonant frequency of RLC network and previously measured elements values calculate the theoretical value of resonant frequency. Compare and discuss the obtained results.

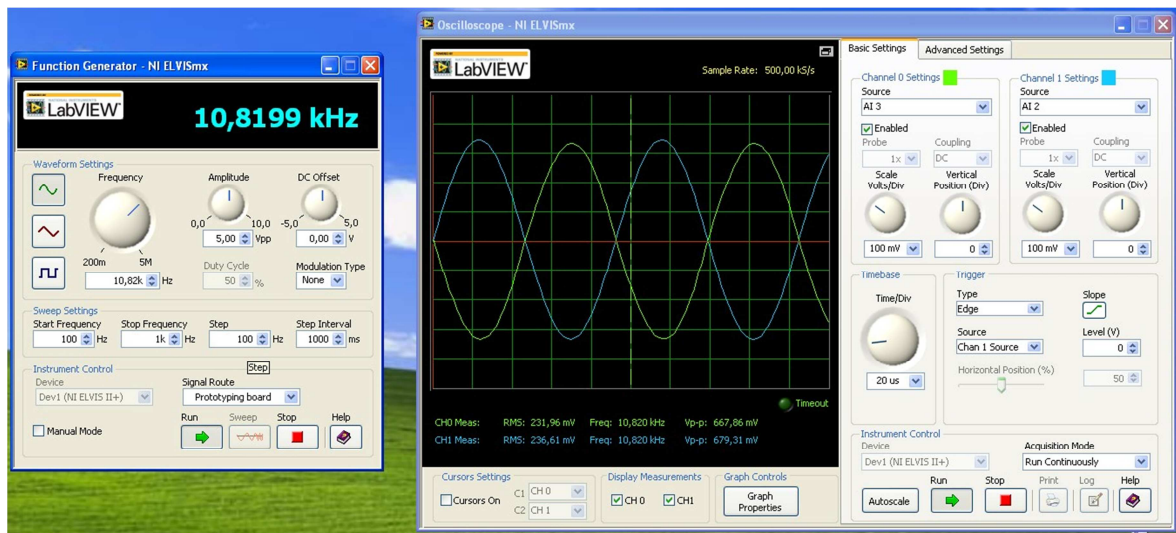


Fig. 4.12. Generator and oscilloscope GUI

Switch the oscilloscope channel sources AI 2 and AI 3 – observe voltage on inductor and capacitor. Set the same value of gain for both oscilloscope channels.

What can be said about observed waveforms? Discuss the obtained results and note appropriate conclusions.

ATTENTION: *In the above presented measurements the differential inputs have been used to observe voltages. It is not a standard procedure, when oscilloscope is utilized. Ask the teacher about the rule of common ground for generator and both channels of oscilloscope.*

4.8. Investigation of series RLC network with the use of Bode analyzer.

Open the analyzer window and the stimulus source – for the connection from Fig. 4.11 choose AI 0 and as the signal response AI 1. Set appropriate parameters and observe frequency characteristics of the circuit.

4.9. Measurement of series RLC circuit with the use of impedance analyzer Imped.

Connect the one-port network between DUT+ and DUT- and measure the impedance with the use of impedance analyzer Imped for the resonant frequency and lower and higher frequency. Note the circuit character for these frequencies. Discuss the circuit behavior.

AN INVESTIGATION OF VOLTAGE DIVIDERS

4.10. Measurements of resistance dividers – influence of load on the divider work.

Construct the voltage divider as it has been shown in Fig. 3.2. In the first case utilize the resistors for example: $R_1=9\text{k}\Omega$ and $R_2=1\text{k}\Omega$, and in the second case for example $R_1=900\Omega$ and $R_2=100\Omega$. At first, the output voltage of the dividers should be measure without load. In the next step the circuits need to be loaded with the use of resistance having several $\text{k}\Omega$ (for example: $4,7\text{ k}\Omega$). Put measurement results into the table, calculate theoretical division ratio and the division ratio for the circuit with and without the load. Discuss the obtained results.

4.11. Measurement of alternating current dividers.

Construct the divider with the use of resistor and inductor or capacitor. Supply the circuit with AC voltage from generator FGEN. Measure the input and output voltages for several frequencies.

With the use of Bode analyzer calculate frequency characteristic of the divider. Discuss the obtained results.

5. LITERATURE

[1] Lecture of Electronics Divices (I. Brzozowski, P. Dziurdzia)

[2] Lectures of Circuits Theory