EXERCISE 54	INVESTIGATION OF ELECTROMAGNETIC RESONANCE PHENOMENON

Measurement procedure

1. List of equipment

- Series RLC resonant circuit
- Power generator OWON AG 1022F
- Digital multimeter – AC voltmeter
- Digital multimeter – AC ammeter

2. Goals

- Plotting a graph of current-frequency characteristic of series RLC resonant circuit
- Determination of resonant frequencies of investigated circuits
- Determination of quality factors of investigated circuits
- Determination of capacitance of used capacitors

3. Measurement setup

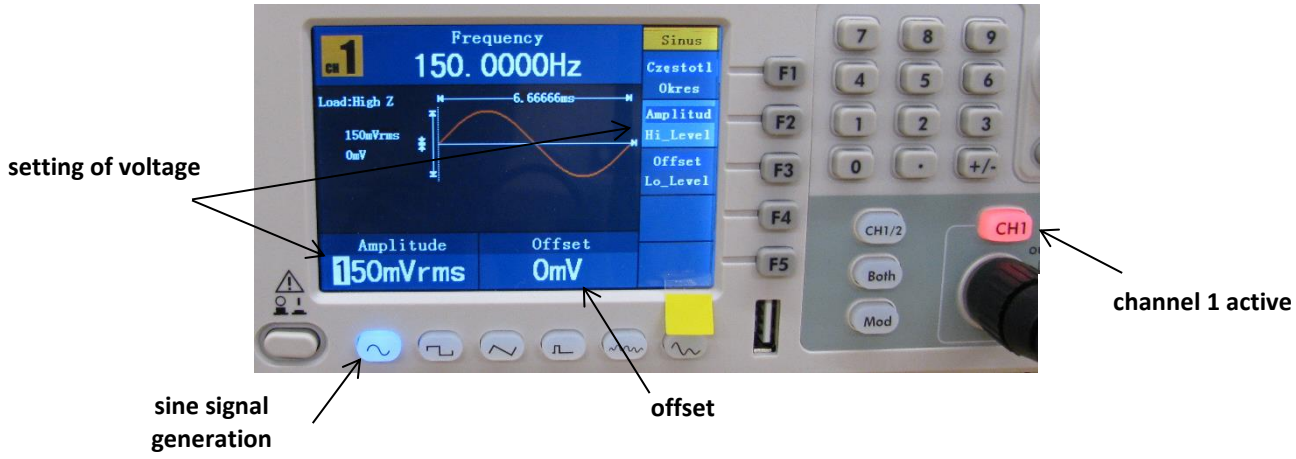

Fig. 1. Front panel of generator OWON AG 1022F.

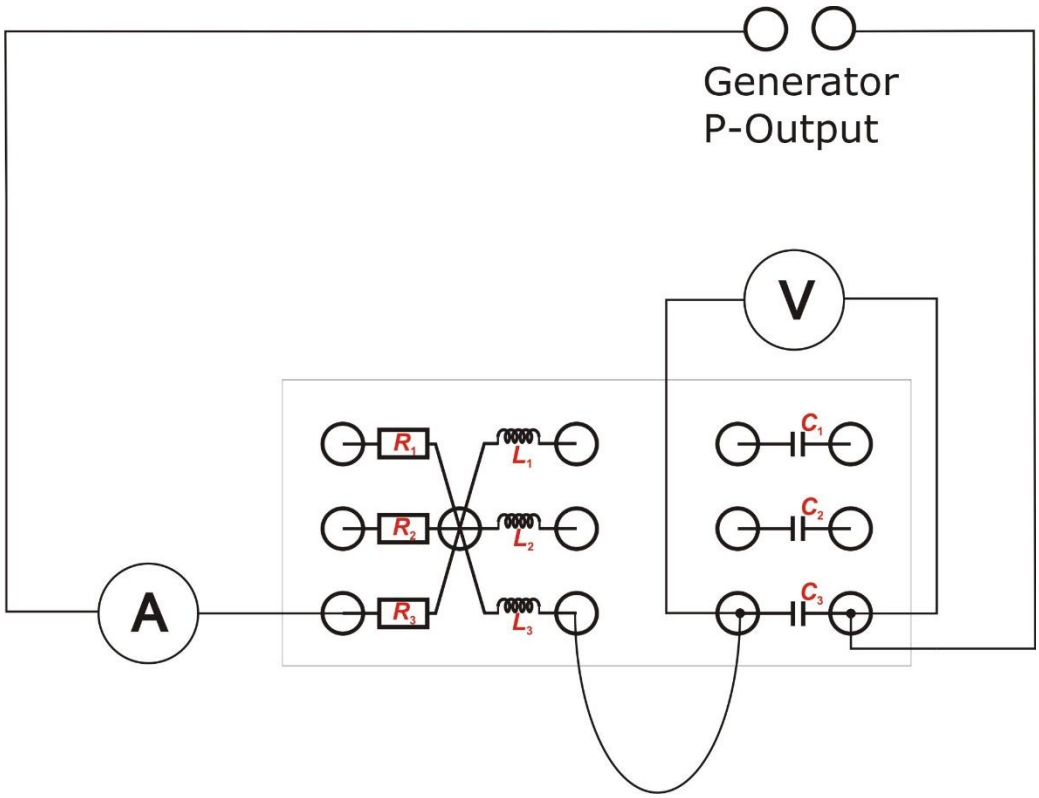

Fig. 2. Measurement setup for current-frequency characteristic of series RLC circuit.

4. Measurements plan

a) Choose the set of $R_xL_xC_x$ according to the teacher's suggestions.
b) Set up the experiment according to Fig. 2 for a chosen set of elements.
c) Make sure that the channel 1 (CH1) of the generator (⑬ - see the generator's manual) is connected to the P-Input ⑩ at the rear panel. Sine signal is obtained from the P-Output ⑨ at the rear panel.
d) Turn on the generator with the button ⑲. Make sure that the generator is set to the sine mode (the leftmost button ⑱ is highlighted, the display shows a sine function). Check if the value of Offset is set to 0 mV. If not, pressing F3 enables to change the Offset value.
e) Set the generator voltage to a value in the range of **0.2-0.4 V**, which corresponds to the output voltage U_0 in the RLC circuit of 2-4 V (10-fold amplified in comparison to the displayed value). To set the voltage value, press F2 (Amplitude). The relevant field in the display will be highlighted, one of the digits is blinking. The required voltage value can be set using the numeric keyboard (confirmed by pressing F2) or by the knob ④ and the direction keys ⑤.
f) Turn on the meters and set the appropriate ranges for AC measurements.
g) Find the preliminary resonance frequency, plan the measurements to properly obtain the resonance curve. Make more measurements around the resonance frequency.
Frequency can be set analogically to voltage setting, by pressing the F1 key. Be careful, the F1 key switches also between the frequency (Hz or kHz), and the period (μs or ms).
Caution! Do not exceed the current of I=100 mA for the inductors L_1 and L_2 and I=50 mA for the inductor L_3.
h) Measure the current in the RLC circuit as a function of frequency for a constant value of voltage U_0 according to the plan.

i) Write down the value of the voltage U_c on the capacitor at the resonance frequency.
j) Repeat measurements for another two remaining inductors L.

5. Analysis of results

a) Plot the characteristic of $I = I(f)$.
b) Determine the resonance frequency f_r and indicate it on the graph.
c) Include uncertainties for chosen measurement points, based on the uncertainties of measurement devices.
d) Calculate the capacity *C* from the equation

$$C = \frac{1}{(2\pi f_r)^2 L} \quad . \tag{1}$$

e) Calculate the compound uncertainty of *C* based on the following equation

$$u_c(C) = \frac{1}{2\pi^2}\sqrt{\left[\frac{u(L)}{2{f_r}^2 L^2}\right]^2 + \left[\frac{u(f_r)}{{f_r}^3 L}\right]^2} \quad . \tag{2}$$

f) Calculate the quality factor of the circuit based on

$$Q = \frac{U_C}{U_0}. \tag{3}$$

g) Calculate its uncertainty

$$u_c(Q) = \sqrt{\left[\frac{u(U_C)}{U_0}\right]^2 + \left[\frac{U_C}{{U_0}^2}u(U_0)\right]^2} \quad . \tag{4}$$

h) Estimate the value of *Q* from the characteristic of $I = I(f)$, according to the relation

$$Q = \frac{f_r}{\Delta f} \quad , \tag{5}$$

where Δf is the width of a peak between points with the amplitude $\frac{1}{\sqrt{2}}$ of the maximum amplitude. Compare it to the one determined in f). Estimate its uncertainty.
i) Repeat for all sets of RLC.

6. Proposed result table (for teacher approval)

Table 1. Results of current-frequency characteristic measurements for series RLC resonant circuit.

lp.	***f*** [Hz]	***u(f)*** [Hz]	***I x10^{-3}*** [A]	***u(I) x10^{-3}*** [A]	***U_c*** [V]	***$u(U_c)$*** [V]	***Cx10^{-6} [F]***	***U(C)x10^{-6} [F]***
1								
2								

Inductance:
L_1 – 10 mH
L_2 – 20 mH
L_3 – 33 mH
Relative uncertainties: 10% for all inductors