

CIRCUITS AND SYSTEMS LABORATORY

EXERCISE 2

VOLTAGE RESONANCE IN *RLC* CIRCUITS WITH SINUSOIDAL, SAW-SHAPED AND RECTANGULAR EXCITATION

1. PROGRAM OF EXPERIMENTS

1.1. RESONANCE EFFECT WITH SINUSOIDAL EXCITATION

The research is made with use of the devices listed below, in configuration shown in figure 1:

- oscilloscope HP 54603B,
- decade resistor,
- decade capacitor,
- decade inductance,
- generator HP 33120A.

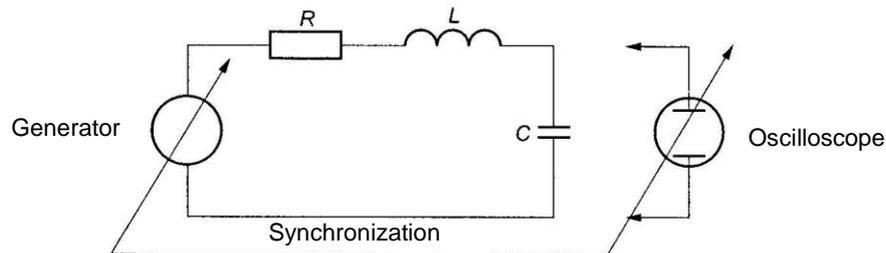


Fig. 1 Measuring configuration diagram

Programming HP 33120A generator

In this exercise one will use HP 33120A generator. The task is to program the device to generate linearly varying frequency of range from 1 to 11 kHz. The following steps needs to be done to achieve this result:

1. set up the function shape (sinusoidal and rectangular will be used),
2. turn sweep mode on (press [Shift] and [Sweep] buttons),
3. enter the menu by pressing [Shift] and [<] (Recall Menu),
4. context will be set automatically into START F position of SWP MENU (the display shows: "1: START F"),
5. enter the setting mode by pressing [v] button,
6. set up the start value 1 kHz by pressing [Enter Number], [1], [kHz],
7. repeat action 3 to enter the menu,
8. use [>] button to display STOP F position of SWP MENU (the display shows: "2:STOP F"),
9. repeat actions 5 and 6, entering 11 kHz for upper range value,
10. accepting changes by pressing [Enter] key will start generating frequency variable signal.

Oscilloscope HP 54603B setup instructions

The HP 54603B digital oscilloscope front panel has a series of control buttons and knobs organized in groups marked with different color frames with titles, e.g. TRIGGER, HORIZONTAL or VERTICAL. Names of these groups will be used in the following instructions for easier localization of controls. There is also a group of buttons below the screen which function depends on the context and is described on the screen above. They will be called the function buttons.

In order to visualize the amplitude spectrum on the oscilloscope, after setting up the generator and connecting X or Y channel to the examined signal source, one must set up the device by following these steps:

1. Press the [Auto scale] button in order to get the signal visible on the screen.
2. In the TRIGGER controls group press [Source] button and select “Ext” by pressing appropriate function key.
3. In the HORIZONTAL group press [Main/Delayed] button and select “Roll” then “Main” with appropriate function keys.
4. Adjust the time scale to 100 ms per division using the [Time/Div] knob in the same controls group (the time scale set is displayed on the screen, above the Y middle axis).
5. Using the adjacent [Delay] knob, set 500 ms delay in order to visualize the whole spectrum on the screen.
6. Because the displayed spectrum is symmetric, it is desirable to move the time axis to the bottom of the screen for better readings by adjusting the [Position] knob in the VERTICAL group. In most cases it is desirable to use the [Volts/Div] knob to set the optimal plot height.
7. Press [Display] button and use the appropriate function key to select “Peak Det” to visualize the spectrum envelope.
8. If the plot is optimally adjusted, one can make a hardcopy of the display:
9. From the STORAGE group press [Auto store] button and wait a few seconds to save the plot history on the screen and press [Stop]. Ensure that the printer is properly connected (pay attention to set the right position if using a printing switch) and ready to accept jobs. Press the [Print/Utility] button, then use the appropriate function key to select “Print Screen” option and the printing will start shortly. Please do not use the oscilloscope controls nor switch off the oscilloscope until the print job is done.

Optimal choice of RLC circuit elements

For the frequency scope used in this exercise the elements optimal values are: $R=100 \Omega$, $C=0,0006 \mu\text{F}$, $L=0,6 \text{ H}$.

1.2. RESONANCE EFFECT WITH RECTANGULAR EXCITATION

The measuring circuit configuration is the same as in paragraph 1.1. Using rectangular excitation allows to observe resonance characteristics for higher harmonics. The results should be written in table 1.

Using oscilloscope with printer, one should achieve inductor and capacitor voltage amplitude characteristics that should be printed out after acceptance of the teacher.

Table 1

Resonance frequency and peak current values for individual harmonics

	1 st harmonic		3 rd harmonic		5 th harmonic		7 th harmonic	
f								
I_{max}								

1.3. RESONANCE EFFECT WITH SAW-SHAPED EXCITATION

The measuring circuit configuration is the same as in paragraph 1.1. Using saw-shaped excitation allows to observe resonance characteristics for higher harmonics. The results should be written in table 2.

Using oscilloscope with printer, one should achieve inductor and capacitor voltage amplitude characteristics that should be printed out after acceptance of the teacher.

Table 2

Resonance frequency and peak current values for individual harmonics

	1 st harmonic		2 nd harmonic		3 rd harmonic		4 th harmonic		5 th harmonic		6 th harmonic		7 th harmonic	
f														
I_{\max}														

1.4. OBSERVATION OF TIME FUNCTIONS OF CURRENT AND VOLTAGE IN RLC CIRCUIT WITH RECTANGULAR AND SAW-SHAPED EXCITATION

One should examine the influence of frequency of rectangular and saw-shaped input voltage base harmonic on the shape of current, U_L and U_C actual values run in the examined circuit for given L and C values. In particular, these run shapes should be observed with the following values of input voltage frequency respectively:

- $f = f_0$
- $f = \frac{1}{3} f_0$
- $f > f_0$

where: $f_0 = \frac{1}{2\pi\sqrt{LC}}$.

Values of R , L and C should be written down in all cases as well as the input voltage amplitude. The inductor and generator resistance should be taken into account when determining resistance of the examined circuit.

2. RESULTS PROCESSING

After conducting the laboratory research, one should:

1. Draw theoretical characteristics of rms values of capacitor voltage and inductor current as a frequency functions for voltage resonance with sinusoidal excitation, using the same RLC elements values as in the exercise. Compare these characteristics with the ones got in the laboratory.
2. For rectangular and saw-shaped input voltage of the given amplitude, calculate amplitude values of input component harmonics, amplitude and phase of current and capacitor and inductor voltage for single frequency given by the teacher. Draw amplitude spectrum charts of input, capacitor and inductor voltage and current for that frequency.
3. Draw theoretical characteristics of RMS current value as a frequency function for voltage resonance with rectangular and saw-shaped excitation, using the same RLC elements values as in the exercise. Compare these characteristics with the ones got in the laboratory.