Laboratory work №4.27.10

Investigation of damped oscillations

Tools: 1) cartridge FPE-10; 2) pulse converter (cartridge FPE-PI); 3) electronic oscillography; 4) electromagnetic waves generator; 5) store of resistances and capacitances; 6) power supply.

Purpose:1) investigation of damped oscillations in oscillatory circuit with different resistances; 2) calculation of logarithmic decrement of damping and oscillatory circuit parameters.

Device and Theory

The principle electrical scheme of the laboratory installation is shown in Fig. 1. A rectangular voltage pulse supplied from the converter pulses (PI) to the oscillator circuit capacitor C. The capacitor is charged almost instantaneously, because the resistance of charging circuit is small. Then the capacitor is discharged through the resistance R and inductor L. If $R<R_{crit}$, then damped oscillations appear in oscillatory circuit.

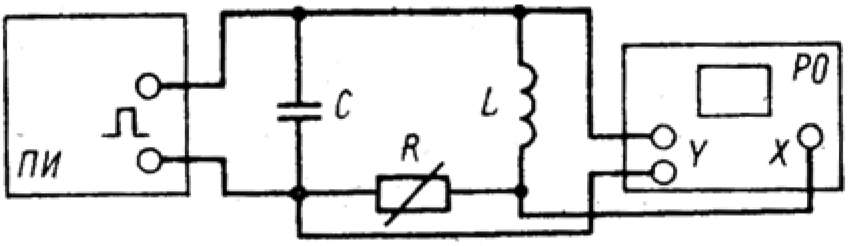

Fig. 1.

The voltage from capacitor of the oscillator circuit supplies the input Y of oscilloscope PO. When scanning is enabled on the oscilloscope we can observe the process of oscillations' damping. When $R >= R_{crit}$ oscillatory process becomes aperiodic. In some cases it is convenient to study oscillatory process in a coordinate system I – U, where I - current in the circuit, and U - the voltage on the capacitor.

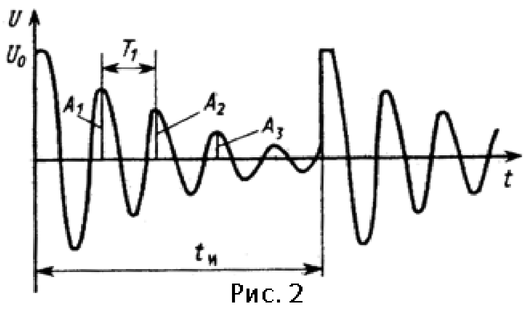

Fig. 2.

Area I – U is called phase and a curve that shows the dependence of the current strength of the voltage, also called phase.

Consider, how the curve will look like if R=0. In this case, the voltage on the capacitor plates changes by law

$$U = U_o \cos(\omega_o t + \varphi)\,, (1)$$

And current in circuit –

$$I = -C\frac{dU}{dt} = CU_o\omega \sin(\omega_o t + \varphi)\,. (2)$$

Removing the time from the equations (1) and (2), you can get the phase curve equation of the form

$$\left(\frac{U}{U_o}\right)^2 + \left(\frac{I}{CU_o\omega_o}\right) = 1. (3)$$

This is the equation of an ellipse. In case of damping oscillations amplitude of voltage and current in the circuit continuously decreasing and the phase curve becomes a spiral that is continuously approaching to focus 0 (fig. 3,a). When R >= R_{crit} oscillatory process in circuit stops and spiral looks like curve, as shown in fig. 3,b.

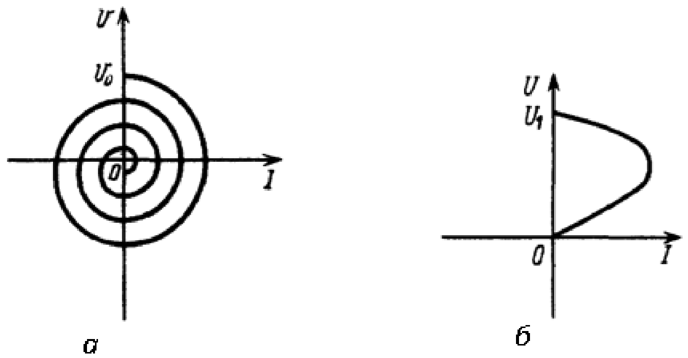

Fig. 3.

Measurement

1. Create installation as it is shown in fig. 4.
2. Set up value Ri = 100 Ohms in the store of resistances.
3. Push and PULSE WIDTH– ROUGH on the pulse converter.
4. Set such values of input voltage parameters of generator PQ: frequency of 250 Hz, output voltage should not be more than 3 V.
5. Prepare oscilloscope to observe signals which parameters are given in p. 4.

After checking scheme by teacher begins to perform the tasks of work.

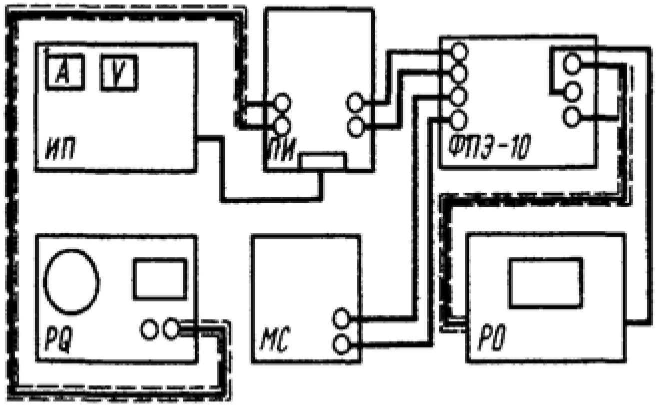

Fig. 4.

Task 1. Study damping oscillation with different resistances of circuit

1. Connect the lab bench and devices to the power supply, set by a scale of sound generator's voltmeter voltage 2 - 3 V, which is necessary to operate the pulse converter.
2. On the screen of the oscilloscope we get a stable picture of one - two periods of damping oscillations (see. Fig. 2). If necessary, change the frequency of pulses, slowly changing frequency of sound generator so that the oscillations' damping was quite full. Turning the knob "PULSE WIDTH" of the pulse converter, make that damping of pulses not to distort the curve of the first period of damping oscillations.
3. Define in the scale of the oscilloscope period of damping oscillations T_1 and distance between neighboring pulses t_i. Calculate the period of damping oscillation in seconds by the formula

$$T = \frac{T_1}{t_i f}, (4)$$

where f – frequency of sound generator.

4. The obtained results write down in the table. 1.

$R_м$	T	A_1	A_2	A_3	λ	β	R_L	L	$R_{крит}$

5. Define in the scale of the oscilloscope amplitudes A_1, A_2, A_3, of damping oscillations and write down their values in the table. 1.According to the formula $\lambda = \ln\frac{A_1}{A_2}$ calculate the logarithmic decrement of damping λ for each pair of values

of the amplitudes A. Find the average value $\lambda = \frac{(\lambda_1+\lambda_2)}{2}$ and write down in the table. 1.

6. Calculate the coefficient of damping $\beta = \frac{\lambda}{T}$. Write it down in the table. 1.

7. Do the measurements and calculations (p. 3 and 5) with other values of R_m (R_m= 300, 500, 600 Ohms).

8. Select a store resistance R_{mcrit},when aperiodic discharge of the capacitor begins. Record the value.

9. Build a graph of the dependence of logarithmic decrementλ from $R_m$and extend it to its intersection with the abscissa (Fig. 5). Segment R_L is the resistance of the oscillator circuit's coil.

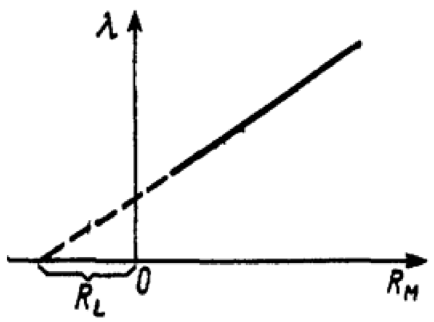

Fig. 5.

Impedance of circuit $R=R_m+R_L$.

$$\lambda = \beta T = \frac{R_m + R_L}{2L} T. (5)$$

10. Using the data of table. 1 and expressing the formula (5) calculate inductance of coil. Using the values of capacitors that are on cartridge FPE-20, calculate the critical resistance R of circuit by a formula

$$R_{crit} = 2\sqrt{\frac{L}{C}}.$$

Compare the calculated results with the experimental value of the critical resistance, i.e.,

$$R_{crit_{exp}} = R_{m_{crit}} + R_L.$$

Task 2. Measurement of logarithmic decrement of damping using phase curve

1. Turn on resistance R = 100 Ohms on store of resistances.
2. Turn on scan of oscilloscope and watch the phase curve on the screen. Move phase curve to place the focus in the middle of the screen.

3. Using curve for the phase measure the voltage and currents that is divided by the period of oscillation, i.e. the distance from the focus of the phase curve to intersection points of the spiral coil with axes of voltage current. The result is listed in table. 2.

$R_м$	U_1	U_2	U_3	λ	I_1	I_2	I_3	λ

4. Measure (p. 3) with other resistance value from store of resistances (R_m=200; 500 ohms). For each R_m calculate the logarithmic decrement of damping write down results in Table 2.
5. Turn on R >= R_{crit}. Draw a curve of aperiodic phase process.
6. Turn off the devices and laboratory bench.

Control questions

1. In the oscillatory circuit in 1 second occurs 100 oscillation. During this time the amplitude of oscillations decreases in e = 2.72 times. Find the logarithmic decrement of damping.
2. What is the critical resistance of oscillator circuit R_{crit}?
3. How does the dependence of logarithmic decrement of damping λ = f (R), where R – resistance of oscillatory circuit, look like?