HDU-ITMO Joint Institute

Electrical Engineering

Laboratory work 2

Research on series and parallel resonance circuits

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Laboratory work № 2: «Research on series and parallel resonance circuits»

OBJECTIVES

to investigate linear alternating current (AC) circuits properties, and its special modes of operation, such as series resonance and parallel resonance.

PROGRAM OF WORK

1. To study and to analyze the frequency characteristics of the electrical circuit with the serial connection of resistive, inductive and capacitive elements.
2. To study and to analyze the frequency characteristics of electric circuit with the parallel connection of branches with inductive and capacitive elements.

OVERVIEW

The lab is aimed at two goals: developing the skill of AC circuit analysis and simulation and investigating of resonance phenomena arising in AC circuits.

Students are to use phasor analysis to get the RMS values of currents and voltages of AC circuit, and frequency analysis to get the insight into circuit behavior under excitation on different frequencies.

The knowing of properties of voltage magnification and current magnification provides the key to understanding of many real-world applications and processes.

GUIDANCE

1. Assemble an equivalent circuit presented in the Figure 2.1, in the «LTspice» application.
2. Set the values for the power source defined by the instructor (Amplitude of EMF - «Amplitude», frequency - «Freq», internal resistance - «Series Resistance»).

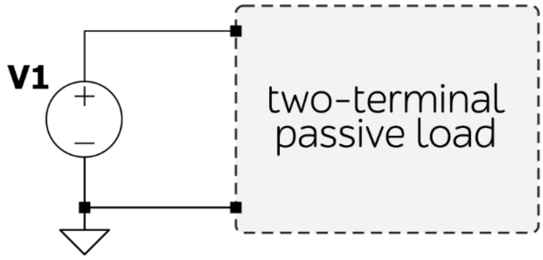
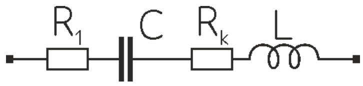
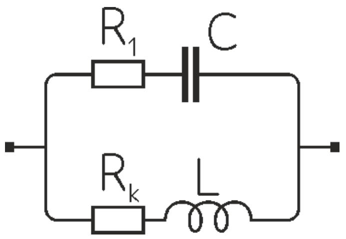


Figure 2.1 - Equivalent circuit of a sine wave EMF and a load (two-terminal passive circuit) in the «LTspice» application.

3. Assemble the circuit with the two-terminal passive load according to the Table 2.1 and set the parameters of the elements specified by the instructor.
4. Calculate resonant frequency for specified parameters of elements - $f_0 = 1/\left(2\pi\sqrt{LC}\right)$ [Hz].

Table 2.1

№	Passive two-terminal load	Calculation equations
1		$I = U/Z,\, R = R_1 + R_k,$ $X = X_L - X_C = \omega \cdot L - 1/(\omega \cdot C)$ $Z = \sqrt{R^2 + X^2},\, \varphi = \mathrm{arctg}(X/R)$
2		$I = U \cdot Y,\, G = G_1 + G_k,\, G_1 = R_1/\left(R_1^2 + X_C^2\right),$ $G_k = R_k/\left(R_k^2 + X_L^2\right),\, B = B_k - B_1,$ $B_1 = X_C/\left(R_1^2 + X_C^2\right),\, B_k = X_L/\left(R_k^2 + X_L^2\right)$ $Y = \sqrt{G^2 + B^2},\, \varphi = \mathrm{arctg}(B/G)$

R_k - active resistance of the inductor; in «LT spice» R_k and L are set as internal parameters «Series Resistance» and «Inductance» of the «Inductor» element.

5. Set the source voltage frequency corresponding to the calculated value of the resonant frequency f_0.
6. Measure RMS values of current I, voltage across the resistor U_{R1}, voltage across the capacitor U_C, voltage across the inductor U_k and the phase shift between voltage and current φ_0 in the resonance mode. Add measurements and calculations results to the Table 2.2.

   Measure phase shift $\varphi = 180° \cdot \Delta h/h$ as shown in the Figure 2.2 (h - half of the sine wave period, measured in seconds, Δh - the length in seconds of the segment between moments of time when sine waves of voltage and current change sign from negative to positive. If the current is ahead of the voltage, as shown in the Figure 2.2, then $\varphi < 0$, if it falls behind - $\varphi > 0$.

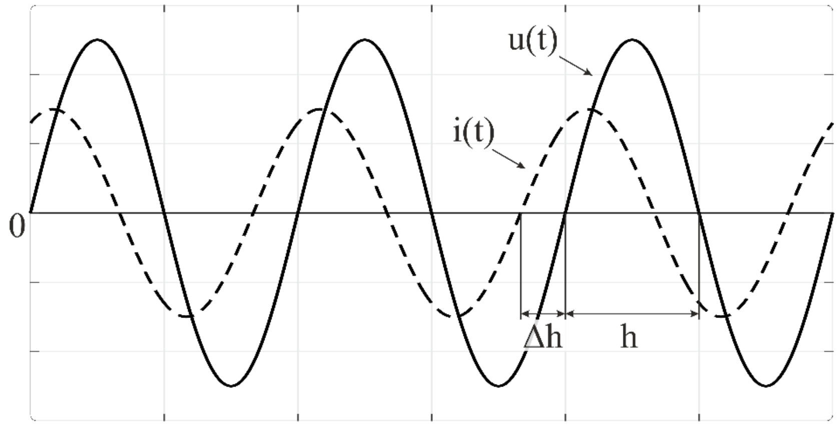


Figure 2.1 - Measuring a phase shift between input voltage and current.

7. Get the measurements of $I(f)$, $\varphi(f)$, $U_{R1}(f)$, $U_k(f)$, $U_C(f)$ for 20 constraint points in range from $0.1 \cdot f_0$ up to $2 \cdot f_0$ by changing the source frequency («Freq» parameter), and put the results of measurements and calculations in the Table 2.2.
8. Put the calculated Q and experimental Q_e quality factor values in the Table 2.2 ($Q = \rho / (R_1 + R_k)$, where $\rho = \sqrt{L/C}$; $Q_e = U_{C0}/U$, U_{C0} and U - RMS values of capacitor voltage and source (input) voltage measured in resonance mode).
9. Assemble an electrical circuit with a two-terminal passive load according to the scheme № 2 from the Table 2.1.
10. Calculate resonant frequency for parameters of elements specified in part 1 of the laboratory work - $f_0' = \frac{1}{2\pi}\left|\sqrt{\frac{(R_2 + R_k)^2}{4L^2} - \frac{1}{LC}}\right|$ [Hz].
11. Set the source voltage frequency corresponding to the calculated value of the resonant frequency f_0'.
12. Measure RMS values of input current I, current in the branch with the inductor I_1, current in the branch with the capacitor I_2 and phase shift angle

φ between the input voltage and the current in resonance mode. Add the measured and calculated values to the Table 2.3.

13. Get the measurements of $I(f)$ $\varphi(f)$ $I_1(f)$ $I_2(f)$ for 20 constraint points in range from $0.1 \cdot f_0$ up to $2 \cdot f_0$ by changing the source frequency («Freq» parameter), and put the results of measurements and calculations in the Table 2.3.

Table 2.2

f	U = __ [V]; R_1 = __ [Ω]; R_k = __ [Ω]; L = __ [mH]; C = __ [mkF]; f_0 = __ [Hz]									
	Calculations					Experiment				
	Q = __					Q_e = __				
	φ	I	U_{R1}	U_k	U_C	φ	I	U_{R1}	U_k	U_C
Hz	°	A	B			°	A	B		
$0.1 \cdot f_0$										
…										
f_0										
…										
$2 \cdot f_0$										

Table 2.3

f	U = __ [V]; R_1 = __ [Ω]; R_k = __ [Ω]; L = __ [mH]; C = __ [mkF]; f_0' = __ [Hz]							
	Calculations				Experiment			
	φ	I	I_1	I_2	φ	I	I_1	I_2
Гц	°	A			°	A		
$0.1 \cdot f_0'$								
…								
f_0'								
…								
$2 \cdot f_0'$								

CONTENT OF THE REPORT

1. The equivalent circuits (1, 2).
2. Calculation formulas and calculations. Completed Tables 2.2 and 2.3.
3. Plots of the calculated and experimental characteristic $I(f)$, $\varphi(f)$, $U_{R1}(f)$, $U_k(f)$, $U_C(f)$ for circuit №1.
4. Plots of the calculated and experimental characteristic $I(f)$, $I_1(f)$, $I_2(f)$, $\varphi(f)$ for circuit №2.