Research on series and parallel resonant circuits

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Objectives

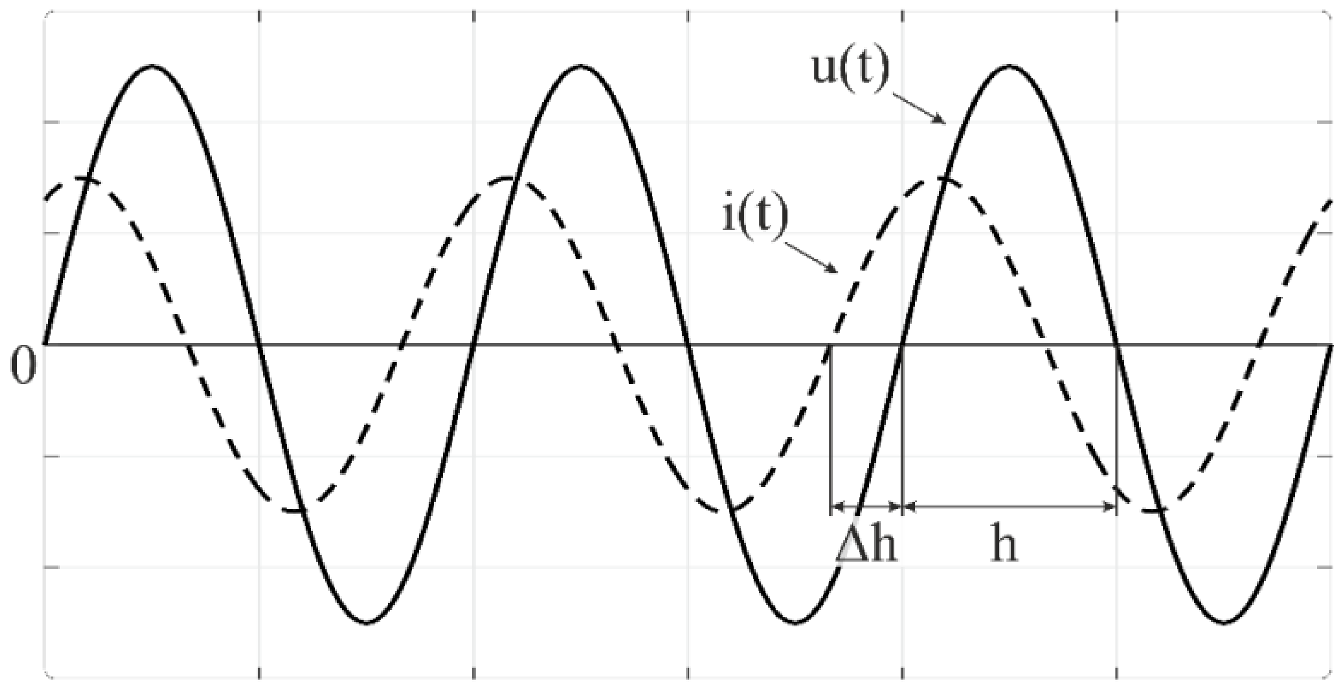
to investigate linear alternating current (AC) circuits properties, and its special modes of operation, such as series resonance and parallel resonance.

Program of work

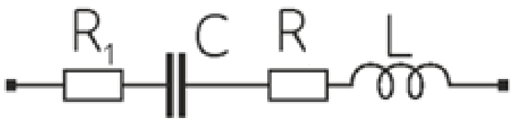
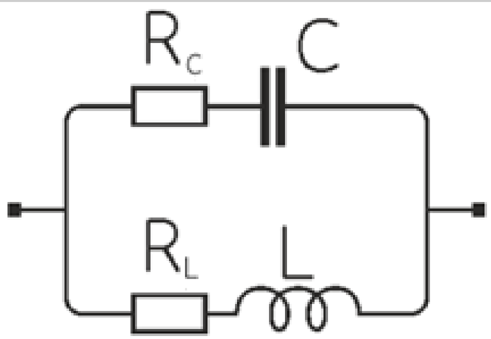
1. To study and to analyze the frequency characteristics of the electrical circuit with the serial connection of resistive, inductive and capacitive elements.
2. To study and to analyze the frequency characteristics of electric circuit with the parallel connection of branches with inductive and capacitive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

Phase shift

Measure phase shift $\varphi = 180° \cdot \Delta h / h$ as shown in the Figure (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 then $\varphi < 0$, if it falls behind - $\varphi > 0$.



Resonant circuits

№	Passive two-terminal load	Calculation equations
1		$I=U/Z, R=R_1+R_L,$ $X=X_L-X_C=\omega\cdot L-1/(\omega\cdot C)$ $Z=\sqrt{R^2+X^2}, \varphi=\mathrm{arctg}(X/R)$
2		$I=U\cdot Y, G=G_C+G_L, G_C=R_C/(R_C^2+X_C^2),$ $G_L=R_L/(R_L^2+X_L^2), B=B_L-B_C,$ $B_C=X_C/(R_C^2+X_C^2), B_L=X_L/(R_L^2+X_L^2)$ $Y=\sqrt{G^2+B^2}, \varphi=\mathrm{arctg}(B/G)$

Series resonant circuit

Calculate resonant frequency for specified parameters of elements – $f_0 = 1/\left(2\pi\sqrt{LC}\right)$ [Hz].

Set the source voltage frequency corresponding to the calculated value of the resonant frequency f_0.

Measure RMS values of current I, voltage across the resistor U_R, voltage across the capacitor U_C, voltage across the inductor U_L and the phase shift between voltage and current φ_0 in the resonance mode. Add measurements and calculations results to the Table

Put the calculated Q and experimental Q_e quality factor values in the Table $\left(Q = \rho/(R_1 + R_L)\right)$, 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).

Series resonant circuit

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

Get the measurements for 20 constraint points in range from $0.1f_0$ up to $2f_0$ by changing the source frequency and enter the results of experiment and calculations in the Table.

Parallel resonant circuit

Calculate resonant frequency

$$f_0' = \frac{1}{2\pi}\left|\sqrt{\frac{(R_C + R_L)^2}{4L^2} - \frac{1}{LC}}\right| \text{ [Hz]}$$

Set the source voltage frequency corresponding to the calculated value of the resonant frequency f_0'.

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

Parallel resonant circuit

f	U = __ [V]; R_C = __ [Ω]; R_L = __ [Ω]; L = __ [mH]; C = __ [mkF]; f'_0 = __ [Hz]							
	Calculations				Experiment			
	φ	I	I_1	I_2	φ	I	I_1	I_2
Hz	°	A			°	A		
$0.1 \cdot f'_0$								
...								
f'_0								
...								
$2 \cdot f'_0$								

Get the measurements for 20 constraint points in range from $0.1f_0$ up to $2f_0$ by changing the source frequency and enter the results of experiment and calculations in the Table.

Special tasks

Task 2.1. Find the expression of group delay $\tau(\omega)$ of series resonant circuit. Use the transfer function $H(j\omega)=U_{R1}(j\omega)/Uin(j\omega)$.

Task 2.2. Find the expression of group delay of parallel resonant circuit. Use the transfer function $H(j\omega)=U_R(j\omega)/Uin(j\omega)$.

The report must include the solution and group delay plot. You can use the numerical values of parameters from your variant.