B. Sc. Part II

Paper IV

Current electricity

Paper IV

Dr. Shiva Kant Mishra
Dept of Physics HDJC

Current electricity.

Series Resonant Circuit

Date 21-6-21

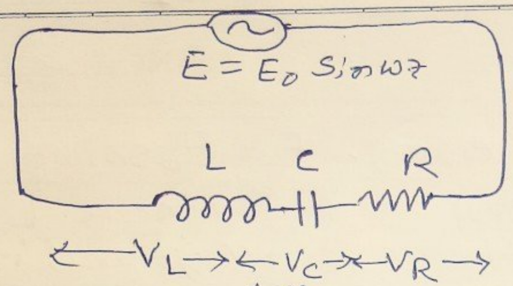
Expt. No. ______ Page No. ______

Let an alternating e.m.f. $E = E_0 \sin \omega t$ be applied to a circuit having an inductance L, Capacitance C and resistance R all joined in series as shown in the figure. The instantaneous current in the same in L, C and R and the vector sum of the potential differences across the three components is equal to the applied e.m.f. The peak value of the current in the circuit can be obtained by a vector method as shown in figure.

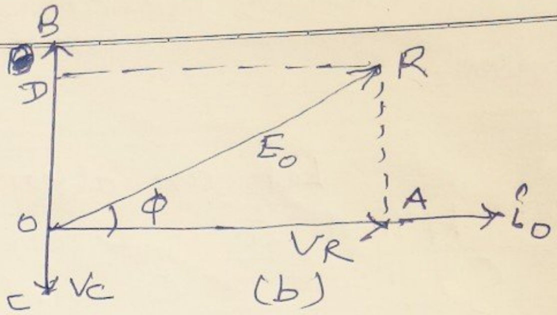
Let OA, OB and OC represent the magnitude and phase of the peak potential differences V_R, V_l and V_c across R, L and C respectively. Their magnitudes $V_R = R i_0$, $V_l = X_l i_0 = \omega L i_0$ and $V_c = X_c i_0 = i_0/\omega C$ where i_0 is the peak value of the current and X_l and X_c are the inductive reactance and the capacitive reactance respectively. The magnitude of the resultant of $\vec{V_l}$ and $\vec{V_c}$, which are opposite in phase, is equal to their difference and can be represented by OD, where OD = OB − OC.

The diagonal OR of the rectangle OARD then represents, in magnitude and direction, the resultant of V_R V_l and V_c and hence E_0. Now $OR^2 = OA^2 + OD^2$.

$$\therefore E_0^2 = V_R^2 + (V_l - V_c)^2 = (R i_0)^2 + (X_l i_0 - X_c i_0)^2$$



(a)



(b)

or $$i_0^2 = \frac{E_0^2}{\sqrt{R^2+(X_1-X_C)^2}}$$

or $$i_0 = \frac{E_0}{\sqrt{R^2+(X_1-X_C)^2}} = \frac{E_0}{Z} \qquad (1)$$

where Z is the impedanced of the circuit. Thus

$$Z = \sqrt{[R^2+(x_1-X_C)^2]} = \sqrt{\left[R^2+\left(\omega L - \frac{1}{\omega C}\right)^2\right]} \qquad (2)$$

The Phase differences between the applied e.m.f. and the resultant current is given by

$$\tan\phi = \frac{V_1-V_C}{V_R} = \frac{X_1-X_C}{R} = \frac{\omega L - \frac{1}{\omega C}}{R} \qquad (3)$$

The equ^n (2) shows that impedance Z of the circuit is a minimum when $X_L = X_C$ and is equal to the resistance R in the circuit. Equ^n (1) shows that under this condition the series circuit allows the maximum peak current to flow through it, and is inphase with the applied e.m.f. The circuit is then called the series resonant circuit.

The frequency at which this resonance taxes place is given by

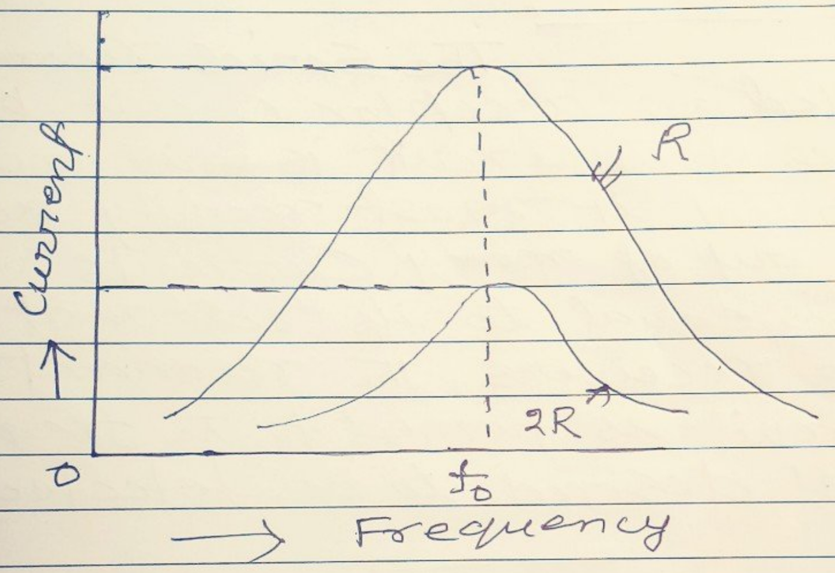
$$X_L = X_C$$

or $$\omega L = \frac{1}{\omega C}$$

or $$\omega = 1/\sqrt{LC}$$

or, $f = \frac{\omega}{2\pi} = \frac{1}{2\pi\sqrt{LC}} = f_0$

which is The natural frequency of The circuit. Thus the resonant frequency depends on the Product of L and C and does not depend on R.



If R, L and C remain fixed and The frequency f of The applied e.m.f. is raised continuously from zero, The Peak Current Varies as shown in figure. At ~~raised~~ first The Current is very small, increases to a maximum when The frequency increases to its resonance Value f_0 and Then falls again.

The Maximum Value of The Current depends on The resistance R in The Circuit being smaller for larger R. As shown in The figure two Curves are Plotted one when The circuit resistance is R and the other when the circuit resistance is 2R.

The resonant current in the second case is half the value in the first case. Also, the resonance is sharper for smaller resistance than for larger resistance. The resonant frequency remains, however, unaffected.

Accepter Circuit :-

The series resonant circuit is often called an acceptor circuit because the impedance of the circuit is minimum at resonance so that it most readily accepts that current out of many currents whose frequency is equal to its resonant frequency. In radio receivers, the resonant frequency of the circuit is turned to the frequency of the signal desired to be detected.