

L-C-R Series and parallel

Resonance

Aim :- To study the frequency response and to find resonant frequencies of L-C-R series and parallel circuits. Also to find the quality factor and band width in L-C-R series circuit.

Apparatus :- A variable non-inductive resistor, a variable capacitor, a variable inductor, a signal generator, an a.c. milli-ammeter and the connecting wires.

Formula :- The resonance frequency $f_0 = \frac{1}{2\pi\sqrt{LC}}$ Hz

Where L = Self inductance (mH)

C = Capacity of the capacitor (μF)

$$\text{Quality factor } Q = \frac{2\pi f_0 L}{R}$$

Where R = Resistance (Ω)

Band width = (f₂ – f₁) (Hz)

$$\text{Also Quality factor } Q = \frac{f_0}{f_2 - f_1}$$

Where f₁ and f₂ are the frequencies at the half power points.

Description and theory :- (Series L-C-R) When the resistor R, inductor L and capacitor C are connected in series with a source of emf E, the circuit is called as the series resonant or series tuned circuit (figure-1). This is an acceptor circuit, that means it allows maximum current to flow through it at a particular (resonant) frequency and at all other frequencies it allows less current.

In A.C. circuits the voltage and the current are usually out of phase. Across the inductor, the current lags behind the voltage by 90°, whereas across the capacitor, the current leads the voltage by 90°. But across the resistor the voltage and current both are in

phase. Under certain conditions, the voltage and current are in phase, even though the circuit consists of L , C and R and the circuit behaves as a pure resistor. This phenomenon is called resonance. This occurs at a single frequency known as resonant frequency. At this frequency the capacitive reactance ($X_c = 1/\omega C$) and the inductive reactance ($X_L = \omega L$) are equal and opposite in direction. So they get cancelled each other and only resistance acts.

The impedance of the circuit is given by $Z = R + j(\omega L - 1/\omega C)$

At resonance the reactive term disappears $\omega L - 1/\omega C = 0$

The impedance is minimum i.e. $Z = R$

The current is maximum $I = E/R$

$$\text{So } \omega L = 1/\omega C$$

$$\omega_0 = \omega = 2\pi f_0 = \frac{1}{\sqrt{LC}}$$

At this frequency the current is maximum and this frequency f_0 is called resonant frequency. The circuit has selective properties. To compare selectivity or sharpness of resonance, a band of frequencies is chosen at which the current falls to $\frac{1}{\sqrt{2}}$ times (half power points) of its maximum value. The frequency difference ($f_2 - f_1$) between the half power points is called the bandwidth.

L-C-R parallel :- Parallel resonant circuit (figure-2) is one in which one branch consists of an inductor L with associated resistor R and the other branch consists of a capacitor C . This is a rejector circuit, that means it rejects the current or allows minimum current to flow through it, at a particular (anti- resonant) frequency and it allows more current at

all other frequencies. So the circuit is not selective. But it is highly selective when energized from a high impedance generator.

The impedance of the circuit is given by

$$\frac{1}{Z} = \frac{1}{R+j\omega L} + \frac{1}{1/j\omega C}$$

At resonance the impedance is maximum.

The impedance at resonance

$$Z = \frac{L}{CR}$$

The anti-resonance frequency

$$f_o = \frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} \text{ Hz}$$

If R-value is small, then

$$f_o = \frac{1}{2\pi \sqrt{LC}} \text{ Hz}$$

Procedure :- For L-C-R series, the circuit is connected as shown in the figure-1. The source resistance and the series resistance should be small. The out put voltage of the signal generator is adjusted to be around 5V. The frequency of the signal generator is changed in steps and the corresponding current values are noted from the a.c. milliammeter. The readings are tabulated. The current values increase with the increase of frequency, up to the resonant frequency, further increase of frequency causes the decrease of current. The L,C and R values are noted to calculate the resonant frequency f_o and Q-factor, using the above formulae.

Note :- The experiment may be repeated with a different values of 'R' . Here the f_o value is un changed, but Q- factor value is changed.

Graph :- A graph is drawn for current against frequency. The frequency corresponding to maximum current is noted and it is the resonant frequency f_0 . The frequencies f_1 and f_2 corresponding to half power points is noted and from it the bandwidth, $(f_1 - f_2)$ is noted. From the values of f_0 , f_1 and f_2 , the quality factor, Q is calculated.

For L-C-R parallel, the circuit is connected as shown in the figure-2. The frequency of the signal generator is changed in steps and the corresponding current values are noted from the a.c. milli- ammeter. The readings are tabulated. But here, the current values decrease with the increase of frequency up to the anti- resonant frequency, further increase of frequency causes the increase of current. The anti- resonant frequency f_0 is noted corresponding to the minimum current in the circuit.

Graph :- A graph is drawn for current against frequency. The frequency corresponding to minimum current is noted and it is the anti- resonant frequency f_0 .

Precautions :- 1) The internal resistance of the source and series resistance should be small.

2) Before going to the experiment the resonant frequency should be calculated from L and C values so that to select the range of frequencies for observation.

Results :-

Table-1

L-C-R Series

S.No.	Frequency (Hz)	Current (mA)
1.		
2.		
3.		
20.		

Table -2

L-C-R Parallel

S.No.	Frequency (Hz)	Current (mA)
1.		
2.		
3.		
20.		

Fig-1

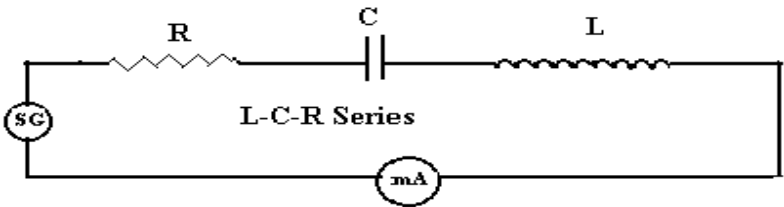


Fig-2

