To Study the Effect of Variation of Resistance in LCR Series AC Circuits

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Abstract:

In introductory physics the series LCR circuit is usually discussed in the context of the AC-driven circuit. A detailed investigation of the effect of resistance on the series LCR circuit has been given. The circuit provides a wide range of laboratory problems, demonstrations, theoretical and computational activities.

In the present work, for fixed values of LC, the effect of resistance on the LCR series AC circuit is studied experimentally. At first it would be checked the effect of resistance on resonant frequency, band width and quality factor. This work also focuses on measuring precise values of passive components such as resistors, inductors and capacitors through non-contact means through inductive or capacitive or resistive coupling for series. However, if one of the circuit components such as the resistance, inductance or capacitance is made to vary, it will cause a change in the output voltage with respect to change in frequency of signal generator.

Keywords: passive components, LCR series circuit, resonant frequency, signal generator, quality factor, band width.

1. Introduction:

LCR circuit is most useful and widely used circuit in electronics since they are simple as two or three components connected in series or parallel. For fixed values of L, C and R, magnitude and phase of the circuit current are controlled by the applied frequency [1]. With the increase in frequency the impedance across the inductance increases and that of across the capacitance decreases. The circuit current increases with frequency and this enhancement of current continues until the impedance of inductance and the impedance of capacitance become equal in magnitude and opposite in phase, cancelling each other. Thus the circuit is completely resistive; no effect of inductance or capacitance remains present [2,3]. At resonance the current flows through the circuit is the maximum and only depends on the total circuit resistance [4,5].At resonance condition the current and applied voltage are in the same phase. The frequency that is responsible to achieve this condition is called resonance

frequency [6]. In series LCR circuit, resonance occurs because energy is stored in two different ways [7,8].When capacitor is charged it stores electric field while magnetic field arises as current flows through the inductor. The stored energy can be transformed from one to other within circuit and the circuit becomes oscillatory. Theoretically it is clear that to achieve the resonance condition the values of L, C and R are

very important for a given range of supplied frequency. Band width is also a key parameter in a LCR series circuit which measure between the frequency at which the power is passed through the circuit components which fallen to half the value passed at resonance [9-10]. For understanding the characteristics of resonators quality factor (Q- factor) is also measure. In the present work the effect of variable resistance, on the resonant frequency, quality factor and band width of LCR series circuit was studied in detail.

2. Experimental Details:

The circuit diagram and the experimental set up of series LCR circuit is shown in fig.1 and fig.2 respectively.

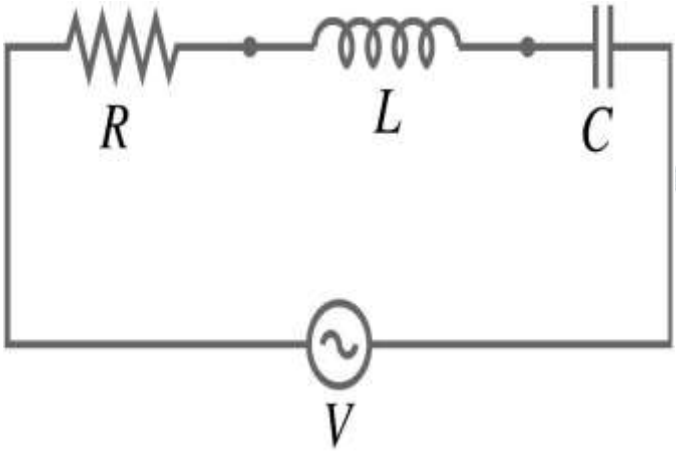

Fig.1: Circuit diagram of series RLC circuit

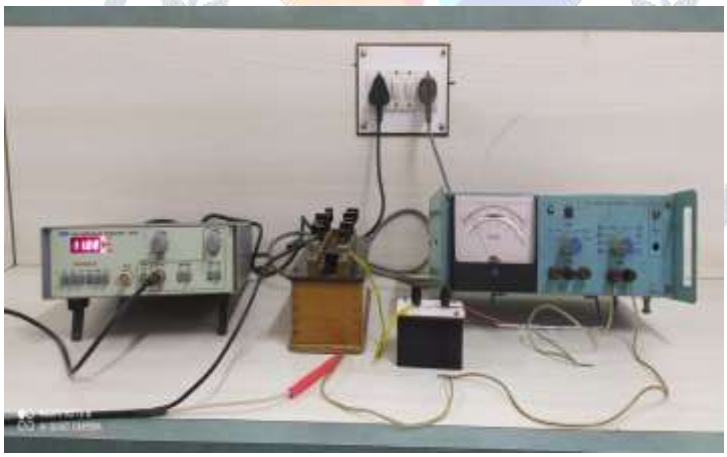

Fig.2: Experimental arrangement of the circuit

In the present work the values of resistance varies with fixed values of LC. The connection of the circuit is shown in fig.1.As the frequency of the circuit increases step by step the value of current increases first and reaches to maximum. Further increase with frequency it starts to decreases. The frequency for which the current reaches to maximum is called resonant frequency (f_r) and the circuit is then termed as resonant circuit. At resonance

the inductive impedance is equal to capacitive impedance but opposite in phase. The resonance frequency is obtained by using the relation:

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

The Quality factor (Q) is given by: $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ ……..2

3) Results:

Value of self-inductance L = 1500mH

Value of capacitance C = 0.01μF

Observation Table 1.1: Frequency response of a series LCR circuit for different resistances

Sr.No	Applied Frequency f (Hz)	Current I (mA)		
		R = 500Ω	R = 1000Ω	R = 1500Ω
1.	700	0.40	0.42	0.42
2.	800	0.42	0.44	0.44
3.	900	0.46	0.46	0.46
4.	1000	0.52	0.52	0.52
5.	1100	0.60	0.58	0.58
6.	1200	0.70	0.68	0.66
7.	1300	0.82	0.78	0.76
8.	1400	0.94	0.90	0.86
9.	1500	1.06	1.0	0.94
10.	1600	1.14	1.06	0.9
11.	1700	0.8	0.70	0.64
12.	1800	0.58	0.56	0.54
13.	1900	0.50	0.5	0.50
14.	2000	0.48	0.46	0.46
15.	2100	0.48	0.44	0.44
16.	2200	0.44	0.42	0.42
17.	2300	0.42	0.42	0.42
18.	2400	0.42	0.42	0.42
19.	2500	0.42	0.42	0.42
20	2600	0.42	0.42	0.42

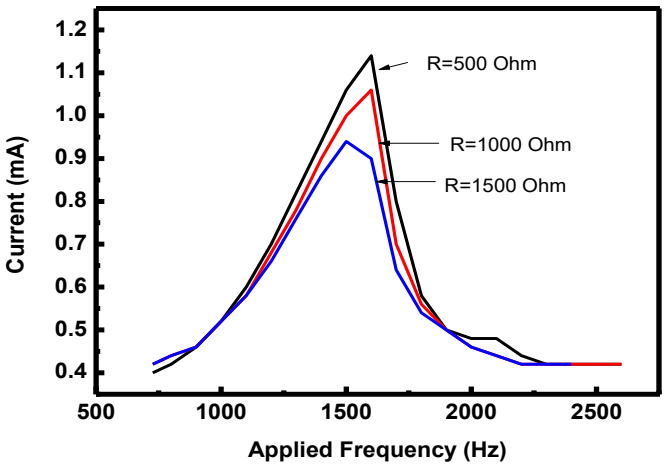

Fig.3. Variation of resonant frequency with resistance

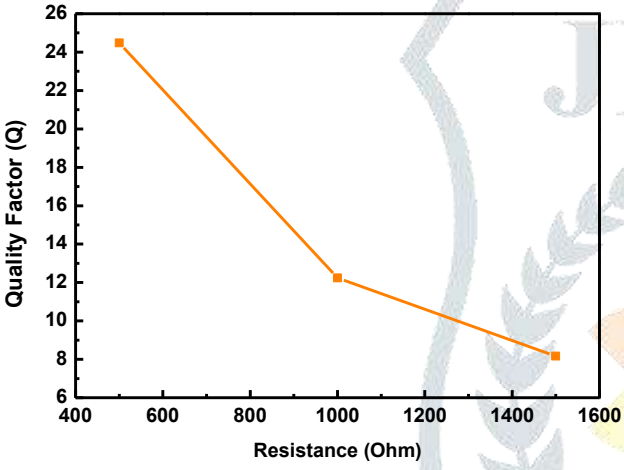

Fig.4.a

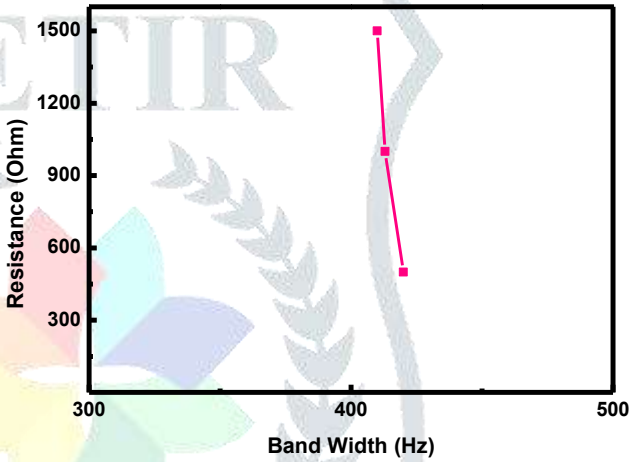

Fig.4.b

The variation of quality factor (Q) and band width with resistance is shown in fig. 4.a and 4.b respectively

4. Discussions and Conclusions:

Experimental results are obtained for LCR series AC circuit. Measurements were recorded with varying applied frequency that results in a change in current at the output. The output value was measured for every frequency increment of 100Hz. An AC signal is used to produce a change in current at the output.

Fig.3, illustrates the graph of variation of applied frequency with different values of resistances. From the graph it reveals that the resonant frequency for each value of resistances is almost equal. It predicts that the resonant frequency of the series LCR AC circuit is independent of the resistance value. From fig.3, it is also reveals that the sharpness of resonance gets decreases as the values of resistances is increased and vice versa.

Fig.4.a shows the variation of quality factor (Q) with resistance. It observed that as the resistance increases the Q value decreases. As Q has non uniformity in variation, so it may be due to resistance connected in series is not the total resistance of the circuit.

Fig.4.b shows that the band width remains constant though there is change in resistance value. Thus it is found that frequency band width is independent of the resistance.

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References:

[1] DipeshChanda et al, International J. of advanced Scientific research and Management, 2017, 2 (11) 68-77.

[2] Chakarabarti P.K Theory of electricity and Magnetism, Sctech publications (India) pvt.ltd.(2014), 947-1037.

[3] Ghosh. B Advanced Practical Physics, 5th Edn. Vol II Sreedhar Publishers 51-64.

[4] Mahajan A.S et al, Electricity and Magnetism. Tata McGraw-Hill publishing company ltd.(2004) , 376-409.

[5] Kumar & Kumar, Electric Circuits & Networks, p.464

[6] Prakash.S. Electricity and Magnetism.31Edn.Pragati Prakashan, (2016), 425-483.

[7] Ghosh.B. Foundations of Electricity and Magnetism 2ndEdn, Books and Allids (P) Ltd, (2009),503-571.

[8] Chattopadhyay. D et al, An advanced course in practical physics, 6th Edn Books & allied (p) ltd. (2002) 347-370.

[9] Sinha.U, Electrical and electronics Measurements and Instrumentation, Reprint, (1992), 144-164.

[10] Tewari K.K , Electricity and Magnetism , 11thEdn S. Chand & Company Ltd. (2011), 553-596.