**UNIVERSITY OF MIAMI**

Department of Electrical and Computer Engineering

EEN 203

*Name:*

*Section:*

*Date:*

EXPERIMENT 7

**RESONANT CIRCUITS**

**PURPOSE:** To study series and parallel resonant circuits. Characteristics such as *bandwidth*, *half power frequencies*, *resonant frequency*, and *quality factor* will be calculated from the circuit responses.

***Equipment***

1 Frequency Generator

1 D.V.M.

Resistors, Capacitors, and Inductors

***Preliminary Work***

a) *Derive* the expressions for the resonant frequency *fo*, low half-power frequency *fL*, high half-power frequency *fH*, bandwidth *BW,* and quality factor *Q* for the circuit of Fig. 6.1.

b) *Derive* the expressions for the resonant frequency *ωo*, low half-power frequency *ωL*, high half-power frequency *ωH*, bandwidth *BW,* and quality factor *Q* for the circuit of Fig. 6.2. (hint: use admittances for parallel elements and assume that Rp >> Rs)

***Experimental Procedure***

I. Series Resonant Circuit:

a) Set up the circuit shown in Fig. 6.1. Adjust the input voltage to 1 Vrms. Make R = 560 Ω, C = 0.047 μF, and L = 22 mH.

**Figure 6.1** Series *RLC* resonant circuit.

b) Compute the quantities below using the given equations.

Resonant Frequency *fo* =

Low Half-Power Frequency *fL* =

High Half-Power Frequency *fH* =

Bandwidth *BW* =

Quality Factor *Q* =

*fo* =

*fH*, *fL* =

*BW* = *fH* − *fL* =

*Q* = =

(*Note:* Make sure that you are consistent with your units. With the exception of *Q*, the formulas given above are in hertz. When calculating *Q* make sure that both the bandwidth and the resonant frequency are in Hz or rad/sec.)

c) Varying the frequency of the source as shown in Table 6.1, measure VR, VL, and VC. Make sure the input voltage Vs remains constant at **each** frequency. Also compute the current in the circuit I, the capacitive reactance XC, the inductor’s equivalent impedance ZL (remember that inductors have a small internal resistance, use the DVM in Ω mode to measure this), the inductive reactance XL, and the equivalent reactive impedance Xeq using the following equations:

I = , XC = , ZL =

XL = **RL is the resistance of the inductor. Be sure**

**to measure this quantity**.

Xeq = XL − XC

d) From the results in part (c), plot, (***Note:* Use semi-log paper for your graphs.)**

(i) VR vs *f* .

(ii) VL and VC vs *f* on the same graph.

(iii) XL, XC, and |Xeq| vs *f* on the same graph.

e) Label the graph of VR vs *f* and identify *fo*, *fL*, *fH*, *BW*, and *Q*. Calculate the %error as compared to the calculated values. Tabulate your results in Table 6.2.

|  | **Measured** | | | **Calculated** | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***f* (Hz)** | **VR (V)** | **VL (V)** | **VC (V)** | **I (mA)** | **XC (Ω)** | **ZL (Ω)** | **XL (Ω)** | **|Xeq| (Ω)** |
| 300 |  |  |  |  |  |  |  |  |
| 500 |  |  |  |  |  |  |  |  |
| 700 |  |  |  |  |  |  |  |  |
| 1 k |  |  |  |  |  |  |  |  |
| 2 k |  |  |  |  |  |  |  |  |
| 3 k |  |  |  |  |  |  |  |  |
| 5 k |  |  |  |  |  |  |  |  |
| 5.5 k |  |  |  |  |  |  |  |  |
| 6 k |  |  |  |  |  |  |  |  |
| 6.5 k |  |  |  |  |  |  |  |  |
| 7 k |  |  |  |  |  |  |  |  |
| 10 k |  |  |  |  |  |  |  |  |
| 20 k |  |  |  |  |  |  |  |  |
| 30 k |  |  |  |  |  |  |  |  |
| 50 k |  |  |  |  |  |  |  |  |
| 70 k |  |  |  |  |  |  |  |  |

**Table 6.1** Measured and calculated data for the circuit in Fig. 6.1.

|  | **Calculated** | **From Graph** | **% Error** |
| --- | --- | --- | --- |
| ***f*o** |  |  |  |
| ***f*L** |  |  |  |
| ***f*H** |  |  |  |
| **BW** |  |  |  |
| **Q** |  |  |  |

**Table 6.2** Frequency response parameters for the circuit in Fig. 6.1.

II. Parallel Resonant Circuit:

a) Set up the circuit shown in Fig. 6.2. Adjust the input voltage to 1 Vrms. Make RS = 3.3 kΩ,

Rp = 10 kΩ, C = 0.047 μF, and L = 22 mH.

**Figure 6.2** Parallel *RLC* resonant circuit.

b) Compute the quantities below using the given equations.

Resonant Frequency *fo* =

Low Half-Power Frequency *fL* =

High Half-Power Frequency *fH* =

Bandwidth *BW* =

Quality Factor *Q* =

*fo* =

*fH*, *fL* = ; R = RS||Rp

*BW* = *fH* − *fL* =

*Q* = =

c) Varying the frequencies as given in Table 6.3, measure Vo. Make sure that Vi is 1 Vrms at **each** frequency.

d) From the results in part (c), plot Vo vs *f*.

e) In the graph of part (d), find and identify *fo*, *fL*, *fH*, *BW*, and *Q*. Calculate the %error as compared to the calculated values. Tabulate your results in Table 6.4. Use your judgement to fill out the missing frequencies in the table given below in order to arrive at a smooth curve.

| ***f* (Hz)** | **Vo (V)** |  | ***f* (Hz)** | **Vo (V)** |
| --- | --- | --- | --- | --- |
| 300 |  |  |  |  |
| 500 |  |  |  |  |
| 700 |  |  |  |  |
| 1 k |  |  | 7 k |  |
| 2 k |  |  | 10 k |  |
| 3 k |  |  | 20 k |  |
| 5 k |  |  | 30 k |  |
|  |  |  | 50 k |  |
|  |  |  | 70 k |  |

**Table 6.3** Measured data for the circuit in Fig. 6.2.

|  | **Calculated** | **From Graph** | **% Error** |
| --- | --- | --- | --- |
| ***f*o** |  |  |  |
| ***f*L** |  |  |  |
| ***f*H** |  |  |  |
| **BW** |  |  |  |
| **Q** |  |  |  |

**Table 6.4** Frequency response parameters for the circuit in Fig. 6.2.

***Discussion of Results***

1. For the parallel resonant circuit, Rp was assumed to be much larger than Rs.

(i) Which quantities were affected by this approximation? (i.e. Q, BW, *f*o, *f*l, *f*h)

(ii) From the results in Table 6.4, do you think this was a reasonable approximation? Explain.

b) Prove that for the series resonant circuit

|VL| = |VC| = *Q|*Vs|

at resonance. (*Hint:* Write the equations for VL and VC in Fig. 6.1.)

c) How could VC and VL get higher values than Vs in part I? (*Hint:* Use the result of part (d) above.)

d) Discuss the applications of resonant circuits, particularly in,

(i) tuning of radio receivers,

(ii) use of doubly tuned circuits for wider bandwidth applications, and

(iii) narrow- and wide-band tuned circuits.

e) Write a conclusion.