Experiment 9

Resonance

ابو ريدة

16/1/2020

Data:

$c = 0.1\ \mu F$

$L = 10\ mH$

$R = 1\ K\Omega\ , 2\ K\Omega$

	R=1 KΩ		R=2 KΩ	
f (KHz)	V(volt)	I(mA)	V(volt)	I(mA)
0.2	0.39	0.39	1.7	0.85
0.3	1.31	1.31	2.44	1.22
0.5	2.08	2.08	3.62	1.81
0.6	2.44	2.44	4.08	2.04
0.8	3.04	3.04	4.72	2.36
1	3.52	3.52	5	2.5
2	5	5	5.75	2.875
3	5.6	5.6	6.1	3.05
4	5.7	5.7	0.15	0.075
4.5	5.75	5.75	6.15	3.075
5	5.75	5.75	6.15	3.075
5.5	5.75	5.75	6.15	3.075
7	5.55	5.55	6	3
10	5.1	5.1	5.8	2.9
20	3.9	3.9	5.2	2.6
50	1.83	1.83	3.32	1.66
80	1.2	1.2	2.22	1.11

Note: The original datasheet signed by Dr.Khalid
is attached to the end of report

Abstract:

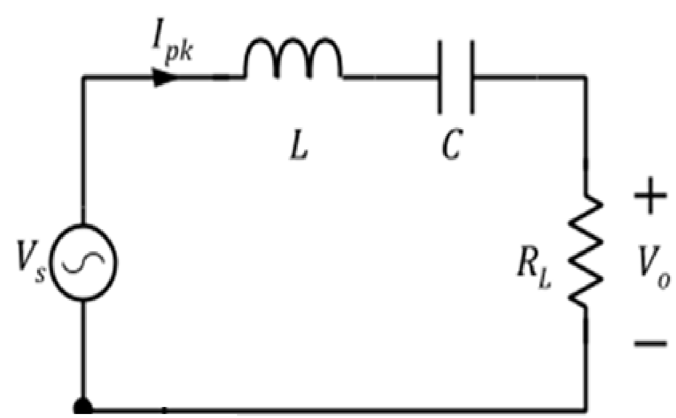
To Define the natural frequency (f_0) and the corresponding angular frequency (ω_0) for an RLC circuit by plotting a graph of I (mA) vs ω_0 (rad) by logarithmic scale for two resister, by recording the resistance voltage values that appear on the oscilloscope, which change as a result of the frequency change (Note: there are two resistances in this experiment R=1 KΩ, 2 KΩ), the define the Quality factor.

Introduction:

Apparatus:

1kΩ and 2kΩ resistors, 0.1 µF capacitor, 10 mH inductor, signal generator, oscilloscope, circuit board .

In this experiment will build this circuit (with different value for R):



The current passing through the circuit is given by:

$$I_0 = \frac{V_0}{\sqrt{R^2+(\omega L-\frac{1}{\omega C})^2}}$$

I_0 is a maximum as a function of ω when :

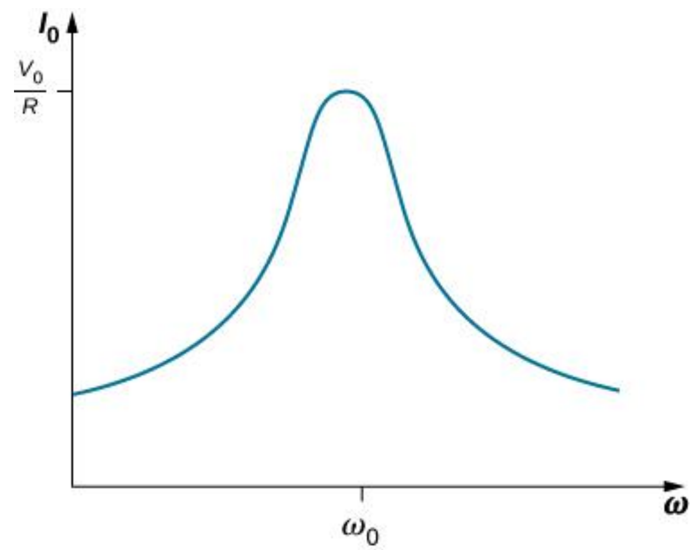
$$\omega L = \frac{1}{\omega C}$$

Note that under such a condition ω is the natural angular frequency of the circuit and equal:

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

When the frequency of the applied voltage matches the natural frequency of the RLC circuit, the current in the circuit reaches its highest level. This is known as resonance, At resonance :

$$I_0 = \frac{V_0}{R}$$



The value of the current is only limited by the resistance of the circuit.

The sharpness of the resonance curve can be quantified using a value known as the quality factor (Q).

$$Q = \frac{\omega L}{R}$$

And at resonance $$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

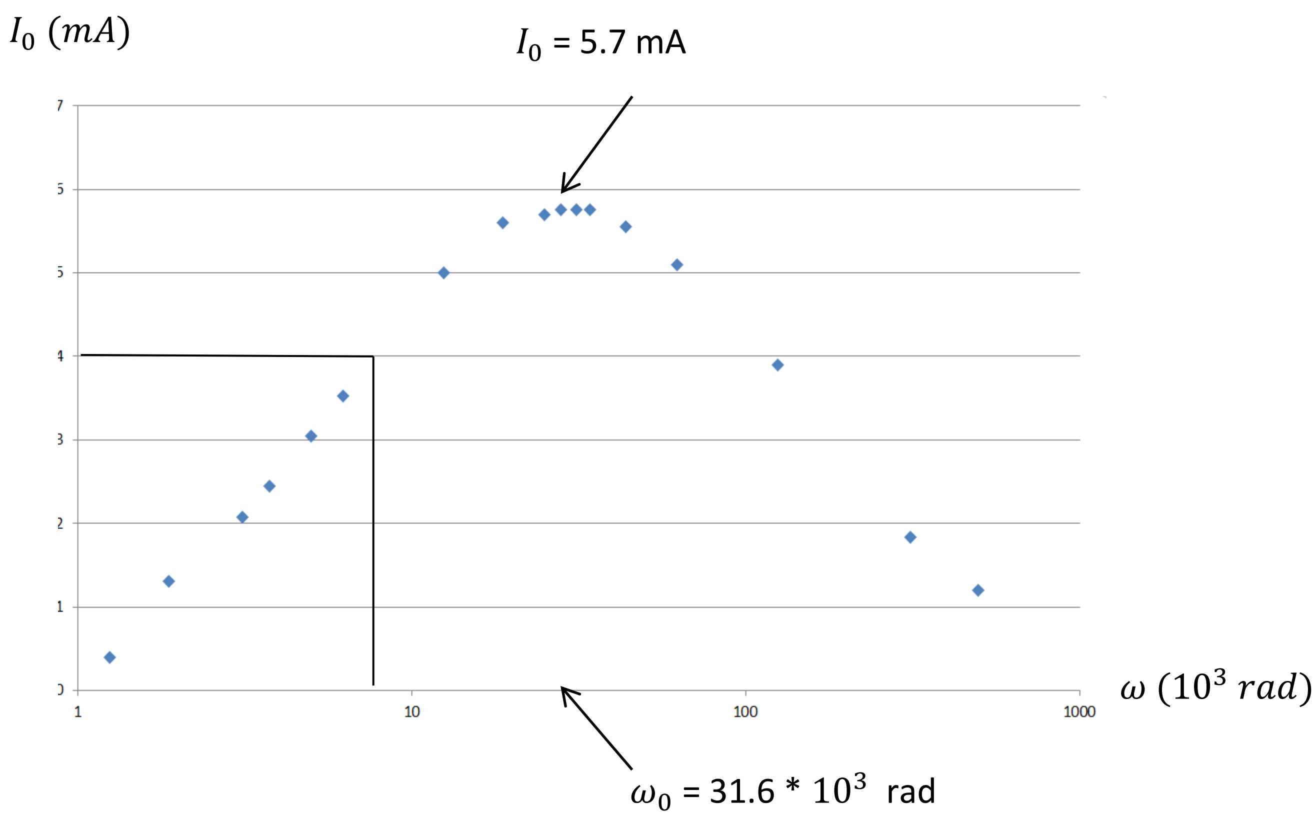
The bandwidth (Δω) is a measure of the sharpness of the resonance curve, it is the range of frequencies between the highest value of I_0 and the value of $\frac{I_0}{\sqrt{2}}$.

$$\text{And} \quad Q = \frac{\omega_0}{|\Delta\omega|}$$

Data and Analysis:

When R = 1 KΩ:

$I_0\ (mA)\ VS\ \ \omega\ (10^3\ rad)\quad with\ log\ scale$



$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$\omega_0 = \frac{1}{\sqrt{10^{-9}}}$$

$$\omega_0 = 31.6 * 10^3 \text{ rad}$$

And I_0 = 5.7 mA

$$\frac{I_0}{\sqrt{2}} = 4\ mA$$

$$\omega_{\frac{I_0}{\sqrt{2}}} = 9.2 * 10^3 \text{ rad}$$

Then:

$$Q = \frac{\omega_0}{|\Delta\omega|}$$

$$Q = \frac{31.6 * 10^3}{|22.4 * 10^3|}$$

$$Q = 1.41$$

Theoretically: $Q = \frac{1}{1000}\sqrt{10^5}$

$$Q = 0.31$$

The percentage of error in this experiment is due to the presence of resistance in the circuit elements

When R = 2 KΩ:

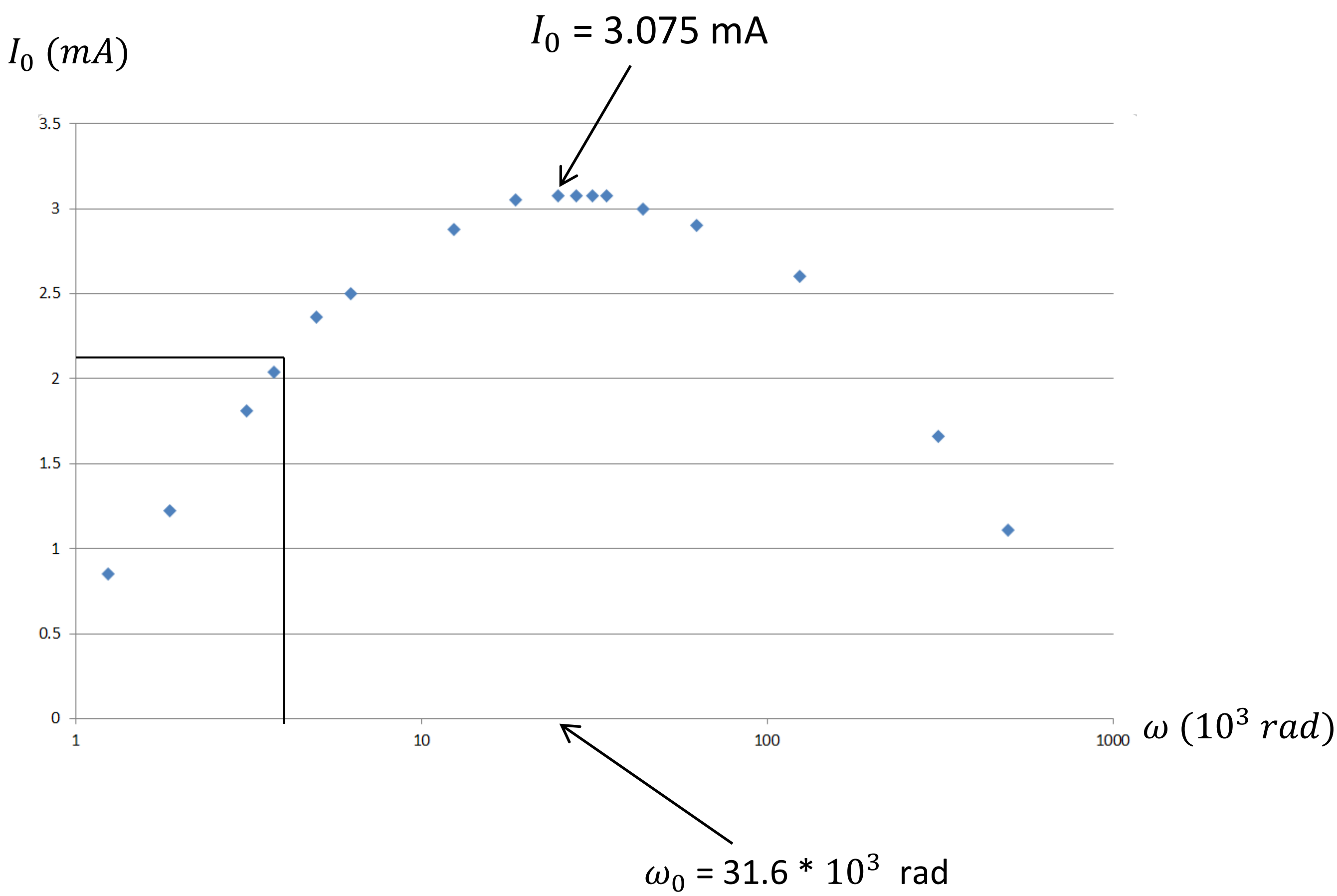
Theoretically:

$$Q = \frac{1}{2000}\sqrt{10^5}$$

$$Q = 0.158$$

Now find Q by plot of the value of I_0 as a function of ω

$I_0\ (mA)\ \ VS\ \ \omega\ (10^3\ rad)\quad with\ log\ scale$



$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$\omega_0 = \frac{1}{\sqrt{10^{-9}}}$$

$$\omega_0 = 31.6 * 10^3\ \text{rad}$$

And $\quad I_0 = 3.075$ mA

$$\frac{I_0}{\sqrt{2}} = 2.174\ mA$$

$$\omega_{\frac{I_0}{\sqrt{2}}} = 7.2 * 10^3\ \text{rad}$$

Then:

$$Q = \frac{\omega_0}{|\Delta\omega|}$$

$$Q = \frac{31.6 \ * \ 10^3}{|24.4 \ * \ 10^3 \ |}$$

$$Q = 1.290$$

The percentage of error in this experiment is due to the presence of resistance in the circuit elements

Conclusion:

Resonance occurs in an electric circuit at a particular resonant frequency when the impedances or admittances of circuit elements cancel each other. In some circuits, this happens when the impedance between the input and output of the circuit is almost zero and the transfer function is close to one, and the relationship between the resistance and the Quality factor is an inverse relationship, as the higher the resistance, the lower the Quality factor.