University of Western Attica
Faculty of Engineering
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Circuit Theory Lab Exercises

4th EXERCISE

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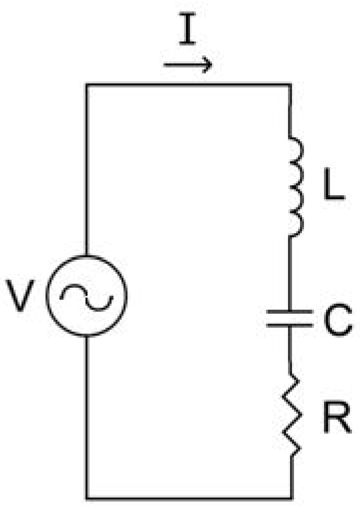
- Task 4 - Coordination

1.1 Theoretical part

RLC circuit is an electrical circuit consisting of an ohmic resistance R , an inductance coil L and a capacitor of capacitance C . We call resonance the phenomenon of forced oscillation in which the frequency of the exciter is identical to the natural frequency of the oscillator.

When a coil and a capacitor are connected in series or parallel, then there is some frequency at which the inductive and capacitive reactance become equal to each other in measure. The point at which the two reactions equal each other is called coordination.

<table>
<tr><th>RLC in series</th><th>RLC in parallel</th></tr>
<tr><td>


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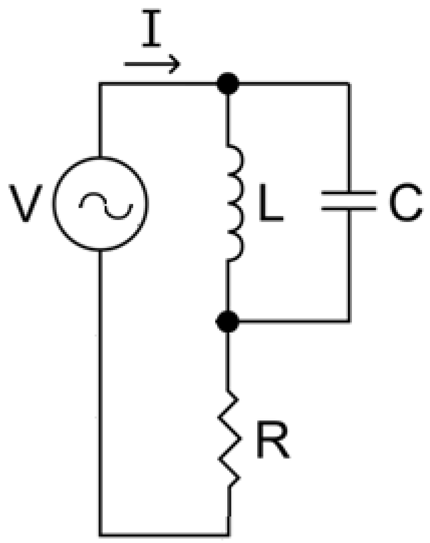
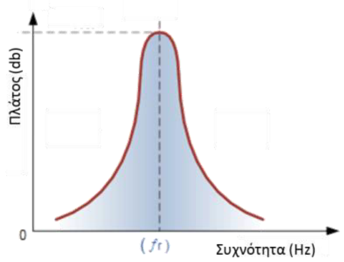


</td></tr>
<tr><th colspan="2">Frequency Response</th></tr>
<tr><td>


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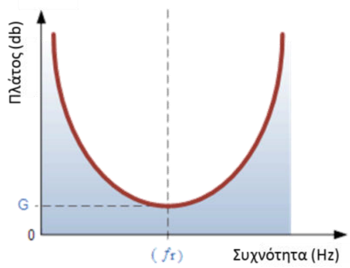


</td></tr>
</table>

In the resonant state, the two reactions cancel each other out, so that only the resistance R "remains" in the circuit.

For the series resonant circuit, the total impedance of the circuit is given by the relation: $Z = \sqrt{R^2 + (X_L - X_c)^2}$.

If $X_L > X_C$ then the circuit exhibits inductive behavior, otherwise the circuit exhibits capacitive behavior.

But at the coordination point $X_L = X_C$ so the total impedance of the circuit is expressed by the relation Z = R .

The frequency at which this phenomenon is observed is called the resonant frequency frequency) and is calculated by the relation $f_r = \frac{1}{2\pi\sqrt{LC}}$.

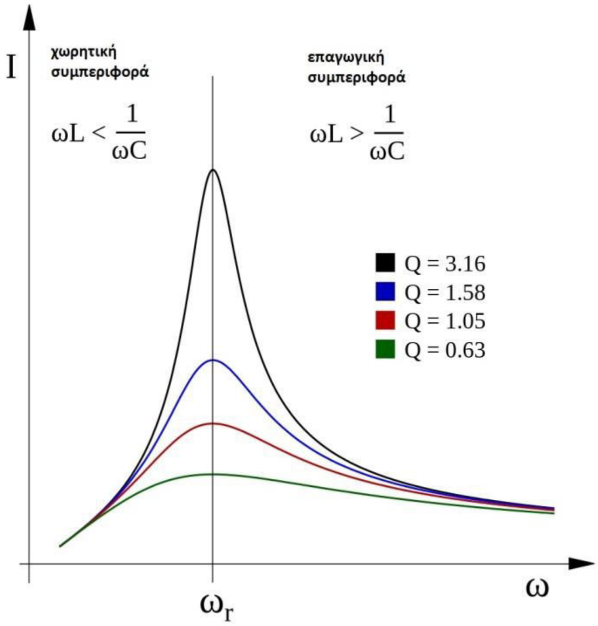
In the resonant circuit in parallel connection, its impedance is given by the relation:$Z = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}}$

In resonant circuits depending on the frequency range in which they are designed to operate, there is at least one frequency (although in most circuits it is 2) at which the output has lost half the power of the input signal.

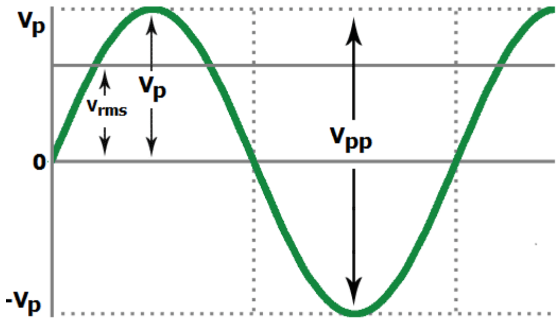
The bandwidth of a resonant circuit is defined as the frequency range that lies between the pair of half-power frequencies, i.e. between the frequencies at which the output signal has lost half of its original power. This point is defined as -3 db or 0.707 of the maximum amplitude. Mathematically, it is expressed by the relation $BandWidth = \frac{f_r}{Q}$.

Q or otherwise the quality (efficiency) coefficient is calculated from the relationship: $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$for resonant circuits in series and, respectively, with the relationship $Q = R\sqrt{\frac{C}{L}}$ for circuits in parallel connection.

Quality factor Q



Vrms & Vp-p voltage relationships



$$V_{rms} = \frac{1}{\sqrt{2}} * V_p = 0.7071 * V_p$$

$$V_{rms} = \frac{1}{2\sqrt{2}} * V_{pp} = 0.35355 * V_{pp}$$

1.1 Laboratory part

To study series & parallel tuned circuit with $f_r = 30$ kHz .

The implementation will be with R - L - C components . For the capacitors, the value C = 47nF will be used in the series circuit, and C=27nF in the parallel connection circuit.

Then select coils that approximate the theoretical values calculated above. The " **Typical coil values** " table from the appendix can be used . Is there a large deviation from the resonant frequency?

Calculate the theoretical values of the coils required for the specific circuits.

Implementation	C	L theoretical	L Standard	Deviation from f_R
In Series	47nF			
At the same time	27 nF			

Implement tuning circuits in series and parallel.

You fed each of the above implementations with a 1V rms sinusoidal input signal .

Connect channel A of an oscilloscope to the input (source) and channel B to the output (at the ends of the circuit resistor).

Accordingly, you connected the bode as well plotter at the input and output of the circuit. Then, complete the table below and graphically represent the gain-frequency relationship. Compare me the corresponding chart by bode plotter.

Connect the corresponding current measuring instruments, and fill in the corresponding column of the following table.

Note: the table below will be completed with measurements for both the series and parallel circuit.

F (Hz)	**Vi(V) Reg. A** **Measurement**	**Vo(V) Reg. B** **Measurement.**	**20log10(Vo/Vi)** **(db) calculable**	**I_{rms} (A)** **Measurement**
1				
10				
100				
500				
1000				
1500				
2500				
5000				
10k				
30k				
50k				
100k				
200k				
500k				
1M				
10M				

Theoretically calculated matrix

F (Hz)	G	X	X_L	X_C	I_{rms}	V_{Lrms}	V_{Crms}
1							
10							
100							
500							
1000							
1500							
2500							
5000							
10k							
30k							
50k							
100k							
200k							
500k							
1M							
10M							

The above table sizes will be calculated based on the following:

Impedance $Z=(R^2+X^2)^{1/2}$ (in Ω)

Reactive resistance $X=X_L-X_C$ (in Ω)

Inductive reactance $X_L=2\pi fL$ (in Ω)

Capacitive reactance $X_C=1/2\pi fC$ (in Ω)

$I_{rms}=V_{rms}/Z$ (in A)

$V_{Lrms}=I_{rms}*X_L$ (in V)

$V_{Crms}=I_{rms}*X_C$ (in V)

Quality factor

For the series tuning circuit, change the resistance R , according to the table below. What do you notice about the current flowing through the resistor R ?

Resistance (Ω)	$Q_{ser} = \frac{1}{R}\sqrt{\frac{L}{C}}$	IR (mA)
1k		
500		
220		
100		
10		
1		

4.3 Questions

- How could the above circuits acquire a variable tuning point?
- Suggest uses for series and parallel tuning circuits.
- Describe the basic criteria of synchronization in series circuit.
- Plot the impedance (impedance of the entire circuit assembly) for a frequency range of 100 Hz to 10M Hz for the series circuit.

1.2 Appendix : Typical values of coils

μH, n H	μH, n H	μH, n H	μH, n H

1.0	10	100	1000
1.1	11	110	1100
1.2	12	120	1200
1.3	13	130	1300
1.5	15	150	1500
1.6	16	160	1600
1.8	18	180	1800
2.0	20	200	2000
2.2	22	220	2200
2.4	24	240	2400
2.7	27	270	2700
3.0	30	300	3000
3.3	33	330	3300
3.6	36	360	3600
3.9	39	390	3900
4.3	43	430	4300
4.7	47	470	4700
5.1	51	510	5100
5.6	56	560	5600
6.2	62	620	6200
6.8	68	680	6800
7.5	75	750	7500
8.2	82	820	8200
8.7	87	870	8700
9.1	91	910	9100