University of Western Attica
Faculty of Engineering
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Circuit Theory Lab Exercises

3rd EXERCISE

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ATHENS
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- Task 3 h – Connections of RLC components in AC voltage

1.1 I think it is part

As mentioned in the first laboratory lesson, capacitors and coils show impedance, which is related to the frequency of the input signal. More specifically, capacitors show a reactive resistance (Capacitive reactance X $_c$) governed by the relationship $X_c = -j\frac{1}{2\pi fC}$, while for coils Inductive reactance X $_L$, and the relationship becomes correspondingly : $X_L = j2\pi fL$.

Looking at circuits 1a and 1b, we can say that since the components show resistance, RL and RC circuits in series behave like a voltage divider which is controlled by the frequency of the input signal. Substituting into the voltage divider equation, we have impedance (the sum of resistance and reactive resistance) $Z = R - jX_c$and

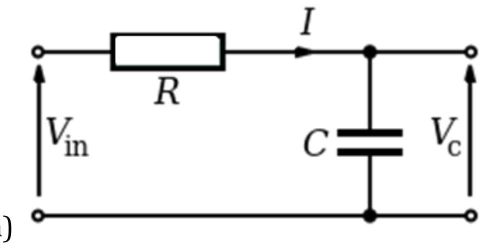
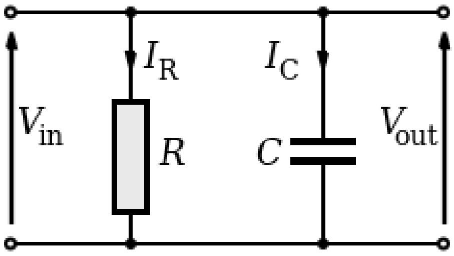
$V_o = \frac{-jX_c}{R_1 + -jX_c} V_i$, for the series RC circuit, while correspondingly for the series RL we have impedance $Z = R + jX_L$and $V_o = \frac{X_L}{R_1 + X_L} V_i$.

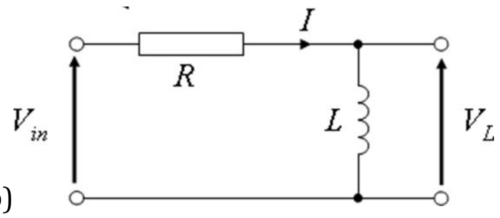
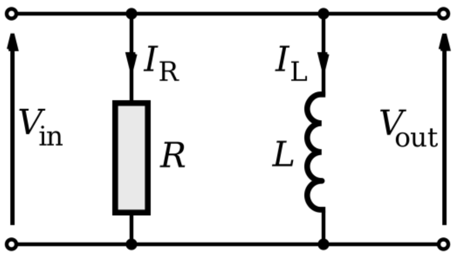
In circuits 2a and 2b, the components are in parallel, so we have $V_i = V_R = V_C$and $V_i = V_R = V_L$corresponding. The two resistors are connected in parallel so the equivalent circuit resistance for the RC circuit is given by the relation $\frac{1}{Z} = \frac{1}{R} - \frac{1}{jX_C}$. Analyzing we arrive at the relationship

$Z = -\frac{R \cdot jX_c}{R - jX_C}$.

Correspondingly for the RL circuit is given by the relationship $\frac{1}{Z} = \frac{1}{R} + \frac{1}{X_L}$.

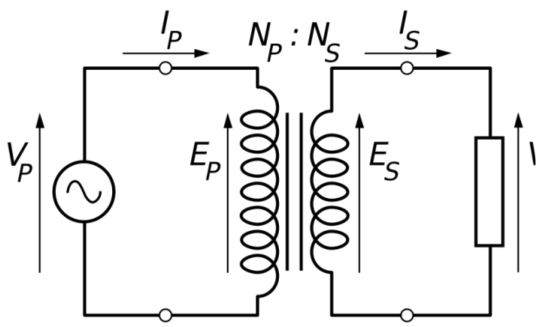
Analyzing we arrive at the relationship $Z = \frac{R \cdot X_L}{R + X_L}$.

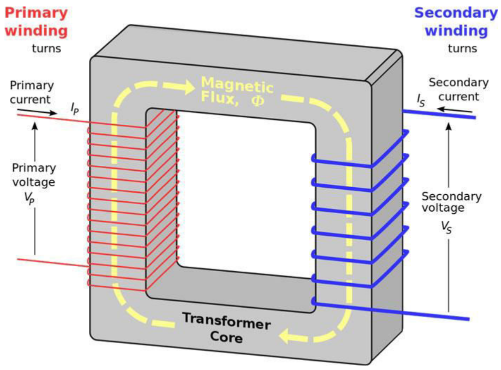
R - C in series	R - C in parallel
 1a)	 2a)

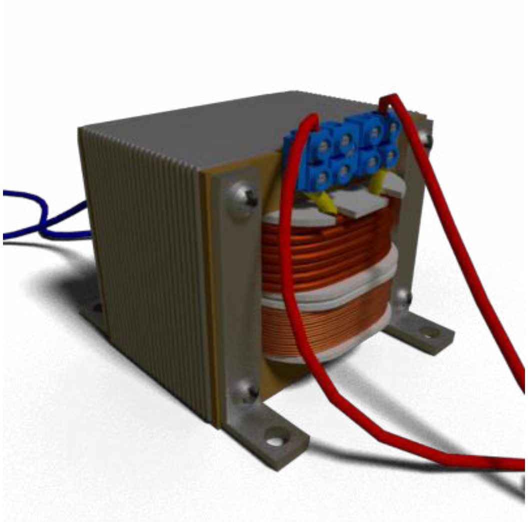
R - L in a row	R - L in parallel
 1b)	 2b)

TRANSFORMER

A transformer is a high efficiency electrical machine that transfers electrical energy between two circuits, through inductively coupled coils. Transformers have a wide range of sizes, depending on the needs of the circuit.



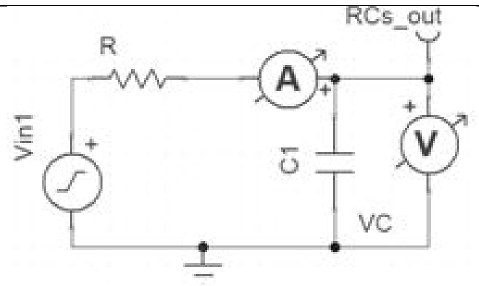


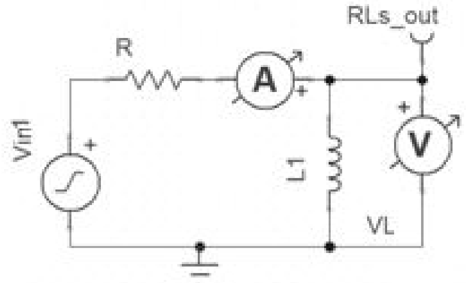


They all operate on the same principles. The two coils are wound around a ferrite frame consisting of thin sheets sandwiched together. A changing signal in the primary coil creates a changing magnetic field. This changing magnetic field induces a changing voltage in the secondary coil. This phenomenon is called **mutual induction** . If a load is connected to the secondary, then there will be an electric charge flow in the secondary winding of the transformer. The relationship governing the voltage and current in the primary and secondary windings of the transformer is related to the number of turns of the two windings and is described below: $\frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{N_p}{N_s}$

1.2 Laboratory part

Series RC lab circuit	RL circuit in series





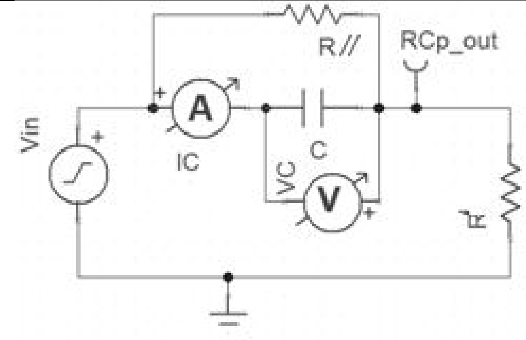
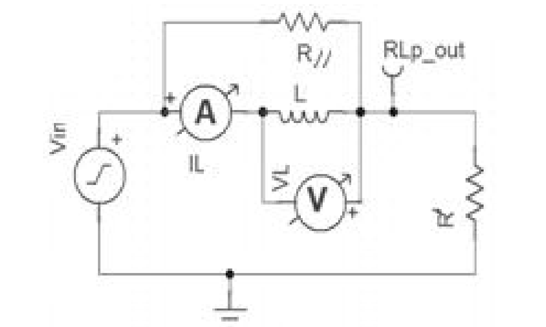
You connected the series RC circuits and RL series. As component values use R = 2 K 2 , C = 470 nF and L = 3.3 mH . Place on each a sine signal of amplitude 1 $V_{in.}$ Connect an ammeter to the junction between resistor and capacitor or resistor and coil. Connect a voltmeter to the ends of the capacitor and the coil respectively. Then fill in the tables below .

F(Hz)	**X_c theoretical (Ω)**	**I_C (A)**	**V_C (V)**	**X_c Calculated (Ω)**
1				
10				
100				
1k				
10k				
100k				

F(Hz)	**X_L theoretical (Ω)**	**I_L (A)**	**V_L (V)**	**X_L Calculated (Ω)**
1				
10				
100				
1k				
10k				
100k				

Compare the expected and calculated values of the impedance of the capacitor and the coil respectively. Graph the change in impedance with frequency, what do you notice?

Circuits in parallel connection:

Laboratory RC parallel circuit	Laboratory circuit RL parallel
	

You have connected the RC $_{//}$ and RL $_{//\ \text{circuits}}$. As component values use R = 2K2, C = 470 nF and L = 3.3 mH . Place on each a sine signal of amplitude 1 V $_{in.}$ Connect an ammeter to the source - resistor branch, an ammeter between the resistor node and the capacitor or coil. Connect a voltmeter to the ends of the capacitor and the coil respectively. At then complete the tables below .

F(Hz)	**X_c Theoretical (Ω)**	**I_C (A)**	**V_C (V)**	**X_c Calculated (Ω)**
1				
10				
100				
1k				
10k				
100k				

F(Hz)	X_L theoretical (Ω)	I_L (A)	V_L (V)	X_L Calculated (Ω)
1				
10				
100				
1k				
10k				
100k				

Compare the expected and calculated values of the impedance of the capacitor and the coil respectively. Graph the change in impedance with frequency, what do you notice? Compare the current flowing through the resistor and the current through the capacitor/inductor versus the frequency of the input signal.

Comment on the existence of the two resistors R' in the parallel circuits.

Give a possible value to these resistors.

1.3 Questions

- Does the impedance of a capacitor to alternating current increase or decrease as the frequency of that current increases? Give reasons.
- At what frequency does a 47 μF capacitor have an impedance of 50 Ω? Analyze your calculations.
- How much inductance would a coil have to have to provide an impedance of 540 Ω at a frequency of 400 Hz? Write your calculations in detail.
- Consider a transformer with a primary to secondary ratio of 100:200000. Apply input signal 4.2 V_{pp}. calculate the voltage that will appear in the secondary winding of the transformer. We can assume him transformer as a booster unit?