University of Jordan
School of Engineering
Electrical Engineering Department

EE 219
Electrical Circuits Lab

EXPERIMENT 4 REPORT & PRE-LAB
TRANSIENT ANALYSIS

Section # ____________ Group # ____________

Student Name **ID**

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EXPERIMENT 4
TRANSIENT ANALYSIS

PROCEDURE A – CAPACITORS AND INDUCTORS

Table 1

	C_1	C_2	C_3
Code or color on the capacitor			
Nominal Value			
Tolerance (%)			
Breakdown voltage			
Capacitor type			
Measured @ f_1			
Deviation (%)			
Measured @ f_2			
Deviation (%)			

3. What are the two frequencies f_1 and f_2 that the RLC meter uses for its measurements?

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Table 2

	L_1		L_2	
Code or color on the inductor				
Nominal Value				
Tolerance (%)				
Measured @ f_1				
Deviation (%)				
Measured @ f_2				
Deviation (%)				
Internal series resistance R_{DC}	@f_1	@f_2	@f_1	@f_2
Internal parallel resistance R_P	@f_1	@f_2	@f_1	@f_2

7. Why do you think the resistance values measured by the two test frequencies are different? Which one should be more accurate and why?

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9. At what frequencies (low or high) should we consider the internal series resistance R_{DC} of the inductor in our calculations? and *Why*?

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10. At what frequencies (low or high) should we consider the internal parallel resistance R_P of the inductor in our calculations? and *Why*?

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PROCEDURE B – OSCILLOSCOPE

4. If the vertical position or horizontal position on the oscilloscope is not set in the middle, perform the necessary adjustments. Also adjust the intensity of the beam so you can clearly see the signal. How many cycles of the square wave do you see on the oscilloscope screen?

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5. Increase the frequency of the signal using the function generator controls. What do you see on the oscilloscope screen?

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6. Decrease the frequency of the signal using the function generator controls. What do you see on the oscilloscope screen?

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7. How do you increase the voltage level coming out of the function generator?

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8. Now increase the voltage level from the function generator. What do you see on the oscilloscope screen?

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9. If you increased the signal voltage level from the function generator until it exceeds the screen limits of the oscilloscope, what should you do to see the signal again on the oscilloscope screen?

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10. What other signal shapes (other than square wave) can the function generator produce? See them on the oscilloscope screen.

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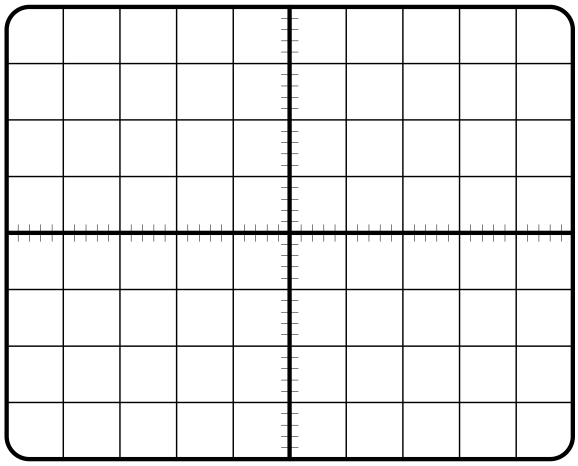
13. Set the function generator to produce a DC offset so that the output voltage ranges between a minimum of 0 V and a maximum of 6 V. Draw what you see on the oscilloscope screen below. Make sure you have channel 1 of the oscilloscope set to 0.5 V/DIV and the sweep set to 0.25 ms/DIV.



14. What is the period (one cycle) of the above square wave signal in units of horizontal screen divisions and also in units of milliseconds?

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<u>PROCEDURE C – TRANSIENT RESPONSE OF RC CIRCUITS</u>

3. What is time constant τ for this first-order RC circuit? Show both the equation and the value.

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5. Use theoretical analysis (increasing and decaying exponential) to determine the voltages and currents in the circuit: $v_S(t)$, $v_C(t)$, $v_R(t)$, $i(t)$ at the time instances shown in Table 3. Record these values in the table? Also show below the mathematical expressions of $v_C(t)$, $v_R(t)$, $i(t)$.

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6. Use the oscilloscope screen to measure the voltages: $v_S(t)$ (on channel 1 of the oscilloscope) and $v_C(t)$ (on channel 2 of the oscilloscope). Record these values in Table 3 for all required time instants. Remember that you can change the oscilloscope horizontal sweep setting to get more accurate readings. Are the measured values close to the theory-based answers?

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7. Now evaluate the *measured* values of $v_R(t)$ and $i(t)$ and record them in Table 3. Remember that you can measure $v_R(t)$ by subtracting the *measured* values of $v_S(t)$ and $v_C(t)$, and you can measure the current $i(t)$ by applying Ohm's law on the resistor using the measured value of $v_R(t)$ (i.e., $i(t) = v_R(t)/R$).

Table 3

Time since switch (ms)	$v_S(t)$		$v_C(t)$		$v_R(t) = v_S(t) - v_C(t)$		$i(t) = v_R(t)/R$	
	Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**
0	6 V							
0.05 [= 0.5τ]	6 V							
0.1 [= τ]	6 V							
0.2 [= 2τ]	6 V							
0.3 [= 3τ]	6 V							
0.4 [= 4τ]	6 V							
0.5 [= 5τ]	6 V							
0	0 V							
0.05 [= 0.5τ]	0 V							
0.1 [= τ]	0 V							
0.2 [= 2τ]	0 V							
0.3 [= 3τ]	0 V							
0.4 [= 4τ]	0 V							
0.5 [= 5τ]	0 V							

8. Notice that you cannot measure $v_R(t)$ by attaching the channel 2 probe to it while still measuring $v_S(t)$ at the same time, since the grounds of channel 1 and channel 2 of the oscilloscope are attached to each other inside the oscilloscope, which means you will short circuit the capacitor. However, there is a trick to measure $v_R(t)$, which is to swap the locations of the resistor and capacitor in the circuit while keeping the oscilloscope connections unchanged. This way, channel 2 of the oscilloscope will show $v_R(t)$ rather than $v_C(t)$. Use this technique to measure $v_R(t)$ without calculations and record the results in Table 4. To speed up your work you can use the cursor feature of the oscilloscope as explained below. Are the results for $v_R(t)$ in Table 3 and Table 4 close or not?

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Table 4

Time since switch (ms)	$v_S(t)$		$v_R(t)$ by swapping	
	Theory	**Meas.**	**Theory**	**Meas.**
0	6 V			
0.05 [= 0.5τ]	6 V			
0.1 [= τ]	6 V			
0.2 [= 2τ]	6 V			
0.3 [= 3τ]	6 V			
0.4 [= 4τ]	6 V			
0.5 [= 5τ]	6 V			
0	0 V			
0.05 [= 0.5τ]	0 V			
0.1 [= τ]	0 V			
0.2 [= 2τ]	0 V			
0.3 [= 3τ]	0 V			
0.4 [= 4τ]	0 V			
0.5 [= 5τ]	0 V			

10. Using the measured values in Table 3, plot (**by hand**) the following two figures using the graph paper attached at the end of the report: (1) $v_S(t)$ and $v_C(t)$ on the same plot versus time; (2) $v_S(t)$ and $i(t)$ on the same plot versus time. Make sure you include both cases of $v_S(t)$ suddenly jumping to 6 V and $v_S(t)$ suddenly dropping to 0 V. For the second plot ($v_S(t)$ and $i(t)$) please use two vertical axes, one to the left for voltage, and one to the right for current. You can use different scales on these vertical axes so that the plot looks intelligible. How much voltage does the capacitor lose as it is discharging after exactly one time constant τ?

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PROCEDURE D – TRANSIENT RESPONSE OF RL CIRCUITS

2. What is time constant τ for this first-order RL circuit? Show both the equation and the value.

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4. Use theoretical analysis (increasing and decaying exponential) to determine the voltages and currents in the circuit: $v_S(t)$, $v_L(t)$, $v_R(t)$, $i(t)$ at the time instances shown in Table 5. Record these values in the table? Also show below the mathematical expressions of $v_L(t)$, $v_R(t)$, $i(t)$.

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5. Use the oscilloscope screen to measure the voltages: $v_S(t)$ (on channel 1 of the oscilloscope) and $v_L(t)$ (on channel 2 of the oscilloscope). Record these values in Table 5 for all required time instants. Remember that you can change the oscilloscope horizontal sweep setting to get more accurate readings. Are the measured values close to the theory-based answers?

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7. Using the measured values in Table 4, plot (**by hand**) the following two figures using the graph paper attached at the end of the report: (1) $v_S(t)$ and $v_L(t)$ on the same plot versus time; (2) $v_S(t)$ and $i(t)$ on the same plot versus time. Make sure you include both cases of $v_S(t)$ suddenly jumping to 6 V and $v_S(t)$ suddenly dropping to 0 V. How much current does the inductor gain as it is being energized after exactly one time constant τ?

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Table 5

Time since switch (ms)	$v_S(t)$		$v_L(t)$		$v_R(t) = v_S(t) - v_L(t)$		$i(t) = v_R(t)/R$	
	Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**
0	6 V							
0.0152 [= 0.5τ]	6 V							
0.0303 [= τ]	6 V							
0.0606 [= 2τ]	6 V							
0.0909 [= 3τ]	6 V							
0.1212 [= 4τ]	6 V							
0.1515 [= 5τ]	6 V							
0	0 V							
0.0152 [= 0.5τ]	0 V							
0.0303 [= τ]	0 V							
0.0606 [= 2τ]	0 V							
0.0909 [= 3τ]	0 V							
0.1212 [= 4τ]	0 V							
0.1515 [= 5τ]	0 V							

8. If you did not know the value of L before you did the experiment, can you measure its value from the above plots? Explain how in detail.

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9. Assume that we increased the frequency of the source voltage $v_S(t)$ to three times its value (from 3 kHz to 9 kHz), sketch (**by hand**) using the graph paper attached at the end of the report an approximate plot showing $v_S(t)$ and $i(t)$. Your plot does not have to be exact, but should show the expected effect. Make sure you include both cases of $v_S(t)$ suddenly jumping to 6 V and $v_S(t)$ suddenly dropping to 0 V.

<u>CONCLUSIONS</u>

Summarize in clear but concise format what you learned from this experiment:

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