University of Jordan
School of Engineering
Electrical Engineering Department

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EE 204
Electrical Engineering Lab

EXPERIMENT 4 REPORT & PRE-LAB
TRANSIENT ANALYSIS

Section # ____________ **Group #** ____________

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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	224J	224M	10μF
Nominal Value	220 nF	220 nF	10μF
Tolerance (%)	± 5 %	± 20%	
Breakdown voltage			50
Capacitor type	Polyester film	Ceramic	Electrolytic
Measured @ f_1	216.62 nF	203.05	9.641
Deviation (%)	1.53%	7.7 %	3.6 %
Measured @ f_2			
Deviation (%)			

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

....

Table 2

	L_1		L_2	
Code or color on the inductor	Brown-black-black-Silver		Brown-black-orange-Silvar	
Nominal Value	10μH		10mH	
Tolerance (%)	± 10%		± 10%	
Measured @ f_1	11.375 μH		9.668 mH	
Deviation (%)	13.75 %		3.32 %	
Measured @ f_2				
Deviation (%)				
Internal series resistance R_{DC}	@f_1	@f_2	@f_1	@f_2

PROCEDURE B - OSCILLOSCOPE AND PEAK-TO-PEAK VERSUS RMS VALUES

6. If the vertical position or horizontal position on the oscilloscope is not set in the middle, perform the necessary adjustments. How many cycles of the sinusoidal wave do you see on the oscilloscope screen?

2 cycles and half ....

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

..Number...of..sinusoidal.wave..on..the..screen.increases.

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

..The..number..of..sinusoidal..wave..on..the..screen.decreases.

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

..Increase..the..peak..voltage..using..the..amplitude..knob.

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

..The..Peak..Value..increases

11. 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?

Edit the vertical scale (Volts per division knob).

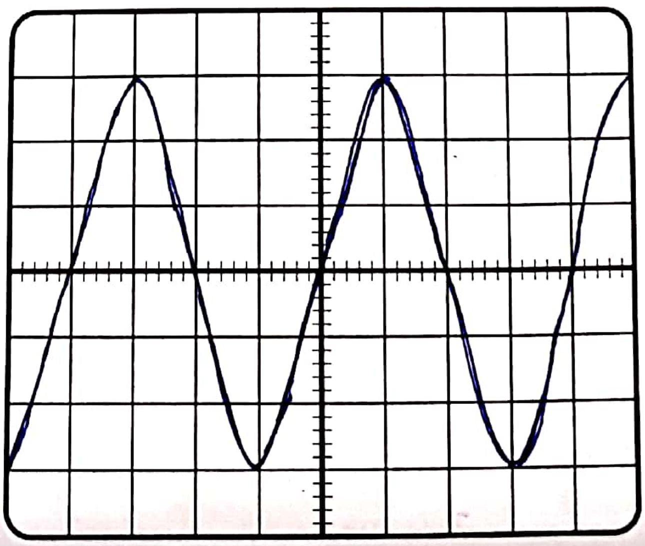
12. What other signal shapes (other than sinusoidal wave) can the function generator produce? See them on the oscilloscope screen.

..Square & triangular.

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

..4 divisions..=.one.milliseconds

16. 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.



17. Use theoretical analysis to determine the **rms value** of the source voltage $v_S(t)$ and the current in the circuit $i(t)$ at the different frequencies shown in Table 3. Record these values in the table? What equation should you use to calculate the current in rms from the peak source voltage V_p?

$V_{rms} = \frac{V_p}{\sqrt{2}}$

Table 3

AC Source Frequency (Hz)	Source V_{p-p} (V) (Oscilloscope)		Source V_{rms} (V) (Oscilloscope)		Source V_{rms} (V) (Voltmeter)		I_{rms} (mA) (Ammeter)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
100	3	2.88	2.121	2.12	2.121	1.87	0.341	0.246
1000	3	2.88	2.121	2.12	2.121	1.87	0.341	0.246
2000	3	2.88	2.121	2.12	2.121	1.87	0.341	0.246

20. Now use the voltmeter to read the *measured* rms value V_{rms} of the source voltage, but record the answer this time in the third column of Table 3. How are the voltmeter and oscilloscope different in reading the AC voltage?

Different some how.

21. What extra information about the source voltage can the oscilloscope provide, which the voltmeter cannot provide? The value of a wave at a moment, shows the shape, amplitude and frequency of the wave, also the noise in the signal (width, puls, shift)

22. Use the ammeter to *measure* the rms value I_{rms} of the current, and record the answer in the last column of Table 3. Are the measurements close to the theoretical answers?

No, there is some different.

23. Does the resistor change its impedance Z_R with frequency?

NO

24. What if you only had an oscilloscope without an ammeter. How would you be able to measure the current in the circuit in rms? *Explain* clearly.

$I_{rms} = \frac{V_{rms}^2}{R} = \frac{V_P^2}{2R} = \frac{V_{P-P}^2}{6R}$

PROCEDURE C – TRANSIENT RESPONSE OF RC CIRCUITS

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

$\tau = RC = 1000 * 0.1 * 10^{-6} = 1 * 10^{-4}$ sec.

$= 10$ ms

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 4. Record these values in the table? Also show below the mathematical expressions of $v_C(t)$, $v_R(t)$, $i(t)$.

$V_c(t) = V_s - V_s e^{-t/\tau}$ (while charging)

$V_c(t)\ V_0 - e^{-t/\tau}$ (while discharging).

$V_R(t) = V_s(t) - V_c(t)$.

$i(t) = \frac{V_R(t)}{R}$

....

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 4 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?

...yes. ....

7. Now evaluate the *measured* values of $v_R(t)$ and $i(t)$ and record them in Table 4. 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 4

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	4 V	4.09	0	0.001	4	4	4	4.01
0.05 [= 0.5τ]	4 V	4.09	1.5738	1.64	2.4262	2.45	2.4262	2.42
0.1 [= τ]	4 V	4.09	2.5285	2.44	1.4715	1.51	1.4715	1.46
0.2 [= 2τ]	4 V	4.09	3.4586	3.52	0.5414	0.61	0.5414	0.57
0.3 [= 3τ]	4 V	4.09	3.801	3.8	0.1991	0.22	0.1991	0.211
0.4 [= 4τ]	4 V	4.09	3.9267	3.9	0.0733	0.08	0.0733	0.074
0.5 [= 5τ]	4 V	4.09	3.973	3.98	0.0269	0.03	0.0269	0.03
0	0 V	0	4	3.99	−4	−4.01	0	0.003
0.05 [= 0.5τ]	0 V	0	2.426	2.35	−2.426	−2.43	−2.426	−2.43
0.1 [= τ]	0 V	0	1.4715	1.4	−1.4715	−1.51	−1.4715	−1.48
0.2 [= 2τ]	0 V	0	0.5413	0.55	−0.5413	−0.62	−0.5413	−0.55
0.3 [= 3τ]	0 V	0	0.1991	0.2	−0.1991	−0.21	−0.1991	−0.189
0.4 [= 4τ]	0 V	0	0.0733	0.071	−0.0733	−0.09	−0.0733	−0.081
0.5 [= 5τ]	0 V	0	0.0269	0.04	−0.0269	−0.04	−0.0269	−0.025

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 5. 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 4 and Table 5 close or not?

yes they are.

Table 5

Time since switch (ms)	$v_S(t)$		$v_R(t)$ by swapping	
	Theory	Meas.	Theory	Meas.
0	4 V	4.09	4	4
0.05 [= 0.5τ]	4 V	4.09	2.4261	2.5
0.1 [= τ]	4 V	4.09	1.4715	1.5
0.2 [= 2τ]	4 V	4.09	0.5413	0.55
0.3 [= 3τ]	4 V	4.09	0.1991	0.22
0.4 [= 4τ]	4 V	4.09	0.0733	0.075
0.5 [= 5τ]	4 V	4.09	0.0269	0.03
0	0 V	0	0	0.01
0.05 [= 0.5τ]	0 V	0	-2.4261	-2.44
0.1 [= τ]	0 V	0	-1.4715	-1.47
0.2 [= 2τ]	0 V	0	-0.5413	-0.55
0.3 [= 3τ]	0 V	0	-0.1991	-0.21
0.4 [= 4τ]	0 V	0	-0.0733	-0.076
0.5 [= 5τ]	0 V	0	-0.0269	-0.03

10. 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 $v_C(t)$ 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 4 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?

Around 2.6 Volts, at one time constant the ~~In the~~ Capacitor loses 65% of its value.

CONCLUSIONS

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

- In first procedure of this experiment we learned how to find the nominal value for capacitors and inductors using the color and number code then how to measure it experimentally using RLC meter.

- In procedure (B) we learned more about the oscilloscope its screen, buttons, knobs and cables then how to use it in measurements to find out different values such as: Peak voltage, frequancy, shape of wave and time of wave that was by using different and suitable sittings like Voltage per division, time per division and using cursure and axis adjustement.

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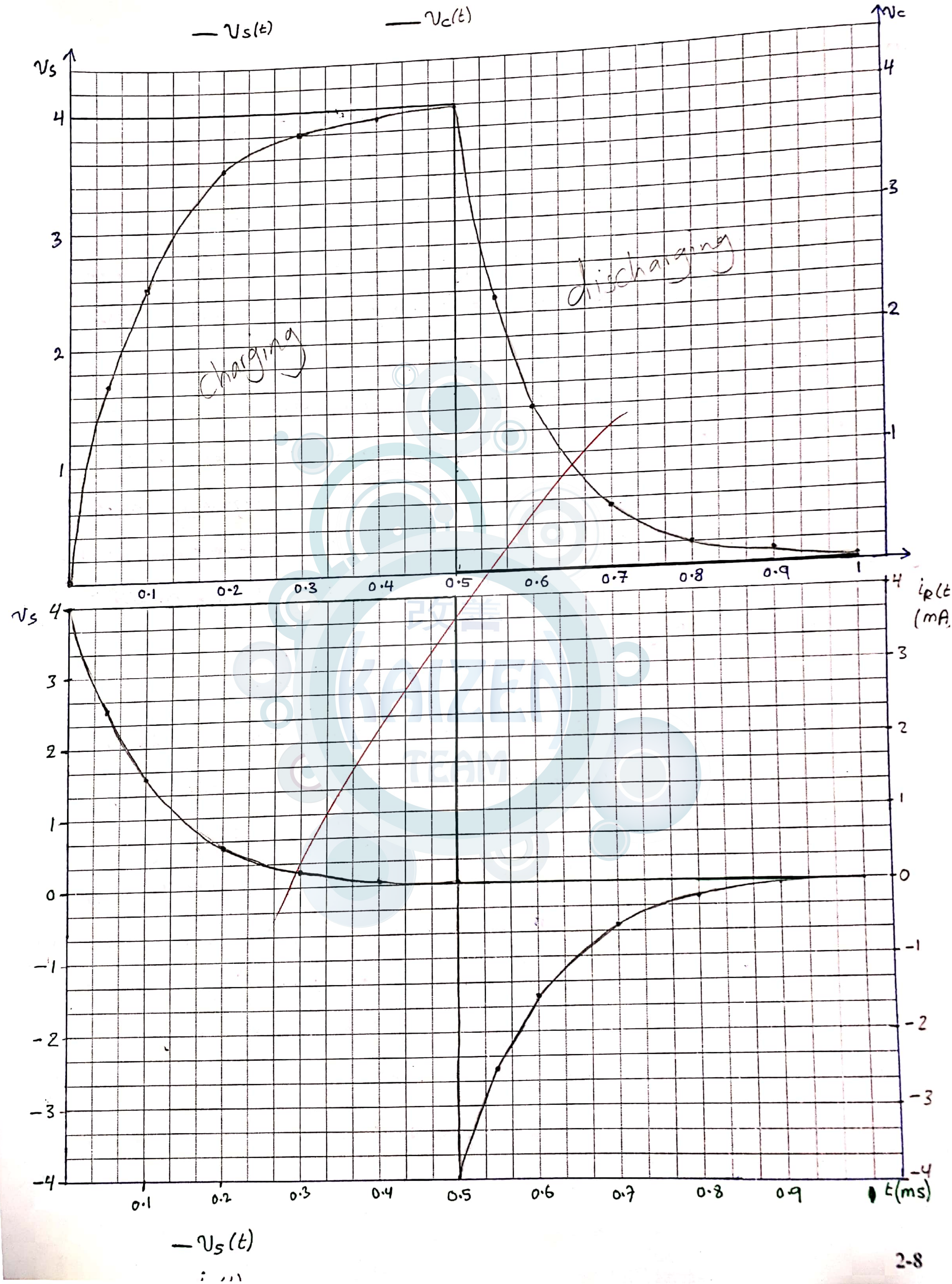
- In the last procedure (C) we use the oscilloscope to find out and understand the transiant response of circuits while the variation of signal from (0 to 4) volts which means charging and discharging for the capacitor and the time of charging and discharging should be longer than 5τ of the RC circuit to have accurate reading acording to the stability of capacitor status (fully charged and fully discharged) then find the current and voltage responce acording to the value and dirction in the resistance then using analysis and graphes to plot these relations and see the relationship and depenency between them with time variation.

** End **


— Vs(t)
— Vc(t)
Vs
Vc
charging
discharging
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
iR(t) (mA)
t(ms)
— Vs(t)