RC Transient Circuits (Lab 3)

RC circuits

Leonardo Fusser, 1946995

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Department of Computer Engineering Technology
Circuit Analysis & Simulation II
Day Yann Fong, Manijeh Kahataie, Andreea Iftimie

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1.0 PURPOSE

- To observe the existence of a series RC time constant with oscilloscope.
- To observe, measure and calculate the exponential charge and discharge of capacitor voltage in a series RC circuit.
- To observe and measure the exponential decay of resistor voltage in a series RC circuit.

2.0 EQUIPMENT NEEDED

- (1x) desktop power supply.
- (1x) desktop waveform generator.
- (2x) 4-band (1/4 watt) resistors.
- (2x) non-polarized capacitors.
- (1x) electronics breadboard.
- (1x) Keysight oscilloscope.
- (?x) BNC cables, oscilloscope accessories and others.

3.0 PRE-LAB

Calculating Power, Resistance, Current & Voltage in Parallel Circuits

1. Based on a RC circuits configuration as stated in Table 1. Assuming the capacitor is uncharged, and will charge up to 10 V. Calculate the time at the end of each of the time constant and the corresponding charging capacitor voltage. Record your calculations in the table. Include necessary steps involved in calculation in your report.

Configuration of RC	**Parameters**	1T	2T	3T	4T	5T
	Calculated voltage (V)	***6.32V***	***8.65V***	***9.5V***	***9.82V***	***9.93V***
R = 10 kΩ C = 47 µF	Time interval (s)	***470mS***	***940mS***	***1.4S***	***1.8S***	***2.3S***
R = 15 kΩ C = 4.7 µF	Time interval (s)	***70.5mS***	***141mS***	***211.5mS***	***282mS***	***352.5mS***

Table 1: Capacitor charging voltages and time constant

Calculations:

$V_t = V_C(1 - e^{-t/Tau})$

$= 10\ (1 - e^{-1/1})$

V_t = 6.32V *(voltage at 1 time constant)*

*same method of calculations was used for the rest.

(for 10kΩ & 47 µF)

Tau = R * C

= 10 * 47

Tau = 470mS

1_{Tau} = 470mS * 1

1_{Tau} = 470mS *(time for voltage to reach 1 time constant)*

*same method of calculations was used for the rest.

(for 15kΩ & 4.7 µF)

Tau = R * C

= 15 * 4.7

Tau = 70.5mS

1_{Tau} = 70.5mS * 1

1_{Tau} = 70.5mS *(time for voltage to reach 1 time constant)*

*same method of calculations was used for the rest.

2. Based on the same circuit configurations, assuming the capacitors will discharge from 10 V to 0 V. Calculate the corresponding discharging capacitor voltage at each time constant. Record your calculations in the Table 2. Include necessary steps of calculation in report.

Parameters	1T	2T	3T	4T	5T
Calculated discharge voltage (V)	***3.67V***	***1.35V***	***0.49V***	***180mV***	***60mV***

Table 2: Capacitor discharging voltages

Calculations:

$V_t = V_C(e^{-t/Tau})$

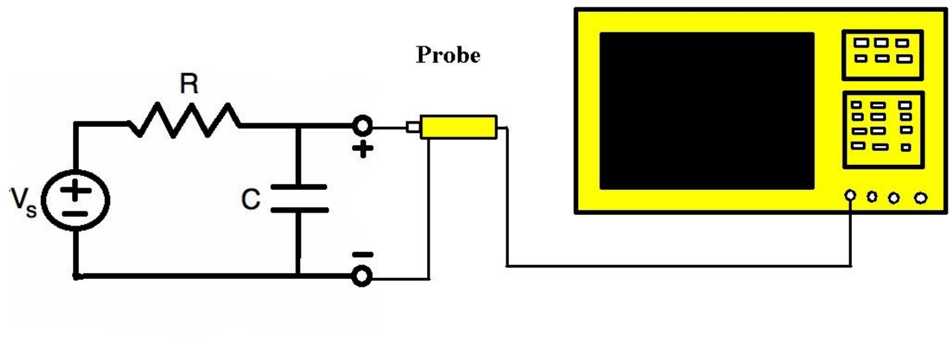
$= 10(e^{-1/1})$

V_t = 3.67V *(voltage at 1 time constant)*

*same method of calculations was used for the rest.

3.

Simple capacitance measurement setup



Source: google images

Where:

R = 10kΩ

C = 47 µF

V_s = 10V DC

4.0 Experiemntal Results

Results from the Procedure section:

4a, b)

Screenshot representing the exponential charge of the 47 µF capacitor (schematic: Question 3)

Parameters used

- Trigger level: 8V
- Slope: Either (triggers on both rising and falling)
- Run control: Single

Comment: The results obtained from the “Table 1” from question 1 are correct as the screenshot above shows that is takes roughly 2.3 seconds (470mS * 5_{Tau} = time for capacitor to completely charge to 100%) for the capacitor to completely charge. The calculated result was 2.35 seconds. As shown in the graph, the voltage of the capacitor is almost near ten volts DC when 2.3 seconds have elapsed. The use of the “cursor” function on the scope was used to determine the measurement values.

c)

Screenshot representing the exponential discharge of the 47 µF capacitor (schematic: Question 3)

Parameters used

- Trigger level: 8V
- Slope: Either (triggers on both rising and falling)
- Run control: Single

Comment: The results obtained from the “Table 2” from question 2 are correct as the screenshot above shows that is takes roughly 2.3 seconds (470mS * 5_{Tau} = time for capacitor to completely discharge to 0%) for the capacitor to completely discharge. The calculated result was 2.35 seconds. As shown in the graph, the voltage of the capacitor is almost near zero volts DC when 2.3 seconds have elapsed. The use of the “cursor” function on the scope was used to determine the measurement values.

6, 7, 8, 9)

Period = 1/F

= 1/1kHz

Period = 1mS

$5_{Tau} = 10^{-3}/2$

= 500µS

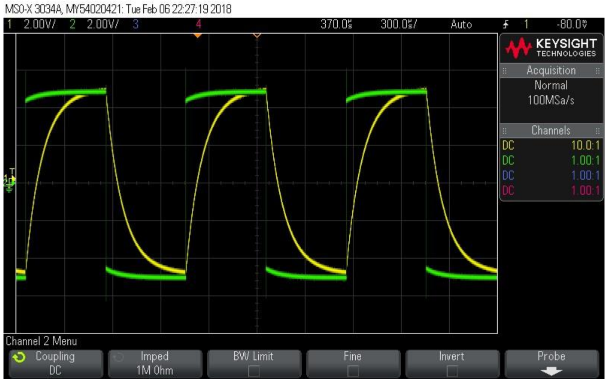
1_{Tau} = 100µS

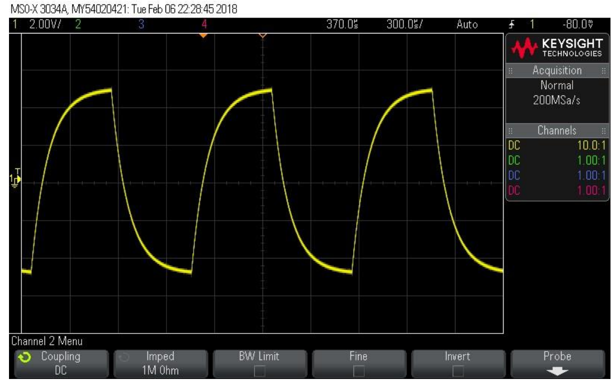
Tau = R * C

C = Tau/R

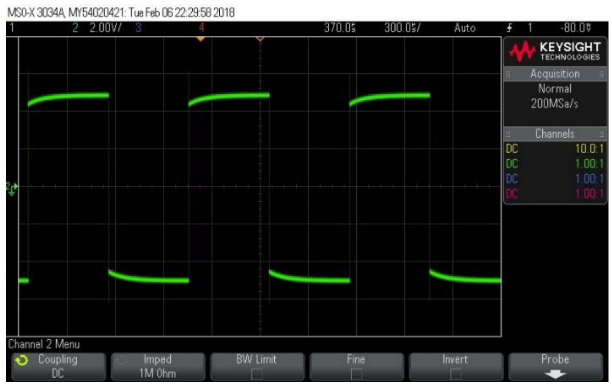
$= 100 * 10^{-6}/1 * 10^{3}$

C = 100nF





Left screenshot: waveform from waveform generator & capacitor / Right screenshot: capacitor only



Output from the waveform generator

Parameters used

- Waveform generator output: 10Vpp
- Waveform generator wave: Square wave
- Waveform generator frequency: 1kHz
- Waveform generator output: High-Z
- Connected to basic RC circuit (R = 1kΩ, C = 100nF-*calculated*)

Comment: The results calculated are close to what was shown during the measurement. As you can see above, the 100nF capacitor almost charges and discharges within each cycle from the supplied waveform from the waveform generator. What is not shown is the cursor function was not used like in the other screenshots, as it wasn't deemed necessary for this purpose. The first screenshot shows both the output from the waveform generator and the charging and discharging of the capacitor. The second and the third screenshots are the charge and discharging of the capacitor and the output from the waveform generator alone respectively.

5.0 Conclusion

- Purpose of this lab has been achieved.
- Understood how to measure the voltage across a capacitor in a RC circuit.
- Understood how to measure and calculate exponential charge and discharge of a capacitor in a RC circuit.
- Understood how to observe the exponential charge and discharge of a capacitor in a RC circuit.
- Adapted/ learned more advanced functions in lab equipment (Keysight BenchVue, store function, etc…)