ELEC 2110

Electric Circuit Analysis

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Section 002

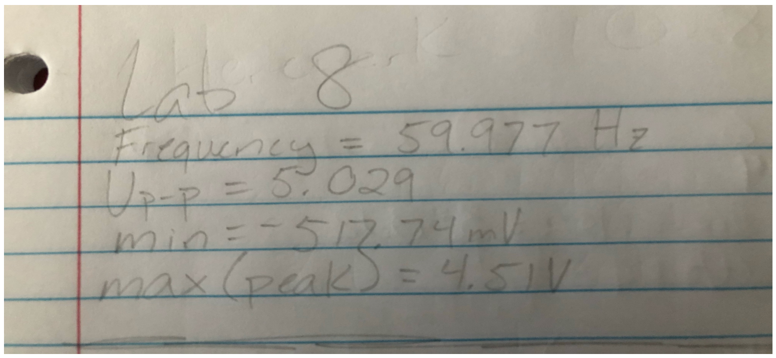
Electrical Measurements: First-Order Transient Circuits

Introduction

Using the NI Elvis Oscilloscope, the student will take measurements of different circuits, and calculate specific components on circuits given. The student will wire up these circuits and then take the measurements on the oscilloscope.

Exercise 1

Open the function generator on the NI Elvis instrument launcher, then match the settings. Then measure the function, V(t) = 2+5cos(377t+0°) V.



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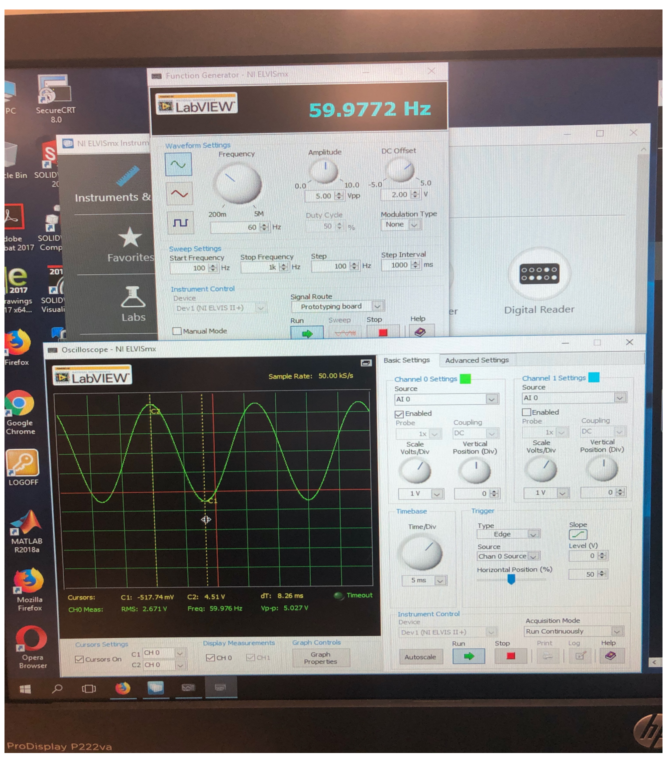

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FGEN and OSCOPE measurements

Summary Table

Frequency	59.9772 Hz
Peak to Peak V	5.029 V
MIN	-517.74 mV
MAX	4.51 V

Exercise 2&3 Questions

Exercise 2: Describe what happens as the trigger level is varied. Now change the trigger level to 4.7V. After several seconds, the measured signal should disappear, and nothing will be measured. Why?

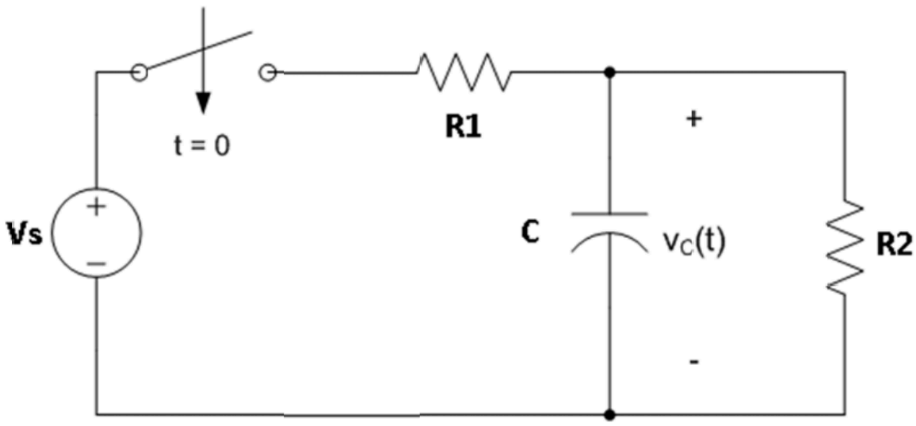
Answer: The trigger level determines at what waveform the voltage sweep will start. When the trigger level is changed, and the signal disappears, it is because the trigger level has been told to sweep voltage at a level to high/low for the desired signal.

Exercise 3: What do the volts/div and Time/div knobs do?

Answer: These knobs do not affect the signal in any way but do change the scaling factor for fitting the signal to screen. The voltage/div knob controls the vertical scale, and the time/div knob controls the horizontal factor. These are used to fit the signal perfectly on screen for more precise measurements.

Exercise 4

Given the charging circuit, solve for k1, k2, k1+k2, and tau1 in terms of Vs, R1, R2, and C.



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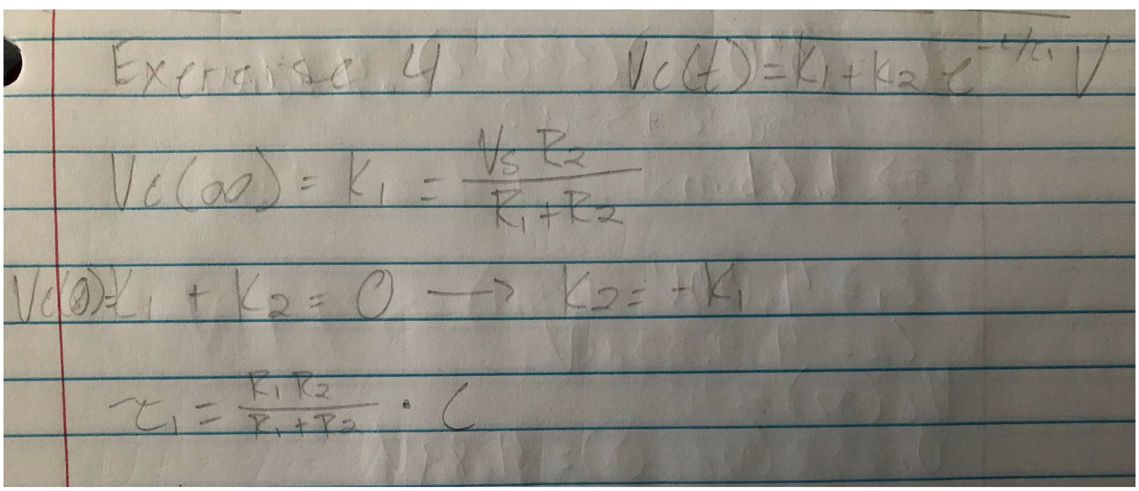
Circuit 1



Exercise 4 $V_C(t) = K_1 + K_2 e^{-t/\tau_1}$ V

$V_C(\infty) = K_1 = \frac{V_S R_2}{R_1 + R_2}$

$V_C(0) = K_1 + K_2 = 0 \longrightarrow K_2 = -K_1$

$\tau_1 = \frac{R_1 R_2}{R_1 + R_2} \cdot C$

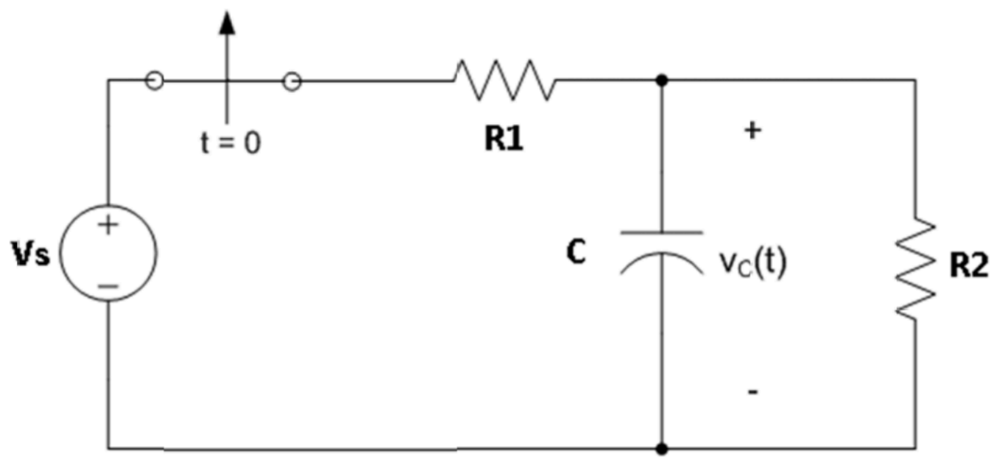
(4)

Summary Table

K1	(VsR2)/(R1+R2)
K2	-K1 or -(VsR2)/(R1+R2)
K1+K2	0
Tau1	((R1R2)/(R1+R2))*C

Exercise 5

Given the discharging circuit, solve for k3, k4, k3+k4, and tau2 in terms of Vs, R1, R2, and C.



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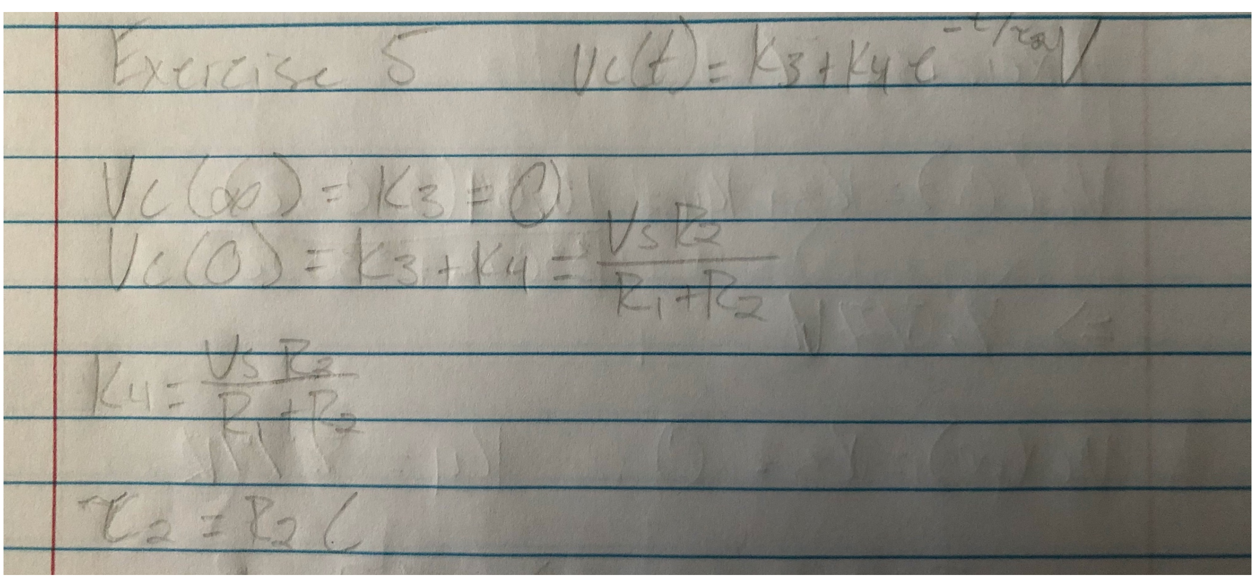
Circuit 2



Exercise 5 $\quad V_C(t) = K_3 + K_4 e^{-t/\tau_2}$ V

$V_C(\infty) = K_3 = 0$

$V_C(0) = K_3 + K_4 = \frac{V_s R_2}{R_1 + R_2}$

$K_4 = \frac{V_s R_2}{R_1 + R_2}$

$\tau_2 = R_2 C$

(6)

Summary Table

K3	0
K4	(VsR2)/(R1+R2)
K3+K4	(VsR2)/(R1+R2)
Tau2	R2*C

Exercise 6

Construct the capacitor charging circuit 1 using:

Vs = 15.5V

R1 = 330 Ohm

R2 = 330 Ohm

C = 10uF

And calculate Vc(0), Vc(infinity), time constant(tau).

Exercise 6

$V_s = 15.54$

$R_1 = 330\,\Omega \qquad R_2 = 330\,\Omega$

$C = 9.67\,\mu F$

$V_c(\infty) = C_1 = \frac{15.54(330\,\Omega)}{330\,\Omega + 330\,\Omega} \Rightarrow 7.77V$

$K_2 = -7.77$

$V_c(0) = 7.77 - 7.77 = 0$

$\tau_1 = \frac{(330\,\Omega)(330\,\Omega)}{330\,\Omega + 330\,\Omega} \cdot 9.67\mu F$

$\Rightarrow 1.61\,ms$

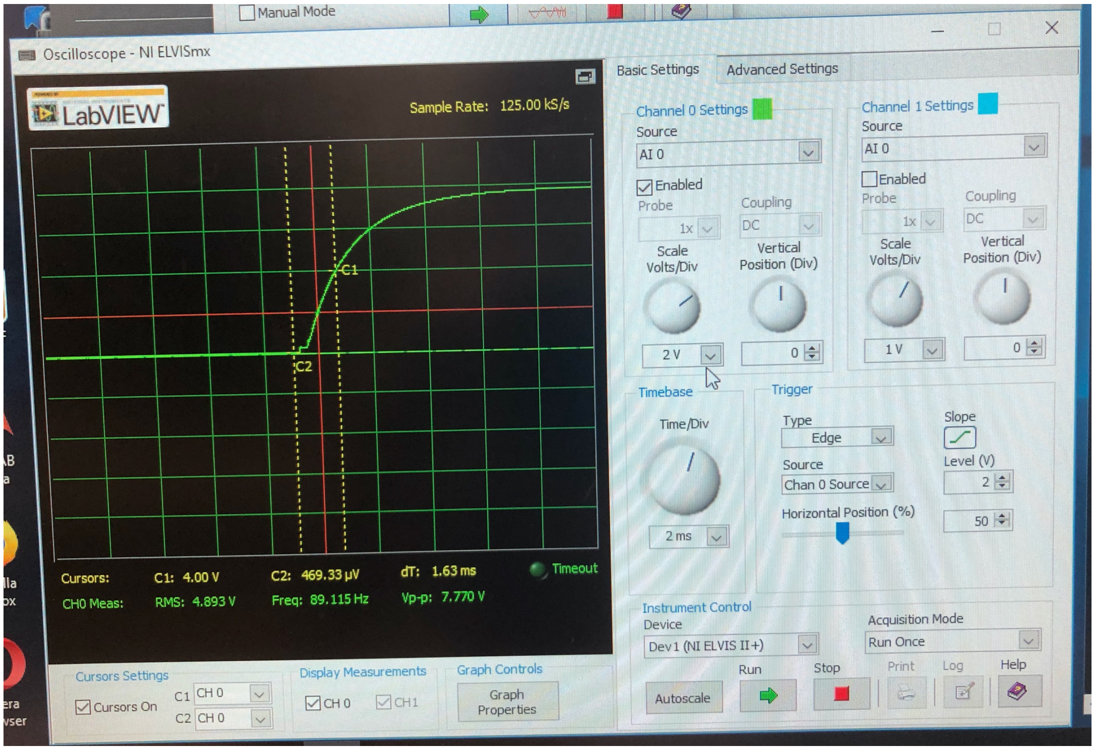
$C_1 = 4.80V$

$C_2 = 469.33\,\mu V$

$V_c(\infty) =$

$0.632(V_c(\infty)) = 4.89V$

$\tau_1 = 1.63\,ms$



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Oscope front panel

Summary Table

Vc(0) = K1+K2	0
Vc(infinity) = K1	7.77 V
Tau	1.63ms

Exercise 7

Construct the capacitor discharging circuit 2 using:

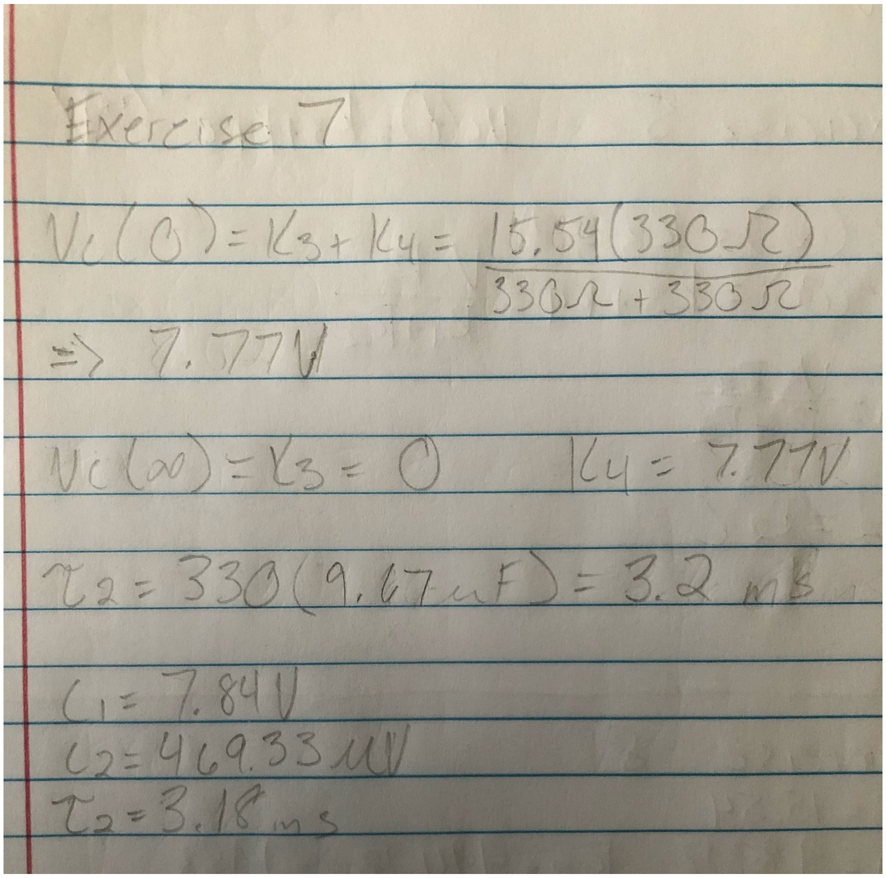
Vs = 15.5V

R1 = 330 Ohm

R2 = 330 Ohm

C = 10uF

And calculate Vc(0), Vc(infinity), time constant(tau).



Exercise 7

$V_c(0) = K_3 + K_4 = \frac{15.54(330\Omega)}{330\Omega + 330\Omega}$

$\Rightarrow 7.77V$

$V_c(\infty) = K_3 = 0 \quad K_4 = 7.77V$

$\tau_2 = 330(9.67\mu F) = 3.2\ ms$

$C_1 = 7.84V$
$C_2 = 469.33\ mV$
$\tau_2 = 3.18\ ms$

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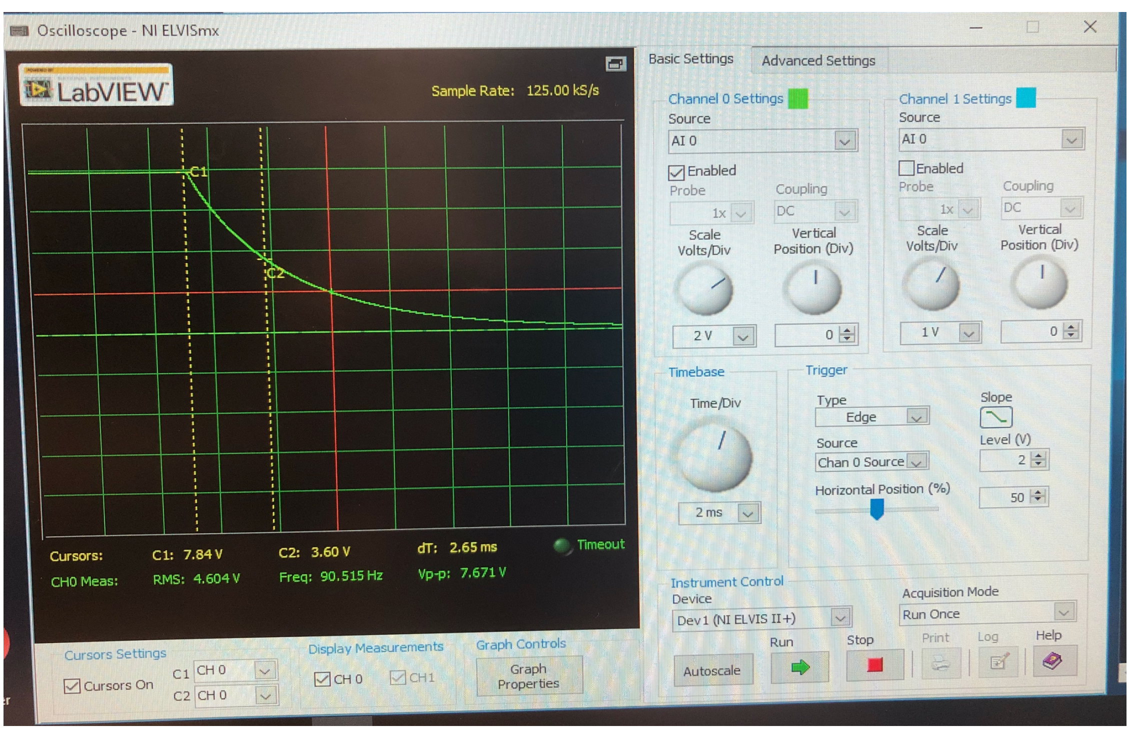


Oscope front panel (10)

Summary Table

Vc(0) = K3+K4	7.77 V
Vc(infinity) = K3	0
Tau	3.18ms

Exercise 8

Repeat exercises 6&7 using:

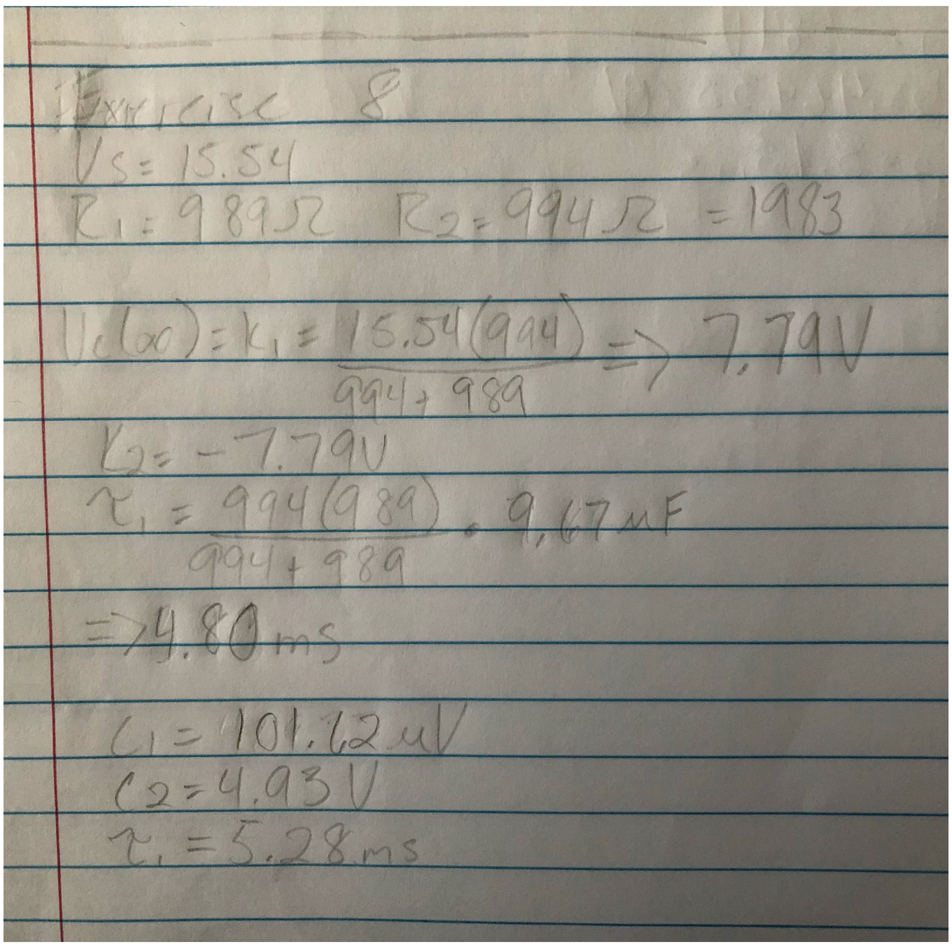
Vs = 15.5V

R1 = 1k Ohm

R2 = 1k Ohm

C = 10uF

Exercise 6



Exercise 8

$V_s = 15.54$

$R_1 = 989\Omega \quad R_2 = 994\Omega = 1983$

$V_c(\infty) = K_1 = \frac{15.54(994)}{994+989} \Rightarrow 7.79V$

$K_2 = -7.79V$

$\tau_1 = \frac{994(989)}{994+989} \cdot 9.67\mu F$

$\Rightarrow 4.80\,ms$

$C_1 = 101.62\,\mu V$

$C_2 = 4.93\,V$

$\tau_1 = 5.28\,ms$

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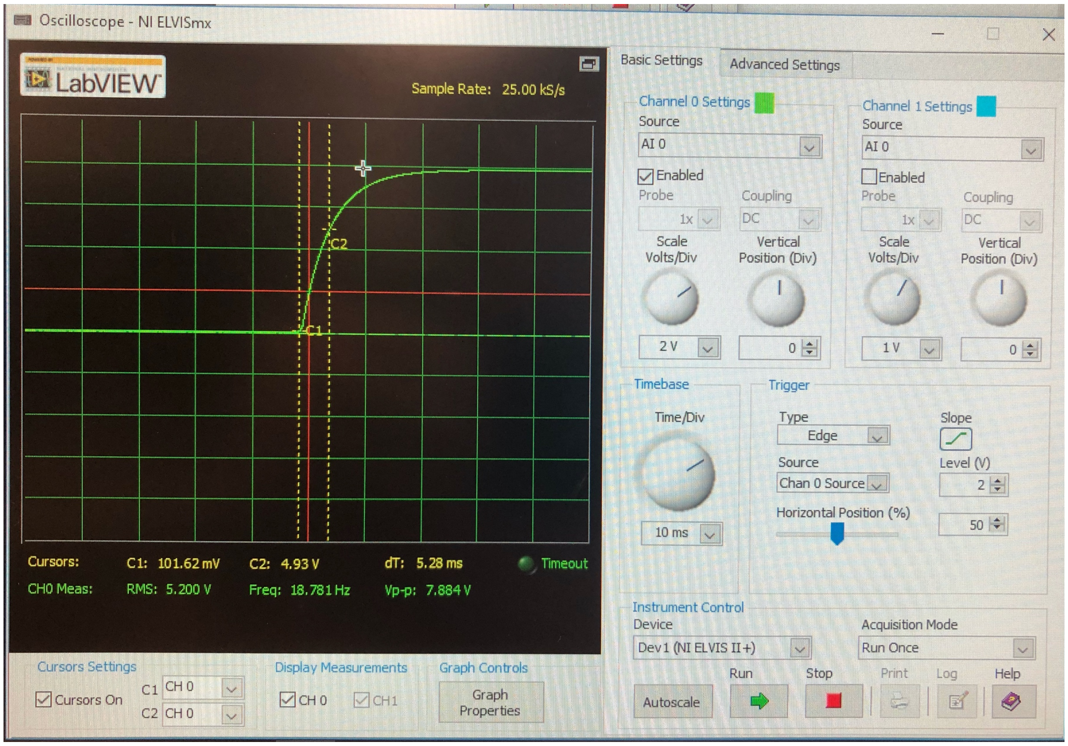

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Oscope front panel

Summary Table

Vc(0) = K1+K2	0
Vc(infinity) = K1	7.79 V
Tau	5.28ms

Exercise 7

Exercise 8

$K_3 = 0$

$K_3 + K_4 = \frac{15.54(994)}{994+989} = 7.79V$

$K_4 = 7.79V$

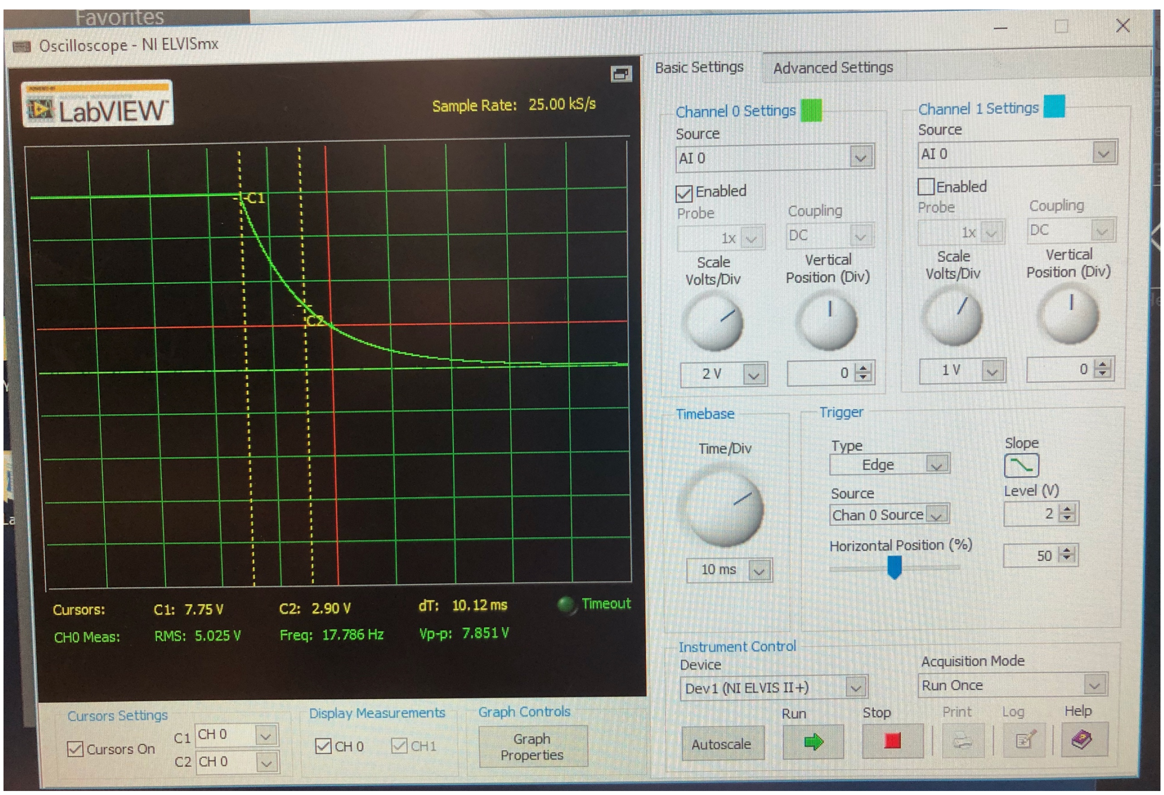
$\tau_2 = 994(9.67uF) = 9.61ms$

$C_1 = 7.74V$

$C_2 = 2.89V$

$\tau_2 = 10.12ms$

(13)



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Oscope front panel

Summary Table

Vc(0) = K3+K4	7.79 V
Vc(infinity) = K3	0
Tau	10.12ms

Exercise 10

Table

Vc(infinity) Exercise 6	7.77 V
Vc(infinity) Exercise 8	7.79 V
Tau1 Exercise 6	1.63ms
Tau1 Exercise 8	5.28ms
Tau2 Exercise 7	3.18ms
Tau2 Exercise 8	10.12ms

Questions:

1.) Compare the final voltage across the charging capacitor. Is one smaller, larger, or the same?
The voltages are the same, due to the fact that everything in the circuit is the same, except for the resistors, which does not change the overall voltage, only the time it takes to get that voltage.

2.) Compare the charging time constant across the charging capacitor. Is one smaller, larger, or the same?
The time constant is slightly higher in exercise 8, since the resistors were changed to a higher resistance, it increases the amount of time it takes the circuit to get to maximum voltage, since the circuit is has to charge up the capacitor before getting to maximum voltage.

3.) Compare the discharging time constant across the discharging capacitor. Is one smaller, larger, or the same?
The time constant is much higher in exercise 8, since the resistors were changed to a higher resistance, it increases the amount of time it takes the circuit to get to maximum voltage, since the circuit has to constantly discharge the capacitor, while trying to raise to maximum voltage.

Conclusion

This lab is very helpful for getting students ready to use an Oscope, a tool critical for helping Electrical Engineers study electric signals. This lab also helps with showing students how to calculate transient circuits, then construct the circuit and test for the same results.

Bibliography

1. Hand-written equations for exercise 1
2. FGEN and Oscope measurements for exercise 1
3. Circuit 1 given for exercise 4
4. Hand-written equations for exercise 4
5. Circuit 2 given for exercise 5
6. Hand-written equations for exercise 5
7. Hand-written equations for exercise 6
8. Oscope measurements and front panel for exercise 6
9. Hand-written equations for exercise 7
10. Oscope measurements and front panel for exercise 7
11. Hand-written equations for exercise 8 part 1
12. Oscope measurements and front panel for exercise 8 part 1
13. Hand-written equations for exercise 8 part 2
14. Oscope measurements and front panel for exercise 8 part 2