ECEN 214 - Lab Report

Lab Number: 8

Lab Title: Transient Response of a 2nd Order Circuit

Section Number: 502

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Lab Date: April 14, 2023

Due Date: April 21, 2023

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Introduction:

In this lab, we were allowed the opportunity to learn more about 2nd order responses. We did this by using a circuit with resistors and capacitors that reacted as a 2nd order response.

Task 1:

Task one consisted of building the circuit in figure 8.1 of the lab manual. Once this was done we set the parameters of 100 Hz with 2 volts for the peak to peak. Once this was done we used channels one and two of the oscilloscope to record the waveforms of the circuit. This was done a total of 5 times to record the waveforms for all the Q values, Q = ¼, Q = ½, Q = $\frac{1}{10}$, Q = 1, and Q = 2.5.

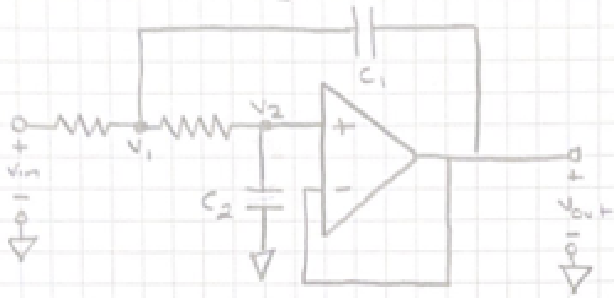
Data and Results:

Theoretical:

Step 1 $V_2 = V_{out}$

KCL at NODE 1: FOR SALLEN-KEY 2nd ORDER CIRCUIT

$$\frac{V_{in} - V_1}{R_1} + \frac{V_{out} - V_1}{R_2} + C_1 \frac{d}{dt}\left(V_{out} - V_1\right) = 0$$



NODE 2:

$$\frac{V_1 - V_{out}}{R_2} = C_2 \frac{dV_{out}}{dt}.$$

Plugging all in:

$$R_1C_1R_2C_2 \frac{d^2V_{out}(t)}{dt^2} + (R_1 + R_2)C_2 \frac{dV_{out}(t)}{dt} + V_{out}(t) = V_{in}(t)$$

$$\frac{d^2V_{out}(t)}{dt^2} + \frac{(R_1 + R_2)C_2}{R_1C_1R_2C_2} \cdot \frac{dV_{out}(t)}{dt} + \frac{1}{R_1C_1R_2C_2} V_{out}(t) = \frac{V_{in}(t)}{R_1C_1R_2C_2}$$

In form, $\frac{d^2y}{dx^2} + P(x)\frac{dy}{dx} + Q(x)y = f(x)$

Use formula,

Assume Solution in form: $V_{out}(t) = e^{st}$

differentiating twice: $\frac{dV_{out}(t)}{dt} = se^{st}$, $\frac{d^2V_{out}(t)}{dt} = s^2e^{st}$

Plugin: $R_1C_1R_2C_2(s^2e^{st}) + (R_1+R_2)C_2(se^{st}) + V_{out}(t) \cdot e^{st} = V_{in}(t)$

Divide by e^{st}:

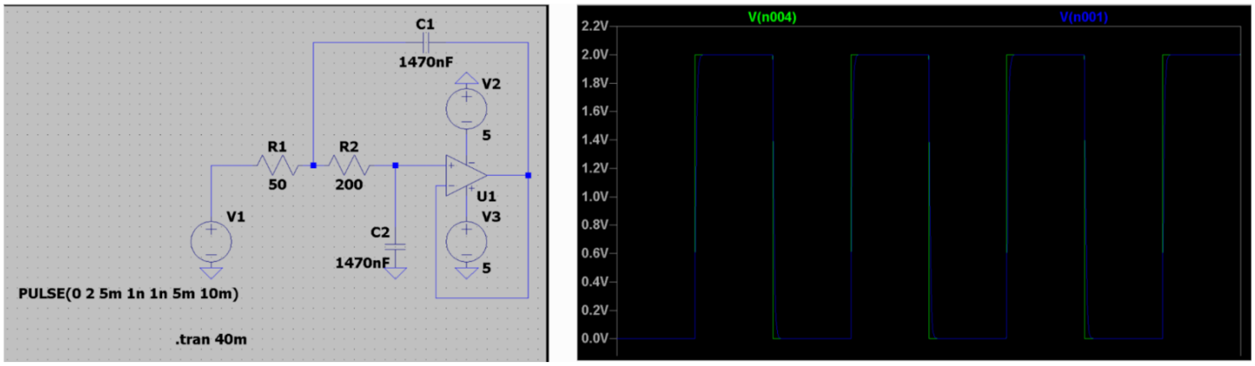
① — $R_1C_1R_2C_2 s^2 + (R_1+R_2)C_2 \cdot s + V_{out} = \frac{V_{in}(t)}{e^{st}}$

② — $s^2 + \frac{(R_1+R_2)C_2}{R_1C_1R_2C_2} \cdot s + 1 \frac{V_{out}(t)}{e^{st}} = \frac{V_{in}(t)}{e^{st}}$

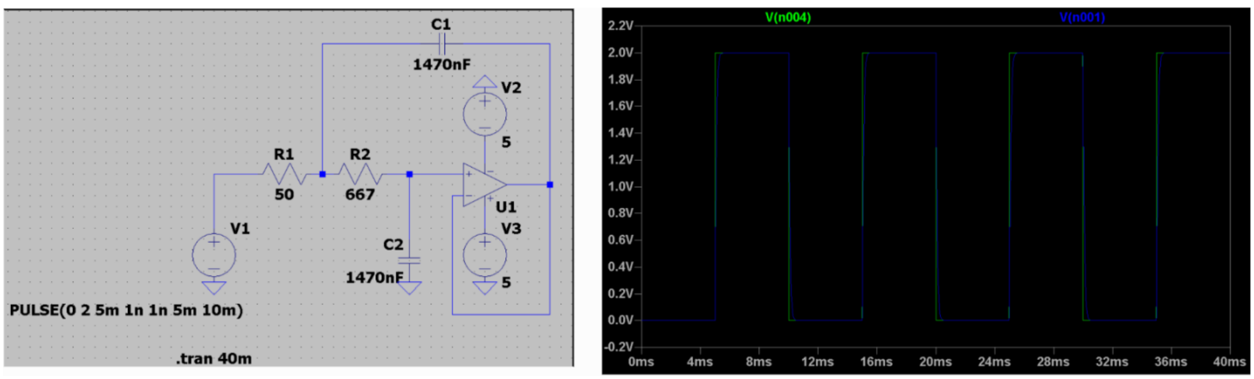
Multiply by $R_1C_1R_2C_2$

$\boxed{\text{Char. Eq} \quad R_1C_1R_2C_2 s^2 + (R_1+R_2)C_2 \cdot s + 1 = 0}$

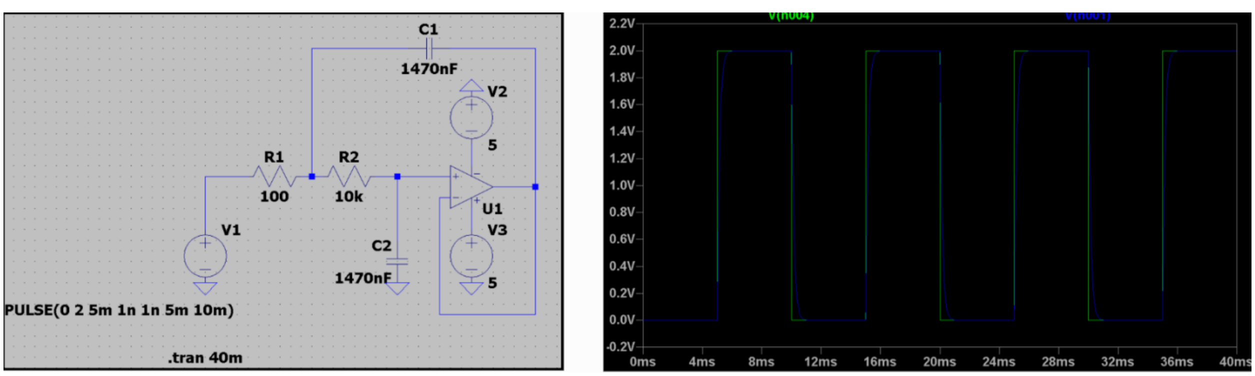
Simulations:



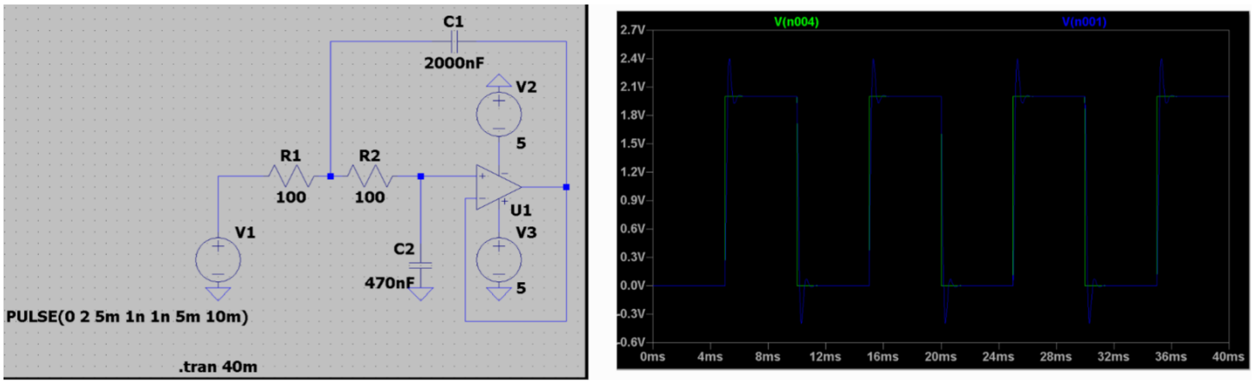
Simulation 1: Q= ½



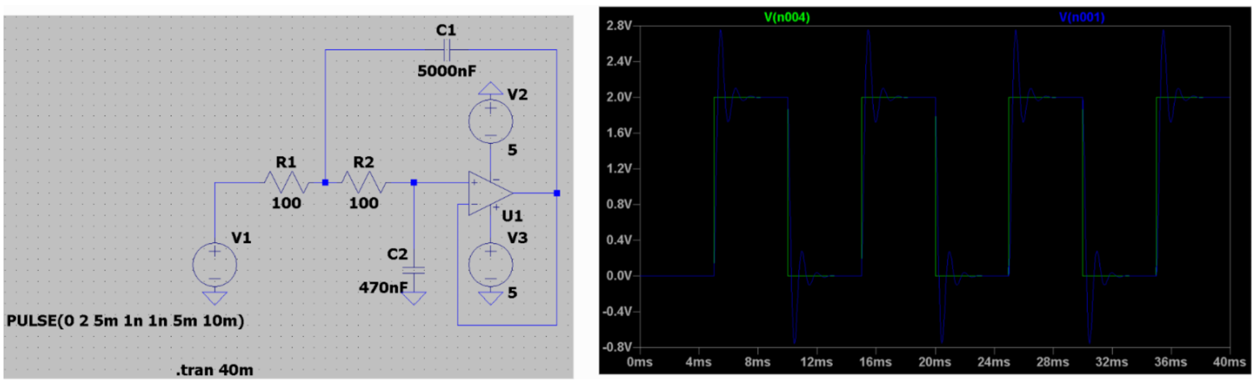
Simulation 2: Q= ¼



Simulation 3: Q= 0.1

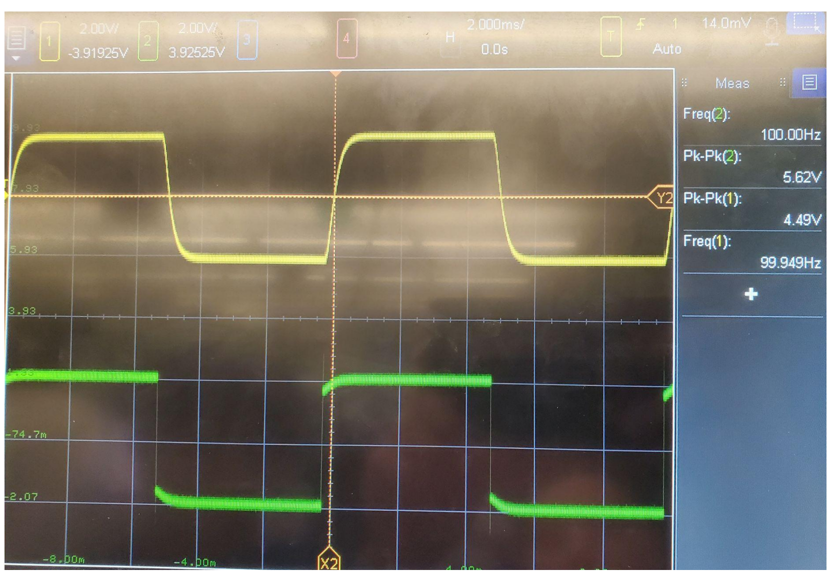


Simulation 4: Q = 1

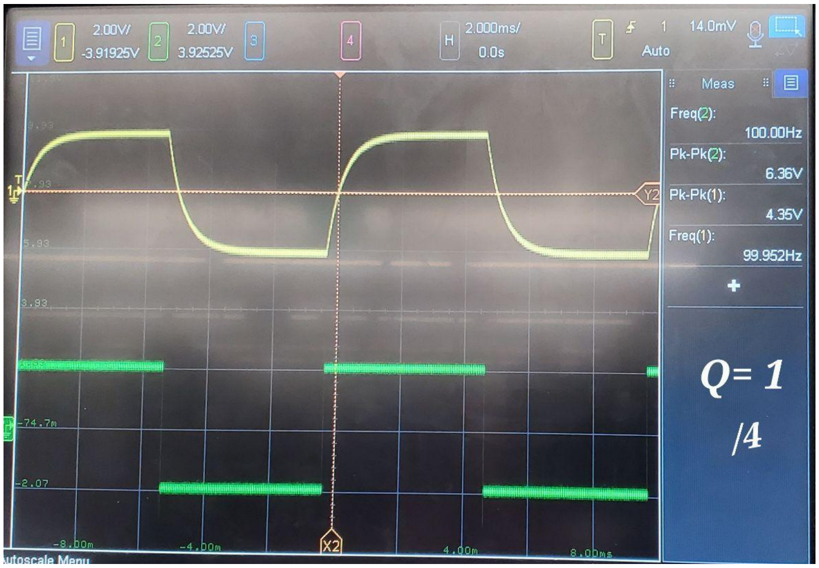


Simulation 5: Q = 2.5

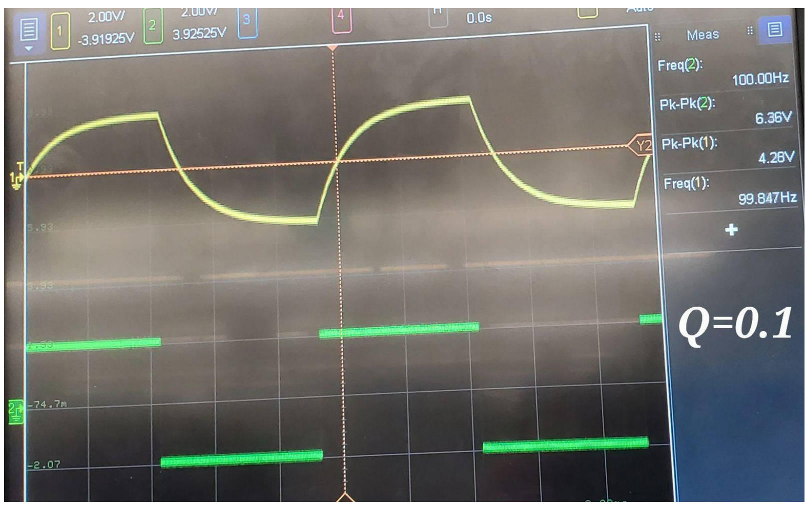
Measured:



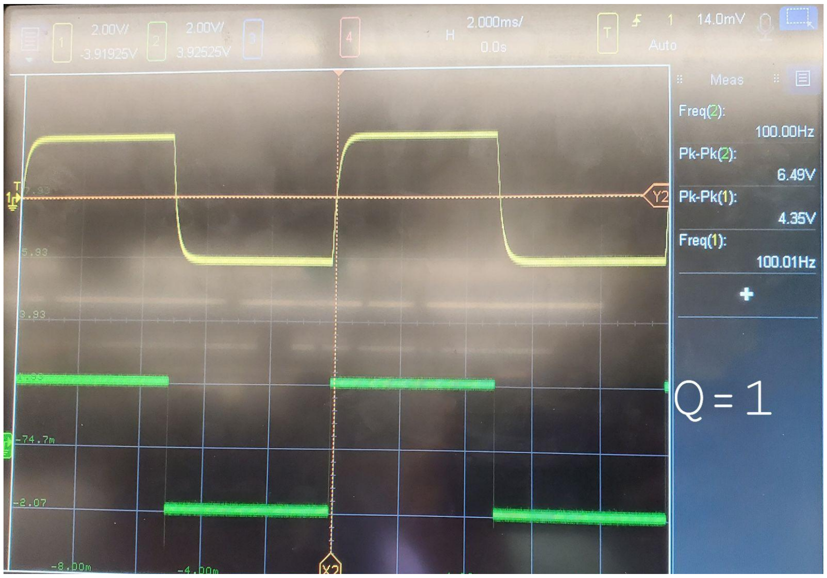
Waveform 1: Q = 1/2



Waveform 2: Q = ¼



Waveform 2: Q = 0.1



Waveform 2: Q = 1

Waveform 5: Q = 2.5

Discussion:

Some changes that could have been made were the capacitor values for the different Q values. The capacitor and resistor values needed could have been changed in order to match the values allowed for this course. We would like to experiment with different values of the capacitors and resistors to get the closest approximation to those measured values from courses allowed with different components.