Lab 1 Report - RC Circuits

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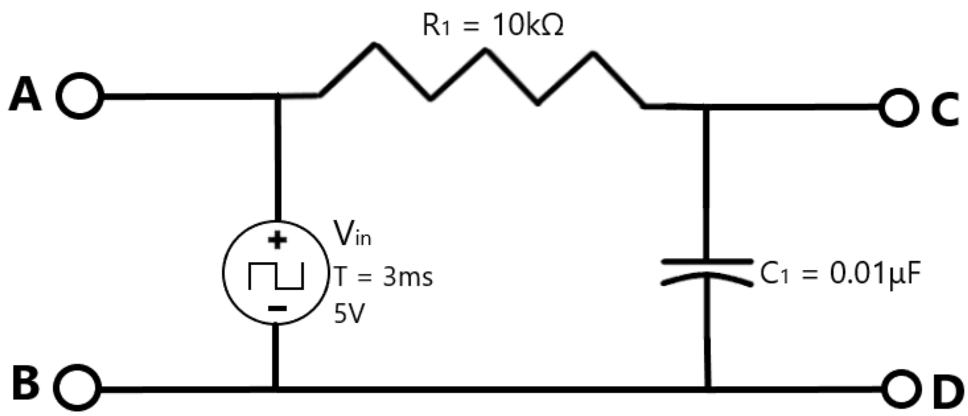
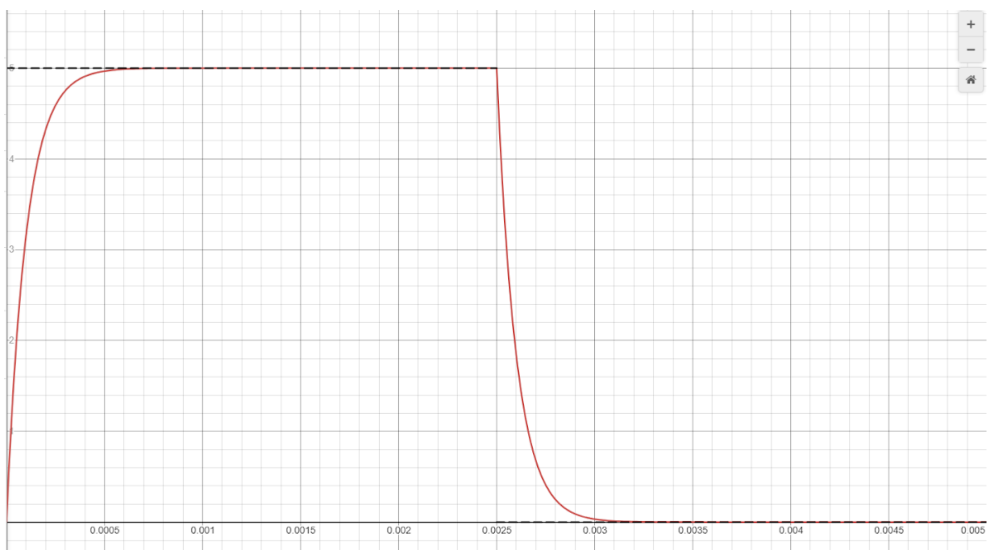
PROCEDURE 1

In this procedure, we constructed our circuit on our breadboard as shown in figure 1.1, attaching the function generator in place of the sinusoidal source in the figure, and attaching the oscilloscope probes across terminals A and B (channel 1) and a second set across terminals C and D (channel 2). We then tuned the function generator to give us a square wave with period T = 3ms, max = 5V, and min = 0V. Once both waveforms were shown on the screen, we printed the image, finding that it was quite similar to the plot we generated for our prelab, but with a shorter plateau than in the prelab (see figures 1.2 and 1.3). Notably, our oscilloscope was measuring a maximum value of 5.2V for our response and not 5V, and this continued throughout the lab. Next, we measured the 10%, 50% and 90% points at the front-end of the response wave using the oscilloscope's cursor feature. Our findings for the rise, fall, and delay times of our circuit were relatively distant from our calculated values, which leads us to believe either instrumentation error or error in our circuit construction altered our results. Next, we used the oscilloscope's measure feature to find the rise and fall times, but went back to the cursor to calculate the delay-times. When comparing our calculations from the previous section and the rise, fall, and delay times from the oscilloscope's own measurements, we find a much smaller error, further indicating that there is likely error arising from our experimental setup (whether that be bad component values, connectors, etc.). We then measured ten values along the rise-curve of the RC response, finding a time constant very close to theory.

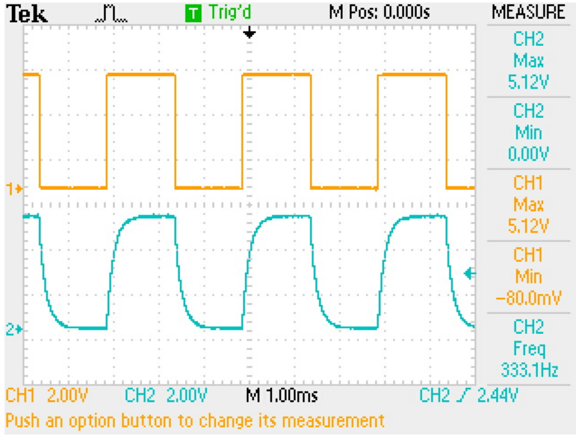
For the final stage of this procedure, we rebuilt the circuit from figure 1.1 into the circuit in figure 1.4 and eventually rebuilt that into figure 1.5 (Note: the oscilloscope and function generator connections are the same as in figure 1.1). For both circuits, we measured at 10 points along the rising curve of the response as we did for the single-stage circuit. In both the two-stage and three-stage circuits we found time constant values very close to theory. As a whole, our data in this procedure proved to closely parallel theoretical values, apart from the theoretical rise, fall, and delay times versus our measured values. This inconsistency is difficult to attribute to anything considering the consistency between our values calculated based on 10%, 50%, and 90% times and the directly measured values for rise, delay, and fall times. However, early in the experiment we had difficulties in completing the circuit such that the oscilloscope could measure the voltage across the capacitor, so it is thus possible that in those early measurements something in the setup may have been increasing resistance or capacitance in the circuit and thus altered our measurements.



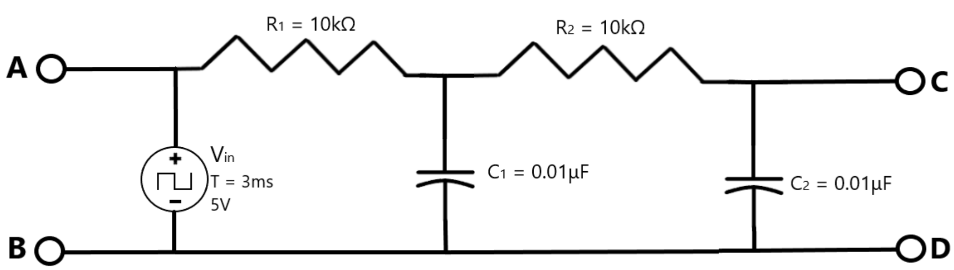
(Figure 1.1) Single-Stage RC circuit used in procedure 1 with oscilloscope connection terminals labeled (A-B for Channel 1, C-D for Channel 2).



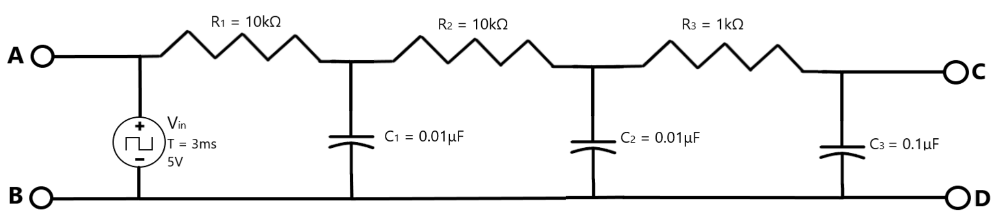
(Figure 1.2) Square wave function and resulting ideal RC response with period 5ms generated in pre-lab.



(Figure 1.3) Square wave function (channel 1) and RC response to function (Channel 2) from oscilloscope.



(Figure 1.4.) Two-Stage RC circuit used in procedure 1 with oscilloscope connection terminals labeled (A-B for Channel 1, C-D for Channel 2).



(Figure 1.5) Three-Stage RC circuit used in procedure 1 with oscilloscope connection terminals labeled (A-B for Channel 1, C-D for Channel 2).

ANALYSIS

(1.1) The shapes seem to be quite close between our measured waveform and our theoretical one from the pre-lab, with no particularly notable differences.

(1.2) T_in = 5ms

- Output values: V_max = 5.2V, V_min= 0.0V

	10% Time	50% Time	90% Time	Rise Time	Fall Time	Delay Time
Theoretical				0.219	0.219	0.069
Calculated				388μs	388μs	108μs
Measured	12μs	108μs	400μs			
Error				77.2%	77.2%	56.5%

Differences in times are likely due to resolution of the oscilloscope and slight operator error due to being new with the equipment, as well as differences between theoretical circuit and real- world practical circuit.

(1.3)

	Rise Time	Fall Time	Delay Time
Calculated	388μs	388μs	108μs
Measured	324μs	348μs	110μs
Error	19.7%	11.5%	1.85%

Differences between our calculated values and measurements could be due to instrumentation resolution and operator error during measurement.

(1.4)

Time	20μs	40μs	60μs	80μs	100μs	120μs	140μs	160μs	180μs	200μs
V_out	720mV	1.28V	1.72V	2.12V	2.48V	2.80V	3.00V	3.36V	3.56V	3.72V

- Theoretical Value: τ = 100μs
- Calculated Value: τ = 103μs

Reasons for a difference of 3% can be concluded from two events. One, as data was collected from the oscillator, the rapid change in values made it difficult to record accurate values. In addition, because the resistors were connected for a long time causing more heat as time continued, the t value could have been larger.

(1.5.)

Two-Stage:

Time	100μs	200μs	300μs	400μs	500μs	600μs	700μs	800μs	900μs	1ms
V_out	760mV	1.64V	2.36V	2.96V	3.40V	3.72V	4.00V	4.24V	4.40V	4.52V

- 10k+10k, 0.01μF&0.01μF (for math)

Three-Stage:

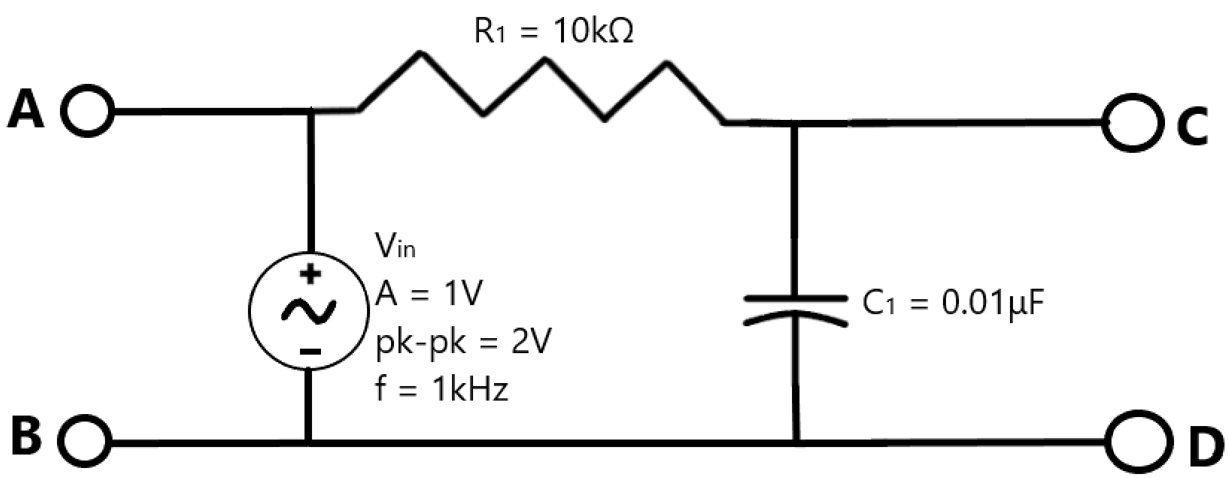
Time	0.4ms	0.8ms	1.2ms	1.6ms	2.0ms	2.4ms	2.8ms	3.2ms	3.6ms	4.0ms
V_out	1.04V	1.92V	2.6V	3.16V	3.60V	3.96V	4.20V	4.40V	4.52V	4.64V

- 10k+10k+1k, 0.01μF&0.01μF&0.1μF (for math)

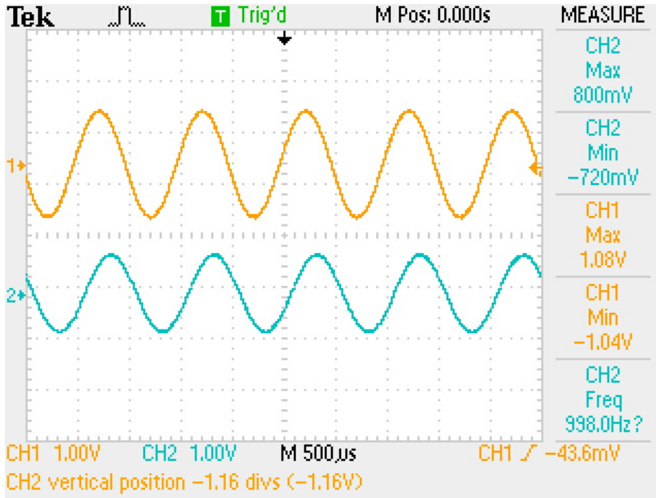
Given the comparison of our theoretical and calculated values, there was a 8% and 5% error difference. This can be attributed to internal error of the equipment and the inaccurate data points within the oscilloscope. In addition, there could be the possibility of the capacitance being larger than the theoretical one and the usage of the same resistor would have caused different values.

PROCEDURE 2

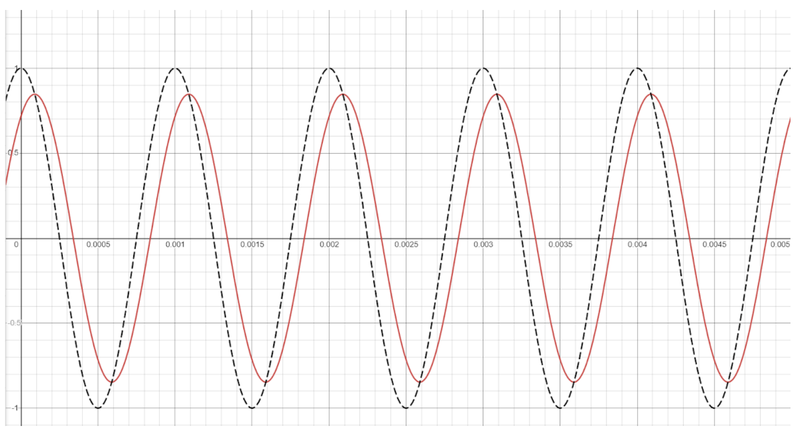
In this procedure, we constructed the circuit shown in figure 2.1, connecting the function generator in place of the sinusoidal voltage source, and connecting the oscilloscope to terminals A-B for channel 1 and C-D for channel 2. Initially, we configured the function generator to output a sine wave that varied from 1V to -1V with a frequency of 1kHz. Our response to the sine wave seems to closely mimic that which we predicted theoretically in the pre-lab. Additionally, by varying frequency, we find that our data closely mimics our theoretical graph of voltage across the capacitor versus frequency. The graph of voltage across the capacitor versus frequency based on our data is notably sharper at the beginning as compared to the theoretical graph of the capacitor voltage. Overall, the sinusoidal input and output of the RC circuit behaved largely as expected, apart from the initial behavior of the resistor voltage.



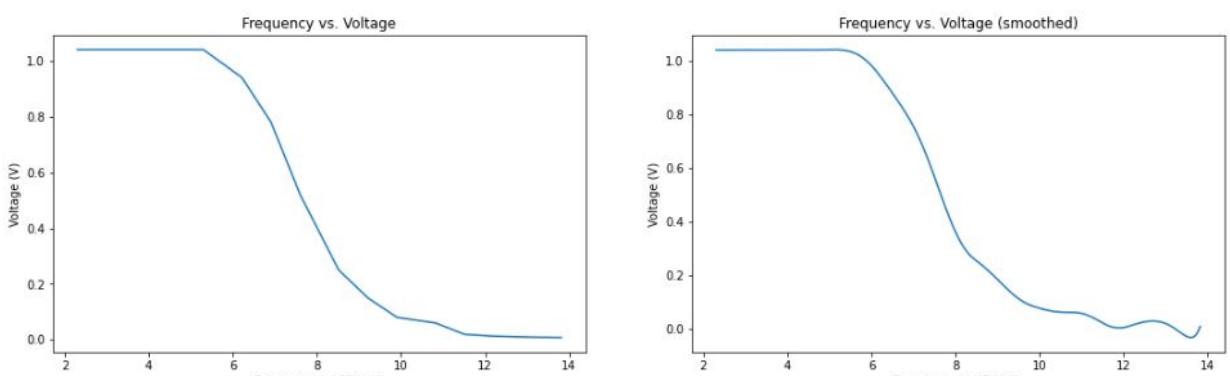
(Figure 2.1) Single-Stage RC circuit used in procedure 2 with oscilloscope connection terminals labeled (A-B for Channel 1, C-D for Channel 2).



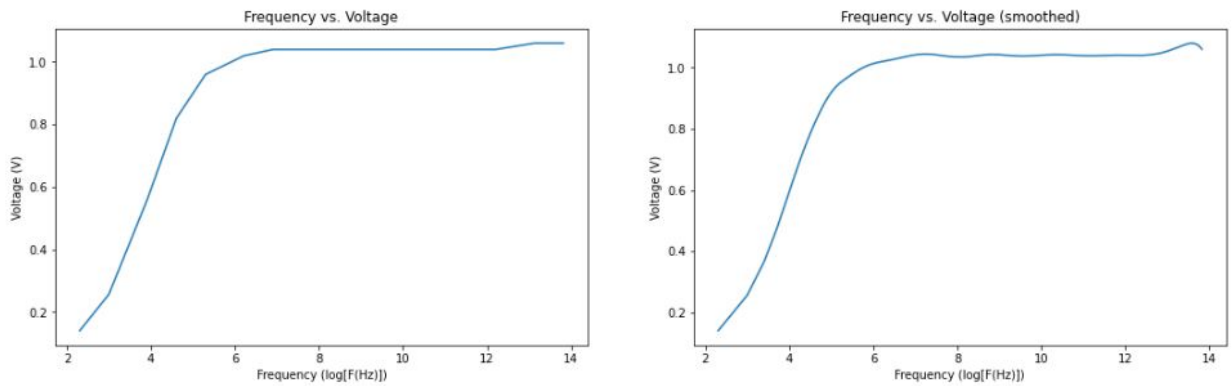
(Figure 2.2) Sinusoidal wave function (channel 1) and RC response to function (Channel 2) from oscilloscope.



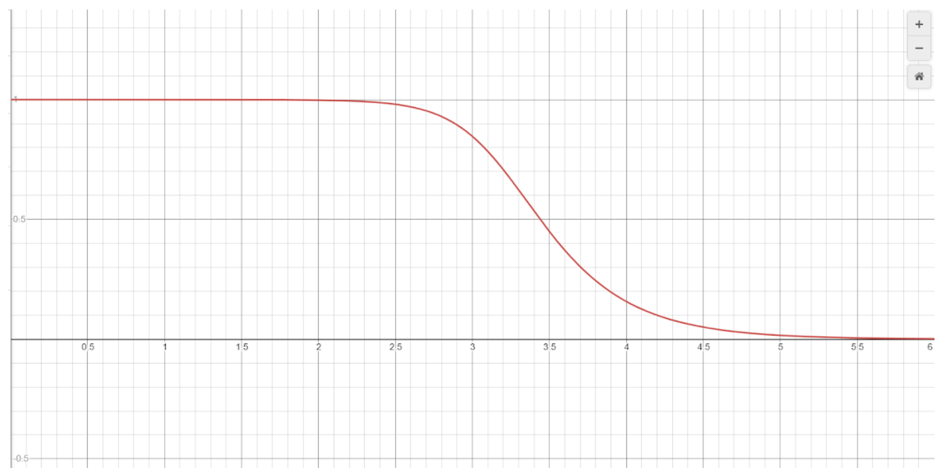
(Figure 2.3) Sine wave function and resulting ideal RC response with frequency 1kHz generated in pre-lab.



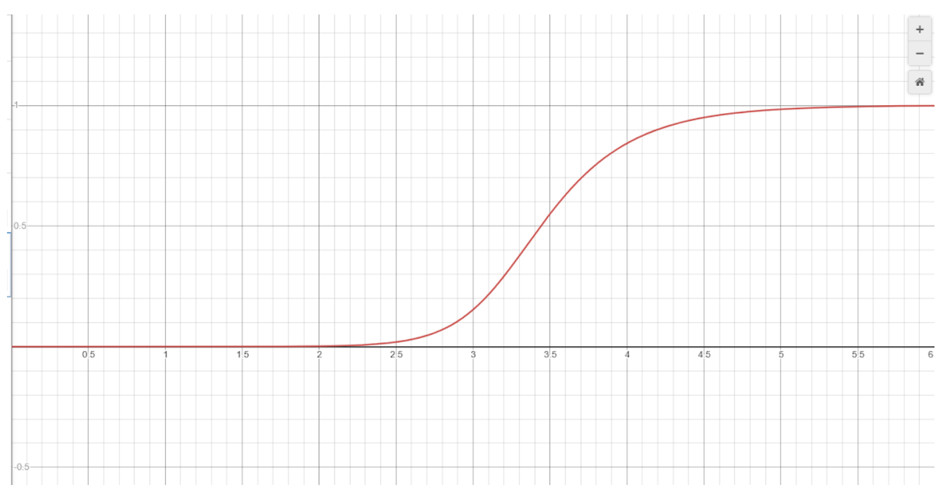
(Figure 2.4) Frequency of input and resulting output voltage over the capacitor.



(Figure 2.5) Frequency of input and resulting output voltage over the resistor.



(Figure 2.6) Frequency of input and resulting output voltage over the capacitor (as found in prelab)



(Figure 2.7) Frequency of input and resulting output voltage over the resistor (as found in prelab).

ANALYSIS

(2.1) Our measured waveform seems to closely mimic the one we found during the prelab, with no notable differences (see Fig 2.2 and 2.3).

(2.2)

Freq	10Hz	20Hz	50Hz	100Hz	200Hz	500Hz	1kHz	2kHz
V_c	1.04V	1.04V	1.04V	1.04V	1.04V	940mV	780mV	520mV
Freq	5kHz	10kHz	20kHz	50kHz	100kHz	200kHz	500kHz	1MHz
V_c	250mV	150mV	80mV	60mV	19mV	12.5mV	8.8mV	7.4mV

Looking over figures 2.4 and 2.6, we find the plot from our data to be quite close to our theoretical graph.

(2.3)

Freq	10Hz	20Hz	50Hz	100Hz	200Hz	500Hz	1kHz	2kHz
V_r	140mV	256mV	560mV	820mV	960mV	1.02V	1.04V	1.04V
Freq	5kHz	10kHz	20kHz	50kHz	100kHz	200kHz	500kHz	1MHz
V_r	1.04V	1.04V	1.04V	1.04V	1.04V	1.04V	1.06V	1.06V

Looking over figures 2.5 and 2.7, the graph of our data is notably sharper to begin, but plateaus similarly to the theoretical graph.