RC Circuit with Oscilloscope

Lab #5

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Objective

Use an oscilloscope to observe the time constant of an RC circuit experimentally.

1 Introduction

Recall from Lab #3 that the time constant τ of an RC circuit is the time during which the voltage decays to $1/e \approx 37\%$ of its value. The time constant is equal to RC.

An analog oscilloscope is an electronic device that plots voltage as a function of time by deflecting an electron beam in a cathode ray tube. In our setup it takes the place of a voltmeter.

2 Procedures and Results

We set up the circuit according to Figure 1, using an oscilloscope as a voltmeter and a function generator in place of a battery.

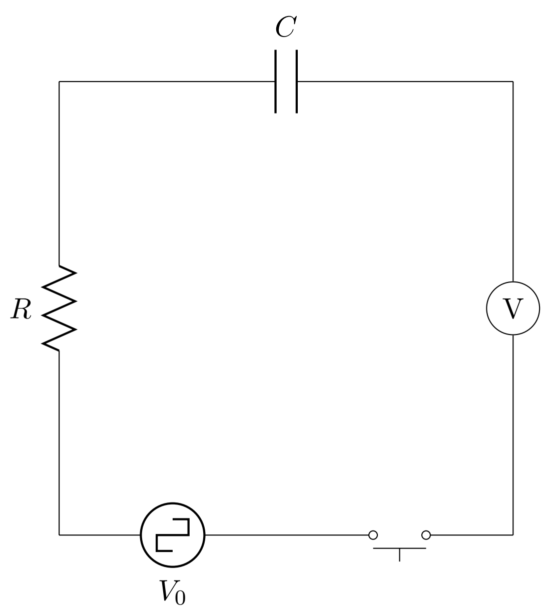
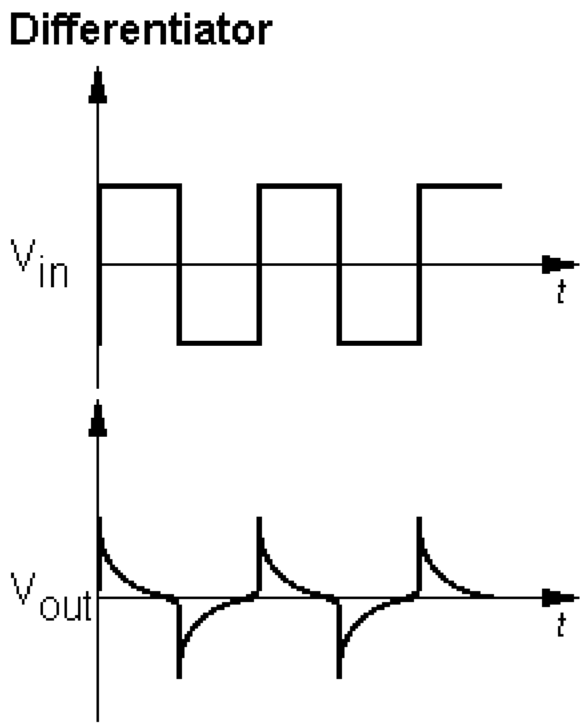
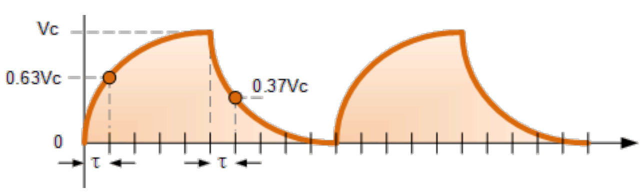


Figure 1: RC circuit

We set the function generator to produce a square wave and observed an output signal that looked like a series of spikes:



We then set the function generator to produce a triangle wave and observed an output signal that looked more like this:



which is more like the waveform we were told would appear. We adjusted the SEC/DIV knob of the oscilloscope until the image was frozen on the screen and adjusted VOLTS/DIV so that the waveform was 8 boxes high. Then, we measured the number of boxes across which the signal rose by 5 boxes.

Table 1: Oscilloscope measurements. Data courtesy of Margaret Burkart

Trial	Resistance	Capacitance	Divisions across	SEC/DIV
1	$10,920\,\Omega$	900 pF	1.2	$20\,\mu$s
2	$5,555\,\Omega$	900 pF	1.9	$20\,\mu$s
3	$1,111\,\Omega$	900 pF	1.9	$20\,\mu$s
4	$5,555\,\Omega$	100 pF	1.8	$20\,\mu$s
5	$5,555\,\Omega$	500 pF	1.9	$20\,\mu$s

3 Discussion

We calculated the observed time constant by multiplying the divisions across by the value of the SEC/DIV knob. A sample calculation is shown for Trial 1:

$$\tau_{observed} = 1.2 \times 20\,\mu\text{s} = 24\,\mu\text{s}$$

We calculated an accepted value for τ by multiplying the resistance by the capacitance:

$$\tau_{accepted} = 10,920\,\Omega \times 900\,\text{pF} = 9.828\,\mu\text{s}$$

Then, we calculated the percent error:

$$\%\,\text{error} = \frac{|\tau_{observed} - \tau_{accepted}|}{\tau_{accepted}} = \frac{|24\,\mu\text{s} - 9.828\,\mu\text{s}|}{9.828\,\mu\text{s}} = 144\%$$

Table 2: Oscilloscope measurements. Data courtesy of Margaret Burkart

Trial	$\tau_{observed}$	$\tau_{accepted}$	% error
1	24 μs	9.828 μs	144 %
2	38 μs	4.9995 μs	660 %
3	38 μs	999.9 ns	3700%
4	36 μs	555.5 ns	6381%
5	38 μs	2.7775 μs	1268%

4 Conclusion

Today