Set 4 - Lab Report

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ELECENG 2CJ4 - Circuits and Systems

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Introduction

The purpose of this lab is to analyse the behavior of first-order RC circuits, their transient and steady state response. This is done through charging and discharging a capacitor which produces a square wave at a certain frequency. By using two voltage thresholds V_{th1} and V_{th2}, the circuit can switch between two voltage saturations. With this, we can shape waves with an integrator circuit connected to the output which produces a triangular wave.

Working Principle of the Circuit

This lab builds a Relaxation Oscillator using an operational amplifier. By charging C1 through R1, the circuit is able to output a square wave. This is determined by R2 and R3 which set voltage thresholds V_{th1} and V_{th2}. The oscillation frequency is determined by R1, C1,V_{th1} and V_{th2} which can be seen below.

$$T_1 = C \times R \times ln(\frac{V_{sat+} - V_{th2}}{V_{sat+} - V_{th1}}) \quad T_2 = C \times R \times ln(\frac{V_{sat+} - V_{th1}}{V_{sat-} - V_{th2}})$$

$$T_{total} = T_1 + T_2$$

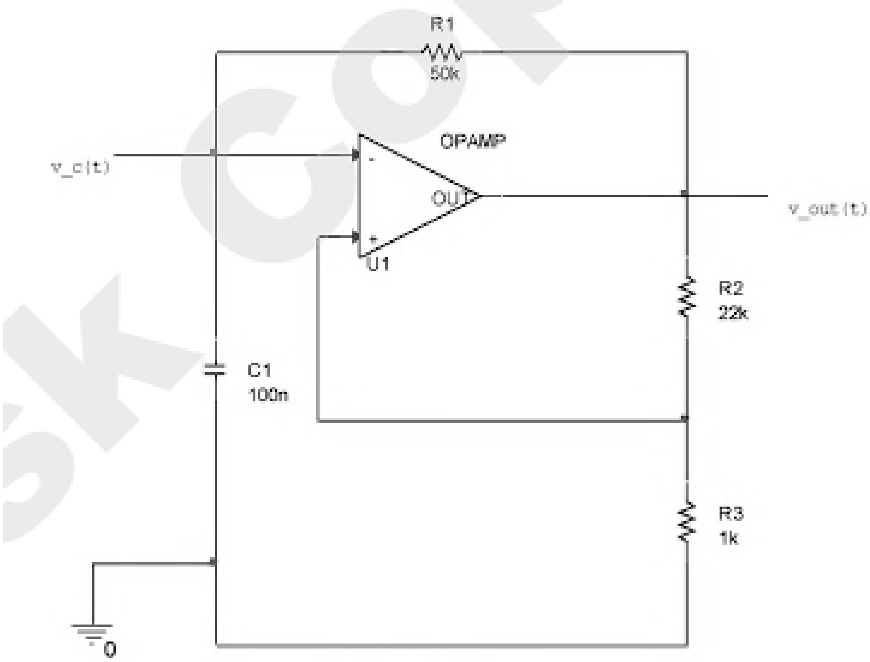

Figure 1: Relaxation Oscillator

Experiment

1. Given the circuit in Fig. 9, calculate the period *T* and frequency *f* of the oscillator.

V_{th1} and V_{th2}

$$V_{th} = \frac{R_1}{R_1+R_2}\left(V_{sat+}\right) = \frac{1k\Omega}{1k\Omega+22k\Omega}(5) = 0.217V$$

$$V_{th} = \frac{R_1}{R_1+R_2}\left(V_{sat-}\right) = \frac{1k\Omega}{1k\Omega+22k\Omega}(5) =- 0.217V$$

Time period

$$T_1 = C \times R \times ln(\frac{V_{sat+}-V_{th2}}{V_{sat+}-V_{th1}}) = (100nF)(50k\Omega)(ln(\frac{5V-(-0.217)}{5V-0.217})$$

$$= 4.34 \times 10^{-4}\ Seconds$$

$$T_2 = C \times R \times ln(\frac{V_{sat+}-V_{th1}}{V_{sat-}-V_{th2}}) = (100nF)(50k\Omega)(ln(\frac{-5V(-0.217)}{-5V-(-0.217)})$$

$$= 4.34 \times 10^{-4}\ Seconds$$

$$T_{total} = T_1 + T_2 = 4.34 \times 10^{-4} + 4.34 \times 10^{-4} = 8.68 \times 10^{-4}\ Seconds$$

Frequency

$$f = \frac{1}{T_{total}} = \frac{1}{4.68\times10^{-4}s} = 1152\ Hz$$

2. Build the Circuit in Fig. 9 and plot the voltage of the capacitor and the output voltage with respect to time (assuming $V_{sat} = \pm 5$). Measure the time period *T* using the Analog Discovery 2 and compare it to the theoretical result

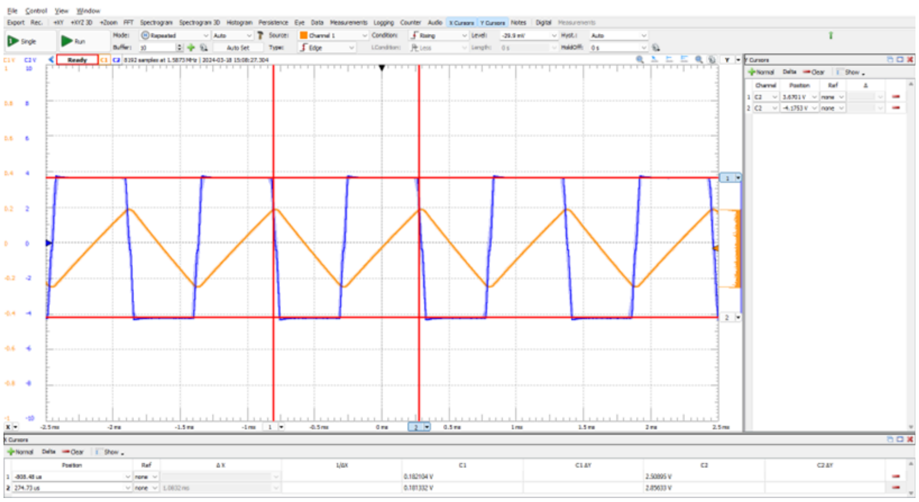

Figure 2: AD3 Output

From the data in the figure above, it can be seen that both the calculated and experimental values are very similar. This can be seen as the value measured from the experiment is 923.19 Hz and the calculated frequency is 1152 Hz. In addition, the percent error calculation below is very low.

$$\%Error = \left|\frac{1152-923.19}{1152}\right| \times 100 = 19.86\%$$

Similarly, when looking at a period, we get a value of around 1.083 ms which is similar to the calculated period of 0.86mS. Calculating percent error reveals a small error which means both are measurements being accurate to the actual values.

$$\%Error = \left|\frac{4.34\times10^{-4}-1.08\times10^{-3}}{4.34\times10^{-4}}\right| \times 100 = 24.42\%$$

3. Can you build a circuit by using another Op-Amp LM358P to generate a triangular output? Explain.

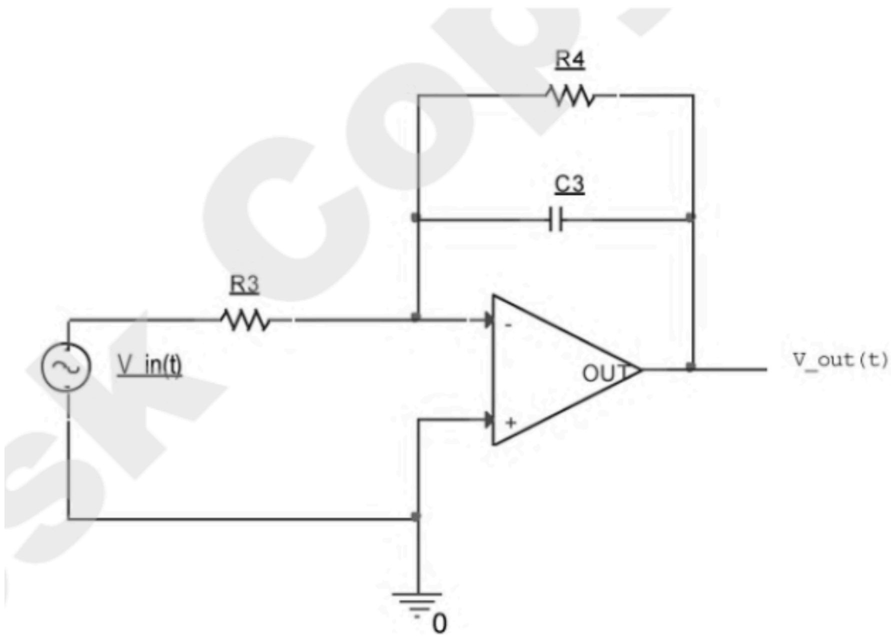

Figure 3: Integrator Circuit

You can build another circuit using another Op-Amp LM358P. In Lab 3, the integrator circuit is able to generate a triangular wave output given a square wave, which is the output of this current circuit. The circuit schematic of the integrator circuit can be seen above. Using this as an output, a triangular wave is achieved. This can be seen in Figure 2 above.

Discussion

The experimental values confirm the expected behavior of the oscillator circuit. The calculations determined the frequency to be 1152 Hz with a period of 0.86 ms. The data collected from the experimental circuits achieved a frequency of 923.19 Hz and a period of 1.08 ms. The relatively low percent error between the two values further confirms the behavior. In addition, the triangular wave was able to be generated with an additional LM358P output. This was done by connecting the output of the original circuit to the input to the new circuit.