Circuits and Systems 2CJ4
Lab 4

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Set 4 Laboratory Experiment

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

Period:

$$T = R_1 C \left(\ln \frac{V_{sat}^+ - V_{th_2}}{V_{sat}^+ - V_{th_1}} + \ln \frac{V_{sat}^- - V_{th_1}}{V_{sat}^- - V_{th_2}} \right)$$

$$V_{th_1} = \frac{R_3}{R_2 + R_3} \cdot (V_{sat}^+)$$

$$= \frac{1}{22+1} \cdot (5)$$

$$= \frac{5}{23} = 0.217$$

$$V_{th_2} = \frac{R_3}{R_2 + R_3} \cdot (V_{sat}^-)$$

$$= \frac{1}{23} (-5)$$

$$= \frac{-5}{23} = -0.217$$

50×10^3 $\quad$ 100×10^{-9}

$$T = 50 \times 100 \left(\ln \frac{5 - (-0.217)}{5 - 0.217} + \ln \left(\frac{-5 - 0.217}{-5 - (-0.217)} \right) \right)$$

$$= (50 \times 10^3) \times (100 \times 10^{-9}) (0.087 + 0.087)$$

$$T = 869.08 \times 10^{-6} s$$

$$= 0.869 ms$$

Frequency:

$$f = \frac{1}{T} = \frac{1}{869.08 \times 10^{-6}} = 1150.64 \text{ Hz}$$

Figure 1: Analytical Calculations

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

Figure 2: Relaxation Oscillator Circuit

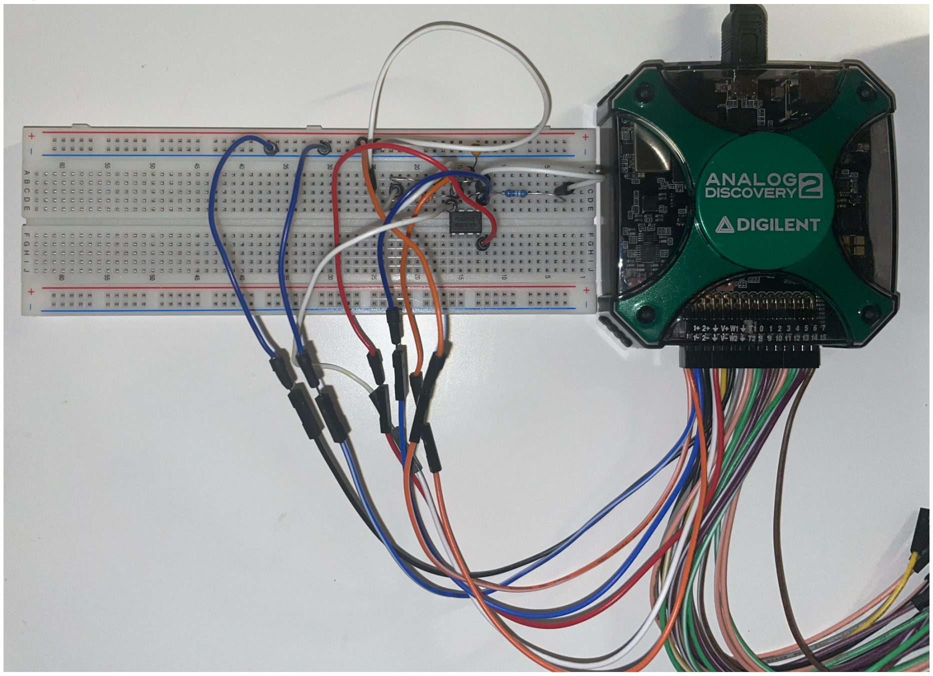
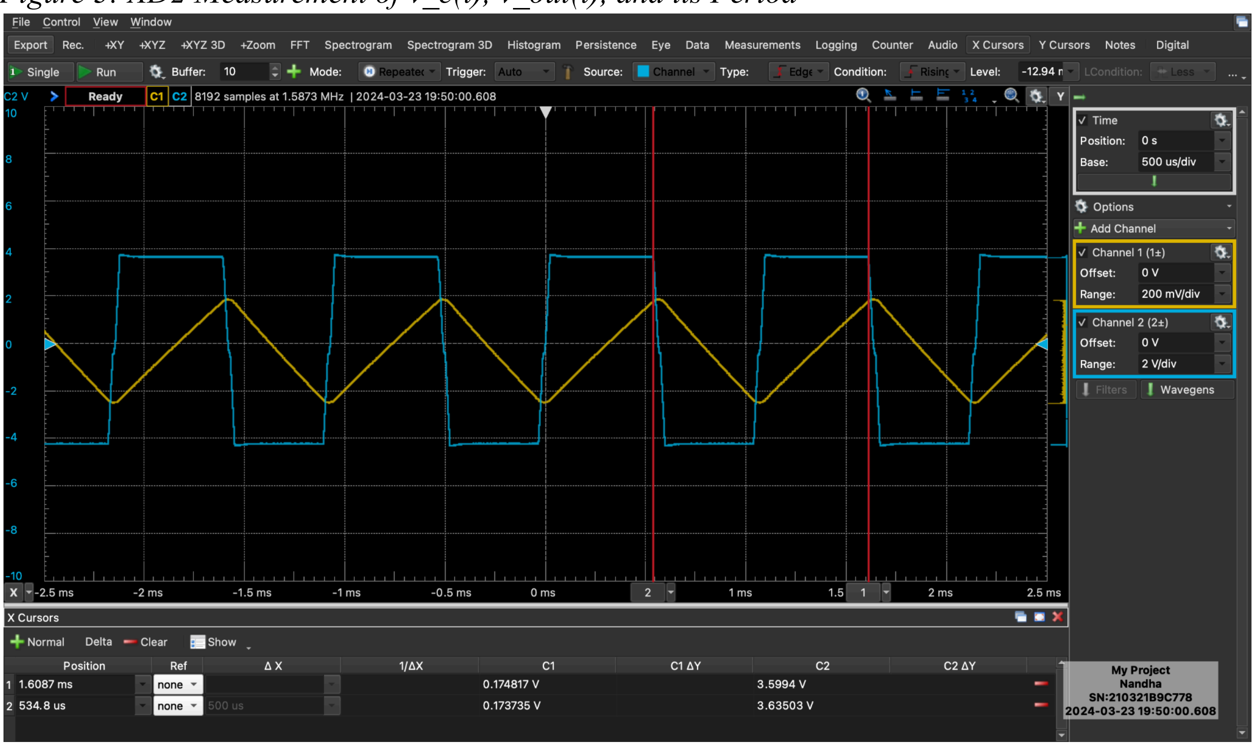


Figure 3: AD2 Measurement of v_c(t), v_out(t), and its Period



$$T = 1.6087\, ms - 534.8\, us$$
$$= (1.6087 \times 10^{-3}) - (534.8 \times 10^{-6})$$
$$= 1.0739\, ms$$

Percent Error:

$$\%\, Error = \frac{Observed\ Value - True\ Value}{True\ Value} \times 100\%$$
$$= \frac{(1.0739\times10^{-3}) - (869.08\times10^{-6})}{869.08\times10^{-6}} \times 100\%$$
$$= 23.57\%$$

Comparison:

The AD2 measurement of the period of the output voltage was 1.0739 ms, while the theoretical value was 869.08 µs, resulting in a percent error of 23.57%, indicating close proximity between experimental and theoretical values; potential discrepancies may stem from factors like internal resistance within the breadboard and environmental conditions affecting the circuit. Additionally, the plot graph of v_c(*t*) forming a triangular wave and v_out(*t*) resembling a square wave confirms the functionality of a relaxation oscillator, as the capacitor charging and discharging cycles in the circuit generate a triangular waveform at v_c(*t*), while the operational amplifier's saturation behavior ensures the output waveform v_out(*t*) closely resembles a square wave.

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

   Yes, it is possible to build a circuit to generate a triangular output by using the other Op-Amp LM358P to create an integrator. Since, the v_out(*t*) generates a square wave due to the saturation behavior, the integrator is able to transform the square wave into a triangular wave.

   Essentially, the output voltage of the relaxation oscillator would be the input that is attached to a resistor which is connected to the negative input pin of the op-amp. Additionally, a capacitor would also be attached to the negative input pin and the output pin of the op-amp. The positive input pin of the op-amp would be grounded.