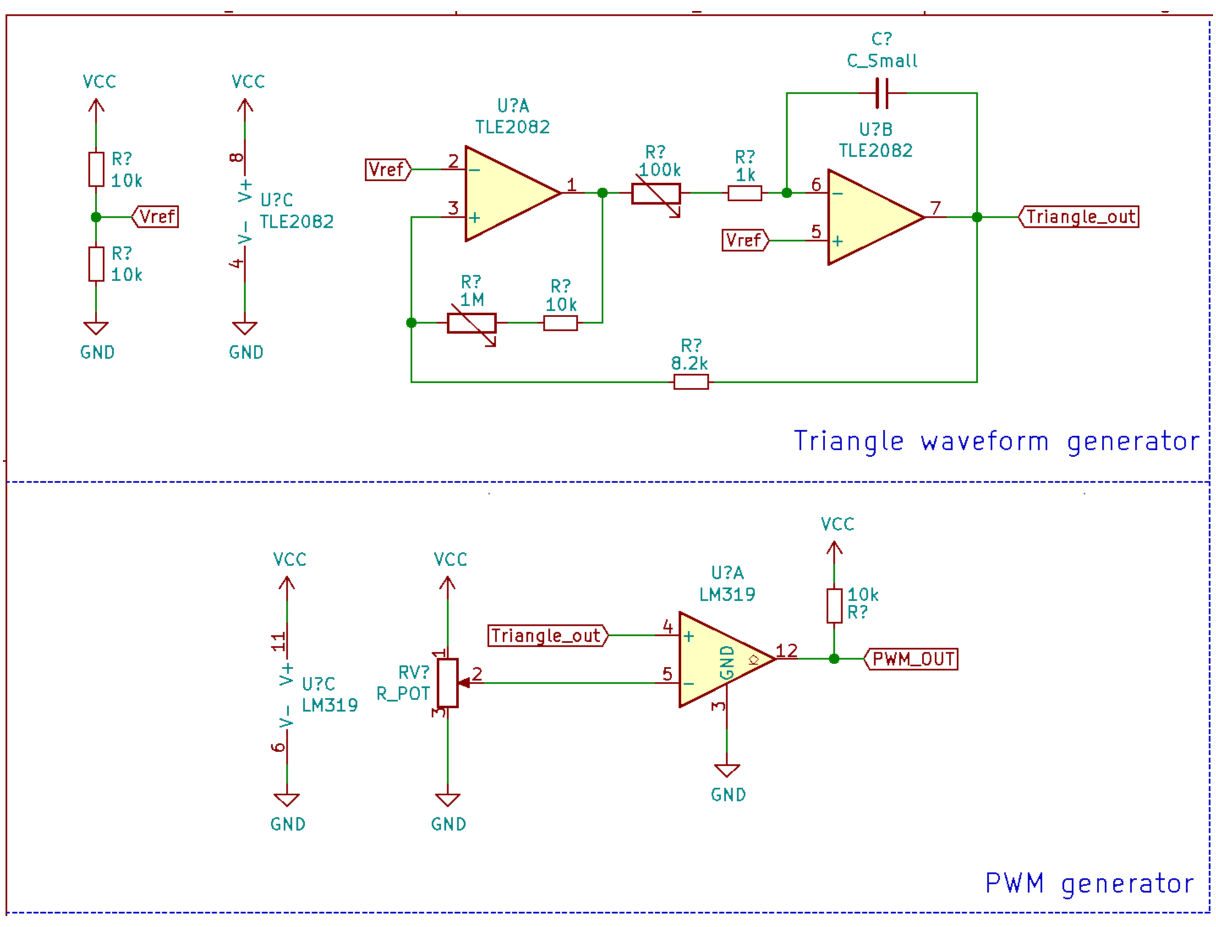
# ECEN405 Lab 1 Report
# Pulse Width Modulation

Niels Clayton : 300437590
**Lab Partner:** Nickolai Wolfe

1. $C_1 = 10\ nF$

2. $f_{min} = 297$ Hz
   $f_{max} = 3.03$ MHz

3. Schematic of the PWM generator




4. Conduction losses:

$$P_{cond} = 0.6\ W$$

   Minimum frequency switching losses

$$P_{sw} = 78.4\ \mu W$$

   Maximum frequency switching losses

$$P_{sw} = 0.799\ W$$

5. Actual photo capturing the look of approval on Danny B's face as I complete the circuit and proudly show him.


6. PUT PHOTOS HERE

7. It was noted that the theoretical minimum and maximum achieved switching frequencies of the circuit were not achieved by the designed circuit. Although it is hard to exactly pinpoint where this issue comes from, there are a range of possible factors that would affect these frequencies. By creating the circuit on a breadboard, we introduce parasitic capacitances, and inductances to the circuit, which will affect the op-amps. It is also possible that op-amp characteristics such as slew rate are affecting the frequency of the output.

8. To get both an inverted and non-inverted signal, you can switch the input terminals of the comparator. Since the LM319 is a dual comparator, it is possible to have both the inverted and non-inverted signals out from the same IC.

9. INSERT BLOCK DIAGRAM

## Appendix

**Q1:** Equation to calculate the capacitor size

$$C_1 = \frac{R_2 + R_3}{4R_1\,(R_4 + R_5)\,F_T}$$

**Q2:** Equations to calculate the minimum and maximum frequencies

$$f_{min} = \frac{R_2}{4R_1\,(R_4 + R_5)\,C_1} = 297\ Hz$$

$$f_{max} = \frac{R_2 + R_3}{4R_1 \cdot R_5 \cdot C_1} = 3.03\ MHz$$

**Q4:**

Conduction switching losses:

$$P_{cond} = R_{DS(on)} \cdot d \cdot I^2 = 0.6\ W$$

Minimum frequency switching losses:

$$P_{sw} = \frac{1}{2} V_{in} \cdot I_o (t_{c(on)} + t_{c(off)}) f_{min} = 78.4\ \mu W$$

Maximum frequency switching losses:

$$P_{sw} = \frac{1}{2} V_{in} \cdot I_o (t_{c(on)} + t_{c(off)}) f_{max} = 0.799\ W$$