Eclectronics Miniproject 1: Hysteretic Oscillator

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1 Introduction

The goal of this project is to design a 2-layer PCB that will flash an LED with a period within ±10% of 1s. All design and analysis files can be found at the following link: bubbleebubbles/eclectronics

2 Design and Analysis

2.1 Initial Calculations

All calculations can be found in the following spreadsheet: Miniproject1 Calculations.
The ratio α is defined as:

$$\alpha = \frac{R_1}{R_1 + R_2}$$

The period T of the oscillator is defined as:

$$T = \tau log \frac{V_{dd} - \alpha(V_{dd} - V_{ref})}{\alpha(V_{dd} - V_{ref})} \frac{V_{dd} - \alpha V_{ref}}{\alpha V_{ref}}$$

where

$$\tau = RC$$

I chose a duty cycle of 50% and the board is powered through a $3.3V$ power supply, thus $V_{dd} = 3.3V$ and $V_{ref} = 1.65V$. My part choices were limited by the provided spreadsheet (see calculations link), so I began by choosing a $10000pF$ capacitor that has a tolerance of 1%. I did the resistor calculation for the RC low-pass filter with a wide range of α values to see which resistance would be the easiest to create with the least number of resistors. After these calculations, I chose $\alpha = 0.16$.

2.2 Simulations and Analysis

I ran simulations in LTspice to check for worst-case scenarios and used MATLAB to parse through the data. I ran a total of 1025 simulations and found that the error was within approximately ±3%. Figure 1 shows the calculated period of each simulation and Figure 2 shows the error for each simulation (desired period is $1s$).

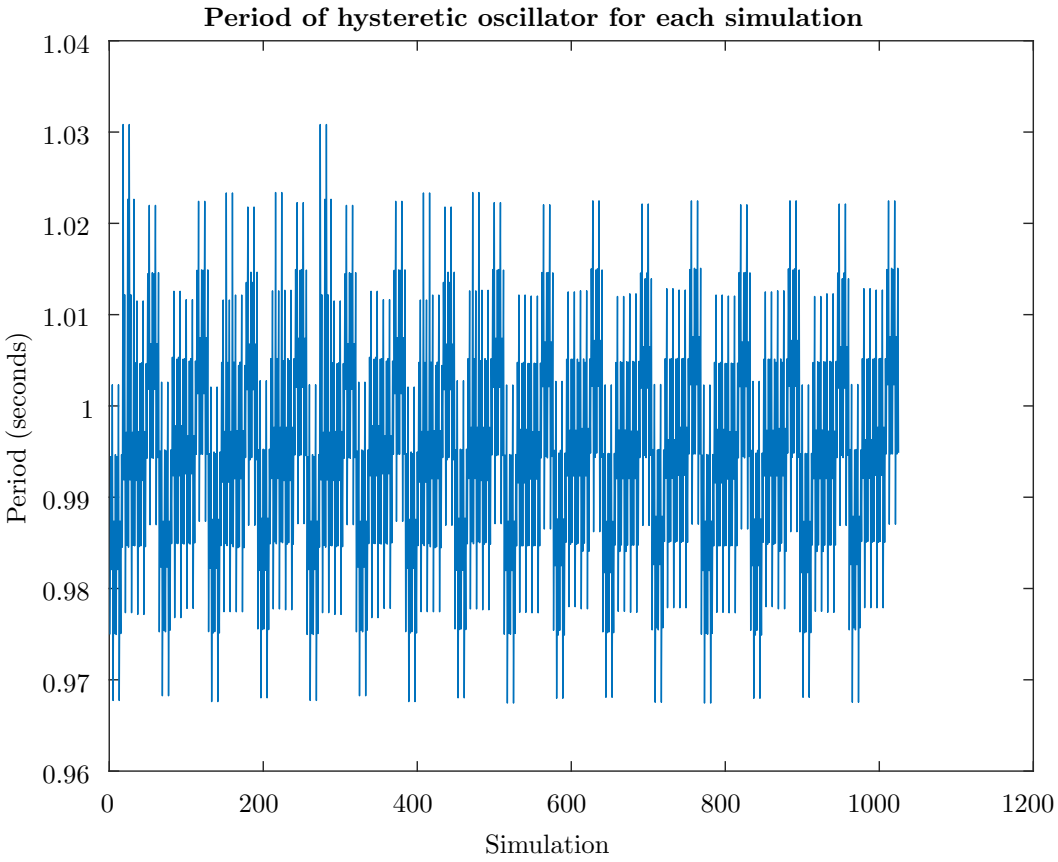

Figure 1: Period of each simulation run in LTspice

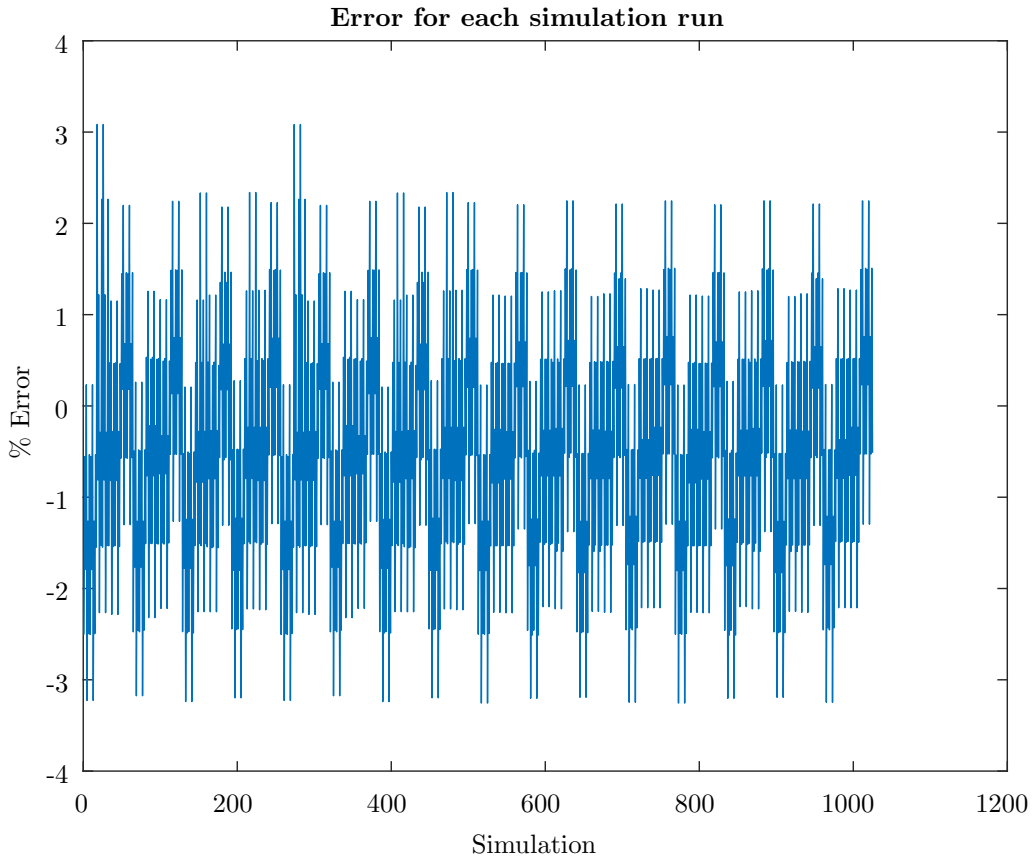

Figure 2: Error for each simulation run in LTspice

2.3 Final Design

The final design consists of four blocks: a USB A 2.0 connector to supply power to the board (Figure 3), a $3.3V$ LDO to power the operational amplifiers (Figure 4), a buffer for V_{ref} to ensure it always stays at $1.65V$ (Figure 5), and the hysteretic oscillator (Figure 6). Images of the PCB are shown in Figure 7 and Figure 8. All design, LTspice, and MATLAB files are provided on github: bubbleebubbles/eclectronics

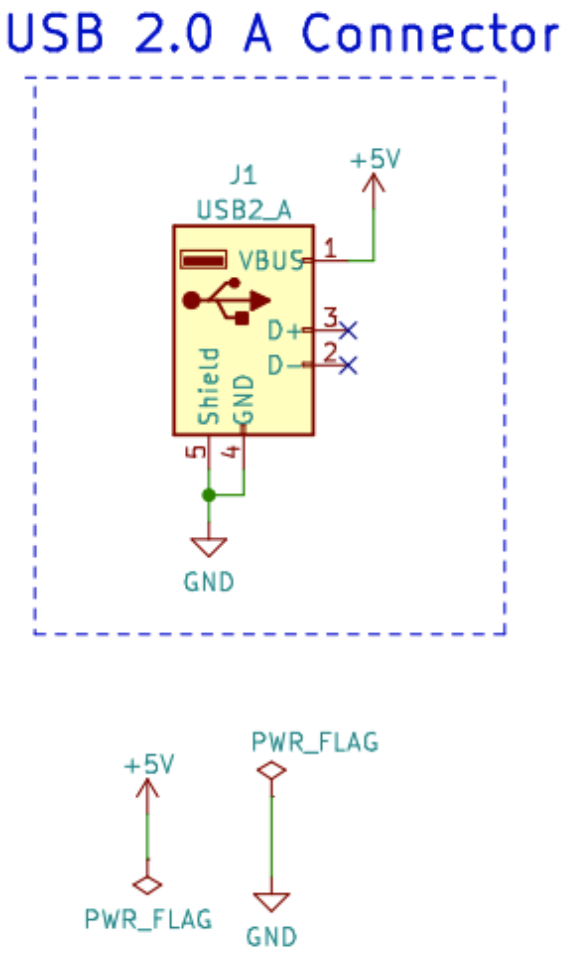

Figure 3: USBA 2.0 Connector

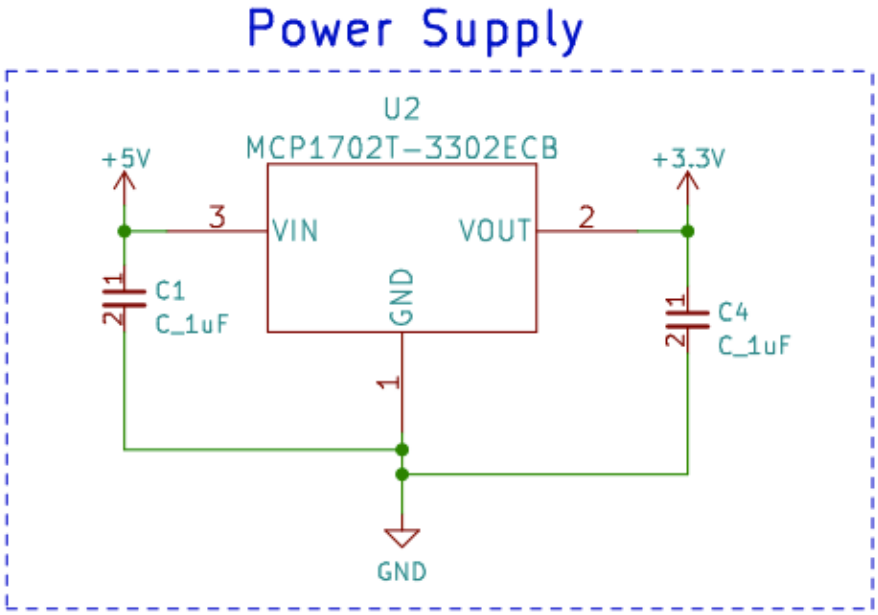

Figure 4: Power Supply

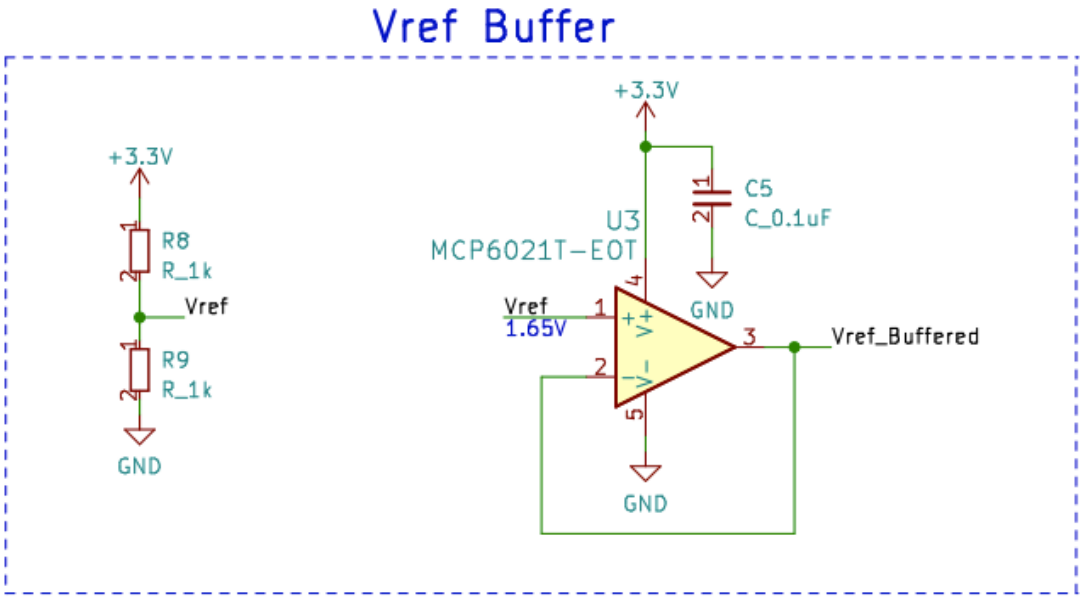

Figure 5: Voltage Follower for V_{ref}

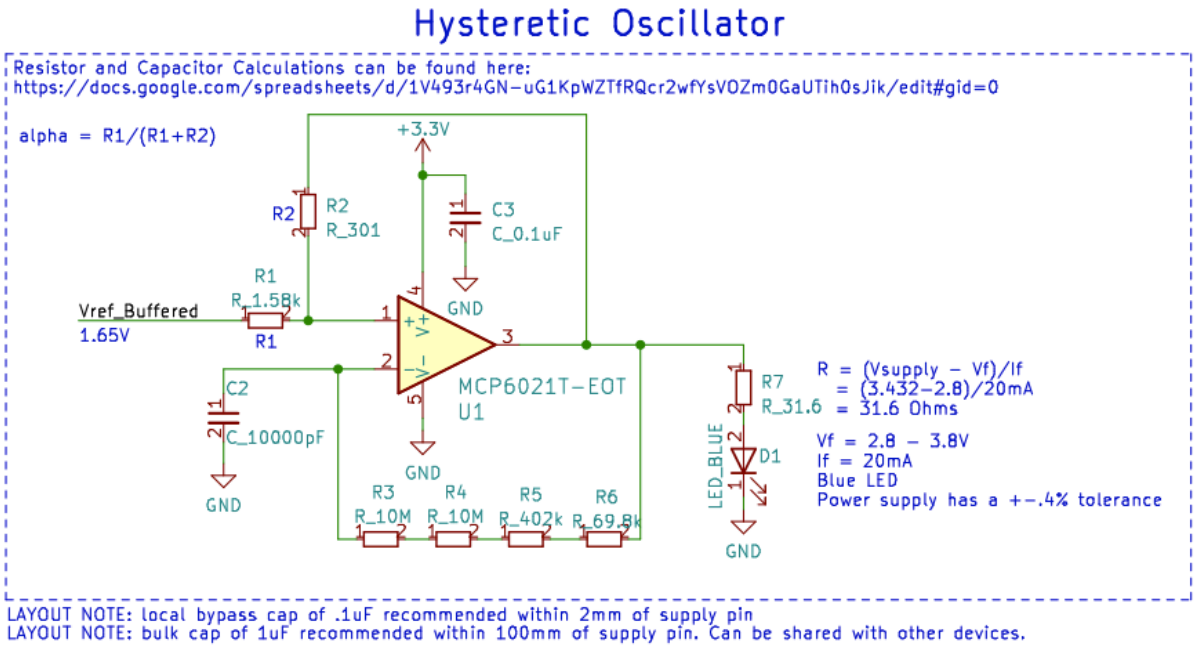

Figure 6: Hysteretic Oscillator

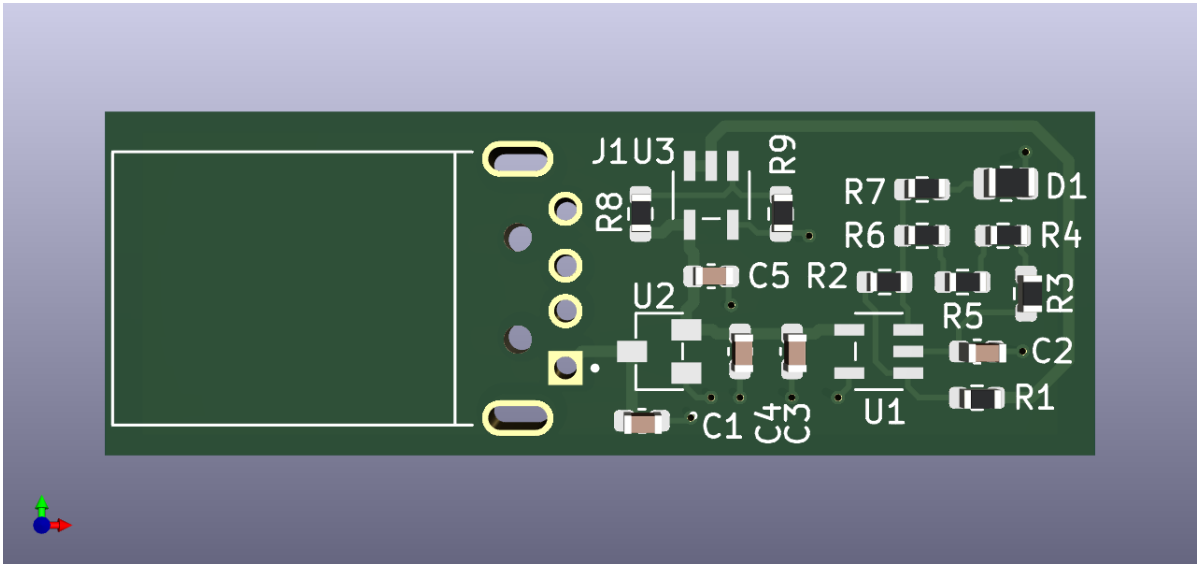

Figure 7: PCB Front

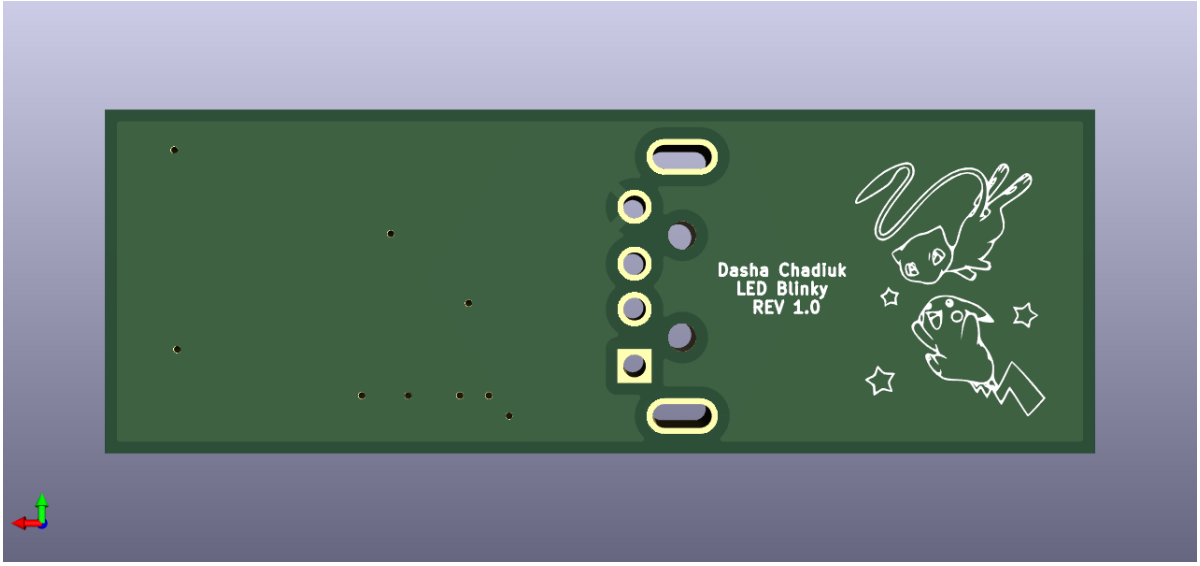

Figure 8: PCB Back