2.3 Operational Amplifiers (Opamps)

2.3.1 Create a photo circuit that can show the output of the LED using an opamp. **Submit a circuit diagram and a snap shot of the oscilloscope on the output of the circuit showing each frequency.**

The circuit diagram is shown as below:

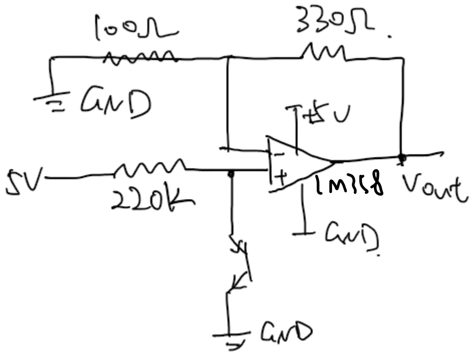

Figure 1 Circuit Diagram of 2.3.2

The screenshot of the oscilloscope is shown as Figure 2 and Figure 3:

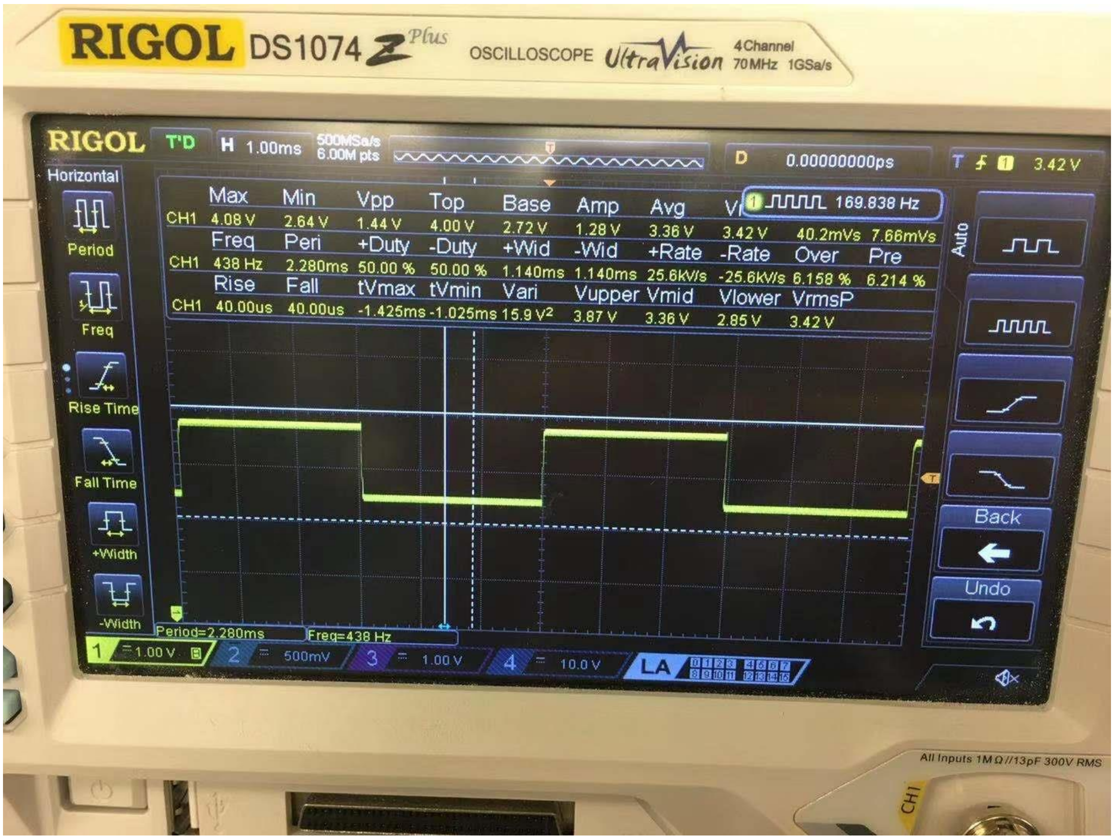

Figure 2 Oscilloscope showing amplitude and frequency of the signal

Figure 3 Oscilloscope showing amplitude and frequency of the signal

2.3.2 Connect the detection circuit to a teensy and create a program that can detect both of the frequencies being transmitted and indicate when each frequency is being detected.

Submit your code, a circuit diagram.

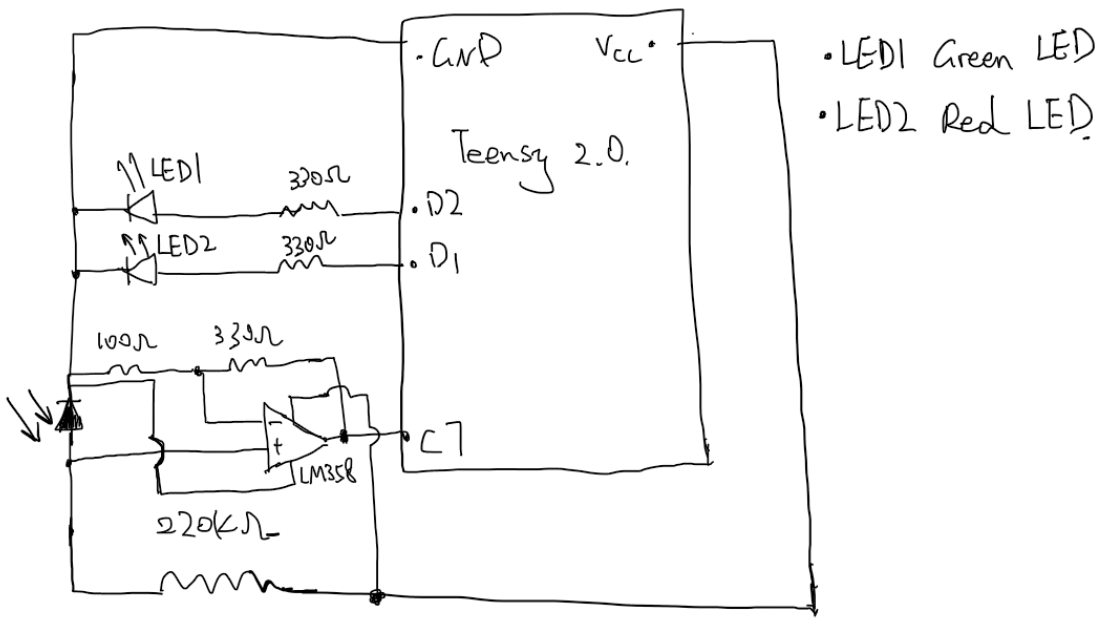

Figure 4 The circuit diagram for 2.3.2

The code is attached in the folder 2_3_2.

The detective part of the circuit is shown in Figure 1. The phototransistor is connected to the ground and the non-inverting pin of the opamp LM339 along with a resistor of 220KΩ, which ensure that the V_{ce} of the phototransistor is large and sensitive enough. The inverting pin of the opamp is connected to resistor of 100Ω and 330Ω., so that the signal could be enlarged by: $1+\frac{330}{100}=4.3$ times. In this case, the output signal would have the same phase with the original signal, and meanwhile, be enlarged to logic high of teensy.

In the code I first write a subroutine that could return the value of counts between two falling edge, so that the frequency of the IR could be detected. After initialization of teensy (I set the prescaler to /1024), in the main loop, if the counts is between 31 and 41, which means a 435Hz IR is received, then turn on LED1. If the counts is between 87 and 97, which means a 170Hz IR is received, then turn on LED2. The calculation of counts is shown as below:
Each count take:

$$1 \div 15625 = 0.064\text{ms}$$

For the 170Hz IR,

$$\text{circle time} = \frac{1}{170} = 5.88ms$$

$$\text{counts} = 5.88 \div 0.064 = 92$$

For 435Hz IR

$$\text{circle time} = \frac{1}{435} = 2.30$$

$$\text{counts} = 2.30 \div 0.064 = 36$$

Considering the error, I set the range of counts to $\text{ideal value} \pm 5$.

Extra credit: Change the amplification of this circuit to maximize the gain. See how far away you can get from the transmitter and correctly receive both frequencies. **Submit your code, a circuit diagram, a paragraph description of your approach and a video of the detection working at a far distance.**

The circuit diagram is shown as below.

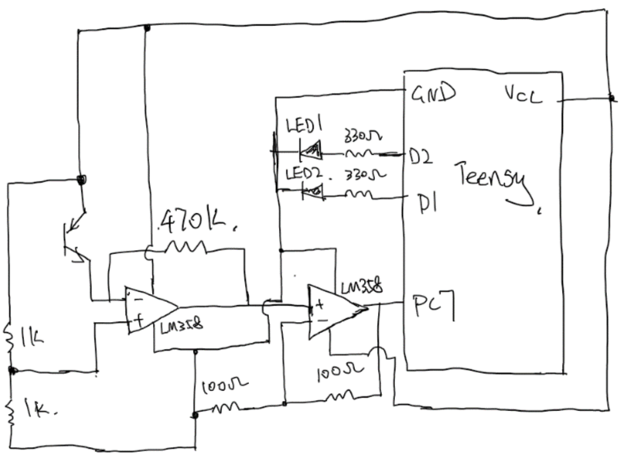

Figure 5 circuit diagram for extra credit

The detective part of the circuit is shown as Figure 6 below:

My detective part of the circuit is different from 2.3.2. The phototransistor is connected to the 5V power supply (on teensy connected to the pin Vcc) and the inverting input pin of the opamp. Also, we use a voltage divider circuit connected to the non-inverting input pin, making sure that the reference voltage of the inverting pin is 2.5V. By fixing 2.5V to the inverting pin, the voltage drop of the phototransistor is always 2.5V. The diagram for I_{PCE} VS E_v-Illuminance is shown as the figure below. (With $V_{ce} = 5V$). The line with $V_{ce} = 2.5$ should be a bit lower than that of $V_{ce} = 5V$.

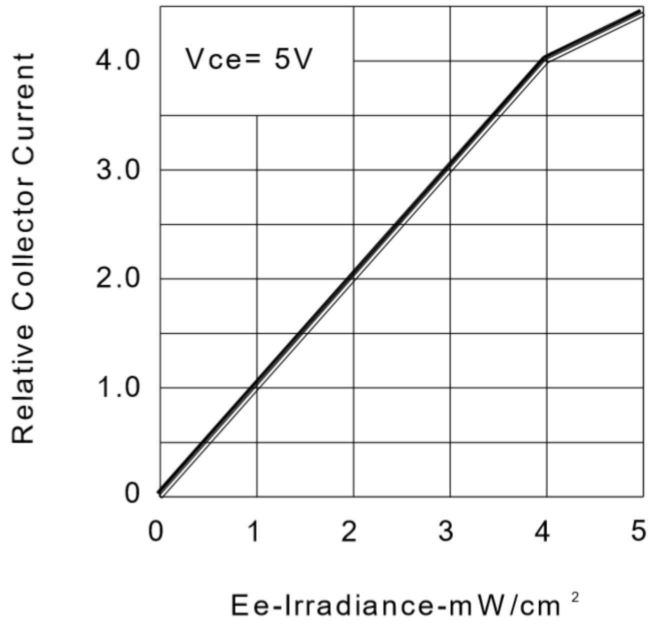

Figure 6 Relative collector current vs iirrandiance

As from Figure 6, we know that by increasing the illuminance of the light, I_{PCE} growth is significant. The voltage drop across the 470K resistor is also change linearly as shown in Figure 7. By amplifying the output signal 2 times, the teensy could receive the logic high / low signal. The code is in the folder 2_3_2_extra and the video is in the link: https://drive.google.com/file/d/1fzvL2ECpN38OnNKHHfvl1Oh0TSc-aJJj/view?usp=sharing

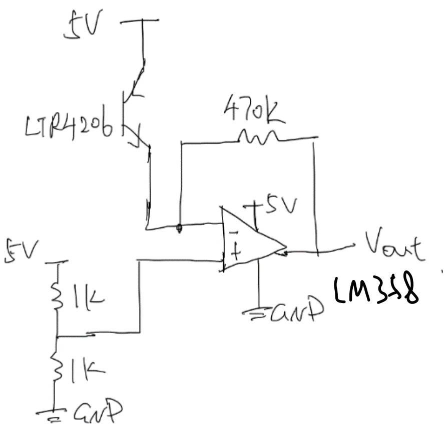

Figure 7 detective circuit of extra credit

2.4 Vive

2.4.1 Create a detection circuit. Show that your circuit can create logic level voltage signals from the Vive pulses. **Submit a circuit schematic, a snapshot of the oscilloscope showing the output of detection circuit.**

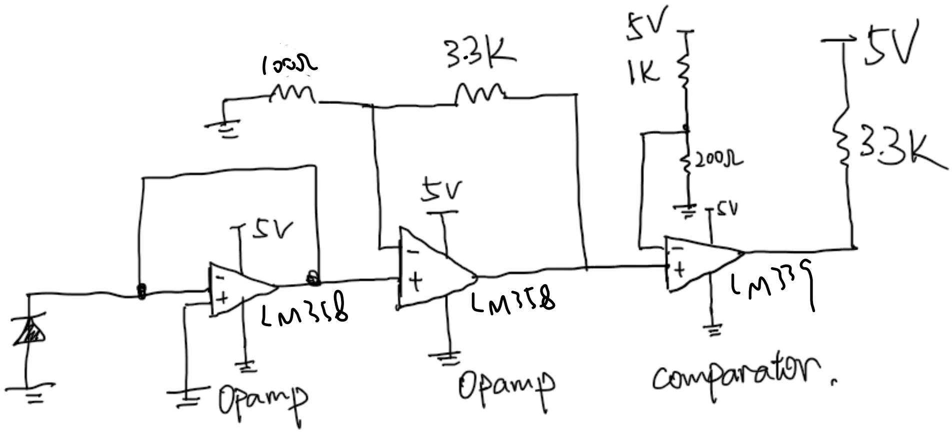

Figure 8 circuit diagram for 2.4.1

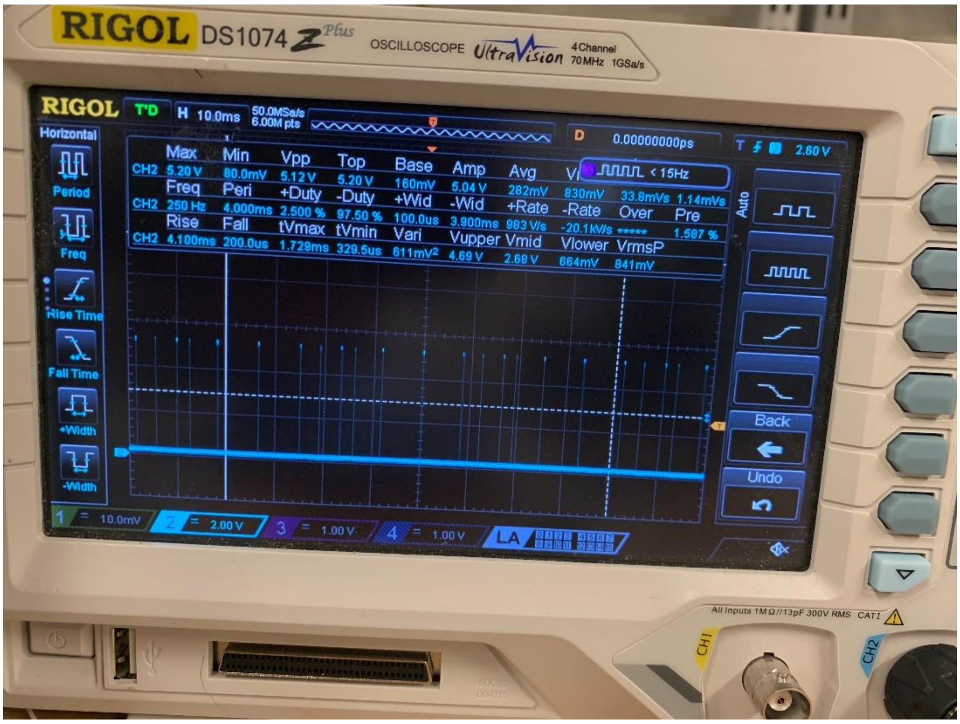

Figure 9 signal after the circuit

2.4.2 Connect your detective circuit into a Teensy and measure the time between the sync pulse and the x and y pulse discriminating between each. **Submit a circuit schematic. Demonstrate to a TA that the device outputs XY values at the near and far distances both under a room light and not.**

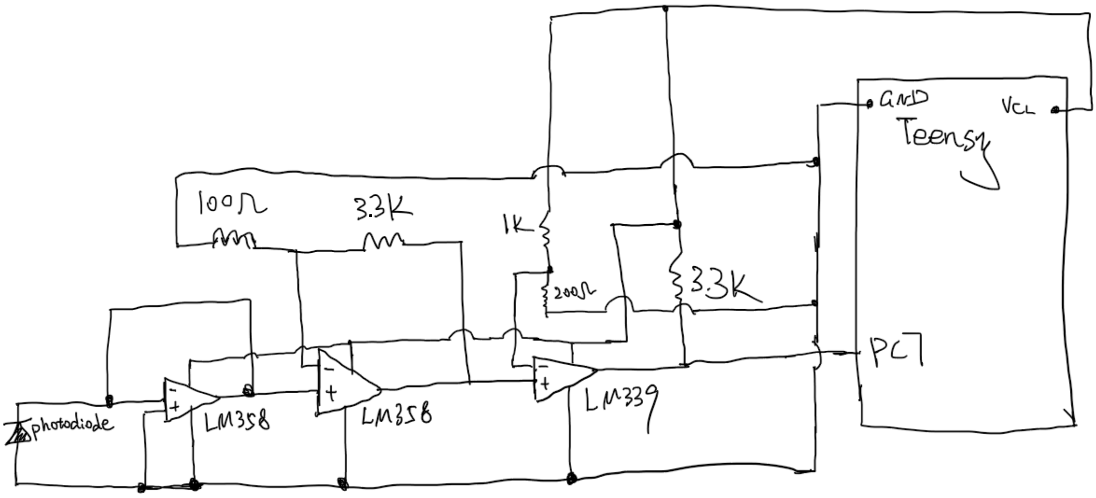

Figure 10 circuit diagram for 2.4.2

The result is in the picture below:

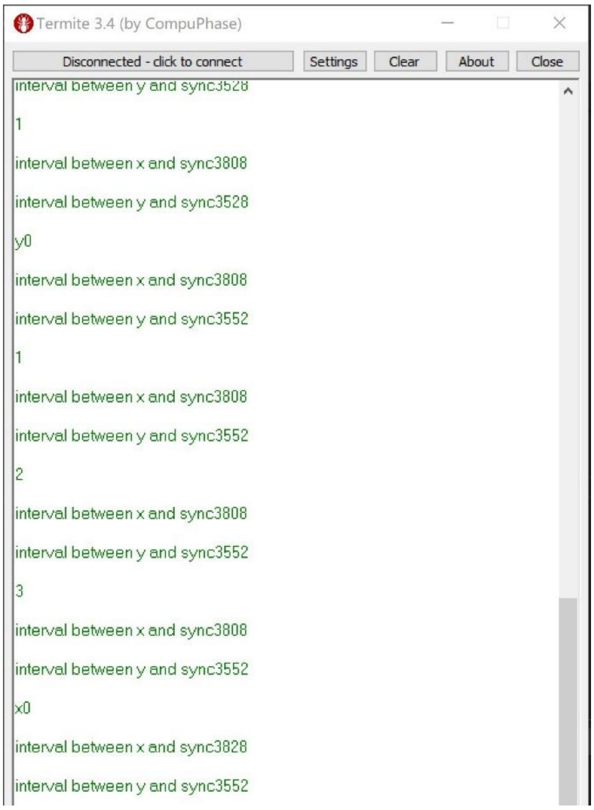

Figure 11 Results of 2.4.2

The circuit diagram is shown as above. The code is in the folder 2_4_2.

Extra credit: Develop a hardware only solution to distinguish between sync pulse and sweep pulse. The output of the circuit will be two digital lines one which indicates that a pulse has occurred by changing state and one that indicates with pulse has occurred by the state of the line.

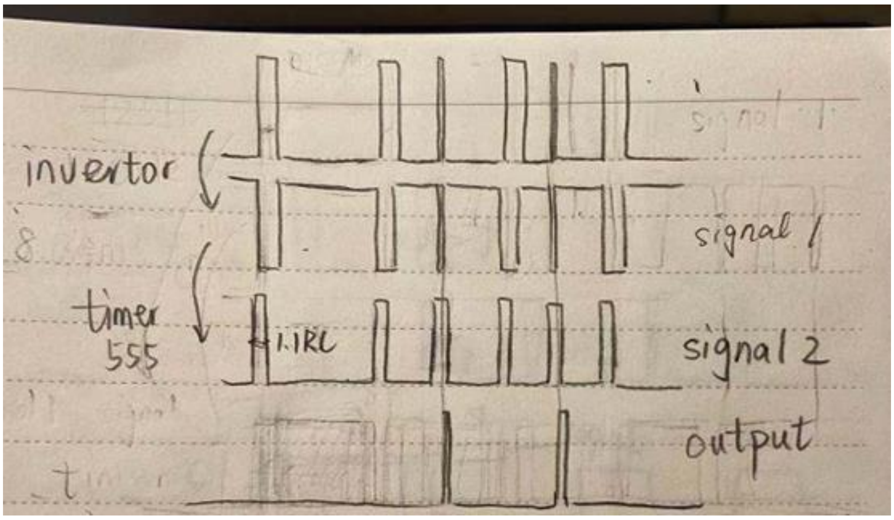

Figure 12 Schematic of Signal Processing

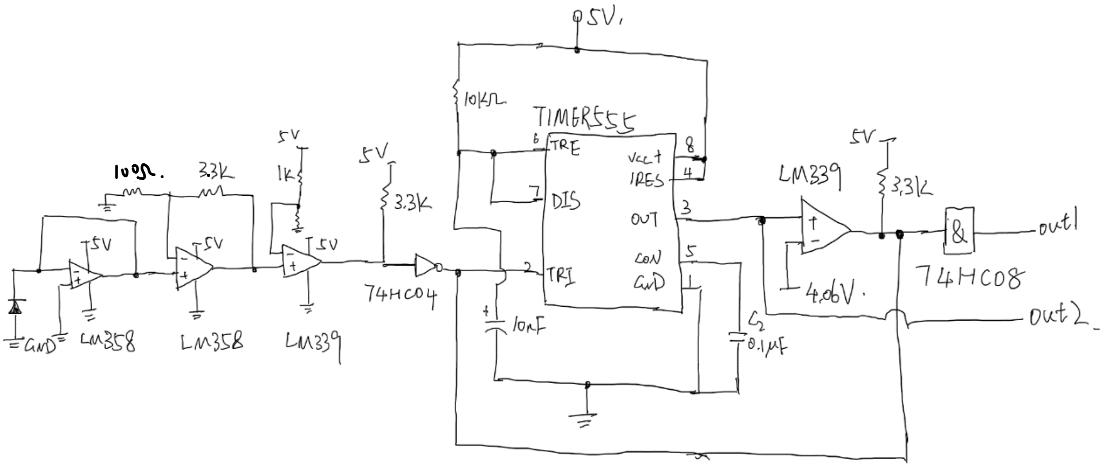

Figure 13 circuit diagram for extra credit

The outcomes of the problem is shown as below:

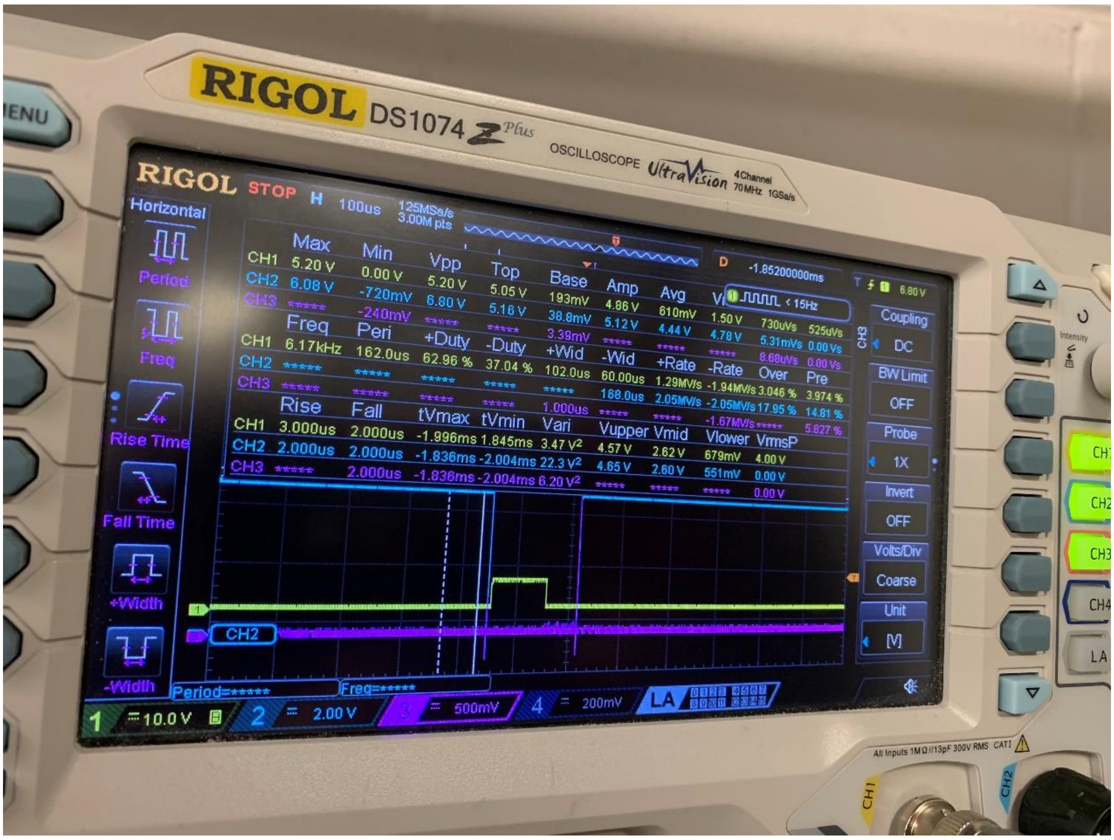

Figure 14 Sync pulse none(purple line)

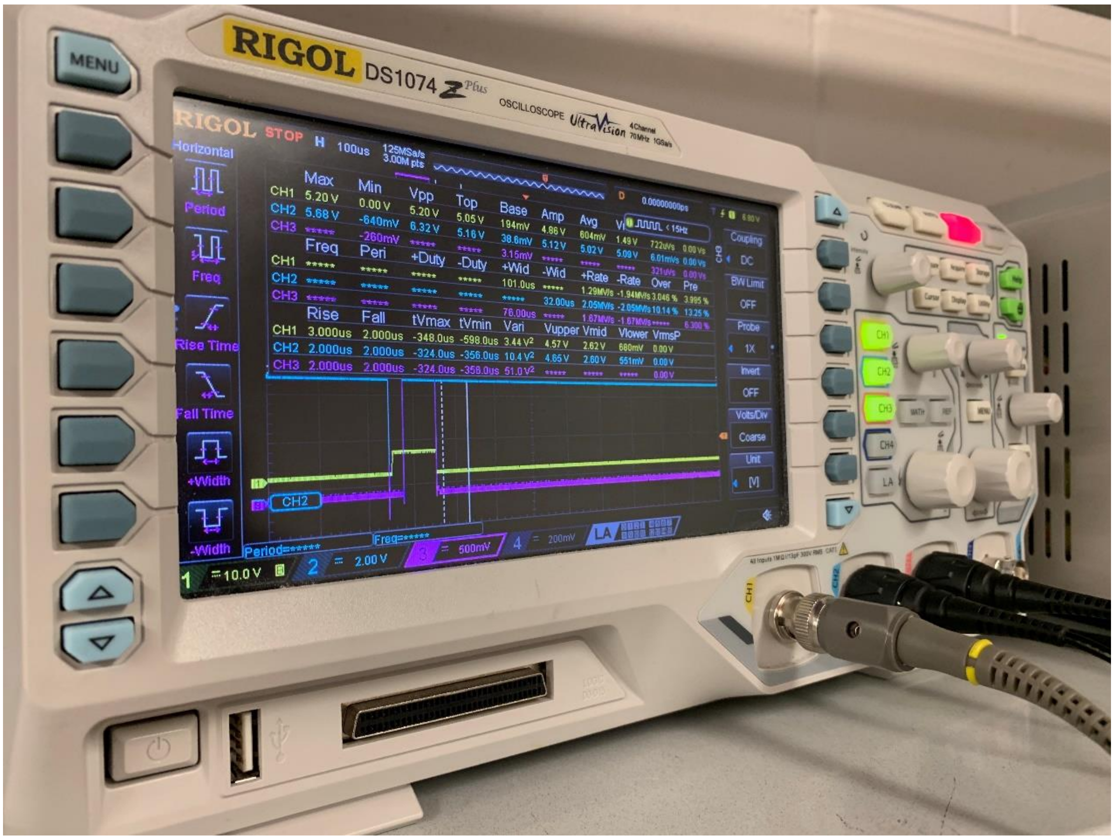

Figure 15 sweep pulse (purple line)