MEAM 5100: Design of Mechatronic Systems Fall 2024

# Lab 2 Part 1 Solutions

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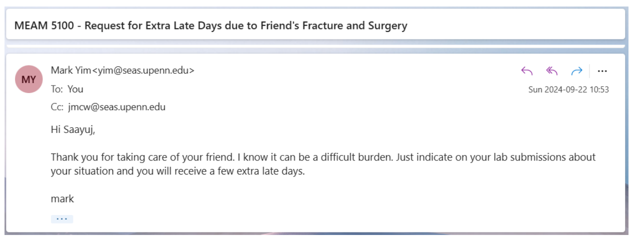
I had requested for extension/extra late days from Prof Yim due to some unforeseen circumstances. He told me to just mention in the lab report so I am attaching the proof here. Thank you for the consideration.


MEAM 5100 - Request for Extra Late Days due to Friend's Fracture and Surgery

MY
Mark Yim<yim@seas.upenn.edu>
To: You
Cc: jmcw@seas.upenn.edu
Sun 2024-09-22 10:53

Hi Saayuj,

Thank you for taking care of your friend. I know it can be a difficult burden. Just indicate on your lab submissions about your situation and you will receive a few extra late days.

mark

Figure 1: Proof of extra late days awarded

# 1 Switches and Debouncing and Input Capture

1. 1.
   - 2 shows the circuit diagram for this question. The negative terminal of the LED LTL-1CHYE and one end of the SPST switch is connected to ground (GND). The other end of the switch is connected to pin C7, and the positive terminal of the LED is connected in series to pin B6. The state of the switch is read through the pullup resistor enabled pin C7, which is used to turn the LED on or off by using pin B6 as output.
   - The commented code is submitted separately on Gradescope.

   2.
   - For the passive low pass filter, I chose a resistor with resistance R = 150Ω and a capacitor with capacitance C = 22$\mu$F, which leads to a cutoff frequency of $f_c = \frac{1}{2*\pi*R*C} = 48.23$ Hz. This is good enough for our application and debounces the switch well. To verify the effectiveness of the RC circuit, check 3. It shows the unfiltered and filtered waveforms for various frequencies. Note that the mean line of the two waveforms has been shifted up and down to align them together for better viewing.
   - The commented code is submitted separately on Gradescope.
   - The circuit diagram is shown in 4.

   3.
   - My fastest mashing time, in terms of counts, was 3842, which translates in time to $time = \frac{3842*4.2}{65536} = 0.2462s$ for a pre-scaler of 1024 and a clock frequency of 16 MHz.

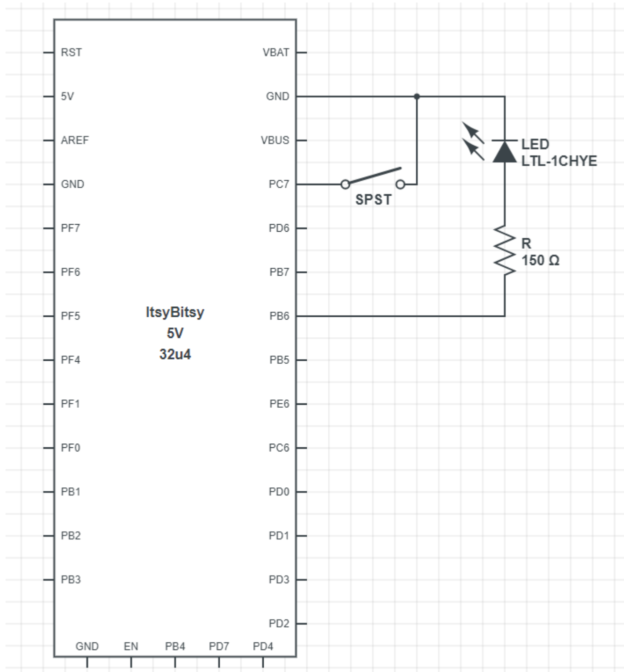



Figure 2: Circuit diagram consisting of SPST switch, LED and resistor

- The commented code is submitted separately on Gradescope.
- The circuit diagram is shown in 5.

4.

# 2 Phototransistors

2. 1. - The table below shows the average voltage at the phototransistor junction under various lighting conditions and with various resistors connected in series.

| Resistor Values (Ω) | Room Light | Covered with Hand | Phone Flashlight |
|---|---|---|---|
| 4.7k | 4.72V | 5V | 165mV |
| 47k | 3.13V | 4.64V | 86mV |
| 470k | 69mV | 2.55V | 43mV |

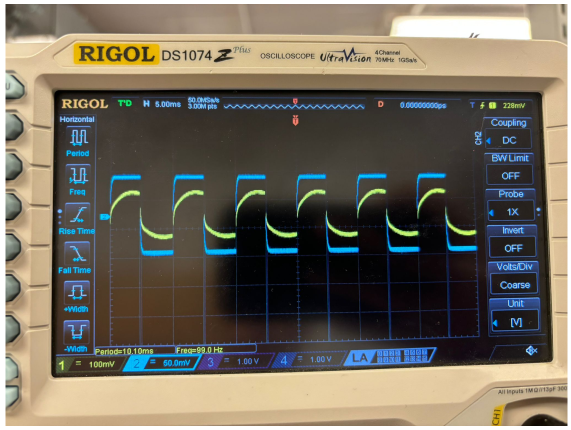
- We can see from the above table that the sensitivity increases from 4.7kΩ to 47kΩ, but reduces from 47kΩ to 470kΩ. Thus, as resistance value increases, sensitivity to light increases, but reaches a max at a particular resistance value and then decreases post that.
- For the ATmega32U4, valid logic input low max. is approx. 0.9V and input high min. is approx 1.9V. So we can see that though the sensitivity of 470kΩ is very low, the output voltage values do reach a valid logic high and logic low for our ATmega32U4.

2. Link to video of LED on when no light falls on the phototransistor and off when there is light on the phototransistor: Link


((a)) 5 Hz


((b)) 25 Hz


((c)) 75 Hz




((d)) 100 Hz

Figure 3: Oscilloscope images showing unfiltered (blue) & filtered (yellow) waveforms

3.
- I used a resistance of 62k$\Omega$ in series with the phototransistor for this question. This enabled the blinking of the LED when I waved my hand over the phototransistor. 6 shows the circuit diagram I made. I switched to another LED here to enhance visibility, but it is still a bit tough to see the LED blinking clearly.
- Link to video of LED blinking when waving hand over phototransistor: Link
- The commented code is submitted separately on Gradescope.

# 3 Frequency Detection

3. 1.
- From the datasheet for LTE-4208 (IR LED), the forward voltage is 1.2V. Thus, for a power supply of 5V, resistor value $R = \frac{5-1.2}{0.02} = 190\Omega$. The closest resistor value was 220$\Omega$ so I chose that in series with the LED.
- The circuit diagram is shown in 7. Note that the IR LED and the IR photosensor must be placed close to and facing each other for good sensing.
- 8 shows the oscilloscope images. Note that the 25Hz signal is measured accurately, while there are minor fluctuations in the measurement of the 662Hz signal.

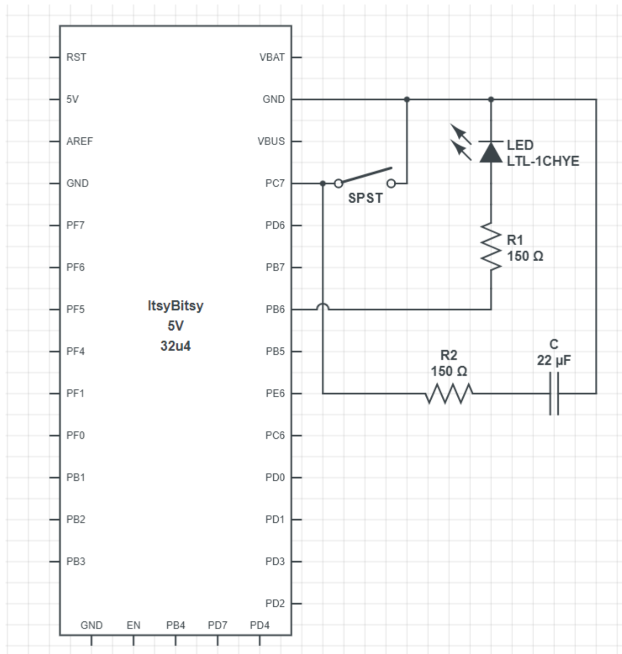



Figure 4: Circuit diagram consisting of LED, SPST, resistors and capacitor

2. - The commented code is submitted separately on Gradescope.
   - The circuit diagram is shown in 9. The resistor values are chosen such that the LEDs are protected from excess current.

# 4 References

1. Latex template from the course CIS 5190 taught this fall.
2. MEAM 5100 Fall 2024 Lecture Slides.
3. Digikey for LED specifications and datasheets.
4. Stack Overflow for writing in C.
5. ItsyBitsy from CircuitLab
6. I performed some of the experiments in the lab with other people but have written my own report.

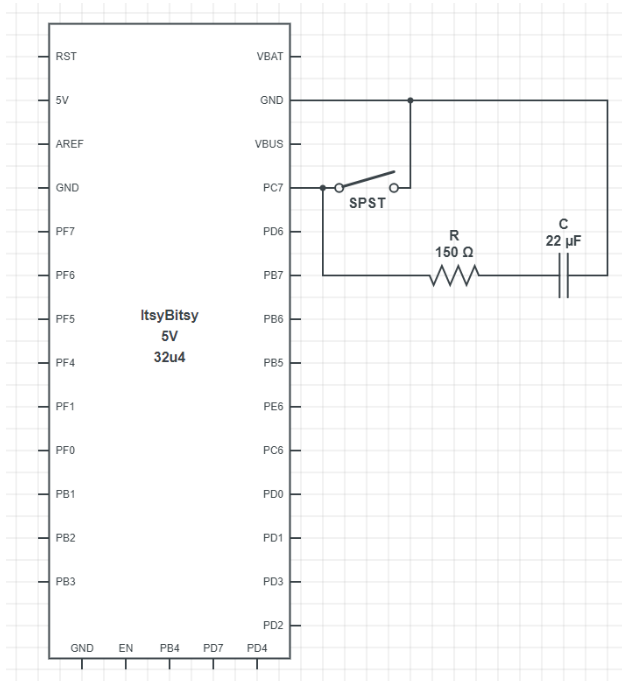



Figure 5: Circuit diagram consisting of SPST, resistor and capacitor

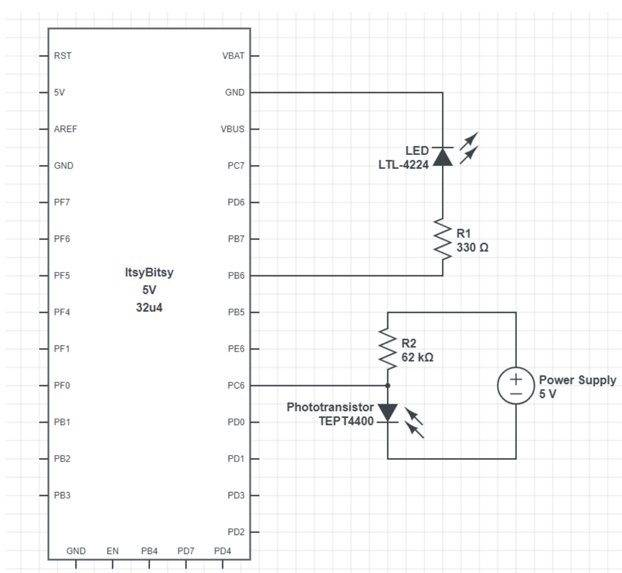



Figure 6: Circuit diagram consisting of LED, phototransistor and resistors

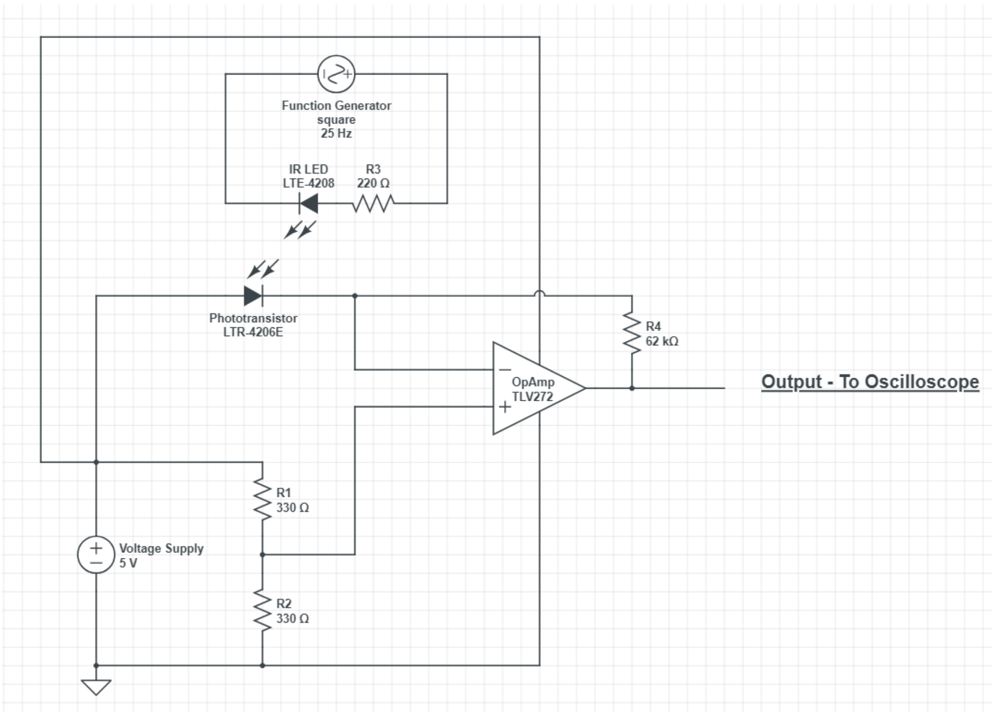
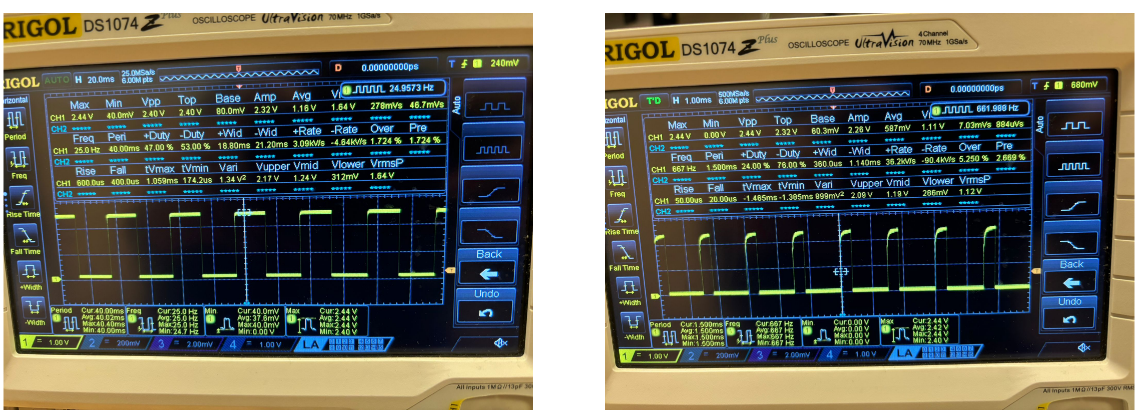



Figure 7: Circuit diagram consisting of LED, phototransistor, function generator, resistors



((a)) 25 Hz ((b)) 662 Hz

Figure 8: Oscilloscope output images of the circuit for two frequencies

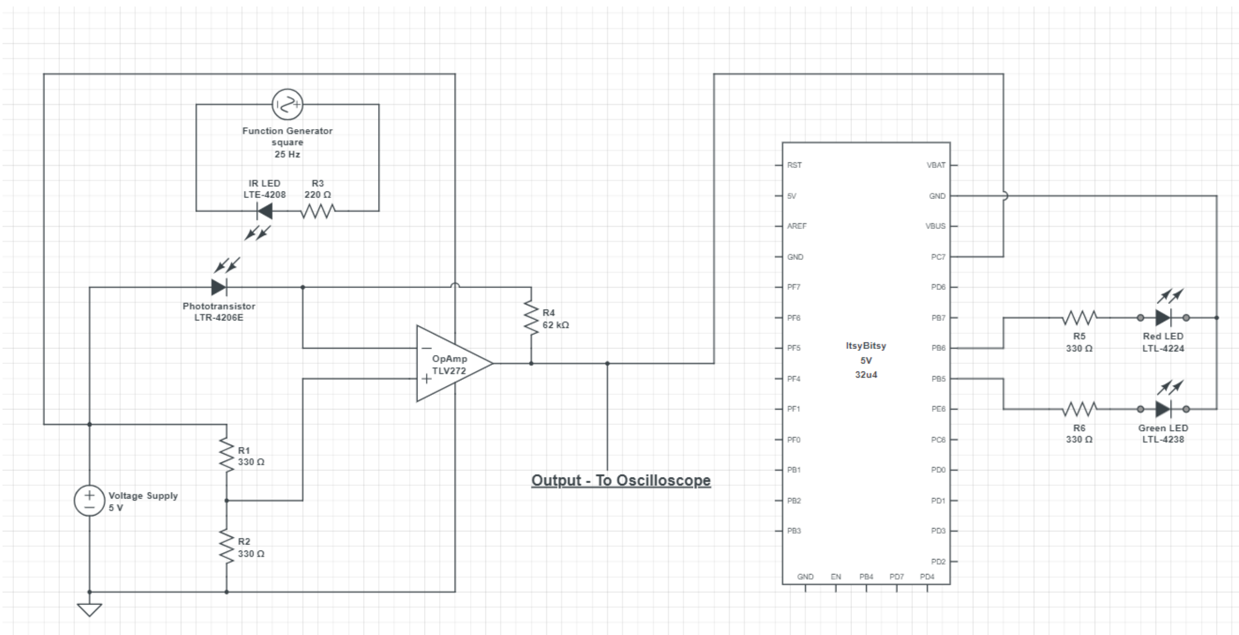



Figure 9: Circuit diagram consisting of LEDs, phototransistor, function generator, resistors