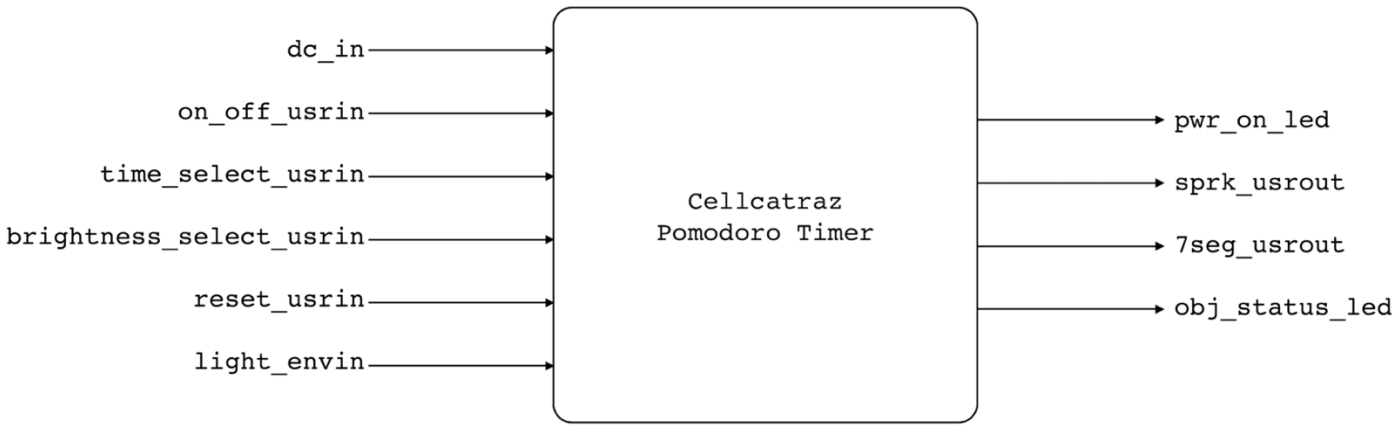
IV. Design Artifacts

A. Black Box Diagram

The Black Box Diagram (Figure 3) shows the inputs and outputs of the Cellcatraz Pomodoro Timer. There are three categories of input: `dc_in`, `_usrin`, and `_envin`. `dc_in` signifies the DC Power input. Inputs that end with `_usrin` are user inputs; these are the switches and pushbuttons summarized in Table 2. Input that ends in `_envin` is environmental input, in this case, ambient light. There are two categories of output: `_led`, which are indicating lights, and `_usrout`, which are the alarm tone and the time displayed on the 7-segment matrix.

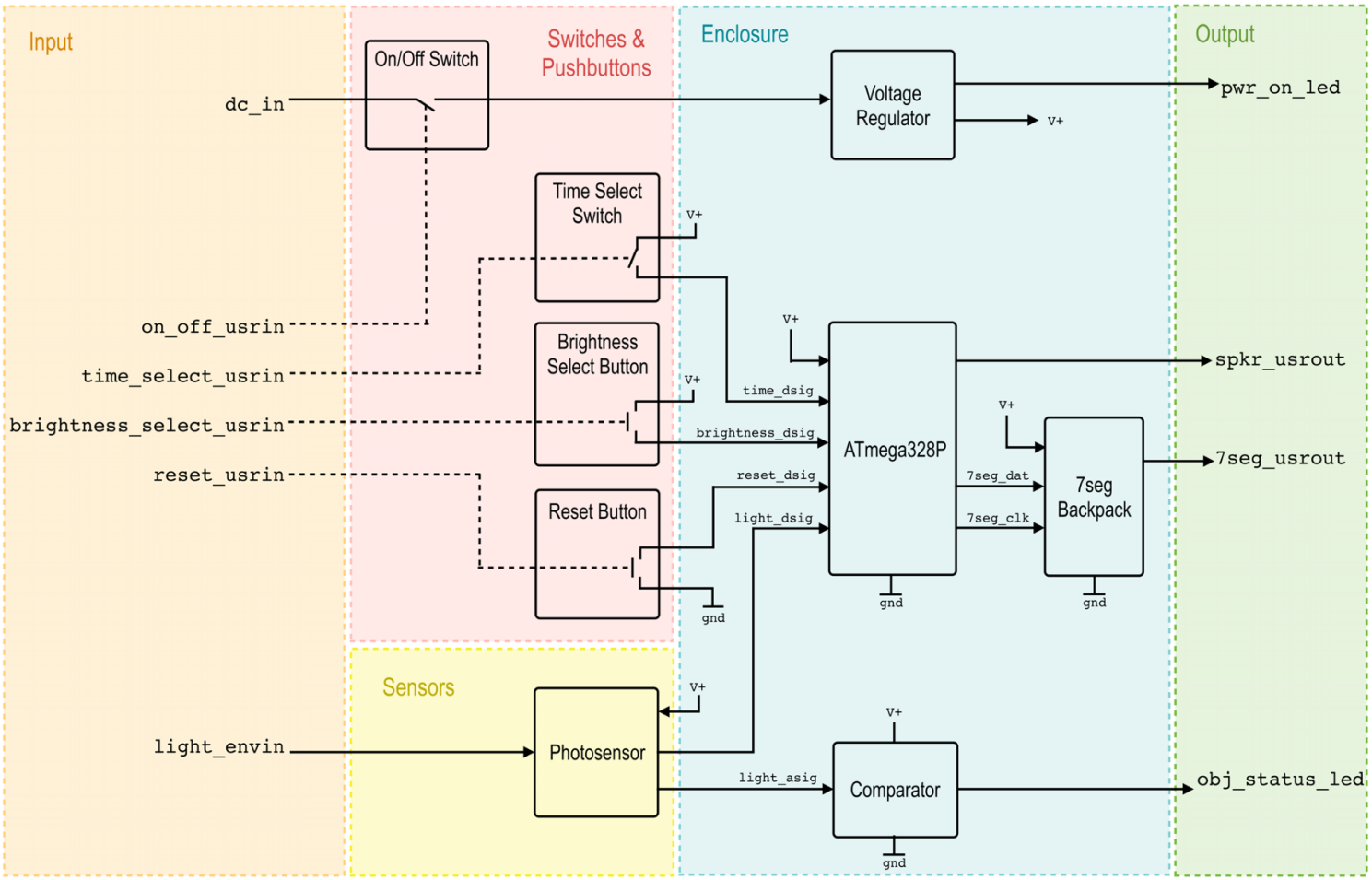
Figure 3: Black Box Diagram



B. Top-Level Block Diagram

The Top-Level Block Diagram includes the major blocks and interfaces of the entire system. Inputs (orange) and Outputs (green) are discussed in Section IV.A and Switches/Pushbuttons (red) are discussed in Section III. Cellcatraz uses one photosensor to detect ambient light. If light is absent (present), that means the cell phone is (not) in the phone bay. A Voltage Regulator is used to step down the input `DC_POWER` to a level of 5V to be used by system components (`V+`) and to light the `pwr_on_led` when `DC_POWER` is available. The `ATmega328P` receives signals from the two `_Select` inputs, the `RESET` pushbutton, and the photosensor. It uses these signals to drive the speaker (or play no tone) and to drive the 7-segment display. A comparator is used to turn on the `obj_status_led` when the phone bay is empty.

Figure 4: Top-Level Box Diagram



C. System Interfaces and Properties

Table 3 includes the properties and definitions of all system interfaces that appear in the Top-Level Block Diagram. Signals are organized by name and type, including various inputs, outputs, and internal signals. The Properties column describes expected behaviors and values for each system interface.

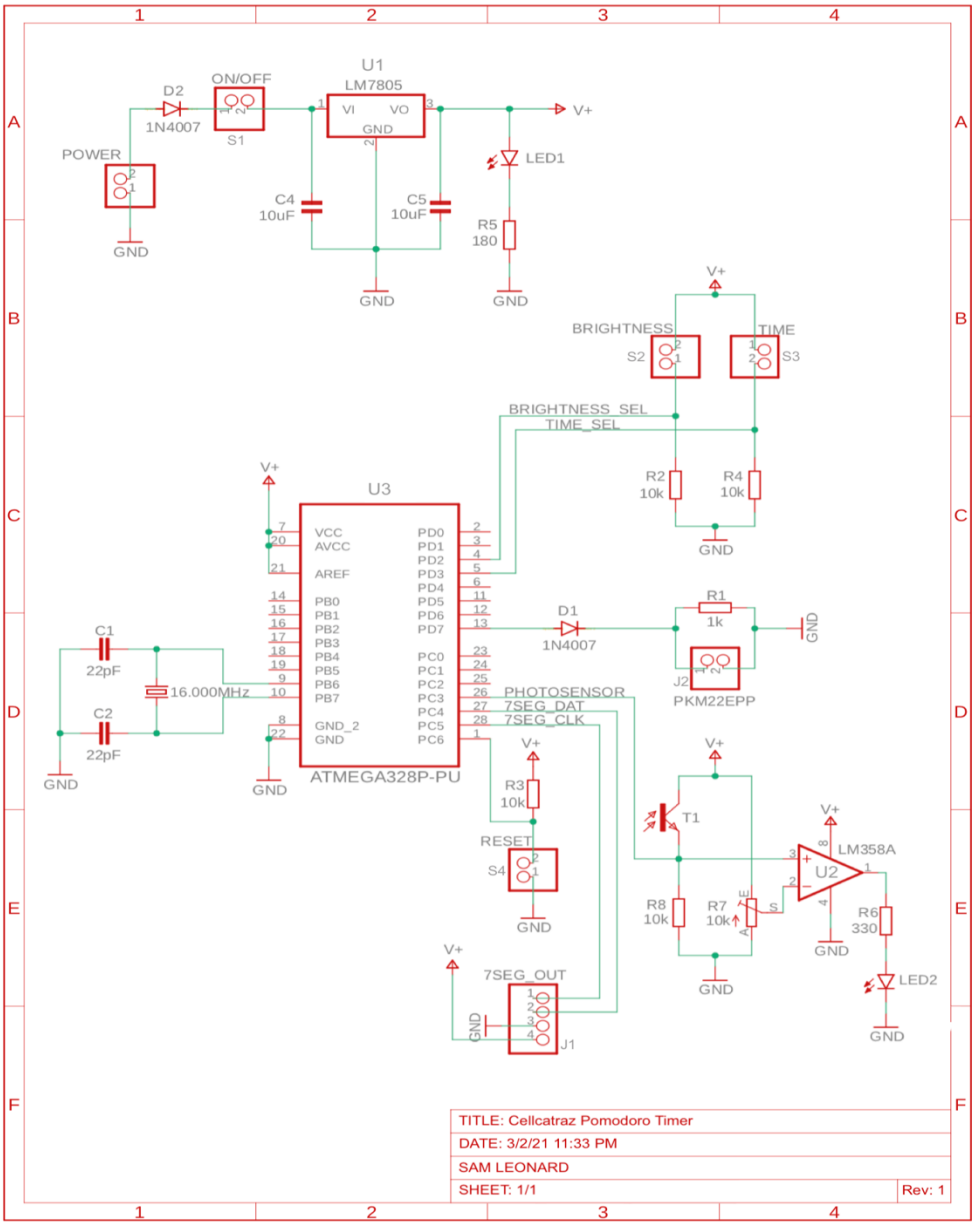
Table 3: System Interfaces and Properties

Name	Type	Properties
dc_in	DC POWER INPUT	9V 1.5A Wall Adapter
on_off_usrin	USER INPUT (SWITCH)	125VAC 6A / 250VAC 3A SPDT, ON/ON, Toggle Switch with Waterproof Cap Actuator Dimensions: length 11mm, Ø3mm
time_select_usrin	USER INPUT (SWITCH)	
brightness_select_usrin	USER INPUT (PUSHBUTTON)	125VAC 3A Normally Open Momentary Pushbutton Actuator Dimensions: Ø6mm
reset_usrin	USER INPUT (PUSHBUTTON)	
light_envin	ENVIRONMENTAL INPUT	Light blocked when object present Light not blocked when object not present
V+	INTERNAL DC	3-5VDC
time_dsig	INTERNAL DIGITAL	5VDC when Time Select SW in 5-minute position 0VDC when Time Select SW in 25-minute position
brightness_dsig	INTERNAL DIGITAL	5VDC when Brightness Select SW depressed 0VDC when Brightness Select SW released
reset_dsig	INTERNAL DIGITAL	5VDC when Reset SW released 0VDC when Reset SW depressed
light_dsig	INTERNAL DIGITAL	5VDC when object present 0VDC when object not present
light_asig	INTERNAL ANALOG	0-5VDC <VREF when object present >VREF when object not present
7seg_dat	INTERNAL DIGITAL	0-5VDC I2C Data Line
7seg_clk	INTERNAL DIGITAL	0-5VDC I2C Clock Line
pwr_on_led	INDICATION LED	LIT when DC POWER present and ON/OFF SW in ON position NOT LIT if DC POWER not present or ON/OFF SW in OFF Ø5mm, Green LED, 20mA MAX
spkr_usrout	USER OUTPUT	≤20mA 440±1Hz
7seg_usrout	USER OUTPUT	4-digit 7-segment display (with colon) Dimensions: 0.75” x 1.97” x 0.56” 3 brightness levels
obj_status_led	INDICATION LED	LIT when object not present NOT LIT when object present Ø5mm, Blue LED, 20mA MAX

D. Electrical Schematic

Cellcatraz includes a LM7805 voltage regulator circuit which steps down the input power to 5V for use throughout the system. A 16.000MHz quartz crystal is used for the ATmega328P oscillator. Diode D2 is a protection diode, and diode D1 ensures no leakage current which would lead to passive buzzing from the speaker. A LM358 comparator is used to drive LED2, the object status LED. Header pins provide connection for input power, all switches and pushbuttons, and connection to the 7-segment display.

Figure 5: Electrical Schematic

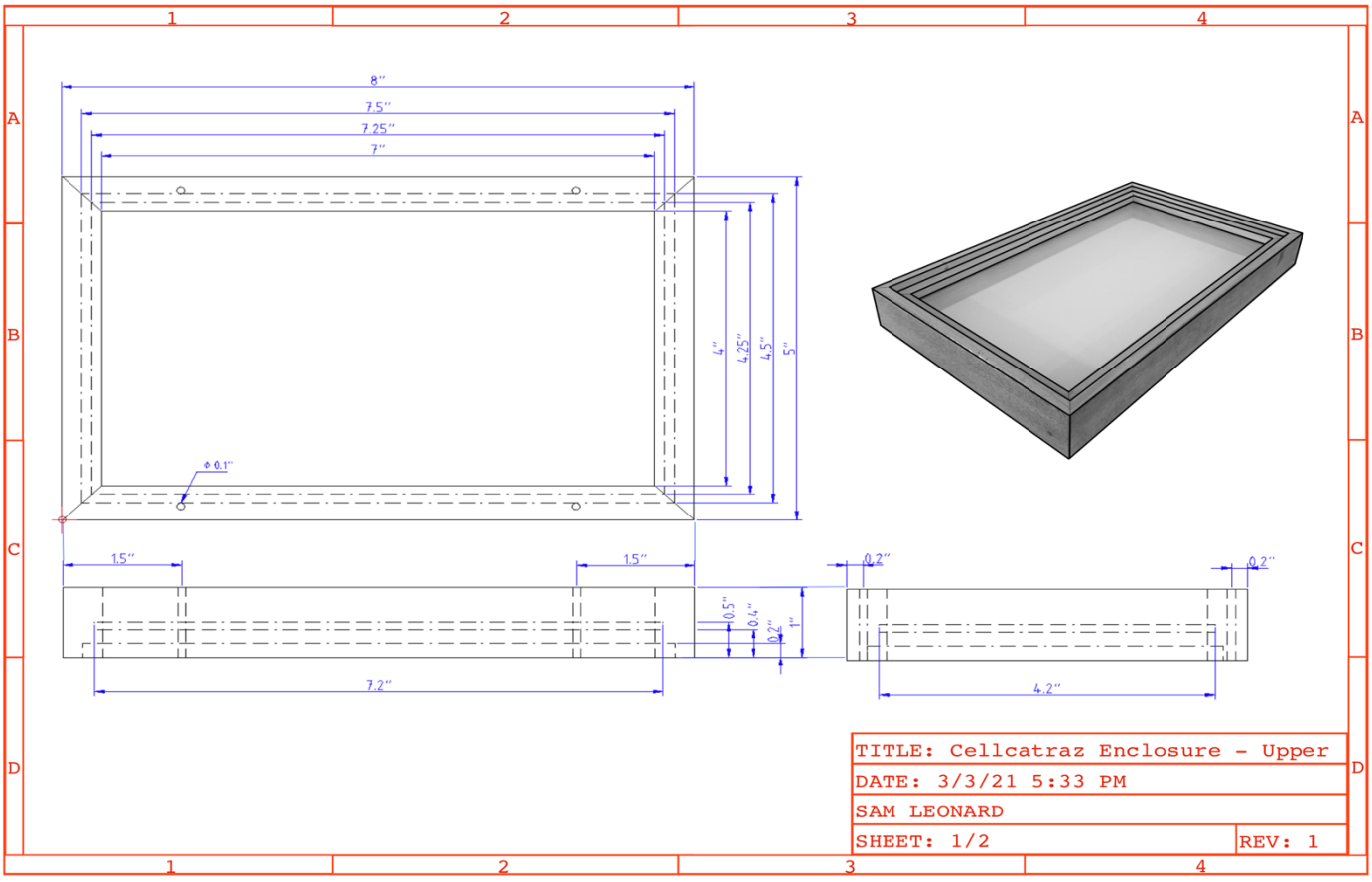


E. Enclosure Mechanical Drawings

The enclosure is fabricated out of wood and glass to create a sleek design that looks nice on a study or work desk, bookshelf, or other similar location. A glass top allows light to hit the photosensor while also providing a way to view the PCB without opening the enclosure. Labels are selected for their readability. All enclosure penetrations, including around the glass, are coated with silicone to ensure that the PCB is protected from spray and foreign objects. A speaker grill with Ø1/16” holes angled 10° below horizontal allows sound to exit for easy hearing while maintaining a spray-proof penetration for the speaker.

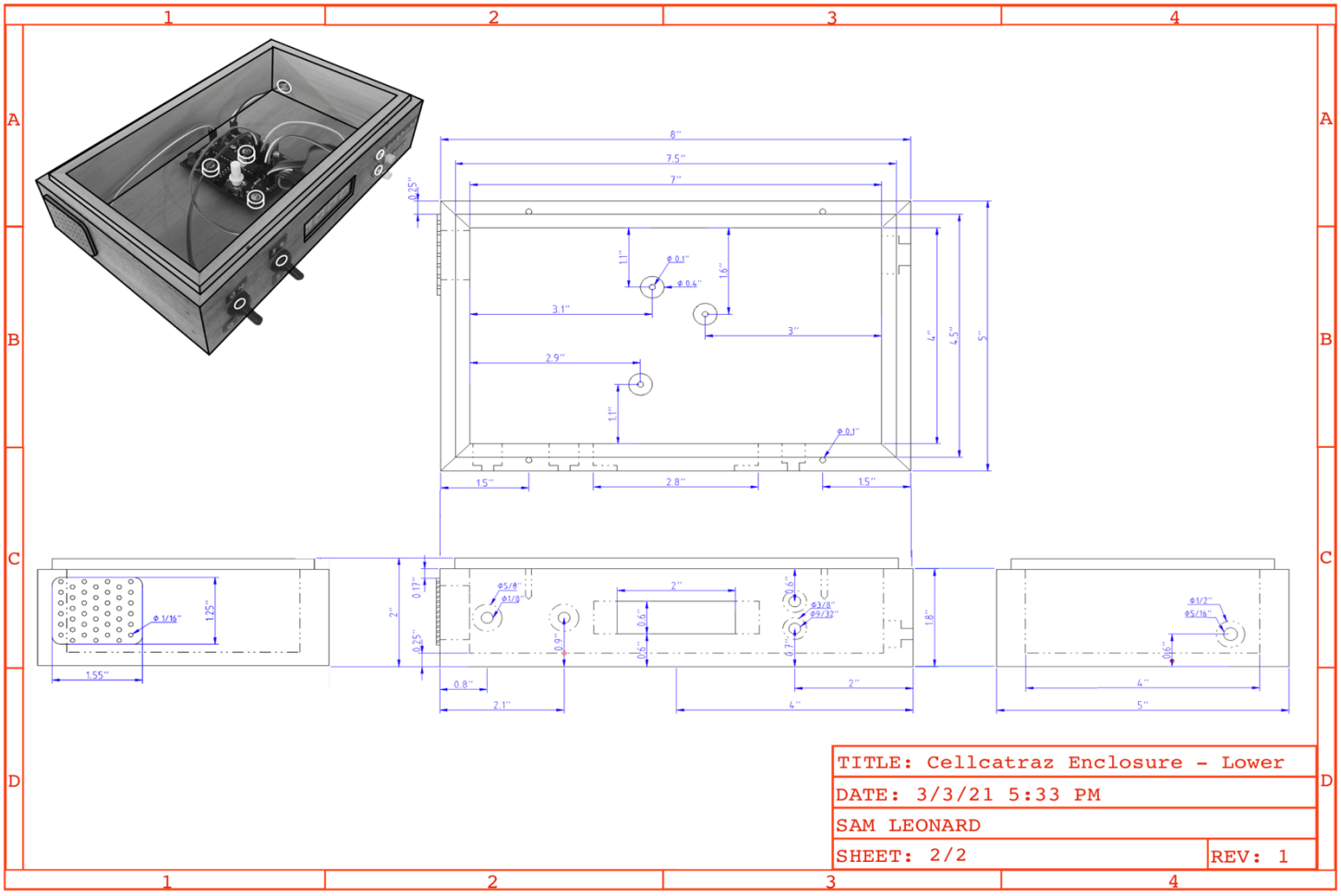
The upper portion of the enclosure provides the phone bay.

Figure 6a: Enclosure Mechanical Drawing (Upper)



The lower portion of the enclosure provides mounting blocks for the PCB and contains all penetrations for the switches, pushbuttons, 7-segment display, barrel jack, and speaker.

Figure 6b: Enclosure Mechanical Drawing (Lower)



V. PCB

The PCB was designed using Autodesk EAGLE. It has a top layer and a bottom layer, and upper and lower ground planes. The PCB is 64.8mm x 50.5mm and contains three holes for mounting. The central component of the PCB is the ATmega328P. There are six sets of 2x1 male header pins for attaching the power input, switches, and pushbuttons. One set of 4x1 male header pins provides connection for the 7-segment display backpack.

Figure 7a: PCB (Top Layer)

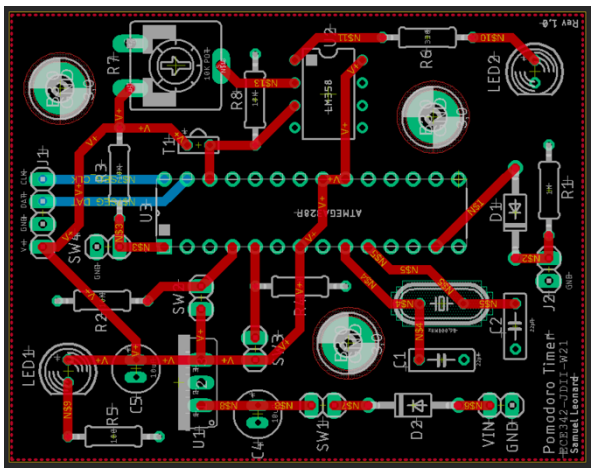


Figure 7b: PCB (Bottom Layer)

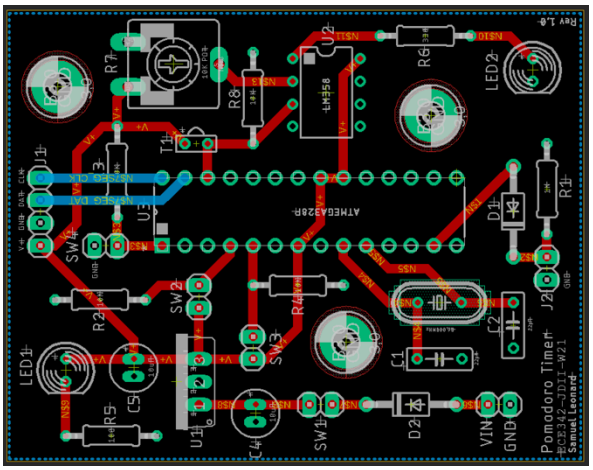


Figure 7c: Physical PCB

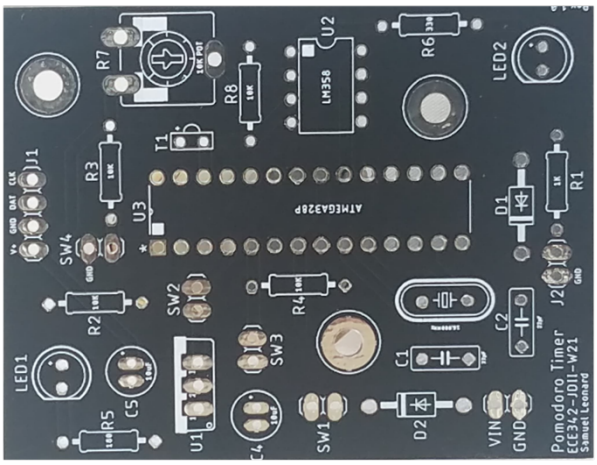
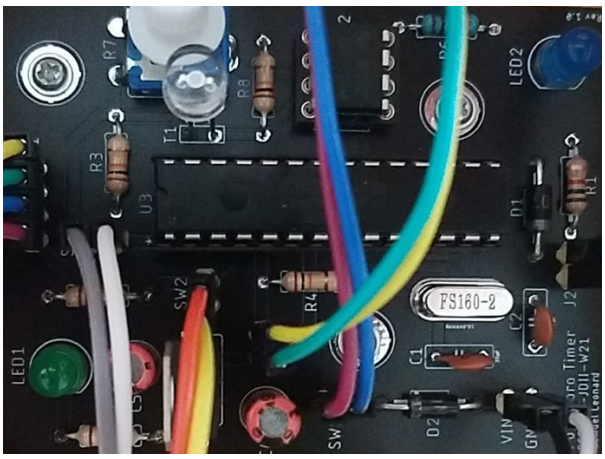


Figure 7d: Physical PCB (Assembled)



VI. Parts List

Part No.	Type	Quantity	Description
1	PCB	1	Pomodoro Timer Rev 1.0
2	Connectors	1	1x36 0.1" Male Header Long
3	Jumpers	1	Female-female jumper set (40 count)
4	Microcontroller	1	ATmega328P
5	OpAmp	1	LM358
6	5V Regulator	1	LM7805T
7	Capacitor	2	10uF 50V, through hole, radial
8	Capacitor	2	22pF 50V, through hole, ceramic disc
9	Resistor	1	1kΩ, through hole
10	Resistor	4	10kΩ, through hole
11	Resistor	1	180Ω, through hole
12	Resistor	1	330Ω, through hole
13	Potentiometer	1	10kΩ potentiometer
14	Diode	2	1N4007
15	LED	1	Ø5mm, through hole, green
16	LED	1	Ø5mm, through hole, blue
17	Crystal	1	16.000MHz, Quartz
18	Phototransistor	1	HW5P-1, through hole
19	Piezo Buzzer	1	PKM22EPPH4001-B0
20	Switch	2	6A 125V/3A 250V, SPDT toggle switch, panel mount
21	Pushbutton	2	125V 3A, NO, momentary pushbutton, panel mount
22	IC Socket	1	28-pin, 0.1" pitch
23	IC Socket	1	8-pin, 0.1" pitch
24	Wall Transformer	1	9V 1.5A
25	Barrel Jack	1	Ø2.1mm, panel mount
26	7-Segment Display	1	Adafruit 0.56" 7-Segment Display with Backpack

VII. System Verification

1. **Customer Requirement:** The system should be **accurate**.
   Engineering Requirement: The timer must be less than 1 second off every minute.
   Video Link: 5-minute accuracy test video, 25-minute accuracy test video
2. **Customer Requirement:** The system must be **safe**.
   Engineering Requirement: The system must use connectors for every module used in the timer system, have a power disconnect switch, and not have any exposed conductors. Wires must be organized in split loom or other protective materials. All devices must be rated at least IP43.
   Video Link: Safety demonstration video
3. **Customer Requirement:** The system should be **intuitive**.
   Engineering Requirement: Every switch and potentiometer on the user interface should have a label that can be read from three feet away by at least 2 people other than the project designer.
   Video Link: Intuitive interface demonstration video
4. **Customer Requirement:** The alarm beep should have an **easy tone to hear**.
   Engineering Requirement: The alarm should be 440 ± 1 Hz.
   Video Link: Alarm frequency test video
5. **Customer Requirement:** The system should have **dimmable timer lights**.
   Engineering Requirement: The LEDs on the timer display should have 3 brightness levels (not 4, not 2, but 3). The brightness level will be selected by a switch, potentiometer or photosensor.
   Video Link: Display brightness demonstration video
6. **Customer Requirement:** The system should **reset** if the user doesn't get back to work quickly.
   Engineering Requirement: When the device is removed, the alarm sounds for 5 ± 0.2 seconds, at which point the system resets. If the device is returned within this time, the alarm stops, and the timer continues to count down.
   Video Link: 5-second alarm accuracy test video
7. **Additional Requirement:** The system must be **ruggedly enclosed**.
   Engineering Requirement: All of the electronics need to be enclosed and safe. One must be able to shake the enclosure vigorously and still have the blocks function after.
   Video Link: Vigorous shake test video

VIII. List of References

[1] A. F. Ward, K. Duke, A. Gneezy, and M. W. Bos, “Brain Drain: The Mere Presence of One's Own Smartphone Reduces Available Cognitive Capacity,” Journal of the Association for Consumer Research, 01-Apr-2017. [Online]. Available: https://www.journals.uchicago.edu/doi/abs/10.1086/691462. [Accessed: 05-Mar-2021].

[2] G. Ellett, “The Pomodoro Technique: Study More Efficiently, Take More Breaks,” Chapman Learning Commons, 2016. [Online]. Available: https://learningcommons.ubc.ca/the-pomodoro-technique-study-more-efficiently-take-more-breaks/. [Accessed: 06-Mar-2021].

[3] ATmega328P Datasheet

[4] LM7805T Datasheet