Project 2C -Traffic Light Enclosure

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Rapid Fabrication and Prototyping

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Introduction

This project focuses on the design and modification of a traffic light enclosure. The enclosure must allow LEDs and header pins to extend through the case walls and be secured using a mechanical fastening method of choice (e.g., slide, clasp, or screws). If screws are used, they must seat into heat inserts. The MCAD model should include clearly labeled features and fully defined sketches.

The purpose of this design is to support a functional miniature traffic light. Traffic lights are electronic signaling devices used to regulate the flow of vehicles and pedestrians by cycling through red, yellow, and green indicators. In this project, a small-scale traffic light circuit was constructed and soldered onto a protoboard to serve as the functional core of the enclosure design.

Assumptions/Requirements

1. Mechanical
   - 1.1. Enclosure shall be constructed from 3D-printable thermoplastic material (e.g., PLA or PETG) within defined wall thickness tolerances.
   - 1.2. Enclosure shall fully contain the protoboard assembly and associated components.
   - 1.3. Enclosure design shall ensure compliance with IP20 rating to prevent finger access to live parts.
   - 1.4. CAD model shall use fully defined sketches and descriptive feature names to support clarity and ease of modification.
   - 1.5. Enclosure shall be free of sharp edges, pinch points, and shall properly isolate electrical connections.
   - 1.6. Enclosure shall consist of two interlocking halves that fasten securely using mechanical methods such as slides, clasps, or screws with heat-set inserts.
   - 1.7. Enclosure shall be oriented for optimized 3D printing, minimizing supports and ensuring dimensional accuracy.

Data

Figure 1 Updated Bill of Materials

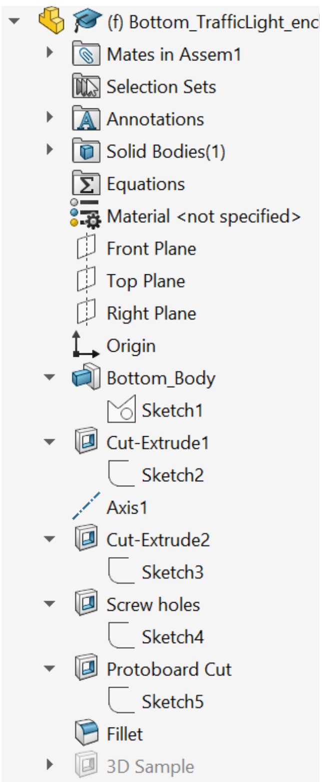
Qty	PN	Description	Unit Price	Supplier	Ext Price
1	B0CWKQFR97	Breadboard	$1.33	Amazon	1.33
1	NE555P	555 Timer	$0.24	Newark	0.24
1	WP7113ID	Red 5mm LED	$0.21	Digi-Key	0.21
1	WP7113SYD	Yellow 5mm LED	$0.37	Digi-Key	0.37
1	LTL-4234	Green 5mm LED	$0.15	Digi-Key	0.15
1		Resistor (27k ohms)	$0.60	Amazon	0.6
1		Resistor (10k ohm)	$0.07	Amazon	0.07
3		Resistor (220 ohms)	$0.06	EE	0.18
1		Capacitors (220 uF)	$0.30	adafruit	0.3
1	SN74LS379N	Flip Flop	$15.26	Amazon	15.26
1	CD4081BE	AND Gate 4 Channel 2 Input	$0.40	Amazon	0.4
1	SN74HC27N	NOR Gate 4 Channel 3 Input	$1.30	Amazon	1.3
		Overture (Colors Vary) PLA Filament 1.75mm (1kg Spool)	$13.29	Amazon	0.18
					20.41

Figure 1 shows the updated Bill of Materials (BOM) listing all components used in the traffic light circuit, including the PLA filament.

Figure 2 Front Disassembled Isometric View

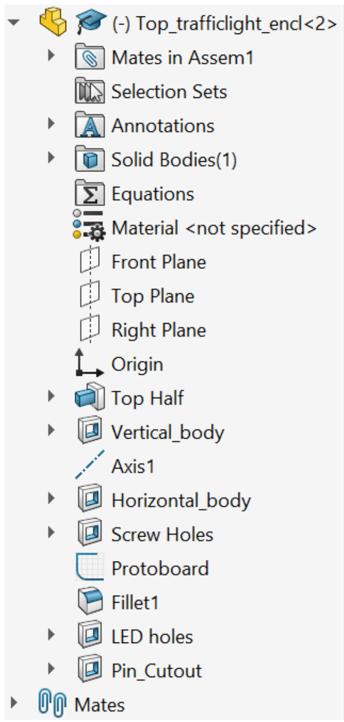
This figure shows the two-piece 3D-printed enclosure designed to house the protoboard assembly. The top cover includes three circular cutouts for the red, yellow, and green LEDs to pass through, while the bottom half features recessed cavities and mounting points for the protoboard. Each corner includes a pocket for heat-set inserts, allowing the enclosure halves to be securely fastened together using machine screws [1]. The design follows standard 3D printing guidelines to ensure proper fit, ease of assembly, and compliance with IP20 protection standards [2].

Figure 3 Expanded SolidWorks design tree for bottom half enclosure.



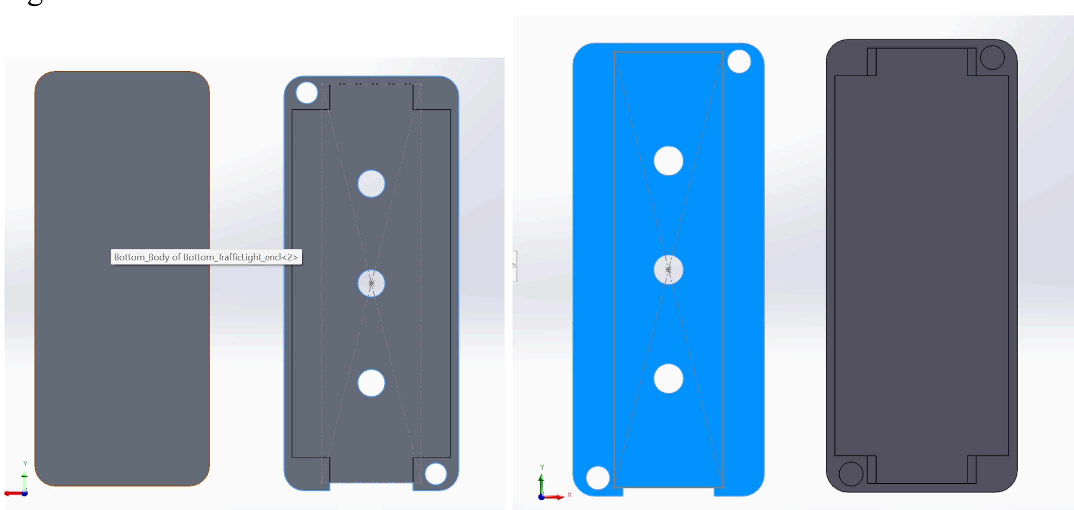
This figure shows the fully defined sketches and labeled features for the bottom half of the traffic light enclosure, including cut extrusions, screw holes, and the protoboard cavity [1].

Figure 4 Expanded SolidWorks design tree for top enclosure.



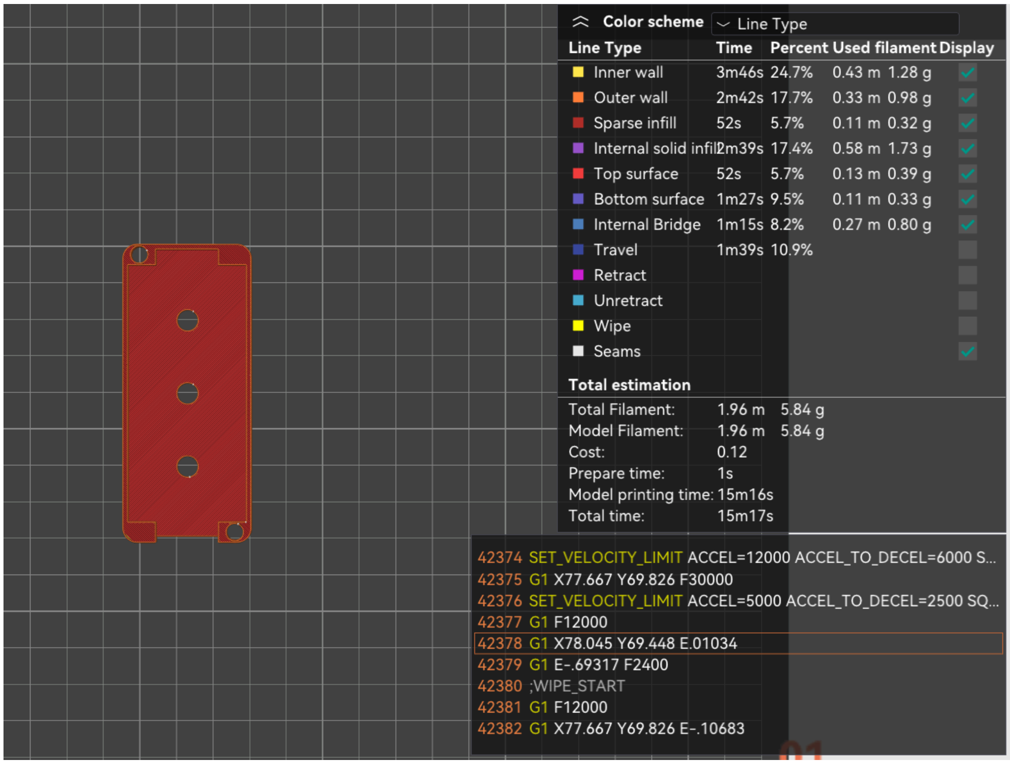
This figure displays the design tree for the top half of the enclosure, featuring clearly named sketches for LED holes, pin cutouts, and screw holes to support model organization and clarity [1].

Figure 4



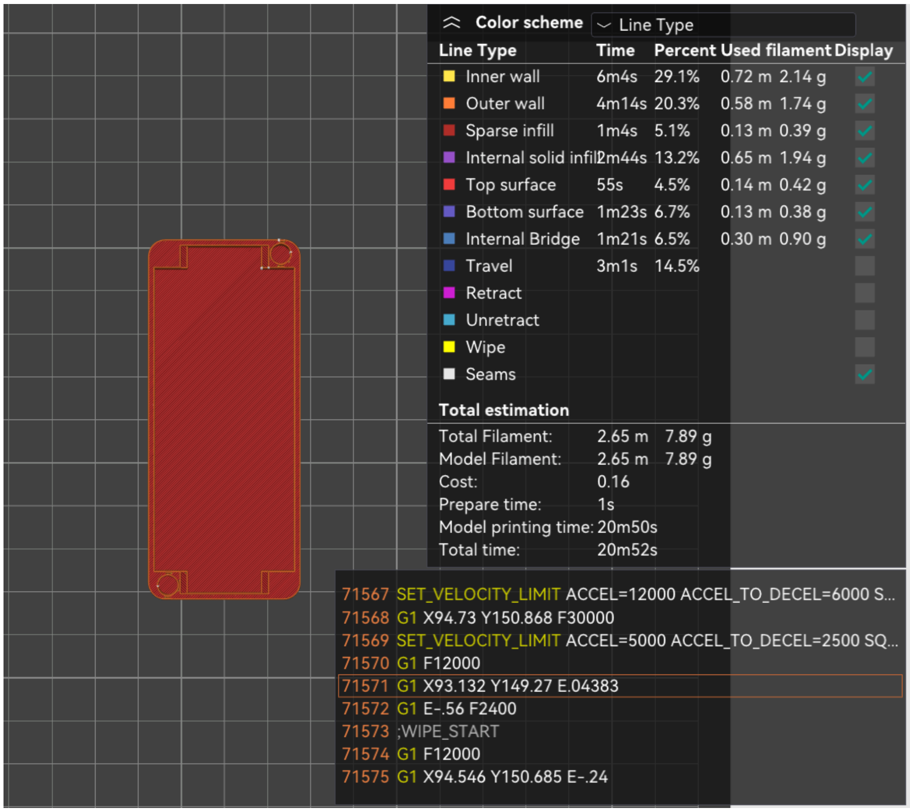
This figure shows the interior of the two-piece 3D-printed enclosure in SolidWorks. The top half includes three circular cutouts for the red, yellow, and green LEDs, while the bottom half contains recessed cavities designed to seat the protoboard securely. Mounting bosses are located at each corner to hold heat-set inserts for screw fastening [1]. The model was created following standard 3D printing design rules to ensure accurate fit, sufficient wall thickness, and IP20 protection compliance [2].

Figure 5 Screenshot of sliced Top Half Enclosure 3D model



This figure displays the sliced view of the top enclosure, featuring three LED cutouts aligned vertically and screw mount locations at each corner. The print is estimated to take about 15 minutes and 17 seconds, consuming 5.84 grams of filament [1].

Figure 6 Screenshot of sliced Bottom Half of Enclosure 3D model

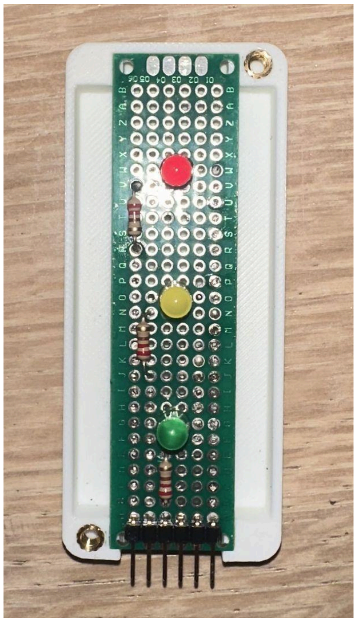


This figure shows the slicing preview of the bottom half of the traffic light enclosure, including the internal walls, infill, and mounting cavities for the protoboard and heat inserts. The slicer estimates a total print time of approximately 20 minutes and 52 seconds using 7.89 grams of filament [1].

Figure 7 Exterior view of case with protoboard and all LED illuminated

This figure shows the completed traffic light enclosure in operation, with the red, yellow, and green LEDs illuminated to demonstrate full circuit functionality. Jumper wires extend from the bottom of the enclosure, providing a secure external connection to the control circuit while maintaining the IP20 protection rating [1]. Brass heat inserts at the corners allow the top cover to be fastened securely, ensuring structural stability during operation [2].

Figure 8 Inside view of case with protoboard



This figure shows the assembled traffic light protoboard secured within the bottom half of the printed enclosure. The header pins extend through the lower opening of the enclosure, allowing external connection to the control circuit. Brass heat inserts are visible at the corners, providing secure fastening points for the top cover and ensuring mechanical stability during assembly and testing [1]. The enclosure was designed and printed following standard 3D printing design guidelines [2] and meets the IP20 protection requirements outlined in IEC 60529 [3].

Reflection

- My first major issue occurred when I didn't correctly measure the diameter of the LEDs for the top half of the enclosure. During my first print, the holes were too small, preventing the LEDs from fitting through the top surface. This mistake forced me to go back into SolidWorks, adjust the dimensions based on the actual LED casing diameter, and reprint the part. This experience taught me how important it is to verify component measurements with calipers rather than relying solely on datasheet approximations, especially when designing tight mechanical fits.
- Another issue I ran into was forgetting to include a cavity for the header pins. In my original design, there was no opening on the enclosure for the pins to pass through, which meant there was no way to connect the traffic light to the breadboard. I had to redesign the bottom half of the case to include a properly sized slot for the header, which added to my reprint time. This reinforced the importance of visualizing how each component

interacts with the enclosure and ensuring that all electrical connections have mechanical clearance.

- Even though my model was complete early on, I underestimated how much time it would take to print, test-fit, and reprint the enclosure, as well as install the heat inserts. The process of waiting for the prints to finish, cooling, and reassembling everything took longer than expected. This taught me to better plan for fabrication time and account for iteration cycles when working on physical prototypes.
- My final issue was that the header pins didn't extend far enough beyond the case wall, which made it impossible to plug the enclosure directly into the breadboard. My only options were to either use jumper wires or reduce the wall thickness, which would drop the enclosure from an IP20 to an IP10 rating. I decided to use jumper cables because it allowed me to maintain the IP20 standard while keeping the enclosure mechanically strong and safe. Although this added a small layer of complexity during setup, it was ultimately a better tradeoff than compromising the protection and durability of the design

References

[1] "Heat-Set Insert Press," *Rowan ECE Resources*, Google Sites. [Online]. Available: https://sites.google.com/rowan.edu/eceresources/heat-set-insert-press. [Accessed: Oct. 17, 2025].

[2] "Design Rules for 3D Printing," *Hubs (HubSpot)*, 2024. [Online]. Available: https://4075618.fs1.hubspotusercontent-na1.net/hubfs/4075618/002-003%203DP%20Rules%20Poster_Hubs_DEF.pdf. [Accessed: Oct. 17, 2025].

[3] "IEC 60529: Degrees of Protection Provided by Enclosures (IP Code)," *International Electrotechnical Commission (IEC)*, 2013.