EN1190 - Engineering Design Project

Department of Electronic and Telecommunication Engineering

Semester 2 (Intake 2023)

Project Report

IronGenius

Automated Switch For Clothing Iron using wired motion Sensor.

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Contents

Abstract

In many households, dry irons are often left switched on after use, leading to fire hazards, overheating, and unnecessary energy consumption. To address this issue, we designed a Smart Auto-Off Multiplug Socket that detects inactivity using a vibration sensor and shuts off power automatically after a set period. The device includes a visual alert (blinking LED) and supports both automatic and manual modes. This project emphasizes safety, energy efficiency, and retrofit usability for non-smart appliances.

1. Introduction

Dry irons are commonly used in households, hostels, and small tailoring shops. One of the key issues faced by users is forgetting to switch off the iron, which leads to overheating, fire hazards, and unnecessary energy usage. Unlike modern smart appliances, traditional irons do not feature built-in safety shutdown mechanisms.

2. Problem description

Electric irons are widely used in households, but forgetting to turn them off after use is a common and potentially dangerous issue. This can lead to overheating, fire hazards, and unnecessary electricity consumption. Most traditional irons lack automatic safety mechanisms, making it essential to introduce smart features that enhance user safety and convenience.

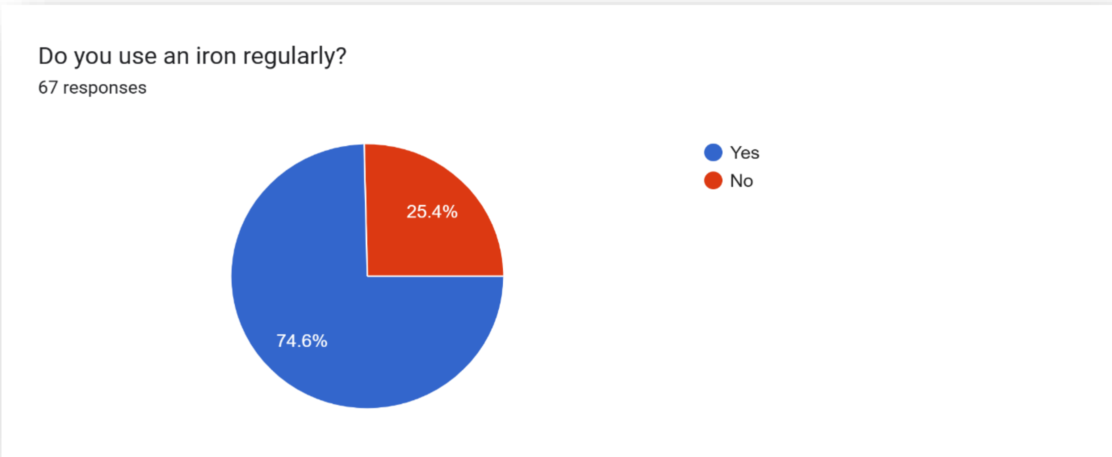
2.1. Motivation

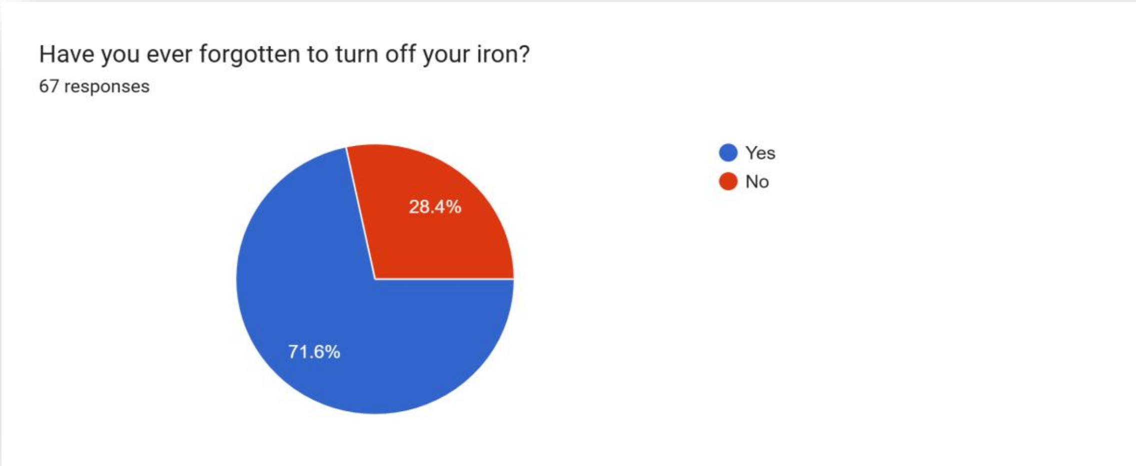
This project is motivated by the need to improve safety and reduce power waste in everyday iron usage. A smart solution with automatic power-off based on motion inactivity offers a practical way to prevent accidents caused by human forgetfulness.

2.2. Justification for Selection

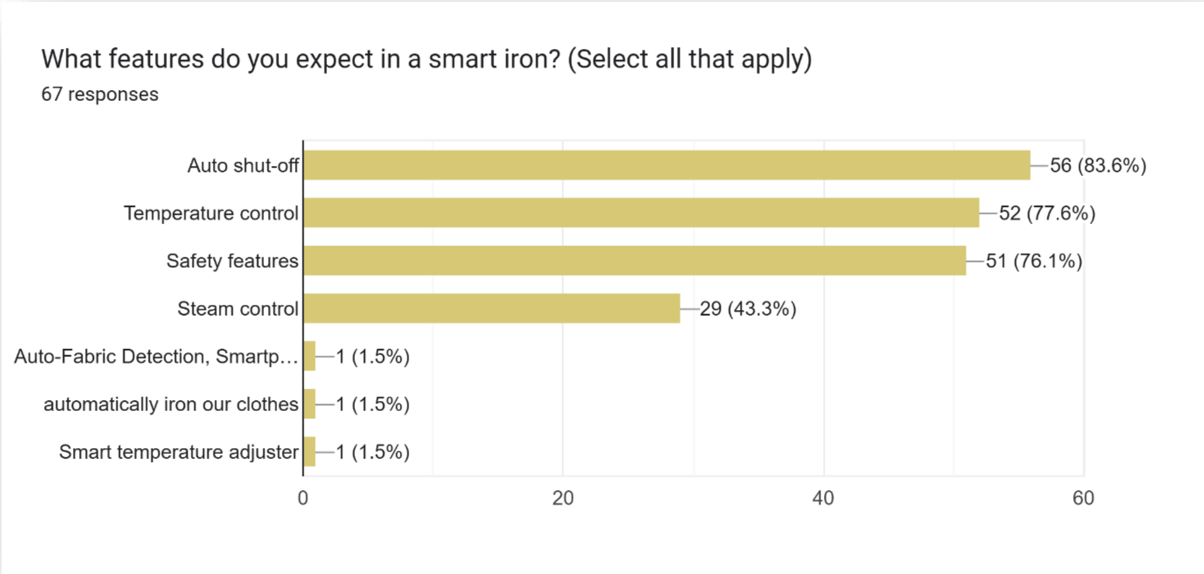
To understand the relevance of the problem, a survey was conducted among 67 individuals:

74.6% of respondents regularly use an iron, and 46.3% use it daily. A significant 71.6% of respondents admitted they have forgotten to turn off the iron, highlighting a serious safety issue.





83.6% (56 out of 67 respondents) specifically selected “auto shut off” as a desired feature in a smart iron, indicating strong user demand for this functionality.



These results confirm that the auto shut-off feature addresses a real and recognized need. Therefore, developing a Smart Iron with Auto Power-Off is both relevant and timely, aiming to enhance household safety and promote smarter energy usage.

3. Technical Feasibility

3.1 Product concept

This project presents a Smart Auto-Off Multiplug Socket which detects inactivity using a motion sensor connected with a wire and automatically cuts off power after a set time. The system is designed to be cost-effective, safe, and easy to retrofit onto any existing dry iron.

3.2 Hardware feasibility

By using the concept of central control and using cost effective and widely available components in the market this all the resource requirements could be fulfilled. Following was the feasibility study done.

- Microcontroller : Simple 8 bit microcontroller with minimum number of pins and small memory was enough for the task.
- Power switching: AC switching components with high current rating (4.3A to 8.7A) were readily available.
- Motion identification: Sensors capable of capturing motion was readily available. Here, a sensor with a simple communication technique was used with the simple low cost MCU.
- Isolation between AC and DC components. : For the safety of the DC components isolation was necessary.

3.3 Firmware feasibility

- Microcontroller programming : Programming Language like Embedded C (C compiler) or assembly language.
- Core Logic: Features like mechanical reset is widely available on some 8-bit MCUs.
- Timers: Prefer availability of internal timers over using crystal oscillators due to simplicity
- Debouncing: Essential for sensor input and the pushbutton input to prevent false triggers from noisy signals. This is a standard firmware technique.
- Power-on State: Firmware should ensure the iron is OFF by default when the plug is first powered on for safety. User interaction would be required to activate it.

3.4 Enclosure **and mechanical features**

- Form factor, size and shape should be familiar with the other house multiplugs. This should be capable to use with any type of (square or round) plug which are used in Sri Lanka.

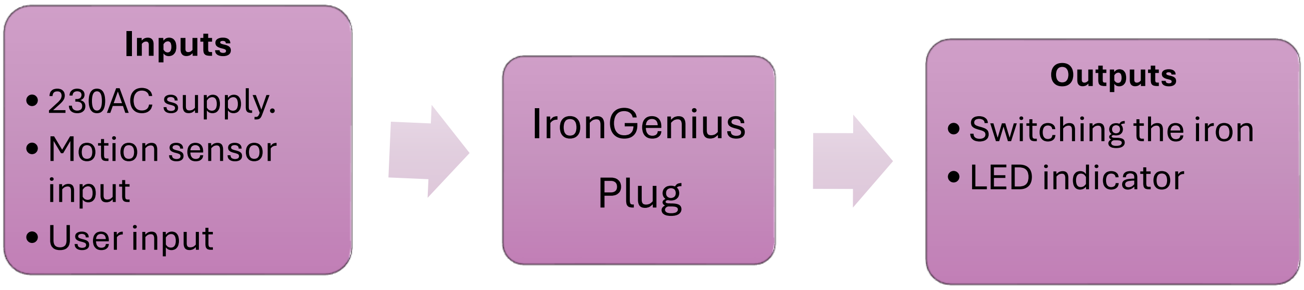
- With the commercial availability of 3D printing technology, it is much feasible to get a high quality. Here a material with good insulation will be chosen for the safety. The durability is considered as a key factor in choosing the material as well.
- Wire attaching mechanism: A user-friendly design with capability of keeping the two wires (Power cable and sensor connector) firmly without making the wires tangling was needed.

3.5 Conclusion

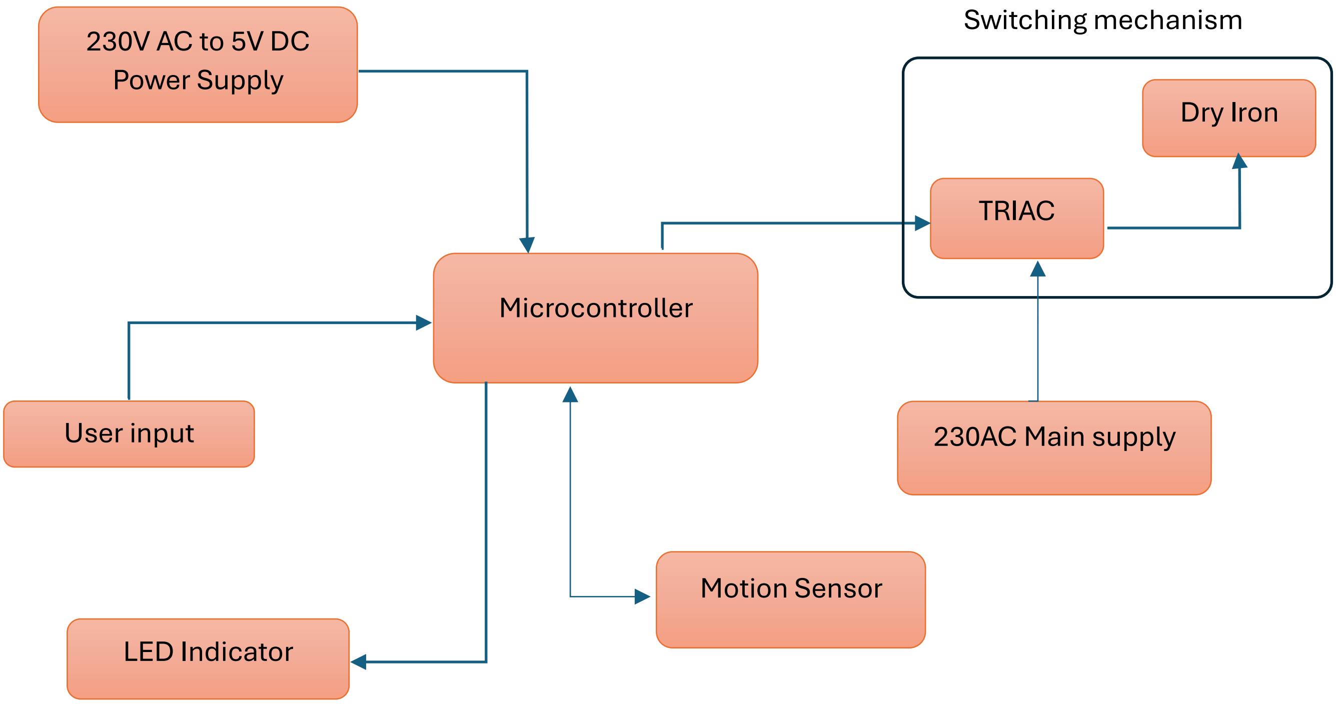
- By considering all these factors, we concluded that this product is highly feasible to go ahead with our product design.

4. Product Architecture

4.1 System level abstraction



4.2 Module level abstraction



4.3 System overview

The system monitors the iron's movement using a motion sensor. If no motion is detected for a certain duration (e.g., 2 minutes), a blinking LED alert is activated. If the user doesn't respond, the relay cuts power to the iron. The system can also be switched to manual mode via a toggle switch.

4.3.1 Power supply

Our system operates from a standard 230V AC mains supply, which must be converted to a stable 5V DC to power the microcontroller, motion sensor, and LED. For this purpose, we used a compact AC-to-DC power supply module.

4.3.2 Main control unit

The main control unit of our Smart Auto-Off Multiplug Socket is built around the microcontroller, which plays a central role in processing sensor input, read motion input from the motion sensor, start/reset a timer based on activity and blink LED before auto-shutoff.

4.3.3 Sensor module

The sensor module in our Smart Auto-Off Multiplug Socket is responsible for detecting whether the iron is being used or left unattended. For this purpose, we selected the vibration (motion) sensor, a simple yet effective component for motion detection.

5. Component Selection

To fulfil our requirements, after a decent amount of time in researching different datasheets, we selected the components that adhere to our circuit's performance.

- Microcontroller selection : Microchip PIC 12F675
    - **Memory:** 1.75KB Program Memory (Flash), 64 bytes RAM, 128 bytes EEPROM. This is ample for handling the simple logic required: reading the vibration sensor, maintaining a timer, controlling the TRIAC driver, and managing a single button/LED.
    - **I/O Pins:** 8 pins, of which 6 are usable I/O. This is sufficient for our product.
    - **Cost :** Around 230LKR for retail.
    - **Voltage:** 2V to 5.5V
    - **Current:** Max 250ma with total max power dissipation of 800mW.
    - Internal oscillator. (4MHz)

Fig: Microcontroller-12F675

Fig: SW-420 Motion Sensor

- Motion sensor : SW420
    - **Sensor Type:** High sensitivity, non-directional vibration switch (typically Normally Closed type, meaning the switch is closed/connected when stable, and opens briefly on vibration).
    - **Operating Voltage:** 3.3V to 5V DC (compatible with PIC MCUs).
    - **Output Type:** Digital switching output (0 or 1, LOW or HIGH). Easy readability for the MCU.
    - Small form factor. (32mm x 14mm x 8mm) Easy to mount on wire.

- Power supply: 230V AC to 5V DC 700ma power supply is used.

Note: Earlier we planned to use an on board capacitive power supply with voltage regulations. Due to the high heat generation and current control issues we had to change this and used this off the shelf power supply circuit as an alternative.

- AC switching : BTA16 600 TRIAC and MOC3021 optocoupler
  - BTA16 600B: Offers control of currents up to 16A with high voltage rating of 600V AC. This ensures that use of irons with power consumption of 1000W to 3000W without an issue.
    Here we used a TRIAC instead of a Relay due to following reasons.
    I. Longer operational life due to no moving parts, no wear and tear on contacts.
    II. Very fast switching speed
    III. More compact for high current ratings compared to an equivalent high-current relay.

Note :

Due to the high heat generated we had to use a heat sink with the TRIAC to keep it under proper temperature.

  - MOC3021 Optocoupler: Provides the necessary electrical isolation between TRIAC and DC components.

Summary of components selected:

Component	Description
Microcontroller-12F675	8-pin microcontroller – serves as the main processing unit
SW-420 Motion Sensor	Detects motion and idle state of the iron
5V Power Supply Module	Converts 230V AC to 5V DC
BTA16 600 TRIAC and MOC3021 optocoupler	TRIAC is used for switching and optocoupler for isolation between AC and DC sides.

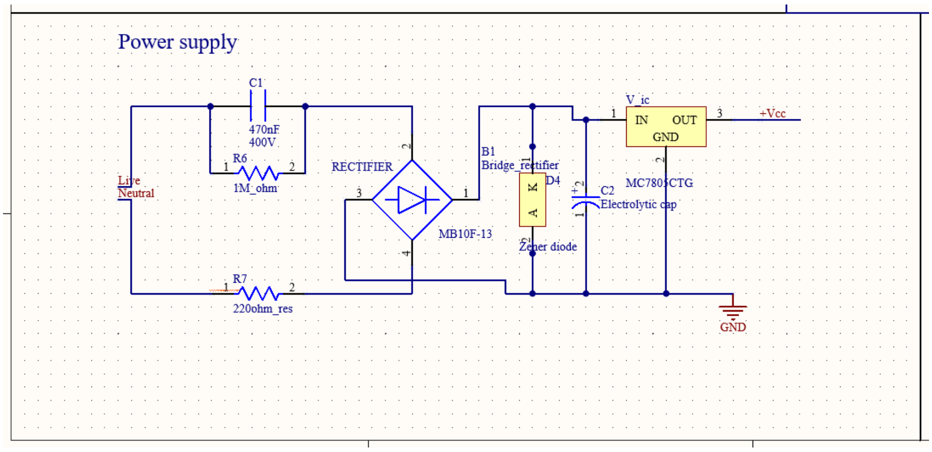
Datasheets:

- Microchip PIC12F675: PIC12F629/675 8-Pin FLASH-Based 8-Bit CMOS Microcontrollers Data Sheet
- SW420 sensor module: Vibration Sensor.pdf
- BTA16 600B: Datasheet - T1610, T1635, T1650, BTA16, BTB16 - Snubberless™, logic level and standard 16 A Triacs
- MOC3021: MOC series optocouplar.pdf

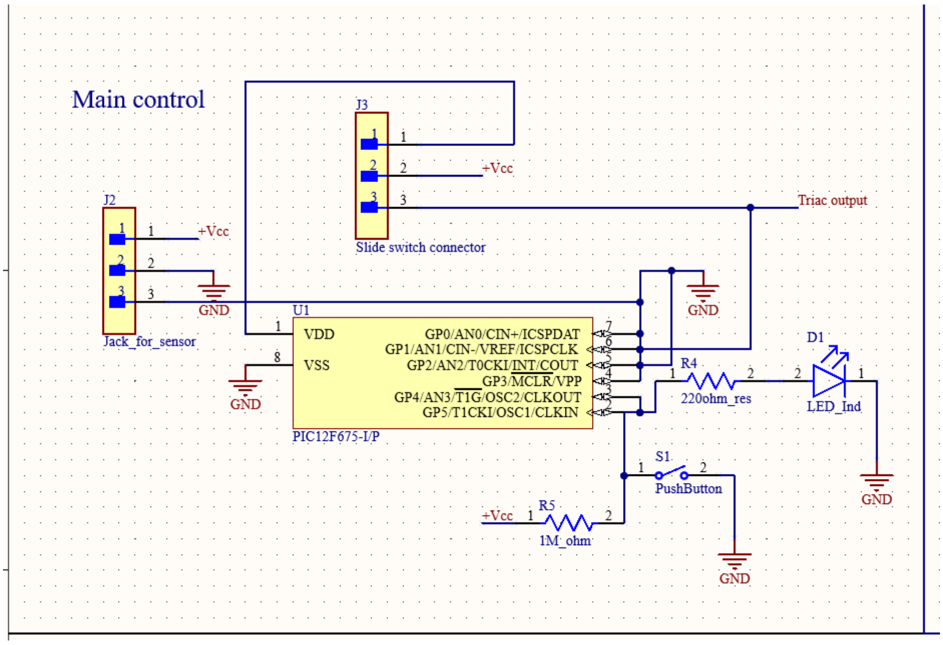
6. Schematic design

Schematic consist of 3 parts.

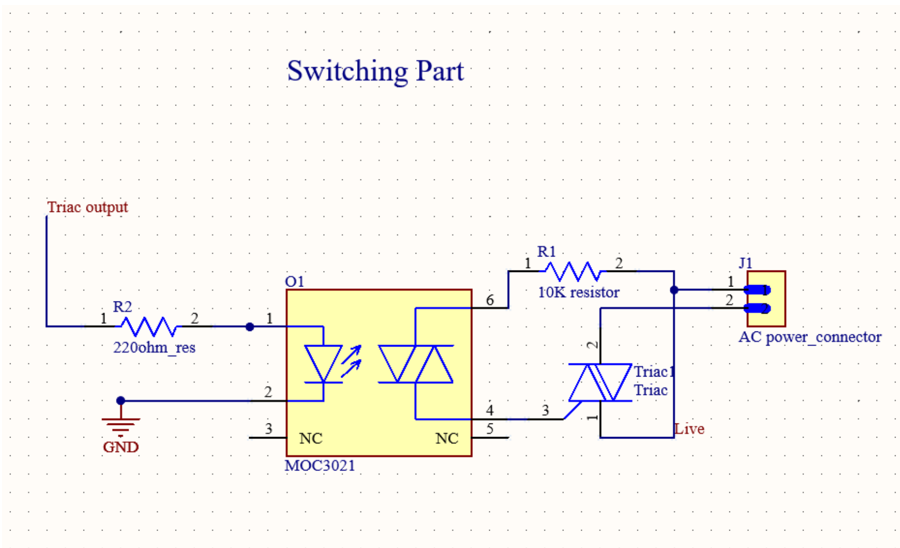
- Power supply.



- Main control circuit.



- AC switching circuit.



7. PCB design

7.1 Introduction

To minimize the size and ensure reliable connections, we designed a custom **two layer** PCB for our smart multiplug. It integrates the microcontroller, sensor interface, and power input/output terminals.

7.2 Key concepts

To minimize the size and ensure reliable connections, we designed a custom **two layer** PCB for our smart multiplug. It integrates the microcontroller, sensor interface, and power input/output terminals.

- **Electrical Safety**
  Designed keeping the minimum distances required between conductors (traces, pads, components) to prevent arcing and electrical breakdown. This was Crucial for preventing electric shock and fire hazards.
  Here we used **EU** standards for separation between AC main current and DC part.

- **Trace Width and Thickness for High Current**
  Traces carrying high current (like the path to/from the TRIAC and the mains outlet) must be wide enough and, ideally, made with thicker copper.

- **Heat Dissipation**

  The BTA16-600B TRIAC will dissipate heat when conducting current, due to its on-state voltage drop. Used large copper pours and wide traces connected to the TRIAC's main terminals and tab to act as heatsinks.

- **Layout and Placement**
  Physically separated the mains AC circuitry (TRIAC, MOC3021 output side, power supply input) from the low-voltage DC circuitry (PIC, SW-420, user interface).
  Implemented a clear zone on the PCB considering to **EU standards** minimum distance.

- **User Interface Elements**
  Designed pads and holes for the pushbutton and status LED, ensuring they align with corresponding holes/cutouts in the enclosure for user accessibility and visibility.

  Provide robust connector for the wire that led to the SW-420 sensor on the iron. Ensuring strain relief for this wire to prevent it from breaking with repeated movement.

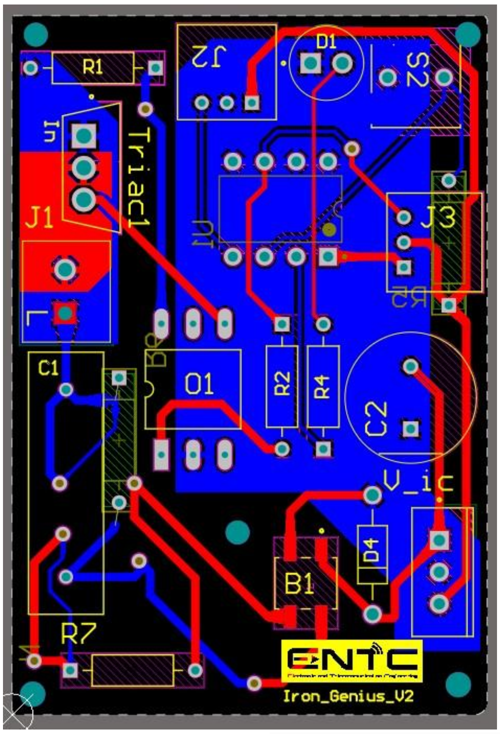


Fig: PCB 2D view

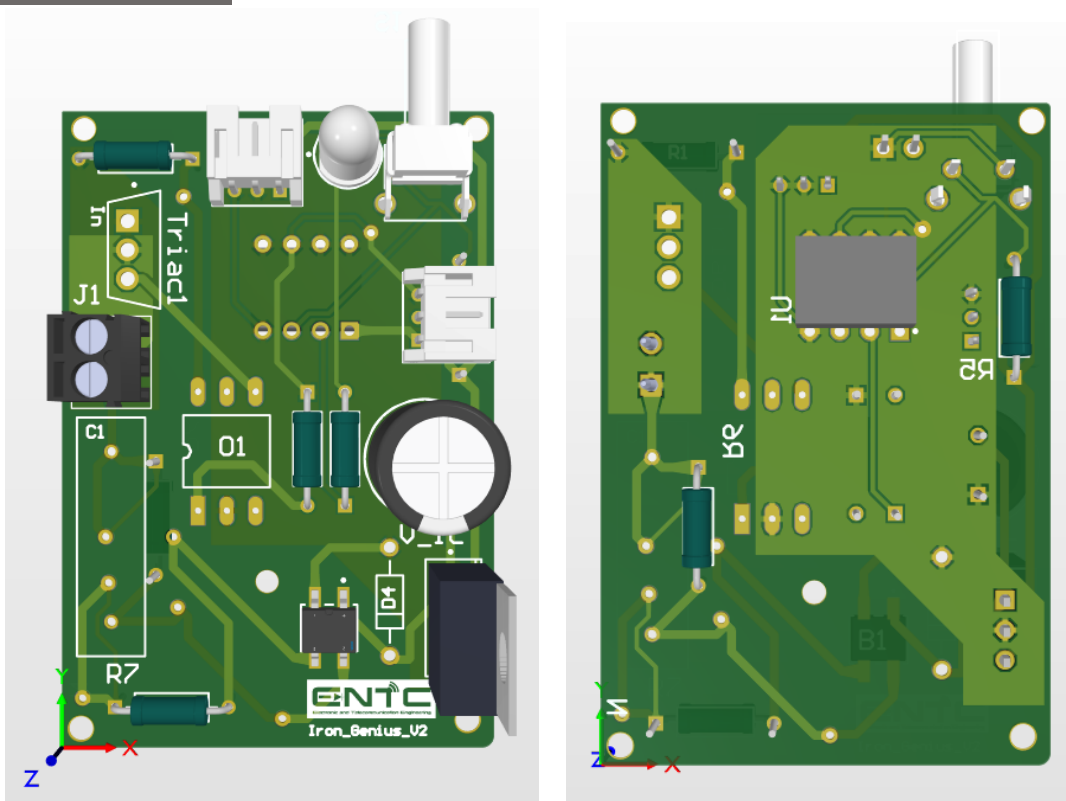


Fig: PCB 3D view

(Top layer, Bottom layer)

7.3 PCB specifications

- **Material: FR4**
- **Thickness:1.6mm**
- **Surface finish: HASL with lead**
- **Copper weight:1oz**

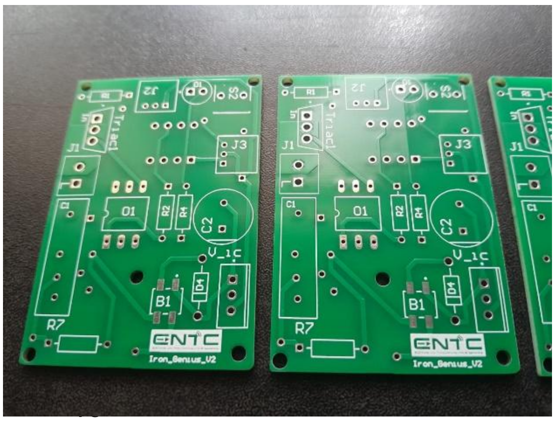


Fig: Bare PCB

8. Enclosure design

We used SolidWorks to design a 3D model of the enclosure that houses the complete system.

8.1 Enclosure

The enclosure has a length of 53 mm, a width of 56 mm, and a height of 68 mm. Since the multiplug socket is relatively large, it may obstruct the on/off button of the wall switch. To prevent this, an additional part with a thickness of 5 mm has been added to the outer side of the back section of the enclosure. The wall thickness is uniformly maintained at 2 mm.

The PCB is mounted on supports integrated into the back section, while additional supports in the front section are provided for mounting the copper plates. Ventilation holes are included in the back section to facilitate heat dissipation. PETG was selected as the material for 3D printing the enclosure due to its strength, durability, and thermal resistance.

Sketching the enclosure

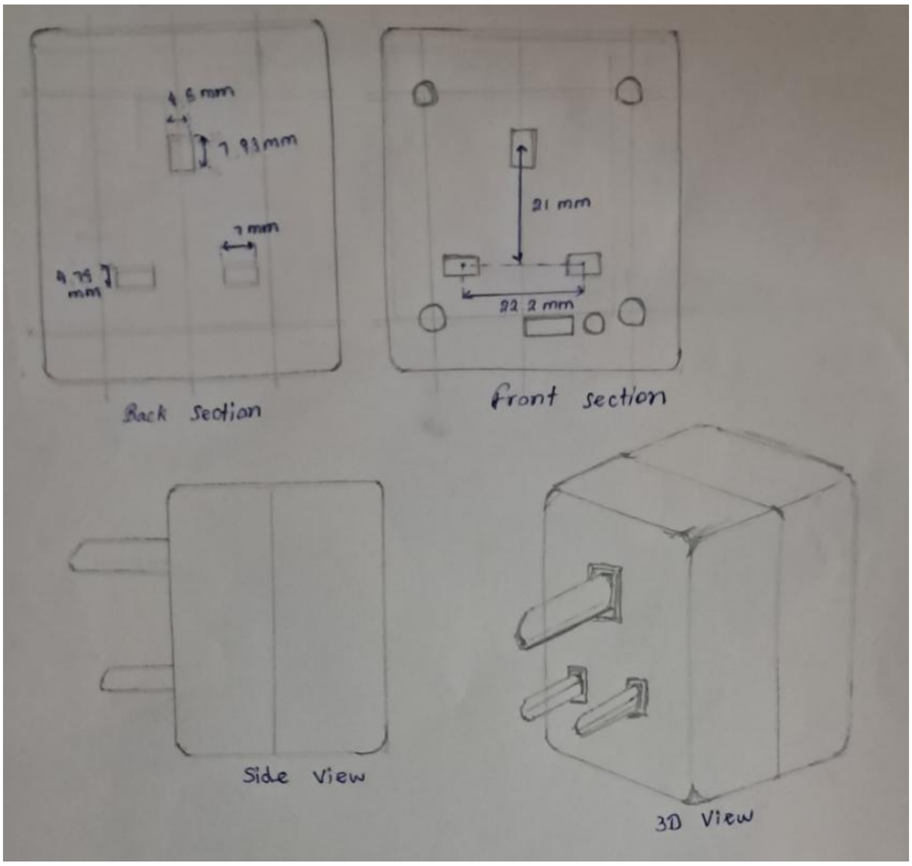


Fig: Initial sketches

Initially, the design included only square holes to accommodate square-shaped plugs. However, the design was later improved to support both square and circular plug types. Additionally, in the early stages of development, the additional 5 mm thickness part at the back of the enclosure was not part of the plan. This feature was introduced later to prevent obstruction of the wall switch.

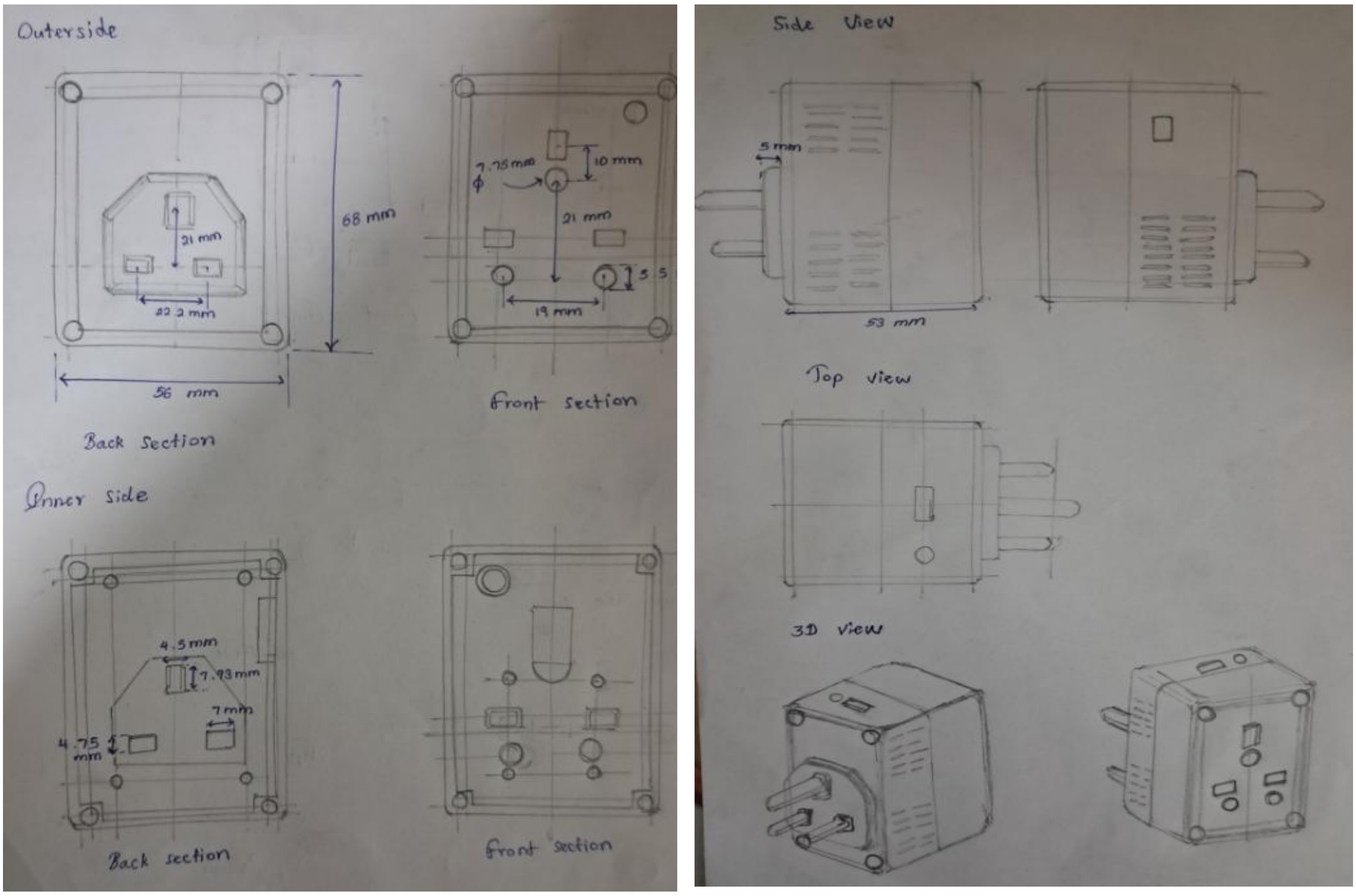


Fig: Final sketches

Solidworks design

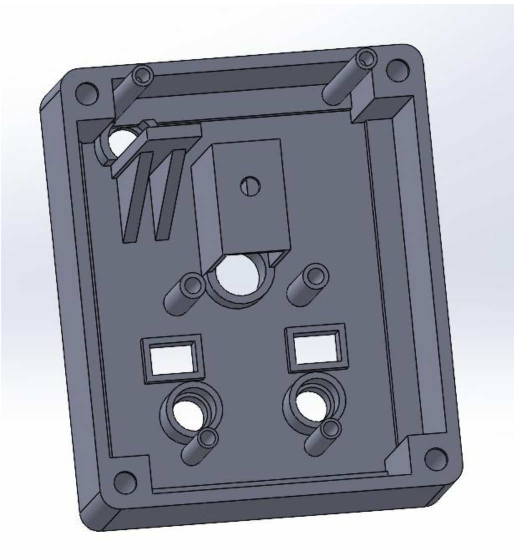


Fig: Front

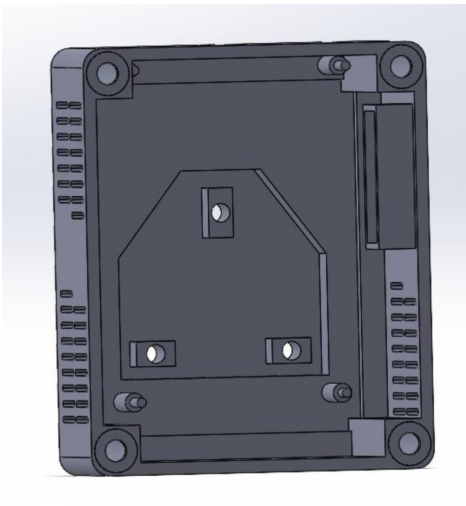


Fig: Behind

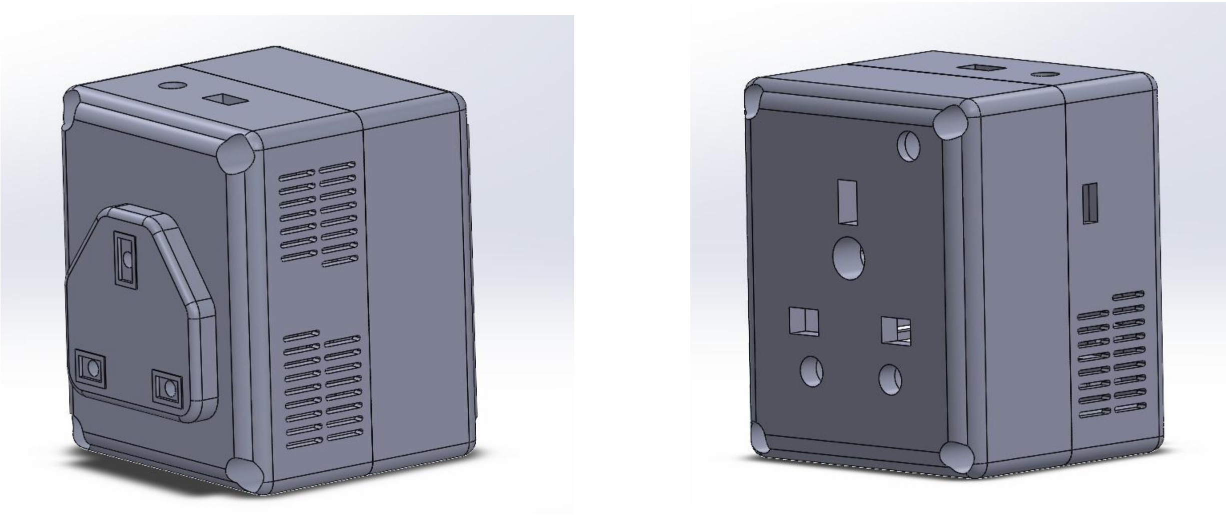


Fig: Assembly

8.2 Sensor module

The SW-420 motion sensor is mounted inside the enclosure near the iron plug connection. It detects motion to determine activity. The sensor is connected directly to the microcontroller and operates on 5V DC. The sensor enclosure has dimensions of 39 mm (length) × 21 mm (width) × 19 mm (height). A semi-circular cutout is provided at the bottom of the lower section to allow the enclosure to be securely placed over the iron's power cable. This design enables the enclosure to be mounted directly onto the wire using double-sided tape. The enclosure is 3D printed using PLA, chosen for its ease of printing, adequate strength for low-stress applications.

Sketching the sensor module

Initially, the sensor module was planned to be attached directly to the iron itself. However, the design was later revised to attach the module to the iron’s power cable instead.

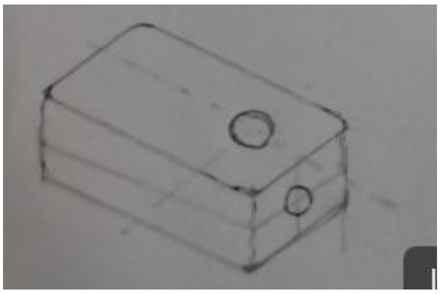


Fig: Initial sketch

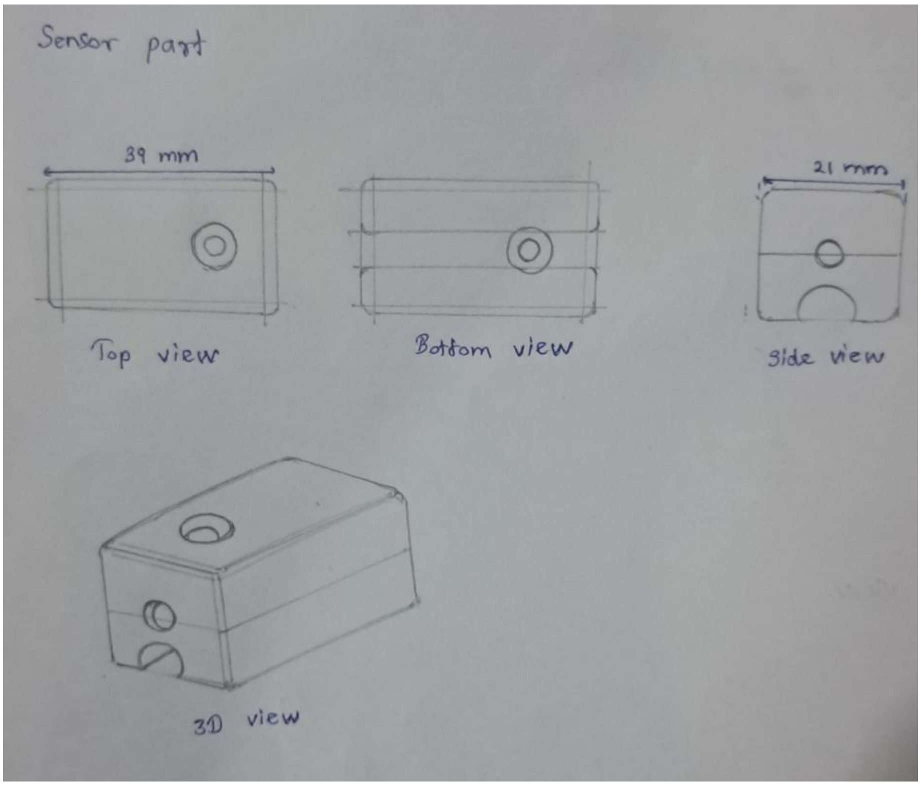
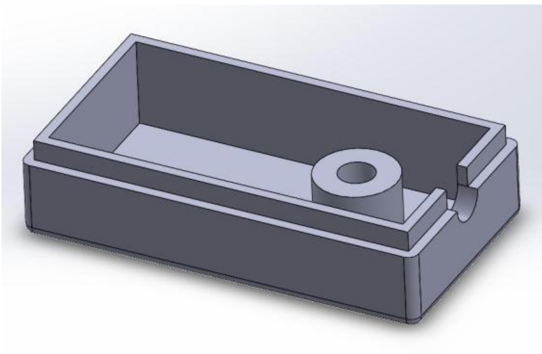
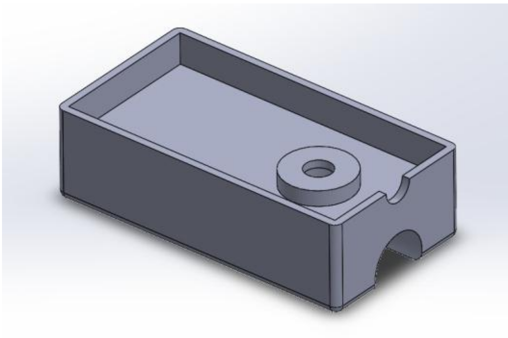


Fig: Final sketches

SolidWorks design





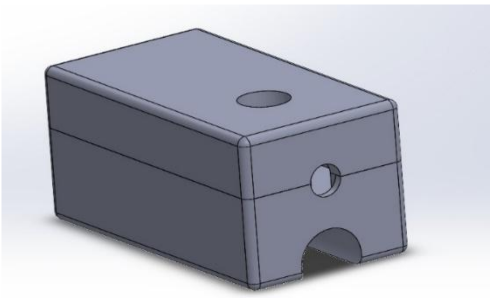


Fig: Assembly

8.3 Wire attaching clips

To ensure that the external cables remain organized and securely held together, small plastic clips were designed and used as cable holders. TPU was selected as the material due to its flexibility and durability, allowing the clips to firmly grip the wires while still enabling easy attachment and removal.

Sketching the clips

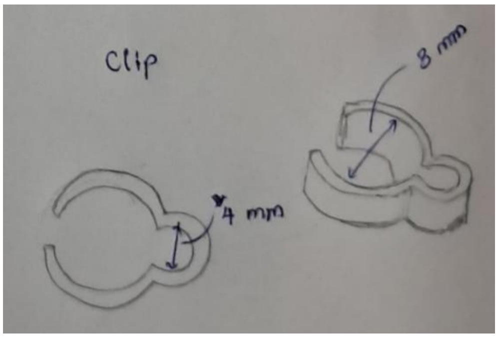


Fig: Initial sketch

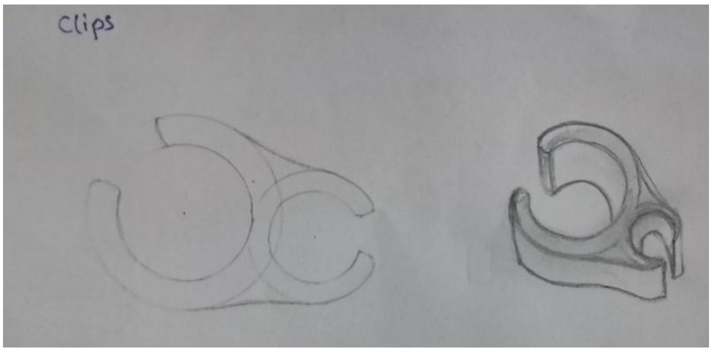
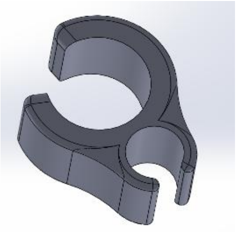


Fig: Final sketch

SolidWorks design



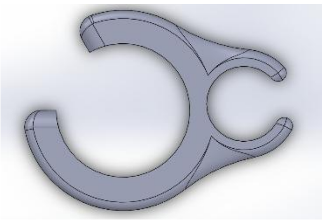


Fig: Wire Clip (Side view, Top view)

9. Final Product

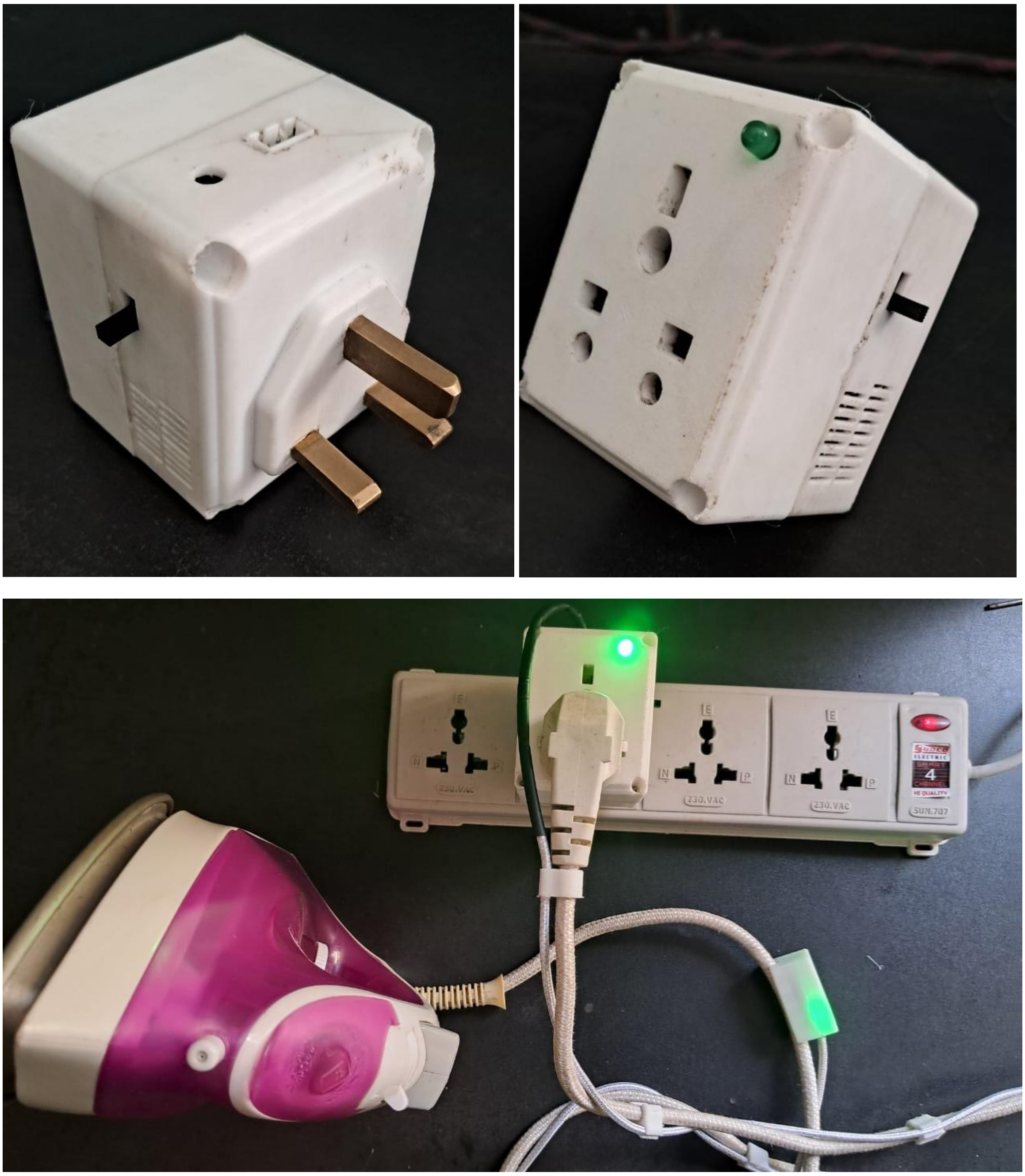


Fig: Final Product

10. Bill of Quantities

Number	Item	Description	Unit price (LKR)	Quantity	Amount (LKR)
1.	PIC12F675MCU	8 pin MCU 8 PDIP package, thru hole	230.00	1	230.00
2.	BTA16 600B TRIAC	3PIN DIP, 600V and standard 16 A TRIACs	40.00	1	40.00
3.	MOC3021	6 PIN PDIP, Optocoupler	40.00	1	40.00
4.	LED	Green colour, 2.3V, Thru hole	4.00	1	4.00
5.	Resistors	220R 10K 1M (Thru hole)	4.00	4	16.00
6.	Push button	2 pin, 24V DC, right angled pushbutton.	10.00	1	10.00
7.	Slide switch	3 Pin, Thru hole	10.00	1	10.00
8.	JST 3 Pin connector	3 Pin, right angled connector	22.00	1	22.00
9.	2 Pin PCB connector		20.00	1	20.00
10.	Power supply	230V AC to 5V DC power 3.5W	230.00	1	230.00
11.	PCB fabrication	Excluding the freight and tax.(2 USD for 5 pieces)	120.00	1	120.00
12.	Connecting wire	1.8m length. With fibre coat.	150.00	1	150.00
13.	Enclosure	3D printed	1600.00	1	1600.00
	Total				2492.00

Note: Here the total cost for the PCB and components is around 800LKR. Due the high cost of 3d printing it came out to be a large sum. Apart from that above prices are retail prices when be buy components in small amounts.

By considering these factors and assuming the cost for the enclosure when mass production to be around 200LKR. We will be able to make this product for a price point around 800-1000LKR.

11. Marketing, Sales, and Beyond

11.1 Marketing Strategy

This product is designed primarily for household users, especially individuals who often use dry irons and may forget to switch them off. The key selling points are safety, convenience, and affordability, making it particularly attractive to budget-conscious consumers.

11.1.1 Target Market

- Households with frequent dry iron usage
- Elderly individuals or busy parents
- Customers looking for affordable smart safety solutions

11.1.2 Value Propositions

- **Fire Prevention**: Automatically turns off dry irons after inactivity, reducing fire hazards.
- **Dual Functionality**: Can be used as both an autonomous switch and a regular multiplug socket.
- **Low Cost**: Designed to be highly affordable, aligning with the low cost of dry irons.

11.1.3 Marketing Channels

- **Social Media Advertising:** Advertise in social medias like Facebook and Instagram.
- **YouTube Demonstrations**: Short videos showcasing the product's automatic shutoff feature.

11.2 Sales Strategy

A simple and accessible sales strategy has been planned to introduce the product to the market and gradually scale its distribution. The product will be sold directly at local markets and online through platforms such as Daraz. It will be offered at an affordable price, targeted within the range of Rs. 1300–1500 LKR, with discounts available for bulk purchases or multiple units. A three-month warranty will be provided, and a simple user manual will be included with each unit to guide users through installation and operation.

11.3 Beyond – Future Development

As a future development, we plan to integrate the device directly into the dry iron, making it more convenient and user-friendly. Additionally, a feature will be introduced to allow users to select the automatic switch-off time based on their preferences. Furthermore, the device will be integrated with a mobile application, enabling remote control and real-time notifications, thereby enhancing usability and safety.

12. Task allocation

Name	Task Allocation
W.U. Deshan – 230130E	Assembling, Enclosure Design, Select components
K.T.G.T.N. Dhananjaya – 230138K	Assembling, CAD Design, Enclosure Testing
D.M.D.P. Dissanayaka - 230155J	Microcontroller Programming, Schematic and PCB Design, Soldering
U. Saruka - 230585C	Prototype Testing, Sensor integration and testing, Debug hardware and firmware.