Multi-Functional Smart Switchboard

A Project Report Submitted by

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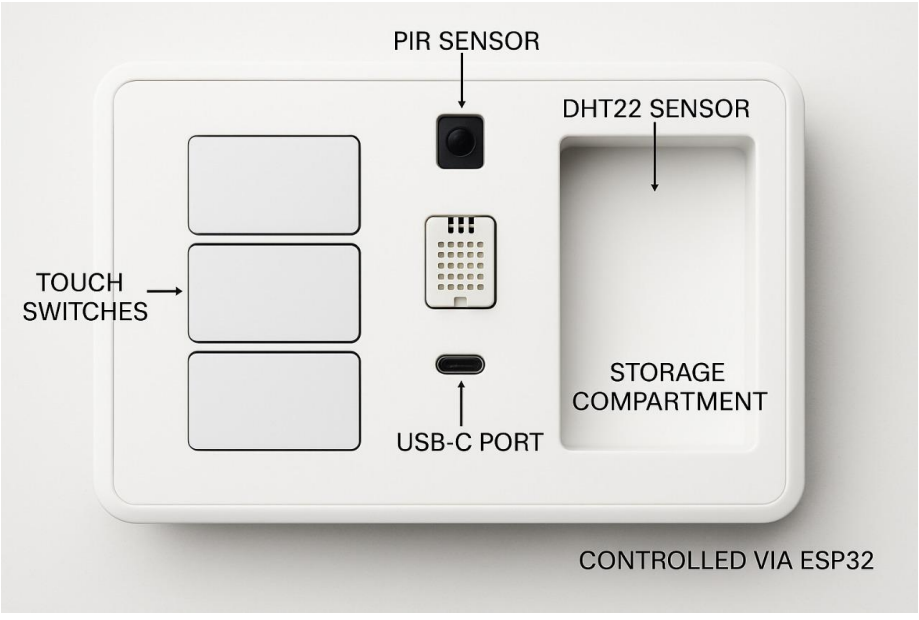
ABSTRACT

The integration of smart technologies into household systems has become increasingly important in enhancing convenience, safety, and energy efficiency. Traditional switchboards, while functional, lack the intelligence and adaptability required to meet modern lifestyle needs.

In response to these limitations, this project presents a Smart Switchboard equipped with IoT capabilities, machine learning-based fan control, and user-friendly features aimed at improving day-to-day home interaction. The system includes touch-sensitive switches, motion detection, and an inbuilt storage space for keys or mobile devices, catering to both utility and smart organization.

A key highlight is the ML-powered fan speed regulation, which adjusts speed based on environmental or user preferences. Additionally, the inclusion of a USB-C charging slot (with a built-in adapter) eliminates the need for external chargers. Through IoT connectivity, the switchboard can be monitored and controlled remotely, offering real-time updates and automation options.

Designed with affordability, modularity, and ease of use in mind, the Smart Switchboard represents a significant step toward intelligent and personalized home systems. This project aims to contribute to the evolution of smart living by offering a practical, innovative, and accessible solution for modern households.



ABBREVIATIONS

- IoT – Internet of Things
- ML – Machine Learning
- USB – Universal Serial Bus
- Wi-Fi – Wireless Fidelity
- ESP32 – Espressif Systems 32-bit Microcontroller
- LED – Light Emitting Diode
- DC – Direct Current
- PCB – Printed Circuit Board
- ADC – Analog to Digital Converter
- BOM – Bill of Materials
- TA – Teaching Assistant
- CAD – Computer-Aided Design
- C-Type – USB Type-C Charging Port
- IR – Infrared Sensor
- MCU – Microcontroller Unit

1. INTRODUCTION

1.1 Problem Statement

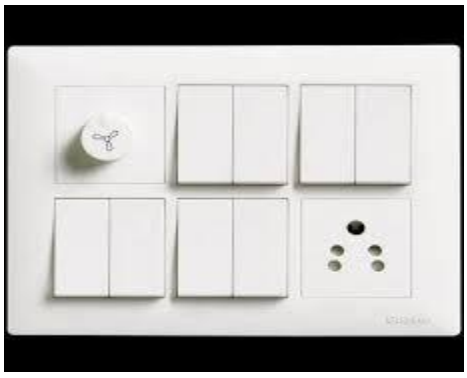
In today's rapidly evolving world, homes are becoming smarter, yet many traditional electrical systems, like switchboards, remain outdated and lack intelligent features. Conventional switchboards offer basic functionality but fall short in areas such as user convenience, energy optimization, and remote accessibility.

Modern households demand advanced solutions that integrate technology for enhanced usability, safety, and automation. There is a growing need for smart switchboards that go beyond just turning devices on or off — solutions that can learn user preferences, optimize power usage, and offer remote monitoring and control through the Internet of Things (IoT).

This project aims to address these needs by developing a Smart Switchboard that incorporates touch-sensitive controls, motion detection, ML-based fan speed regulation, and an inbuilt mobile/key storage unit. A C-type charging port with a built-in adapter also eliminates the dependency on external chargers.

By leveraging ESP32, sensor modules, and wireless communication, the switchboard allows for seamless automation and control via smartphones or other smart devices. It ensures greater accessibility, safety, and convenience while keeping the system cost-effective and energy-efficient.

Ultimately, this project seeks to enhance everyday living through smart technology, making home automation more inclusive, user-friendly, and adaptable to modern lifestyles.



1.2. Motivation

The motivation behind developing the **Smart Switchboard** arises from the increasing demand for smarter, safer, and more user-friendly electrical control systems in modern households. Traditional switchboards lack intelligence, remote access, and adaptability, making them inefficient for today's dynamic lifestyle needs. With the integration of **IoT**, **machine learning**, and **sensor technology**, this project aims to transform a basic utility into a **multi-functional, intelligent hub** for home control.

This switchboard is designed to not only automate everyday electrical functions but also enhance safety, convenience, and energy efficiency. Key features such as **touch-sensitive buttons**, **ML-based fan speed regulation**, **motion detection**, and **a built-in mobile/key storage unit** directly address the practical concerns of everyday users. Moreover, the inclusion of **real-time control through Wi-Fi**, and **a Type-C charging port with an inbuilt adapter** aims to simplify daily tasks and reduce the need for external devices.

The key motivating factors include:

1. **Affordability of the product**
2. **Ease of use and intuitive interface**
3. **Compact and ergonomic design**
4. **Real-time remote monitoring and control via IoT**
5. **Multi-functionality: fan control, charging, storage, and motion detection**
6. **Customizable touch-based interaction**
7. **Smart environment responsiveness (via motion sensing and ML)**

8. **Support for future integration with smart home assistants**

9. **“Find My Device” feature for locating lost keys or mobiles stored in the unit**

This project envisions a future where everyday electrical controls are no longer static but smart, adaptable, and personalized to each user’s lifestyle.

1.3. Objective

The primary objective of this project is to design and develop a **Smart Switchboard** that enhances the functionality, safety, and convenience of traditional electrical switchboards by integrating **IoT**, **machine learning**, and **sensor-based automation**. This smart system aims to provide users with real-time control, intelligent fan regulation, and added utility features such as built-in storage and universal charging, all within a compact and user-friendly design.

The switchboard is intended to support both **manual and wireless control**, allowing users to operate electrical appliances locally or remotely through a mobile device. By incorporating touch-sensitive interfaces, motion detection, and automated fan speed regulation, the system promotes **energy efficiency** and **ease of use**, especially in modern smart homes.

The application will primarily focus on assisting users in the following tasks:

1. **Touch-Based Operation:** Replace mechanical switches with smooth, touch-sensitive controls.

2. **Real-Time Monitoring & Control:** Enable IoT-based control of lights, fans, and appliances via mobile apps.

3. **ML-Based Fan Speed Regulation:** Automatically adjust fan speed based on ambient conditions or usage patterns.

4. **Motion Detection:** Automatically turn on lights or alert users upon detecting movement.

5. **Device Charging:** Provide a **Type-C charging port** with an inbuilt adapter for mobile devices.

6. **Find My Device Feature:** Locate stored keys or mobile using a buzzer trigger from the app.

7. **Inbuilt Storage:** Secure space for keeping essentials like keys or phones while charging.

8. **Compact and Aesthetic Design:** Designed to be sleek, space-saving, and modern.

Ultimately, this project strives to transform the way users interact with electrical systems by making homes smarter, safer, and more responsive to user needs.

2. LITERATURE SURVEY

There are several research papers and studies focused on home automation, smart energy systems, and the integration of Internet of Things (IoT) into household electrical infrastructure. These works span across areas such as energy efficiency, safety in electrical systems, user experience in smart homes, and intelligent fan or appliance control.

2.1. Challenges in Traditional Switchboards

Ramesh B. and Santhosh K. (2019) conducted a study titled *"Design of IoT-Based Home Automation System"*, where they discussed the limitations of conventional switchboards in adapting to dynamic user needs and the lack of remote access. Their work highlighted the growing need for

intelligent systems that could be accessed remotely, especially for the elderly or physically challenged users.

Anitha Devi et al. (2021) presented research on *"Touch-Controlled Smart Switch Using Arduino and IoT"*. The study focused on developing a cost-effective touch switchboard that allows users to operate devices wirelessly. However, the scope was limited to switching functionality and lacked multifunctional integration such as charging modules or storage features.

Pradeep Yadav and Arvind Kumar (2022) reviewed *"Smart Home Automation using ESP32"*, emphasizing the role of Wi-Fi-enabled microcontrollers for energy management. Their work introduced real-time appliance monitoring and control through a mobile interface. While comprehensive in connectivity, their system lacked mechanical design integration and support for embedded storage or ML-based control.

These papers underline a common trend: existing smart switchboards are often limited in features, user convenience, or scalability. Most designs don’t provide all-in-one solutions that blend **aesthetics**, **multi-functionality**, and **machine intelligence**. Furthermore, very few systems incorporate **storage units**, **fan speed automation**, or **"Find My Device"** functionalities—highlighting a gap your project aims to bridge.

2.2. Limitations of Conventional Switchboards and Home Electrical Systems

In traditional home environments, conventional switchboards come with several limitations that affect **user convenience**, **safety**, and **technological adaptability**. Here are some of the core challenges that inspired the development of our Smart Switchboard system:

1. **Manual Operation Only**: Traditional switchboards require physical access to turn on/off devices, which is inconvenient for the elderly,

people with disabilities, or users with limited mobility.

2. **No Remote Access or Monitoring**: These systems offer no way to monitor or control appliances remotely, limiting the potential for energy management and real-time decision-making.

3. **Lack of Intelligent Control**: Fan speed, lighting, and power consumption cannot be automatically adjusted based on user behavior or environmental changes, reducing comfort and efficiency.

4. **No Integration with Modern Charging Standards**: Most switchboards do not support modern USB or Type-C charging ports, requiring additional adapters and cluttering the space.

5. **No Feedback or Notifications**: Conventional systems provide no real-time feedback (e.g., motion alerts, usage status), which could otherwise help in smart energy consumption and home security.

6. **No Personalization or Regional Language Support**: There's no option to give feedback in regional languages or tailor functionality based on user preferences.

7. **Missing Location Awareness**: Losing or forgetting portable devices (like the smart stick/remote controller) can be frustrating. Traditional systems don’t include any kind of "Find My Device" functionality.

8. **No Storage Utility**: Users often have to carry extra holders or organizers for mobile phones, chargers, or keys while using a switchboard area. Conventional setups lack built-in storage or holding compartments.

This project addresses all the above limitations by creating a **compact, intelligent, multifunctional switchboard** that integrates **IoT**, **ML**, **touch**,

and **design innovations** to improve usability, comfort, and overall home automation experience.

3. Gaps in Existing Solutions

Despite the advancements in home automation and electrical systems, current solutions still fall short in addressing the needs of modern users, especially in terms of **smart functionality, accessibility, and user-friendliness**. Some of the key limitations of existing systems are:

1. **Lack of Intelligent Fan Control**: Traditional switchboards offer fixed-speed or manual control fans. Even existing smart switches rarely use ML-based systems that adjust fan speed based on room conditions or user habits.

2. **No Integrated Charging Options**: Users are required to use external adaptors or power bricks for Type-C devices. This clutters the space and increases dependency on multiple outlets.

3. **Absence of Storage Utility**: Conventional switchboards don’t account for user behavior like placing a phone or keys nearby while charging. This creates a missed opportunity for ergonomic and convenient design.

4. **Limited Feedback and Sensing**: There’s no mechanism to provide real-time alerts, motion detection, or touch-sensitive operations in most available switchboards.

5. **No Personalization or Accessibility Features**: Features like regional language feedback, gesture recognition, or adaptive brightness/sound are rarely integrated, making the system less inclusive for diverse users.

6. **High Cost of Existing Smart Switches**: Commercially available smart home systems are often expensive and require professional

installation, making them inaccessible to middle-class homes or student prototypes.

4. Our Solution to the Problems

Our **Smart Switchboard** is a **cost-effective, multi-functional, and user-centric innovation** designed to overcome the above limitations. Key enhancements in our solution include:

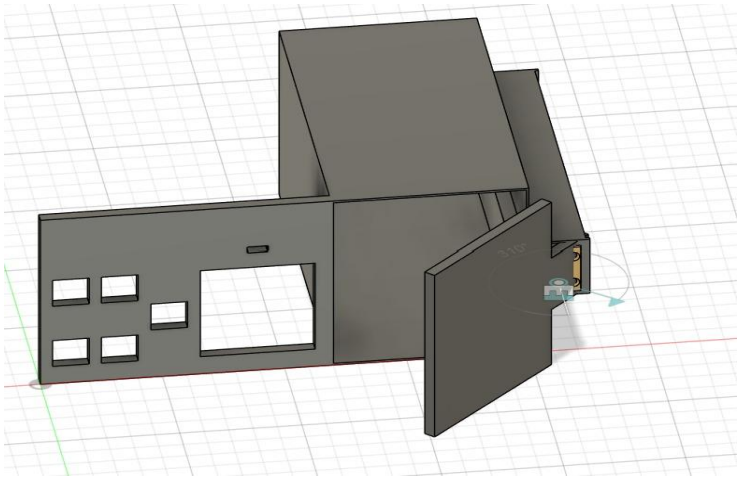
1. **ML-Based Fan Speed Regulation**: Our switchboard uses machine learning to regulate fan speed automatically based on temperature, time of day, or user preference patterns—providing intelligent climate control.

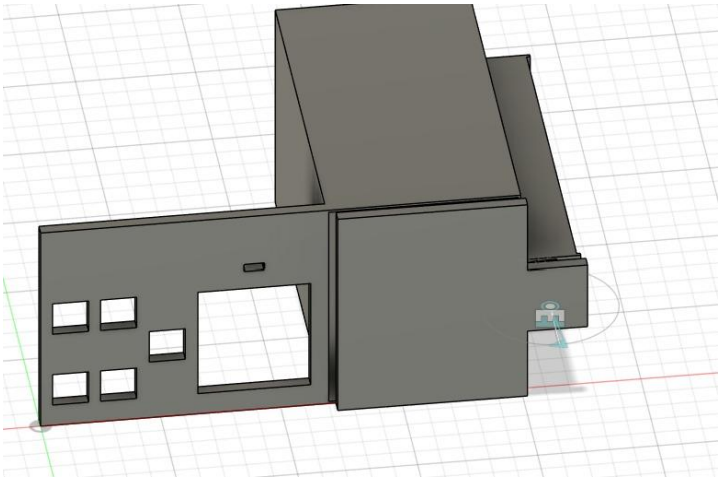
2. **In-Built Type-C Charging Port**: The board includes a Type-C female slot with an internal adapter, allowing users to charge their phones without needing external bricks, saving space and improving efficiency.

3. **Integrated Storage Module**: A compact slot within the board allows users to place their phones or keys safely while charging—combining utility with design aesthetics.

4. **Touch-Sensitive Interface with Motion Detection**: Touch buttons replace traditional mechanical switches, while an IR motion sensor detects user presence for smart lighting or alert features.

5. **Compact and Modular Design**: The entire system is designed to be lightweight, easy to install, and customizable for different environments like homes, hostels, or small offices.





5. Products in the Market:

Currently, there are several smart switchboards and home automation systems available, such as **Wipro Smart Switches**, **Anchor by Panasonic Smart Panels**, and **Schneider Electric's ZENcelo series**. These products offer features like app-based control, voice assistant integration (Google/Alexa), and energy monitoring. However, **they often lack additional user-centric features such as built-in storage**, personalized ML control for fan speed, motion detection, or Type-C mobile charging without an adapter.

Moreover, **most of these systems are costly and complex to install**, making them less suitable for public infrastructure like railway stations or hostels where simplicity, durability, and fast utility access are required. Our solution bridges these gaps with a multifunctional, budget-friendly, and modular design.

6. Methodology:

1. **Design Conceptualization:**
   The project began with defining the core objectives of the **Smart**

Switchboard, such as **fan speed regulation using ML**, **touch-sensitive switches**, **motion detection**, and a **direct Type-C mobile charging port**. The design also includes a **built-in storage compartment** for keys or mobiles while charging. These features were selected to improve everyday convenience in both homes and public spaces like **railway stations** with minor changes.

2. **Material Selection:**
   We used **Acrylic Sheet** for the entire switchboard body, including the outer casing and internal storage compartment, it was chosen due to its ease of cutting, lightweight nature, and strength, making it ideal for custom prototypes and rapid modifications.

3. **Component Integration:**
   The following key hardware components were embedded into the design:

   - **ESP32 microcontroller** – manages all input/output and runs ML models for fan speed control.
   - **DHT11/22 Temperature Sensor** – monitors room temperature to assist in intelligent fan speed regulation.
   - **Touch Sensors** – replace conventional mechanical switches, offering a modern, sleek interface.
   - **PIR Motion Sensor** – detects human motion to automate lighting or fan control.
   - **Type-C Charging Port** – allows direct mobile charging without an adapter, especially useful in public places like railway stations where passengers may only carry a cable.

This methodology ensures the switchboard is user-friendly, innovative, and adaptable for both home and public installations.

7. Development of Electronic System

The **Smart Switchboard** integrates modern sensors, user-friendly interfaces, and smart control logic to enhance daily usability and automation. This section outlines the core components used and their integration within the system:

1. Microcontroller Unit

The entire system is controlled using an **ESP32** microcontroller, which processes sensor inputs, manages the logic for fan speed regulation using temperature data, handles touch inputs, and communicates with other modules. It acts as the brain of the switchboard.

2. Temperature-Based Fan Control

To enable intelligent fan speed regulation:

- **Sensor Used:** DHT22
- **Function:** Measures ambient **temperature** and **humidity** to help adjust fan speed using a trained **Machine Learning model** running on the microcontroller or connected module.

3. Motion Detection System

- **Sensor Used:** PIR (Passive Infrared) Sensor

- **Function:** Detects human motion in front of the switchboard to automatically trigger lights or display indicators, enhancing energy efficiency and user comfort.

4. Touch-Sensitive Switching

- **Component Used:** Capacitive Touch Sensors

- **Function:** Replaces traditional physical switches with **touch-based controls** for fan, light, and other appliances, giving the board a modern and sleek look.

5. USB Type-C Charging Port

- **Component Used:** USB Type-B to Type-C breakout board

- **Function:** Provides **direct charging** for mobile phones using a **Type-C port** without requiring an external adapter. Especially useful in **public places like railway stations**, where passengers may only carry a cable.

6. Power Supply

- **Component Used:** SMPS (Switched-Mode Power Supply)

- **Function:** Converts AC mains to required DC voltage levels for all components and modules, ensuring **safe and efficient power**

delivery across the system.

This modular and scalable design not only simplifies regular switchboard operations but also integrates modern smart features like automation, motion sensing, and efficient power usage.

8.Bill of materials:

Components	Functionality	Cost
PIR Motion sensor	Motion Detection	60
ESP32	All functionalities (central controller)	400
DHT22 Sensor	Fan Regulation (Temperature/Humidity)	121
USB Type A break down	USB-A Charging	60
SMPS Power Supply	Power Supply	232
Touch Sensiive Switch Modules	Touch-based Control	50
Jumper Wires	Used for electrical connections.	190
	Total	1113

10. Future Enhancements

As part of the continuous innovation and development roadmap for the Smart Switchboard, several future enhancements are envisioned to improve performance, usability, and user experience:

1. Implementation of Decision Trees for Smart Control Logic

Currently, device control is based on simple conditional (if-else) statements. In future versions, we plan to incorporate Decision Tree algorithms for more dynamic and intelligent decision-making. This will allow the switchboard to learn from sensor data (temperature, motion,

usage history) and make optimized control decisions tailored to user behavior and environmental conditions.

2. Addition of Radium Stickers for Low-Light Usability

To increase the usability during nighttime or in low-light environments, radium stickers will be added around key areas such as touch points and charging ports. This ensures easier identification and operation without needing external lighting.

3. CAD Model Optimization

The CAD model will be refined to improve space efficiency and aesthetic appeal. Enhancements will include:

- Better internal arrangement of components (e.g., power supply, sensors, and wiring)
- Sleeker external design
- Modular design features to allow easy upgrades or maintenance

4. Enhanced Mobile Charging Support

While the current design includes a 5V Type-C charging port, future versions will feature fast-charging support (e.g., 9V or 12V output) to cater to modern mobile devices. This will make the system even more practical for high-traffic public areas like railway stations or bus stands.

These enhancements aim to make the Smart Switchboard not just a prototype, but a scalable, user-centric, and intelligent solution ready for real-world applications.

11. Conclusion

In conclusion, the development of the **Smart Switchboard** marks a forward-thinking innovation in enhancing everyday electrical infrastructure, especially in public and semi-public environments like **railway stations**. Powered by the **ESP32 microcontroller**, the system brings together intelligent features such as **touch-sensitive controls**, **motion detection using a PIR sensor**, **environment monitoring via DHT22**, and **fast mobile charging through a USB Type-C port**—eliminating the need for separate charging adapters.

One of the standout features is the built-in **storage compartment** for keeping essentials like mobile phones or keys during charging, improving organization and usability. The ESP32 enables **wireless connectivity** and future expansion possibilities like **app-based control**, **OTA (Over-The-Air) updates**, or **IoT integration**.

Additionally, the use of an **SMPS power supply** ensures reliable and efficient power delivery across all components, while the inclusion of safety and user-friendly elements like **radium stickers** and **modular design via Fusion 360 CAD modeling** further enhances the practicality of the system.

Looking ahead, the project aims to incorporate **Decision Tree algorithms** to enable dynamic control logic, optimize power usage, and personalize user interactions based on sensor data. Enhancements in **CAD design**, **charging speed**, and **user visibility** are also part of the innovation pipeline.

Ultimately, the Smart Switchboard demonstrates how modern embedded systems and thoughtful engineering can converge to build smarter, safer, and more user-friendly solutions for both home and public utility applications.