Innovative Journal for Opportunities and Development in Science & Technology,
Volume 6, Issue 5, April 2026
Paper Id: – IJ2026V6I5 -2 A-E
ISSN 2582-6026

SMART SWITCH BOARD

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ABSTRACT - An sophisticated electrical control system called the Smart Switch Board was created to increase the efficiency, safety, and convenience of using office and home equipment. Switches in conventional electrical systems are manually manipulated, which may be time-consuming, inconvenient, and even dangerous. People frequently neglect to turn off equipment, which leads to wasteful power use and higher electricity costs. By offering a cutting-edge solution that enables customers to effectively and remotely manage appliances using wireless technology, the Smart Switch Board initiative seeks to get around these restrictions. A Wi-Fi-capable microcontroller is used in the system's architecture and serves as its primary controller. In order to operate connected appliances, it accepts orders via a mobile application and executes them. Relay modules are utilized as electronic switching device that allows the controller to turn appliances ON or OFF safely. The system also includes a regulated power supply to ensure proper functioning of all components. Additional components such as indicator LEDs, driver circuits, and manual switches are included to improve system performance and reliability. The Smart Switch Board enables users to control multiple appliances such as lights, fans, and other electrical devices using a smartphone. The wireless communication feature allows users to operate appliances from any location with internet connectivity. This feature improves user convenience and reduces manual effort. Additionally, the system provides better safety by reducing direct contact with electrical switches. This minimizes the risk of electrical hazards and improves system reliability. Another important feature of the Smart Switch Board is energy efficiency. The system allows users to monitor and control appliances remotely, helping to reduce unnecessary power consumption. If a user forgets to switch off appliances, they can easily turn them off remotely using the mobile application. This helps in reducing electricity consumption and lowers energy costs. The system is also flexible and scalable, allowing additional appliances to be integrated without major modifications.

Keywords: Smart Switch Board, Wi-Fi Control, Relay Module, Smart Home, Energy Efficiency, Remote Control, IoT, Home Automation, ESP8266, Wireless Communication

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I. INTRODUCTION

The Smart Switch Board is a cutting-edge home automation system created to enhance modern homes' energy efficiency, safety, and convenience. Traditional electrical switchboards are changing into intelligent systems that can operate remotely and be automated thanks to the Internet of Things' (IoT) explosive expansion. Through wireless connection and mobile-based control, the suggested smart switch board allows users to operate electrical equipment in the home, including lights, fans, and other gadgets. By utilizing internet connectivity, this technology minimizes human labor and enables customers to control their household appliances from any location.

The paper is built around a Wi-Fi-enabled microcontroller that acts as the central processing unit of the system. It receives commands from a mobile application as well as from a wireless remote control, providing multiple control options for the user. The integration of cloud-based communication ensures that the system remains accessible even when the user is not physically present near the switchboard. This flexibility makes the smart switch board highly suitable for homes, offices, classrooms, and industrial environments. In this system, switching operations are performed using relay modules connected to electrical appliances. These relays function as electronically controlled switches that allow low-voltage control signals to operate high-voltage devices safely. A driver circuit is used to amplify control signals and ensure proper functioning of the relays. This design enhances the reliability of the system and protects the control unit from electrical disturbances. Each relay is assigned to a specific appliance, allowing independent control and operation.

II. OBJECTIVES

How To Create a Smart Switch Board System with Intelligence

- To Make Electrical Appliance Remote Control Possible
- To Cut Down on Energy Use
- To Boost User Comfort and Convenience
- To Make Electrical Systems Safer
- To Effectively Manage Several Appliances

III. SYSTEM OVERVIEW

The Smart Switch Board system is a cutting-edge technology that uses an infrared remote and a mobile application to operate electrical appliances. To effectively operate appliances like lights and fans, the system combines wireless transmission, microcontroller processing, and relay switching. The Blynk mobile app, internet access, ESP8266 NodeMCU, IR receiver, IR remote, driving circuit, relay modules, and electrical appliances are the primary parts.

The working of the system begins when the user sends a command through the mobile application. This command is transmitted via the internet to the microcontroller. The ESP8266 NodeMCU receives the command and processes it to control the connected appliances. The microcontroller then sends output signals through its GPIO pins to the driver circuit.

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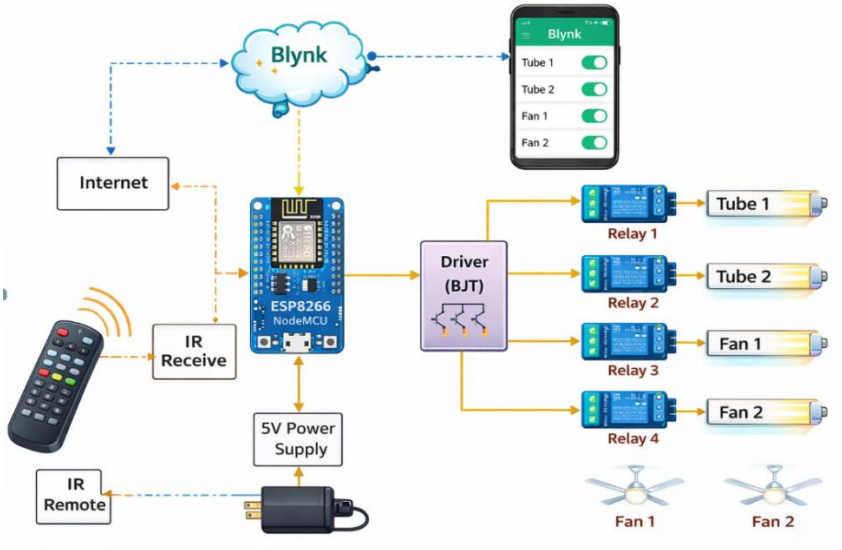

Fig.1- Proposed System

The IR remote provides an alternative control method. When a button is pressed, the IR receiver detects the signal and sends it to the NodeMCU. The controller decodes the signal and activates the required relay.

The driver circuit amplifies the signal using transistors, allowing relays to operate efficiently. The relay modules act as switches that control high-voltage appliances. A regulated 5V power supply provides stable voltage to ensure reliable system operation.

HARDWARE COMPONENTS

- **ESP8266 Microcontroller**

The ESP8266 plays a crucial role in the Smart Switch Board project as the main Wi-Fi communication module and controller. It enables wireless control of electrical appliances through a smartphone, web server, or IoT platform. The ESP8266 connects to the local Wi-Fi network and allows users to send commands remotely. When a user presses a button on the mobile application or web interface, the signal is transmitted over the internet and received by the ESP8266 module. The ESP8266 processes the received command and sends output signals to the relay module, which switches the connected appliances ON or OFF accordingly.

In the Smart Switch Board, the ESP8266 is programmed using Arduino IDE or similar software. The module continuously monitors incoming data from the Wi-Fi network. Once it receives a command, it checks the instruction and activates the corresponding GPIO pin. These GPIO pins are connected to relay channels that control devices like lights, fans, and other electrical appliances. When the GPIO pin goes HIGH or LOW, the relay switches the connected load. This enables users to control multiple appliances from anywhere using their smartphone.

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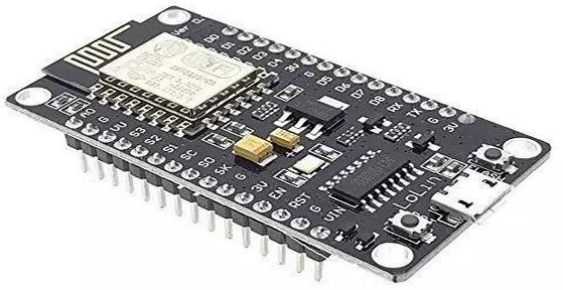

Fig.2- ESP8266 Microcontroller

- **4-Channel Relay Module**

The 4-Channel Relay Module plays an important role in the Smart Switch Board project by acting as an interface between the low-voltage control circuit and high-voltage electrical appliances. Since microcontrollers such as ESP8266 operate at low voltage levels (3.3V or 5V), they cannot directly control high-voltage devices like lights, fans, or home appliances. The 4-Channel Relay Module solves this problem by using electromagnetic relays that safely switch high-voltage loads using low-voltage signals from the controller.

In the Smart Switch Board, the ESP8266 sends control signals to the relay module through its GPIO pins. Each relay channel is connected to one GPIO pin of the ESP8266. When a user sends a command through a mobile application or web interface, the ESP8266 receives the signal and activates the corresponding relay channel. When the relay receives a HIGH or LOW signal (depending on module type), the electromagnetic coil inside the relay gets energized. This causes the relay contacts to change position, turning the connected appliance ON or OFF. Each relay channel has three main terminals: Common (COM), Normally Open (NO), and Normally Closed (NC). When the relay is not activated, the COM terminal is connected to NC. When the relay is activated, COM switches to NO, allowing current to flow through the connected appliance. This switching mechanism allows safe and efficient control of multiple electrical devices.

Fig. 3-Channel Relay Module

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- **IR Receiver Module**

The IR Receiver Module plays an important role in the Smart Switch Board project by enabling wireless control of electrical appliances using an infrared remote control. This module receives infrared signals transmitted from a remote and converts them into digital signals that can be processed by the microcontroller such as the ESP8266. This allows users to control lights, fans, and other appliances without physically touching the switchboard, improving convenience and accessibility.

Fig.4- IR Receiver Module

In the Smart Switch Board system, the IR receiver module is connected to the ESP8266 microcontroller through a digital input pin. When a user presses a button on the IR remote control, the remote sends infrared signals in the form of encoded pulses. These pulses are transmitted through infrared light, which is invisible to the human eye. The IR receiver module detects these signals using a photodiode sensor. The module then demodulates and converts the received signals into digital output pulses.

The ESP8266 continuously monitors the output pin of the IR receiver module. When a signal is received, the ESP8266 reads the encoded data and identifies which button was pressed on the remote. Based on the programmed instructions, the ESP8266 activates the corresponding relay channel. For example, pressing button "1" on the remote may turn ON a light, while pressing button "2" may turn OFF a fan. This process allows quick and efficient control of multiple appliances

- **Manual Switches**

Manual switches play an important role in the Smart Switch Board project by providing direct physical control of electrical appliances. Although the system is designed for smart control using Wi-Fi, mobile applications, or IR remote, manual switches act as a backup control method. This ensures that users can operate appliances even when internet connectivity fails, the microcontroller stops working, or the smartphone is unavailable. Manual switches improve system reliability and provide flexibility for users.

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Fig.4- Servo Motor

Manual switches play an important role in the Smart Switch Board project by providing direct physical control of electrical appliances. Although the system is designed for smart control using Wi-Fi, mobile applications, or IR remote, manual switches act as a backup control method. This ensures that users can operate appliances even when internet connectivity fails, the microcontroller stops working, or the smartphone is unavailable. Manual switches improve system reliability and provide flexibility for users.

IV. WORKING PRINCIPLE

Relay-based switching, microcontroller processing, and wireless connection form the foundation of the Smart Switch Board's operation. Using a remote control or a mobile application, the system enables users to operate electrical equipment like fans and lights. The ESP8266 NodeMCU is the system's central controller, processing orders to operate appliances.
A command sent by the user via the Blynk mobile application is sent to the ESP8266 NodeMCU via the internet. After processing the command, the microcontroller uses its GPIO pins to deliver output signals. The driver circuit receives these signals and uses them to turn on the relay module. The linked appliances are turned ON or OFF by the relay, which functions as an electrical switch.The system also supports manual control using an IR remote. When a button is pressed on the remote, the IR receiver detects the signal and sends it to the microcontroller. The controller decodes the signal and activates the appropriate relay. A regulated power supply ensures stable voltage for proper system operation, making the Smart Switch Board efficient, reliable, and user-friendly.

Circuit Diagram:

The Smart Switch Board system shown in the previous PCB diagram is an IoT-based home automation solution built around the ESP8266 NodeMCU microcontroller. The overall working of the system is based on wireless control through the Blynk platform as well as manual control using an IR remote. The ESP8266 acts as the central processing unit, receiving commands from both the internet (via Wi-Fi) and the IR receiver, processing them, and controlling electrical appliances through a relay driver circuit.

The ESP8266 NodeMCU is powered using a regulated 5V DC power supply connected through a DC jack. Internally, the NodeMCU operates at 3.3V, and it contains a built-in voltage regulator to step down the 5V input. It features GPIO pins that are used for interfacing with external components. In this system, multiple GPIO pins are connected to the base of BJT transistors (driver circuit), which in turn control the relay module. The ESP8266 has an operating voltage of 3.3V, Wi-Fi, and a clock speed of 80–160 MHz, making it suitable for IoT applications.

The IR receiver module is connected to one of the digital GPIO pins of the ESP8266. It typically

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operates at 3.3V or 5V and is used to receive infrared signals from a remote control. When a button on the IR remote is pressed, the receiver decodes the signal and sends a corresponding digital signal to the ESP8266. The microcontroller interprets this signal and triggers the appropriate output, allowing local control of appliances without internet connectivity

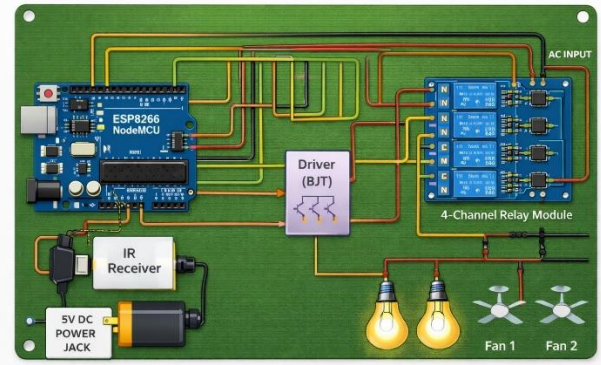

Fig.5- Cicuit Diagram

The AC load section consists of two tube lights and two fans. The live wire from the AC supply is connected to the COM terminal of each relay, and the NO terminal is connected to the respective appliance. The neutral wire is directly connected to all appliances. When a relay is activated, it completes the circuit, turning ON the appliance. This ensures electrical isolation between the low-voltage control circuit and high-voltage AC supply, enhancing safety. The system also integrates with the Blynk mobile application, which allows users to control appliances remotely via the internet. The ESP8266 connects to a Wi-Fi network and communicates with the Blynk cloud server using an authentication token. When the user toggles a switch on the mobile app, a command is sent to the ESP8266, which then activates or deactivates the corresponding relay. This enables real-time control from anywhere.

In terms of overall working, when power is supplied, the ESP8266 initializes and connects to the Wi-Fi network. It continuously monitors inputs from both the Blynk app and the IR receiver. Based on the received command, it sends control signals to the respective GPIO pins. These signals are amplified by the BJT driver circuit and used to energize the relay coils, thereby controlling the connected appliances.

Flow Chart of the System:

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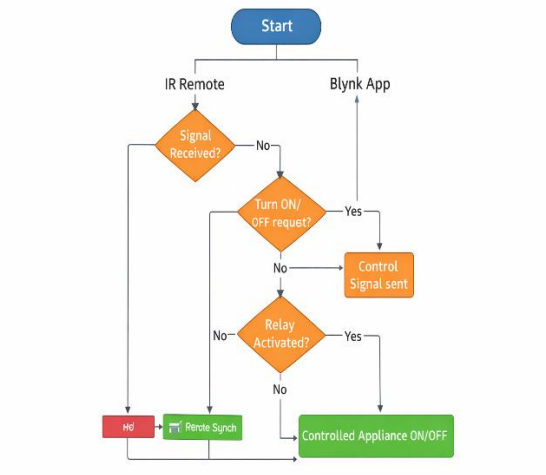

Fig.6- Flow Chart of the proposed system

The Smart Switch Board project's flow chart explains how to use an IR remote and the Blynk mobile app to manage household appliances using yes/no decision-making. From initialization to appliance control, the system operates in a logical order. Below is a Yes/No explanation of how the flow chart operates.

Start is the first step in the procedure, during which the ESP8266 NodeMCU, relay module, IR receiver, Wi-Fi connection, and power supply are all initialized. The controller looks for input sources when the system is turned on. The Blynk App and IR Remote are the two input sources that are accessible. Following startup, the system determines if the IR remote has sent a signal. The initial group of decisions

asks "Signal Received?" If Yes, the system proceeds to the next step to identify the command sent from the remote. If No, the system waits for another input and also checks the Blynk App for control commands.

If the signal is received from the IR remote, the system then checks whether it is a valid command. This leads to the next decision block "Turn ON/OFF request?" If Yes, the controller identifies which appliance is selected such as Tube Light 1, Tube Light 2, Fan 1, or Fan 2. If No, the system ignores the signal and returns to standby mode waiting for another command.

When the system receives a valid ON/OFF request, the ESP8266 sends a control signal to the relay driver circuit. This signal is passed through the transistor driver (BJT) which amplifies the signal and activates the corresponding relay channel. After sending the command, the system checks the next decision block "Relay Activated?"

If Yes, the relay switches ON or OFF the selected appliance. The appliance such as light or fan gets controlled accordingly. After successful switching, the system updates the status and shows the output as "Controlled Appliance ON/OFF". This confirms successful execution of the command.

If No, it means the relay did not activate properly. In this case, the system checks for synchronization. It moves to Remote Sync block where the controller attempts to resynchronize the control signal and relay operation. This ensures reliable operation and prevents incorrect switching. Simultaneously, the system also supports control through the Blynk App. The flow chart shows another input path from

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the Blynk application.

Experimental Set up

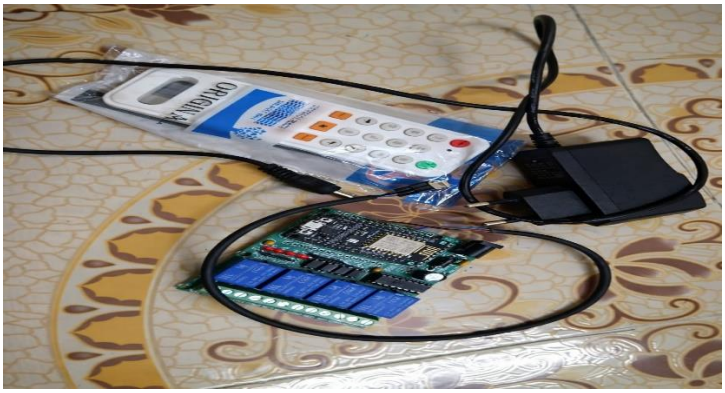

Fig.7- Experimental Set up

V. RESULT AND DISCUSSION

The Smart Switch Board project's picture performance and results utilizing the Blynk mobile application interface. The Blynk app dashboard with toggle switches for managing devices like Tube 1, Tube 2, Fan 1, and Fan 2 is seen on a smartphone in the image's middle. This shows that the system's user-friendly interface enables real-time ON/OFF management of several electrical equipment. The Remote Monitoring section emphasizes that customers may utilize the internet to view the current status of linked devices from any location. Because users are not obliged to be physically present close to the switchboard, this guarantees flexibility and ease. Every instruction supplied from the application is verified to be correctly performed and reflected in the system by the Control Verification section.

The Reliable Connectivity portion emphasizes that the system maintains a stable and continuous connection between the Blynk app and the ESP8266 NodeMCU. This is crucial for uninterrupted operation and quick response to user inputs. Meanwhile, the User-Friendly Interface section shows that the application is simple, intuitive, and easy to operate, even for non-technical users.Overall, the image demonstrates that the Smart Switch Board project successfully integrates IoT technology with the Blynk platform, providing efficient remote control, accurate performance, and a seamless user experience. The results show that solar power generation increases from morning to afternoon, reaching maximum output around midday. The battery voltage increases during charging and provides stable power to the ESP32 microcontroller and relay modules. The system maintained high efficiency (around 85–90%), ensuring reliable operation of home appliances controlled through the IoT platform.

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Fig.8- Result Analysis

VI. CONCLUSION

The Smart Switch Board idea offers a cutting-edge and effective way to use smart technology to regulate electrical appliances. To offer dependable and adaptable control, the system incorporates essential parts such the ESP8266 Wi-Fi module, relay module, IR receiver, manual switches, and regulated power supply. The system is comfortable and easy to use since users may operate appliances remotely using manual switches, an IR remote, or a mobile application. By enabling users to efficiently monitor and regulate appliances, the initiative increases energy efficiency. It lowers wasteful power use and contributes to reduced electricity bills. The use of manual switches guarantees system dependability even in the absence of internet access. The relay module securely regulates high-voltage appliances, while the ESP8266 manages communication and processing. This Smart Switch Board is cost-effective, easy to install, and suitable for homes, offices, hospitals, and industries. It also offers future expansion possibilities such as voice control and sensor-based automation. In conclusion, the Smart Switch Board enhances convenience, safety, and efficiency, making it a practical and innovative solution for modern smart home automation systems.

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