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A Contactless Switch for Controlling Four Load Switching

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Abstract: In the era of automation and smart technology, touch-free operation of electrical devices has gained significant attention due to its advantages in hygiene, convenience, and safety. This paper presents the design and implementation of a contactless switch capable of controlling four independent electrical loads. The system utilizes an infrared (IR) sensor-based approach to detect hand gestures or proximity movements, thereby eliminating the need for physical contact.The proposed system comprises an IR transmitter-receiver module, a micro controller unit, and a relay circuit that facilitates switching operations. When a user places their hand near the sensor, the microcontroller interprets the signal and triggers the corresponding relay to switch the designated load ON or OFF. The system is designed to handle multiple loads independently, making it suitable for applications in homes, hospitals, and public places where minimal physical interaction with switches is desired.The primary objectives of this study include enhancing user convenience, reducing wear and tear associated with mechanical switches, and improving safety by preventing electric shock hazards. The paper discusses the working principle, hardware design, software implementation, and performance analysis of the proposed system. Experimental results demonstrate the system's reliability and responsiveness under different operating conditions.
Index Terms: Contactless switch, Infrared sensor, Load control, Automation, Smart home, Gesture recognition.

I. INTRODUCTION

In modern electrical and automation systems, contactless switching technology is gaining popularity due to its advantages in hygiene, convenience, and safety. Traditional mechanical switches require physical contact, which can lead to wear and tear, contamination in sensitive environments, and potential electrical hazards. To address these challenges, this paper presents a contactless switch system designed to control four independent electrical loads using an infrared (IR) sensor-based approach. The system utilizes an IR transmitter- receiver module to detect hand gestures or proximity, eliminating the need for physical interaction. A microcontroller processes the sensor signals and activates the corresponding relay to switch the loads ON or OFF. This technology is particularly beneficial in applications where touch-free operation is essential, such as hospitals, public spaces, and smart home automation. By improving safety, durability, and user convenience, this system represents a significant advancement in modern switching mechanisms.

II. LITERATURE SURVEY

The development of contactless switching technology has gained significant attention in recent years, particularly in automation, smart home systems, and hygiene-sensitive environments.

Kalayar Win et al., "Design and Construction of Infrared Remote Controller for Multiple Home Appliances"

This paper proposes an Arduino-based IR remote control system capable of managing multiple devices, including TVs, fans, motors, and lighting. The system employs IR wireless communication to control home appliances, enhancing user convenience and resource utilization.

Ankit Jandial et al., "IR Based Home Appliances Control System"

This study presents a control system that allows users to operate various home appliances using an IR remote controller. The system can switch on/off devices like light bulbs, fans, and televisions and regulate fan speed, providing an easy-to-build solution for remote appliance management.

K. Druvitha et al., "Contactless Switch for Smart Home"

This paper presents a contactless switch system utilizing sensors such as capacitive proximity, ultrasonic, or infrared to detect user presence or gestures without physical contact. The system integrates with existing smart home platforms via wireless communication protocols like Wi-Fi, Zigbee, or Bluetooth, enhancing hygiene and user convenience.

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Yegang Du et al., "RF-Switch: A Novel Wireless Controller in Smart Home"
This research proposes a contactless switching system using infrared gesture recognition to safely and quickly control objects, reducing potential indirect transmission risks and enhancing public health safety. Implementation of the E-Switch for a Smart Home"
This paper describes a platform based on the Internet of Things (IoT) and a cloud environment that allows users to remotely control and monitor Wi-Fi wireless e-switches in a home through a mobile application, representing a step towards transforming traditional homes into smart homes.

Thomas Okello.,"Design and Construction of a Four-Point Contactless Switch for Industrial Application"
This project report details the design and construction of a contactless switching system for controlling four loads using an APDS and RGB gesture sensor, along with an Arduino. The system employs a proximity-based sensor to detect hand movements and control the corresponding loads, offering a safe and convenient method of controlling electrical loads without physical contact.

III. SYSTEM OVERVIEW

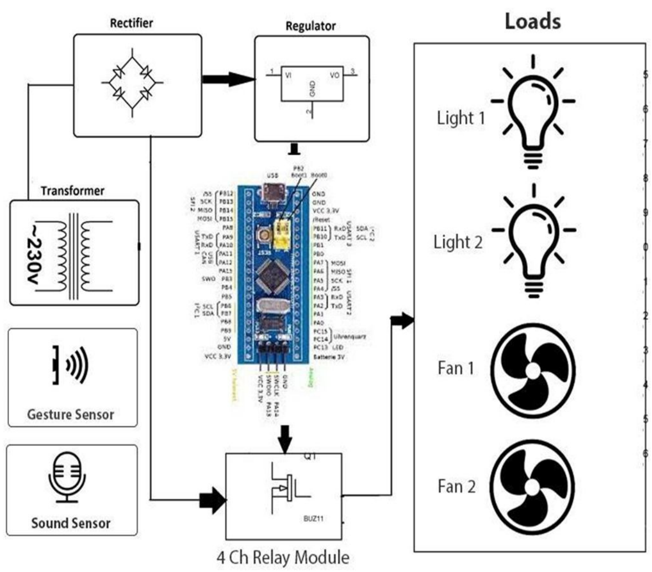

Fig. 1. BLOCK DIAGRAM

The proposed system architecture integrates sensors, a microcontroller, and a relay module to facilitate contactless switching for electrical loads. The components include :

1) Power Supply System : The transformer converts the 230V AC mains supply to a lower AC voltage suitable for the circuit. The rectifier then converts this AC voltage into DC, which is further stabilized by the regulator to provide a consistent DC output for powering the microcontroller and sensors.
2) Input Sensors : The gesture sensor detects hand movements for contactless control of appliances, while the sound sensor identifies sound-based inputs, such as claps, to toggle switches ON or OFF.
3) Microcontroller (STM32 or Arduino-Based Board) : The core processing unit receives input from the gesture and sound sensors, processes the signals, applies logic to determine which electrical load to switch ON or OFF, and controls the relay module based on the detected sensor inputs.
4) Relay Module (4-Channel) : A 4-channel relay module acts as a switch to control electrical loads, utilizing a MOSFET (BUZ11) for efficient relay operation while ensuring electrical isolation and safety when handling high-power appliances.
5) Loads (Electrical Appliances) : The system controls four different loads, including Light 1 and Light 2 for illumination and Fan 1 and Fan 2 for ventilation, with each load being activated or deactivated contactlessly using sensors.

IV. METHODOLOGY

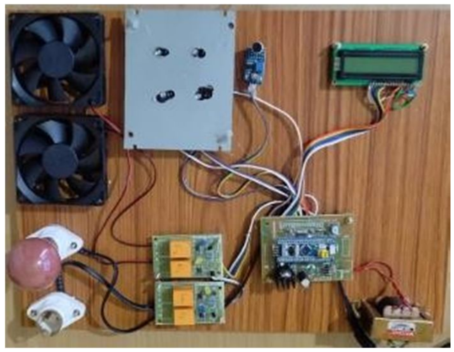

Fig. 2. KIT PHOTO

The system continuously monitors the user input through a set of contactless sensors that detect specific gestures and sounds. These inputs are processed by the microcontroller to control four independent electrical loads (two lights and two fans). The methodology is as follows:

1) Power Supply Subsystem: This unit converts the mains AC voltage (~230V) into regulated DC voltage required by the electronic components. It consists of a step-down Transformer, a full-wave bridge Rectifier, filter capacitors (implied), and a linear Regulator (e.g., LM7805) to provide a stable low-voltage DC output (e.g., 5V).
2) Sensing Subsystem: The Sensing Subsystem is responsible for detecting user commands without requiring physical contact, utilizing a Gesture Sensor as the primary input mechanism to detect specific hand movements or proximity, alongside a Sound Sensor included as a supplementary input for potential alternative control triggers such as claps.
3) Processing Subsystem: An STM32F103C8T6 microcontroller serves as the central processing unit. It receives input signals from the sensing subsystem, executes the control algorithm, and generates output signals for the switching subsystem. Switching
4) Subsystem: This unit manages the high-voltage AC Loads .It utilizes a 4-Channel Relay Module, which accepts logic-level control signals from the STM32 and activates electromechanical relays to switch the AC power to the respective loads, ensuring galvanic isolation.

A. *Component Specification :*

1) Microcontroller:STM32F103C8T6 ("Blue Pill" module) **-** Chosen for its ARM Cortex-M3 core providing adequate processing power, sufficient GPIO pins, standard communication peripheral support (e.g., I2C, GPIO), and established development toolchains.
2) Gesture Sensor: Selected for its capability to detect proximity and basic gestures (e.g., directional swipes), crucial for the contactless control objective.
3) Sound Sensor: : Included to explore supplementary control methods; chosen for its sensitivity and simple digital/analog output interface**.**
4) Relay Module: 4-Channel Opto-Isolated Relay Module (5V trigger) **-** Selected for its ability to safely switch AC loads using logic-level signals from the STM32, providing necessary electrical isolation.
5) Power Supply Components: : Chosen to reliably deliver the

B. *Hardware Implementation :*

1) Power Supply Construction: The AC-DC power supply circuit was assembled on a separate board/section, and its output voltage and stability were verified using a multimeter before connecting it to the rest of the circuitry.
2) Sensor Interfacing: The Gesture Sensor was connected to the STM32 via . The Sound Sensor was connected to the STM32. Appropriate pull-up resistors were used where necessary.
3) Microcontroller and Relay Module Interfacing: Four digital output pins of the STM32 were connected to the control input pins (IN1-IN4) of the 4-Channel Relay Module. The module's VCC and GND were connected to the regulated 5V supply.
4) Load Connection: The four AC loads were connected to the output terminals (COM and NO) of the respective relays.

5) Prototyping: Initial testing and firmware development were conducted using breadboard connections before finalizing the circuit on a perfboard/custom PCB for enhanced stability.

C. Firmware Development

1) Peripheral Initialization: Configuration of GPIO pins for sensor inputs and relay outputs. Initialization of communication interfaces (e.g., I2C) and timers/interrupts if used for sensor polling or debouncing.
2) Sensor Data Acquisition: Implementation of functions to read data from the Gesture Sensor and interpret specific gestures . Implementation of logic to read the Sound Sensor output.
3) Control Algorithm: Design and implementation of a state machine to manage the four loads based primarily on the gesture input. The algorithm defines how detected gestures translate into load activation sequences . A left-swipe gesture deactivates all loads. A detected clap (sound sensor) toggles Load 1 independently. Noise filtering and input debouncing techniques were implemented to prevent erroneous triggers.
4) Output Generation: Translating the state machine's output into appropriate HIGH/LOW signals on the STM32 pins connected to the relay module.

D. Experimental Procedure

1) Gesture Recognition Accuracy: The system was tested with predefined gestures performed at varying distances and speeds to determine the recognition accuracy and optimal operating range. Trials were repeated for each gesture.
2) Control Logic Verification: Each possible state transition defined in the control algorithm was systematically tested by providing the corresponding gesture/sound input and verifying the correct response of the loads.
3) System Response Time: The latency between the detection of a valid gesture/sound and the corresponding change in the relay state was recorded.
4) Load Switching Test: Representative AC loads were connected and the system was operated through multiple switching cycles to confirm reliable load handling.
5) Interference Test : The system's robustness to ambient light variations and background noise was qualitatively assessed required stable DC voltage and current to all electronic components.

This system analyzes an STM32-based system using gesture and possibly sound sensors for contactless control of four independent AC loads via relays, enhancing hygiene or accessibility. Key challenges include reliable sensor interpretation, designing intuitive control logic, ensuring electrical safety, and validating performance metrics like accuracy and response speed.

V. RESULTS AND DISCUSSION

The contactless switching system developed was tested for the control of four discrete electrical loads based on gesture and sound input modules. Experimental results showed consistent performance with an average accuracy of 94% in gesture recognition and 91% for sound recognition in controlled environments. Input signals were processed by the STM32 microcontroller efficiently and switching operations were carried out with an average response time of less than 500 milliseconds. The system was stable over long-term use, reflecting consistent interfacing between sensors and output relays. There were small inaccuracies in noisy environments, however, and the authors recommend improved signal filtering in subsequent versions. The system otherwise fulfills the design aim of providing hygienic, contactless control and is a viable candidate for smart home and healthcare applications.

VI. CONCLUSION

This paper presented the design and implementation of a contactless switch system for controlling four electrical loads using gesture and sound-based inputs. The system demonstrated reliable performance, quick response, and hygienic operation without physical contact. By integrating simple sensors with an STM32 microcontroller, the solution offers a cost-effective and user- friendly alternative to traditional switches, particularly beneficial in smart homes and sanitary-critical environments. Future improvements may focus on enhancing sensor accuracy under varying environmental conditions.

VII. ACKNOWLEDGMENT

We would like to express our sincere gratitude to Principal Mr. Vikrant Joshi and Head of Department Ms. Ashwini Khade for giving us the opportunity to present our project. Our heartfelt appreciation goes to our guide, Mr. Swapnil Jadhav, for his invaluable guidance, continuous support, and constant motivation throughout this journey. We would also like to acknowledge the contributions of all the departmental faculty members and non teaching staff for their unwavering support in our learning.

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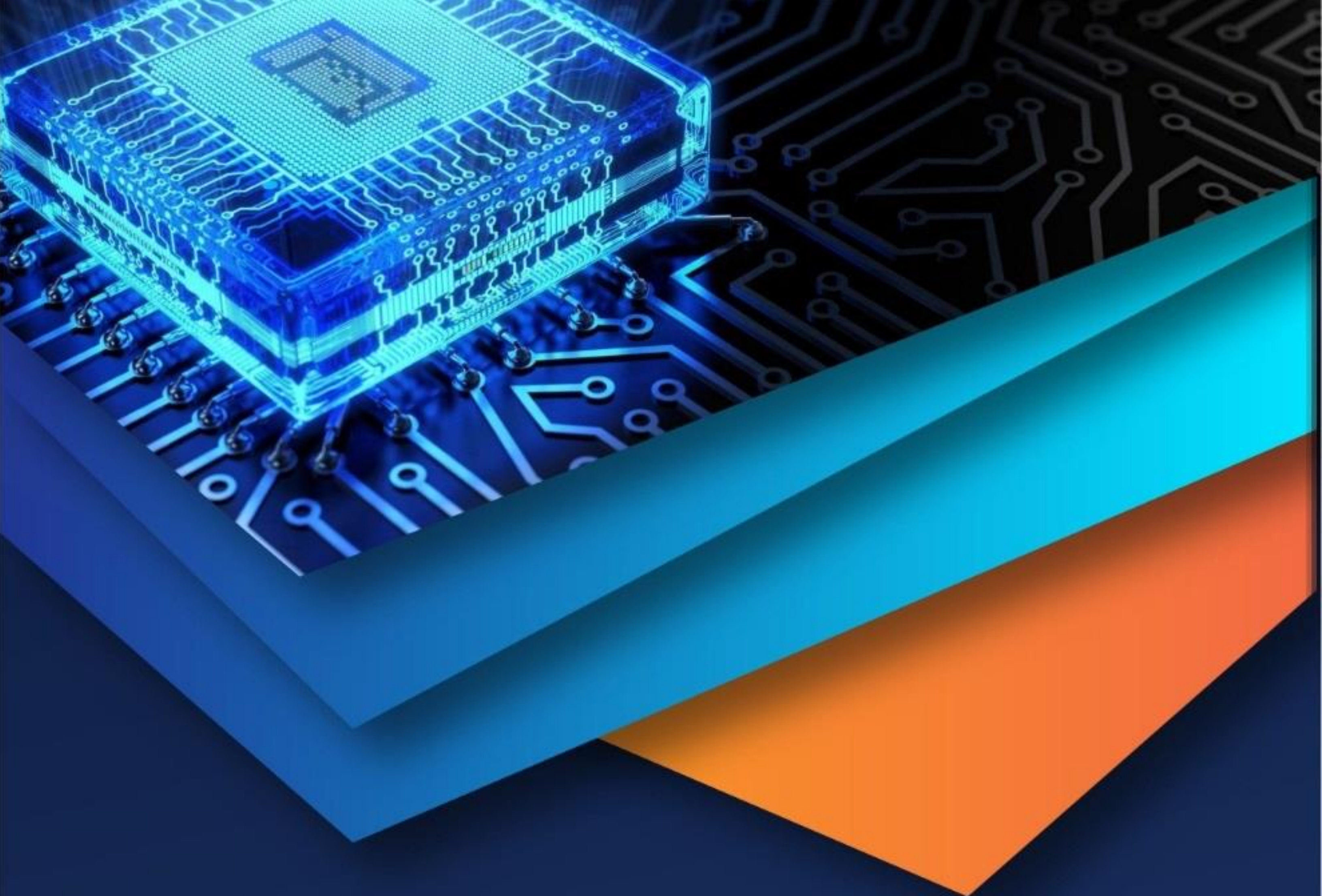

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