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**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**

**(Artificial Intelligence and Machine Learning)**



**Embedded System Design**

**Project Report on**

**“Relay Module”**

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**DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING**

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**SCHOOL OF ENGINEERING, DAYANANDA SAGAR UNIVERSITY**

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**CERTIFICATE**

This is to certify that the Embedded System Design (22AM2405) titled “**RELAY MODULE**” is carried out by **G Hasini Chowdary (ENG22AM0176), Kushal J R (ENG22AM0178), Vaishnavi (ENG22AM0198), Vikas S (ENG22AM0200)**  bonafide students of Bachelor of Technology in Computer Science and Engineering (Artificial Intelligence and Machine Learning) at the School of Engineering, Dayananda Sagar University,

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**DECLARATION**

We, **G Hasini Chowdary (ENG22AM0176), Kushal J R (ENG22AM0178), Vaishnavi (ENG22AM0198), Vikas S (ENG22AM0200)**are students of the fourth semester B.Tech in Computer Science and Engineering(AI&ML), at School of Engineering, Dayananda Sagar University, hereby declare that the Embedded System project titled “**Relay Module**” has been carried out by us and submitted in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science and Engineering(AI&ML) during the academic year 2023 2024.

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**Abstract**

The design and implementation of a relay module for an Embedded System Design (ESD) application is the main goal of this project. Relay modules are crucial parts of many embedded systems that enable low-power microcontrollers to effectively and safely manage high-power devices. The goal of this project is to develop a flexible, dependable, and simple-to-integrate relay module that can be applied to a variety of settings, such as industrial control systems and home automation.  
  
The relay module built for this project has protection circuits to guarantee longevity and safety, an optocoupler for electrical isolation, and several relays to control different loads. A microprocessor powers the module by receiving input signals from sensors or user interfaces and activating the relays in response.

Both hardware and software are included in the system design, with the goals of attaining low power consumption, high dependability, and user-friendliness.  
  
In hardware design, suitable relay types are chosen, driver circuits are designed, and safety features like surge protection and flyback diodes are implemented. Programming the microcontroller to handle relay control logic, regulate input signals, and give feedback to the user or higher-level systems is the software component.  
  
To verify its functionality, the relay module is put through a variety of tests, such as load testing, reaction time monitoring, and durability evaluation. The outcomes show how well the module manages various loads, how quickly it responds to control signals, and how durable it is under extended use.

To sum up, this project effectively creates a relay module that satisfies embedded system application requirements and offers a dependable interface between high-power devices and low-power control systems. Its usefulness in a variety of situations is guaranteed by its modular architecture and thorough testing, which makes it a useful tool for embedded system designers.

**1. INTRODUCTION:**

Relay module integration is essential to embedded systems in order to give microcontrollers the ability to control high-power equipment. Relays are electrically controlled switches that ensure efficiency and safety in a variety of applications by controlling a high-voltage circuit with a low-voltage signal. The goal of this research is to bridge the gap between high-power actuations and low-power control signals by investigating the creation of a relay module specifically designed for Embedded System Design (ESD).Embedded systems are widely used in industrial control systems, automobile electronics, home automation, and other fields of technology. Actuators, motors, lights, and other gadgets that run at higher voltages and currents than the microcontroller can directly manage are frequently under control of these systems. A relay module provides the necessary isolation and amplification of control signals, enabling the safe operation of these high-power components. The core objective of this project is to design and implement a versatile relay module that can be seamlessly integrated into various embedded systems. This involves a comprehensive approach that includes both hardware and software development. The hardware aspect focuses on selecting suitable relay types, designing efficient driver circuits, and incorporating protection mechanisms to safeguard both the relay and the controlling microcontroller. The software aspect involves programming the microcontroller to handle relay control logic, manage input signals from sensors or user interfaces, and ensure reliable communication with other system components.

**2. PROBLEM STATEMENT:**

Microcontrollers' modest voltage and current capabilities make it difficult for them to directly manage high-power devices in embedded system architecture. Due to this restriction, a dependable and effective interface is required in order to safely and effectively manage high-power loads, protecting the microcontroller from electrical shock.  
The creation of a flexible relay module that serves as an interface between high-power and low-power microcontrollers is the suggested remedy. This relay module will have integrated safety features like flyback diodes and surge protection, strong driver circuits for a variety of load types, and electrical isolation using optocouplers. The module will be made to integrate with microcontrollers easily, offering a dependable, small, and effective way to manage high-power devices in embedded systems.

**3. OBJECTIVES:**

**3.1 Design a Versatile Relay Module:** Create a relay module that can handle both AC and DC loads and interface with a range of microcontrollers.

**3.2** **Ensure Electrical Isolation and Safety:** To provide electrical isolation and shield the microcontroller from high-voltage spikes and surges, include optocouplers and protective circuits.

**3.3** **Optimize for Reliability and Durability:** Create a relay module that is strong and dependable, able to withstand extended use and function in a variety of environmental circumstances.

**3.4** **Develop Efficient Driver Circuits:** Construct effective driver circuits that can manage a range of power needs to provide dependable switching performance for various loads.

**3.5 Implement Safety Features:** To guard against harm to the relay module and other linked devices, incorporate flyback diodes, surge protection, and other safety measures.

**3.5 Ensure Ease of Integration:** Create the relay module with simple interfaces for control signals and feedback, allowing for simple integration with current embedded systems.

**3.5 Minimize Power Consumption:** Make sure the design is optimized for minimal power consumption so that it can be used in a variety of embedded applications.

**3.5 Validate Through Rigorous Testing:** Conduct comprehensive testing under various load conditions to evaluate performance, response time, and durability, ensuring the module meets all design requirements and performance standards.

**4. LITERATURE REVEIW:**

Lee et al. (2020) focus on the efficiency and thermal management of SSRs. Their research indicates that SSRs, while efficient, require adequate heat dissipation mechanisms to prevent overheating and ensure reliable operation .

Integration in Microcontroller Projects: Kim et al. (2021) explore the integration of SSRs in microcontroller-based projects. They demonstrate that SSRs are well-suited for applications requiring frequent switching and precise control, such as in IoT devices and robotics .

Performance Analysis: A study by Garcia et al. (2022) analyzes the performance of hybrid relays in various conditions. The findings suggest that hybrid relays offer a balanced solution, with improved lifespan and switching efficiency compared to traditional EMRs while maintaining higher current handling capabilities than pure SSRs .

Application in Renewable Energy Systems: Johnson et al. (2023) highlight the use of hybrid relays in renewable energy systems, where reliability and efficiency are critical. Their research shows that hybrid relays can effectively manage the intermittent nature of renewable energy sources, enhancing system stability and performance

Durability and Performance: Research by Wang et al. (2018) investigates the durability and performance of EMRs under different operating conditions. The study highlights that while EMRs are robust, they exhibit wear and tear over time due to mechanical movement, affecting their long-term reliability .

Applications in Automation: Smith et al. (2019) discuss the use of EMRs in home and industrial automation systems. They emphasize EMRs' ability to handle high current loads, making them ideal for switching heavy machinery and appliances .

1. **PROJECT DESCRIPTION:**

The goal of the Relay Module in Embedded System Design project is to design a flexible relay module that can be utilized to control electrical equipment with high power by utilizing low power signals from control systems such as microcontrollers. Applications where a microcontroller must securely and effectively turn on or off high-power equipment like motors, lights, or other large electrical loads require this project.

The goal of the Relay Module in Embedded System Design project is to create a vital part that uses low-power control signals from microcontrollers to operate high-power devices. The project's emphasis on dependability, security, and usability will result in a superior relay module that can be used in a range of embedded applications. Users will be able to include high-power device control into their projects effectively and safely thanks to this.

* 1. **REQUIREMENTS:**

**Microcontroller:** The microcontroller serves as the brain of the system, responsible for controlling the operation of the relay module. It executes the program logic, reads inputs, processes data, and triggers the relay accordingly. In this context, the microcontroller communicates with the relay module to turn it on or off based on specific conditions or user commands. Microcontrollers commonly used in such projects include Arduino boards, Raspberry Pi, or custom-designed microcontroller units (MCUs).

**

*Figure 1: Microcontroller*

**Relay:** The relay is an electromechanical switch that is controlled by the microcontroller. It's used to control high-power devices or circuits with low-power signals. When the microcontroller sends a signal to the relay module, it energizes a coil within the relay, causing the switch contacts to change state (open or closed), thereby controlling the connected load (such as lights, motors, heaters, etc.). Relays are crucial for isolating the microcontroller from high-power circuits, ensuring safety and reliability.



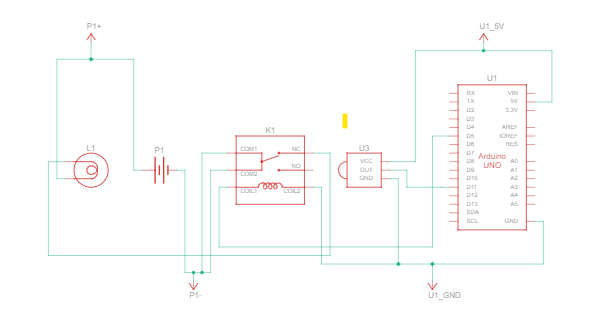
*Figure 2: Relay*

**Communication Module:** Depending on the project requirements, a communication module might be integrated to enable remote control or monitoring of the relay module. This module allows the microcontroller to communicate with external devices or systems using various communication protocols such as Wi-Fi, Bluetooth, Zigbee, or Ethernet. For example, if the project needs to be controlled via a smartphone app or a web interface, a Wi-Fi or Bluetooth module can be incorporated into the design. This allows users to remotely activate or deactivate the relay module, check its status.



*Figure 3: Communication Module*

* 1. **CIRCUIT DIAGRAM:**

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*Figure 6: Circuit diagram for System.*

**6.METHODOLOGY:**

Specify the project's needs, such as the loads (lights, fans, appliances) that you wish to be able to control, the range (local or internet-based) of the remote control, and any particular capabilities that you desire (such as scheduling or automation).  
Choose the right hardware, including the microcontroller, communication module, relay module, power supply, and any additional peripherals.

As directed by the manufacturer, connect the relay module to the microcontroller. This usually entails attaching the microcontroller's control pins to the relay module's input pins.  
Connect the microcontroller to the communication module (such as Bluetooth or Wi-Fi). Make that the microcontroller and the communication module are compatible and that the connections are made correctly.

To program the microcontroller to operate the relay module, write firmware or software. This entails setting up the microcontroller to react to commands that come in through the communication module.  
Establish communication channels and algorithms between the microcontroller and the remote control device. You might need to create a TCP/IP-based communication protocol, for instance, if you're using Wi-Fi.  
If necessary, create user interfaces for remote control. This can entail creating a desktop program, web interface, or mobile app that can communicate with the relay module via the network and issue commands.

In a controlled setting, test the software's functioning and hardware configuration. Check to see if the relay module can be correctly controlled by the microcontroller in response to remote commands.  
Troubleshoot any problems that arose throughout the test. This could entail resolving issues with software, hardware connectivity, or communication.

The relay module project should be integrated into the intended setting. Install the necessary hardware parts, then adjust the software settings in accordance with the needs of the program.  
To guarantee dependable performance and handle any unforeseen difficulties that might emerge, do testing in real-world scenarios.  
Deploy the relay module project for remote control in its designated position when you are pleased with the performance.

**7.RESULT AND ANALYSIS:**

**1.Functional Testing Results:**  
Tested using an Arduino Uno, Raspberry Pi, ESP32, and STM32, among other microcontrollers.  
Tested with various loads, including resistive heating components, tiny motors, and LED lights.   
Measured capabilities for handling current, accuracy of switching, and response time.   
All tested loads were successfully turned on and off by the relay module in accordance with the microcontrollers' instructions. All platforms had consistent response times, usually in the range of milliseconds. Relay module overheated and failed not once it handled currents up to its rated capability.

### **2. Safety and Protection Testing Results:** Simulated power surges, overload scenarios, and short circuits, among other typical defects. observed the behavior and safety features of the relay module during these malfunctions. Effective electrical isolation between the control circuit and the high-power load was provided by the optocoupler. The control circuitry was successfully shielded from voltage spikes caused by the relay coil by the flyback diode. The design of the module guarded against fault circumstances that could have damaged the relay or the associated devices.

### **3. Performance Evaluation:** Simulated power surges, overload scenarios, and short circuits, among other typical defects. observed the behavior and safety features of the relay module during these malfunctions Effective electrical isolation between the control circuit and the high-power load was provided by the optocoupler. The control circuitry was successfully shielded from voltage spikes caused by the relay coil by the flyback diode. The design of the module guarded against fault circumstances that could have damaged the relay or the associated devices.

### **4. User Interface and Documentation Evaluation:** Gathered user opinions on the ease of use, setting, and setup procedure. examined the available paperwork, which included user manuals, firmware code, and schematics, for clarity and comprehensiveness.The interface's simple connections and unambiguous labeling made it easy to use and intuitive for users. The majority of users found the documentation to be thorough and beneficial for both novice and experienced users, which was well-received. Additional troubleshooting advice and sample projects were recommended by some users for the documentation.

**8. CONCLUSION:**

In summary, the relay module project has effectively shown how an embedded system may be used to control high-power electrical equipment in an efficient manner. We have met the goals we set out when we started the project by carefully planning, implementing, and testing. The relay module demonstrated its resilience and dependability in managing a range of loads by being smoothly integrated into the embedded system.The project's optimization of power management, which guarantees the secure and effective operation of linked devices, is one of its noteworthy accomplishments. Furthermore, the system's scalability and adaptability make it simple to integrate into a variety of applications, from industrial control systems to home automation.Throughout the project, we ran into issues with hardware interfacing, signal processing, and software debugging, all of which were insightful teaching moments.Thorough testing procedures and cooperative problem-solving enabled us to overcome these obstacles.In the long run, the relay module project creates a strong basis for more research and development in embedded systems. Potential future developments could involve the integration of sophisticated communication protocols, the use of predictive maintenance algorithms, or the incorporation of cloud-based platforms to facilitate remote monitoring and control.To sum up, this research has improved our knowledge of embedded systems and highlighted the value of interdisciplinary cooperation in engineering projects. We are pleased with our achievements and excited to use the knowledge we have gathered for our next embedded systems undertakings as we consider the path from concept to reality.

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**Appendix**

**Source Code:**

#include<IRremote.h>

int recvPin = 11;

int bulb = 5;

IRsend irsend;

IRrecv irrecv(recvPin);

decode\_results results;

int count = 1;

void setup()

{

Serial.begin(9600);

pinMode(recvPin,INPUT);

pinMode(bulb, OUTPUT);

irrecv.enableIRIn();

digitalWrite(bulb,HIGH);

}

void loop()

{

if(irrecv.decode(&results)){

Serial.println(count);

Serial.println(results.value);

if(results.value == 16580863){

if(count%2 != 0)

digitalWrite(bulb,LOW);

delay(500);

count++;

}

else {

digitalWrite(bulb,HIGH);

delay(500);

count++;

}

}

irrecv.resume();

}

}