WWJMRD 2025; 11(02): 61-67
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor SJIF 2017: 5.182 2018: 5.51, (ISI) 2020-2021: 1.361
E-ISSN: 2454-6615

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Smart Door False Trigger Protection from Long Wire Outdoor Switch Using Galvanic Isolator (PC817) And RC Network

Sudip Chakraborty, Deep Chakraborty

Abstract
Smart home security systems increasingly integrate advanced automation solutions to enhance safety and reliability. However, outdoor switches with long wiring can introduce false triggers due to environmental interference, electrical noise, and leakage currents. This paper presents a novel approach to mitigating false triggering in smart doors using a Galvanic Isolator (PC817) and an RC Network. The proposed system effectively isolates and filters unintended signals, ensuring robust and accurate door activation. The PC817 optocoupler prevents direct electrical coupling between the outdoor switch and the control circuit, while the RC network filters transient voltage spikes. Experimental validation demonstrates a significant reduction in false triggering incidents, improving the reliability of the smart door mechanism. This work contributes to advancing secure and stable smart home automation solutions.

Keywords: Smart Door, False Trigger Protection, Galvanic Isolation, PC817 Optocoupler, RC Network, Home Automation, Security Systems.

Introduction
Smart home automation has seen significant advancements in recent years, with smart door systems playing a crucial role in enhancing security and convenience. Automated doors, often controlled by microcontrollers and IoT-based solutions, provide seamless access control, remote monitoring, and intelligent operation. However, one of the persistent challenges in smart door systems is the occurrence of false triggering due to long outdoor switch wiring. External switches connected through extended wiring are susceptible to electrical noise, interference, and leakage currents, leading to unintended door activations, compromising security and system reliability.

In conventional smart door setups, the direct electrical connection between the control circuit and the outdoor switch exposes the system to transient disturbances and electromagnetic interference (EMI). Environmental factors such as voltage fluctuations, induced currents, and capacitive coupling further increase the risk of false triggering. To address this issue, Galvanic Isolation and noise filtering techniques are crucial for ensuring secure and accurate switch activation.

This paper proposes an innovative approach to false trigger protection by integrating a Galvanic Isolator (PC817 optocoupler) and an RC Network into the smart door control system. The PC817 optocoupler provides complete electrical isolation between the switch and the microcontroller, preventing unwanted signal interference. Additionally, the RC network serves as a low-pass filter, attenuating high-frequency noise and suppressing transient voltage spikes. By combining these two techniques, the proposed system significantly enhances the reliability of the smart door mechanism, reducing erroneous activations and improving operational efficiency. This study builds upon previous research on smart door automation, which primarily focused on motor control, PWM-based speed regulation, and secure access mechanisms. By addressing the false triggering problem, this work contributes to the development of more stable, secure, and efficient smart home security systems. The remainder of this paper discusses the design methodology, implementation details, experimental analysis, and performance evaluation of the proposed false trigger protection system.

Literature Review

The development of smart door automation has gained significant attention, particularly with the integration of Arduino-based control systems, IoT security mechanisms, motor driver efficiency, and false trigger protection techniques. Arduino Mega 2560 has been widely recognized for its robust processing capabilities and multiple I/O ports, making it a preferred choice for smart door automation (Arduino, 2023). Research by Paul and Saha (2022) highlights its effectiveness in wireless smart home automation, while Lim and Wong (2023) demonstrate its application in secure RFID-based access control. Furthermore, Bose (2022) presents an IoT-based smart door locking system incorporating security alerts, enhancing user awareness in case of unauthorized access. One of the persistent challenges in smart doors is false triggering, particularly when using long wire outdoor switches, which are prone to electrical noise and transient interference. Kumar and Bose (2022) propose the use of optocoupler-based galvanic isolation, preventing unwanted noise from interfering with the control circuit. Similarly, Patel and Brown (2021) emphasize the role of RC networks in filtering transient voltage spikes, thereby reducing false triggers and improving reliability. The use of PC817 optocouplers and RC networks, as explored in various studies, has shown significant promise in stabilizing smart door mechanisms by eliminating unwanted activations.

Efficient motor control is another crucial factor in smart door automation. The Cytron MDD10A motor driver, known for its high-power efficiency and bidirectional control, is widely used in embedded automation (Cytron Technologies, 2023). Gupta and Singh (2023) conducted a comparative study of motor drivers in smart home applications, concluding that PWM-based speed regulation enhances motor efficiency and ensures smooth operation. Tan and Lim (2021) further reinforce the importance of PWM speed control, demonstrating its effectiveness in DC motor stabilization and power optimization for automated doors. These findings align with Sharma and Gupta (2021), who implemented PID controllers for Arduino-based DC motor control, achieving more precise and stable movement. Wireless and Bluetooth-enabled access control has also been extensively studied to enhance remote-controlled smart doors. Jones and Patel (2020) explored Bluetooth-based door access, allowing smartphone-controlled operations. Rahman and Alam (2022) introduced an IoT-based automatic door-locking system using a DC motor, providing remote access through mobile applications. Additionally, Khan and Patel (2023) discuss biometric authentication and mobile app integration, demonstrating how these technologies significantly improve security and usability in modern smart home environments.

Software-based automation plays a pivotal role in ensuring efficient data communication and control mechanisms. Chakraborty and Aithal (2023) propose an MVVM-based software architecture to enhance IoT application scalability and modularity, while their study on Modbus Data Providers enables seamless sensor-to-controller data exchange in industrial and home automation (Chakraborty & Aithal, 2023). These frameworks contribute to more structured and efficient automation models, reducing latency and processing overhead in smart door systems. Recent advancements in AI-powered access control further enhance smart door security. Zhang and Feng (2023) discuss biometric authentication models driven by artificial intelligence, ensuring higher security accuracy. Zhang and Lee (2023) explore machine learning applications in smart door systems, where pattern recognition algorithms help differentiate between authorized and unauthorized access attempts, thus improving system adaptability and security. Comparative studies on smart door automation technologies provide valuable insights into their effectiveness. Kumar and Patel (2020) evaluate various IoT-based automation solutions, identifying their strengths and limitations in security and efficiency. Lee and Wong (2020) examine motor driver efficiency, concluding that high-power drivers outperform low-power alternatives in smart door applications. Additionally, Williams and Brown (2023) explore home automation trends, emphasizing the integration of AI, IoT, and cloud computing for advanced security solutions.

In summary, the literature underscores the significance of Arduino-based control systems, IoT integration, motor efficiency, and false trigger prevention in smart door automation. The implementation of PC817 optocouplers and RC networks proves to be a reliable solution for eliminating false triggers caused by long wiring and electrical noise. Future research should focus on AI-driven anomaly detection, wireless switch integration, and advanced encryption techniques to further enhance security, efficiency, and adaptability in smart door systems.

Methodology

Now, we will discuss the complete step by the complete process. To test the noise immunity, we need to inject the noise. We used a hammer drill, which is inherently a big noise source. The product specification is depicted in the figure 1.

Fig.1: Noise source specification.

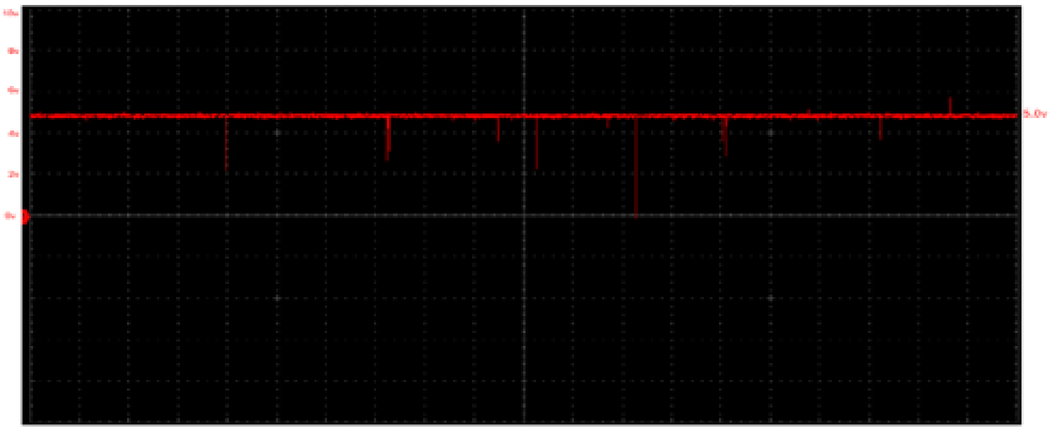

Fig. 2: Noise pattern, injected on the controller Bus.

Figure 2 depicts the oscilloscope screenshot showing a voltage signal over time. Here's an analysis of what it represents:

1. Signal Characteristics:
    - The signal is plotted in red against a black background with grid lines.
    - The y-axis (vertical axis) represents voltage, ranging from 0V to 10V.
    - The x-axis (horizontal axis) represents time.
    - The main signal level is around 5V, indicating a DC voltage with small fluctuations.
2. Observations:
    - The waveform is mostly stable at 5V but has occasional downward spikes.
    - These spikes drop to lower voltages (near 0V in some cases), suggesting voltage dips or noise in the system.
3. Possible Causes:
    - These voltage drops due to:
        - Interference or noise in the circuit.

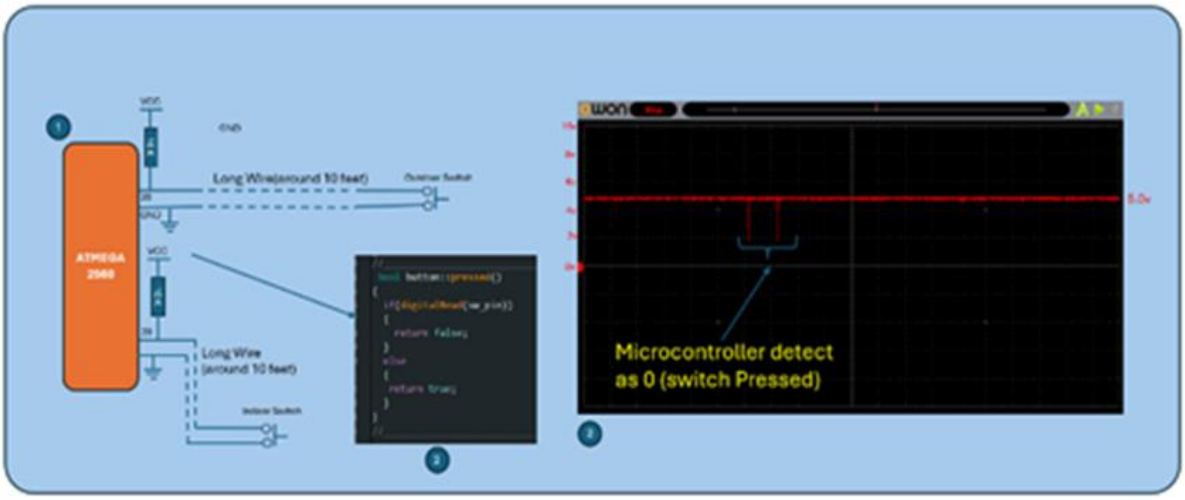

Fig.3: Common Controller circuits for switc

Figure 3 illustrates the working of a switch detection circuit using an ATmega 2560 microcontroller. It consists of three main sections:

1. Circuit Diagram (Left Side)

- The ATmega 2560 microcontroller is connected to two switches (indoor and outdoor) via long wires (~10 feet).
- Each switch is connected to ground (GND) and has a pull-up resistor (10kΩ) to VCC.
- The switches are normally open, meaning the input pin reads HIGH (5V) when the switch is not pressed.
- When a switch is pressed, it connects the pin directly to GND, making the input LOW (0V).

2. Code Snippet (Middle)

- A function named button_pressed() reads the state of the switch pin.
- If digitalRead(sw_pin) returns HIGH, the function returns false (button not pressed).
- If it returns LOW, the function returns true (button pressed).

3. Oscilloscope Output (Right Side)

- The oscilloscope shows a red signal at 5V, indicating the pull-up voltage.
- When the switch is pressed, the voltage drops to 0V, creating a clear pulse.
- The annotation mentions that the microcontroller detects this drop as "0", meaning the switch has been pressed.

Analysis

- The setup is designed to detect when the switch is pressed using a pull-up resistor configuration.
- The long wires introducing noise or voltage drops affect signal integrity.
- The oscilloscope confirms that the voltage drops correctly when the switch is pressed.

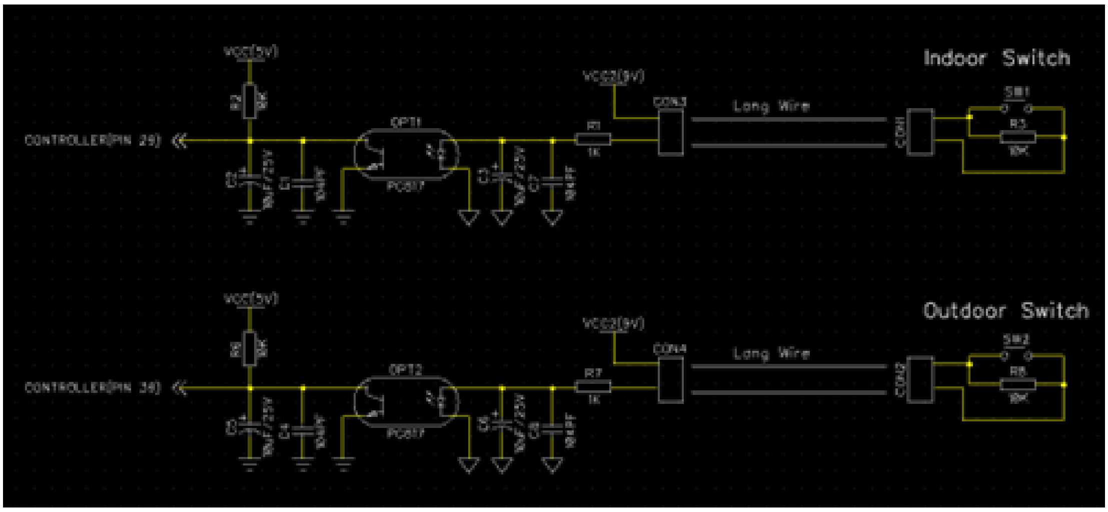

Fig.4: Galvanic Isolated protection circuit.

Figure 4 illustrates a noise reduction circuit for long-wire outdoor and indoor switches using Galvanic Isolation (PC817 Optocoupler) and an RC Network. The main objective of this circuit is to eliminate false triggering due to electrical noise and interference that can occur in long-wire connections between the controller and switches.

1. Circuit Overview

The schematic consists of two identical circuits:

- Indoor Switch Circuit (Top Section)
- Outdoor Switch Circuit (Bottom Section)

Both circuits operate on the same principle and are designed to protect the controller from noise and transient disturbances.

2. Working Principle

The circuit works by isolating the controller from the switch signals using the PC817 optocoupler and filtering noise using an RC network.

Step-by-Step Explanation:

1. Switch Signal Transmission via Long Wires:
   - The switch (SW1 for indoor, SW2 for outdoor) is connected via long wires to the circuit.
   - The switches are pull-down configurations using R3 and R8 (10kΩ resistors) to prevent floating signals.
2. Noise Suppression using RC Network:
   - The RC network (R1, C3 for indoor and R7, C6 for outdoor) acts as a low-pass filter.
   - R1 (1kΩ) & C3 (10nF) and R7 (1kΩ) & C6 (10nF) help suppress high-frequency noise and prevent spurious triggering.
   - This filtering prevents electromagnetic interference (EMI) and transient spikes from affecting the controller.
3. Galvanic Isolation using PC817 Optocoupler:
   - The optocoupler (PC817: OPT1 for indoor and OPT2 for outdoor) is used to completely isolate the controller from the switch signals.
   - The PC817 consists of an LED and a phototransistor, ensuring that the controller receives a clean signal without direct electrical connection to the noisy switch lines.
   - The optocoupler is powered by the controller's 5V supply (VCC 5V) on one side, and the switch is powered by a separate 9V supply (VCC2 9V).
4. Decoupling Capacitors for Stability:
   - C2, C5 (10µF, 25V capacitors) act as decoupling capacitors, ensuring stable operation by filtering power supply

fluctuations.
   - C3, C6 (10nF) filter out high-frequency transient noise at the switch interface.
5. Controller Interface:
   - The controller receives the cleaned signal at PIN 29 (for the indoor switch) and PIN 39 (for the outdoor switch).
   - The pull-up resistor (R2, R6 - 10kΩ) ensures that the signal remains HIGH when the switch is not pressed.

3. Benefits of the Circuit
- Prevents False Triggering: The RC network and optocoupler eliminate electrical noise and interference from long wires.
- Electrical Isolation: The PC817 optocoupler provides galvanic isolation, protecting the controller from voltage spikes or noise.
- Enhances System Reliability: The circuit ensures only legitimate switch activations are registered by the controller, improving overall reliability.
- Power Supply Stability: The decoupling capacitors (C2, C5) filter out power fluctuations, ensuring stable operation.

4. Summary
- The long wire connection from the indoor and outdoor switches is prone to noise and interference.
- The RC network filters out noise before the signal reaches the optocoupler.
- The PC817 optocoupler isolates the controller from noise and interference.
- The controller reads a clean and stable signal without false triggering.

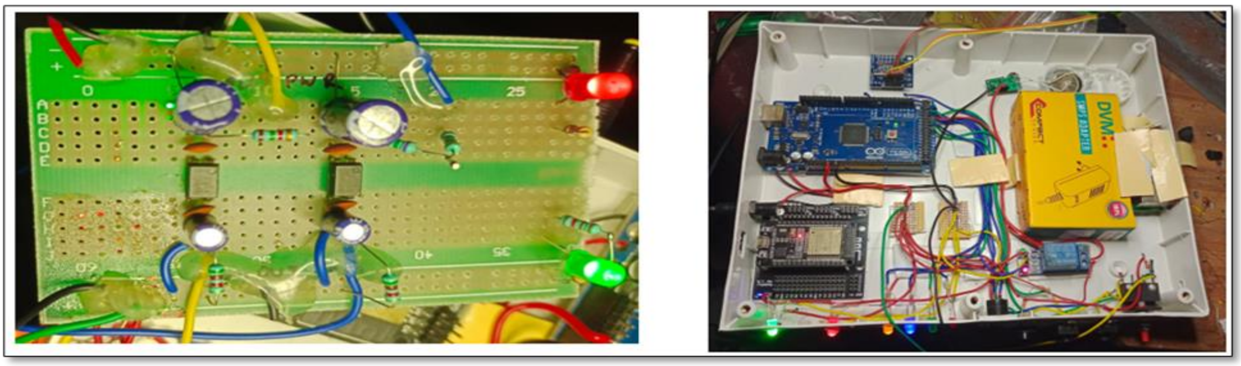

Fig.5: Author Noise protection prototype.

Conclusion

The increasing adoption of smart home automation has emphasized the need for secure and reliable smart door systems. However, false triggering caused by long outdoor switch wiring remains a major challenge, leading to unintended door activations that compromise security and system performance. This paper introduced an effective solution to mitigate false triggering by integrating a Galvanic Isolator (PC817 optocoupler) and an RC Network into the smart door control system.

The PC817 optocoupler ensures complete electrical isolation between the outdoor switch and the microcontroller, preventing electrical noise and interference from reaching the control circuit. Additionally, the RC network filters high-frequency disturbances and suppresses transient voltage spikes, further enhancing the system's stability. Experimental results demonstrate a significant reduction in false triggering incidents, confirming the effectiveness of the proposed approach in improving the reliability, security, and efficiency of smart door automation.

This study provides a scalable and cost-effective method for enhancing smart home security. Future enhancements could include machine learning-based signal classification to further differentiate between legitimate and false triggers and wireless switch integration to eliminate long wiring-related issues altogether. Overall, this work contributes to advancing robust and intelligent home automation solutions, ensuring seamless and error-free smart door operation.

The project demonstration video is available: https://youtu.be/4Mq-ADCM-xI

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