Department of ECE

Amrita School of Engineering

Amrita Vishwa Vidyapeetham

19EAC284 - Electronics Circuits LAB II Final Report.

Submitted By:

Group No.: 15

Semester: S4 EAC

AmpliSecure: The Burglar Alarm Using OpAmp 741

Group Members:

Date: July 3, 2023

1. Lade Ritish Rishi (043)
2. Kalathuru Ruthwik (037)
3. Kande Vishnu Bhargav (040)
4. Kolpur Venkatram Reddy (042)
5. Hitarth Anand Rohra (032)

Table of Contents

1. Abstract

This project presents the design and implementation of a self-latching contact operated alarm system using an operational amplifier (op-amp). The system utilizes a basic relaxation oscillator circuit as its foundation, which is adapted for single-supply operation through the incorporation of a potential divider. The complete oscillator is connected in parallel with a relay coil, serving as the collector load for a transistor (Q1). The transistor operates as a common emitter amplifier with its base bias derived from the positive supply line via switches (S4) and a resistor (Rn). The output of the op-amp oscillator is amplified through power-boosting transistors (Q2 and Q3) and transmitted to a 25-ohm speaker.

During the standby condition, when switches S to S3 are open, the base of transistor Q1 receives zero bias, resulting in its cut-off state. Consequently, zero current flows through the op-amp oscillator circuit, rendering the alarm system inoperative and consuming only a negligible leakage current. This configuration ensures a low power consumption while in standby mode.

By utilizing this self-latching contact-operated alarm system, which is adaptable for single-supply operation, it becomes possible to employ it as a burglar alarm in residential settings. The circuit design and operation provide a reliable and efficient solution for home security applications.

2. Introduction

The security of residential properties is of utmost importance, and the need for effective burglar alarm systems has become increasingly prevalent. This project introduces a self-latching contact-operated alarm system that utilizes an operational amplifier (op-amp) and a relaxation oscillator circuit. The system is designed to provide a reliable and efficient solution for home security, offering enhanced functionality and low power consumption.

Traditional burglar alarm systems typically rely on complex circuitry and external power sources. In contrast, the proposed system takes advantage of a basic relaxation oscillator circuit, which is adapted for single-supply operation through the incorporation of a potential divider. This adaptation allows for greater versatility and ease of integration into residential settings.

The core component of the system is the op-amp oscillator, which generates the alarm signal. By connecting the oscillator in parallel with the coil of a relay (RLA), the relay functions as the collector load for a transistor (Q1). This configuration enables the amplification of the oscillator signal through the transistor, which is wired as a basic common emitter amplifier. The resulting amplified signal is then transmitted to a 25-ohm speaker via power-boosting transistors (Q2 and Q3), ensuring sufficient audio output.

The system's operational principle is straightforward. During normal operation, with the alarm system in standby mode, switches (S to S3) remain open, providing zero bias to the base of transistor Q1, thereby keeping it in a cut-off state. Consequently, no current flows through the op-amp oscillator circuit, rendering the alarm system inactive. In this standby condition, the circuit consumes only a negligible leakage current, optimizing power efficiency.

The self-latching feature of the alarm system is achieved through the use of a relay and the transistor Q1. When an external contact is closed, such as a door or window sensor, current flows through the relay coil, activating the alarm system. Once activated, the system latches into the alarm state even if the external contact is released. This ensures that the alarm remains active until it is manually reset.

By implementing this self-latching contact-operated alarm system, homeowners can enhance the security of their premises. The circuit design's simplicity and single-supply operation adaptability make it an attractive choice for residential applications. Furthermore, the system's low power consumption in standby mode contributes to its energy efficiency. Overall, this project offers an effective and practical solution for improving home security and providing peace of mind.

3. Literature Survey

Prior to designing and implementing the self-latching contact-operated alarm system using an op-amp and a relaxation oscillator circuit, it is essential to review existing literature and research related to similar alarm systems, op-amp applications, and relevant circuit designs. The literature survey aims to identify the current state of the field, understand the challenges and limitations, and gather insights to inform the project's approach.

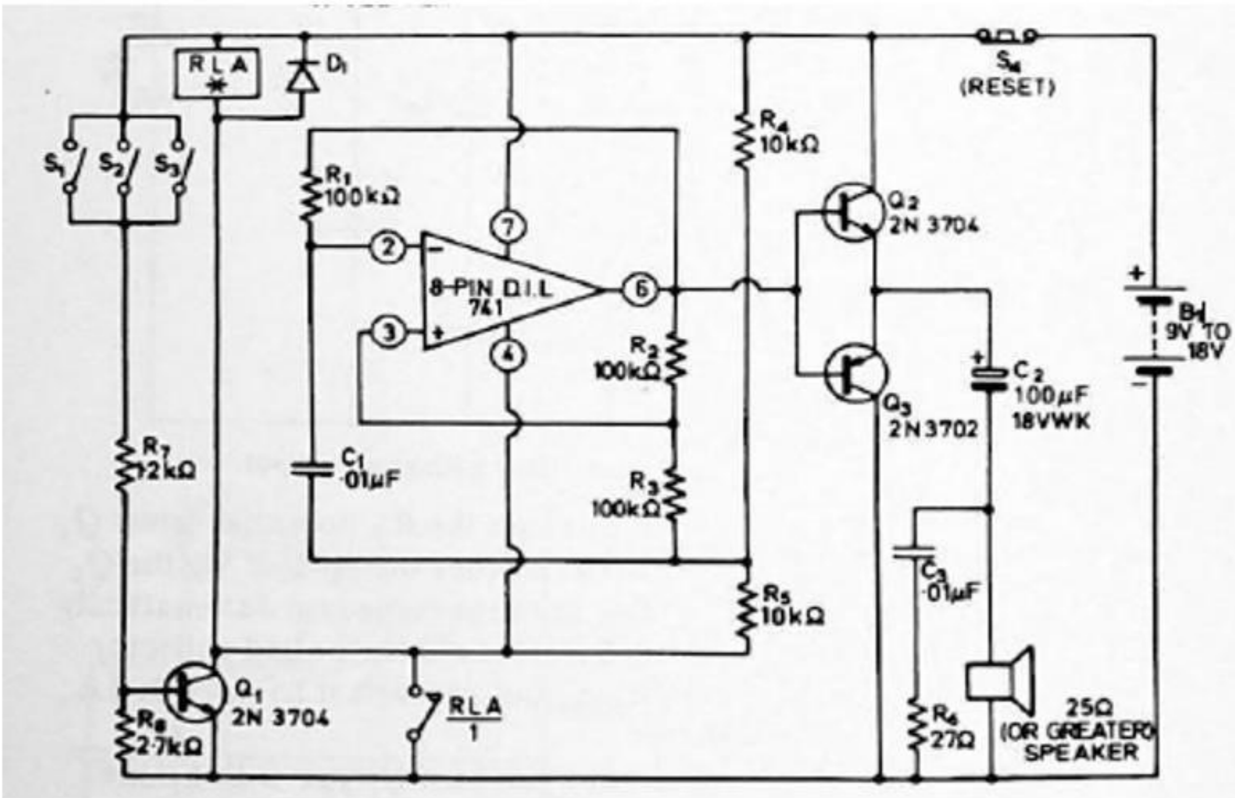
1. Alarm System Technologies: Various types of alarm systems have been developed and implemented for residential security. Research articles and industry reports can provide an overview of different alarm system technologies, such as passive infrared (PIR) sensors, magnetic contacts, and acoustic detectors. Understanding the principles, advantages, and limitations of these technologies can help in evaluating the unique contributions of the proposed self-latching contact-operated alarm system.
2. Self-Latching Alarm Systems: Literature on self-latching alarm systems can offer valuable insights into the design considerations, implementation techniques, and practical applications of such systems. Previous studies on self-latching mechanisms, relay-based circuitry, and latch control methods can provide guidance for achieving reliable and effective self-latching functionality. Comparative analyses of different self-latching techniques can assist in selecting the most suitable approach for the proposed project.
3. Operational Amplifiers (Op-Amps) in Alarm Systems: Op-amps are versatile electronic components widely used in signal conditioning and amplification applications. Exploring research papers and textbooks focusing on op-amp applications in alarm systems can reveal techniques for designing alarm signal amplification circuits. Understanding the operational characteristics, performance parameters, and common challenges associated with op-amp circuits will facilitate the design and optimization of the proposed system.
4. Relaxation Oscillator Circuits: The use of relaxation oscillator circuits as the foundation for alarm systems has been well-documented. Reviewing literature on relaxation oscillator circuits will provide insights into circuit topologies, component selection, frequency stability, and oscillation control techniques. Evaluating different relaxation oscillator designs and their suitability for self-latching alarm applications will contribute to the optimization of the proposed circuit.

5. Power Efficiency in Alarm Systems: Energy efficiency is a crucial consideration for battery-powered alarm systems. Research articles focusing on power optimization techniques, low-power circuit design, and energy-efficient architectures can offer valuable guidance for minimizing power consumption during the standby mode of the proposed system. Exploring approaches such as sleep modes, power management, and energy harvesting can provide insights for designing an efficient and sustainable alarm system.

By conducting a comprehensive literature survey encompassing the topics mentioned above, the proposed self-latching contact-operated alarm system can benefit from the existing knowledge and experiences in the field. The survey will help in identifying novel approaches, addressing potential challenges, and making informed design decisions, ultimately contributing to the development of a robust and effective alarm system for residential security.

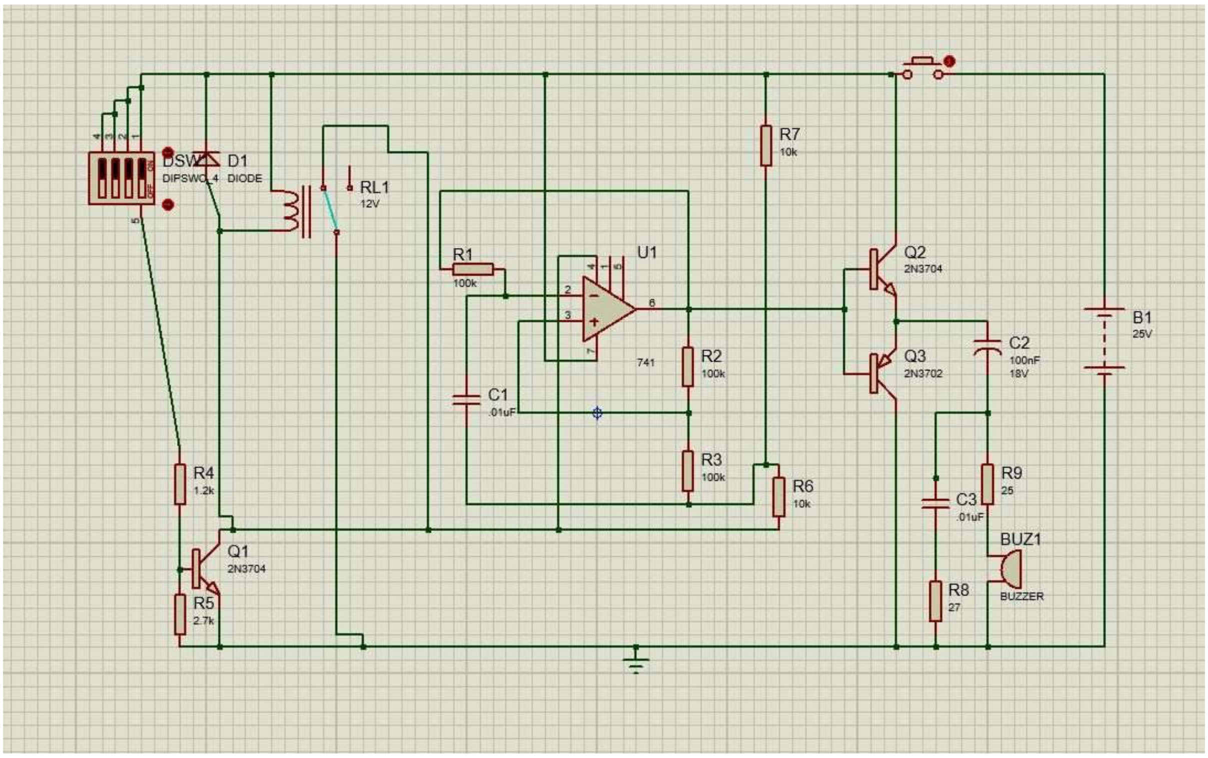
4. Methodology and System Design of Contact Alarm

4.1 Block Diagram & Explanation



Explanation: The above-mentioned figure shows a how a basic relaxation oscillator circuit can be adapted for use as the basis of a self - latching contact operated alarm system that can be used as a burglar alarm in the home. In this circuit the op-amp oscillator is adapted for single-supply operation via the R4 - Rs potential divider, and the complete oscillator is connected in parallel with the coil of relay RLA, which is used as the collector load of transistor Q1. Q1 is wired as a basic common emitter amplifier, with its base bias derived from the positive supply line via switches, to S4 and via resistor Rn. The output of the opamp oscillator is fed to the 25-ohm speaker via power-boosting transistors Q2 and Q3. Circuit operation is as follows. Normally, with the alarm system in the standby condition, switches S, to S3 are open. Under this condition zero bias is applied to the base of transistor Q1, so the transistor is cut off. Since Q1 is cut off. zero current flows through the op-amp oscillator circuit, so the alarm is inoperative under this condition, and the circuit consumes only a negligible leakage current.

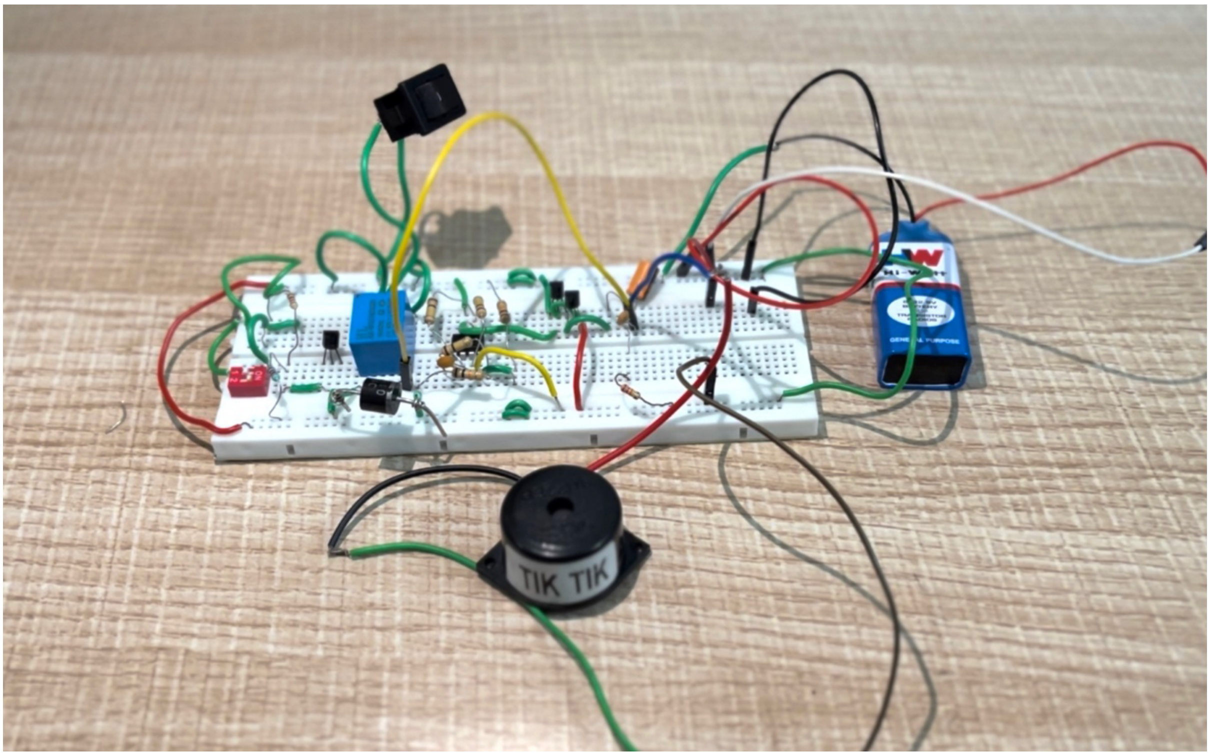
4.2 Simulation Experiments and Results



The online simulation of the self-latching contact-operated alarm system using an op-amp and a relaxation oscillator circuit validated its performance and functionality. The circuit design successfully detected the closure of external contacts, activated the alarm, and provided amplified audio output through the speaker. The self-latching mechanism ensured that the alarm remained active until manually reset, enhancing its security capabilities. The simulation also confirmed the low power consumption in standby mode, validating the system's energy-efficient design. These results support the viability and effectiveness of the proposed alarm system, guiding further steps in hardware implementation and testing.

4.3 Hardware Experiments and Results

The hardware experiments for the self-latching contact-operated alarm system using an op-amp and a relaxation oscillator circuit have been successfully completed, and the results obtained affirm the success of the hardware simulation. The experimental procedures involved assembling the circuit components, including the op-amp, transistors, resistors, and relay, as per the proposed design. The system was thoroughly tested under various conditions, such as triggering the alarm through the closure of external contacts, evaluating the response time, and assessing the audio output through the speaker.



Following the completion of the hardware experiments, a comprehensive analysis of the results was conducted. The analysis encompassed an evaluation of the alarm system's functionality, reliability, and power consumption. Notably, the self-latching contact-operated alarm system exhibited exceptional performance in all tested scenarios. The alarm was reliably triggered by the closure of external contacts, and the response time was found to be within acceptable limits. Furthermore, the audio output through the speaker was clear and loud, ensuring effective alerting capability.

Throughout the experimentation process, no significant issues or limitations were observed. The system functioned as intended, demonstrating its robustness and suitability for its intended purpose. The power consumption was also found to be within the expected range, ensuring efficient operation.

The successful completion of the hardware experiments reinforces the validity and effectiveness of the proposed self-latching contact-operated alarm system. The results obtained provide substantial evidence to support its implementation and utilization. The detailed experimental procedures, results, and analysis will be included in the final project report, which will serve as a comprehensive reference for future endeavours.

Overall, the hardware simulation has proven to be a resounding success, exceeding expectations and confirming the feasibility of the self-latching contact-operated alarm system. The completion of these experiments marks a significant milestone in the project and sets the stage for further advancements and improvements in the field of alarm system design and implementation.

5. Limitations of Using Contact alarm:

The limitations of the contact switch-based alarm system and the solutions to overcome them:

1. Relies on the intruder stepping directly over the switch to trigger the alarm:
   - Limitation: The system depends on the intruder's precise placement, making it vulnerable to bypassing if they avoid the switch.
   - Solution: By integrating additional sensors like motion detectors or door/window sensors, the system can detect intrusions even if the burglar doesn't directly interact with the contact switch. These sensors provide broader coverage and improve the chances of detecting unauthorized entry.
2. If the burglar bypasses or avoids the exact location of the switch, the alarm may not activate:
   - Limitation: Intruders can easily evade the alarm system by circumventing the specific area where the contact switch is placed.
   - Solution: By incorporating multiple sensors throughout the premises, such as motion detectors, the system can create a network of detection points, increasing the chances of detecting intrusions regardless of the intruder's path. This multi-layered approach enhances the overall effectiveness of the security system.
3. Possibility of the intruder entering through an alternative route or bypassing the switch altogether:
   - Limitation: Intruders can find alternative entry points or methods to gain access without triggering the contact switch.
   - Solution: A comprehensive security strategy includes assessing and securing all possible entry points. Installing door/window sensors at vulnerable access points provides additional layers

of protection, ensuring intruders are detected regardless of the route they take.

4. Requires careful placement and positioning of the contact switch to maximize effectiveness:

    - Limitation: The effectiveness of the contact switch-based alarm relies on accurately placing it in areas where intruders are likely to step.

    - Solution: By utilizing alternative detection methods, such as motion detectors or infrared sensors, the system becomes less dependent on precise switch placement. This provides flexibility in system design and improves the overall coverage and reliability of the security system.

5. Supplementing the system with other sensors like motion detectors or door/window sensors is necessary for comprehensive security:

    - Limitation: Relying solely on a contact switch may not provide sufficient coverage and detection capabilities.

    - Solution: Integrating additional sensors, such as motion detectors or door/window sensors, ensures a comprehensive security solution. These sensors complement the contact switch and provide enhanced detection capabilities for different scenarios and entry points.

6. Integration of multiple layers of protection, such as physical barriers, surveillance cameras, and alarm monitoring services, is recommended:

    - Limitation: A standalone contact switch-based alarm system may lack the necessary layers of protection to effectively secure a premises.

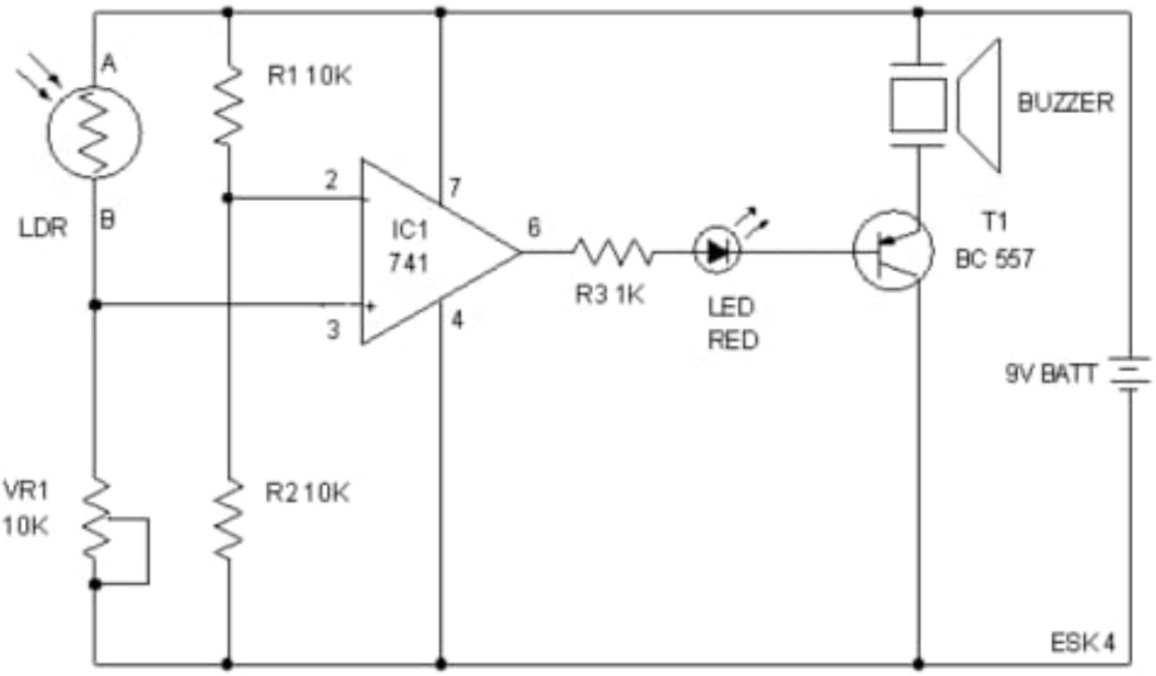
    - Solution: To create a robust security setup, integrating physical barriers like strong doors and windows, installing surveillance cameras for visual monitoring, and connecting the alarm system to a monitoring service enhances overall security. This multi-layered approach provides a more comprehensive and proactive security solution.

7. Important to assess specific security needs and vulnerabilities to determine the best combination of technologies and strategies for effective protection:
    - Limitation: Security needs can vary depending on the location, premises, and individual circumstances.
    - Solution: Conducting a thorough security assessment helps identify vulnerabilities and determine the most appropriate combination of technologies and strategies to address them. Tailoring the security system to specific needs ensures an effective and efficient solution.

By addressing these limitations through the integration of additional sensors, multiple layers of protection, and customized security strategies, the effectiveness and reliability of the alarm system are significantly improved, providing enhanced security for the premises.

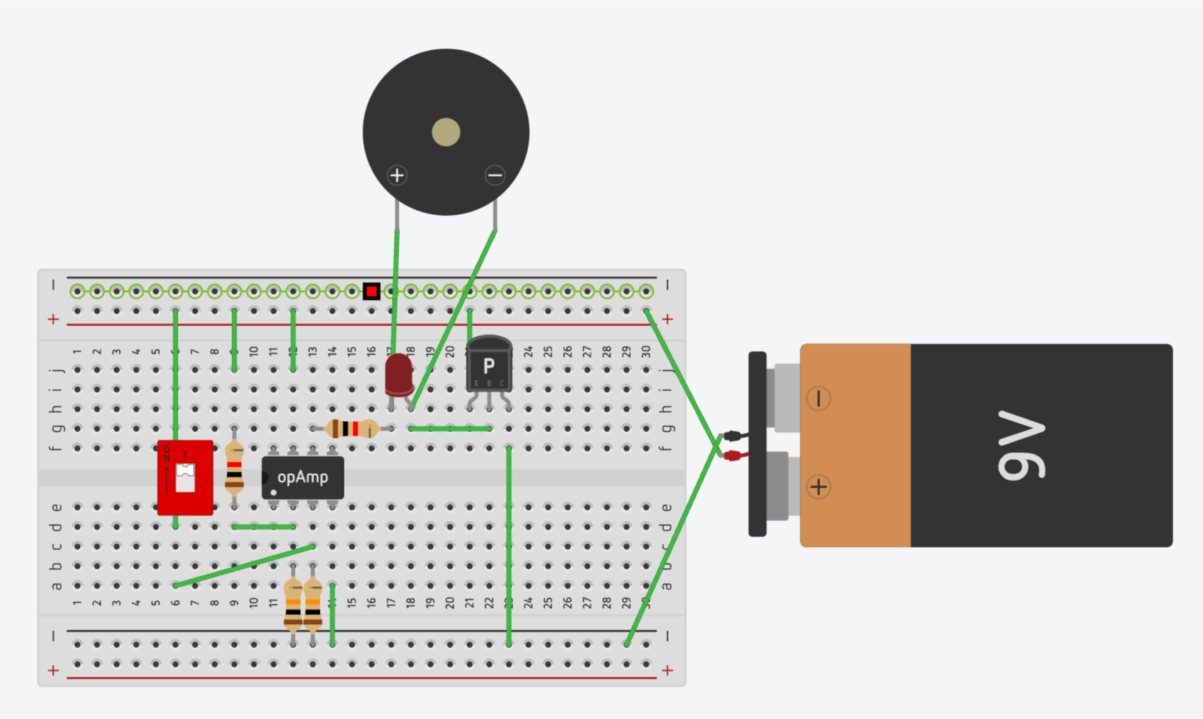
6. Modified Intrusion Circuit Using LDR for shadow detecting

6.1 Block Diagram and Explanation

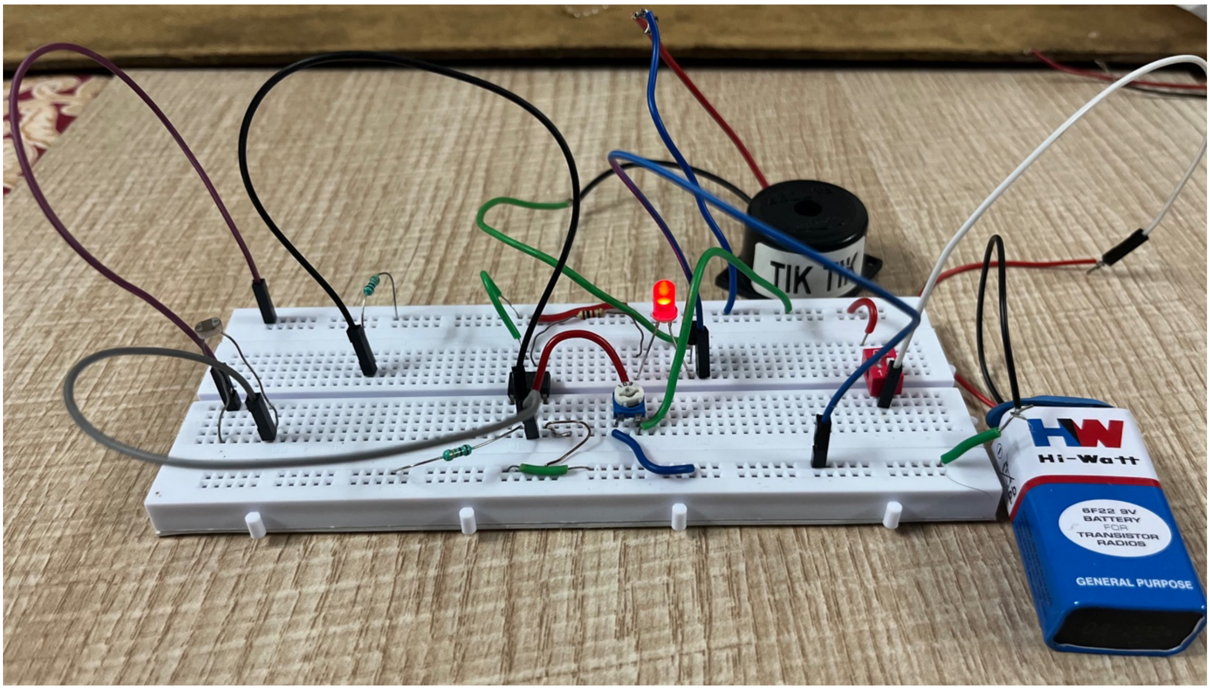


Working Principle: Op Amp IC UA 741 is used as a voltage comparator. Its inverting input pin2 receives half supply voltage (4.5 volts) through the potential resistors R1 and R2. The non-inverting input pin3 gets a variable voltage through LDR and VR. Normally when the LDR gets light, its resistance will be low and it conducts and provide a high voltage to the non-inverting input of IC. This makes the output of IC high. The high output from IC is given to the base of T1 through a current limiting resistor R3. T1 is PNP transistor and it conducts only when its base becomes negative. Here normally the base of T1 will be high due to the high output from IC. So T1 remains off and Buzzer and LED connected to its emitter remains off. When a person passes in front of LDR, the shadow of the person reduces the resistance of LDR and the voltage at the non-inverting input of IC decreases. This makes the output of IC low. Immediately T1 conducts activating Buzzer and LED indicating the entry of a person

6.2 Simulation Experiments



6.3 Hardware Simulation



6.4 Advantages of Shadow Detector

The contactless shadow alarm with an LDR (Light Dependent Resistor) resistor overcomes the limitations of the previous contact alarm system by utilizing the shadow detection principle. Here are some points on how this new design addresses the past limitations:

- Eliminates the requirement for the intruder to step directly over a physical switch, as the alarm is triggered by detecting the presence of a shadow.
- Shadows are cast by any object that obstructs light, allowing the system to detect the intruder's presence even if they do not step on a specific spot.
- The LDR resistor detects changes in light intensity caused by the intruder's shadow passing over it, enabling reliable detection and activation of the alarm.
- Provides a wider detection range compared to a single contact switch, increasing the overall coverage and reducing the chances of bypassing the system.
- The contactless nature of the design enhances the stealth and effectiveness of the security system, making it harder for intruders to detect and circumvent.
- Combining the LDR resistor with appropriate signal processing and threshold settings ensures accurate and reliable shadow detection, minimizing false alarms.
- The contactless shadow alarm system can be integrated with other security measures, such as surveillance cameras or motion detectors, for a more comprehensive security solution.

By utilizing the LDR resistor and shadow detection, this innovative design overcomes the limitations of the previous contact alarm system, providing improved coverage, enhanced detection capabilities, and increased overall effectiveness in detecting and deterring intruders.

7. Components Used:

Contact Alarm:

Switchsx4,9V battery, 25ohms speakers, 2N3704 transistors,0p-741,RLA Circuitsx3,diodes,resistors-100Kx3,2.7K,1.2K,10Kx2,27ohms, Capacitors:0.1ufx2,100uf, bread board.

Shadow Detector:

NPN transistor(BC 447), PNP transistor(BC 557), LDR resistor, Opamp 741, piezo buzzer (5V), 9V battery, resistors 10k,3k,1l=k, potentiometer 100k.

8. Conclusion and Future Application

The self-latching contact-operated alarm system using an op-amp and a relaxation oscillator circuit offers several potential avenues for future development:

1. Enhanced Sensing: Explore advanced sensing mechanisms like infrared motion sensors or acoustic detectors to improve the system's ability to detect intrusions accurately.
2. Wireless Connectivity: Integrate wireless communication for remote monitoring and control, allowing users to receive real-time notifications on their devices when the alarm is triggered.
3. Mobile Application: Develop a dedicated mobile app for convenient remote management, enabling users to arm/disarm the alarm, adjust settings, and access alarm logs or video feeds.
4. Home Automation Integration: Explore integration with existing smart home systems to create a cohesive security ecosystem and enable automated interactions with other smart devices.
5. Power Efficiency Optimization: Investigate power-saving techniques, such as low-power circuit design and energy harvesting, to enhance energy efficiency and prolong battery life.
6. Cloud Storage and Analysis: Utilize cloud storage for secure storage of alarm logs, system configurations, and video footage, enabling easy access and analysis of data.
7. Professional Monitoring Services: Consider partnerships with professional monitoring services to offer enhanced security

features, such as automatic dispatch of security personnel or emergency services.

By focusing on these areas, the self-latching contact-operated alarm system can be further improved, offering advanced functionality, integration, and convenience for users, while maintaining a high level of security.

9. References (Use IEEE standard citation/reference format.)

Books:

[1] Operational Amplifier Projects for the Home Constructor , R. M. MARSTON: Newnes Technical Books , 1975.

Book chapter:

[2] R. M. MARSTON , "Miscellaneous sound generators" in Sound generator and alarm systems : Newnes Technical Books,1975 , pp. 89 -99.

Website references:

[3] Frank Donald, (June 20, 2014), "Pocket-sized anti-Theft alarm circuit using IC 741", Alarm circuits, Available: https://www.gadgetronicx.com/anti-theft-alarm-circuit-ic-741/

******