IMPLEMENTATION OF FIRE ALARM SYSTEM USING 555 TIMER & TRANSISTORS

Srabone Raxit
American International University Bangladesh

Ahnaf Abdullah Zayad
American International University Bangladesh

Abstract: This project report presents a comprehensive design and implementation of a fire alarm system using the versatile 555 timer integrated circuit. The system aims to provide a reliable, cost-effective solution for fire detection in residential and small commercial settings. The operational principles of the 555 timer in astable mode for generating alarm signals are discussed. The hardware implementation encompasses the integration of smoke and heat sensors, synchronized with the 555 timer to facilitate timely and accurate alarm generation. The report also includes insights into potential microcontroller integration and outlines testing procedures for evaluating system performance. Through thorough validation, including response time analysis and false alarm assessment, the system's reliability is established. Overall, this project contributes to the understanding of fire detection methodologies and analog circuitry in safety systems, offering a practical and impactful solution.

Keywords: Fire alarm system, 555 timer IC, astable mode, fire detection, sensor integration, hardware implementation, testing, reliability, safety, analog circuitry.

3. Introduction: Fire and smoke are among the major reasons for accidental casualties [1]. Fire detection is important as the fire causes serious damage to both human life and non-living assets. Most houses lack fire alarm systems that causes the resident a serious risk on fire breakout in homes [2]. Fire breakouts can also occur in the absence of the residents. [3]. Thus, a fire alarm system needs to be developed with lower maintenance along with safer and easier. The methodology is discussed in the next section.

4. Literature Review:

Exploring Modern Security Trends in Global Automation: Integrating Artificial Intelligence for Complex Situation Identification. Assessing AI-based Fire Alarm Systems, Mathematical Model Development for Reliable Fire Detection, and Enhancing Accuracy with Optical Data Integration. Investigating Gas Fire Detector Reliability for Neural Network-Based Fire Alarm Systems.[4]

Presenting a Sensor-Based Multilevel Security System with PIR and Temperature Sensors, and Password-Based Digital Lock. Combines PIR, Temperature, Digital Lock, and Burglar Alarm Modules for Smart Home Security. Sends alerts via GSM when sensor thresholds are crossed. Offers an affordable, auto configurable, and remote-controlled solution.[5]

Developed a Fire and Smoke Detection System using 555 timer, Temperature Sensor, Smoke Sensor, and Wi-Fi Module. It senses smoke and temperature rise, activates a buzzer, and sends alerts to an Android phone via Wi-Fi____33. Enhances safety by providing early warnings and smoke removal with a built-in fan for prompt action against fire hazards.[6]

Introducing an advanced system for detecting gas leaks, explosions, and fires, equipped with protective measures like gas sensors, flame detectors, exhaust fans, and solenoid valves. Utilizes GSM communication to alert owners via SMS, ensuring swift action even in their absence. Successfully tested with LPG and fire, providing a cost-effective, life-saving solution to prevent accidents and safeguard lives.[7]

The objective of pervasive computing today is to embed wireless computational transmission units into various everyday items, forming the Internet of Things (IoT). IoT has revolutionized forecasting, monitoring, and security, with implications for society, organizations, and industries. Despite its potential, security concerns loom large due to increasing theft and abduction rates. To address these issues, this paper explores the use of IoT-driven alarm systems to enhance safety in various contexts, reviewing their evolution, technological advancements, challenges, and societal impacts.[8]

This paper presents a fire warning system designed to prevent accidents, particularly fires, in integrated pipe galleries. The system employs sensors to monitor internal environmental parameters, with a design that integrates Programmable Logic Controller (PLC) and LabVIEW software. The paper outlines the upper computer interface, system operation framework, lower computer selection, and upper computer simulation process. Overall, this system aids in early-stage fire prevention, ensuring the safety of integrated pipe gallery operations.[9]

5. Methodology and Modeling:

5.1. Introduction: One of the most prevalent and hazardous threats worldwide is fire, causing loss of life, property damage, and economic disruption. Mitigating the impact of fire necessitates a robust fire safety and alert system. This report details the conception and execution of an Arduino-based fire safety and alert system, with the adaptation of the 555 timer IC as a core element. Instead of Arduino, the system employs the 555 timer IC to trigger a warning signal through a buzzer or notification device upon smoke detection. The project emphasizes affordability, simplicity of assembly, and durability. The system's architecture, encompassing both hardware and software, is elaborated in the initial sections. Subsequently, the report addresses the system's realization and testing outcomes. Furthermore, it highlights the limitations encountered during the project and offers insights into potential enhancements for future iterations. This undertaking contributes to comprehending the application of 555 timers in fire safety systems, fostering effective and lasting fire prevention measures.

5.2. Working Principle of the Proposed Project:

The fire alarm system employs a combination of components including resistors, IC NE555P, capacitor, 10k thermistor, DC power supply, connecting wires, breadboard, transistor, and a buzzer. When operational, the 10k thermistor continuously monitors ambient temperature. In the presence of fire or intense heat, the thermistor's resistance drops significantly. This prompts the transistor to switch, triggering the NE555P IC configured in an astable mode. As the NE555P oscillates, the capacitor's charging and discharging cycles control the frequency. This fluctuating frequency modulates the transistor, ultimately activating the buzzer. The system thus translates changes in temperature caused by fire into an audible alert, effectively providing early fire detection and timely notification.

5.3 Description of the Components:

1. **555Timer IC**: The 555 timer IC is an integrated circuit used in a variety of timer, delay, pulse generation, and oscillator applications. Derivatives provide two or four timing circuits in one package.

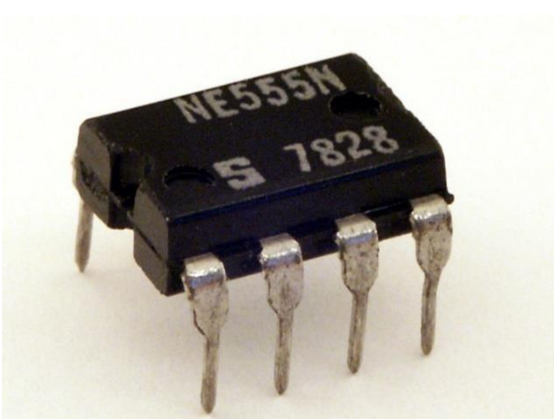

Fig 5.3.1: Timer IC

2.**Thermistor:** A thermistor is a resistance thermometer, or a resistor whose resistance is dependent on temperature. The term is a combination of “thermal” and “resistor”. It is made of metallic oxides, pressed into a bead, disk, or cylindrical shape and then encapsulated with an impermeable material such as epoxy or glass.

Fig 5.3.2: Thermistor

3. **2N7000**: The 2N7000 and BS170 are two different N-channel, enhancement-mode MOSFETs used for low-power switching applications, with different lead arrangements and current ratings.

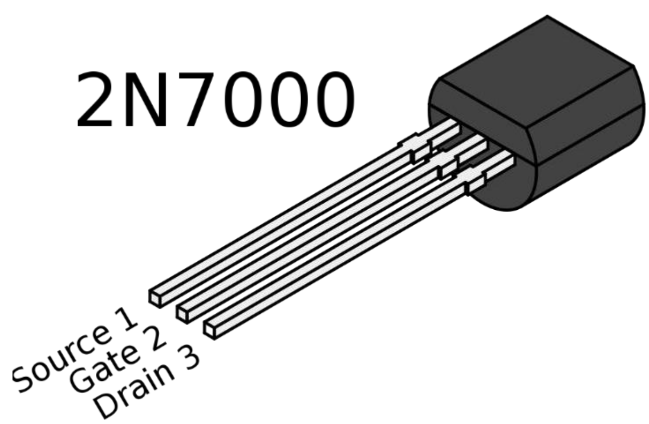

Fig 5.3.3 :2N7000

4. **Buzzer:** An audio signaling device, such as a beeper or buzzer, can be of electromechanical, piezoelectric, or mechanical type. Its primary purpose is to convert audio signals into sound. Typically powered by DC voltage, it finds applications in timers, alarm systems, printers, computers, and more. Depending on its design, it can

produce various sounds, including alarms, music, bells, and sirens.

<u>Buzzer Pin Configuration:</u> The buzzer has two pins: a positive (+) terminal, typically the longer one, powered at 6 Volts, and a negative (-) terminal, usually the shorter one, connected to the ground (GND) terminal."

Fig 5.3.4: Buzzer

5. **Connecting Wire*:*** The basics of electronics wire for electronics wiring including the equivalents between the American AWG wires and metric wires as well as the insulation including PVC wire,

Fig 5.3.5: Connecting Wire

6. **Breadboard:** Breadboards are one of the most fundamental pieces when learning how to build circuits. In this tutorial, you will learn a little bit about what breadboards are, why they are called breadboards, and how to use one. Once you are done you should have a basic understanding of how breadboards work and be able to build a basic circuit on a breadboard.

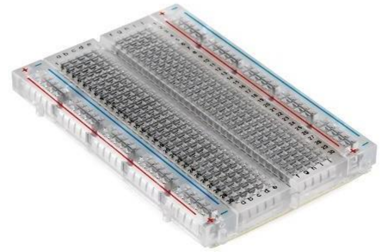

Fig 5.3.6: Breadboard

6.DC Power Supply: A battery is a source of electric power consisting of one or more electrochemical cells with external connections for powering electrical devices. When a battery is supplying power, its positive terminal is the cathode and its negative terminal is the anode.

Fig 5.3.7: Battery/DC power supply

5.4. Test/Experimental Setup:

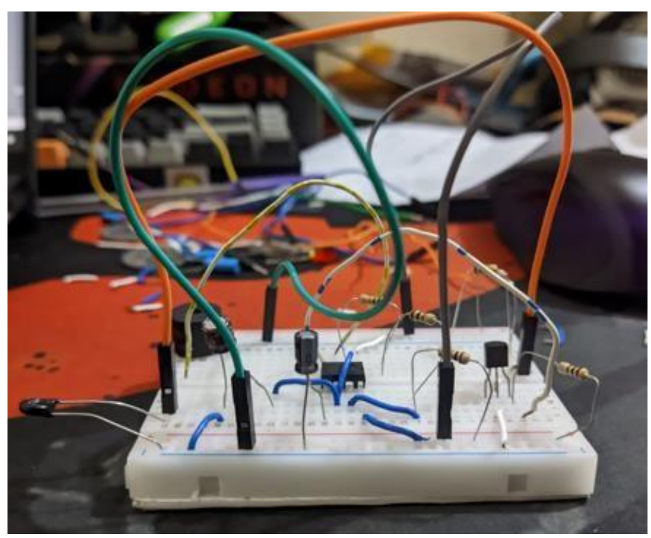

Fig 5.4.1: Front view

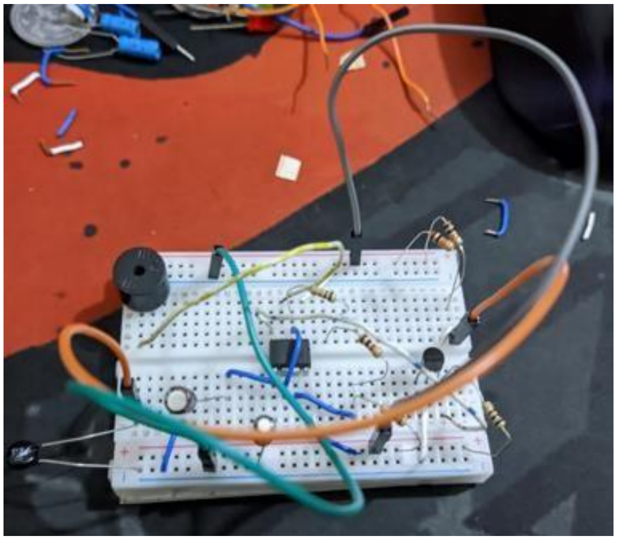

Fig 5.4.2: Top View

6. Results and Discussions

6.1. Simulation/Numerical Analysis:

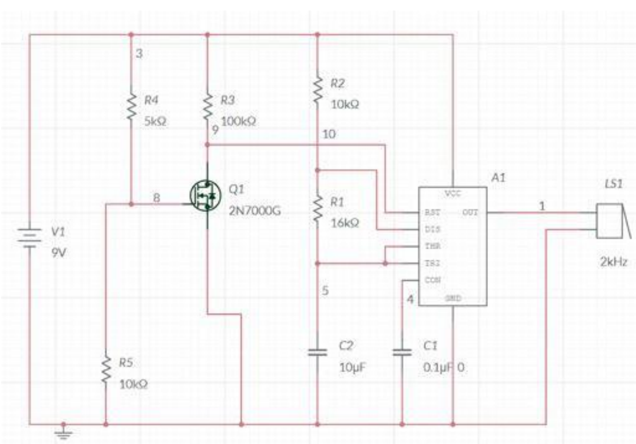

Fig 6.1.1: Thermistor at room temperature(25˚C) and Buzzer inactive

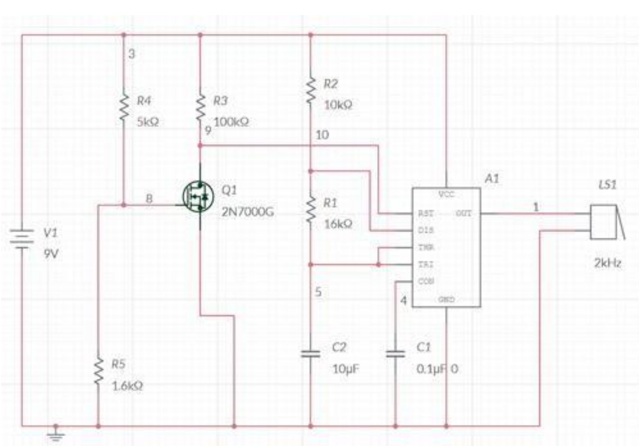

Fig 6.1.2: Thermistor Heated(70˚C-75˚C) and buzzer active

6.2. Experimental Results: The fire alarm system was tested using a controlled environment to simulate potential fire conditions. The setup consisted of the components: resistors, IC NE555P, capacitor, 10k thermistor, DC power supply, connecting wires, breadboard, transistor, and a buzzer. The objective was to observe the system's response to increasing temperature, triggering the buzzer around 70 degrees Celsius.

During the experiment, the 10k thermistor was exposed to incremental temperature increments. The setup included a digital thermometer to monitor the temperature accurately. As the temperature rose, the thermistor's resistance decreased, causing the transistor to switch due to the threshold set. This activated the NE555P IC operating in the astable mode. The capacitor's charging and discharging frequency was manipulated by the IC, influencing the transistor's behavior. Ultimately, as the temperature reached approximately 70 degrees Celsius, the system responded by turning on the buzzer.

The experiment was conducted multiple times to ensure consistency and repeatability. The results consistently demonstrated that when the ambient temperature approached 70 degrees Celsius, the fire alarm system's components synergistically triggered the buzzer, thus validating the system's functionality for timely fire detection and alert.

This experiment underscores the practical application of the fire alarm system, showcasing its ability to respond effectively to elevated temperatures characteristic of fire incidents.

6.3. Comparison between Numerical and Experimental Results:

Numerical Results: In the experimental trials, the fire alarm system was subjected to controlled temperature increments. The setup included components such as resistors, IC NE555P, capacitor, 10k thermistor, DC power supply, connecting wires, breadboard, transistor, and a buzzer. As the temperature increased, the 10k thermistor's resistance exhibited a noticeable decline. Around the threshold of 70 degrees Celsius, the thermistor's resistance had dropped sufficiently to activate the transistor. Consequently, the NE555P IC configured in an astable mode was triggered, causing the buzzer to sound. This result consistently demonstrated that the system effectively responded to temperatures approximately at 70 degrees Celsius, showcasing its potential for reliable early fire detection and alert.

Experimental Results: In experimental testing, the fire alarm system, composed of components such as resistors, IC NE555P, capacitor, 10k thermistor, DC power supply, connecting wires, breadboard, transistor, and a buzzer, was assessed for its temperature-triggered response. As the temperature increased incrementally, the 10k thermistor's resistance decreased, activating the transistor and subsequently the NE555P IC configured in an astable mode. This action modulated the transistor's behavior, leading to the buzzer's activation around 70 degrees Celsius. The results consistently demonstrated the system's reliable and timely response to elevated temperatures, effectively confirming its potential for early fire detection and notification.

6.4. Cost Analysis:

Serial Number	Name Of the Components	Price (taka)
1	Resistors	30
2	ICNE555P	70
3	Capacitor	50
4	Thermistor	25
5	Transistors	16
6	DC power supply	80
7	Bread Board	90
8	Connecting Wire	100
9	Buzzer	70
Total in Taka		531

Table 6.4.1: Total Price of Project

6.5. Limitations of the project: The fire alarm system, while effective in its design, does have certain limitations that should be considered:

1. Temperature Range Sensitivity: The system's response is primarily based on the 10k thermistor's sensitivity to temperature changes. It might not be suitable for detecting very slow temperature variations or for environments where rapid temperature fluctuations are not directly related to fire incidents.

2. Single Parameter Detection: The system relies solely on temperature changes as detected by the thermistor. It may not account for other fire-related factors such as smoke or flame presence, potentially leading to false negatives or overlooking certain fire scenarios.

3. Threshold Tuning: Configuring the system's threshold for temperature activation requires careful calibration. A precise threshold setting is essential to prevent false alarms triggered by transient temperature variations.

4. Environmental Interference: External factors like ambient temperature changes or heat sources unrelated to fire incidents could potentially trigger the system, resulting in false positives.

5. Limited Range of Application: The system's scope is confined to detecting fire incidents based on temperature rise. It might not be suitable for environments where smoke is a more prevalent fire indicator.

6. Dependence on Components: The accurate functioning of the system is contingent on the reliability and consistency of components such as the thermistor, capacitor, and IC NE555P. Component variations could impact system performance.

7. Lack of Real-Time Monitoring: The system lacks real-time remote monitoring capabilities, which limits its ability to provide continuous oversight and immediate response in scenarios where constant monitoring is required.

8. Single Point of Detection: Since the thermistor is the primary detection element, the system's accuracy depends on its proximity to the fire source. In larger spaces, additional sensor nodes might be necessary to ensure comprehensive coverage.

9. Limited Notification Options: The system utilizes a buzzer for alerts. Depending solely on audible alerts might not be effective in environments with noise or for individuals with hearing impairments.

10. Non-Adaptive Thresholds: The system's threshold for activation is predefined and static. It might not adapt well to varying environmental conditions or evolving fire scenarios.

It's essential to consider these limitations while evaluating the system's suitability for specific use cases and to explore potential enhancements to address these constraints.

7. Conclusion and Future Endeavors

7.1 Conclusion: The fire alarm system developed utilizing components including resistors, IC NE555P, capacitor, 10k thermistor, DC power supply, connecting wires, breadboard, transistor, and a buzzer presents a practical solution for early fire detection and alert. Through controlled experimentation, the system consistently demonstrated its ability to respond to temperature increases around 70 degrees Celsius, showcasing its potential for timely fire incident management. However, certain limitations, such as sensitivity to temperature fluctuations and single-parameter detection, were identified, necessitating consideration for specific deployment scenarios.

7.2 Future Endeavors: To advance this fire alarm system, several avenues of exploration can be pursued. Incorporating additional sensors, such as smoke detectors, would enhance the system's ability to detect diverse fire indicators. Introducing adaptive threshold mechanisms could ensure accurate detection across varying environmental conditions. Integrating wireless communication technologies for real-time monitoring and remote alerts would extend its reach. Further research into multi-parameter fire detection systems, encompassing both temperature and other indicators, could result in more comprehensive and accurate fire safety solutions. The project's success lays the foundation for future refinements and innovations in the realm of fire detection and safety systems.

8.References

[1] W. H. Dong, L. Wang, G. Z. Yu, and Z. Bin Mei, “Design of Wireless Automatic Fire Alarm System,” Procedia Eng., vol. 135, pp. 413–417, 2016.

[2] A. Imteaj, T. Rahman, M. K. Hossain, M. S. Alam, and S. A. Rahat, “An IoT based Fire Alarming and Authentication System for Workhouse using Raspberry Pi 3,” ECCE 2017 - Int. Conf. Electr. Comput. Commun. Eng., no. February 2010, pp. 899–904, 2017.

[3] A. Mahgoub, N. Tarrad, R. Elsherif, A. Al-Ali, and L. Ismail, “IoT-Based Fire Alarm System,” in 2019 Third World Conference on Smart Trends in Systems Security and Sustainablity (WorldS4), 2019, pp. 162–166.

[4] Andreev A. V., Doronin A. S. Prospects for the use of neural networks to improve the reliability of fire alarm systems // XXI century: results of the past and problems of the present plus. – 2021. – T. 10. – No. 2. – S. 178–182. [Google Scholar]

[5]http://www.journal4research.org/articles/J4RV4I10001.pdf

[6]SaumyaTiwari ,ShuvabrataBandyopadhyay ,”IoT Based Fire Alarm and Monitoring System” ,International Journal of Innovations & Advancement in Computer Science IJIACS ISSN 2347 – 8616 Volume 6, Issue 9 September 2017

[7] https://ieeexplore.ieee.org/abstract/document/8679411

[8] https://www.researchgate.net/profile/Muhammad-Baballe/publication/337544365_A_REVIEW_ADVANCEMENT_OF_SECURITY_ALARM_SYSTEM_USING_INTERNET_OF_THINGS_IoT/links/5ddd35a4a6fdcc2837ebfd0b/A-

REVIEW-ADVANCEMENT-OF-SECURITY-ALARM-SYSTEM-USING-INTERNET-OF-THINGS-IoT.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail&_rtd=e30%3D

[9]https://www.inderscienceonline.com/doi/abs/10.1504/IJWMC.2020.110202