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Design And Implementation of an Automated Gas Cooker Using Timer and Infrared Remote-Control Technology

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Abstract - Gas cookers are widely used in both restaurants and households around the globe. However, they pose significant safety risks, including accidents that can lead to loss of lives and properties. This research paper addresses these concerns by designing and developing an automated gas cooker system with infrared remote control, aimed at improving both safety and functionality in home kitchens. The system features two operating modes, namely, a standard mode and a timed mode. The system is designed based on a microcontroller and integrates key components such as an LCD display, a relay-controlled solenoid valve, and a timer. Simulations were conducted using Proteus software, with C/C++ programming employed to handle control functions. The system effectively manages cooking durations, processes user inputs, and enhances safety by automatically shutting off the gas supply when the preset time elapses. Simulation results confirmed that the system performed as expected, with the LCD accurately displaying the remaining cooking time and signaling a Time's up notification to deactivate the gas supply. Furthermore, experimental testing validated that the physical implementation matched the simulation, confirming the system's reliability in practical applications. Overall, the results demonstrate the system's effectiveness in managing cooking tasks while ensuring user safety.

Index Terms- Automated Gas Cooker, Infrared Remote Control, Timer, Safety Mechanism, Solenoid Valved

I. INTRODUCTION

Technological progress has significantly revolutionized operations management, reshaping approaches, processes, models, and systems across various sectors. This transformation has sparked the emergence of automated home appliances, fueled by an increasing desire for enhanced safety and convenience [1]. However, "introducing an automatic gas cooker equipped with features such as remote control and a timer represents a significant advancement in creating a smarter kitchen. This innovation seeks to enhance user convenience while mitigating the risks associated with traditional gas cookers. Besides, automation in home appliances has evolved from simple timer mechanisms to sophisticated systems utilizing microcontrollers and wireless technologies like Bluetooth, GSM, Wi-Fi, and Zigbee. These advancements allow users to operate their devices remotely via key fobs, smartphones, or tablets, improving energy efficiency by minimizing energy loss due to poor remote management [2].

Moreover, safety is paramount in today's market, particularly for products that involve flammable materials, where even small malfunctions can cause severe damage. Ensuring the safety of users is critical, which makes the incorporation of robust safety features in appliances essential. The primary goal of the proposed automated gas cooker system is to improve safety, reliability, and ease of use for consumers [3]. For instance, Alkali et al in [4] developed an automatic gas cooker control system utilizing an Arduino Uno as the primary control unit. This system incorporates a flame sensor, a servo motor, and a utensil detector. The flame sensor identifies the presence of a flame and regulates the gas flow to ignite the burner. Meanwhile, the utensil detector automatically shuts off the gas when it senses the absence of a cooking utensil, effectively extinguishing the flame. This design improves safety by preventing gas leaks and is especially advantageous for novice users and individuals with disabilities, thereby enhancing accessibility and user-friendliness.

Nonetheless, in another study, [5] proposed an automatic gas cooking control system that utilizes a microcontroller-based design. The system is built around an ATmega32 microcontroller, which coordinates the interactions between various components, including a servo motor, an MQ-2 gas sensor, a seven-segment display, and a mechanical gas valve. The microcontroller oversees the system's functionality, ensuring seamless communication between these elements. The term 'automatic' in this context refers to the system's ability to perform certain tasks autonomously, such as detecting gas leaks and stopping operation when a leak is identified or when the cooking time has elapsed. Users can input data like cooking duration and the amount of gas needed. When the set time ends or a gas leak is detected, the system automatically shuts off the ignition. This design significantly enhances safety and reliability, providing an efficient method for controlling gas usage in cooking applications.

Moreover, Ogunremi et al, [6] explored the design, construction, and performance evaluation of a dual self-igniting gas cooker, using locally sourced materials such as stainless steel, regulators, gas cylinders, and various burner components. The cooker, modeled using AutoCAD 3D drawings, includes gas rings, a cooktop, and a heating element. Performance tests, including a cold start and rice boiling, were conducted to assess functionality. Although initial evaluations were based on visual inspections, more precise measurements would require high-capacity thermometers. The study found that burner efficiency varied between 50% and 93%, influenced by factors such as wind, ambient temperature, and burner size. It was also noted that real-world efficiency is generally lower than the figures obtained under controlled conditions.

Extensive research in [7] introduced an advanced automatic gas stove that integrates Internet of Things (IoT) technology to enhance safety. The system uses a gas solenoid valve to automatically manage gas flow, allowing the stove to be turned on and off as needed. Users can monitor and control the stove remotely through an Android smartphone via Wi-Fi. Additionally, the stove features a motion sensor to prevent accidents caused by negligence during cooking. In [8], an automated gas stove system was developed using an Arduino module and sensors to improve safety and functionality. It features a gas sensor, sound sensor, and motor to adjust the stove's knob in critical situations, with a sound sensor tracking the number of whistles. Users can select between normal and cooking modes via a keypad, while a GSM module sends text alerts for real-time monitoring. The system aims to reduce fuel consumption and manual effort but faces limitations such as reliance on GSM in areas with poor network coverage, increased complexity, and the sound sensor's reduced effectiveness in noisy environments.

Kader et al in [9], developed a smart gas stove aimed at improving kitchen safety and reducing gas wastage. The system, powered by an ATmega328p microcontroller, includes a solenoid valve that automatically shuts off the gas when the stove is inactive. It only activates the gas burner when a flame is present and a pot is on the burner. For added safety, an exhaust fan automatically turns on if smoke, excessive gas, or high temperatures are detected. Additionally, the stove features a timer for scheduled cooking and can be controlled via Bluetooth, including voice commands. Research in [10] proposed an automatic safety gas stove aimed at enhancing domestic LPG safety by preventing potential hazards during stove usage. This project utilizes an AT89C51 microcontroller and is designed to automatically turn off the gas under various conditions. It operates in three modes, namely, detection mode, timer mode, and remote access mode. An IR sensor is used to detect the presence of a utensil near the burner, and the timer mode shuts off the gas after a specified duration. Additionally, the remote access mode enables users to turn off the stove using a mobile phone, with a DTMF module that transmits signals to the microcontroller. This system showcases the potential for kitchen automation and significantly improves both safety and convenience.

The advancement of automated gas cookers has significantly enhanced convenience and safety; however, current models still encounter several challenges. These include complicated installation processes, limited integration with smart home systems, and inadequate safety features. Many existing models are not user-friendly due to maintenance difficulties, and advanced technology often entails high costs. This paper seeks to resolve these issues by developing a cost-effective and user-friendly automatic gas cooker. The proposed system will incorporate a unified control platform featuring infrared remote control and timer functionalities to simplify usage. Additionally, it will improve compatibility with modern smart home technologies and bolster safety through automatic gas shut-off mechanisms that respond to flame detection, gas leaks, and the presence of cooking utensils.

II. METHODOLOGY OF THE PROPOSED DESIGN

This chapter details the structured approach adopted for the design and implementation of the automatic gas cooker system. It covers the key procedures and operational strategies employed throughout the project. The process started with the development of computer-based models and writing of the system's code, which were critical for assessing the overall functionality. Proteus software was utilized for system simulation, ensuring that each component operated as intended. Following the successful completion of simulations, a physical prototype was constructed. A series of experiments were then conducted to validate the system's performance. Microsoft Excel was used to perform statistical analyses, comparing data from both the simulations and experimental results to confirm the reliability and accuracy of the system.

A. Design Concept of the Proposed Design

This section provides an in-depth analysis of the design principles and techniques employed in developing the automatic gas cooker system. The system is designed to ensure both safety and efficiency by integrating hardware and software components that function cohesively. At the core is a microcontroller, responsible for processing inputs from the user interface, including buttons and remote control, and controlling outputs like the servo motor, solenoid valve, and buzzer. The microcontroller operates on a stable 5V power supply, crucial for ensuring the system's reliability. Gas flow is regulated by the solenoid valve, activated based on user commands. Information such as cooking time and system status is displayed on an LCD, providing real-time feedback. Additionally, the system incorporates safety measures, with a buzzer that triggers an alert in case of hazards like gas leaks. The microcontroller continuously monitors and adjusts the system to maintain safe operation. Figure 1 illustrates the block diagram, while Figure 2 presents the logical flow model of the automatic gas cooker system, incorporating a timer and infrared remote-control functionality.

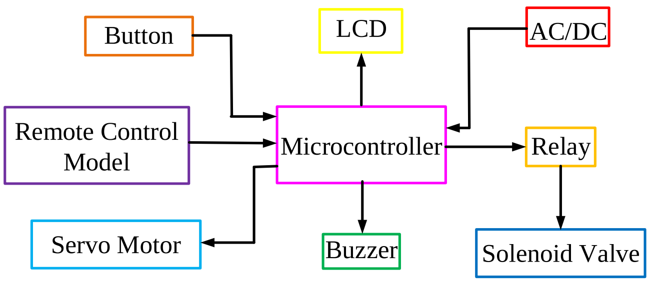

Figure. 1. Block Diagram of an automatic gas cooker system

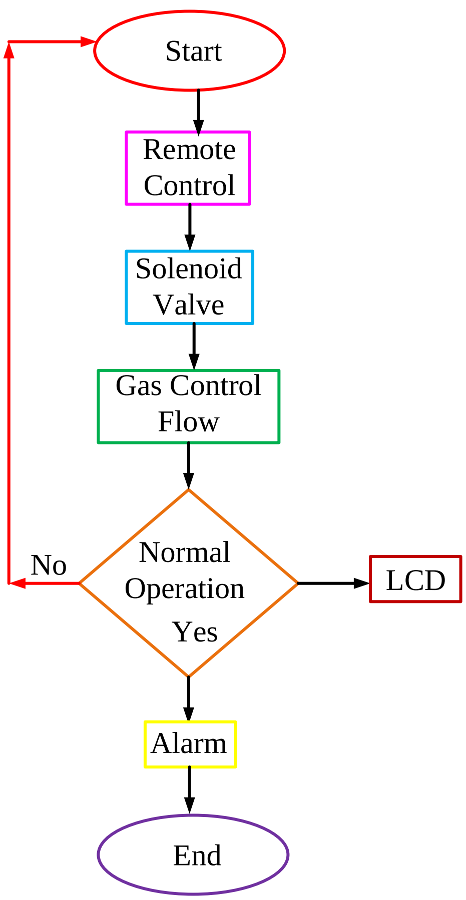

Figure. 2 Flow chart model of automatic gas cooker system

Figure 3 shows the complete circuit diagram of the automatic gas cooker system, utilizing infrared control technology.

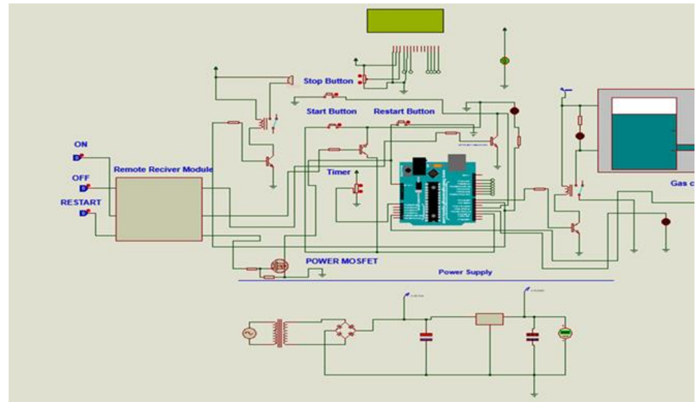

Figure. 3. Circuit Diagram of an automatic gas cooker system

B. *Operation of the Proposed Design*

At the core of the system is the microcontroller, which serves as the central control hub, coordinating the functions of connected components. The button unit (Start, Stop, and Restart) sends signals to the microcontroller, enabling manual control over the cooking process. The microcontroller also manages the servo motor, which adjusts the gas valve, controlling gas flow according to the cooking settings. The LCD display unit provides real-time updates on cooking time and system status, giving users a visual interface for monitoring. For safety, the microcontroller monitors various sensors for potential hazards, such as gas leaks or overloads. In case of an issue, it triggers an alarm system, activating a buzzer powered by a 12V supply. The power supply, comprising a step-down transformer, bridge rectifier, and resistors, ensures stable voltage across the system. An isolation relay protects the microcontroller from high-power circuits, which it controls to regulate the solenoid valve. The solenoid valve, in turn, governs the gas flow from the cylinder, following the microcontroller's commands.

III. CONSTRUCTION PROCEDURE

The construction of the automatic gas cooker system was carried out using a step-by-step approach to ensure all components were properly connected and integrated according to the design specifications. The process began by wiring the components based on the circuit diagram, making sure that every connection was secure and accurate. The microcontroller, sensors, and other hardware were then mounted on a sturdy base, forming the physical structure of the system. Integrating the software with the hardware was a crucial step to ensure proper functionality. Once assembly was complete, the system underwent thorough testing to confirm that all components worked harmoniously. Figure 4 illustrates the overall assembly, highlighting key components such as the microcontroller, LCD display, button unit, and alarm

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system. Figure 5 provides a detailed view of the solenoid control and power supply units.

Figure 4. Overall Assembly of the Automatic Gas Cooker System

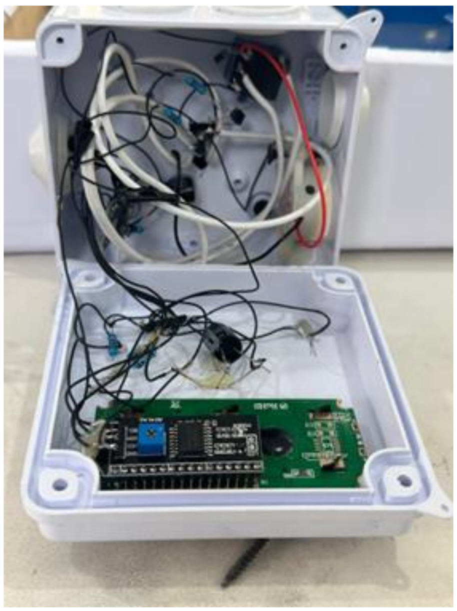

Figure 5. Detailed Construction of the Solenoid Control Unit and Power Supply Unit

IV. RESULTS OF THE PROPOSED DESIGN

This section of the paper provides an in-depth analysis of the simulation and experimental results related to the automatic gas cooker system design. The simulation outcomes are reviewed to confirm the system's performance and ensure it aligns with the design goals. Additionally, real-world experiments were conducted to evaluate the system's functionality under practical conditions. A comparative analysis of the simulation data and experimental findings is presented to give a complete evaluation. Microsoft Excel was used to create graphs, offering a visual representation of the relationship between the simulated and experimental results.

A. Simulation Results

The performance of the designed automatic gas cooker system was tested by loading and observing its operation. The system was first simulated using Proteus software, and the results are shown in Figure 6. During the simulation, the LCD display showed "0 mins," indicating that the cooking time was initially set to zero. At this stage, the system successfully powered on, as confirmed by the display. This demonstrates that the system initializes correctly and responds accurately to user inputs, allowing effective control over the cooking time.

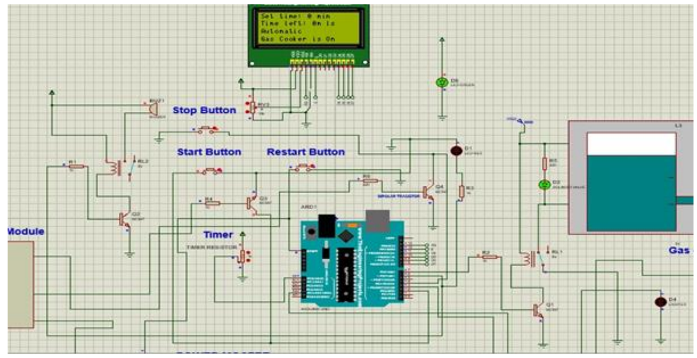

Figure 6. LCD display when the cooking time was set to 0 minute

As the simulation progresses, the system begins counting down the set cooking time. Once the time elapses, the system transitions to a "time's up" state. As depicted in Figure 7, the gas cooker turns off, and the LCD displays "Times Up." This confirms that the system accurately detects the end of the cooking period and automatically shuts off the gas supply, ensuring both safety and energy efficiency.

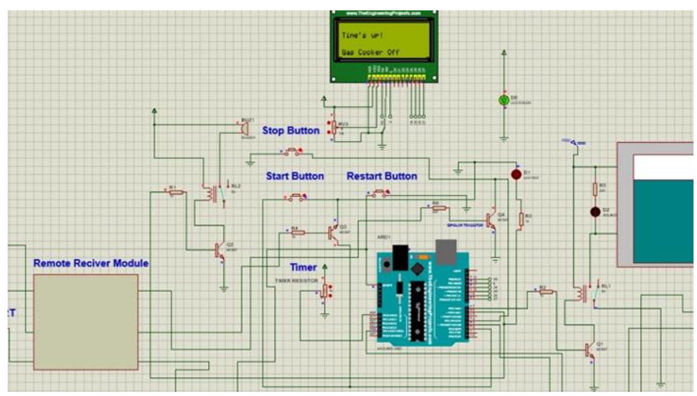

Figure 7: LCD Display Showing Time's Up and Automatic Gas Cooker Turned Off

Figure 8 shows the LCD display when the cooking time was set to 1 minute. As the countdown progressed, the display read "59 seconds," confirming that the timer was functioning properly. The gas cooker remained operational during this time, as indicated on the display. This result verified that the system accurately tracked the countdown and maintained continuous operation. The smooth transition from 1 minute to 59 seconds without any interruption demonstrated the system's reliability in handling time-sensitive tasks.

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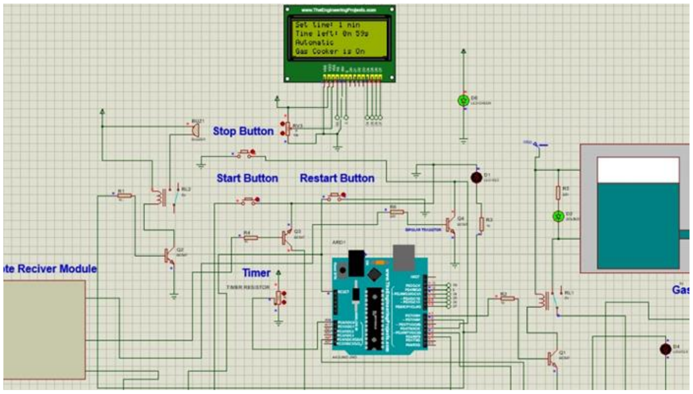

Figure 8. LCD display when the cooking time was set to 1 minute

Figure 9 displays the LCD showing "Time's Up" after the 1-minute countdown, at which point the automatic gas cooker switched off. This verifies that the system responded accurately when the set time elapsed, confirming proper functionality.

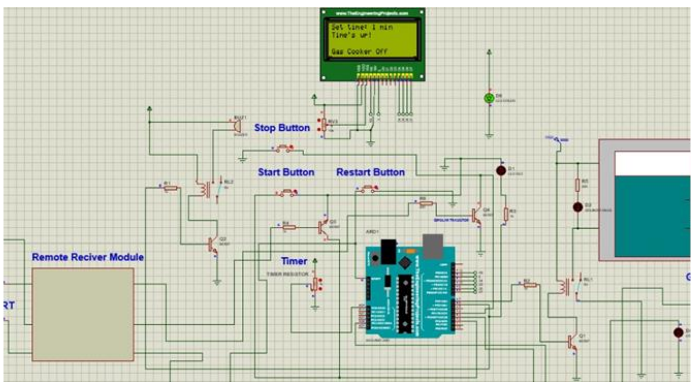

Figure 9. LCD Display Showing Countdown from 1 Minute to 59 Seconds and Automatic Gas Cooker Turned Off When Time's Up

Figure 10 displays the LCD output when the cooking time was set to 2 minutes. As the countdown commenced, the screen showed "1 min 55 seconds," confirming that the system accurately tracked the elapsed time. Throughout this interval, the automatic gas cooker remained operational, as indicated on the display. This test demonstrated the system's precision in time management, ensuring the gas cooker functioned correctly within the specified time frame.

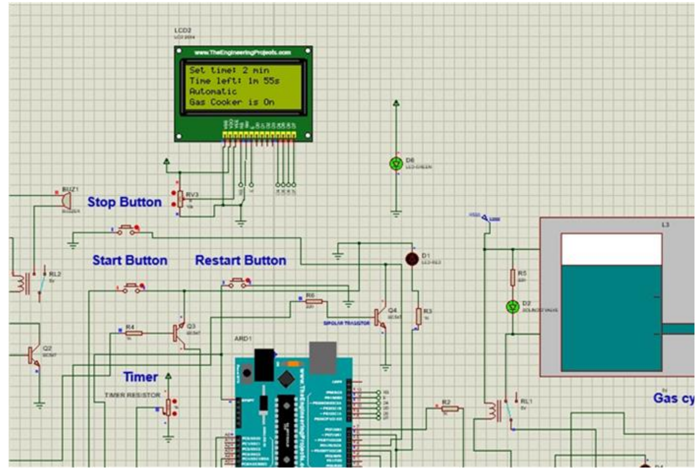

Figure 10. LCD display when the cooking time was set to 2 minutes

Figure 11 shows the LCD display reading "Time's Up" after the 2-minute countdown, at which point the automatic gas cooker turned off. This confirms that the system responded appropriately when the set time expired.

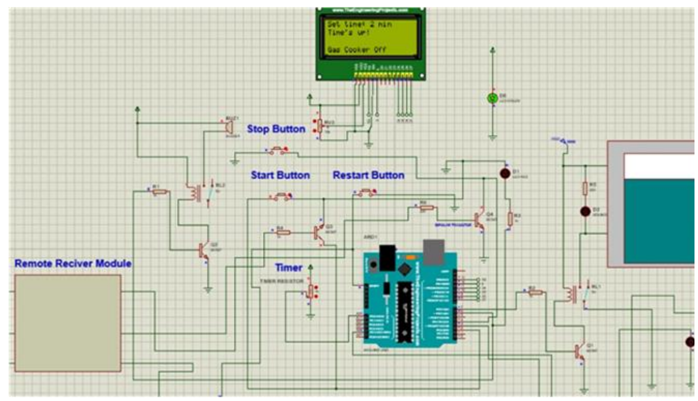

Figure 11. LCD Display Showing Time's Up after 2-minute, Automatic Gas Cooker Turned Off

Figure 12 displays the LCD output when the cooking time was set to 3 minutes. As the countdown progressed, the display showed "2 mins 57 seconds," indicating that the system was accurately tracking the elapsed time. Throughout this period, the automatic gas cooker remained active, as confirmed by the display. This result further demonstrates the system's ability to manage longer cooking durations while maintaining precise time tracking and continuous operation.

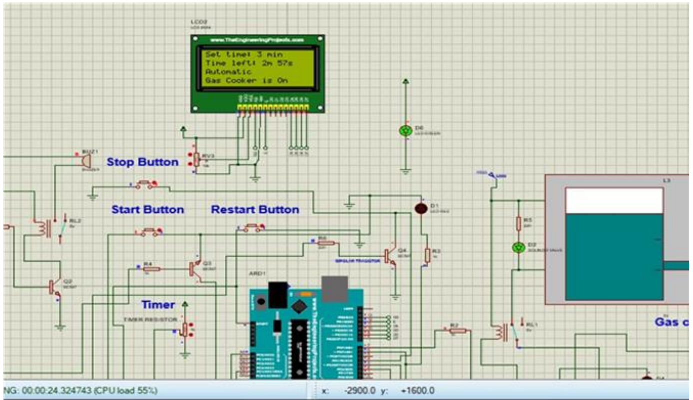

Figure 12. LCD display when the cooking time was set to 3 minutes

Figure 13 illustrates the LCD display after the cooking time was set to 3 minutes. As the countdown elapses, the display shows "Time's Up," indicating that the set time has fully elapsed. At this moment, the automatic gas cooker turns off, as reflected on the display. This confirms that the system accurately tracks longer cooking durations and appropriately shuts down the cooker once the time is reached. The seamless transition from active cooking to shutdown highlights the system's reliability in managing time-sensitive tasks, ensuring safety and precision in operation.

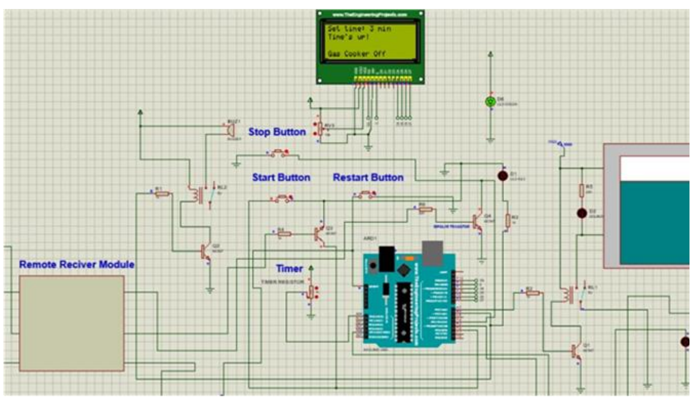

Figure 13. LCD Display Showing 'Time's Up,' Gas Cooker Off After 3-Minute Countdown

Figure 14 shows the LCD display when the cooking time was set to 4 minutes. As the countdown begins, the screen reads "3 mins 56 seconds," with the automatic gas cooker remaining operational. This result highlights the system's capability to accurately track and display the remaining time while ensuring the cooker continues to function.

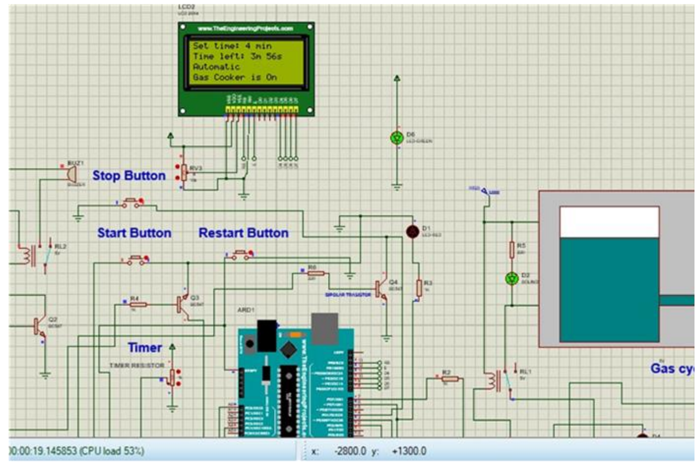

Figure 14. LCD display when the cooking time was set to 4 minutes

Figure 15 shows the LCD display after the cooking time was set to 4 minutes. When the countdown ends, the display reads "Time's Up," and the automatic gas cooker turns off. This demonstrates that the system effectively manages longer cooking durations, accurately tracks elapsed time, and ensures the cooker shuts down at the end of the set period. The transition from displaying the remaining time to showing "Time's Up" confirms the system's capability to handle extended cooking times while maintaining reliable operation.

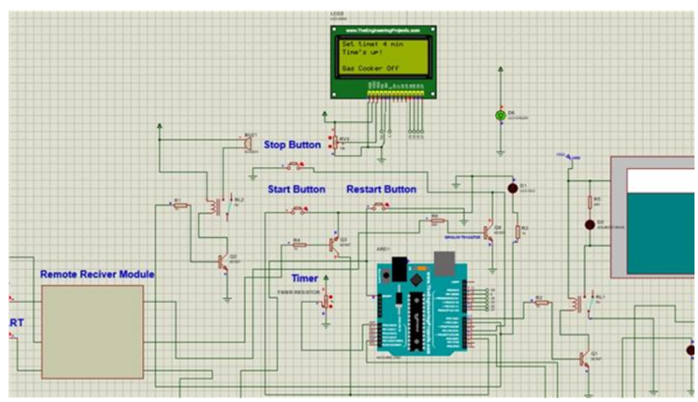

Figure 15. LCD Display Showing Time's Up, Gas Cooker Off After 4-Minute Countdown

B. Experimental Results

The experimental results were obtained by testing the circuit in practice to validate the outcomes observed during the simulations. Figures 16, 17, 18, 19 and 20 present the results of these practical experiments, which closely align with the simulated data. These experiments confirmed that the system's performance under real-world conditions matches the predictions made during the simulation, demonstrating the reliability and accuracy of the design.

Figure 16 displays the scenario when the cooking time was set to 0 minutes. The LCD reads "0 minutes and 0 seconds," indicating that the automatic gas cooker is on. This result corresponds to the initial state of the system, where the cooking process is ready to begin immediately.

Figure 16. Implemented result when the time was set to 0 minutes

Figure 17 shows the system when the cooking time was set to 1 minute. The LCD displays "48 seconds," indicating that the automatic gas cooker is operational. This result demonstrates the system's capability to accurately track and display the remaining time as it counts down from the set duration.

Figure 17. Implemented results when the time was set to 1 minutes

Figure 18 illustrates the system's performance when the cooking time was set to 2 minutes. The LCD shows "1 minute and 50 seconds," indicating that the automatic gas cooker remains active. This result confirms that the system accurately counts down and displays the remaining time, validating its functionality during this test.

Figure 18. Implemented results when the time was set to 2 minutes

Figure 19 shows the system's performance when the cooking time was set to 3 minutes. The LCD displays "2 minutes and 50 seconds" remaining, indicating that the automatic gas cooker is still operating. This confirms that the system accurately tracks and displays the elapsed time, ensuring it functions as intended during the experiment.

Figure 19 Implemented results when the time was set to 3 minutes

Figure 20 shows the system's performance when the cooking time was set to 4 minutes. The LCD displays "3 minutes and 48 seconds" remaining, indicating that the automatic gas cooker is still operational. This demonstrates that the system accurately monitors and displays the elapsed time, confirming its reliability in managing cooking durations as intended.

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Figure 20 Implemented results when the time was set to 4 minutes

Table 1 presents the results comparing the time displayed in the simulation with that observed in the experimental testing of the automatic gas cooker system.

Time Setting (mins)	Simulation Display	Experimental Display
0	0 minutes, 0 seconds	0 minutes,
1	59 seconds	48seconds
2	1 minute 55 seconds	1 minute 50 seconds
3	2 minutes 57 seconds	2minutes 50seconds
4	3 minutes 56 seconds	3minutes51 seconds

Figure 21 illustrates the graph comparing the simulation and experimental results of the automatic gas cooker system, utilizing a timer and infrared remote control.

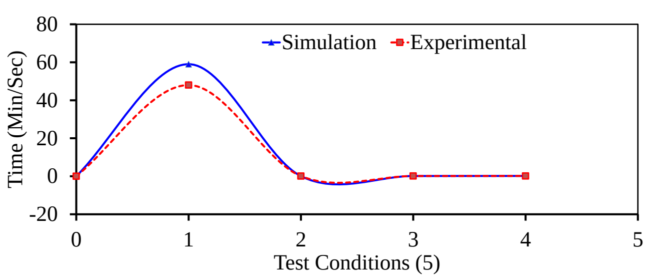

Figure 21. Graph of an automatic gas cooker using timer and infrared remote control

V. DISCUSSION OF THE PROPOSED DESIGN

The design results indicate that both the experimental and simulation outcomes for the automatic gas cooker system performed well, with only minor discrepancies observed during testing. The data presented in Table 1, along with the accompanying graph, provide a clear understanding of the system's operation and its ability to manage timing tasks. Figures 6 to 15 illustrate the simulation results, while Figures 16 to 19 depict the experimental findings. As shown in Figure 6, the LCD accurately displayed "0 minutes" when the system was activated, confirming that the gas cooker began operation immediately. In Figure 7, when the countdown reached zero, the gas cooker turned off, demonstrating that the system responded correctly to the timer reaching its limit.

Figure 8 shows the LCD displaying a countdown from 59 seconds for a 1-minute cooking duration, with the cooker remaining operational until the time expired, as confirmed in Figure 9. This result indicates the system's effectiveness for 1-minute cooking tasks. Similarly, Figures 10 and 11 reveal that the system functioned as expected for a 2-minute setting, with the LCD showing "1 minute and 55 seconds" while the cooker remained on until the timer elapsed. For the 3-minute setting, Figures 12 and 13 confirm accurate time tracking, displaying "2 minutes and 57 seconds," with the cooker shutting off at the end of the cooking period. Finally, for the 4-minute duration, Figures 14 and 15 demonstrate the system displaying "3 minutes and 56 seconds" and successfully turning off the cooker at the conclusion of the set time.

Figures 16 to 20 present the initial conditions and experimental results. Figure 16 shows the starting state of the experiment, while Figure 17 depicts the system set to 1 minute, with the LCD reading "48 seconds." Figure 18 presents the experimental reading for a 2-minute setting, showing "1 minute and 50 seconds," and Figure 19 shows the time for a 3-minute duration, also reflecting "1 minute and 50 seconds." Finally, Figure 20 displays the experimental reading of "3 minutes and 51 seconds" for the 4-minute interval. While the simulation and experimental results were largely consistent, some small differences were noted. For instance, during the 1-minute test, the simulation indicated 59 seconds, whereas the experiment showed 48 seconds. Similar minor discrepancies were observed in other trials, likely due to delays in hardware signal processing. The graph in Figure 21 highlights these variations, illustrating that although the system operated reliably, the experimental results occasionally lagged behind the simulation.

VI. CONCLUSION

This research work successfully designed and developed an automatic gas cooker system by integrating key components and technologies to ensure enhanced functionality and safety. Initial simulations using Proteus verified the effective interaction of elements such as the microcontroller, button unit, remote control, servo motor, LCD display, buzzer, and solenoid valve. Afterward, the system was physically assembled and experimentally tested.

The experimental outcomes closely aligned with the simulation results, demonstrating the system's capability to manage cooking times, process user commands, and respond to safety alerts. The comparison of simulation and experimental data confirmed the accuracy and reliability of the design. Moreover, Excel-generated graph provided visual clarity, supporting a comprehensive performance analysis of the system.

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