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Departement of Electrical and Electronic Engineering

Option: Electronic and Telecommunication Technology

DESIGN AND IMPLEMENTATION OF SMART DIGITAL THERMOMETER SYSTEM

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Research project submitted in partial fulfillment of the requirement for award of advanced diploma in Electronic and Telecommunication Technology

Supervised by: Eng.GATESI Annuarita

September 2024

DECLARATION

I, AVOUNGOU Emmanuelle Declare that this research study is my original work and has not been presented for a Degree or any other academic award in any University or Institution of Learning". No part of this research should be reproduced without the authors' consent or that of Ulk Polytechnic Institute.

Sign: ____________________________ Date: _________________

CERTIFICATION

I confirm that the work reported in this research project was carried out by the candidate under my supervision and it has been submitted with my approval as the UPI supervisor.

Name: Eng. GATESI Annuarita

Sign: ____________________________ Date: _________________

APPROVAL SHEET

This research project entitled " Design and Implimentation of Smart Digital Thermometer System " prepared and submitted by AVOUNGOU Emmanuelle in partial fulfillment of the requirement for award of advanced diploma (A1) in Electronics and Telecommunications Technology has been examined and approved by the panel on oral examination.

Name and Sig. of Chairperson: ___________________________

Date of Comprehensive Examination: __________________

DEDICATION

This is dedicated to the Almighty God, who has been my source of Strength, Grace, and Wisdom all these while throughout the period of my year academic. His Grace and Favour have been able to run my year academic, scaling through the hurdles of my academic pursuit.

I also want to dedicate my report work to my family and many friends. A special feeling of gratitude goes out to my dear parents, Mr and M. AVOUNGOU, whose words of encouragement and push for tenacity keep ringing in my ears. My brother David has never been far from me and is really special.

I would like to share this report with my many friends and church family who have been supporting me throughout the process.

I also dedicate this work and give a special thank you to my best friend, Mindjombo Mbandza Audy Ulrich, for being there for me throughout the whole A1 program. You have been my best cheerleader.

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I would like to extend my deepest gratitude to all those whose help has enabled me to complete this project report successfully.

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Least but not least, I wish to extend my deep gratitude to family and friends for their understanding, encouragement, and patience during the completion of this project. Their unwavering support was always there to motivate me on a consistent basis.

All the above mentioned contributions by each of these individuals have significantly contributed to bringing this report into shape and have furthered my learning. I am sincerely indebted to all their inputs and participation.

ABSTRACT

This project entitled "Design and Implementation of a Smart Digital Thermometer System" aims to explore the effectiveness and benefits of using smart digital thermometers to maintain safety standards. The main objective is to evaluate how a smart digital thermometer can help prevent dangerous temperature through an email alert. This project aims to address these challenges by creating a smart thermometer with wireless connectivity for remote monitoring, making it suitable for use in environmental safety.

The methodology employed in this research involves a mixed-methods approach, combining a review of existing literature on smart digital thermometer security technologies in various environments.

The study results revealed that smart digital thermometers provide more accurate and reliable temperature measurements, are easy to use, and can be integrated into broader preventive safety management systems. Additionally, their ability to provide real-time alerts via mobile apps or connected systems has been shown to significantly improve response times during critical temperature fluctuations.

Based on these findings, it is recommended that general industry, especially small businesses and households, adopt smart digital thermometers as part of their standard preventive security protocols. Further research should focus on the cost-benefit analysis of widespread implementation and potential integration with other preventive security technologies.

Keywords: Smart thermometer, Microcontroller, New technologies, safety standard

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LIST OF ACCRONYMS AND ABBREVIATIONS

WI-FI: Wireless Fidelity

LCD : Liquid-Crystal Display

GPIO: General-Purpose Input/Output

DC: Direct Current

SPI: Serial Peripheral Interface

UART: Universal Asynchronous Receiver/Tranasmitter

CPU: Central Processing Unit

OTP ROM : One-Time Programmable Read-Only Memory

RAM: Random Access Memory

CHAPTER 1: GENERAL INTRODUCTION

1.0 Introduction

Nowadays, one of the main imperatives present in virtually any aspect of today’s life, whether it’s in the health sector, industry, or households, is the need for accurate real-time temperature monitoring. A temperature controller is a device that is used to control temperature. It does this by first measuring the temperature (process variable), it then compares it to the desired value (set value).

These integrated systems can monitor body temperatures in real-time, track the location of individuals, and provide automatic alerts when abnormal temperatures are detected. This combination is especially useful in scenarios like fire emergencies, where monitoring both the environmental and body temperature of individuals in hazardous conditions can save lives (Bryant, 2015).[1]

Smart digital thermometers utilizing infrared technology have emerged as powerful tools for non-contact temperature measurement. These thermometers use infrared sensors to detect the infrared radiation emitted by objects, allowing for quick and accurate temperature readings without physical contact.

The integration of GPS tracking technology into these systems further enhances their utility, particularly in emergency situations. By pairing real-time temperature measurement with location-based services, these smart thermometers enable emergency responders to monitor individuals or environments from a distance and provide rapid assistance when needed. This is especially useful in scenarios where high body temperature or environmental conditions could indicate a dangerous situation, such as a fire emergency or public health crisis (Brown & Adams, 2018).[2]

Smart digital thermometers leveraging infrared (IR) technology have emerged as a vital tool for non-contact temperature measurement, providing accurate and instantaneous readings. Infrared thermometers operate by detecting the infrared radiation emitted by an object, offering a safer and quicker alternative to traditional thermometers, especially in health-critical scenarios (Smith, 2019) [3].

The need for accurate temperature readings is crucial in situations like fire emergencies or pandemics, where a person's temperature can indicate a critical condition that requires immediate attention. Integrating infrared temperature sensing technology with communication systems like GSM and GPS ensures that emergency responders can receive timely alerts with precise location information, enabling quick and effective intervention (Jones, 2020).[4]

The use of communication modules, such as GSM or IoT platforms, ensures that alerts can be automatically sent via SMS or call, alongside GPS coordinates, ensuring rapid response in emergency situations. This combination of technology ensures that the Smart Digital Thermometer can be used not only for personal health monitoring but also as a crucial tool in emergency management scenarios (Green & White, 2020).[5]

The growing need for this kind of technology is driven by various factors, including the rise in global health crises such as pandemics, the demand for faster emergency response in healthcare systems, and the logistical challenges faced by service providers in managing large fleets and mobile units. By implementing an integrated system that combines health monitoring and GPS tracking, this study aims to address these challenges, providing a scalable and adaptable solution for various industries.

1.1 Background of the study

This study introduces a Smart Digital Thermometer with Infrared Technology integrated with a GPS-based services tracker. The system is designed to monitor temperature in real time using non-invasive infrared technology while simultaneously tracking the location of service providers (e.g., ambulances, medical units) using GPS. This integration provides crucial health and location data to healthcare professionals and emergency services, facilitating faster response times and more efficient coordination during medical emergencies.

The advancement of technology has introduced various innovations to enhance the efficiency and effectiveness of healthcare and service-oriented industries. One of these innovations is the integration of infrared temperature sensing and GPS-based tracking. In recent years, smart health monitoring devices, particularly those leveraging non-contact infrared thermometers, have become crucial for public health, especially during global health crises such as the COVID-19 pandemic. Similarly, GPS-enabled tracking systems have revolutionized service industries by enabling real-time location monitoring and optimizing operational efficiencies.

Infrared thermometers, such as the Smart Infrared Electronic Thermometer DN-997, provide instant readings within one second and feature advanced algorithms for optimized temperature calibration. They are designed for various applications, including measuring forehead and ear temperatures, making them versatile tools in healthcare. The accuracy of these devices is crucial; for instance, many models maintain a precision level of ±0.2 °C, which is essential for reliable health assessments.

The integration of infrared thermometer technology with GPS tracking systems has gained increased attention in recent years, particularly in response to global health challenges such as the COVID-19 pandemic**.** Infrared thermometers have been widely used for non-contact temperature measurement, which is crucial for reducing the spread of infections. These devices are not only employed in clinical settings but also in public spaces, airports, and homes due to their accuracy, speed, and safety (Chen, 2020).[6]

To enhance the utility of infrared thermometers, adding GPS tracking allows for real-time location monitoring of patients or individuals in need of health services. This system can provide instant alerts when an abnormal body temperature is detected, enabling emergency response teams **or** healthcare providers to quickly locate and assist the affected individual (Ahmed et al., 2022). Such technologies are particularly valuable in remote or high-risk areas, where timely intervention is essential for preventing further complications or transmission of diseases.[7]

1.2 Problem Statement

In emergency situations such as the medical and service sector, there is a need for integrated systems to monitor health and track location in real time. Traditional methods of temperature measurement are often slow, require physical contact, and do not provide simultaneous updates on the status of services such as ambulances or emergency units. In addition, communicating critical health and location data remotely poses significant challenges, leading to delays in response and decision-making. Conventional infrared thermometers, while effective for temperature readings, lack the ability to automatically notify caregivers or emergency responders when a high fever is detected, which may delay timely medical intervention (Jones & Lee, 2021).[8]

Without a system that unifies temperature monitoring with real-time GPS tracking, medical providers, public safety officials, and logistics services struggle to manage emergency responses, leading to inefficiencies, longer response times, and missed opportunities for rapid intervention.
Additionally, sectors such as public health, logistics, and transportation face challenges in ensuring continuous monitoring of critical parameters, such as temperature and location, during operations. Therefore, there is a need for a system that can provide accurate temperature data and

real-time location tracking, enabling better communication, faster response times and better decision making.This gap in emergency response capabilities underscores the need for a smart thermometer system that can automatically alert responders with precise location information, enabling faster, more efficient interventions to mitigate health risks and potential contagion (Patel & Verma, 2021).[9]

1.3 Objectives of this project

1.3.1. Main objective

The main objective of this study is to design and implement a smart digital thermometer.

1.3.2. specific objectives

The specific objectives of this Study are as follows:

i. To extend my knowledge in temperature measurement based on real-time monitoring by using novel technology.
ii. To track and monitor the real-time location of the service provider (e.g., ambulance, transport service) using GPS technology.
iii. To investigate on how we can use alarm to provide information on LCD screen when the temperature exceeds normal limits.

1.4. Research questions

The following are research questions based on the aforementioned specific objectives:

i. How can someone use novel technology in temperature measurements based on real time monitoring systems?
ii. Is it possible to know the real time location for tested of temperature?
iii. What can someone do so that they get information to know whether the temperature is in normal range or exceeds the normal limits?

1.5. Scope of the Project

The study focuses on the design and implementation of smart digital thermometer based on GSM as well as novel technologies like infrared sensors.

1.6 Significance of the study

This study is of considerable importance in the healthcare sector and other service sectors. By integrating temperature monitoring with location tracking, the system can improve the efficiency of certain services, ensuring that service providers are better prepared to respond to emergencies. The system can also be applied to other sectors where monitoring of temperature-sensitive products or tracking the location of assets is essential, such as in cold chain logistics, public transportation, and security services.

In addition, this project has added advantages over the traditional thermpmeter due to its benefits such as cost-effective and scalable, enabling widespread adoption across different sectors. The system's ability to monitor and transmit data remotely in real time improves decision-making, enhances communication, and ensures timely interventions, ultimately leading to better outcomes for people and service providers.

1.7. Organization of the study

The study is organized as follows:

Chapter 1: General Introduction, which provides the background, problem statement, objectives, significance, and scope of the study.

Chapter 2: Literature Review, which discusses the existing systems and studies relevant to the smart digital thermometer and GPS tracking technologies.

Chapter 3: Research Methodology, outlining the design, development, and implementation of the proposed system.

Chapter 4: System Design and Implementation of system, presenting the findings from the system testing and evaluation.

Chapter 5: Conclusion and Recommendations, summarizing the outcomes and offering suggestions for future improvements. At the end, references and appendices are provided.

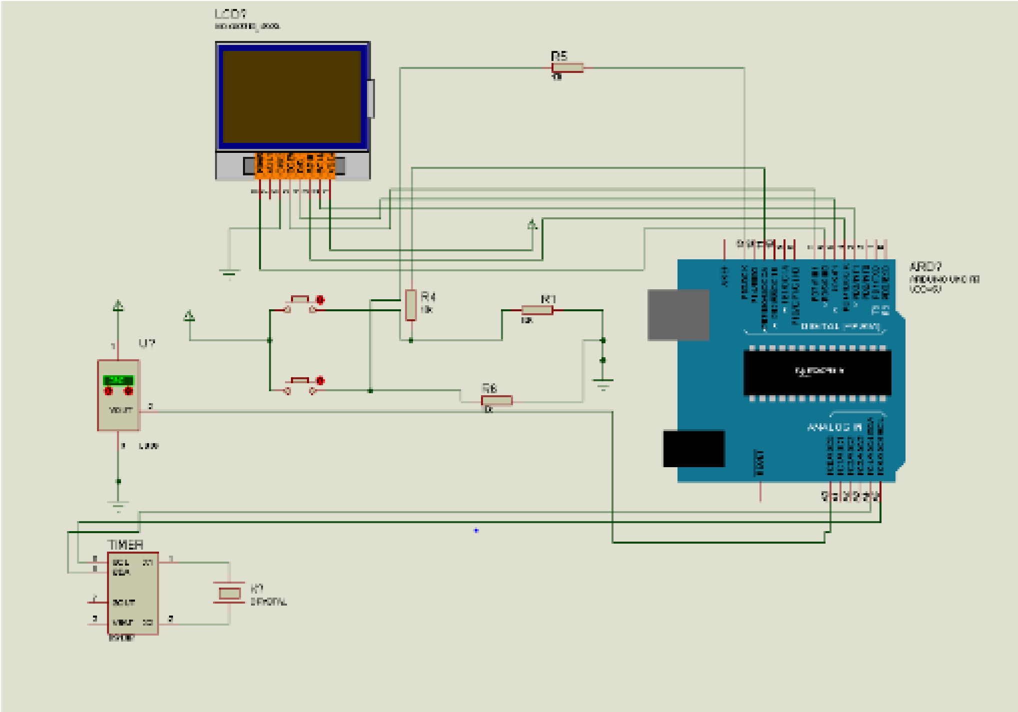
CHAPTER 2: LITERATURE REVIEW

2.0. Introduction

This chapter presents the literature review will cover the development and application of these technologies by listing the different components of this project with descriptions, types, examples, and specifications.

2.1. Smart digital thermometer system

The smart digital thermometer equipped with infrared technology and GPS service tracking device is an advanced monitoring system designed to accurately measure such as body temperature, track the individual's location and send real-time alerts in case of abnormal temperature. This system combines temperature monitoring, location tracking and communication technologies to offer a comprehensive management tool that can be crucial in emergency situations where timely information and intervention are essential. This system is applicable to Airports, railway stations, and other public spaces can benefit from the smart thermometer system. It can automatically screen passengers for fevers and notify authorities if a high temperature is detected, aiding in the prevention of the spread of infectious diseases. Hospitals can implement this system to monitor patients' vitals in real-time, particularly those in critical care units. The GPS feature is useful for tracking patients in home healthcare setups or during patient transfers between facilities. The infrared thermometer can also be used to measure the temperature of environments surrounding a fire. If certain areas become too hot, potentially leading to flashover or further fire spread, the system can send an alert to fire management teams**,** providing precise GPS coordinates for immediate action.



Circuit diagram of digital thermometer

2.1.1. Components overview for digital thermometer system

2.1.1.1 Temperature sensors

A temperature sensor is a device that uses an electrical signal to measure temperature and present the temperature in a readable format. These devices are usually thermocouples or resistance temperature detectors. Temperature sensors take observations of heat and cold and translate them into electrical signals. These components are frequently found in appliances such as microwaves, refrigerators, thermometers, and water heaters. Additionally, they have a wide range of uses, such as in geotechnical monitoring.

Figure 1: Digital temperature sensor [10]

Types of temperature sensor

There are three types of components in temperature sensors. There are essential components of a temperature sensor including thermocouple or extension cables and wires, as well as the sensing elements. The following are examples of components which complete the sensor: insulating beads, connectors, connecting heads, and protecting tubes. There are also associated components that are necessary in the use of sensors like converters and controllers.

With the MLX90614 Contactless Infrared (IR) Digital Temperature Sensor, you can find out how hot an object is anywhere between -70°C and 382.2°C. details. Operating Voltage: 3.6V to 5V (in versions of 3V and 5V available) Current Supply: 1.5 mA. Range of Object Temperature: -70°C to 382.2°C.

Figure 2: the MLX90614 [11]

Applications

- Medical Applications
- Industrial Applications
- Automotive Applications
- Consumer Electronics
- Aerospace Applications
- Food and Agriculture
- Robotics and Automation
- Environmental Monitoring
- Research and Development
- Safety and Security

2.1.1.2 Microcontroller

A small computer on a single integrated circuit is called a microcontroller (MC, UC, or μC) or microcontroller unit (MCU). A microcontroller is made up of memory, programmable input/output peripherals, and one or more CPUs, or processor cores. Along with a tiny quantity of RAM, program memory on the chip is frequently provided in the form of NOR flash, OTP ROM, or ferroelectric RAM. Unlike microprocessors, which are made up of numerous discrete chips and are utilized in personal computers and other general-purpose applications, microcontrollers are intended for embedded applications.

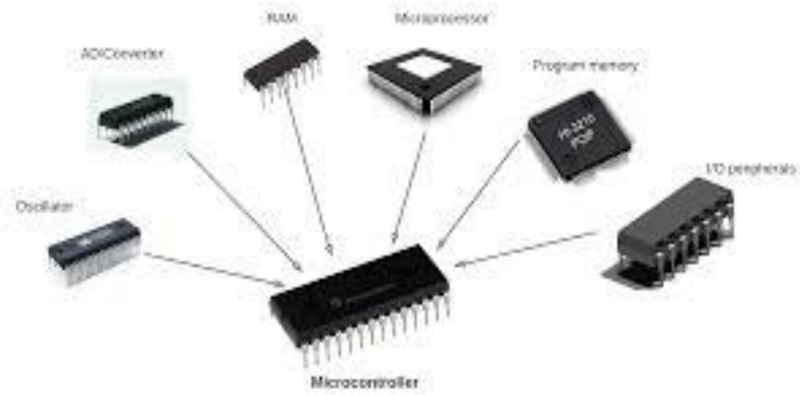


Figure 3: Microcontroller [12]

Types of microcontroller

Microcontrollers can be classified according to data size and architecture. Common types include the following:

- **8-bit microcontroller.** These MCUs can only transmit 8 bits of data at a given time. However, they consume less power compared to larger data sizes.
- **16-bit microcontroller.** These microcontrollers have higher clock speeds and more memory than 8-bit microcontrollers. They are two times faster than 8-bit microcontrollers.
- **32-bit microcontroller.** These high-speed microcontrollers are faster and have more processing capacity than 16-bit ones. However, their power consumption is significantly higher.

Microcontroller uses in this project is ESP32. With Bluetooth and Wi-Fi connectivity, a highly integrated design, and a dual-core Tensilica Xtensa LX6 CPU, the ESP32 is a low-cost, low-power system on a chip microcontroller family. Espressif Systems created the popular SoC microcontroller known as the ESP32. This microcontroller is inexpensive and incredibly flexible, finding use in a wide range of fields including as robotics, embedded systems, home automation, wireless communication, and Internet of things devices.

Figure 4: ESP32 microcontroller [13] Figure 5: ESP32 pinout [14]

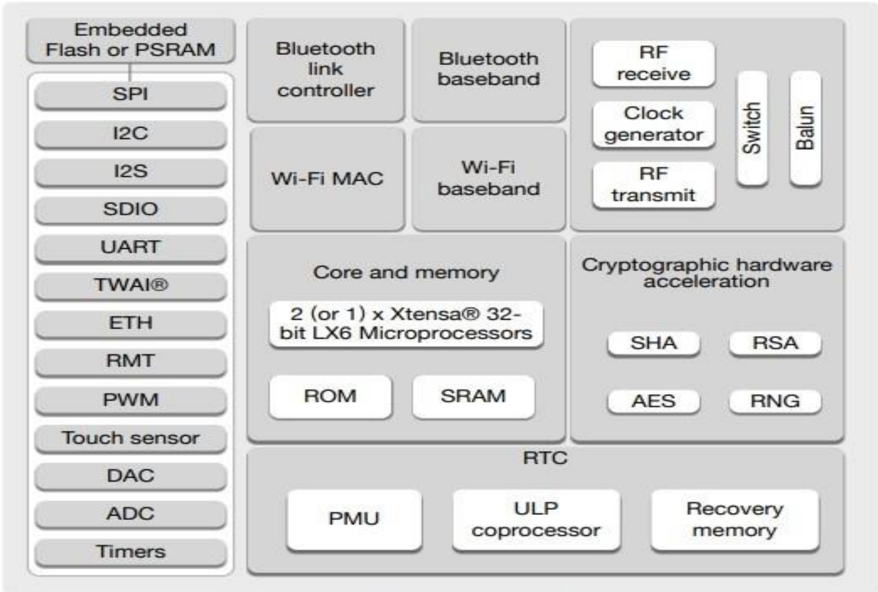


Figure 6: ESP32 block diagram[15]

Application

ESP32 has a broad range of applications across several industries. The following list provides some applications.

- **Internet of Things (IoT) Devices:** The ESP32 is perfect for creating IoT devices like asset trackers, weather stations, smart home gadgets, and industrial monitoring systems since it has built-in Wi-Fi and Bluetooth connectivity.

- **Home Automation:** Using Wi-Fi or Bluetooth connectivity, ESP32 can be used to build home automation systems that control lighting, appliances, security systems, and other smart home devices.
- **Robotics:** Wireless communication and control in robot projects are made possible by the ESP32's ability to control motors, sensors, and actuators in robotics applications.

  Wearables: Because of its low power consumption, the ESP32 is a good fit for wearable technology, including fitness trackers, smartwatches, and health monitoring systems.

2.1.1.3 Display

"Display" refers to the act of displaying content on a screen, often known as a monitor. Display screens come with a variety of devices, including instrument panels, televisions, and computer monitors. They are employed for a wide range of functions. They are available in different sizes and shapes depending upon their use and application requirements.

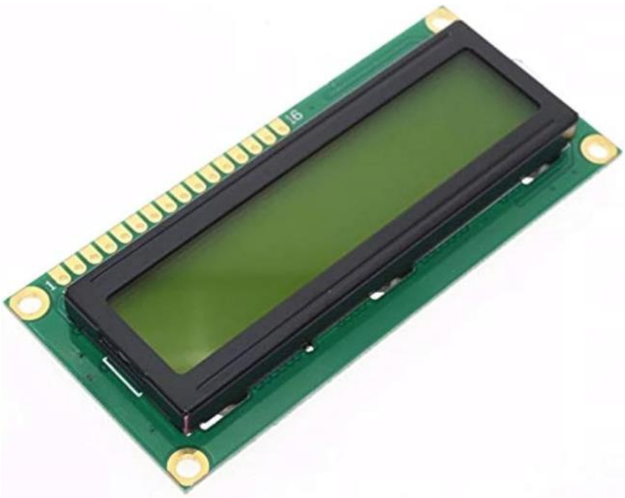


Figure 7: Display screen [16]

Types of LCD

The many kinds of LCD display fall into the following categories:

Monochrome (single color)

- Static
- Graphic
- Character
- Custom

Multi-Color

- TFT
- OLED
- FSC (Field Sequential Color LCD)
- EBT (Excellent Black Technology) aka VA (Vertical alignment)
- CSTN

The LCD 16×2 I2C is the display uses in the project . A 16-by-2 liquid crystal display has two rows of 16 characters each, for a total of 32 characters of information that can be shown. Alphanumeric data is frequently displayed using it in a variety of electrical gadgets. To create characters and symbols on the screen, a 16x2 LCD display manipulates liquid crystals to either block or allow light to pass through. It is operated by transmitting commands and data to its controller, which controls the information display.

Figure 8: LCD 16×2 I2C [17]

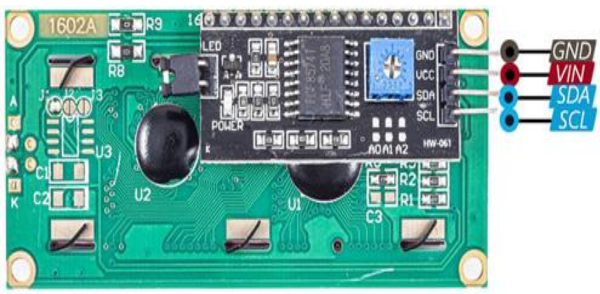


Figure 9: LCD I2C pinout [18]

2.1.1.4 GSM

A GSM (Global System for Mobile Communications) module is a hardware device that allows a microcontroller, computer, or other system to communicate over a mobile network. It enables devices to send and receive data, such as text messages (SMS), make voice calls, or use mobile data for internet access via GPRS (General Packet Radio Service). GSM technology is widely used for cellular communication around the world.

Figure 10 : GSM module [19]

Types of GSM

- Telephony services or teleservices.
- Data services or bearer services.
- Supplementary services.

This is GSM/GPRS SIM900 module, it provides you a way to communicate using cell phone network. it can be used into a great number of wireless projects that use SMS, MMS, GPRS, Audio

Figure 11: GSM SIM900 [20]

Applications

The GSM/GPRS module demonstrates the use of AT commands**.** They can feature all the functionalities of a mobile phone through a computer like making and receiving calls, SMS, MMS, etc. These are mainly employed for computer-based SMS and MMS services. LED(Light Emitting diode).

2.1.1.5 GPS Neo-6M

The Global Positioning System, or GPS for short, is a satellite-based navigation system made up of a network of 24 satellites. With no setup or membership fees, GPS is the greatest navigation technology available today. It operates around the clock. Through the technique of trilateration, one GPS gadget uses data straight from satellites to find a spot-on Earth. Radio transmissions are used by a GPS receiver to trilaterally measure distances. Through tiny processors and antennas included within the GPS modules, dedicated RF frequencies receive data supplied directly to the GPS from satellites. If four or more satellites are detected by the module antennas, they precisely determine the position and time. Furthermore, it is simple to integrate Arduino with the GPS for positioning and location.

Figure 12: LED pinout [21]

Applications

- positioning
- navigation
- anti-theft
- information reading
- T-BOX
- ADAS
- driving records
- tracking

2.1.1.6 Wires

A wire is a metallic conductor that is flexible and used in circuits for the purpose of carrying electric current. Mostly, copper and insulated live cable are used to make it. Wires are used to create electrical conductivity between two parts of an electrical circuit. They offer very little impedance to the flow of current.

Figure 13: Wires [22]

2.1.1.7 Development board of ESP32

The development board includes programming and reset buttons, a power regulator to provide a constant 3.3V to the ESP32, and a CP2102 USB-TTL serial converter; all module pins are broken out to 0.1″ headers. The module works well in areas with limited space since it has a printed antenna on the PCB.

Figure 14: board of ESP32 [23]

2.1.1.8 Real-time clock

The main purpose of a real time clock, or RTC, is to maintain precise timekeeping even when a device is in low power mode or the power source is turned off. An embedded quartz crystal resonator, an oscillator, and a controller make up an RTC. Because they are all-in-one devices, they are designed to outperform separate components, make integration easier in new designs, and get to market faster. RTCs are utilized in many different applications, where they are essential for accurately recording the current time in addition to serving as timers, alarms, and interrupt devices and lowering power usage.

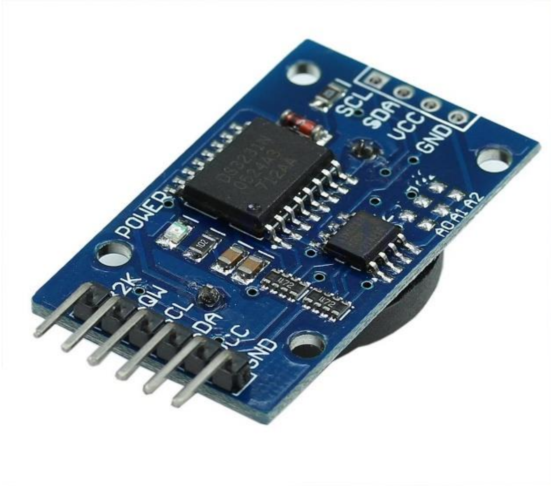


Figure 15: RTC Module [24]

Types of RTC

- Real time clock with radio-
- Real time clocks in software-
- Real time clock in the past-

The DS1307 I2C Real Time Clock chips (RTC), I2C EEPROM Memory 24C32 32K, Adopt LIR2032 rechargeable lithium battery, with the charging circuit, Solved the problem of DS1307 with battery backup can not read and write, It is used in date and time applications.

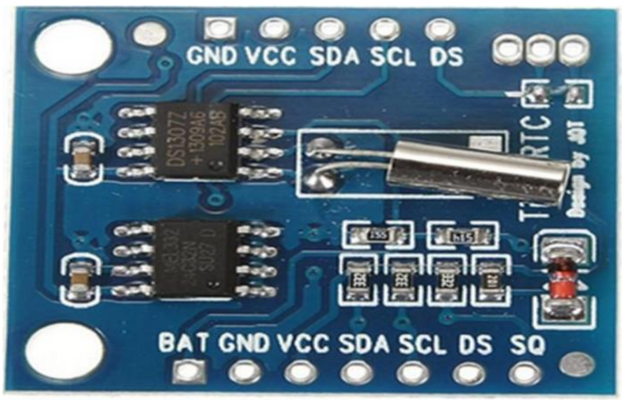


Figure 16 : RTC DS1307 [25]

Applications

- Video Conferencing and Voice Calls
- Live Streaming
- Online Gaming
- Customer Support (Live Chat)
- Telemedicine
- Collaboration Tools
- IoT (Internet of Things) Devices
- Online Education
- Financial Services
- Social Media
- Emergency Services

2.1.1.9 Buzzer

A buzzer module is an electronic device used to produce sound or a buzzing noise in response to an electrical signal. It is commonly used in systems for audio alerts, notifications, alarms, and feedback. Buzzers are widely used in electronics projects, home appliances, and embedded systems to signal events like error messages, time alerts, or sensor triggers.

Figure 17: Buzzer module [26]

Type of buzzer

- Passive Buzzer
- Active Buzzer
- Piezo Buzzer
- Electromechanical Buzzer
- Sirens

This is a Small Continous Sound Electronic Active Buzzer. It is great to add Audio Alert to your electronic designs. It operates on a DC 3-24V supply, uses a coil element to generate an audible tone.

Figure 18: Buzzer [27]

Applications

- Alarm Systems
- Clock and Timer Alarms
- Music and Melody Playback
- Automation and Control Systems.
- Education and Learning Projects

2.2 Related study

Smart digital thermometers have been shown to significantly improve the accuracy, convenience, and reliability of temperature monitoring in preventive security. This section reviews related studies that focus on the application of smart digital thermometers at different stages of the environment. The combination of infrared thermometer technology with GPS tracking is increasingly being studied and applied in various fields such as healthcare, emergency response, and logistics. This integration aims to provide real-time temperature monitoring and location tracking for better service delivery, especially in critical situations. Below are several related studies that have explored similar systems, their applications, and their impact on improving response times, safety, and efficiency.

A study by Wang et al. (2020) reviewed the “accuracy and reliability of infrared thermometers in clinical settings”, concluding that infrared technology is a practical tool for non-invasive and rapid temperature measurements. The study highlights the importance of real-time monitoring in preventing the spread of infectious diseases .

Dorn et al. (2019) examined the use of “real-time GPS tracking for ambulance services” and found that it significantly reduced response times and improved the coordination between hospitals and emergency vehicles. The study emphasized the importance of tracking technology in ensuring timely medical care .

In a study by Singh and Patel (2021)**,** a “smart prevetive system” was developed using infrared sensors to measure body temperature and GPS to track the location of people. The system was tested in remote areas where care access is limited, and the results demonstrated its effectiveness in remote people monitoring and emergency alerts .

Ahmed et al. (2022) explored the use of “GSM modules in smart devices” for transmitting critical data to hospitals in real-time. Their system was capable of sending alerts when the patient’s body temperature exceeded normal levels, and the GPS location was also transmitted to emergency response teams .

Liu, T., & Wang, J. (2020). "Preventive Safety Measures Using Smart Temperature Monitoring in Hazardous Industries." *International Journal of Industrial Safety*, 15(1), pp. 42-55.

As technological advances continue, smart thermometers are expected to play an increasingly important role in ensuring preventing safety in the future.

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

This chapter presents the research methodology employed in the study on the effectiveness of smart digital thermometers in preventive safety. The methodology outlines the research design, and analysis methods. The research methodology for the smart digital thermometer system encompasses a structured approach to design, development, and testing. By employing both descriptive and experimental research designs, the study aims to create a reliable and effective thermometer system, addressing current gaps and enhancing preventive safety through advanced temperature monitoring technology.

3.1 Research Instrument

In this study, the primary instrument is a smart digital thermometer equipped with infrared technologyand an services tracking system using GPS. The system is built with components including the ESP32 microcontroller, DS1307 real-time clock, MLX90614 infrared temperature sensor, NEO-6M GPS module, SIM500L GSM module, LCD with I2C interface , and a buzzer for alerts. The research design focuses on developing, testing, and validating the performance of this integrated system in real-time emergency service applications.

3.2 Research Design

The research follows a developmental experimental design aimed at building and testing a functional prototype of the smart thermometer and servives tracking system. The process is divided into several key phases, as outlined below:

3.2.1 Design and Development Phase

This phase involves designing the hardware and software components of the system. The steps are as follows:

3.2.2 Component Selection and Integration:

- ESP32 microcontroller serves as the core platform to control all peripherals.
- MLX90614 infrared sensor is used to measure temperature without contact.
- NEO-6M GPS module provides real-time location tracking.

- SIM500L GSM module enables communication with healthcare facilities, sending critical data such as temperature and location.
- DS1307 RTC provides real-time date and time stamps for recording purposes.
- LCD I2C displays the measured temperature, location coordinates, and date/time.
- Buzzer acts as an alert system when temperature readings exceed normal levels.

3.2.3 Circuit Design and Assembly:

- The components are connected based on their interfaces (I2C for the LCD and RTC, UART for GPS and GSM).
- Power supply design is ensured to handle the current needs of the GSM module and other peripherals.

3.2.4 Software Development:

- Firmware is written for the ESP32 to interface with all the modules, collect data from the temperature sensor, and integrate GPS coordinates.
- The system sends SMS alerts with location, temperature, and timestamp data when a temperature threshold is crossed.
- The buzzer is triggered e.g when the body temperature exceeds a predefined threshold (e.g., 38°C) to alert the medical personnel immediately.
- The LCD continuously displays the body temperature, date, time, and GPS coordinates.

3.2.5 Testing and Calibration Phase

Once the hardware and software are developed, the system undergoes rigorous testing to ensure accuracy and reliability.

1. Sensor Calibration:

- The MLX90614 infrared sensor is calibrated to ensure precise temperature readings. Testing is done by comparing its readings with a standard medical thermometer across different individuals and environmental conditions.

2. GPS Accuracy Testing:

- The NEO-6M GPS module is tested for real-time tracking accuracy, especially in urban and rural areas where prevention services would operate. The system is tested for signal loss or delays in different geographical conditions.

3. Real-Time Communication Testing:

- The SIM500L GSM module is tested for its ability to send real-time SMS alerts to healthcare facilities or dispatch centers. The system is tested in various network conditions (low-signal, high-signal areas) to ensure reliable communication.

4. **RTC and LCD Functionality**:

- The **DS1307 RTC** is tested for accuracy in maintaining time, and the **LCD** is tested for real-time display of all necessary data (temperature, time, date, and location).

5. **Buzzer Alert Testing**:

- The buzzer is tested to ensure that it triggers properly when the temperature exceeds the threshold and that it generates a loud enough sound for notification in noisy services environments.

3.2.3 Field Testing Phase

After initial testing, the prototype is deployed in a real-world services environment to simulate emergency scenarios.

1. **Temperature Monitoring in Transit**:

- The system is installed in an prevention services, and temperature readings are taken during patient transport. The focus is on how quickly and accurately the system reads the temperature and how effective the alerts are.

2. **GPS Tracking in Emergency Response**:

- The GPS tracking feature is used to monitor the prevention's service location in real-time, ensuring that the dispatch center can accurately predict arrival times.

3. **Real-Time Data Transmission**:

- Testing how effectively the system sends SMS alerts to healthcare facilities with patient data (temperature, location, and time). The hospital's preparedness based on this data is evaluated.

4. **End-User Feedback**:

- Paramedics and hospital staff provide feedback on the usability, response time, and effectiveness of the system in a live emergency setting. Any issues or delays in the system are noted for further refinement.

3.2.4 Data Collection and Analysis Phase

In this phase, data collected from the field tests are analyzed to evaluate system performance.

1. **Accuracy of Temperature Readings**:

- Comparison between the smart thermometer readings and traditional thermometers across multiple patients is conducted to check for consistency and reliability.

2. **Response Time of Alerts**:

- The time taken to send an SMS alert after detecting abnormal temperature is recorded to assess how quickly the system can notify medical personnel.

3. **GPS Location Precision**:

- GPS tracking data is compared with actual mapped routes to measure accuracy.

4. **System Reliability**:

- Overall system performance (temperature measurement, GPS tracking, SMS alerting, and buzzer functionality) is monitored to identify any potential weaknesses or areas for improvement.

The research instrument for this study involves a systematic approach to developing, testing, and validating a smart thermometer and services tracking system using infrared and GPS technology. By following these procedures, the study ensures that the developed system is functional, reliable, and can provide real-time data to improve emergency medical services. This research will provide insight into how modern technology can be effectively used to enhance healthcare delivery during emergencies.

3.3. Validity and Reliability of the Instrument

This study focuses on the validity and reliability of the Smart Digital Thermometer with Infrared Technology and Services Tracker using GPS. The system's validity is crucial for accurate and reliable performance in real-time applications, especially in emergency services. The system's validity is established through content validation, construct validation, criteria validation, and test-retest reliability. Content validation ensures that the system covers all necessary aspects of emergency services monitoring, such as accurate non-contact body temperature measurement, precise real-time location tracking, accurate time and date data, and real-time communication.

Criteria validation ensures that the smart thermometer aligns with medical-grade instruments, and the GPS module's accuracy meets established criteria. Reliability refers to the system's consistency and dependability over time and across different scenarios. Strategies employed include internal consistency, test-retest reliability, environmental testing, and durability and system stability.

By employing these strategies, the smart digital thermometer and GPS-based services tracker system can consistently provide accurate, real-time data to medical personnel during emergencies. The careful calibration and repeated testing of the system's sensors, GPS, and communication modules ensure that the system can be relied upon for emergency use, contributing to improved patient care and faster response times.

CHAPTER 4: DESIGN AND IMPLEMENTATION OF SMART DIGITAL THERMOMETERS.

4.0 Introduction

This chapter focuses on the system design, analysis, and implementation of the smart digital thermometer used in emergencies applications. The chapter provides a detailed explanation of how the system was developed, including its components, functionality, and performance. The system design addresses the requirements for accurate and efficient temperature monitoring, while the analysis explores the performance metrics and technical considerations. Finally, the chapter discusses the implementation process, highlighting how the smart digital thermometer is integrated into preventive safety practices.

4.1 Block diagram

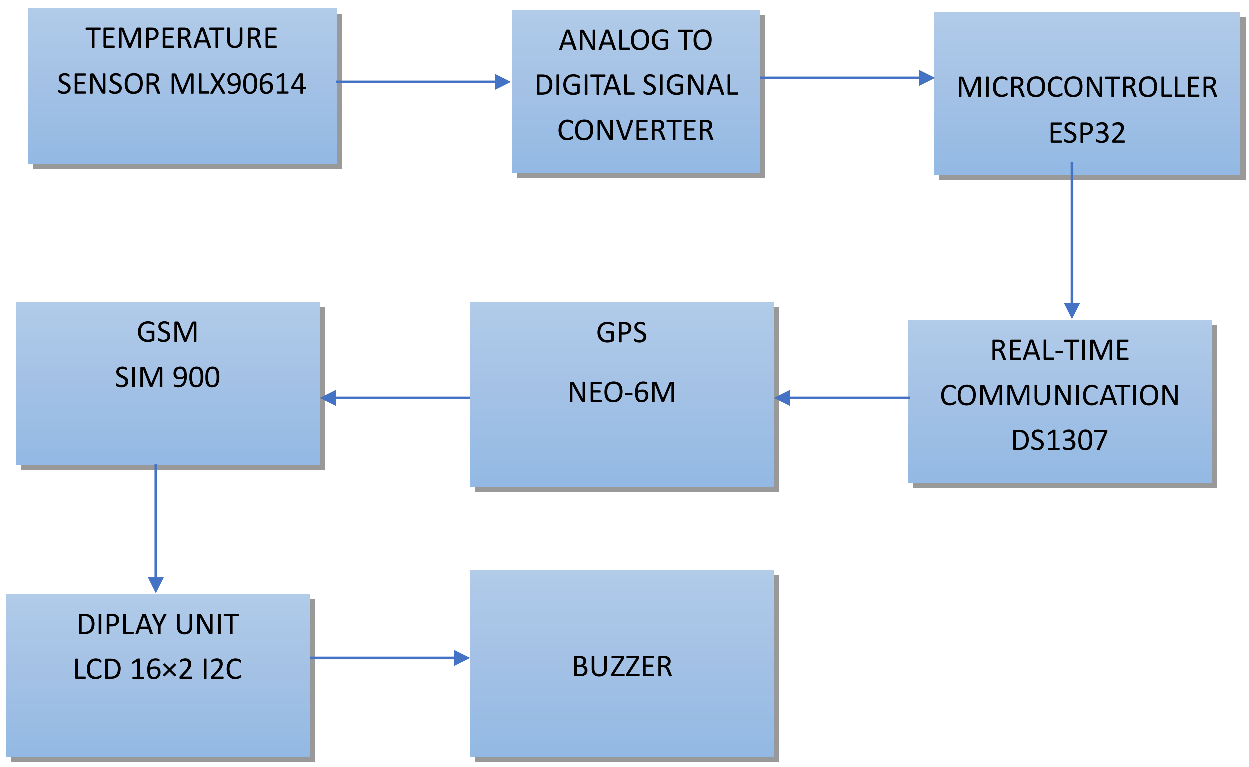


Figure 19 : Block diagram of proposed smart digital thermometer

4.2 flowchart

The following figures shows the flowchart of the project:

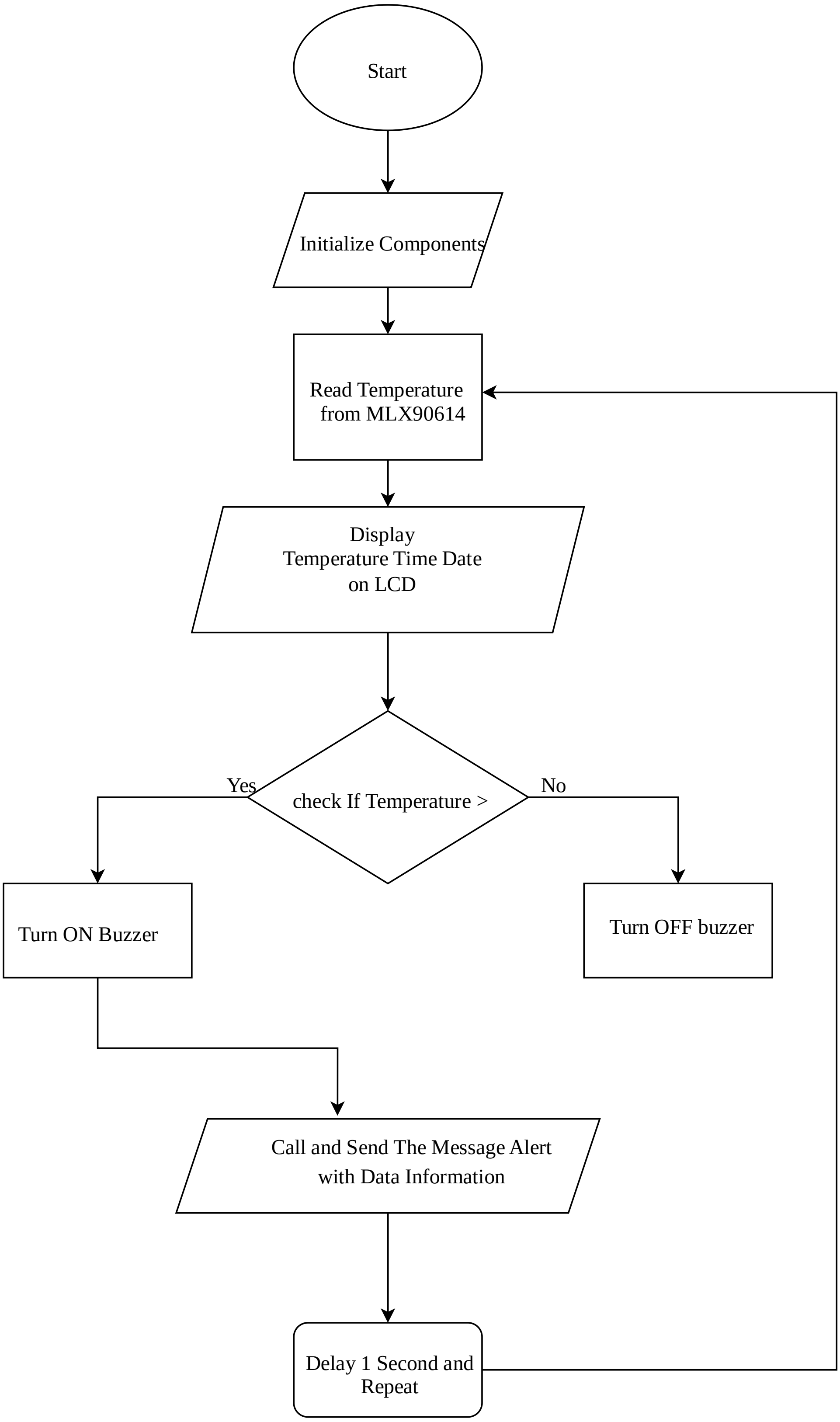


Figure 20: Flowchart of system

4.3. Drawings

Circuit diagram

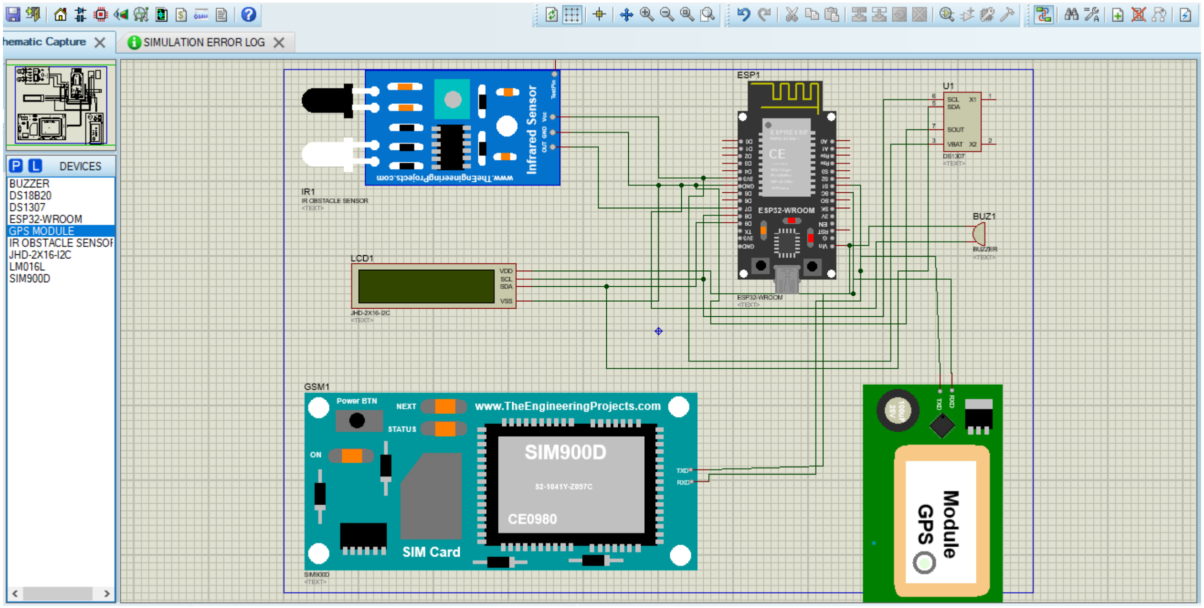
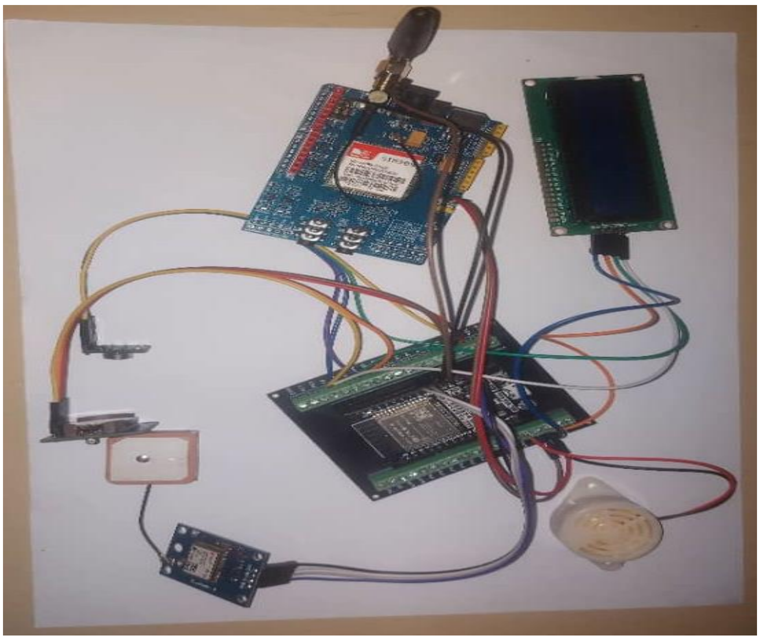


Figure 21: circuit diagram of Smart Digital Thermometer

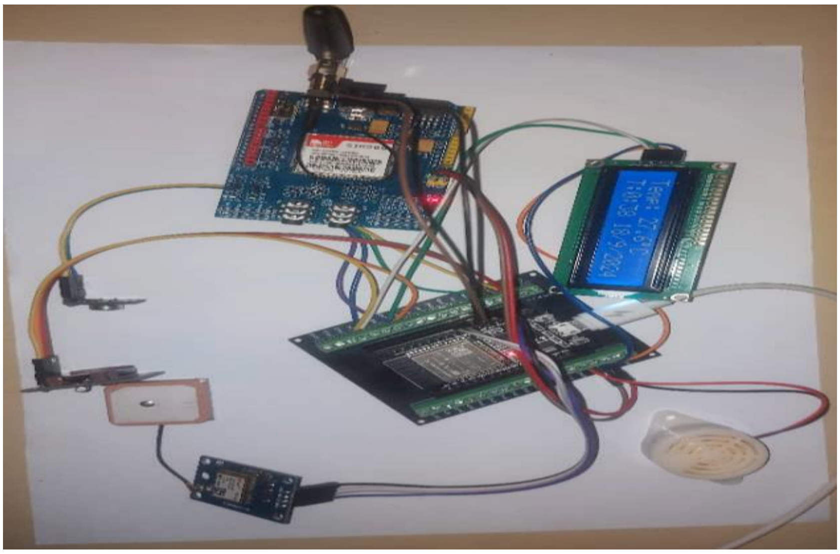
4.5 implementation

This sections presents two scenarios for the implementation of the proposed project i.e. the first figure presents the experiment before activation while the second one presents the situation on what happens after the system activation.

First figure before activation



Second figure after activation



Components used

1. **ESP32 WROOM**: Central microcontroller for managing data and communication.
2. **MLX90614**: Infrared temperature sensor for measuring temperature.
3. **DS1307**: Real-time clock (RTC) module for accurate time and date.
4. **NEO-6M**: GPS module for tracking location.
5. **SIM900**: GSM module for sending SMS alerts.
6. **LCD I2C**: Display module for showing temperature, time, and location.
7. **Buzzer**: Alert mechanism for audible notifications.
8. **Power Supply**: Suitable power source for the components.

Implementation Steps

Wiring and Setup

Connect the Components:

- **MLX90614**: Connect SDA to ESP32 D21 and SCL to D22.
- **DS1307**: Connect SDA to ESP32 D21 and SCL to D22.
- **NEO-6M**: Connect TX to ESP32 RX D2 and RX to ESP32 TX D4
- **SIM900**: Connect TX to ESP32 RX2 and RX to ESP32 TX2
- **LCD I2C**: Connect SDA to ESP32 D21 and SCL to D22.
- **Buzzer**: Connect to a digital pin D13 on the ESP32.
- **Power Supply**: Ensure that all components are properly powered.

Data Analysis

The system monitors the temperature against a predefined threshold. The system determines if the temperature data exceeds the threshold to trigger alerts If the temperature exceeds the normal limit (e.g. in the event of a fire or fever), an alert is triggered. The DS1307 provides the exact time and date that the temperature measurement is taken. This is essential for recording and referencing when alerts are generated. The system ensures accurate synchronization of the time and date with the temperature data. The GPS records the location where the temperature measurement was taken. This information is added to the alert message for better situational awareness. The system verifies that the location data is correctly captured and included in the alert. Alert Mechanism When a temperature threshold exceedance is detected, the system activates the buzzer and updates the LCD display with the current temperature, time and date. The system confirms that the buzzer and LCD functions are working properly and reflecting real-time data. The SIM900 GSM module sends an SMS containing temperature, time, date and location data to a designated recipient or authority. The system validates that the message is sent correctly and contains all the necessary information.

Interpretation of Results

If the system detects a temperature above the set threshold, it indicates a potential emergency, such as a fever or fire. The combined functionalities of temperature sensing, location tracking, and alerting ensure immediate response. The SMS alert provides critical information for timely intervention. Accurate time stamping, location data, and alert mechanisms are essential for effective monitoring and response. The integration of these components in a single system enhances both preventive and reactive safety measures.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the final conclusions drawn from the implementation of the smart digital thermometer with infrared technology and GPS tracking. It also provides recommendations for enhancing the system and suggestions for further research to explore potential improvements and applications.

5.1 Conclusion

The integration of infrared thermometer technology with GPS tracking in a smart system has demonstrated significant potential in enhancing real-time monitoring and preventive safety measures. The MLX90614 infrared thermometer effectively measures temperature with high accuracy. The system successfully detects temperature anomalies, which is crucial for early detection of fever or other issues. The NEO-6M GPS module provides precise location data, enabling real-time tracking of the service provider's location. This capability ensures that emergency response teams can be effectively dispatched and coordinated based on the exact location of incidents. The combination of temperature measurement, location tracking, and alerting through the SIM900 GSM module and buzzer offers a robust mechanism for notifying relevant authorities in case of emergencies. The system's ability to send SMS alerts with detailed information about temperature, time, date, and location ensures timely interventions. The LCD I2C display provides real-time visibility of information, including temperature readings, time, and date. This feature allows users to monitor the system easily and take immediate action if necessary. The successful integration of multiple technologies into a single system demonstrates the feasibility of creating comprehensive solutions for preventive safety. The ESP32 WROOM microcontroller effectively manages data processing and communication among the various components. This research is considered important in any situation involving temperature taking and ensuring that information is relayed for proper assistance. Smart digital thermometers, with wireless connectivity and real-time data tracking, offer potential improvements in monitoring temperature more accurately than traditional thermometers. By ensuring compliance with safety regulations, these devices can play a crucial role in environmental safety prevention.

5.2 Recommendations

Based on the findings and challenges of this study on the Smart Digital Thermometer with Infrared Technology and Services Tracker using GPS, the following recommendations are made:

For Emergency Medical Services (EMS) Providers:

- **To adopt Smart digital thermometer Technologies**: EMS providers should consider incorporating smart digital thermometers with GPS tracking systems in their ambulances. These systems provide real-time monitoring of patients' vital data, including temperature and location, which can help paramedics make faster decisions and improve patient outcomes.
- **To provide Training for Paramedics**: Paramedics should receive proper training on how to use these integrated systems effectively. Familiarizing them with the features, such as temperature monitoring and real-time data transmission to hospitals, will ensure seamless operation during emergencies.
- **To allow Integration with Hospital Systems**: Hospitals should integrate the incoming data from ambulances, such as patient temperature and location, into their information systems. This would allow medical staff to better prepare for the arrival of patients and allocate necessary resources in advance.

For Policy Makers and Health Administrators:

- **To make Standardization of Equipment**: Policy makers should set guidelines for the standard use of GPS-enabled tracking systems with medical monitoring tools in emergency vehicles to ensure uniformity and compatibility across various service providers.
- **To allocate Funding and Support**: Governments and health organizations should allocate resources to fund the implementation of these advanced monitoring systems in both urban and rural emergency services.

Young researchers: Design a thermometer that is lightweight, portable, and easy to handle.Compare different models to analyze which provide the most reliable data under various conditions.Explore the use of low-power electronics and consider renewable energy sources like solar or kinetic energy for charging or powering the device.Consider also integrating wireless technologies like Bluetooth or Wi-Fi to sync data with smartphones or health apps.

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[17]:https://www.faranux.com/product/lcd-16x2/

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APPENDICES

APPENDIX 1. ESP32 CODE

```
#include <Wire.h>
#include <Adafruit_MLX90614.h>
#include <LiquidCrystal_I2C.h>
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
#include <RTClib.h>
#include <WiFi.h>
#include <ESP_Mail_Client.h>  // Include the ESP_Mail_Client library

// Initialize components
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
LiquidCrystal_I2C lcd(0x27, 16, 2);   // LCD I2C address 0x27, 16 columns, 2 rows
TinyGPSPlus gps;
RTC_DS1307 rtc;
SoftwareSerial sim900(18, 19);        // RX, TX for SIM900
const int buzzer = 13;                // Buzzer pin

// Constants
const float TEMP_THRESHOLD = 38.0;    // Threshold temperature in Celsius

// Wi-Fi Credentials
const char* ssid = "Emmanuelle's Galaxy A71";          // Replace with your Wi-Fi SSID
const char* password = "Emma1963";   // Replace with your Wi-Fi Password

// Email Credentials
#define SMTP_HOST "smtp.your_email_provider.com"
#define SMTP_PORT 465
#define AUTHOR_EMAIL "avoungoue97@gmail.com"
#define AUTHOR_PASSWORD "avoungou1963"
#define RECIPIENT_EMAIL "avoungou97@gmail.com"
```

```
// SMTP Data Object
SMTPSession smtp;
SMTP_Message message;

void setup() {
  // Initialize Serial for debugging
  Serial.begin(115200);

  // Initialize components
  mlx.begin();
  lcd.begin(16,2);
  rtc.begin();
  sim900.begin(9600);
  pinMode(buzzer, OUTPUT);

  // Set up RTC
  if (!rtc.isrunning()) {
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));  // Set the time based on compilation
time
  }

  // Initialize LCD display
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Smart Thermometer");
  delay(2000);
  lcd.clear();

  // Connect to Wi-Fi
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to Wi-Fi...");
  }
```

```
  Serial.println("Connected to Wi-Fi");

  // SMTP Server settings
  smtp.callback(smtpCallback);
  smtp.debug(1);
}

void loop() {
  float temperature = mlx.readObjectTempC();
  DateTime now = rtc.now();

  // Display temperature, time, and date on the LCD
  lcd.setCursor(0, 0);
  lcd.print("Temp: ");
  lcd.print(temperature, 1); // Display the temperature in Celsius
  lcd.print((char)223); // Display ° character
  lcd.print("C");

  lcd.setCursor(0, 1);
  lcd.print("T:");
  lcd.print(now.hour(), DEC);
  lcd.print(':');
  lcd.print(now.minute(), DEC);
  lcd.print(' ');

  lcd.print(now.day(), DEC);
  lcd.print('/');
  lcd.print(now.month(), DEC);
  lcd.print('/');
  lcd.print(now.year(), DEC);

  // Check if temperature exceeds threshold
  if (temperature > TEMP_THRESHOLD) {
    // Make buzzer sound
    digitalWrite(buzzer, HIGH);
```

```
    delay(5000); // 5 second buzz
    digitalWrite(buzzer, LOW);

    // Get GPS location
    String gpsLocation = getGPSLocation();

    // Send SMS with temperature, time, date, and GPS location
    sendSMS(temperature, now, gpsLocation);

    // Make a call to the specific number
    makeGSMCall();

    // Send email with temperature, time, date, and location
    sendEmail(temperature, now, gpsLocation);

    delay(5000);  // Wait for 5 seconds before next reading
  }
}

// Function to get GPS location
String getGPSLocation() {
  String location = "No GPS";
  while (sim900.available() > 0) {
    gps.encode(sim900.read());
    if (gps.location.isUpdated()) {
      location = String(gps.location.lat(), 6) + ", " + String(gps.location.lng(), 6);
      break;
    }
  }
  return location;
}

// Function to send SMS via SIM900
void sendSMS(float temp, DateTime now, String gpsLocation) {
  sim900.println("AT+CMGF=1");  // Set SMS mode to text
```

```
  delay(1000);

  // Send SMS to the desired number
  sim900.println("AT+CMGS=\"+250783153593\"");  // Replace with recipient's number
  delay(1000);

  // Message body
  sim900.print("ALERT! Temp: ");
  sim900.print(temp, 1);
  sim900.print("C Time: ");
  sim900.print(now.hour(), DEC);
  sim900.print(':');
  sim900.print(now.minute(), DEC);
  sim900.print(" Date: ");
  sim900.print(now.day(), DEC);
  sim900.print('/');
  sim900.print(now.month(), DEC);
  sim900.print(" GPS: ");
  sim900.print(gpsLocation);

  sim900.write(26);  // Ctrl+Z to send message
  delay(1000);
}

// Function to make a GSM call
void makeGSMCall() {
  sim900.println("ATD+250783153593;");  // Replace with the phone number to call
  delay(30000); // Call duration of 30 seconds
  sim900.println("ATH");  // Hang up the call
}

// Function to send an email via ESP_Mail_Client
void sendEmail(float temp, DateTime now, String gpsLocation) {
  message.sender.name = "Smart Thermometer";
  message.sender.email = AUTHOR_EMAIL;
```

```
  message.subject = "Temperature Alert!";
  message.addRecipient("Recipient Name", RECIPIENT_EMAIL);
  // Create the email body
  String emailBody = "ALERT! Temperature exceeded the threshold.\n";
  emailBody += "Temperature: " + String(temp, 1) + "C\n";
  emailBody += "Time: " + String(now.hour()) + ":" + String(now.minute()) + "\n";
   emailBody += "Date: " + String(now.day()) + "/" + String(now.month()) + "/" +
String(now.year()) + "\n";
  emailBody += "Location: " + gpsLocation + "\n";

  message.text.content = emailBody;

  // Connect to the SMTP server and send the email
  if (!smtp.connect(SMTP_HOST, SMTP_PORT, true)) {
    Serial.println("SMTP connection failed!");
    return;
  }

  // Login to the email account
  if (!smtp.login(AUTHOR_EMAIL, AUTHOR_PASSWORD)) {
    Serial.println("SMTP login failed!");
    return;
  }
  // Send the email
  if (!MailClient.sendMail(smtp, message)) {
    Serial.println("Email sending failed!");
  } else {
    Serial.println("Email sent successfully!");
  }
  smtp.closeSession();
}
// SMTP callback function for debug info
void smtpCallback(SMTP_Status status) {
  Serial.println(status.info());
}
```

PPENDIX 2. COST ESTIMATION

Table of devices and prices.

Devices	Quantity	Unit/Price
Microcontroller ESP32	1	15,500rwf
MLX90614	1	2,5000rwf
LCD display 16×2	1	8,000rwf
Battery 3.7V	2	13,000rwf
buzzer	1	1,000rwf
Wires	15	3,000rwf
ESP32 Development Board Breakout Board GPIO	1	8,000rwf
RTC DS1307	1	5,000rwf
GSM SIM900	1	22,000rwf
GPS Neo-6M	1	12,500RWF
	TOTAL PRICE	**113,000rwf**