BTMAS: Baby Temperature Monitoring and Alarming System using Ardunio

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Abstract:- Baby Temperature Monitoring and Alarming System (BTMAS) is a mechanism that notifies parents when a baby's body temperature falls or rises beyond acceptable bounds based on health guidelines. A system called the planned BTMAS alerts parents when their child's temperature rises or falls below predetermined thresholds. This system gathers information from the hardware used to take the baby's temperature, evaluates that information, shows the baby's current temperature, and notifies the parents if it is abnormal. The hardware tools are configured to collect data, evaluate it based on predetermined criteria, and alert parents through an audio alarm in the event that the temperature drops below 36.5 oC or rises above 36. If the temperature reaches dangerously high levels, the system will immediately contact the parents via a GSM module. Lastly, it determines whether the baby's temperature has changed significantly enough to trigger an SMS alert to the parents telling them to seek emergency medical attention. The suggested technique enables parents to take the necessary precautions in advance by assisting them in regularly monitoring their children's body temperatures. The goal of this work is to serve as an illustration of a system that supports a remote telehealth monitoring system. It makes use of mobile devices to track health. The findings of this affordable system demonstrated that it responds quickly to temperature changes, that the audible alert functions well, and that using a cell phone as an alarming device functions nearly perfectly.

Keywords:- *Baby Temperature, Monitoring, Alarming System, Arduino, Portable Devices.*

I. INTRODUCTION

The health of children will always be an area of concern among parents**.** When compared to adults, children are more susceptible to illness. It is crucial to keep children in a secure and healthful environment and to get medical help if they become ill for this reason. Body temperature is a well-established essential indicator of humans. It is measured frequently at home and at regular intervals in the medical context to try to estimate a person's level of "sickness" [1]. Fever is one of the body's initial responses to infection and is a common symptom of sickness. Body temperatures are an early warning indication of infection. So a device that can help parents to keep track of their children's body temperature seems mandatory.

In affluent nations, the proportion of women in the labor force has grown dramatically in recent years, impacting the care of newborns in many households. Owing to the elevated cost of living, it is anticipated that both parents work. But they also have to take care of their kids, which increases their burden and stress—especially for the mother.

It's not always possible for working parents to make time for their kids. They either pay a babysitter to watch their kids while they work, or they send their kids to stay at their parents. When their kids are with other people, some parents worry about their safety. As a result, they visit their homes to see how their children are doing during their breaks, such as lunch or tea break. A baby monitoring device that can assess the health of babies in real time is suggested as a solution to these problems. A baby monitoring system that can transmit information and quickly alert parents in case of an emergency, cutting down on the time needed to handle such circumstances.

The portable electronics of today, especially mobile phones, are the technology of the future due to their ease of use and portability. Therefore, the goal of our research is to develop a program that can monitor an infant's temperature and transmit vital information to their phones. Stated differently, BTMAS is a mechanism that alerts caregivers when a child's temperature rises or falls below predetermined thresholds. This system gathers information from the physical components that take the baby's temperature, evaluates the information, shows the baby's current temperature on the screen, notifies the parents if the temperature is abnormal [2], and also looks for a spike in the baby's temperature to alert the parents to the need to take the child to the doctor right away.

Every year, about 2,300 babies in the US pass away from SIDS. A baby younger than a year old that dies suddenly and without apparent cause is said to have SIDS (sudden infant death syndrome). Professionals have proposed a number of potential causes for SIDS. One of them is the baby's body overheating, which raises its temperature and causes the infant to pass away unexpectedly [3].

We designed a device that regularly checks a baby's temperature and sounds an alarm to notify the baby's caregiver and the parents if the baby's temperature changes significantly. This was motivated by SIDS, the significance of the baby's health and temperature, the modern fast pace of life, and the rising cost of living, which keeps parents away from their babies.

The project's goal is to create a system that supports remote telehealth monitoring. The idea is to create a system that continuously checks the baby's temperature and determines whether it is normal or abnormal. primarily to assist working parents in caring for their kids as a source of comfort and relief for the parents, and to attempt to lower the risk of SIDS by making use of portable devices.

II. MATERIALS & METHODS

Many studies have presented case studies in order to track people's health and determine how healthy they are, particularly children. However, the programs that do the work in this field have faced numerous hurdles in terms of widespread adoption. These issues arise as a result of parental concerns over the usage of sensors on their children's bodies [4].

The study in [5] states that wearable sensors were used in the design and implementation of a non-invasive neonatal temperature monitoring system by W. Chen, S. Dols, S. B. Oetomo, and L. Feijs. The technique for monitoring the temperature was demonstrated using soft bamboo fabrics and NTC sensors. Because of the prototype belt's capabilities over the standard patient monitor, the design's results, which were tested on newborns at Mxima Medical Center's (MMC) NICU in Veldhoven, the Netherlands, were accurate.

According to the findings in [6], L.-g. Ma, R.-f. ZHANG, and J. Zhang developed a monitoring system in this study using a temperature sensor (AD590). The sensor uses a single chip to control the temperature and gather data on body temperature. If the temperature difference between the skin and the clothing is less than the recommended level, this mechanism turns on the heater. When the temperature rises above the typical range, however, the heating system is switched off. The nurse is reminded about the infant by the device.

Another study [7] by Majed A. Suhaim et al. used an EHealth sensor shield and a body temperature sensor applied to the baby's skin. The temperature sensor was connected to a Raspberry Pi via the internet of things (IoT) to read the baby's body temperature and send the data to an Android app. The app then used the connection to send alerts if the temperature dropped or rose above normal.

The methodology was divided into several sections. The first step is to develop a general concept of how the baby temperature monitoring and alarming system (BTMAS) will function and how it will be able to give us the necessary controlling, monitoring, and alarming. The hardware, circuit design, and experimental component testing are covered in the second section. Writing the software that would be uploaded to the microcontroller is the subject of the third section. The last step involves testing the system, connecting the design, getting the temperature to show on a screen, and activating the alarm systems collectively. Regarding the research of the tools that have been used in this research, we have added the following list to show each tool alone:

- Arduino Uno: Arduino is a simple microcontroller board that provides an environment for open source development, which will allow to make computers that drive both functional and projects alike.[8]
- LM35 Precision Centigrade Temperature Sensor: The LM35 is a precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. It allows to measure body temperature by placing the sensor on body skin directly.[9]
- Liquid Crystal Display (LCD): To display temperature and current state of the baby.[10]
- SIM900 GSM/GPRS Shield: GSM stands for Global System for Mobile Communications and is the global standard for mobile communications while GPRS stands for General Packet Radio Service. GPRS is a mobile service on the 2G and 3G cellular communication. It's used to receive temperature info from Arduino and acts upon it.[11]
- KY-012 Active Piezo-Buzzer Module: This Buzzer creates a sound with a frequency of 2,5kHz and it is used as an alarming system.[12]

The temperature scale we employed in our study is explained here in accordance with the article "What is a normal temperature?" Make sure the temperature is within a safe range. This is an important consideration. As per reference [2], the guide illustrates the range of all possible temperatures, their meaning, and the appropriate actions to take. As illustrated in fig. 1, there are six temperature levels that parents should be aware of when taking a child's temperature.

- Normal temperature: A baby's temperature is considered normal if it is between 36 and 37 degrees Celsius. If the baby's body temperature is below 36 degrees Celsius, the baby has to be warmed.
- Low-grade temperature: A baby has a low-grade temperature if their temperature is between 37 and 37.5 degrees Celsius. Although the body may be experiencing heat from a hot car or from the warm weather, this is not thought to be a fever.
- Elevated temperature: The baby has an elevated temperature if its temperature is between 37.5 and 38 degrees Celsius. This could be attributed to the body being ill, or as a side effect of routine immunization.
- Fever: A baby is said to have a fever if their temperature is between 38 and 38.5 degrees Celsius. This could point to a viral disease or infection.
- Very high temperature: A baby has a very high temperature if their temperature is between 38.5 and 39 degrees Celsius. The infant requires medication to lower the temperature if it is extremely high.

- Extremely high temperature: A baby with a temperature between 39 and 40 degrees Celsius is considered to have a very high one. This indicates that the baby is in danger, and you need to get emergency medical attention.

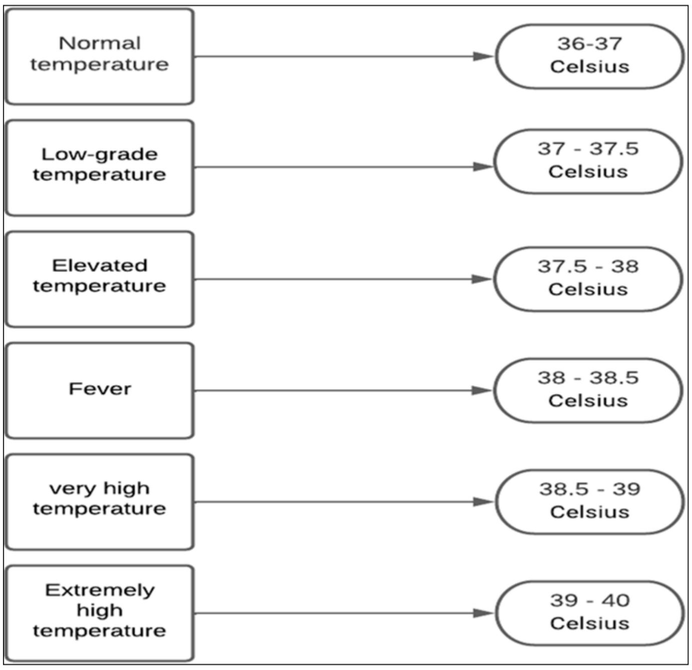

Fig 1 Temperature Range Levels in Infants

Logically to make this system we first have to come up with the concept and sequential steps that it would operate based upon. Figure (2) demonstrates how we designed the system.

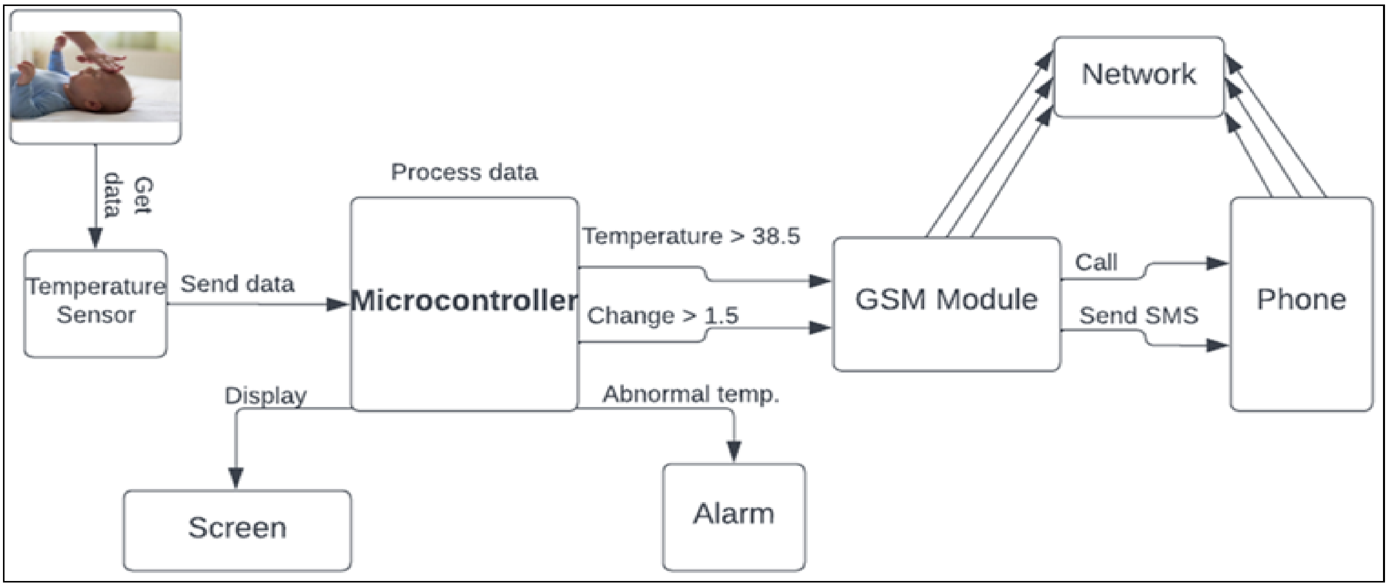

Fig 2 System Design

The infants' body will have the temperature sensor affixed to it, particularly beneath their armpits. It will transmit its measurement to the microcontroller, which will process the data it receives and show the temperature value on a screen. An audible alarm will sound if the baby's temperature deviates from normal, alerting anyone nearby to come check on them. In the event that the baby is neglected and the temperature continues to rise to dangerous levels, a General System for Mobile (GSM) module will contact the parents by phone, enabling them to take immediate action. This process is repeated every five minutes. If the temperature suddenly jumps from one of the six temperature levels to another, the GSM module notifies the parents via the temperature value that a significant change in their infant's temperature has occurred during the previous five minutes.

We essentially laid the foundation for the remaining work now that we have a general understanding of the functions and operations of this system. Initially, the design of the hardware.

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An Arduino Uno is used as the microcontroller in the suggested temperature monitoring and alarm system to process sensor data and turn on the other components as needed. Additionally, an LCD (16X2) screen is used to display the baby's temperature and its condition—normal or abnormal—and an LM35 temperature sensor is used in this work to obtain the temperature value from the infant's body and send it to the Arduino. If the temperature was abnormal, an alarm was set using the KY-012-Joy-IT active buzzer. Additionally, because the GSM/GPRS shield SIM900 is compatible with Iraqi networks, we used it to notify the parents via phone call or SMS in the event that the temperature drastically changes or reaches extremely high values. Finally, a potentiometer was employed to modify the LCD screen's contrast.

A 9V battery powers the Arduino, which also provides power to the remaining parts (shield not included). The shield has its own power supply because it uses a lot of energy when it is in operation. This power source can be a 9V battery, a rechargeable lithium battery, or continuous power from a 5V 2A power adapter.

The final circuit diagram, schematic, and hardware connection that we used are depicted in the figures below. And it includes the primary elements:

- Arduino Uno
- LM35 Sensor
- GSM / GPRS Module
- LCD
- Active Buzzer
- Potentiometer
- Two 9V Batteries
- Breadboard and Weirs

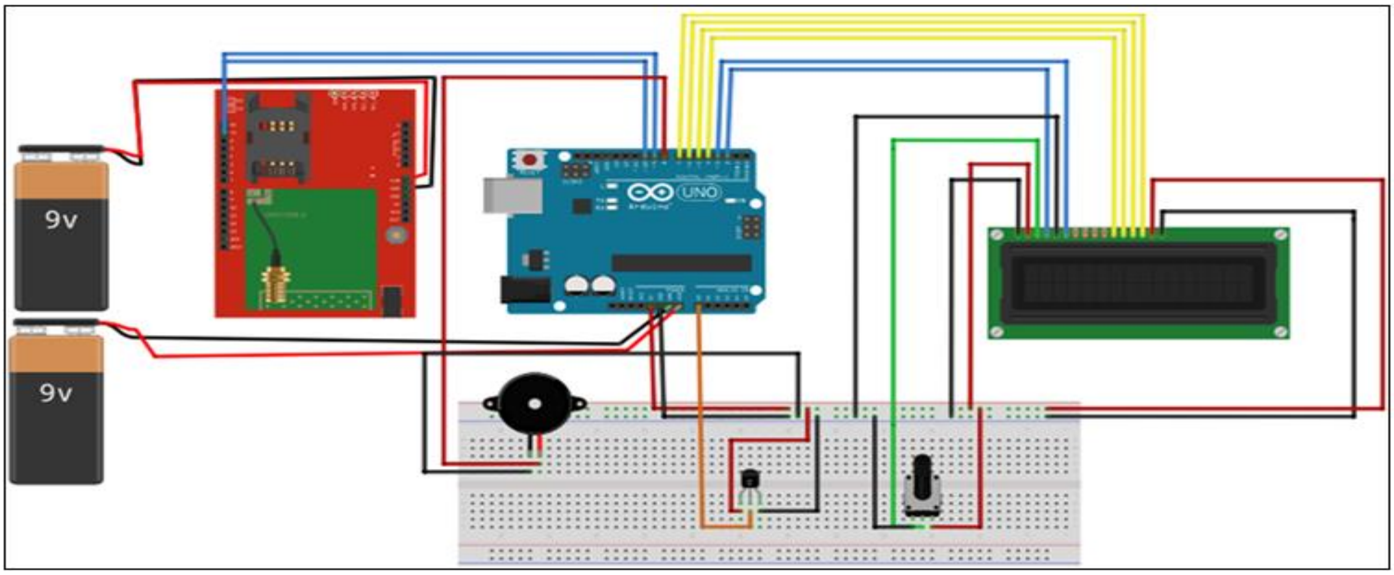

Fig 3 Connection Diagram

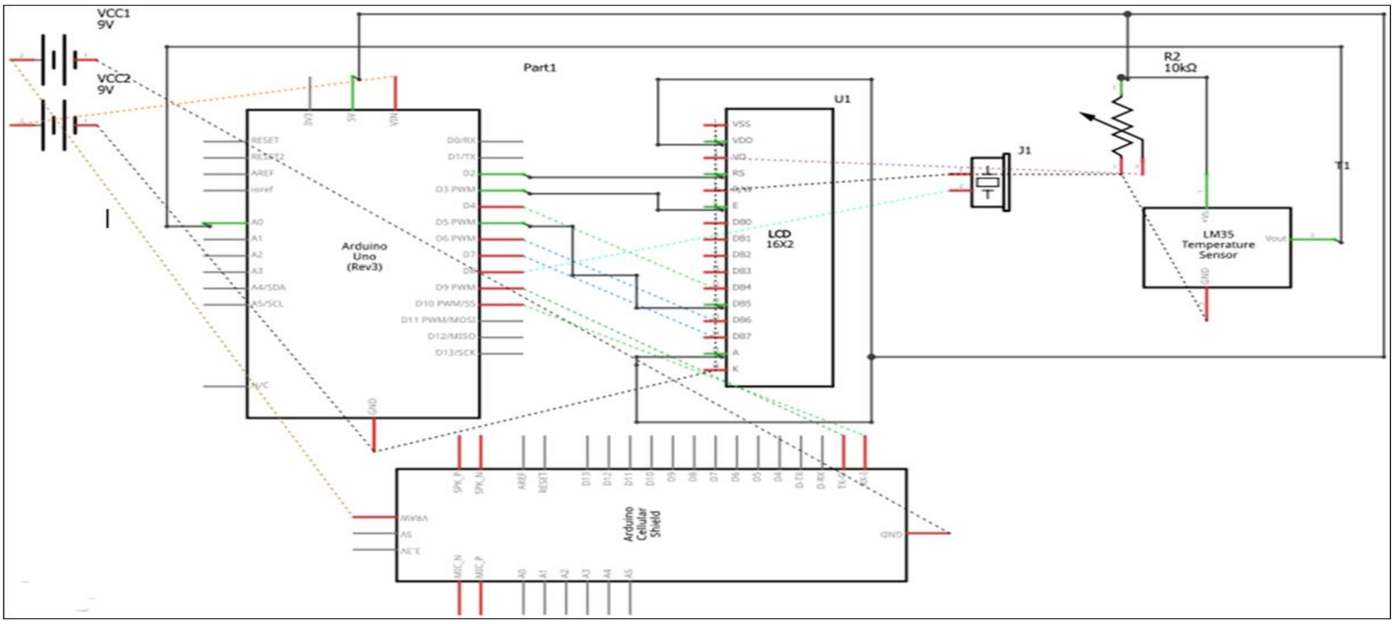

Fig 4 Scematic

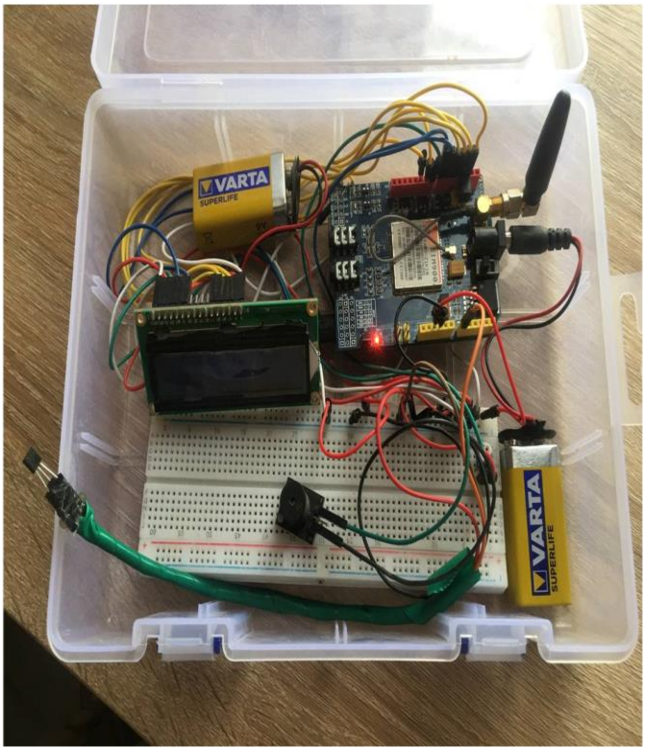

Fig 5 Final Circuit Connection

Now that the hardware work is complete, the components need to be programmed to create the finished system. Prior to writing the system's final code, each component was first programmed independently to ensure that everything works as it should.

When programming the components individually was complete, we started to write the final program as follows:

After the inclusion of the libraries for the components we use, we created distinct functions to initiate the buzzer, send a message, and place a call. We set it to the baud rate (19200) that the shield operates at. Upon startup, the program immediately enters a while loop with a one-minute delay. This loop is used just once to obtain the initial temperature reading before being abandoned. Once the temperature is measured for the first time, it is shown on the screen and a counter is started. The sensor sends the temperature reading to the microcontroller each time it reaches a predetermined threshold, in this case five minutes. When the temperature reaches extremely high values (38.5 or higher), the shield would call one of the parents because it's reaching very dangerous values. If the temperature is abnormal, the buzzer will sound, alerting anyone nearby. As previously mentioned, this process is repeated every five minutes. As a result, if there is a significant difference between the current and previous readings of the infant's temperature, the shield will notify the parent with the new reading via SMS text message.

The figure below shows the flowchart that we made and wrote our code based on it.

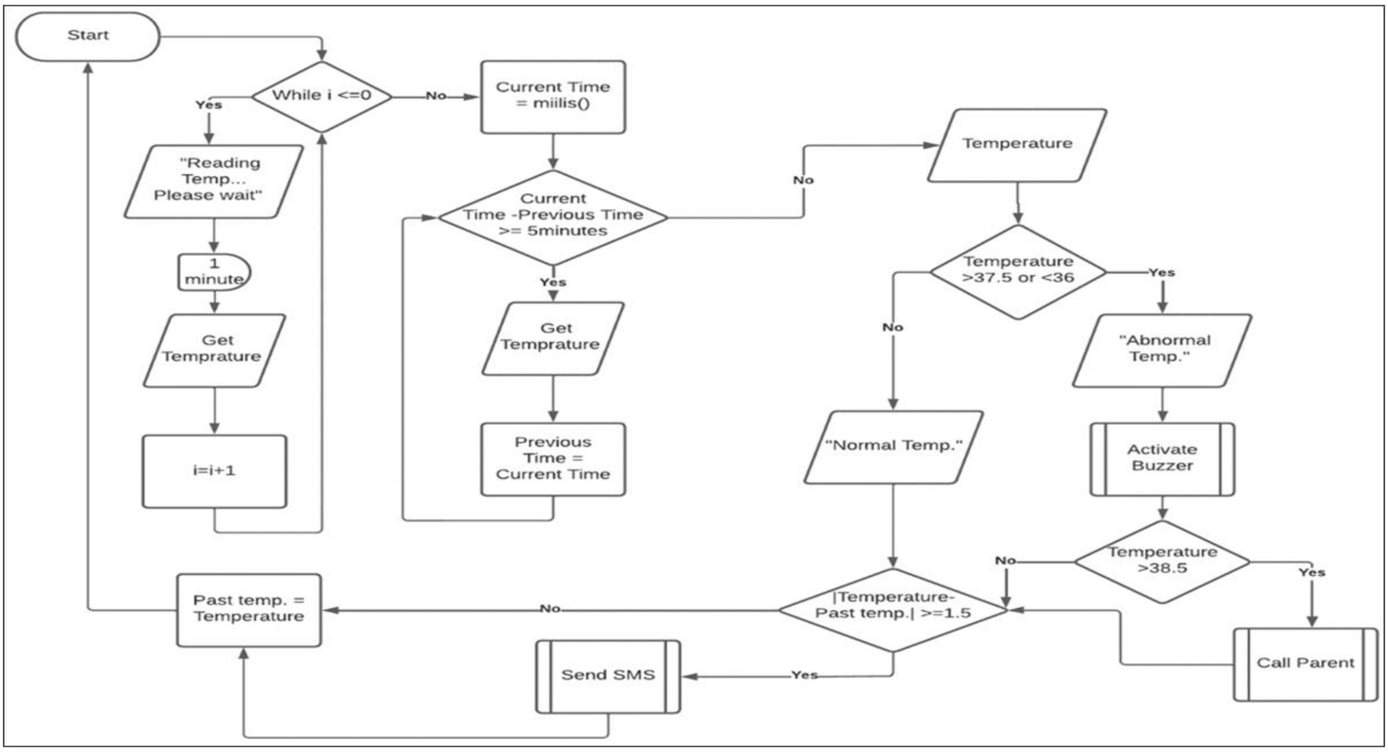

Fig 6 Flowchart

Now that the testing stage has concluded and every single component has been connected, tested, and programmed. It's now time to join the system's parts, upload the finished code, and watch the system come to life.

Every part of the system was operating in conjunction with every other part, with no part interfering with any other part. Every five minutes, the temperature sensor sent a value that was shown on the screen; the buzzer would sound whenever the value deviated from normal, and the shield would send out alerts while the other parts were working. The shield required a delay for the call duration, which we set to 30 seconds, so when it made the call, it had to halt the other components. This was the only intervention that occurred. Everything else was operating together harmoniously.

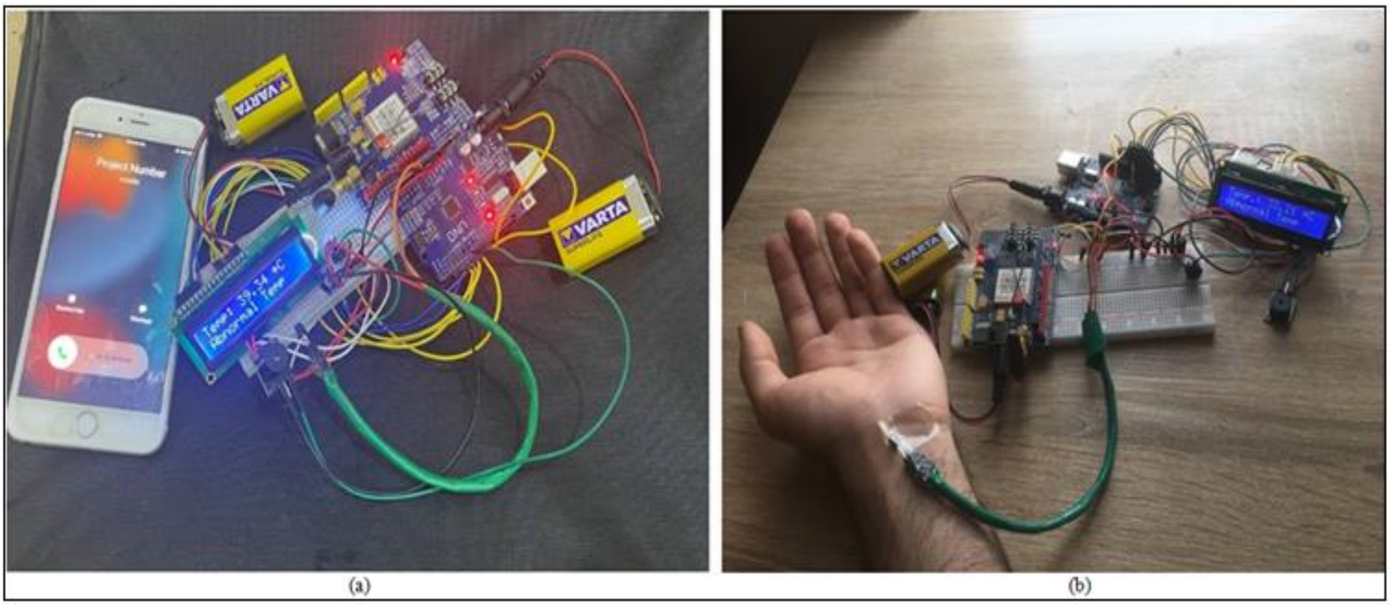

Fig 7 System Operating

III. RESULTS & DISCUSSION

A. Results

We will take a look at the results we obtained and discuss them in the next section of the chapter.

This project makes use of an LM35 sensor. In order to test the sensor's ability to respond to temperature rise, we placed a hot object on it at 32 oC and continuously recorded its readings for a minute. After that, we took out the heat source to observe how well it decimated heat. Figure 8 presents these findings.

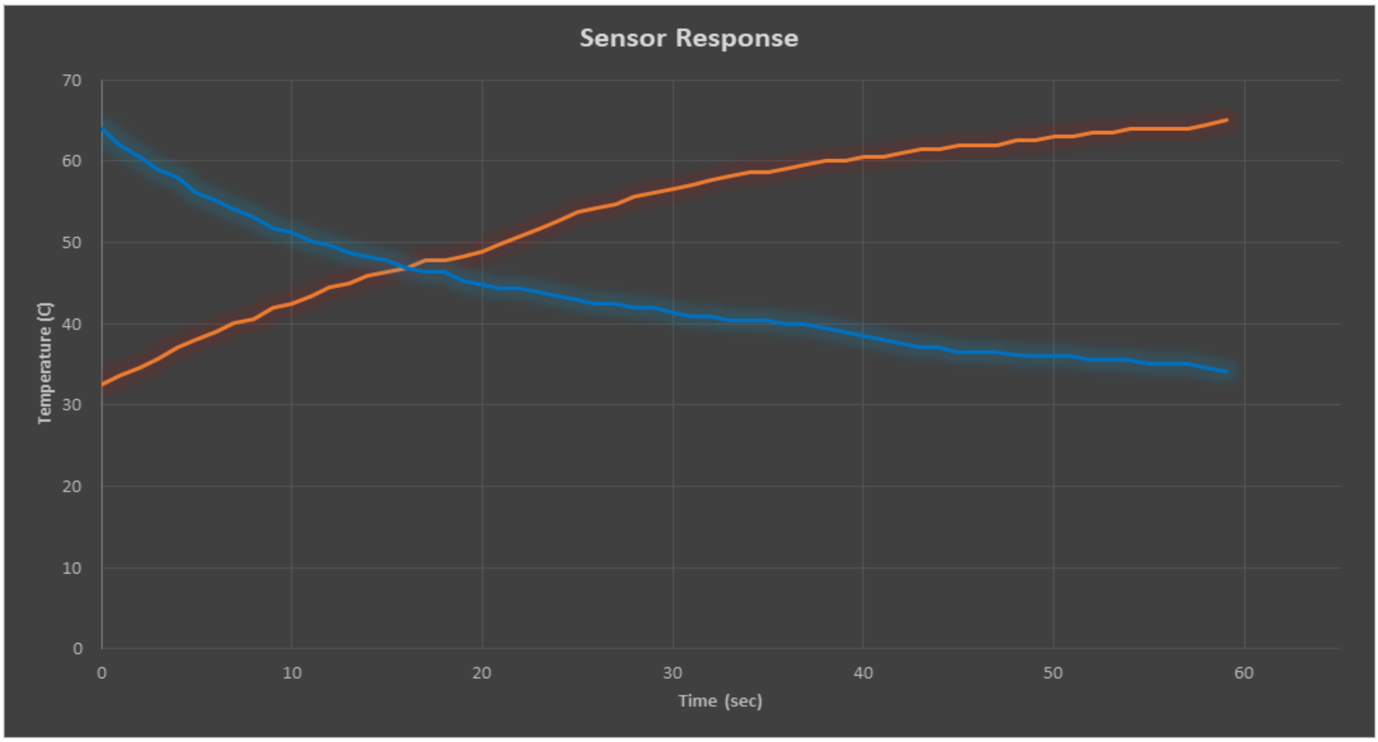

Fig 8 Sensor Response

Every degree Celsius is converted to 10 millivolts by the sensor, which outputs voltage at a linear scale factor of 10 mV/C. The relationship between the output voltage and Celsius degree is depicted in the following figure. The Y-axis displays the corresponding voltage values in millivolts, while the X-axis displays the temperature values in degrees Celsius.

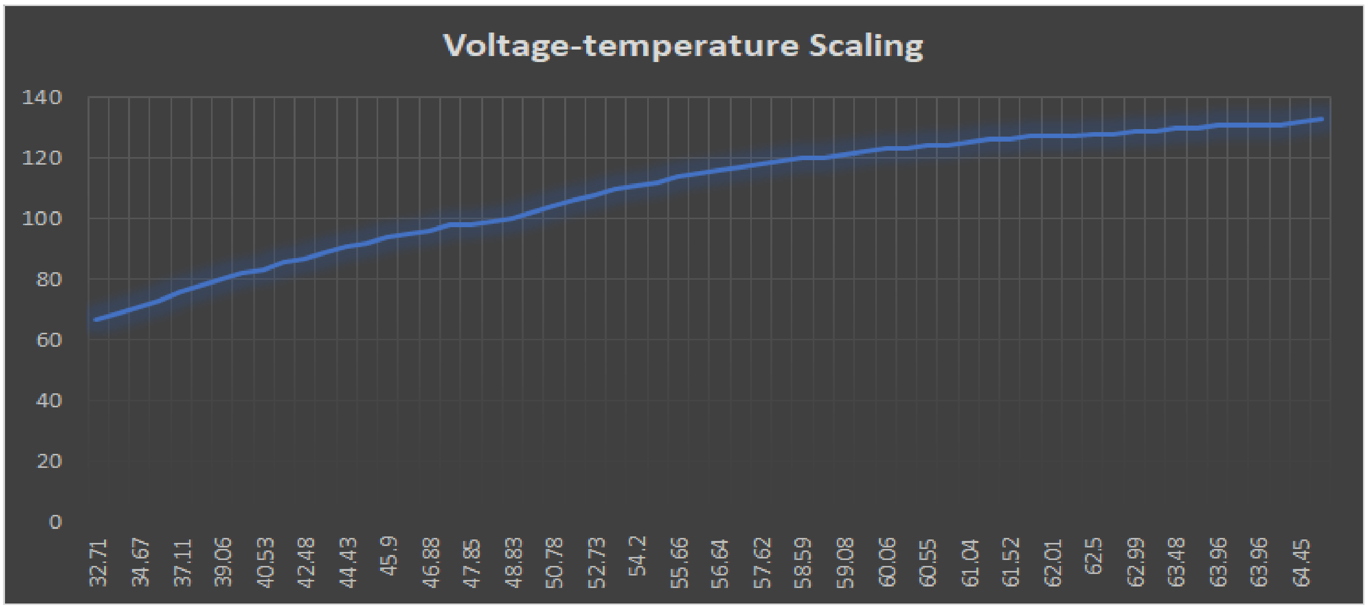

Fig 9 Sensor Celsius v. Voltage Output

The temperature readings were then taken at predetermined intervals of time (2 seconds), as indicated in the figure below, to determine how long it would take to move over every temperature range from very low to very high.

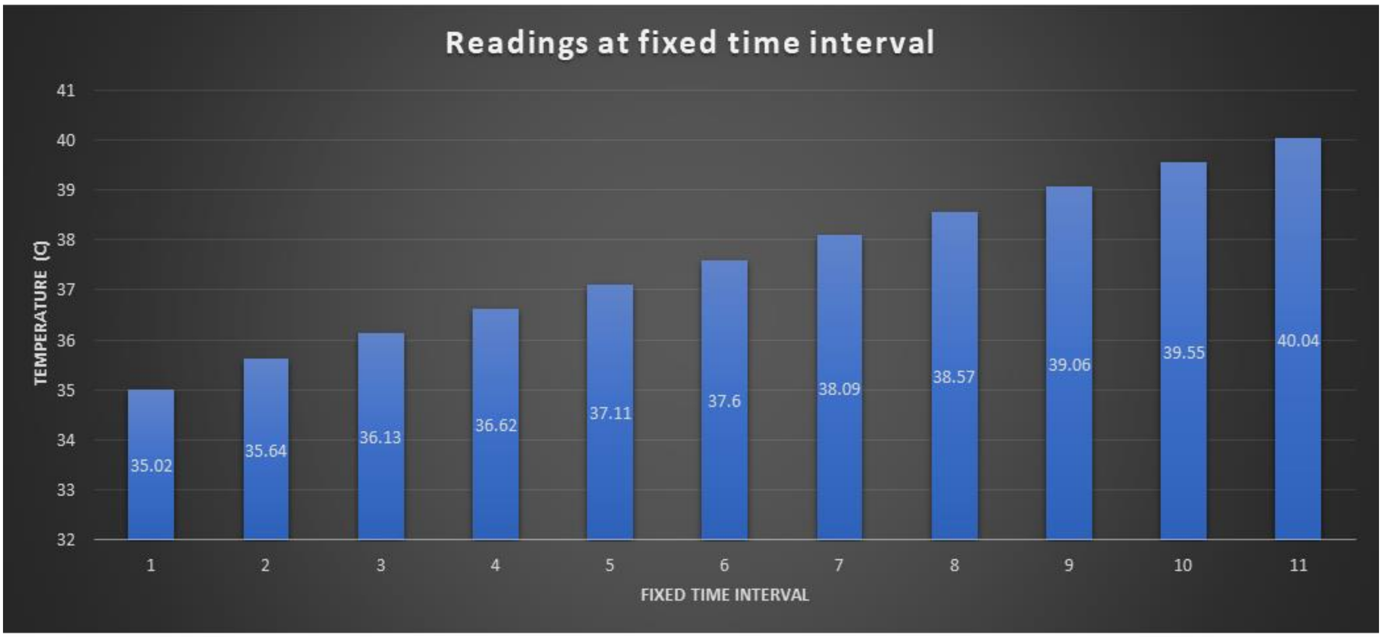

Fig 10 Readings from Low to Extremely High Temperature

We utilized an active buzzer, KY-012-Joy-IT, for the alarm system. By measuring its db levels at various distances, we were able to determine how much noise it produces in the air. The outcomes are displayed in the table that follows.

Table 1 Buzzer db Levels at Different Distances

Distance (cm)	db
0	100.4
1	96.1
5	90.2
10	85.8
70	73
100	65

The SIM900 chip-containing shield is put to use. Our tests revealed that it takes the shield between 55 and 60 seconds to establish a network connection. Additionally, it takes about five seconds for the SMS message to be sent once it is necessary. The shield takes five to six seconds to make the call, and it can continue calling for up to forty-five seconds. We did, however, program it for 30 seconds.

The shield has demonstrated that it needs a significant amount of power to function, particularly to make phone calls and use less for sending SMS messages.

B. *Discussion*

We will discuss the results obtained which were shown in the previous section.

The sensor is highly practical because it has a quick response time and uses little power. Since it returned from the peak value to a temperature value 2 degrees away from the starting value in just one minute, it is gaining heat at a rate that is roughly equal to the rate that it is losing heat. Additionally, it only took 11 intervals to go from a low temperature to an extremely high temperature, demonstrating the sensor's quick response.

When used as an alarm, the buzzer uses very little power and produces high noise levels at various distances, ranging from noise comparable to a loud shout to noise comparable to a washing machine [13]. Testing revealed that, crucially for alarming purposes, the buzzer can be heard outside the room.

It's not a big deal if the shield takes a minute to connect to the network; the first temperature reading appears after that time, giving the shield more time to connect. Additionally, it doesn't take long to respond—sending a message or making a call only takes about 5 seconds, which is a very short amount of time.

The shield's main drawback is that it requires a lot of power to operate, meaning the Arduino cannot supply it with power. It requires a battery or adapter (9V 1A or 5V 2A) as its own power supply.

We faced the following limitations in this research

- Temperature Sensor: Since we were unable to find a medical sensor on the market, we used the sensor for research purposes even though it was not intended for use in medicine.
- Shield Power: As previously mentioned, the shield requires its own power source due to its high power consumption. After several uses, it also depleted a 9V battery, so we replaced it in this work with a power adapter.
- Call Delay Time: When making the call, all other must hold until the call is done.

IV. CONCLUSION

The proposed system takes the baby's temperature in order to identify any internal illnesses, such as infections, the common cold, and pneumonia, which all have fever as a common symptom when the body temperature rises. It determines whether the infant is hypothermic or has a fever. Additionally, since elevated temperature is thought to be one of the possible causes of SIDS, the system continuously monitors the infants' temperatures in an effort to lessen the likelihood that the syndrome will occur.

The system under demonstration used a temperature sensor to monitor an infant's temperature in an efficient and budget-friendly manner. If the baby's temperature is abnormal, the sensor's values are shown on a screen, and anyone nearby will be alerted by an audible alarm. After every reading, if the temperature jumps from one level to another, the parents will receive an SMS message informing them of the situation. If the temperature reaches high and dangerous values without anyone intervening, the parents will be called.

The objective of this project was to create a temperature monitoring system that would allow working parents to easily check on their child's well-being. The system performs as intended in the specifications, and the goals were met. The baby's temperature is continuously monitored by the system, which displays this data on the screen and notifies the parents of any abnormalities through two different alarm mechanisms: one that sounds on the baby's phone and the other that uses audio.

The system is quick and efficient, as evidenced by the results from the previous chapter. As Figure 8 illustrates, the sensor responds to temperature changes very quickly. When measured at a fixed interval of 2 seconds, Figure 9 shows that the temperature changes at 11 intervals, from very low to extremely high. As Table 1 illustrates, the buzzer functions well as an alarm because it generates loud noises, and the shield also functions as an alarm at extremely high and dangerous temperature values.

Future development of the system can lead to a more robust system and more features to be provided for the parents. The main development can be mentioned briefly as:

- Using a medical temperature sensor is recommended like MAX30205 for example.
- Using a rechargeable Lithium battery to power the shield.
- In addition to sending a message when the temperature level changes. The system can be programmed to send the temperature values on demand when the parent send it a message requesting the value.
- If the temperature keeps getting worse, it is possible to make the shield call more than once and keep calling until the parent denies the call just to make sure that the parent is now aware.
- The system's sole purpose upon design was temperature monitoring. To provide a broader range of monitoring for the infant, additional vital signs, such as heart rate and breathing rate, could be added.

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