

# Development of Real Time Human Body Temperature (Hypothermia & Hyperthermia) Monitoring & Alert System with GSM & GPS

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**ABSTRACT:** The research in the field of wireless health (Medical) monitoring system has become a hot topic as the development and popularization of information processing and wireless data transmission techniques with biomedical sensors are increasingly becoming popular day by day. Now a day's people use their smart phones not only for communication but also to detect & monitor their health conditions. Physiological parameter monitoring is always a complicated work and its accurate measurement & control can save the people if timely remedial assistance is provided. Bio vitals such as blood pressure, heart rate, rate of respiration, ECG & body temperature are important parameters which are required to be monitored continuously. Among them, human body temperature is the first bio vital sign checked by the medical professional's. There are variety of standards of human body temperature, based on the scale of temperature, place where it is measured etc. This paper proposes 51architecture based low cost real time human body temperature (hypothermia [low] & hyperthermia [high]) monitoring system using LM35DZ temperature sensor. For clinical trials, the system was tested in the hospital for different age & weight people. Finally, we compared these results with readings taken by Doctor with traditional instrument like Hg thermometer. The system is supported with GSM & GPS technologies. The GSM architecture is for information transformation through SMS and GPS is for location awareness. The developed system is aimed at aged or elderly people, as the movement of these people is restricted because of health/age factor. The combination of these latest technologies in a single module fulfils the requirements of delivering critical information to concerned people or medical experts.

**KEYWORDS:** Temperature Sensor, Microcontroller, Hypothermia, Hyperthermia, GSM and GPS.

## I. INTRODUCTION

Health is one of the global challenges for the humanity. According to WHO, the highest attainable standard of health is a fundamental right for an individual. As the population of senior citizens and their chronic diseases increases, the number of people who need constant medical assistance also increases a lot. Thanks to the latest wireless transfusion & monitoring network that not only helps the physician & nurses to provide excellent treatment and comforts to the patient but also regulates the method of therapy based on the physiological data. Mobile health care is the integration of mobile computing & health monitoring. Intensive care units are houses for continuous monitoring of patients, a modernized health care system should provide better health care services to the people at any time & from anywhere in an economic & patient friendly manner. But in many of intensive care units, patients are hampered by the attached physiological monitoring & treatment equipments, which not only obstruct the nursing staff but also hinders the patient from moving freely. Currently, the health care systems are undergoing a cultural shift from a traditional approach to a modernized patient centered approach. Vital signs are measurement of the human body's most basic functions. The four main vital

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signs which are routinely monitored by the medical experts are body temperature, heart rate, respiration rate and blood pressure. The body temperature is the first vital sign that physician examines.

**Body Temperature:** Temperature is a measure of the degree of heat intensity. Human body temperature is an expression of its molecular excitation. The human body's core temperature varies from day to day, and from time to time, but these fluctuations are small, usually not more than 1.0°C. Humans are homoeothermic and body temperature is regulated at about 37°C ±1°C. The thermoregulatory center in the hypothalamus plays a very active role in keeping body temperature in the normal range. External and internal heat sources influence body temperature. Temperature is read to establish a baseline of normal body temperature for the location and measuring conditions. The main reason for examining body temperature is to hunt for any signs of systemic infection or inflammation in the presence of a fever. Temperature depression needs to be evaluated. It is also important to review the trend of the patient's temperature. A patient with a fever of 38 °C does not necessarily show a menacing sign if his previous temperature has been higher. Body temperature is maintained through a balance of the heat produced by the body and the heat lost from the body. Monitoring human body temperature comes under preliminary clinical examination.

**Classification of Human Body Temperature:** According to medical science, human body temperature is classified in to five types. 1) Hypothermia 2) Normothermia or eutheria or Normal 3) Fever 4) Hyperthermia 5) Hyperpyrexia as shown in the table.

Human Body Temperature Classification	
Type	Range
Hypothermia (Below Normal)	<35.0 deg C (95.0 deg F)
Normal Body Temperature	36.5 to 37.5 deg C (97.7 to 99.5 deg F)
Fever (Above Normal)	>37.5 or 38.3 deg C (99.5 or 100.9 deg F)
Hyperthermia (High Temperature)	>37.5 or 38.3 deg C (99.5 or 100.9 deg F)
Hyperpyrexia (Extreme High Temperature)	>40.0 or 41.5 deg C (104.0 or 106.7 deg F)

**Measurement of Body Temperature:** Recording a person's body temperature is a first stage of a full clinical examination. There are various types of medical thermometers and different sites used for measurement. 1) In the anus [rectal temperature] 2) In the mouth [oral temperature] 3) Under the arm [auxiliary temperature] 4) In the ear [tympanic temperature] 5) In the Vagina [vaginal temperature] 6) In the bladder 7) On the skin of the forehead over the temporal artery. Auxiliary temperature measurement is the safe & simple method of measuring human body temperature. Auxiliary method involves measurement of temperature under the arm. Temperature under the arm is about 36.4 deg C. Other than mercury thermometer, electronics sensor devices like thermocouple, thermistor and IC temperature sensors are also used for auxiliary measurement. Electronic thermometers which use a thermocouple sensor are widely used in clinical diagnosis. In auxiliary measurement ambient temperature is also influences the measurement. Thermometers are available in invasive (direct contact to the body) and Non-invasive (indirect contact to the body) types. This paper proposes a system to perform Auxiliary measurement of the body temperature based on LM35DZ temperature sensor. The system is able to evaluate both hypothermia and hyperthermia temperature. The proposed system is rigorously tested in the hospital for clinical trials. Finally the results are compared.

## II. RELATED WORK [LITERATURE SURVEY]

From the literature survey we came to know that, latest technologies for control & measurement of bio vitals have been used by the researchers. Also employed wireless devices/sensors and advanced communication techniques for this purpose. M.V.M Figueredo et.al makes use of the telemedicine system using mobile telephony in which wireless sensors collects the data and sends through RS232 to a server with internet facility for physiological parameter monitoring [1]. P.S Pandian et.al suggests the wireless sensor network for variety of bio sensors and its adaptability to wearable

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

physiological monitoring system using personal area network [2]. Piyush V. Savaliya et.al reports the advantage of use of short distance communication method such as Bluetooth for measurement of human physiological signals based on FPGA method [3]. M. Vinaykumar et.al uses ARM controller with GSM communication technique for collection & transmission of bio-signals wirelessly on a cell phone [4]. Sriram K Vasudevan et.al examines the feasibility of Zigbee communication technique which collects & transmits the bio signals to a PC, so that within the premises of the hospital doctor can monitor the patient [5]. Priya. M et.al developed PIC based wireless ICU monitoring system that uses Zig-bee protocol. Wireless sensors collect the data and Zig-bee is used to transmits these data to a PC through RS232 so that doctor can monitor patient's vital information on his PC remotely [6]. Rifat Shahriyar et.al developed intelligent mobile health monitoring system by using a combination of technologies such as wearable body sensor network, patient's personal home server and an intelligent medical server for monitoring various physiological parameters [7]. Amna Abdullah et.al has designed a real time wireless health monitoring system using Zig-bee communication protocol with lab-view software for recording human bio signals [8]. S. Elango et.al reports the development of an in-home healthcare system for monitoring health related bio signals using Wireless Sensor Network module with Lab-VIEW which sends the medical data to WSN gateway through wireless media [9]. Ping Wang et.al tries to implement physiological parameter monitoring system for in-patient which has two parts one is patient physical state data acquisition module and the other is Zig-Bee module [10].

V. Ramya et.al provides a device which will continuously monitors the vital parameters of multiple patients with data logging facility using PIC microcontroller & GSM techniques [11]. D.J.R. Kiran kumar et.al proposes a real time portable health monitoring system built on programmable system on chip (PSoC) which has a zigbee communication module sends all the physiological data to a PC from which doctor can access the data on his PC [12]. Archita Agnihotri et.al., suggests the use of GSM communication technique for sending the acquired physiological data to cell phone of medical professional, the system collects all data with reliable sensors and sends on GSM network [13]. Neeta V Desai et.al designed a health monitoring system which continuously monitors bio vitals of a in-home patient using wireless non-contact radio frequency electromagnetic fields to transmit & receive the signals [14]. Johevajile K.N et.al reports design of a non invasive, accurate low cost biomedical sensor interface for processing bio vitals such as blood pressure & body temperature and checks its accuracy with simulated circuits using mat lab [15]. P. Karthick et.al proposes a wireless health monitoring system that uses variety of biosensors for sensing the human bio vital signals, the acquired data is transmitted through ZigBee transmitter & it is collected at ZigBee receiver. The system also uses GSM & ARM processor [16]. Gunalan M.C et.al., also makes use of ZigBee protocol for communicating acquired bio vitals to a PC which acts as a central monitoring system which uses Lab View software [17]. Kalpana P.M et.al., suggest to use PIC microcontroller based wireless embedded system for human health monitoring in which data collected from the nodes are transmitted to ZigBee transmitter in turn to a PC which is connected to network wherein data is stored, displayed and retrieved [18]. Ch. Srikanth et.al., reports smart embedded medical diagnosis unit using ARM core based beagle-bone black with Adriano platform which provides a integrated development environment for monitoring personal health [19]. This paper proposes a low cost 51 architecture microcontroller based embedded system that monitors the human body temperature. The developed system makes use of GSM & GPS network to transmit this vital information & location awareness. It also compares the values recorded from the developed system under clinical trials with the values recorded by doctor with traditional methods.

### III. THE SYSTEM OUTLINE

This paper proposes a simple 51 architecture family of microcontroller based human body temperature monitoring system. The system uses high sensitive LM-35DZ temperature sensor for measurement of human body temperature. The proposed system also makes use of GSM technology & its functionality for mobile communication to transmit the physiological signal information to an authorized person's cell phone. The system has GPS technology for location identification. The system has additional functionality to responds to SMS sent by the caretaker/doctor, verifies the authenticity and then sends a reply to SMS with which it is possible to know the status of physiological parameter of concern person.

**IV. METHODS AND MATERIALS**

Fig.1 shows the functional block diagram of the proposed systems. The system is built on Atmels 89c52 Microcontroller. The other components are LM-35DZ temperature Sensor, Signal Conditioning Circuit, GPS receiver, GSM modem, LCD display unit, ADC, physiological parameter setting knobs etc. Many of the components are common for a normal embedded system. We will discuss few components in brief in the following sections.

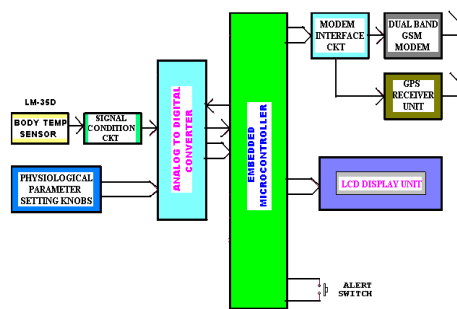


Fig.1. Functional Block Diagram of the systems

1. 89c052- Microcontroller.
2. Dual Band GSM Modem.
3. GPS Receiver
4. LM-35D Temperature Sensor
5. Analog to Digital Converter (ADC)
6. Signal Conditioning Circuit
7. LCD Display unit.
8. Physiological parameter settings Knobs
9. Emergency Switches

**1. Embedded microcontroller:** The 51 architecture Microcontroller of Atmel make 89C52 is used for this work and it controls all the activities of the system by executing a program stored into its flash program memory. It is an 8-bit microcontroller with 8-k bytes of internal flash program memory, 256-byte data memory and 4-I/O ports. It is having a full duplex serial UART and internal timer/counter. It is best choice for compact embedded system design for such applications with low cost.

**2. Dual band GSM modem:** It is a wireless MODEM which can send & receive data through the GSM network. It requires a SIM card and connectivity to the GSM network. It has built in TCP/IP stack. The GSM MODEM communicates with the embedded microcontroller system with the help of AT commands. This modem works on two frequencies i.e. 900 MHz and 1800 MHz for up-linking and down-linking. Therefore it is a Dual band GSM MODEM. It is designed to work on RS232 standard, hence, while connecting to microcontroller, a RS232 to TTL level converter is essential.

**3. GPS receiver:** A network of satellites that constantly transmit coded information, which makes it possible to accurately identify locations on earth by measuring distance from the satellites, is called GPS. GPS are capable of sending information through a simple serial link. The GPS Receiver which is used in this system will receive the coordinates needed from the GPS satellites and then send the information to the microcontroller. As it is very compact in size and low power consumption, it can be used in many embedded portable devices. It is having the ability to refresh its data once every second and therefore will be continuously updating the coordinate values for the microcontroller as the person changes location.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

**Subscriber Identity Module:** SIM card is main feature of GSM. It is a detachable smart card containing the user's subscription information and phonebook due to which connectivity can be established with the network.

**Short Message Service (SMS):** SMS is very important service of GSM and is widely used by mobile phone users as a cheap and convenient method of communication through text. Since SMS technology is a cheap, convenient and flexible way of conveying data, Hence, many of wireless embedded system designers adapts this method for remote monitoring and controlling various parameters.

**4. Temperature Sensor (LM-35DZ):** The temperature sensor chosen for this project is LM35DZ. It is a low cost temperature sensor widely used in industry and medical application. It is an industry standard semiconductor transducer, suitable for the temperature range of  $-50^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ . It is a direct voltage o/p device. It produces  $10\text{mV}/^{\circ}\text{C}$  of surrounding temperature. This voltage is amplified to make it suitable for the ADC to sense and for calibration. Since the output of sensor is  $10\text{mV}/^{\circ}\text{C}$ . The resolution of the ADC is  $20\text{mV}$ . Hence the signal is amplified precisely twice.

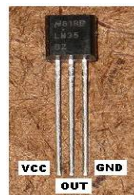


Fig.2. Image of Temperature Sensor-LM35DZ

**5. Analog to digital converter (ADC):** The ADC section is responsible to convert the analog signal into a binary number. When any analog signal is applied at its inputs and a command is given to start the conversion process, an ADC converts the input signal into a proportional binary value, by taking some time. When it finishes conversion and is ready with the digital data, it indicates with an end of conversion signal. The microcontroller can now read the digital data from ADC. An 8-bit, successive approximation type ADC 0809 is used.

**6. Signal Conditioning Circuit:** The signal from the sensor is fed to signal condition circuit. This circuit is used for signal conditioning and standardization. It gives required gain to the temperature signal. It also facilitates for the calibration of the sensor output signal. It comprises of OP-AMPS this analog signal is then fed to an ADC for converting it into a binary (digital) number.

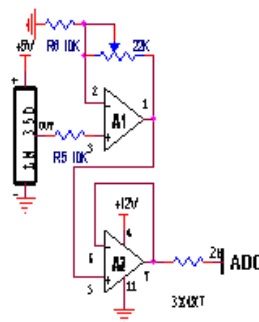


Fig.3. Signal conditioning circuit diagram

**7. LCD display Unit:** It is used for displaying the messages locally. The system uses this LCD module for displaying various messages according to the situation, Position, parameters and the code received. It is a 2-line, 16 character type LCD module with backlit facility. The microcontroller sends the signals to LCD module through its ports.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

**8. Physiological parameter settings Knobs:** These potentiometers facilitate to set the initial values of the bio-vital signal (Body temperature). This facility is given to the doctor to set the body temperature of a particular patient, as the doctor himself knows these values very accurately if he monitors ones or twice. Any abnormalities in the set values will be reported to doctor immediately through SMS.

**9. Emergency Switches:** It is a push button switch. In case of emergency, if the patient presses this emergency switch, the system becomes active, takes the readings and sends the message to doctor with fresh bio-vital information.

## V. SYSTEM SOFTWARE

The developed system is a dedicated embedded system based on 51 architecture; hence, software was written in assembly language without using any general operating system & stored in the memory of the controller. The assembly language programming also reduces the code size, which is the main restriction when 51 architecture is used. When power is switched ON the system comes to ON condition from RESET position then the program is executed and controller freshly takes readings for local display on LCD with and also sends SMS to doctor.

## VI. EXPERIMENTAL RESULT & DISCUSSION

The designed system was tested in the hospital for clinical trials. Initially we have asked the Casualty Medical Officer (CMO) of the hospital to record the body temperature readings of 10 different age & weight patients with traditional mercury thermometer. Then we have used the developed instrument to the same 10 patients and obtained the body temperature readings with temperature sensor. The results are shown in table 1.

TABLE 1. COMPARISON OF HUMAN BODY TEMPERATURE READINGS TAKEN BY DOCTOR AND THAT OF READINGS OBTAINED FROM THE DEVELOPED INSTRUMENT

Sl No	Subject Identity	Weight In Kg	Body Temperature taken by the Instrument with temperature Sensor		Body Temperature taken by Doctor with normal Hg Thermometer	
			In deg C	In Deg F	In deg C	In deg F
1.	Subject-1	68	37.0	98.62	36.6	97.82
2.	Subject-2	47	38.0	100.43	37.7	100.0
3.	Subject-3	55	36.0	96.82	35.7	96.26
4.	Subject-4	72	38.0	100.43	37.5	99.50
5.	Subject-5	67	36.0	96.82	36.0	96.80
6.	Subject-6	75	36.0	96.82	36.2	97.16
7.	Subject-7	40	37.0	98.62	37.0	98.60
8.	Subject-8	48	36.0	96.82	35.8	96.44
9.	Subject-9	78	37.0	98.62	36.4	97.52
10.	Subject-10	65	37.0	98.62	36.9	98.42

Lastly, we compared the readings taken by the CMO & the readings taken with the help of developed instrument. After having discussion with the CMO, we came to know that, there is always 0.5-1.0 deg variation in the temperature with the analog & digital signals which is normally admissible. And the table shows nearly same variations. The photo of the experimental set is shown in fig.4 & in the event of abnormality in the body temperature, the system sent message on to the doctor's cell phone shown in fig.5. The photo-snap of the experimental set up while it was on clinical trials in the hospital is shown in fig.6. The system has demonstrated its feasibility with GSM network for human body temperature monitoring and notification in case of medical emergencies.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

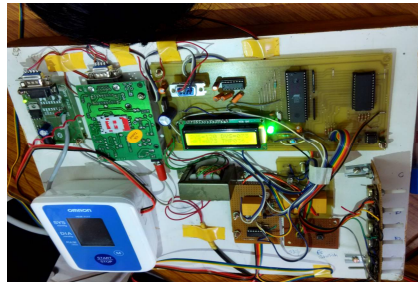


Fig.4. The experimental setup

The system also checks hypothermia & hyperthermia. The location identification is achieved through GPS. The system gets the geographical locations from GPS receiver to calculate the latitude and longitude of the place/location and prepares a SMS and sends the information through the GSM modem to the mobile phone of the doctors as in fig.5.



Fig.5. Cell phone with SMS sent by developed system

The details of this SMS are as follows:

- Body Temperature (BT) = 033
- The GPS locations are:
  - LAT=1718.8014.N (Latitude North)
  - LON=07652.6666.E (Longitude East)



Fig.6. Photograph of the instrument while on clinical trial

From the above discussions it is clear that the system is fully automatic, wireless, portable and practically suitable for patients.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

## VII. CONCLUSION

The main goal of this work is to sense, send, display and store the physiological parameter such as human body temperature. The system is simple, low cost as it is implemented on 51 Architecture Microcontroller and portable. The reduction of the cost of hospitalization & assistance and to increase patient's quality of life is the aim of this work. The system has functioned satisfactorily and can be used by elderly people or people suffering from variety of medical ailments & thus to improve medical care quality of adult people.

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