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Design and Implementation of Microcomputer based Device for Measuring Various Physiological Parameters

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Abstract

There are many conventional devices used for individual measurement of Blood Pressure, Heart Rate and Body Temperature. The Devices used in the measurement are such as sphygmomanometer, oscillometric, etc (for blood pressure measurement), stethoscope, pulse meter, etc (for heart rate measurement), thermometer, forehead temperature strips, etc (for temperature measurement). In the present Scenario there is no device available which can measure all these parameters by a single unit at home. Only one parameter or two at the most can be measured with a single device. So there is an essential need to develop such an integrated measuring instrument. This present paper describes the device which can measure all these parameters. The present device is implemented with use of microcontroller and GSM module, which can transmit the data through SMS to the doctor.

1. Introduction

In this present era, the life of human turn out to be very fast and busy, and it is so fast enough that they are not being paid the time to take-care about their health and also in the case of emergency, a patient need to wait for a doctor or need to call through cell phone and informing the status of the measurement even if which has been done with any device. So a device in desired by which we be able to check some of the important human body parameters like blood pressure, heart rate and body temperature at home for the personal use or regular monitoring of our health and also inform to the two persons by a message on their cell phones (doctor and the loved one because one person may not receive the message due to bad network). Thus, this paper presents the development of physiological parameters measuring device using G1SM module based on microcontroller.

With the help of this device we be capable of easily daily monitor our systolic pressure, diastolic pressure, heart rate and body temperature at home and be able to prevent us from the diseases like hypertension (causes blood vessel damage, stroke, heart failure, heart attack, kidney failure, etc), hypotension (causes dehydration, fainting, nausea, vomiting, etc) , fever, hyperthermia and hypothermia.

According to a survey nearly 139 million Indians were suffering from high blood pressure at the end of 2008 [1] and it is

increasing day by day. The child health in India is still under critical condition. As per UNICEF – India is among those countries with highest child mortality rate, hyperthermia & hypothermia are one of the main reasons behind it. In 2009

India has a child under 5 year's mortality rate of 65.6/1000 (Figure 1). That means 65.6 out of 1000 children dies before reaching the age of 5 years [2]. Though it is decreasing sharply for last few decades but it still remains one of the highest in the World.

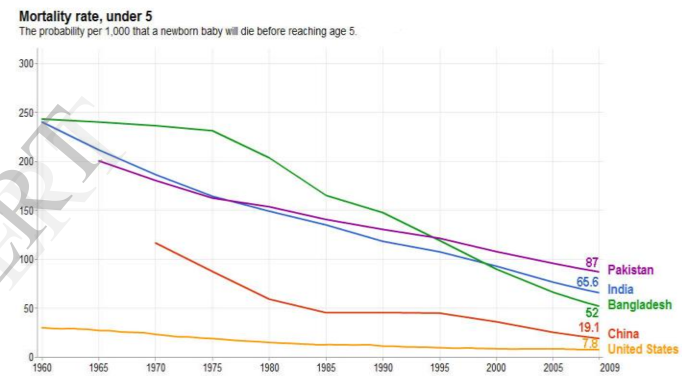

Figure 1: Graph of Child Mortality Rate

This device also offer the convenience to a patient and a doctor too because now the patient not to be hospitalized for ambulatory care [3] in case of hypertension (high blood pressure) until in critical condition, because medical treatment can be made at home without get hospitalized and now doctors can also monitor and make a data base of their patient's present health condition by messages on his cell phone without regular meetings with them.

One more advantage of this automatic home purpose system is that it put away us from "white coat syndrome" [4] , which results in a much higher blood pressure reading than normal reading, due to the authoritative doctor, the foreboding, sterile exam room, and the smells of normal doctor's office such as alcohol and disinfectant. All this is not relaxing and put some stress on us. Some unaware doctors may prescribe medication, when in fact; we don't need it at all. As soon as we leave the doctor's office, our blood pressure returns to normal.

We can measure our blood pressure by two methods i.e., invasive and non-invasive, out of these the non-invasive blood pressure measurement is probably the most common medical

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measurement, due to its clinical significance and simplicity. There are two Conventional non-invasive methods for blood pressure measurement rely on the use of an inflatable occlusive cuff followed by analysis of the Korotkoff sounds by either stethoscopic or electronic auscultation known as sphygmomanometeric and oscillometric methods [8-9], the comparison of blood pressure measurements using korotkoff sounds and oscillometry is shown in Figure 2. But in the sphygmomanometer we need an extra device like stethoscope for the measurement and the accuracy is also affected by the hearing ability of the trained operator. Whereas in the oscillometric method has the advantage that no stethoscope need to be applied to the patient in addition to the arm cuff and also there is no need of a trained operator because now the patient can measure his blood pressure by own.

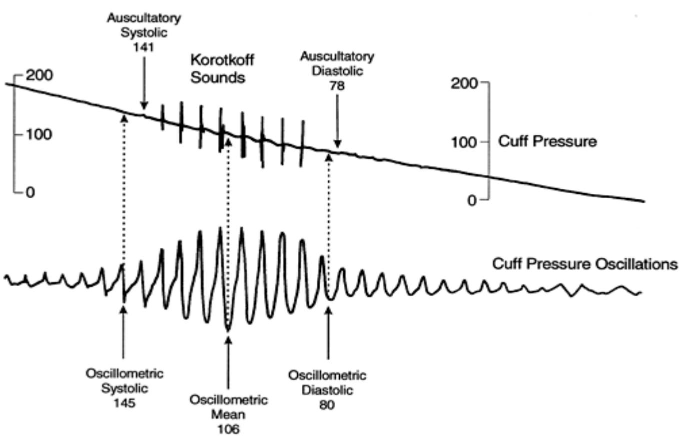

Figure 2: Comparison of Blood Pressure Measurements using Korotkoff Sounds and Oscillometry.

The oscillometric method is very convenient for nonprofessional users who want to monitor their blood pressure at home. It is handy, and easy to operate for those people who perform a daily self-examination.

The organization of the paper is as follows: In section II, we discuss the proposed design that also presents module description for our proposed system. Detailed circuit analysis description is provided for each block used in this section. In section III, we present the software implementation along flow chart diagram. In section IV, port wise hardware implementation and schematic description are shown. Finally, some conclusions and future scope are offered in section V & section VI.

2. Proposed work

The block diagram of this proposed work is shown in the Figure 3. A cuff is put on an arm, and then we will pump the air into the cuff by air pump. At the start, the air is pumped to be above the systolic value, which will prevent the flow of blood in artery. As a result, the pressure pulsations or oscillations introduced within a cuff bladder are sensed by a pressure sensor/transducer located within the cuff.

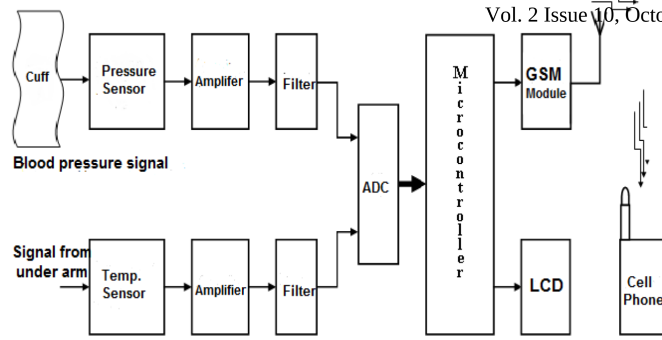

Figure 3: Block Diagram of Proposed System

A very faint blood flow oscillations begin to be detected as the air pressure in the cuff coincides with systolic blood pressure (SBP). As air pressure is slowly released from the occluding cuff, the amplitude of these pulsatile oscillation increases to a point and then decreases as blood flow to the limb normalizes. Although the oscillation with the greatest amplitude has been shown to correspond reliably with mean arterial pressure, determinations of SBP, which are associated with a marked increase in amplitude of oscillations, and diastolic blood pressure (DBP), which are associated with the point at which oscillations level off. At the same time the measurement of heart rate starts. Similarly a temperature sensor/transducer will placed under the arm or in the mouth for the purpose of measuring the temperature of body.

Since the output of these blood pressure and temperature sensors are analog in nature, because of that these analog signals from the sensor should be digitizes using an Analog to Digital Converter (ADC) to feed the digitizes signals into the microcontroller unit (MCU), which will work as a main unit of this system and display the result on a LCD (Liquid Crystal Display) for user use and will also capable to send two messages on predefined cell phones numbers by a GSM module, which is connected to MCU via serial port [6-8]. In the proposed work, there are two interfacing, first the input interfacing (the pressure transducer & temperature sensor interfaced with the micro-controller) and the output interfacing (the micro-controller interfaced with LCD and GSM module).

A. Pressure Sensor

In the proposed work the used pressure sensor is 2SMPP-02, to sense the blood pressure oscillations [9-10]. The SPD series of pressure sensors are silicon based and encapsulated in modified plastic dual in line packages, to accommodate six to eight pins for through-board printed circuit mounting. The sensors come in two distinct types: Gauge and absolute. These 2SMPP series of pressure sensors are available from 0 – 40 kPa and due to this it is widely used in medical applications. The output voltage is proportional to the pressure that is measured. The sensor is compensated for offset, sensitivity, temperature drift and nonlinearity. The SPD pressure sensor is especially well suited for use in combination with the UTI (Universal Transducer Interface). The UTI provides signal conditioning for the sensor and converts the output to an RS232 or USB signal.

B. *Temperature Sensor*

The LM35 is used as a temperature sensor for the proposed work [11-12]. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. LM 35 has a scale factor of .01V/^{o}C. The LM35 does not require any external calibration or trimming and maintains an accuracy of ±0.4 ^{o}C at room temperature and +/- 0.8 ^{o}C over a range of 0 ^{o}C to +100 ^{o}C. Another important characteristic of the LM35 is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1 oC temperature rise in still air.

C. *ADC*

In the proposed work to convert measured analog pressure and temperature signals in to appropriate digital signal we use an Analog to Digital Converter (ADC0809). ADC0809 is an 8-bit analog-to-digital (A/D) converter. It is an 8-channel multiplexer with address logic and its output meet with TTL voltage level specifications and also no zero of full scale adjust required. The pressure and temperature signals are fed to the pin no. 3 & 2 of this chip, respectively. Port 1 of micro-controller is used to interface with this ADC.

D. *Micro-controller*

In the proposed work, all input and out devices are interfaced through the ports of standard microcontroller AT89C51 [13-14]. The device is manufactured by Atmel Corp. and the Atmel Flash 8051 is called AT89C51. The AT89C51 is a low cost, low power, high performance CMOS 8-bit microcontroller with 4Kbytes of programmable and Flash erasable read only memory (PEROM). The processor Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. The AT89C51 provides the following standard features: 4K bytes of Flash ROM, 128 bytes of RAM, 32 I/O lines (4 ports P0, P1, P2 & P3 of 8 I/O lines), 2 timers, 6 interrupt sources and 1 serial port.

E. *LCD interfacing with Microcontroller*

The system consists of a LCD display. After calculating the blood pressure, heart rate and temperature of human the micro-controller display all details on this LCD. LCD display used here is having 16x2 size. It means 2 lines each with 16 characters. This 16x2 LCD is connected to Port 0 of micro- controller as shown in the Figure 4.

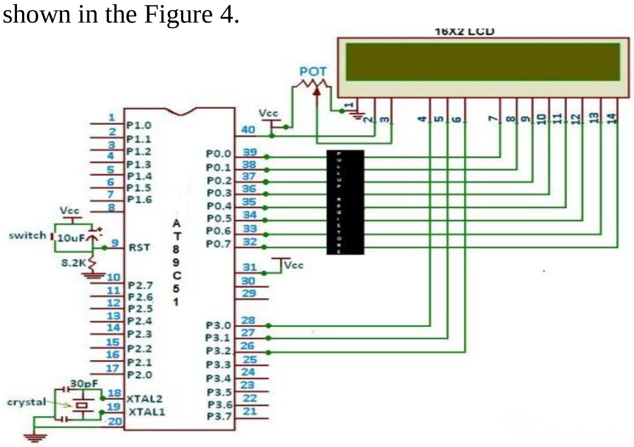

Figure 4: Interfacing of 16x2 LCD with 8051 Micro-controller

To display any character on LCD micro-controller has to send its ASCII value to the data bus of LCD.

F. *Interfacing with GSM Module*

GSM module is used to establish communication between a microcontroller and a GSM system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries.

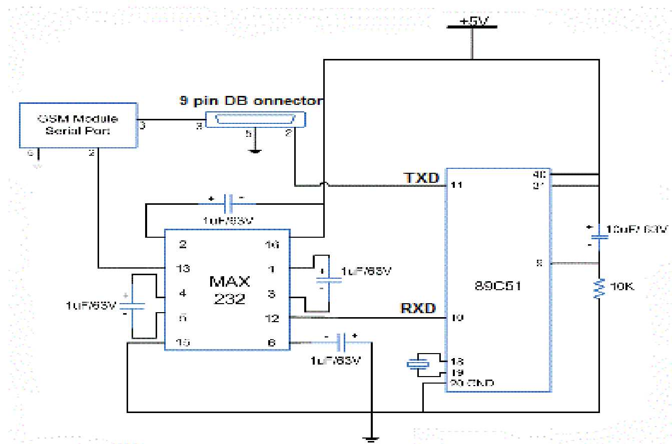

Figure 5: Interfacing of GSM Module with 8051 Micro-controller

Since we cannot connect a GSM module to the micro-controller directly because the output of the microcontroller is not compatible with the GSM module. The interfacing of GSM Module with 8051 microcontroller is shown in Figure 5. To make GSM module compatible we require the DB9 connector and MAX-232 connector and we connect it through RXD (Pin 10) and TXD (Pin 11) of microcontroller [15], as shown in the Figure 5. This will enable the microcontroller to send message or call to a predefined phone number. This GSM module is controlled by sending instruction called AT commands.

G. *MAX 232*

RS-232 is a standard for serial binary data interconnection between a DTE (Data Terminal Equipment) and a DCE (Data communication equipment, like modem or other communication device). Here RS232 means "Recommended standard no. 232", EIA standard for serial communication. The operating circuit of MAX232 is shown in Figure 6.

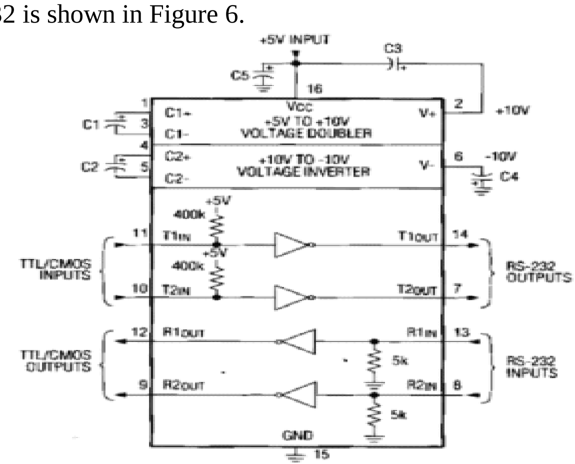

Figure 6: Operating Circuit of MAX 232

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In RS-232 serial port protocol states -15v to represent binary 1 and +15v represent binary 0. For TTL communication this is incompatible since TTL uses 0v to represent binary 0 and +5v to represent 1. So we need a device which can convert serial signal voltage levels to TTL logic level and also vice versa and for this purpose we use MAX232. The MAX232, show in Figure. 6, is an integrated circuit first created by Maxim Integrated Products. In our proposed work it is used to check Baud rate and changes the voltage level because micro-controller is TTL logic compatible.

3. Software implementation

The micro-controller AT89C51 was programmed using the assembly language. Programming is done on Keil software to generate the *.hex file. Various steps to program 8051 are shown below:

1. Write the code in a notepad file.
2. Generate *.hex file is using Keil software.
3. Burn *.hex files is into the micro-controller using burner.

Here we set initial serial data rate to 9600. The flow chart of the system is shown in the Figure 7.

A. Micro-controller Operation

Vital role of micro-controller AT89C51 in 'Proposed Work' is as follows:

1. Set initial bad rate to 9600
2. It will receive the blood pressure signal from the Pressure transducer which is placed within the cuff.
3. It will receive the body temperature signal from the Temperature transducer which is placed under the arm or within mouth.
4. It will act as a master to communicate with memory.
5. It will manipulate the data and display the results on the LCD display.
6. It will also connected with a GSM module which is capable of sending the message on predefined cell numbers.

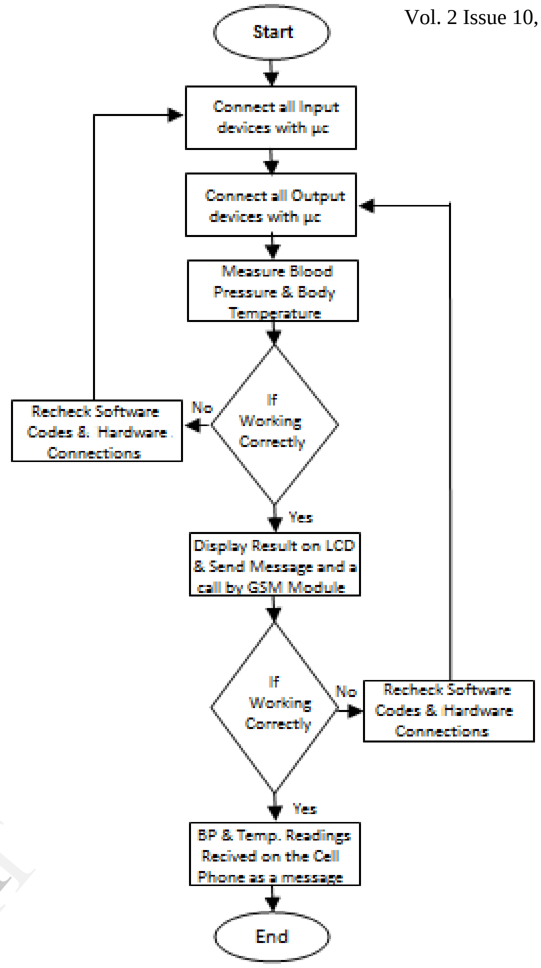

Figure 7: Flow Chart of Proposed Work

B. Micro-controller Operation

Vital role of micro-controller AT89C51 in 'Proposed Work' is as follows:

4. Set initial bad rate to 9600
5. It will receive the blood pressure signal from the Pressure transducer which is placed within the cuff.
6. It will receive the body temperature signal from the Temperature transducer which is placed under the arm or within mouth.
4. It will act as a master to communicate with memory.
5. It will manipulate the data and display the results on the LCD display.
6. It will also connected with a GSM module which is capable of sending the message on predefined cell numbers.

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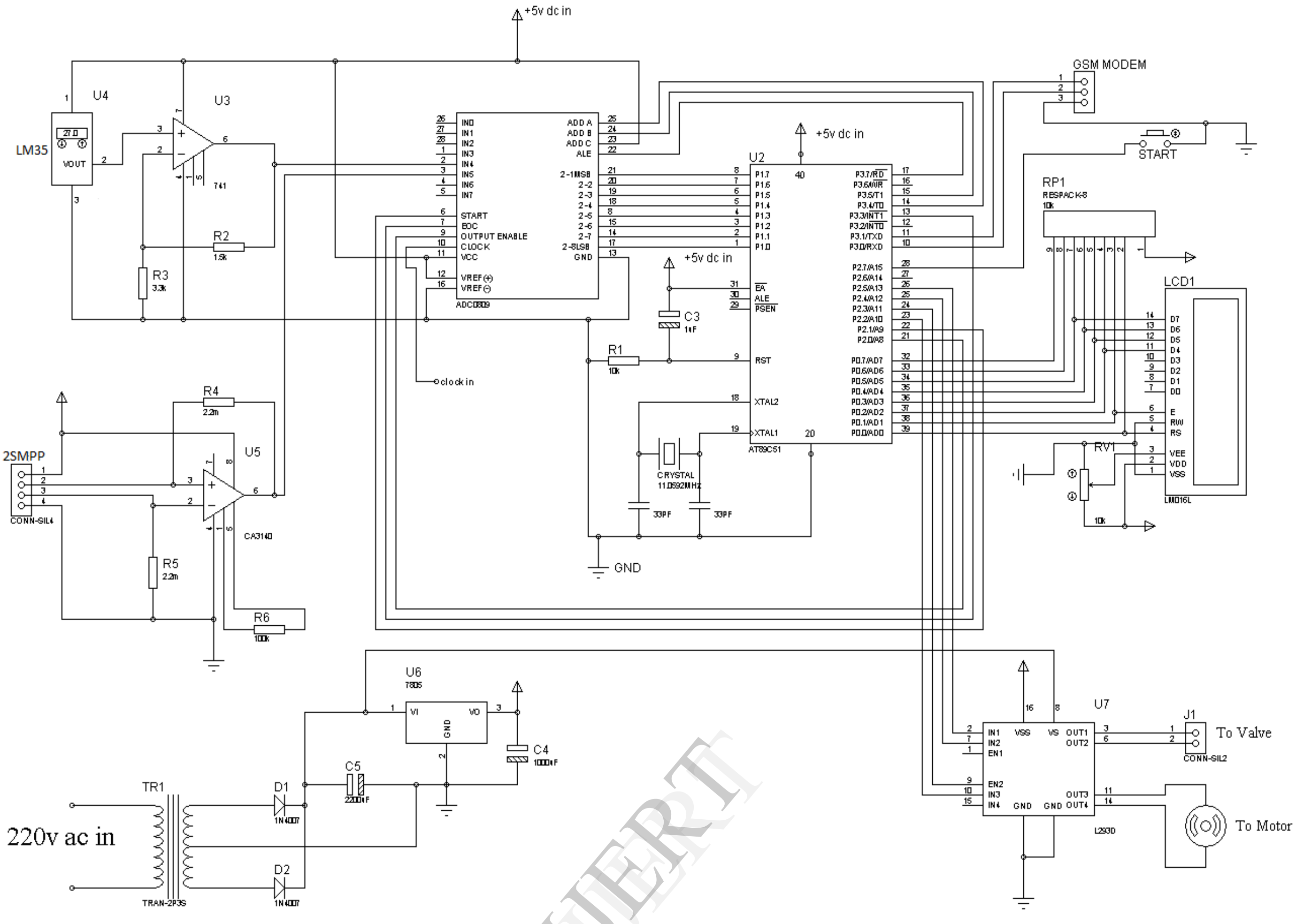

Figure 8: Schematic of Port wise Hardware Implementation

4. Port wise hardware implementation and schematic description

The schematic of port wise hardware implementation of proposed system is shown in the Figure 8, and the SMS message that has been sent to the doctor or the loved one is shown in the Figure 9.

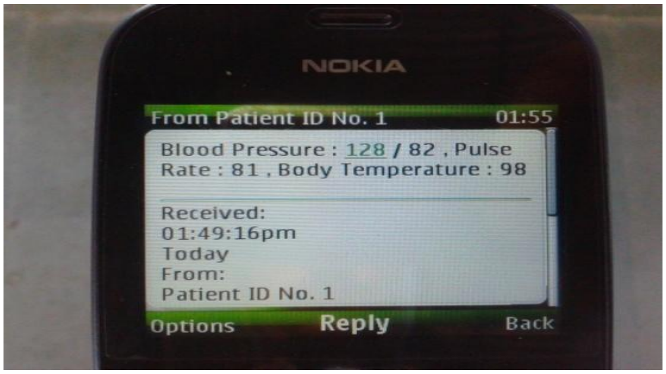

Figure 9: Cell Phone Showing the Message

5. Conclusion

In this paper, a various physiological parameters using GSM module based on microcontroller has been discussed. The proposed system for the measurement of various physiological parameters like blood pressure, heart rate and human body temperature using GSM module based on microcontroller is very useful for home purpose. Which be able to directly display the readings on LCD for the user to see the results and can also send the readings of these parameters on the predefined cell phone numbers as a message. So now doctors can easily observe and maintain the health data of a particular patient without regular meetings with him.

6. Future Scope

In future with necessary modification in hardware connection and software codes, we be capable of add more devices in this system for more body parameters measurement like sugar in blood, pH, etc.

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