Intelligent Baby Monitoring System

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Abstract—This paper presents a design of a Baby Monitoring System based on the GSM network. A prototype is developed which gives a reliable and efficient baby monitoring system that can play a vital role in providing better infant care. This system monitor vital parameters such as body temperature, pulse rate, moisture condition, movement of an infant and using GSM network this information is transferred to their parents. Measurements of this vital parameters can be done and under risk situation conveyed to the parents with alarm triggering system to initiate the proper control actions. The system architecture consist of sensors for monitoring vital parameters, LCD screen, GSM interface and a sound buzzer all controlled by a single microcontroller core.

Keywords- Baby monitoring, vital parameters, microcontroller, GSM network.

I. INRODUCTION

In the past few decades, female participation in the labour force in the industrialized nations has greatly increased in present society. Subsequently, infant care has become a challenge to many families in their daily life. Mother is always worries about the well being of her baby[1].

As we seen in India both the parents need to work and look after their babies/infants, so more workload and stress is there on such families especially on female counterparts. If a system is developed which continuously gives updates about their infants during illness or during normal routine then it will be of great help to such members as they can work in stress less environment giving more fruitful output. Also urgent situation condition can be quickly be noticed and handled within less time. Usually, when a young baby cries, the cause is one of the following things i.e. they are hungry, tired, not feeling well or need their diaper changed. So we developed a prototype which can monitor the activities of the babies and/or infants along with finding one of the above causes and give this information to their parents[2].

This proposed system give a peace of mind to loved ones when they are away from their infant as they can get an update status of their wellbeing. The other advantage is the programmability of alarm conditions can alleviate any inaccuracy through a normal sensor. Communication is done by GSM interface in which Short Messaging Service (SMS) is fundamental part of the original GSM system and its progress.

In this way just by an infant's few biomedical parameters parents can get information about their health.

II. LITERATURE SURVEY

Many home-care systems are available but majority of this system are specially designed for the aged people and patients. These systems can monitor their health status, automatically send out emergency signals, and have other functions. However, the caring methods for infants are not the same. Children and adults require different type of care because they are totally dependent for their normal functions on someone else. Infants cannot give any feedback about their discomfort or health complaints. Infants cannot express themselves like old people, e. g when an infant has a fever, he/she can only express his/her discomfort by crying. Hence, a home-care system specially designed for infants is today's need which would substantially lighten parents' especially mother's burden. In support of this requirement many research papers and patents for healthcare application are studied with the intention of possible solutions to take care of the infant. Author had developed a system which is based on commercial GSM network. Vital parameters such as body temperature measurement using LM 35[1,6], Heart rate using IR Transmitter and Receiver, respiratory rate by using Piezo film sensor located on Patient's Chest and blood Pressure are sensed, amplified with variable gain, filtered and given to microcontroller. Remote subsystem with GSM module receives data which is then send to a server by a USB port. Data are stored on the server and remotely displayed in a web site. In SMS based telemedicine system, patients temperature measured by Infrared temperature sensor MLX 90614 and ECG signals acquired with electrodes interfaced with the microcontroller PIC16F877[3].A wearable hardware gadget is developed which captures the biological status of the baby such as motion, temperature and heart rate sensors (both optical and pressure) which are controlled by the microcontroller and connected to the Bluetooth module to provide wireless communication[5]. In paper[14], the temperature and humidity parameters are monitored. A skin-temperature probe, the air temperature-probe was used to monitor the temperature around the baby and humidity of incubator was monitored using the humidity sensor from SYHS2XX

series. This signals are interfaced to PIC microcontroller 18F4550 and GSM modem is used for communication.

Patents are also searched to find novelty in baby care monitoring system. In design, (Patent No. 2002/0057202 A1)[16], system is developed which monitors breathing ,fever and volume of baby sleeping in the crib. There is a module having three sensors attached to the diaper. This signals are amplified, transmitted by transmitter and at remote station there is receiver, multiplexer which applies this signal to audible alarm to alert mother to take appropriate action. U.S. Patent No.6,043,747 (Altenhofen), Wherein a parent unit can record messages Which may then be transmitted to the baby unit to soothe or calm the baby[17]. The baby unit includes a microphone and can transmit sounds to the parent unit. However, in order for the parent to detect a problem With the child, the parent must constantly monitor the sounds being transmitted from the baby unit. The next U.S. Patent No. 6,450,168 B1[18],includes an infant's sleep blanket/garment which is offered as either a sleep sack or a sleep shirt, depending on the age of the infant. The sack with no arm holes for newborns and with arm holes and sleeves for older infants. Here thermometers incorporated to monitor the infant's temperature as he sleeps. U.S. Patent No. 4,895,162 [19], in Which a soft belt containing a pair of electrodes is positioned around the torso of an infant such that the electrodes are in position to monitor vital signs, such as respiration and pulse. Monitoring lead Wires connect the electrodes to a monitor unit proximate the infant.

III. SYSTEM ARCITECHTURE

The architecture of the system consist of both hardware and software. Block diagram is as shown in Fig.1,hardware components were assembled according to the block diagram. The code is written in embedded C and is burnt into the microcontroller .

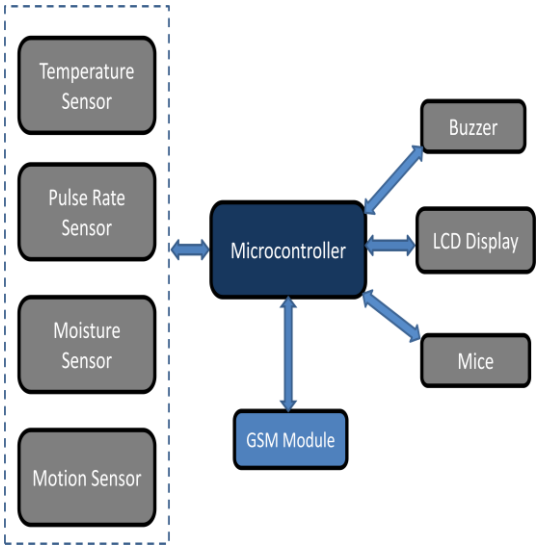

Fig. 1. Block Diagram of Proposed System

The following subsections provide more details of the components used in our prototype:

A. Temperature Sensor

Human body needs special type of sensors for reliable readings which led to the choice of using the LM35 temperature sensors in our prototype[1,6]. It operates at 3 to 5 V and can measure temperature in the range of -40 C to +125 C which is sufficient for the targeted body temperature range .It is having linear response and easy conditioning. The sensor's output is an analog DC voltage signal which is read by the microcontroller using an analog pin linked to an ADC. The ADC used has a resolution of l0-bits, 1024 levels, with a sample rate of 9600 Hz and input voltage range depending on the ground and Vee. The output voltage of the LM35 is analog and in the linear range of -1 V to 6 V with accuracy of ±0.5 °C can be converted from volts to degrees of Celsius and Fahrenheit .

The placement of sensors is also important for accurate measurements. In our prototype it is placed in the socks of an infant wrapped in cotton so that no irritation made.

The temp sensor and actual readings are listed in table below:

TABLE I

Serial No	Actual Temp (^{0}C)	Practical Temp(^{0}C)
1	32	36.1
2	31	35.6
3	32.5	36.7
4	33	37.2

B. Pulse Rate Sensor

The components used are 5mm photodiode and 5mm light emitting diode. The system consist of IR transmitter and receiver, high pass filter ,amplifier and comparator .By using this circuit component biological signal in mill volt is converted to larger magnitude about one to two volt and then send it to the microcontroller.

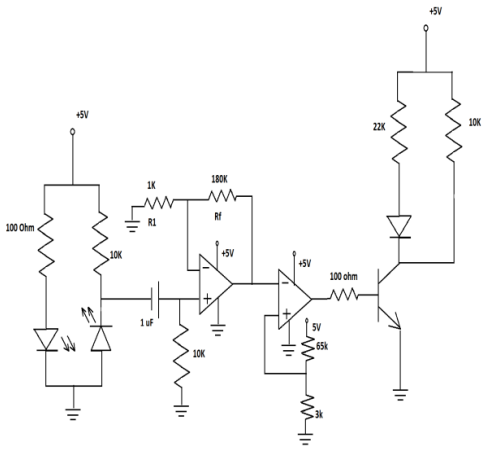

Fig. 2. Pulse Rate Sensor Circuit

Pulse rate will be measured from the finger using optical sensors and displayed on the LCD. The transmitter-sensor pair is clipped on one of the fingers of the

subject. Pulse rate signal is applied to the Non-inverting input terminal as shown in Fig. 2.Voltage gain of Non Inverting amplifier is given by Equation 1+ Rf/R1.

Gain=1+ 180/1=181.

This amplified signal is given to comparator circuit where voltage divider circuit is used. Voltage at non-inverting input is compared with reference voltage and whatever voltage is generated is applied to the base of transistor. There is a 100 Ohm resistor at the base of transistor used to limit the current flowing to the base of transistor. As soon as the voltage across this resistor increases beyond 0.7V the transistor turns ON and at the output we get 0v and the LED D2 glows.

The pulse-rate sensor and actual readings are listed in table below:

TABLE II

Serial No	Actual pulse rate	Practical pulse rate
1	72	78
2	66	72
3	70	76
4	54	60

C. Moisture Detection Sensor

To determine the moisture condition i.e. urine detection ,two pairs of copper electrodes are placed under the cloth on which baby is sleeping. The signal obtained is given to microcontroller.

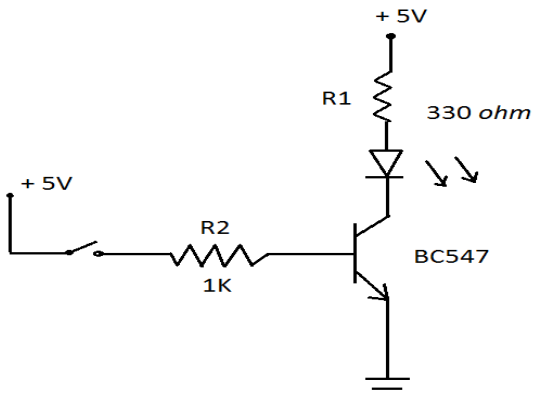

Fig. 3. Moisture Detection Circuit

For detection of urine ,transistor as a switch circuit is used as shown in Fig.3 When urine is present switch is closed transistor turns on. When urine is absent switch is open, transistor turns off.

D. Motion Sensor

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at our feet, or they could be dynamic - caused by moving or vibrating the accelerometer. By measuring the amount of static acceleration due to gravity, one can find out the angle the device is tilted at with respect to the earth. By sensing the amount of dynamic acceleration, one can analyze the way the device is moving. Accelerometers use the piezoelectric effect - they contain microscopic crystal structures that get stressed by accelerative forces, which cause a voltage to be generated. The three axis accelerometer are basically used to identify the movements across the three axis i.e. x-axis, y-axis, z-axis. The accelerometer used in this system is ADXL335, [20] which is small low profile package, can measure minimum full scale range of +/- 3g as shown in Fig.4.In this way movement of an infant is monitored by placing accelerometer properly. It is positioned in the socks of an infant so accurate motion will be detected.

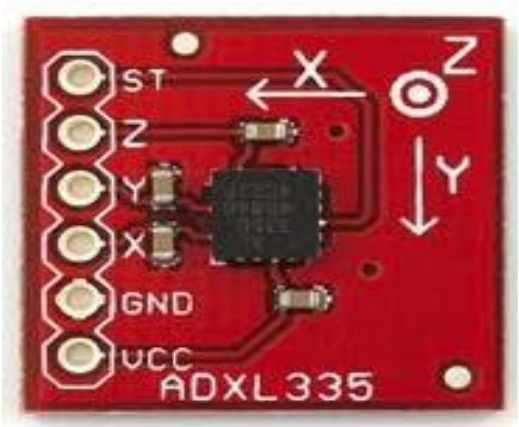

Fig. 4. ADXL335 Accelerometer

E. LCD screen

In our prototype 16 X 2 LCD module is used. It has 2 rows and 16 column therefore total 32 characters are displayed. It has two operation modes, one uses all 8 pins and the other uses only 4 of them. The 4-bit mode was used to manage the LCD screen. All sensor output is displayed continuously as it is being measured.

F. GSM Module

GSM (Global System for Mobile communication) is a digital mobile telephony system. With the help of GSM module interfaced, we can send short text messages to the required authorities as per the application. GSM module is provided by SIM uses the mobile service provider and send SMS to the respective authorities as per programmed. This technology enable the system a wireless system with no specified range limits. In this way, whenever the safe range of the vital parameter of an infant is violated, the programmed microcontroller produces an alarm and GSM Modem interfaced with the microcontroller sends an alert SMS to the parent's mobile number deploying wireless technology.

G. Controller

The PIC 18f4520 is an 8-bit microcontroller, which has an on-chip eight channel 10-bit Analog-to-Digital Converter(ADC).The amplified and conditioned sensor signals are fed to the microcontroller.

IV. SOFTWARE DETAILS

PIC18F4520 is used as a micro-controller in a proposed system. The sensors namely pulse rate sensor, accelerometer, temperature sensor, moisture sensor and sound detector are interfaced with analog channel of ADC of micro-controller. The values taken from this sensor are displayed after every 2msec of delay. Power on reset function of PIC micro-controller resets all the values. The micro-controller read output of ADC after every 2 seconds. Temperature of an infant is read by microcontroller, the software is developed in such a way that upper limit of temperature is set, if crosses that limit ,buzzer will be on and alert message send to mother. Similar conditions are considered for other sensors.

V. RESULTS

The system was tested carefully on an infant, the results found to be same as the one's measured by standard instrument. While testing this system on an infant parent's concern was considered. During the execution of the system snapshots of the display were taken. The system being a complete hardware design and the data available on cell phone and LCD display have been captured. Test results of the system are given below, shows successful implementation of the system. Fig.5 and Fig.6 shows hardware module and the actual implemented system.Fig.7,8,9 shows a sample readings of infant onto the LCD attached to the module on an infant's side. The reading were matched to the readings taken by standard instrument and found to be same.Fig.10 and Fig.11 shows message received on parent's cell phone when some abnormal condition exists. Message shows temperature is high and moisture condition exists.

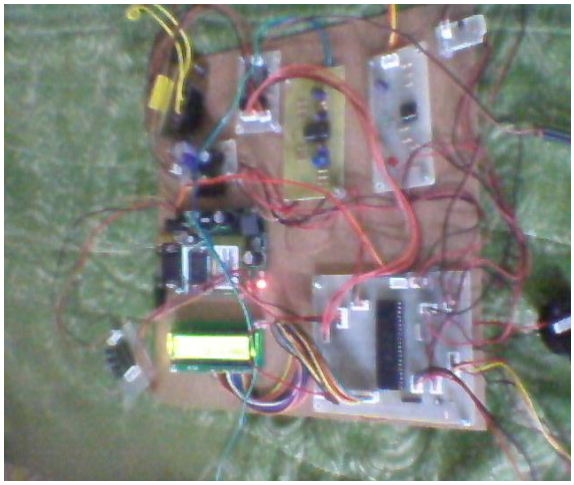

Fig. 5. Hardware Module of the Implemented System

Fig. 6. Actual Implemented System

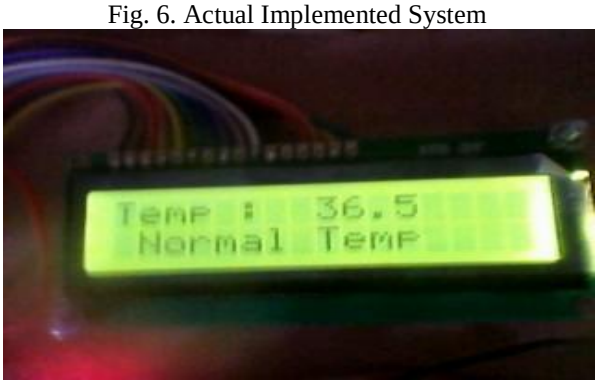

Fig. 7. LCD displaying Infant's Temperature

Fig. 8. LCD displaying Infant's Urine detection condition

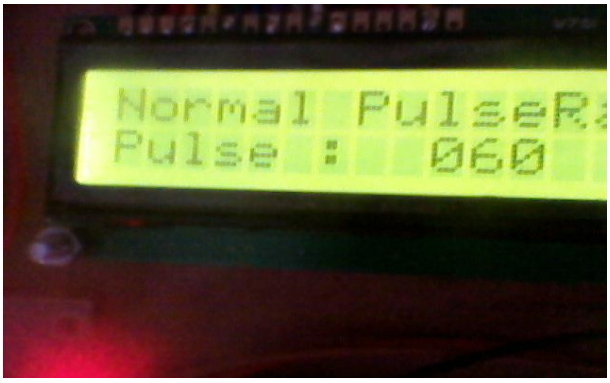

Fig. 9. LCD displaying Infant's Pulse Rate value

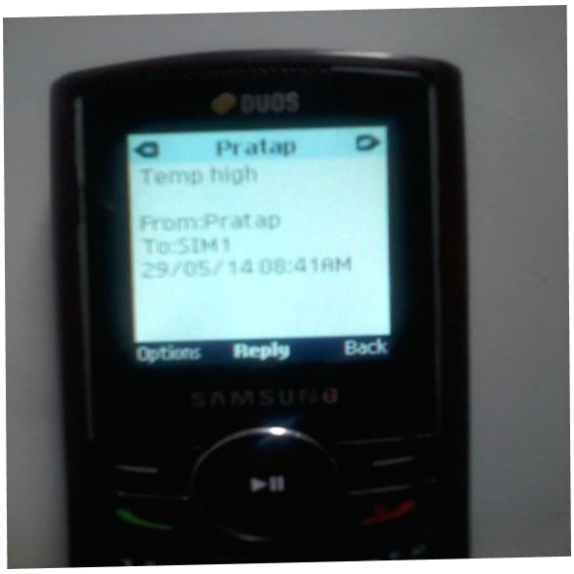

Fig. 10. SMS received on parent's cell phone

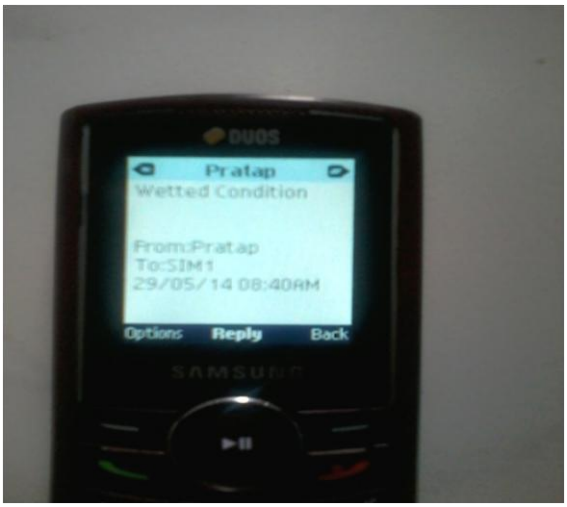

Fig. 11. Message received on parent's cell phone

VI. CONCLUSION

Proposed Infant Monitoring System is an inexpensive and simple to use, which can improve the quality of infant-parent communication. This system expressively provides the parents with the feeling of assurance. The constant capturing of multiple biological parameters of the baby and analysis of the overall health helps mother to understand the internal status of the baby. As GSM technology is used which makes the users to communicate for longer distances. This is a convenient system to monitor the baby's health condition from any distance.

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