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# Improvement on Patient Monitoring and Fall Prevention Via Wireless Sensor Networks

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**Abstract**

In medicine, monitoring is the observation of a disease, condition or one or several medical parameters over time. Patient monitoring systems are gaining their importance as the fast growing global elderly population increases the demand for caretaking. It can be performed by continuously measuring certain parameters by using medical monitor (bed side monitor) or by repeatedly performing medical tests. In this paper, we present the patient monitoring system by using 3 sensors namely, body temperature sensor, MEMS accelerometer sensor and heart beat sensor. These sensors senses the biomedical signal of the patient under study and executes with the controlled coding of the mother processor that is microcontroller and further it hooks the wireless cell phone and using the application software, the text application protocol of the cell phone is used to alarm the respective doctors. Thus the experimental result shows that our scheme is fast and reliable.

***Key words***: *MEMS accelerometer sensor, Heart beat sensor, Temperature sensor, Microcontroller, Application software.*

## 1. Introduction

According to Kinsella [1] report the global elderly population is fast growing. The aging society is bringing its impact on many developing countries and the changes brought about by the aging society include an increasing demand for caretaking; thus, patient monitoring systems are gaining their importance in reducing the need for human resources. In recent world, continuous monitoring of the pathological parameters is an important challenge, which consumes more memory units and need more complex processor which counts for more money. Also currently, a number of studies have been proposed to address the issues of transmitting vital signs in hospital over wireless transmission. In this paper we use zigbee technology for wireless transmission. Our entire project can be classified into four sections, firstly the signal acquisition from the transmitter section, secondly the signal processing and monitoring for patients. There are two different types of battery. One is lithium battery which supplies the device which is working in normal condition. The other is button cell battery. Usually this button cell battery doesn't work. When lithium battery exhausts its power, the button cell battery turns to supply power and transmit a battery exhausted message to the server.

Sensors continuously monitor and provide analogue/digital signals in response to inputs of various features of the patient like temperature, heart beat and conversion into digital form; thirdly decision making with the help of an algorithm where they obtained signal values are compared with the standard values. Finally if an abnormal value is detected alarm is switched on at the server room and also a message is sent to the duty doctor. In our project a switch is kept near the patient so that as soon as the nurse enters into the ward they press the switch near to the patient so that the alarm stops, indicating that a care taker is near to the abnormal patient. Also the transmission of the condition about the patient is intimated to the respective doctors.

As said earlier, we use zigbee technology for wireless transmission which supports wireless mesh networking and multiple hopping. Therefore for indoor transmission of vital signs, wireless mesh networking is a convenient technology which can dynamically establish multi hop network topology without prior configuration. The WMN devices could change locations and configure itself on the fly. Hence, they are adopted for indoor positioning. [2].

Our paper is organized as follows. We start it with a schematic layout of our whole project followed by the explanation about Zigbee and 3 types of sensors used. We also mention about the server and the application created in it. Then we are explaining out our project advantages and applications followed by the conclusion.

## 2. Schematic layout

Firstly, the regulated power supply is used to regulate the supply to 5v DC and it is given to the microcontroller. Due to miniaturisation of sensors they consume less amount of the total power. To keep high reliable power supply for all devices, we adopt back up power strategy. In this way, when the main battery could not able supply enough power for the device, therefore a backup battery works for helping the doctors and nurse to keep basic movement and these outputted signals can be read by a reader or an instrument. Usually the sensor signal is weak in nature and hence it requires processing. The processing may include amplification and noise cancellation. The amplified signal is converted into the corresponding digital signals if required using an analogue to digital converter by means of which, it provides the easiest way to communicate. These digital processed signals are given to a decision algorithm which is previously written in the form of hex code within the microcontroller and stored in

the memory of a microcontroller. These signals are compared with the standard statistics of a normal standard values. Finally the data/ health condition of the patient is transmitted to the doctor (receiving wireless device (i.e) zigbee). LCD displays are used to display the good and bad conditions of the patient. Alarm and SMS to the doctor acts as an indicator to indicate abnormal condition of a patient under observation and the doctor can take immediate action depending upon the patient's condition.

The following figure explains the schematic diagram of the patient monitoring system. Here the output of all sensors is analogue in nature, so it is converted into a digital form so that the output is in three bit format. Here an analogue to digital convertor TLC 2543 is used. Then the output is fed to the microcontroller. By using wireless sensor network technology the further operations are carried out.

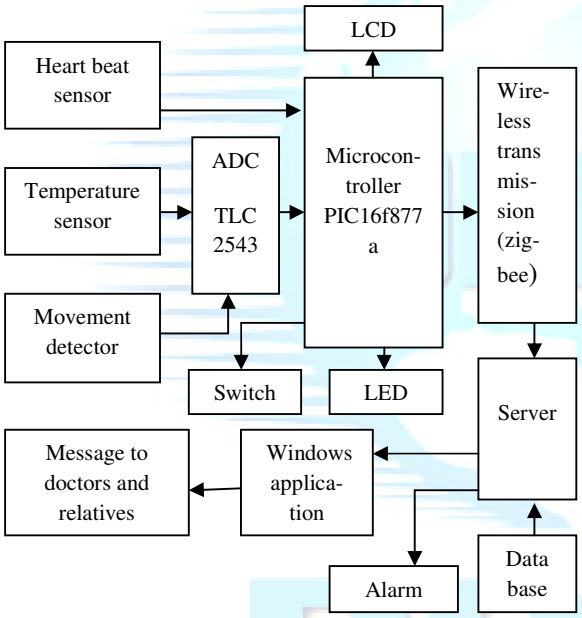


Fig 1: Schematic Layout of Wireless Patient Monitoring

## 2.1 Zigbee

The name of ZigBee comes from the zigzagging path a bee (a data packet) takes to get from flower to flower (or node to node) [3]. ZigBee is primarily intended for low power and low duty-cycle sensors. ZigBee nodes can be active for less than 1% of the time. For instance, an off-line node can connect to a network in about 30 ms. Waking up a sleeping node takes about 15 ms, as does accessing a channel and transmitting data. Our healthcare system will get benefit from this technology. In large outdoor monitoring area, not all of nodes should work all the times. These nodes could go to sleep, and wake up until a new task coming.

As an IEEE 802.15.4 based standard, ZigBee is described by referring to the 7-layer OSI model for layered communication systems. But not all of these 7 layers are defined, ZigBee Alliance only specifies four layers (Physical, Data Link, Network, and Application), as well the Application Layer (APL) that allows end-developers design custom applications that use the services provided by the lower layers. Fig. 1 shows the ZigBee protocol stack architecture adopted by the alliance. It should be noted that the ZigBee Alliance choose to use an already existing data link and physical layers specification. These are published IEEE 802.15.4 [4] standards for low-rate personal area networks. The network and application layer are defined by the alliance itself.

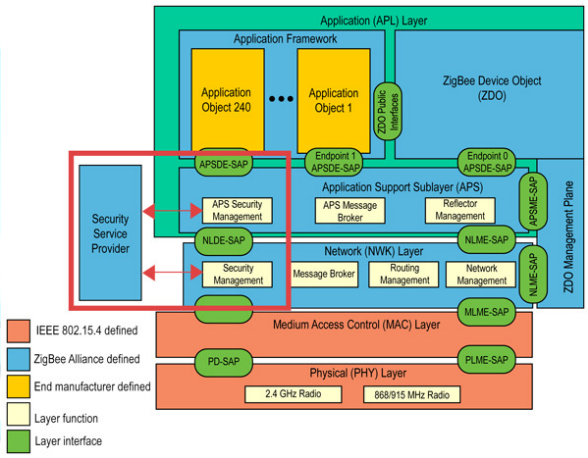


Fig 2: Zigbee Protocol Stack Architecture

## 2.2 Temperature sensor

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 °C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every °C rise/fall in ambient temperature, *i.e.*, its scale factor is 0.01V/°C.

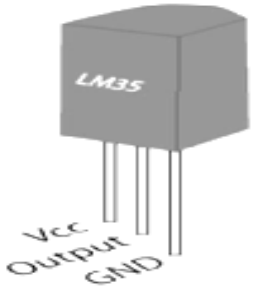


Fig 3: LM35 Temperature Sensor

## 2.3 Heart beat sensor

Heart rate is the number of heart beats per unit of time and it is usually expressed in beats per minute (bpm). In adults, a normal heart beats about 60 to 100 times a minute during resting condition. The resting heart rate is directly related to the health and fitness of a person and hence is important to know. You can measure heart rate at any spot on the body where you can feel a pulse with your fingers. The most common places are wrist and neck. You can count the number of pulses within a certain interval (say 15 sec), and easily determine the heart rate in bpm.

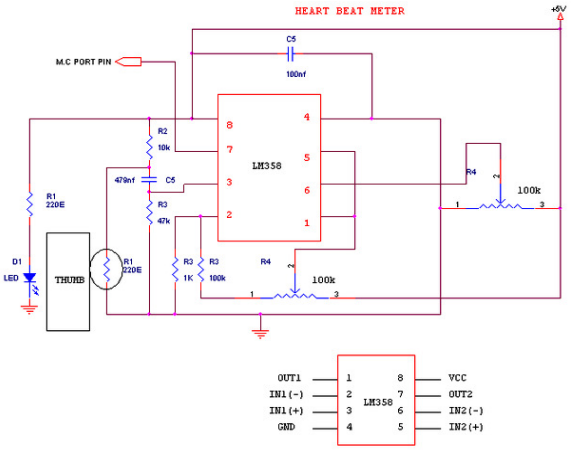


Fig 5: Heart beat sensor using LM358

Heart rate measurement indicates the soundness of the human cardiovascular system. This project demonstrates a technique to measure the heart rate by sensing the change in blood volume in a finger artery while the heart is pumping the blood.

This project describes a microcontroller based heart rate measurement system that uses optical sensors to measure the alteration in blood volume at fingertip with each heart beat. The sensor unit consists of an infrared light-emitting-diode (IR LED) and a photodiode. The IR diode transmits an infrared light into the fingertip (placed over the sensor unit), and the photodiode senses the portion of the light that is reflected back. The intensity of reflected light depends upon the blood volume inside the fingertip. So, each heart beat slightly alters the amount of reflected infrared light that can be detected by the photodiode.

## 2.4 Analogue to digital convertor

The analogue to digital convertor used in this research is TLC2543. A brief explanation about this 20 pin IC is given as follows. The TLC2543 is a 12-bit, switched-capacitor, successive-approximation, analogue-to-digital converter (ADC). This device, with three control inputs [chip select (CS), input-output clock (I/O CLOCK), and address input (DATA INPUT)], is designed for communication with the serial port of a host processor or peripheral through a serial 3-state output. The device has an on-chip 14-channel multiplexer that can select any 1 of 11 inputs or any 1 of 3 internal self-test voltages. The sample-and-hold function is automatic. At the end of conversion, the end-of-conversion (EOC) output goes high to indicate that conversion is complete.

Here the pin AIN0-10 refers to the analogue input. These 11 analogue-signal inputs are internally multiplexed. Pin number 10 is GND, the ground return terminal for the internal circuitry. Next is the Chip select which is at pin number 15. A high-to-low transition on CS resets the internal counters and controls and enables DATA OUT, DATA INPUT, and I/O CLOCK. Next is pin number 16 DATA OUT which is in the high-impedance state when CS is high and active when CS is low. Pin 17 is Serial-data input. A 4-bit serial address selects the desired analogue input or test voltage to be converted next. Pin 13 is the negative reference voltage. The lower reference voltage value is given to this pin. Pin 14 is positive reference voltage. The upper reference value is given to this pin. Pin 20 Vcc is the positive supply voltage. The maximum supply voltage given to this IC is +6.5V.

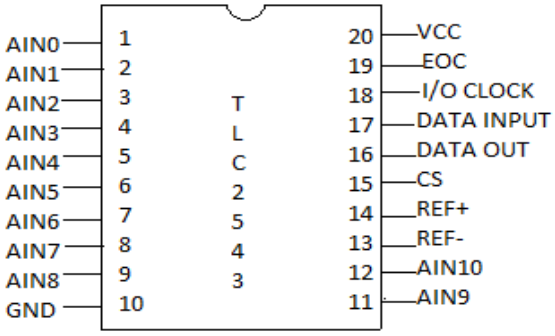


Fig 4: Pin diagram of TLC2543

## 2.5 MEMS accelerometer sensor

MEMS stands for micro-electromechanical systems, and MEMS sensors comprise a class of devices that are micro machined from bulk silicon. 5v supply is given to the sensor MX2125. Here P6 and P7 refer to the ports of the micro controller to which it is connected. This sensor is a 3D sensor which checks for the movement in 3 dimensions. A particular axis is located for the patient and the value is fixed for it. The range is up to 1000 to 1600. It may vary under any situations. If any abnormal movement like fall or drowsiness is detected, alarm signal is switched on automatically.

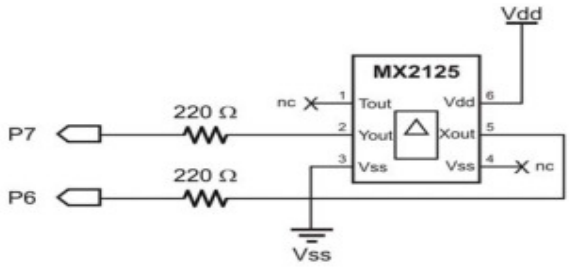


Fig 6: MEMS Sensor

## 2.6 Server based applications

After the signals are transmitted to the microcontroller and detected they are sent to the server for timely update and immediate message to the doctors and relatives. A serial port from the microcontroller is connected to the server. In a memory storage device all the values of the sensors are updated in a timely manner. Dot net and SQL server is used to create a database about the patient and the details like their bed number, the type and number of sensors connected to their body, the corresponding doctor's mobile number and relatives mobile number and also other parameters if necessary. From the server an alarm is connected to the nurse room indicating that a patient has got an abnormal value. A program is written in embedded C to design the project effectively and MPLAB IDE v 8.60 is the software used to run these programs and bring out this project in a more efficient manner.

## 3. Advantages

*A. Benefits to Physicians*

i) Improved diagnosis and better treatment management.
ii) Quick and timely follow-up of patients.

B. *Benefits to Patients and also Parents*

i) Reduced visit to hospitals for long term follow-up care.
ii) Earlier discharge of patients leading to shorter length of stay in hospitals.

C. *Hospital Benefits*

i) Significant reduction in unnecessary visits.
ii) Hospitalization for specialized care at tertiary hospitals.

*D. Future scope*

With the above mentioned system, keeping this as the basic foundation in Tele-medical fields we can build a more robust system that Integration of inpatient and outpatient services, creating user networks. With further 4-G technology we can build Wireless Long Distance [WiLD] Clinical Applications deliver expertise to anywhere in the world and medical Transportation.

## 4. Applications

*A. In Biomedical Fields*

Biomedical engineering is the application of engineering principles and techniques to the medical field. This field seeks to close the gap between engineering and medicine.

*B. Remote Monitoring Purposes*

Remote Monitoring refers to accessing and monitoring a device from a distant location. At times it is not possible to monitor a device continuously by being with it.

C. *Remote Consultation*

A consultant usually works for a consultancy firm or is self employed, and engages with multiple and changing clients. Remote Consultancy is a way of service that experts with affluent operating theoretical knowledge and practical experience communicate with us directly.

*D. Agriculture*

In fields, to measure the water level and the amount of chemical content in the water due to the addition of pesticides through wireless technology. The birds entering into the fields can also be monitored. A large area monitoring is done in this process.

## 5. Conclusion

From this project we can conclude that this can be one of the best methods for bio medical application where the doctors can analyse the subject condition from the place where they are sitting and hence proper and timely Medicare to the patient can be given by avoiding serious conditions. Therefore this project uses a reliable transmission and avoids errors in the system during transmission. The next step focuses on how to extend more sensor module and improve the power consumption so as to conduct further research on monitoring of more psychological parameters. Our project can also seamlessly integrate with next generation technology of wireless wide area networks to achieve real time patient monitoring.

## Acknowledgments

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