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Intelligent Wireless Patient Monitoring and Tracking System (Using Sensor Network and Wireless Communication)

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Abstract

Aim of our work is to monitor the human body temperature, blood pressure (BP), Pulse Rate and ECG and tracking the patient location. The human body temperature, BP, Pulse Rate and ECG are detected in the working environment; this can be sensed by using respective sensors. The sensed information is send to the PIC16F877 microcontroller through signal conditioning circuit in the patient unit. A desired amount of sensor value is set and if it is exceeded preliminary steps should be taken by the indicating by buzzer.The sensor information will be transmitted from the patient unit to the main controller unit with the help of Zigbee communication system which is connected with the microcontrollers in the both units. The main controller unit will send those sensed data as well as the location of that patient by the help of GPS Module to the observer/doctor. The observer/doctor can receive the SMS sent by GSM module and further decision can be taken. The message is sent to a mobile phone using Global system mobile (GSM) Modem. MAX232 was a driver between microcontroller and modem.

Keywords: LM35, Heart Beat Sensor, ECG Sensor, BP Sensor, Zigbee module, GSM module, GPS modulle, PIC16F877A Microcontroller.

I Introduction

During the last quarter of the century, there has been a tremendous increase in the use of electrical and electronic equipment in the medical field for clinical and research purpose. In medical instrumentation, the main function is to measure or determine the presence of some physical quantity that may be useful for diagnostic purposes. Therefore, many types of instrumentation systems are used in hospitals and physician‟s clinics**.**The primary purpose of medical instrumentation is to measure or determine the presence of some physical quantity that may assist the medical personnel to make better diagnosis and treatment. Accordingly, many types of instrumentation systems are presently used in hospitals and other medical facilities.

Certain characteristic features, which are common to most instrumentation systems, are also applicable to medical instrumentation systems. In the broadest sense, any medical instrument would comprise of the following four basic functional components: Measurand, Transducer/Sensor, Signal conditioner and display system.

Patient monitoring system in all ICUs is the most needed and essential device for monitoring the patient‟s vitals. As the physicians cannot stay next to the patients for all time round the clock, we go up for the wireless patient monitoring and tracking system , to have a quantitative assessment of the important physiological variables of the patients. Patient monitoring systems are used for measuring continuously or at regular intervals, automatically, the values of the patient‟s important physiological parameters. The choice of proper parameters, which have high information content, is

an important issue in the patient monitoring system. The important parameters are ECG, heart rate, pulse rate, blood pressure, body temperature, respiratory rate and SPO_2. Wireless telemetry permits examination of the physiological data of human under normal conditions and in natural surroundings without any discomfort or obstruction to the person under investigation.This system consists of simple and low cost components that are capable of processing real time temperature, ECG, BP, heart rate and transmitting the same. There exists a demand for such a system, as current implementations are complex to use and high in cost.Our system design aims to provide solutions to the problem encountered in acquiring temperature, ECG, BP and heart rate from the subject, as well as providing remote transmission of the data. All papers which we followed states that, patient is stationary and the observer in a remote location. The availability of the patient stationary can be possible to make a good hardware and software development is possible.The main aim of our work is to show how persons suffering from cardiovascular and other hypertension disease can directly monitor their physiological parameters without effecting to their daily activities by using the GSM,GPS and Zigbee.

II Working Principle

The system majorly consists of three major units: i) Patient unit, ii) Main Controller unit, iii) Observer unit and these units consist of eight major components: i) Heart rate sensor, ii) LM35 Temperature Sensor, iii) ECG Sensor, iv) BP Sensor, v) ZIGBEE module, vi) GSM modem, vii) GPS modem, viii) Microcontroller (PIC16F877A). Let us see the brief explanation of circuitry.

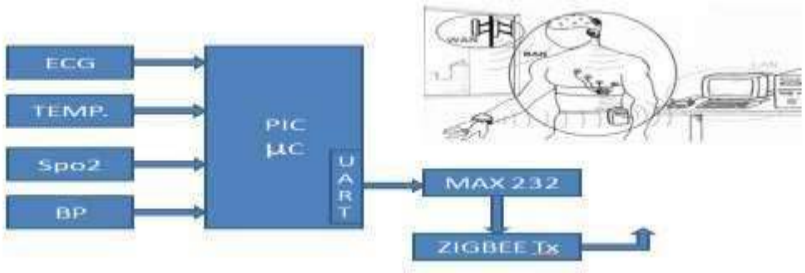

Figure-1: Block Diagram of Patient Unit

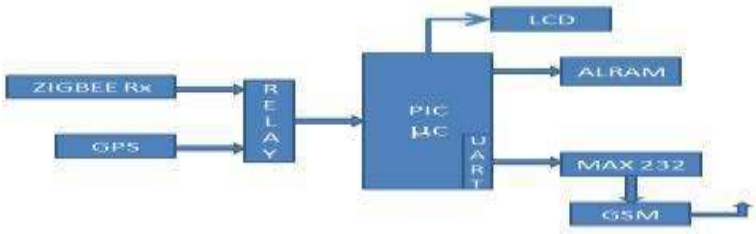

Figure-2: Block Diagram of Main Controller Unit

Figure-3: Block Diagram of Observer Unit

A. **Patient unit** [1-5]

Figure-1 shows the patient unit consists of four different types of sensors for measure the temperature, heart rate, BP and ECG of the human body in its working environment. The sensors are connected in the basis of Body Sensor Network. The microcontroller of the patient unit acquires the sensor information by the help of the signal conditioning circuit. And in the mean time microcontroller passes that acquired information the Main Controller Unit by the help of the Zigbee transmitter module.

B. **Main Controller Unit** [2-5]

Figure-2 shows the main controller unit consists of Zigbee reviser module, GSM and GPS modem. The information of the patient unit received by the microcontroller by Zigbee receiver module and the same time it also receives the location through GPS modem by making the switch on and off condition of the Really which is connected in between the GPS modem and Zigbee receiver. Hear the LCD of the controller unit shows the sensor output information and the Buzzer is for the any critical condition of the patient. By the use of the GSM modem all the information of the patient vital parameters and location of the patient will transmit to the Observer/Doctor‟s mobile as a SMS.

C. **Observer/Doctor Unit** [1-6]

Figure-3 shows this unit is Observer‟s/Doctor‟s mobile. In the Inbox display of the massage box it will show all the information like all vital signs and the location of the patient.

D. **Body Area Network** [1,7,3,4]

A body area network (BAN), also referred to as a wireless body area network (WBAN) or a body sensor network (BSN), is a wireless network of wearable computing devices. In particular, the network consists of several miniaturized body sensor units (BSUs) together with a single body central unit (BCU). A WBAN system can use WPAN wireless technologies as gateways to reach longer ranges.

Figure-4: Body area network [7]

The rapid growth in physiological sensors, low-power integrated circuits, and wireless communication has enabled a new generation of wireless sensor networks, now used for purposes such as monitoring traffic, crops, infrastructure, and health. Figure-4 shows the body area network which field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with real-time updates of medical records through the Internet. A number of intelligent physiological sensors can be integrated into a wearable wireless body area network, which can be used for

computer-assisted rehabilitation or early detection of medical conditions. The information will be transmitted wirelessly to an external processing unit. This device will instantly transmit all information in real time to the doctors throughout the world.

If an emergency is detected, the physicians will immediately inform the patient through the computer system by sending appropriate messages or alarms.

III System Hardware

The system contains different types of sensors, drivers and communication modules in its three units.

E. **LM35 Temperature Sensor** [8,9,10,6]

It is also known as analog temperature sensor. It provides a voltage output that is linearly proportional to Celsius (centigrade) temperature. It uses a solid state technology to determine the temperature. If the temperature increases means voltage also increases. By amplifying the voltage change it is easy to generate an analog signal which is directly proportional to temperature. They are precise, never wear out, don"t need calibration work for any environmental conditions. It can be consistent between sensor and readings.

F. **Heart rate** [9,11]

It consists of light emitting diode and light detection resistor which are placed parallel to each other. LED emits Infrared rays so that, when the finger is placed in between LED and LDR so that there exists some systolic pressure. LED emits IR rays which are travelled through finger and blood flows with arteriole pressure. Whenever systolic pressure is applied, normal pressure of blood flow is disturbed at finger tip which is high and IR rays penetrate through blood and are received by LDR. The signals are analog which are converted into digital by Analog-Digital Converter suitable for the MCU.

G. **ECG Sensor**

Electrocardiography is a transthoracic interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the surface of the skin and recorded by a device external to the body. The recording produced by this noninvasive procedure is termed an electrocardiogram.

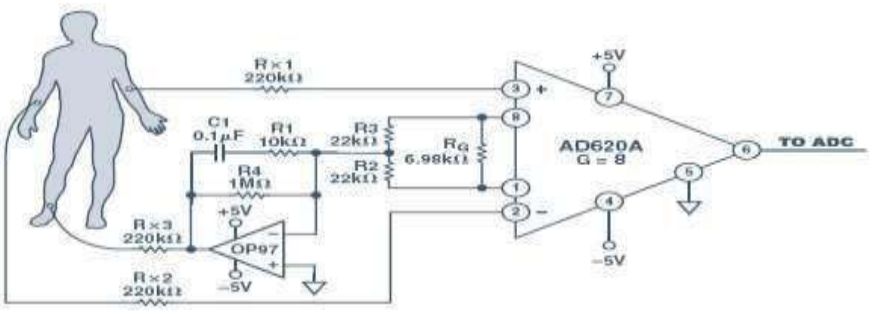

Figure-5: ECG sensor Circuit

Figure-5 shows an ECG is used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart. Most ECGs are performed for diagnostic or research purposes on human hearts, but may also be performed on animals, usually for diagnosis of heart abnormalities or research.

H. **BP Sensor**[6]

The Blood Pressure sensor is used to measure arterial blood pressure in humans (noninvasively). It measures the pressure signal caused by the interaction between the cuff and the blood flow through the brachial artery. The pressure sensor uses the SenSym SDX05D4 pressure transducer. This element has a membrane that flexes as pressure changes. It is arranged to measure differential pressure.

The sensor produces an output voltage that varies in a linear way with pressure. Special circuitry minimizes the errors that might be caused by changes in temperature. The sensor is delivered with standard adult size adjustable cuff (27 cm to 39 cm) and bulb pump.

I. **PIC16F877A Micro-controller** [11,12,13]

In this system, the switching pulses required for multilevel inverter operation are generated using PIC16F877A Microcontroller, thus reducing the overall system cost and complexity. A microcontroller is an embedded chip consisting of a powerful CPU tightly coupled with fixed amount of memory (RAM, ROM or EPROM), various devices such as serial port, parallel port, timer/counter, interrupt controller, ADC, DAC, everything integrated on to a single silicon chip. It does not mean that any micro controller should have all the above said features on chip. Depending on the area of application for which it is designed, the on chip may not include some of the sections.

J. **Zigbee Module** [2]

The Zigbee is a one of the wireless personal area network medium and it has been called the "Internet of things". It is a device which transmits and receives the data continuously to communicate two medium with the help of RF wave, which are not having any interconnection to communicate with each other. ZigBee targets the application domain of low power, low duty cycle and low data rate requirement devices.

In this system we are using CC2500 RF Zigbee module. It is having the long range data integrity and it consumes low power.

K. **GPS Modem** [14]

The Global Positioning System (GPS) is a satellite based navigation system that can be used to locate positions anywhere on earth. Designed and operated by the U.S. Department of Defence, it consists of satellites, control and monitor stations, and receivers. GPS receivers take information transmitted from the satellites and uses triangulation to calculate a user‟s exact location. GPS is used on incidents in a variety of ways, such as: i. To determine position locations. ii. To navigate from one location to another. iii. To create digitized maps. iv. To determine distance between two points or how far you are from another location.

L. **GSM Modem** [14,15,11,6]

GSM is the acronym for Global System for Mobile Communication. The GSM modem consists of a slot for inserting subscriber identity module (SIM). GSM network generally contains three major stations 1). Mobile Station, 2) Base station subsystem and 3) Network subsystem. The mobile station contains an International Mobile Station Equipment Identity (IMEI) number and SIM has IMSI number. The base station subsystem contains Base Transceiver Station which has an antenna for communication and a Base Station Controller that controls multiple base stations. Network subsystem contains visitor location register (VLR), home location register (HLR), Authentication Centre (AuC) and equipment identity register (EIR). Mobile switching centre (MSC) is the major part which is the gate way for communi-

cation between mobile station and public switched telephone network (PSTN). HLR stores the information about the subscriber and the current location of subscriber. VLR provides the services to the subscribers of HLR who are visitor users. AuC gives the security of the user and to identify the location of the subscriber. EIR is also for security purpose and to identify the mobile station. By connecting the MAX232 to GSM modem, the serial data transmission can be done. Operation support system (OSS) is used to control the traffic of users. In order to communicate with the GSM modem we have a special set of commands called SMS AT commands. AT commands are in Table-1[14].

AT+CMGD	Delete SMS Message
AT+CMGF	Select SMS Message Format
AT+CMGL	List SMS Messages
AT+CMGR	Read SMS Message
AT+CMGS	Send SMS Message
AT+CMGW	Write SMS Message To Memory
AT+CMSS	Send SMS Message From Storage
AT+CMGC	Send SMS Command
AT+CNMI	New SMS Message Indication
AT+CPMS	Preferred SMS Message Storage
AT+CRES	Restore SMS Settings
AT+CSAS	Save SMS Settings
AT+CSCB	Select Cell Broadcast SMS Messages
AT+CSDH	Show SMS Text Mode Parameters
AT+CSMP	Set SMS Text Mode Parameters
AT+CSMS	Select Message Service

Table-1: SMS AT Command [16]

M. **MAX232 Driver** [2,14,15,5,6]

The GSM, Zigbee and GPS support digital data transmission. MAX232 is uses parallel-in-serial-out shift registers to convert the digital data in the serial form for wireless communication. UART IC in PIC16F877A microcontroller allows the digital data transmission in the form of bits per second in asynchronous manner. RS232 standards are commonly used in computer serial ports for serial communication transmission of data, which are not Transistor transistor logic (TTL) compatible.

N. **LCD**

LCD stands for liquid crystal display, it is an output device used for displaying alphanumeric characters. It is a 16-pin device, which is, separated into 8 data lines, 3 control lines, 2 power supply lines, 2 lines for back light and last line for contrast adjusting. LCD as an in built memory which is used to store data which as to be displayed which can also be read back. A LCD has two registers named command register and data register. The data register is used to display data in LCD, There are different types of commands like „clear screen, cursor blink, start data from first line, start data from second line etc., which should be written in the command register. In order to display the data “one”, its corresponding ASCII value should be written in the data register.

IV Results

By the use of respective sensors the body temperature, heart rate, ECG and blood pressure of a person by taking the average of readings by fixing maximum and minimum values and the data is transferred to microcontroller. The transmitted digital data after conversation from analog data by ADC, the data stores EPROM and the data is displayed on LCD. By MAX232 the digital data converts into serial form for GSM communication so that the respective vital sign values are received by the doctor/observer in his mobile phone

Figure-6: Full Setup

In figure-6 it shows that how the sensors placed in the patient body and how the system works in the real time.

Figure-7: Patient Unit

In figure-7 this unit contains all the sensors for acquiring vital sign information from the patient body and it transmits the same information to the main Controller Unit by the use of the Zigbee transmitter module.

Figure-8: Main Controller Unit

In figure-8 this unit receives the patient information by Zigbee receiver and the location of the patient by GPS. By the use of GSM the MCU sends the respective information to the Observer mobile as SMS.

Figure-9: Out Put in LCD

In figure-9 the LCD of the main controller unit it will show the output value of the all those sensors which is connected in the patient unit.

V . Conclusion

Thus we have built the prototype for "Intelligent Wireless Patient Monitoring And Tracking System". By using this system, the circuit of the prototype containing PIC161F877A Microcontroller, GSM Modem, GPS Modem, ZIGBEE, LCD, respective sensors and other hardware circuit so that the message can be transferred to corresponding observer/doctor's mobile phone for taking necessary precautions to take care about the patient in a given fixed time interval. The auto alarm facility in this systems works for the abnormal conditions, when the reading of the vital signs exceeds from fixed level. Tracking of patient location can be done continuously by using GPS environment. By using GSM network continuous monitoring also can be done for the corresponding patient. The device have enough scope of improvement by further research.

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