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ZIGBEE BASED WEARABLE HELTHCARE SYSTEM FOR PATIENT

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Abstract— **Patient healthcare system is gaining importance due to emergence of psychological pressure and cardiac diseases which demands for monitoring of health status of patient. System is proposed to monitor patient's health conditions using physiological sensors. To monitor patient's System consists of patient unit and second is receiver unit. Patient unit used to acquire the patient's parameter using temperature sensor, ECG sensor, heart beat sensor, sweat sensor and impact sensor. These parameters are acquired and processed using microcontroller present at patient unit and are sent wirelessly using ZigBee transceiver to the host computer present at monitoring room. At receiver unit ZigBee receives the signal and send it to controller. Controller would detect medical distressed conditions on comparing the measured values with threshold values and for distress condition send SMS alert to the hospital or caretaker using GSM module. The microcontroller also displays the measured parameters on GUI of host computer. The proposed device would improve the functional effectiveness of the patient healthcare system taking by attending the problems in real time and can save many lives.**

Index Terms— **Home monitoring, physiological parameters, sensors, wireless transmission, ZigBee.**

I. INTRODUCTION

Wireless sensors and sensor networks have become an important topic to research, scientific and technological field. As sensor networks have been developed now days, a new application domain of sensors has opened up in the wireless technology. Wireless sensor networks provide more challenges to solve limited energy & restricted life time problem in real time. Due to advances in sensor technology there is development of small, lightweight medical sensors. This sensor can be worn by patients while wirelessly transmitting data, so he or she can move at open environment. Many new researches are also focused on health care services for improving quality of human life. This is achieved by designing and fabricating sensors which are either in direct contact with the human body (invasive) or indirectly in contact with human body (non-invasive).

One of the reasons for rising health care services is increase in population and rise ageing population. Cardiac diseases places stress on current health care system. Chronicle diseases and psychological pressure are behind the mortality of elderly people. One statistic provided by the health department of U.S. is that by 2050 over 20% of the world's population will be above 65 years of age. This results in a requirement for medical care for such elderly people. After long illness or surgery patient require continuous monitoring under medical care. The cost of hospitalization for long term monitoring is ever increasing and it is also expensive to assign a person for such monitoring. Hospitals are also looking for sending people back to their home as soon as possible to recoup at home [1]. During the recovery period, several physiological parameters of patient's are needed to be continuously measured. Hence, there is urgency of remote monitoring of patients at home. Also telemedicine are gaining added importance and urgency now a day's. Many elderly people are forced to live in a rest home or in other sheltered living arrangement. They want to live independently and want to keep control of their own lives. Yet at the same time they have high risk of injury or even death because of a fall or stroke. Such people need to be monitored continuously and when patient goes under the abnormal condition they require immediate attention. So, Continuous patient monitoring system is gaining importance, which provides an accurate, comfortable, reliable, flexible, non-invasive and low-cost monitoring unit for patient that unites all these demands.

In this paper, we describe system that does data collection, monitoring and processing of physiological parameters of patient through wireless approach. Therefore the system has been developing for continuously monitoring patient's parameters using patient unit which incorporate sensors such as temperature, impact, ECG, sweat and heart rate. To detect fall condition a fall detection sensor has been incorporated. These parameters are acquired and processed using LPC2148-ARM7 TDMI-S controller and are sent wirelessly using ZigBee transceiver. Receiver unit is at the monitoring room where the parameters are displays on the computer and for the critical condition SMS is send to hospital or caretaker. In Section II, we present the system's complete overview. All sensors are explained in Section III. The hardware details are explained in Section IV. The test results in Section V. This paper ends with a discussion and future development.

II. SYSTEM DETAILS

Fig. 1 shows the functional block diagram of the system hardware. The system has been developed to take several inputs of patient to measure physiological parameters such as temperature, heart rate, ECG signal, sweat value and detection of any fall using sensors. The inputs from the sensors are acquired and processed using microcontroller. The measured parameters are sent wirelessly through the ZigBee Module to a host computer present at monitoring room, where we display the measured values on the Graphical User Interface (GUI).

The parameters are heart rate in beats per minute (BPM), body temperature in degree Celsius, fall detection as sudden body movement, sweat value and ECG graph are displays on the computer. If the person is medically distressed message is send to the doctor or caretaker to indicate the patient is in distress condition and they need immediate attention.

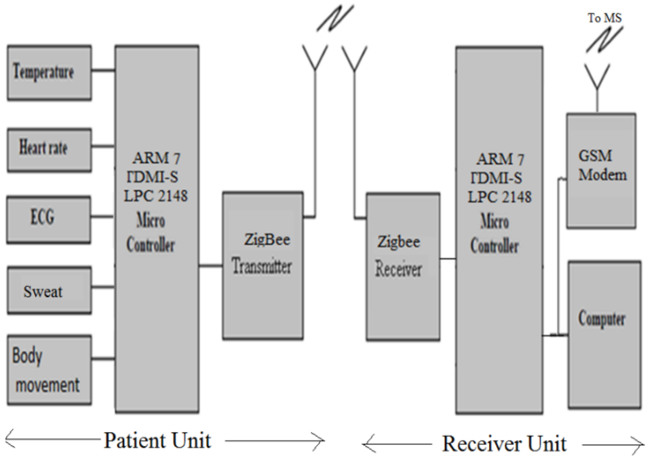

Fig. 1 Functional block diagram of the system hardware

III. DETALES OF THE SENSING SYSTEM

The various sensors are use for sensing patient's parameters. The descriptions of individual sensors used in this system are as follows.

A. Temperature Sensor

Temperature measurement is one of the fundamental requirements for Body condition detection. Body temperature is not fixed and changes with cyclic change. LM35 precision sensor is used for temperature measurement, whose output is proportional to the temperature (in centigrade). The sensor circuitry is sealed so as it is not subjected to oxidation and other processes. The sensor is placed on the wrist of patient to measure skin temperature. The changes in body temperature would indicate whether the patient is undergoing any of the condition such as trauma, injury, heart attack, stroke and burns. Using LM35 we measure skin temperature more accurately. LM35 is a three Pin (Vcc, Output, GND) high precision temperature sensor with a resolution of 10mV/ºC starting at 0V. It's operating temperature is in the ranges from -55°C to 150°C.

The sensor converts the skin temperature to the analog output and give to the microcontroller, which has ADC with 10Bit resolution. As IC has sensitivity of 10mV/°C. It does not require offset voltage subtraction to reproduce the Fahrenheit and Celsius temperature scales. Fig 2 shows the transfer characteristics of LM35 temperature sensor. The reference voltage for ADC is of 5V. Output of ADC has to be converted into the some right value. For the max value of input voltage 5V, the ADC will read it as 1023, for the input of 2.5V; the reading would be 512 and so on. The step for ADC is simply calculated using the equation: Step = Vref /1024, Here 4.883 mV is the minimum voltage our ADC can read as step. We get 001 as reading for 4.883mV input voltage and 003 for 9.766mV input voltage and so on.

ADC Reading converted to Celsius degrees is as follow, As ADC has a step size of 4.883mV and Sensor's sensitivity is of 10mV/°C, conversion of input voltage to Celsius is done by dividing this input voltage by 0.01,

Vin (in Volts) =ADC Reading*0.004883

Temperature (°C) = Vin/0.01=ADC Reading*0.4883

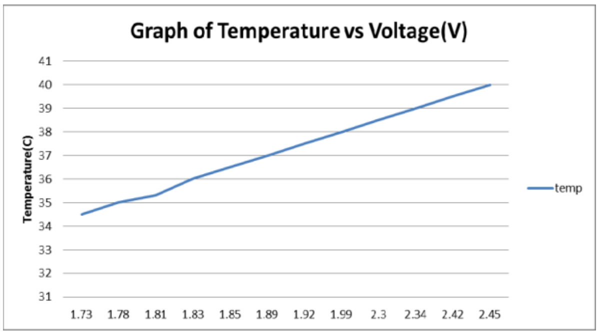

Fig 2 Transfer characteristics of LM35

B. Heart beat sensor

The sensor consists of LED and light dependant resister. The LED is of super bright red light and passes less light in to the figure when blood pulse pumps from heart and goes through blood vessels. For this less light LDR has high resistance and less current passes through it. So with each heart pulse the signal at output of LDR varies.

This variation in signal is converted to electrical pulse. These pulses are then amplified and triggered through an amplifier which gives output of +5V logic level signal. To indicate each heart beat LED is also used which blinks on each pulse. Fig 3 shows the heart beat sensing arrangement.

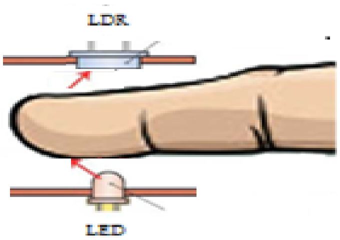

Fig. 3 Heart Beat Sensor

LM358 low power dual OPAMP is used along with LED and LDR in Heart beat sensor. For heart beat monitoring LM358 is connected to a LDR and LED. LM 358 includes two stages of amplifier and one comparator stage. The amplifier increases the signal level and comparator compare this increased signal with reference voltage which is inbuilt in the IC. The output of the LM358 at pin 7 is the number of pulses and is then given to the microcontroller to count the number of the pulses per minute Fig 4 shows the heart rate sensor output which is 84bpm.

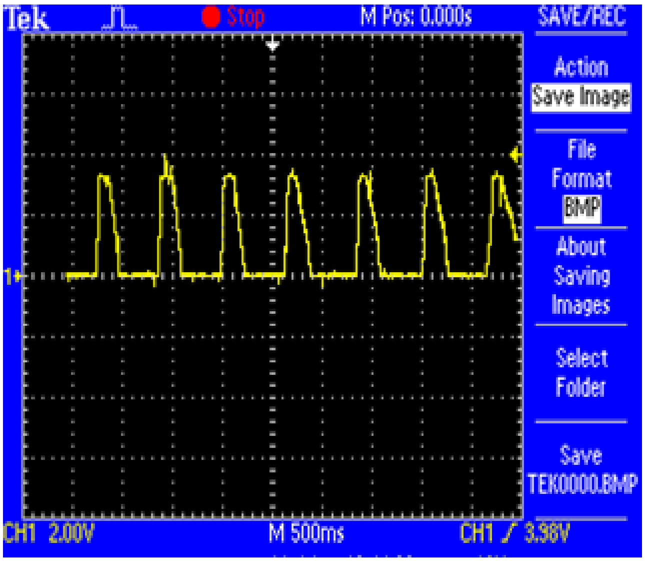

Fig 4 Heart Rate sensor output

C. Impact sensor

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs used as an impact sensor. It contains a signal conditioning circuitry with a polysilicon surface micro-machined sensor to implement open-loop acceleration measurement architecture. The analog output voltages are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion of the patient. It also provides low voltage of about 1.8V to 3.6V and power consumption is 350µA.The ADXL335 includes a Sleep Mode that makes it ideal for handheld battery powered electronics.

The ADXL335 uses a single structure for sensing the X, Y, and Z axes. As a result, the three axes' sense directions are highly orthogonal and have little cross-axis sensitivity. The X, Y axis signal is used to analyze movement of patient. Fig 5 Shows the X and Y axis waveforms when sudden body impact is applied. Xout and Yout are connected to channel1 and channel2 of DSO, respectively.

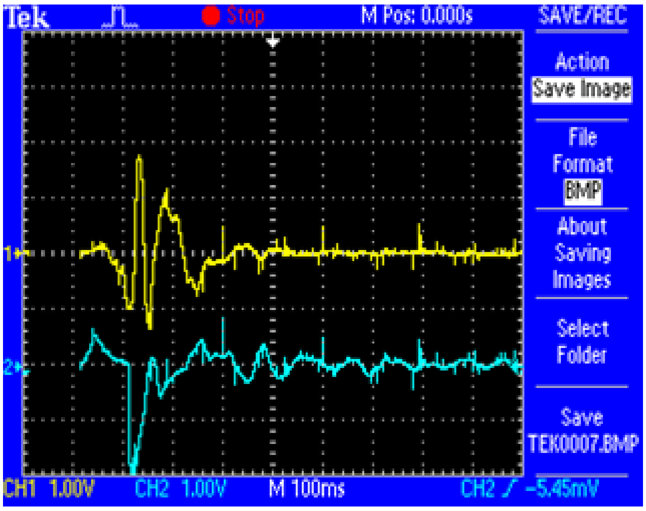

Fig 5 X axis, Y axis waveforms

D. ECG sensor

Before the actual condition occurs, many of the heart disease symptoms are nonexistent yet electro-Cardio-graph can reveals the heart disease condition. Electro-Cardio-graph is determined by measuring difference in electrical energy obtained from the electrodes placed in both right arms, left arm and taking voltage from figure as reference voltage. Fig 6 shows the electrode lead arrangement where there are three electrodes placed at RA, LA and Finger.

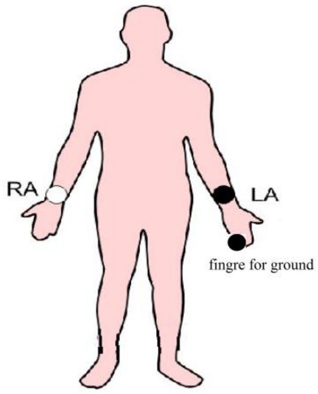

Fig.6 Electrode Arrangement

Fig 7 shows the ECG circuit and sensors electrodes. The measured signal from electrodes is given to differential amplifier and then to the filter for noise reduction. This filtered signal is then given to the ADC of microcontroller for conversion.

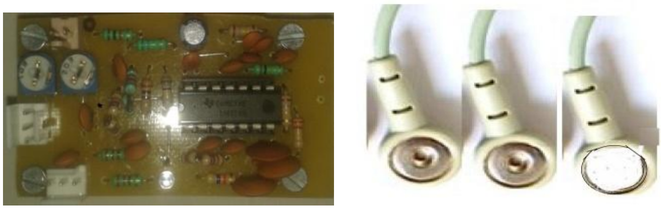

Fig.7 ECG circuit and Electrode

ECG measured at the output of the circuit is shown in Fig 8. From ECG various cardiac disease symptoms detection such as arrhythmia detection is possible.

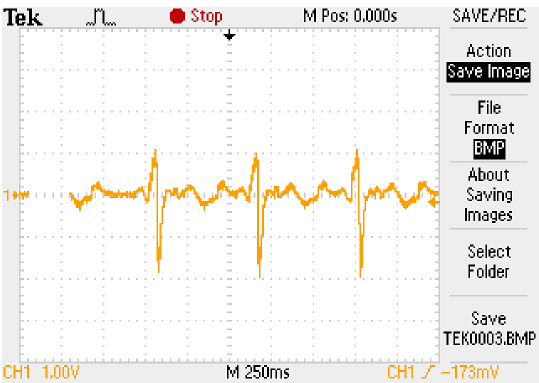

Fig 8 shows the output of ECG circuit

E. Sweat sensor

Sweat sensor is designed by using small PCB over which we draw a zigzack path using tin wire and passes signal through them as shown in fig 9. It's resistance varies with varying sweat value. So signal varies with sweat values are given to ADC of controller for sweat measurement. Where controller convert measured value to the percentage.

Fig 9 Sweat Sensor

IV. MICROCONTROLLER INTERFACING AND COMMUNICATION

The microcontroller used is LPC 2148-ARM TDMI-S .The microcontroller is programmed using Embedded C language. Inputs from the Temperature sensor, ECG sensor, sweat sensor and Impact sensor are fed to ADC channel. At ADC each signal is sampled at predefined rate. Heart beat sensor signal is given as interrupt signal to the microcontroller. These signals are acquired and processed using microcontroller and are sent wirelessly using ZigBee transceiver to the receiver unit which is present at monitoring room. The received signals are then displayed on the host computer present in monitoring room. Fig 10 shows the interfacing of transmitting unit present at patient side.

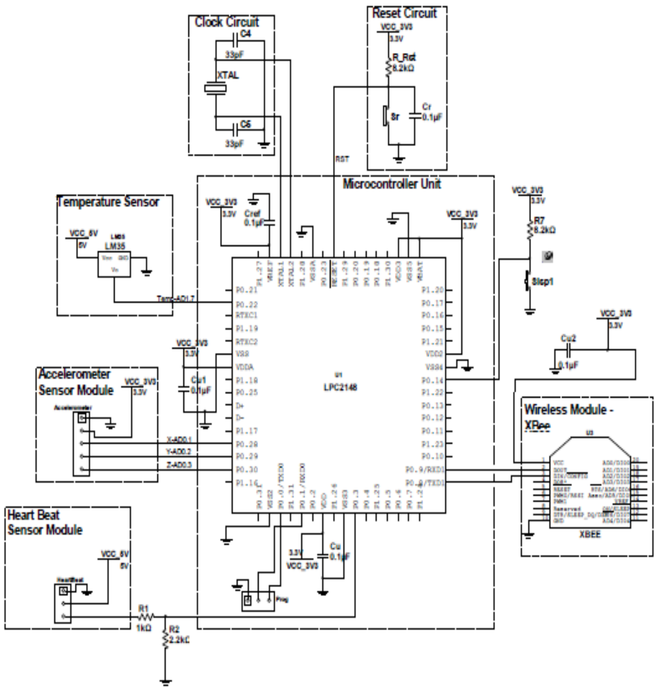

Fig 10 The interfacing unit at transmission side.

A. Communication

Communication between sensing unit at patient side and receiving unit at monitoring room is done wirelessly using ZigBee transceiver and using ZigBee protocol. The XBee/XBee-PRO ZNet 2.5 OEM (formerly known as Series 2 and Series 2 PRO) RF Modules were used to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band. The protocol supports Point-to-point, point-to-multipoint and peer-to-peer topologies also supported Self-routing, self-healing and fault-tolerant mesh topology.

This microcontroller was chosen, because of its low-power consumption, and built-in UART function for serial transmission of data to ZigBee module for wireless transmission.

B. XBee Module

These modules provide a easy to configure network, with a high data rate up to 230400 Baud/s. They come in a preconfigured mode and automatically establish the communication between the devices. These modules provide easy configuration of networks also has preconfigured mode and establishes communication automatically. To connect the module the output Tx and Rx of microcontroller is needed with four wires extra two for power supply and ground. The Power-Supply (3.3 V), Ground and TX and RX of the Microcontroller are connected to VCC, GND, DIN and DOUT of the ZigBee module.

1) Configuration and Setup:To configure the XBee Modules, X-CTU software is needed. To set up a network each network needs one Coordinator and several End devices. All modules should have the same firmware and PAN-ID. The Coordinator sends Broadcast commands if everything is setup currectly and End devices can send to Coordinator only.

2) Communication Protocol: An own communication protocol is needed which shows sensor outputs and also avoid corrupted data. The XBee Modules does not provide a checksum bits during transmission or any other possibility to verify the correctness of the received data. The send string contained the sensor data. Each sensor unit sends their data every 2 s to the coordinator, where the data has to be tested collectively for correctness.

V. EXPERIMENTAL RESULTS

A. Graphical User Interface (GUI)

The GUI is programmed in Visual Basic and captures the serial communication. The string received has the values from each sensor data which is then collected and displayed on the GUI as measured parameter.

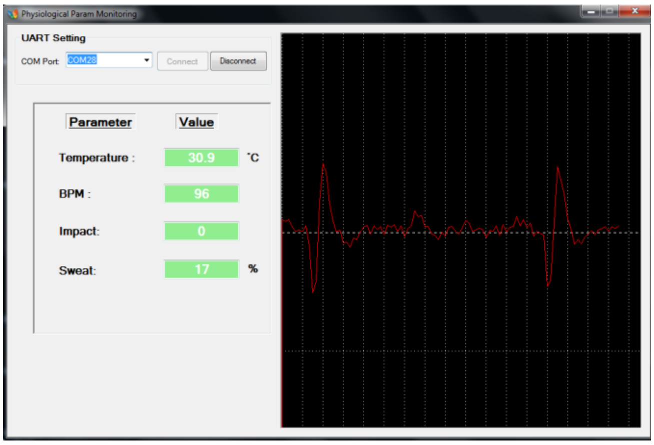

Fig 11 GUI output

Fig 11 shows the GUI output. The output displays the temperature in degree Celsius, heart rate in BPM, impact value 1 for sudden movement, and sweat value in percentage. Also the ECG signal of patient taken by ECG electrode is also displayed on GUI.

B. Disply on Mobile Unit

At receiving unit microcontroller compares sensed parameters with the threshold values and if there is any distress condition then using GSM modem system send SMS alert to the hospital or caretaker.

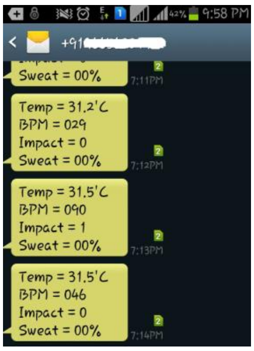

Fig 12 SMS alert

Fig 12 shows the SMS sent to hospital or caretaker. 1st SMS is for 29 BPM which shows low BPM bellow 60, 2nd for impact 1 which shows sudden body movement and 3rd for low BPM. Similarly SMS are also send when BPM are higher than 110, temperature is above 37 °C and Sweat value above 50%.

VI. DISCUSSION AND FUTURE DEVELOPMENTS

In this paper, we discussed wireless embedded device for monitoring physiological parameters of patient. The sensed parameters were continuously monitored wirelessly within the range up to 300 feet. Systems require low cost, Low power and also detects distress condition in hospital as well in home. System sends distress condition to hospital or caretaker though SMS, which saves many lives by attending the problem in real time.

For future development the device can modify to sense more parameters using more sensors. We also extend the system with power fault detection circuit for accurate monitoring system.

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