International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 5, May - 2013

Wireless Embedded Device Based On Miwi Technology For Monitoring Physiological Parameter

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***Abstract*— Patient monitoring system are gaining importance due to the emergence of cardiac diseases which demands for monitoring of health status of patient. Therefore a system has been developed to monitor physiological parameters such as temperature, ECG, heart rate of patient. To detect distress condition a fall detection sensor has been incorporated. Theses parameters are sent wirelessly using MiWi wireless protocol to the receiver unit which is connected to the computer. The computer has monitoring software which displays these parameters. The device also detects medical distressed conditions by comparing with threshold values and sets off alarm and sms alert to the hospital or caretaker. This device can improve the functional effectiveness of the medical care taking by attending the problems in time which saves many lives.**

Keywords— ECG, Health monitoring, MiWi, heart rate measurement, fall detection, sensors, wireless transmission.

1. INTRODUCTION

Rising health care costs and increasing chronic diseases are placing a strain on current health care services. Elderly patients , particularly those with chronic conditions ,require continuous long –term monitoring to detect changes in their condition as early as possible In general ,the greater part of elderly suffer from various chronic diseases, based on World Health Statistics(WHO) .Chronicle diseases and psychological pressure are behind the death of 80 percent of elderly people .Most research activities are focusing on monitoring health status of the patient in real time manner enhancing security and integrity of the patient.

Advances in sensor technology have enabled the development of small, lightweight medical sensor that can be worn by patients while wirelessly transmitting data. This frees patient from wired sensor, allowing him or her to move at leisure and increase comfort in daily environment.

Many new research is focused at improving quality of human life in terms of health [1] by designing and fabricating sensors which are either in direct contact with the human body(invasive) or indirectly (non-invasive). One of the reasons for more development in this area is the global population and rise ageing population [2], one statistic provided by the U.S. Department of Health 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, which is expensive for long-term monitoring and long waiting lists for consultations with health professionals. The cost of hospitalization is ever increasing, so is the cost of rehabilitation after a major illness or surgery. Hospitals are looking at sending people back as soon as possible to recoup at home. During this recovery period, several physiological parameters need to be continuously measured. Hence, telemedicine and remote monitoring of patients at home are gaining added importance and urgency [6]. Patients are being monitored using a network of wireless sensors. Therefore there is need for an accurate, flexible, non-invasive, comfortable, reliable, and low-cost monitoring unit that unites all these demands.

In this paper, we describe data collection, monitoring and understanding physiological status of patient through wireless approach for patient health care management. To accomplish these physiological parameters such as body temperature, Electrocardiogram, heart rate, fall detection system has been developed. These parameters are acquired using sensors and sent to analogy to digital convertor for digitization which is built in microcontroller PIC16F877A.These signals are sent wirelessly to remote computer. In Section 2, we present the system complete overview. Sensors are explained in Section 3. The hardware details in Section 4. The test results in Section 5. The paper ends with a discussion and future development.

2. SYSTEM OVERVIEW

Fig .1 shows the functional block diagram of the system hardware. The system has been developed to measure physiological parameters of humans such as temperature, ECG, heart rate and detection of any fall. The inputs from sensors are acquired and processed. The processed signals are sent wirelessly using MiWi transceivers to the host computer. The values are displayed in the host computer in Graphical User Interface. The parameters are heart rate in beats per minute(BPM),body temperature ECG, fall detection in both the axis If the person is medically distressed, an alarm is generated and also sms is sent to the hospital for immediate attention.

3. DETAILS OF SENSING SYSTEM

There are four sensors a temperature sensor, ECG sensor, heart rate sensor and a fall detection sensors.

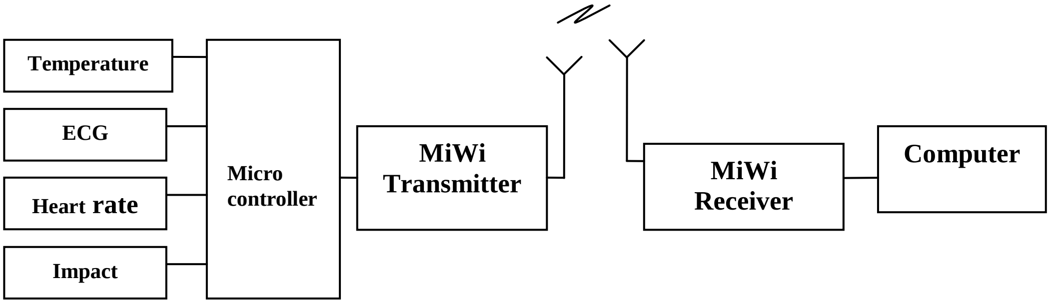

Fig1. Functional block diagram of system hardware

3.1. Temperature Sensor

The measurement of temperature is one of the fundamental requirements for body condition detection. Body temperature is not fixed; it is responsive to cyclic change. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in centigrade). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes.The sensor is mounted on the wrist to measure skin temperature.The changes in body temperature would indicate whether the patient is undergoing any following condition such as trama,injury,heart attack,stroke and burns. With LM35, temperature can be measured more accurately. LM35 is a Three-Pin(Vcc,Output,GND)high precision temperature sensor having a resolution of 10mV/C starting at 0V .The operating temperature range isfrom-55°Cto150°C.

The sensor gives an analog output depending on the measured temperature .This voltage can be measured using microcontroller which has ADC of 10Bit resolution .The IC has sensitivity of 10mv/°C requires no offset voltage subtraction to reproduce the Fahrenheit and Celsius temperature scales. Fig 2 shows the transfer characteristics of LM35 temperature sensor.

The output of ADC has to be converted into the right value. The ADC reference voltage is given as 5V.. If the input voltage is 5V which is the max value, the ADC will read it as 1023, if the input was 2.5V; the reading would be 512 and so on. The ADC step is simply calculated using the equation : Step = Vref/1024 , in our case its 4.883 mV, that's the minimum voltage our ADC can read, an input of 4.883mV would give us a reading of 001and input of 9.766mV would give us a reading of 002, and so on.

Converting ADC Reading to Celsius degrees: ADC has a step size of 4.883mV

Vin (in Volts) =ADC Reading*0.004883

Sensor's sensitivity is 10mV/°C, converting this voltage to Celsius is done by dividing the input voltage by 0.01,

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

Glass thermometer is taken as standard and a graph is plotted. The accuracy was found to be .09°C. Fig 3 shows graph plotted against standard versus measured temperature.

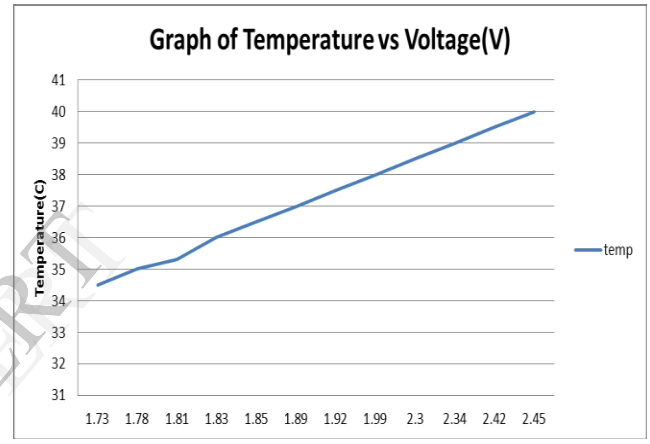

Fig 2 Transfer characteristics of LM35

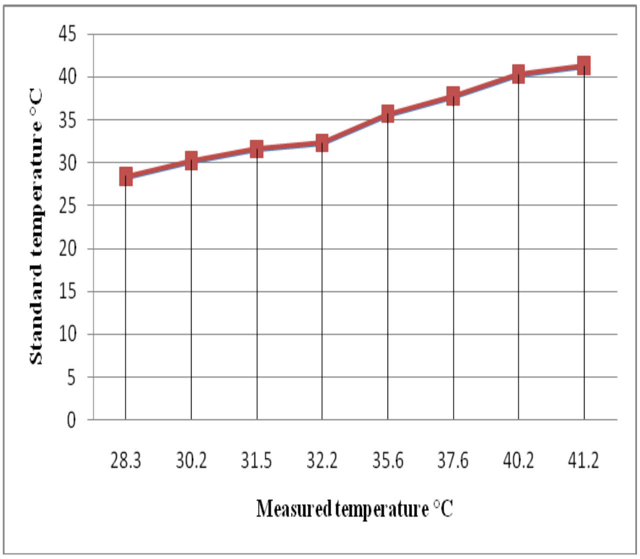

Fig 3 Measured versus Standard temperature

3.2 .ECG sensor

Many heart disease symptoms are nonexistent yet electro-cardio-graph can reveals heart disease condition before the actual condition occurs. Electro-Cardio-graph is determined by measuring difference in electrical energy from the electrodes placed in both right arms, left arm taking voltage from right leg as reference. There are three electrodes placed at (RA, LA, and RL).Fig 3shows the electrode arrangement. Disposal electrodes are used to extract signals Fig 4 shows the ECG circuit and sensors arrangement. The measured input from electrodes is given to differential amplifier and then through the filter for noise reduction. This filtered signal is given to the ADC input of microcontroller .ECG measured at the output of the circuit is shown in Fig 5. From ECG various cardiac disease symptoms such as arrhythmia detection is possible.

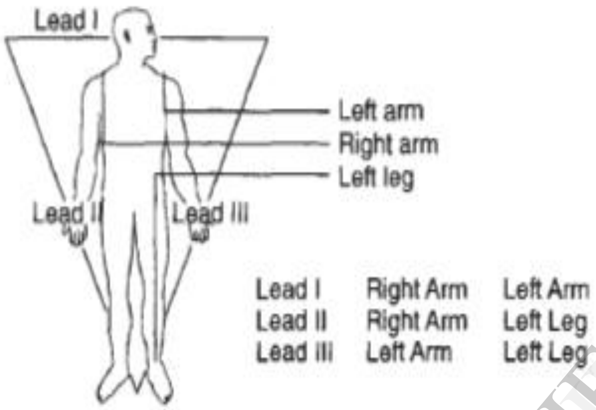

Fig.3 Electrode Arrangement

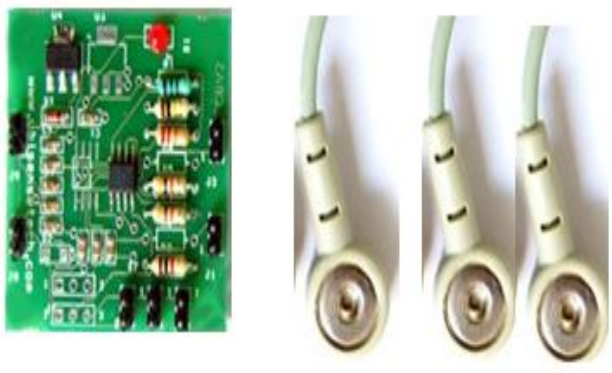

Fig.4 ECG circuit and Electrode

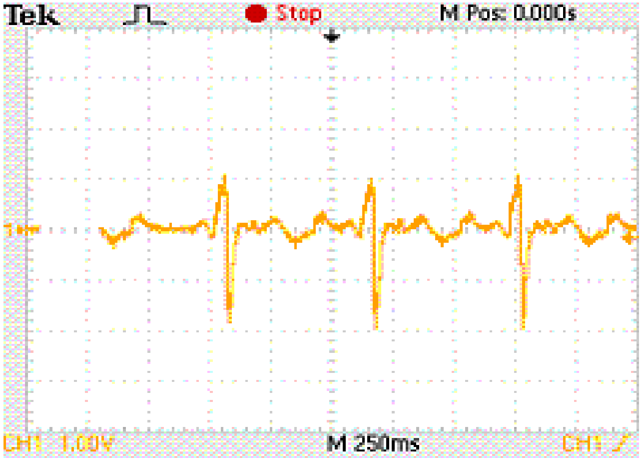

Fig 5 shows the output of ECG circuit

3.3.3 Heart beat sensor

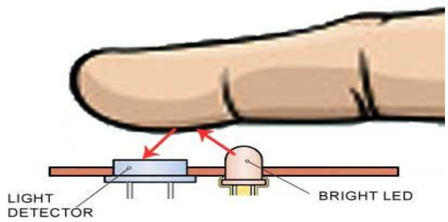

Fig. 6 Heart Beat Sensor

The sensor consists of a super bright red LED and light detector. The LED needs to be super bright as the maximum light must pass spread in finger and detected by detector. When the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal. The output signal is also indicated by a LED which blinks on each heart beat .Fig 6 shows the heart beat sensing principle.

The heart rate is measured using hardware interrupt facility of microcontroller. The time period of the wave is measured using Timer 0.The timer0 generates a tick every 10us.The total tick count in one period is measured. The frequency is calculated using

Frequency = 1000000/count*10

The heart rate per minute is calculated as

BPM=Frequency * 60

Fig 6 shows the heart rate sensor circuit. Heart beat sensor consists of LM358 low power dual OPAMP. The heart beat monitoring system consists of LM358 which is in turn connected to an photo detector and LED. LM 358 includes

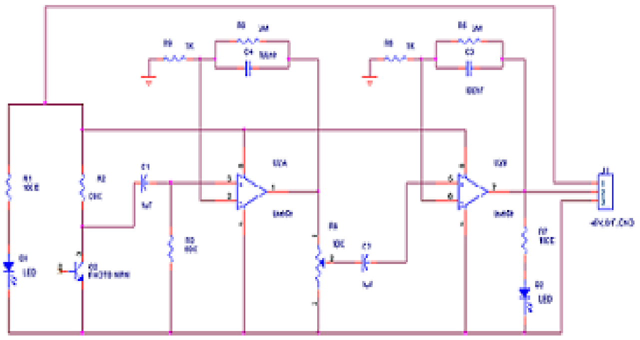

Fig 6 Circuit of heart rate measurement circuit

two stages an amplifier and a comparator stage. The amplifier here increases the level of the signal and the comparator is used to compare the photo detector voltage to the reference voltage inbuilt in the IC. LED is connected to the 8 pin and photo detector is connected to 3 pin. The output of the LM358 at pin 7 is given to microcontroller, it counts number of pulses. Fig 7 shows the heart rate sensor output which is 84bpm.

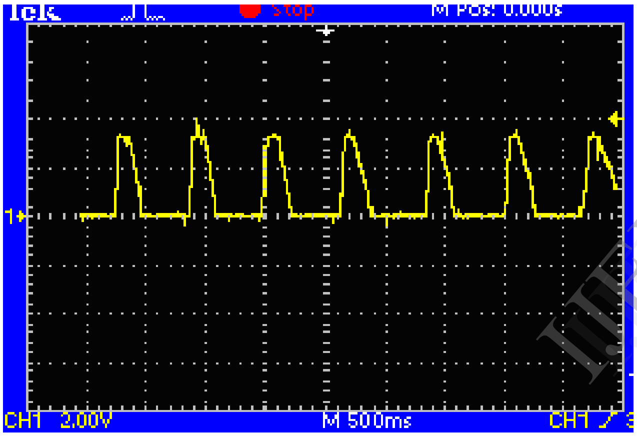

FIG 7 HEART RATE SENSOR OUTPUT

3.4. Impact sensor

The MMA7361L is a low power, low profile capacitive micro machined accelerometer used as an impact sensor .It provides two-axis response. The device provides analog voltage, the amplitude of which is directly proportional to acceleration. It also provides low voltage of about 2.2V to 3.6V and power consumption is 400µA. It has 0g-Detect which detects linear freefall, and g-Select which allows for the selection between 2 sensitivities. Zero-g offset and sensitivity are factory set and require no external devices. The MMA7361L includes a Sleep Mode that makes it ideal for handheld battery powered electronics. Fig 8 shows interfacing accelerometer with microcontroller .The impact on the X, Y axis is used to analyze movements.

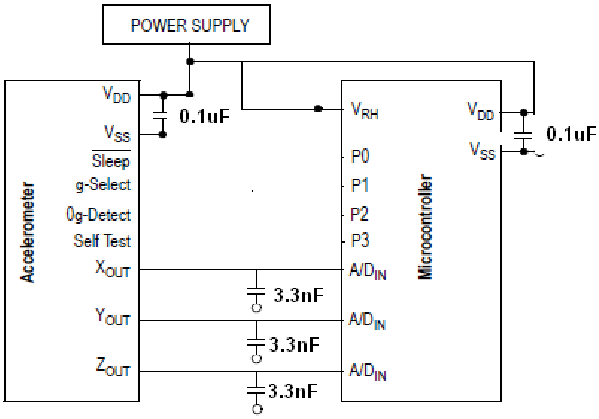

Fig 8 Interfacing accelerometer with microcontroller

Fig 9 Shows the X axis, Y axis, waveforms when sudden impact is applied. Xout is connected to channel1 of DSO, Yout is connected to channel2.

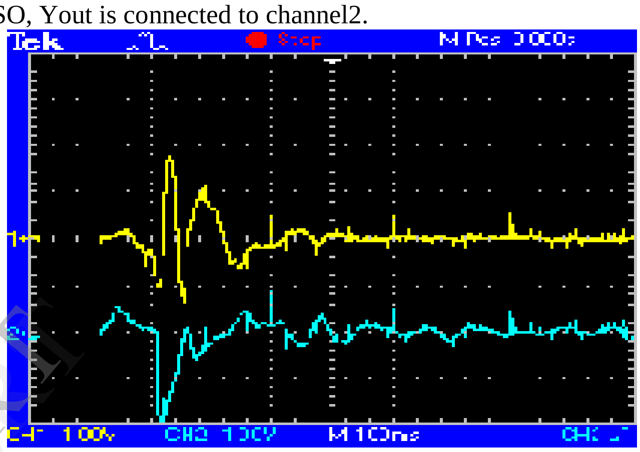

Fig 9 X axis, Y axis waveforms

4. MICROCONTROLLER INTERFACING AND COMMUNICATION

The microcontroller used is PIC16877A.The microcontroller is programmed using Embedded C language. Inputs from the Temperature sensor, ECG sensor and Impact sensor are fed to ADC channel. The digital signals from heart rate sensor are given to ports. Each sensor's signal is sampled at predefined rate using interrupt driven algorithms. Fig 10 shows the interfacing circuit

4.1Communication

Communication between sensing unit and receiving unit is done wirelessly using MiWi protocol. Microchip networking protocol MiWi is based on the MAC and PHY layers of the IEEE 802.15.4 specification, and is tailored for simple network development in the 2.4 GHz frequency band. The protocol provides the features to find form and join a network, as well as discovering nodes on the network and route to them. It is particular method for making smaller applications that needs relatively small network size, with few hops between using Microchip's MRF24J40 2.4 GHz transceiver for IEEE 802.15.4 compliant networks. Its supports peer to peer, mesh, star topologies .The maximum number of hops between is 4.

MiWi has 2 interfaces to manage it. One is MiMAC interface which communicate with Microchip RF transceivers and the other is MiApp interface which interact with application layer.

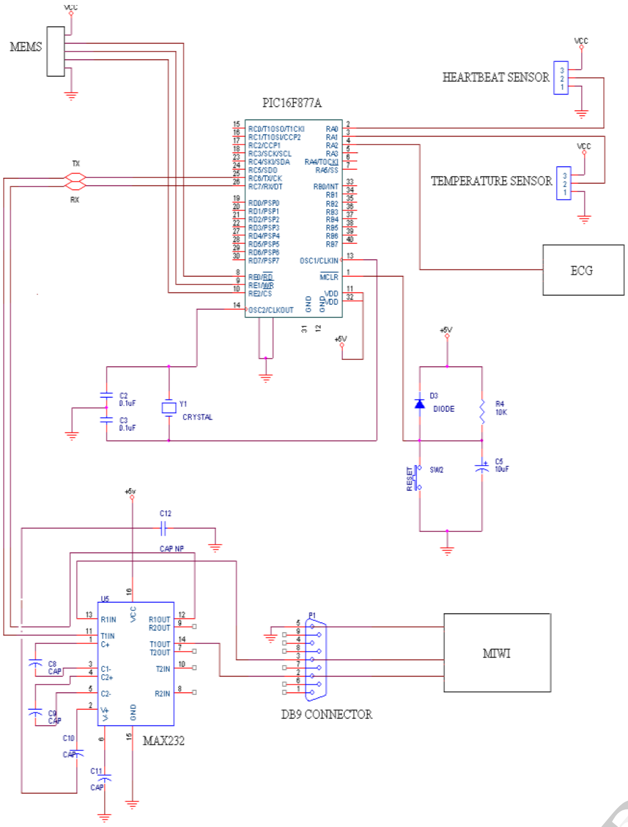

Fig 10 Interfacing circuit

The MRF24J40 is an IEEE 802.15.4-2003 compliant transceiver supporting MiWi™, ZigBee™ and other proprietary protocols. The MRF24J40 device integrates a receiver, transmitter, VCO and PLL into a single integrated circuit. It uses advanced radio architecture to minimize external part count and power consumption. The MRF24J40 MAC/ base band provide hardware architecture for both IEEE 802.15.4 MAC and PHY layers. It mainly consists of TX/RX FIFOs, a CSMA-CA controller, super frame Constructor, receive frame filter, security engine and digital signal processing module. The MRF24J40 is fabricated by advanced 0.18 µm CMOS process and is offered in a 40-pin QFN 6x6 mm2 package.

The MRF24J40 consists of four major functional blocks:

1. An SPI interface that serves as a communication channel between the host controller and theMRF24J40
2. Control registers which are used to control and monitor the MRF24J40.
3. The MAC (Medium Access Control) module that implements IEEE 802.3™ compliant MAC logic.
4. The PHY (Physical Layer) driver that encodes and decodes the analog data. The device also contains other support blocks, such as the on-chip voltage regulator, security module and system control logic.

MIWI protocols are intended for use in embedded applications requiring low data rates and low power consumption. MIWI's current focus is to define a general-purpose, inexpensive, self-organizing mesh network that can be used for industrial control, embedded sensing, medical data collection etc. The resulting network will use very small amounts of power.

The reason this microcontroller was chosen was the low cost, low power consumption and built in UART function for serial communication of data transfer using MiWi module for wireless transmission.

4.2 MiWi transmitter and receiver module

These modules provides easy configuration of networks, Provides preconfigured mode and establishes communication automatically. To connect the module the output Tx and Rx of microcontroller is needed.

4.2.1 Configuration and setup:

To configure X-CTU software is needed. To setup each network needs one Coordinator and several End devices .All modules should have the same firmware and PAN-ID. The Coordinator sends Broadcast commands and End devices can send to Coordinator only.

4.2.2 Communication Protocol:

The transmission of data does not provide checksum to verify the correctness of received data. The send string contains 27 characters. The first characters are name of the user followed by raw sensor data.

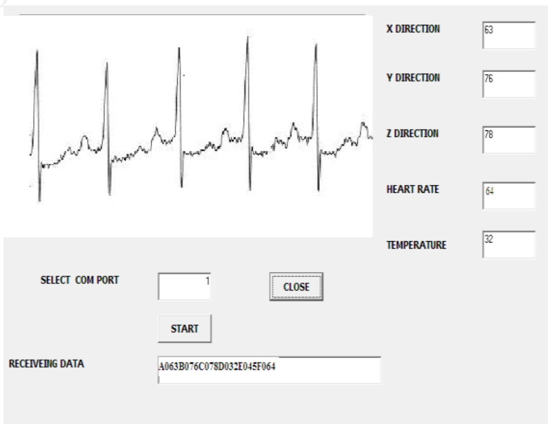

Fig 11 Screen shot of GUI output

Graphical User Interface (GUI): The GUI is programmed in VB and captures the serial communication. The address and sensor data are collected and stored in Access database. The Database contains table in which the data's are stored. In the GUI the data can be displayed as graph or values. Fig 11 shows the GUI output. The output displays the ECG in real time basis, displays X, Y, Z impact values, heart rate in bpm, and temperature in degree Celsius. The interface is provided with a facility for checking the receiving data .In Patient unit data's are displayed in LCD unit. Therefore a cross checking of transmitting and receiving data can be done

ISSN: 2278-0181
Vol. 2 Issue 5, May - 2013

which increases the effectiveness of the device. The receiving data contains the address followed by the data A for X value, B for Y value, C for Z value, D for Temperature, E for Heart rate, F for ECG value.

5. UNIT

The Unit in Fig 12 shows the Patient Unit which contains the analog processing unit and the sensors assembly test setup .This unit also contains LCD display section shown in Fig 13 which displays X, Y, Z axis impact values, H for heart rate in bpm, T for Temperature in degree centigrade, E for ECG values. Buzzer unit is placed in patient unit which generates alarm on false condition

Fig 12 Patient Unit

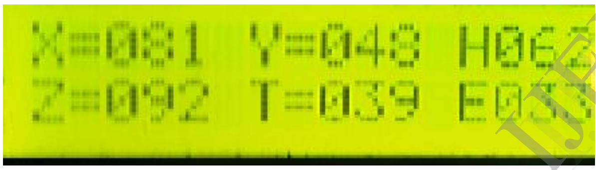

Fig 13 Output in LCD in patients unit

VI.DISCUSSIONAND FUTURE DEVELOPMENTS

In this paper, we discussed wireless embedded device for monitoring physiological parameters. The device could involve microcontroller PIC16877A and sensors interfaced with microcontroller. The system will monitor four parameters such as skin temperature, pulse rate, body impact and ECG. The ECG would indicate various cardiac arrhythmias. These parameters were continuously monitored wirelessly within the range up to 300 feet. The novel aspect was low cost, low power and detection of medical distress in cardiac patient in hospital as well in home. The assertiveness is an important factor of this system that the patient is gaining confidence enough that he/she can be taken care by the sophisticated monitoring and control processes.

For future development the device can incorporate more sensors and power fault detection circuit for monitoring system.

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