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Remote Patient Monitoring and Logging System using ZigBee

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ABSTRACT
Remote Patient Monitoring is an alternative to regular home check-ups of patients with special medical conditions, physically challenged and the elderly who are unable to regularly visit a healthcare facility. Remote Patient Monitoring system allows the patient to be monitored remotely from their home itself. The system described here allows data acquisition from the fixed sensors. It is cheaper to monitor the elderly and infirm about patient physical states to the remote system. The doctor can directly monitor the patient's information. This paper also includes the web part; the patient's database is monitored through embedded web server. The monitoring center receives the information from the patient and maintains the database, based on it the doctor can judge the patient status and then diagnose. The system uses the IEEE 802.15.4 standard and low cost Zig-Bee technology for wireless communication between the patient data acquisition system and the patient monitoring system and it supports the distance from 30m to 100m depends upon the power and output. Zig-Bee uses frequency bands of 2.4 GHz, and its transmission rate is 20 kbps to 250 kbps. The proposed system uses the high end processer ARM (Advanced RISC Machine).

Keywords
ARM, ECG, Embedded Web Server, Remote Patient Monitoring, Zig-Bee.

1. INTRODUCTION
A patient monitor is an instrument that collects and displays physiological data, often for the purpose of watching for, and warning against, very serious changes in physiological state. Patient monitoring systems can also help the patient, caregiver, and the provider make more informed decisions. Care delivery is improved with the use of patient monitoring systems as the data can trigger alarms or alert prompting provider intervention with the potential and then to improve health outcomes. Patient monitoring is focused on wireless or remote patient monitoring (RPM) and is a big growth area for patient monitoring which receives an influx of funding to advance the technology [10] [11].

2. RELATED WORK
In the year 2006, Marci Meingast, Tanya Roosta, Shankar Sastry [1] has developed security mechanisms for Remote Patient Monitoring systems in which the various security issues are solved. This is a new technology in healthcare information technology such as Electronic Patient Records EPR. This integrated system allows the patient's information to others hackers easily. In order to restrict these security issues in data access, storage, data and conflicting policies mining are solved by providing role based access, data encryption, authentication mechanisms, policy development and data mining rules. These are implemented before the widespread use of the new technologies in Health Care Information Technology

In the Year 2011, Shobaranimada and Sandhyarani S [6] has developed a biotelemetry system use the biosensor to measure heart rate and blood pressure from human body, Using Zig-Bee the measured signal sends to the PC via the RS-232 serial port communication interface. Through the internet system send the signal to remote PC or PDA. When the measured signals change over the standard value, the personal computer will send short message to absent manager's mobile phone.

In the Year 2011, S.Josephine Selvarani [5] has developed an on-line health monitoring of physiological signals of humans such as temperature and pulse using Zig-Bee by which the temperature and pulse of humans can be monitored from a distant location and some abnormalities can be easily indicated via SMS .The physiological measurements obtained from the Temperature Sensor and Heart Beat Sensor are transmitted to the programmed microcontroller to the PC through Zig-Bee. The PC collects the physiological measurements and also sends SMS, to the indicated mobile number through a GSM modem.

In the year 2011, B.Chiranjeevini Kumari and K.Rajasekar [3] has proposed a PSoC microcontroller and GSM modules which eliminating the cables attached to patient. PSoC has inbuilt ADC and Programmable Gain amplifier which enabled single chip implementation. The hardware complexity is also simple and reduces cost. The basic principle of this system is to read the bio medical signals from the biomedical sensor modules and perform the tasks of data conversion, sending SMS using GSM, as well as providing the ability of simple pre-processing such as waveform averaging or rectification. Heart beat is sensed by using a high intensity type LED and LDR When the finger is placed between the LED and LDR. So the patient has a freedom of doing daily activities and still be under continuous monitoring.

In the year 2012, Ms. Kadam Patil D. D. and Mr. Shastri R. K. [2] has developed an embedded digital stethoscope using an embedded processor with the help of PC connectivity. The data can be transmitted through wireless transmission using Zig-Bee module. A microphone is used to pick up the sound of the heart beat PC connectivity is provided through serial port where from audio and video can be made available through LAN and internet for telemedicine consultation. Heart beat signals are sensed, sent, displayed, monitored, stored, reviewed, and analyzed.

3. SYSTEM DESIGN

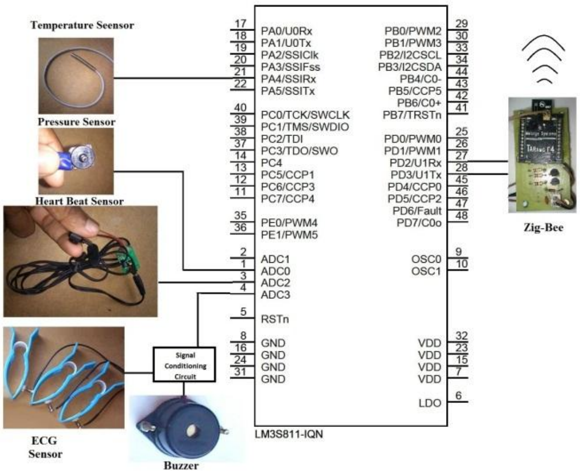


Figure 1: Data Acquisition at Remote Patient

Remote Patient Monitoring (RPM), or tele monitoring, describes services where a patient's vital signs (e.g., blood pressure, HBR) and other biometric data (e.g. pulse oximetry) and subjective data is collected by monitoring devices, typically in the patient's residence. This data is transferred electronically to a clinician (provider, nurse or allied health professional) who analyzes, responds and stores the data. The remote monitoring and interactive devices allows the patient to send in vital signs on a regular basis to a provider without the need for travel. In this Tele Communication project the hardware equipment's used are:

- Microcontroller (MCU),
- Sensors,
- Receiver and
- Transmitter.

The microcontroller sends the information of the temperature, blood pressure, heart beat rate and ECG of the patient to the remote PC through the Zig-Bee module [7]. Data acquisition at remote patient is shown in Fig 1.

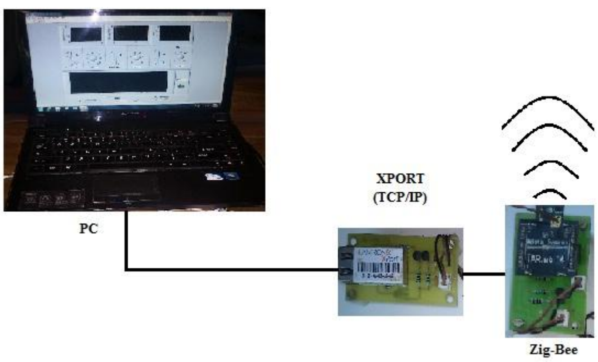


Figure 2: Patient Monitoring at Local System

Fig 2 shows the patient monitoring at local system. The wireless communication between the data acquisition system and remote system is achieved through Zig-Bee which is a low cast, battery powered IEEE 802.15.4 standard device. The received data is sent through embedded web server then monitored and maintain the database.

4. HARDWARE DESCRIPTION

4.1 ARM cortex-M3 Microcontroller

In the microcontroller, DS18B20 digital thermometer is connected to PA4/SSIRx, PIN 21 because DS18B20 gives the digital output. MPX5010 pressure sensor is connected to ADC0, PIN 1 because MPX5010 gives the analog output. Heart beat sensor is connected to ADC2, PIN 3 because the sensor gives the analog output. ECG electrodes connected to ADC3, PIN 4 because it gives the analog output. Zig-Bee's Tx pin is connected to Microcontroller's PD2/U1Rx, PIN 27 and Rx pin is connected to Microcontroller's PD3/U1Tx, PIN 28 [17].

4.2 Temperature Sensor

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of -55°C to +125°C and is accurate to ±0.5°C over the range of -10°C to +85°C. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply. Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems [12]. Fig 3 shows the interfacing temperature sensor with microcontroller.

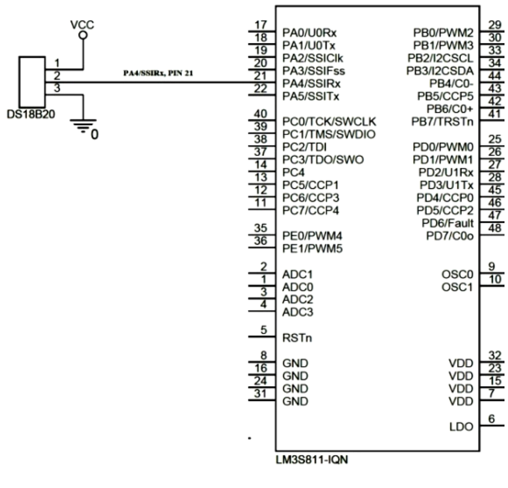


Figure 3: Interfacing Temperature Sensor with ARM Cortex (M3)

4.3 Pressure Sensor

The MPX5010/MPXV5010G series piezoresistive transducers are state-of the-art monolithic silicon Pressure Sensors designed for a wide range of applications, but particularly those employing a microcontroller or microprocessor with ADC inputs. This transducer combines advanced micromachining techniques, thin-film metallization, and bipolar processing to provide an accurate, high level analog output signal that is proportional to the applied pressure [15]. Fig 4 shows the pressure sensor.

Figure 4: Pressure Sensor

4.4 Heart Bate Rate Sensor

The TCNT2000 is a reflective sensor in a miniature SMD package. It has a compact construction where the emitting light source and the detector are arranged in the same plane. The operating infrared wavelength is 940 nm. The detector consists of a silicon phototransistor. The sensor analog output signal (photo current) is triggered by detection of reflected infrared light from a close by object. The sensor has a built in daylight blocking filter, which greatly suppresses disturbing ambient light and therefore increases signal to noise ratio. Fig 5 shows the prototype of heart beat sensor.

Figure 5: Prototype of Heart Beat Sensor

Heart rate measurement is one of the very important parameters of the human cardiovascular system. The heart rate of a healthy adult at rest is around 72 beats per minute (bpm). Athletes normally have lower heart rates than less active people. Babies have a much higher heart rate at around 120 bpm, while older children have heart rates at around 90 bpm. The heart rate rises gradually during exercises and returns slowly to the rest value after exercise. The rate when the pulse returns to normal is an indication of the fitness of the person. Lower than normal heart rates are usually an indication of a condition known as bradycardia, while higher than normal heart rates are known as tachycardia. Table 1 average heart beat rate.

Table 1: Average Heart Beat Rate

AGE	RANGE	AVERAGE RATE
0-1 Month	100-180	140
2-3 Month	110-180	145
4-12 Month	80-180	130
1-3 Years	80-160	120
4-5 Years	80-120	100
6-8 Years	70-115	92.5
9-11 Years	60-110	85
12-16 Years	60-110	85
>16 Years	60-100	80

4.5 ECG

The heart is a two stage electrical pump and the heart's electrical activity can be measured by electrodes placed on the skin. The electrocardiogram can measure the rate and rhythm of the heartbeat, as well as provide indirect evidence of blood flow to the heart muscle. A standardized system has been developed for the electrode placement for a routine ECG. Ten electrodes are needed to produce 12 electrical views of the heart. An electrode lead, or patch, is placed on each arm and leg. The signals received from each electrode are recorded. The printed view of these recordings is the electrocardiogram. By comparison, a heart monitor requires only three electrode limbs – one each on the right arm, left arm, and left chest. It only measures the rate and rhythm of the heartbeat. This kind of monitoring does not constitute a complete ECG [16]. Fig 6 shows the electrode limb.

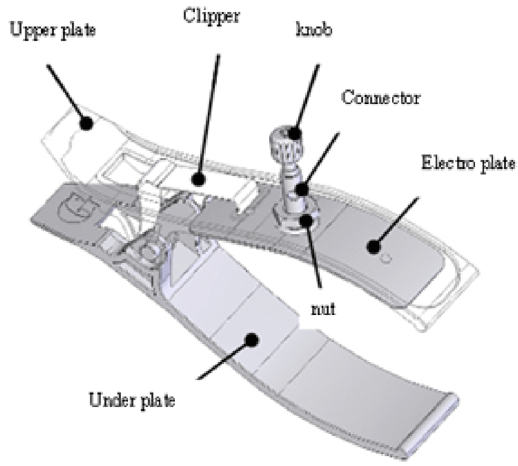


Figure 6: Electrode Limbs

Usually more than 2 electrodes are used and they can be combined into a number of pairs (For example: Left arm (LA), right arm (RA) and left leg (LL) electrodes form the pairs: LA+RA, LA+LL, RA+LL). The output from each pair is known as a lead. Each lead is said to look at the heart from a different angle. Different types of ECGs can be referred to by the number of leads that are recorded, for example 3-lead, 5-lead or 12-lead ECGs (sometimes simply "a 12-lead"). A 12-lead ECG is one in which 12 different electrical signals are recorded at approximately the same time and will often be used as a one-off recording of an ECG, typically printed out as a paper copy. 3- and 5-lead ECGs tend to be monitored continuously and viewed only on the screen of an appropriate monitoring device, for example during an operation or whilst being transported in an ambulance. There may, or may not be any permanent record of a 3- or 5-lead ECG depending on the equipment used.

It is the best way to measure and diagnose abnormal rhythms of the heart, particularly abnormal rhythms caused by damage to the conductive tissue that carries electrical signals, or abnormal rhythms caused by electrolyte imbalances. In a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though not all areas of the heart are covered. The ECG cannot reliably measure the pumping ability of the heart, for which ultrasound-based (echocardiography) or nuclear medicine tests are used. It is possible to be in cardiac arrest a normal ECG signal (a condition known as pulse less electrical activity).Fig 6 shows the three lead configurations.

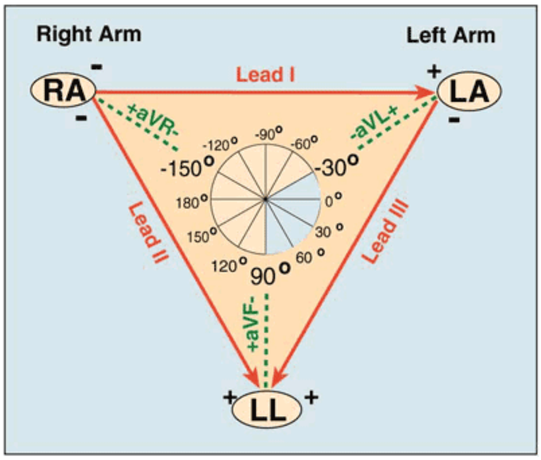


Figure 6: Three Lead Configurations

The output of an ECG recorder is a graph (or sometimes several graphs, representing each of the leads) with time represented on the x-axis and voltage represented on the y-axis. A dedicated ECG machine would usually print onto graph paper which has a background pattern of 1mm squares (often in red or green), with bold divisions every 5mm in both vertical and horizontal directions. It is possible to change the output of most ECG devices but it is standard to represent each mV on the y axis as 1 cm and each second as 25mm on the x-axis (that is a paper speed of 25mm/s). Faster paper speeds can be used - for example to resolve finer detail in the ECG. At a paper speed of 25 mm/s, one small block of ECG paper translates into 40 ms. five small blocks make up one large block, which translates into 200 ms. Hence, there are five large blocks per second. A calibration signal may be included with a record. A standard signal of 1 mV must move the stylus vertically 1 cm that is two large squares on ECG paper.

4.6 Buzzer

Fig 7 shows the Buzzer is used to sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Here it is used for indicate the noise for ECG and beeps.

Figure 7: Buzzer

4.7 Zig-Bee

Zig-Bee and IEEE 802.15.4 are standards-based protocols that provide the network infrastructure required for wireless sensor network applications. 802.15.4 defines the physical and MAC layers, and Zig-Bee defines the network and application layers. For sensor network applications, key design requirements revolve around long battery life, low cost, secured, reliable and self-healing, easy and inexpensive to deploy, small footprint, and mesh networking to support communication between large numbers of devices in an interoperable and multi-application environment. Low cost Zig-Bee technology for wireless communication between the patient data acquisition system and the patient monitoring system and it supports the distance from 30m to 100m depends upon the power and output. Zig-Bee uses frequency bands of 2.4 GHz, and its transmission rate is 20 kbps to 250 kbps. The application areas of Zig-Bee are, Automation of Home, Building and Industries [4] [9]. Fig 8 shows the Zig-Bee module.

Figure 8: Zig-Bee module

4.8 Personal Computer for Patient Monitoring

PC is the main element of the communication between the PC and the Zig-Bee, PC receives the data from the transmitted side device, but the data cannot be received directly from the Zig-Bee, so it employs a serial communication with the Zig-Bee. The Received data is sent through the embedded web server.

4.9 Embedded Web Server

Fig 9 shows the embedded web server. The embedded web server technology is the combination of embedded device and Internet technology, which provides a flexible remote device monitoring and management function based on Internet browser and it has become an advanced development trend of embedded technology. Through this embedded web server user can access their equipment's remotely. The equipment mentioned here could be home appliances and factory devices. The main part is TCP/IP suite and user development platform for this embedded web server. The embedded web server design includes a complete web server with TCP/IP support and Ethernet interface. It also includes support for sending mail, and software for automatic configuration of the web server in the network. The web server reference design includes complete source code written in C-language. The advantage is easy to maintain and low cost [12].

Figure 9: Embedded Web Server

5. SOFTWARE DESCRIPTION

5.1 Embedded C

Embedded C is a set of language extensions for the c programming language by the C standards committee. It introduces a number of features not available in normal C and basic I/O hardware addressing. It is having the declaration of microcontroller registers and special function as header files, we can include these files to make easy implementation. Embedded C has same flow and programming methodology as C. It has unlimited number of source files, mixed C and assembler programming. It’s Compatibility integrates into the MPLAB IDE, MPLAB ICD and most 3rd-partydevelopment tools and Runs on multiple platforms: Windows, Linux, UNIX, Mac OS X, Solaris EX:- Kiel C.

5.2 Lab VIEW

LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavours of UNIX, Linux, and Mac OS.

Steps for creating front panels and block diagram:

Step 1: Launch LabVIEW to create the following front panel. Right-clicking the mouse will bring up a menu of graphical elements (NI calls them controls). One can then click and drag the desired control into the front panel (gray area).

Step 2: Create the block diagram. The block diagram is invoked by clicking window show block diagram from the panel’s menu bar. Again, one right clicks the mouse to bring up a menu of block element functions.

Step 3: Click the play button (arrow icon) on the front panel’s menu bar. Contrast this with clicking the continuous play button (arrows in a circle icon) experiment by clicking on the rocker switches or typing numbers (e.g. integers and reals) in the text box. Fig 10 shows the Lab VIEW block diagram.

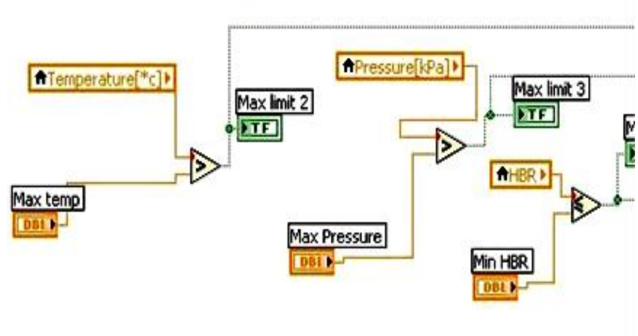


Figure 10: Block Diagram for Creating Sensor

6. IMPLEMENTATION

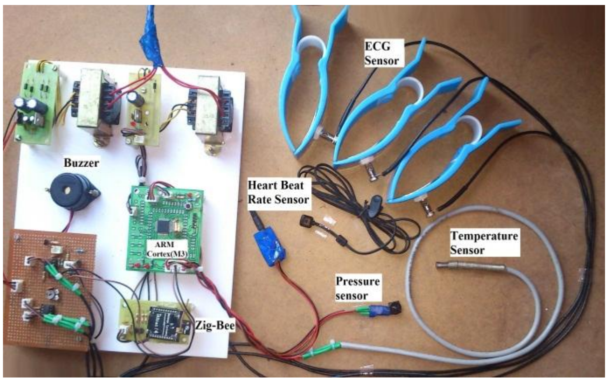


Figure 11: Data Acquisition at Remote Patient

The 12v AC supply to the step down transformer, in power supply unit, converts AC to DC using bridge rectifier. Temperature sensor senses the temperature of the patient from the sensor and sent it to the microcontroller. Similarly, blood pressure, heart and ECG sensed then sent to the microcontroller. Then all the information is monitored using PC through Zig-Bee. Fig 11 shows the data acquisition side.

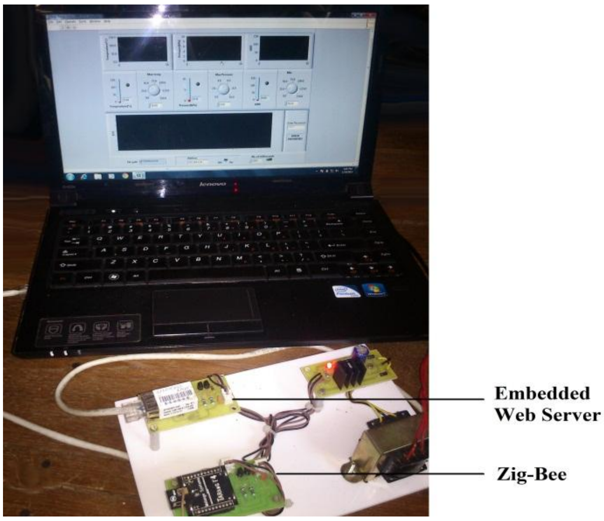
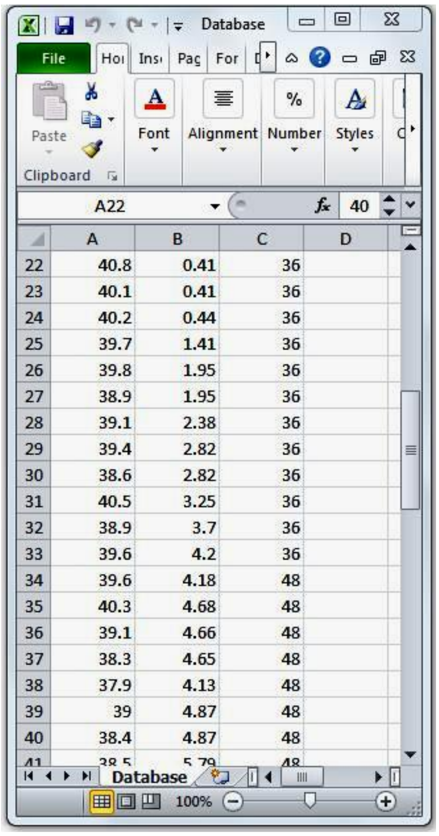


Figure 12: Patient Monitoring at Local System

The received data is monitored and maintained through the embedded web server. Using the embedded web server doctor can logging the system and views the patient status at any time in any place. Fig 12 shows the monitoring side.



	A	B	C	D
22	40.8	0.41	36	
23	40.1	0.41	36	
24	40.2	0.44	36	
25	39.7	1.41	36	
26	39.8	1.95	36	
27	38.9	1.95	36	
28	39.1	2.38	36	
29	39.4	2.82	36	
30	38.6	2.82	36	
31	40.5	3.25	36	
32	38.9	3.7	36	
33	39.6	4.2	36	
34	39.6	4.18	48	
35	40.3	4.68	48	
36	39.1	4.66	48	
37	38.3	4.65	48	
38	37.9	4.13	48	
39	39	4.87	48	
40	38.4	4.87	48	

Fig 13: Database

Fig 13 shows the maintained database. The temperature, pressure and heart beat rate are the digital output so it can be stored in database. Using this data base doctor can able to know the remote patient status.

6.1 Patient Monitoring at Local System

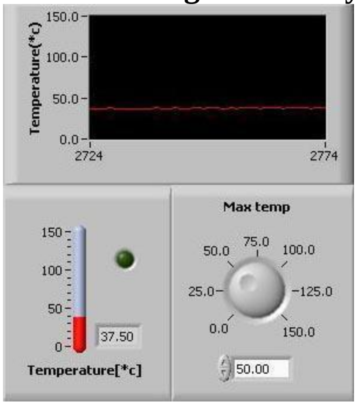


Figure 14: Temperature Monitoring

In front-end the temperature is monitored at the local PC. If patient's temperature increases more than maximum value then the green light will indicate for the high temperature. Fig 14 shows the sensed temperature is below the set point and blink the visual alarm (Green LED-OFF) is provided. The set point may be varied manually at the front- end itself.

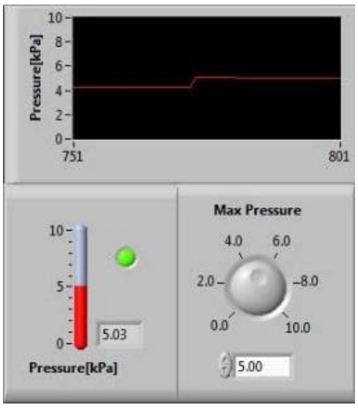


Figure 15: Pressure Monitoring

In front-end the pressure is monitored at the local PC. If patient's pressure increases more than maximum value then the green light will indicate for the high pressure. Fig 15 shows the sensed pressure is above the set point and blink the visual alarm (Green LED-ON) is provided. The set point may be varied manually at the front- end itself.

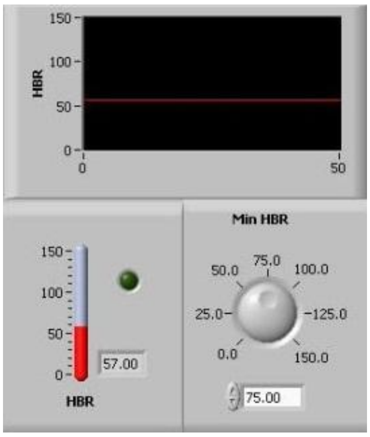


Figure 16: HBR Monitoring

In front-end the heart beat is monitored at the local PC. If patient's heart beat increases more than maximum value then the green light will indicate for the high heartbeat. Fig 16 shows the sensed heart beat is below the set point and blink the visual alarm (Green LED-OFF) is provided. The set point may be varied manually at the front- end itself.

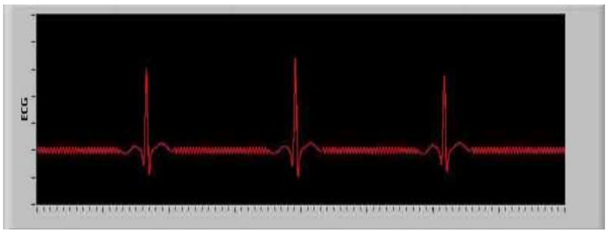


Figure 17: ECG Monitoring

In front-end ECG is monitored at the local PC. Fig 17 shows the ECG representation. The electrocardiogram can measure the rate and rhythm of the heartbeat, as well as provide indirect evidence of blood flow to the heart muscle. A standardized system has been developed for the electrode placement for a routine ECG.

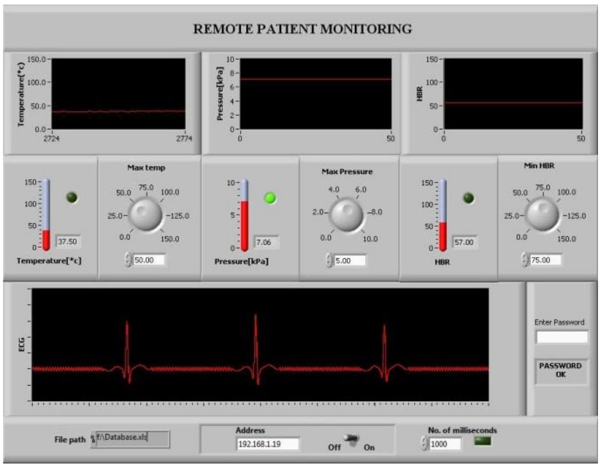


Figure 17: Patient Monitoring at Local System

Fig 17 shows the front-end for the patient monitoring (after enable) at local PC. Enter the password for logging the system. The entered password was OK so it monitors the patient current status. The graphical representation shows the graphical form of low and high indications. Manually can able to change the storing timing of database.

7. CONCLUSION

The Remote Patient Monitoring System is basically used in telemedicine application which monitors the patient's vital signs and parameters remotely and dynamically in real time. In the existing system considers only minimal parameters for monitoring and have been used expensive wireless communication methods. But in this system we have considered more parameter with low cost wireless communication technology. It is very useful to the remote patients, and also has an advantage of low-power consumption, which is attractive for portable applications. The another advantage of this approaches is the Zig-Bee wireless communication technology, which breaks the traditional monitoring and transfusion pattern in home and ICU thus the quality and efficiency of medical treatment are improved. This project presents some challenges of hardware and software design for medical wearable device based on low-power medical sensors and microcontroller with a recent tremendous impact in many medical applications. The patient has a freedom of doing daily activities and still be under continuous monitoring (very suitable for old age people). All the health conditions status is transferred though the Embedded Web Server and all the patient status is maintained in the hospital database. Using this database doctor can able to know the remote patient status.

8. REFERENCES

[1] Marci Meingast, Tanya Roosta, Shankar Sastry, "Security and Privacy Issues with Health Care Information Technology", IEEE, 2006.

[2] Ms.Kadam Patil D. D. and Mr.Shastri R. K., "Design of Wireless Electronic Stethoscope Based on Zig-Bee", International Journal of Distributed and Parallel Systems, Volume -3, 2012.

[3] B.Chiranjeevini Kumari, K.Rajasekar, "Implementation of SMS based Heartbeat Monitoring System using PSoC Microcontroller", International Journal of electronics & communication technology, Volume -2, 2011.

[4] D.J.R.Kiran Kumar, NaliniKotnana, "Design and Implementation of Portable Health Monitoring System using PSoC Mixed Signal Array Chip", International Journal of Recent Technology and Engineering, Volume-1, 2012.

[5] S. Josephine Selvarani, "Online Health Monitoring System using Zig-Bee", International Journal on Computer Science and Engineering, Volume -3, 2011.

[6] Shobaranimada, Sandhyarani.S, "An Adaptive embedded system for helping patients", International Journal of Computer Trends and Technology, volume2, 2011.

[7] Shaojie Lin, Qiong Liu, Xiaoming Wu, Shanglin Li and Zhicong Zhao, "Wireless monitoring system via Zig-Bee in ICUs", IFMBE Proceedings, Volume -19, 2008.

[8] Robert G. Lupu, Andrei Stan, Florina Ungureanu, "Wireless Device for Patient Monitoring", World Congress on Engineering, Volume-2, 2008.

[9] K. Noimanee, S. Noimanee, P. Khunja, and P. Keawfoonrungsie, "Medical Consult-Based System for Diagnosison WiMAX Technology", International Journal of Applied Biomedical Engineering Vol.3, No.1 2010.

[10] V.Ramya, Anuradha Kumari, "Embedded Intensive Patient Care Unit", David Bracewell, et al. (Eds): AIAA 2011, CS & IT 03, pp. 169–176, 2011.

[11] Sherin Sebastian, Neethu Rachel Jacob, Yedu Manmadhan, Anand V. R. , M. J. Jayashree, "Remote Patient Monitoring System", International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.5, September 2012.

[12] Ashwin K. Whitchurch, Jose K. Abraham, and Vijay K. Varadan, "Design and Development of a Wireless Remote Point-of-Care Patient Monitoring System", IEEE Region 5 Technical Conference, 2007.

[13] Milan tork, "The System for Spiroergometric Data Measuring and Evaluation", Measurement Science Review, Volume 1, Number 1, 2001.

[14] M.Chaitanya Suman, K. Prathyusha, "Wireless ECG System Based on ARM LPC 2103 Processor", IJECT Vol. 3, Issue 1, Jan. - March 2012.

[15] Mrs. Rajashri Patil , Prof.Balaji Hogade, "On Line Real Time Health Monitoring of ICU Patients using ARM7", International Journal of Computer Science and Network (IJCSN) Volume 1, Issue 3, June 2012.