Review of development & deployment of wireless ECG monitoring systems

Mr. Mangesh Deepak Vaidya, *M.E. Student,*
Prof. V.D. Shinde, *Assistant Professor,*
Prof. Dr. Sanjeev N. Jain, *Professor,*
Department of Electronics Engineering,
*SSVPS Bapusaheb Shivajirao Deore College of Engineering*

Abstract: *Due to dynamic life style problems related to Heart are increasing every day and it's vital that diseases related to heart should be diagnosed by simple medical techniques. The heart diseases can be diagnosed by (ECG) Electrocardiogram signals. ECG measures electrical potentials from the body surface with contact electrodes, thus it is treated as one of the important signals. As the people are becoming more conscious about their health problems, the need for well-equipped hospitals and diagnostic centers is increasing day by day. Motivation of this paper is understand the development of efficient & affordable wireless biometric systems that can monitor multiple patients' health parameters simultaneously and can effectively deliver the data to a patient monitoring system.*

I.   Introduction

With increasing in complexity of Health & Disease scenario, medical practitioners moreover rely on technology for analyzing patient's health condition & for understanding the suitable and possible treatment. Use of technology is known for assisting medical profession for easy & precise decisions making but on the other hand increasing medical treatment cost while making it dearly for wide range of social class [1]
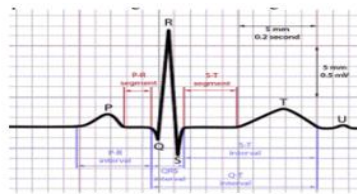
ECG Stands for Electrocardiogram. ECG is basically used to check your heart Rhythm and electrical activity. In this sensors are attached to skin which detects the electrical signal produced by the heart each time the heart beats [2] An ECG is painless way to diagnose common heart problem in all ages ,it helps us to know heart is abnormal, if there are blocked arteries in heart, whether there was previous heart attack, and also helps to determine how well the device(pacemaker)is working properly or not, if you have install it in your heart. An ECG should be done if there are following signs and symptons such as chest pain, dizziness, heart palpitation, rapid pulse, shortness of breath, weakness, fatigue, or decline in ability of exercise. An ECG is safe process .There is no risk of electrical Shock during the test because electrode do not produce electricity .It only records the activity of Heart. Before ECG is done the patient have to shave the body parts if there are presence of hair, so that the patches can be stick to your body. One it is done patient is allowed to lie on table where ECG sensors (electrodes)are attached to body by Technician and result are seen by Doctor .Doctors basically check the Heart Rate, Heart Rhythm, Heart Attack, Inadequate blood and oxygen supply to the heart, Structural Abnormalities. Doctors need to keep monitoring all the patients in there wards continuously, and this requires more number of skilled nurses. It's not feasible for the doctors to go to each ward and monitor each patient frequently. Patient in the ICU need constant monitoring of their physiological parameters such as measurement of blood pressure, temperature, heart rate, ECG, EEG etc. and transmitting this data to the doctor's cabin continuously [3]. ECG result can be transmitted from one place to another place by communication or wired communication, for wired communication coaxial cable is required where data cannot be transferred to large distance, and also data can be transferred wireless.

Few methods have been reviewed herein this effort to survey the ECG monitoring & teleporting the data of the electrocardiogram. While going through the study mainly three methods have been focused on, which are discussed in the following sections.

Wireless ECG monitoring using BLUETOOTH:

Bluetooth is known as a short-range technology using a wireless communication technology designed to exchange data from fixed and mobile devices over a short distance using microwave radio waves in the range of 2.402 GHz to 2.48 GHz. It is mainly used as an alternative to wired connections for file sharing between nearby portable devices to connect to mobile phones and music players as Bluetooth enabled headphones. In the most commonly used short-range mode up to 10 meters (30 feet), the transmit power is limited to 2.5 mW. From a technical standpoint, there are three types of devices: "classic" Bluetooth, dual-mode Bluetooth, and single-mode Bluetooth. A device that usually requires maintenance and always requires a high-speed connection. Some authors have studied the use of the Bluetooth method to transmit ECG signals over a limited relay range. Bluetooth devices use radio waves instead of wires or cables to connect to cell phones, smartphones, or computers. Bluetooth uses a wireless technology called frequency hopping. Bluetooth breaks the transmitted data into packets. Although there are many differences, the following stand out as the most important benefits of Bluetooth 5.0 [4]

WIRELESS ECG MONITORING WITH BLUETOOTH RISC MSP430FG439

ECG monitoring using BLUETOOTH uses system of Software and Hardware. This method consists of Embedded Technology and Network technology for monitoring the system. In this monitoring wireless transmission of ECG signals are given to PC through Bluetooth where the doctors can easily read it. The system CPU uses TI ultra low power 16bit RISC MSP430FG439. MSP430FG439 is mainly characterized by its ultralow power consumption, external high integration of CPU and portable devices suited for low power. MSP430FG439 includes a 12bit ADC with external eight channel. A Bluetooth based portable ECG Monitoring System is presented in this method in order to solve the problem existed in the traditional one. This system can be used not only as a real-time monitoring system in hospitals, but also as a remote monitoring system for families by uploading to the Internet via a Bluetooth network. With the advent of Bluetooth technology, wireless portable ECG monitoring systems will be possible. The process delivers low power consumption, high precision, and excellent functionality through a low power design, high precision sampling, and complete monitoring software [5]
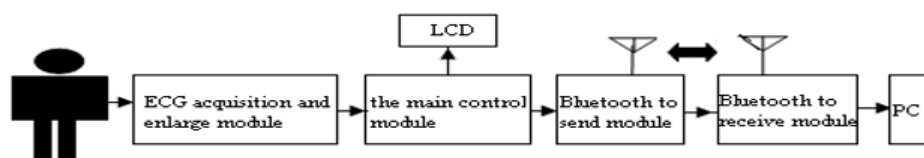

Block diagram of ECG monitoring using BLUETOOTH fig1

WIRELESS ECG MONITORING WITH BLUETOOTH ARM11

Another method is based on the Bluetooth wireless ECG acquisition system supported by the ARM11 module, which includes the ECG acquisition module, Bluetooth module software development and system software development. Data is processed by microprocessor-based systems and displayed results perfecting human-computer interaction techniques. This method consists of low cost, low power consumption, strong noise immunity and high reliability, which is the key to making the patient's activity free and making the ECG device a family. Advances in embedded and network technologies have made ECG devices smaller, more portable and more remote. Bluetooth-based mobile wireless technology is constantly permeating into industrial production, medical care, home life and other fields. Ideal choice for implementing wireless medical monitoring systems In the suggested method it states that the employed filter characteristics have been altered and interference related to the low frequency pulse and random noise have been nullified while changing process of filtering and operation the parameters of the soft filter to yield the ideal effect monitoring with such portable ECG monitor achieve.

Therefore, use ARM11, By changing the filtering process and the operating parameters of the software filter, the filter characteristics are changed to eliminate low frequency pulse interference and random noise, making the portable ECG monitor ideal for effectiveness monitoring.. [6]
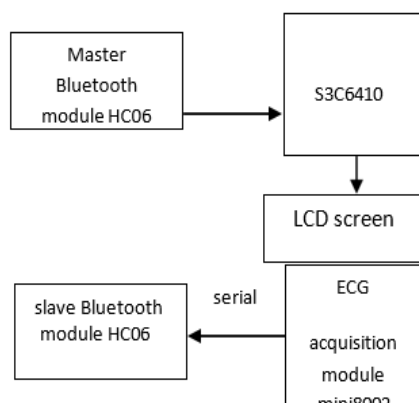
WIRELESS ECG MONITORING WITH BLUETOOTH RISC ATMEGA16

Next method employs an ATMEGA 16 microcontroller to process the ECG signal and this signal was transmitted to the PC using Bluetooth. This paved the way for a clear ECG signal indicative of the subject's heart condition. There are various operating programs as well as Bluetooth types for programming bio signals and capturing them from a PC. Therefore, the specific program and Bluetooth are selected according to the design and purpose

The device is user-friendly and allows doctors to know the subject's heart abnormalities. It also gives the subject some awareness of the condition of his or her heart. Much effort has been put into making this device at a low cost, so installing this program on a PC will give you an idea of his heart condition without any special monitoring device. [7]

WIRELESS ECG MONITORING WITH BLUETOOTH RISC THE MSP430FG439's ONCHIP OPAMP AND THE CC2540's

This method collects ECG data from a portable ECG monitor and then transmits it to a smartphone using the Bluetooth 4.0 low energy protocol. The ECG data is eventually transmitted via the 3G mobile network to the remote doctor's medical records management platform. The ECG signal is sent to the Health Smart Phone using the low-power Bluetooth 4.0 protocol. The Health Smart Phone is based on the ARM series microprocessor and is built into the Android operating system. Health smartphone can log into health server and retrieve medical records. Doctors can provide health advice to the patient's health smartphone via 3G mobile network. This makes it easy for two-way communication between doctors and patients to take place anytime, anywhere. The 3G transmission module was developed because of the need to send ECG data with high accuracy, timeliness and efficiency. When the ECG waveform is stable, press the send button and switch to the 3G transmit module. Thereafter, real-time ECG transmission is performed through a mobile communication medium. After sending the ECG data, user information must also be entered into the mobile phone. Therefore, it is easier for doctors to diagnose by storing health parameters in the remote database of the medical records management platform.

This document proposes a new solution for mobile ECG monitoring system based on Bluetooth 4.0 and Android system. The system takes full advantage of the MSP430FG439's on-chip op amp and the CC2540's transmission convenience and low power consumption. [8]

Advantages of Bluetooth monitoring system
IT has low power consumption
High accuracy
Good function with low power design
Sampling at high precesion
Complete monitoring software

Disadvantages of Bluetooth monitoring system
It cannot be used for long distance communication
ECG monitoring system using GSM/GPRS
General Packet Radio Service (GPRS) is a packet oriented mobile data standard on the 2G and 3G cellular communication network`s global system for mobile communications (GSM). GPRS was established by European Telecommunications Standards Institute (ETSI) . It is now maintained by the 3rd Generation Partnership Project (3GPP). GPRS is typically sold according to the total volume of data transferred during the

billing cycle. In 2G systems, GPRS provides data rates of 56–114 kbit/sec 2G cellular technology combined with GPRS is sometimes described as 2.5G, that is, a technology between the second (2G) and third (3G) generations of mobile telephony. It provides moderate speed data transfer, by using unused time division multiple access (TDMA) channels in, for example, the GSM system. GPRS is integrated into GSM Release 97 and newer releases. GSM is the abbreviation of Global System for Mobile Communications. GPRS is a packet data bearer and transmission service developed on the basis of the GSM system. 4. The most fundamental difference between GPRS and GSM system is that GSM is a circuit switching system, and GPRS is a packet switching system. [13]

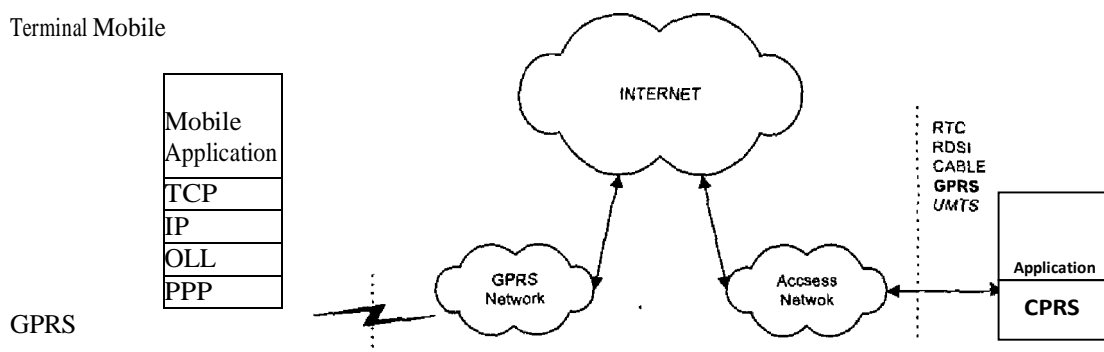## WIRELESS ECG MONITORING WITH GSM/GPRS ARX MODEL

Data compression of ECG signals is practically very important. This method is an ECG compression method for efficiently transmitting an ECG signal through a GPRS network. Testing on clinically measured ECG signals confirms very good performance in terms of compression ratio. When using GPRS as a signal compression method, there are significant problems that arise in many applications. Various methods have been proposed over the years to solve this problem. Signal compression methods fall into two general categories: lossy and lossless. Lossless ECG compression is essential for storing and transmitting electrocardiograms. The goal of ECG compression should be not only to transmit or store signals with fewer bits, but also to preserve clinically relevant information. Prediction methods are a subclass of lossless methods. These methods use redundancy between the patterns, bits, and leads of the ECG signal, so only new information needs to be encoded. Correlation of ECG samples is important. In this article, we present an approach based on prediction methods using the ARX model for lossless ECG compression. One way to predict the ECG signal on the ARX module is to characterize the ECG signal lead as the output of a linear system whose input is another lead of the same signal. The following analysis describes a system with one input and one output corresponding to the ECG signals from the test database. It is straightforward to generalize to systems with multiple inputs. Fixed linear systems are the most important class of dynamic systems. The proposed method claims to present effective tool for ECG compression that remains lossless. The paper describes ARX model which employs compression of ECG signal over GPRS system efficiently.

This method represents an efficient approach to lossless ECG compression. The ARX model described is common in control theory and is rarely used in data compression. This document proposes the use of this model in ECG signal compression for efficient transmission over the GPRs network [6]

WIRELESS ECG MONITORING WITH GSM/GPRS PORTABLE DATA ACQUISATION CONSOLE (PAC)

This method proposes the development of a new Portable Data Acquisition Console (PAC) terminal with portability, autonomy, signal acquisition and digital processing, data compression and encryption, and GPRS channels. The GPRS modem provides a data channel and a GSM voice channel for direct patient-to-physician communication. This method consists of a new GSM transport feature. A prototype containing a GSM data modem was developed and the concept proved to be technically feasible. However, despite the technological advances, telecommunications infrastructure and modern equipment required for comprehensive, high-quality telemedicine services, they are still very expensive. However, it is the abnormal ECG signal that experts are interested in. Instead of doing signal processing after transmission, it is done before. Here information-compressed data, that is, the amount of data is not only reduced but also optimized. In this method, scanning is enabled before transmission. The background of this ECG pre processor is to reduce the amount of data being transmitted. Instead of constant communication with experts, where most of the information is useless, only problematic ECGs are sensed and forwarded further.

Terminal Mobile

GPRS

In this way, the prototype can be used standalone with GPSIGPRS modem equipment. The main purpose of the prototype is to provide 24/7 medical remote assistance to customers.. [10]

WIRELESS ECG MONITORING WITH GSM/GPRS PACKET LEVEL ERROR CORRECTION

In this method real time continuous electrocardiogram (ECG) transmitting method through GPRS network is presented, which is based on a packet level forward error correction (PFEC) method with simultaneously considering low power consumption. This method was basically used to to overcome the limitations of conventional route ECG test and hours of monitor, and more importantly offers some significant advantageous than other current available mobile monitoring system, such as the Cardio Net Mobile Cardiac Outpatient Telemetry Service. Carrying such a mobile unit, patient can go about his/her daily activities, but his/her ECG signals and current geographic position located by GPS would be real timely acquired and compressed, continuously transmitted to a hospital monitoring centre wherever they go . In this method a test program is developed to send data at customized intervals, where the quantity of data can be changed, and time information and the ID of packets are included. The data are sent through GPRS network and then through internet to another computer, where another program is developed to set up a TCP or UDP server to receive data. The data are then stored for further analysis and the time when a packet came is also recorded. NTP (Network Time Protocol) is used to implement synchronization between two computers. In order to reduce the power consumption of the handheld terminal, it is recommended to increase the packet size rather than the number of packets. Therefore, an encoding method including FEC data in data packets is required. This method calculates the difference between the receive and transmit times of each packet, and then the maximum and average values of the differences are called "maximum delay" and "average delay". In the meantime, we consider lost and erroneous packets, and then divide it by the total number of packets to get "loss rate" and "error rate"

A method of transmitting ECG through a GPRS network based on the PFEC method while considering low power consumption. This proposed method is used over UDP protocol for data transmission.. [11]
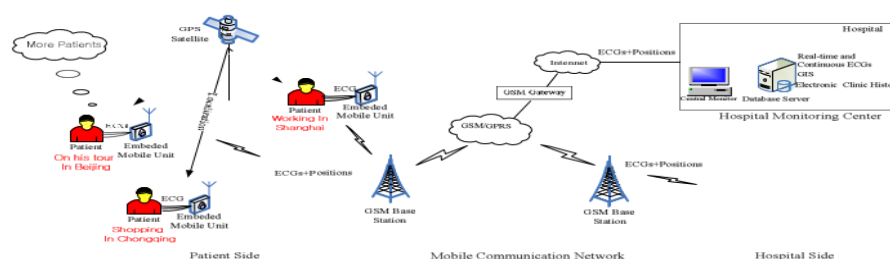
WIRELESS ECG MONITORING WITH GSM/GPRS TI COMPANYS MSP430F2418 AND SIMCOM COMPANYS SIM300

This method consists of remote ECG monitoring system solution based on GPRS wireless communication technology , it adopts TI company`s MSP430F2418 as the main controller, uses SIMCOM company's SIM300 module as GPRS communication module, combining ECG signal acquisition circuit and doctor workstation to construct remote ECG monitoring system. The system is composed of three parts, which includes: ECG signal acquisition part, wireless transmission part and doctor workstation part. e. The initialization includes: Set the

In this method the method of a remote ECG monitoring system is presented, based on which a hardware circuit for detecting ECG signals is designed. Efficient ECG signal detection is realized by designing reasonable bandpass filter parameters. After discussing and analyzing the control method of the SIM300 GPRS module, use the MSP430F2418 to design the corresponding hardware control method. It completes the ECG data collection and AT command control of the GPRS module to realize the wireless transmission of ECG data. Using VB6.0 and SQL Server2000 development tools based on Winsock network programming technology, the design of a remote ECG monitoring system based on GPRS wireless network is implemented to design and develop remote ECG monitoring software on a doctor's workstation.. [12]

Wireless ECG monitoring using ZIGBEE

Zigbee is a wireless technology developed as an open global standard to meet the unique needs of low-cost, low-power wireless IoT networks. The Zigbee standard works with IEEE 802.11. ... this protocol allows devices to communicate in a variety of network topologies, with battery life of several years. Zigbee is an IEEE 802.15.4-based specification of a set of high-level communication protocols used to create small, low-power digital radio personal area networks that require wireless connectivity. Therefore, Zigbee is a low power, low

data rate, proximity (ie, personal space) wireless ad hoc network. The technology defined in the Zigbee specification aims to be simpler and cheaper than other wireless personal area networks (WPAN) such as Bluetooth and more common wireless networks such as WiFi. Applications include wireless light switches, home energy monitors, traffic management systems, and other consumer and industrial devices that require slow, short-range wireless data transmission. Due to its low power consumption, the transmission distance is limited to a line-of-sight of 10-100 meters, depending on the output power and environmental characteristics. [14] Zigbee devices can send data over long distances by routing data through a mesh network of intermediate devices and reaching distant devices. Zigbee is typically used in low data rate applications that require long battery life and a secure network. (The Zigbee network is protected by a 128-bit symmetric encryption key.) Zigbee has a defined rate of 250 kbps, which is ideal for intermittent data transmission from sensors or input devices. Zigbee was invented in 1998, standardized in 2003 and revised in 2006. Its name refers to the wiggle dance that bees make when they return to the hive[11]

WIRELESS ECG MONITORING WITH ZIGBEE WEB BASED

The method consists of a web-based ECG monitoring system using the ZigBee , which can log signals to a database, manage data analysis, and alert doctors when anomalies are detected. The system is based on wireless ECG monitoring and is called MA MultiAgent ECG Monitoring (MA WEMS). MA WEMS applies ZigBee technology for agent-to-agent communication. The device allows ECG monitoring of multiple patients from a user GUI window on the computer. MA WEMS provides continuous remote monitoring, analysis and diagnosis of a patient's condition. This prototype makes it easy to collect dynamic signals as patients perform their daily activities in hospitals or for chronic patients in wards. . ECG signals shown here are not limited to one PC. The signal can be observed from any PC equipped with a Zigbee module and installed with the MA WEMS GUI software. The ZigBee seems to be the best choice for prototypes with characteristics such as lower data rates, lower power consumption, less complexity and more connected devices compared to Bluetooth for the medical sensor network.

In this prototype system, we presented an ECG signal monitoring scheme for multiple targets in real-time monitoring mode, where targets are   at   different ranges. The advantages of MA WEMS are cost-effectiveness, low power consumption and portability. It is also practical for use in hospitals where nurses can more easily monitor a patient's heart, reducing workload or time. MA WEMS provides data logging of ECG signals required for cardiac diagnosis. The data can be easily imported into third-party software such as 29 Lab VIEW or MA TLAB, which plays an important role in the analysis and diagnosis of heart problems [15]

WIRELESS ECG MONITORING WITH ZIGBEEPRO(S2) AND PIC18F452

This design consists of two segments: a transmit end with a ZigbeePRO (S2) module for transmitting data, a PIC18F452 that processes the data and first stores it in the EEEPROM, an LCD for the display, and a 9V battery. .. On the receiving side, there is another ZigBeePRO (S2) module that handles the reception of data sent from the sending side, and a PC with Visual Studio software that has a developed graphical user interface (GUI). You can analyze the received data. Software system design is divided into two parts. The first part is designed to process and store the ECG signal implemented in the PIC18F452, and the second part is implemented in the graphical user interface (GUI) using Visual Studio 2012 on the receiving side. increase. A Microcontroller software Microcontrollers and liquid crystal displays (LCDs) must be initialized before they can be used. Initialization and programming are implemented using MPLAB IDE v8.46, which is C-based software. B. XCTU Software XCTU Software is a Windows-based application provided by Digi, the manufacturer of XBeePRO (S2) modules. This program is designed to interact with the firmware files found in Digi's HF products to provide an easy-to-use graphical user interface. The ZigBee module must be configured before it can be used for serial communication between hardware and software connections. This setting requires you to install the XCTU software created to configure the ZigBee module

The proposed design has several interesting technical features, such as excellent versatility (embedded microcontroller system), low cost power supply (energy saving method), liquid crystal display (LCD), built-in data storage, remote configuration of wireless parameters, bidirectional there is. - directional data link (half duplex with reverse telemetry) and the ability to add additional nodes. For this purpose, the ZigBee PRO(S2) RF module manufactured by Digi International Inc. was selected. Supports unique requirements for low-cost, low-power wireless sensor networks. These modules require minimal power and ensure reliable data transfer between devices. [16]

WIRELESS ECG MONITORING WITH ZIGBEE,RFID AND RS232

The system consists of three parts: a control interface, patient information and emergency display panels, and a location menu. Nursing staff can support patient care with this system. RFID devices are used to read patient data, and relevant data and signal strength for each zone is sent to the wireless communication

module via ZigBee network characteristics and to the host via RS232. The process of operation is to give each patient an active RFID tag for login and use this tag to move to the appropriate area. To the extent appropriate, when the router detects the ID number sent by the active RFID tag, the ID number and received signal strength are sent to the wireless communication module via ZigBee and then to the host via RS232. .. The host side uses a back-end system developed in C to receive the router ID code and the signal strength of the active RFID tag compared to the received signal strength (RSS). Maximum signal strength represents the shortest distance to that region. To identify the patient, the fields display patient identification number, patient-defined ID, router ID code, router zone, signal strength, and last read access time.

In this study, a medical positioning system was completed using RFID, ZigBee technology and a graphical human-machine interface. As a result of the test, it was found that medical staff can reduce medical negligence by using the medical positioning system and know the condition of each patient in real time. When a patient is in an emergency, the emergency button on the active tag can be pressed to send a rescue signal to the receiving party so that medical staff can provide timely assistance [17]

WIRELESS ECG MONITORING WITH ZIGBEE ARDUINA/GENUINO

Arduino/Genuino Uno is a microcontroller board primarily based totally at the ATmega328P (datasheet). It has 14 virtual input/output pins (of which 6 may be used as PWM outputs), 6 analog inputs, a sixteen MHz quartz crystal, a USB connection, a strength jack, an ICSP header and a reset button. It includes the whole thing had to aid the microcontroller; without a doubt join it to a laptop with a USB cable or strength it with a AC-to-DC adapter or battery to get started.. You can tinker together along with your UNO without worring an excessive amount of approximately doing some thing wrong, worst case situation you may update the chip for some bucks and begin over again. "Uno" method one in Italian and became selected to mark the discharge of Arduino Software (IDE) 1.zero. The Uno board and model 1.zero of Arduino Software (IDE) had been the reference variations of Arduino, now developed to more moderen releases. The Uno board is the primary in a chain of USB Arduino forums, and the reference version for the Arduino platform; for an intensive listing of current, beyond or old forums see the Arduino index of forums [18] The web application requires the following software in Server (computer) and Client (computers)Server-side Requirements Operating System : Windows 7/8, Mac OS 10.8.5Arduino IDE (Programming) Software Requirement for Arduino SOFTWARE REQUIREMEN FOR ARDUINO ,PROTEUS Embedded C programme

II. Conclusion

This paper suggests various methods of wireless ECG monitoring, including Use of Bluetooth, GSM / GPRS, and Zigbee. Each method has its own strengths and weakness. WIRELESS ECG MONITORING WITH BLUETOOTH RISC MSP430FG439 consists of low power consumption, high precision, and excellent functionality through a low power design, high precision sampling, and complete monitoring software, WIRELESS ECG MONITORING WITH BLUETOOTH ARM11 consists of low frequency pulse and random noise have been nullified WIRELESS ECG MONITORING WITH BLUETOOTH RISC ATMEGA16 . gives the awareness of the condition of his or her heart. Much effort has been put into making this device at a low cost out of which all wireless ECG monitoring using ARM11 is I think better because because of low frequency pulse and as all noise is nullified

Wireless ECG monitoring using GSM/GPRS The ARX model is an ECG compression method for efficient transmission of ECG signals over GPRS networks. Wireless ECG MONITORING WITH PORTABLE DATA ACQUISITION CONSOLE (PAC) GSM/GPRS.here information has the advantage of detecting and delivering only obsolete and problematic ECGs, and GSM/GPRS WIRELESS ECG MONITORING WITH PACKET ERROR CORRECTION is configured with low power consumption and is currently The ECG signal of your geographic location is determined in real time by GPS. GSM/GPRS TI COMPANYS MSP430F2418 and SIMCOM COMPANYS Wireless ECG monitoring with SIM300 is received using SIM300 module feedback method, serial port baud rate, number local port, then compressed and continuously sent to hospital monitoring center. Low power consumption model of all this, wireless ECG monitoring with packet level error correction GSM/GPRS consists of low power consumption and real-time operation.

ZIGBEE WEB-BASED WIRELESS ECG MONITORING consists of MAWEMS, which is economical, low-power and portable. Automatically. Wireless ECG monitoring with ZIGBEE ARDUINA/GENUINO consists of one node and can operate freely in an open area of about 20-100 meters and perform ECG measurements wirelessly. First of all, the WIRELESS ECG MONITORING method of the ZIGBEE ARDUINA/GENUINO method above is better because it allows you to work smoothly and accurately in an open space

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