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WIRELESS ECG

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ABSTRACT

In the recent years, world is experiencing high rate of heart diseases. Heart diseases have become one of the leading causes of death and World Health Organization (WHO) states that cardiovascular diseases are the world's largest killers. India has a population of approximately 1.25 billion people, more than one sixth of the world's population and experiencing heart disease as the single largest cause of death in the country with heart attacks being responsible for one third of all deaths caused by heart diseases. Heart attack and stroke are life-and death emergencies. Patients suffering from heart attack have to undergo regular check-up of their heart functioning. It is highly risk taking job, as the patient has to go to hospital for diagnosis. So, in order to wipe out Heart strokes, there is a new emerging technique which is WIRELESS ECG SYSTEM. This wireless monitoring system increases the quality of life of patient and will place a major role in the Future Technology.

Keywords: *ECG, Zigbee, MSP430, Bluetooth, wireless, Cardiac*

1. Proposal:

The aim of this project is to develop a system for monitoring a patient's heartbeat and transmitting the recorded data over the internet, via a wireless router in the patient's home. The data is then stored in a database for viewing and analysis by technicians and ECG analysis software..The objective of the work was to make a simple wireless home electrocardiogram (ECG) transmission system for home and ambulance use. The wireless ECG monitoring system significantly improves the quality of life of the cardiac patients, reflected primarily in the permanent monitoring. In case of an accident, an immediate alarm is being transmitted to the physician. The task has been accomplished by Bluetooth technology, ECG detector and personal computer as monitor.

A portable wireless ECG monitor terminal links to the phone via Bluetooth, and mobile phone establishes communication with the remote monitoring center. The mobile phone connects the monitoring center and the monitoring terminal. The system can apply in the communities or families. The structure of such system which is centered by a mobile phone and portable monitoring terminals. If mobile phone receives a command of collecting ECG signals from the monitoring center, it will transfer the command to the monitoring terminal, which will start to acquire physiological signals of the patient, or if the monitor center wants former ECG data, the phone will send a new command to the terminal, which will begin to upload history data. If the terminal finds abnormal heart rhythm of the patient, it will transfer an alarm to the phone immediately. The moment the phone answers the alarm, it will send danger warning to the monitoring center which is as shown in the Figure 1.

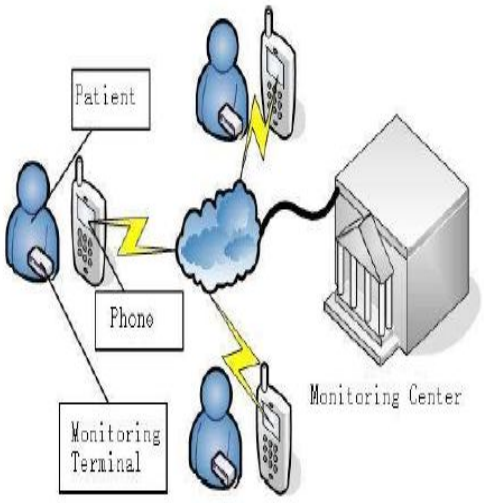

Figure 1: ECG MONITORING SYSTEM

2. ECG System Design:

A design system consisting of a single Master and two Slave network design was incorporated into this project. The master node comprises of the interface to the PC which is responsible for communicating directly with each particular slave. The two slave nodes which are placed on the patient's body to collect ECG data will in turn send data packets through the RF transceivers to the master which will display the ECG information through a graphic user interface (GUI).

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2.1. ECG Master:-

The master ECG node is responsible for receiving the two measured values and combining the information to produce an ECG signal of the patient. Its basic Structure includes a PC connected to the radio transceiver. The Nios Soft-core Processor is used as the interface between the PC and the transceiver. For both master and slave design the Single Chip RF Transceiver, nRF401 which operates at 433MHz is used. Frequency Shift Keying (FSK) modulation and demodulation capabilities are handled with this chip. Figure shows the block diagram of our Master Node.

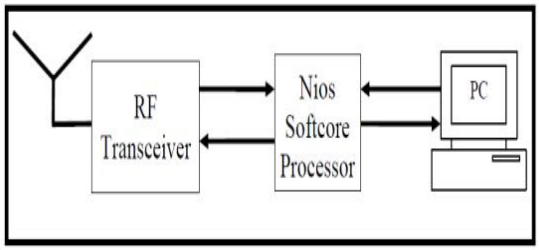

Figure2: Block diagram of Master Node

As explained earlier the master node is designed on a Nios Soft-core Processor and hence this controls the RF transceiver. The code for this processor is written in C and it is responsible for sampling the incoming data and creating the outgoing packets. Furthermore the software is designed such that the master has control over the slave node in terms of transmission slot time. This is executed using the Time Division Duplex (TDD) Scheme. A simple operating system (OS) to handle the different tasks called WSPOS was also considered. Both these concepts are explained in detail later. The ECG Graphical User Interface Program which is created in Visual C++ is used to display the patient's ECG to the user. This software will calculate the received measurements from each slave node and perform signal processing and conditioning on the received measurements from the slave nodes.

2.2. ECG Slave

The ECG slave nodes are placed on the heart of the patient to measure bio potentials which are then transmitted wirelessly to the Master ECG node. The slave node consists of an electrode connected to an amplifier allowing an adequate signal to be transferred. This signal needs to be recognizable by the Baseband Processor and therefore next it is then passed through an Analog to Digital Converter to convert it into a digitized signal. Our design uses a MSP430FG4618. Finally the microcontroller sends the packet via the RF transceiver to the master node using the necessary packet format. A block diagram of the slave node is shown in Figure3

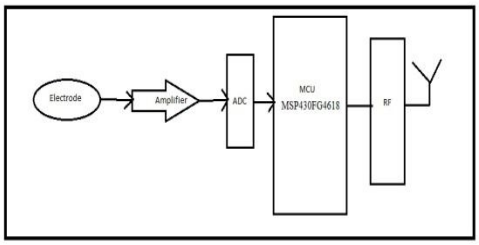

Figure3: Block diagram of Slave Node

The software for the Slave ECG nodes baseband processor (MSP430FG4618) was created in C format, also incorporating an operating system. Periodically, the slave node will sample the patient's body voltage source every 3 milliseconds. This information is then logged into the Flash Memory in the microcontroller. During the slaves transmission slot, which is determined by the packet received from the master, it will extract the stored data and transmit it wirelessly to the master.

3. HARDWARE ARCHITECTURE

Figure presents the hardware architecture of the proposed system, which consists of the microcontroller, ECG signals measurement module, ECG signals storage module and communication module. The functions of the proposed system are as follows:

- Acquisition of real-time ECG signals at 250Hz sampling frequency
- Storage of one hour ECG signals, which also can be expanded according to needs of users;
- ECG signals pre-processing and heart rates calculating. These functions are done in MSP430FG4618
- ECG data transmission mode selection. The monitoring center can choose real-time mode, regular mode or irregular transmission mode
- Alarm function based on heart rate
- Real-time transmission of ECG signals (maximum power)can last more than 24 hours.

Ultralow-power microcontroller MSP430FG4618 of Texas Instruments is served as the controlling and calculating unit. The architecture, combined with five low-power modes, is optimized

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to achieve extended battery life in portable measurement applications. The device features a powerful 16- bit RISC CPU, 16-bit registers, two 16-bit timers, a high performance 12-bit A/D converter and etc. The 12-bit A/D converter digitalizes ECG signals at 512Hz sampling frequency. MSP430FG4618 is the controlling center of the portable wireless ECG monitor, responsible for the overall operation of the system. The microcontroller communicates with the mobile phone, pre-processes ECG signals and calculates heart rates. The specific implementation is depicted as follow. 16M Flash chip MX25L1605DM1I-12G produced MACRONIX is served for ECG data storage module. The microcontroller communicates with Flash through the universal serial communication interface (USCI) in SPI mode. MX25L1605 address range is from 000000h to 1FFFFFh. For purpose of accurate indexing, the Flash memory space is divided into two parts, part A and part B. Part A from 000000h to 004000h is reserved for saving time synchronization data sent by the phone, and time synchronization data is used as the indexes of historical data. Part B from 004000h to 1FFFFFh is reserved for saving the continuous ECG data, and part B is covered after an hour ECG data by cyclic address. The Bluetooth module IDS-BM4A assembled in the terminal is used to communicate with the mobile phone. MSP430 communicates with the external Bluetooth module in UART module. MSP430 receives control words from the mobile phone via Bluetooth in the interrupt service routine.

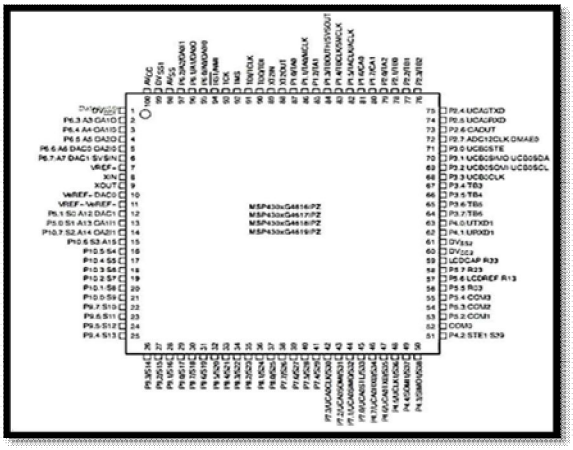

Figure 4: MSP430FG4618

However in the Wireless ECG design the need is for a short range and low power wireless network, and therefore most of the above technologies can be ignored. When deciding upon the wireless protocol, focus is put towards two protocol standards which not only provide a more than convenient replacement for cables, but with their capacity for autonomous interaction and rich functionality, will become increasingly popular in the search for hassle free wireless communication. These are:

- ZigBee
- Bluetooth

3.1 ZigBee:

One of the emerging standards in the move toward a wireless world is an approach called ZigBee. Pioneered by Phillips, it has since formed into an alliance of companies working together to create a wireless communication protocol. The ZigBee stack unlike Bluetooth is relatively straight forward. Like Bluetooth, the ZigBee technology operates in the 2.4 GHz ISM band. The maximum data rate achievable on this technology is 250 kbps. On top of that, it caters for a range of between 10 meters to 75 meters depending on the power consumption required for a given application. The main purpose of this standard is to provide its customers with three main features:-

- Low data rate
- Low power consumption
- Low cost

3.2 Bluetooth

Bluetooth is a pure ad hoc networking protocol used especially for short-range, low power wireless communication radio link between two devices operating in the unlicensed 2.4 GHz industrial scientific and medical (ISM) band. The frequency used is around 2.4.2.483 GHz .The Bluetooth module transmits at 1mW(0 dBm) at a useful data speed of 721 kbps per piconet. It can accommodate up to eight devices per piconet, in which the expected coverage range is around 10 m. In addition, the Bluetooth technology is capable of engaging in several piconets present in the same vicinity in a Time Division Multiplexing fashion. This phenomena, known as scatternet gives Bluetooth a more versatile look. If used in the wireless ECG system, this would provide as easy method of transferring ECG data between doctors and possibly to a central computer to collect data of all patients. The Figure 5 given below shows the block diagram of Bluetooth

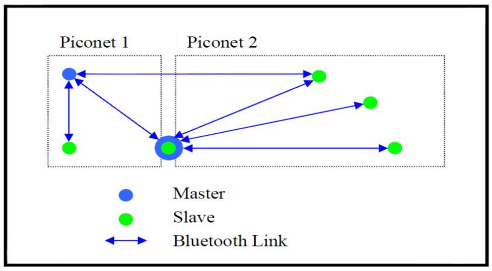

Figure5: Bluetooth

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4. WIRELESS CARDIAC MONITORING SYSTEM

The developed wireless ECG monitoring system has all the good properties of the three mentioned recorders and even the right properties for tele-health. The reasons are as follows: Only through long-term ECG monitoring many cardiovascular diseases are precisely diagnosable, because the ECG system is a vital instrument for monitoring the electrical activity of the heart. Currently it is prone to human error simply because the wires are constantly getting in the way by the medical personnel or the patient himself. The chosen wireless system is Bluetooth. The Bluetooth ECG enables free movement of the patient without unnecessary weight and wires. Also, the wireless ECG monitoring system is very small and compact, and as such enables a comfortable and discrete wearing for the patients. It consists of the wireless-Bluetooth enabled ECG device and the PC. The PC receives the data 24/7, which means that it monitors the ECG of the person the whole time. By allowing the connection of the system to an electronic patient file makes the visit to a physician for delivering the captured data unnecessary. Furthermore, the system allows monitoring troublesome changes of ECG and a fast reaction by medical personnel by sending the alarm via any kind of telephone connection (fixed or mobile), because all data is immediately accessible, which helps an emergency doctor to introduce the right procedure. The wireless ECG monitoring system has several possibilities for an application. Apart from the mentioned case of the application on the patient at home, it is also possible to monitor high risk patients in a hospital, without restriction of mobility. Wireless ECG monitoring system provides accurate measurements of the electrical activity of the heart, which are displayed on a graphic user interface (GUI) that is easy to use and understand. The wireless transmitter itself is low-power, run on one AAA battery. Underneath the electronic components sits a removable and rechargeable battery that powers the device enough to monitor ECG data continuously for one day, or for several days if only monitoring heart rate. The simplified Wireless ECG is as given below Figure6:

Figure6: Wireless ECG in Mobile

Conclusion

Presented system is a preliminary solution for monitoring heart activity of multiple patients. With the development of modern society, the health care becomes more and more community-oriented and family oriented. The developed wireless ECG monitoring system has the advantage over the non-wireless systems due to its every day applicability in preventive, pre-operative, curative or post operative phase. Also, it can be used at home and in ambulatory or hospital settings. Since the ECG system is the vital instrument for monitoring the electrical activity of the heart, and the heart is the vital organ for the human body, it is of tremendous

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importance to be aware that wireless technologies bring us a step forward in development of human race. Remote ECG monitoring system is a community oriented and family- oriented medical model. For heart disease is random and risky, we have designed a portable wireless. ECG monitor terminal can detect real-time signals, send arrhythmia alarms and upload ECG data according to the requirements of the remote monitoring center. With the assistance of remote monitoring center, the patients can acquire good services of 24 hours of ECG monitoring without affecting daily activities.
This system is able to accurately and reliably acquire, transmit, record and real-time display the ECG signal. The key feature of this system is that it consumes significantly less power than traditional wireless medical devices.

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