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Heart Rate Monitoring System Using Wireless Link

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ABSTRACT: Heart rate plays an important role to indicate healthy life of human being.ECG signal is traditional method of measuring and monitoring heart rate. The given design is non ECG technique, uses simple technique to pick up the sound of the heart beat and send the beat signal wirelessly to a computer. The system is a low-cost with a very small size, light weight and easy to use by the patient. A microphone is used to pick up the sound of the heart beat. The signal is processed, sampled and sent wirelessly using ZigBee protocol. Heart beat signals are sensed, sent, displayed, and monitored. PCB can be used to further reducing size and weight of the sensing unit. The device is most useful if it is portable. This requires a battery to be able to power all of the necessary components as well as the power output of the battery to be regulated.

KEYWORDS: non-ECG; heart rate monitor, microphone, ZigBee

I. INTRODUCTION

Heart rate and heart rhythm are used to monitor patients who have symptoms of dizziness, palpitation, presyncope and syncope. Some researchers concluded that an abnormal heart-rate profile during exercise and recovery is a predictor of sudden death. In addition, heart rate profile during activity of daily living is an important indicator of health. The best way to measure heart rate is to use a standard ECG recorder and calculate instantaneous heart rate from R-R interval. Several types of wearable devices called "heart rate monitors" are developed within decades for the purpose of exercise training. One of such device is the 24-hour ambulatory (Holter) monitors. However, in some cases, this measuring technique is not feasible in the field. Motivation of the work is driven by the need for a simple system to continuously monitor the heart beat. The system is designed for ease of use and targeted a special group of patients such as the elderly people who cannot easily put the electrodes on their body. Currently, tele-monitoring of vital sign and physiological activities, in both normal and abnormal situations, is interesting for the purpose of emergency event detection or long term data-storage for later diagnosis or for the purpose of medical exploration.

This data acquisition system is designed to capture heart beat signal of a patient. The sensor senses the heart beat, collects and sends the beat signals over a wireless link to a data base. Heart rate is measured by using heart rate sensor. By using phonocardiogram as heart rate sensor one can listen heart sound which is used to calculate heart rate. The phonocardiograph is an instrument used for recording the sounds connected with the pumping action of the heart. This sound s provides an indication of heart rate and its rhythm city. They also give useful information regarding effectiveness of blood pumping and valve action. The phonocardiograph provides a recording of waveforms of heart sound. These waveforms are diagnostically more important and revealing than sounds themselves.

A. Origin of Heart Sound

The sounds are produced by mechanical events that occur during the heart cycle. These sounds can be from movement of heart wall, closure of walls and turbulence and leakage of blood flow. The first sound, which corresponds to R wave of the ECG, is longer in duration, greater in intensity, lower in frequency than second sound. The sound is produced principally by closures of valves between the upper and lower chamber of heart. The closure of mitral and tricuspid valve contributes largely to the first sound. The frequency of these sound are in range of 30to100Hz and duration is between 50 to 100ms.The second sound is Higher in pitch than first, with the frequency above 100Hz and duration between 25 to 50 ms. This sound occurs at the closure of aortic and pulmonic valves.

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II. SYSTEM DESIGN

The system includes a bandage size heart beat sensing unit, a wireless communication link, and a networkable computer and a data base, as shown in fig 1. The sensing unit is low power device, small size to give an ease of use and a high degree of freedom in movement to the patients who wear the device.

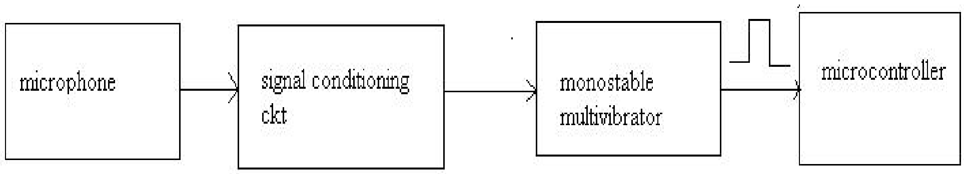

Fig 1. System Block Diagram

A. Microphone:

Microphone is the basic part of the phonocardiograph. Microphone is device which converts mechanical vibrations at the body surface into electrical signals suitable for recording. It is used to listen the sound of heart to the skin. The microphone is mounted in the circuit board and taped on the skin at the heart location. The sound of heartbeat will be picked up, amplified and filtered. Microphone used is low cost electrets condenser type having a flat response from dc to 10 KHz. Two types of microphones are commonly in use for recording phonocardiogram. They are the contact microphone and air coupled microphone. They are further categorized in to crystal type or dynamic type based on their principle of operation. The crystal microphone contains a wafer of piezoelectric material, which generates potentials when subjected to mechanical stresses due to heart sounds. They are smaller in size and more sensitive than dynamic microphone. The dynamic type microphone consists of a moving coil having fixed magnetic core inside it. The coil moves with heart sound and produce voltage because of its interaction with the magnetic flux.

Fig 2.Electret Condensor Microphone

B. Amplifier:

The amplifier used for phonocardiograph has wide bandwidth with frequency range of about 20 to 2000Hz. PCG amplifiers usually have gain compensation circuit to increase the amplification of high frequency signals, which are usually of low intensity. In general, high frequency component of cardiovascular sound have a much smaller intensity than the low frequency component and that much information of medical interest is contained in high frequency part.

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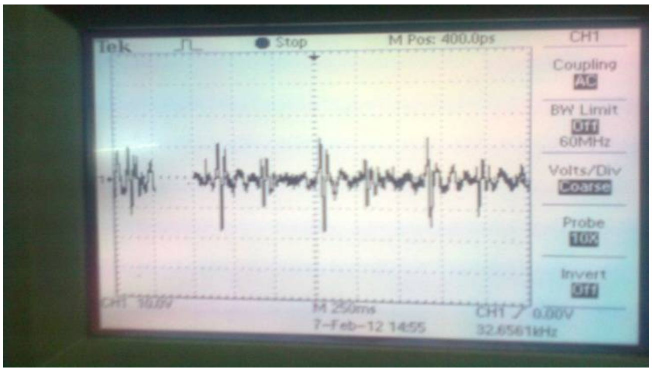

Fig 3. Analog Output of Heart Sound

C. **Monostable multivibrator**:

A mono-stable circuit using a timer IC is used to capture the edge of the heart beat signal. The timer generates a digital signal (pulse) corresponding to every beat of the heart. The heart beat signal in analog form can be very noisy and the echo from the sound of the beat picked up by the microphone can trigger the mono-stable circuit which causes error. The ON-time of the timer circuit is designed to eliminate such mishap (i.e., providing only one pulse per beat). This ON-time is determined by a time constant of an RC circuit connected to the 555 timer. The time is set to be T=1.1RC=200ms. This time covers the mishap for a maximum number of 200 beats per minute.

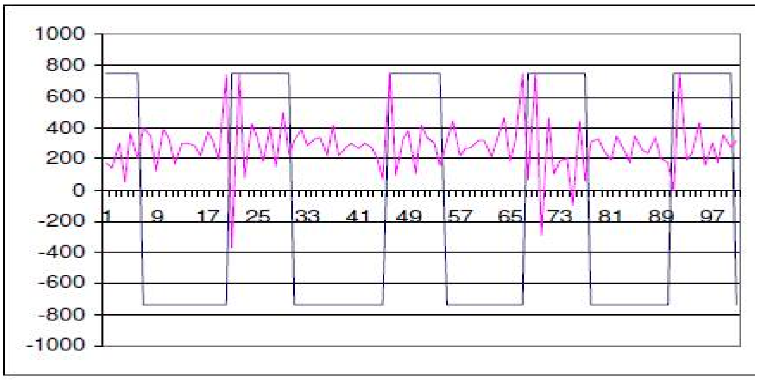

Fig 4. Digital output corresponding to each heart beat

D. **Microcontroller:**

The Processor used is AT89S52.The AT89S52 is a low power, high performance CMOS 8-bit microcontroller with 8K bytes of in system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU within system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly flexible and cost effective solution to many embedded control applications. The AT89S52 provides the following standard features:

8K bytes of Flash

256 bytes of RAM,

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32 I/O lines,

Watchdog timer,

two data pointers,

three 16-bit timer/counters,

a six-vector two-level interrupt architecture,

a full duplex serial port,

On-chip oscillator and clock circuitry.

In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

E. Wireless Communication

Wireless communications is the transfer of information between two or more points that are physically not connected.The wireless communication in the system is implemented using ZigBee technology. ZigBee is simple, less expensive IEEE 802.15.4 Standard developed for Short range, Wireless Networks such as Wireless Personal Area Network (WPAN) and Home Area Network (WHAN).

Key Features of ZigBee:

Short Range approximately 50 m Low cost

Consumes Low-power Targeted at radio-frequency (RF) Range - 860 MHz to 2.4 GHz

Uses a low data transfer rate Wireless Mesh Networking

The low power requirement assures longer life with smaller batteries.

The mesh networking provides high reliability and more extensive range.

The ZigBee module used is of MAX stream, Xbee. Its frequency is 2.4GHz with output of 1-63mW.Its range is 30m to 1.6km with data rate of 250Kbps. It is three layer models. Network and Application support Layer, Physical Layer, and Media Access Control Layer. Figure 8 shows the mapping of ZigBee protocol on the ISO-OSI seven layer models.

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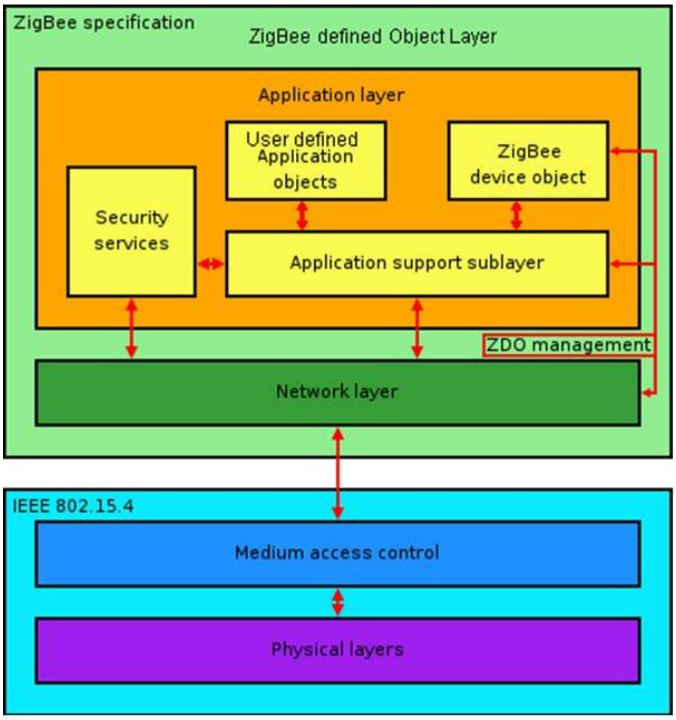

Figure 5. Mapping of ZigBee Protocol on seven layer model

The Data enters as an asynchronous serial signal. Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The module Universal Asynchronous Receiver Transmitter, (UART) performs tasks, such as timing and parity checking, that are needed for data communications. Serial communications depend on the two UARTs to be configured with compatible settings (baud rate, parity, start bits, stop bits, data bits).Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure 5 below. Data enters the module UART through the DI pin (pin 3) as an asynchronous serial signal. The signal should idle high when no data is being transmitted.

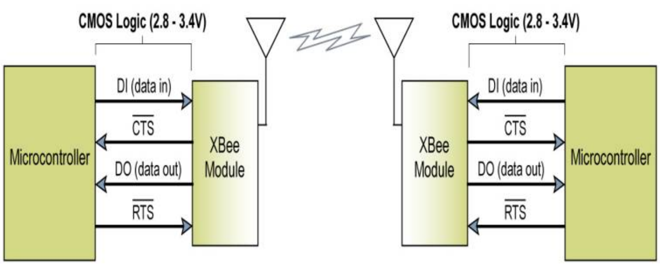

Fig 6. System Data Flow Diagram in a UART-interfaced environment

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IV. RESULTS AND CONCLUSION

Microphone pick up heart sound and convert it in to electrical signal. This signal is amplified then converts it in to digital signal using timer IC. These pulses are counted by microcontroller and count is transferred to personal computer by using wireless link. Following figure shows actual heart rate sensor.

Fig 7. Heart Rate Sensor

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