

Zigbee based Heart Rate Monitoring System for Premature Babies

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Abstract-- The project prototype proposes a novel method of measuring the heart rate of premature babies using Zigbee technology. This heart rate monitoring system can be used in hospitals where heart rate has to be monitored continuously over a long period of time. CC2520 offers low power consumption, low cost, high battery life, less interference with other wireless devices and hence is ideal for heart rate monitoring systems. It is capable for remote monitoring and is less expensive than other heart rate monitors available in the market which use Bluetooth technology. The project has overcome major problems like power consumption, flexibility and mobility. In this project, Zigbee aims at upgrading heart monitoring systems such as ECG. The Zigbee wireless network is used to monitor the heart rate of premature babies kept in different locations meters apart. The first stage is to collect the heart pulse and convert it to an acceptable range of the microcontroller (i.e.) conversion of analog input into samples or digitized output to be fed to the microcontroller. How the 8051 microcontroller is used in the computation module forms the second stage. The third stage is the communication module, which is realized through the Zigbee protocol stack to enable the wireless transmission. The low power and highly efficient CC2520 EMK Zigbee module acts as a communication module. Finally, the data collected from the process is to be monitored at the remote location.

I. INTRODUCTION

The domain of the problem chosen is biomedical. This domain inspired much because of the concern for the premature babies as it is very crucial to have a constant look on the development of a premature baby. According to a report published recently by THE HINDU, India has the highest number of deaths due to premature births, and ranks 36th in the list of pre-term births globally. The ranking included 199 countries. Of the 27 million babies born in India annually (2010 figure), 3.6 million are born prematurely, of which 303,600 don't survive due to complications. The baby needs to receive special care in the NICU before he/she is able to go home. Sometimes, the babies may have to be kept in the incubator, nourished intravenously and placed on oxygen. Currently most hospitals use ECG (Electrocardiography) for monitoring a baby's heart rate. However, a reliable remote monitoring system is usually absent. This project proposes a solution to upgrade existing health monitoring systems in hospitals by providing remote monitoring capability. This solution may be applicable to any kind of patients apart from premature babies. For example, monitoring the vital

information such as heart rate, blood pressure, etc of the inmates of an old age home could be a potential application. Using this remote heart beat monitoring with wireless technology, hospital staff can be alerted well in advance thus preventing near deaths.

II. BACKGROUND

A wireless heart rate monitoring system was developed by T.W.Nam et al. for rehabilitation patients who are taking physical therapy inside a rehabilitation center. A monitoring system that can monitor patient's heart rates so that it gives physical therapist early warning if necessary. The PSD was designed to be wearable and low power consumption. The CMS was designed to monitor multiple patients simultaneously and generate a warning signal if necessary. They used the RF module based on the Nextronics's NEXAR_3A (receiver) and NEX-AT-3A (transmitter) for communication between PSD and CMS. Then the information was passed to the PC through RS-232C interface. The communication speed was found to be slow. Junho Park et al. also proposed the similar approach replacing the wireless network with Zigbee. Jovanov et al. developed a Wireless Body Area Network of Intelligent Sensors for Patient Monitoring using standard ZigBee compliant radio and a common set of physiological, kinetic, and environmental sensors. Though the solutions were suggested earlier itself they did not prove to be successful either due to their cost involved or efficiency. So this project has achieved in terms of both these parameters.

III. SYSTEM OVERVIEW

A. Proposed Solution

The block diagram of the proposed solution is shown in Figure 1. The first block in the figure emphasizes the analog ECG signal obtained from the signal conditioning unit. This is fed as input to the 8051 microcontroller that is programmed via Keil μ Vision IDE and loaded by SPI Flash Programmer after being converted to digital input. This incorporates the logic to count the number of pulses. This count is immediately transmitted through the ZigBee module to another 8051 microcontroller which is assumed to be the central coordinator.

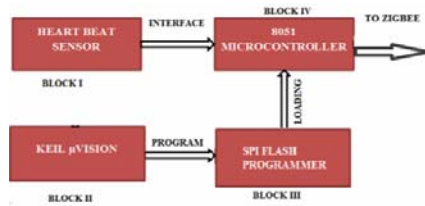


Figure 1 Block diagram of the solution

The over-all stage by stage block diagram of the proposed solution is shown in Figure 2.

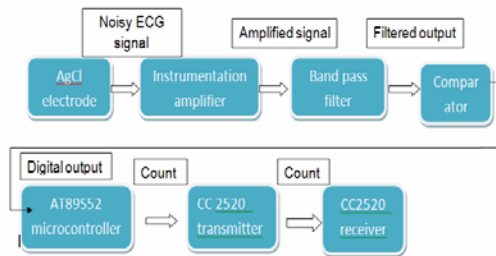


Figure 2 Stage by stage block diagram of the proposed solution

The first block gives the noisy ECG signal from the silver chloride electrode used, to the instrumentation amplifier INA128. It is designed to a gain of 30. The amplified output is passed to a band pass filter that is implemented as cascade combination of second order high pass filter and third order low pass filter. The cut-off frequency of the low pass filter is 150Hz and that of the high pass filter is 0.3Hz. This filtered signal is fed to the comparator that gives a digital output which is given as input to the AT89S52 microcontroller. It is programmed with the suitable logic to count the number of pulses by counting the number of peaks and transmitting them via CC2500 ZigBee module. It is in turn received by another ZigBee module that acts as the receiver it is assumed to be the central coordinator.

IV. IMPLEMENTATION

This section is divided into hardware and software implementation. Each individual modules are explained below.

A. Hardware Implementation

The hardware used for the implementation includes

- INA128
- TL082
- Zigbee module
- AT89S52 Microcontroller

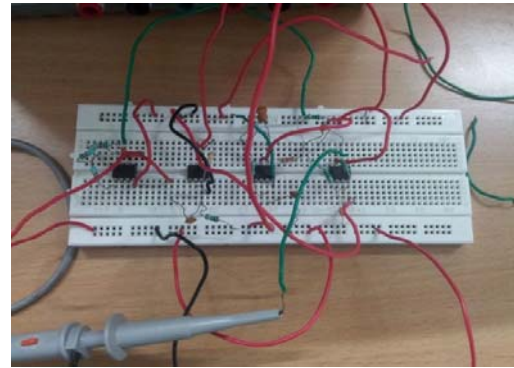


Figure 3 Hardware schematic

An instrumentation (or instrumentational) amplifier is a type of differential amplifier that has been outfitted with input buffers, which eliminate the need for input impedance matching and thus make the amplifier particularly suitable for use in measurement and test equipment. INA128 is being used because it is a low power, general purpose instrumentation amplifier which offers high precision. The hardware schematic of the entire setup is shown in figure 3. The signal from electrode on the left arm is given as input to the inverting terminal and the right arm electrode signal is given to the non-inverting terminal. The right leg is placed on the ground for grounding the circuit. The input is as obtained in the CRO as shown in the Figure 4.



Figure 4 Input from the silver chloride electrode

It can provide a wide variety of gain between 1 and 10000. Also since it has very low internal noise the IC does not contribute to the noise in the ECG signal.

The second component used in this stage is TL082 that is used as a band pass filter which is nothing but a high pass and low pass filter connected in cascade. The cutoff frequencies of the high pass and the low pass filter are calculated in such a way that the bandwidth is approximately equal to 140Hz. The filter is a fifth order filter which is constructed using 3 ICs with the first IC as second order high pass filter, the remaining 2 ICs as 2nd order and 1st order low pass filters. The output after the filter is obtained as seen in the CRO as shown in the figure 5.

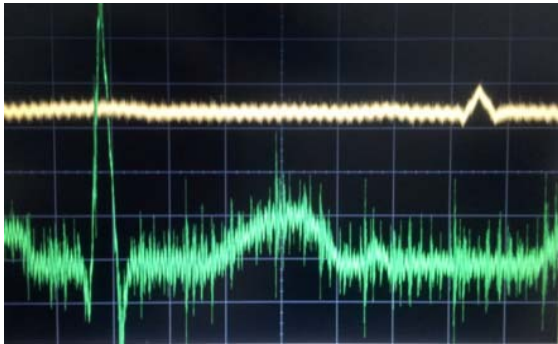


Figure 5 ECG signal obtained after the signal conditioning unit

B. Software Implementation

The algorithm that is used in the logic developed in the AT89S52 microcontroller using Keil μ-Vision is described in Figure 6.

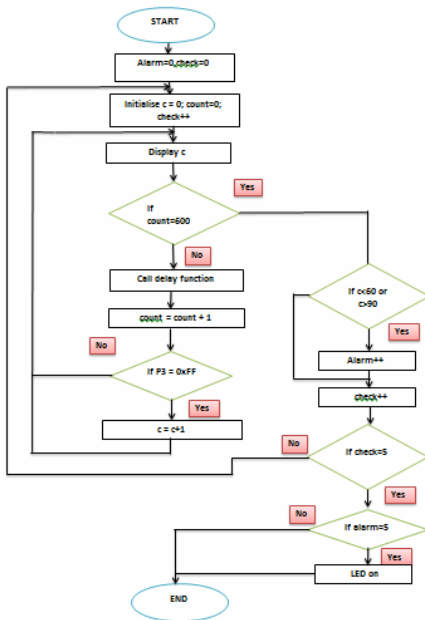


Figure 6 Flowchart of the algorithm implemented

1. First, c (which is the heart rate count) initialised to 0. Count (which is used to count till 60 seconds) is set to 0.
2. Display c continuously.
3. Check if the count reaches 600 (delay unit is for 0.1 seconds. 600*0.1 = 60 seconds). When it reaches 600, jump to step 8.
4. Call delay function.
5. Count incremented by 1.

6. If port P3 = 0xFF (i.e. high), c (heart rate count) incremented by 1.
7. Jump to step 2.
8. End.

This logic is implemented in Keil μ-Vision IDE and programmed through SPI Flash Programmer. Then the count alone is transmitted via ZigBee to the central coordinator. The results thus obtained are discussed in the next section.

V. EXPERIMENTAL RESULTS

The heart rate monitor designed was used to measure the heart rate of 5 persons. The count was displayed in the 7-segment display and the comment was passed in the LCD as whether it was normal or abnormal. The results obtained were tabulated in Table 1.

Table 1 Recorded Heart Rate of 5 persons

NAME	HEART RATE	COMMENT
A	66	Normal
B	72	Normal
C	68	Normal
D	59	Bradycardia
E	71	Normal

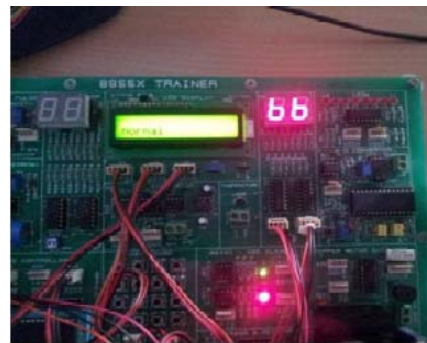


Figure 7 Output for a subject

Figure 7 shows the output obtained from the microcontroller for a subject. The count is displayed as and the condition is termed to be “normal”.



Figure 8 Overall Setup

Figure 8 shows the count being transmitted via the ZigBee module to another ZigBee module, assuming it to be the central coordinator. This way, intimation can be given to the doctor.

VI. RESULTS AND DISCUSSIONS

The goal of the project was to design and implement a heart rate monitor that would be handy, cost effective and simple to use in comparison with the existing methods to measure the heart rate using pulse count. This has been implemented using a signal conditioning unit, AT89S52 micro controller and cc2520 ZigBee module. The results so obtained have been enclosed.

A ZigBee network based wireless heart rate monitoring system for rehabilitation patients who are taking physical therapy inside a rehabilitation center is the future scope of the project. The main focus of this study is to develop an unconstrained monitoring system

that can monitor patients' heart rates continuously so that it gives physical therapist early warning in real time if necessary. A small scale implementation of the project is being implemented presently. A prototype model is developed. A large scale implantation may include a number of wireless setups similar to the one discussed above and thus the heart rate monitor can be implemented on a large scale with low power consumption. The results so obtained need to be consolidated and sent to the concerned individual in the hospital to monitor the condition of the patient continuously and emergency situation if any can be attended to.

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