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DESIGN OF A MICROCONTROLLER BASED DIGITAL HEART BEAT RATE MONITOR

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Abstract- *Heart is one of the most vital organs that circulates oxygen and nutrient carrying blood around the body in order to keep it functioning which is very important to diagnosis some heart diseases. When the body is exerted the rate at which the heart beats will vary proportional to the amount of effort being exerted. The aim of this paper is to implement a Digital Heart Beat Rate Monitor system based on a Microcontroller and output in LCD as a display unit. A circuit with microcontroller is designed which would measure the heart rate. It explain how a single-chip microcontroller can be used to analyze heart beat rate signals in real-time by measuring voltage according to the pulses of the heart. A display of the heart rate will be obtained by measuring the time between signal peaks and then calculating the frequency of the peaks in units of beats per minute.The main feature of this device is portability, minimize in size, easy to operate and affordable. So the patients can measure their pulses without the help of any experts when necessary with high accuracy for better medical treatment*.

Keywords: Heart Beat Rate Monitor, Microcontroller, ECG, ADC, LCD.

1. INTRODUCTION

A real-time algorithm has been developed for the simultaneous measurement of the fetal and maternal heart rates from the abdominal signal, which was sampled with 13-bit resolution at 500 *Hz* [1] where a microcontroller based system has been developed and the proposed algorithm implemented in real-time. Early diagnosis for heart disease is typically based on tape recording of Electrocardiogram (ECG) signal which is then studied and analyzed using a microcomputer. Monitoring the heart rate signal the display function as monitor was developed for ambulatory abdominal ECG recorder [2]. A PIC17C44 (Microchip Technology Inc.) microcontroller based system has been developed to test the possibility of performing the above functions with the ECG signals recorded from the abdomen of pregnant women containing different signal conditions [3]. Again embedded-type noncontact bio-radar heart and respiration rate monitoring system was proposed at [4] where ADC was implemented for de offset measurement.

The 8-bit microcontroller-based transmitter digitizes the preconditioned ECG and identifies the signal in real-time using a robust QRS detection algorithm. Data is output from the microcontroller only when an abnormal heart rate or low battery voltage is detected. They tried to show the receiver and transmitter unit as a biotelemetry system and finally result output exhibited by the appropriate alarms [5].

A long-term study of ECG signal during everyday activity is required to obtain a broad spectrum of heart disease categories based on heart rate changing. Many techniques have been implemented, such as the use of a minicomputer in intensive care to observe patients or microprocessor-based card in portable system. In this case, the disadvantage is the restriction of patient movement. Tape systems for recording ECG signals are bulky, heavy and prone to mechanical failure. In addition, these systems need large batteries. In order to reduce the size, weight and power consumption of the system, a single chip Reduced Instruction Set Computer architecture microcontroller was chosen.

2. OBJECTIVE

a) A circuit with microcontroller is designed which would measure the heart rate.
b) A program is written by which heart rate can be calculated.
c) Finally display the measured output in a digital display

3. GENERAL OVERVIEW

By detecting the voltage created by the beating of the heart, its rate can be easily observed and used for a number of health purposes. 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. The implementation of the heart rate monitor involves low

cost amplifier and filter components coupled with a sophisticated microcontroller and LCD screen. First of all the signal that comes from human body is amplified and filtered then the signal comes to microcontroller with an analogue to digital convertor and finally the LCD display shows heart rate the in units of beats per minute. A blog diagram is shown in fig.3 of measuring heart rate.

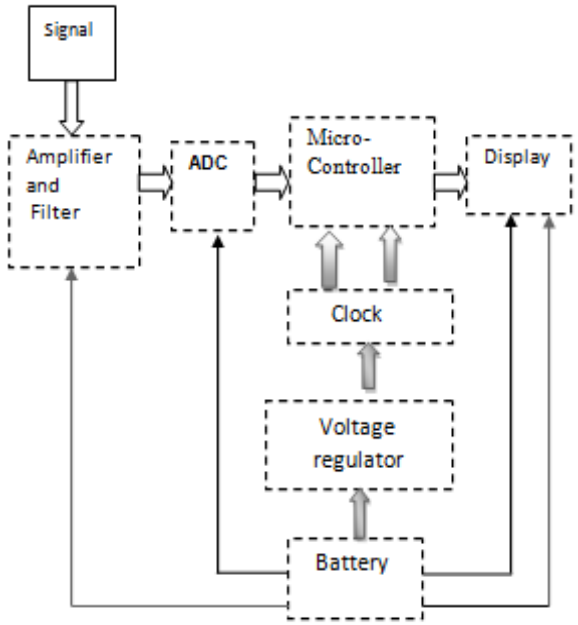

Fig.3: Heart Rate Monitor Working System Diagram

4. RESEARCH MODEL

To make a digital heart beat rate monitor where at first the model was developed through some analysis. All the equipment was selected based on the project work. The equipment that was used in this project is divided mainly into two sections.

4.1 In Control Section

It included mainly with microcontroller .A PIC16F72A model is used to get as input pulse of regulated voltage using variable resistance (VR). Pin diagram and manual feature of PIC16F72A is available at [9]. In fig.6 it shows the output to the LCD monitor as display unit by compiled program into it.

4.2 In Electrical Section

It consists with crystal oscillator, resistors, variable resistance (VR), LED, pushbutton switches, voltage regulator (7805), capacitors, transistor, bread board, LCD displays. Researchers also checked with voltage regulator 7805 for supplying 5 volts continuously supply for switching voltage of microcontroller and also with adapter for same purposes.

5. CONTROL DEVICES

5.1 Microcontroller

Microcontrollers are purely digital devices which work on logic0 and logic1 voltages; still they are widely used for analog signal processing. There are specialized signal processors chips available which are custom made for particular applications; however a general purpose microcontroller is more than enough for small kind of signal processing applications like audio signal input and output. The microcontroller can read the analog input voltage by sampling it and converting it to their digital values. The Analog to Digital Converter (ADC) available in almost all the microcontrollers help in this task.

Developing a PIC microcontroller based project simply takes six steps:

1. Type the program into a PC
2. Assemble the program
3. Optionally simulate the program on a PC
4. Load the program into microcontroller program memory
5. Design and construct the hardware
6. Test the project

5.2 Power Supply

The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. This project needs 5V power supply which is vital for the microcontroller circuit and 12V is the main supply for my projects. We had to use an IC7805 in this circuit which is available at [6, 7, and 8]. This is a regulatory type IC that has two purposes: it removes pulsation and also gives 5V output.

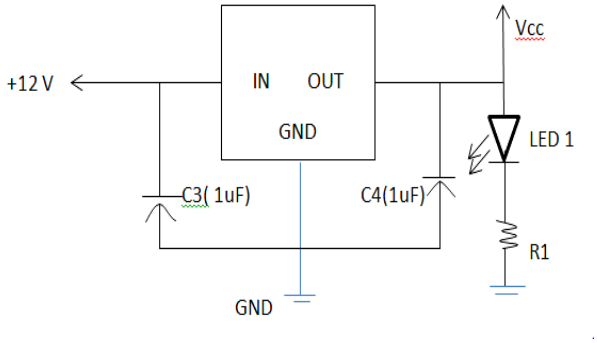

Fig.5.2: circuit diagram of VR 7805

When the switch is turned ON, the 12V supply will go into the VR regulator and O/P of the regulator from the third pin is a constant 5V supply which is very important to the microcontroller from damages. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

Table 1: Pin configuration

Pin No	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

5.3 Analog to Digital Converter (ADC)

The PIC is required to receive an analog voltage from the voltage divider circuit. In this project the build in of ADC in PIC 16F72A [9] is chosen because it is easier to use and less circuitry is needed. As the resistance is changed, the voltage at the analog to digital converter input is varied, which changes the digital value of the ADC. The

analog-to-digital (A/D) converter module has five inputs for the PIC16F72. A timer can be used to generate the sampling time period. The sampled values can then read and modify by the microcontroller. The modified signal is then output by the microcontroller in the form of Pulse Width Modulated (PWM) waves. Most of the microcontrollers have the PWM module which helps them in generating analog voltage output at an external device.

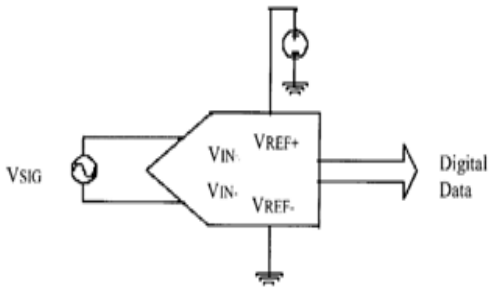

Fig.5.3: Basic ADC measurement circuit

5.4 LCD Interfacing as a Display Unit

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments. The reasons being LCDs are economical, easily programmable.

5.4.1 Pin Description for LCD

Table-2**:** Function of LCD

Pin No	***Function***	***symbol***
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7-14	8-bit data pins	DB0- DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground(0V)	Led-

6. CIRCUIT DIAGRAM OF A HEART RATE MONITOR

Simulation of our complete project displayed in **fig.6** which was written in Proteus and circuit design application software by micro C language [11]. Operational amplifier is used. We used LM-324 module for this purposes where four individual Operational Amplifier circuit is installed with two input and one output port. It is used in control section to get proper tuning voltage from input signal as D1, D2 LED BIRG hardware devices.

Microcontroller synchronize the tuned signal according to command of installed program into it. The program for digital heart beat rate monitor is available at in [10] and operating frequency was set as 20 MHz crystal oscillator. As it is compiled with 3 input/output ports PORTA, PORTB, PORTC, the output for LCD monitor selected from PORTB. A infrared diode was taken for receive the bit from blood circulation which transmit the signal to infrared (IR) receiver. It's happen just by only soft touching on this electronic device shown in fig.7.2. It is important to note that there is only receiver infrared diode was used. Circulations of blood act as a single infrared transmitter.

7. EXPERIMENTAL SETUP

Our complete setup was installed in bread board as skeletal form in fig.7.1 and fig.7.2 with accessories before final fabrication. This project needs 5V power supply which is vital for the microcontroller circuit and 12V is the main supply for my projects. VR7805 provides 5V regulated power supply.

When the switch is turned ON, the 12V supply will go into the VR regulator and O/P of the regulator from the third pin of it is a constant 5V supply which is very important to the microcontroller from damages. Capacitors of suitable values can be connected with input and output pins depending upon the respective voltage levels.

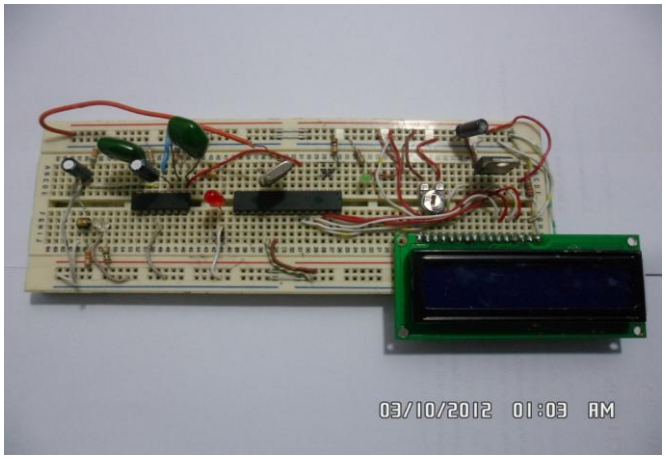

Fig.7.1: Bread board circuit with LCD

It is used in control section to get proper tuning voltage from input signal. Researchers had to used LM-324 module for this purposes where four individual Operational Amplifier circuit is installed with two input and one output port.

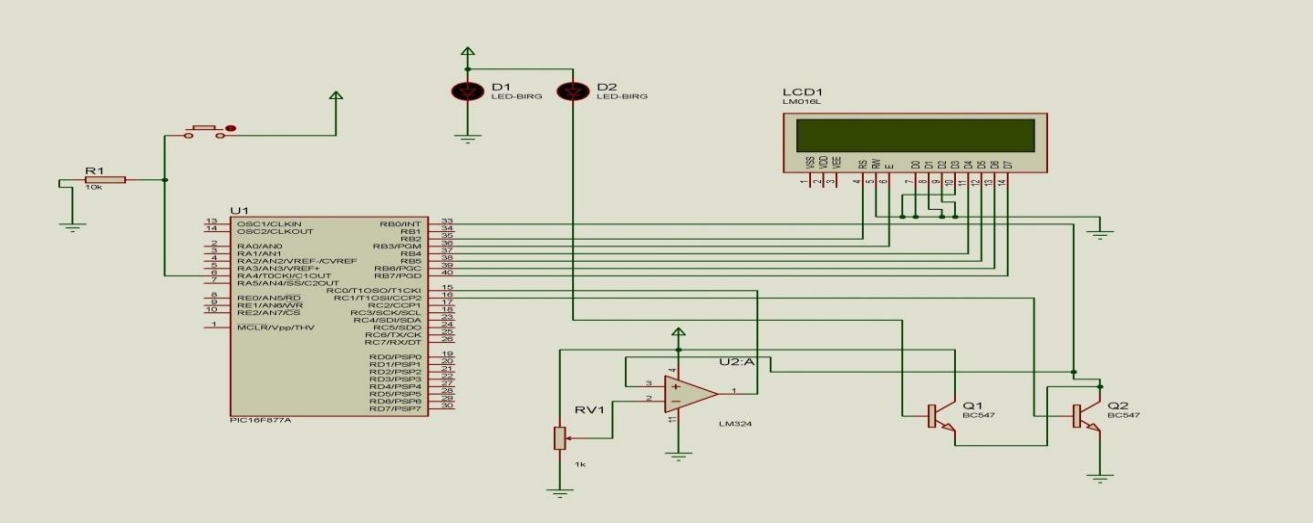

Fig.6: Bread board circuit diagram.

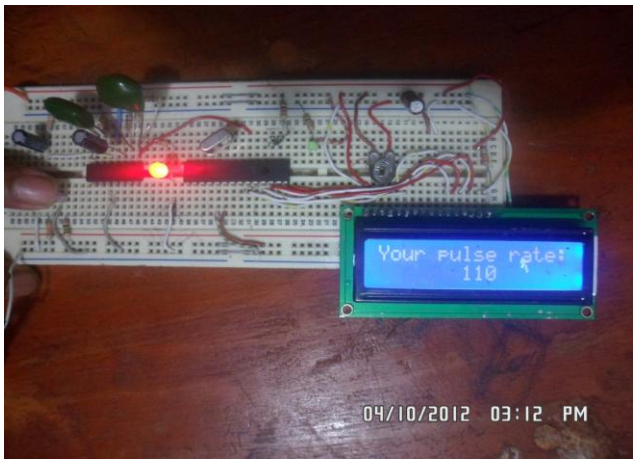

Fig.7.2: Bread board circuit with pulse output

8. RESULT AND DISCUSSION

For the purpose of implementation of a heart rate monitor we needed to study about sensor, analogue to digital convertor, voltage regulator, microcontroller and other related components.

Table-3: Manual reading Vs. Digital reading of heart beat per minute

Time	Manual reading of heart beat per minute	Digital reading of heart beat per minute	Error
7 am	76	80	5.26%
12 am	90	95	5.56%
4 pm	88	100	12.0%
6 pm	92	100	8.69%
10 pm	78	90	15.38%

There is some variation in manual reading and digital reading of heart beat rate. Infect we can say that of two the manual reading is more perfect. The variation occurs due to various reasons such as voltage variation, loose connection and incorrect placement of finger in the circuit board.

9. CONCLUSION

The implementation of a heart monitor involves low cost amplifier and filter components coupled with a sophisticated microcontroller and LCD screen. In this method, the overall diagnosis time and the amount of data handled is also minimized. The real-time decision is taken to inform the patient on his heart rhythmic conditions. The programmable methodology employed in the design also allows others biomedical signals, such as breathing rate and patient movements to be transmitted. Final goals of this project are reducing the hospitalization and assistance costs. Later it's our wish to research on it and to improve it.

10. ACKNOWLEDGEMENT

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