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PORTABLE HEART RATE METER

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Abstract— ***The design and implementation of a portable microcontroller based heart rate meter system is discussed in this project. The design considerations for this project are mostly influenced by the proposed users of the system. These users are medical practitioners in developing countries, who have very limited medical infrastructure. Hence, low cost, low power, portability, and ease of use are factors that are considered at every stage of the design. This system explores a low power microcontroller, the AT89C2051, manufactured by Atmel Instruments for signal analysis. This is a compact system capable of acquisition, amplification, and interpretation of biological signals (ECG), as well as notification whenever cardiac conditions such as tachycardia and bradycardia are experienced.***

Tachycardia is a resting heart rate more than 100 beats per minute. This number can vary as smaller people and children have faster heart rates than average adults. Bradycardia is defined as a heart rate less than 60 beats per minute although it is seldom symptomatic until below 50 bpm when a human is at total rest. Trained athletes tend to have slow resting heart rates, and resting bradycardia in athletes should not be considered abnormal if the individual has no symptoms associated with it. Again, this number can vary as children and small adults tend to have faster heart rates than average adults.

Keywords—microcontroller, heart rate meter

I. INTRODUCTION

Heart rate can be measured either by the ECG waveform the finger (pulse method). The blood flow into the finger (pulse method). The pulse method is simple and convenient. When blood flows during the systolic stroke of the heart into the body parts, the finger gets its blood via the radial artery on the arm. The blood flow into the finger can be sensed photo electrically.

To count the heart beats, here we use a small light source on one side of the finger (thumb) and observe the change in light intensity on the other side. The blood flow causes variation in light intensity reaching the light-dependent resistor (LDR), which results in change in signal strength due to change in the resistance of the LDR.

The most functional indicator of cardiac activity is the Electrocardiogram (ECG or EKG). The electrocardiogram is a quasi-periodical, rhythmically repeating signal synchronized by the function of the heart, which acts as a generator of bioelectric events. Electrical signals from the heart characteristically precede the normal mechanical function and monitoring these signals has great clinical significance. The ECG provides valuable information about a wide range of cardiac disorders such as the presence of an inactive part (infarction) or enlargement of the heart muscle.

An electrocardiogram (ECG) is a graphical trace of the voltage produced by the heart. There are 5 identifiable features in an ECG trace which corresponds to different polarization stages that makes up a heartbeat. These deflections are denoted by the letters P, Q, R, S and T.

By detecting the R peaks and measuring the time between them the heart rate can be calculated and then displayed.

A persons heart rate before, during and after exercise is the main indicator of their fitness. Measuring this manually requires a person to stop the activity they are doing in order to count the number of heart beats over a period of time. Measuring the heart rate using an electrical circuit can be done much quicker and more accurately.

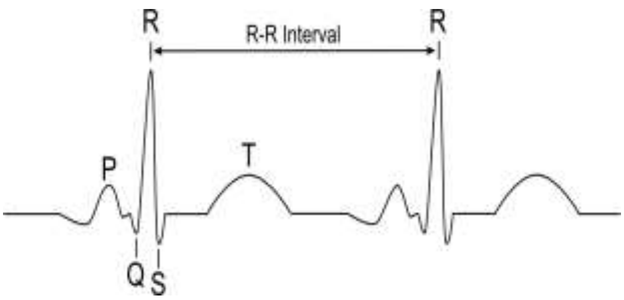

Fig: 1.1.2 ECG signal

HR = 1,500/RR interval in millimeters, HR = 60/RR interval in seconds, or HR = 300/number of large squares between successive R waves.

Worldwide, coronary heart disease, the most common type of heart disease, claims over 7 million lives every year. Up to half of these deaths occur even before emergency services can step in to intervene. In countries without a healthcare system as sophisticated as that of the United States, this number is much closer to 100%.

The goal of this project is to create an ECG monitoring and alert system that can detect cardiac abnormalities such as tachycardia, bradycardia and possibly other arrhythmias. The design of this system was greatly influenced by a specific set of users, and hence, was tailored towards them and their environments.

A portable system equipped to monitor heart rhythms would serve as a means for exposure of possibly

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fatal cardiac activity and would be a very useful product. Most places have little to no infrastructure, and there is a lack of basic amenities such as water, food, electricity, hospital - things that come standard in the western world. Since there is no reliable source of constant power supply, and there is a lack of medical equipment, this project focuses on the design of a portable, low power, and low cost alternative to the sophisticated cardiac monitoring systems that are found in most hospitals. These systems would be easy to operate, easy to transport and would be used to monitor admitted patients in these areas; patients who unfortunately can't afford the luxury of accommodation in the few well equipped hospitals that exist in their locale.

This device would also prove invaluable in a war zone. Injured soldiers close to the front line may need cardiac monitoring at the on-site medical facility. In a situation like this, where there is need for something portable, inexpensive, and reliable, this system will be able to provide some level of temporary cardiac monitoring.

II. PROJECT DECRIPTION.

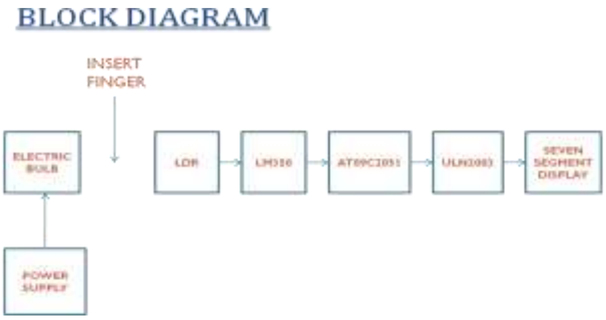

Fig 2: Block Diagram

- A 6V electric bulb for light illumination of flesh on the thumb behind the nail and the LDR (Light Dependent Resistor) as detector of change in the light intensity due to the flow of blood.
- The photo-current is converted into voltage and amplified by operational amplifier IC LM358 (IC1). The detected signal is given to the non-inverting input (pin 3) and its output is fed to another non-inverting input (pin 5) for squaring and amplification.
- Output pin provides detected heartbeats to pin 12 of the AT89C2051 microcontroller.
- Microcontroller evaluates time between peaks and heart rate is obtained which is then converted from hex to bcd.
- The bcd value is given to seven segment displays through ULN2003 which is used for driving displays.
- Transistors as switch is used for selecting the displays either ON/OFF.

Microcontroller IC AT89C2051 (IC2) is at the heart of the circuit. It is a20-pin, 8-bit microcontroller with 2 KB of Flash programmable and erasable read-only memory (PEROM), 128 bytes of RAM, 15 input/output (I/O) lines, two 16-bit timer/counters, a five-vector two-level interrupt architecture, a full duplex serial port, a precision analogue comparator, on-chip oscillator and clock circuitry. Port-1 pins P1.7 through P1.2, and port-3 pin P3.7 are connected to input pins 1 through 7 of IC ULN2003 (IC3), respectively. These pins are pulled-up with 10-kilo-ohm resistor network RNW1. They drive all the segments of the 7-segment display with the help of inverting buffer IC3

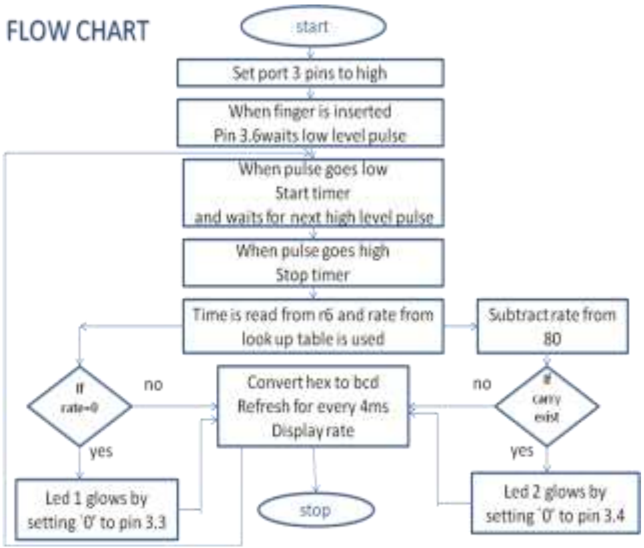

Fig 3: Flow Chart

The displays are selected through port pins P3.0, P3.1 and P3.2 of the microcontroller (IC2). Port pins P3.0 down through P3.2 are connected to the base of transistors T3 through T1, respectively. Pin 6 of IC2 goes low to drive transistor T1 into saturation and provide supply to the common-anode pin (either pin 3 or pin 8) of DIS1.

Similarly, transistors T2 and T3 drive common-anode pin 3 or 8 of 7-segmentdisplays DIS2 and DIS3, respectively. Only three 7-segment displays are used. IC2 provides segment-data and display-enable signals simultaneously in time-division-multiplexed mode for displaying a particular number on the 7-segment display unit. Segment- data and display-enable pulses for the display are refreshed every 5ms. Thus the display appears to be continuous, even though it lights up one by one.

Switch S2 is used to manually reset the microcontroller, while the power on reset signal for the microcontroller is derived from the combination of capacitor C4 and resistor R8. An 11.0592MHz crystal is used to generate the basic clock frequency for the microcontroller. The circuit is powered by a 6V battery. Port pin P3.6 of the microcontroller is internally available for software checking. This pin is actually the output of the internal analogue comparator, which is available internally for comparing the two analogue levels at pins 12 and 13. As pins 12 and 13 of

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IC2 can work as an analogue comparator, these are used for sensing the rise and fall of the pulse waveform and there by evaluate the time between two peaks and hence the beat rate.

The output of the pulse pick-up preamplifier is fed to pin 12 of the microcontroller. Pin 13 of the microcontroller is connected to the preset for reference-level setting of the comparator. Thus voltages at pins 12 and 13 are always compared. The signal rise and the fall at pin 12 are sensed by the program.

The internal timer of the microcontroller is used to find the time taken for one wavelength. This time is converted into the heart beat rate in beats per minute by a pre-calculated look-up table. The program notes the time between the high-to low and low-to-high transitions of the wave.

This time in microseconds is converted in steps of 4 ms for comparison with the values already stored in the look-up table. This number is used to find (from the look-up table) the heart rate in beats per minute. The number so obtained is converted into a 3-digit number in binary-coded decimal (BCD) form. The same is output to the 7-segment LED displays in a multiplexed manner. The display shows the rate for a while and proceeds to another measurement. Thus beat rates obtained from time to time are visible on the display.

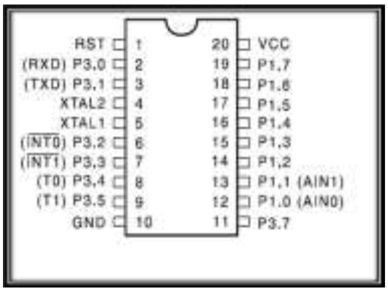

Fig 5: Pin Diagram of AT89C2051

- **VCC** - Supply voltage.
- **GND** - Ground.
- **Port 1**

Port 1 is an 8-bit bidirectional I/O port. Port pins P1.2 to P1.7 provide internal pull-ups. P1.0 and P1.1 require external pull-ups. P1.0 and P1.1 also serve as the positive input (AIN0) and the negative input (AIN1), respectively, of the on-chip precision analog comparator. The Port 1 output buffers can sink 20 mA and can drive LED displays directly. When 1s are written to Port 1 pins, they can be used as inputs. When pins P1.2 to P1.7 are used as inputs and are externally pulled low, they will source current (IIL) because of the internal pull-ups. Port 1 also receives code data during Flash programming and program verification.

- **Port 3**

Port 3 pins P3.0 to P3.5, P3.7 are seven bidirectional I/O pins with internal pull-ups. P3.6 is hard-wired as an input to the output of the on-chip comparator and is not accessible as a general purpose I/O pin. The Port 3 output buffers can sink 20 mA. When 1s are written to Port 3 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 also serves the functions of various special features of the AT89C2051 as listed below:

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	INT0 (external interrupt 0)
P3.3	INT1 (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)

Table 1: Port 3 Alternate functions

Port 3 also receives some control signals for Flash programming and programming verification.

- **RST**

Reset input. All I/O pins are reset to 1s as soon as RST goes high. Holding the RST pin high for two machine cycles while the oscillator is running resets the device. Each machine cycle takes 12 oscillator or clock cycles.

- **XTAL1**

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

- **XTAL2**

Output from the inverting oscillator amplifier.

LDR

LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically

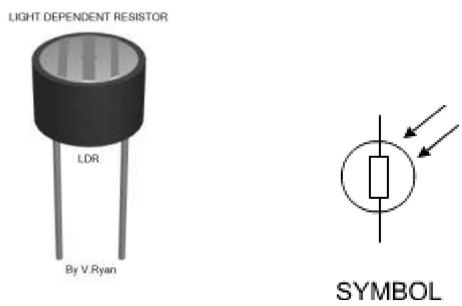

Fig 6: LDR

When the light level is low the resistance of the LDR is high. This prevents current from flowing to the base of the transistors. Consequently the LED does not light.However, when light shines onto the LDR its resistance falls and current flows into the base of the first transistor and then the second transistor. The LED lights. The preset resistor can be turned up or down to increase or decrease resistance, in this way it can make the circuit more or less sensitive.

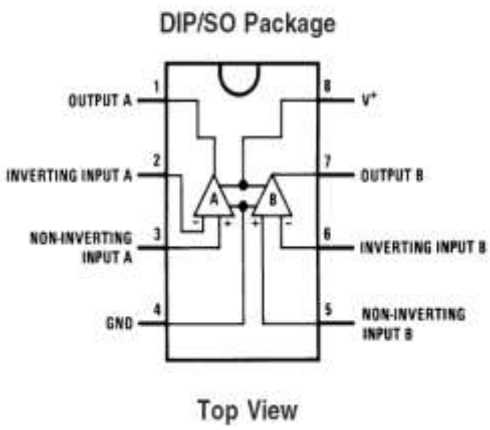

Fig 7: Operational Amplifier LM 358

It is a 8-pin operational amplifier. It contains two operational amplifiers as shown in below figure A and B are the two operational amplifiers. Internally frequency compensated for unity gain. Low input offset voltage is set to 2 mV. Differential input voltage range equal to the power supply voltage .Large output voltage swing.

Seven Segment LED Display

One common requirement for many different digital devices is a visual numeric display. Individual LEDs can of course display the binary states of a set of latches or flip-flops. However, we're far more used to thinking and dealing with decimal numbers. To this end, we want a display of some kind that can clearly represent decimal numbers without any requirement of translating binary to decimal or any other format.

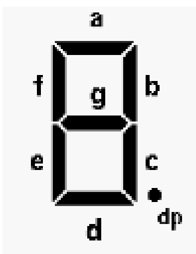

Fig: 8 Layout of Seven Segment Display

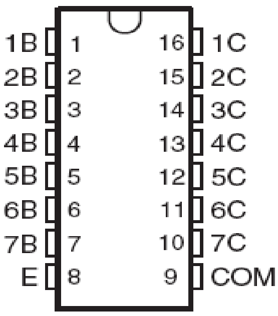

Fig: 9 Pin diagram of ULN2003

The LEDs in a seven-segment display are not isolated from each other. Rather, either all of the cathodes, or all of the anodes, are connected together into a common lead, while the other end of each LED is individually available. This means fewer electrical connections to the package, and also allows us to easily enable or disable a particular digit by controlling the common lead. (In some cases, the common connections are made to groups of LEDs, and the external wiring must make the final connections between them. In other cases, the common connection is made available at more than one location for convenience in laying out printed circuit boards. When laying out circuits using such devices, you simply need to take the specific connection details into account.)

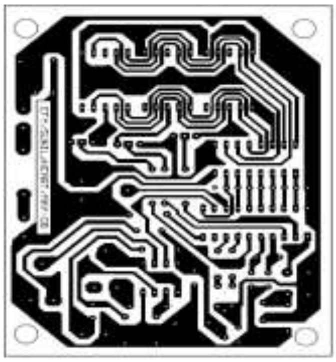

Fig 10: single-side, actual-size PCB layout

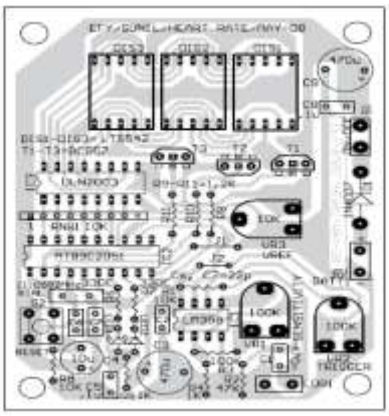

Fig 11: Component layout for the PCB

A PCB populated with electronic components is called a printed circuit assembly (PCA), printed circuit board assembly or PCB Assembly (PCBA). In informal use the term "PCB" is used both for bare and assembled boards, the context clarifying the meaning.

Alternatives to PCBs include wire wrap and point-to-point construction. PCBs must initially be designed and laid out, but become cheaper, faster to make, and potentially more reliable for high-volume production since production and soldering of PCBs can be automated. Much of the electronics industry's PCB design, assembly, and quality control needs are set by standards published by the IPC organization.

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III. RESULTS

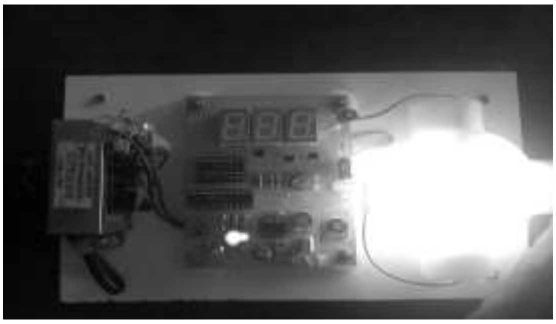

Fig 12: Working of the kit

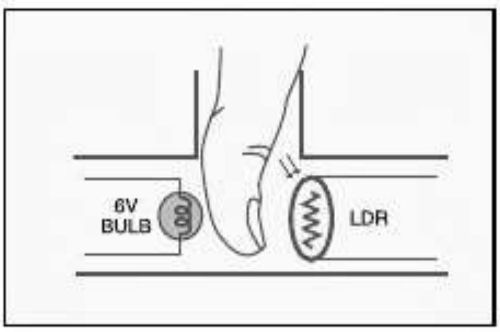

Fig 13: 'T' tube with finger inserted

After inserting the finger we will observe the heart rate in displays and by connecting the pin 3 of IC 1 to CRO we also observe the heart beat signal.

Fig 14: Displaying of Heart-Rate

IV. CONCLUSION

All in all, this project achieved a lot of its goals. The project implemented a low cost, low power, LCD heart rate display system using microcontroller technology. Lists of accomplishments include portability, reliability and analog to digital conversion and also the system is easily accessible.

Thus, it is possible to measure heart rate by using microcontroller was proved. In this also sometimes it shows high value due to unusual mains picked up by the transducer. Hence, to measure accurate heart- rate advanced microcontrollers like MSP430FG4816 are used.

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