Developing a Heart Rate Monitor Using 8051 Microcontroller

Final Report

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Objective

To measure the heart rate of a human using the 8051 micro-controller.

Project Description

The project depicts a procedure of measuring the heart rate of a human through a fingertip using the 8051 micro-controller. At the point when the heart thumps, it is pumping blood all through the body, making the blood volume inside the finger change. This fluctuation can be identified through an optical arrangement instrument, comprising of IR LEDs set next to each other.
The sign can be intensified further for the μ**C** to check the rate of fluctuation, which would happen to be the heart rate. The IR LED transmits an infrared light in the fingertip, a piece of which is reflected back. The photodiode captures the segment of light reflected back. With a high-gain amplifier, this amplitude change of reflected light can be changed over to a pulse.

Software Requirements

1. Editor for schematic drawing - Eagle[1].
2. Keil[2] development tools for the 8051 Microcontroller
3. Sunrom ISP Programmer[3]

Hardware Requirements

Components	Quantity
AT89S52 8051 Microcontroller[4] Kit	1
IR Transmitter and Receiver	1
16x2 LCD Module	1
General Purpose Operational Amplifiers LM324	3
DC Power Source	2
Capacitors	5
Resistors	10
Connecting Wires	Multiple
SPDT Relays	1

Description of Major Components Used

1. **IR Transmitter and Receiver**
   IR Transmitter is a light-sensitive bipolar transistor. The transmitter sends an infrared pulse which is reflected by the finger and its reflection is detected by the receiver. When the heart beats, the volume of blood cells under the sensor increases and this reflects more IR waves to sensor and when there is no beat the intensity of the reflected beam decreases. The IR sensor detects this and send this ahead as an output.

2. **AT89S52 Microcontroller**
   A microcontroller (abbreviated μ**C**) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. It has various interrupts, one of them being the timer interrupt. We use this to count the number of times the heart beats with the help of the output obtained from the IR sensor.

3. **Operational Amplifier LM324**
   We have used two Op-amps in our project, both of which are used for amplification of the feeble signal obtained from the IR sensor.

4. **Comparator**
   This Op-amp acts as a low-pass filter, that passes signals with a frequency lower than a certain cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. We count the number of **highs** obtained to calculate the final result. The count is maintained by the timer of the μ**C**.

5. **16x2 LCD Module**
   A LCD Module is a form of electronic display. It displays welcome messages and the final output of heartbeat monitor in beats per minute (bpm).

Procedure

1. The device senses the heart rate from the finger tip using IR reflection method and displays it on a LCD module in beats per minute (bpm).

2. In medical terms, the technique used here for sensing heart rate is called ***photoplethysmography*** (PPG). It is the process of optically estimating the volumetric measurement of an organ.

3. When the heart expands (*diastole*) the volume of blood inside the finger tip increases and when the heart contracts (*systole*) the volume of blood inside the finger tip decreases.

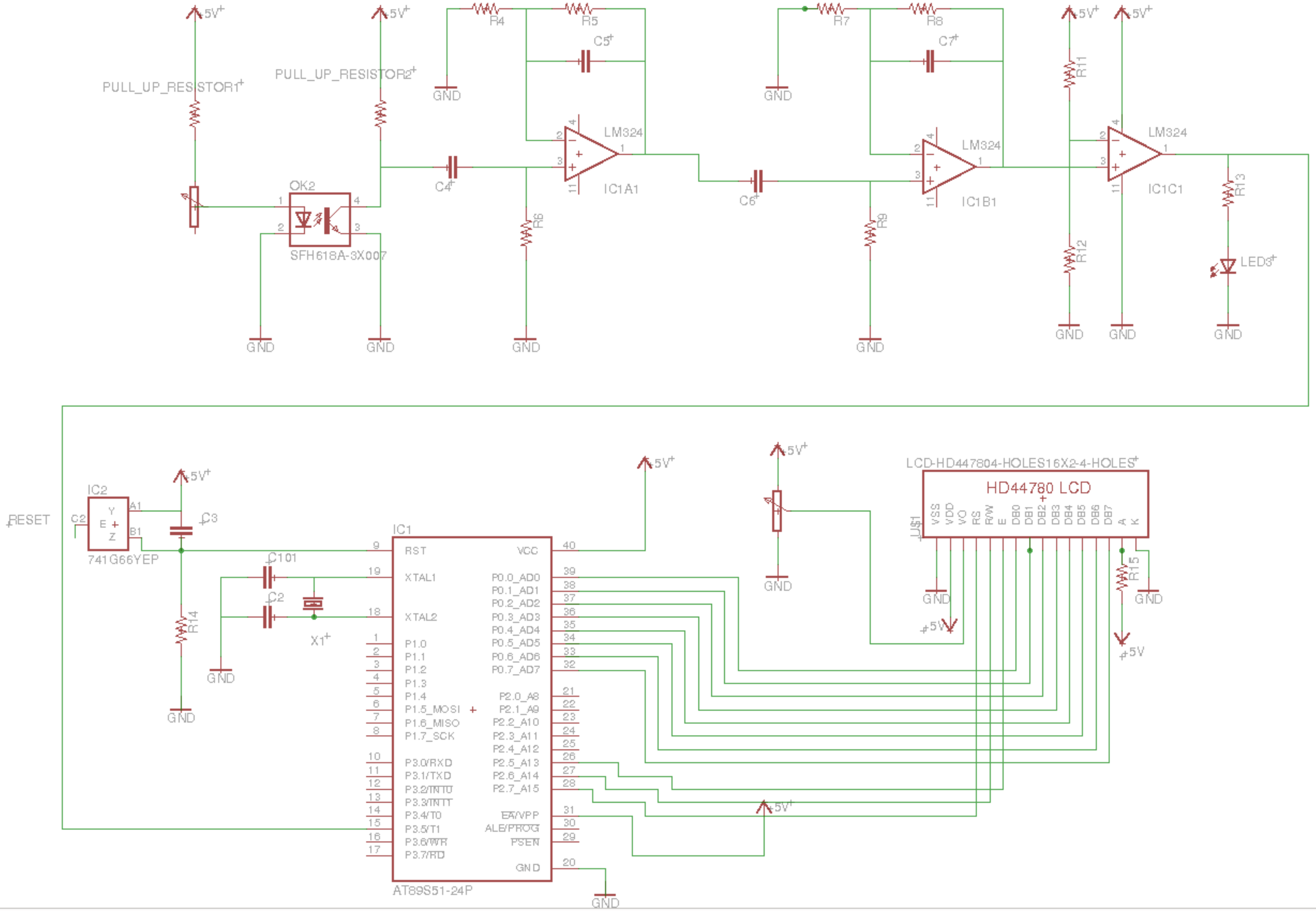
4. The resultant pulsing of blood volume inside the finger tip is directly proportional to the heart rate.

5. For this, an IR transmitter/receiver pair is placed close to the finger tip. When the heart beats, the volume of blood cells under the sensor increases and this reflects more IR waves to sensor. In a similar way, the intensity

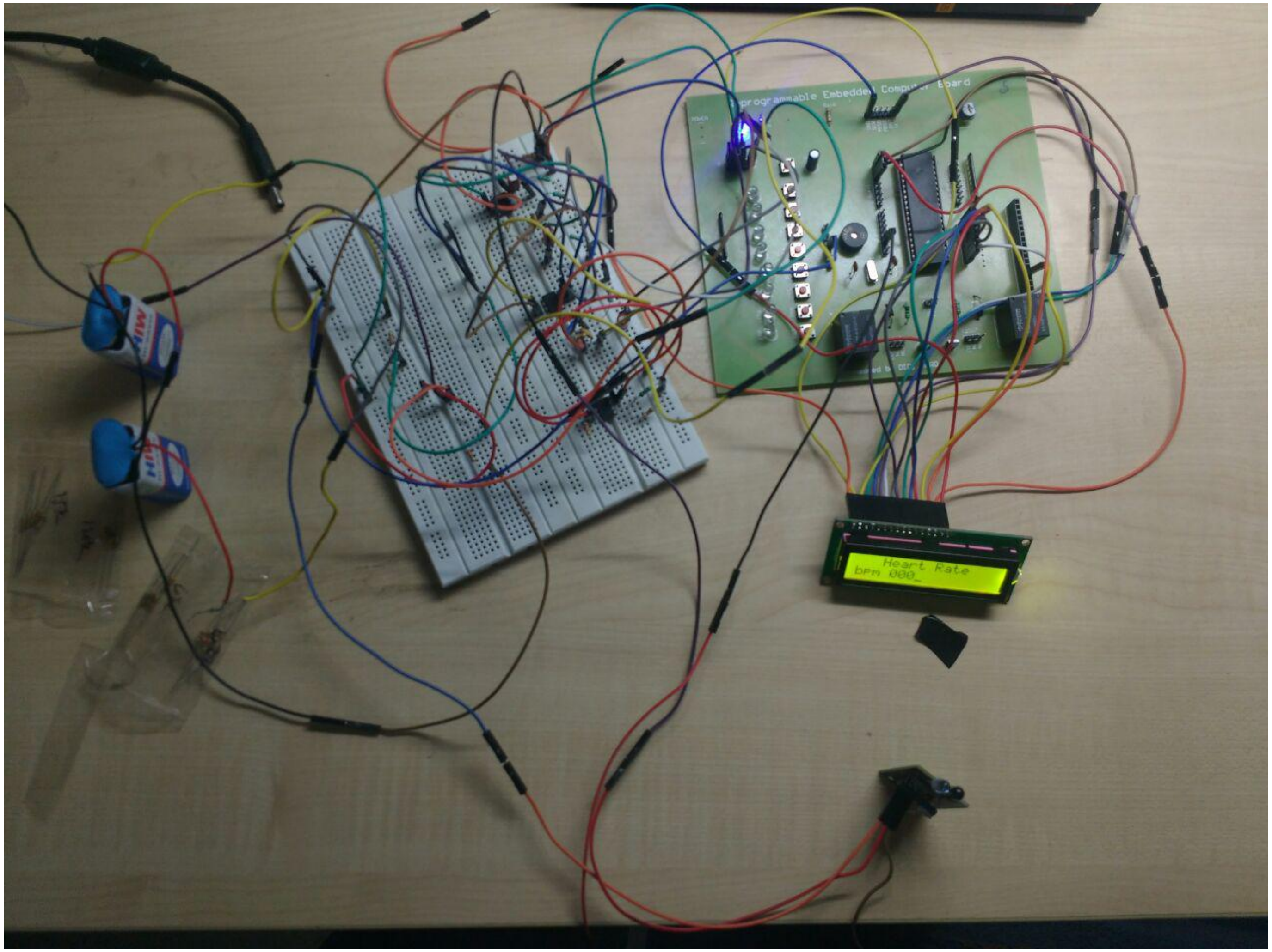
of the reflected beam decreases when it is the opposite.

6. The pulsating reflection is converted to a suitable current or voltage pulse by the sensor.
7. When more light falls on the photo transistor, we receive a higher output from the sensor. When less light falls on the photo transistor, we receive a lower output from the sensor. This is because the variation in the collector voltage is directly proportional to the heart rate.
8. However, this voltage variation is feeble, so, additional signal conditioning stages are necessary to convert it into a $\mu\mathbf{C}$ recognizable form. For this, the signal is passed through a low pass filter (the set of 2 op-amps).
9. The output of the filter stage will be a voltage fluctuating between 0 and 0.35 volts. We deploy a comparator (3rd op-amp) to convert this signal into a digital signal.
10. Whenever the output voltage of the filtered signal goes above 0.3V, the output of the comparator goes to 0 and whenever the output voltage of the filter stage goes below 0.3V, the output of the comparator goes to positive saturation, i.e., 1.
    The result will be a pulse (digital) fluctuating between 0 and 5V at a rate equal to the heart rate.
11. This pulse is fed to the microcontroller for counting. The counter is maintained by the Timer interrupts of the $\mu\mathbf{C}$.
12. These Timer interupts, then, send the output value to the LCD Module connected to the $\mu\mathbf{C}$.
13. The result is displyed on the LCD in beats per minute (bpm).

Interfacing Diagram



Final Circuit



Psuedo Code

pseudocode

```
1.  Initialize the program variables
        a.  Count = 0                 ;Here, we initialize a timer to calculate the no. of times the signal is captured by receiver.
        b.  Reset the LCD, Display a welcome message
        c.  Set the Data Pointer to Accumulator in 8051
2.  Configure the ports as output ports
    a.  MOV P1, #00H        ;Set P1 as output port
    b.  MOV P2, #00H        ;Set P2 as output port
3.  Set internal Timer interrupts 0 and 1 T0 and T1 to maintain the counter.
    \\The counter increments whenever the IR sensor detects a change in the pulse\\
4.  Get Count in 15 sec.
5.  Count = 4 times Count   ;Get the total number of heartbeats in 1 minute
6.  Display the Count on LCD
```

The complete source code can be found here[5].

Result

The heart rate monitor functions as expected and displays the number of beats per minute on the LCD.

Concepts Involved in the Project

1. 8051 μ**C** basic architecture.
2. 8051 μ**C** addressing modes (almost all the addressing modes have been deployed).

3. The knowledge of Timer Interrupts (T0 and T1) in 8051.
4. Arithmetic multiplication and division in 8051.
5. Interfacing the μ**C** with LCD module and IR sensor.

References

[1] Eagle PCB Design
`https://cadsoft.io`

[2] 8051 Development Tools
`http://www.keil.com/c51/`

[3] SUNROM Programmer 6.1
`http://www.sunrom.com`

[4] 8-bit Microcontroller with 8K Bytes In-System Programmable Flash
`http://www.atmel.com/Images/doc1919.pdf`

[5] GitHub link for Heart-Rate-Sensor Source Code
`https://raw.githubusercontent.com/mridulg/Heart-Rate-Sensor/master/src/heart_rate.asm`

[6] `http://mobileeducationkit.net/labmanuals/LAB-Manual-8051.pdf`