Microcontroller measures heart rate through fingertip

by rajbex on June 21, 2011

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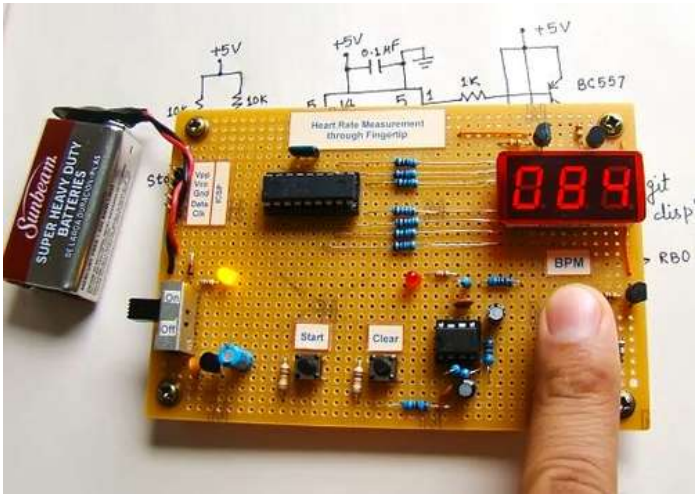
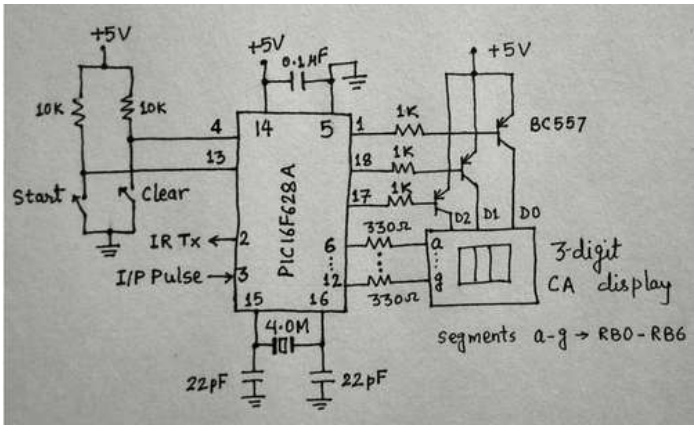
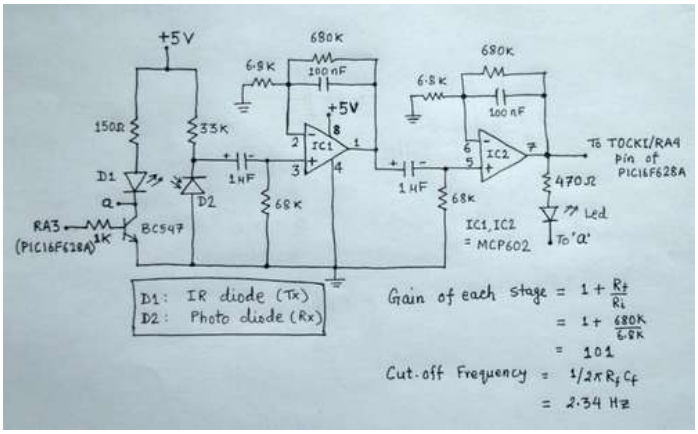
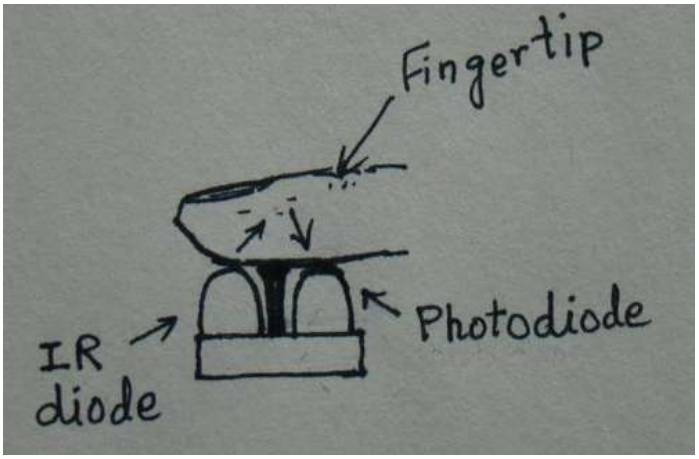
Intro: Microcontroller measures heart rate through fingertip

Heart rate is a very vital health parameter that is directly related to the soundness of the human cardiovascular system. This project describes a technique of measuring the heart rate through a fingertip using a PIC microcontroller. While the heart is beating, it is actually pumping blood throughout the body, and that makes the blood volume inside the finger artery to change too. This fluctuation of blood can be detected through an optical sensing mechanism placed around the fingertip. The signal can be amplified further for the microcontroller to count the rate of fluctuation, which is actually the heart rate.



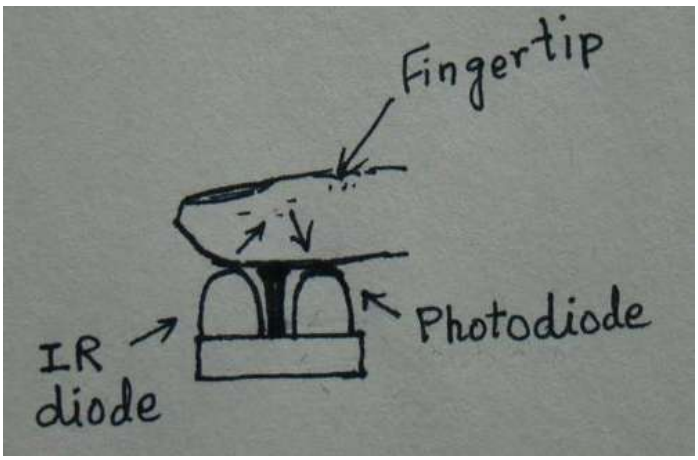






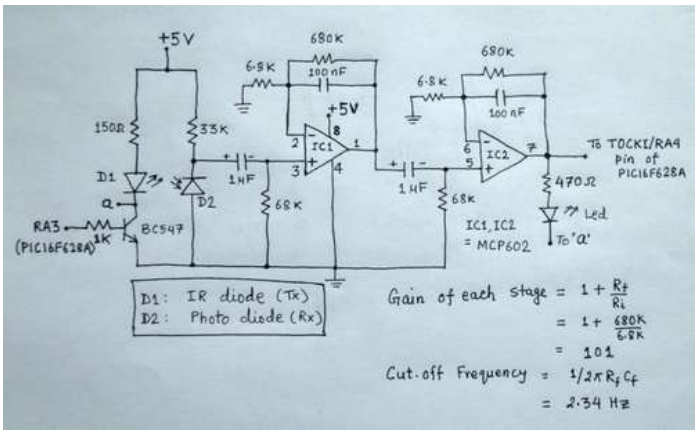
Step 1: Sensor assembly

The sensor unit consists of an infrared light-emitting-diode (IR LED) and a photo diode, placed side by side, and the fingertip is placed over the sensor assembly, as shown below. The IR LED transmits an infrared light into the fingertip, a part of which is reflected back from the blood inside the finger arteries. The photo diode senses the portion of the light that is reflected back. The intensity of reflected light depends upon the blood volume inside the fingertip. So, every time the heart beats the amount of reflected infrared light changes, which can be detected by the photo diode. With a high gain amplifier, this little alteration in the amplitude of the reflected light can be converted into a pulse.



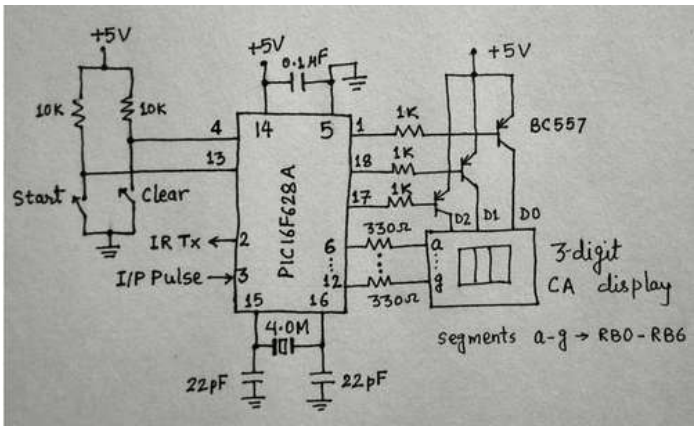
Step 2: Signal conditioning circuit

The reflected IR signal detected by the photo diode is fed to a signal conditioning circuit that filters the unwanted signals and boost the desired pulse signal. The circuit diagram above shows the IR LED (D1) and the photo diode (D2) along with the signal conditioning circuit made of two stage operational amplifiers configured as active low pass filters. The cut-off frequencies of both the filters are set to about 2.5 Hz, and so it can measure the pulse rate up to 2.5*60 = 150 bpm. The gain of each filter is about 100, which gives the total 2-stage amplification of 10000. This is good enough to convert the weak pulsating signal into a TTL pulse. Note that at the input of each OpAmp filter stage, there is a 1 uF capacitor to block any DC component in the signal. At the output is connected a LED that will blink with heart beat. The cathode of LED gets the ground path through the collector of BC547 transistor. In order to save the battery life, the transistor is turned on for 15 seconds by PIC16F628A microcontroller while the measurement is going on. The number of pulses counted within this interval is multiplied by 4 to get actual beats per minutes (bpm).



Step 3: Microcontroller and display circuit

The PIC16F628A runs at 4.0 MHz using an external crystal. The two tact switches are used for Start and Clear functions. You should rest your fingertip on the sensor assembly before pressing the Start button. You can use fore finger or middle finger for this. Once the Start button is pressed, the microcontroller turns on the BC547 transistor (in the signal conditioning circuit). This turns the IR LED on, and the LED starts blinking with the fluctuation in the blood volume inside finger arteries. After 15 seconds, the measurement is completed and the result is displayed on a 3-digit seven segment LED display.



Step 4: Device in action

This video shows the heart rate measuring device in action.

CLICK TO PLAY VIDEO

The firmware for PIC16F628A was developed in C and compiled with mikroC Pro for PIC compiler from mikroElektronika.
You can find the source code and HEX files attached here with or can also view the program on my **blog site** .

File Downloads

PulseMeter.zip (21 KB)
[NOTE: When saving, if you see .tmp as the file ext, rename it to 'PulseMeter.zip']

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Comments

13 comments **Add Comment**

chuckie25 says: Jul 29, 2011. 3:43 PM **REPLY**
hi yes can you please provide a parts list when i compared the diagrams to the picture of the device there were more componenets on the picture than the diagrams are showing i would graetly appricieate it thank you

athomas21 says: Jul 27, 2011. 8:10 AM **REPLY**
i am an engineering student in 3rd year....i liked the idea of ur project and would like to ask can dis be made using a 8051 microcontroller for my project since i am restricted just to use them and how feasible is this using a controller like 8051?

carraherlee says: Jul 19, 2011. 11:35 AM **REPLY**
very interesting, and the conditioning circuit is nice.
I have been going directly into a micro-controller and doing the noise filtering there, however an opamp would be a nice way to increase the snr to the i think 8 bit DAC on an msp430.

here is what i am building for my 1yr old niece who is prone to asthma attacks.
http://www.oximetry.org/pulseox/principles.htm
this will also measure pulse but more interesting, in my opinion, is that it attempts to measure deoxy/oxy-hemoglobin via point spectroscopy and isosbestic point analysis (http://en.wikipedia.org/wiki/Isosbestic_point), using an infrared and red led alternatively pulsed and measured. the goal is to make it a low oxy-Hb alarm system (no visual output), that is small and preferably comfortable enough so that she doesnt try to pull it off.
I will post the build information when i am finished with this project.

bertus52x11 says: Jun 23, 2011. 8:47 AM **REPLY**
Great project!
If I would like to build this for measuring my hartrate at a different place of my body, does the theory (light being relflected by the blood) work for the larger artery as well? I guess so, but I can imagine that sunlight influences the accuracy. Does it ever miss a beat (I mean, is it very sensitive to the position of your fingertip?)

rajbex says: Jun 23, 2011. 3:48 PM **REPLY**
It's not much sensitive to position but you can get error if you move your finger while the device is taking measurements. This is because the active low pass filter has the gain of 10000, which is good enough to amplify the very weak low frequency signal created due to the motion of the finger. In order to prevent the interference from ambient light condition, both the IR LED and the photo diode must be surrounded with some opaque materials. Some of these issues are discussed in the comments section on my blog here: http://embedded-lab.com/blog/?p=1671

bertus52x11 says: Jun 25, 2011. 5:59 AM **REPLY**
Thanks! I'm putting this project on my "to do" list!

DJJules says: Jun 23, 2011. 6:11 AM **REPLY**
Nice Project! I especially like the analog front end to this. Well done.

Jules

alfredhenriksen says: Jun 25, 2011. 5:06 AM **REPLY**
Agreed. I loved it, so easy and creative in solving a "easy" task, I could'nt even believe that he used just a ordinary optical sensor.

I liked also that he didn't manufacture a PCB, a protoboard is good enoght and makes it cooler and easier for peoples to begin with electronics. It may be baffling to somebody who "only" see readymade PCB's. Not me! :D

Now do we need to find out how to make the device to detect the difference between the first and middle finger....

taylorglenn says: Jun 23, 2011. 9:55 AM **REPLY**

Are the "Start" and "Clear" buttons momentary switches?

rajbex says: Jun 23, 2011. 3:53 PM **REPLY**

Yes, they are momentary tact switches.

Phil B says: Jun 23, 2011. 5:44 AM **REPLY**

Some exercise machines and programs utilize heart rate during a workout to adjust intensity for the desired benefits. It would be great to add lengths of flexible wire between the sensor and the rest of the circuit so the sensor could be attached by spring clip to an ear lobe or to a fingertip for a continuous reading during exercise. Thank you for a very nice Instructable.

ray_Bond says: Jun 23, 2011. 5:04 AM **REPLY**

let me try it first :)

wilgubeast says: Jun 22, 2011. 9:43 AM **REPLY**

This is really cool. No more staring at the clock and feeling for a pulse in my wrist or neck. Better living through microcontrollers.