Fingertip Heartrate Measurement

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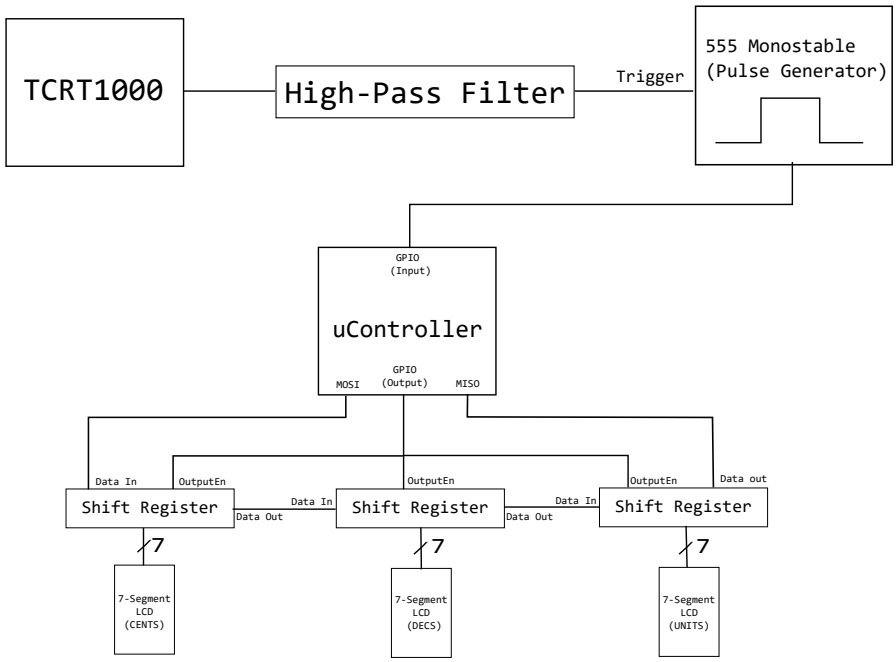
The envisaged system will measure the heartrate using an infrared measurement sensor, the TCRT1000. The system's main components are a TCRT1000 sensor, analog circuits, an 8-pin microcontroller, three 7-segment displays and shift-registers.

1 Project Overview

The TCRT1000 sensor outputs a current proportional to the infrared light, reflected by the blood. This way, everytime that there is a heartbeat, this reflection will be higher due to the higher concentration of blood. After this, the resulting waveform will be high-pass filtered to enhance the voltage peak that represents the heartbeat. This peak will be fed to a monostable 555 timer that, every time it is triggered by this peak, will produce a voltage pulse with a fixed duration, which will be captured by one of the micro-controller's General Purpouse Input/Outputs (GPIO).

The microcontroller will then process the incoming pulses and evaluate the inter-arrival time, and extrapolate the heartbeat from this information. Then, at fixed intervals, it will compute a value for the heartrate, and output each one of the 3 decimal digits (since a person's heartbeat is generally between 60-200 beats per minute, we only need 3 digits to represent it) to three 7-segment displays. Each 7-segment display will have a **shift-register** that will keep the value stored in its intermediate memory, and they will be arranged in a *daisy-chain* fashion, connected to the MISO and MOSI interfaces of the microcontroller.

This arrangement can be better understood by observing the following figure.



2 Lab and Industrial prototype

The laboratory prototype will be developed using a PIC32MX120F032B from Microchip in a breadboard. This is already tested because it was used on other projects, so it won't be necessary to debug this configuration (the basic PIC32MX120F032B IC and the discrete components necessary). The power supply is already designed (basically and 9v battery and a 3.3 voltage regulator). The analog circuitry will be mounted on the breadboard and we will test it with an oscilloscope to ensure correct behaviour.

The industrial prototype will use an 8-pin PIC16F18313 microcontroller. The power supply will be identical to the one used in the laboratory prototype. The remaining hardware is also 'portable', and, for that reason, it will be the same from the lab prototype.

3 Development Approach

Stages of Development

The first step will be the design of the analog circuitry that serves as the basis of the interface. This will include the dimensioning of the high-pass filter, calculating the appropriate gain to appropriately trigger the 555 timer – even when the pulse is relatively dim – and to calculate the appropriate 555 pulse duration, and the corresponding values for C and R that will define it.

This pulse will first actuate a LED and, after we are sure that is works appropriately, we will develop the microcontroller-side software, and debug the calculated heart-rate values, transferring them to a computer via its UART interface.

After this is done, we can start to develop the software for the 7-segment drivers, and the associated daisy-chain configuration, again debugging using the UART interface.

When both of these halves are complete, we will merge them together, and check if the system works as a whole. After this, we will finally develop a suite of software tests that will be embedded in the project, and will be run everytime the system is startup.

Software used and Organization Policies

We will use MPLABX as the Integrated Development Environment to develop the software for the microcontrollers, and also as a debugging platform. Cadsoft's Eagle will be used to keep the project schematic updated, and to develop the final tentative board for a hypothetical final product.

Everytime we commit to a hardware component placement/design, we will update the Eagle schematic; this way, we will have a quick reference if some wire is inadvertly disconnected, and it will also be easier to design the PCB board at the end of the project. We will also keep a Git-Hub folder with all the schematics and source code of our project, where you will be able to keep up with the work that we are developing.

4 Component List

Component	Price (per unit)	# of units
TCRT1000 (IR Sensor)	€1.06	2
LD1117V33-DG (3.3 voltage regulator)	€0.71	2
PIC16F18313 (microcontroller)	€0.69	2
LM555CNNS/NOPB-ND (555 timer)	€1.10	2
74HCT595N (shift-register)	€1.78	4
TDSL5160 (7 segment display)	€1.90	3