

PO BOX – Pulse Oximeter

ABSTRACT – By: MT2278

MOTIVATION

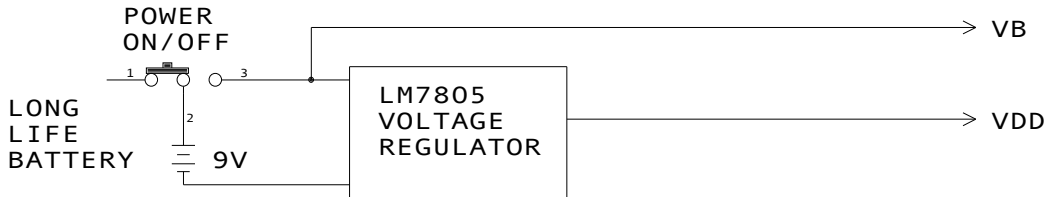
The purpose of this paper is twofold; to demonstrate the concept of Pulse Oximetry using a Microchip dsPIC30F Digital Signal Processor and as an entrant into the 2007 Microchip 16-Bit Embedded Control Design Contest sponsored by Microchip and Circuit Cellar.

Over the past number of years I have had experience with the nursing home setting since my uncle had spent two years there. It is very common for bed-ridden patients to contract pneumonia during the flu season. A pulse oximeter is normally used to determine if the patient is having difficult time breathing. A particular nursing home my uncle was at had one such instrument. During the winter, he had contracted pneumonia; I asked the nurse if he could be examined. They had to wait for the oximeter because it was being used in another part of the building. Because of the instruments high cost, the nursing home couldn't afford a second or perhaps a third.

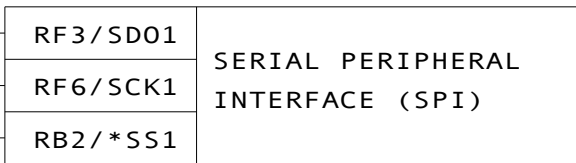
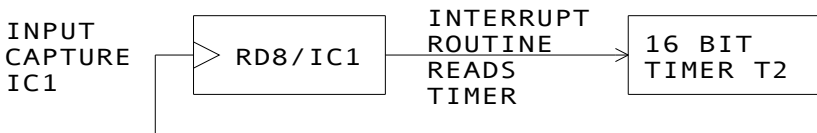
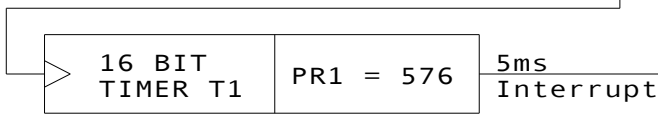
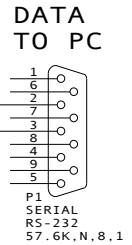
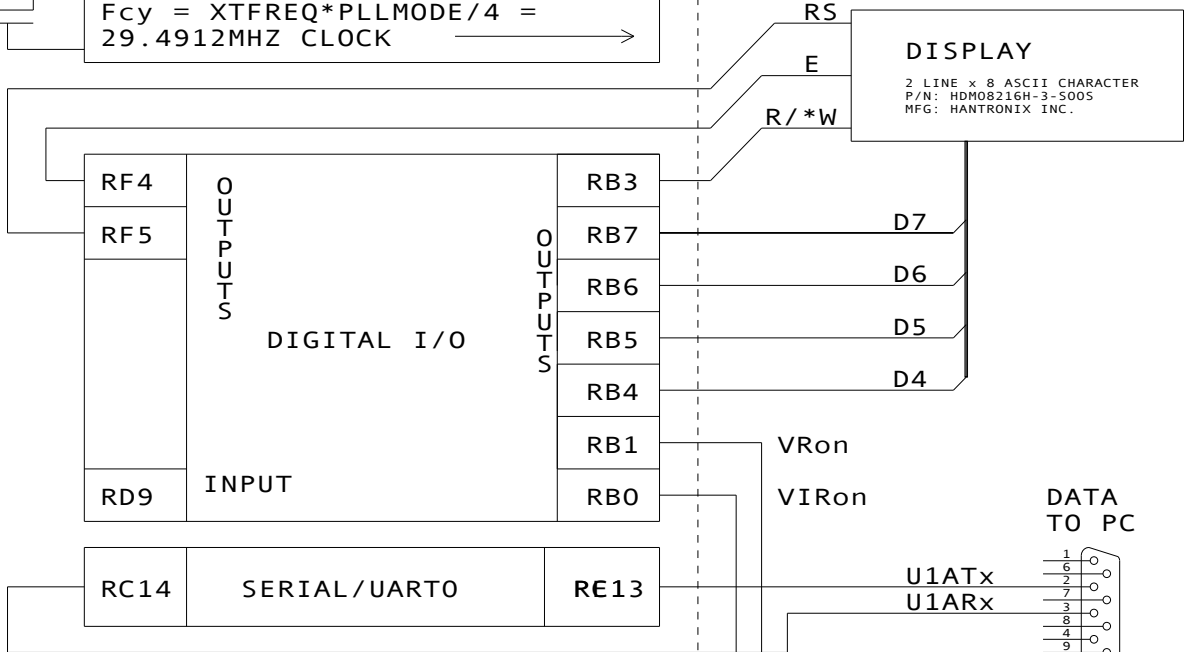
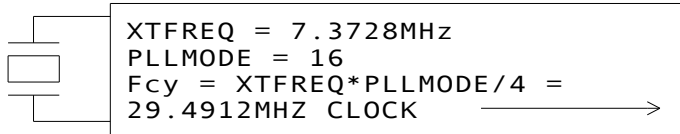
Some time earlier, when my mother was hospitalized with what the doctors thought was pulmonary fibrosis, my wife and I looked for a pulse oximeter that we could purchase that she could use when she came home from the hospital. They were all very expensive. During our search, we read an interesting article of an individual who was on the same quest. With his level of the fibrosis disease, he was able to exercise. He wanted to monitor his oxygen level during his workout. He couldn't find a unit that he could afford. His question was - does anybody make one? With the low cost and availability of microchips, I can't understand why these instruments are so expensive and why they are not available at your local drugstores like glucose meters.

AFFORDABLE MODEL

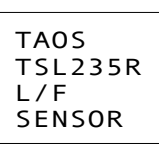
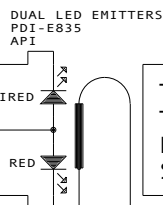
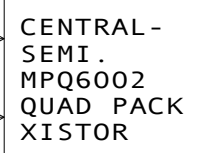
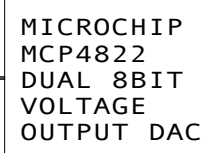
After multiple attempts in trying to work out a usable model for a pulse oximeter, I was very excited when this opportunity to work with the Microchip product came forth. Not only does Microchip have great processors at affordable prices, but they have other support devices to support the design. Having worked with Microchip products in the past, I know they have a great support team in place when assistance is required. The goal to complete this project as a contestant in the Microchip/Circuit Cellar contest is only a step in getting the PO Box to market as a product.



MICOCHIP 16-Bit 28-Pin Starter Board



SAMPLE CLOCK (100 Hz)
 TRIGGERS INTERRUPT ROUTINE WHICH IS SET UP AS A STATE MACH.
 THIS STATE MACHINE MULTIPLEXES AND SEQUENCES THE LED LIGHT SOURCES. IT ALSO SETS UP TIMER T2 AND INPUT CAPTURE IC1 TO MEASURE THE TAOS LTF OUTPUT IN THE FORM OF A PERIOD. THESE PERIODS ARE CONVERTED TO FREQUENCIES WHICH ARE PROPORTIONAL TO THEIR CORRESPONDING LED INTENSITY. THE PROGRAM USES THE INTENSITY SAMPLES TO DETERMINE HEART-RATE AND OXYGEN SATURATION.



FINGER

APPROACH

The block diagram on the next page shows the basic architecture of the system. **PO Box** was designed around the 16-bit 28-Pin Development tool that Microchip markets. The board was used in conjunction with the ICD-2 tool and the C30 compiler in the MPLAB environment. A small board was designed that connects to the 28-Pin development board through a header. I called this the mezzanine board since it sits atop the Microchip board. The mezzanine board holds a display and all the necessary circuitry to interface to the sensor and a host computer. The UART on the microchip was used during the development of this project to display real-time data. Since the data out of the UART was ASCII, I wrote a small LabVIEW (scope) program to display this data. The Idea was to layout a concept, come up with a working model (goal for this contest). Then, layout a board that contains all the circuitry while keeping the cost down (the normal engineering feat). The Microchip 28-pin board was a good choice for doing the development work. It allowed access to all the hardware inside the chip allowing me to make choices on which hardware to use.

After reading an interesting article in Circuit Cellar a number of years ago (Dec 2004/Jan 2005) about using a Light to Frequency converter chip built by Taos Inc. (Texas Advanced Optoelectronic Solutions), I was motivated to develop a sensor using the newer LTF technology. The sensor that I developed was made from a commercially available 1" Velcro strap cut to about 4-6" length. Two holes are punched into the strap at a distance equal to 1/2 the girth of the index finger. The LTF sensor and LED emitter package peeks through these holes. An old abandoned serial mouse cable was used to connect the sensor to the instrument. The beauty of the sensor is that it is very affordable and reusable.

Using surface mounted devices, I am hoping to make the final product of small physical size and weight so that it can be mounted somewhere on the arm (Velcro strap) for the person interested in monitoring the vitals while exercising.

RESULTS

I had very good results with the system at present, but there is a lot of room for improvement. I am relatively new in the area of Digital Signal Processing and had difficulty using the Microchip 'Digital Filter Design Lite' tool. I developed all the filters using the old fashion method of converting the analog equivalent to an IIR filter. I used floating point operations instead of fixed integer. But all-in-all, it worked out well. The software uses a 4th order LP filter on both the IR and RED signals (cleans them up very nicely). On the next page is an output from the system which shows the results. A differentiator and peak follower are used to look for

sharp transitions in the filtered signal for framing the heart-wave. This is required to take timing measurements to calculate the heart rate and to measure the SPO₂. A DC tracking filter is also part of the software. The result of the filtered signal and the DC are used to calculate the AC portion of the signal which contains the arterial component which has 97% of the oxygen. Finally the heart rate and SPO₂ are averaged using a Simple Moving Average filter. The result is a relatively stable reading.

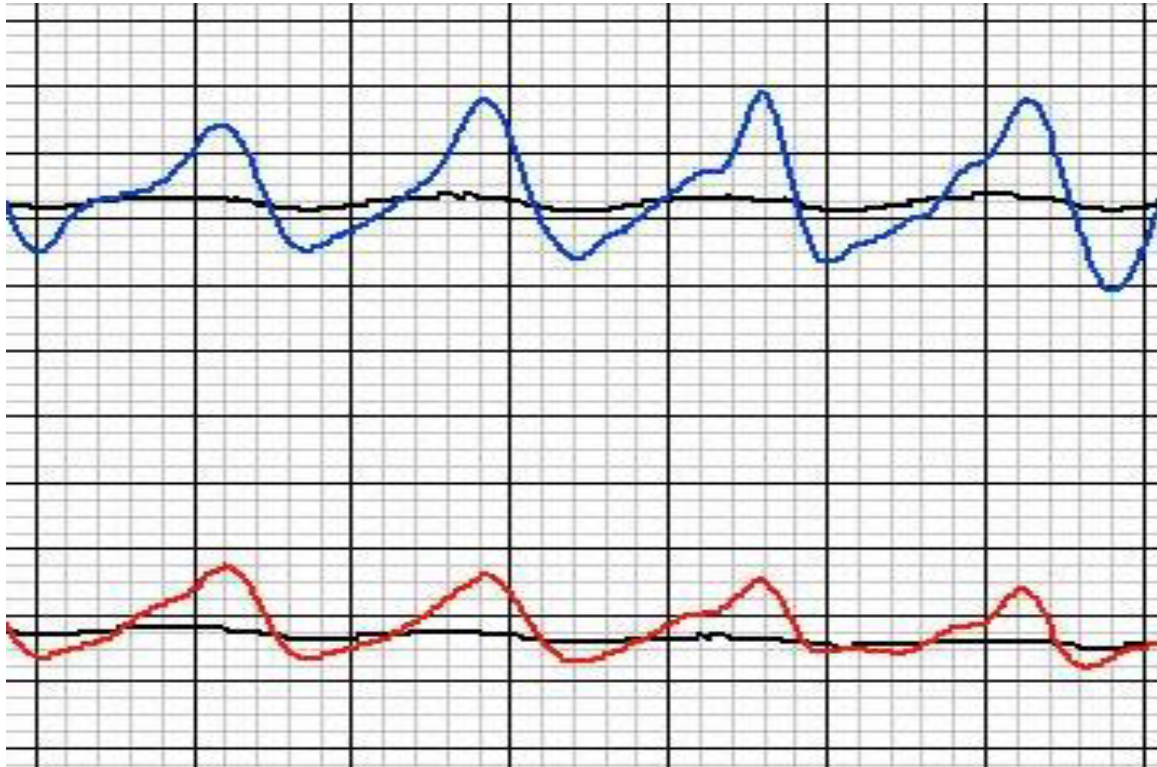


FIGURE 1: Response from Sensor (RED – Redlight)/ BLUE – IR light

CONCLUSIONS

I am very happy with the results of this project. The only regret is that I wish that I had spent more time and did a circuit board layout from the get-go. The mezzanine board was built using point-to-point wiring. It had problems mainly with the hardware because of the way the board was built. The next steps are to do a board layout and refine the software. Hopefully a fine product can come out of this work.

