

# gPod Accessible Blood Glucose Meter

Week 3

February 7, 2006

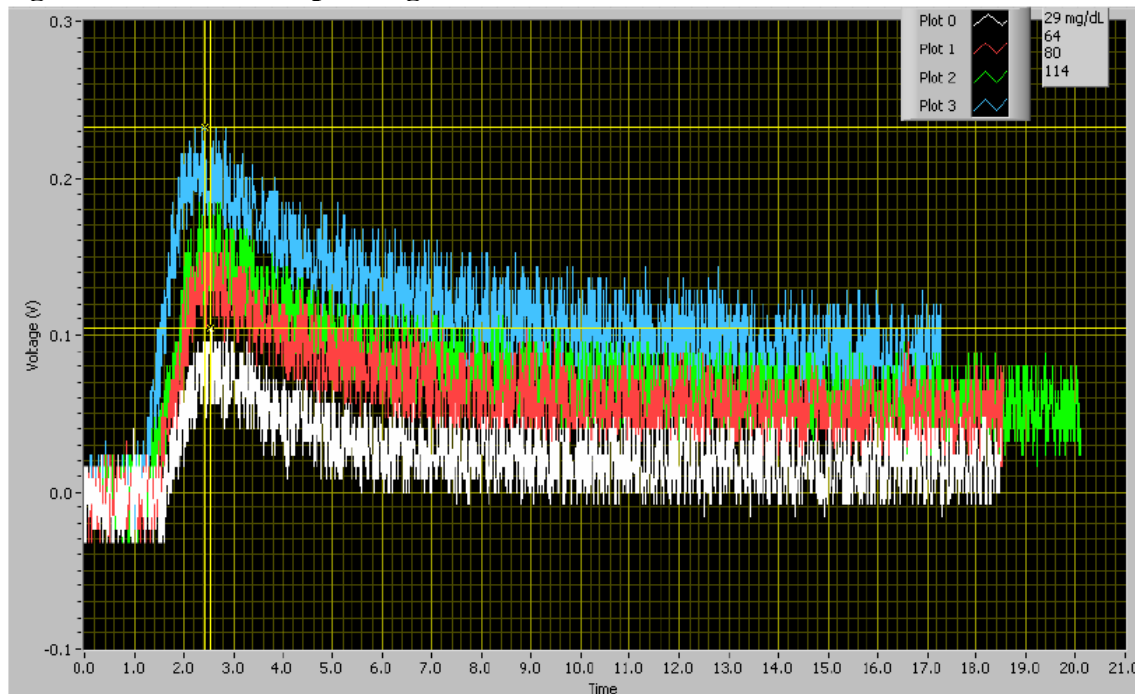
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## Work Completed

Week 3 made significant progress with the interpretation of the glucose data. An experiment was ran that tested several glucose solutions of different concentrations. This was done first diluting the standard control solution which has a concentration of about 114 mg/dL with deionized water. The stock solution was diluted to about 29 mg/dL to begin with. This solution was then applied to a test strip in the One Touch Ultra Meter to verify what the actual concentration was. Once that was known, the same solution was then applied to the test circuit to record the voltage output that would result. This output was then saved for later analysis. To test a new concentration, 2 drops of the stock solution were added to the diluted beaker, which would then increase the overall concentration of the beaker about 10 mg/dL. This procedure was repeated for 8 trials with the concentrations as follows:

29, 38, 54, 64, 74, 80, 94, and 114 mg/dL.

**Figure 1: Glucose Outputs Signals for Various Trials**

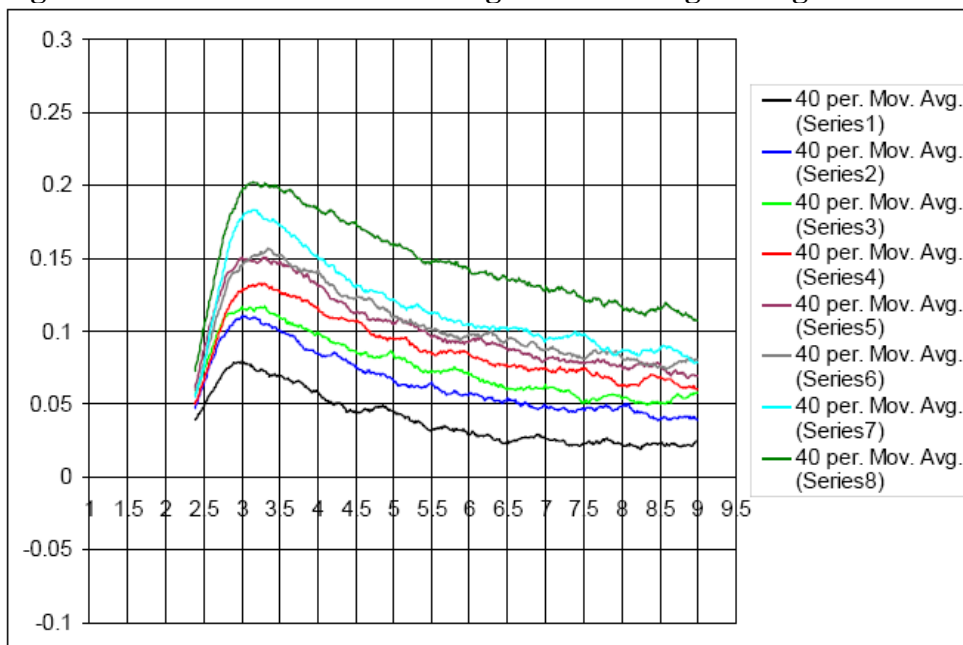


After completion of the testing, all the saved data on the oscilloscope was then loaded into Excel and analyzed. In Excel, several steps had to be taken to make the data something that could be usable. The first problem was that all the trials had peaks that began at slightly different times within the 25 second window. This was due to when the sample was applied to the test strip as the oscilloscope collected data across the screen.

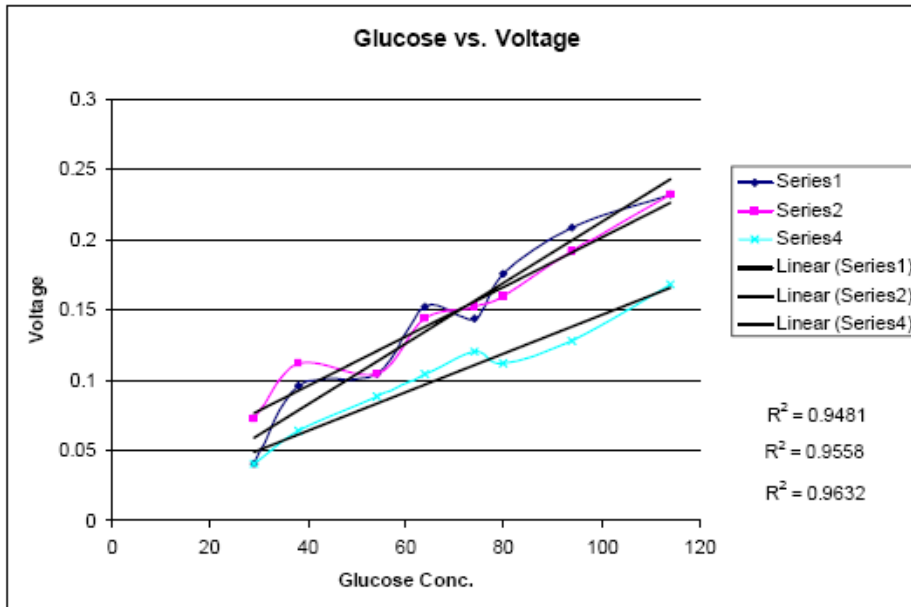
To overcome this, I deleted the beginning portions of each trial to where the data became exclusively positive. This would then begin each data set at the point where the sample is applied and the voltage begins to peak. The result of this can be seen in Figure 1.

Following that, the noise of the signal had to be dealt with. The first thought was to apply a trend line to the data to try and obtain a single continuous line that would represent the mass of data points. However, because of the shape of the voltage output signal, there were not many trend lines that could be applied. One trend line that did work was a 'moving average' trend line. Figure 2 shows the graph of the trials after being aligned to the same sample time having the trend line applied. The method for measuring is that at some time after the peak, there is a linear portion with which the measurement can be taken, and accurate results obtained. It seems that about 1 second after the voltage peak (represented by the 4 second line in Figure 1) is an appropriate time to take measurement. However, this is where the method of the trend line gave rise to a problem. Because it is a trend line, it has no real data points. So to obtain data for 1 second after the peak, the raw signal data had to be used. Sample data sets were then plotted and a linear trend line was added to determine exactly how linear the results were. This plot is shown in Figure 3. The  $R^2$  values that are on the side of the plot represent how linear the data is. An  $R^2$  value of 1 means the data is perfectly linear. The best value we received was .9632 which isn't bad, but could use improvement. Overall this tells us that our circuit is promising, and should be able to give an accurate reading once a relationship is made.

**Figure 2: Plot of Glucose Data Using 40 Pt. Moving Average**



**Figure 3: Plot of Glucose versus Voltage for Certain Times Around 1 Second after Sample Application**



At the beginning of the week we received the new speech chip and DIP adapter. Dave took the chip and board to his place of work in Massachusetts to do the surface mount soldering. Due to the small spacing of the pins on the chip, the facilities at his work were better suited for surface mount soldering. The chip and adapter can be seen in Figure 4.

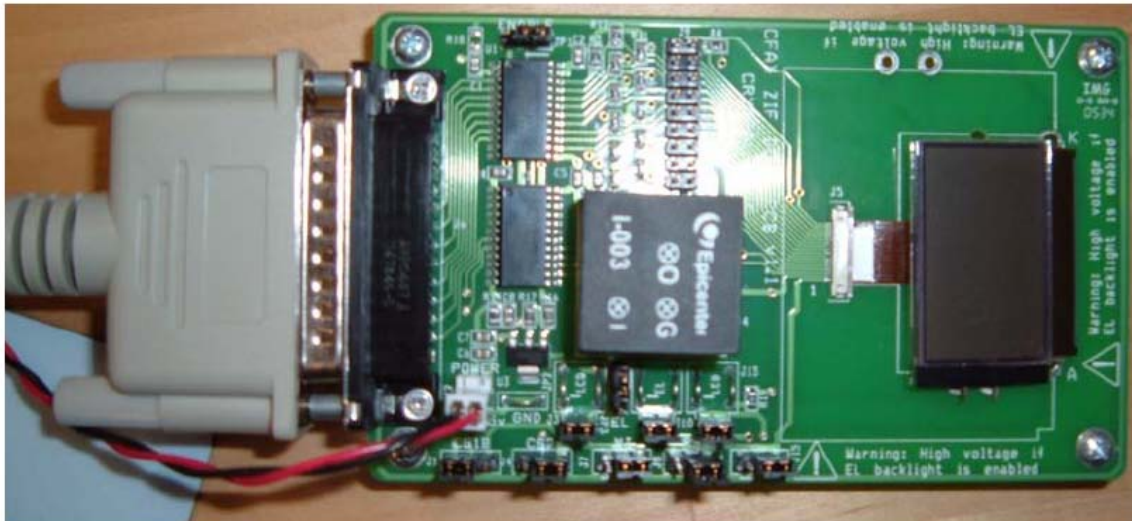
During the remainder of the week Dave worked with the microprocessor. The first stage of this process involved learning MPLab and the procedures necessary to program the microprocessor. Secondly, he spent time looking for example code for analog-to-digital conversion. He found a program for the PIC16F874 microprocessor in a lab from BME 252 and edited the assembly code to suit the PIC16F874A. Some of the changes involved renaming the ports and registers and changing some of the configuration settings. The microprocessor was programmed successfully with the A/D example code and demonstrated on the QIK Start Education Board using the LED's and a potentiometer. As the voltage level was increased the LED's could be seen incrementing. Table 1 shows the digital counts representing a variety of analog voltages.

**Table 1: Analog, Binary, Decimal Count values.**

Analog Voltage	Binary Representation	Decimal Count
0.00	00000000	0
1.06	00110110	54
3.06	10011101	157
5.00	11111111	255

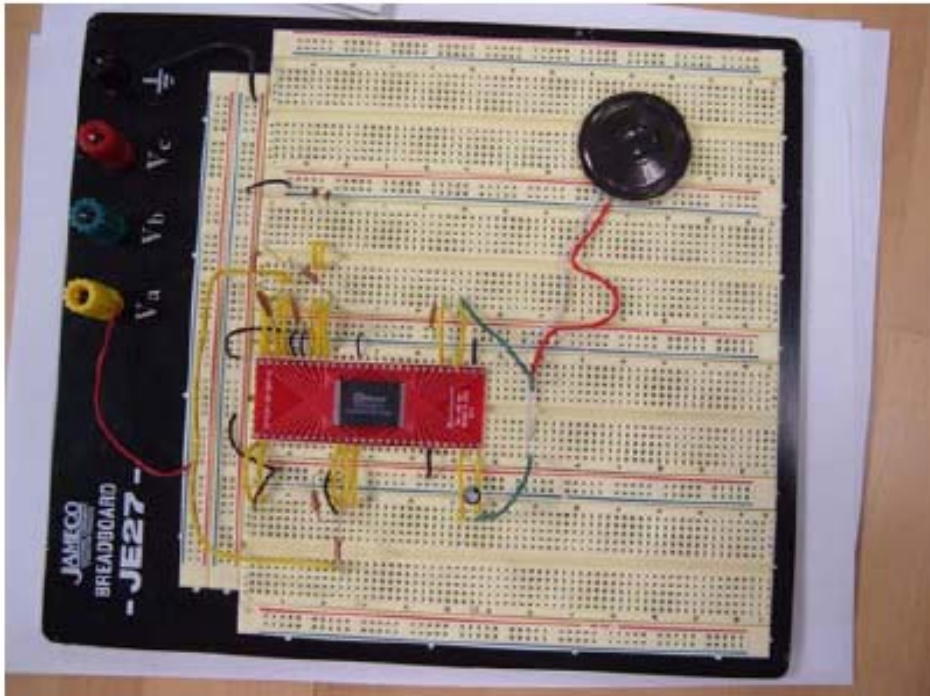
The LCD demo board and new LCD screen were received on Friday. A longer power cable was first needed to accommodate the test setup on the workbench. The board and LCD screen were connected to the computer via the parallel port. Using the CFAX WinTest software available from the Crystalfontz website, initial tests showed the LCD screen to be working correctly. Figure 2 shows the LCD screen attached to the demonstration board.

**Figure 4: CFAX ZIF Demo Board and CFAX12864A screen.**



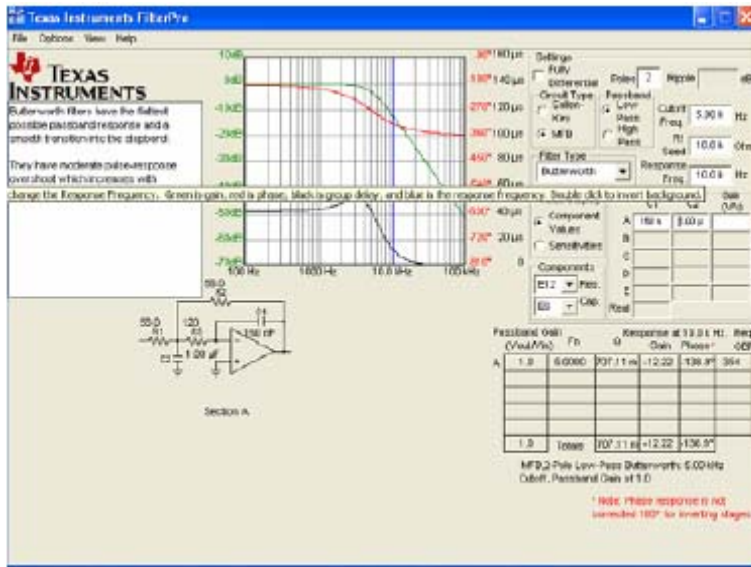
Matt started to work on the speech chip once Dave had finished soldering the Winbond chip onto the DIP adapter. He first looked over the data sheet for the Winbond chip and examined which pins would need to be connected. The speech chip was then attached to a proto-board and wired up as seen below in Figure 5. Though it was then realized that 2 resonators were needed for the speech chip to run the clocks. A 24.00 MHz resonator was needed for the chip's clock and a 5.00 MHz resonator was needed for the input pin since the chip can handle only 5 MHz at a time. These two resonators were ordered from digikey. Without these two resonators the work on the speech chip came to a halt since they are necessary for the chip to work. Though, he did attach the speaker also to the speech chip circuit by soldering two wires onto the pads of the speaker.

**Figure 5: Speech Chip and DIP adapter.**



A filter was added to the glucose circuit in hopes that some noise might be reduced such as noise from cell phone and wireless signals. Though after hooking up the filter to the circuit, there was no noticeable change in the perceived noise at the output of the signal. The Filter was designed using the program FilterPro. The FilterPro design for our filter can be seen below in Figure 6. When examining the FFT of the output signal there was no difference between when the filter was hooked up and not hooked up. Then there was the 5 volt gain that appeared at the output of the circuit. The filter was then redesigned with 2 poles instead of 3 poles as before. The same problems persisted with the output such as the 5 volt offset and the filter not filtering anything. The filter was debugged by grounding the input so that the output should be zero. It was noticed that the output was not zero but slightly above. So the input was examined and then ground itself and it was determined that ground had a few milli-volts. The same happened when a known voltage was applied to the filter. This meant that the filter was working correctly. It was decided that the filter was un-needed since regardless of the gain the filter was not filtering anything from glucose signal.

**Figure 6: FilterPro Designed Filter**



## Future Work

Mike will continue to work with the glucose circuit and generate accurate glucose/voltage curves. This work depends on the delivery date of the higher concentration glucose solutions.

This week Dave plans to focus on learning how to write the microprocessor code using the PICC compiler. The current A/D code is configured to use the +5V supply as the reference voltage. The glucose meter will only require a voltage range from 0-2V. The code will be modified to use a different reference voltage to increase the accuracy of the A/D converter. The code will also be changed to use all 10 bits of the A/D converter. The final change to the A/D code will be to use the input voltage from the glucose circuit. I will also work to display the decimal equivalent of the LED output on the LCD display on the programming board. This will help me work on the binary to floating point conversions as well as start to understand the basics of LCD communication. In addition to the work on the A/D code, I will also begin learning how to work with the LCD screen. By the end of the week I plan to be able to write values to the LCD screen using the PC.

Matt will work with the speech chip once the required crystal oscillators arrive. He will continue setting up the circuit and working on the voltage supply circuit. By the end of the week we plan on having the speech circuit working and successfully converting text to speech.

## Project Review

So far, so good. No major set-backs occurred this week and significant progress was made in all areas being worked on. It feels as though within the next few weeks, the major components to this project will be on their way to completion. Goals for this week

are to get the A/D code configured for our project, get accurate glucose measurements, and successful text-to-speech conversion. Total costs to date are \$470.07.

**Hours Worked**

Mike: 14 Hours

Matt: 19 Hours

Dave: 23 Hours