CPE 490 Semester Project S14

## Goals

To complete a project using creativity and the embedded design skills learned this semester.

## Grading

This project is worth 225 points out of 1000 total for the class. Demonstration of the fully working design to an instructor is worth 60% or a maximum of 135 points. The written report is worth the remaining 40%. The bonus sections will be worth 45 extra points. The project must be done and turned in by 5/04/14 at 5PM.

## Overview

Using the Explorer 16 development Board create a meter that measures the Root Mean Square (RMS) value of a voltage and a current signal. The meter will calculate the average power and the apparent power. As a bonus feature (worth up to 10% extra, 22.5 points, on the grade) the meter will indicate the phase angle (in degrees) between the two signals and will indicate if the current leads or lags the voltage. In addition, 10% more bonus can be earned by using DMA techniques to get ADC information.

## Design

### Hardware

In order to get a hold of the ANx Pin for the analog input we will insert a prototype board into the card edge connector on the Explorer 16 board this will give us access to most pins on the dsPIC33. These boards will be available in the lab.

We will assume that any voltage conditioning will be done external to our project so the input channel will just be to an ANx pin and a ground pin. We will expect a voltage signal that will remain between 3 volts and ground on the analog input channel.

### AC Signals

The two signals that we measure will be either coming from a commercial power grid. Since we want to sell the meter to a broad market the frequency will either be 50 Hz (Europe and many other places) or 60 Hz (USA and others). The accuracy of the frequency on a power grid is quite good on average and you can safely assume that it will always be within 1% of either frequency.

Since our explorer 16 is running on a single rail – 0 – 3.3 V it is impossible to read negative going signals. We are depending on the EEs on another team to design a circuit that adds a DC offset to the AC signal that will ensure that the AC signal will always be found to be between 0 and 3 V going into the ADC. Since the EE’s are not that good we don’t exactly know the offset voltage so we must find it by taking an average measurement (no need to display this). We then can subtract off the average voltage or the DC content and recover the AC signal.

Since we are a power meter the signal amplitudes are scaled down as follows:

Voltage signal – 350 VDC field signal will be represented as a 1.5 VDC signal sampled by dsPIC33 ADC

Current signal – 50 ADC field signal will be represented as a 1.5 VDC signal sampled by the dsPIC33 ADC

### RMS Values

The meter is to display the Root Mean Square Value of the signal in field units. This must be true RMS meter so it is NOT permissible to do peak detection and divide by the square root of 2.

### Sampling Rate

Sampling must be done greater than the Nyquist rate by at least 5 times. More over you want to do the average function over a time period that is exactly an integer multiple of the signal being measured. Since the frequency could be 50 or 60 Hz you can either detect the frequency or simple selected a time period that is evenly divisible by the time period for either 50 or 60 Hz (the latter is recommended).

### Display update Rate

The display update rate must be at least once every second.

### Average Power

This is in Watts and is found by finding the average instantaneous power

### Apparent Power

This is in Watts and is found by multiplying the RMS value of the current by the RMS value of the voltage.

### Phase Angle (50% of the bonus)

The phase angle will be given in degrees, and will include the word ‘lagging’ when the current lags the voltage and ‘leading’ when the current leads the voltage signal.

### Direct Memory Access

This project can be done in two ways, one easy way is to do single analog to digital conversion read the results and then immediately do another and read the results. The other better, but harder to set up way would be to use simultaneous sampling and give the ADC Direct Memory Access (DMA) and then read blocks of data. I will give you sample code that you can use to get you started on the DMA code.

### RTOS (50% of the bonus)

The FREERTOS port that we used in the last lab can be used to complete this project. Using the RTOS shows a higher level of competency in the class and a bonus will be awarded.

### Human Interface

You can select the mode that you are displaying by pushing one or more of the push button available on the Explorer 16 board, your choice. The display is up to you but the resolution of all values shown should have at least 5 significant digits.

## Project Report

Please write up your reports as follows:

### Data sheet

Publish a data sheet for your meter, state in the verification section how you came up with the data sheet values. The data on accuracy should be based on actual test that you do on the final design. Don’t forget to take in to account the accuracy of the equipment you are using to verify the design. The data sheet should include:

Accuracy for each display – RMS current, voltage, average power, apparent power, and phase angle.

The number of bits used for the analog input.

Range restrictions in voltage and frequency for when the data sheet is true.

Update rate of the screen.

### Design Specification

List the specifications that the design must meet.

### Design

Describe your design (software in this case). Software should be described by a flow chart or a state diagram. Describe how the software divides up the real time problems, that is; how is the processor time divided? It might be nice to show a timing diagram that describes when the ADC is read, values are calculated, and displays made. Finally list your well commented final code.

### Verification

Describe how you verified that your design meets all the design specifications and how you got values for your data sheet. If it is not obvious give a procedure in how the verification was done. List all data that was gathered and the equipment used to get it. Describe all analysis done on the data gathered. You are encouraged to use graphs and diagrams if appropriate. Again someone should be able to use your lab book and independently run through the verification. (This could be important if someone wanted to see the effects of a modification of your design.)

### Conclusions and Limitations

Describe what can be logically concluded from your work. State the limitations to these conclusions. If you want you can also list future work that you would like to do.