

## ME 135 SPRING 2008

### ASSIGNMENT 4: OSCILLOSCOPE ANALOG TO DIGITAL CONVERSION

**Due: Thursday, March 13**

#### Background

This is the first assignment involving actual hardware. With hardware it is key to make sure everything is connected and turned on. Specifically, check that the black box is powered as indicated by the LED on the front (the switch is on the back in the upper left corner), that it is connected to the ETS computer via the MIO and DIO cables, and that the ETS computer is on and connected to the LAN. In addition, that particular ETS computer and RIO card must be target devices in your project. Then try the test application before you run your own.

This assignment is also intended to introduce you to some of the fundamental properties and limitations of analog to digital conversion. The FFT power spectrum is particularly useful for highlighting these limitations.

#### Task

Your task is to create an oscilloscope panel interface for reading a voltage signal sent to the analog-to-digital card. Your oscilloscope should have at a minimum the following features:

- 1) The ability to scale and shift the x (time) and y (voltage) axes.
- 2) The ability to change your sampling frequency.
- 3) Cursors for measuring both time and voltage difference.
- 4) FFT power spectrum display as well as the normal time amplitude graph.
- 5) Simulated signals on a second channel.

Triggering is also a helpful feature, but will be considered optional for this assignment.

Note that two VI's have been included in the example project. The ETS VI is run remotely on the ETS computer while the Windows VI is run locally. In this case, you will probably not have to modify the ETS VI, but look through it, because you will need to understand how it works for future assignments. Because the ETS machine has a faster clock speed than Windows, the timed loops are running much more rapidly and large arrays of data are being passed through a shared variable to the Windows VI.

For this project, you will need to connect the function generator to the AIO channel of the black box. Use the BNC cables on the wall of the lab and BNC-to-banana plug converters. It may also be helpful to scope your signal while testing your code. Use a BNC T junction to branch the signal to a traditional oscilloscope.

## Questions

- 1) Make sure you have the decibel terminal on the FFT power spectrum set to true. What are the units on the axes of the FFT plot?
- 2) What is the range of the FFT? Change your sampling frequency (e.g. 10 kHz, 5 kHz, 2 kHz, 1 kHz). How is the range of the FFT related to the sampling frequency?
- 3) Set your sampling frequency to 10 kHz. What happens to the FFT when the frequency of the signal increases past 5 kHz? What happens when it increases past 10 kHz? Past 20 kHz? This phenomenon is known as aliasing. Without testing it out, what would a sine wave at 107 kHz look like on your FFT? Test it out.
- 4) What is the resolution of the FFT? Change the amount of sampling time (e.g. 0.01 sec, 0.02 sec, 0.05 sec, 0.1 sec) you feed into the FFT. How is the resolution of the FFT related to the amount of time sampled?
- 5) What is the magnitude of the FFT? Where does this come from?
- 6) Set your signal amplitude to the maximum ( $\pm 10$  V) that can be read by the board. Where is the baseline of the FFT (in decibels)? What is the difference in decibels between the maximum and the minimum of the FFT? What real multiplier does this correspond to? Which power of 2 does this correspond to? How is this value related to the number of bits in your analog-to-digital converter?
- 7) Set the signal amplitude back to  $\pm 1$  V. Which harmonics are prominent in the square and triangle waves?

## Deliverables

A quick start guide explaining how to use your interface. A report answering the seven questions listed above.

All of the VI's and project files needed to make your program run. Please comment your VI's so that someone seeing them for the first time can quickly pick up the structure of your code.