**EE 316 Computer Engineering Junior Lab**

**Design Project 4**

**Spring 2017**

**Specification: Signal Analyzer/Generator**

**Due Date: Thursday, March 16 - lab demo**

**Monday, April 4, written report due.**

**Parts list:**

* Two function generators
* A Bluetooth dongle and a RF transceiver.
* an Analog to Digital Converter (ADC) chip
  + an ADC0808/0809 8-bit chip from National Semiconductor
  + or, an optional PmodAD2 - 4 channel 12-bit A/D converter with I2C interface
* A digital blue box or breadboards.
* A couple of Op-AMPs (LM741 compatible), capacitors, resistors, etc.

Design a system to sample, store, digitally analyze and recreate analog waveforms. Periodic waveforms will be generated by function generators. The input waveform should have amplitudes in the range [-2.5, 2.5 volts]. **Note:** The ADC’s in lab only allow positive analog voltages; thus, the input signal will need to be added to 2.5 volts using an op-amp adder configuration with a gain of 1.

Up to two separate signals will be captured using an ADC chip connected to Xilinx NEXYS4 board. The hardware will then send the data from the ADC to the PC. A Bluetooth dongle and a RF transceiver will be used to create a serial link with the PC. You will be using the maximum allowable baud rate for the serial link. However, this limits the highest frequency that can be sampled in real time and be sent to PC. However, system should allow sampling of higher frequencies than that the serial link can support. One way to do this is to store the data in a RAM on the FPGA and then send the data to the PC after the sampling period is over.

On the PC, the user should be able to display a representation of the sampled waveform. The display should include a horizontal and vertical grid with appropriate markings or a legend that permits time and voltage measurements to be made directly from the screen. Make the system that functions like a single or dual trace digital storage oscilloscope. There should be some control on the vertical axis (Volts/division) and the horizontal sweep time (sec/division).

The user should also be able to calculate the Fast Fourier Transform (FFT) of the sampled input signal and displayed on the PC screen. The FFT should be applied to a "windowed" version of the input signal. The FFT plot should also have a grid and/or indicators that permit approximate measurements to be made in the frequency domain directly from the screen. The FFT should be displayed in two parts, as a magnitude and phase over the frequency range [-Fs/2, Fs/2], where Fs is the sampling frequency. The analyzer software must be in C++ or JAVA.

The system should also be able use part of the data stored in the RAM or in the PC to recreate the periodic analog signals. You will use the pulse width modulation (PWM) technique with an appropriate analog filter to reduce the high frequency noise. The output signal(s) should to be displayed on an oscilloscope and should be compared to the signal generated by the function generator.

**Option :** If you use the PmodAD2 chip, you will get a bonus of 10 points.

**Performance objective are:**

* to maximize the bandwidth of analog signals that can be sampled, stored and analyzed without aliasing and
* to make the user interface easy to use.

You may automate and provide the user with some additional measurement options. These are somewhat open to your creativity, but they should be meaningful and have a sound technical basis for the measurement. For example, the peak-to-peak and the RMS voltages are two suggested choice. You may have up to 4 such measurements.

**Documentation:**

**FFT:**

This is the manual for the GNU Scientific Library FFT routines (the source code that we are making available)

<http://www.gnu.org/software/gsl/manual/html_node/Fast-Fourier-Transforms.html>

**Op-Amp:**

<http://www.physics.udel.edu/~nowak/phys645/The_operational_amplifier.htm>

**IRB:** This project has potential applications in many areas including digital and analog signal processing and biomedical fields, etc. To carry out experiments on human subjects and monitor some of the vital signs (such as heart-beat rate, EKG, EEG, blood oxygen content, etc, using sensors) one needs to develop a set of specifications, guidelines and a list of special instruments, devices, sensors that could potentially be used to monitor vital signs of a human subject. In our lab will not use any human subjects. This is because there are regulations that deal with using human subjects in experiments. Special precautions are needed to carry out experiments because of health and safety, ethical, and privacy concerns. At Clarkson, to perform research or experiments on human subjects in labs, one needs permission from the Institutional Review Board (IRB):

<http://www.clarkson.edu/dor/compliance/human_subjects.html>

Be sure to study Clarkson’s Policy on performing experiments on human subjects and take notes in your notebook.

Teams:

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| --- | --- | --- | --- | --- | --- | --- |
| **Team1** | **Team2** | **Team3** | **Team4** | **Team5** | **Team6** | **Writer** |
| Bruska | Griffin | Bruce | Lowit | Oliver | Marsanskis |  |
| Craddock | Straw | Trahan | Zander | Heck | Shippee |  |
| Farden | Law | Michaels | Kuhns | Beyer | strenk |  |