LAB #3: Introduction Digital Data Acquisition

Equipment:

- Function Generator (Tektronix CFG250)
- Oscilloscope (Tektronix TDS 2014)
- PC Computer with National Instruments Data Acquisition Board
- National Instruments LabVIEW software package
- Dynamic Microphone

Objectives:

The purpose of this lab is to introduce you to computer-based digital data acquisition with A/D converters. You will explore the effect of A/D saturation and resolution on signal fidelity. You will also see how signals can be output by using a D/A converter.

Procedure:

In your lab notebook you should make a habit of writing down everything you do. Do not just answer the questions. Your homework for this lab will be to answer the questions (labeled “Q” and “HWQ”) posed below. Please use separate sheets of paper for the homework. The questions labeled as “HWQ” are to be answered on your homework only, not during the lab.

1 A/D Converter

The A/D converter has a maximum input range of ±10 V, i.e. signals outside of this range will saturate. The gain works by spreading the $2^{12}=4096$ counts over a smaller range, which effectively increases the resolution of the A/D. For example, for a gain of 2, the range of voltages is ±5 V.

1.1 With the aid of the scope, setup the function generator to output a 500 Hz sawtooth wave (4 volts peak-to-peak, with zero offset).

Connect the function generator to Ch 0 of the A/D (i.e. analog input channel 0).

Setup the LabVIEW program as follows. Launch LabVIEW by selecting the LabVIEW icon from the start menu in windows. Select OpenVI from the window that pops up and open c:\Lab3\daq.vi. The VI (Virtual Instrument) is started by pressing the run button (indicated by a right arrow) that is located below the menus. After the VI starts running you should be able to vary all the parameters within the VI for the various tasks without quitting the VI. When you are done, you can stop the VI by pressing the EXIT VI button.

The VI has two functions: it can RECORD data (located on the left side) and PLAYBACK the recorded data (located on the right side). When the RECORD button is pressed you will be prompted to choose a filename of type *.SCL (it stands for scaled data) to store the data (the default filename is DATA.SCL). The A/D starts acquiring the data as soon as you enter a filename. As the data are being acquired, you should see the recorded data plotted on a chart below the record button. When you wish to stop recording, press the STOP button on the record side. You can also set the
parameters **Sampling frequency (Hz)** and **Gain** for the input channel. Similarly when the PLAYBACK button is pressed you will be prompted to select the file to be opened. The parameters that can be set during playback include **Output frequency (Hz)**, **Resolution** and **Gain**. A playback can be stopped midway using the STOP button on the PLAYBACK side.

Set the RECORD side of the VI to the following:

- Gain = 1
- Sampling frequency = 10 KHz

Sample the waveform for a few seconds by clicking on “Record” and then “Stop.” You should see a well-resolved sawtooth wave on the “Record”-side plot.

Q: What is the minimum resolvable voltage than can be measured with the A/D at these settings?

Now change the gain to 10 and re-record a few seconds of the waveform.

Q: At what voltage does the voltage clip (saturate)?
Q: Is this voltage consistent with what you expect for your settings?

1.2 Now, use the scope to reduce the amplitude of the sawtooth wave to ±10 mV (peak-to-peak). Change the gain back to 1 and re-record this lower amplitude signal.

Q: Looking at the plot…what is the smallest voltage change that the A/D can resolve?

HWQ: Is this what you expect for a 12 bit A/D, with a range of ±10 V and a gain of unity?

1.3 Now change the gain to 10 and re-record.

Q: Does the signal appear better resolved?

2 **D/A Converter**

The D/A converter is also 12 bit and therefore outputs a signal that has at most 4096 levels.

2.1 Use the function generator and scope to output a *sine* wave (500 Hz, 2V peak-to-peak). Record a few seconds of the signal with the A/D set to the following:

- Gain=1
- Sampling frequency=10 kHz

2.2 Replay the signal through the D/A converter by using the “Playback” side of the VI and the following settings:

- Gain = 1
- Output frequency = 10 kHz
- Resolution = 12 bits
2.3 Connect the output of Ch 0 of the D/A (i.e. analog output channel 0) to your scope to see that it is indeed outputting the expected signal.

2.4 Now connect Ch 0 of the D/A to the speaker. The speaker has a built-in amplifier (hence the volume control knob on it) and so it can be driven by the low-power signal from the D/A.

Replay the recorded waveform at resolutions of 12, 10, 8, 4 and 2.

Q: Describe what you see (on the graph), and hear, as you decrease the resolution.

Q: What is the lowest resolution setting that doesn’t seem to compromise the quality of the signal?

3 Microphone

3.1 Connect the microphone output into the scope and talk into it. Vary the pitch of your voice and see how the signal changes. Get an idea of the amplitude of the voltages output from the microphone. Next, connect the microphone to Ch 0 of the A/D.

Set the Record settings to the following: Gain=200, Sampling frequency=44 kHz.

Record for several seconds while speaking into the microphone.

3.2 Replay this signal into the speakers (output frequency=44 kHz, gain=100, resolution=12 bits)

3.3 Try replaying the signal different frequencies (e.g. 100 kHz and 25 kHz).

3.4 Reset the frequency to 44 kHz (leave the gain at 100) and replay with different resolutions: 12, 10, 8, 4, 2 bits.

Q: Describe what you hear as you lower the resolution.

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