Introduction to Labview and Data Acquisition

Objective

This lab is intended to familiarize you with the standard LABVIEW GUI interface used through the remainder of the lab and the data acquisition system in use for this class. No report has to be written for this lab. At the end of this lab you should understand all the interface elements on the LABVIEW GUI and will have used a function generator to generate input signals to the DAQ system, seen the effect of using different voltage ranges on the board resolution and clipping (or saturation) due to inappropriate limits.

Take notes as you go. Discuss with the TA, if you get unexpected results or run into problems.

Apparatus

1. Personal computer with LABVIEW software
2. National Instruments PCI data acquisition board and junction box
3. Signal generator

Signal Generator

Look at the function generator. It can generate signals of various shapes, amplitudes and frequencies. Get familiar with the instrument. See also Figure 1.

- Identify frequency button, amplitude button and wave form buttons.
- The signal generator has several advanced features related to sweeping the frequency automatically; these features are not used in this lab.
- Go over the interface elements with your lab partner, discuss any open questions you may have.

Figure 1: Signal Generator – Front Panel
**MAIN DAQ GUI**
The main data acquisition GUI in this lab is a Labview application similar to the one developed in the temperature lab. However, it is more advanced and allows for the display of multiple input channels and automatically calculates the FFT of the signals that are acquired. Also filtering can be applied to the data before doing the FFT calculation. It is important that you understand the information presented in this GUI.

- Start the LabView software by clicking the “Meas. Lab Main DAQ GUI” icon
- Once the GUI has loaded, go over the screen with your lab partner and make sure you understand the function/meaning of the different visual elements. See also Figure 2. Discuss with your TA, if you have questions!

![Figure 2: Labview – Data Acquisition Software – Screen Shot](image)
SETUP EXPERIMENT

- Connect a coax cable from the function generator to the junction box. Why coax? Discuss with your lab partner! Where do you connect the cable on the junction box? How does that affect the settings on the LABVIEW GUI panel?

- You will notice BNC terminators on some of the analog input channels on the connector block. Why do you think they are there?

COLLECT DATA

- Set the frequency on the function generator to a 20Hz sine wave. Start collecting data (try both continuous acquire and one time acquire). Watch the display! What is going on?
  - An electrical signal is sent to the data acquisition board. The signal has the shape of a single frequency sine wave.
  - The DAQ board digitizes the signal. Several things happen at this point:
    - The voltage range setting on the DAQ board and the bit resolution determine the voltage resolution of the board
    - A saturation error may occur, if the selected voltage range is too small for the max amplitude of the signal.
    - The DAQ sampling rate determines the time resolution of the digitized signal and also the highest frequency, which can be detected.
    - The duration of the data collection (frame size) determines the lowest frequency, which can be resolved from the signal.
  - The digitized signal is displayed on the screen versus time and also versus frequency (using an FFT algorithm). Keep in mind that the digital display is not necessarily a good approximation of the real signal, if you did not carefully choose the sampling rate, voltage range and sampling time.

ADJUST VOLTAGE RANGE AND SIGNAL STRENGTH

1. Use continuous display with an input signal of a sine wave of about 20Hz. Adjust the amplitude to about 3V. Change the board input range to the largest possible range (What is it? If you don’t remember, pull up the specs for the board). Calculate the theoretical voltage resolution of the board for this setting and write it in your notebook.
2. Change the amplitude of the signal. Watch what happens. If you have autoscaling on, watch, how the y-axis changes. Turn the amplitude button to the lowest possible value. Now press the button above “Attenuator” labeled 20dB. This reduces the amplitude of the signal. Keep pressing the other two “dB” buttons to reduce the signal further until the signal looks very noisy with distinct levels of voltage. Each level represents a distinct binary number from the A/D conversion but displayed as a voltage value. The distinct steps in the display show the discrete resolution of the board. Pause the display, if necessary. Compare the observed resolution from the screen to the theoretical resolution of the board based on the voltage range setting and number of bits of the A/D converter of the board. They should match. If not, check your settings and discuss with the TA.
3. Next, reduce the board input range to the smallest possible range and collect more data. The sine signal should now again look like a sine wave rather than noise. Calculate the voltage resolution now.
4. Turn off the attenuation (dB buttons) to return to about 3V signal strength without changing the voltage range. Now the signal is saturated at the low voltage limits (observe the clipping). Readjust the voltage limits to a value appropriate for your signal.

This experiment shows how important it is to choose the right voltage range based on actual signal magnitude. Both saturation error and resolution error can distort the signal, if voltage ranges are chosen improperly.

CROSS TALK ON OPEN CHANNELS

Within the data acquisition board the separate channels are not totally isolated. There is a multiplexer in the board, which switches between the channels to read the applied voltage and pass it on to the A/D converter. This can lead to “cross-talk”, signal from one channel leaking into another channel.

5. Remove the BNC terminators from channels next to the signal input channel and then look at the signal on these channels by displaying multiple channels. Notice the “cross-talk” between channels: an apparent signal appears on channels, where no signal is applied. This is noise in the electrical circuits due to the open connection on the unused channels.

6. Add the BNC terminators to the channels displaying “cross-talk” noise. Now what happens?

- Change settings either on the function generator or computer; predict what is going to happen before you make a change. Take notes as you go. If you expect a result different from what actually happens, stop and discuss with the TA.

OTHER DATA ACQUISITION PARAMETERS

Adjust the following parameters on the signal generator or on the GUI interface and observe the result.

7. signal frequency
8. sampling rate
9. sample size (= frame size)
10. graph properties (x and y axis limits)

Thoroughly familiarize yourself with the system at hand. Don’t hesitate to ask your lab instructor, when in doubt.

STORE FUNCTION GENERATOR AND CABLES, LOGOFF FROM COMPUTER

Useful Sampling Equations

\[
\begin{align*}
    f_{\text{Nyquist}} &= f_s / 2 \\
    f_s &= \text{Sampling freq.} \\
    f_{\text{min}} &= 1 / T \\
    T &= \text{Sampling time period} \\
    \Delta t &= 1 / f_s \\
    \Delta t &= \text{Sampling time incr.} \\
    T &= M \times \Delta t \\
    M &= \text{Number of samples (Frame size)} \\
    \omega &= 2\pi f \\
    \omega &= \text{angular freq.}
\end{align*}
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