

PH2150 Introduction to Data Acquisition – Analogue to Digital Conversion

Introduction

Data acquisition (DAQ) is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer.

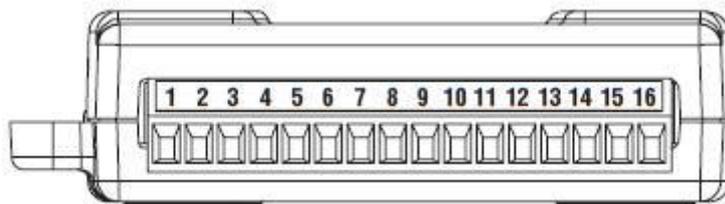
This section of the course uses an Analogue to Digital Converter (ADC) to acquire a signal from a function generator and perform measurements on the signal. How an ADC actually does the conversion is beyond the scope of this course but there are many websites with good explanations of ADCs.

The ADC used is the USB-6008 Data Acquisition unit from National Instruments (NI). The unit can perform functions such as Analogue Input, Analogue Output, Digital Input/Output and Digital Counting. The datasheet for this unit can be downloaded from the NI website (www.ni.com and search for USB-6008).

Using the USB-6008

Start Labview 2010 and open **read usb6008 ADC.vi**. When run, this VI collects data from the ADC and displays it on a graph. Set **Rate** to 1000 (samples per second) and **Count** to 100. The ADC will acquire 100 samples at 1000Sa/s, taking 0.1s to do this. Leave the **Channel** as *Dev1/ai0*.

Connect the output from the signal generator to the ADC pins as described below:



Pin 1	GND	Ground (Black Common terminal on Function Generator)
Pin 2	AI0 +	Signal (Red Output terminal on Function Generator)
Pin 3	AI0 -	Link to Pin 4 with a short wire
Pin 4	GND	Link to Pin 3

Set the generator to about $2V_{pp}$ (2 volts peak-to-peak) at 10Hz and Sine-wave output. Run the VI – you should see one cycle of a sine wave on the screen. Experiment using different input frequencies and signal amplitudes as well as different sample rates. Are all viewed waveforms as you expect?

Aliasing

Start with a signal input of about $2V_{pp}$ and 1kHz. Set the sample rate to 10kSa/s and number of counts to 100. Calculate the frequency displayed on the graph (hint: calculate the time taken for the acquisition and count the number of cycles on the graph). Increase the input frequency to 10kHz, in steps of 1kHz, and adjust the number of counts to show several cycles on the graph and estimate the frequency shown. Plot a graph of measured frequency versus input frequency and explain your results.

Continue increasing the input signal to 20kHz (in steps of 1kHz) and plot the results. Describe the shape of the plotted graph and explain the results obtained. If the experiment is done carefully the phenomenon of **aliasing** should be apparent. Generate an equation/equality to associate sampling frequency and input frequency such that aliasing is eliminated. Describe some real-world examples of aliasing (hint: spoked wheels and strobe lamps).

Quantisation

Set the signal input to $100mV_{pp}$ and 500Hz. Set the sample rate to 10kHz and display a few cycles of the signal on the graph. Reduce the input amplitude in steps of about 10mV down to 10mV. What happens to the waveform displayed? The resolution of an ADC is the smallest voltage change discernible. What is the resolution of the ADC you are using? If an ADC has a 12-bit converter and a full-scale range of 10V, what is the resolution of the ADC?

Labview signal analysis

Labview can provide information on acquired signals such as fundamental frequency. Using **read_usb6008_ADC.vi** as a starting VI, add **Buneman Frequency Estimator** from the **Signal Processing>>Spectral Analysis** palette. The output from the VI is **Beta** – how is this value related to the waveform frequency? Add the necessary numeric functions to the diagram and make an indicator to display the frequency on

the front panel. What conditions are required to get a good frequency estimate (number of cycles captured, signal resolution etc)?

Add **Auto Power Spectrum** and display the output on a second **Waveform Graph**. The input **dt** is the time interval between successive samples – wire this input from **Rate** along with a suitable numeric function. The output from this VI gives information on the spectrum (frequency content) of the signal. The largest peak is the fundamental frequency. Any harmonics present contribute to a measure of the **harmonic distortion** of the signal.

If you get time, you can investigate some other VIs, such as **Signal Processing>>Signal Operation>>Peak Detector** (to help count the number of cycles) and **Signal Processing>>Filters** (to help remove noise). What signal conditions, or VI parameters, are required for optimum use of these VIs?

Write-up

Your work should be presented as a regular laboratory write-up, with a maximum of **four pages**, and emailed to **G.Boorman@rhul.ac.uk**. Add sufficient graphs/VIs as appropriate to demonstrate your understanding of the use and limitations of ADCs.

Ensure your VIs (both front panel and diagram) are clear and readable, with suitable comments to describe how to use the VI.