

ENG H191: Hands on Labs

Data Acquisition

Engineering Disciplines Explored: All

MOTIVATION

Engineering Applications

Much of the work done in engineering fields is involved with gathering and analyzing data. When dealing with an engineering problem, there are often several unknown values or parameters that must be determined before any creative problem-solving can take place. In fact, the very formulation of a problem statement might depend heavily on measurements or information regarding some system, be it physical, electrical, chemical, or computational. Further data is usually required later in the engineering process in order to test the performance or effectiveness of a solution.

The process of gathering and analyzing information is called data acquisition. In the past, this kind of work was very tedious and time-consuming. It often involved manually taking hundreds or thousands of measurements and then mathematically analyzing them, often using graphical means. Today, this process is made much more efficient and accurate by technology. Data acquisition systems are available that allow engineers to quickly measure and analyze millions of data points using a computer and some additional hardware. These systems are increasingly user-friendly and flexible. The same hardware can be used to take measurements on a wide range of physical parameters, from position to temperature to pH levels. They allow a moderately-experienced computer user to set up a single application to measure, analyze, and display data in a matter of minutes.

Although new technology has made data acquisition much faster and easier, it has not turned it into a brainless activity. A lot of thought and creativity go into deciding the type and amount of information to collect, how to collect it, and how to analyze and use it. Engineers are responsible for these decisions, and they often have a profound effect on the overall success of an engineering project.

Objectives

- Gain experience using a data acquisition system
- Demonstrate ability to use basic LabView functions

Basic Principles

This lab write-up will cover the following basic principles:

- Components of a data acquisition system
- Sensors
- Signal conditioning
- Analog-to-digital conversion

Lab Experience

The lab experience will include observation and experimentation with:

- Creating a LabView application to analyze spot speed traffic data
- Determining the shutter speed of a camera using a LabView application

Fundamentals

A data acquisition system (DAQ) consists of several integrated components. A block diagram of these components is shown in Figure 1, below.

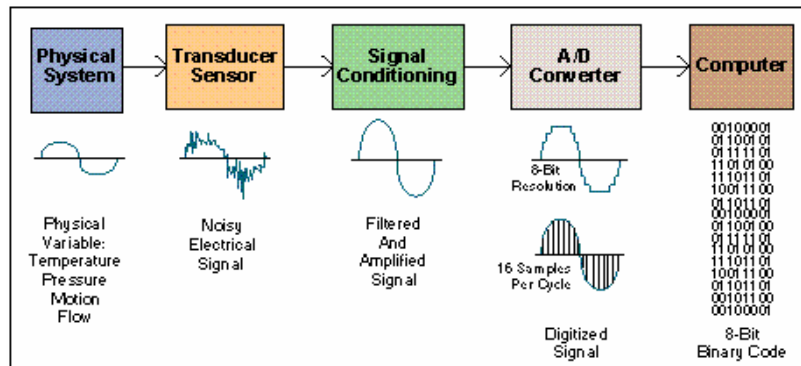


Figure 1: Block diagram of data acquisition system

The overall goal of the system is to measure some physical quantity and then represent the measurements in some digital format that can be stored and analyzed using a computer. The five blocks shown in this figure are described in more detail below.

Physical System

The physical system is the quantity or variable that is being measured. The type of measurements that can be collected using a data acquisition system is limited by the types of sensors available. This is an important consideration for engineers when choosing a data acquisition system for a particular application.

Transducer/Sensor

A transducer (or sensor) is a device that translates some physical phenomenon to an electrical signal. Transducers are available to measure a wide range of physical quantities, such as temperature, pressure, position, fluid flow, light, pH, sound, and many others. For a particular type of measurement, there may be several choices of different sensors. Often sensors are rated by the range of values which they can detect or the amount of noise they introduce into the DAQ. When choosing a sensor, engineers must consider the requirements for their application as well as the cost of the available sensors.

Signal Conditioning

This block of the DAQ has two main functions: to reduce noise in the electrical signal coming from the sensor, and to amplify or attenuate the signal. Noise is any unwanted

part of a signal. It is often random in nature. All transducers will introduce some amount of noise. Additional noise may come from other electronics within the DAQ or from sources in the environment. Electrical circuitry can be used to filter the noise from the signal. In addition to noise reduction, the signal conditioning block may need to amplify or attenuate the signal. For example, say a transducer outputs a signal that is between 0 and 1 volts, and this signal needs to go into an analog-to-digital converter (the next block in the system) with a range from 0 to 5 volts. Then the signal will need to be amplified by a factor of five.

Analog to Digital Converter

The purpose of the analog to digital (A/D) converter is to represent the analog signal coming from the signal conditioning block as a digital (usually binary) value so that it can be used by a computer. The most important properties of an A/D converter are its range, resolution, and sampling rate.

The *range* of an A/D converter is the range of input voltages that it can accept. For best performance, it is ideal that the expected range of the analog signal coming from the signal conditioning block matches the range of the A/D converter.

Recall that an analog signal can take on any value (it is continuous), while a digital signal is either on or off. If we have just one digital signal (1 bit), there are 2 possible values – either on or off (0 or 1). If we have two digital signals (2 bits), there are now 4 possible values – 00, 01, 10, or 11. In general, an n -bit digital signal can have 2^n possible values. For an A/D converter, the number of possible values that can be represented as a digital signal is the *resolution*. The resolution is usually given in number of bits. Say we have a 1-bit A/D converter with an input range of 0-4 volts. There are two possible output values, so the input range is divided into two partitions. Any time the input is between 0 and 2 volts, the converter will output a 0, and any time the input is between 2 and 4 volts, the converter will output a 1. Now, say we have a 2-bit converter with the same input range. Now there are four possible output values, so the input range will be split into four partitions. A table of input ranges and resulting outputs is shown below.

Table 1: Input/output for 2-bit A/D converter with range 0-4 volts

| Input range (volts) | Output |
|---------------------|--------|
| 0-1 | 00 |
| 1-2 | 01 |
| 2-3 | 10 |
| 3-4 | 11 |

We can see that using an A/D converter with a higher resolution will result in an output that more accurately represents the input value.

The last property of an A/D converter that we will discuss here is the sampling rate. The A/D converter works by taking a snapshot of the analog input value and then outputting the digital value to the computer. This process then repeats. The frequency at which these snapshots, or samples, are taken is the *sampling rate*. Engineers have to choose a

sampling rate that is appropriate to their particular application. For example, a data acquisition system built to measure the growth of a tree might have a sampling rate of one sample per month, but measuring the wing movements of a hummingbird would require something more like 20,000 samples per second.

When deciding on a resolution and sampling rate for an A/D converter, cost is often a factor. In general, higher resolutions and sampling rates mean greater cost. Another important factor, though, is the size of the data. Doubling the sampling rate will double the amount of data collected. So will increasing the resolution by one bit. The size of the data can be thought of as a cost, since more data will require more memory for storage. Also, computation time for data analysis may increase exponentially with the size of the data.

Computer system

The final block of the data acquisition system is the computer. The main function of this block is to store and/or process the collected data. Depending on the application, a DAQ computer system might be a powerful supercomputer capable of doing complicated data analysis in real-time or a simple portable device capable only of storing data so that it can be used later.

Software packages are available now that allow users to quickly build a data acquisition system for many different types of applications using the same hardware. In today's lab, we will be using one of these.

Lab Experience

The lab experience is divided into two parts which should be done in a two person group. It does not matter in which order they are completed.

Part1 – Analyzing Traffic Speed Data with LabVIEW

Some data is available which mimics traffic speed data that may have been taken during the Spot Speed Study from ENG 191. The purpose of this exercise is to build a LabVIEW Virtual Instrument to read in that data and to analyze it. The instrument will determine the mean, median, mode, and standard deviation of the data as well as produce the frequency response and cumulative frequency response plots. Please follow the instructions provided at your lab bench for this exercise.

Part2 – Measuring the Shutter Speed and Flash Duration of a Disposable Camera

For this exercise, the students will build a virtual oscilloscope in LabVIEW to measure the shutter speed of a one-use camera using a light probe. The result will be a pulse of a certain duration which will be shown graphically and will also be automatically measured and indicated numerically. Please follow the instructions provided at your lab bench for this exercise.

Lab Report

There is no formal report required for this lab. In order to receive credit, each group of two students must turn in the printed screen capture of the Block Diagram for both lab exercises. In addition, the Front Panel screen capture should be given for each result obtained for both lab exercises; this would be three result screens for Part1 and one result screen for Part2. The recommended way to print the screen captures is to first capture the active window with the keyboard command “ALT - PrtScrn”; this will copy the active window to the clipboard. Then create a new Word document and paste the clipboard image to the document. **Please also label each image with a descriptive identification and include your names and seat numbers with the printout.**