Data Acquisition System

INTRODUCTION

- Data acquisition 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.
- DAS or DAQ typically measures an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound and converts the analog waveforms into digital values for processing and analysis.
- A DAQ consists of sensors, DAQ measurement hardware, and a computer with programmable software.
- A Data Acquisition System is comprised of three parts; an I/O sub-system, a host computer and the controlling software. Hence these systems are often referred to as embedded DAQ syste

NEED OF DATA ACQUISITION SYSTEMS

- Data acquisition systems interface between the real world of physical parameters, which are analog, and the artificial world of digital computation and control.
- DAQ are used widely because they are low cost, accurate, and relatively simple to implement.
- Data acquisition systems are capable of measuring hundreds of variables simultaneously.
- They are now used by most engineers and scientists for laboratory research, industrial control, test, and measurement of input and output data to and from a computer.
- Industries that presently employ such automatic systems include steel making, food processing, paper production, oil refining, chemical manufacturing, textile production, cement manufacturing, and others.

COMPONENTS OF DATA ACQUISITION SYSTEM

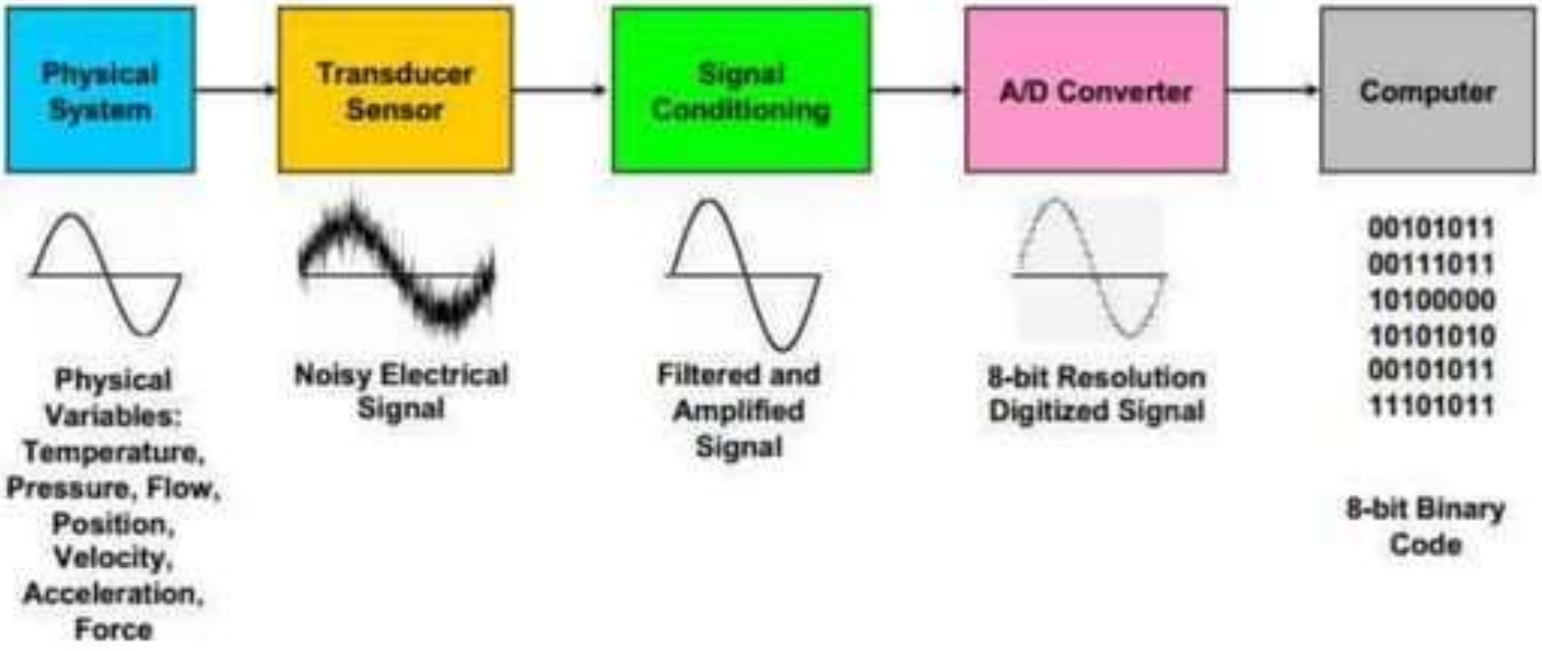
- Sensors which measure physical variables such as temperature, strain, pressure, flow, force and motion (displacement, velocity and acceleration).
- Signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values.
- Analog-to-digital converters, which convert conditioned sensor signals to digital values which can be used by the computer.
- A computer with the appropriate application software to process, analyze and log the data to disk. Such software may also provide a graphical display of the data.

DAQ MODULE

DAQ module can be divided into three categories:

- Source and the system: It consists of the system from which the data is to be acquired with the help of different sensors and the signal conditioning circuit.
- DAQ hardware: It acts as an interface between the signal and a PC. DAQ cards often contain multiple components (multiplexer, ADC, DAC, high speed timers, RAM). These are accessible via a bus by a microcontroller, which can run small programs.
- DAQ software: Specialized DAQ software may be delivered with the DAQ hardware. DAQ software is needed in order for the DAQ hardware to work with a PC.

DAQ MODULE


Physical System
Transducer Sensor
Signal Conditioning
A/D Converter
Computer
Physical Variables: Temperature, Pressure, Flow, Position, Velocity, Acceleration, Force
Noisy Electrical Signal
Filtered and Amplified Signal
8-bit Resolution Digitized Signal
00101011
00111011
10100000
10101010
00101011
11101011
8-bit Binary Code

SENSORS

- In order to sense and measure physical variables such as pressure, flow and motion, it is necessary to use transducers or sensors, which convert physical variables into electrical signals and transmit these signals to a signal conditioning device or directly to the data acquisition board.
- The six distinguishable energy forms that are usually measured are:
  - Radiant: Light, infrared radiation, nuclear radiation
  - Mechanical: Displacement/velocity/acc, Force/Torque
  - Thermal: Temperature, Heat flux
  - Electrical: Resistance, Capacitance, Voltage, Current, Energy, Power
  - Magnetic: Magnetic Flux density
  - Chemical: pH, Chemical Composition

SIGNAL CONDITIONING

The signal conditioning device performs the following main functions:

- Supplies power to the transducer when required.
- Amplify, filter and digitize the sensor signal. E.g.Using a programmable gain amplifier.
- Provide an appropriate output signal that can be easily processed by the analog to digital convertor.

DAQ HARDWARE

The DAQ hardware turns the computer into a measurement and automation system. The main criteria to consider while selecting a DAQ device for a specific application are:

- Type of input channels:

a).Single ended input channels

b).Differential input channels

- Compatibility with variety of protocols
- No. of analog input channels
- Sampling rate
- Resolution
- Accuracy

DAQ HARDWARE

The hardware basically consists of :

- The Analog to Digital convertor

  ADCs transform an analog voltage to a binary number (a series of 1's and 0's). The number of binary digits (bits) that represents the digital number determines the ADC resolution.

- Interfaces

If the DAQ system is in the form of modules then it can be connected to the computer's ports (parallel, serial, USB, etc.) or if in form of cards then they are connected to slots (ISA, MCA, PCI, PCI-E, etc.) in the motherboard.

DAQ SOFTWARE

- DAQ software is needed in order for the hardware to work with a PC.
- It is the most critical factor in obtaining reliable, high performance operation.
- The software transforms the PC and the hardware into a complete data acquisition system which can analyze and display the parameters acquired from the source.

The different softwares available are broadly classified into two categories:

- Programmable Software involves the use of programming languages such as C++, Visual C++, BASIC, etc. The advantage of using these softwares is it provides flexibility but it increases the complexity of the code.
- Data acquisition software packages do not require programming. They enable developers to design the custom instrument best suited to their application. E.g. LabView, MATLAB, etc

DATA ACQUISITION PROCESSORS

- For real time data acquisition DAP boards are available which have on board processors.
- All data acquisition processor boards consist of:
  - Onboard processors.(e.g. Intel)
  - Multitasking, real-time operating system.
  - Onboard memory.
  - Support external expansion boards to increase the number of data channels.

DATA ACQUISITION PROCESSORS

Some of the major advantages of using DAP boards are:

- Each Data Acquisition Processor (DAP) board gives the system an additional processor running a real-time operating system that can be controlled from a Windows application.
- Two or more DAP boards, in the same PC or on a network, can work together as a single synchronized system. This is highly advantageous for large scale data acquisition, like in process industries.
- High quality measurement: DAPs can provide direct measurements with 15+ accurate bits in the best case. DAP onboard filtering and careful calibration can yield measurement accuracy even in the presence of random noise.
- High sampling rates: Data Acquisition Processors are built for speed. At the low, slow end of the DAP product line, sampling rates are 800,000 samples per second, without sacrificing sampling accuracy at these speeds. Some other data acquisition cards sample fast, but not many can maintain accuracy at their maximum rates.
- Signal generation: In addition to sampling, Data Acquisition Processors can also generate signals: complex waveforms, digital alarm outputs, and digital or analog control commands. These processes do not interfere with sampling or reduce its capacity. Output clocking accuracy is the same as the input clocking accuracy.
- Real time response: The reserve of processing power necessary for high-speed data transfers also make it possible for a DAP to respond to external events reliably. Delays of 10 milliseconds or much longer are common in a loaded PC workstation. But on a DAP, updates are

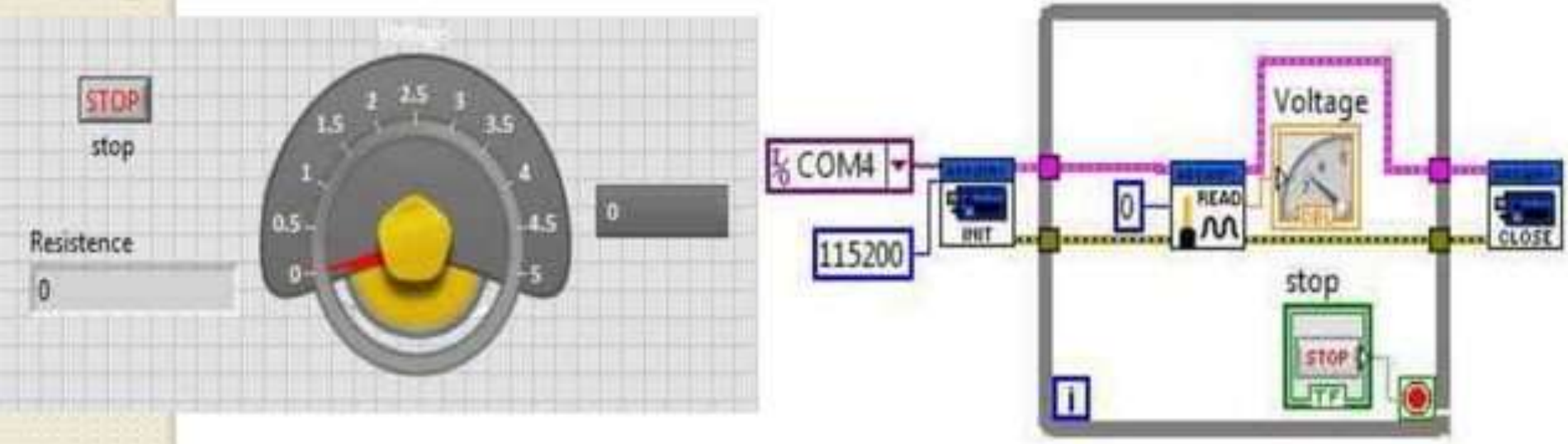
ADVANTAGES

- Reduced data redundancy
- Reduced updating errors and increased consistency
- Greater data integrity and independence from applications programs
- Improved data access to users through use of host and query languages
- Improved data security
- Reduced data entry, storage, and retrieval costs
- Facilitated development of new applications program

DISADVANTAGES

- Database systems are complex, difficult, and time-consuming to design
- Substantial hardware and software start-up costs
- Damage to database affects virtually all applications programs
- Extensive conversion costs in moving form a file-based system to a database system
- Initial training required for all programmers and users

Arduino based DAQ using LabView



Interfacing a 10KΩ Potentiometer with LabView using Arduino Uno

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