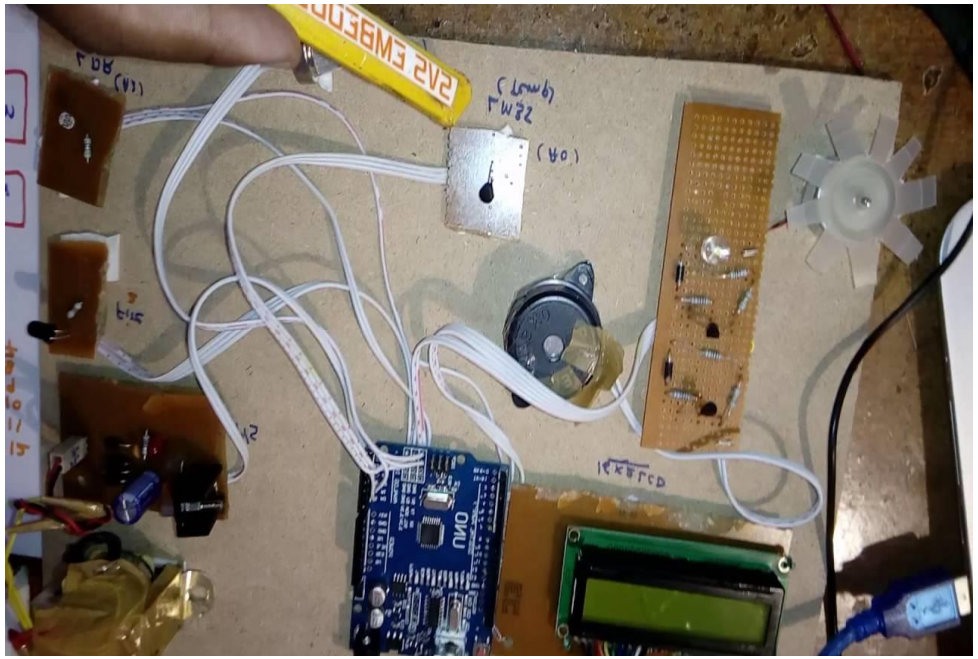


ME772A Mechatronics
Introduction to Data Acquisition
14-11-2018

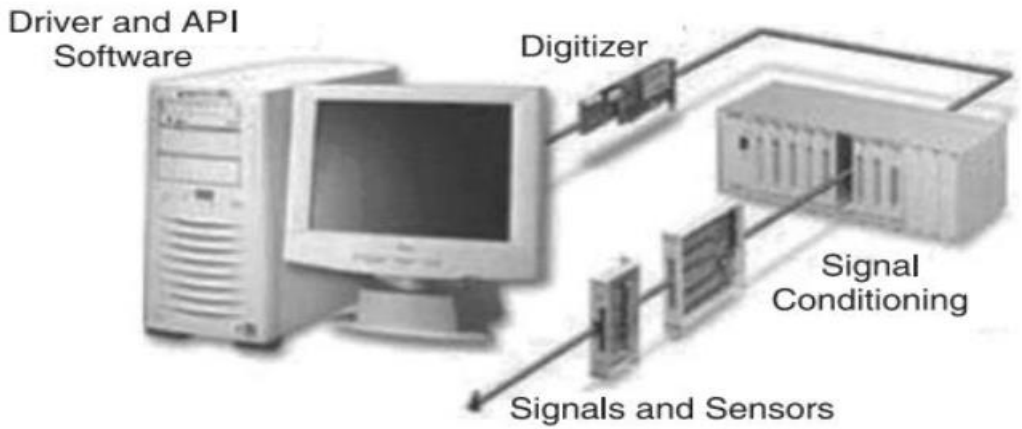
Introduction to DAS or DAQ

- The fundamental task of a DAQ (Data Acquisition) system is to measure or generate real-world physical signals.
- It involves gathering signals from measurement sources and digitizing the signal for storage, analysis and presentation on a personal computer.
- Scientists and Engineers can choose from PCI, PXI, USB, Firmware, parallel, or serial ports for data acquisition in test, measurement, and automation applications.
- It typically converts analog signals into digital form easy for processing.
- When building a basic DAQ system, the required components are transducers, signals, signal conditioning, DAQ hardware, and driver and application software.
- It plays a critical role in fields such as life science research, civil engineering and industrial maintenance etc.
- Real time data acquisition systems generate and display measurements without delay.

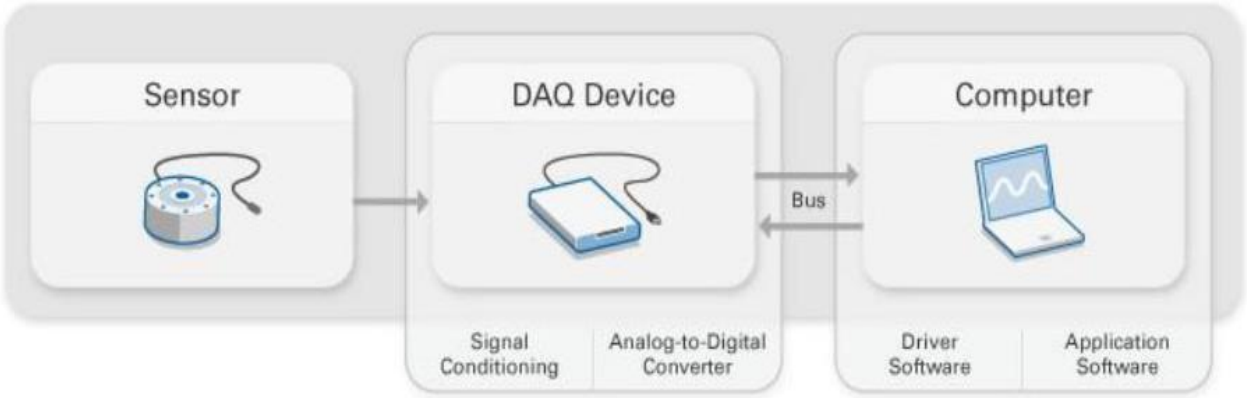
Objective of a DAS/DAQ system

- DAS must acquire the necessary data at correct speed and at correct time.
- To Understand how to properly sample a signal for digital processing.
- To Understand how the digital data to be coded.
- To Familiar about the components of A/D converter.
- To Understand how the A/D and D/A converter functions and recognise their limitation.
- Must be able to compute unit performance indices using on line real time data.
- To handle the data in a efficient manner.
- Must be reliable, easy to operate and must be user friendly.

Parts of a DAQ System



Data acquisition system



Parts of a DAQ System

Sensors that convert physical parameters such as temperature, pressure, motion, stress, flow etc into electrical signals.

Sensors can be of any shape or size, and the process of data acquisition may involve any number of sensors.

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 ones.

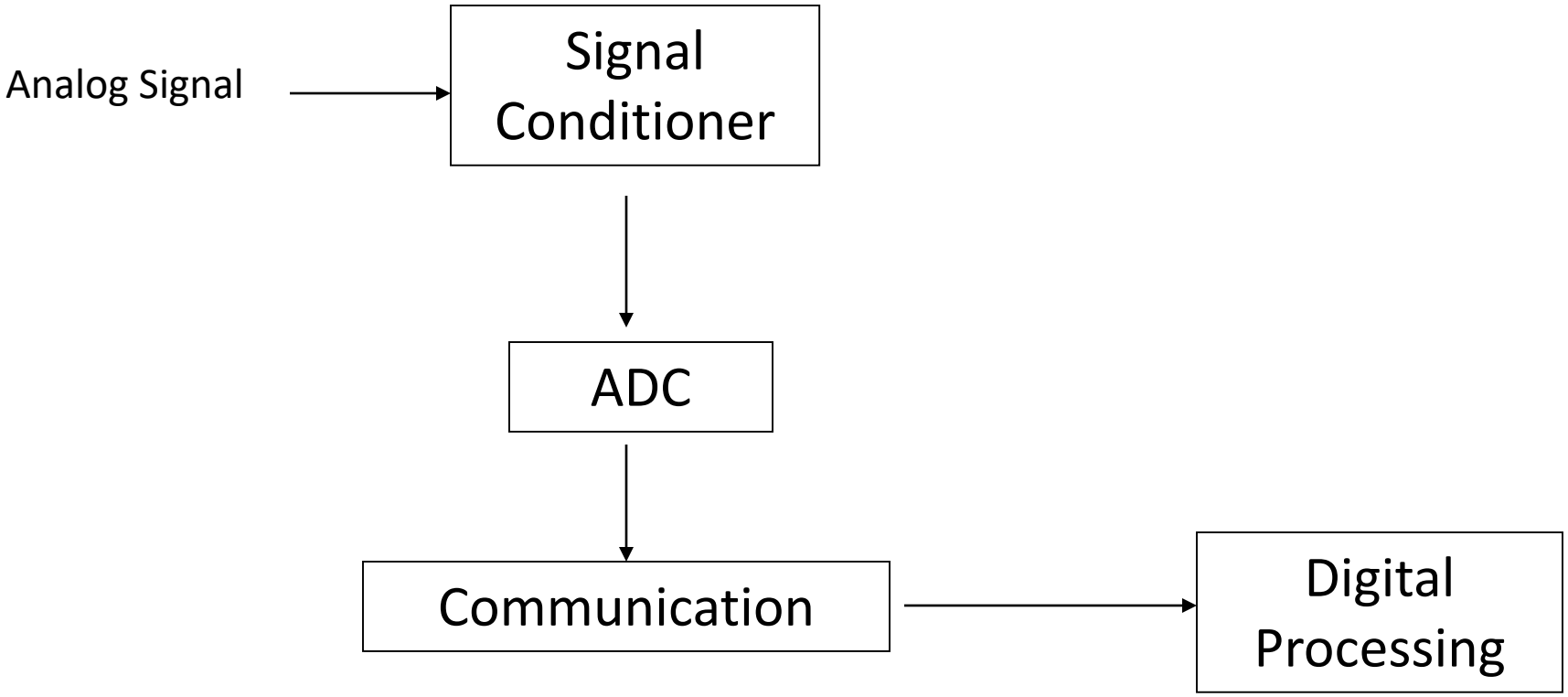
Driver software allows you to access and control your hardware. It Integrates the data acquisition hardware with signal conditioning hardware.

It can access multiple subsystems on a given data acquisition board.

A computer with the appropriate application software to process, analyse and log the data to disk. Such software may also provide a graphical display of the data.

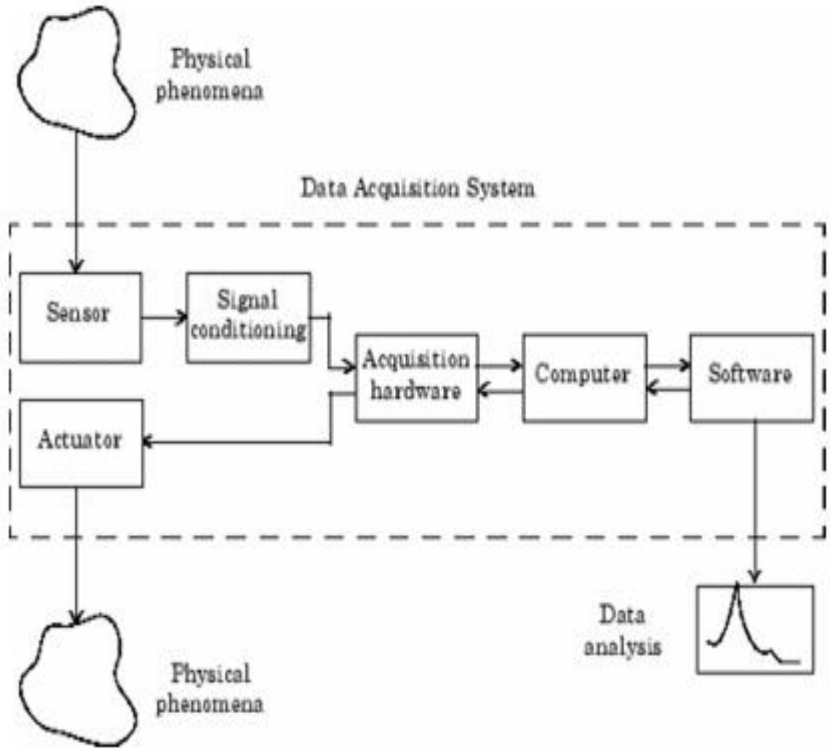
Data acquisition applications are usually controlled by software programs developed using various general purpose programming languages such as Assembly, BASIC, C, C++, C#, Fortran, Java, LabVIEW, Pascal, etc. Stand-alone data acquisition systems are often called data loggers. It can be used to record data over time.

General Data Acquisition System



Data Acquisition System

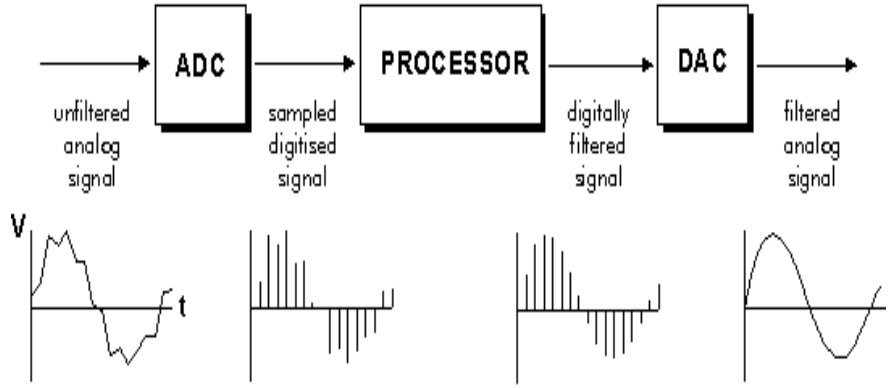
- The **purpose** of any data acquisition system is to ***acquire analog signals*** and present them to the MCU in a form that can be manipulated.
- The **main components** of any general data acquisition system consists of the following:
  1. ***Transducers (sensors)***
  2. ***Analog Multiplexer***
  3. ***Signal Conditioning (Amplification, Filtering, ..)***
  4. ***Sample and Hold Circuit***
  5. *Analog to Digital Converter*
  6. **Microcomputer System**
  7. *Digital to Analog Converter*
  8. ***Actuator***

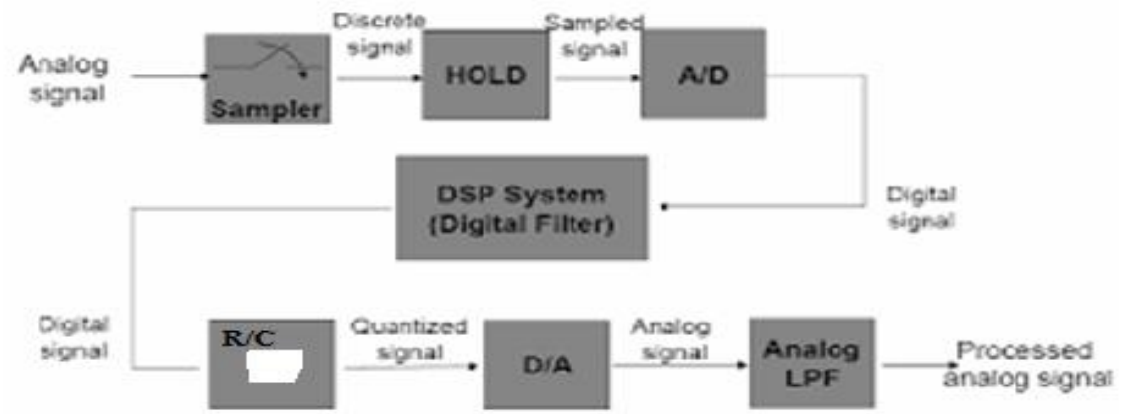


Signal Conditioning

Functions: modify the analog signal to match the performance of the ADC

- Pre-filtering: Remove the undesirable high frequency components.
- Amplification: Amplify the signal to match the dynamic range of the ADC.
- Isolation
- Linearization

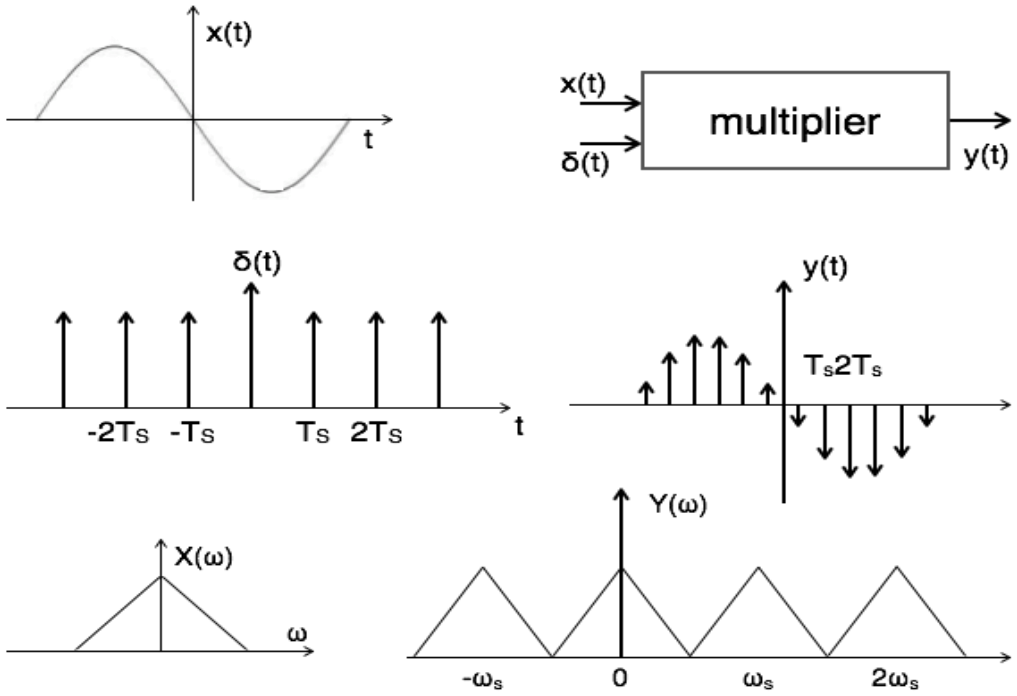


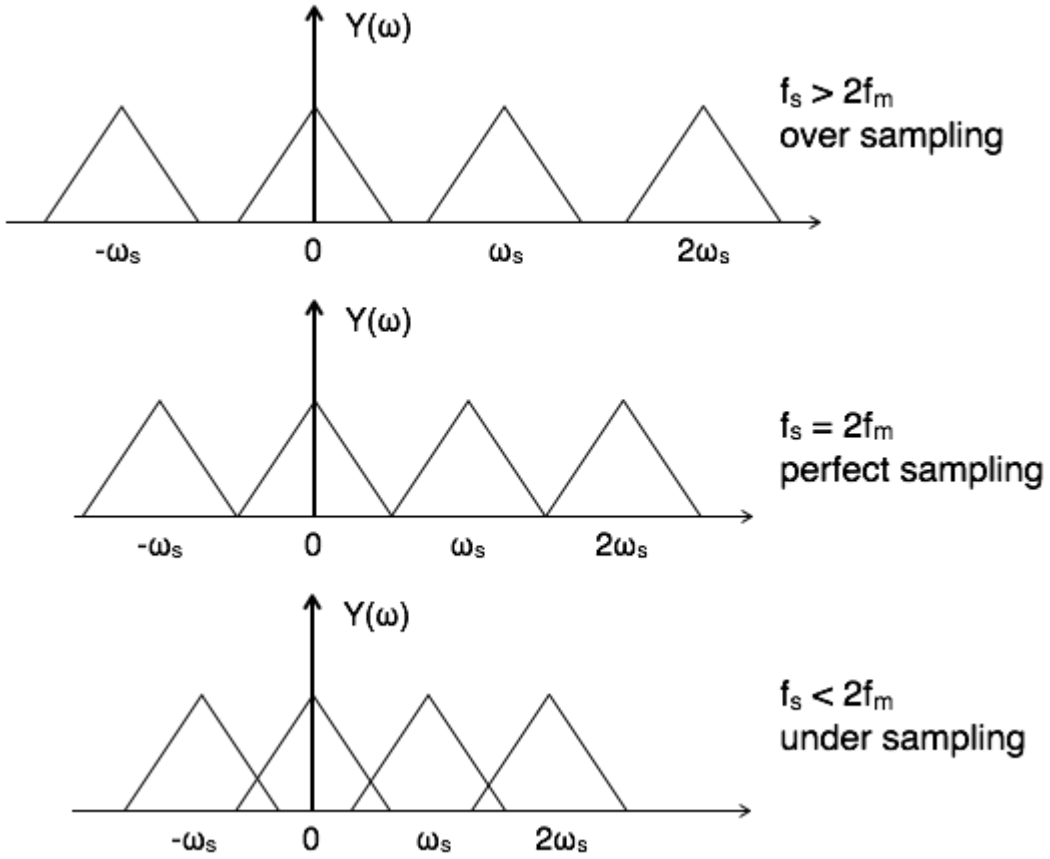


Sampling Process

Sampling Theorem

statement: A continuous time signal can be represented in its samples and can be recovered back when sampling frequency f_s is greater than or equal to the twice the highest frequency component of message signal. i. e.fs≥2fm.





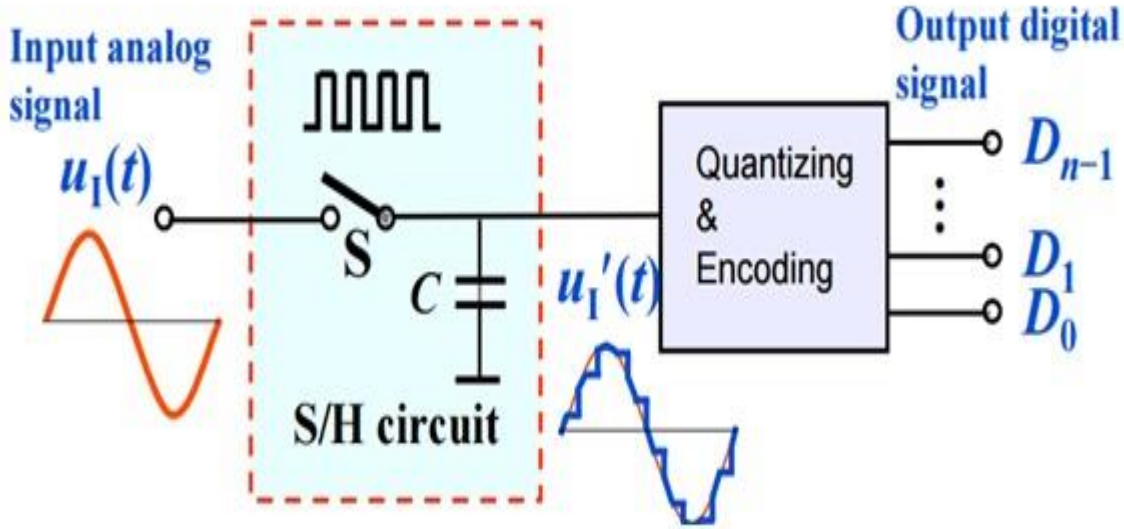
Analog-to-Digital Conversion (ADC)

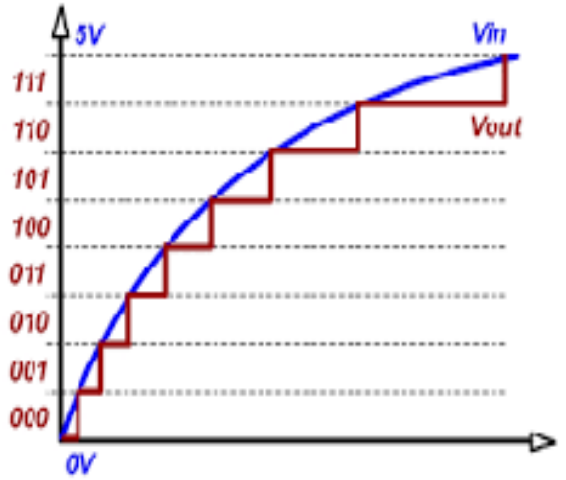
Function: convert analog signals into digital signals

- Sample & hold
- Numerically evaluate the signal at discrete instants of time.

Quantization and coding: transformation of a continuous analog input into a set of discrete output state

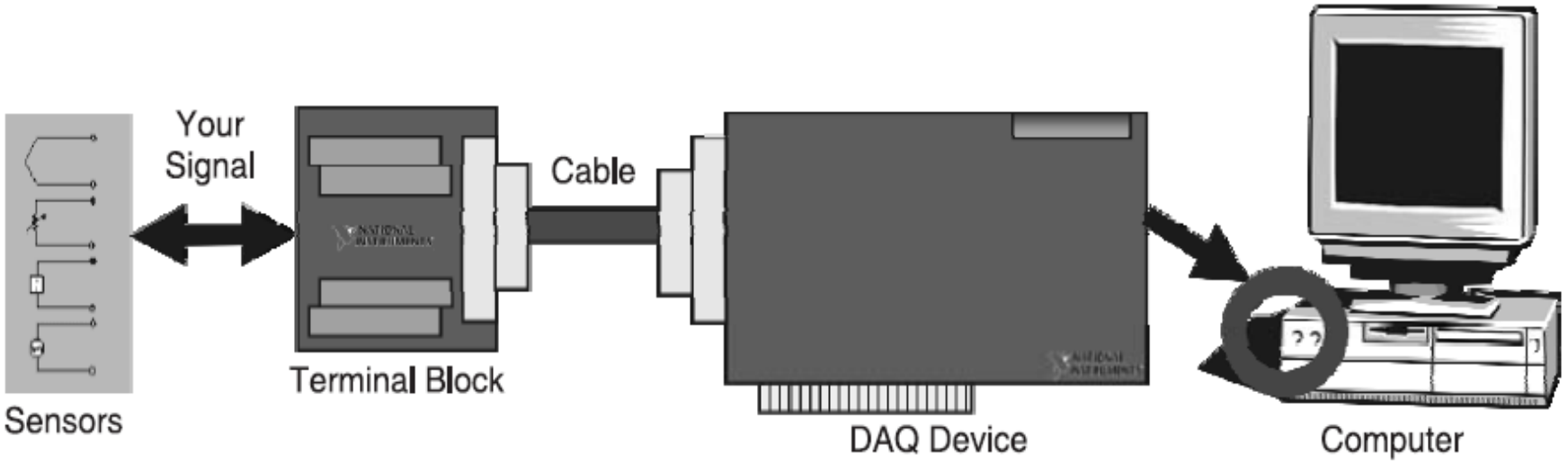
- Coding: the assignment of a digital code word or number to each output states
- Number of possible state: $N=2^n$, n is the number of bits





DAQ HARDWARE

- The DAQ hardware acts as the interface between the computer and the outside world. It primarily functions as a device that digitizes incoming analog signals so that the computer can interpret them.
- Other data acquisition functionality includes Analog Input/Output, Digital Input/Output, Counter/Timers and Multifunction which is a combination of analog, digital, and counter operations on a single device.
- National Instruments offers several hardware platforms for data acquisition. The most readily available platform is the desktop computer.
- National Instruments offers PCI DAQ devices that plug into any desktop computer.



Typical DAQ system

Analog-to-Digital Conversion

- Acquiring an analog signal with a computer requires a process known as analog-to-digital conversion which takes an electrical signal and translates it into digital data so that a computer can process it.
- Analog-to-digital converters (ADCs) are circuit components that convert a voltage level into a series of ones and zeroes.
- ADCs sample the analog signal on each rising or falling edge of a sample clock. In each cycle, the ADC takes a snapshot of the analog signal, so that the signal can be measured and converted into a digital value.
- A sample clock controls the rate at which samples of the input signal are taken. Because the incoming, or unknown signal is a real world signal with infinite precision, the ADC approximates the signal with fixed precision.
- After ADC obtains this approximation, the approximation can be converted to a series of digital values.
- Some conversion methods do not require this step, because the conversion generates a digital value directly as the ADC reaches the approximation.

Digital-to-Analog Conversion

- Digital-to-analog conversion is the opposite of analog-to-digital conversion. In digital-to-analog conversion, the data starts in the computer. The data might have been acquired earlier using analog input or may have been generated by software on the computer.
- A digital-to-analog converter (DAC) accepts this data and uses it to vary the voltage on an output pin over time.
- The DAC generates an analog signal that the DAC can send to other devices or circuits. A DAC has an update clock that tells the DAC when to generate a new value.
- The function of the update clock is similar to the function of the sample clock for an analog-to-digital converter (ADC). At each cycle the clock, the DAC converts a digital value to an analog voltage and creates an output as a voltage on a pin.
- When used with a high speed clock, the DAC can create a signal that appears to vary constantly and smoothly.

Applications of Data Acquisition

1. Process Control
2. Machine Control
3. Factory Automation
4. Testing Measurement
5. Environmental Monitoring
6. Food Processing
7. Medical applications

Practice Problems

1.Simplify the following function F(a, b, c, d)=Σm(0,1,2,6,8,9,10)using Karnaugh map method.

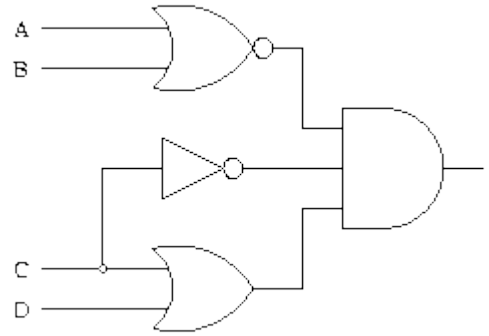
2.Simplify the following function F(A,B,C,D)= Σm(1,5,3,7)using Karnaugh map method.

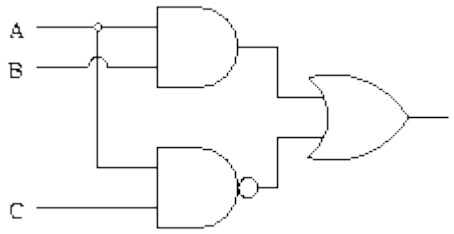
3.Simplify the function F=AB'C + A'BC +ABC' + A'B'C + AB‘C’ using K-map Reduction method.

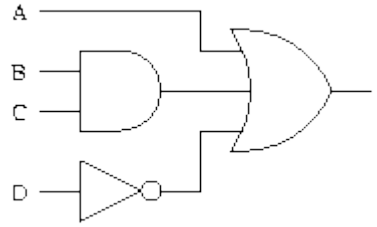
4.Simplify the following function F(w, x, y, z)=Σm(0,2,4,5,6,7,8,10,13,15)using Karnaugh map method.

5. How many number of minimum NAND gates are required to implement the Boolean function A + AB’+ AB’C?

6. Derive the logic Boolean function for the given logic circuit.







7.Can you design a two bit Magnitude comparator Logic Circuit?

8. Design a 8*1 Multiplexer circuit using logic gates.

Thank you