Measurements

If you have a smart project, you can say "I'm an engineer"

Lecture 1

Staff boarder

Dr. Mostafa Elsayed Abdelmonem

Measurements

- **Lecture aims:**
  - Formulate advanced signals into measured signals
  - Develop complete system

Introduction

A data acquisition system consists of many components that are integrated to:

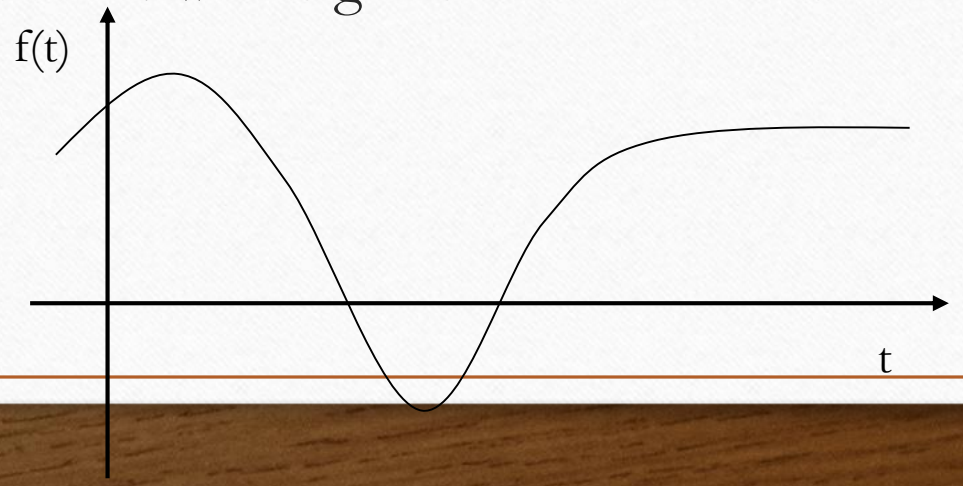
- Sense physical variables (use of transducers)
- Condition the electrical signal to make it readable by an A/D board
- Convert the signal into a digital format acceptable by a computer
- Process, analyze, store, and display the acquired data with the help of software

What is a Signal?

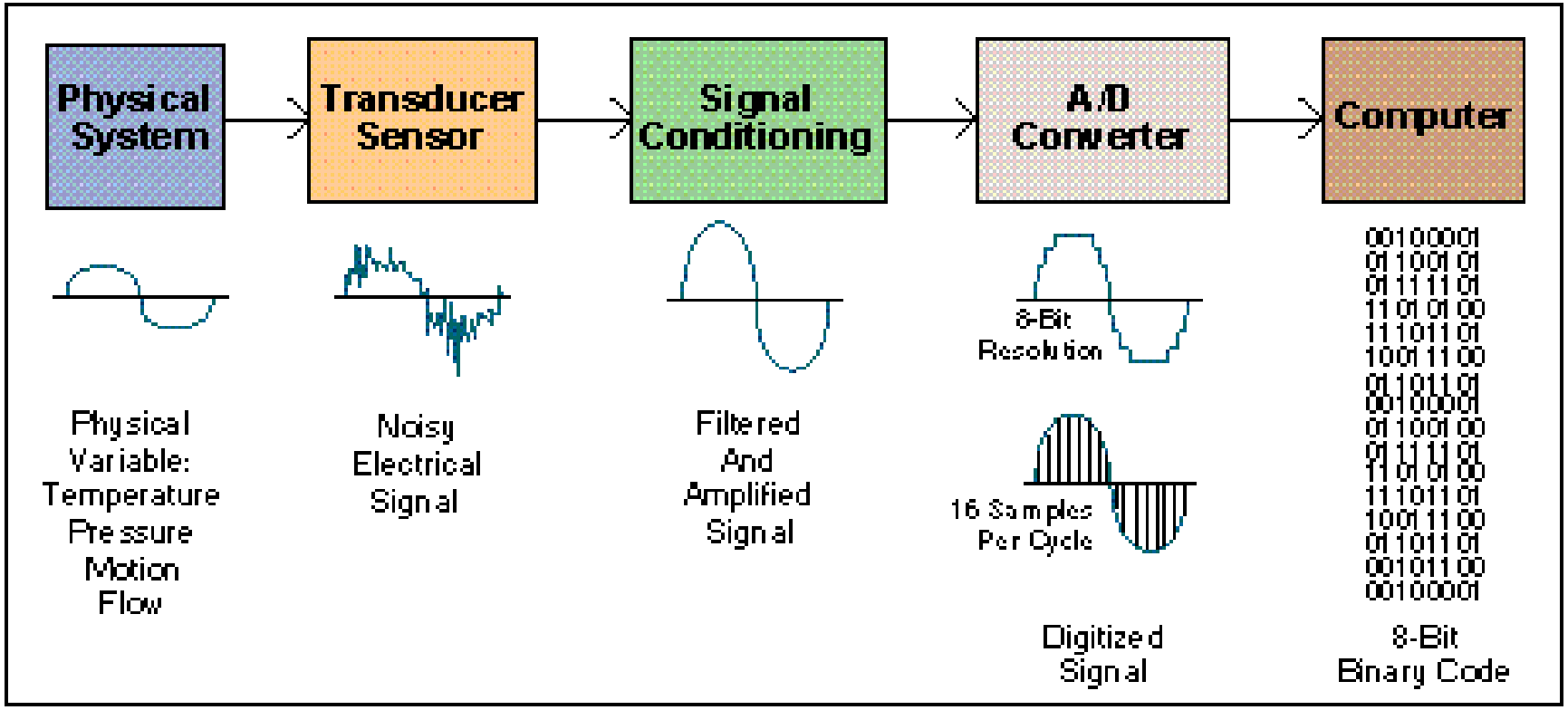
- A signal is a pattern of variation of some form
- Signals are variables that carry information
- Examples of signal include:
- Electrical signals
  - Voltages and currents in a circuit
- Acoustic signals
  - Acoustic pressure (sound) over time
- Mechanical signals
  - Velocity of a car over time
- Video signals
  - Intensity level of a pixel (camera, video) over time

How is a Signal Represented?

- Mathematically, signals are represented as a function of one or more **independent variables**.
- For instance a black & white video signal intensity is dependent on x, y coordinates and time t $f(x,y,t)$
- On this course, we shall be exclusively concerned with signals that are a function of a single variable: time



Data Acquisition System Block Diagram



Transducers

Sense physical phenomena and translate it into electric signals.

Examples:

- Temperature
- Pressure
- Light
- Force
- Displacement
- Level
- Electric signals
- ON/OFF switch

Signal Conditioning

Electrical signals are conditioned so they can be used by an analog input board.

The following features may be available:

- Amplification
- Filtering
- Linearization

Analog to Digital (A/D) Converter

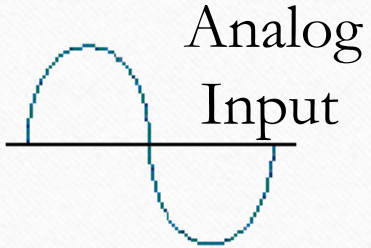
- Input signal
- Sampling rate
- Throughput
- Resolution
- Range
- Gain

A/D Converter: Input Signal

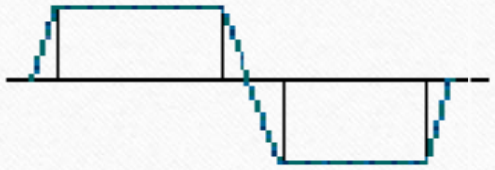
- Analog
  - Signal is continuous
  - Example: strain gage. Most transducers produce analog signals
- Digital
  - Signal is either ON or OFF
  - Example: light switch.

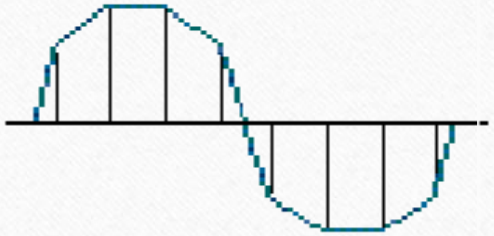
A/D Converter: Sampling Rate

- Determines how often conversions take place.
- The higher the sampling rate, the better.



4 Samples/cycle





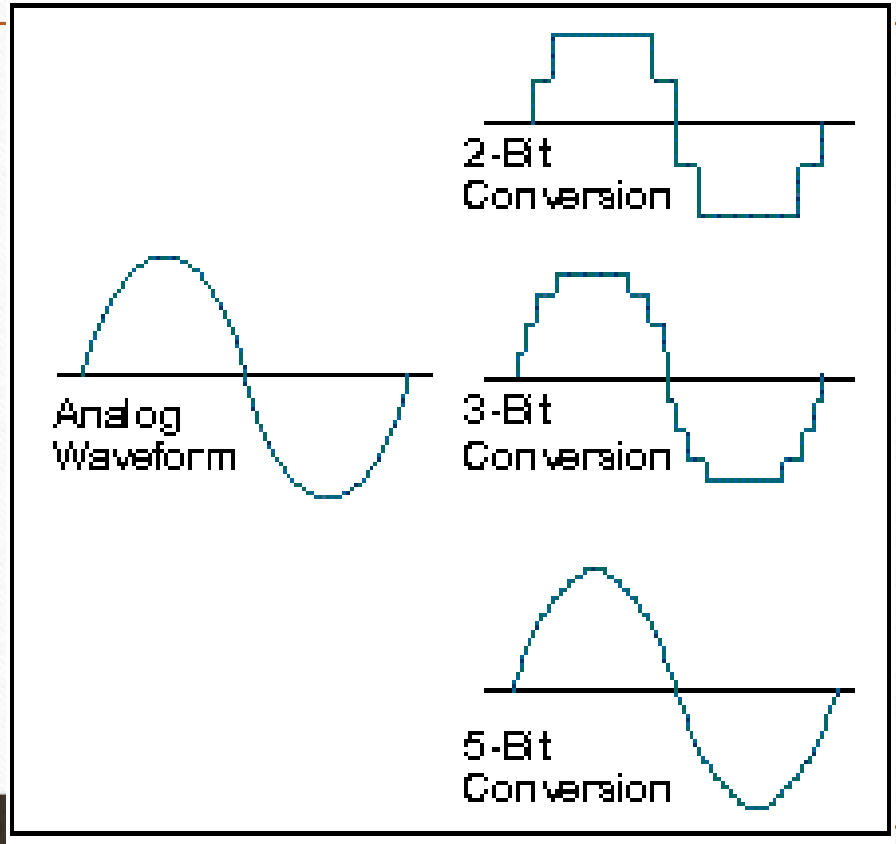
16 Samples/cycle

8 Samples/cycle

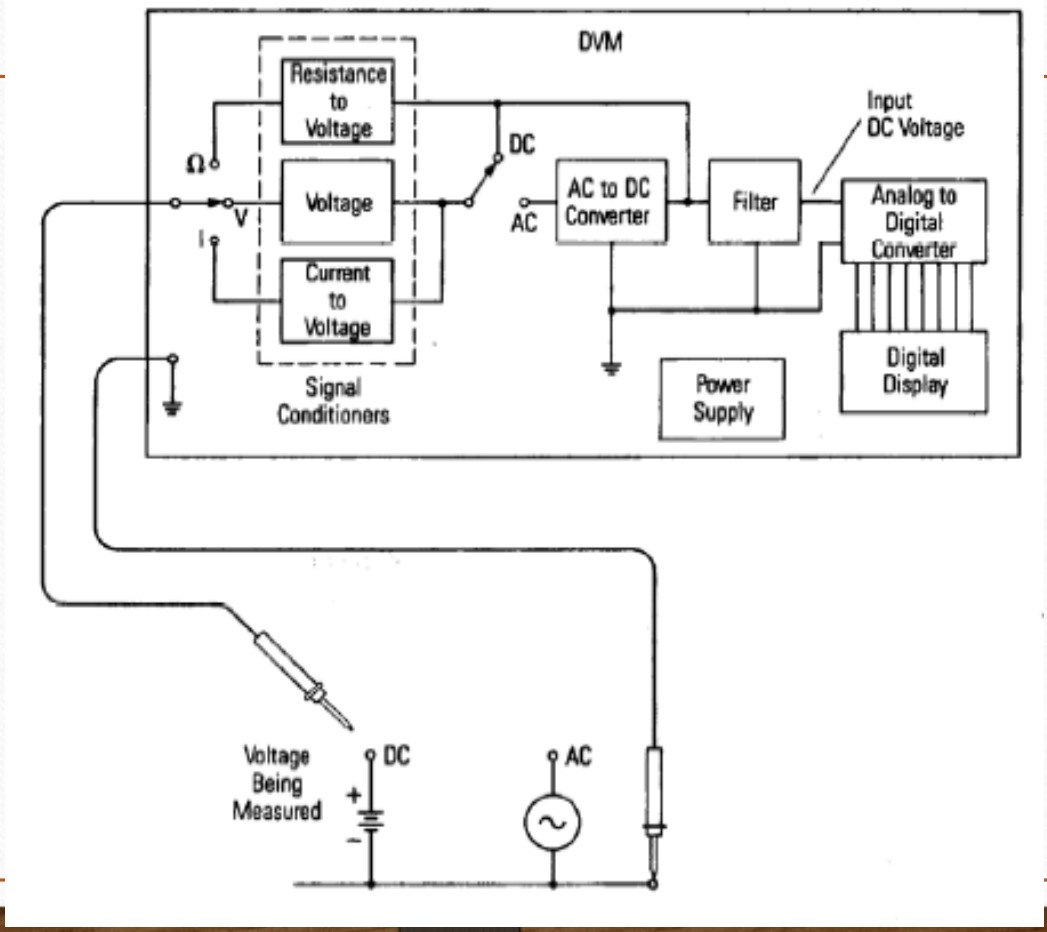
A/D Converter: Range

- Minimum and maximum voltage levels that the A/D converter can quantize
  - Ranges are selectable (either hardware or software) to accurately measure the signal

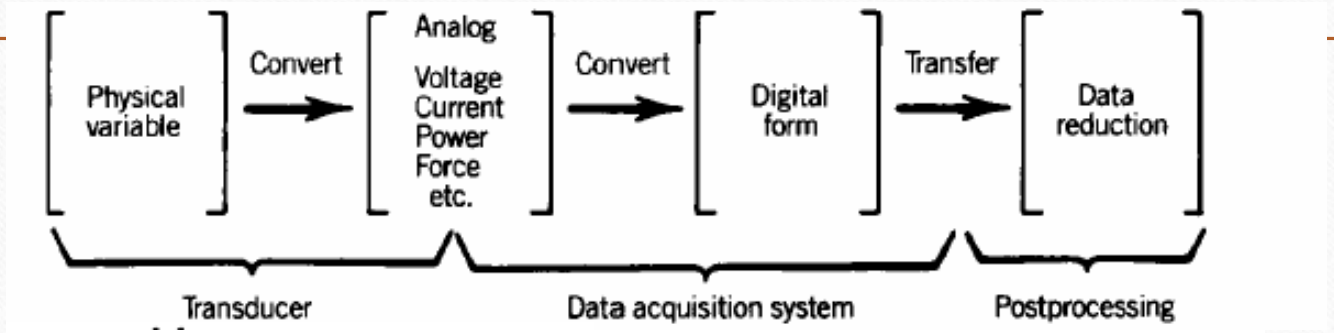
A/D Converter: Resolution

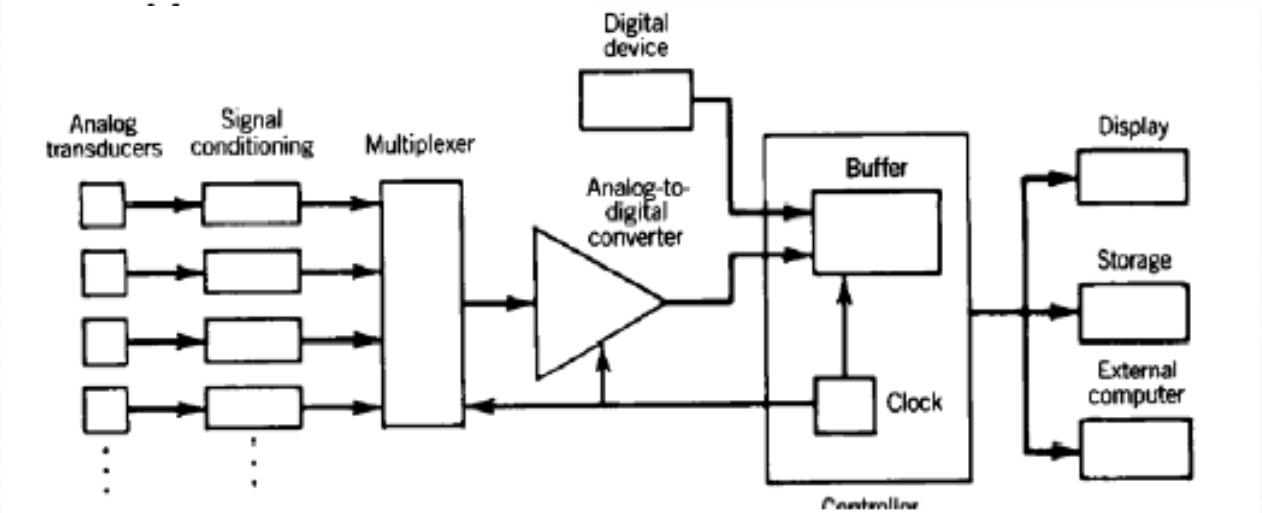


DAC Hardware/DMM

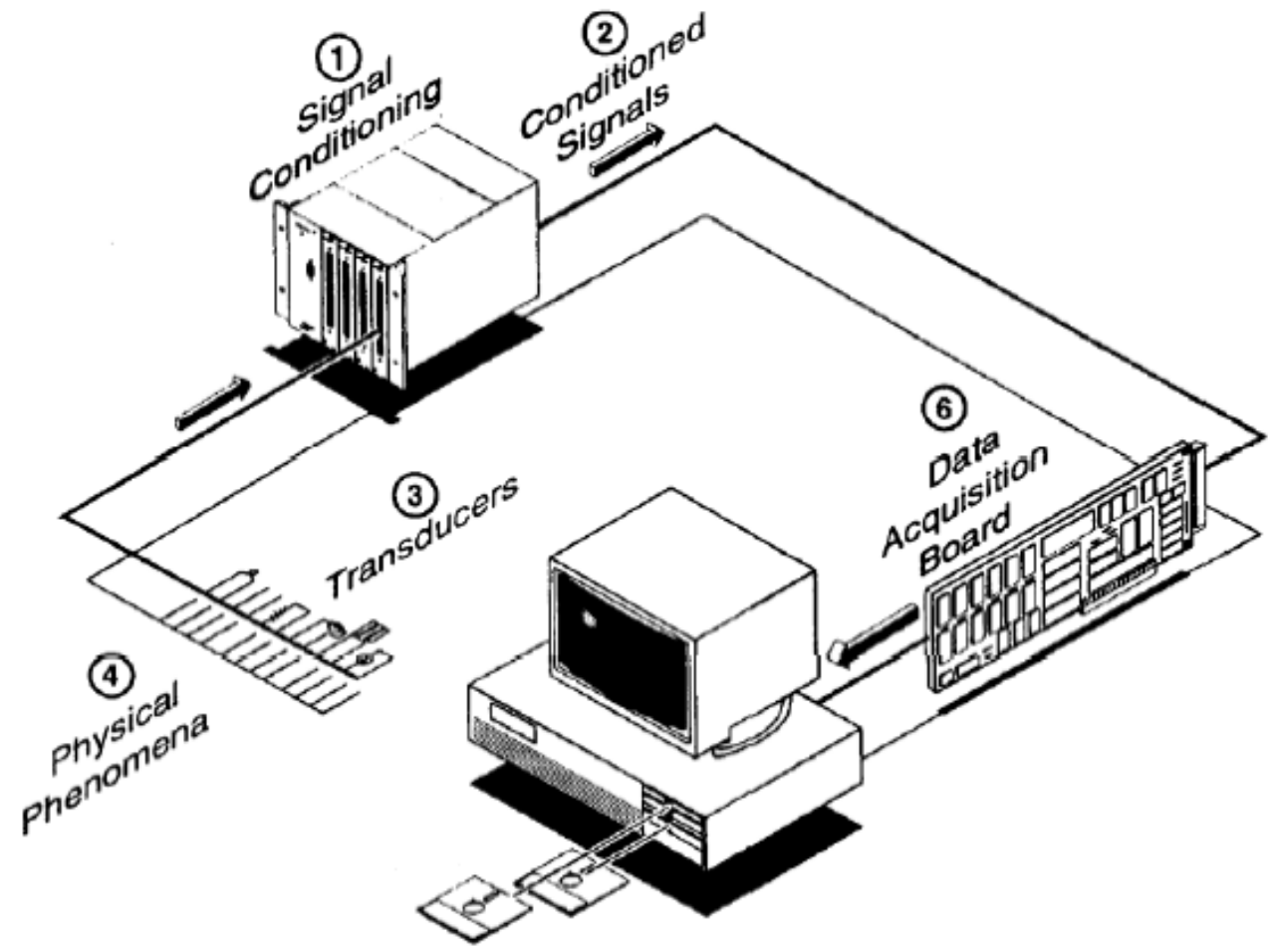


DAQ System


Physical variable
Convert
Analog
Voltage
Current
Power
Force
etc.
Convert
Digital form
Transfer
Data reduction
Transducer
Data acquisition system
Postprocessing


Digital device
Analog transducers
Signal conditioning
Multiplexer
Analog-to-digital converter
Buffer
Clock
Display
Storage
External computer

DAQ System


1
Signal Conditioning
2
Conditioned Signals
3
Transducers
4
Physical Phenomena
6
Data Acquisition Board

DAQ Functions

- **Analog I/O**
  - Generate DC Voltages
  - Read analog signals
- **Digital I/O**
  - General low (0V) and high (5V) pulses
  - Read digital pulses
- **Timing I/O**
  - Generate pulse trains (square waves)
  - Read frequency, time values

DAC Performance Specifications

- The output voltage can only take on a discrete number of values = 2n.
- Common DACs have n = 8, 10, or 12-bit.
- The **resolution** will be based on the reference voltage.

Example 1: 4-bit DAC can take on 16 levels. If *Vref* = 5 volts, then the **resolution** is 5/16 volts, or 0.3125 volts.

Example 2: 8-bit DAC having a 10 V reference has a **resolution** of 39.06 mV.