Signals

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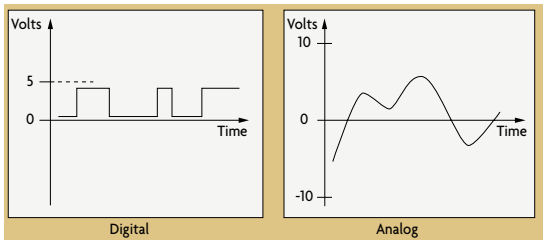
ME 361: Instrumentation & Measurement

Signals

- Signals are often described as being either analog, digital, or pulse. They are defined by how they convey useful information (data). Attributes such as amplitude, state, frequency, pulse width, and phase can represent data.
- In instrumentation and control applications most analog signals are in the range of -10 to +10 volts or 4 to 20 mA.
- Digital and pulse signals have binary amplitude values, they are represented by only two possible states–low and high. Transistor-transistor-logic (TTL) levels are often used.
- The electrical equivalents produced by input transducers are most commonly in the form of voltage, current, charge, resistance, or capacitance.

Analog & Digital Signals



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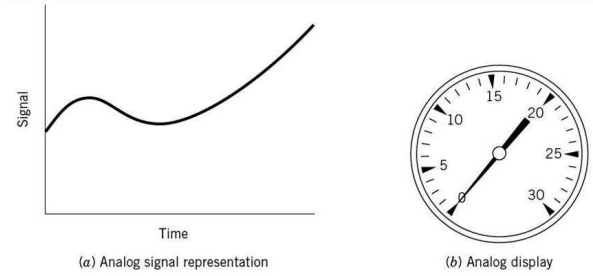
- Natural processes tend to vary smoothly over time (*analog*).
- Computers manipulate data in *digital* form of 0 & 1's.
- Digital form of data transmission involves noise immunity.
- Pulses are easier to detect than to read analog values.

Analog & Digital Signal Concepts



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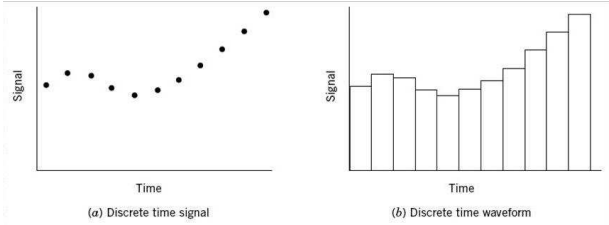

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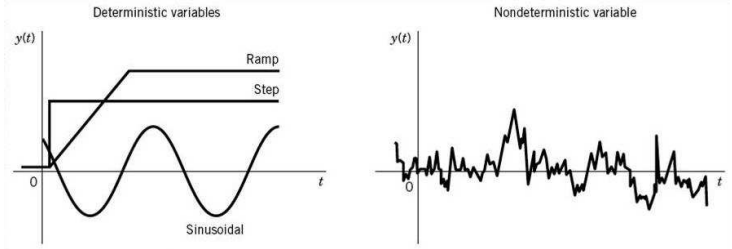
Dynamic Signal Representation



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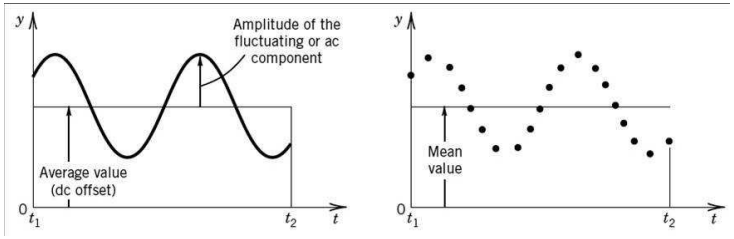

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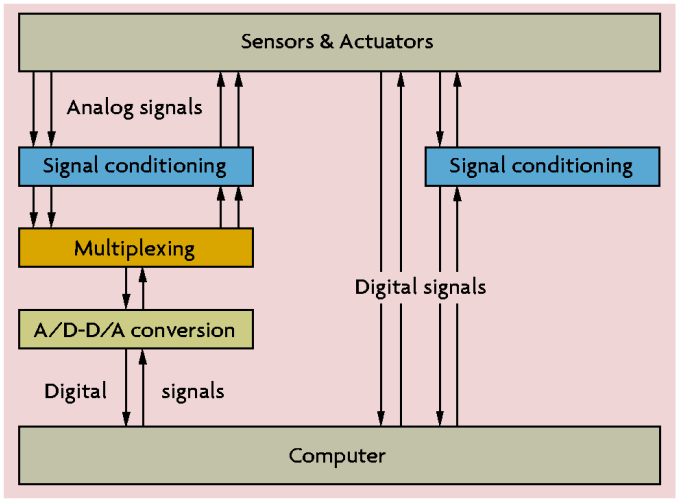
Basic Signal Conditioning Requirements for Interfacing



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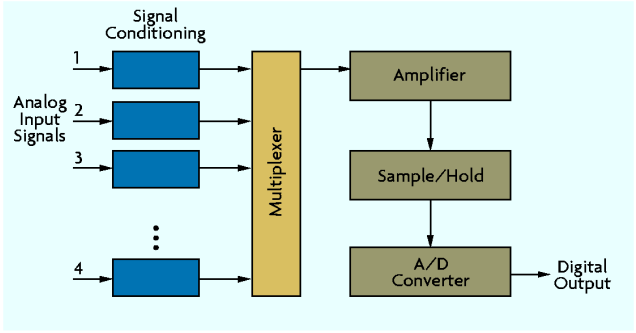
Analog Input Flow Diagram



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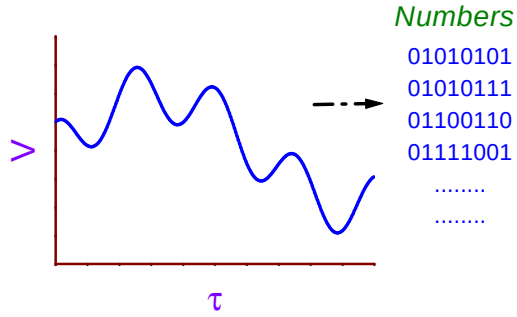
- **Multiplexer (MUX)** - A switching device that sequentially connects multiple inputs or outputs in order to process several signal channels with a single A/D or D/A converter.
- **Sample-and-Hold (S/H) Circuit** - to acquire and store an analog voltage on a capacitor for subsequent processing.

Analog to Digital Conversion

- In A/D conversion process continuous electrical signals are converted to the digital language of computers.
- If a 8-bit ADC has a 0-to-2.56 V input signal range, then a 0 V input could produce an output word of 00000000_2, while the +2.56 V level seen at the input would produce an output word of 11111111_2.



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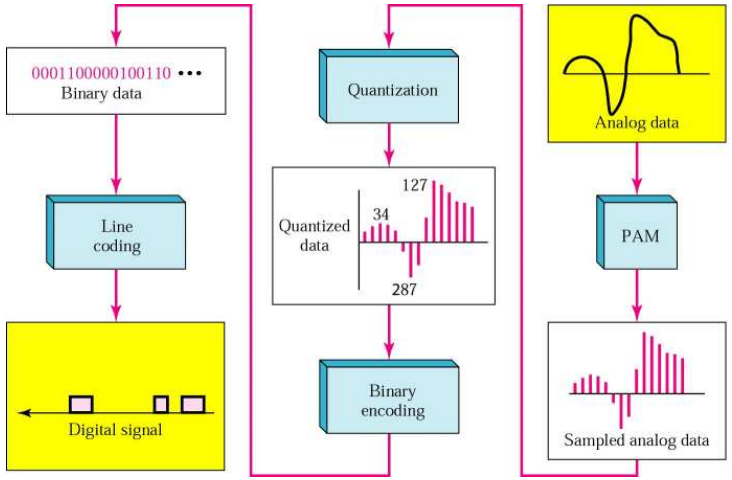
Analog to Digital Signal Conversion Steps



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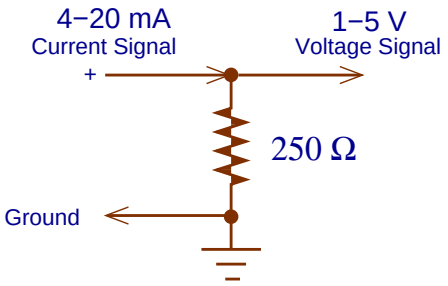
General Signal Conditioning Functions

- **Scaling** - Low level signals should be amplified to increase the resolution and to reduce noise. Conversely, high voltage signals may need to be attenuated.
- **Filtering** - A variety of physical devices and circuits are available to keep separate desired signals from specific frequencies of undesirable electrical noise such as ac line pick-up or other EMI/RFI.
- **Isolation** - Used to protect personal and equipment from high voltages and spikes. Isolators block circuit overloads while simultaneously passing signal of interest.
- **Excitation** - Signal conditioning also generates excitation for some transducers. Strain gauges, thermistors, and RTDs, for example require external voltage or current excitation.

- **Linearization** - Many transducers, such as thermocouples, have a nonlinear response to changes in the phenomenon being measured. Signal conditioning is applied to have linear output for a given nonlinear input signal.
- **Current-to-voltage conversion** - Many transducers generate a current signal, usually 4 to 20 mA or 0 to 20 mA. Current signals are less sensitive to noise and voltage drop due to lead resistance & these can be readily converted to a voltage signal using a simple resistor.



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Examples of Signal Processing Requirements

Sensor	Electrical Characteristics	Signal Conditioning Needs
Thermocouple	Low voltage output Low sensitivity Nonlinear output	Cold-junction compensation High amplification Linearization
RTD	Resistance output Low resistance (100 ohms typical) Low sensitivity Nonlinear output	Current excitation 4-wire/3-wire configurations Linearization
Thermistor	Resistance output High resistance and sensitivity Drastically nonlinear output	Voltage or current excitation Reference resistor Linearization
IC Temp. Sensor	High level voltage or current output Linear output	Power source Moderate gain
Strain Gauge	Resistance output Low resistance Very low sensitivity Nonlinear output	Excitation Bridge configuration 3-wire connection Linearization

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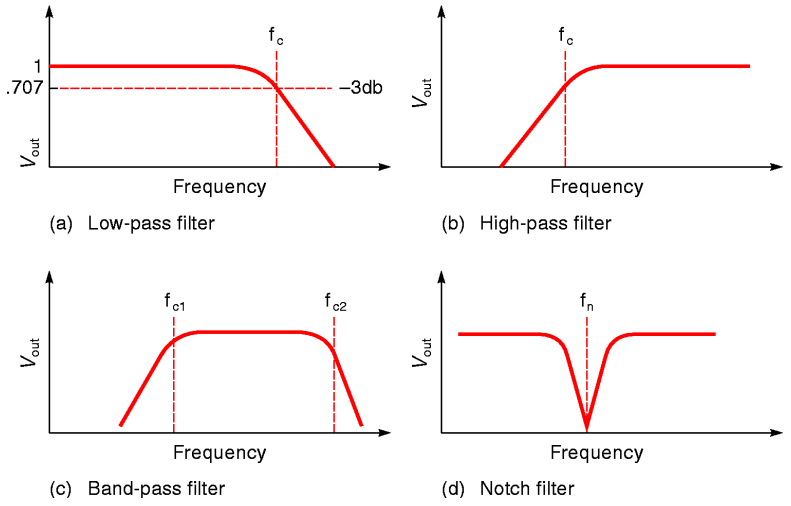
Signal Filter Classifications

- **Low Pass Filter** - Lower frequencies are passed to the output with little attenuation, and the higher frequencies are significantly attenuated (i.e., not passed).
- **High Pass Filter** - Lower frequencies are attenuated.
- **Band Pass** - Only a narrow band of frequencies are passed and all others are significantly attenuated.
- **Band Reject/Notch Filter** - A narrow band of frequencies are highly attenuated. A common use of this filter is to eliminate 50 Hz interference found on signal lines.

Characteristics of Real Filters



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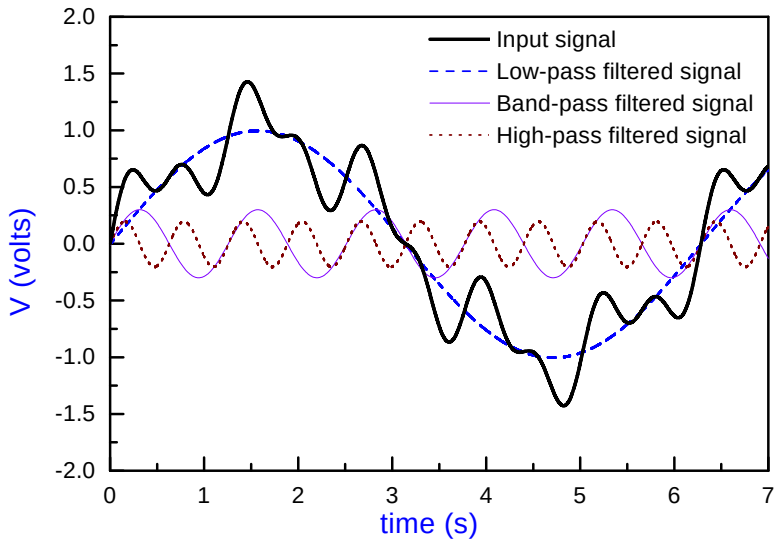
Example of Filtering



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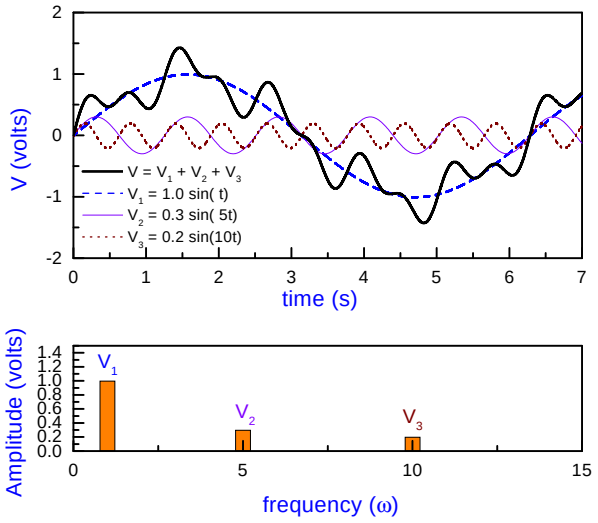
Frequency Spectrum Diagram



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