CLASS 17: ANALOG VS. DIGITAL

ENGR 102 – Introduction to Engineering

Analog vs. Digital

Analog vs. Digital

- ***Analog*** signals
  - ***Continuous in time and amplitude***
  - All physical phenomena – pressure, temperature, velocity, strain, position, etc. – are ***analog*** in nature
    - ***Any value*** at ***any time***
- ***Digital*** signals
  - ***Discrete in time and amplitude***
    - Can only assume a ***finite number of discrete values*** at ***discrete instants in time***
    - Representations of analog signals that are easily stored and processed

Analog vs. Digital – Example

- Temperature is an analog quantity
  - Any value at any instant in time

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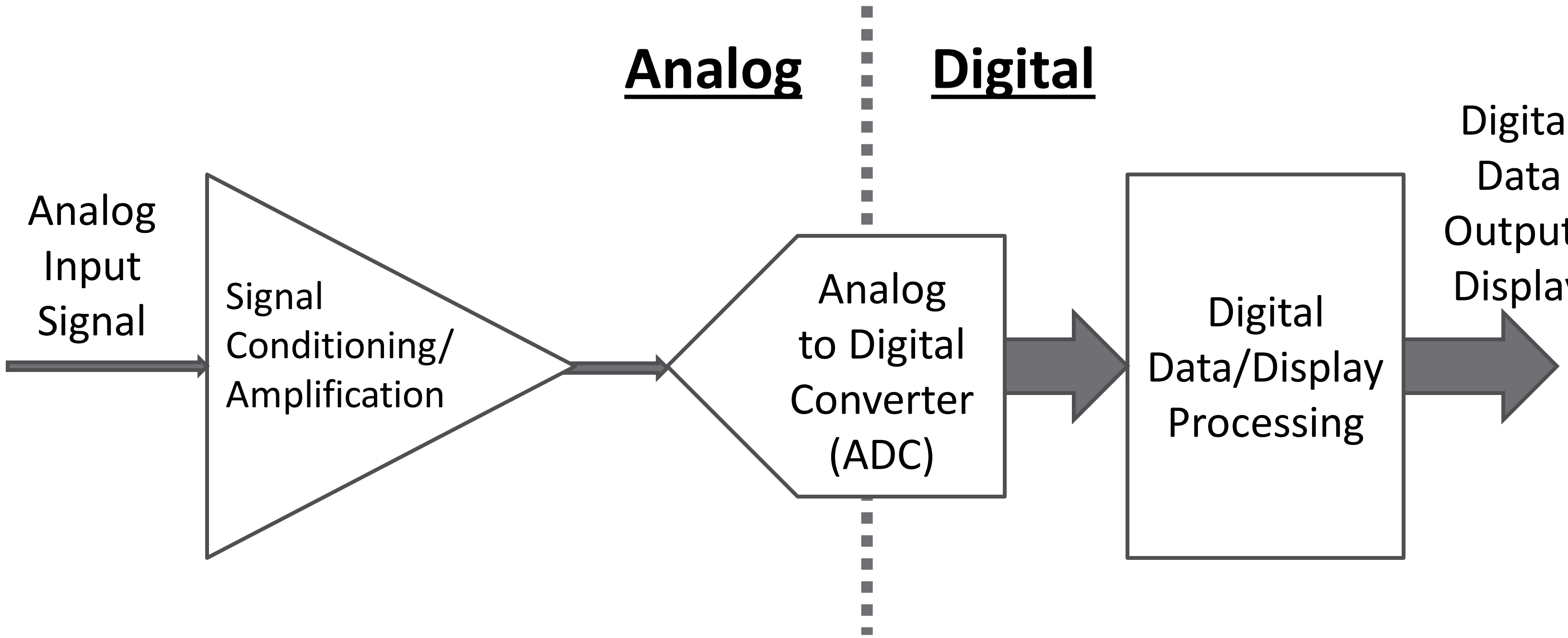
- Mercury thermometer
  - Analog
  - Mercury can be any height at any time
- Digital thermometer
  - Samples actual temperature at discrete instants in time
  - Represents sampled value with one of a finite number of possible values

Digital Measurement System



Analog input signal converted to a digital signal in an **analog-to-digital converter** (ADC or A/D)

Analog-to-Digital Conversion

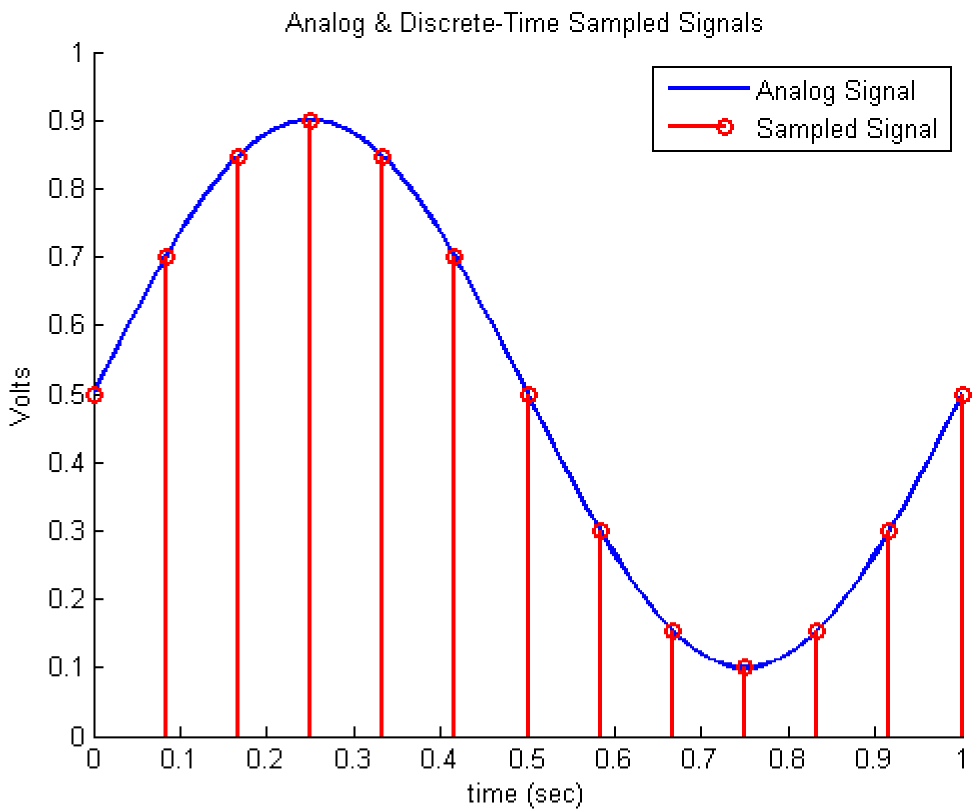
- Analog-to-digital conversion – two steps:
  - Sampling
  - Quantization

- ***Sampling***
  - Analog signal measured at discrete instants in time
  - Series of discrete-time (but continuous in amplitude) samples

- ***Quantization***
  - Mapping of samples to a finite number of ***discrete amplitude*** values
  - Each quantization level corresponds to a continuous input range

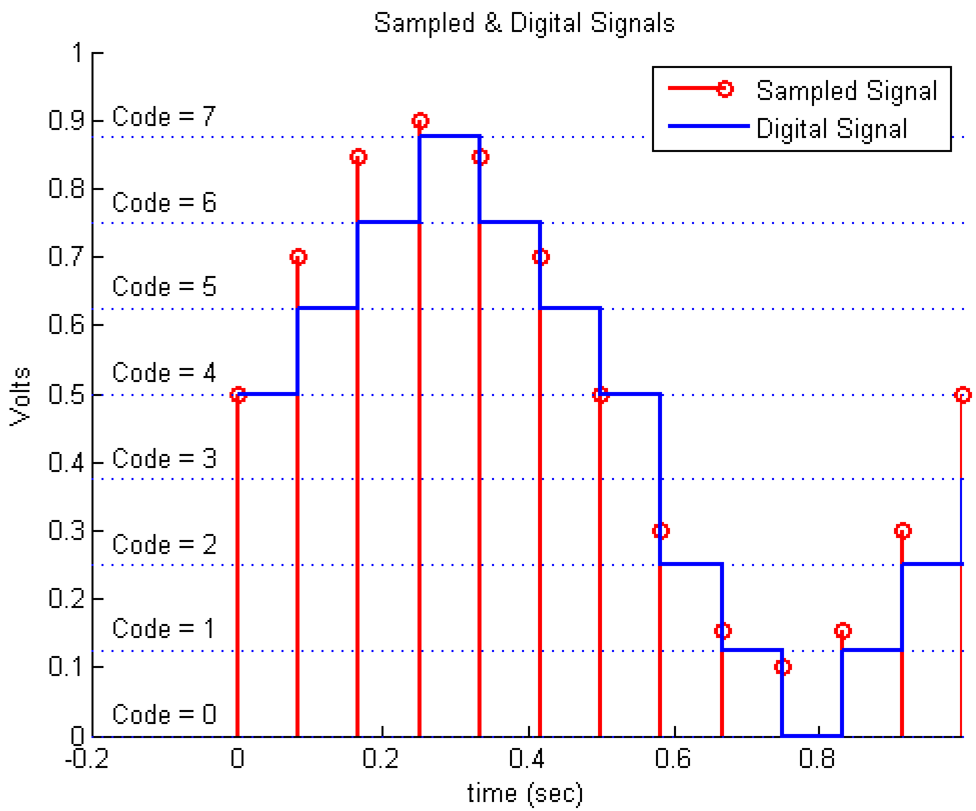
A/D Conversion – Sampling

- ***Sampled signal***
  - Discrete in time
  - Continuous in amplitude



A/D Conversion – quantization

- ***Digital signal***
  - Quantized samples
  - Discrete in time
  - Discrete in amplitude
- Amplitude values expressed as ***codes***
  - # of A/D codes = 2^N
    - N = # of bits
    - 10-bit A/D has 1024 distinct ***quantization levels***
  - Digital signal stored as ***binary*** values



Analog-to-Digital Conversion

Exercise

- A temperature sensor IC has the following specs:
  - $V_{out} = 10\ mV/°C$
  - Temperature range: $0°C \ldots 100°C$
- Write code to measure the sensor output voltage with a 10-bit A/D and convert that to a temperature in $°C$ and $°F$.
- What A/D code corresponds to a temperature of $25°C$?

Analog-to-Digital Conversion

Exercise

- A water level sensor has a current output
  - $I_o = 0 \ldots 20\ mA$ for $d = 0 \ldots 5\ m$ -> 0…5m
- You plan to use the sensor to measure depths ranging from $0\ m \ldots 4\ m$
- Use a current-sense resistor to convert output current to a voltage
  - Map the I_o for $0\ m \ldots 4\ m$ depth range to $0\ V \ldots 5\ V$ ADC input range
- Determine the value of R_{sense}
- Write code to read the sensor and convert to a depth in meters