Bab 7. Sensor/Transmitter and Filtering

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Session Outlines & Objectives

Outlines

- Common sensor type used to measure physical quantities in process control
- Static and dynamics properties of sensor/transmitter

Objectives

- Know the properties of sensor/transmitter affecting process control performances
- Know the sensor/transmitter used in process control

Measurement System & Devices

- A measurement system is any set of interconnected parts that include one or more measurement devices
- Measurement devices perform a complete measuring function, from initial detection to final indication
- Measurement devices such as sensors, or primary elements, measure the variable

Sensor, Transmitter & Transducer

- Sensor
  - Primary sensing element
  - Converts the physical quantity to signal that can be recognized by other component such as display, transmitter
- Transmitter
  - Generates an industrial standard signal from the sensor output
  - Standard instrumentation signal levels
    - Voltage: 1 – 5 VDC, 0 – 5 VDC, -10 – +10 VDC, etc.
    - Current: 4 – 20 mA
    - Pneumatic: 3 – 15 psig
- Transducer
  - Changes one instrument signal value to another instrument signal value
  - Signal conversion
  - I/P or P/I transducer: current-to-pressure or vice versa
  - P/E or E/P: pressure-to-voltage or vice versa

Sensor Types

- Flow rate
  - Orifice, venturi, magnetic, ultrasonic, Coriolis effect
- Pressure
  - Bellows, bourdon tube, diaphragm
- Liquid level
  - Displacement, float, differential pressure
- Temperature
  - Thermocouple, RTD, thermistor
- pH
  - pH electrode
- Viscosity
  - Pressure drop across venturi or vane deflection
- Composition
  - Density, conductivity, IR, UV

Primary Measuring Element Selection & Characteristics

- Transmitter Gain
- Range
  - Span & Zero
- Response time
- Accuracy
- Precision
- Sensitivity
- Dead band
- Costs
- Installation problems

Transmitter Gain, Range, Span & Zero

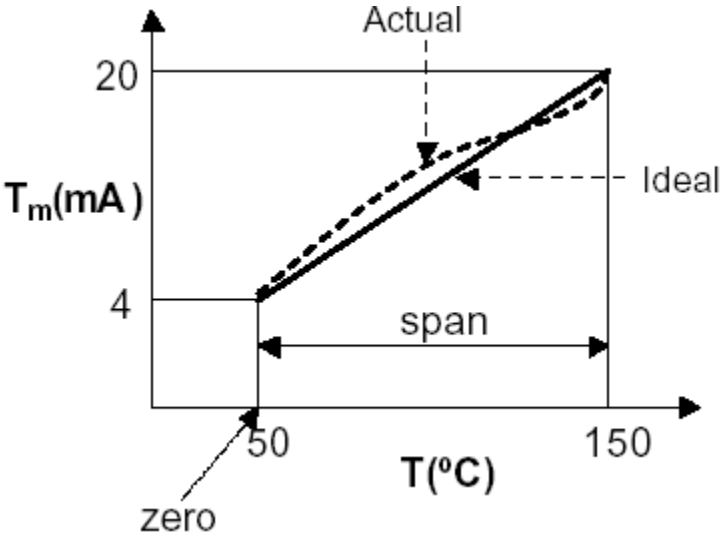
- Transmitter Gain (K_T): adjustable
  - Amplification ratio: (output span) / (input span)
- Span and Zero: adjustable
  - Span: magnitude of range of transmitter signal
  - Zero: lower limit of transmitter signal

Ex.: Temperature transmitter

$$K_T = \frac{(20\ \text{mA} - 4\ \text{mA})}{(150\ ^{o}\text{C} - 50\ ^{o}\text{C})} = 0.16\ [\text{mA}/^{o}\text{C}]$$

Span = 100 ^{o}C

Zero = 50 ^{o}C

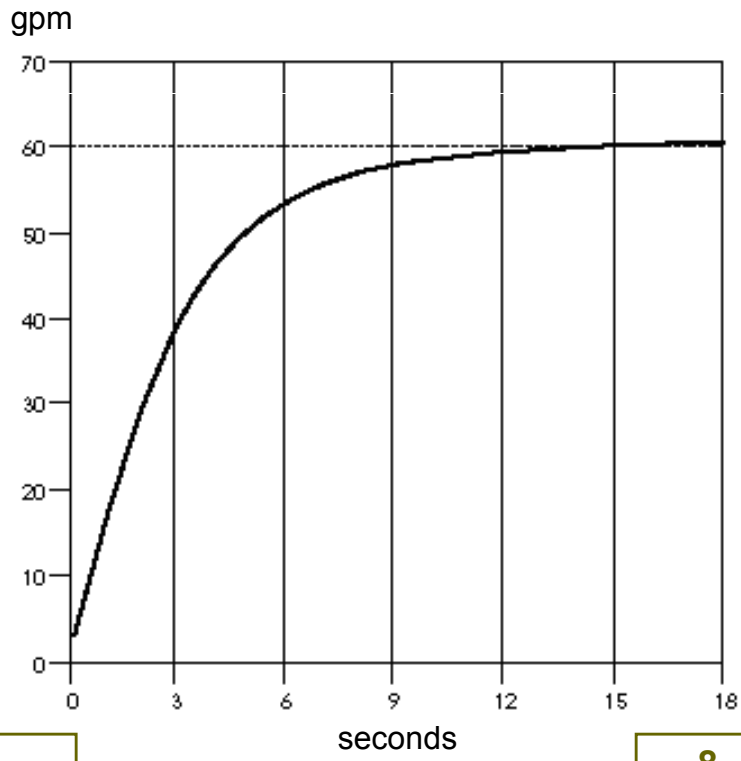


Response Time

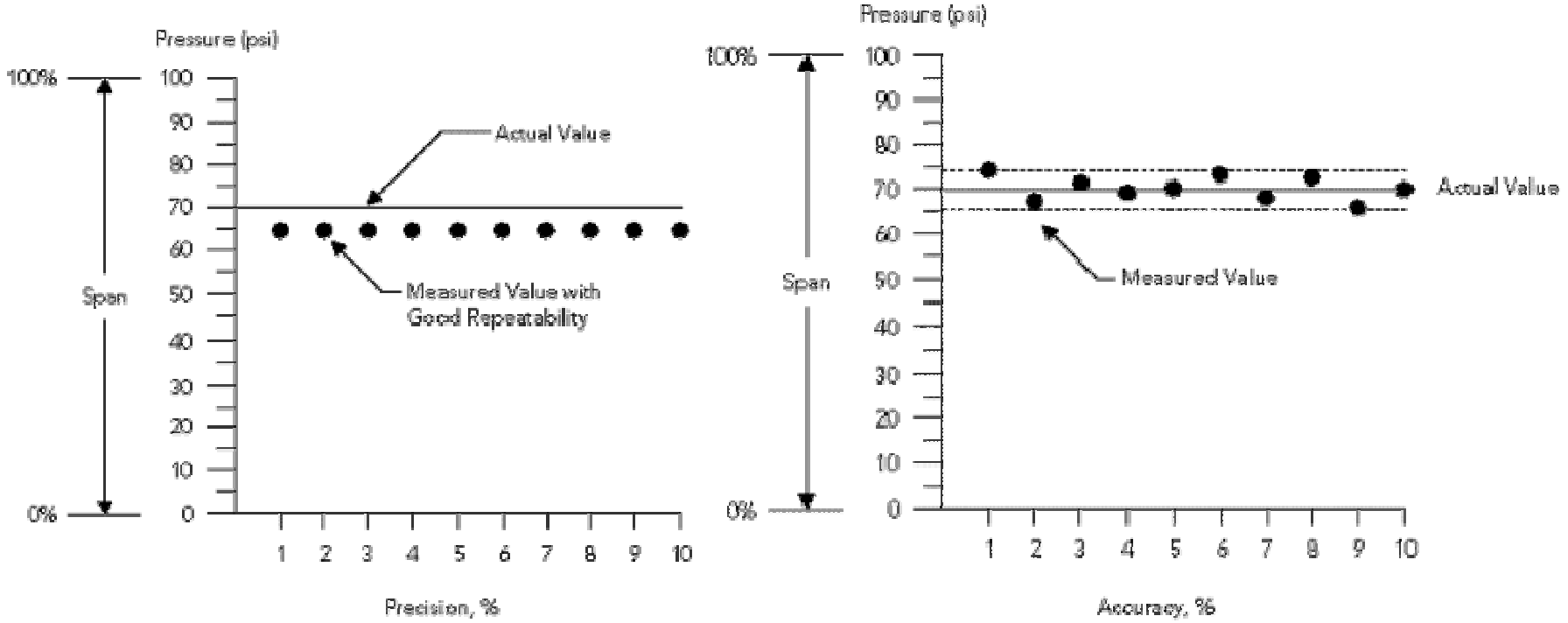
- Response time is the amount of time required for a sensor to respond completely to a change in input
- The response time of the control loop is the combination of the responses of all the parts, including the sensor

Example:

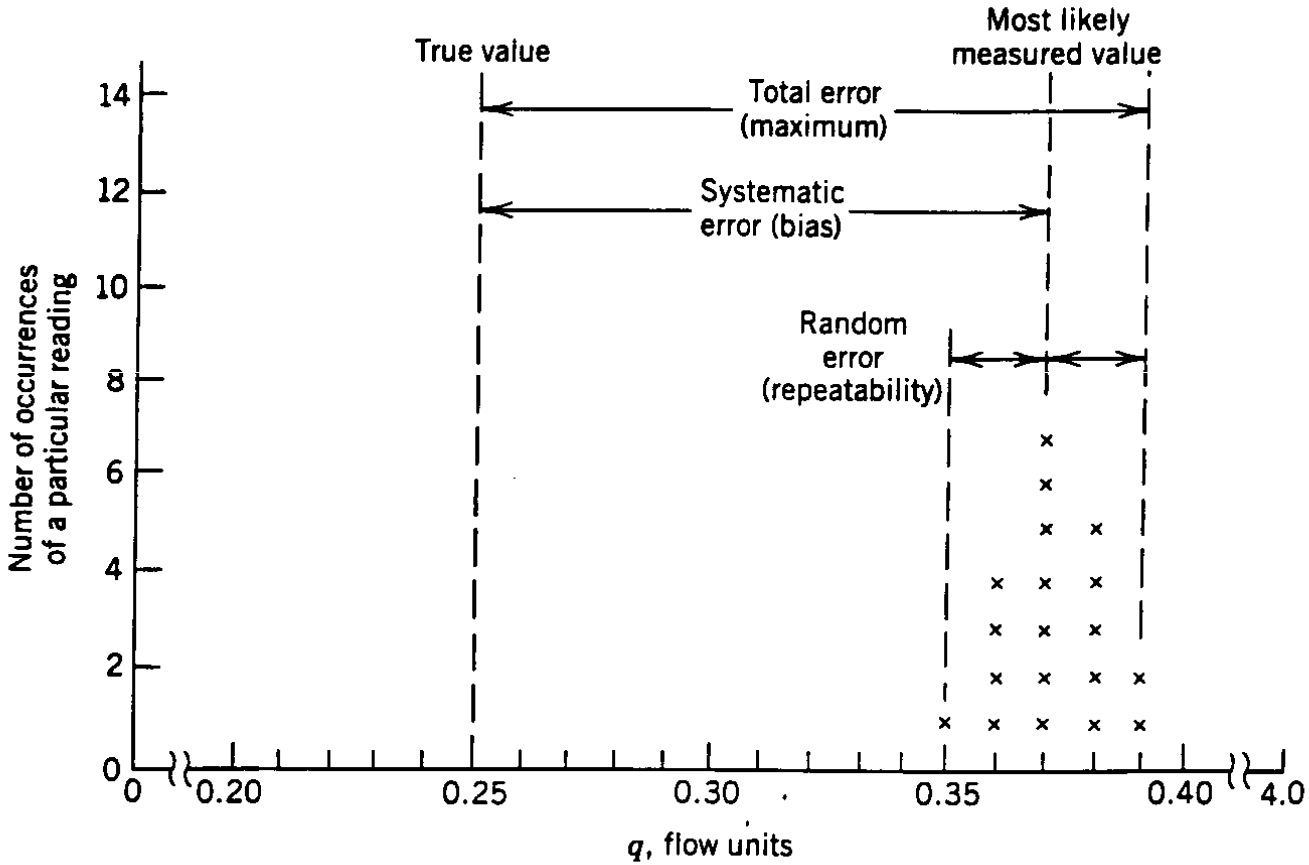
	Calculation	Sensor Measurement
After one time constant, the sensor registers 63.2% of the change	0.632 x 60 =	37.92 gpm
After two time constant, the sensor register 63.2% of the remaining difference	60 – 37.92 = 22.08 0.632 x 22.08 = 13.95 13.95 + 37.92 =	51.87
After three time constant, the sensor register 63.2% of the remaining difference	22.08 – 13.95 = 8.13 0.632 x 8.13 = 5.14 5.14 + 51.87 =	57.01



Precision vs. Accuracy



Error Types



Analysis of types of error for a flow instrument whose range is 0 to 4 flow units.

Sensitivity, Dead band & Dead time

- The sensitivity of the sensor is a measurement of how small a change in the process variable it can actually measure
  - The greater the sensitivity, the greater the sensor's reaction to an input stimulus
- Dead band is the "unresponsiveness" of the sensor
  - It describes how much change to the process is required before the sensor actually responds to it or even detects it
  - The term sensitivity has frequently been used to denote dead band, but the terms are not truly interchangeable
  - Sensitivity refers to the reaction of the sensor
- Dead time applies to the time it takes for the sensor to react

Costs & Installation Problems

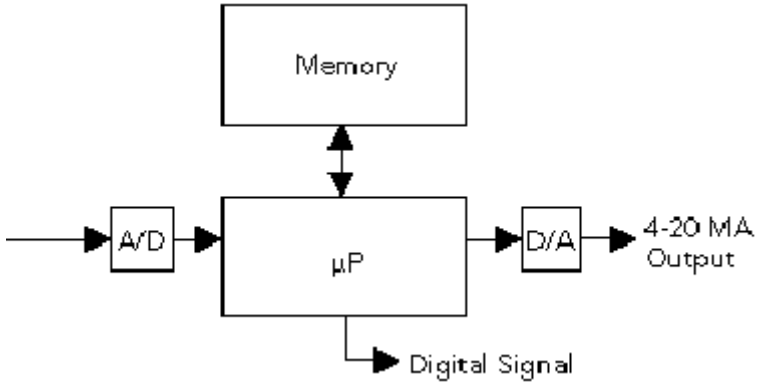
- Cost:
  - The initial purchase
  - Maintaining the instrument
- Installation problems:
  - Can include special problems in the environment such as humidity, vibration, temperature, or dust
  - Can also be anything that causes a problem to the devices installed, such as, installing the device in a difficult to reach location

Signal Transmission Types

- Electronic
- Pneumatic
- Optical
- Radio
- Hydraulic

Smart Transmitters

- They can convert analog signals to digital signals (A/D), making communication swift and easy and can even send both analog and digital signals at the same time as denoted by D/A



- Features:
  - Configuration
  - Re-ranging
  - Signal conditioning
  - Self-diagnosis

