

Instrumentation Technology
INST-1010

Process Control Signals

Basile Panoutsopoulos, Ph.D.
CCRI
Department of Engineering and Technology

B. Panoutsopoulos Engineering Physics II 1

Today's meeting

- Call Attendance
- Announcements

- Collect Homework
- Give examination
 - Display time clock
- Collect examinations

- Previous examination
 - Return
 - Discussion

- Introduce topic
 - Provide Handouts
 - Socratic discussion
 - Practice - Problems

B. Panoutsopoulos Engineering Physics II 2

Process Signals

- Process control
 - Depends on information about process variables
 - Information about process variables goes to the central control room
 - Information results in process changes sent to valves, motors, etc. to control process
- Signals represent process variables
 - Provides remote monitoring and control
 - Eliminates potentially dangerous exposure
 - Standard analog signal using
 - low pressure air, low electrical current, low electrical voltage
 - See text Fig 3-1

Instrumentation: Signals 3

Kinds of Signals

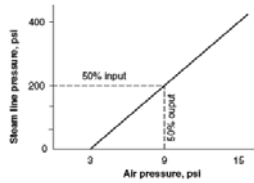
- Electrical
 - Analog - continuous range of values
 - Digital – discrete values, 1/0, on/off, true/false
- Pneumatic
 - Low air pressure

Instrumentation: Signals

4

114-3 #1

Fig. 3-1. Steam line pressure vs air pressure



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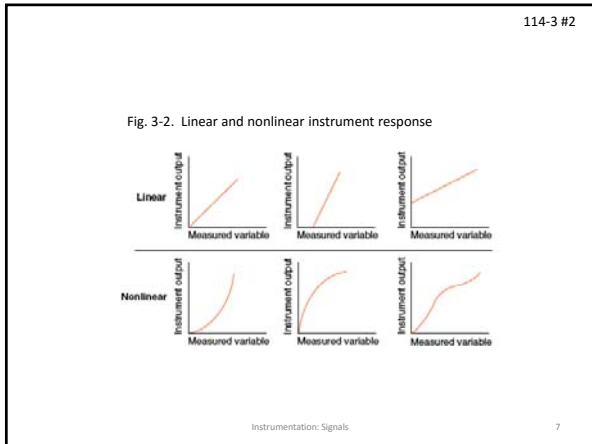
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Linear and Nonlinear Transducers

- Plot of transducer's response straight line for a linear device
- Plot of transducer's response not a straight line for a nonlinear device
- See Fig 3-2 in text
- Both types are common, and can be used reliably, but not necessarily interchangeably

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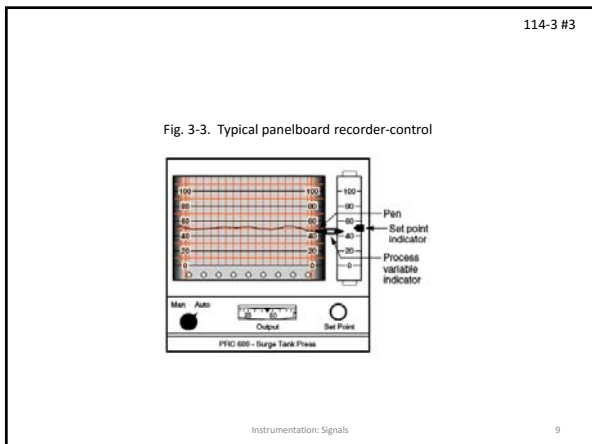
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Signal Operating Values

- Range
 - Maximum and minimum limits of measuring instrument
 - Exceeding range limits may damage instrument
- Span
 - Difference between maximum and minimum range limits
 - Device may have span adjustment
- See Fig 3-3 in text

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Error in Signal Measurement

- Zero Error
 - Offset in reading due to non zero initial setting
 - Lowest reading, the 0.0 reading, must be set correctly
- Span Error
 - Full range, 100% of span, not used
 - Must be set correctly,
 - Mmay interact with zero setting
- Hysteresis
 - Error resulting from delay between action and reaction of measurement. Error may be different when measuring change from above setpoint, than from below setpoint

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10

Error in Signal Measurement

- Deadband
 - Part of range where output doesn't change relative to change of input
 - Lack of sensitivity
 - May be a desirable characteristic
- Nonlinearity error
 - Error resulting from inherent nonlinearities of device
 - Expressed as %
 - Text page 33 examples

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11

Controller Output

- Final element adjusts process to bring measured variable back to setpoint
- Controller output must be compatible with final element, and should generally exceed range of final element
 - Rpm range, valve range

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12

Pneumatic Signal Transmission

- Standard pressure 3 to 15 psi, 0 to 100%
 - Less commonly used, but still widely used for final control element
 - Small amount of pressure for large amount of force
 $F = P/A$
See example text page 35
- Distance limitation
 - Air travels at speed of sound, 1200 ft/sec
 - Too slow for controlling systems over distances
 - Electrical signals travel at speed of light, 984 M ft/sec

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13

Flapper Nozzle System

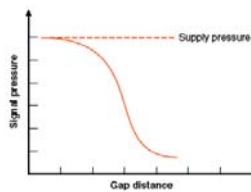
- Simple device used to control signal pressure
- Signal pressure inversely proportional to the flapper distance from nozzle, Fig 3-6

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14

114-3 #6

Fig. 3-6. Flapper-nozzle signal pressure vs gap distance



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15

Electrical Signal Transmission

- Ohm's Law, $V = I R$, describes relationship between voltage, current, and resistance
- Power Supply
 - Source of electrical power used to provide energy for electrical components of system
 - Often used to convert ac to dc power
 - May have battery back-up
 - Should have good noise immunity
 - System cabling may use shielding to reduce noise
- Current sent between instruments and control room may use current
 - Std ranges: 4-20mA, 10-50mA, 1-5mA, 0-5mA
- Voltage ranges in instrumentation
 - Std ranges: 1-5V, 0-10V

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16

Current – Pneumatic Systems

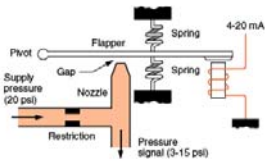
- Typically 4-20mA current devices
- I/P device
 - 4-20mA for 3- 15psi
- P/I device
 - Inverse of above
- Direct acting, reverse acting, proportional
- See text Fig 3-7, 3-8

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17

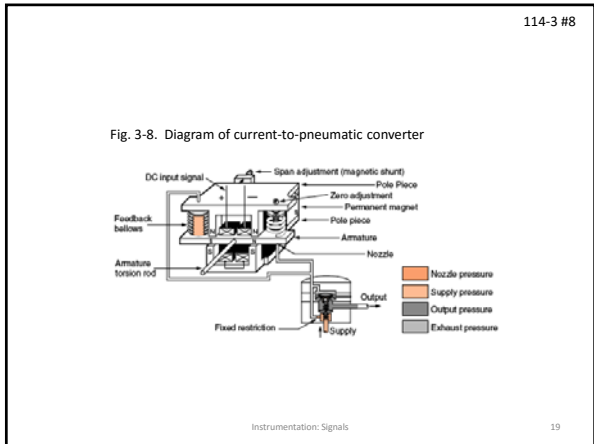
114-3 #7

Fig. 3-7. Simplified diagram of current-to-pneumatic converter



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18



Transmission of Other Signals

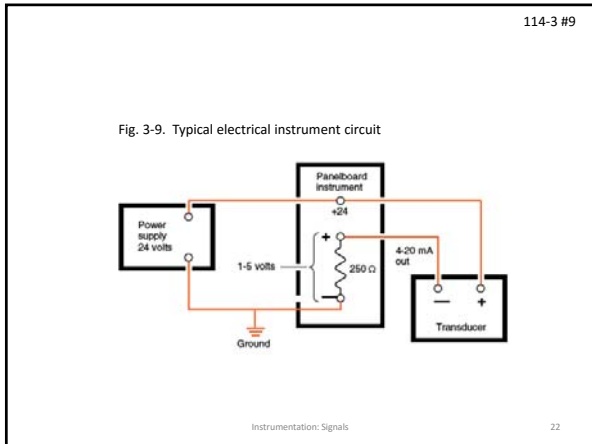
- Digital Signals
 - Variety of standards for data and pulse information
 - Pulse signals typically used for frequency monitoring
- Optical Signals
 - Light, visible and invisible, used instead of current
 - Fiber optic cable used instead of wire
 - Transmitter typically an LED
 - Receiver typically a photodiode

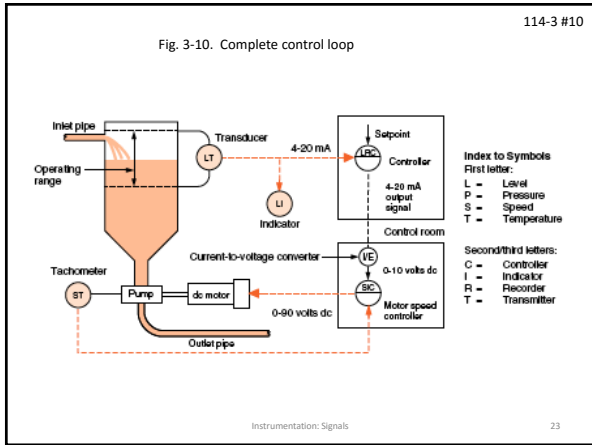
Instrumentation: Signals 20

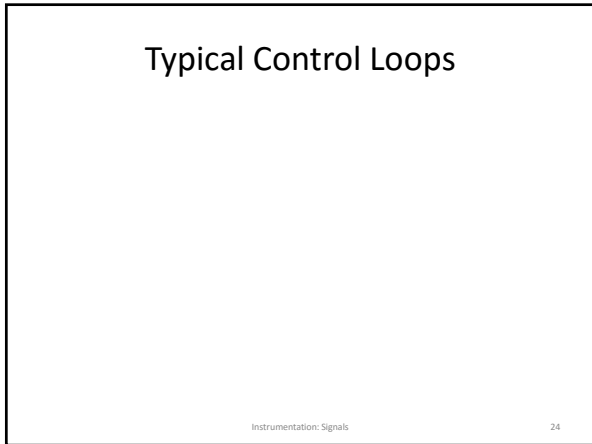
Typical Control Loops

- See Fig 3-9 for Current Loop Example
- See Fig 3-10 for Complete Control System

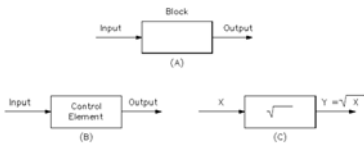
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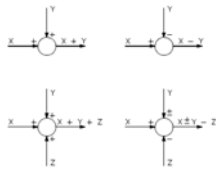
Block and Arrows



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25

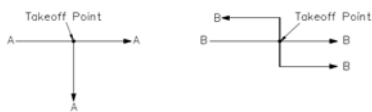
Summing Points



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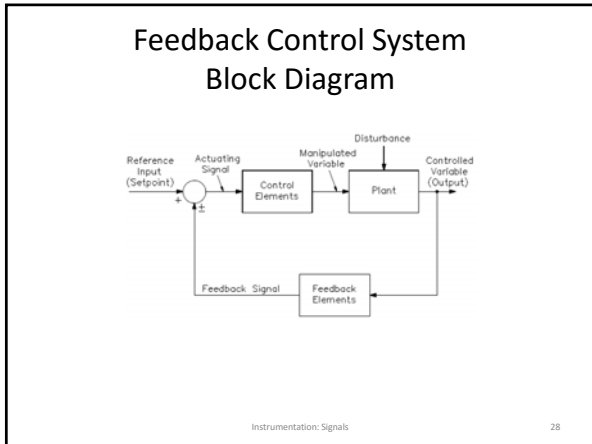
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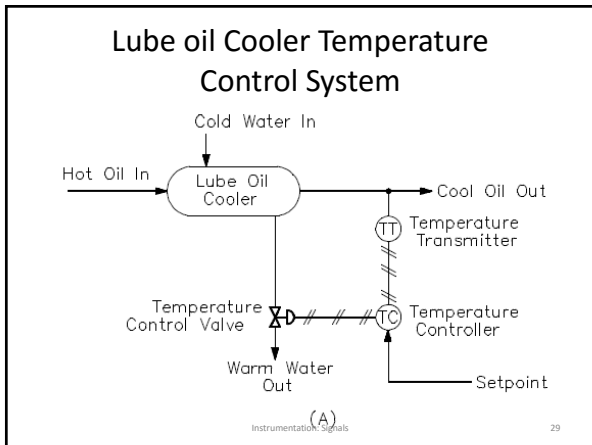
Take-off Points

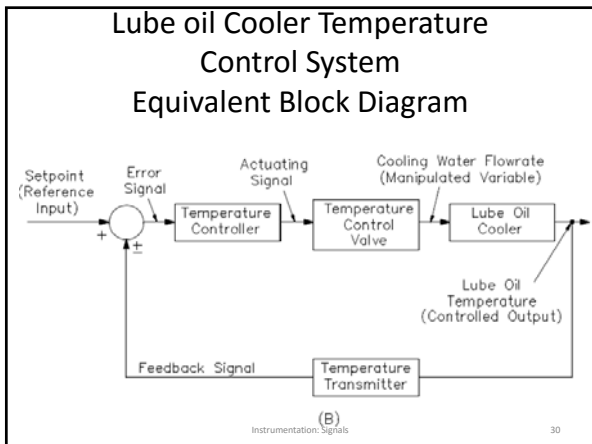


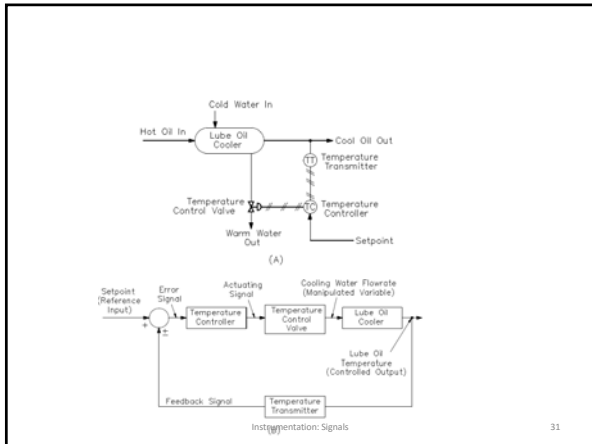
Instrumentation: Signals

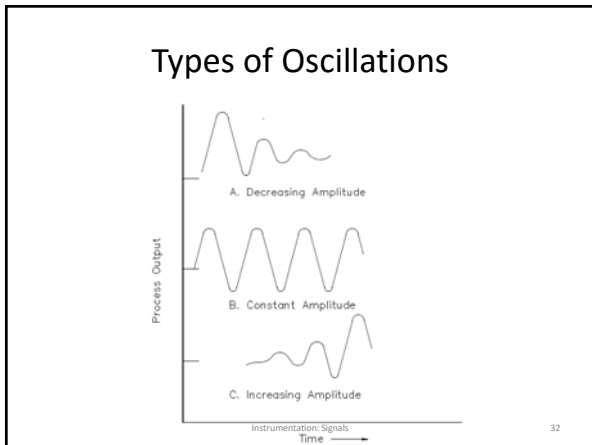
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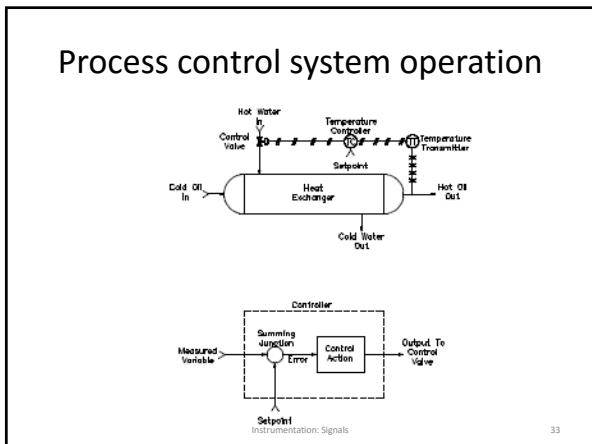


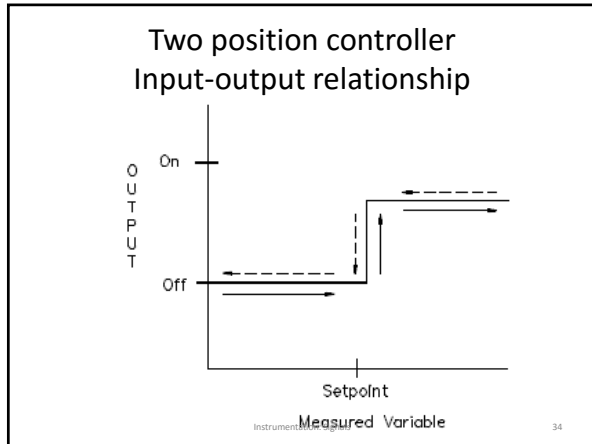


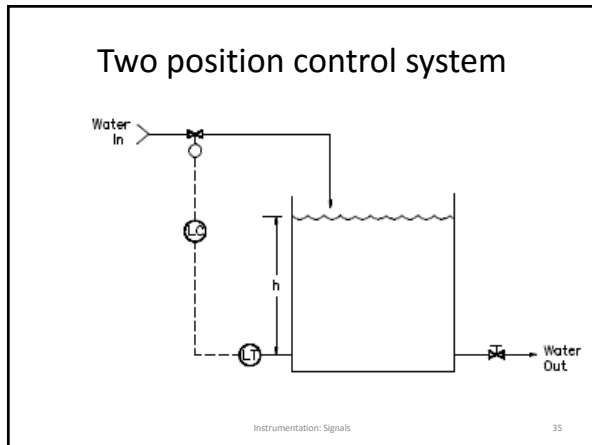


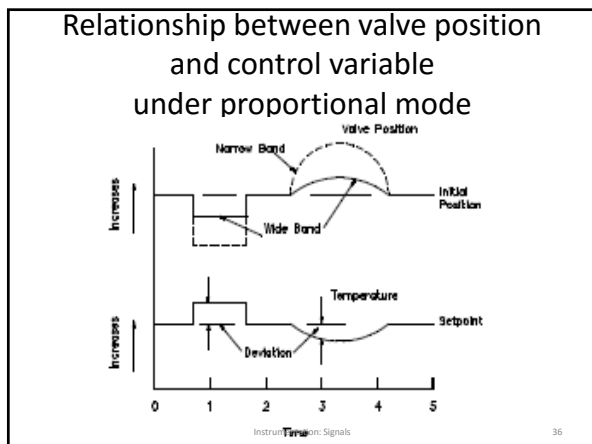


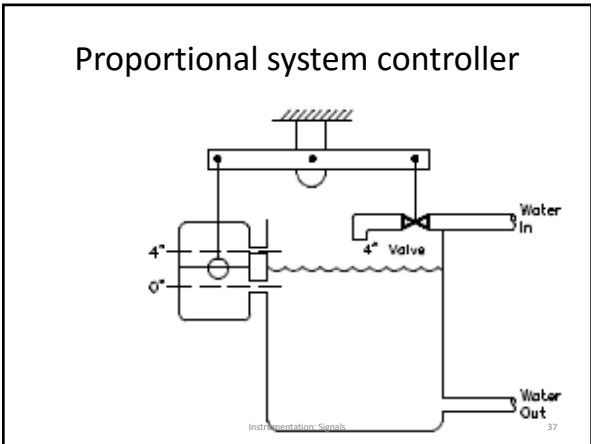


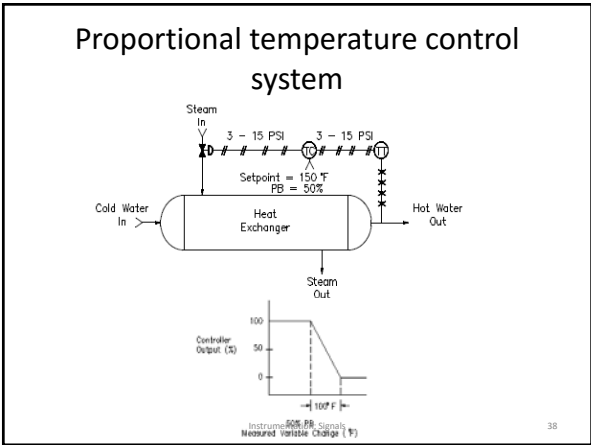


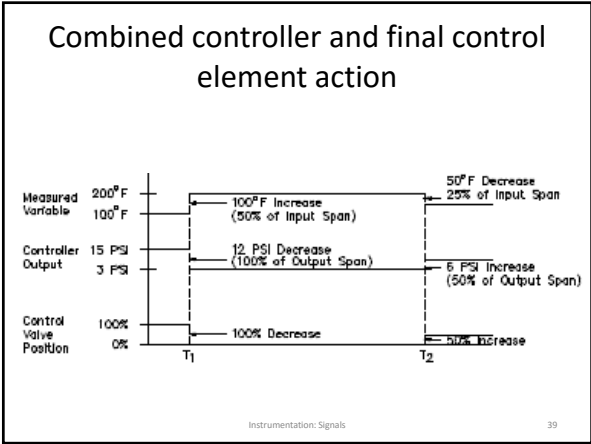


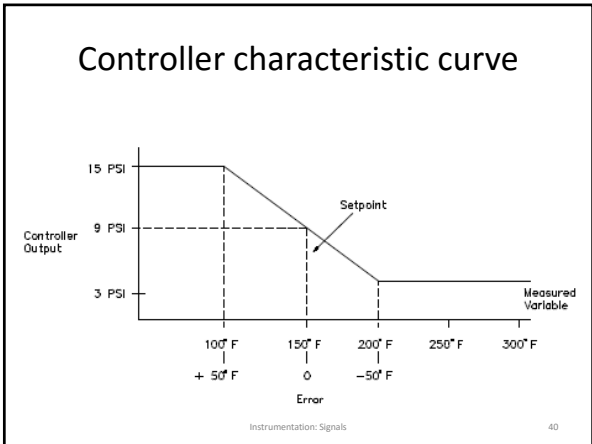


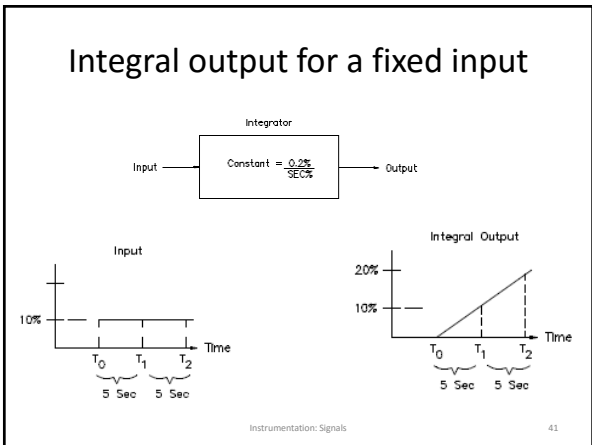


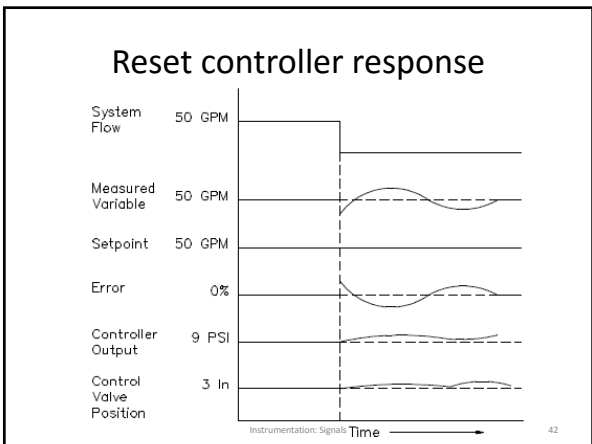


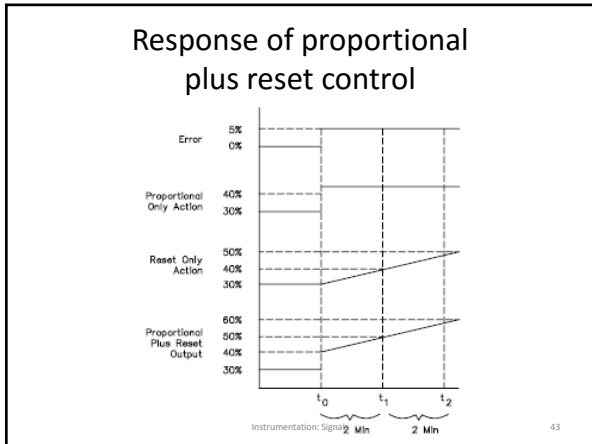


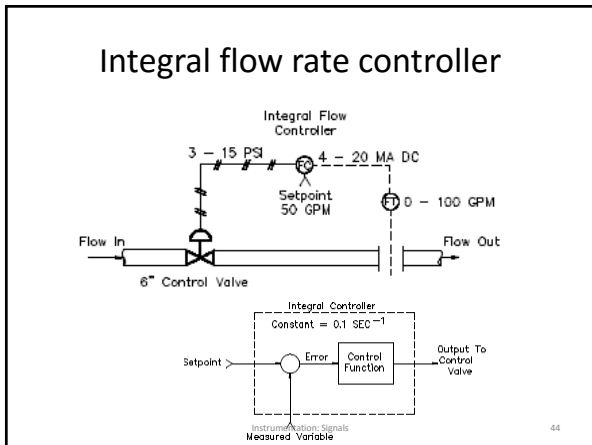


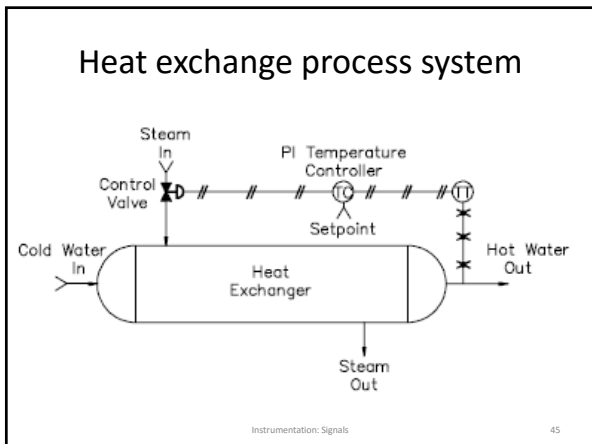




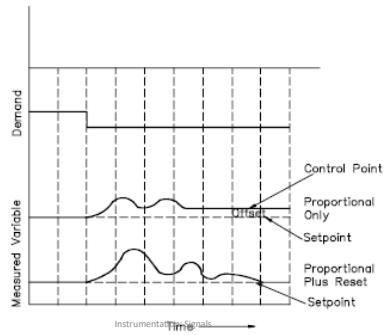




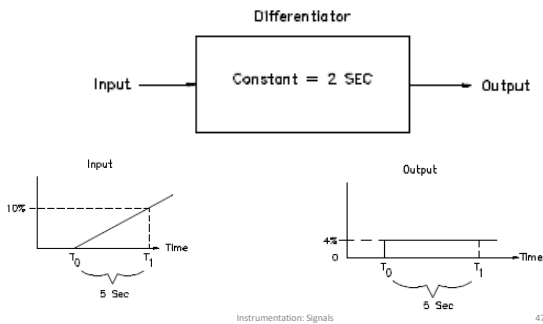




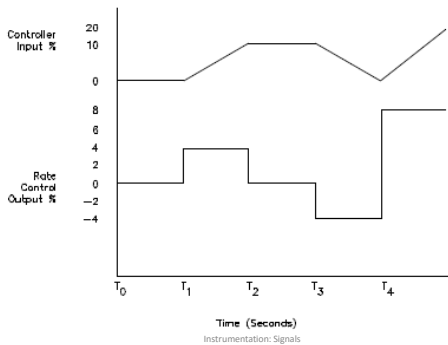
Effect of disturbance on reverse acting controller



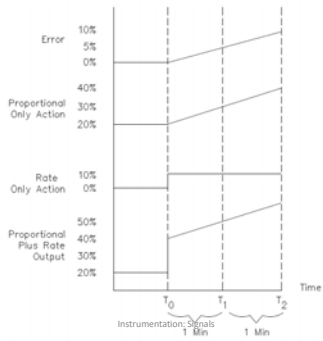
Derivative output of a constant change of rate input



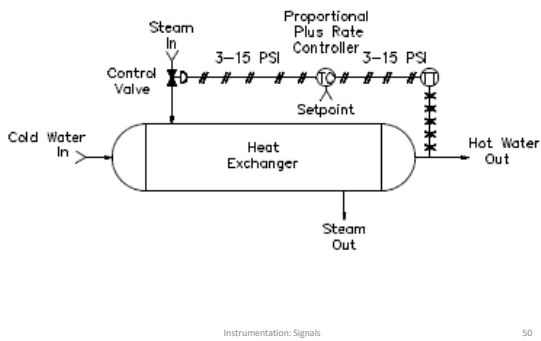
Rate control output



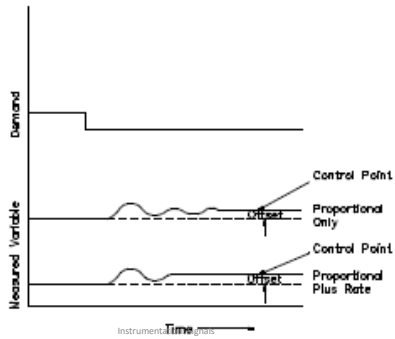
Response of proportional plus rate control

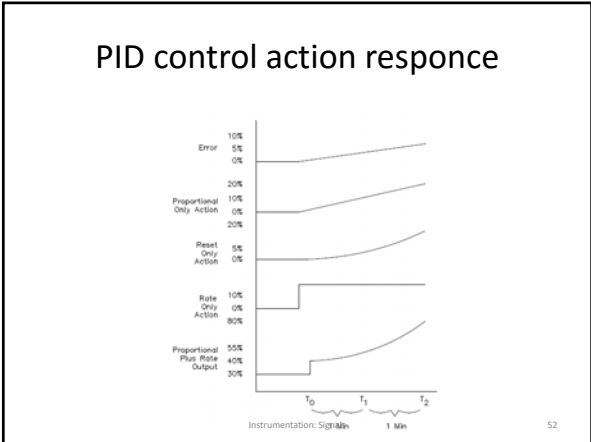


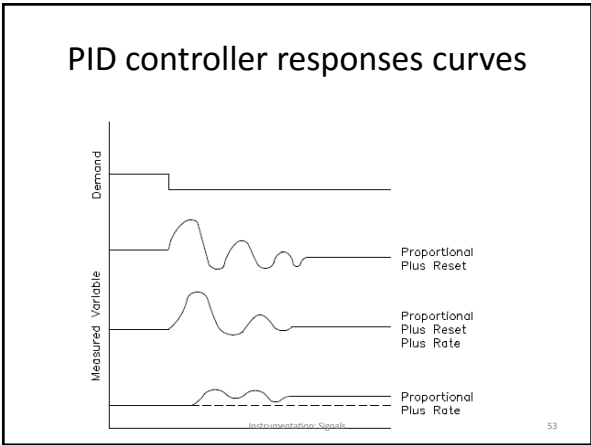
Heat exchange process

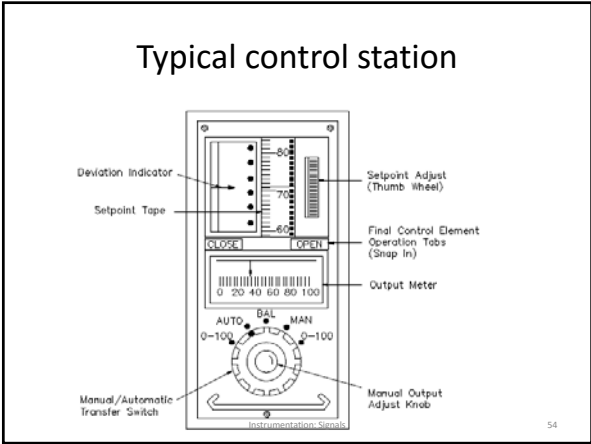


Effect on disturbance on proportional plus rate reverse acting controller









Deviation indicator

Setpoint 60% and Process 60% (0% Deviation)

Setpoint 60% and Process 50% (-10% Deviation)

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Self balancing control station

Setpoint Indicating Drum

Deviation Indicator

Setpoint Adjustment Thumbwheel

Output Signal Meter

Manual Pushbutton (Decrease Output)

Manual Pushbutton (Increase Output)

Manual Mode Indication Light

Automatic Mode Indication Light

Manual Mode Selection Button

Automatic Mode Selection Button

Instrumentation: Signals 56

Pneumatic actuator

Air to close / Spring to open

Mechanical Stop

Supply Air Connection

Upper Chamber

Diaphragm

Housing

Lower Chamber

Spring

Local Position Indicator

Stem

Control Valve

Instrumentation: Signals 57

