

Lecture 10 Chapter 12 Actuators



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Chapter 12 Actuators (FCEs)

- Learning outcomes
 - Pp.12-3
- Contents:
 - Basic components – final control element
 - Pneumatic diaphragm valves
 - Valve positioners
 - Hydraulic valves and actuators
 - Electrical actuators:
 - Solenoid valves
 - Linear motors
 - Rotary motors (DC & AC motors)

Chapter 12

- Where in a control system is an actuator?

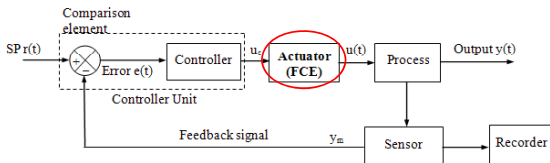


Figure 1 General structure of a feedback control system

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- Pneumatic diaphragm valve:
 - Construction
 - Principle
 - Valve body design
 - Single-seated
 - Double-seated
 - Valve plugs

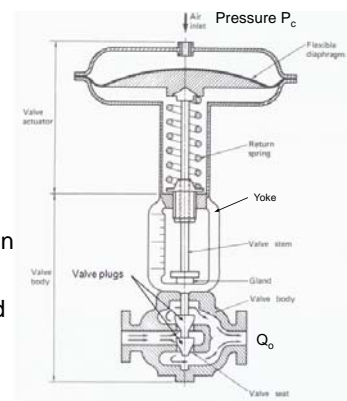


Figure 2 A pneumatic diaphragm control valve

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- Pneumatic diaphragm valves

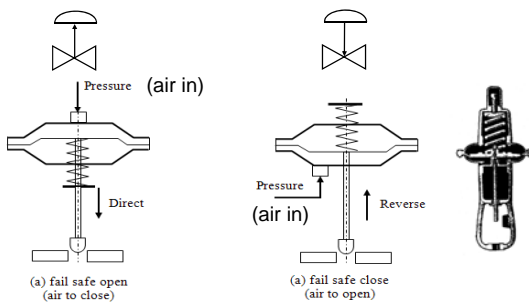


Figure 4 Fail safe open and fail safe close/shut valves

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- Pneumatic diaphragm valves: characteristics

$$x = \frac{A}{k} p_c \quad q_o = K_q x$$

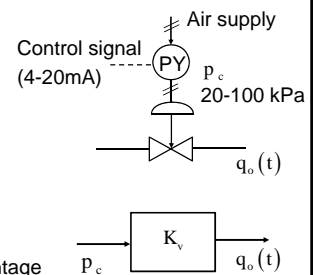
$$\frac{Q_o(s)}{P_c(s)} = K_v$$

$$Q = K_v f(x) \sqrt{\frac{\Delta P_v}{s.g.}}$$

$$f(x) = x \quad \rightarrow \quad \text{Linear}$$

$$f(x) = \alpha x^{-1} \quad \rightarrow \quad \text{Equal-percentage}$$

$$f(x) = \sqrt{x} \quad \rightarrow \quad \text{Quick-opening}$$



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- Valve flow characteristics – Shapes of plug

http://www.spiraxsarco.com/resources/team-engineering-tutorials/control-hardware-el-pn-actuation/control-valve-characteristics.asp

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- Applications of pneumatic valves

Figure 5 Flow diagram for installation of the valve

Figure 7 Application of a pneumatic valve in a level control system

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- Valve positioners

http://www.hitewell.com

http://www.dembla.com

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- Applications of valve positioner

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Control Valve, Tank, Level Transmitter, μP-based Controllers Recorder, Diagram & Connectors, Process Cart Trainer

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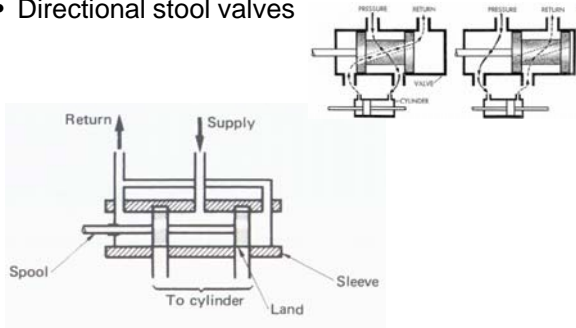
- Hydraulic valves and actuators/Electro-hydraulic actuators:
 - Hydraulic servo valves: to control flow of fluid from the pump to the actuator
 - Hydraulic actuators: linear, hydraulic servo-valve cylinder (an integral controller), electro-hydraulic actuators

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- Hydraulic valves and actuators – Hydraulic servo valves
 - Sliding: spool valve
 - Seating: flapper valve
 - Flow-dividing: jet-pipe valve

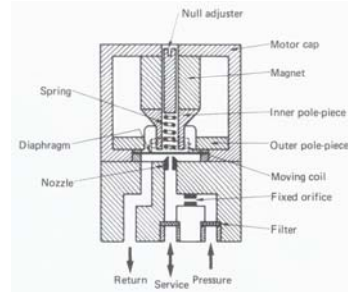
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- Directional stool valves



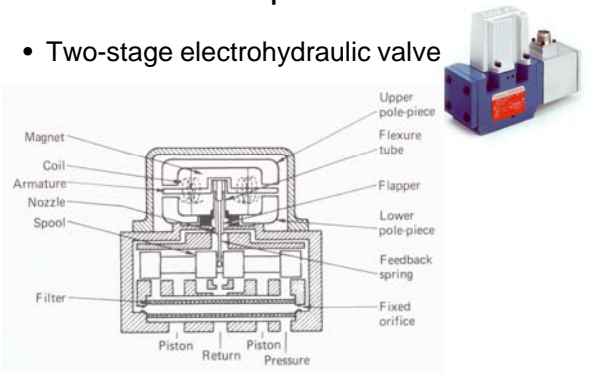
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- Flapper valves (nozzle-flapper)



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- Two-stage electrohydraulic valve



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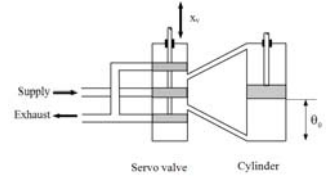
- Hydraulic actuators:
 - Linear actuators



- Hydraulic servo-valve cylinder – Integral controller

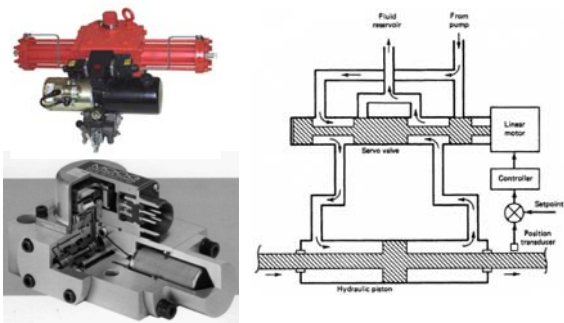
$$\theta_o = \frac{K_v}{A} \int_0^t x_v dt$$

$$\frac{\theta_o(s)}{x_v(s)} = \frac{K_v}{A} \frac{1}{s}$$



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- Electro-hydraulic actuators:



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- Electro-hydraulic actuators:
 - Applications: steering machines

<http://www.nauticexpo.com>



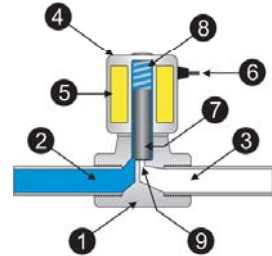
<http://www.rolls-royce.com>

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- Electrical actuators & valves:
 - Solenoid valves
 - http://www.societyofrobots.com/actuators_solenoids.shtml
 - Linear motors
 - Rotary actuators (motor valves)
 - DC motors:
 - Brushed motors
 - Brushless (EC – electronically commutated) motors)
 - AC motors (several types)
 - Stepper motors

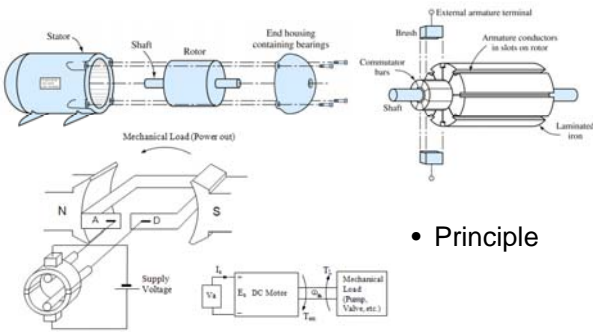
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- Solenoid valves
 - Construction and principle



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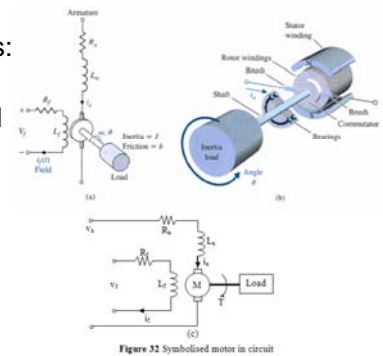
- DC (Brushed) motors: construction



- Principle

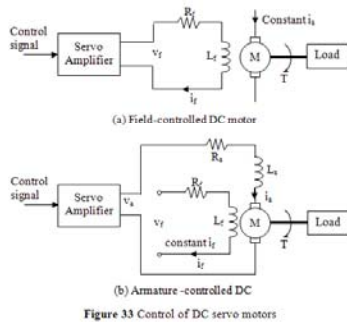
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- Electric motor valve actuators: DC motors
 - Field-control
 - Armature-control



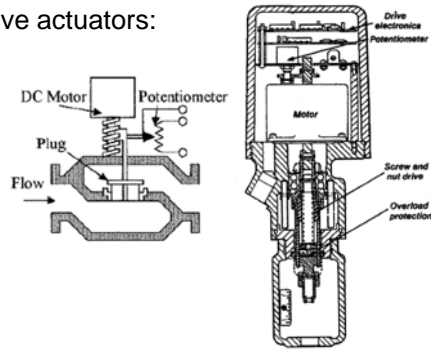
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- DC motors:
 - Field-control
 - Armature-control



Chapter 12

- Motor valve actuators:



Chapter 12

- Summary of Chapter 12
 - Basic components – final control element
 - Pneumatic diaphragm valves
 - Valve positioners
 - Hydraulic valves and actuators
 - Electrical actuators & valves:
 - Solenoid valves
 - Linear motors
 - Rotary motors (DC, AC, stepper motors)

Any Questions?



Further information

- **Valves, piping, and pipelines handbook** by T. Christopher Dickenson
- Steam Engineering Tutorials:
<http://www.spiraxsarco.com/resources/steam-engineering-tutorials.asp>
- Fisher Controls International Inc. (1999). *Control Valve Handbook*.
<http://www.documentation.emersonprocess.com/groups/public/documents/book/cvh99.pdf>
- <http://www.pacontrol.com/Valves.html>