Design and Modeling of Fluid Power Systems

ME 597/ABE 591 Lecture 11

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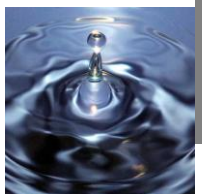

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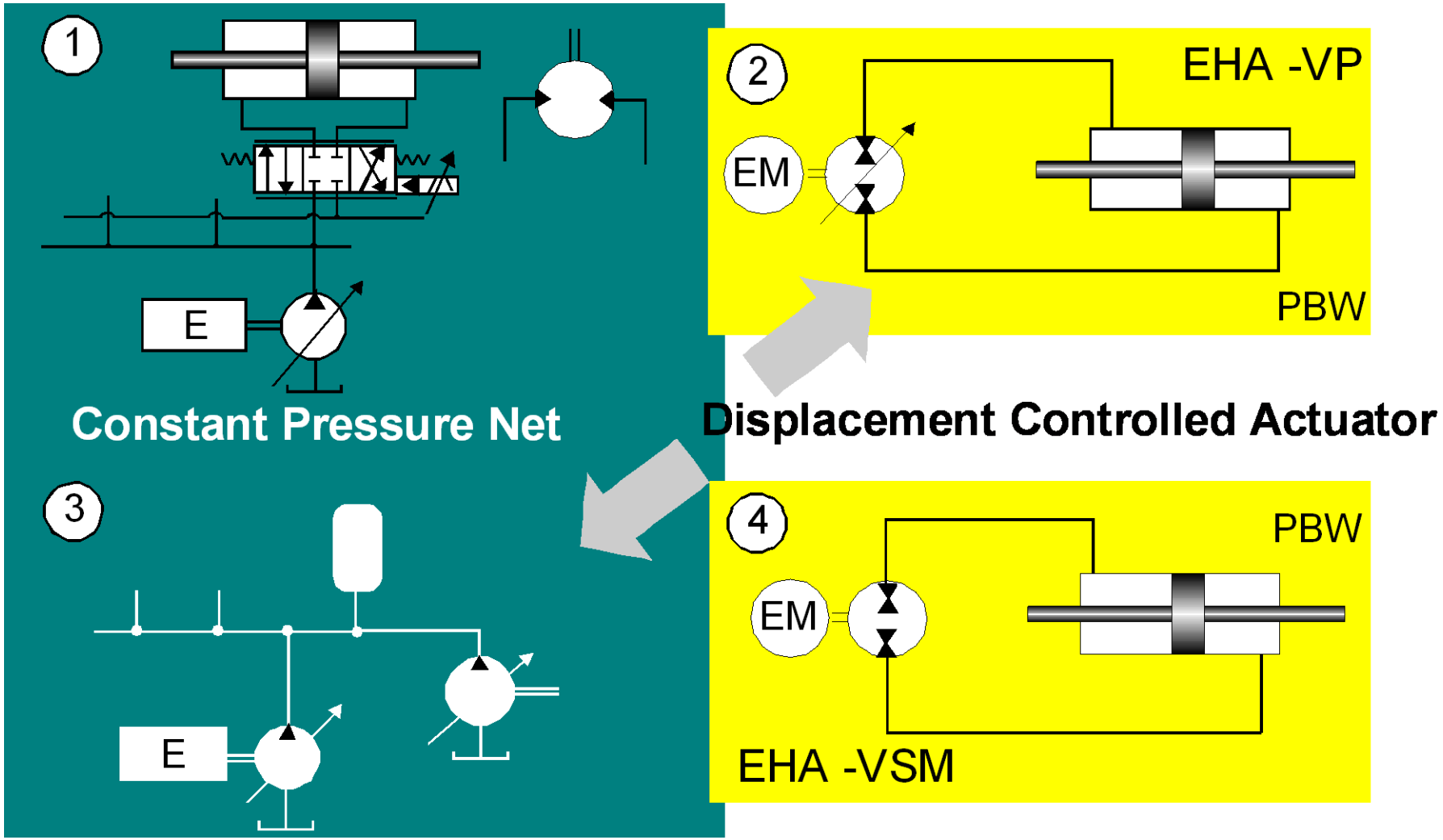
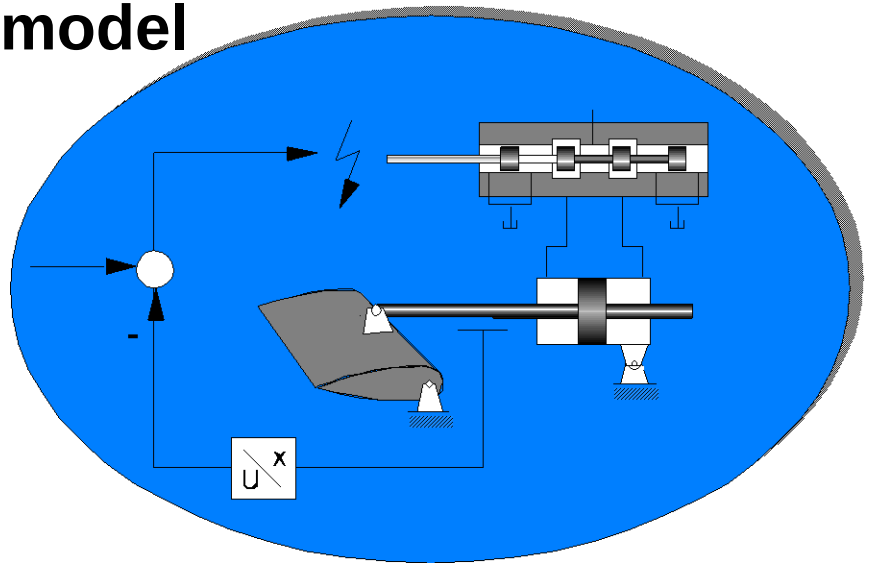
Classification of hydraulic actuators

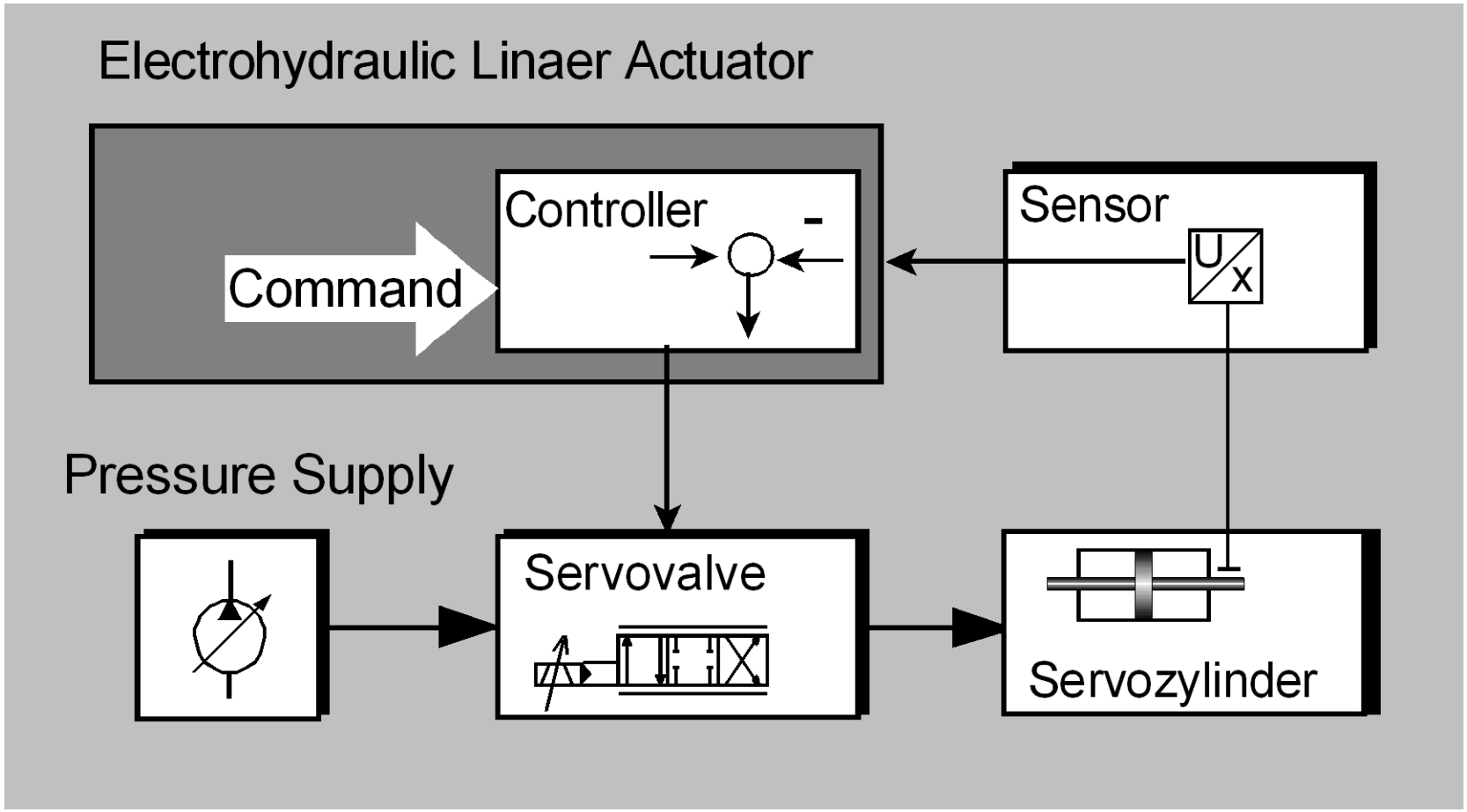


Contents

- Classification of hydraulic actuators
- Valve controlled actuators
- Sizing of actuator components
- Linear actuator - Nonlinear model
- Linear actuator – linearized model
- Rotary actuator
- Cartridge valve technology



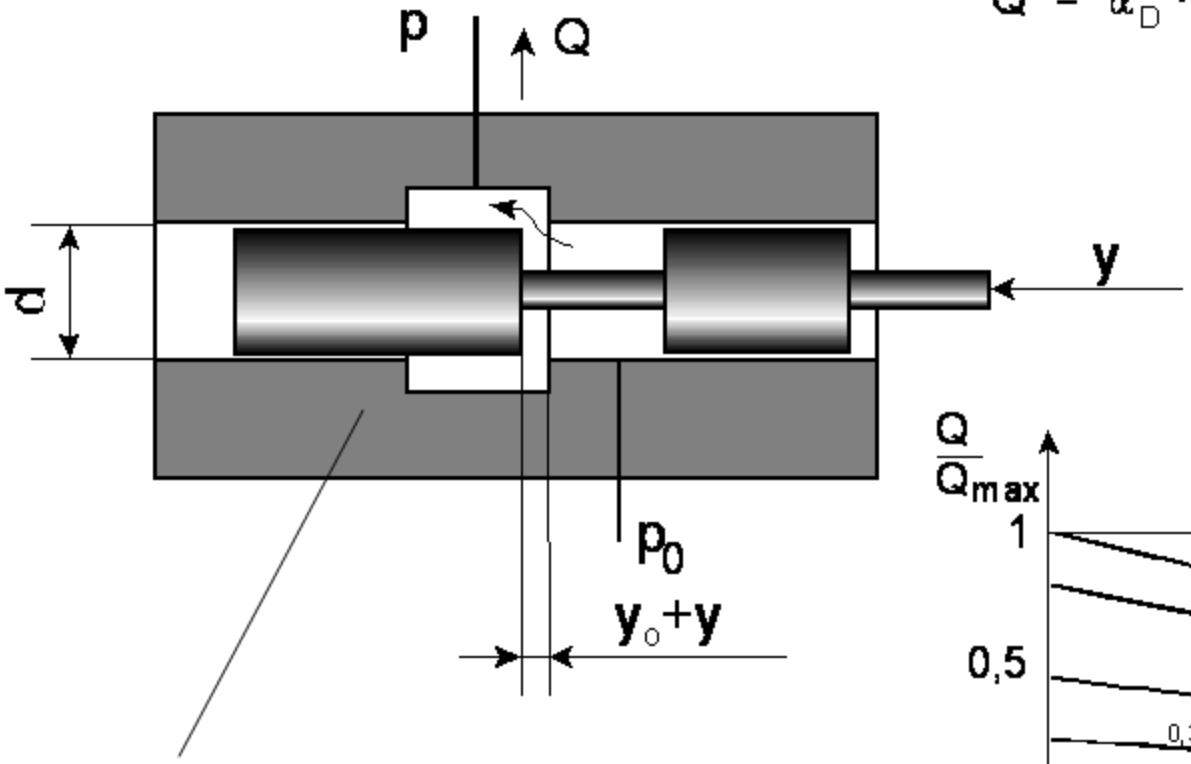
Valve controlled actuator



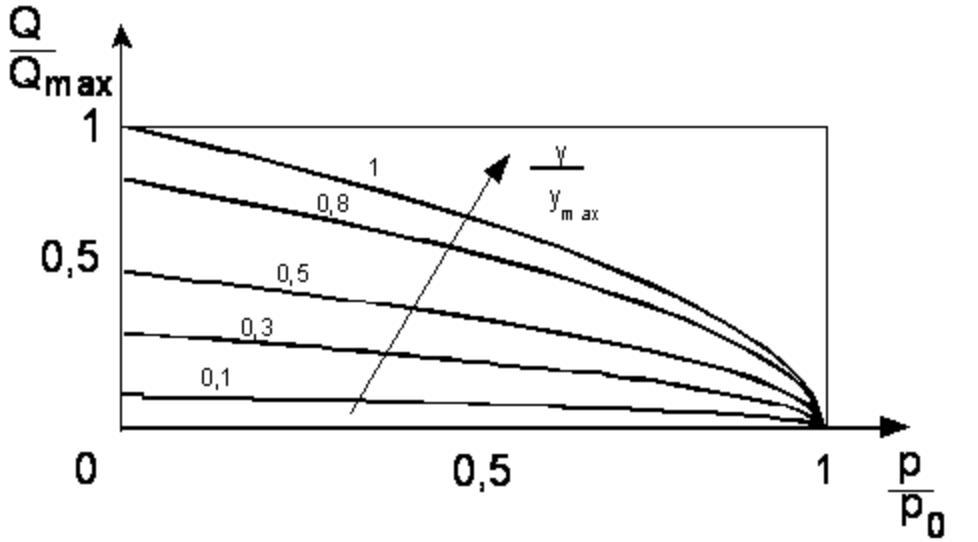
Hydraulic Resistances

Variable resistance (turbulent)

$$Q = \alpha_D \cdot \pi \cdot d\,(y_0 + y)\sqrt{\frac{2}{\varrho}}\sqrt{p_0 - p}$$



Spool valve

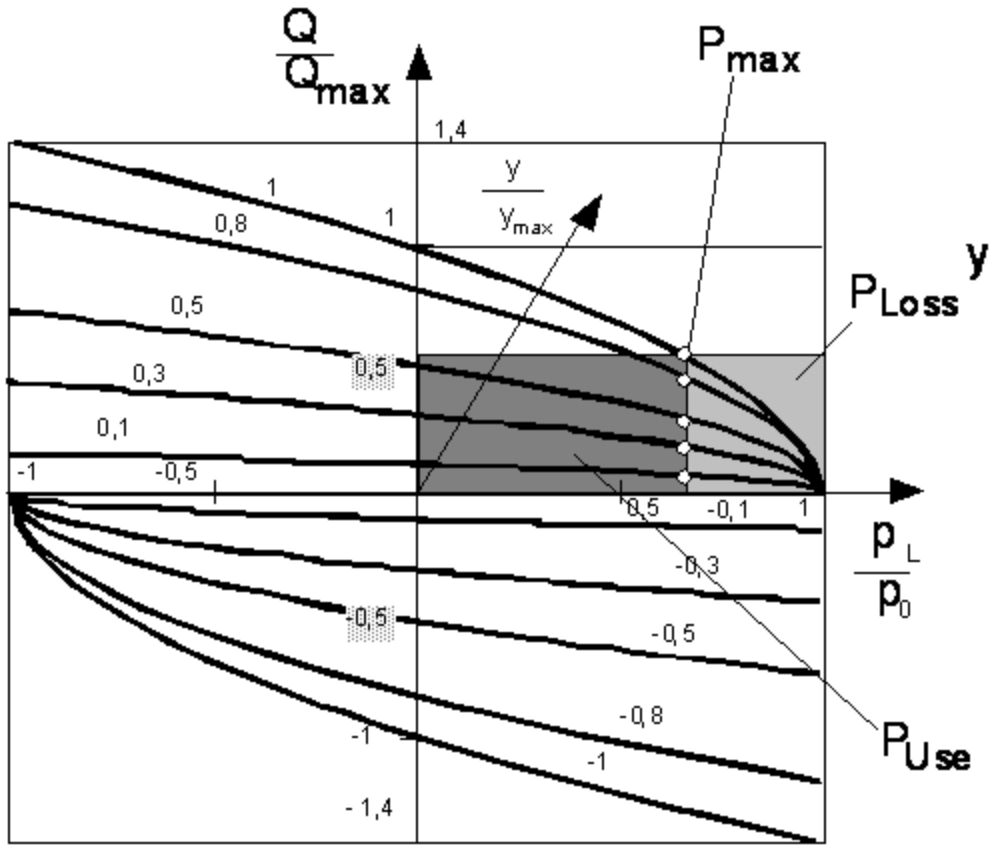


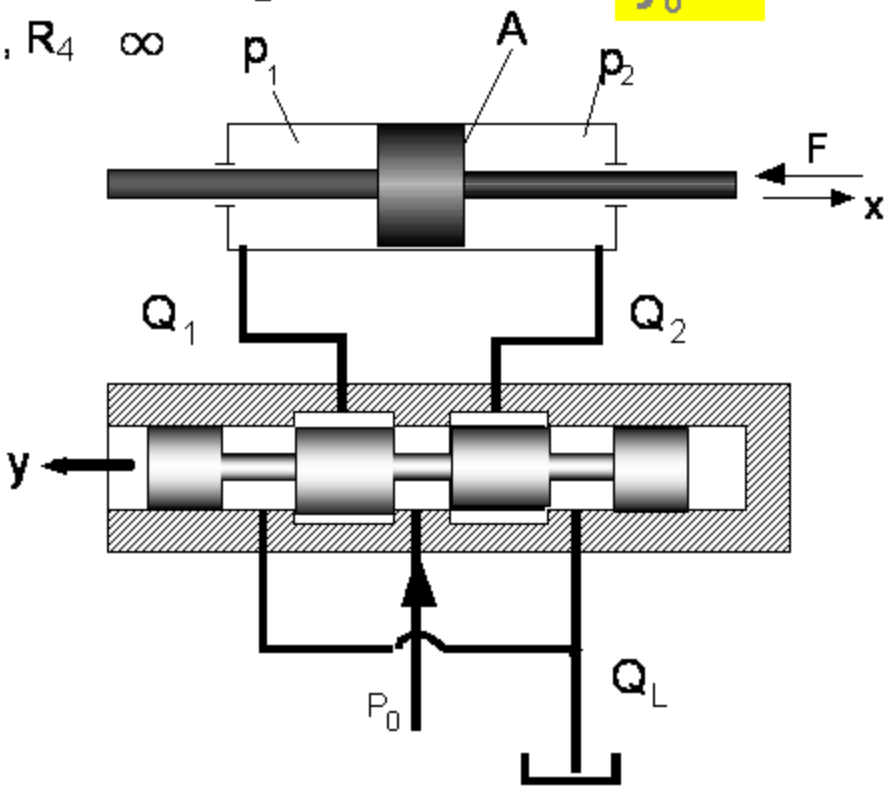
Zero Lap Configuration

$p_L = \Delta p = p_1 - p_2$; $F = A \cdot \Delta p = A \cdot p_L$

for $y > 0$ follows R_1, R_3 variable and R_2, R_4 ∞

$y_0=0$



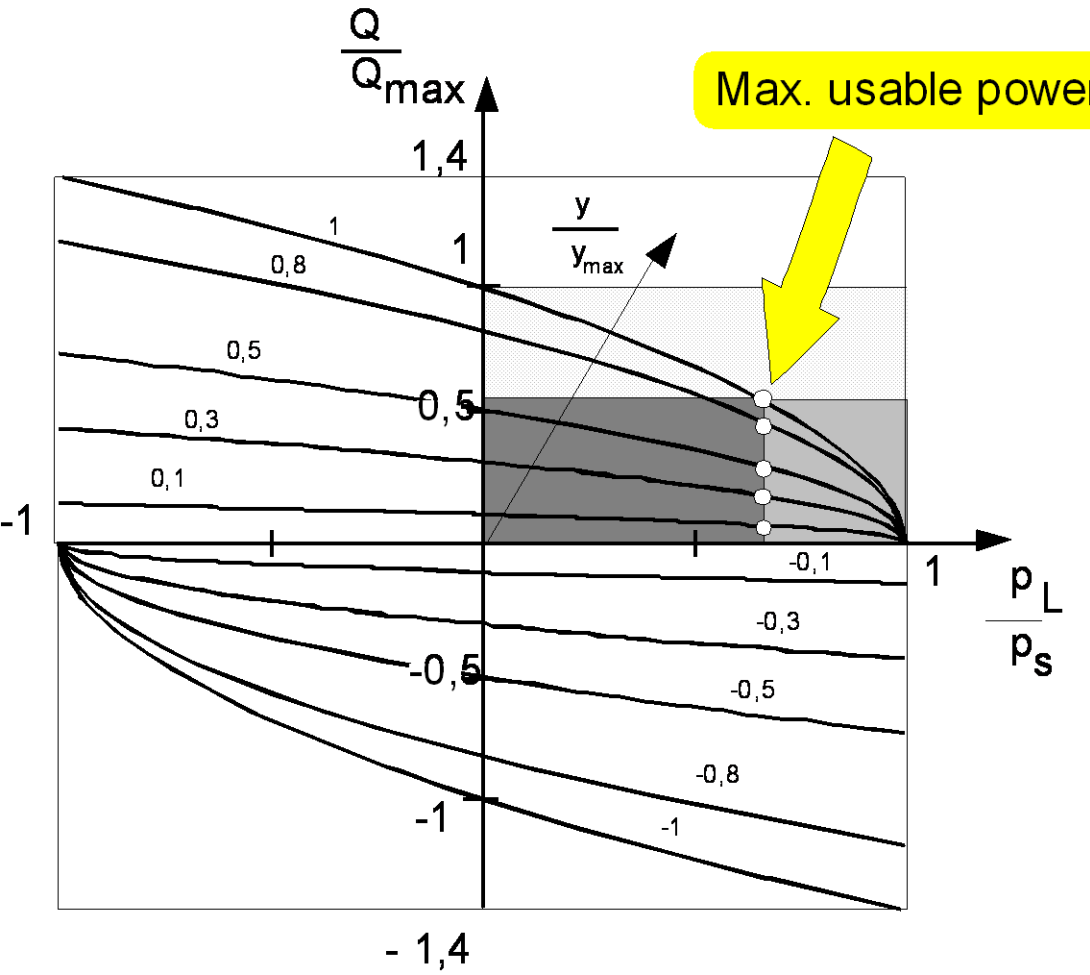


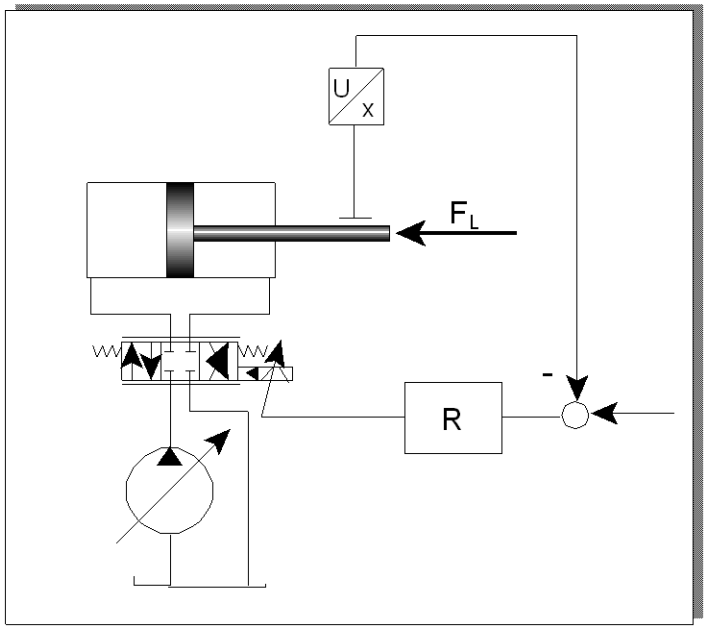
Normalized pressure p_L/p_0

Pressure-flow metering characteristics

Usable power

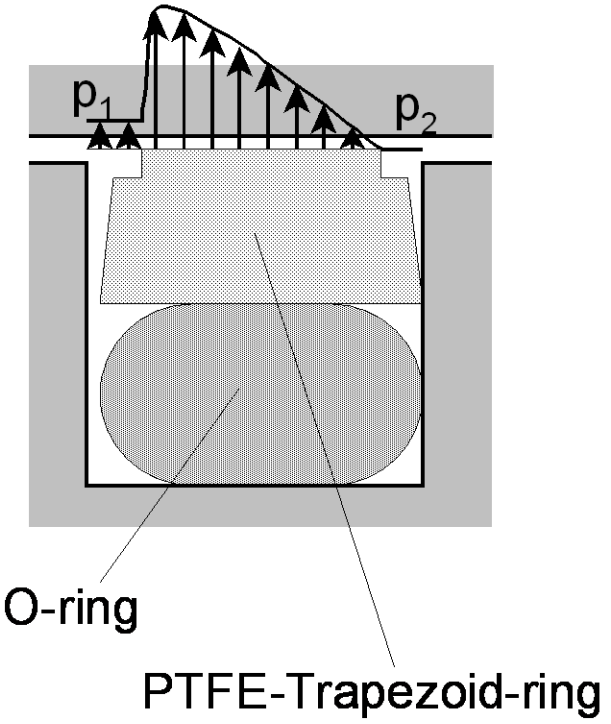
Power loss

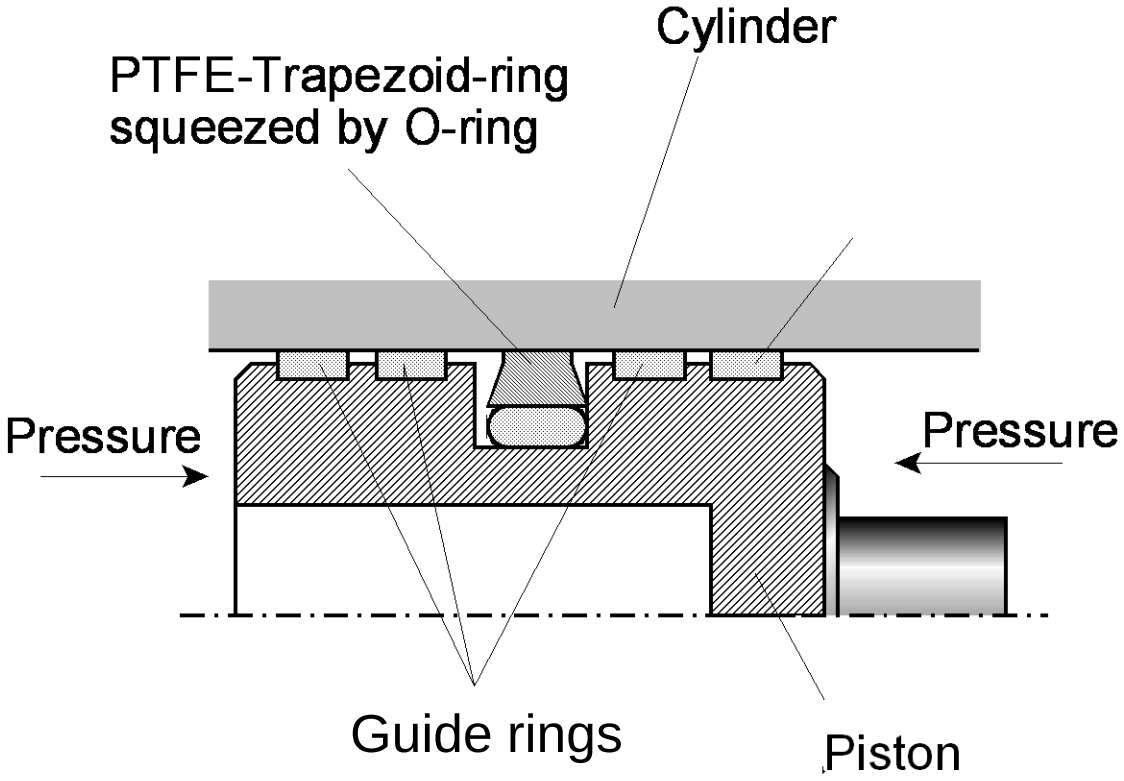




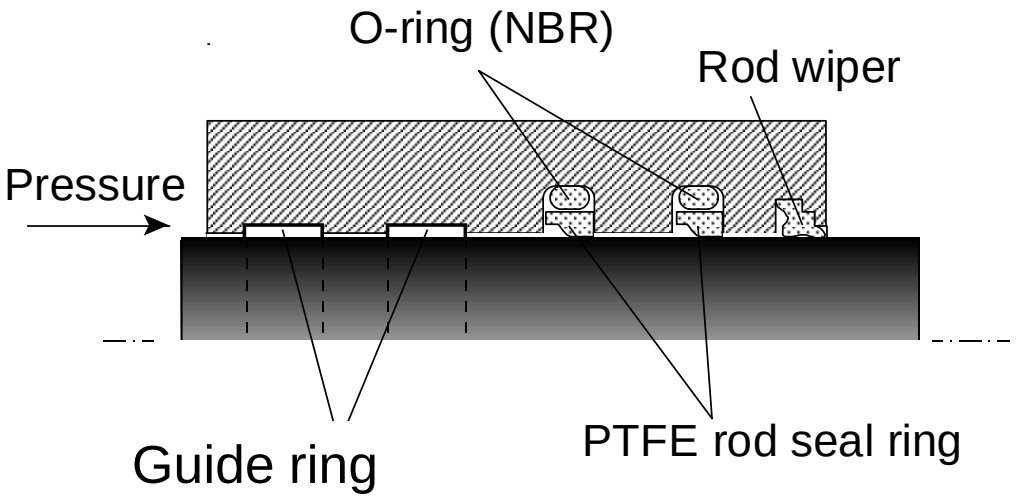
Cylinder seals

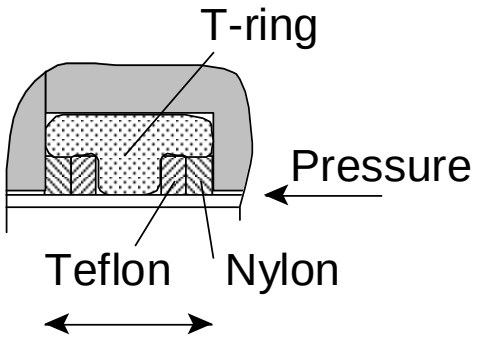
Piston seals to reduce friction

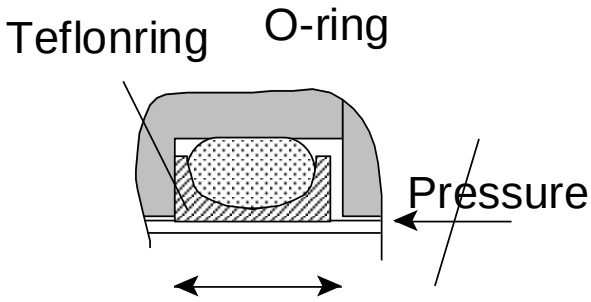




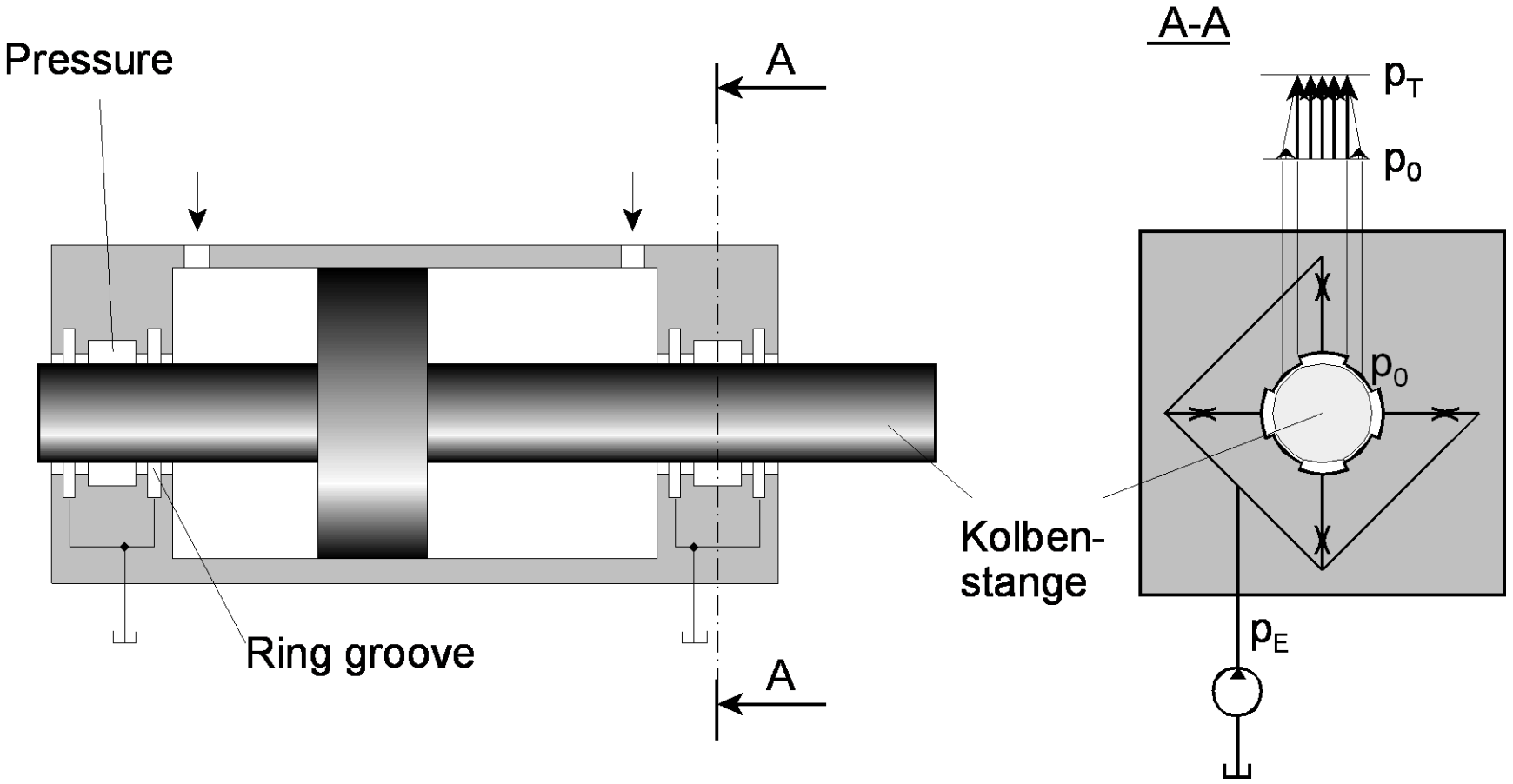
Piston rod seals







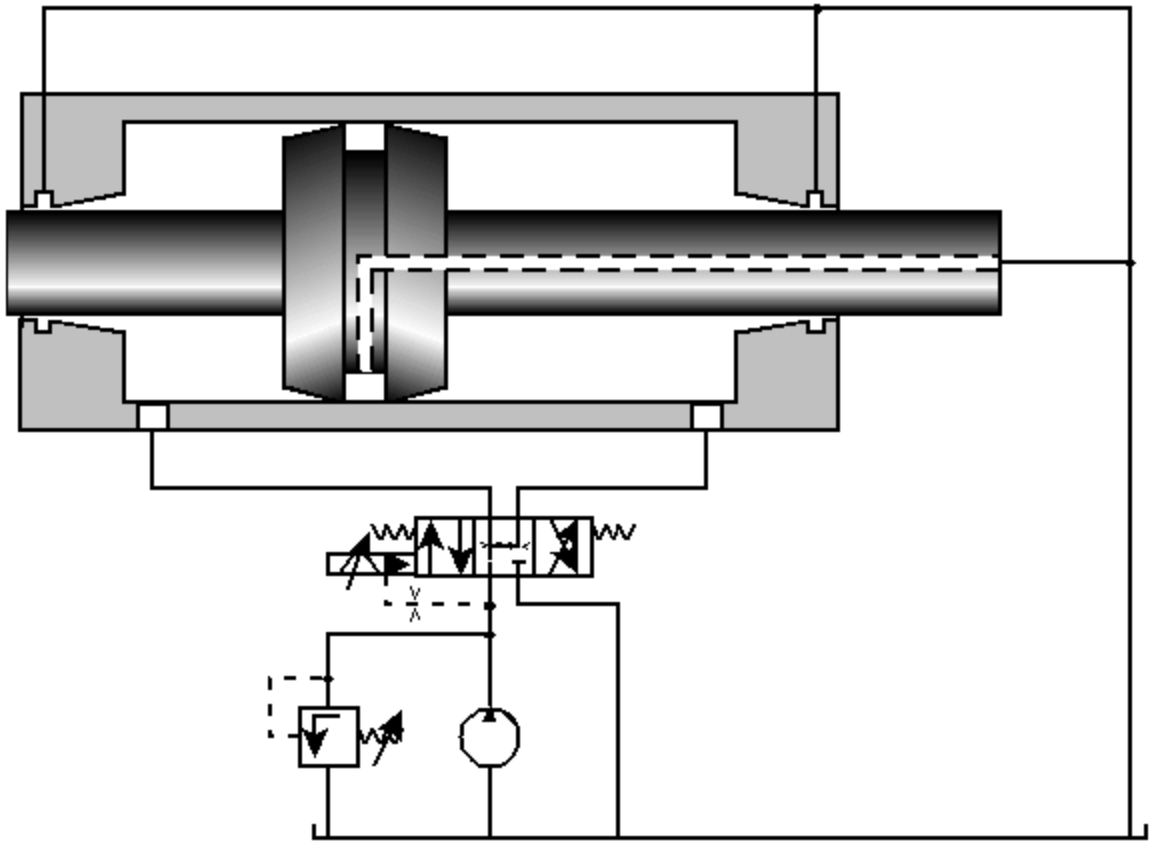
Hydrostatic cylinder rod bearing



Servo cylinder design

No stick slip

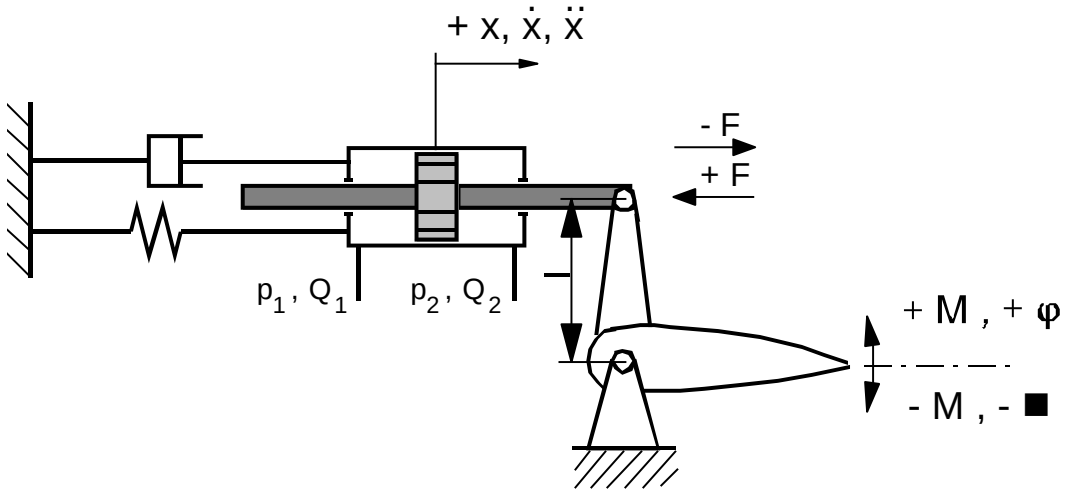
Combined hydrostatic/hydrodynamic bearing



Actuator Design

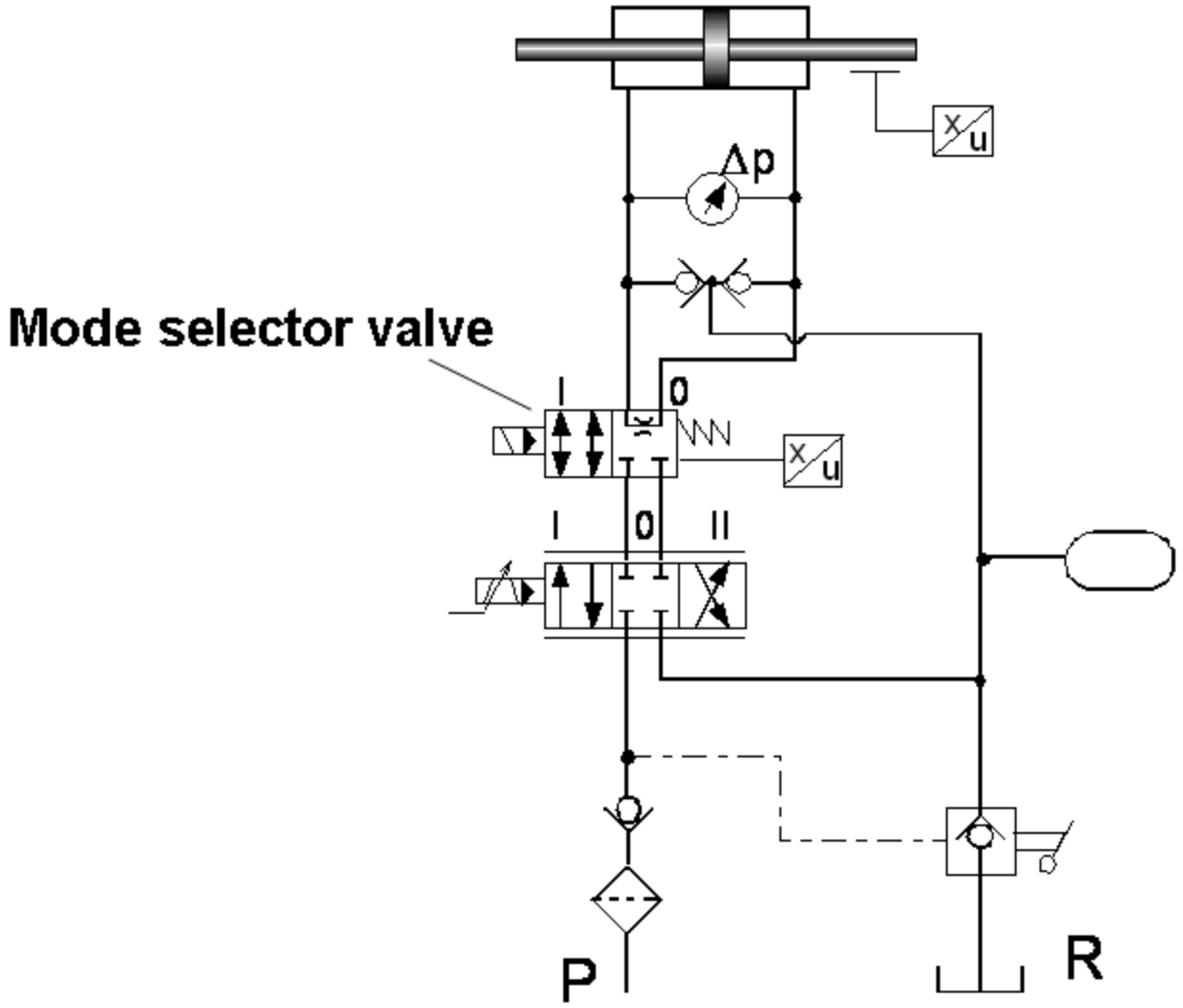
Aileron actuator

Roll control of the airplane

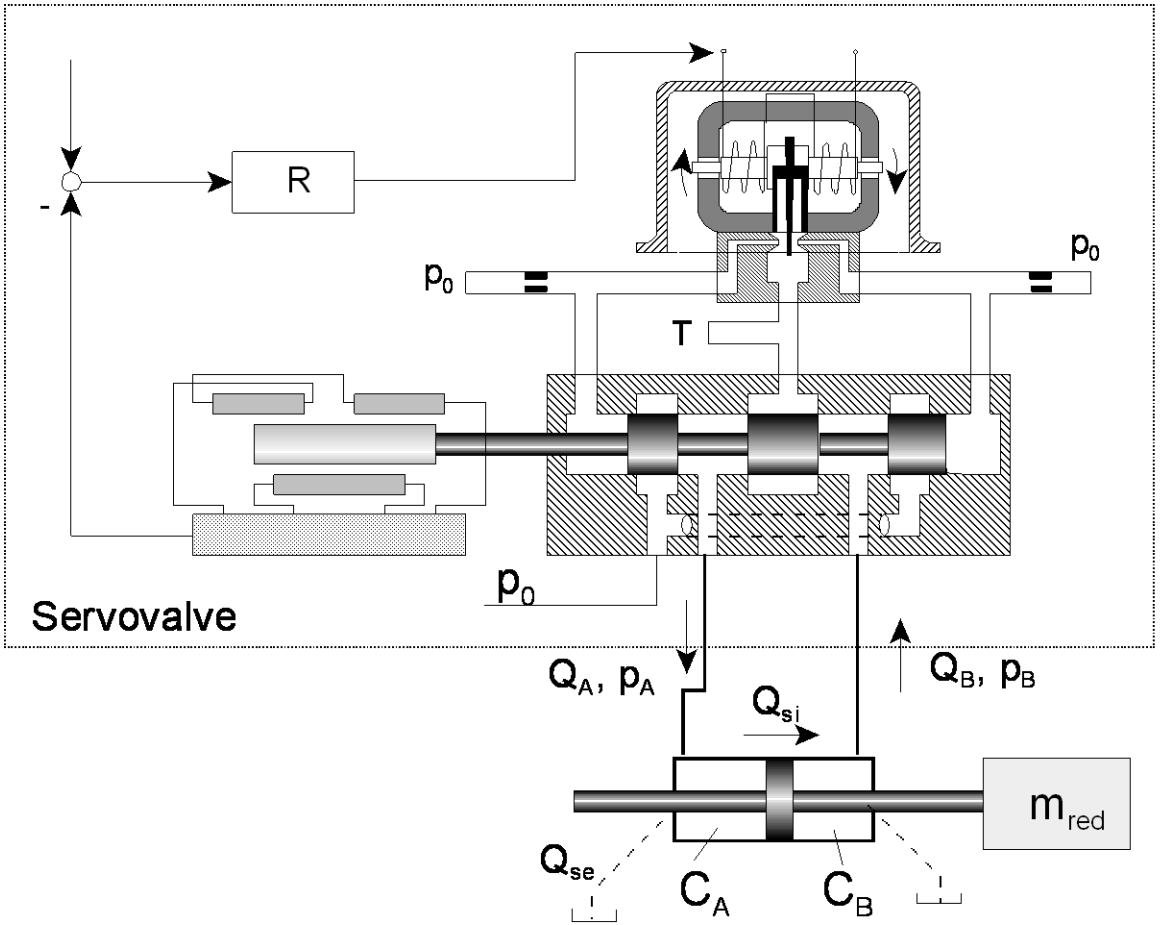


Surface angle	$\varphi = \pm 25°$
max. rate	$\dot{\varphi} = 60°/s$
max rate during flight	$\dot{\varphi} = 25°/s$
max. hinge moment	$M = \pm 1800$ Nm
lever	$l = 45$ mm
actuator load @ max rate during flight	$F = 35$ kN

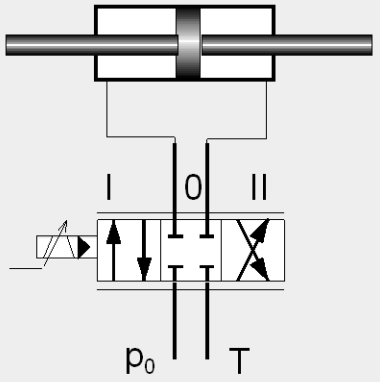
Aileron actuator



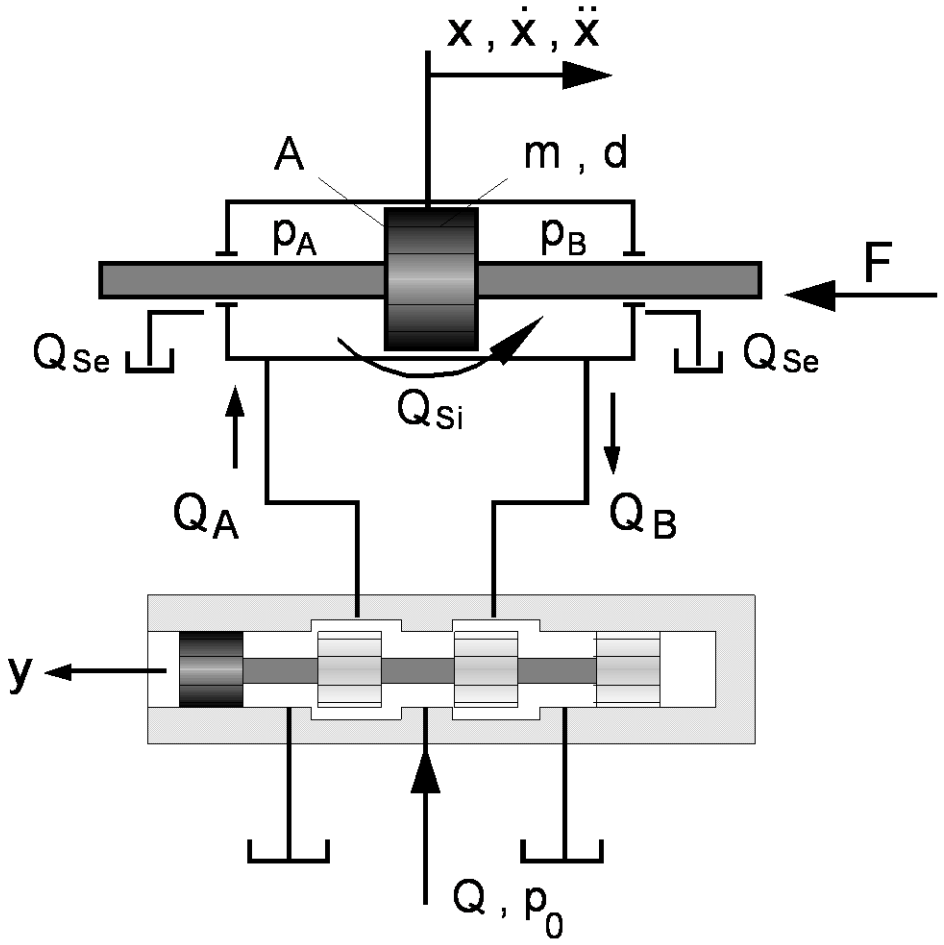
Valve controlled actuator



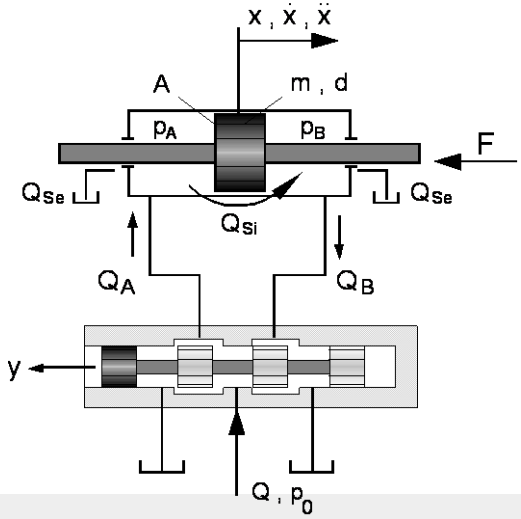
Circuit



Valve controlled linear actuator

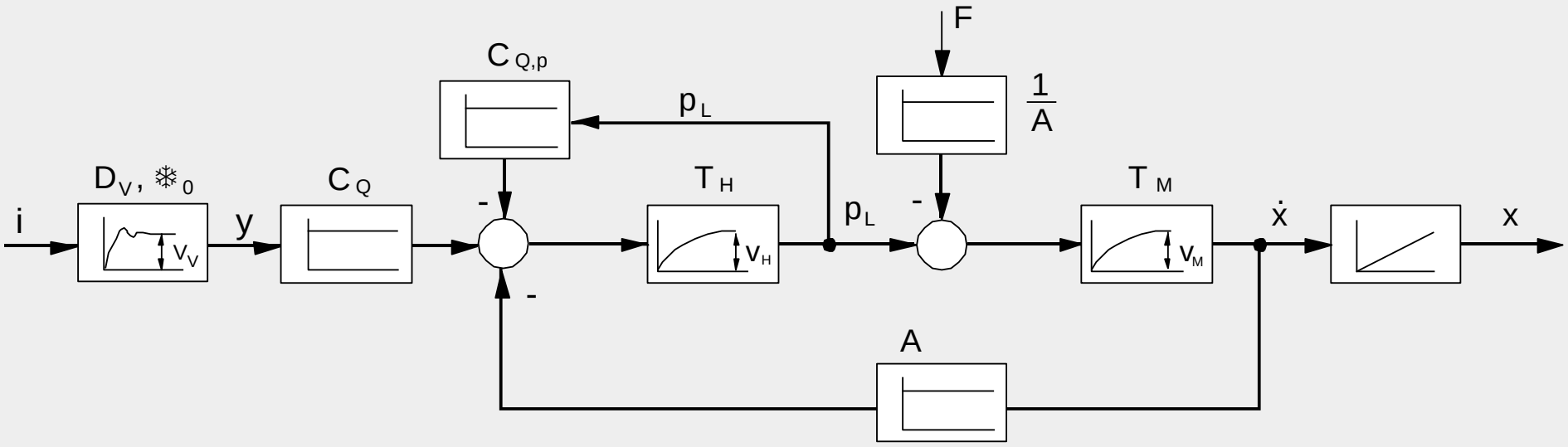


Linear model of valve controlled linear actuator

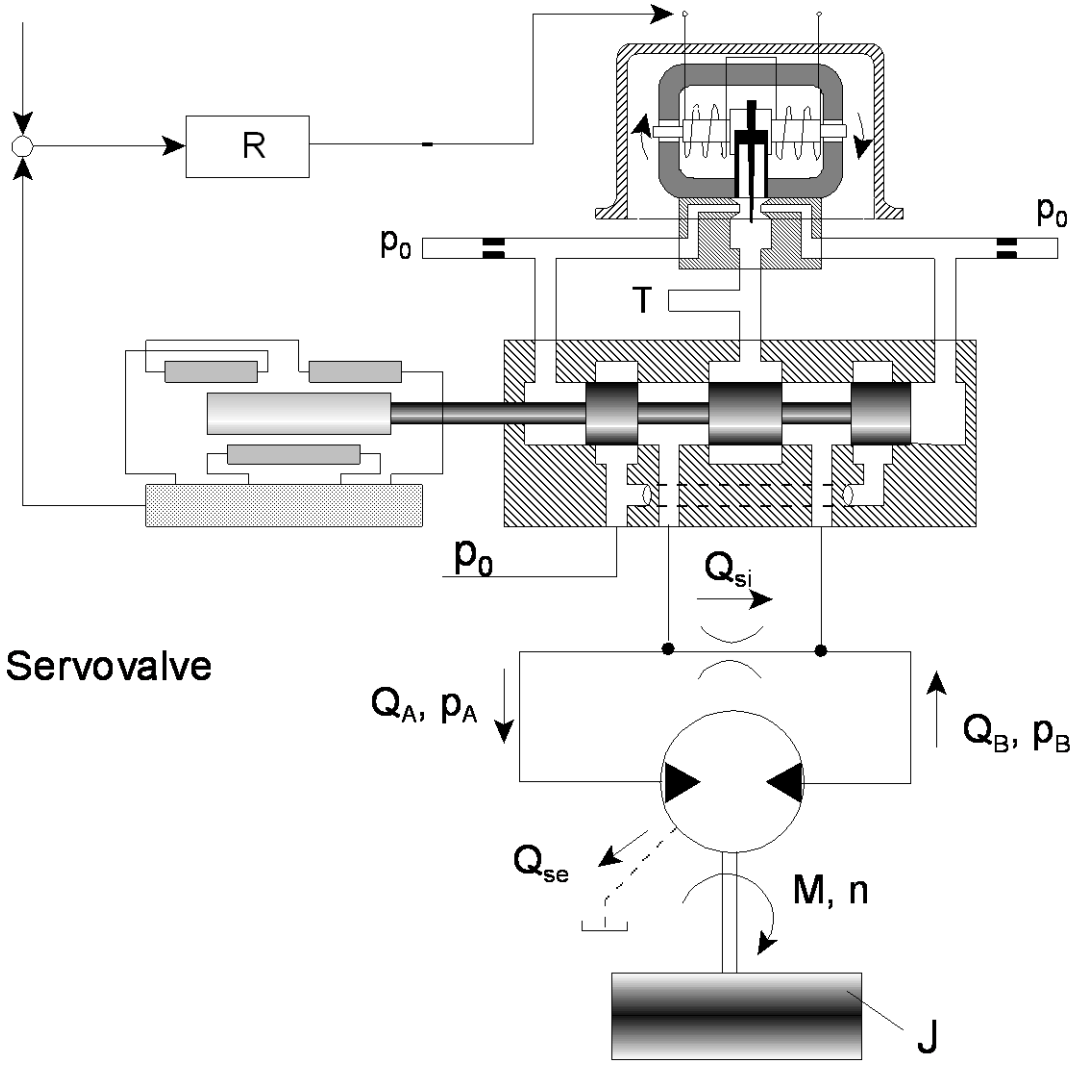


$$T_m = \frac{m}{d_{vis}} \qquad V_m = \frac{A}{d_{vis}}$$

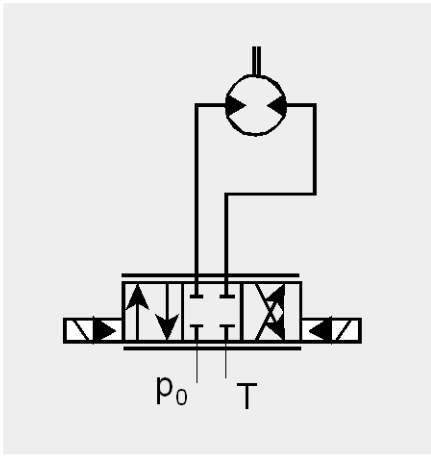
$$T_H = \frac{C_H}{2\left(C_{Q,p} + k_p\right)} \qquad V_H = \frac{1}{C_{Q,p} + k_p}$$



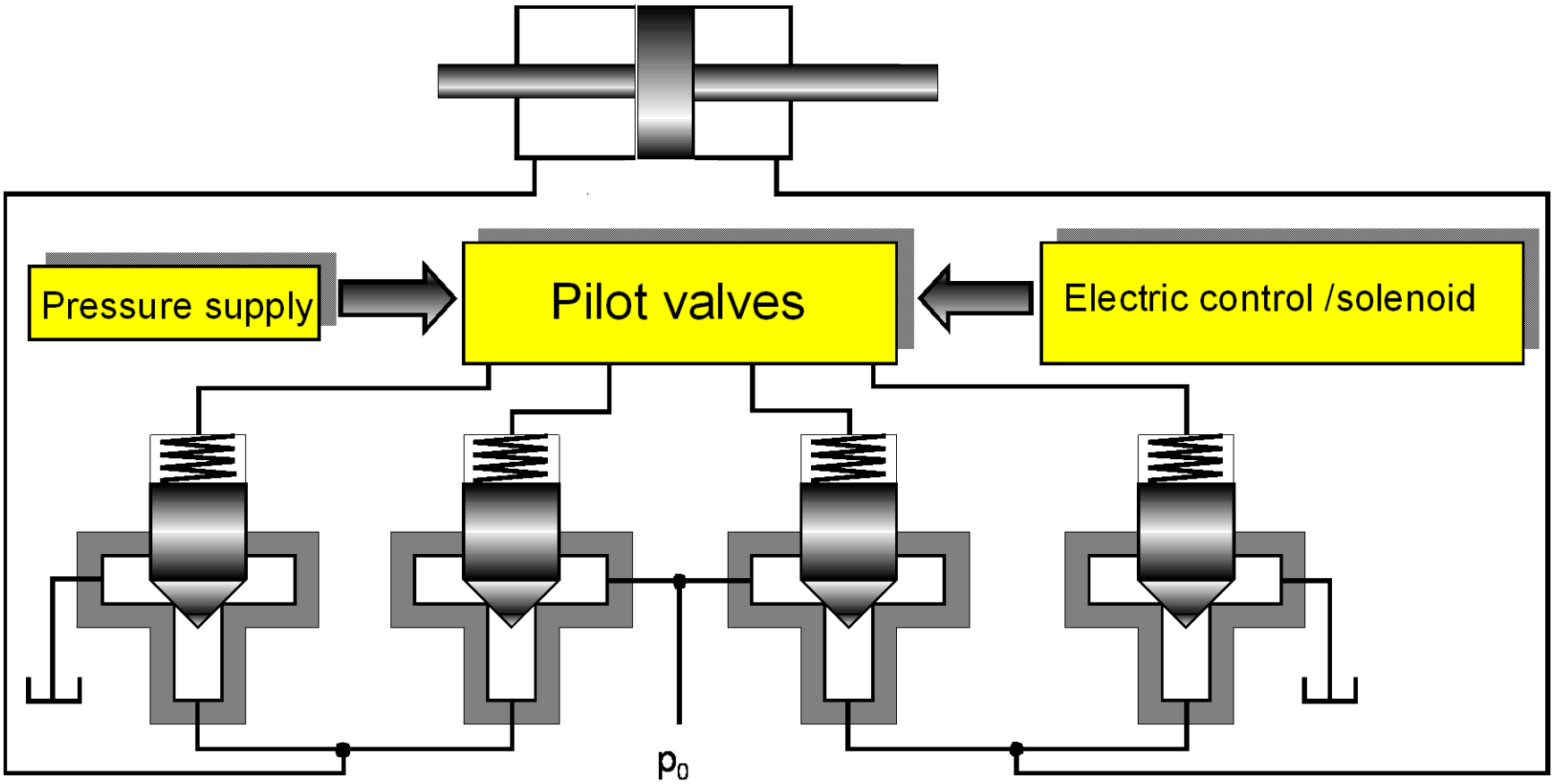
Valve controlled rotary actuator



Servovalve

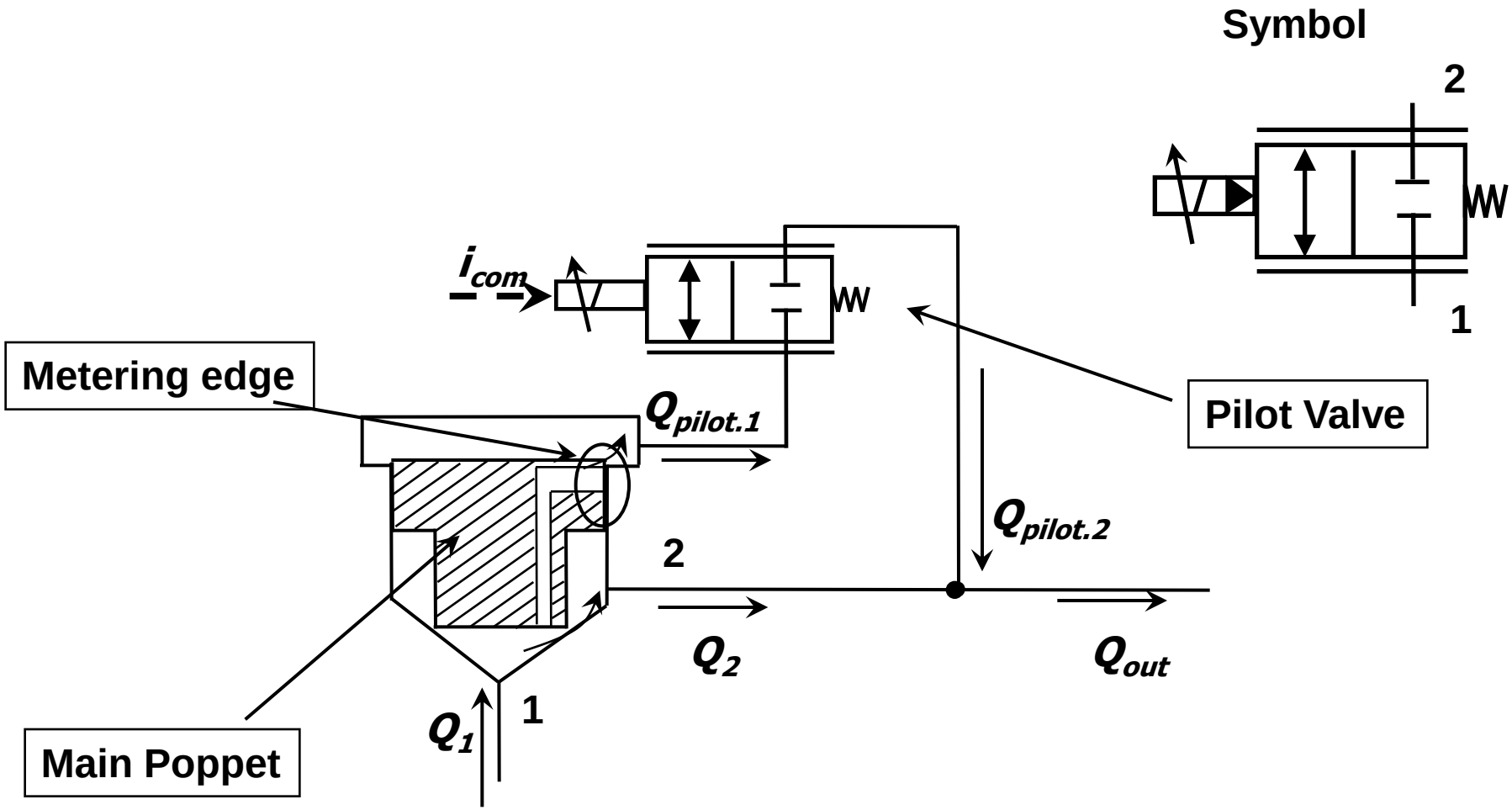


Cartridge valve technology

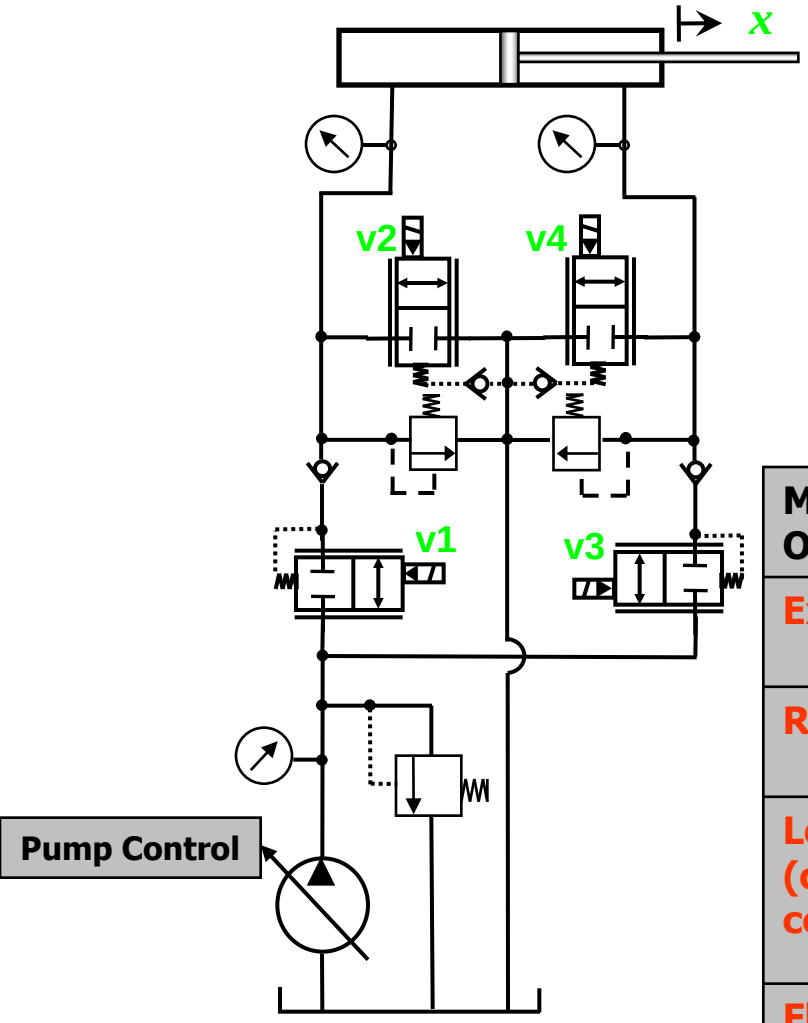


Cartridge valve technology

Valvistor® Principle



Cartridge valve technology



Mode of Operation	Valve1 (i1)	Valve2 (i2)	Valve3 (i3)	Valve4 (i4)
Extension	Controlled	Closed (i2=0)	Closed (i3=0)	Controll
Retraction	Closed (i1=0)	Controlled	Controlled	Closed (i4=0)
Locked (closed center)	Closed (i1=0)	Closed (i2=0)	Closed (i3=0)	Closed (i4=0)
Floating	Closed (i1=0)	Open	Closed (i3=0)	Open

Cartridge valve technology