Design and Modeling of Fluid Power Systems

ME 597/ABE 591 Lecture 10

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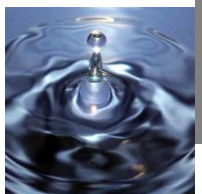

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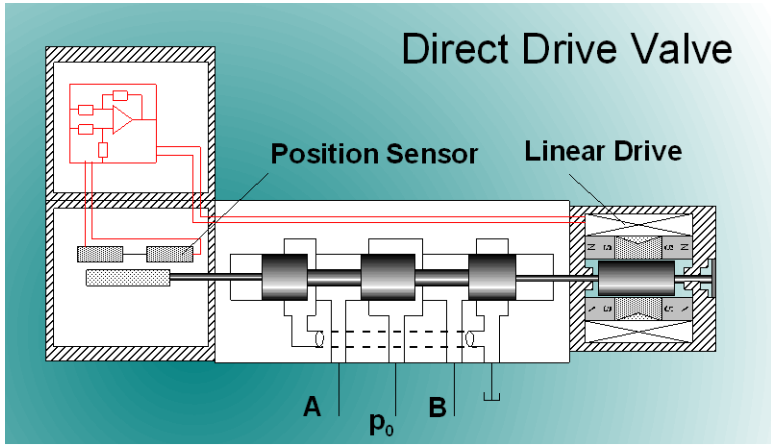
Contents

- Proportional valves - servovalves
- Electromechanical actuators - overview
- Pilot operated proportional valves
- Internal feedback systems
- Pressure – flow metering characteristics

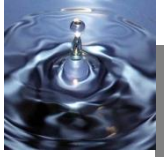
Experimental determination of:

- Flow gain, pressure gain
- Dynamic characteristics



- Linearization of pressure/flow characteristics

Proportional Valves



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Single or multiple stage

Signal

Electromechanical actuator

mechanical - hydraulical convertor

controlled hydraulic power

hydraulic power supply

$x_e=i_e$

F

x

Proportional solenoid

$x_e=i_e$

F

N S S N

x

N S S N

p_0

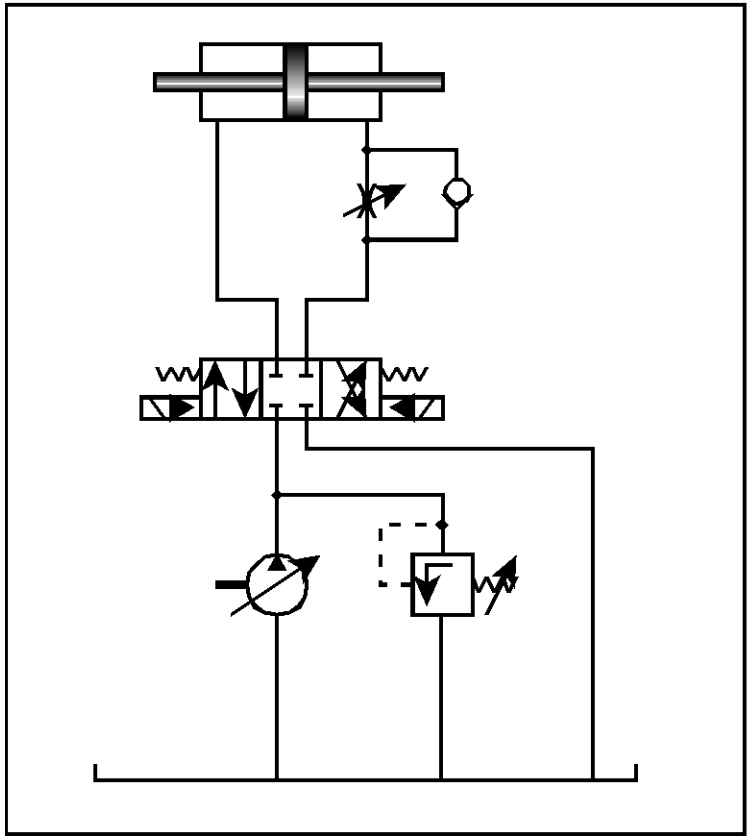
A

B

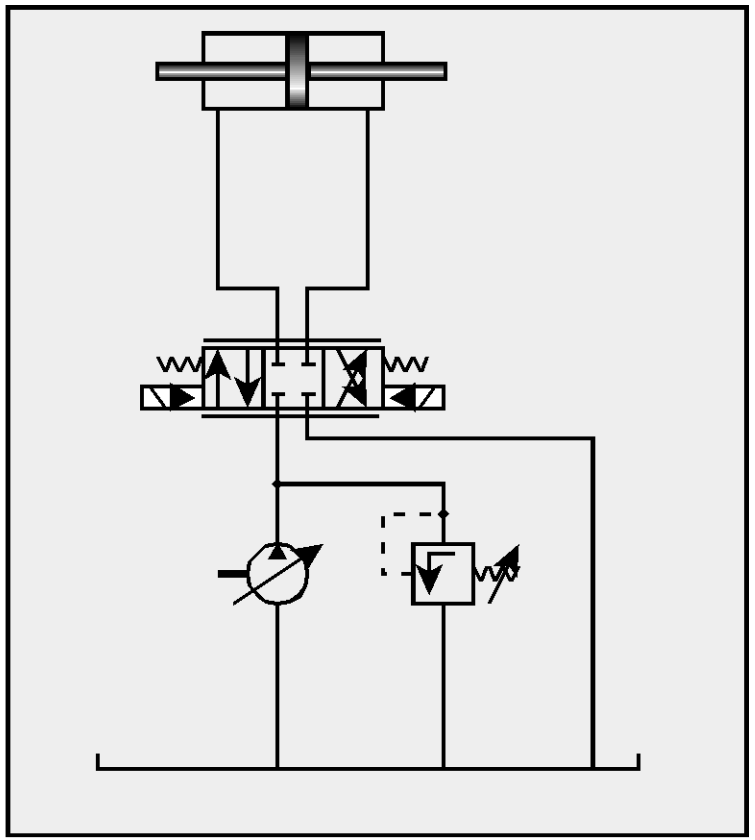
Circuit simplification

Velocity control

with one way restrictor valve

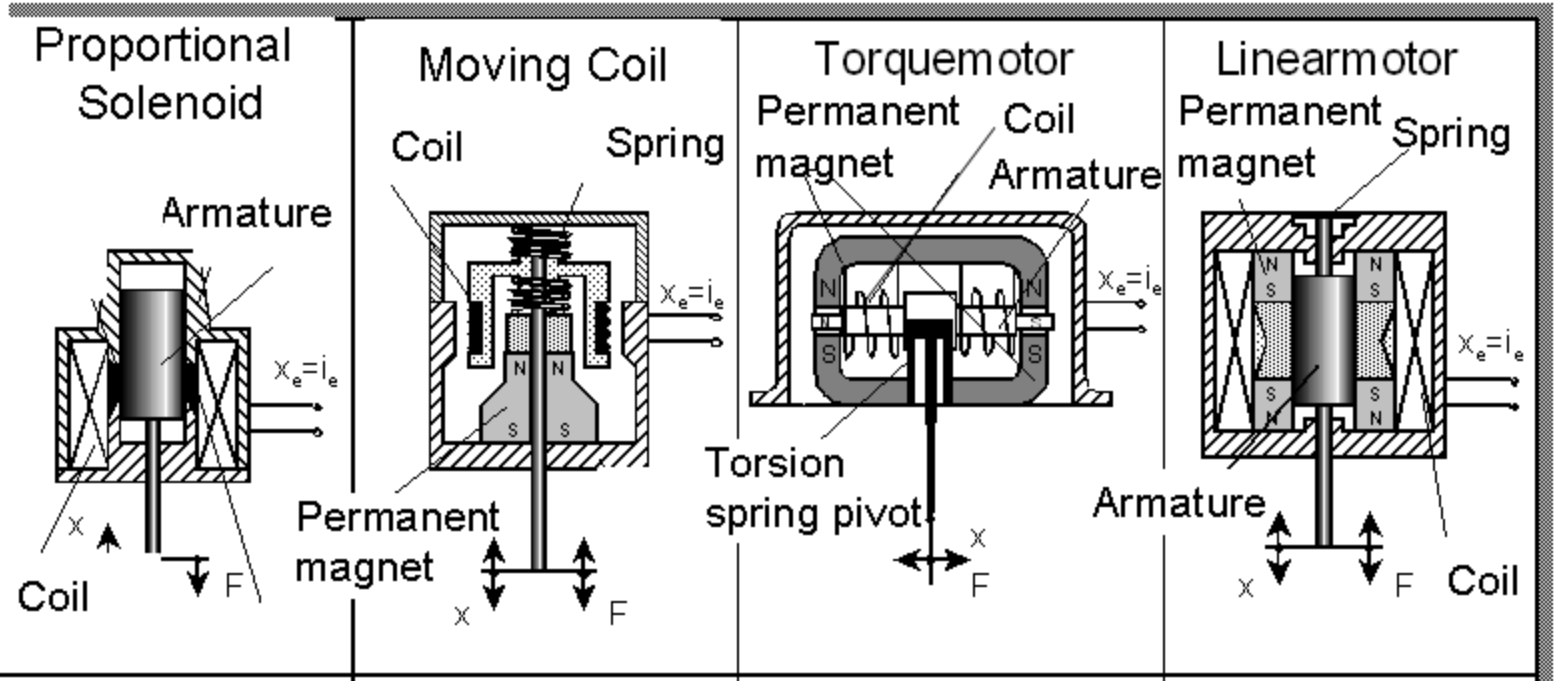


with proportional valve



Electromechanical actuators

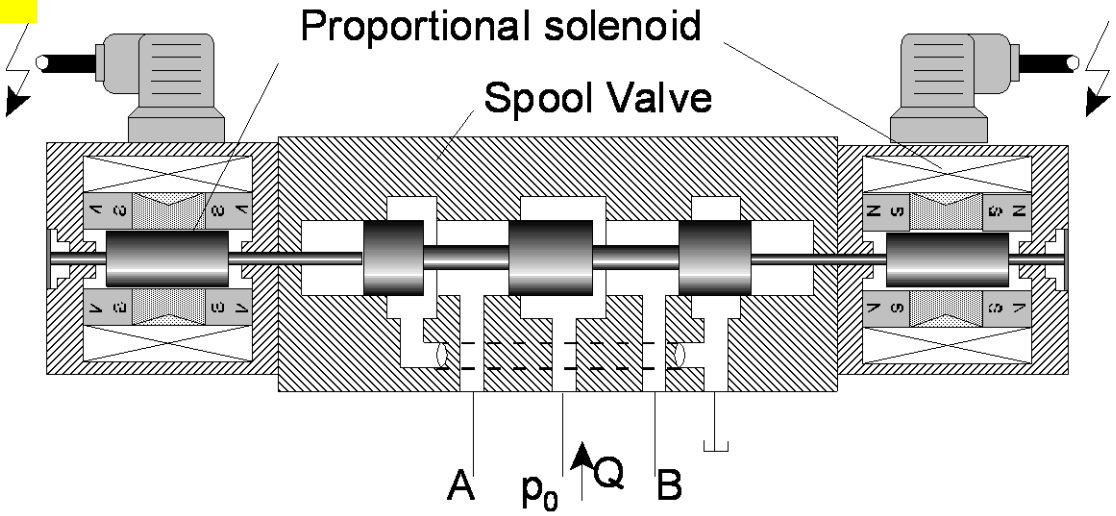
as input device of proportional & servovalves



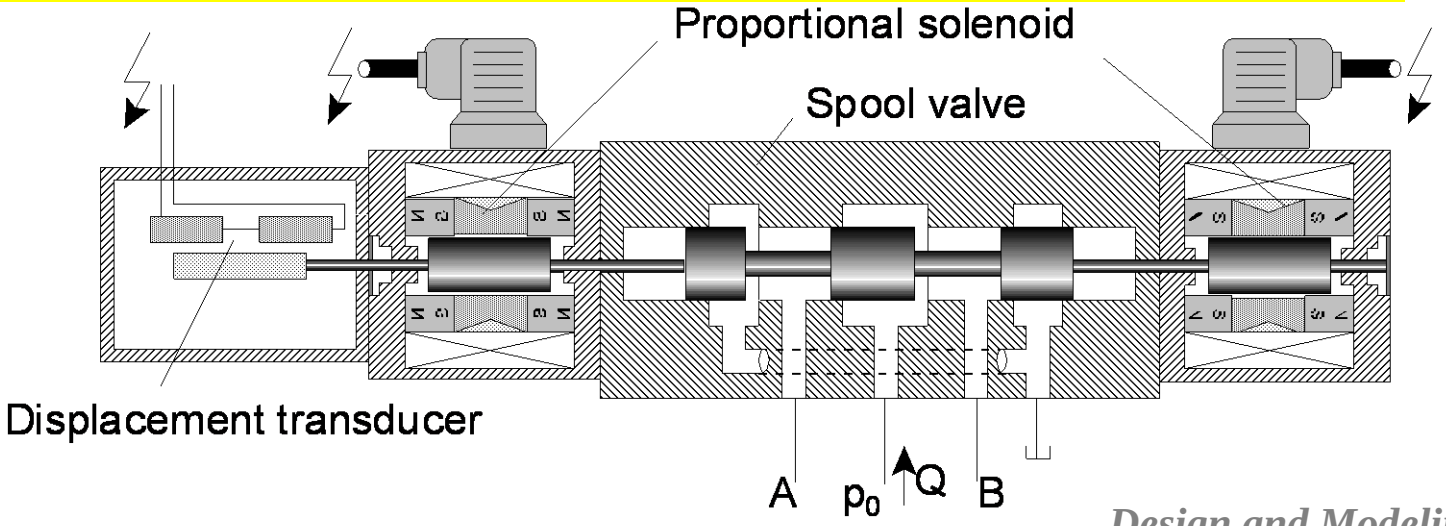
Power [W]	5	···	40	0,2	···	5	0,02	···	4	10	···	40
Work [Nmm]	20	···	1000	8	···	80	2	···	40	400	···	2000
Linearity [%]	0,5	···	6	1	···	7	1	···	2	0,5	···	6
Bandwidth [Hz]	10	···	150	100	···	200	100	···	300	10	···	200

Proportional valves

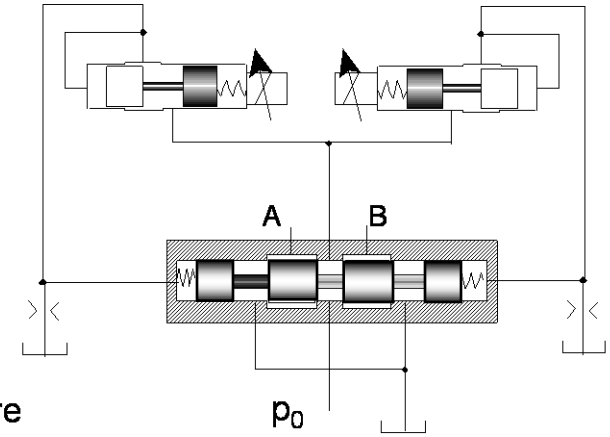
Direct operated



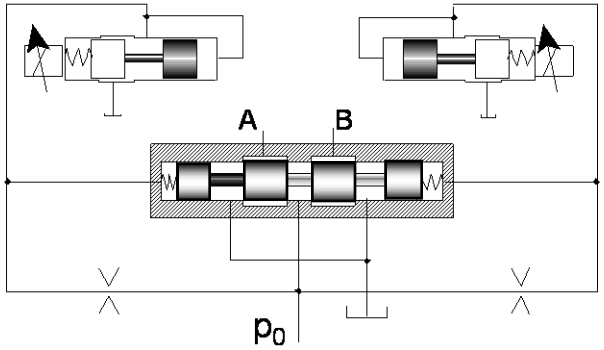
Direct operated with internal closed position control loop



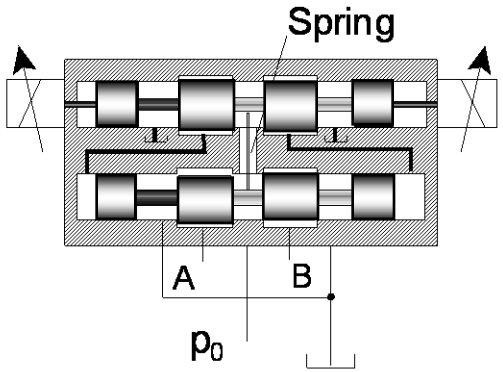
Pilot operated proportional valves



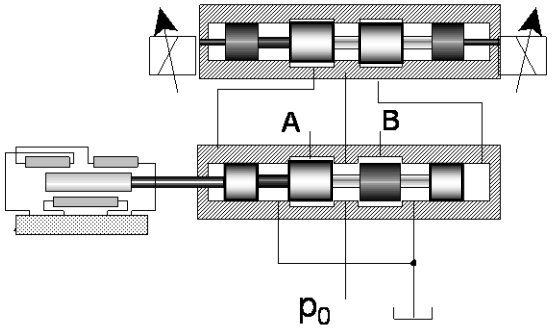
Using pressure reducing valve



Using pressure relief valve



Internal position control of main spool by force feedback



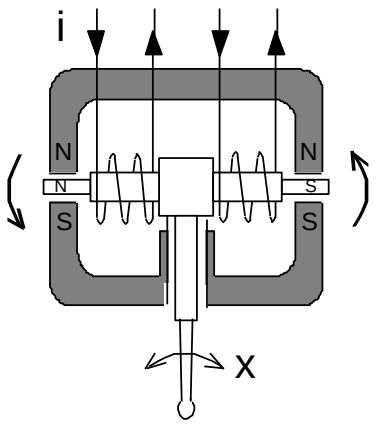
Internal position control of main spool by electric position feedback)

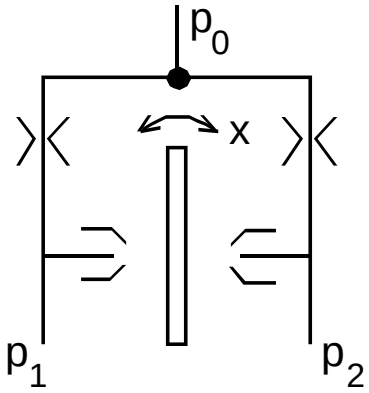
Servovalve

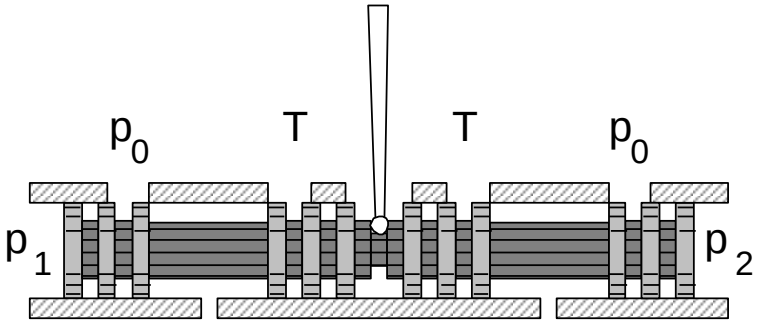
Single and Two-stage electrohydraulic servovalves

1st stage (pilot stage) **2st stage**

Torque-Motor + **Flapper- nozzle** + Main spool



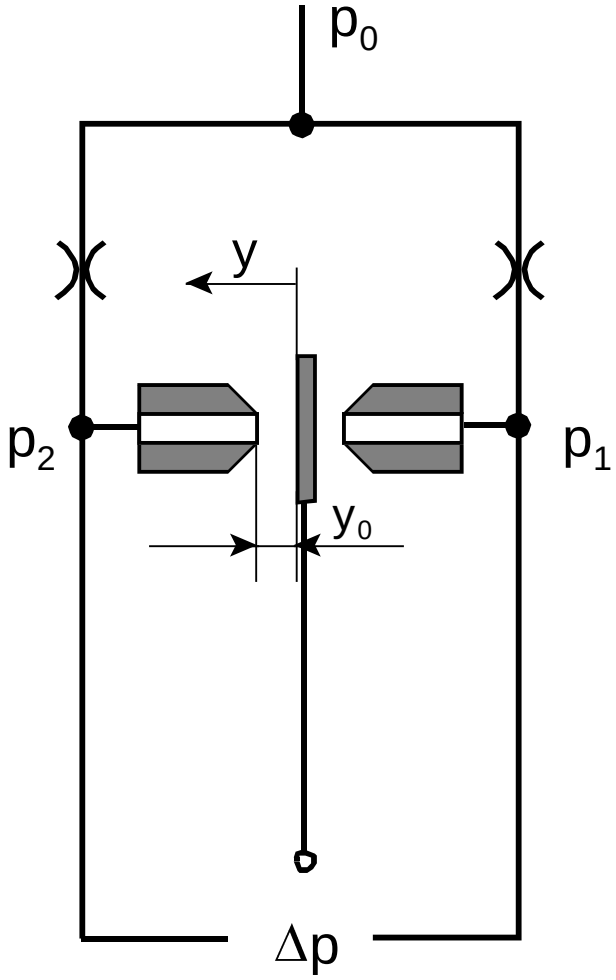




or Jet Flapper system

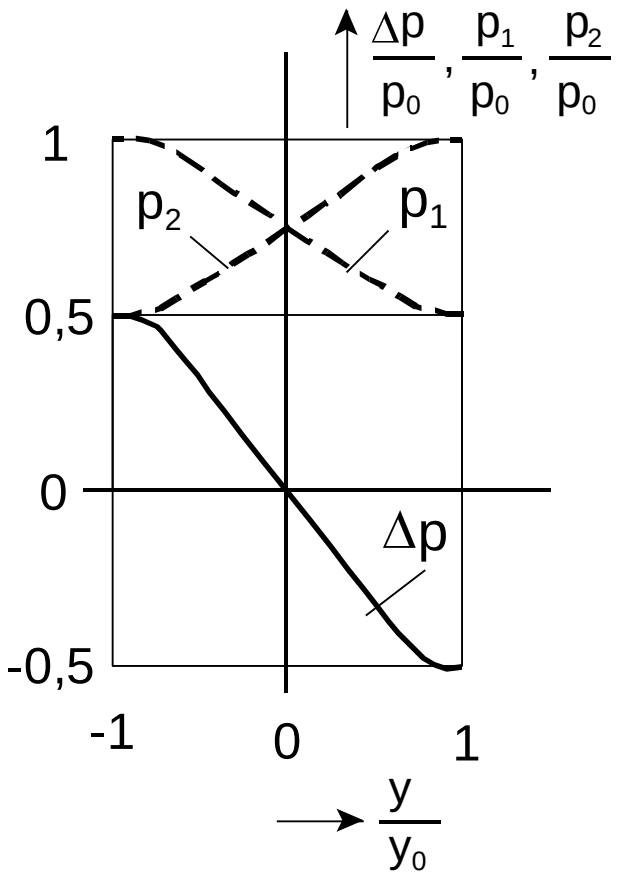
Flapper nozzle system

Double jet flapper valve



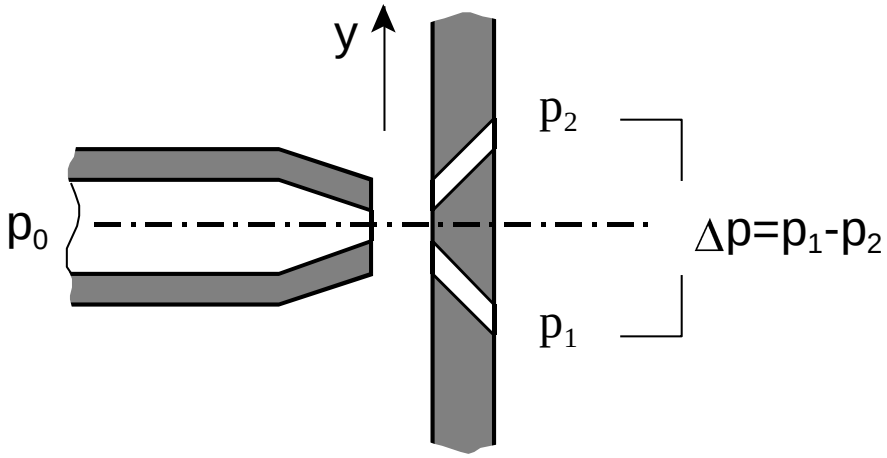
$\Delta p \sim y$

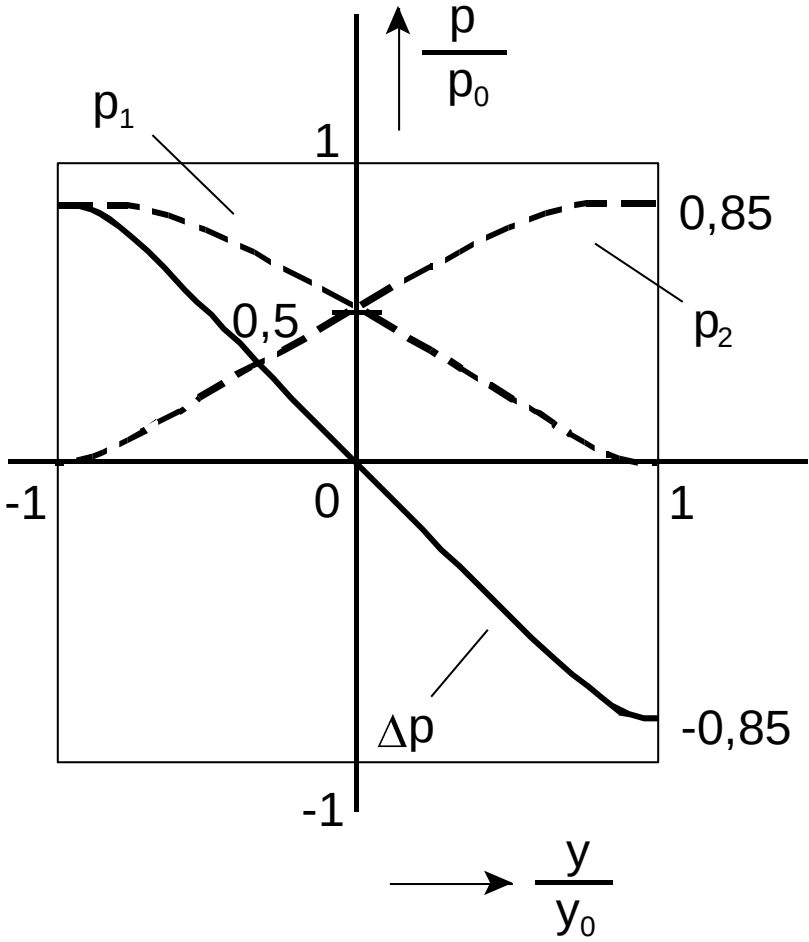
Measured curve



$\Delta p = p_1 - p_2$

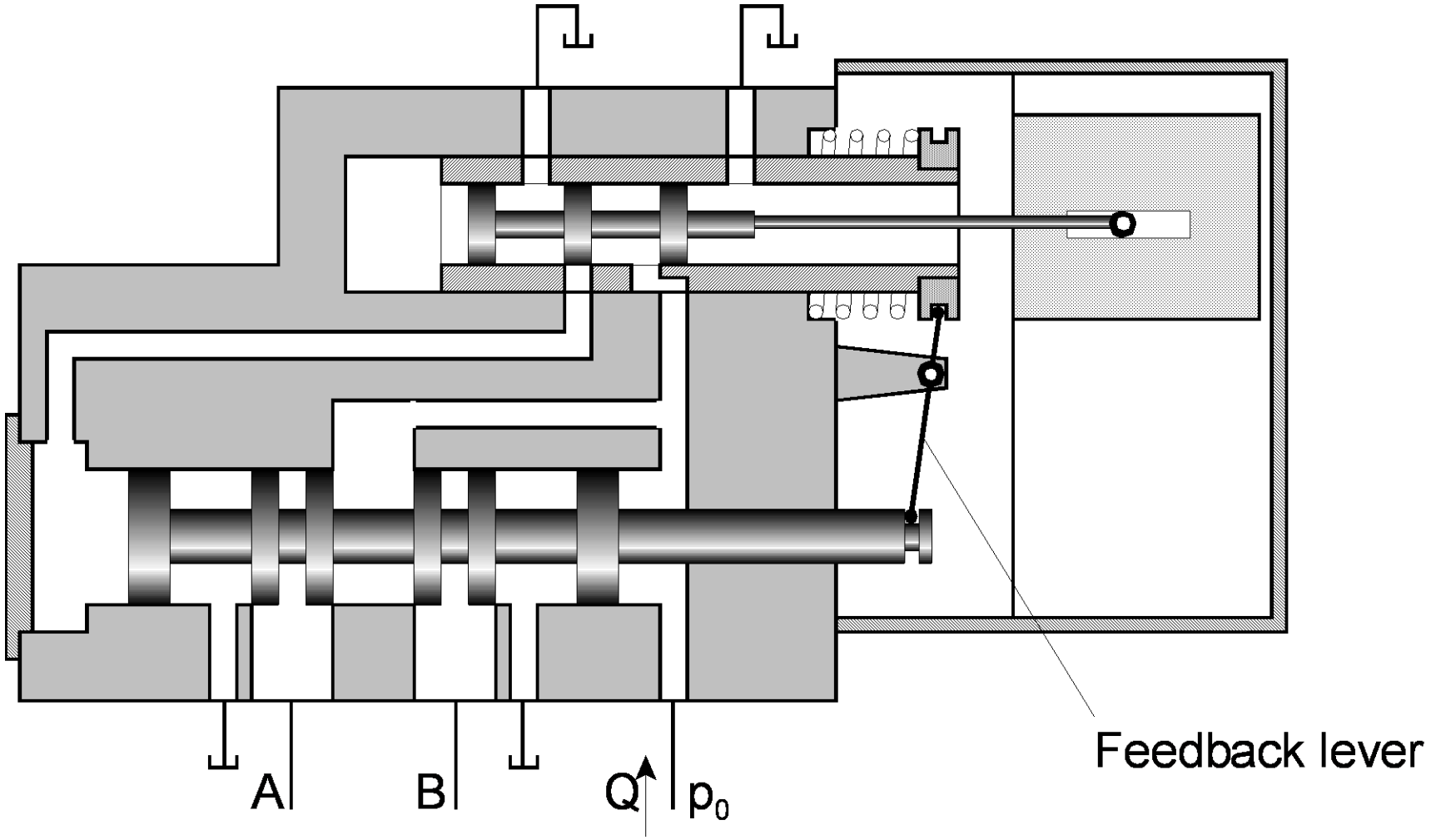
Jet Flapper system



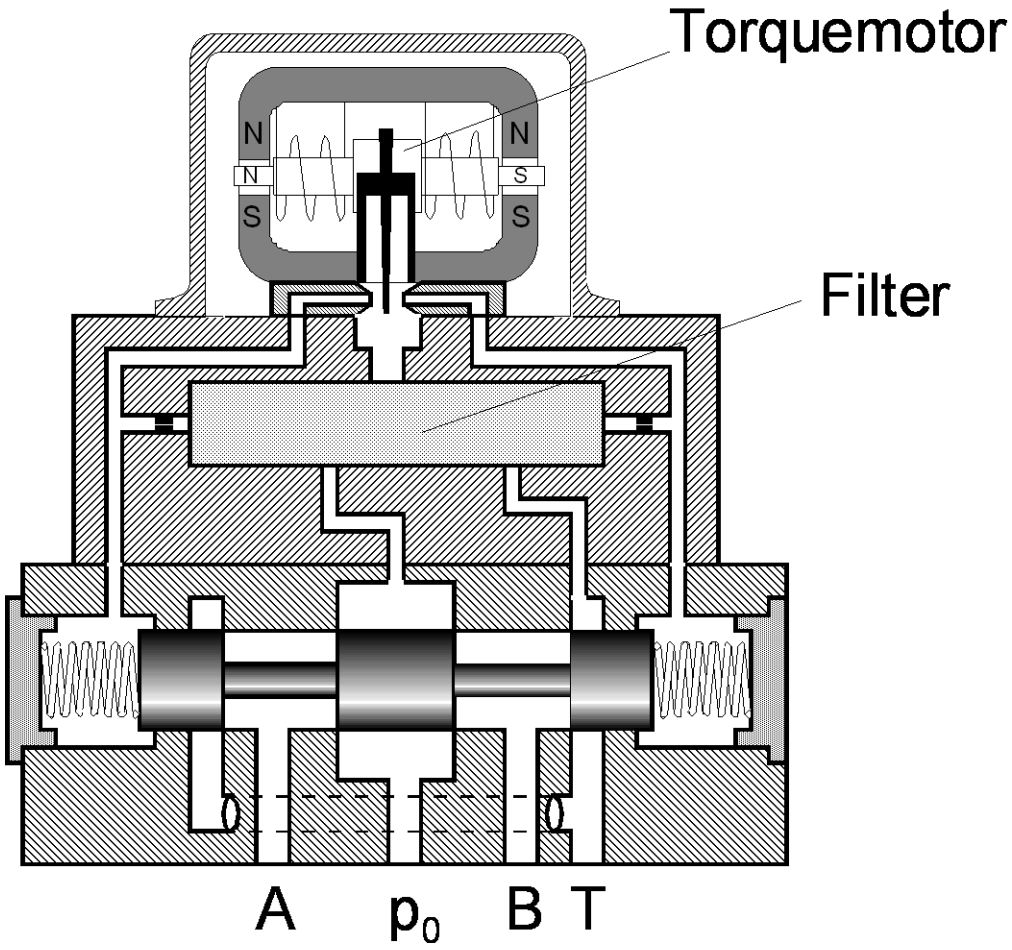


Good linear behavior

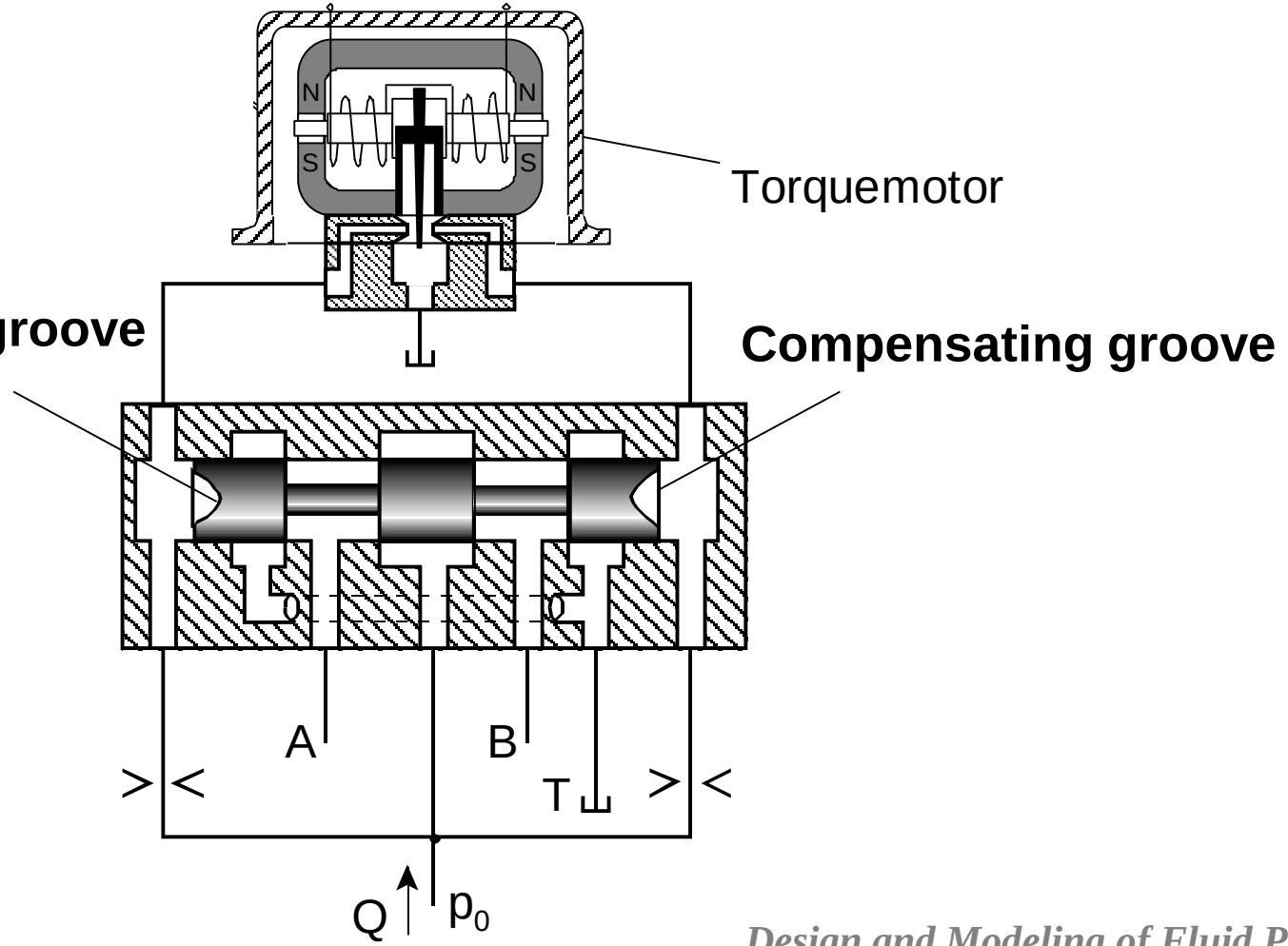
Servovalve with mechanical feedback



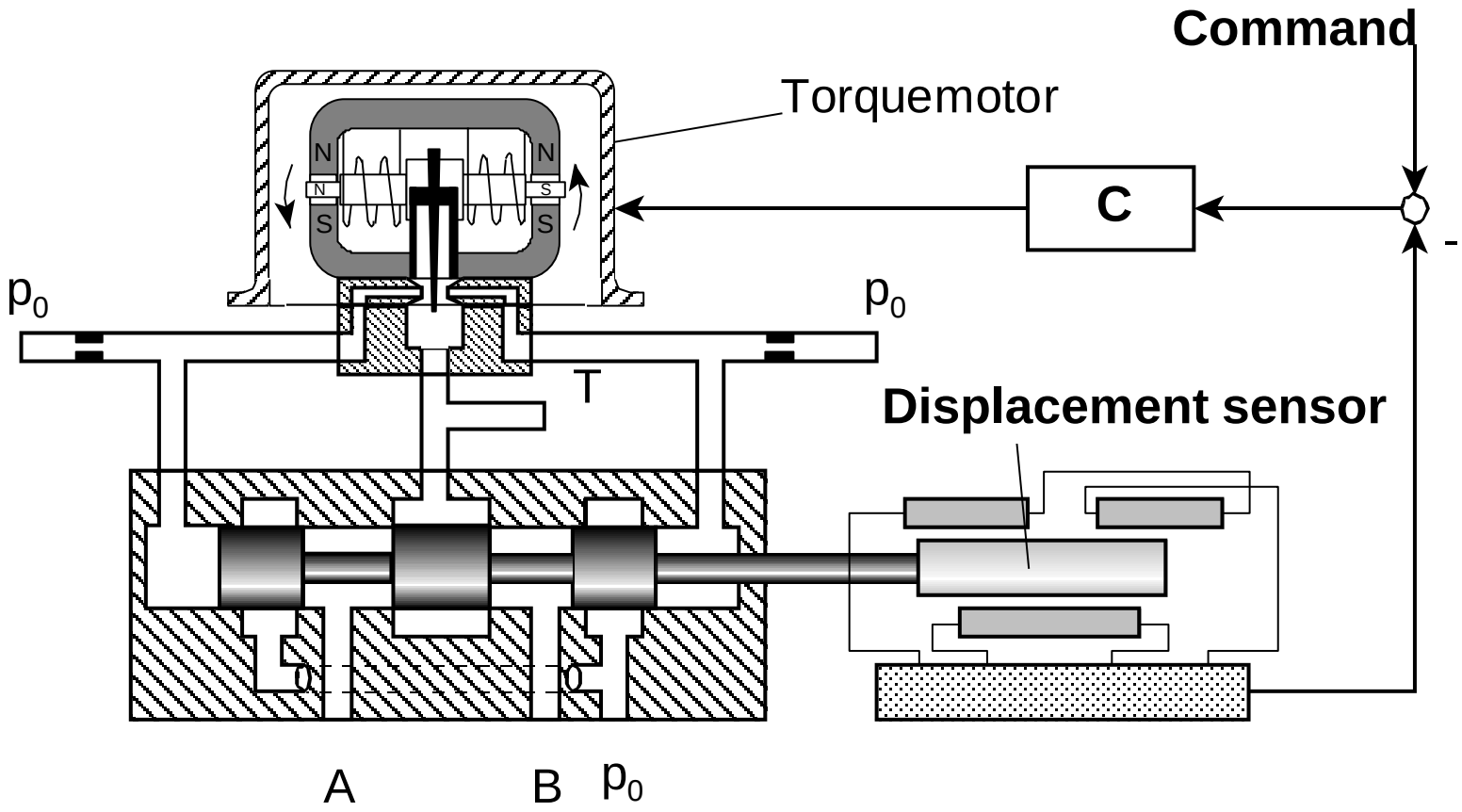
Servovalve with mechanical force feedback



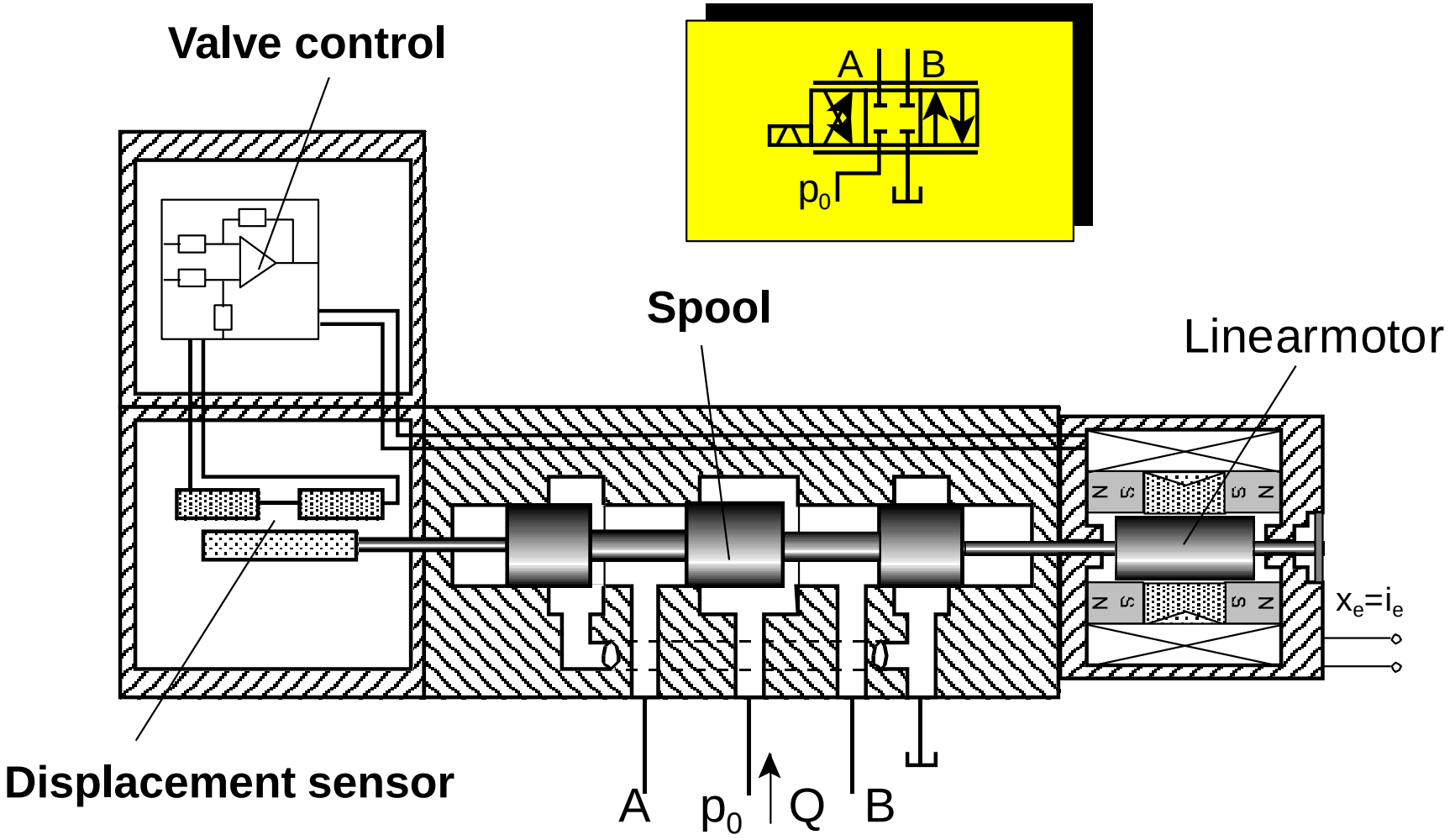
Servovalve with hydraulic force feedback



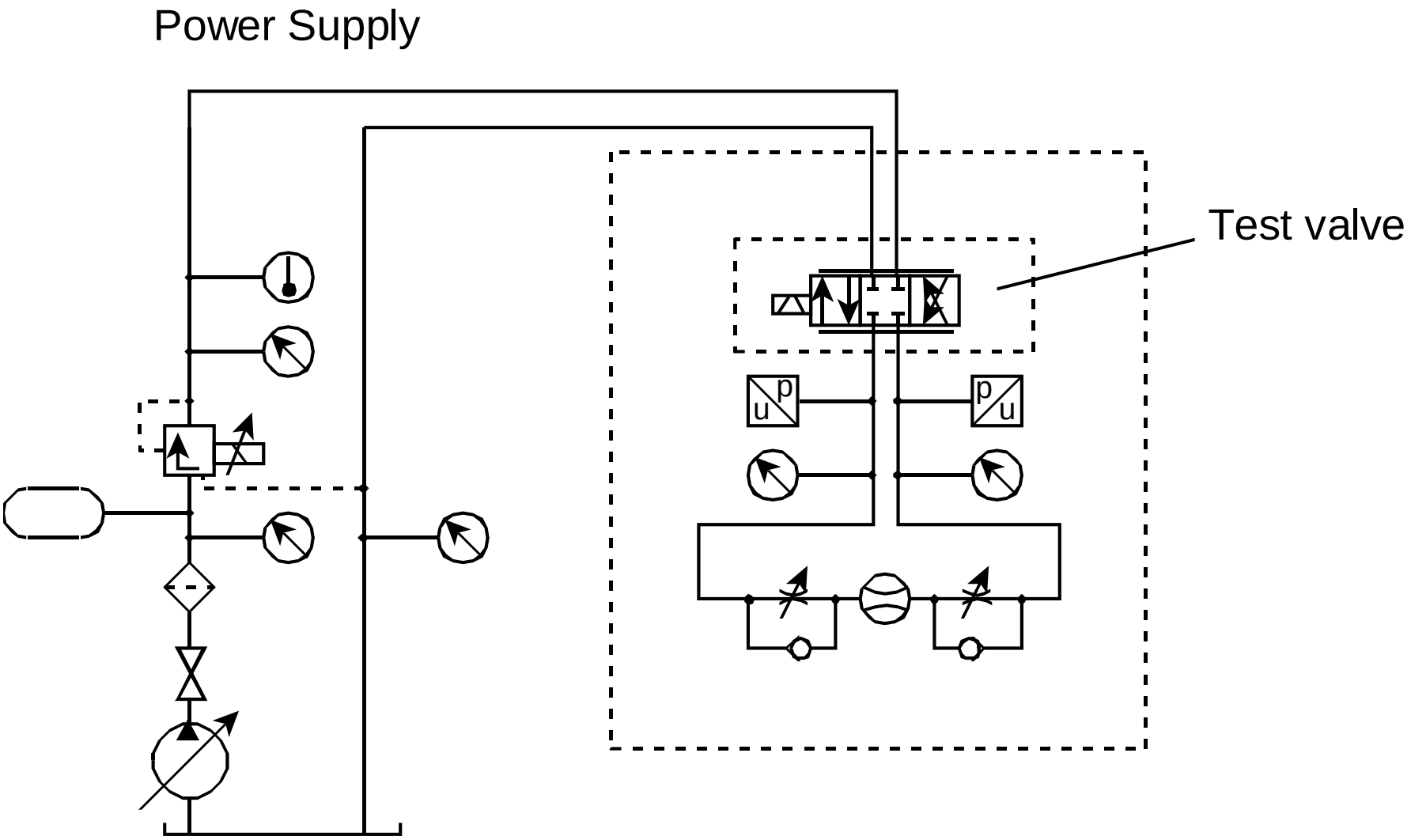
Servovalve with electrical position feedback



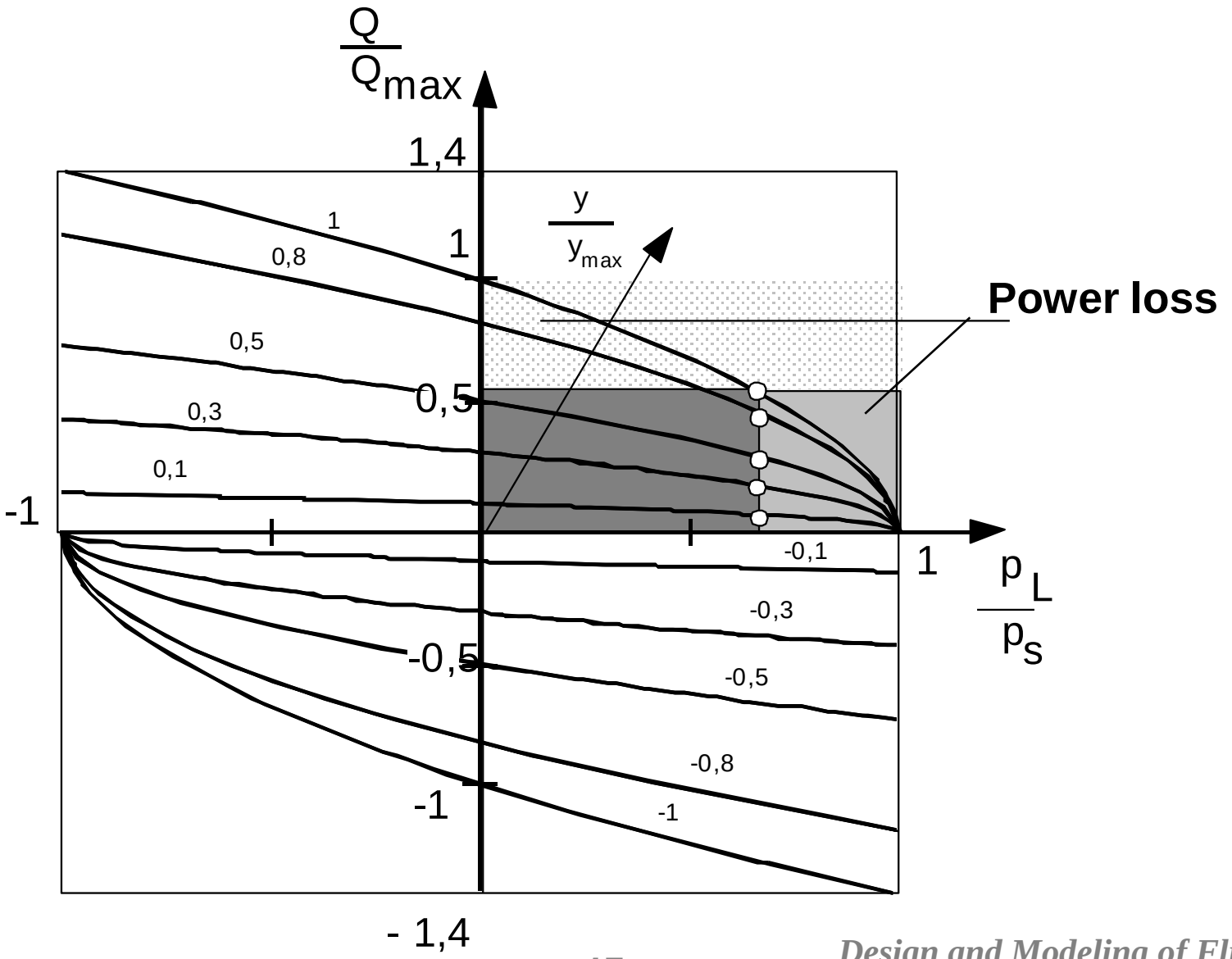
Single stage servovalve



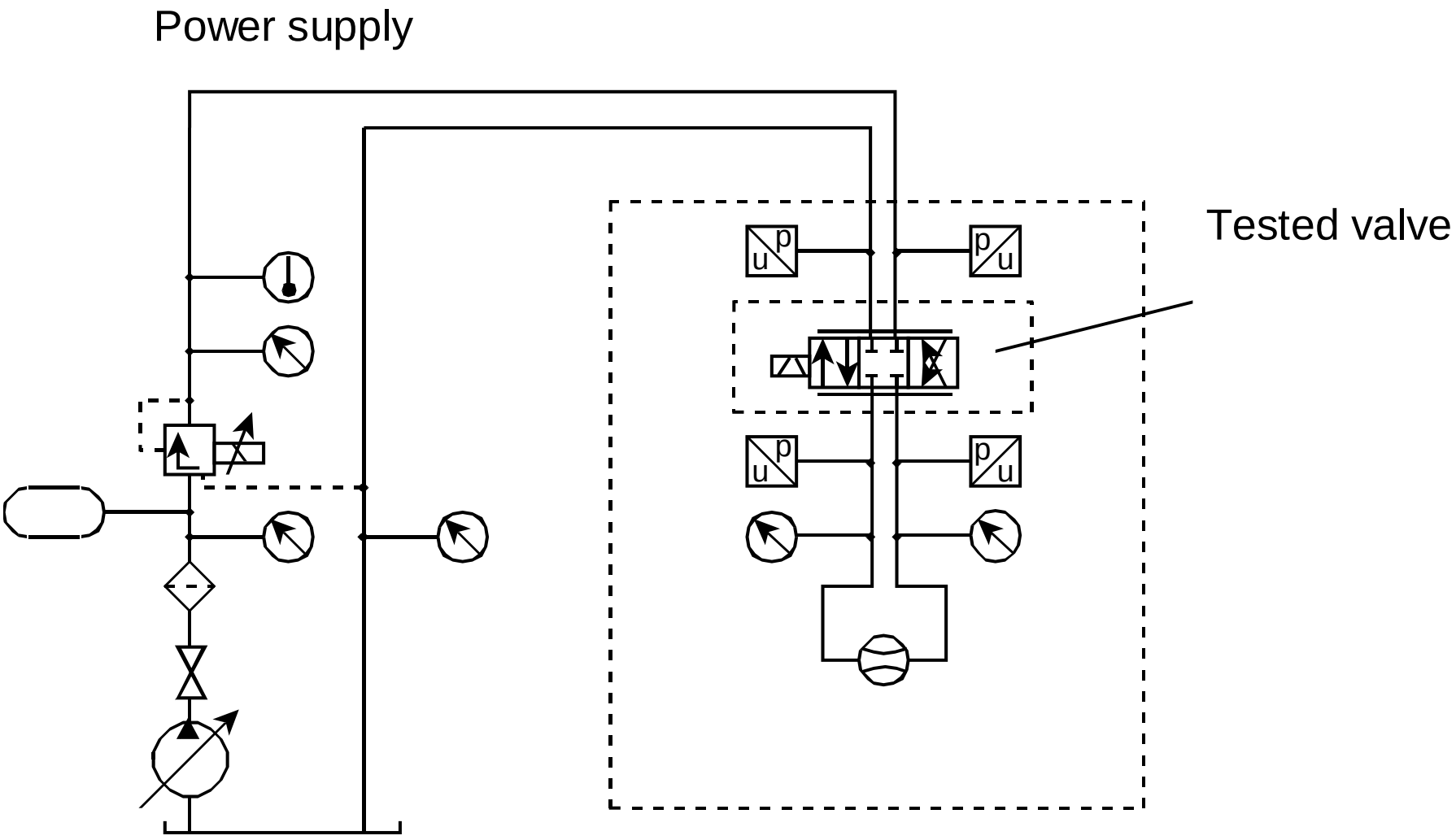
Pressure – flow curve measurement



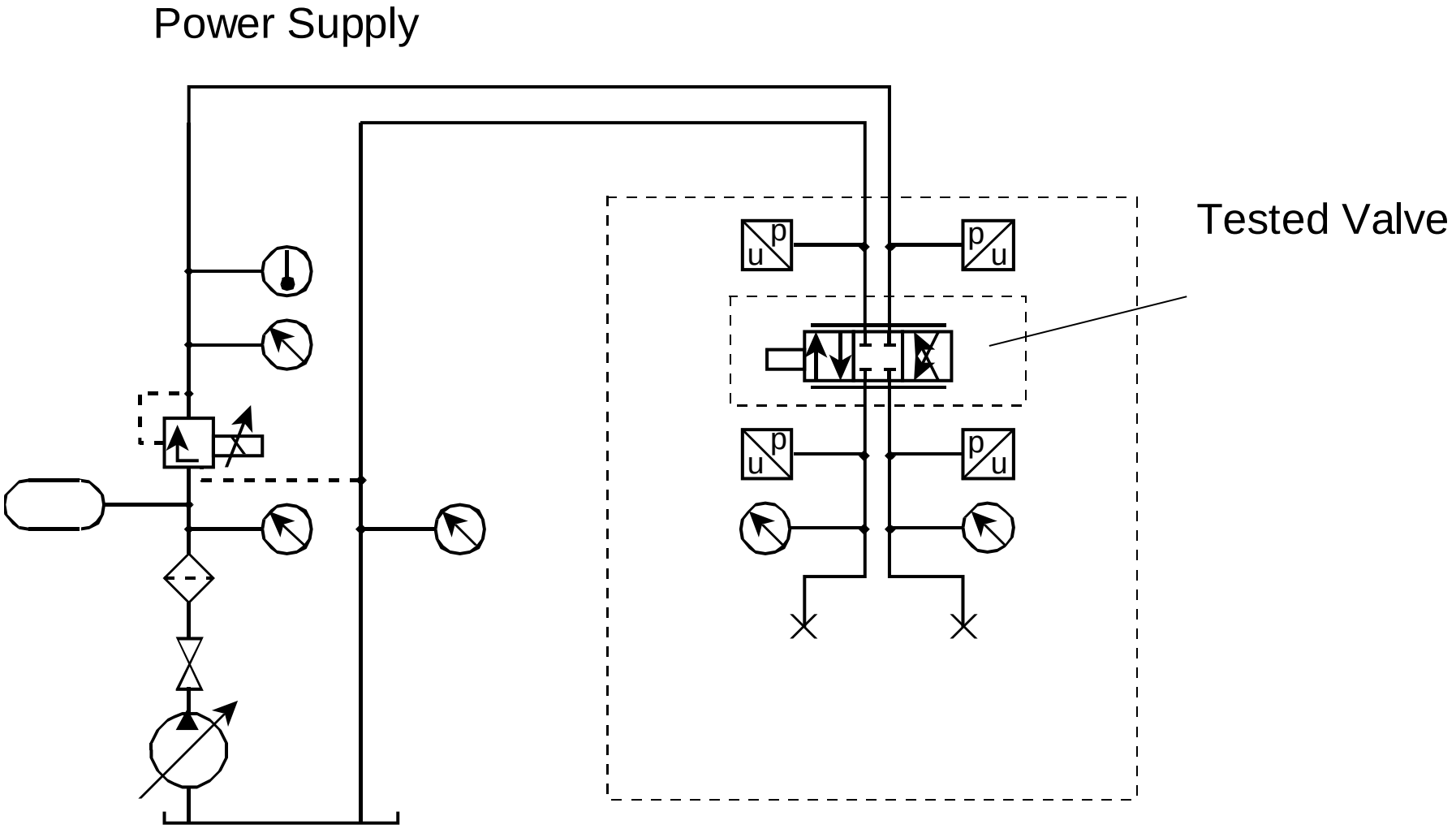
Pressure – flow curve



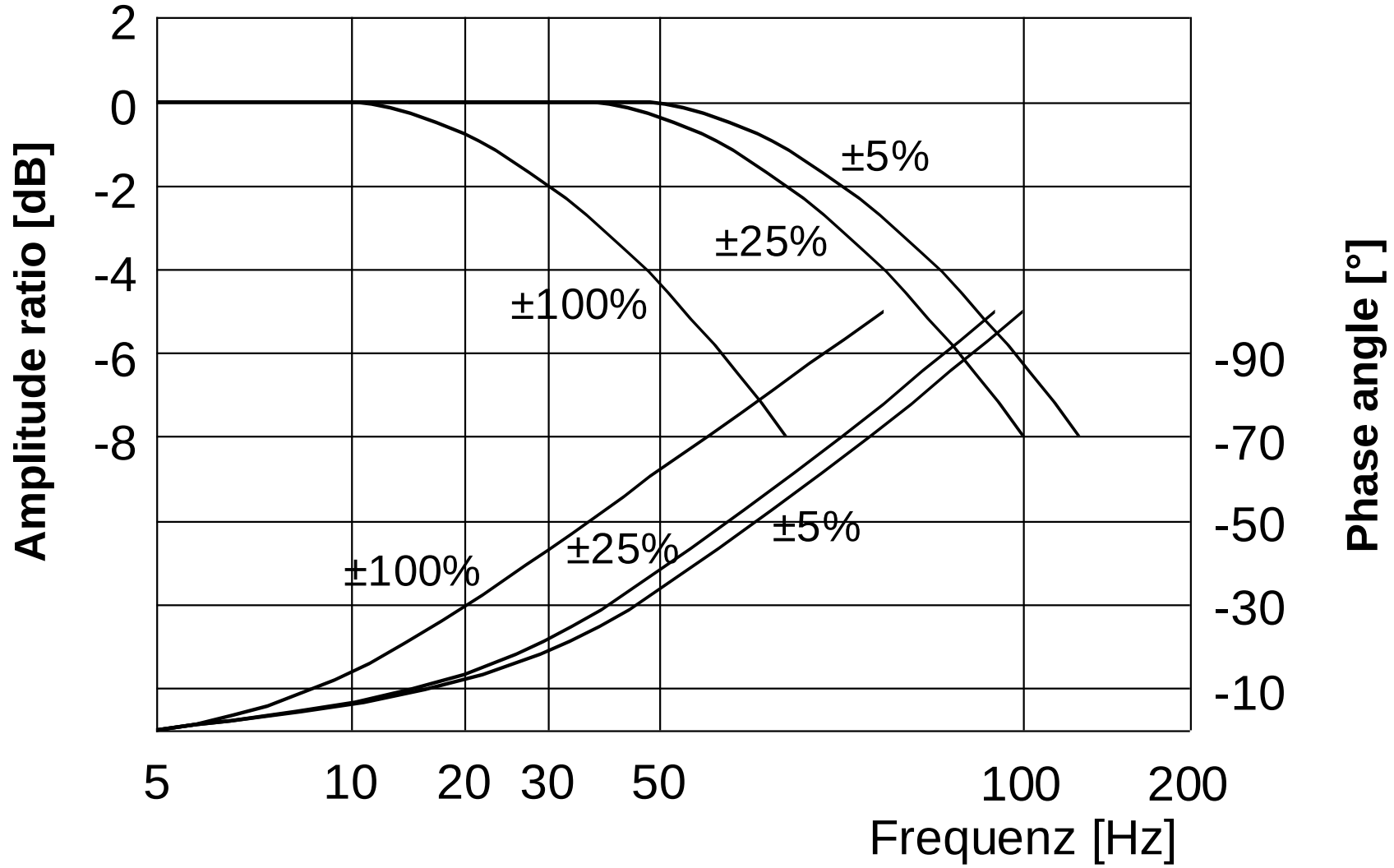
Measurement of flow gain



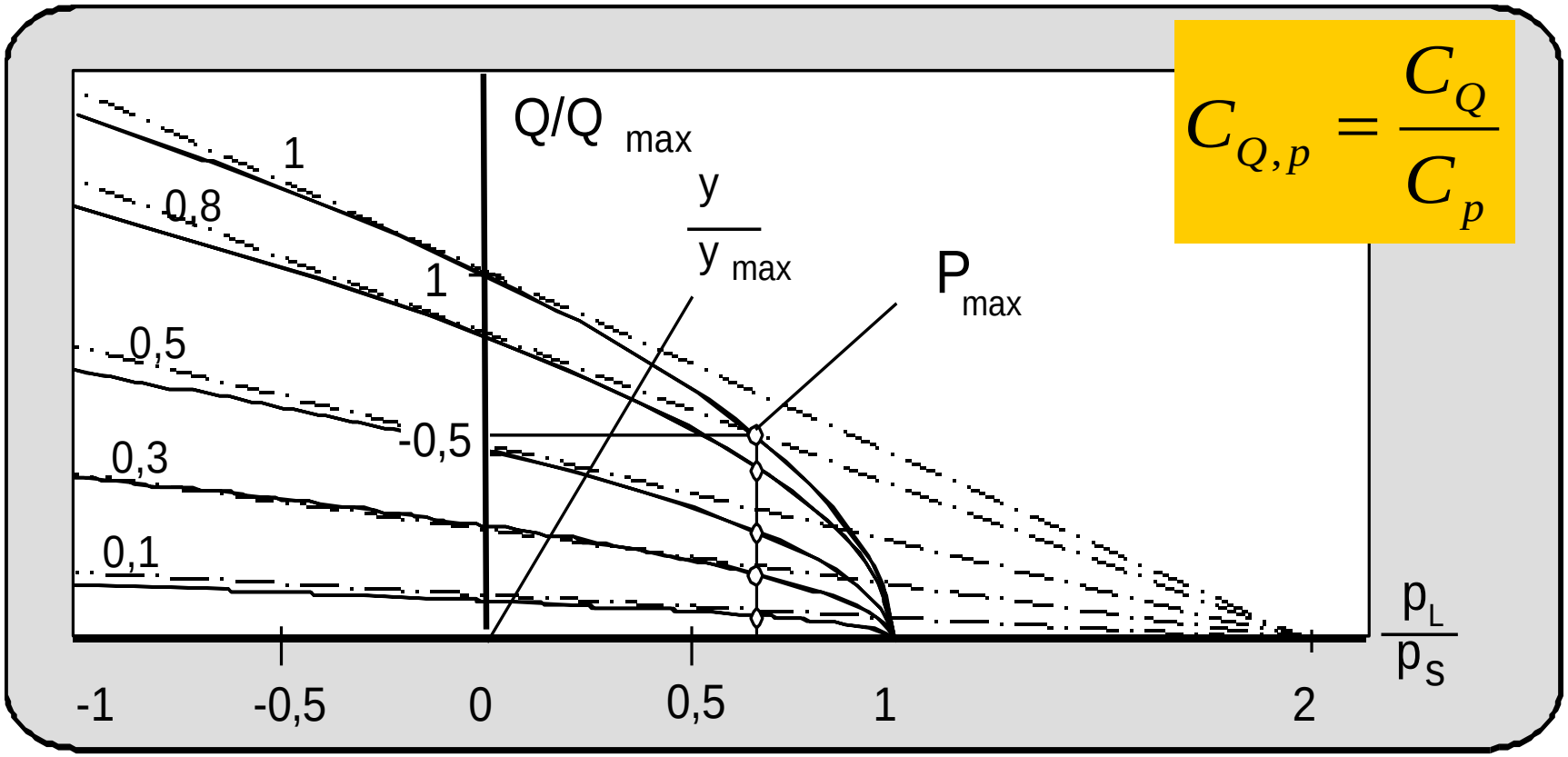
Measurement of pressure gain



Measurement of frequency response



Linearization of pressure-flow curve



$$C_{Q,p} = \frac{C_Q}{C_p}$$

Using Taylor Series expansion

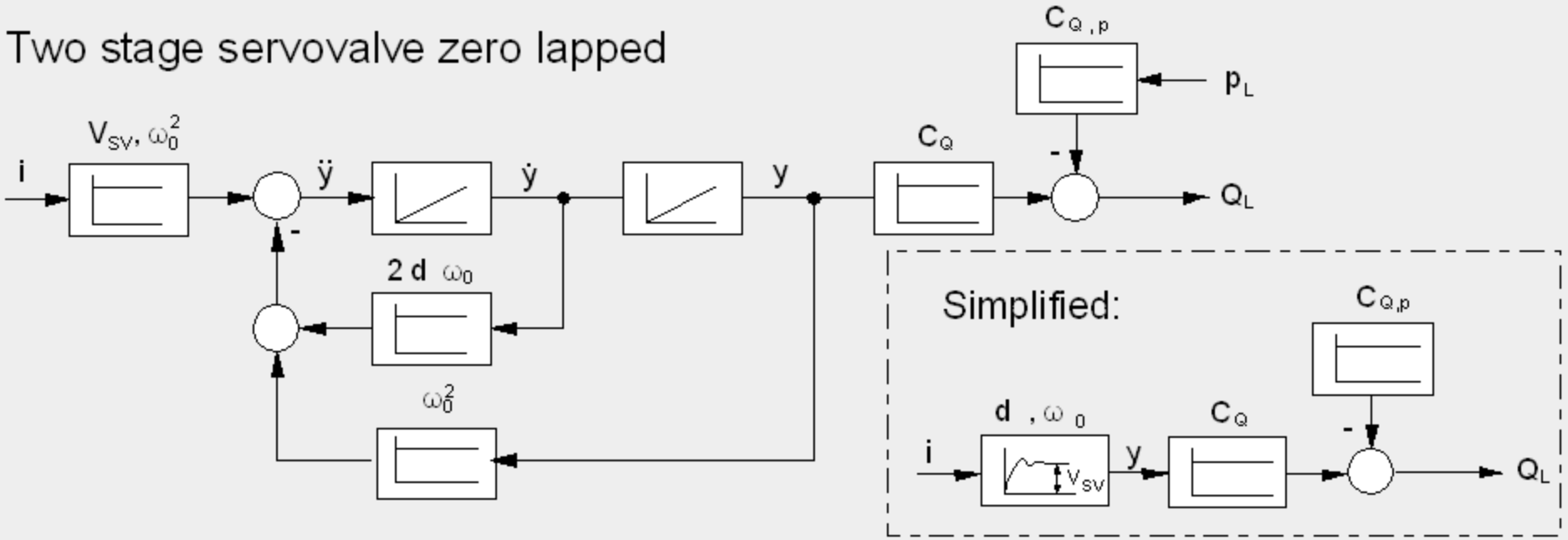
$$Q = B \cdot y \sqrt{\frac{1}{2}\left(p_0 - p_L \cdot sign\left(y\right)\right)} \quad \Rightarrow \quad Q = C_Q \cdot y - C_{Q,p} \cdot p_L$$

SV - Linear model

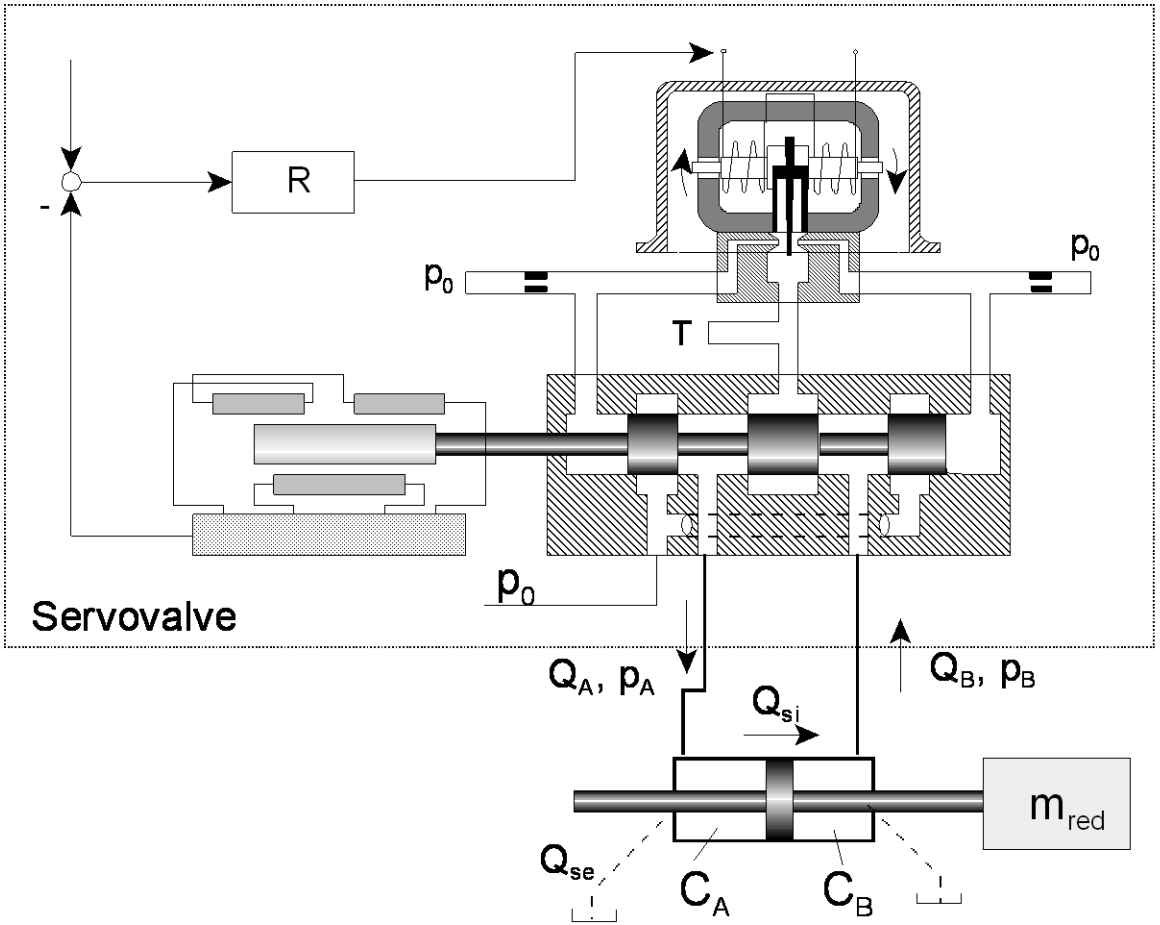
$$\ddot{y} + 2\,d\,\omega_0 \cdot \dot{y} + \omega_0^2 \cdot y = V_{SV} \cdot \omega_0^2 \cdot i$$

$$Q_L = C_Q \cdot y - C_{Q,p} \cdot p_L$$

Two stage servovalve zero lapped



Valve controlled actuator



Circuit