BASIC FEEDBACK AND ITS VARIOUS TYPES

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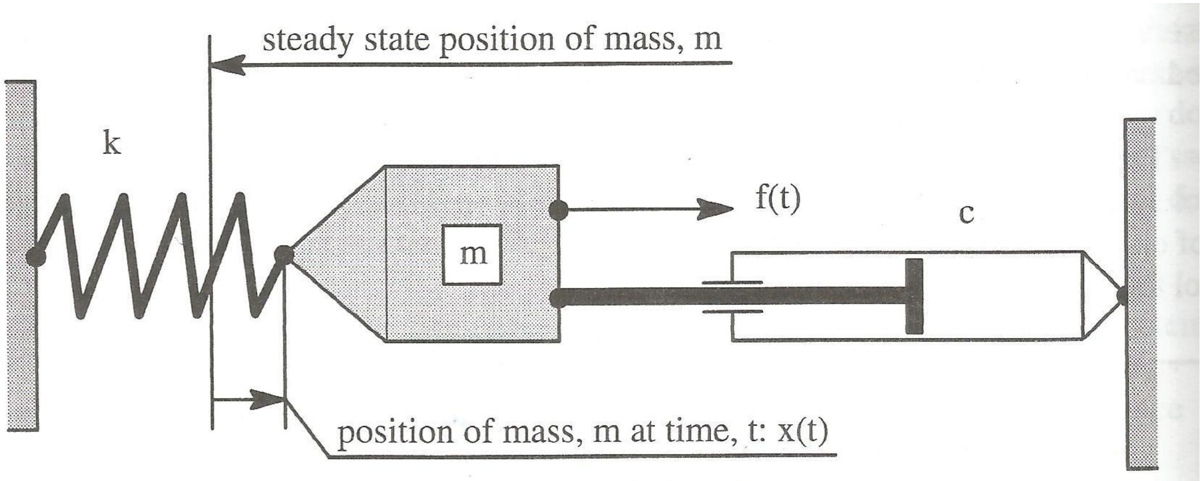
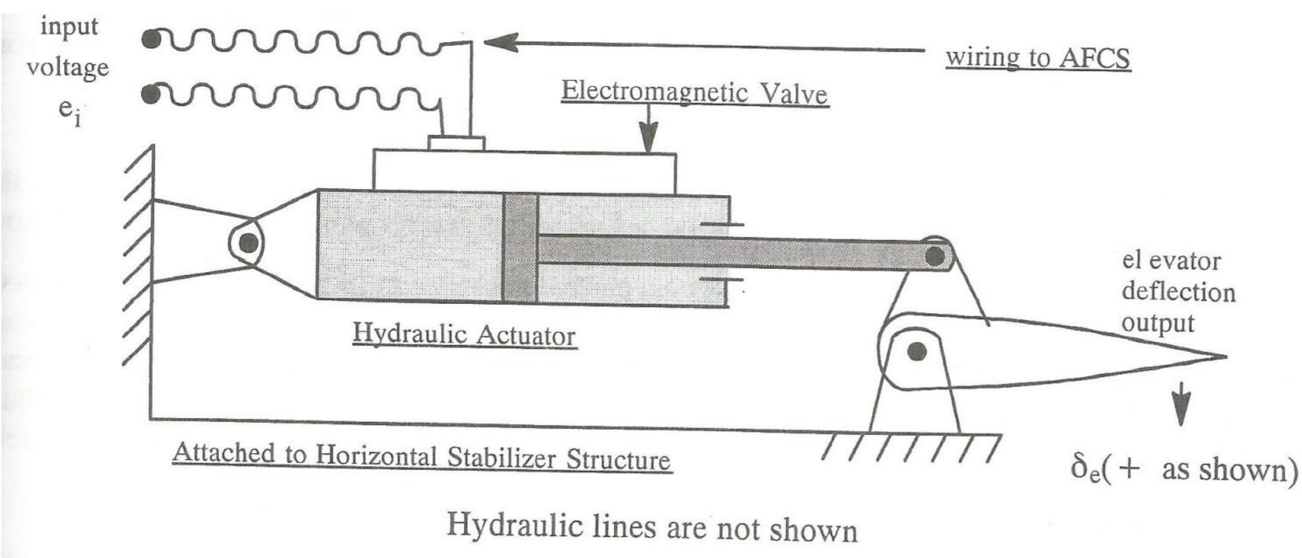
- The fundamental idea behind feedback control is to modify the stability characteristic of given system which has unsatisfactory inherent stability behavior.

- For example if a system has insufficient damping a feedback may arranged in order to improve the damping.

- As a general rule, any one of the following feedback may be used to improve the damping
  - Position feedback (also called stiffness feedback)
  - Velocity feedback (also called rate feedback)
  - Acceleration feedback





Example of Spring – Mass – Damper system

$$The\ equation\ of\ motion\ \ for\ the\ system$$

$$m\ddot{x}+c\dot{x}+kx= f(t)$$

$$Takinglaplase\ transform\ for\ the\ initial\ condition\ yields$$

$$ms^2x(s)+csx(s)+kx(s)= f(s)$$

$$\left(ms^2+cs+k\right)x(s)= f(s)$$

$$\frac{x(s)}{f(s)}=\left(\frac{1}{ms^2+cs+k}\right)$$

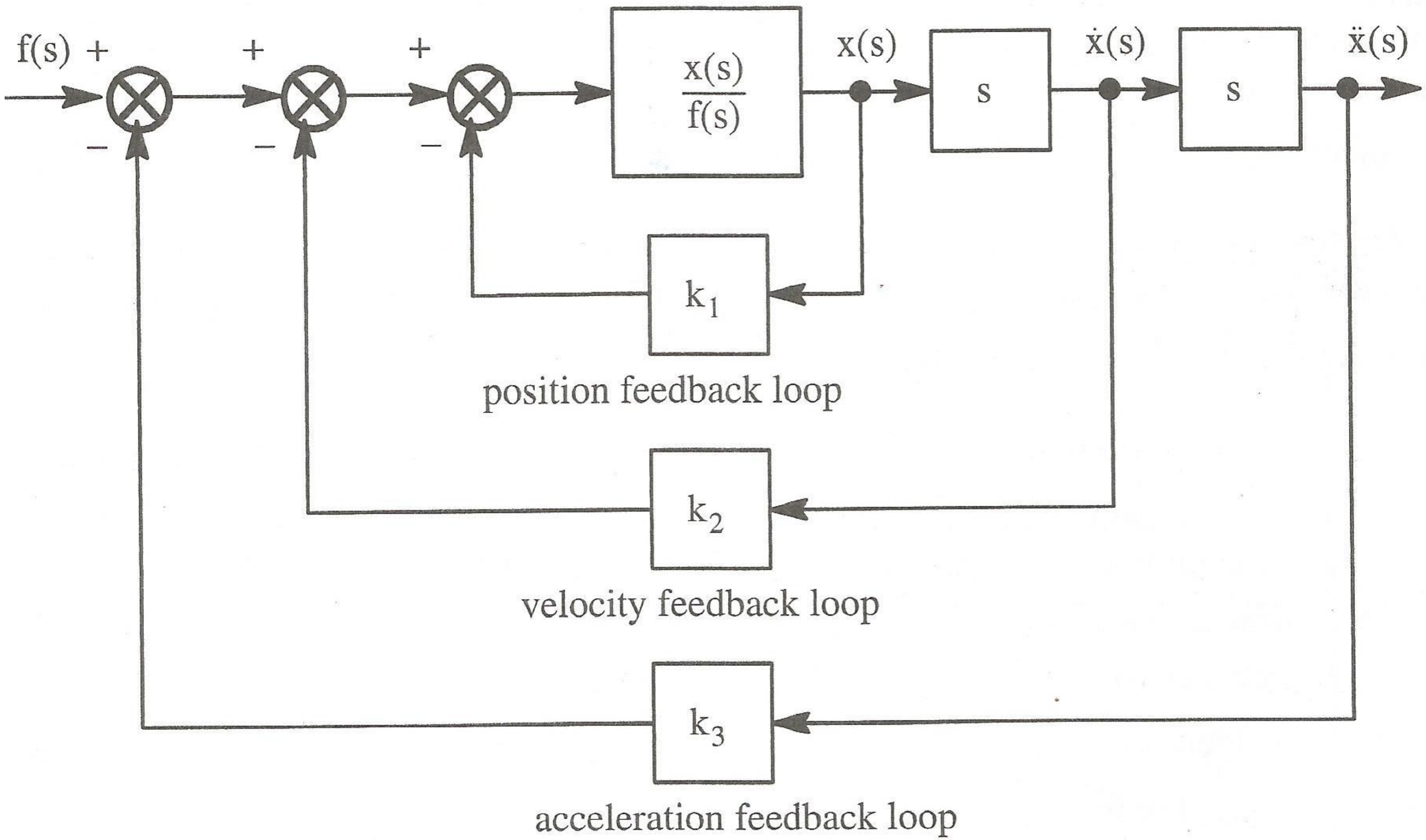
$$The\ dynamic\ stability\ behaviour\ of\ \ the\ system\ is\ determined\ completely\ by\ the$$
$$roots\ of\ its\ characteristic\ equation\ also\ called\ "systemequation".$$

$$ms^2+cs+k=0$$

The roots of this equation taking the following form

$$s_{1,2} = \frac{-c \pm \sqrt{c^2 - 4mk}}{2m}$$

Note: The system will be stable as long as $C > 0$.



Block diagram of the system with three feedback loops

$$m\ddot{x}+c\dot{x}+kx=f(t)$$

The above equation of motion now modified as (because of feedback)

$$m\ddot{x}+c\dot{x}+kx=f(t)-k_1x-k_2\dot{x}-k_3\ddot{x}$$

Taking the laplase transformation for zero initial condition

$$\left\{(m+k_3)s^2+(c+k_2)s+(k+k_1)\right\}x(s)=f(s)$$

$$\frac{x(s)}{f(s)}=\left(\frac{1}{(m+k_3)s^2+(c+k_2)s+(k+k_1)}\right)$$

The characteristic equation for the feedback system is

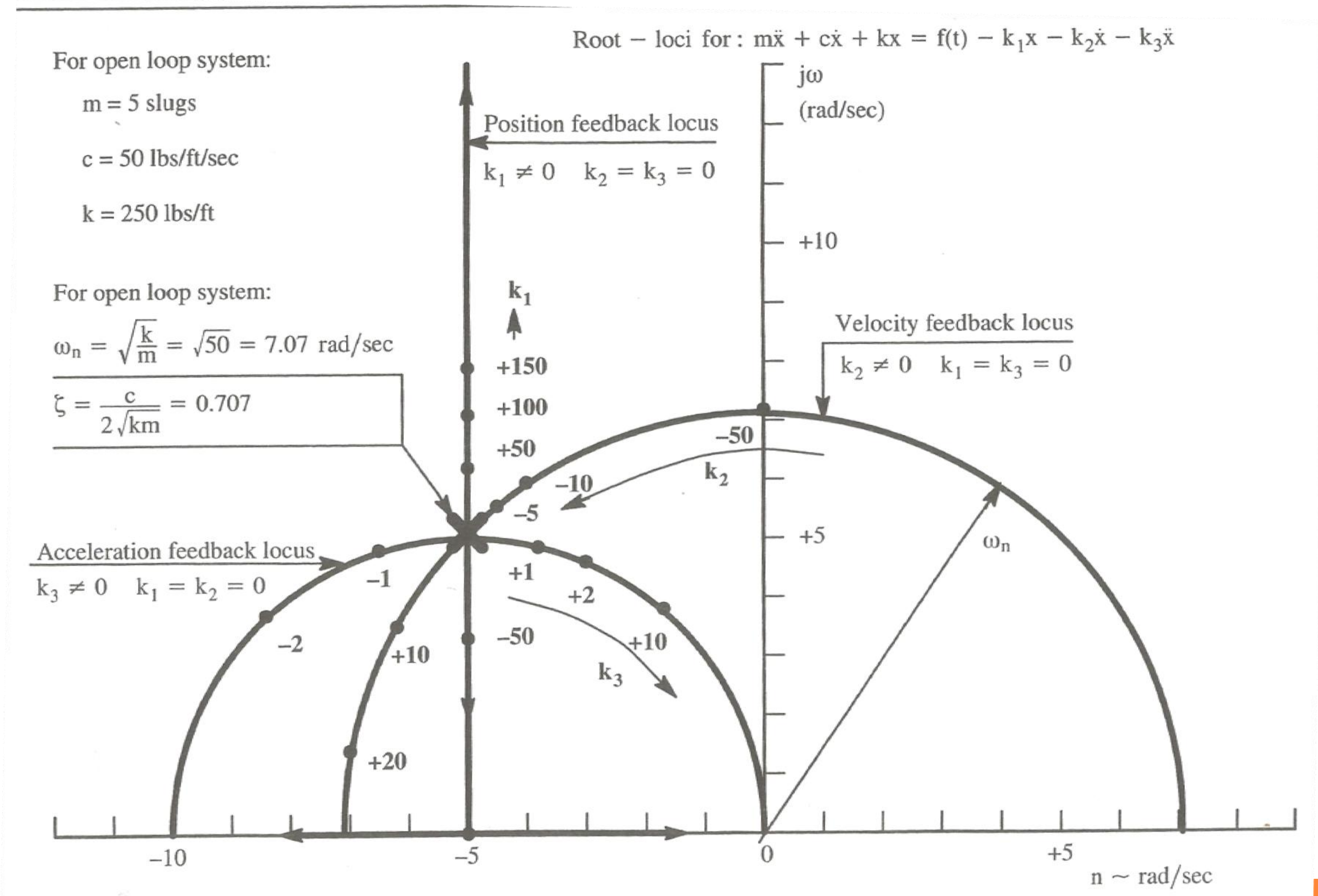
$$(m+k_3)s^2+(c+k_2)s+(k+k_1)=0$$

The roots of this characteristic equation may be expresed as

$$s_{1,2} = \frac{-(c+k_2) \pm \sqrt{(c+k_2)^2 - 4(m+k_3)(k+k_1)}}{2(m+k_3)}$$

- The above equation is said to be "augmented system equation". From the above equation it is clear that the role of the feedback gain k1,k2,k3 is to alter the root in the S-plane.

- The effect of varying the position, velocity and acceleration feedback gains are shown in the figure.



Root locus for Position – Velocity and Acceleration feedback

Position Feedback

- Position feedback k1 affects both the undamped natural frequency and damping ratio of the closed loop system.
- The root locus of the case is a straight line which passes through the open loop system poles.
- It is noted that the real part of the closed loop system roots remains constant as k1 is varied while k2 and k3 are kept at zero.

Velocity feedback

- Velocity feedback or rate feedback k2 affects the damping ratio of the closed loop system only.
- The root locus in the case is a circular around the orgin of the S-plane.
- It is noted that the undamped natural frequency of the closed loop system remains constant as k2 is varied while k1 and k3 are kept at zero.

Acceleration feedback

- Acceleration feedback k3 affects both the undamped natural frequency and damping ratio of the closed loop system.
- The root locus is a circle with the origin at the point n= -05rad/sec.
- Note that k3 is varied towards infinity , the undamped natural frequency tends towards zero.

- By selecting any combination value of k1,k2,k3 it is possible to place the poles of the closed loop system at an arbitrary desired location in the

S-plane

Thank you