# Sensitivity

# SYSTEM SENSITIVITY

System sensitivity is the ratio of the change in the system transfer function to the change of a process transfer function (or parameter) for a small incremental change.

# SENSITIVITY OF SYSTEM TO PARAMETER VARIATIONS

System are time-varying in its nature because of inevitable uncertainties such as changing environment , aging , and other factors that affect a control process.All these uncertainties in open-loop system will result in inaccurate output or low performance. However, a closed-loop system can overcome this disadvantage.

# *Continue*

A PRIMARY ADVANTAGE OF A CLOSED-LOOP FEEDBACK CONTROL SYSTEM IS ITS ABILITY TO REDUCE THE SYSTEM'S SENSITIVITY TO PARAMETER VARIATION.

SENSITIVITY ANALYSIS → ROBUST CONTROL

# EFFECT OF PARAMETER VARIATIONS

If process  is change as

- Open-loop system

- Closed-loop system

# CONTINUE

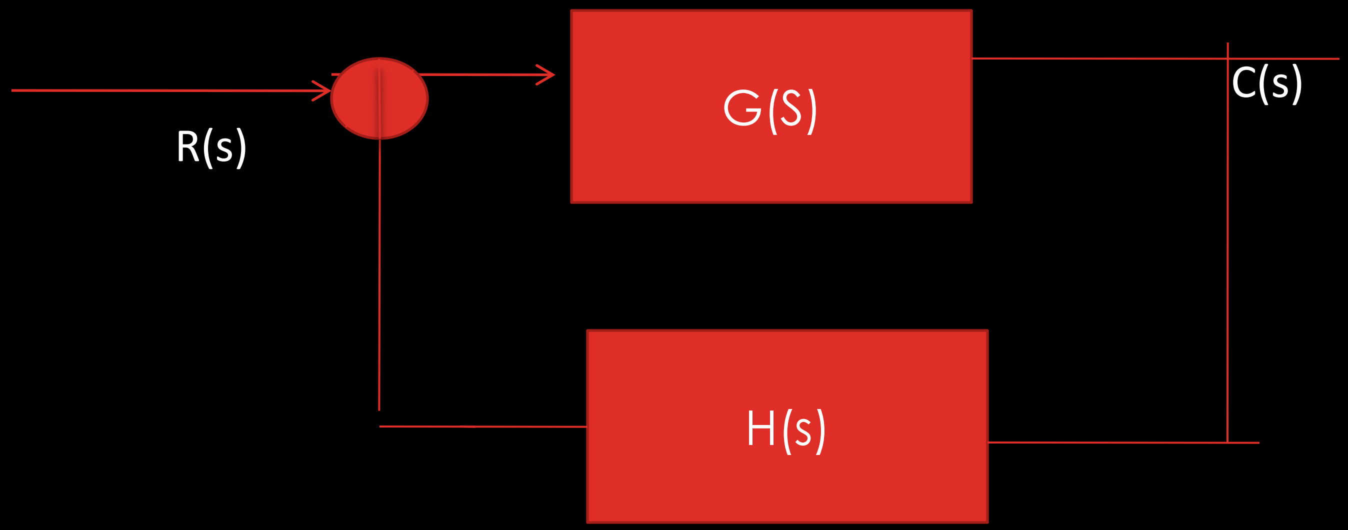
In the limit, for small incremental changes, last formula is

# SENSITIVITY

- Measure of the effectiveness of feedback in reducing the influence of the variations (changing environment) on system performance.
- It gives an assessment of the system performance as affected due to parameter variation.

# EFFECT OF TRANSFER FUNCTION PARAMETER VARIATIONS IN AN OPEN LOOP CONTROL SYSTEM

# EFFECT OF TRANSFER FUNCTION PARAMETER VARIATIONS IN AN CLOSED LOOP CONTROL SYSTEM



$$M(s)=\frac{C(s)}{R(S)}=\frac{G(s)}{1+G(S)H(S)}\rightarrow(1)$$

$$C(S)+\Delta \mathrm{C(S)}=\frac{[\mathrm{G(S)}+\Delta \mathrm{G(S)}]}{1+[G(S)H(S)+\Delta \mathrm{G(S)H(S)}]}\mathrm{R(S)}$$

$$=\frac{[\mathrm{G(S)R(S)}\ ]}{1+[G(S)H(S)+\Delta \mathrm{G(S)H(S)}]}+\frac{\Delta \mathrm{G(S)R(S)}}{1+[G(S)H(S)+\Delta \mathrm{G(S)H(S)}}$$

$NEGLECT\ \Delta \mathrm{G(S)\ AS\ \Delta G(S)} << \mathrm{G(S)}$

$\therefore \Delta \mathrm{G(S)H(S)\ CAN\ BE\ NEGLECTED}$

$$=\frac{[\mathrm{G(S)R(S)}\ ]}{1+[G(S)H(S)]}+\frac{\Delta \mathrm{G(S)R(S)}}{1+[G(S)H(S)+\Delta \mathrm{G(S)H(S)}}$$

$PUT\ EQN.1\ \mathrm{EQN.3}$

$$\Delta \mathrm{C(S)}=\frac{\Delta \mathrm{G(S)}}{1+G(S)H(S)}\mathrm{R(S)}$$

1+ G(S)H(S) IN A CLOSED LOOP .

-O/P VARIATIONS MORE SENSITIVE IN OPEN LOOP SYSTEM

- SENSITIVITY OF OVERALL TRANSFER FUNCTION M(s) W.R.T. FWD PATH T.F. G(s)

$$S_G^M = \frac{\partial M(S)/M(s)}{\partial G(S)/G(s)}$$

OPEN LOOP CONTROLSYSTEM

$$M(S) = \frac{C(S)}{R(S)} = G(s)$$

$$\frac{M(S)}{G(S)} = 1$$

*DIFFERENTIATING* $M(s)$ W.R.T. G(s)

$$S_G^M = \frac{G(S)}{M(S)} \cdot \frac{\partial M(S)}{\partial G(S)} = 1$$

- SENSITIVITY OF OVERALL TRANSFER FUNCTION M(s) W.R.T. FWD PATH T.F. G(s)

CLOSED LOOP CONTROLSYSTEM

$$M(S) = \frac{C(S)}{R(S)} = \frac{G(s)}{1+G(s)H(s)}$$

DIFFERENTIATING M(s) W.R.T. G(s)

$$\frac{\partial M(S)}{\partial G(S)} = \frac{[1+G(S)H(S)]-G(S)H(S)}{[1+G(S)H(S)]^2}$$

$$\frac{\partial M(S)}{\partial G(S)} = \frac{1}{[1+G(S)H(S)]^2}$$

$$\therefore S_G^M = \frac{G(S)}{M(S)} \cdot \frac{\partial M(S)}{\partial G(S)} = \frac{1}{1+G(S)H(S)}$$

SENSITIVITY OF OVERALL TRANSFER FUNCTION W.R.T. FWD PATH T.F. IN CASE OF CLOSED LOOP SYSTEM IS REDUCED BY 1+G(S)H(S) AS COMPARED TO

OPEN LOOP SYSTEM

$$M(S) = \frac{G(S)}{1+G(s)H(s)}$$

$$DIFFERENTIATING \text{ W.R.T. G(S)}$$

# EXAMPLE OF SENSITIVITY

- Feedback amplifier
- Goal: Reduce the sensitivity to parameters variation, that is enhance the robustness to change in amplifier gain.