LTI system

- *Linear time-invariant systems*

  A linear system satisfies the principles of *superposition* and *homogeneity*

TYPE OF SIGNALS AND SYSTEMS

- **TIME INVARIANT SYSTEMS**

A time invariant system has parameters which are independent of time. Expressing this mathematically, if

(15)

then $$y(t) = S[u(t)]$$

(16)

for a time variant system. $$y(t+\tau) = S[u(t+\tau)]$$

Thus any system is involving switches or having a time varying parameters is not time invariant. A simple example of a time varying system is a system where the gain is equal to the time *t*.

As an example consider a system where

(17)

where the input is a pulse. $$S[u(t)] = tu(t)$$

TYPE OF SIGNALS AND SYSTEMS

- **LINEAR TIME INVARIANT (LTI) SYSTEMS**

  ☺ If a system is both linear and time invariant then we call it a linear time invariant system. Most of the techniques for analysing systems in this study rely on the system being (LTI) or a close approximation.

  ☺ In practice analysis based on assuming a LTI is very powerful, because

  - it is good approximation to most real word systems
  - it is easy to analyse and obtain results
  - it is easy to predict its behaviour

TYPE OF SIGNALS AND SYSTEMS

- **CAUSAL SYSTEM**
  - No real word system can have an output which precedes the input, e.g.

$$y(t) = x(t-14)$$ is a causal system.

$$y(t) = x(t+14)$$ is an anti-causal system

because the value of y(t) at time t = 0 depends on the value of x(t) at time t = 14, i.e. at some time in the future.

  - A bank account is an example of a causal system since before the system gives you an output (interest) you have to insert an input (i.e. deposit). Banks do not give interest on money that you have yet to deposit and thus are firm believers in causality.

The roles of feedback

Benefits:

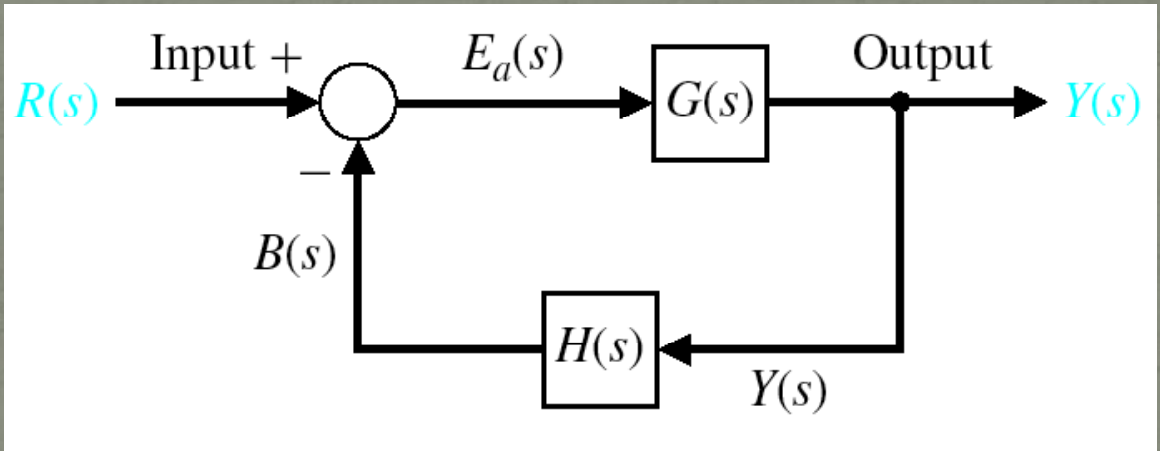
- Reduce error (eliminating the error)
- Reduce sensitivity or Enhance robustness
- Disturbance rejection or elimination
- Improve dynamic performance or adjust the transient response (such as reduce time constant)

Goal

We extend the ideas of modeling to include control system characteristics:

- **sensitivity to model uncertainties,**
- **steady-state errors,**
- **transient response characteristics to input test signals,**
- **disturbance rejection.**

Feedback control



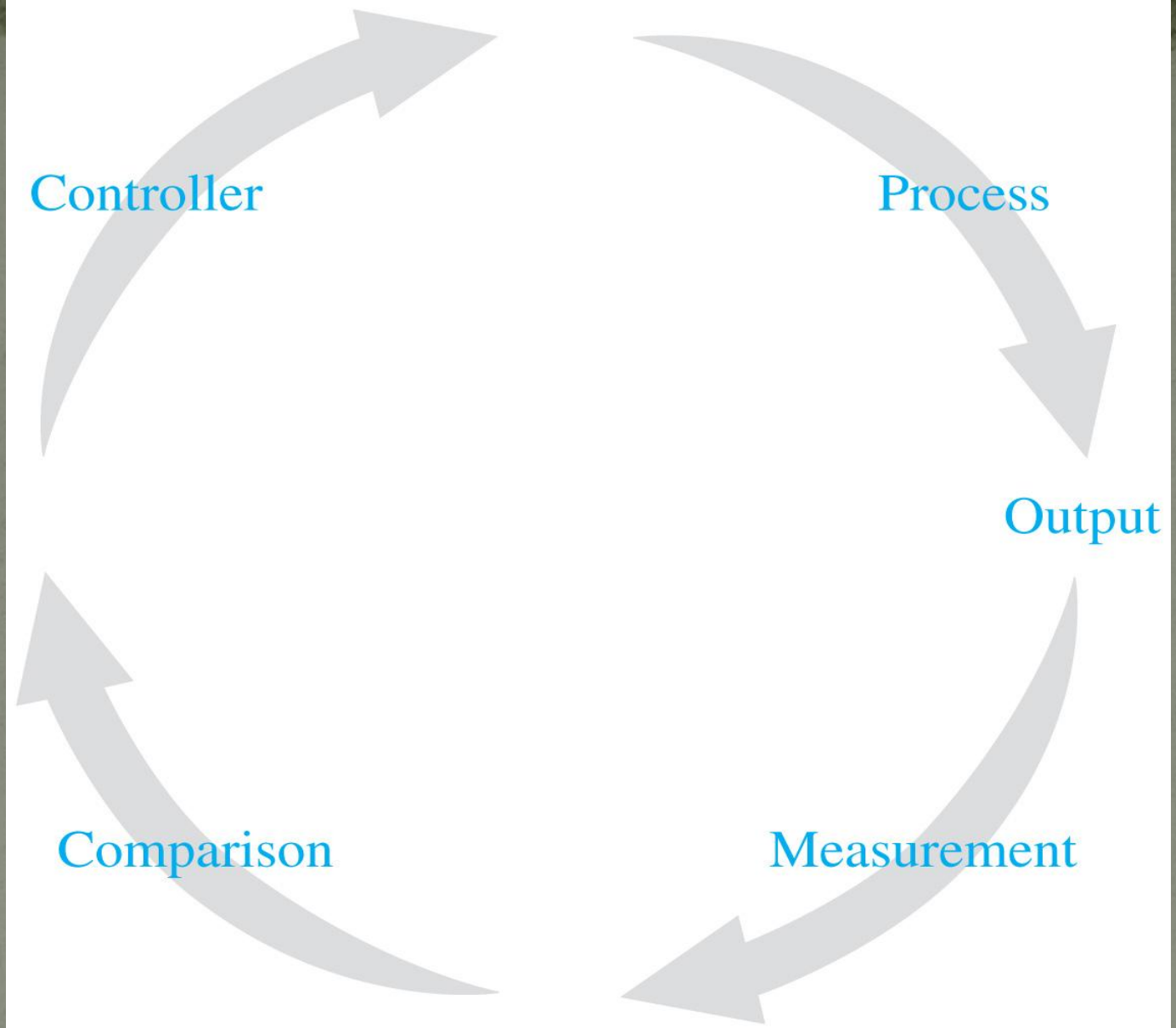


Figure: 04-01

Advantages of the closed-loop feedback control

- **Decreased sensitivity of the system to variations in the parameters of the process**
- **Improved rejection of the disturbances**
- **Improved measurement noise attenuation**
- **Improved reduction of the steady-state error of the system**
- **Easy control and adjustment of the transient response**

3.3 Transient response of system

- *Transient response* is the response of a system as a function of time. It is one of the most important characteristics of control system.
- If transient response is not satisfying, what shall we do?

3.4 Disturbance in a feedback control system

- *Disturbance signal* is an unwanted extraneous input signal that affects the system's output signal, such as noise for amplifier,wind gusts for radar antennas,etc.
- Feedback control can completely or partially eliminate the effect of disturbance signal.

3.6 The cost of feedback

- Increase of complexity
- Loss of gain
- Instability