CONTROL SYSTEMS

TOPIC THREE

TIME RESPONSE- INTRODUCTION

- The first step in analyzing a control system is to derive a **Mathematical Model** of the system.

- Once such a model is obtained the analysis of the system is greatly simplified.

- In analyzing & designing control systems there must be a basis of comparison of performance of various control systems.

- The basis is set up by specifying particular **Test Input** signals.

- The commonly used test input signals are those of **Step Function, Ramp Function, Parabolic Function, Impulse Function, Sinusoidal Function etc.**

- With these **Test Signals** , the mathematical analysis of control systems can be carried out easily ,since these signals **are very simple functions** of time.

TIME RESPONSE- INTRODUCTION CONT------

- The type of input to be used for analyzing a system is determined by the form of the input that the system will be subjected to, most frequently under normal operation.

- Once a control system is designed on the basis of Test Signals, the performance of the system in response to actual inputs is generally satisfactory

- The **Time Response** of a control system is usually divided into two parts, the **Transient Response** & the **Steady-state Response**.

- **Transient Response** is defined as that part of the response that **goes to zero as time becomes large.**

- Since **Inertia , Mass , Inductance etc.** cannot be avoided in physical systems ,the responses cannot follow sudden changes in the input, instantaneously & transients are usually observed.

- **Steady-state Response** is simply the **fixed response when time reaches infinity.**

SECOND ORDER SYSTEMS

- The behaviour of a system which contains **two independent energy storing** elements is completely described by a second order differential equation.

- The independent energy storing elements may consist of Inductance & Capacitance or Mass & Spring etc.

- The study of Second Order Systems is important because the behaviour of many higher order systems can frequently be described in terms of an equivalent second order system

TRANSIENT RESPONSE SPECIFICATIONS

- Systems with energy storage cannot respond instantaneously & will exhibit transient responses whenever they are subjected to inputs or disturbances.

- The performance characteristics of a control system are normally specified in terms of the transient response to a unit step input since it is easy to generate & sufficiently drastic.

- If the response to a step input is known it is mathematically possible to compute the response to any other input.

- The transient response of a practical control system often exhibits damped oscillations before reaching steady-state

- Some of these specifications do not apply to other cases.

- For eg., for the Critically damped & Over damped case the terms Peak Time & Maximum Overshoot do not apply.

- The Maximum Overshoot & the Rise Time conflict with each other ie both the Maximum Overshoot & the Rise time cannot be made small simultaneously.

- If one of them is made smaller ,the other necessarily becomes larger

STEADY-STATE ERROR

- Steady–state error is the difference between the input & the output

for a prescribed test Input as t tends to ∞

- Steady-state error is a measure of system accuracy when a specific type of input is applied to a control system

- Steady-state errors in control systems are almost unavoidable & in a design problem one of the objectives is to keep the error to a minimum.

- If the reference input r(t) & the controlled output c(t) are dimensionally the same, for eg. a voltage controlling a voltage ,a position controlling a position & are at the same level or the same order of magnitude ,the error signal is simply

$$e(t) = r(t) - c(t)$$

- However sometimes it may be inconvenient to provide a reference input that is at the same level or even of the same dimension as the controlled variable.

- Under these conditions the error signal cannot be defined simply as the difference between the reference input & the controlled output.

- The input & output signals ust be of the same dimension & at the same level before subtraction.
- Therefore a non-unity element H(s) is usually incorporated in the feedback path.