Dynamic Characteristics of Instruments

B Tech 4th Semester

Instrumentation and control

Mechanical Engineering

Transient Response

➢When an input is applied to an instrument or a measurement system, the instrument or the system cannot take up immediately its final steady state position.

➢It goes through a transient state before it finally settles to its final "steady state" position.

➢Some of the measurements are made under such conditions as to allow the sufficient time for the instrument or the measurement system to settle to its final steady state conditions.

➢Under such conditions the study of behaviour of the system under transient state, known as "transient response" is not of much of importance.

➢However, in many areas of measurement systems applications it becomes necessary to study the response of the system under both transient as well as steady state conditions.

➢In many applications, the transient response of the system, i.e., the way system settles down to its final steady state conditions is more important than the steady state response.

➢The transient response in the instruments is on account of the presence of energy storage elements in the system, such as, electrical inductance and capacitance, mass, fluid and thermal capacitances etc.

➢The systems exhibit a characteristic of **sluggishness or slowness** on account of presence of these elements.

Dynamic Response &Characteristics

➢ In several applications the measurement systems are subjected to inputs which are not static but dynamic in nature, which means the inputs vary with time. Since the input varies from instant to instant, so does the output.

➢ The behaviour of the system under such conditions is described by the dynamic response of the system and the characteristics of the measuring system under such conditions are known as dynamic characteristics.

Dynamic Characteristics :

The set of criteria defined for the instruments, which are changes rapidly with time, is called 'dynamic characteristics'.

Dynamic characteristics of a measuring instrument refer to the case where the measured variable changes rapidly.

As in case of sensors in control system cannot react to a sudden change in measured variable immediately. A certain amount of time is required before the measuring instrument in control system technology can indicate any output based on the input received by the measuring instrument.

The dynamic behaviour of the measuring instruments is judged for the following three types of inputs -
(i) Step Input
(ii) Linear Input
(iii) Sinusoidal Input
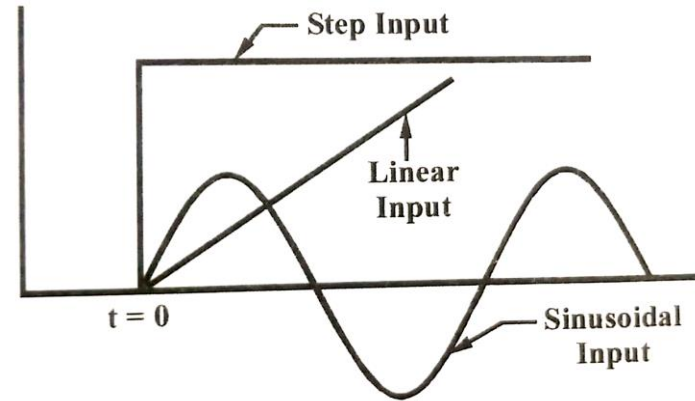
(i) Step Input- In this case, the input changes instantaneously by a finite value and then remains constant.

(ii) Linear Input- In this case, the input changes linearly with time

(iii) Sinusoidal Input- In this case, the input changes according to a sinusoidal function of constant amplitude.

The dynamic characteristics of any measurement system are:

(i)   Speed of response and Response time

(ii)   Lag

(iii)   Fidelity

(iv)   Dynamic error

Out of the above four characteristics the Speed of Response and the Fidelity are desirable in a dynamic system, while Lag and Dynamic error are undesirable.

Speed of Response & Response Time

➢ **Speed of Response** is defined as the rapidity with which an instrument or measurement system responds to changes in measured quantity.

➢ **Response Time** is the time required by instrument or system to settle to its final steady position after the application of the input.

➢For a step input function, the response time may be **defined as the time taken by the instrument to settle to a specified percentage of the quantity being measured, after the application of the input**.

➢This percentage may be 90 to 99 percent depending upon the instrument.

➢For **portable instruments** it is the time taken by the pointer to come to rest within 0.3 percent of final scale length.

➢For switch board (panel) type of instruments it is the time taken by the pointer to come to rest within 1 percent of its final scale length.

Measuring Lag

➢ **The delay in the response of an instrument to a change in the measured quantity is known as *measuring lag*.**
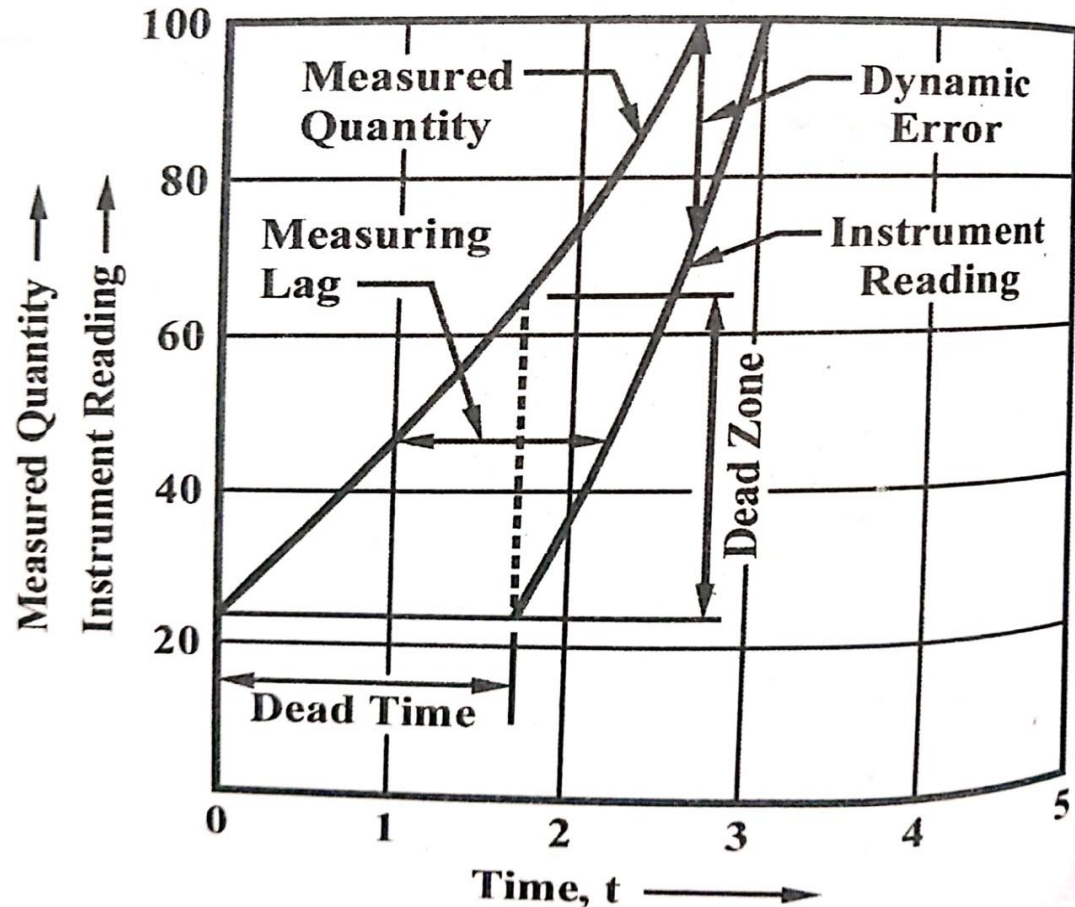
➢ This lag is usually quite small, but this small lag becomes highly important when high speed measurements are required.

➢ In the high speed measurement systems, as in dynamic measurements, it becomes essential that the time lag be reduced to minimum.

Measuring lag is of two types :

i) **Retardation type:** In this type of measuring lag the response begins immediately after a change in measured quantity has occurred.

ii) **Time delay:** In this type of measuring lag the response of the measurement system begins after a dead zone after the application of the input

Fidelity

- Fidelity of a system is defined as the ability of the system to reproduce the output in the same form as the input.

- It is the degree to which a measurement system indicates changes in the measured quantity without any dynamic error.

- Supposing if a linearly varying quantity is applied to a system and if the output is also a linearly varying quantity the system is said to have 100 percent fidelity.

- Ideally a system should have 100 percent fidelity and the output should appear in the same form as that of input and there is no distortion produced in the signal by the system. In the definition of fidelity any time lag or phase difference between output and input is not included.

Dynamic Error

➢ **The dynamic error is the difference between the true value of the quantity changing with time and the value indicated by the instrument if no static error is assumed.**
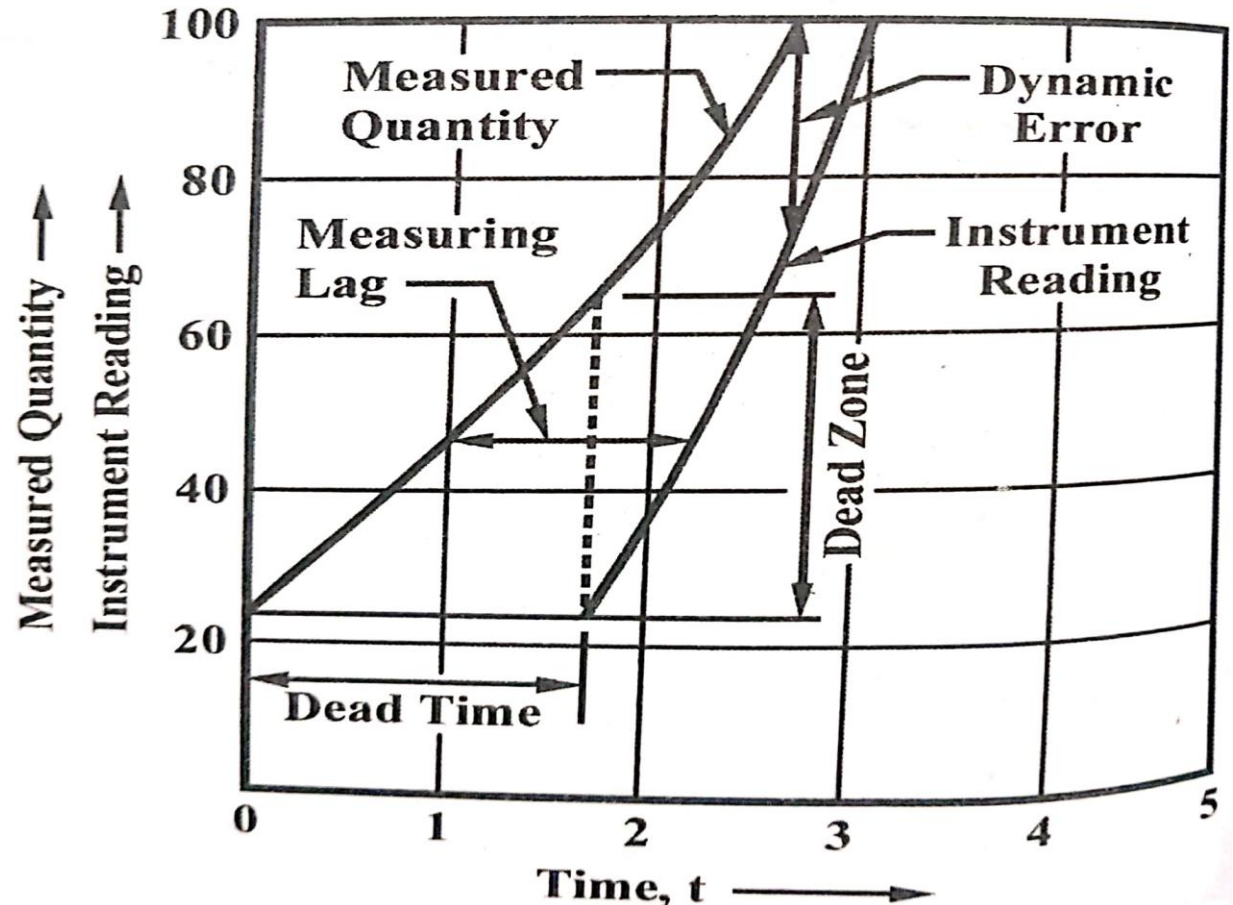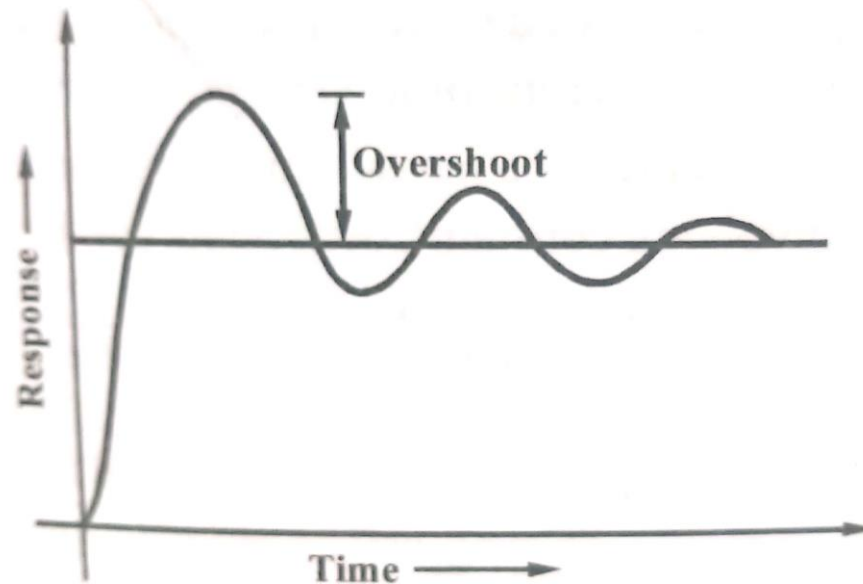
- However, the total dynamic error of the instrument is the combination of its fidelity and the time lag or phase difference between input and output of the system.
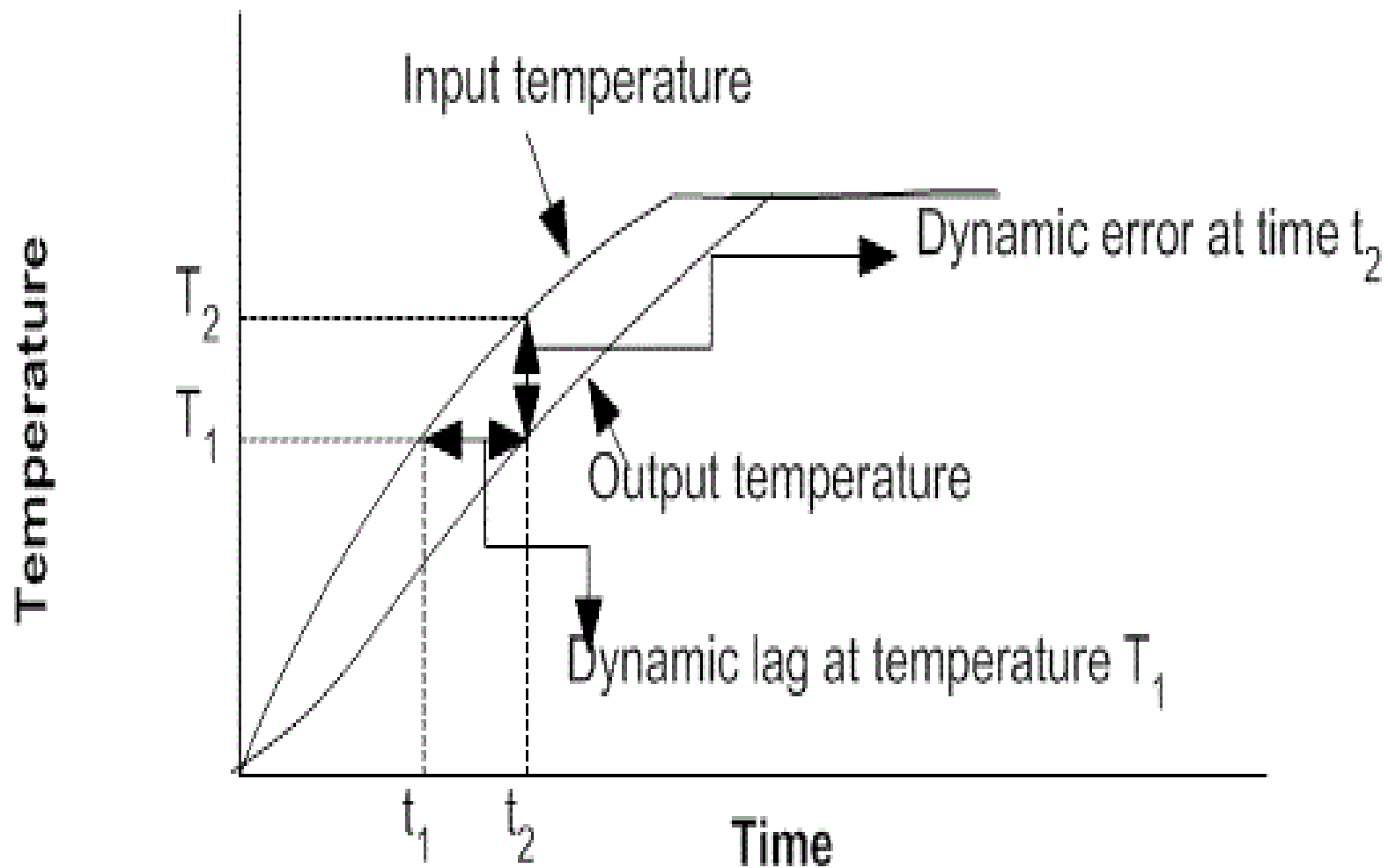
Overshoot

Moving parts of instruments have mass and thus possess inertia. When an input is applied to instruments, the pointer does not immediately come to rest at its steady state (or final deflected) position but goes beyond it or in other words overshoots its steady position.

- The overshoot is evaluated as the maximum amount by which moving system moves beyond the steady state position. In many instruments, especially galvanometers it is desirable to have a little overshoot but an excessive overshoot is undesirable.

Thank You