# Dynamic Characteristics of Measurement System

When an instrument is required to measure a time varying process variable, one has to be concerned with “Dynamic Characteristics” which quantify the dynamic relation between input and output.

The behavior of the system when inputs vary with time and so does the output, is called dynamic response.

Dynamic characteristics of Measuring System are:

1. Speed of response - Desirable
2. Measuring lag - Undesirable
3. Fidelity - Desirable
4. Dynamic error - Undesirable

# Types of Dynamic Inputs

- Periodic Input – Varying cyclically with time or repeating itself after a constant interval T.
- Transient Input – Varying non-cyclically with time.
- Definite duration. Becomes zero after time T.

Random Input – Varying randomly. No definite period and amplitude.

Examples:

1. Vibration excitation due to unbalance of rotating body is harmonic.
2. Pressure variation in I.C. engine is periodic. 3. Forces due to an explosion are transient.
4. Pressure fluctuations in fluid flow due to turbulence are of random type.

## Formulation of System Equations

A general measurement system can be mathematically described by differential equation

$$(A_nD^n + A_{n-1}D^{n-1} + A_{n-2}D^{n-2} + --------+ A_1D + A_0)$$

$$I_o = (B_mD^m + B_{m-1}D^{m-1} + B_{m-2}D^{m-2} + ----$$

$$----+ B_1D + B_0)\, I_i$$

$A_s$' & $B_s$' = Constants, depending upon physical parameters of the system.

$D^k$ = Operative derivative of the order

k $I_o$ = Output Information

$I_i$ = Input Information

## Zero order system

- Output is directly proportional to input, no matter how the input varies.
- The output is faithful reproduction of input without any distortion or time lag.

$$I_o = S\, I_i$$

S = Sensitivity of system

- Eg.- Mechanical Levers, Amplifiers, Potentiometer, etc.
- The value of static sensitivity is obtained through process of static calibration.

First order system

$$I_o(\tau D + 1) = S\, I_i$$

$\tau$ = Time constant

S = Sensitivity

Examples –

- Velocity of a true falling mass -

Air pressure built in bellows

- Mercury in glass thermometer -

Thermisters & thermocouples

- Resistance- Capacitance network

Second order system

$$\left[ \frac{D^2}{W_n^2} + \frac{2\Upsilon D}{W_n} + 1 \right] \quad I_o = S\, I_i$$

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Example –

-Piezoelectric pickup -

Spring mass system

-Pen control system on X-Y plotters -U-V

Galvanometer