DYNAMIC CHARACTERISTICS

Dr. V. Karteek
Assistant Professor, EIED
Thapar Institute of Engineering & Technology,
Patiala, Punjab

DYNAMIC CHARACTERISTICS

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

The various static characteristics are:

- Speed of response
- Measuring lag
- Fidelity
- Dynamic error

DYNAMIC CHARACTERISTICS

- **Speed of response:** It is defined as the rapidity with which a measurement system responds to changes in the measured quantity.
- **Measuring lag:** It is the retardation or delay in the response of a measurement system to changes in the measured quantity.
- **Dynamic error:** It is the difference between the true value of the quantity changing with time & the value indicated by the measurement system if no static error is assumed. It is also called measurement error.
- **Fidelity** is defined as the degree to which a measurement system indicates changes in the measured quantity without any dynamic error

TIME RESPONSE

The time response of a system is the output (response) which is function of the time, when input (excitation) is applied.

Time response of a control system consists of two parts

- Transient Response
- Steady State Response

Mathematically,

$$c(t) = c_t(t) + c_{ss}(t)$$

STANDARD SIGNALS

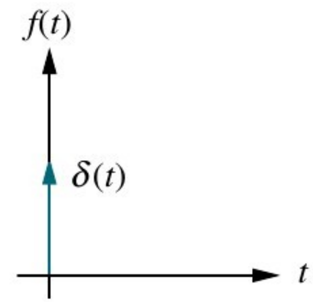
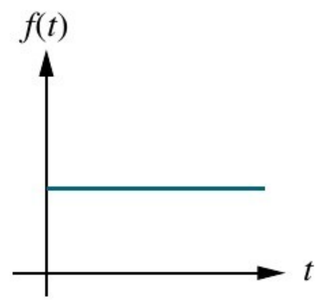
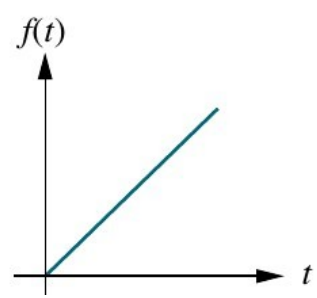
The measurement systems may be subjected to any type of input. To study the dynamic behavior of measurement systems, certain standard signals are employed for which the mathematical equations have been developed. These standard signals are:

(i) Step input, (ii) Ramp input, (iii) Parabolic input, and (iv) Impulse input.

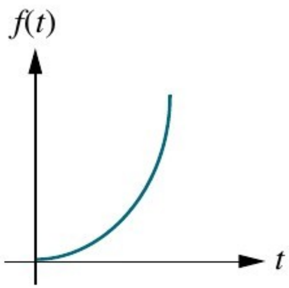
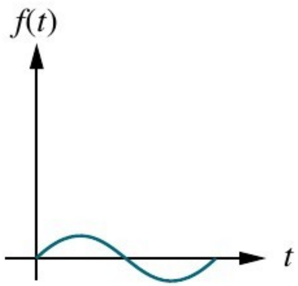
The above signals are used for studying dynamic behavior in the time domain and the dynamic behavior of the system to any kind of inputs can be predicted by studying its response to one of the standard signals.

TEST SIGNALS

The dynamic behaviour of a system is judged and compared under application of standard test signals. For time response analysis of a control system, following input signals are used:

Input	Function	Description	Sketch	Use
Impulse	$\delta(t)$	$\delta(t) = \infty$ for $0- < t < 0+$ $= 0$ elsewhere $\int_{0-}^{0+} \delta(t)dt = 1$		Transient response Modeling
Step	$u(t)$	$u(t) = 1$ for $t > 0$ $= 0$ for $t < 0$		Transient response Steady-state error
Ramp	$tu(t)$	$tu(t) = t$ for $t \geq 0$ $= 0$ elsewhere		Steady-state error

CONTINUED

Parabola	$\frac{1}{2}t^2u(t)$	$\frac{1}{2}t^2u(t) = \frac{1}{2}t^2$ for $t \geq 0$ $= 0$ elsewhere		Steady-state error
Sinusoid	$\sin \omega t$			Transient response Modeling Steady-state error

$$X(s) = \int_{-\infty}^{\infty} x(t)e^{-st}dt$$

$$x(t) = \frac{1}{2\pi j}\int_{\sigma-j\infty}^{\sigma+j\infty} X(s)e^{st}ds$$

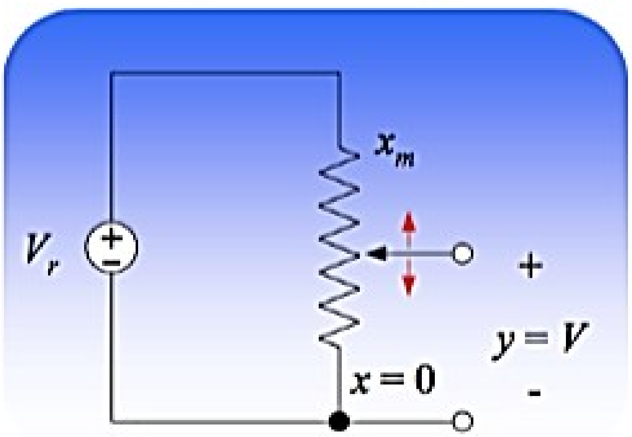
Item no.	$f(t)$	$F(s)$
1	$\delta(t)$	1
2	$u(t)$	$\dfrac{1}{s}$
3	$tu(t)$	$\dfrac{1}{s^2}$
4	$t^n u(t)$	$\dfrac{n!}{s^{n+1}}$
5	$e^{-at}u(t)$	$\dfrac{1}{s+a}$
6	$\sin(\omega t)u(t)$	$\dfrac{\omega}{s^2+\omega^2}$
7	$\cos(\omega t)u(t)$	$\dfrac{s}{s^2+\omega^2}$

ORDER OF A SYSTEM

The order of a dynamic system is the order of the highest derivative of its governing differential equation. Equivalently, it is the highest power of S in the denominator of its transfer function.

Zero order system

The behavior is characterized by its static sensitivity, K and remains constant regardless of input frequency (ideal dynamic characteristic).



$$V = V_r \cdot \frac{x}{x_m} \text{ here, } K = V_r / x_m$$

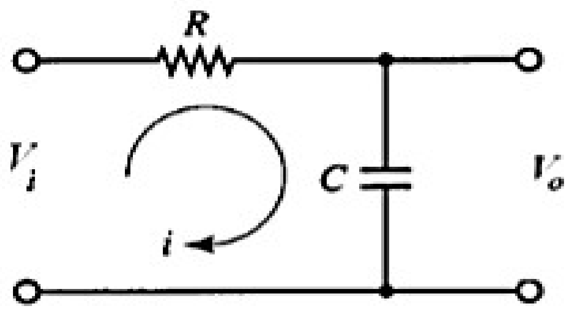
Where $0 \le x \le x_m$ and V_r is a reference voltage

A linear potentiometer used as position sensor is a zero-order sensor.

FIRST ORDER SYSTEM

RC CIRCUIT AS FIRST ORDER SYSTEM

- Consider



Using Kirchoff's Voltage Law,

$$V_i(t) = Ri(t) + \frac{1}{C}\int i(t)$$

$$V_o(t) = \frac{1}{C}\int i(t)dt$$

CONTINUED

- Taking the Laplace of these eq.

$$V_i(s) = RI(s) + \frac{1}{sC} I(s)$$

$$V_o = \frac{1}{sC} I(s) \qquad \Rightarrow I(s) = sCV_o$$

Putting this value in main equation, we get

$$V_i = (sCR + 1)V_o$$

$$\boxed{G(s) = \frac{V_o}{V_i} = \frac{1}{1 + sCR}}$$

- is the transfer function of the given RC circuit.

Thank You