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Exp 2:- Frequency response of second order System

Aim:- To determine frequency response of second order system and Evaluation of frequency domain Specification

Theory:- The frequency response of a sytem is the steady state response of a System to the Sinosidal input signal. The commonly used methods to skotch frequency response for given System are

→ Body plot
→ Polar plot
→ Nyquist plost

Frequency domain Specification:-

These are the measures of the performance characteristics of a control System

(i) **Resonant peak magnitude (M_r):-**

It is the maximum value of closed loop frequency response

$$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

(ii) **Resonant frequency (ω_r):-**

The frequency at which the System magnitude is maximum

$$\omega_r = \omega_n\sqrt{1-2\xi^2}$$

Cut off frequency (ω_c):-

The frequency at which the system magnitude $[M(j\omega)]$ is $[1/\sqrt{2}]$ times its maximum value

Band width:-

It is the range of frequencies upto cutoff frequency

$$\omega_b = \omega_n\sqrt{(1-2\xi^2) + \sqrt{4\xi^4 - 4\xi^2 + 2}}$$

Gain margin:-

It is the factor by which gain can be raised before instability occurs

$$GM = \frac{1}{G(j\omega_c)} \text{ at } \omega_c = \omega_{PCO}$$

$\omega_{PCO} \rightarrow$ The phase crossover frequency is the frequency at which

$\angle G(j\omega)$ is -180°

Phase margin:-

The phase in degrees which can be raised in a system without making it unstable.

$$PM = 180^\circ + G(j\omega_c) \quad \text{where } \omega_c = \omega_{GCO}$$

$\omega_{GCO} \rightarrow$ the gain crossover frequency is the frequency at which $|G(j\omega)| = 1$

Theoretical Calculations :-

① $T.f = \frac{100}{s^2+10s+100}$ Comparing this with $\frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$

$\omega_n = 10$

$2\xi\omega_n = 10$

$\xi = 0.5$

$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}} = 1.15$

$\omega_r = \omega_n\sqrt{1-2\xi^2} = 7.07\,rad/sec$

$\omega_b = \omega_n\sqrt{(1-2\xi^2)+\sqrt{4\xi^2-4\xi^2+2}}$

$\omega_b = 12.72\ rad/sec$

② $T.f = \frac{12}{(s+3)(s+4)} = \frac{12}{s^2+7s+12}$

$\omega_n = \sqrt{12} = 3.46$

$2\xi\omega_n = 7$

$\xi = \frac{7}{2\times\sqrt{12}}$ $\xi = 1.01$

$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}}$ $\omega_r = \sqrt{\omega_n^2(1-2\xi^2)}$

These Equations are valid only

when $0 \leq \xi \leq 0.707$