Experiement-2

511831

Frequency response of second order system

Aim :- To obtain frequency response of a second order system calculation of frequency domain specifications.

Apparatus :- PC with matlab software

Theory :-

Frequency response is defined as the magnitude and phase difference between the input and output sinosoids. It is obtained by applying a sinusoidal input with different frequency and observing magnitude and phase of output. If $G(j\omega)$ is transfer function the $G(j\omega)$ vs ω given frequency plot.

→ Frequency response can be obtained by using bode plot, polar plot and Nyquist plot.

→ This gain and phase magnitudes are obtained from the plots helps to decide the

Frequency domain specifications are the measures of performance and charecteristics of control system

1. Reasonant frequency (ω_r) :-

The frequency at which system has maximum magnitude is called resonant frequency

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

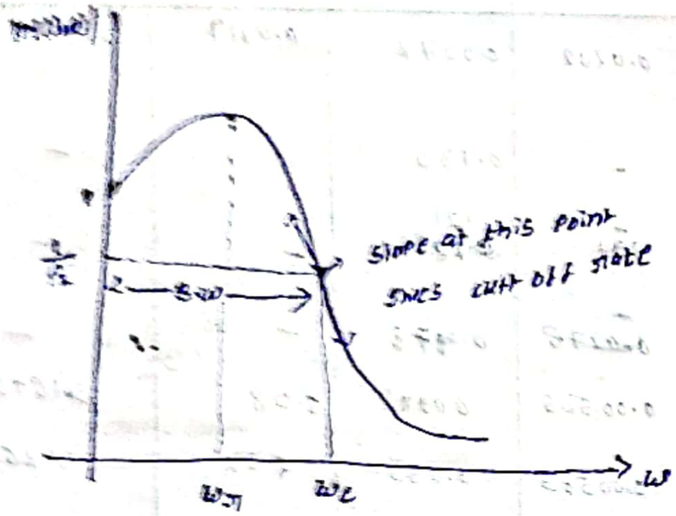
2. Resonant Peak magnitude (M_r) :-

The reasonant peak magnitude is the maximum value of the closed loop frequency response

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

Scanned with CamScanner

$$|M(j\omega)| = \frac{1}{\sqrt{1-\left(\frac{\omega}{\omega_n}\right)^2 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}}$$



5. Bandwidth (ω_b):-

For feedback control system the range of frequencies over which $|M(j\omega)|$ is equal to (or) greater than $(M_0/\sqrt{2})$ is defined as the bandwidth

$$\boxed{\omega_b = \omega_n \left\{ (1-2\xi^2) + \sqrt{(1-2\xi^2)+1} \right\}^{1/2}}$$

Procedure

1. open matlab command window
2. open new script File
3. Enter the code and obtain its bode plot
4. Run the program and obtain PM and GM from ~~table~~ bode plot and frequency domain specifications
5. Tabulate the observations theoritically and practically and observe
6. observe the wave form and exit

6. Theoritical values

For second ordersystem

1) $T.F = \frac{121}{s^2+11s+121}$

$\omega n^2 = 121 \quad \omega n = 11$

$2\xi\omega n = 11 \quad \xi = 1/2$

$\boxed{\xi < 1}$

underdamped system

2) $T.F = \frac{15}{(s+3)(s+5)} = \frac{15}{s^2+8s+15}$

$\omega n^2 = 15 \quad \omega n = \sqrt{15}$

$2\xi\omega n = 8$

$\xi = \sqrt{\frac{16}{15}}$

$\boxed{\xi > 1}$

overdamped system

1) Reasonant frequency

1) $\omega r = \omega n\sqrt{1-2\xi^2}$

$= 11\sqrt{1-2(1/2)}$

$= 11/\sqrt{2} = 7.77$

$\boxed{\omega r = 7.77 \text{ rad/sec}}$

2) For overdamped system reasonant peak is obtained at intial position only

i.e $\boxed{\omega r = 0}$

2) Reasonant peak magnitude

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

$= \frac{1}{2\times\frac{1}{2}\sqrt{1-(\frac{1}{2})^2}}$

$\boxed{Mr = 1.1547}$

2) $Mr = \cancel{\frac{1}{2\xi\sqrt{1-\xi^2}}}$

$\boxed{Mr = 1}$

3). Band width:

$$\omega b = \omega n\left[(1-2\xi^2) + \sqrt{(1-2\xi)^2+1}\right)^{1/2}$$

$$= 11\sqrt{1-2(1/2)^2+\sqrt{(1-(1/2)^2)^2+1}}$$

$$= 13.97$$

$$\boxed{\omega_b = 13.97}$$

At $\omega_{gc} = 11\ rad/sec$

$$\angle G(j\omega)H(j\omega) = -\tan^{-1}\left(\frac{11\omega}{121-\omega^2}\right)$$

$$= -90^\circ$$

$$PM = 180 + \angle G(j\omega)H(j\omega)$$

$$PM = 180^\circ + (-90^\circ)$$

$$\boxed{PM = 90^\circ}$$

2) $$\omega_b = \sqrt{15}\sqrt{1-2\left(\frac{16}{15}\right)+\sqrt{\left(1-\frac{32}{15}\right)^2+1}}$$

$$= \sqrt{15}\sqrt{-\frac{17}{15}+\sqrt{\frac{289}{285}+1}}$$

$$= \sqrt{15}\sqrt{\frac{-17}{15}+1.1511}$$

$$\boxed{\omega_b = 2.2814}$$

$$\omega_b = 2.2814$$

At $\omega_{gc} = 0\ rad/sec$

$$\angle G(j\omega)H(j\omega)$$

$$= -\tan^{-1}(\omega/3) - \tan^{-1}\left(\frac{\omega}{5}\right)$$

$$PM = 180 + \angle G(j\omega)H(j\omega)$$

$$P.M = 180 + 0$$

$$\boxed{PM = 180^\circ}$$

Observation table

	$TF = \frac{121}{s^2+11s+121}$		$TF = \frac{15}{(s+3)(s+5)}$	
Parameters	Theoritical	practical	Theoritical	practical
ω_n	7.77		0	
M_n	1.1547		1	
ω_b	13.97		2.28M	
gain cross over freq	11 rad/sec		0 rad/sec	
phase cross over frequency	Infinity		infinity	
gain margin	infinity		infinity	
phase margin	90°		180°	

Inference:-

The degree of stability depends on gain margins and phase margin. The bode plot gives clear discription of steady state response of the system for different frequencies

Result:-

The frequency response of system has been studied for 2nd order system.