1

Control Systems

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		Contents		10	Oscillator	2
1	Signal Flow Graph 1.1 Mason's Gain Formula 1.2 Matrix Formula		1 1 1	Abstract—This manual is an introduction to contr systems based on GATE problems.Links to sample Pytho codes are available in the text.		
	1.2	Matrix Porniura	1	Do	wnload python codes using	
2	Bode 2.1 2.2	Plot Introduction	1 1 1		o https://github.com/gadepall/school/t ontrol/codes	runk/
	2,2	Example	1			
3	Second order System		1		1 Signal Flow Graph	
	3.1	Damping	1	1.1 N	Aason's Gain Formula	
	3.2	Example	1	1.2 N	Aatrix Formula	
4	Routh Hurwitz Criterion		1		2 Bode Plot	
-	4.1	Routh Array	1	2.1 I	ntroduction	
	4.2	Marginal Stability	1		Example	
	4.3	Stability	1	2.2	3 Second order System	
	4.4	Example	1	3.1 I	Damping	
5	State-Space Model		1		Example	
	5.1	Controllability and Observ-			4 ROUTH HURWITZ CRITERION	
		ability	1	111	Routh Array	
	5.2	Second Order System	1		•	
	5.3	Example	1		Marginal Stability	
	5.4	Example	1		Stability -	
6	Nyquist Plot		1	4.4 E	Example	
Ü	11,740	1100	•		5 STATE-SPACE MODEL	
7	Compensators		2	5.1	Controllability and Observability	
	7.1	Phase Lead	2	5.2 S	Second Order System	
	7.2	Example	2	5.3 E	Example	
8	Gain Margin		2	5.4 B	Example	
	8.1	Introduction	2		6 Nyquist Plot	
	8.2	Example	2	6.1.	The number of directions and encir-	clements
9	Phase Margin		2		around the point -1+j0 in the complete by the Nyquist plot of $G(s) = \frac{1-s}{4+2s}$	ex plane
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Solution: First, we need to draw the polar plot of given G(S). In the polar plot, substitute $s = j\omega$

Substitute $s = Re^{j\theta}$

$$G(j\omega) = \frac{1 - j\omega}{4 + 2j\omega} \tag{6.1.1}$$

$$\lim_{\omega \to \infty} G(j\omega) = \frac{1 - j\omega}{4 + 2j\omega}$$
 (6.1.2)

$$\lim_{\omega \to \infty} G(j\omega) = \frac{j\omega(\frac{1}{j\omega} - 1)}{j\omega(\frac{4}{j\omega} + 2)}$$
(6.1.3)

$$\lim_{\omega \to \infty} G(j\omega) = \frac{-1}{2} \angle 0 \tag{6.1.4}$$

which is equal to $\frac{1}{2}\angle -180$

Now substitute $\omega = 0$

$$\lim_{\omega \to 0} G(j\omega) = \frac{1 - j\omega}{4 + 2j\omega} = \frac{1}{4} \angle 0 \qquad (6.1.5)$$

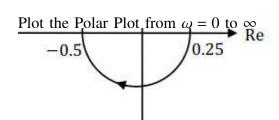
$$\angle(G(j\omega)) = \tan^{-1}(\frac{-\omega}{1}) - \tan^{-1}(\frac{\omega}{2}) \quad (6.1.6)$$

so from this at $\omega = 0$ $\angle G(j\omega) = 0$ and at $\omega = \infty$ $\angle G(j\omega) = -180$

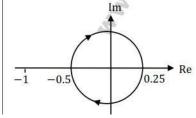
$$|(G(j\omega))| = \frac{\sqrt{1+\omega^2}}{\sqrt{16+4\omega^2}}$$
 (6.1.7)

when $\omega = 0 \mid (G(j\omega)) \mid = \frac{1}{4}$ and at $\omega = \infty \mid (G(j\omega)) \mid = \frac{1}{2}$

So, we have to plot first 0.25 on positive x-axis then we have to turn -180 degrees from that point i.e 180 degrees clockwise(in this case).



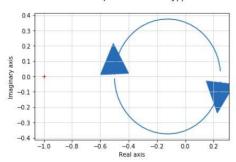
Draw the Mirror image of the Polar Plot.



$$\lim_{R \to \infty} G(Re^{j\theta}) = \frac{1 - Re^{j\theta}}{4 + 2Re^{j\theta}} = \frac{-1}{2}$$
 (6.1.8)

As there are no $e^{j\theta}$ terms.

There will be no enclosed Nyquist path here. So, for this Transfer function G(s), the Nyquist plot is the Polar plot and its mirror image with respect to real axis.



As from the observed plot the co-ordinate -1 + j0 is outside the contour.

Hence, the number of encirclements around the the given co-ordinate is zero.

7 Compensators

- 7.1 Phase Lead
- (6.1.7) 7.2 Example
- 8 Gain Margin
- 8.1 Introduction
- 8.2 Example

9 Phase Margin
10 Oscillator