Control Systems

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Contents

***Abstract*—This manual is an introduction to control systems based on GATE problems.Links to sample Python codes are available in the text.**

1 Stability

1.1 Bode Plot

1.1. The asymptotic Bode magnitude plot of minimum phase transfer function G(s) is show below.
Consider the following two statements.

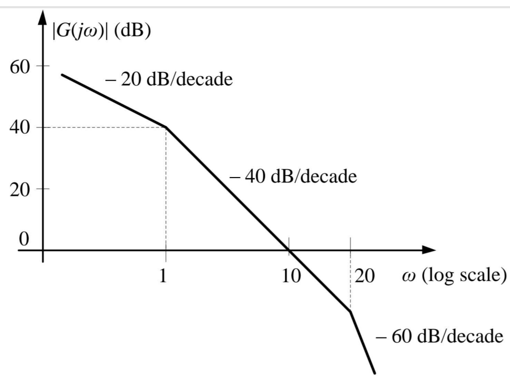

Fig. 1.1

Statement 1: Transfer function G(s) has 3 poles and one zero
Statement 2: At very high frequency $(\omega \to \infty)$, the phase angle $\angle G(j\omega) = -3\pi/2$

Which of the following is correct ?
(A) Statement 1 is true and Statement 2 is false.
(B) Statement 1 is false and Statement 2 is true.
(C) Both the statements are true.
(D) Both the statements are false.

Solution:
Since, each pole corresponds to -20 dB/decade and each zero corresponds to +20 dB/decade. Therefore, from the given Bode plot we can get the Transfer equation,

$$G(s) = \frac{k}{s(1+s)(20+s)} \tag{1.1.1}$$

Now, from the Transfer equation we can conclude that, there are three poles (0, -1 and -20) and no zeros.

$\therefore$ Statement 1 is false ....(1)

Calculating phase:

Since we know that,
phase ϕ is the sum of all the phases corresponding to each pole and zero.
phase corresponding to pole is =

$$-tan^{-1}(\frac{imaginary}{real}) \tag{1.1.2}$$

phase corresponding to zero is =

$$tan^{-1}(\frac{imaginary}{real}) \tag{1.1.3}$$

Now take,

$$s = j\omega \tag{1.1.4}$$

$$\Rightarrow G(j\omega) = \frac{k}{j\omega(1+j\omega)(20+j\omega)} \tag{1.1.5}$$

Therefore,

$$\phi = -tan^{-1}(\frac{\omega}{0}) - tan^{-1}(\omega) - tan^{-1}(\frac{\omega}{20}) \tag{1.1.6}$$

$$\phi = -90^\circ - tan^{-1}(\omega) - tan^{-1}(\frac{\omega}{20}) \tag{1.1.7}$$

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$$\because \omega \to \infty \tag{1.1.8}$$

$$\phi = -90^\circ - 90^\circ - 90^\circ \tag{1.1.9}$$

$$\phi = -270^\circ \tag{1.1.10}$$

$$\phi = -3\pi/2 \tag{1.1.11}$$

$\therefore$ Statement 2 is true ....(2)
thus, from (1) and (2) option (B) is correct.

2 Routh Hurwitz Criterion

3 Compensators

4 Nyquist Plot