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

1.1.1. The asymptotic Bode magnitude plot of minimum phase transfer function G(s) is show below.

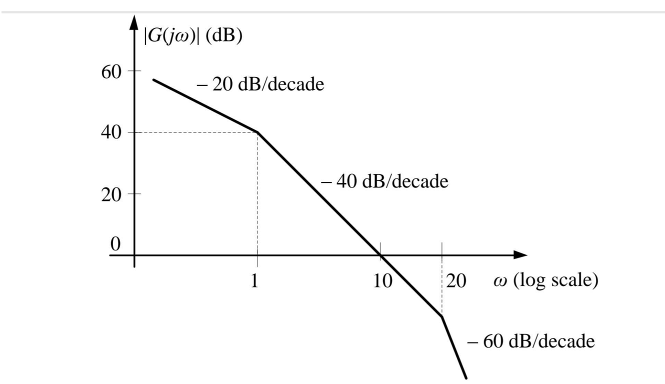

Fig. 1.1.1

1.1.2. Verify if the transfer function G(s) has 3 poles and one zero.

1.1.3. Verify if at very high frequency ($\omega \to \infty$), the phase angle $\angle$ G(jω)=-3π/2
Solution:

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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,

$$G(s) = \frac{k}{s(1+s)(20+s)} \tag{1.1.3.1}$$

Python Plot of the transfer function is as shown in the figure

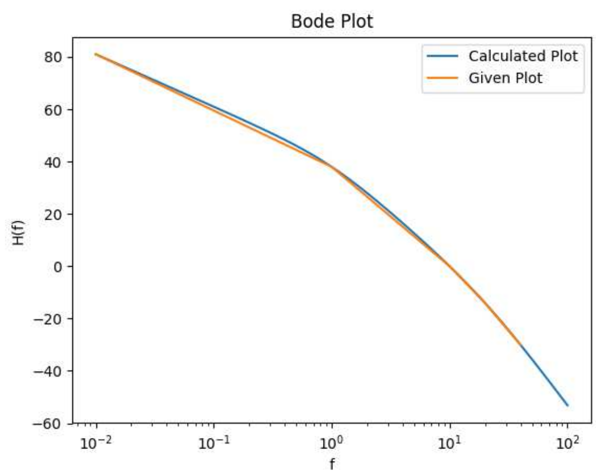

Fig. 1.1.3

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 =

$$-tan^{-1}(\frac{imaginary}{real}) \tag{1.1.3.2}$$

phase corresponding to zero is =

$$tan^{-1}(\frac{imaginary}{real}) \tag{1.1.3.3}$$

Now take,

$$s = j\omega \tag{1.1.3.4}$$

$$\Rightarrow G(j\omega) = \frac{k}{j\omega(1 + j\omega)(20 + j\omega)} \tag{1.1.3.5}$$

Therefore,

$$\phi = -tan^{-1}(\frac{\omega}{0}) - tan^{-1}(\omega) - tan^{-1}(\frac{\omega}{20}) \tag{1.1.3.6}$$

$$\phi = -90^\circ - tan^{-1}(\omega) - tan^{-1}(\frac{\omega}{20}) \tag{1.1.3.7}$$

$$\because \omega \to \infty \tag{1.1.3.8}$$

$$\phi = -90^\circ - 90^\circ - 90^\circ \tag{1.1.3.9}$$

$$\phi = -270^\circ \tag{1.1.3.10}$$

$$\phi = -3\pi/2 \tag{1.1.3.11}$$

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

2 Routh Hurwitz Criterion

3 Compensators

4 Nyquist Plot