GATE 2022 IN.53

EE23BTECH11010 - VENKATESH BANDAWAR*

Question: In a unity-gain feedback control system, the plant $P(s) = \frac{0.001}{s(2s+1)(0.01s+1)}$ is controlled by a lag compensator $C(s) = \frac{s+10}{s+0.1}$ The slope (in dB/decade) of the asymptotic Bode magnitude plot of the loop gain at $\omega = 3$rad/s is _ _ _ _ _ _ _ (in integer)   (GATE 2022 IN)

Solution:

Parameter	Description	Value
$P(s)$	Plant Transfer Function	$\frac{0.001}{s(2s+1)(0.01s+1)}$
$C(s)$	Lag Compensator	$\frac{s+10}{s+0.1}$
$L(s)$	Loop gain=$P(s) \times C(s)$	$\frac{0.001(s+10)}{s(2s+1)(0.01s+1)(s+0.1)}$
ω	Angular Frequency	3rad/s

TABLE I: Given Parameters list

$$Gain(K) = \lim_{s \to 0} L(s) \qquad (1)$$

Excluding s and $\frac{1}{s}$,

$$K = \lim_{s \to 0} \frac{0.001(s+10)}{(2s+1)(0.01s+1)(s+0.1)} \qquad (2)$$

$$= 0.1 \qquad (3)$$

$$|L(s)| = 20 \log_{10} K \qquad (4)$$

$$= -20dB/decade \qquad (5)$$

Zero of L(s) = 10

$$|L(s)| = 20 \log_{10} \omega \qquad (6)$$

Poles of L(s) = 0, 0.1, 0.5, 100

$$|L(s)| = -20 \log_{10} \omega \qquad (7)$$

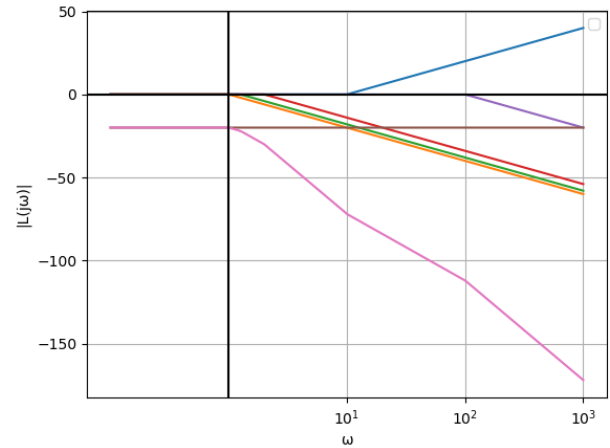Solpe of Bode magnitude plot (at $\omega = 3$) = -60 dB/decade

Fig. 1: Pink Line = Bode magnitude plot of loop gain