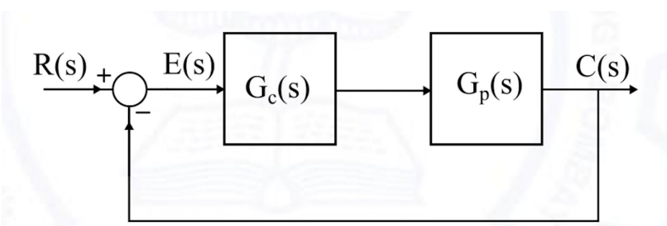
GATE.2021.EE.46

EE22BTECH11004 - Allu Lohith

Consider a closed-loop system as shown,

$$G_p(s) = \frac{14.4}{s(1+0.1s)}$$

is the plant transfer function and $G_c(s) = 1$ is the compensator. For a unit-step input, the output response has damped oscillations. The damped natural frequency is ________ rad/s. (Round off to 2 decimal places.)



Solution: As we know that:

Parameter	Description	Value
$G_n(s)$	Plant transfer function	$\frac{14.4}{s(1+0.1s)}$
$G_c(s)$	Transfer function of the compensator	1
ω_n	Damped natural frequency	-
T	Overall tranfer function	$\frac{C}{R}$

TABLE 0
PARAMETERS

$$E = R_c - C_c \tag{1}$$
$$EG_cG_p = C \tag{2}$$
$$\tag{3}$$

So,

$$E = \frac{Cs(1+0.1s)}{14.4} \tag{4}$$
$$\frac{Cs(1+0.1s)}{14.4} = R - C \tag{5}$$
$$R = C\left(\frac{s(1+0.1s)}{14.4} + 1\right) \tag{6}$$
$$\frac{C}{R} = \frac{14.4}{0.1s^2 + s + 14.4} \tag{7}$$

The characteristic equation is $0.1s^2 + s + 14.4$ which is of the form $s^2 + 2\zeta\omega_n s + \omega_n^2$, So

$$\omega_n^2 = 144 \tag{8}$$
$$\omega_n = 12 rad/s \tag{9}$$

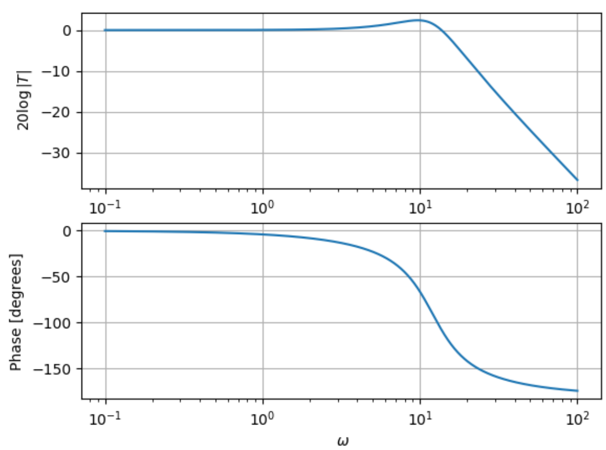


Fig. 0. Bode Plot - Magnitude and Phase Response