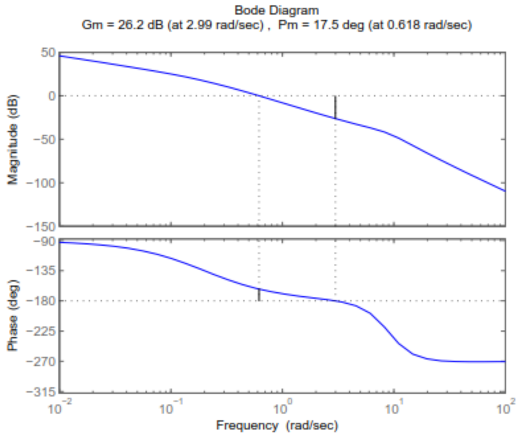
(E9.1) A system has the loop transfer function

$$L(s) = G_c(s)G(s) = \frac{2(1 + s/10)}{s(1 + 5s)(1 + s/9 + s^2/81)}$$

Plot the Bode diagram. Show that the phase margin is approximately 17.5° and that the gain margin is approximately 26.2 dB.

Ans.



(P9.2) Sketch the Nyquist plots of the following loop transfer functions L(s) = Gc(s)G(s), and determine whether the system is stable by applying the Nyquist criterion:

(a) $L(s) = G_c(s)G(s) = \frac{K}{s(s^2+s+6)}$

(b) $L(s) = G_c(s)G(s) = \frac{K(s+1)}{s^2(s+6)}$

If the system is stable, find the maximum value for K by determining the point where the Nyquist plot crosses the w-axis.

Ans.

(a) $G_c(j\omega)G(j\omega) = \frac{K}{j\omega(-\omega^2+j\omega+6)} = \frac{K[-\omega^2-j\omega(6-\omega^2)]}{[(6-\omega^2)^2\omega^2+\omega^4]}$

- To determine the real axis crossing, we let $\mathrm{Im}\{G_c(j\omega)G(j\omega)\} = 0 = -K\omega(6-\omega^2)$ or $\omega = \sqrt{6}$
- Then, $\mathrm{Re}\{G_c(j\omega)G(j\omega)\}_{\omega=\sqrt{6}} = -\frac{K\omega^2}{\omega^4}\Big|_{\omega=\sqrt{6}} = -\frac{K}{6}$
- So, -K/6 > -1 for stability. Thus K < 6 for a stable system.

(b) $G_c(j\omega)G(j\omega) = \frac{K(j\omega+1)}{-\omega^2(j\omega+6)}$

- The polar plot never encircles the -1 point, so the system is stable for all gains K (See Figure 10 in Table 9.6 in Dorf & Bishop).

(P9.4) The Nyquist plot of a conditionally stable system is shown in Figure P9.4 for a specific gain K.

(a) Determine whether the system is stable and find the number of roots (if any) in the right-hand s-plane. The system has no poles of Gc(s)G(s) in the right half-plane.

(b) Determine whether the system is stable if the -1 point lies at the dot on the axis.

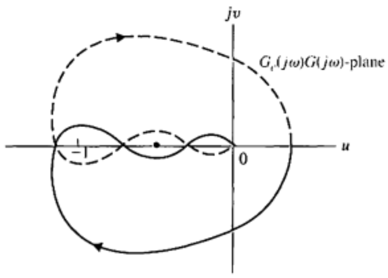


FIGURE P9.4 Nyquist plot of conditionally stable system.

Ans.

(a) P = 0, N = 2, therefore Z = 2. The system has two roots in the right-hand s-plane.

(b) In this case, N = +1 − 1 = 0, so Z = 0. Therefore, the system is stable.