Control Systems

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

Download python codes using

```
svn co https://github.com/gadepall/school/trunk/
    control/codes
```

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8.1. Loop Tranfer function of a feedback system is

$$G(s)H(s) = \frac{s+3}{s^2(s-3)} \tag{8.1.1}$$

Take the Nyquist contour in the clockwise direction.
Then the Nyquist plot of G(s)H(s) encircles -1 + j0
(A) Once in clockwise direction
(B) Twice in clockwise direction
(C) Once in anticlockwise direction
(D) Twice in clockwise direction

Solution: Substituting $s = \jmath\omega$ in (8.1.1),

$$G(\jmath\omega)H(\jmath\omega) = \frac{j\omega+3}{(j\omega)^2(j\omega-3)} \tag{8.1.2}$$

$$G(\jmath\omega)H(\jmath\omega) = \frac{j\omega+3}{\omega^2(3-j\omega)} \tag{8.1.3}$$

$$\left|G(\jmath\omega)H(\jmath\omega)\right| = \frac{\left(\sqrt{\omega^2+9}\right)}{(\omega)^2\left(\sqrt{\omega^2+9}\right)} \tag{8.1.4}$$

$$\left|G(\jmath\omega)H(\jmath\omega)\right| = \frac{1}{(\omega)^2} \tag{8.1.5}$$

$$\angle G(\jmath\omega)H(\jmath\omega) = \tan^{-1}\left(\frac{\omega}{3}\right) - (\pi/2 + \pi/2 - \tan^{-1}\left(\frac{\omega}{3}\right)) \tag{8.1.6}$$

$$\angle G(\jmath\omega)H(\jmath\omega) = 2\tan^{-1}\left(\frac{\omega}{3}\right) \tag{8.1.7}$$

8.2. Find $G(j\omega)H(j\omega)$ for the Nyquist plotting
Solution: From (8.1.5) and (8.1.7)

$$G(\jmath\omega)H(\jmath\omega) = \frac{1}{(\omega)^2}\angle 2\tan^{-1}\left(\frac{\omega}{3}\right) \tag{8.2.1}$$

8.3. Nyquist plot and verify your result
Solution:
For the Nyquist plot,
We need to draw the polar plot by varying ω from 0 to ∞

$$\lim_{\omega\to\infty} G(\jmath\omega)H(\jmath\omega) = 0\angle 180 \tag{8.3.1}$$

$$\lim_{\omega\to 0} G(\jmath\omega)H(\jmath\omega) = \infty\angle 0 \tag{8.3.2}$$

The Nyquist plot is as shown

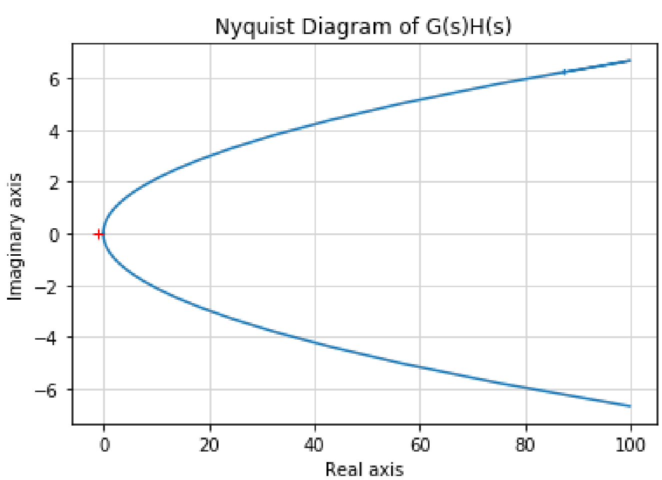

Fig. 8.3

Since there are two poles on the origin we get 2 infinite radius semicircles which start where the mirror image ends and terminate where the actual plot started in clockwise direction.

```
codes/es17btech11009.py
```

Above code gives us the Nyquist plot

The Nyquist plot of G(s)H(s) encircles -1 + j0 once in clockwise direction