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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6.1. The number of directions and encirclements around the point -1+j0 in the complex plane by the Nyquist plot of $G(s) = \frac{1-s}{4+2s}$

Solution: Substitute s = $\jmath\omega$ evaluate magnitude and phase at $\omega = 0$ and $\omega = \infty$

$$G(\jmath\omega) = \frac{1 - \jmath\omega}{4 + 2\jmath\omega} \tag{6.1.1}$$

$$\angle G(\jmath\omega) = \tan^{-1}\left(\frac{-\omega}{1}\right) - \tan^{-1}\left(\frac{\omega}{2}\right) \tag{6.1.2}$$

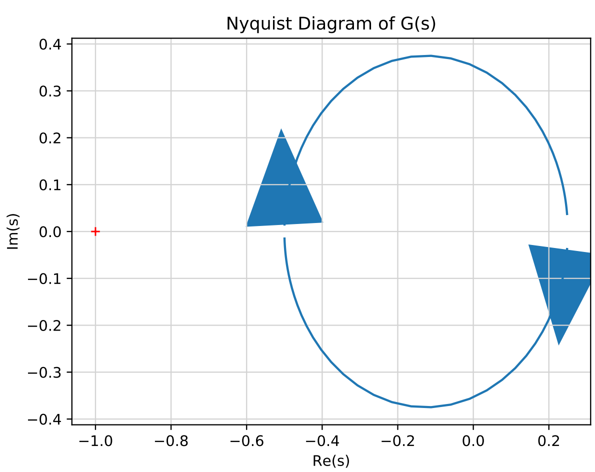
so from this at $\omega = 0$ $\angle G(\jmath\omega) = 0$
and at $\omega = \infty$ $\angle G(\jmath\omega) = -180$

$$\left|G(\jmath\omega)\right| = \frac{\sqrt{1 + \omega^2}}{\sqrt{16 + 4\omega^2}} \tag{6.1.3}$$

when $\omega = 0$ $\left|G(\jmath\omega)\right| = \frac{1}{4}$
and at $\omega = \infty$ $\left|G(\jmath\omega)\right| = \frac{1}{2}$
Plot first 0.25 on positive x-axis then turn -180 degrees from that point i.e 180 degrees clockwise(in this case).
Substitute $s = Re^{\jmath\theta}$

$$\lim_{R\to\infty} G\left(Re^{\jmath\theta}\right) = \frac{1 - Re^{\jmath\theta}}{4 + 2Re^{\jmath\theta}} = \frac{-1}{2} \tag{6.1.4}$$

As there are no $e^{\jmath\theta}$ terms. There will be no enclosed Nyquist path here. So, for this Transfer function $G(s)$,the Nyquist plot is the the Polar plot and its mirror image with respect to real axis.



As from the observed plot the co-ordinate -1 + j0 is outside the contour.
Hence,the number of encirclements around the the given co-ordinate is zero.

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