

Control Systems

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Abstract—The objective of this manual is to introduce control system design at an elementary level.

Download python codes using

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

1 STABILITY

1.1 Second order System

2 ROUTH HURWITZ CRITERION

3 COMPENSATORS

4 NYQUIST PLOT

- 4.1. Using Nyquist criterion, find out the range of K for which the closed loop system will be stable.

$$G(s) = \frac{K}{(s+1)(s+3)}$$

$$H(s) = \frac{1}{(s+5)(s+7)} \quad (4.1.1)$$

4.2. The system flow can be described by Fig. 4.2

4.3. Find the open loop transfer function $G(s)H(s)$

Solution: From (4.1.1),

$$L(s) = G(s)H(s) = \frac{K}{(s+1)(s+3)(s+5)(s+7)} \quad (4.3.1)$$

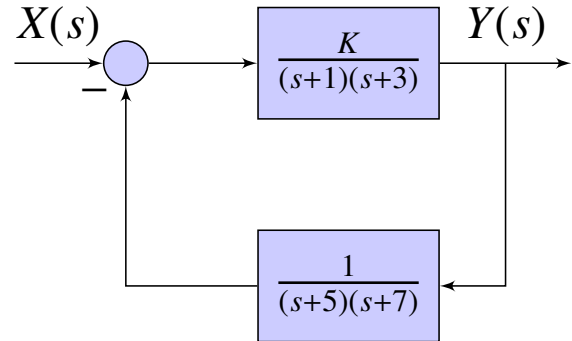


Fig. 4.2

$$L(j\omega) = G(j\omega)H(j\omega) = \frac{K}{(j\omega+1)(j\omega+3)(j\omega+5)(j\omega+7)} \quad (4.3.2)$$

- 4.4. Sketch the Nyquist plot.

Solution: The Nyquist plot is a graph of $\text{Re}\{L(j\omega)\}$ vs $\text{Im}\{L(j\omega)\}$. Let's take $K=1$ and draw the nyquist plot.

The following python code generates the Nyquist plot.

```
/codes/es17btech11015.py
```

The Fig. 4.4 shows the Nyquist plot for $K = 1$

- 4.5. Using the Nyquist Stability criterion, determine the value of K for which the system in (4.1.1) is stable.

Solution:

Nyquist criterion—For the stable system :

$$Z = P + N = 0, \quad (4.5.1)$$

where,

Z = Poles of $\frac{G(s)}{1+G(s)H(s)}$ in right half of s plane

P = Poles of $G(s)H(s)$ in right half of s plane

N = No. of encirclements of $G(s)H(s)$ about -1 in the Nyquist plot

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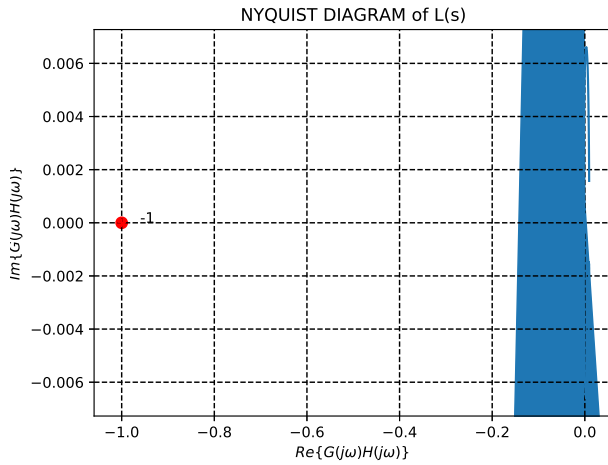


Fig. 4.4

Since from the equation (4.3.1), $P = 0$

So, for Z to be equal to 0, we have to choose the range of K such that N is equal to 0.

4.6. Find the range of K from Nyquist criterion.

Solution: From the figure 4.4, we can observe that the plot is not cutting the x-axis. If we consider the Nyquist plot with K term even then the plot won't cut the x-axis.

So, $N = 0$ irrespective of K .

Therefore, the system is stable for

$$-\infty < K < \infty \quad (4.6.1)$$