

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
```

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1 POLAR PLOT

1.1 Introduction

1.2 Example

1.3 Example

1.4 Example

1.5 Example

1.6 Example

1.7 Example

2 BODE PLOT

2.1 Gain and Phase Margin

2.2 Example

2.3 Example

3 PID CONTROLLER

3.1 Introduction

4 NYQUIST PLOT

4.1. Using Nyquist criterion find the range of K for which closed loop system is stable.

$$G(s) = \frac{K}{s(s+6)}. \quad (4.1.1)$$

And,

$$H(s) = \frac{1}{s+9} \quad (4.1.2)$$

Solution: The system flow can be described as,

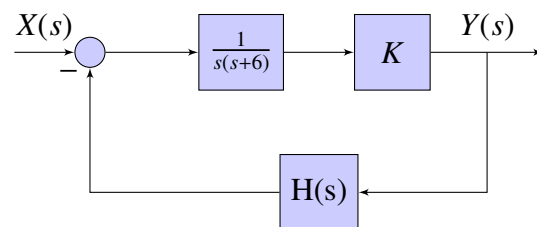


Fig. 4.1

$$G_1(s) = \frac{1}{s(s+6)}. \quad (4.1.3)$$

For Nyquist plot,

$$\text{Im}\{G_1(j\omega)H(j\omega)\} = \frac{-(54 - \omega^2)}{(\omega)(\omega^2 + 56)(\omega^2 + 81)} \quad (4.1.4)$$

$$\text{Re}\{G_1(j\omega)H(j\omega)\} = \frac{-15\omega}{(\omega)(\omega^2 + 56)(\omega^2 + 81)} \quad (4.1.5)$$

From 4.1.4 and 4.1.5

$$\Rightarrow K < 810 \quad (4.1.11)$$

And also,

$$K > 0 \quad (4.1.12)$$

$$\Rightarrow 0 < K < 810 \quad (4.1.13)$$

The following python code generates Fig. 4.1

codes/ee18btech11028_1.py

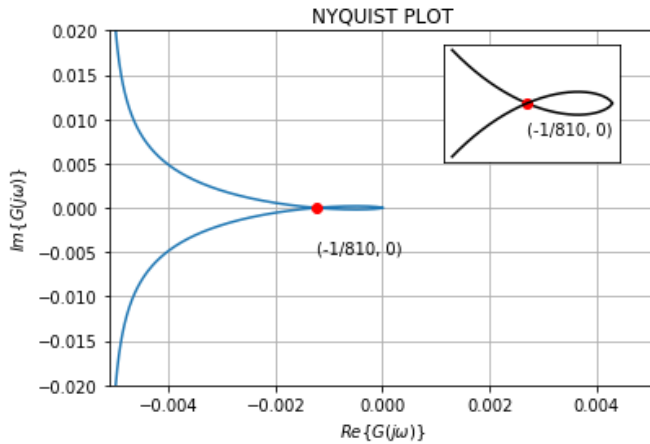


Fig. 4.1: Nyquist plot for $G_1(s)H(s)$

Nyquist Stability Criterion:

$$N = Z - P \quad (4.1.6)$$

where Z is # unstable poles of closed loop transfer function, P is # unstable poles of open loop transfer function and N is # clockwise encirclement of $(-1/K, 0)$.

For stable system,

$$Z = 0 \quad (4.1.7)$$

From 4.1.2 and 4.1.3,

$$P = 0 \quad (4.1.8)$$

$$\Rightarrow N = 0 \quad (4.1.9)$$

Since, there is a zero at origin, an infinite radius half circle will enclose the right hand side of end points of the Nyquist plot.

$$\Rightarrow \frac{-1}{K} < \frac{-1}{810} \quad (4.1.10)$$