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 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

2.1. Using Nyquist criterion, find out whether the system below is stable or not

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$$G(s) = \frac{41}{s^2(s+3)} \tag{2.1.1}$$

$$H(s) = (s+4) \tag{2.1.2}$$

Solution: According to the Nyquist criteria the number of unstable closed-loop poles (Z) is equal to the number of unstable open-loop poles (P) plus the number of clockwise encirclements (N) of the point (-1,j0) of the Nyquist plot of G(s)H(s), i.e

$$Z = N + P \tag{2.1.3}$$

Open loop transfer function :

$$G(s)H(s) = \frac{41(s+4)}{s^2(s+3)} \tag{2.1.4}$$

Closed loop transfer function:

$$T(s) = \frac{G(s)}{1+G(s)H(s)} = \frac{41}{s^3+3s^2+41s+164} \tag{2.1.5}$$

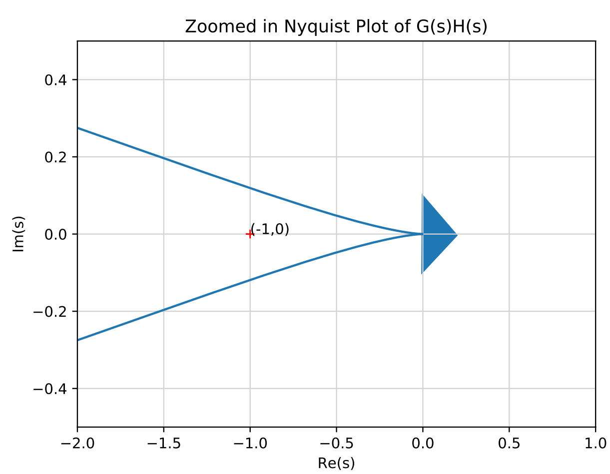

Fig. 2.1.1

In Fig.2.1.1 it can be seen that there is a clockwise encirclement around (-1+0j). As the open loop transfer function has zero pole of multiplicity 2, therefore it should be assumed that the phasor travels 2 times clock-wise along a semicircle of infinite radius.

N=2, P=0

$$\implies Z = 2 \tag{2.1.6}$$

Therefore, The system T(s) is unstable as it has two poles on the right side of the s plane. The following code generates the nyquist plot

```
codes/ee18btech11041.py
```

3 PID Controller

3.1 Introduction