***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
```

1 Signal Flow Graph

1.1 Mason's Gain Formula

1.2 Matrix Formula

2 Bode Plot

2.1 Introduction

2.2 Example

3 Second order System

3.1 Damping

3.2 Example

4 Routh Hurwitz Criterion

4.1 Routh Array

4.2 Marginal Stability

4.3 Stability

4.4 Example

5 State-Space Model

5.1 Controllability and Observability

5.2 Second Order System

5.3 Example

5.4 Example

6 Nyquist Plot

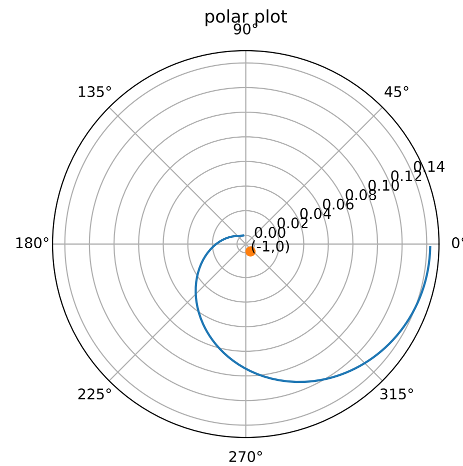
6.1 Polar plots

6.1. Plot the polar plot of

$$G(s) = \frac{1}{(s+1)(s+2)(s+3)}. \tag{6.1.1}$$

Solution: For polar plot we have to plot magnitude of $G(s)$ versus its phase by varying ω from 0 to ∞.
The following python code generates the polar plot below:

```
codes/ee18btech11033.py
```



6.2. How to tell about the stability of a closed loop system based on the polar plot above?
Solution: The polar plots are for open loop transfer function,hence the reference point for determining stability is shifted to (-1,0).
- If (-1,0) is to the left of the polar plot then the closed loop system is stable.
- If (-1,0) is on the right side of the polar plot then the closed loop system is unstable.
- If t(-1,0) is on the polar plot then the closed loop system is marginally stable.

Therefore, from the above plot since (-1,0) is on the right side of the polar plot the system is unstable.

7 Compensators

7.1 Phase Lead

7.2 Example

8 Gain Margin

8.1 Introduction

8.2 Example

9 Phase Margin

10 Oscillator

10.1 Introduction

10.2 Example