Contents

***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

1 Stability

2 Routh Hurwitz Criterion

3 Compensators

4 Nyquist Plot

5 State Space Analysis

5.0.1. A second-order LTI system is described by the following state equations

$$\frac{\partial x_1(t)}{\partial t} - x_2(t) = 0 \tag{5.0.1.1}$$

$$\frac{\partial x_2(t)}{\partial t} + 2x_1(t) + 3x_2(t) = r(t) \tag{5.0.1.2}$$

$$c(t) = x_1(t). \tag{5.0.1.3}$$

where $x_1(t)$ and $x_2(t)$ are the two state variables and r(t) denotes the input. The output is $c(t)$. Express this in terms of the state space model.
Solution: From (**??**), (5.0.1.1)-(5.0.1.3) can be expressed as

$$\dot{\mathbf{x}}(t) = \mathbf{A}\mathbf{x}(t) + \mathbf{B}\mathbf{u}(t) \tag{5.0.1.4}$$

$$\mathbf{y}(t) = \mathbf{C}\mathbf{x}(t) + \mathbf{D}\mathbf{u}(t) \tag{5.0.1.5}$$

where

$$\mathbf{A} = \begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix} \tag{5.0.1.6}$$

$$\mathbf{B} = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \tag{5.0.1.7}$$

$$\mathbf{C} = \begin{pmatrix} 1 & 0 \end{pmatrix} \tag{5.0.1.8}$$

$$\mathbf{D} = 0 \tag{5.0.1.9}$$

5.0.2. Find the system transfer function $H(s)$.
Solution: From (**??**),

$$H(s) = \mathbf{C}(s\mathbf{I} - \mathbf{A})^{-1}\mathbf{B} + D\mathbf{I} \tag{5.0.2.1}$$

$$= \frac{1}{s^2 + 3s + 2} \tag{5.0.2.2}$$

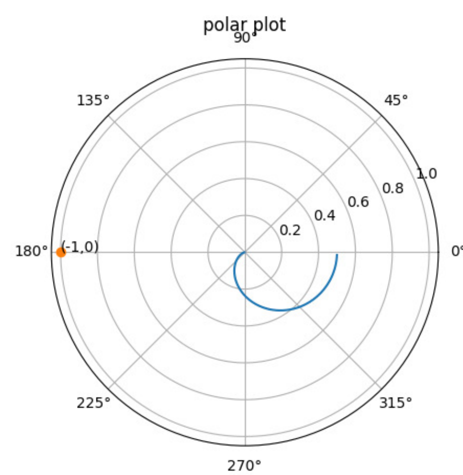
using the code in codes/ee18btech11031.py

5.0.3. Identify the damping type.
Solution: From (**??**) and

$$\omega = \sqrt{2}, \zeta = \frac{3}{2\sqrt{2}} > 1 \tag{5.0.3.1}$$

From Table **??**, the sytem is overdamped.

5.0.4. Consider H(s) as the open loop transfer function for a unity feedback system. Deduce conclusions on stability of the system employing the polar plot.
Solution: For polar plot: Use the code in codes/ee18btech11031(2).py



Conclusion: Since the point $(-1, 0)$ is not enclosed by the contour in **??**, the closed loop system is stable.