

CONTENTS

1	Stability	1
2	Routh Hurwitz Criterion	1
3	Compensators	1
4	Nyquist Plot	1

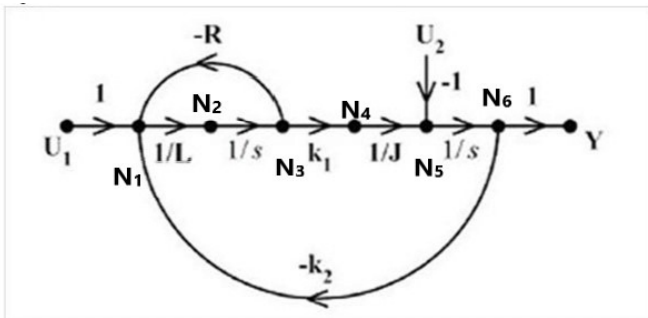
Abstract—This manual is an introduction to control systems based on GATE problems. Links to sample Python codes are available in the text.

Download python codes using

1 STABILITY

2 ROUTH HURWITZ CRITERION

2.1. In a system whose signal flow graph is shown in the figure, $U_1(s)$ and $U_2(s)$ are inputs. The transfer function $\frac{Y(s)}{U_1(s)}$ is



Solution:

$$\left. \frac{Y(s)}{U_1(s)} \right|_{U_2(s)=0} \quad (2.1.1)$$

Using Matrix Formula:

The transition equations are

$$N_1 = U_1 - RN_3 - k_2 N_6 \quad (2.1.2)$$

$$N_2 = \frac{N_1}{L} \quad (2.1.3)$$

$$N_3 = \frac{N_2}{s} \quad (2.1.4)$$

$$N_4 = k_1 N_3 \quad (2.1.5)$$

$$N_5 = \frac{N_4}{J} \quad (2.1.6)$$

$$N_6 = \frac{N_5}{s} \quad (2.1.7)$$

State Transition Matrix :

$$\mathbf{T} = \begin{pmatrix} 0 & 0 & -R & 0 & 0 & -k_2 \\ \frac{1}{L} & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{s} & 0 & 0 & 0 & 0 \\ 0 & 0 & k_1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{J} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{s} & 0 \end{pmatrix} \quad (2.1.8)$$

$$\mathbf{U} = (\mathbf{I} - \mathbf{T})^{-1} \quad (2.1.9)$$

$$(\mathbf{I} - \mathbf{T}) = \begin{pmatrix} 1 & 0 & R & 0 & 0 & k_2 \\ \frac{-1}{L} & 1 & 0 & 0 & 0 & 0 \\ 0 & \frac{-1}{s} & 1 & 0 & 0 & 0 \\ 0 & 0 & -k_2 & 1 & 0 & 0 \\ 0 & 0 & 0 & \frac{-1}{J} & 1 & 0 \\ 0 & 0 & 0 & 0 & \frac{-1}{s} & 1 \end{pmatrix} \quad (2.1.10)$$

U_{50} will be the gain of the system

$$U_{50} = \frac{\begin{vmatrix} \frac{-1}{L} & 1 & 0 & 0 & 0 \\ 0 & \frac{-1}{s} & 1 & 0 & 0 \\ 0 & 0 & -k_2 & 1 & 0 \\ 0 & 0 & 0 & \frac{-1}{J} & 1 \\ 0 & 0 & 0 & 0 & \frac{-1}{s} \end{vmatrix}}{\begin{vmatrix} 1 & 0 & R & 0 & 0 & k_2 \\ \frac{-1}{L} & 1 & 0 & 0 & 0 & 0 \\ 0 & \frac{-1}{s} & 1 & 0 & 0 & 0 \\ 0 & 0 & -k_2 & 1 & 0 & 0 \\ 0 & 0 & 0 & \frac{-1}{J} & 1 & 0 \\ 0 & 0 & 0 & 0 & \frac{-1}{s} & 1 \end{vmatrix}} \quad (2.1.11)$$

Gain can be found by cofactor expansion or else by running the code in (1.2.5). Gain obtained is

$$\frac{Y(s)}{U_1(s)} = \frac{k_1}{s^2 L J + s R J + k_1 k_2} \quad (2.1.12)$$

3 COMPENSATORS

4 NYQUIST PLOT