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 svn co https://github.com/gadepall/school/trunk/control/codes

1 Stability

1.1 Second order System

2 Routh Hurwitz Criterion

2.1. consider a standard negative feedback transfer function configuration with

$$G(s) = \frac{1}{(s+1)(s+2)} \tag{2.1.1}$$

and

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

the closed loop system to have poles on the imaginary axis,the value of α should be equal to **Solution:** The transfer function for negative

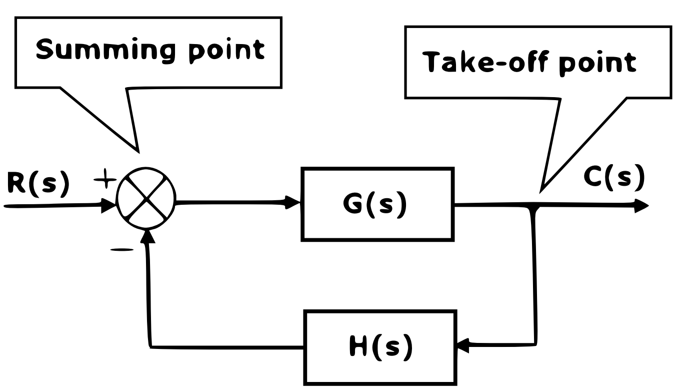

Fig. 2.1

feedback is given by

$$\frac{Y(s)}{X(s)} = \frac{G(s)}{1+G(s)H(s)} \tag{2.1.3}$$

where

$$G(s) = \frac{1}{(s+1)(s+2)}, H(s) = \frac{s+\alpha}{s} \tag{2.1.4}$$

Characteristic equation is..,

$$1 + G(s)H(s) = 0 \tag{2.1.5}$$

$$=> 1 + \left[\frac{1}{(s+1)(s+2)}\right]\left[\frac{s+\alpha}{s}\right] = 0 \tag{2.1.6}$$

$$=> s^3 + 3s^2 + 3s + \alpha = 0 \tag{2.1.7}$$

For poles to lie on imaginary axis any one entire row of hurwitz matrix should be zero. Constructing the routh array for the characteristic equation obtained in equation

$$s^3 + 3s^2 + 3s + \alpha = 0 \tag{2.1.8}$$

$$\begin{vmatrix} s^3 \\ s^2 \end{vmatrix}\begin{vmatrix} 1 & 3 \\ 3 & \alpha \end{vmatrix} \tag{2.1.9}$$

$$\begin{vmatrix} s^3 \\ s^2 \\ s^1 \end{vmatrix}\begin{vmatrix} 1 & 3 \\ 3 & \alpha \\ \frac{9-\alpha}{3} & 0 \end{vmatrix} \tag{2.1.10}$$

$$\begin{vmatrix} s^3 \\ s^2 \\ s^1 \\ s^0 \end{vmatrix}\begin{vmatrix} 1 & 3 \\ 3 & \alpha \\ \frac{9-\alpha}{3} & 0 \\ \alpha & 0 \end{vmatrix} \tag{2.1.11}$$

For poles on jω axis any one of the row should be zero.

$$\frac{9-\alpha}{3} = 0 \; or \; \alpha = 0 \tag{2.1.12}$$

But when $\alpha = 0$ poles does not lie on the imaginary axis

$$9 - \alpha = 0 \tag{2.1.13}$$

$$\alpha = 9 \tag{2.1.14}$$

put α in the characteristic equation we get

$$s^3 + 3s^2 + 3s + 9 = 0 \tag{2.1.15}$$

poles are

$$s = -3, -j\sqrt{3}, j\sqrt{3} \tag{2.1.16}$$

3 Compensators

4 Nyquist Plot