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

1.1 Second order System

2 Routh Hurwitz Criterion

3 Compensators

4 Nyquist Plot

4.0.1. For the unity feedback system G(s), find the closed loop frequency response using constant M and N circles.

$$G(s) = \frac{1000}{(s+3)(s+4)(s+5)(s+6)} \quad (4.0.1.1)$$

Solution: M circle are constant magnitude loci and N circles are constant phase loci of the closed loop transfer function. let,

$$g(j\omega) = x + jy \quad (4.0.1.2)$$

T be the closed loop transfer function.

$$T = \frac{g(j\omega)}{1 + g(j\omega)} \quad (4.0.1.3)$$

$$T = \frac{x + jy}{1 + x + jy} \quad (4.0.1.4)$$

A. hence, magnitude is given by -

$$M = \frac{\sqrt{x^2 + y^2}}{\sqrt{(1+x)^2 + y^2}} \quad (4.0.1.5)$$

rearranging,

$$[x - \frac{M^2}{1 - M^2}]^2 + y^2 = [\frac{M^2}{1 - M^2}]^2 \quad (4.0.1.6)$$

For different values of M,it represents a family of circles. The intersection of niquest plot with M circles plot gives the magnitude plot of

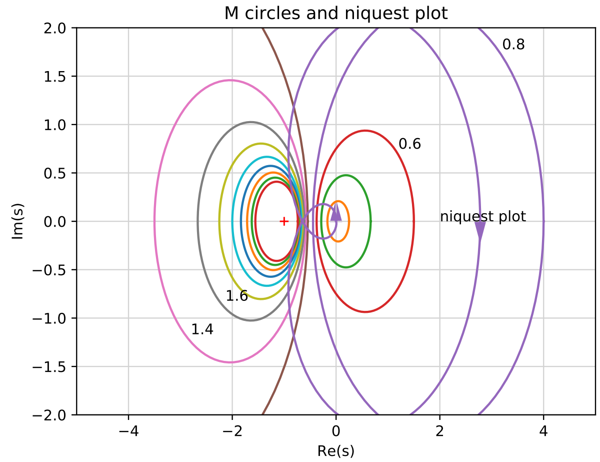

Fig. 4.0.1

closed loop system.

B. phase is given by -

$$\phi = \arctan\frac{y}{x} - \arctan\frac{y}{1+x} \quad (4.0.1.7)$$

$$\tan\phi = \frac{y}{x^2} + x + y^2 \quad (4.0.1.8)$$

substituting $\tan\phi = N$

$$N = \frac{y}{x^2} + x + y^2 \quad (4.0.1.9)$$

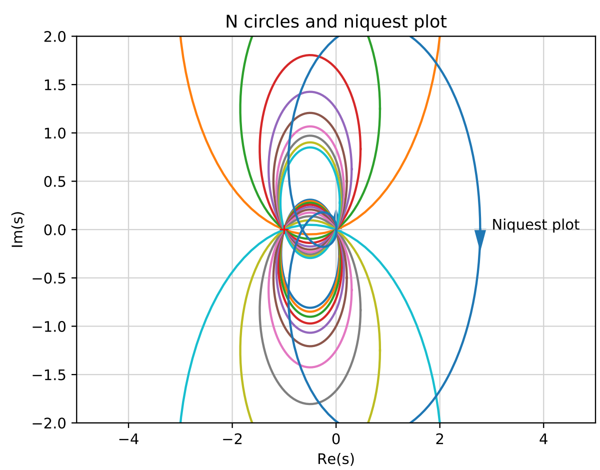

Fig. 4.0.1

For different values of N,it represents a family of circles. The intersection of niquest plot with N circles plot gives the phase plot of closed loop system.

Hence closed loop frequency response is -

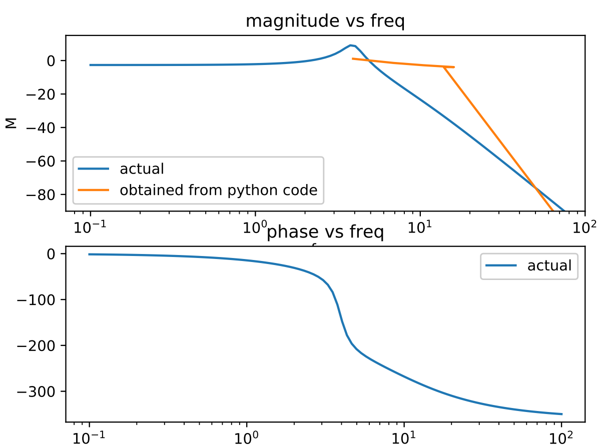
magnitude vs freq
0
−20
−40
−60
−80
M
actual
obtained from python code
10^{-1}
10^{0}
10^{1}
10^{2}
phase vs freq
0
−100
−200
−300
actual
10^{-1}
10^{0}
10^{1}
10^{2}

Fig. 4.0.1