4.3 RELATIVE STABILITY

The relative stability indicates the looseness of the system to stable region. It is an introduction of the strength or degree of stability.

In time domain the relative stability may be measured by relative settling times of each root or pair of roots. The settling time is inversely proportional to the location of roots of characteristics equation. If the root is located far away from the imaginary axis, then the transients' dies out faster and so the relative stability of the system will improve.

In frequency domain the relative stability of a system can be studied from nyquist plot. The relative stability of the system is given by closeness of polar plot to -1+j0 point. As the polar plot gets closer to -1+j0 point the system moves towards instability.

The relative stability in frequency domain are quantitatively measured in terms of phase margin and gain margin. Consider a G(j®)H(j®) locus .let this locus cross the real axis at point-A and unit circle drawn with origin as centre cuts this locus at point-B.

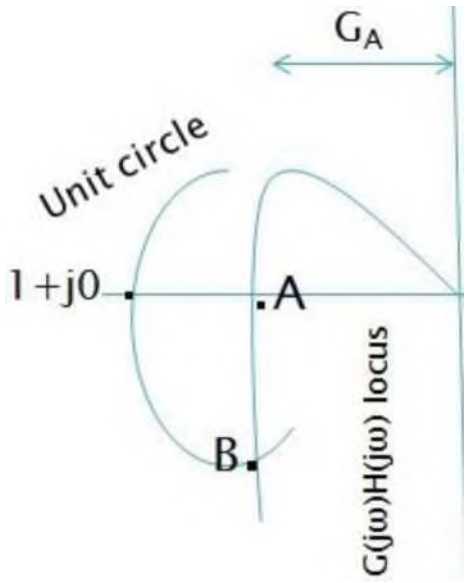

Figure 4.3.1: G(j®)H(j®) locus

[Source: "Control System Engineering" by Nagoor Kani, page-4.54]

If the gain of the system is increased, then the locus will shift upwards and it may cross real axis at -1+j0 point. When the locus passes through -1+j0 point, GA— 1 and y- -- 0. Hence the closeness of G(j®)H(j®) locus shown in fig 4.3.1 to the critical point - 1+j0 can be measured in terms of intercept G_A and angle y. The value of G_A and angle y are quantitative indications of relative stability. These values are used to define gain margin and phase margin as practical measures of relative stability.

Gain Margin & Phase Margin

Gain margin is a factor by which the system gain can be increased to drive the system to the verge of instability.

$$\text{Gain margin in db} = -20 \log G_A$$

The phase margin is defined as the amount of additional phase lag at gain crossover frequency required to bring the system to verge of instability.

$$\text{Phase margin, } \gamma = 180^0 + p_{gc}$$