5.3 STABILITY CONSIDERATIONS:

STABILITY:

Is the ability of an amplifier to maintain effectiveness in its nominal operating characteristics such as physical temperature, signal frequency, source & load coefficient etc.

STABILITY REQUIREMENT:

Stability then implies that the magnitudes of the reflection coefficients are less than unity.

$$|\Gamma_L| < 1 \ , \ |\Gamma_S| < 1$$

$$|\Gamma_{in}| = S_{11} + \left| \frac{S_{12} \, S_{21} \, \Gamma_L}{1 - S_{22} \, \Gamma_L} \right| < 1$$

$$|\Gamma_{out}| = S_{22} + \left| \frac{S_{12} \, S_{21} \, \Gamma_S}{1 - S_{11} \, \Gamma_s} \right| < 1$$

TYPES OF STABILITY:

  i)   UNCONDITIONAL STABILITY:

A network is said to be "unconditionally stable" in a frequency range if:

$$|\Gamma_{in}| < 1 \ \& \ |\Gamma_{out}| < 1$$

$$|\Gamma_L| < 1 \ \& \ |\Gamma_S| < 1$$

  ii)   CONDITIONAL STABILITY:

A network is said to be "conditionally stable" or "potentially unstable" in a frequency range if:

$$|\Gamma_{in}| < 1 \ \& \ |\Gamma_{out}| < 1$$

STABILITY CIRCLES:

  i.   Input stability circle
  ii.   Output stability circle

OUTPUT STABILITY CIRCLE:

In Fig 5.31, For output stability circle $|\Gamma_{in}| = 1$

$$|\Gamma_{in}| = \left| S_{11} + \frac{S_{12} \, S_{21} \, \Gamma_L}{1 - S_{22} \, \Gamma_L} \right| = 1$$

$$|S_{11} \, (1 - S_{22} \, \Gamma_L) + S_{12} \, S_{21 \, \Gamma_L}| = |1 - S_{22} \, \Gamma_L|$$

$$|S_{11} - S_{11} \, S_{22} \, \Gamma_L + S_{12} \, S_{21} \, \Gamma_L| = |1 - S_{22} \, \Gamma_L|$$

$$|S_{11} - (S_{11} \, S_{22} - S_{12} \, S_{21})\Gamma_L| = |1 - S_{22} \, \Gamma_L|$$

$$S_{11} \, S_{22} - S_{12} \, S_{21} = \Delta$$

$$|S_{11} - \Delta\Gamma_L| = |1 - S_{22} \, \Gamma_L|$$

$$|S_{11}| - \Delta|\Gamma_L| = 1 - |S_{22} \, \Gamma_L|$$

$$|S_{22} \, \Gamma_L| - \Delta|\Gamma_L| = 1 - |S_{11}|$$

$$(S_{22} - \Delta) \, |\Gamma_L| = 1 - |S_{11}|$$

Multiply $(S_{22}{}^* + \Delta^*)$ both sides

$$|\Gamma_L|\{(S_{22} - \Delta)\} \, \{(S_{22}{}^* + \Delta^*)\} = \{1 - |S_{11}|\}\{(S_{22}{}^* + \Delta^*)\}$$

$$|\Gamma_L|\{|S_{22}|^2 - |\Delta|^2\} = |S_{22}{}^*| + |\Delta^*| - |S_{11} \, S_{22}{}^*| - |S_{11} \, \Delta^*|$$

$$|\Gamma_L|\{|S_{22}|^2 - |\Delta|^2\} = |S_{22}{}^*| + \left| S_{11}{}^* \, S_{22}{}^* \right| - |S_{12}{}^* S_{21}{}^*| - |S_{11} \, S_{22}{}^*| - |S_{11} \, \Delta^*|$$

$$|\Gamma_L| = \frac{|S_{22}{}^*| + |S_{11}{}^* \, S_{22}{}^*| - |S_{12}{}^* S_{21}{}^*| - |S_{11} \, S_{22}{}^*| - |S_{11} \, \Delta^*|}{|S_{22}|^2 - |\Delta|^2}$$

$$|\Gamma_L| = \frac{|S_{22}{}^*| - |S_{12}{}^* S_{21}{}^*| - |S_{11} \, \Delta^*|}{|S_{22}|^2 - |\Delta|^2}$$

$$\left| \Gamma_L - \frac{|S_{22}{}^* - S_{11} \, \Delta^*|}{|S_{22}|^2 - |\Delta|^2} \right| = \left| \frac{S_{12} \, S_{21}}{|S_{22}|^2 - |\Delta|^2} \right|$$

The equation for the output stability circle ($|\Gamma_{in}| = 1$) drawn in the Γ_L plane cab be written as,

$$|\Gamma_L - C_L| = R_L$$

$$C_L = C_{out} = \frac{(S_{22} - S_{11}{}^* \Delta)^*}{|S_{22}|^2 - |\Delta|^2}$$

$$R_L = r_{out} = \left| \frac{S_{12} \, S_{21}}{|S_{22}|^2 - |\Delta|^2} \right|$$
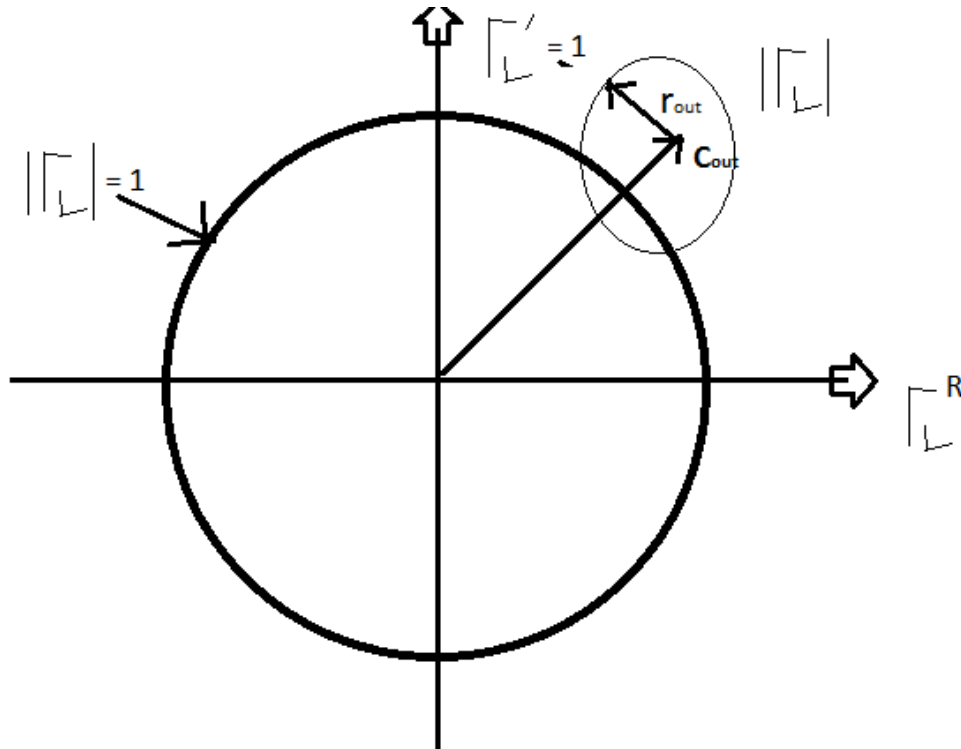
Fig: 5.3.1 Output stability circle

INPUT STABILITY CIRCLE:

In Fig 5.3.2, The input stability circle ($|\Gamma_{out}|$ =1) drawn in the Γ_S plane cab be written as,

$$|\Gamma_S - C_S| = R_S$$

$$C_S = C_{in} = \frac{(S_{11} - S_{11}{}^*\Delta)^*}{|S_{11}|^2 - |\Delta|^2}$$

$$R_S = r_{in} = \left|\frac{S_{12}\ S_{21}}{|S_{11}|^2 - |\Delta|^2}\right|$$

Special case: unconditional stability:

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2}{2|S_{12}||S_{21}|} > 1$$
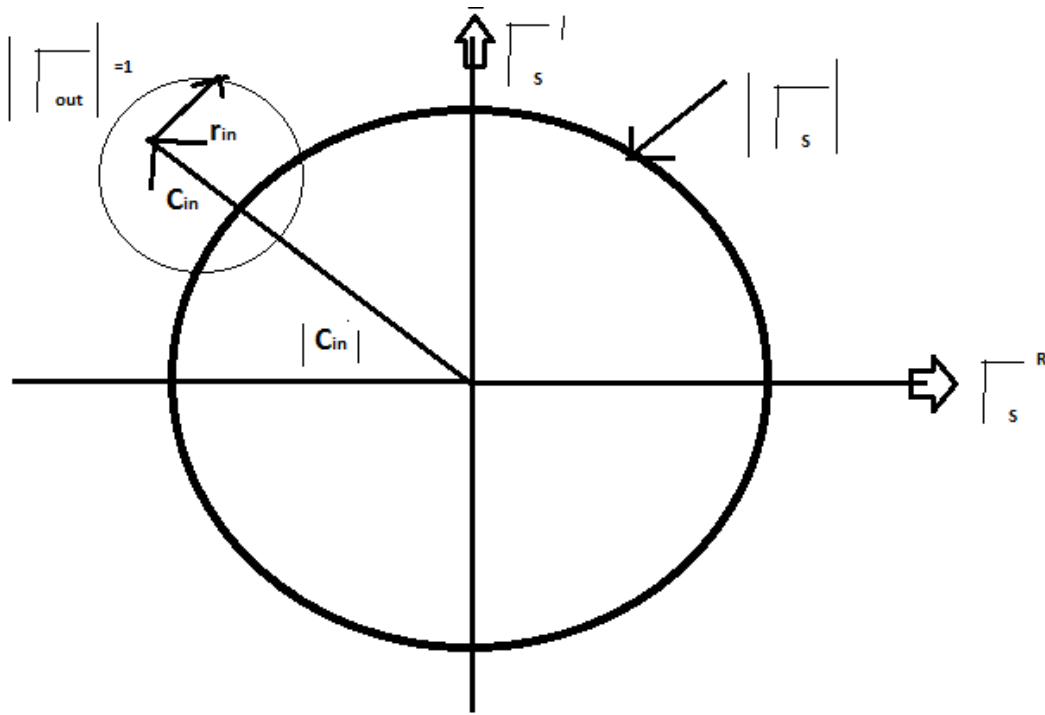
$$|\Delta| = |S_{11}\ S_{22} - S_{12}\ S_{21}| < 1$$

Fig: 5.3.2 Input stability circle