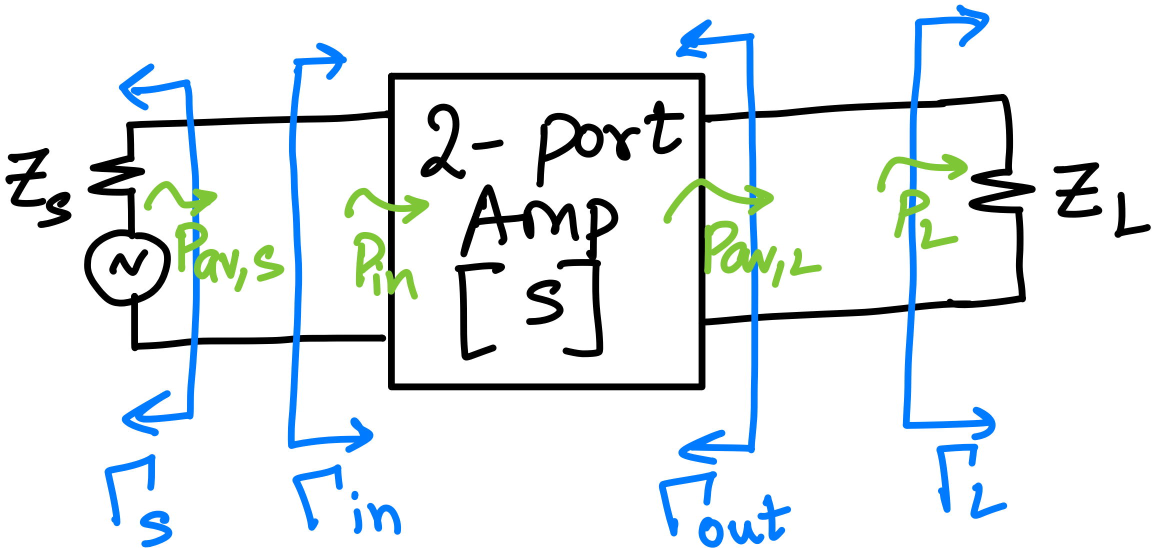
RF Amplifier



$$\Gamma_s = \frac{Z_s - Z_0}{Z_s + Z_0} \qquad \Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}.$$

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

$$\Gamma_{out} = S_{22} + \frac{S_{12}S_{21}\Gamma_s}{1 - S_{11}\Gamma_s}$$

(Pozar Sec 12.1)

$P_{av,s}$ = Power the source would deliver to a conjugate matched load (amp)

P_{in} = Actual power delivered to the load (amp)

$P_{av,L}$, P_{out} are similarly defined.

Gain definitions

G_T : Transducer Power Gain $= \dfrac{P_L}{P_{av,s}}$ } Includes both i/p & o/p match

G_P : Operating Power Gain $= \dfrac{P_L}{P_{in}}$ } Only depends on Z_L

G_A : Available Power Gain $= \dfrac{P_{av,L}}{P_{av,s}}$ } Only depends on Z_S.

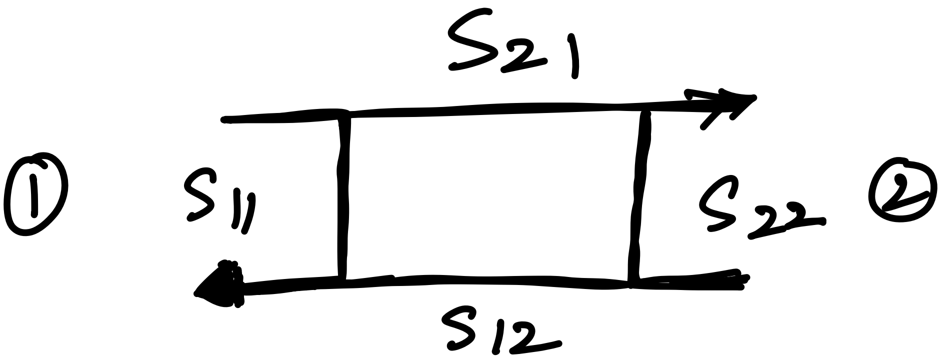
$$G_T = \frac{|S_{21}|^2 \left(1 - |\Gamma_S|^2\right)\left(1 - |\Gamma_L|^2\right)}{|1 - \Gamma_S \Gamma_{in}|^2 \, |1 - S_{22}\Gamma_L|^2}$$

$$G_A = \frac{|S_{21}|^2 \left(1 - |\Gamma_S|^2\right)}{|1 - S_{11}\Gamma_S|^2 \left(1 - |\Gamma_{out}|^2\right)}$$

$$G_P = \frac{|S_{21}|^2 \left(1 - |\Gamma_L|^2\right)}{\left(1 - |\Gamma_{in}|^2\right)\left(1 - S_{22}\Gamma_L|^2\right)}$$

Amplifier Specifications

1) Gain 2) Bandwidth (-3dB)
3) Group delay 4) Noise Figure
5) Large signal parameters (Compression, Harmonics...)
6) P_{DC} 7) Efficiency 8) Stability.



Stability of RF Amplifiers

- $|\Gamma_{in}| > 1$ or $|\Gamma_{out}| > 1$ there is a **potential** for instability.

- If $|\Gamma_{in}| < 1$ & $|\Gamma_{out}| < 1$ then it is guaranteed to be stable.

Stability Circles

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

$$\Gamma_{out} = S_{22} + \frac{S_{12}S_{21}\Gamma_S}{1 - S_{11}\Gamma_S}$$

$$|\Gamma_{in}| = 1$$

$$\Rightarrow \left| S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1 - S_{22}\Gamma_L} \right| = 1 \quad \text{solve for } \Gamma_L$$

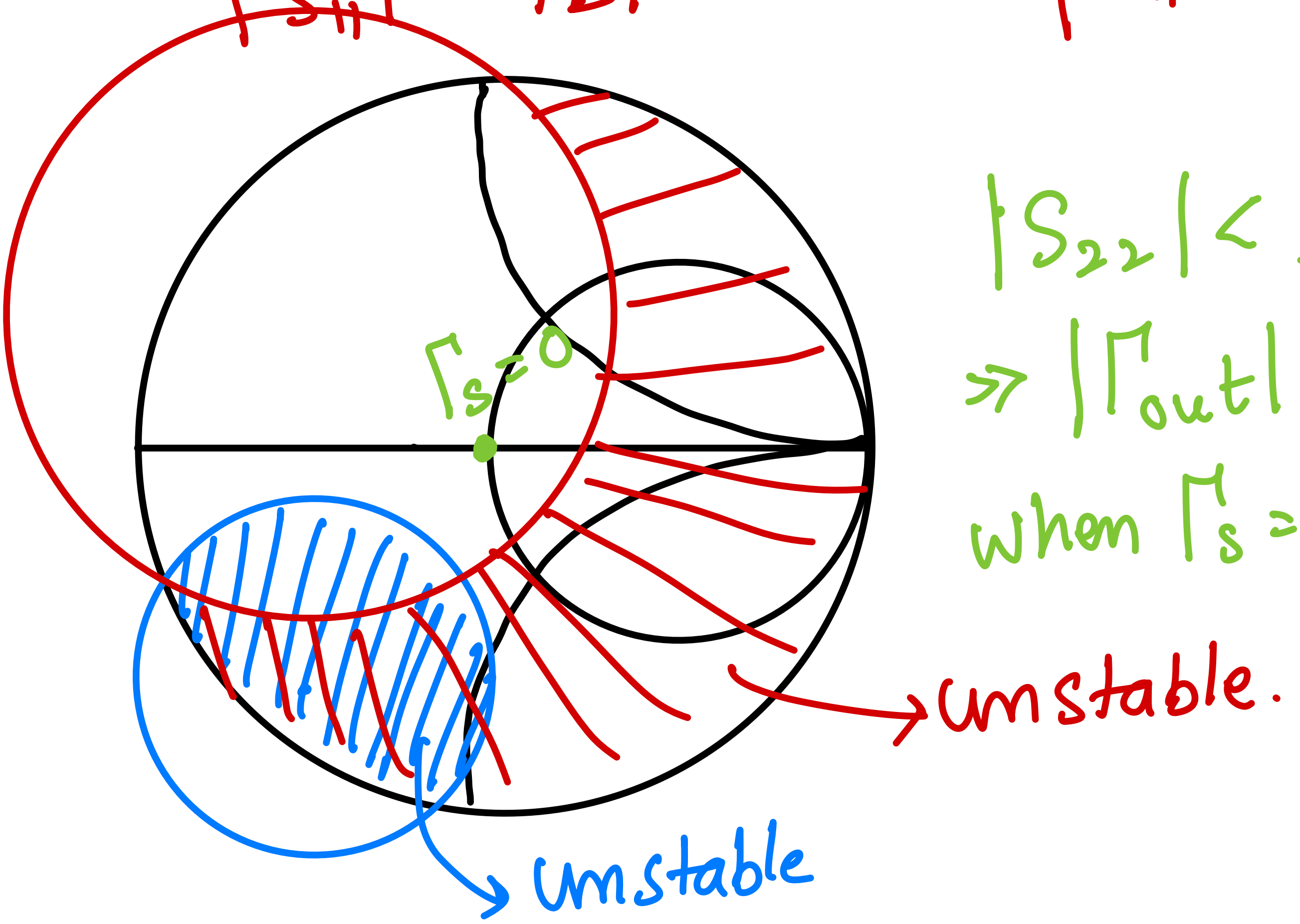
⋮ Pozar Sec 12.2

$$\left| \Gamma_L - \underbrace{\frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2}}_{\text{Center}} \right| = \underbrace{\left| \frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2} \right|}_{\text{Radius.}}$$

$\Delta \rightarrow S_{11}S_{22} - S_{12}S_{21}$

$$C_L = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} \qquad R_L = \left| \frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2} \right|$$

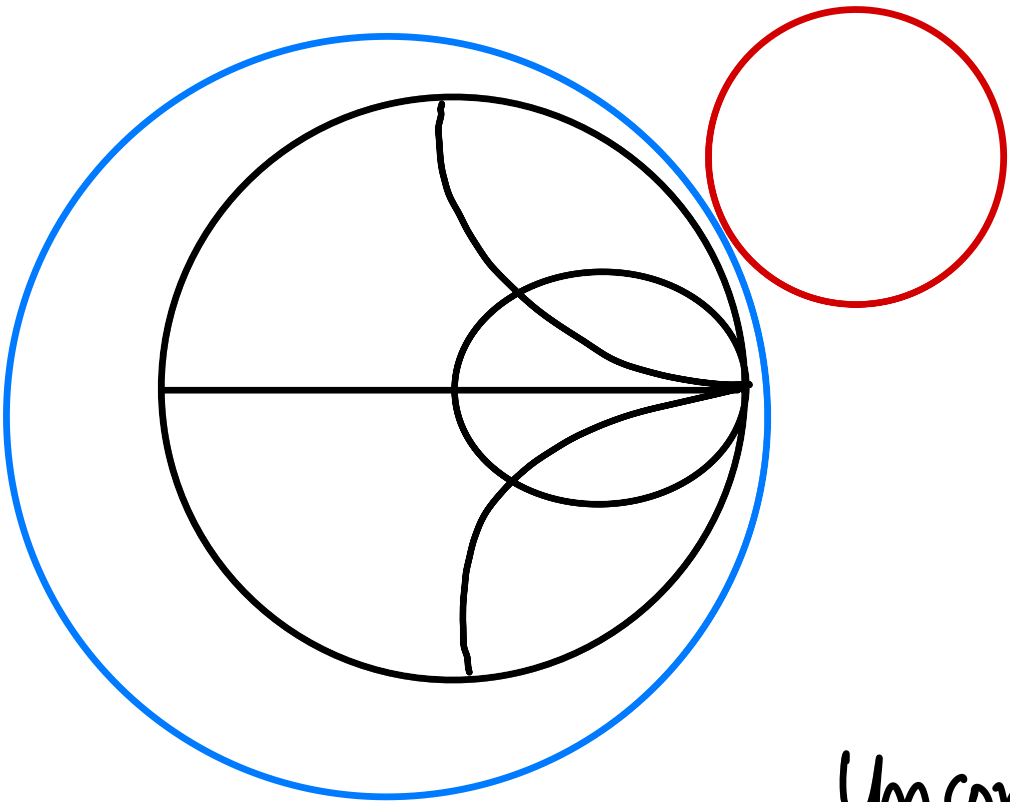
$$C_S = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} \qquad R_S = \left| \frac{S_{12} S_{21}}{|S_{11}|^2 - |\Delta|^2} \right|$$



$|S_{22}| < 1$

$\Rightarrow |\Gamma_{out}| < 1$

when $\Gamma_S = 0$



$|S_{11}| < 1$

$|S_{22}| < 1$

$$\big|\, |C_L| - |R_L| \,\big| > 1 \Rightarrow \text{Unconditional Stability.}$$

⋮

K-Δ Test

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

$$|\Delta| = |S_{11}S_{22} - S_{12}S_{21}| < 1$$

μ-Test

$$\mu = \frac{1 - |S_{11}|^2}{|S_{22} - \Delta S_{11}^*| + |S_{12}S_{21}|} > 1$$

$\mu \rightarrow$ is also a measure of stability.

Steps

1. Measure S-parameters.
2. K-Δ or μ-test for unconditional stability. } over freq range.
3. Plot the source & load stability circles.
4. Then proceed with picking Z_S, Z_L.