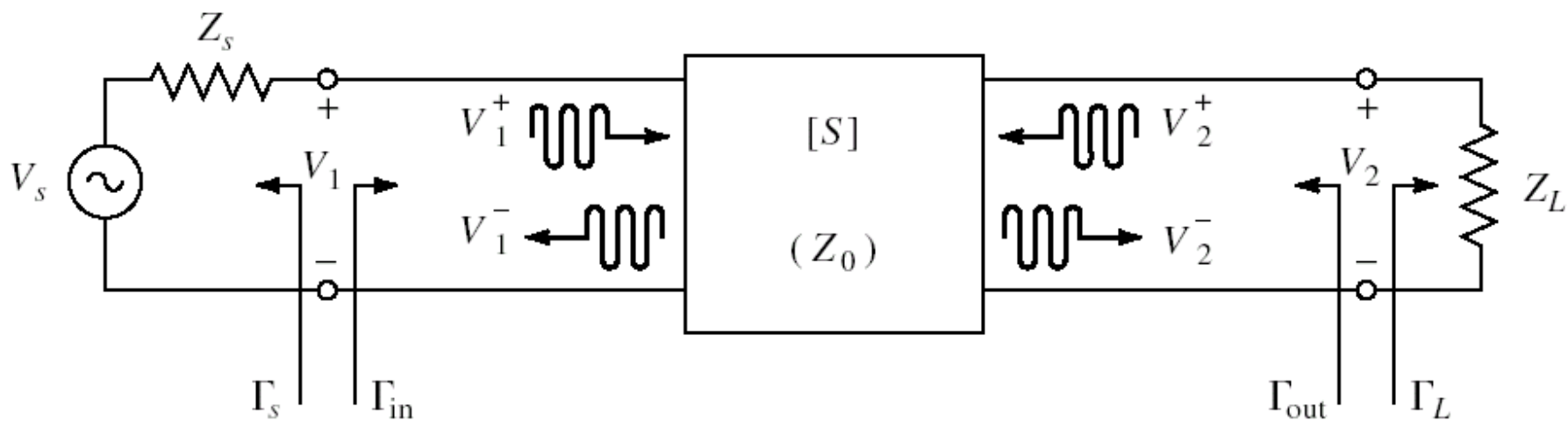


# Amplificatoare de Microunde

Proiectarea unui singur etaj



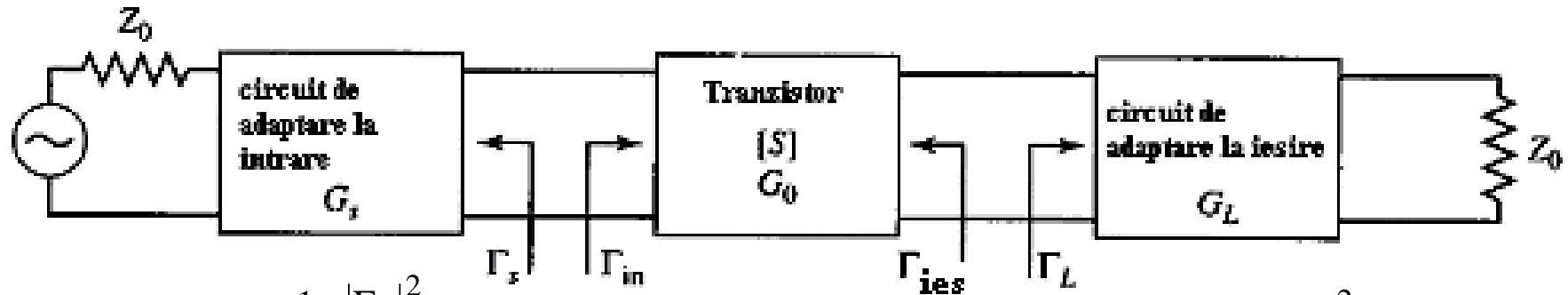
$$V_1^- = S_{11}V_1^+ + S_{12}V_2^+ = S_{11}V_1^+ + S_{12}\Gamma_L V_2^-,$$

$$V_2^- = S_{21}V_1^+ + S_{22}V_2^+ = S_{21}V_1^+ + S_{22}\Gamma_L V_2^-.$$

$$\Gamma_{in} = \frac{V_1^-}{V_1^+} = S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1 - S_{22}\Gamma_L} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0},$$

$$\Gamma_{out} = \frac{V_2^-}{V_2^+} = S_{22} + \frac{S_{12}S_{21}\Gamma_s}{1 - S_{11}\Gamma_s}.$$

# Schema bloc a unui amplificator cu un tranzistor



$$G_S = \frac{1 - |\Gamma_S|^2}{|1 - \Gamma_S \Gamma_{in}|^2}$$

$$G_0 = |S_{21}|^2$$

$$G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \Gamma_L|^2}$$

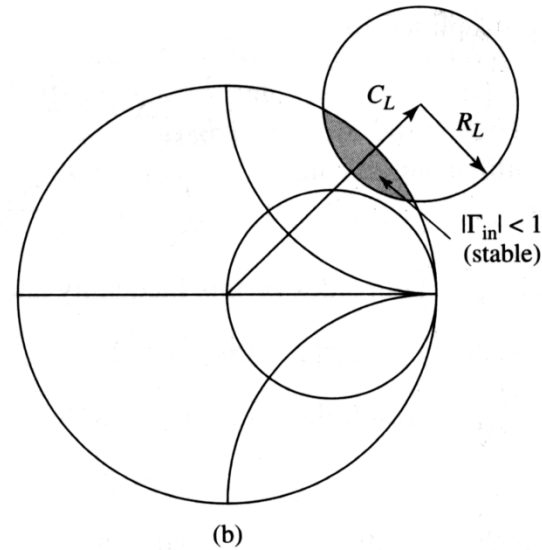
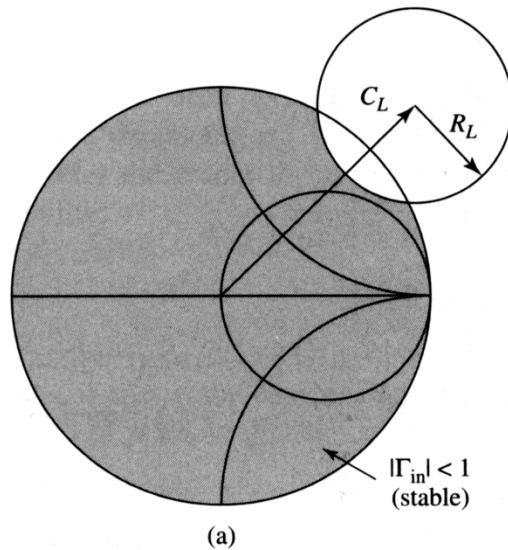
$$G_T = G_S G_0 G_L$$

# Cercurile de stabilitate

cercul de stabilitate la ieșire :  $|\Gamma_{in}| = 1$     cercul de stabilitate la intrare     $|\Gamma_{ies}| = 1$

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

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



$$|\Delta| < 1$$

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

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

# Conditia Rollet

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

# Criteriul $\mu$

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

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

$$\Gamma_S = e^{j\phi} \quad e^{j\phi} = \frac{S_{22} - \Gamma_{\text{out}}}{\Delta - S_{11}\Gamma_{\text{out}}} \quad \left| \frac{S_{22} - \Gamma_{\text{out}}}{\Delta - S_{11}\Gamma_{\text{out}}} \right| = 1$$

$$|\Gamma_{\text{out}}|^2(1 - |S_{11}|^2) + \Gamma_{\text{out}}(\Delta^* S_{11} - S_{22}^*) + \Gamma_{\text{out}}^*(\Delta S_{11}^* - S_{22}) = |\Delta|^2 - |S_{22}|^2$$

$$|\Gamma_{\text{out}}|^2 + \frac{(\Delta^* S_{11} - S_{22}^*)\Gamma_{\text{out}} + (\Delta S_{11}^* - S_{22})\Gamma_{\text{out}}^*}{1 - |S_{11}|^2} = \frac{|\Delta|^2 - |S_{22}|^2}{1 - |S_{11}|^2}$$

$$\left| \Gamma_{\text{out}} + \frac{\Delta S_{11}^* - S_{22}}{1 - |S_{11}|^2} \right|^2 = \frac{|\Delta|^2 - |S_{22}|^2}{1 - |S_{11}|^2} + \frac{|\Delta^* S_{11} - S_{22}^*|^2}{(1 - |S_{11}|^2)^2} = \frac{|S_{12} S_{21}|^2}{(1 - |S_{11}|^2)^2}$$

$$|\Gamma_{\text{out}} - C| = R$$

$$C = \frac{S_{22} - \Delta S_{11}^*}{1 - |S_{11}|^2},$$

$$R = \frac{|S_{12} S_{21}|}{1 - |S_{11}|^2},$$

$$|C| + R < 1 \quad |S_{22} - \Delta S_{11}^*| + |S_{12} S_{21}| < 1 - |S_{11}|^2$$

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

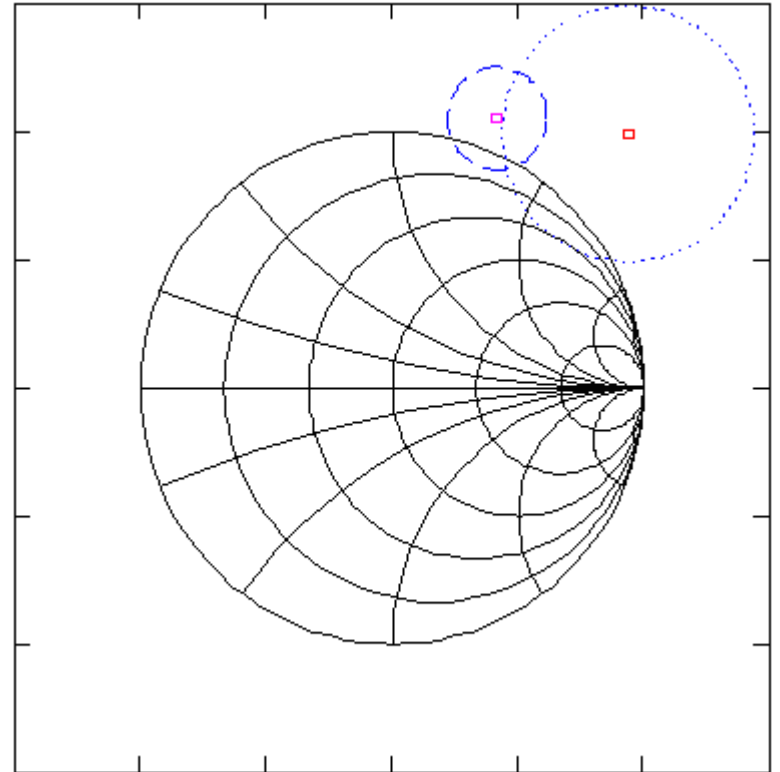
## Exemplu

$$S = \begin{matrix} 0.894e^{-j60.6^\circ} & 0.02e^{j62.4^\circ} \\ 3.122e^{j123.6^\circ} & 0.781e^{-j27.6^\circ} \end{matrix}$$

$$\Delta = S_{11}S_{22} - S_{21}S_{12} = 0.696 \angle -83^\circ$$

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{12}S_{21}|} = 0.607$$

$$\mu = 0.86$$



$$C_L = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} = 1.361 \angle 47^\circ$$

$$C_S = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} = 1.132 \angle 68^\circ$$

$$R_L = \frac{|S_{12}S_{21}|}{|S_{22}|^2 - |\Delta|^2} = 0.5$$

$$R_S = \frac{|S_{12}S_{21}|}{|S_{11}|^2 - |\Delta|^2} = 0.199$$

# Adaptarea simultana - tranzistorul bilateral

$$\Gamma_{in} = \Gamma_S^* \quad G_{T \max} = \frac{1}{1 - |\Gamma_S|^2} |S_{21}|^2 \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

$$\Gamma_{ies} = \Gamma_L^*$$

$$\Gamma_S^* = S_{11} + \frac{S_{12}S_{21}}{\frac{1}{\Gamma_L} - S_{22}} \quad \Gamma_L^* = S_{22} + \frac{S_{12}S_{21}}{\frac{1}{\Gamma_S} - S_{11}} \quad \Gamma_S = S_{11}^* + \frac{S_{12}^*S_{21}^*}{1/\Gamma_L^* - S_{22}^*},$$

$$\Gamma_L^* = \frac{S_{22} - \Delta\Gamma_S}{1 - S_{11}\Gamma_S},$$

$$\Gamma_S(1 - |S_{22}|^2) + \Gamma_S^2(\Delta S_{22}^* - S_{11}) = \Gamma_S(\Delta S_{11}^* S_{22}^* - |S_{11}|^2 - \Delta S_{12}^* S_{21}^*)$$

$$+ S_{11}^*(1 - |S_{22}|^2) + S_{12}^* S_{21}^* S_{22}.$$

$$(S_{11} - \Delta S_{22}^*)\Gamma_S^2 + (|\Delta|^2 - |S_{11}|^2 + |S_{22}|^2 - 1)\Gamma_S + (S_{11}^* - \Delta^* S_{22}) = 0$$

$$\Gamma_S = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1}$$

$$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2$$

$$C_1 = S_{11} - \Delta S_{22}^*$$

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2}$$

$$B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2$$

$$C_2 = S_{22} - \Delta S_{11}^*$$



$$B_1^2 - 4|C_1|^2 = B_2^2 - 4|C_2|^2 = 4(K^2 - 1)|S_{12}|^2|S_{21}|^2$$

$$G_{TU_{\max}} = \frac{1}{1 - |S_{11}|^2} |S_{21}|^2 \frac{1}{1 - |S_{22}|^2}.$$

$$G_{T_{\max}} = \frac{|S_{21}|}{|S_{12}|} (K - \sqrt{K^2 - 1}).$$

$$G_{msg} = \frac{|S_{21}|}{|S_{12}|}$$

## Exemplu

- *Să proiectăm un amplificator pentru un câștig maxim la 4 GHz utilizând un circuit de adaptare cu un singur stub. Să se calculeze și să se reprezinte grafic pierderile de întoarcere la intrare și câștigul între 3 și 5 GHz.*

## Solutie

$$\Delta = S_{11}S_{22} - S_{12}S_{21} = 0.488 \angle -162.289^\circ$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} = 1.195$$

$$\Gamma_S = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} = 0.872 \angle 123.407^\circ$$

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2} = 0.876 \angle 61.026^\circ$$

$$G_S = \frac{1}{1 - |\Gamma_S|^2} = 4.17 = 6.201 \text{ dB}$$

$$G_0 = |S_{21}|^2 = 6.76 = 8.299 \text{ dB}$$

$$G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2} = 1.67 = 2.227 \text{ dB}$$

$$G_{T \max} = 6.201 + 8.229 + 2.227 = 16.657 \text{ dB}$$

$$y_S = \frac{Y_S}{Y_0} = Y_S Z_0 = Y_S \cdot 50 = \frac{1 - \Gamma_S}{1 + \Gamma_S} = 0.3 - j \cdot 1.819$$

$$y_L = \frac{1 - \Gamma_L}{1 + \Gamma_L} = 0.089 - j \cdot 0.586$$

$$y_S(\theta) = \frac{1 - \Gamma_S \cdot e^{2j\theta}}{1 + \Gamma_S \cdot e^{2j\theta}} \quad \Re e[y_S(\theta)] = 1 \quad \theta = 0.75$$

$$l_{L1} = 0.206 \lambda$$

$$l_{S1} = \frac{\theta}{2\pi} = 0.119 \lambda \quad y_S(0.75) = 1 + j \cdot 3.559$$

$$l_{Lstub} = 0.206 \lambda$$

$$l_{Sstub} = \frac{1}{2\pi} \arctan(\Im m(y_S(0.75))) = 0.206 \lambda$$



