# Diseño de Amplificadores de Microondas

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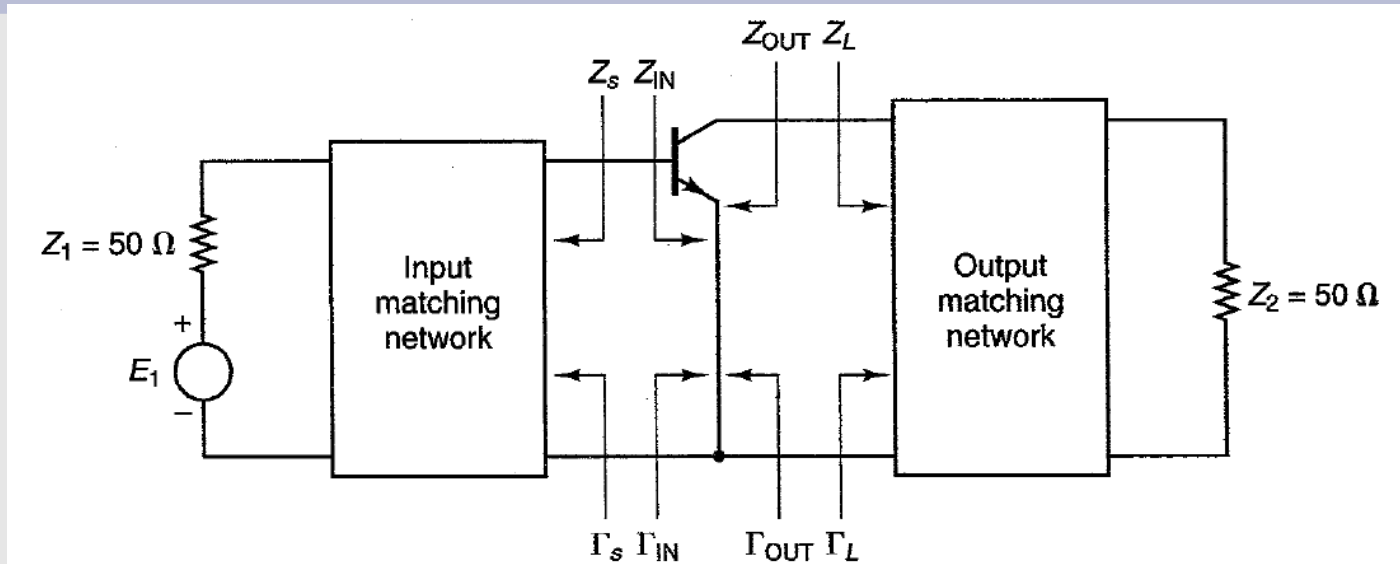
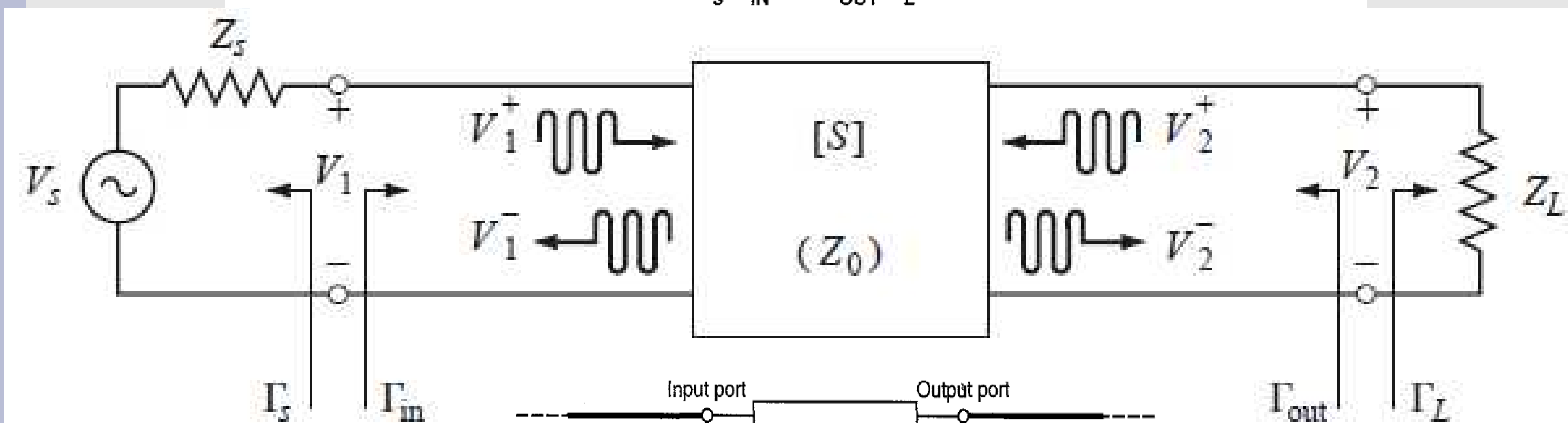
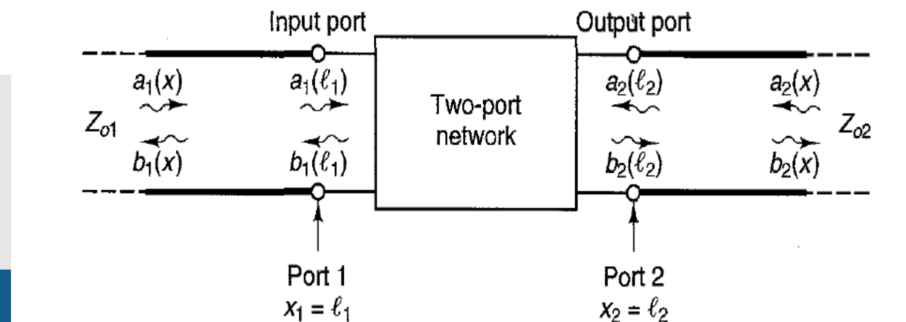
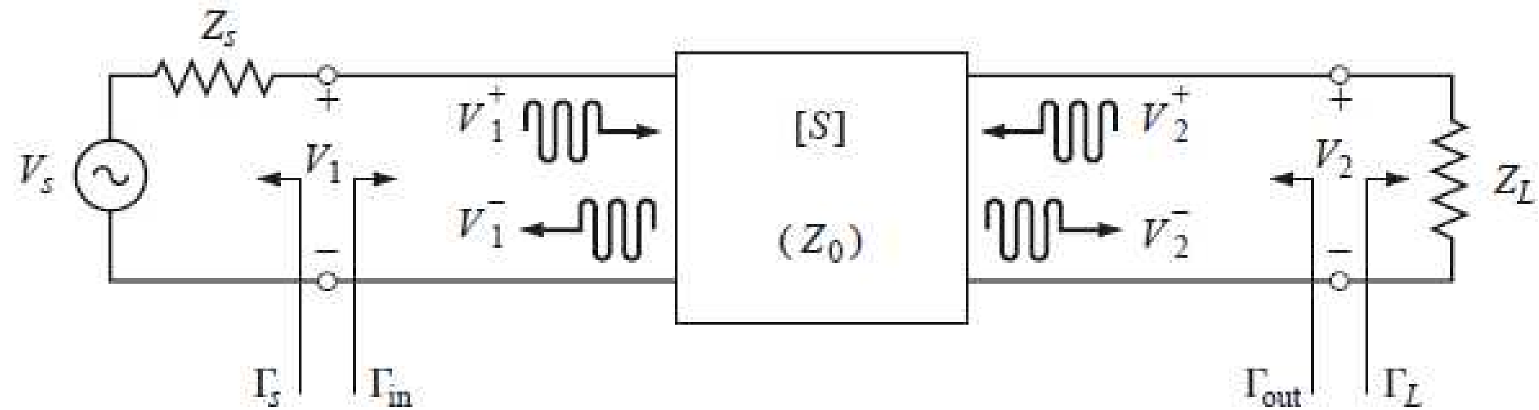
# Estructura Basica Amplificador de Microondas



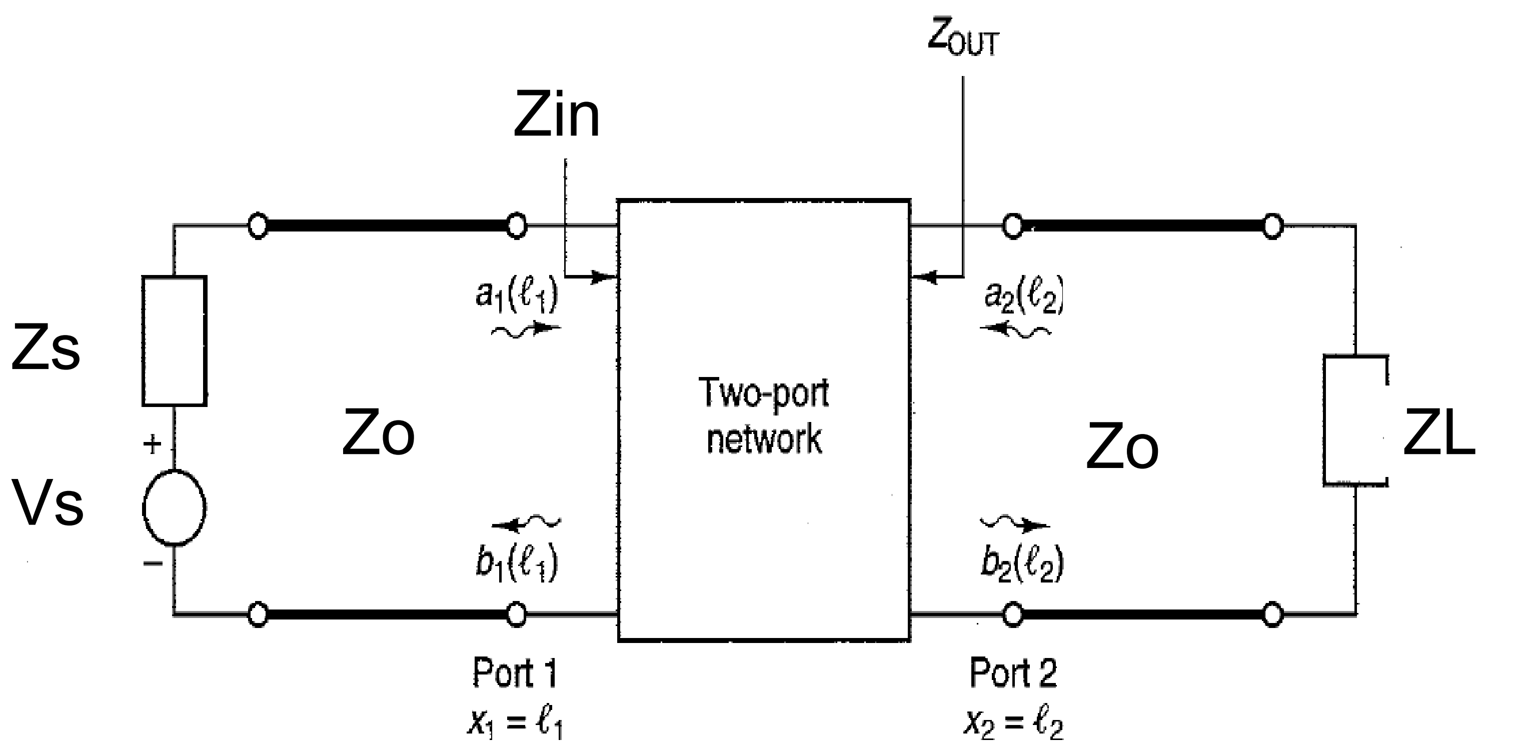



# Adaptaciones (1)

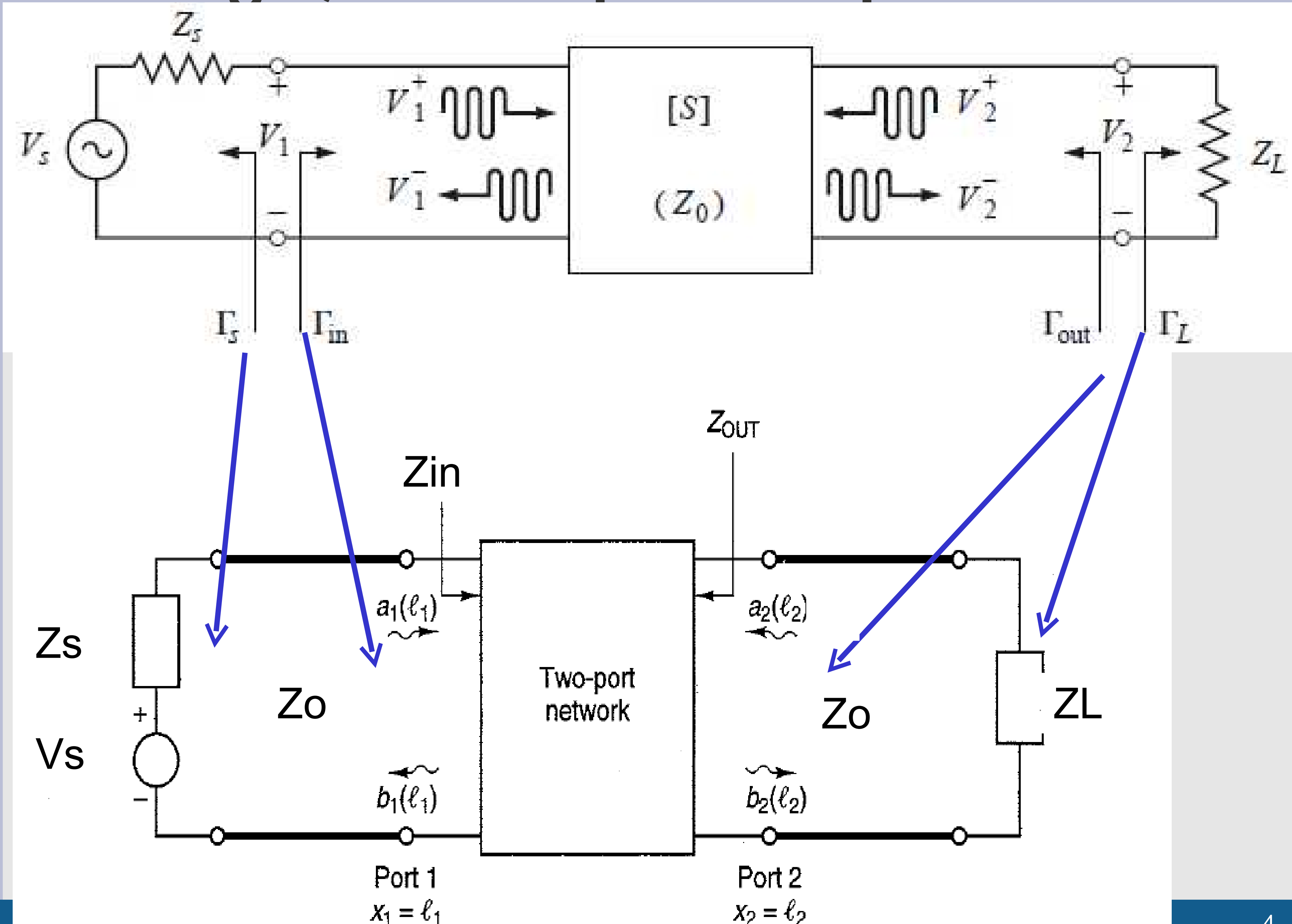



$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$$

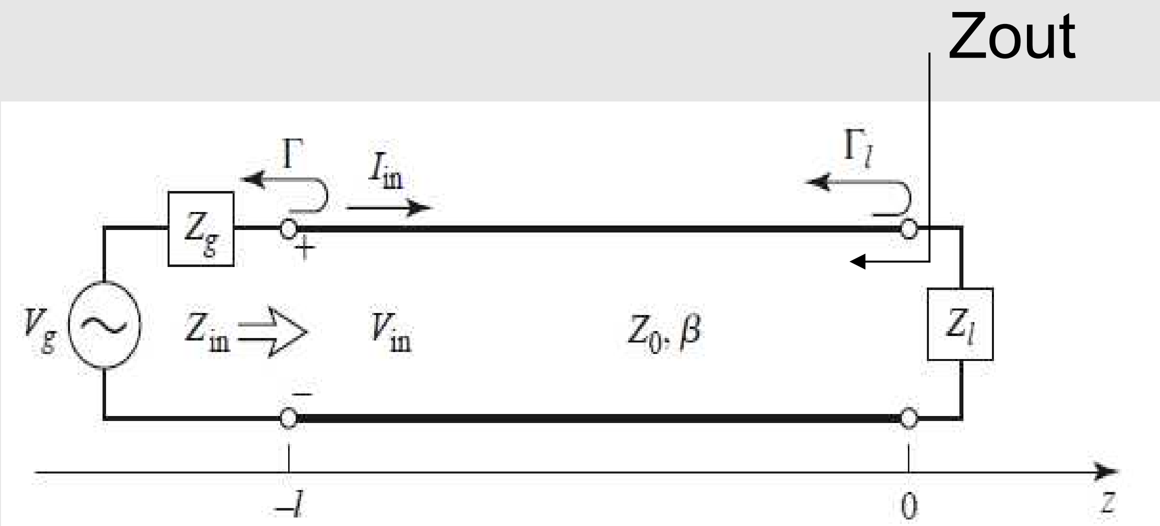
$$\Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0}$$



# ¿ Quién adaptado a quién ?



# Adaptaciones dos tipos: no reflexiones y máxima potencia




$$\Gamma_\ell = \frac{Z_\ell - Z_0}{Z_\ell + Z_0}$$

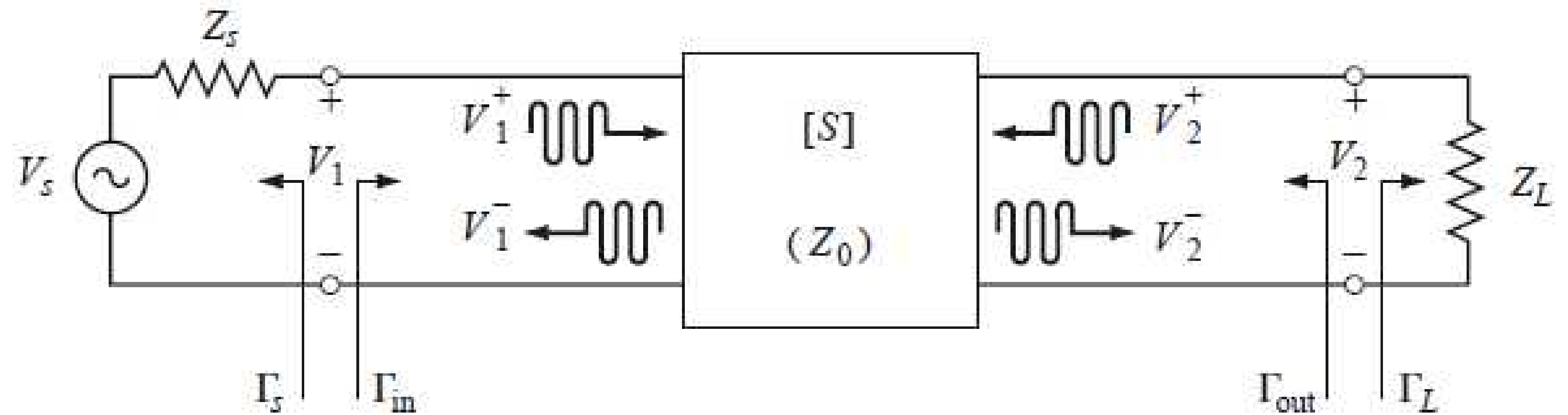
$$Z_{in} = Z_0 \frac{1 + \Gamma_\ell e^{-2j\beta\ell}}{1 - \Gamma_\ell e^{-2j\beta\ell}} = Z_0 \frac{Z_\ell + jZ_0 \tan \beta\ell}{Z_0 + jZ_\ell \tan \beta\ell}$$

Si Zg = Zo / ZL = Zo => no hay reflexiones

Si Zg = Zin* hay máxima transferencia del generador a la red
(como Zin = f(frec) => vale a una frecuencia)
Si ZL = Zout* hay máxima transferencia de la red a la carga

Si Zo real y Zg = Zo = ZL: Se cumplen ambas cosas al mismo tiempo

# Ganancias




$$G_p = \frac{P_L}{P_{IN}} = \frac{\text{power delivered to the load}}{\text{power input to the network}}$$

Power Gain

$$G_T = \frac{P_L}{P_{AVS}} = \frac{\text{power delivered to the load}}{\text{power available from the source}}$$

Transducer Gain

$$G_A = \frac{P_{AVN}}{P_{AVS}} = \frac{\text{power available from the network}}{\text{power available from the source}}$$

Available Power Gain

# Ganancias

$$G = \frac{P_L}{P_{IN}}$$ Power Gain

$$G_T = \frac{P_L}{P_{AVS}}$$ Transducer Gain

$$P_{IN} < P_{AVS} \Longrightarrow G \geq G_T$$

$$P_{IN} = P_{AVS} \Leftrightarrow Z_i = Z_S^* \Rightarrow G = G_T$$

$$G_A = \frac{P_{AVN}}{P_{AVS}}$$ Available Power Gain

$$P_L < P_{AVN} \Longrightarrow G_A \geq G_T$$

$$P_L = P_{AVN} \Leftrightarrow Z_{out} = Z_L^* \Rightarrow G_A = G_T$$

Bi-conjugate Match o entrada y salida simultaneamente adaptadas al conjugado (Zi = Zs*, Zout = ZL*) => $G_{p,\ max} = G_{T,max} = G_{A,max}$

# Parámetros S: Propiedades S21 (2)

$$S_{21} = \frac{2\sqrt{Z_{o1}}}{\sqrt{Z_{o2}}} \frac{V_2(l_2)}{E_{1,TH}}$$

Si Z01 = Z02=Z0

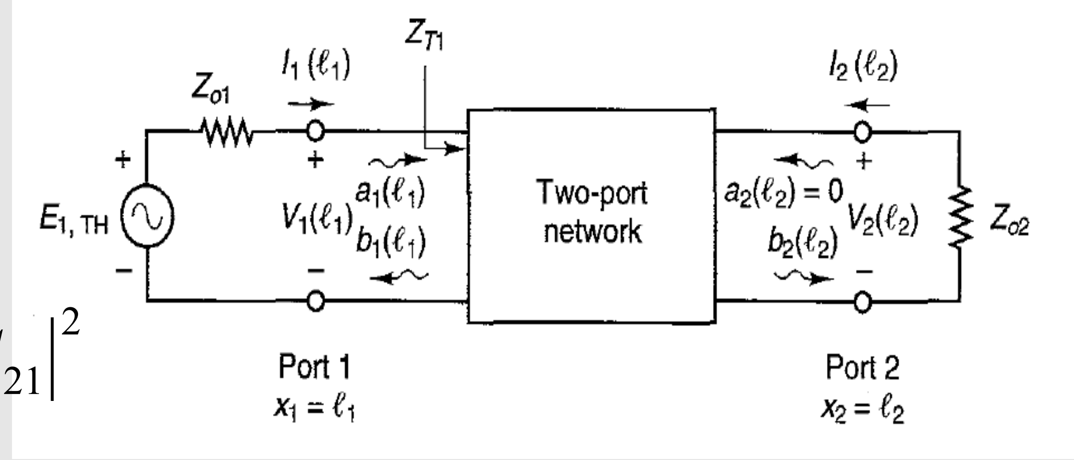
Si $Z_{T1} = Z_{01}$ => Av (ganancia en voltaje del bloque)

$$|S_{21}|^2 = \frac{\frac{1}{2}|V_2(l_2)|^2 / Z_{o2}}{|E_{1,TH}|^2 / 8Z_{o1}}$$

**Potencia entregada a la carga Zo2 ($P_L$)**

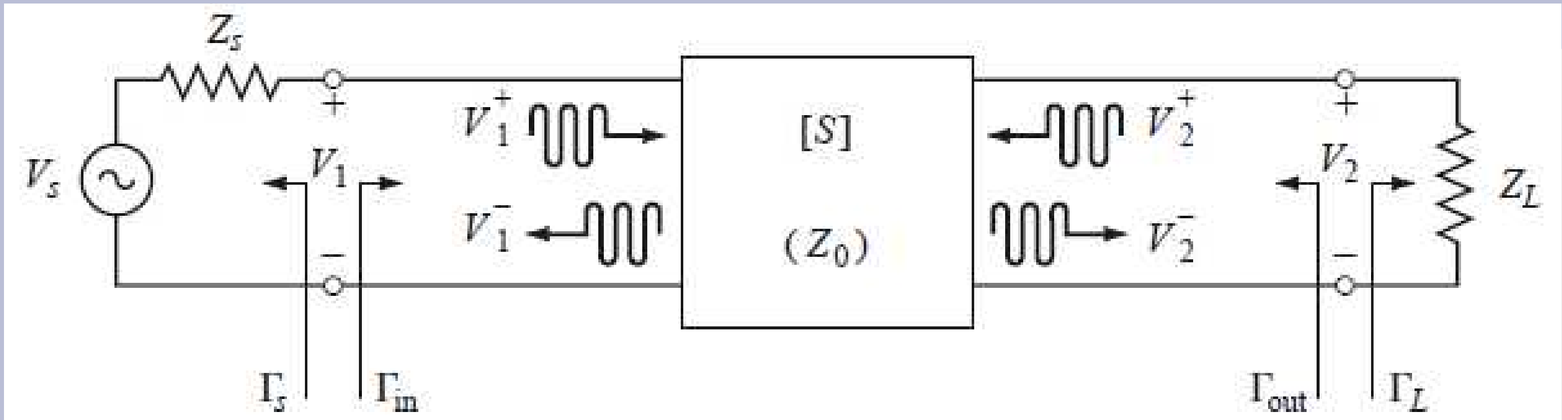
**Potencia disponible en la fuente $E_{1,TH}$**

Acá Zs = Z01 (Zo), ZL=Z02 (Zo) => Γs =0, ΓL = 0




$$\text{Transducer Gain}: G_T = \frac{P_L}{P_{AVS}} = |S_{21}|^2$$

# $\Gamma$in , $\Gamma$out




$$\Gamma_{in} = \frac{V_1^-}{V_1^+}$$

$$\Gamma_{out} = \frac{V_2^-}{V_2^+}$$

$V_2^+ = \Gamma_L V_2^-$ Por definición de $\Gamma$L

$$V_1^- = S_{11} V_1^+ + S_{12} V_2^+ = S_{11} V_1^+ + S_{12} \Gamma_L V_2^-$$
$$V_2^- = S_{21} V_1^+ + S_{22} V_2^+ = S_{21} V_1^+ + S_{22} \Gamma_L V_2^-$$

Usando definición de parámetros S y de $\Gamma$L =>
2 ecs con 2 incognictas V1-, V2-

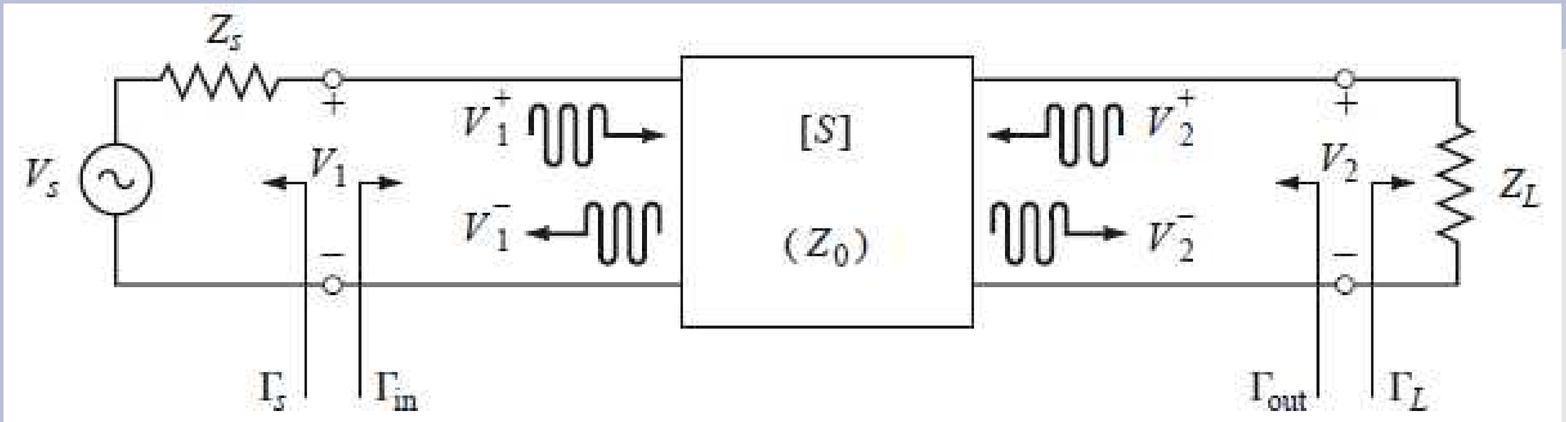
Resolviendo sistema y despejando V1- y V2- =>

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

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

# $P_{IN}$

$$G_p = \frac{P_L}{P_{IN}} = \frac{\text{power delivered to the load}}{\text{power input to the network}}$$



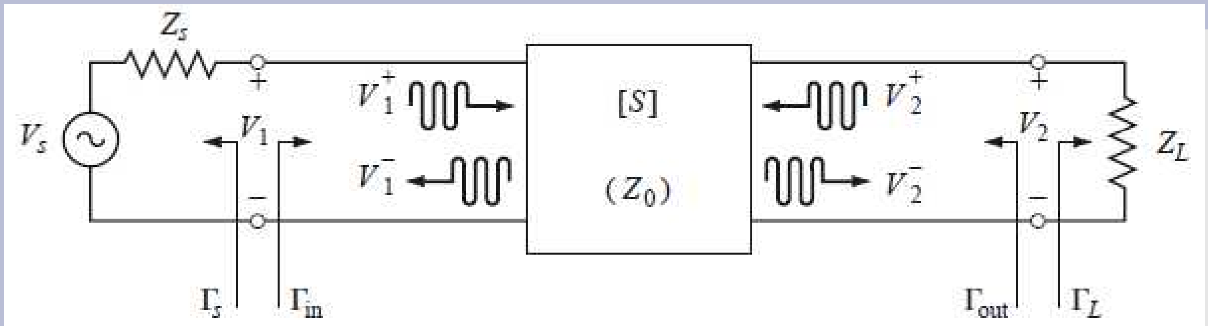

$$P^+ = \mathrm{Re}\left[V_{rms}^+ . I_{rms}^{+\,*}\right] = \frac{1}{2}\mathrm{Re}\left[V^+ .(I^+)^*\right] = \frac{1}{2}\mathrm{Re}\left[V^+ . \frac{(V^+)^*}{Zo}\right] = \frac{1}{2}\frac{|V^+|^2}{Zo}$$ Potencia incidente

$$P^- = \mathrm{Re}\left[V_{rms}^- . I_{rms}^{-\,*}\right] = \frac{1}{2}\mathrm{Re}\left[V^- .(I^-)^*\right] = \frac{1}{2}\mathrm{Re}\left[V^- . \frac{(V^-)^*}{Zo}\right] = \frac{1}{2}\frac{|V^-|^2}{Zo}$$ Potencia reflejada

$$P_{IN} = P^+ - P^- == \frac{1}{2.Zo}\left(|V_1^+|^2 - |V_1^-|^2\right)$$

$$V_1^- = \Gamma_{IN}.V_1^+ \Rightarrow P_{IN} = \frac{1}{2.Zo}\left(|V_1^+|^2 - |V_1^-|^2\right) = \frac{|V_1^+|^2}{2.Zo}\left(1 - |\Gamma_{IN}|^2\right)$$

# $P_{IN}=f(V_S)$




$$V_1 = V_S \frac{Z_{in}}{Z_S + Z_{in}} = V_1^+ + V_1^- = V_1^+ (1 + \Gamma_{in})$$

$$Z_{in} = Z_0 \frac{1 + \Gamma_{in}}{1 - \Gamma_{in}}$$

$$\Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0}$$

$$V_1^+ = \frac{V_S}{2} \frac{(1 - \Gamma_S)}{(1 - \Gamma_S \Gamma_{in})}$$

$$P_{in} = \frac{1}{2Z_0} \left|V_1^+\right|^2 \left(1 - |\Gamma_{in}|^2\right) = \frac{|V_S|^2}{8Z_0} \frac{|1 - \Gamma_S|^2}{|1 - \Gamma_S \Gamma_{in}|^2} \left(1 - |\Gamma_{in}|^2\right)$$

# $P_L$, G

Análogamente a como se hizo con $P_{IN}$

$$P_L = P_{incidente} - P_{reflejada} = \frac{1}{2.Zo}\left(\left|V_2^-\right|^2 - \left|V_2^+\right|^2\right) \Rightarrow \quad P_L = \frac{|V_2^-|^2}{2Z_0}\left(1 - |\Gamma_L|^2\right)$$

De def. de parametros S y $\Gamma_L$ $\quad V_2^- = S_{21}V_1^+ + S_{22}V_2^+ = S_{21}V_1^+ + S_{22}\Gamma_L V_2^-$

$$P_L = \frac{|V_1^+|^2}{2Z_0}\frac{|S_{21}|^2\left(1 - |\Gamma_L|^2\right)}{|1 - S_{22}\Gamma_L|^2} = \frac{|V_S|^2}{8Z_0}\frac{|S_{21}|^2\left(1 - |\Gamma_L|^2\right)|1 - \Gamma_S|^2}{|1 - S_{22}\Gamma_L|^2\,|1 - \Gamma_S\Gamma_{in}|^2}$$

$$P_{in} = \frac{1}{2Z_0}|V_1^+|^2\left(1 - |\Gamma_{in}|^2\right) = \frac{|V_S|^2}{8Z_0}\frac{|1 - \Gamma_S|^2}{|1 - \Gamma_S\Gamma_{in}|^2}\left(1 - |\Gamma_{in}|^2\right)$$

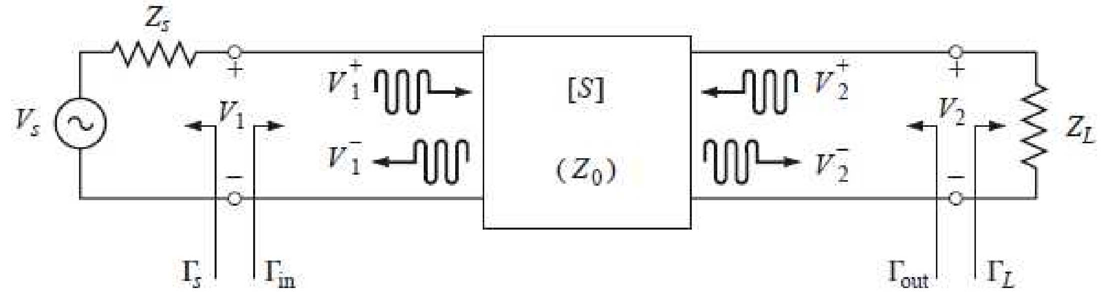
$$G = \frac{P_L}{P_{in}} = \frac{|S_{21}|^2\left(1 - |\Gamma_L|^2\right)}{\left(1 - |\Gamma_{in}|^2\right)|1 - S_{22}\Gamma_L|^2}$$

# $P_{AVS}$, $G_T$

$P_{AVS}$ : Potencia disponible de la fuente $= P_{IN} \Leftrightarrow Z_S = Z_{in}^* \underbrace{\Leftrightarrow}_{Z_o \text{ real}} \Gamma_S = \Gamma_{in}^*$

$$P_{\text{in}} = \frac{1}{2Z_0}\left|V_1^+\right|^2\left(1-|\Gamma_{\text{in}}|^2\right) = \frac{|V_S|^2}{8Z_0}\frac{|1-\Gamma_S|^2}{|1-\Gamma_S\Gamma_{\text{in}}|^2}\left(1-|\Gamma_{\text{in}}|^2\right)$$

$$P_{\text{avs}} = P_{\text{in}}\Big|_{\Gamma_{\text{in}}=\Gamma_S^*} = \frac{|V_S|^2}{8Z_0}\frac{|1-\Gamma_S|^2}{\left(1-|\Gamma_S|^2\right)}$$



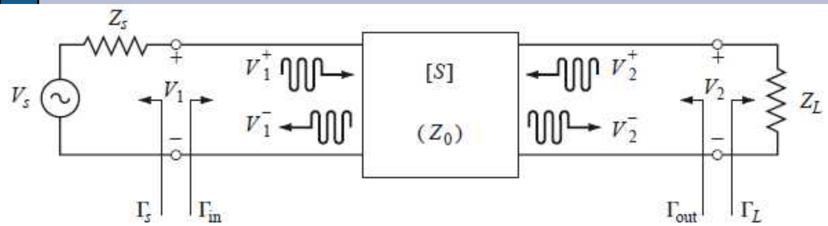

$$P_L = \frac{|V_S|^2}{8Z_0}\frac{|S_{21}|^2\left(1-|\Gamma_L|^2\right)|1-\Gamma_S|^2}{|1-S_{22}\Gamma_L|^2\,|1-\Gamma_S\Gamma_{\text{in}}|^2}$$

Si $\Gamma_L = \Gamma_S = 0$ (entrada y salida adaptadas para reflexión 0)

$$G_T = \frac{P_L}{P_{AVS}}$$

$$G_T = \frac{1-|\Gamma_s|^2}{|1-\Gamma_{IN}\Gamma_s|^2}|S_{21}|^2\frac{1-|\Gamma_L|^2}{|1-S_{22}\Gamma_L|^2}$$

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




# $P_{AVN}$, $G_A$

$$G_A = \frac{P_{AVN}}{P_{AVS}}$$

$$P_{avn} = P_L\Big|_{\Gamma_L=\Gamma_{out}^*} = \frac{|V_S|^2}{8Z_0}\frac{|S_{21}|^2\left(1-|\Gamma_{out}|^2\right)|1-\Gamma_S|^2}{|1-S_{22}\Gamma_{out}^*|^2\,|1-\Gamma_S\Gamma_{in}|^2}\Bigg|_{\Gamma_L=\Gamma_{out}^*}$$

$$P_L = \frac{|V_S|^2}{8Z_0}\frac{|S_{21}|^2\left(1-|\Gamma_L|^2\right)|1-\Gamma_S|^2}{|1-S_{22}\Gamma_L|^2\,|1-\Gamma_S\Gamma_{in}|^2}$$

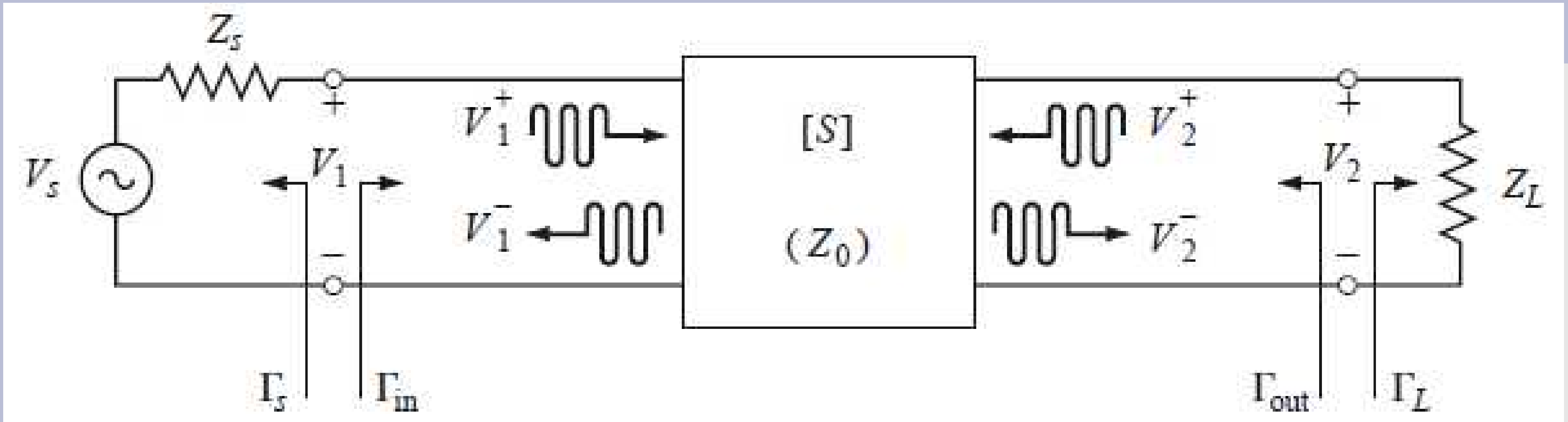
$$\Gamma_{in} = \frac{V_1^-}{V_1^+} = S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1-S_{22}\Gamma_L} = \frac{Z_{in}-Z_0}{Z_{in}+Z_0} \Rightarrow |1-\Gamma_S\Gamma_{in}|^2\Big|_{\Gamma_L=\Gamma_{out}^*} = \frac{|1-S_{11}\Gamma_S|^2\left(1-|\Gamma_{out}|^2\right)^2}{|1-S_{22}\Gamma_{out}^*|^2}$$

$$P_{avn} = \frac{|V_S|^2}{8Z_0}\frac{|S_{21}|^2\,|1-\Gamma_S|^2}{|1-S_{11}\Gamma_S|^2\left(1-|\Gamma_{out}|^2\right)}$$

$$P_{avs} = P_{in}\Big|_{\Gamma_{in}=\Gamma_S^*} = \frac{|V_S|^2}{8Z_0}\frac{|1-\Gamma_S|^2}{\left(1-|\Gamma_S|^2\right)}$$

$$G_A = \frac{1-|\Gamma_s|^2}{|1-S_{11}\Gamma_s|^2}|S_{21}|^2\frac{1}{1-|\Gamma_{OUT}|^2}$$

# Resumiendo Ganancias




$$G = \frac{P_L}{P_{IN}} = f(\Gamma_L, [S])$$

$$G = \frac{P_L}{P_{in}} = \frac{|S_{21}|^2 (1 - |\Gamma_L|^2)}{(1 - |\Gamma_{in}|^2)\, |1 - S_{22}\Gamma_L|^2}$$

Power Gain

$$G_T = \frac{P_L}{P_{AVS}} = f(\Gamma_S, \Gamma_L, [S])$$

$$G_T = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_{IN}\Gamma_s|^2} |S_{21}|^2 \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

Transducer Gain

$$G_A = \frac{P_{AVN}}{P_{AVS}} = f(\Gamma_S, [S])$$

$$G_A = \frac{1 - |\Gamma_s|^2}{|1 - S_{11}\Gamma_s|^2} |S_{21}|^2 \frac{1}{1 - |\Gamma_{OUT}|^2}$$

Available Power Gain

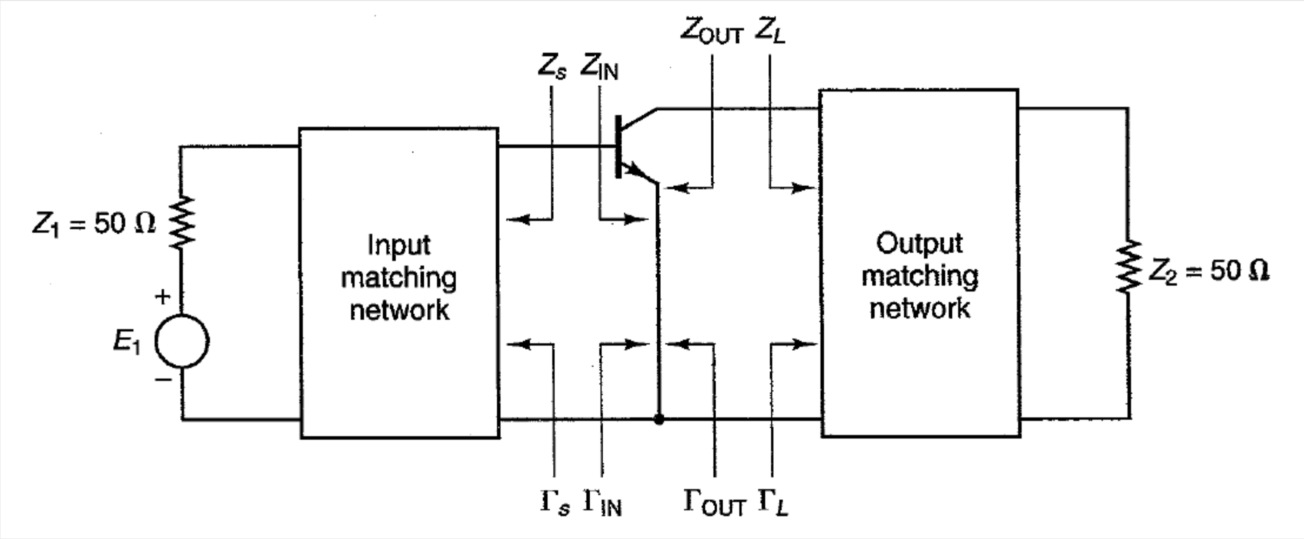
$$\Gamma_{in} = S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1 - S_{22}\Gamma_L} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

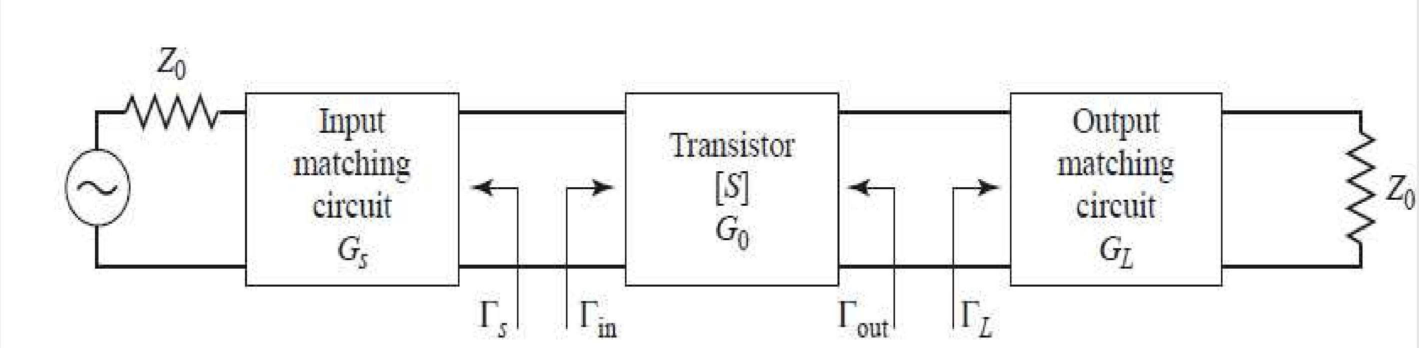
$$\Gamma_{out} = S_{22} + \frac{S_{12}S_{21}\Gamma_S}{1 - S_{11}\Gamma_S}$$

$$\Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0}$$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$$

# Ganancias en estructura de amplificador




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

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

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

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

$$G_T = G_S G_0 G_L$$

$G_S$, $G_L$ pueden ser >1 al reducir las pérdidas que habría debido a desadaptación

Si transistor “unilateral” (S12=0 o despreciable)

$$\Gamma_{in} = S_{11}$$