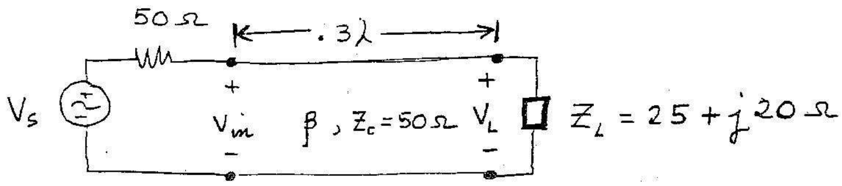
INEL 5306 – Microondas

Ejemplo Línea de transmisión

① Para la línea de transmisión que se muestra, determine la impedancia de entrada (Z_{in}) usando el Smith Chart.



* Normalizando : $\frac{25 + j20}{50} = 0.5 + j0.4$ (Punto "A")

* Trazar círculo de $|\Gamma|$ constante : $\frac{|\Gamma|}{1} = \frac{3.4}{8.2} \Rightarrow |\Gamma| = .414$

$\Gamma = .414 \angle 127^\circ$

* Me muevo hacia el generador ("~~counter~~ clockwise") una distancia de : $\ell/\lambda = 0.3$ ó 216°

En la escala de afuera equivale a moverme al punto $0.074 + 0.3 = \underline{\underline{0.374}}$

* Leo impedancia en punto B :

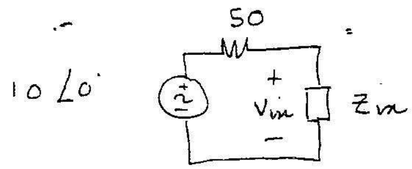
$z \simeq 0.725 - j0.725$

$Z_{in} = 36.25 - j36.25\ \Omega$ (Smith Chart)

Usando ecuación para Z_{in}

$Z_{in} = 35.44 - j35.2\ \Omega$ (Teórico)

b) Si $V_s = 10\angle 0°$; Determine V_{in}



$$V_{in} = \frac{(10\angle 0)(36.25 - j36.25)}{50 + 36.25 - j36.25}$$

$$V_{in} = 5.47\angle -22.2° \text{ V}$$

c) Determine V_L,

$$V(z) = V_o^+ e^{-j\beta z} + V_o^- e^{+j\beta z}$$

$$V(z) = V_o^+ \left(e^{-j\beta z} + \Gamma_L e^{+j\beta z}\right)$$

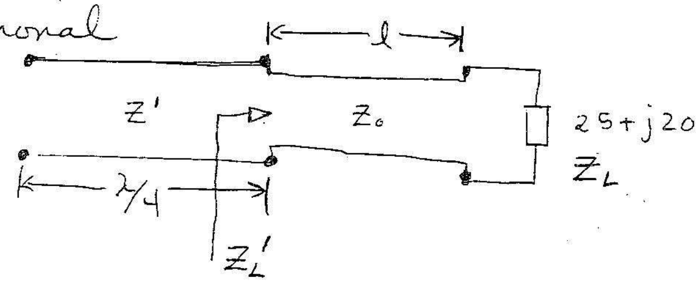
$$V(z=-0.3\lambda) = V_o^+ \left(e^{+j108°} + \underbrace{.414\, e^{j127°}}_{\Gamma_L} \cdot e^{-j108}\right) = 5.47\angle -$$

$$V_o^+ (1.089\angle 85.65°) = 5.47\angle -22.2° \Longrightarrow \underline{\underline{V_o^+ = 5.02\angle -1}}$$

$$V_L = V(z=0) = V_o^+ (1 + \Gamma_L) = \underline{\underline{4.12\angle -84° \text{ V}}}$$

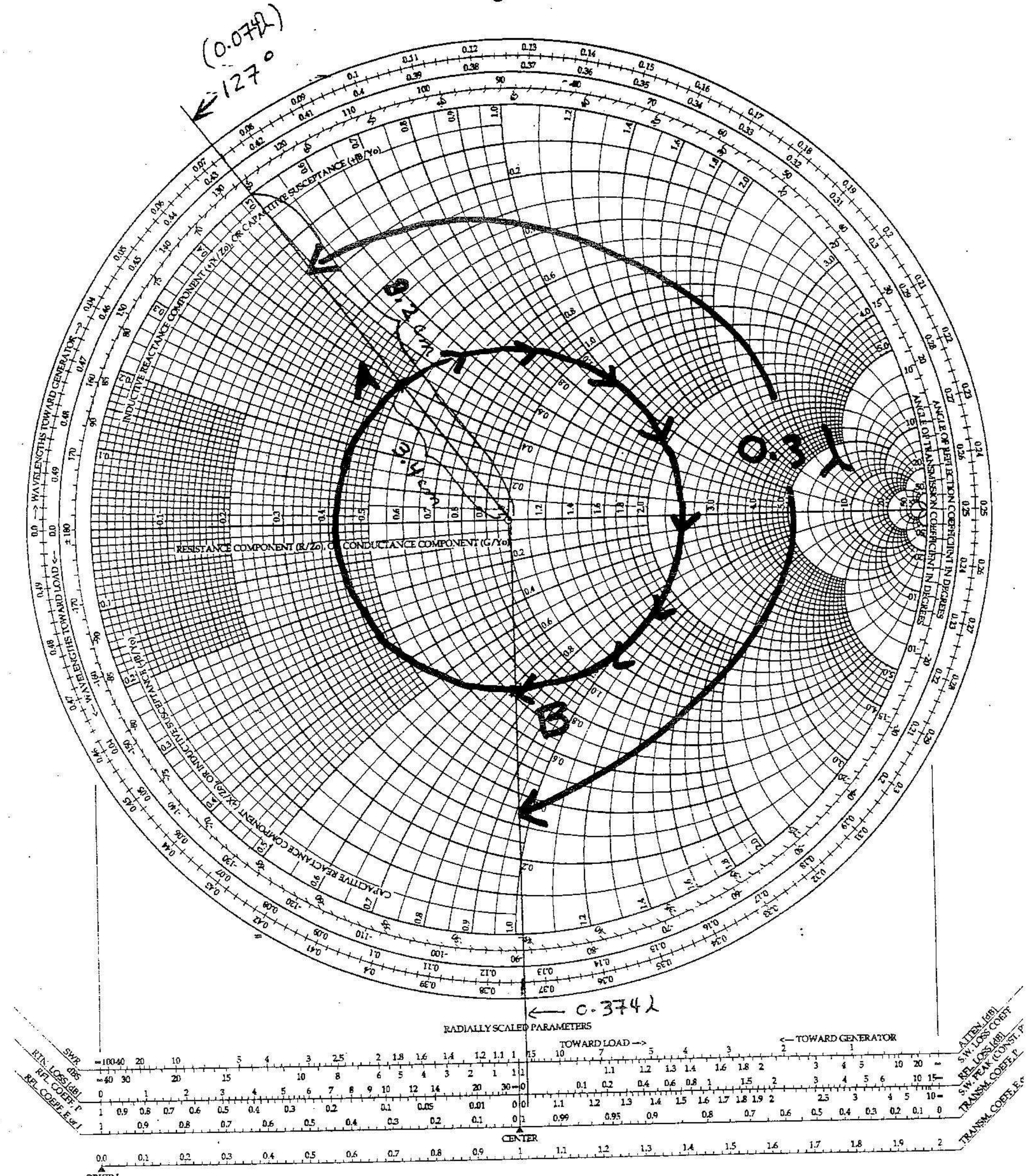
d) Usando un transformador de $\lambda/4$, acople la carga a una impedancia de 50Ω.

* Hacemos la carga <u>real</u>, usando línea adicional



The Complete Smith Chart

Black Magic Design

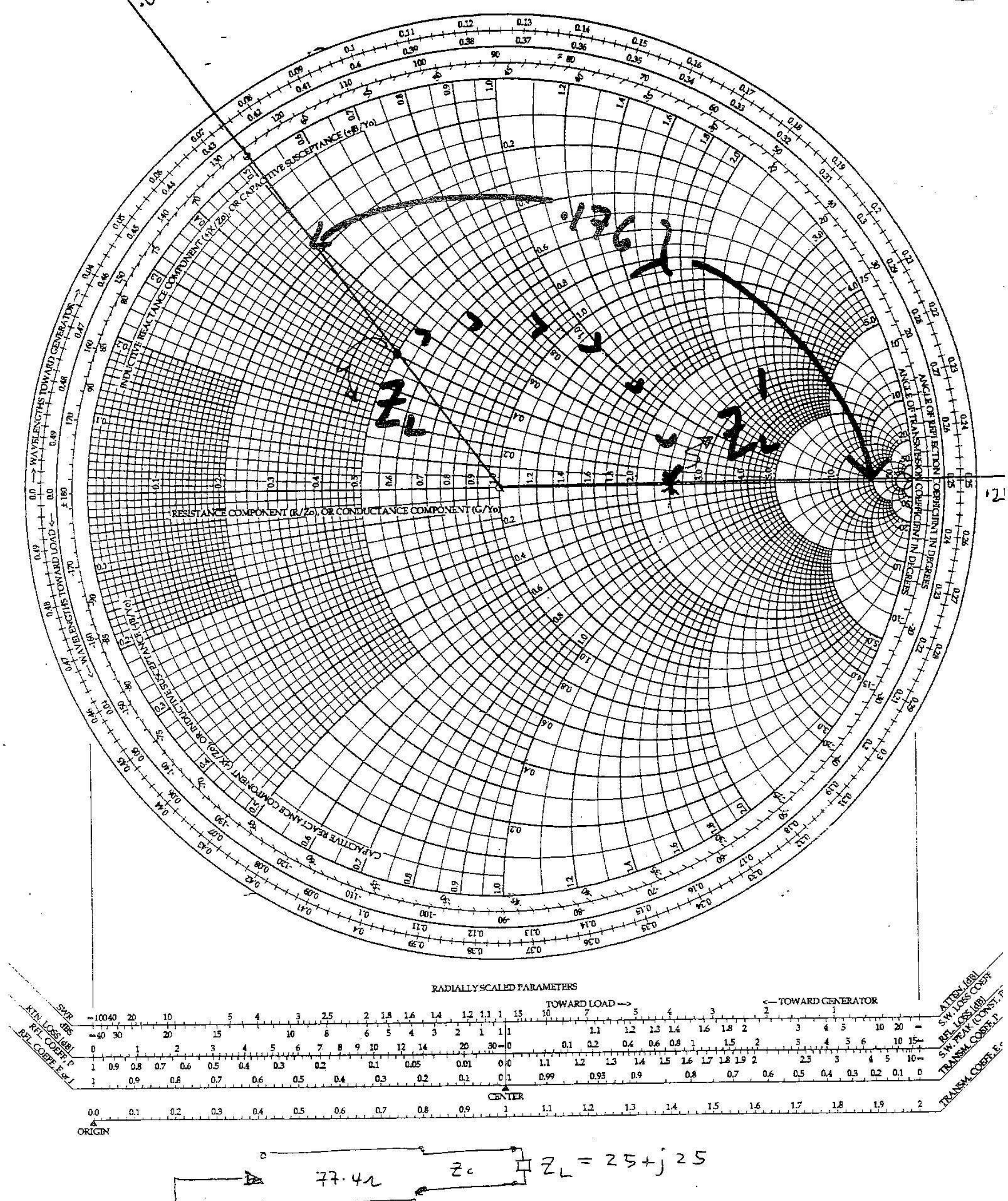


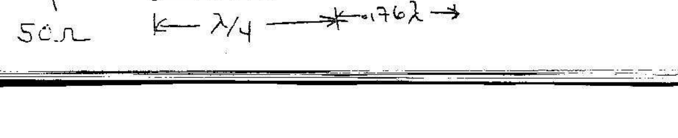
The Complete Smith Chart

Black Magic Design

$Z_L' = (2.4)(50) = 120\Omega$

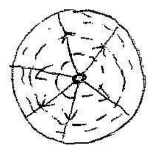
$Z' = \sqrt{(120)(50)} = \underline{77.4\Omega}$





Microcinta – Línea de Transmisión plana.

Coaxial –



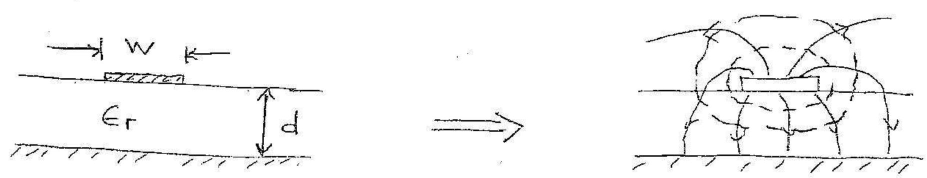
Coaxial ⟹ Se propaga modo TEM

$$u = \frac{1}{\sqrt{\mu \epsilon}} = \frac{3 \times 10^8}{\sqrt{\epsilon_r}} = \frac{c}{\sqrt{\epsilon_r}}$$

$$\lambda = u/f = \frac{3 \times 10^8}{f} \frac{1}{\sqrt{\epsilon_r}} = \frac{\lambda_o}{\sqrt{\epsilon_r}}$$

$$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{\lambda_o / \sqrt{\epsilon_r}} = \beta_o \sqrt{\epsilon_r}$$

Microcinta –



Para microcinta usamos ϵ_{eff}

$$u = \frac{c}{\sqrt{\epsilon_{eff}}}$$

$$\lambda = \frac{\lambda_o}{\sqrt{\epsilon_{eff}}}$$

$$\beta = \beta_o \sqrt{\epsilon_{eff}}$$

W ⟶ controla impedancia característica

largo ⟶ controla fase.

Microstrip : Equations

$$\epsilon_e = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \frac{1}{\sqrt{1 + 12d/W}}.$$

$$Z_0 = \begin{cases} \dfrac{60}{\sqrt{\epsilon_e}} \ln\left(\dfrac{8d}{W} + \dfrac{W}{4d}\right) & \text{for } W/d \leq 1 \\ \dfrac{120\pi}{\sqrt{\epsilon_e}\left[W/d + 1.393 + 0.667 \ln\left(W/d + 1.444\right)\right]} & \text{for } W/d \geq 1. \end{cases} \quad 3.196$$

For a given characteristic impedance Z_0 and dielectric constant ϵ_r, the W/d ratio can be found as

$$\frac{W}{d} = \begin{cases} \dfrac{8e^A}{e^{2A} - 2} & \text{for } W/d < 2 \\ \dfrac{2}{\pi}\left[B - 1 - \ln(2B - 1) + \dfrac{\epsilon_r - 1}{2\epsilon_r}\left\{\ln(B - 1) + 0.39 - \dfrac{0.61}{\epsilon_r}\right\}\right] & \text{for } W/d > 2, \end{cases} \quad 3.197$$

where

$$A = \frac{Z_0}{60}\sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r - 1}{\epsilon_r + 1}\left(0.23 + \frac{0.11}{\epsilon_r}\right)$$

$$B = \frac{377\pi}{2Z_0\sqrt{\epsilon_r}}.$$

Considering microstrip as a quasi-TEM line, the attenuation due to dielectric loss can be determined as

$$\alpha_d = \frac{k_0 \epsilon_r (\epsilon_e - 1) \tan\delta}{2\sqrt{\epsilon_e}(\epsilon_r - 1)} \text{ Np/m}, \tag{3.198}$$

where $\tan\delta$ is the loss tangent of the dielectric. This result is derived from (3.30) by multiplying by a "filling factor,"

$$\frac{\epsilon_r(\epsilon_e - 1)}{\epsilon_e(\epsilon_r - 1)},$$

which accounts for the fact that the fields around the microstrip line are partly in air (lossless) and partly in the dielectric. The attenuation due to conductor loss is given approximately by [8]

$$\alpha_c = \frac{R_s}{Z_0 W} \text{ Np/m}, \tag{3.199}$$

where $R_s = \sqrt{\omega\mu_0/2\sigma}$ is the surface resistivity of the conductor. For most microstrip substrates, conductor loss is much more significant than dielectric loss; exceptions may occur with some semiconductor substrates, however.

— **EXAMPLE 3.7 Microstrip Design**

Calculate the width and length of a microstrip line for a 50 Ω characteristic impedance and a 90° phase shift at 2.5 GHz. The substrate thickness is $d = 0.127$ cm, with $\epsilon_r = 2.20$.

Solution

We first find W/d for $Z_0 = 50\ \Omega$, and initially guess that $W/d > 2$. From (3.197),

$$B = 7.985, \qquad W/d = 3.081.$$

So $W/d > 2$; otherwise we would use the expression for $W/d < 2$. Then $W = 3.081d = 0.391$ cm. From (3.195) the effective dielectric constant is

$$\epsilon_e = 1.87.$$

The line length, ℓ, for a 90° phase shift is found as

$$\phi = 90° = \beta\ell = \sqrt{\epsilon_e} k_0 \ell,$$

$$k_0 = \frac{2\pi f}{c} = 52.35 \text{ m}^{-1},$$

$$\ell = \frac{90°(\pi/180°)}{\sqrt{\epsilon_e} k_0} = 2.19 \text{ cm}.$$

$\frac{\lambda_m}{4} = \ell$

$\frac{\lambda_0/\sqrt{\epsilon_{eff}}}{4} = \ell$

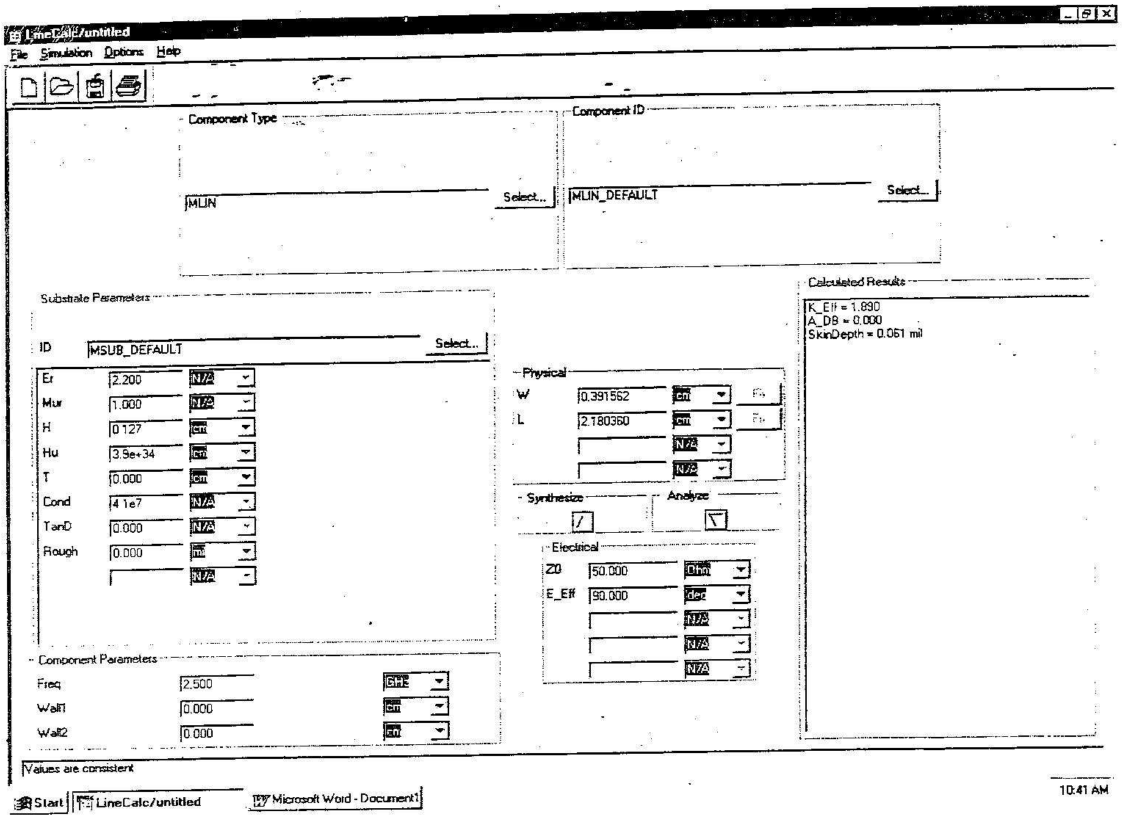
$\beta\ell = \frac{\pi}{2} = \beta_0 \sqrt{\epsilon_{eff}}\, \ell$

$\frac{\pi}{2} = \frac{2\pi}{\lambda_c} \sqrt{\epsilon_{eff}}\, \ell$

$\frac{\pi}{2} = \frac{2\pi}{c/f_0} \sqrt{\epsilon_{eff}}\, \ell$

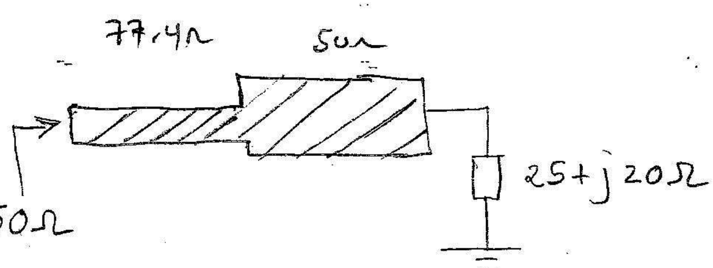
$\ell = \left(\frac{1}{2}\right)\left(\frac{c}{f}\right)\left(\frac{1}{2}\right)\frac{1}{\sqrt{\epsilon_{eff}}} = 2.19$ cm

ADS 2003C → ADS Tools → LineCalc.



→ Rogers Corp

→ Taconics.



$Z_0 = 77.4\Omega \quad E = 90^\circ$

$W_1 = ? \quad L_1 = ?$

$Z_0 = 50\Omega \quad E = .176\lambda = 63.36^\circ$

$W_1 = ? \quad L_1 = ?$