#1

$$R = \frac{\sqrt{\pi f \mu_c \sigma_c}}{2\pi\sigma_c}\left(\frac{1}{a}+\frac{1}{b}\right)$$

$$L = \frac{\mu}{2\pi}\ln\frac{b}{a}$$

$$G = \frac{2\pi\sigma}{\ln\left|\frac{b}{a}\right|}$$

$$C = \frac{2\pi\epsilon}{\ln\left|\frac{b}{a}\right|}$$

cobre $\sigma_c = 6\times10^{7}\ S/m$, $\mu_c = \mu_o$

polietileno $\epsilon_r = 2.25$ $\mu = \mu_o$

$f = 800\,MHz$

$a = 0.47mm = 4.7\times10^{-4}$

$b = 1.435mm = 1.435\times10^{-3}$

$$R = \underbrace{\frac{\sqrt{\pi(800\times10^{6})(4\pi\times10^{-7})(6\times10^{7})}}{2\pi(6\times10^{7})}}_{7.49\times10^{-6}}\underbrace{\left(\underbrace{\frac{1}{4.7\times10^{-4}}}_{2127.6}+\frac{1}{1.435\times10^{-3}}\right)}_{2824.5}$$

$R = 435\,k\Omega/m$

$$L = \frac{4\pi\times10^{-7}}{2\pi}\ln\left|\frac{1.435}{0.47}\right| \approx 2.23\times10^{-7}\ H/m$$

$G = 0$ σ is for polietileno

$$C = \frac{2\pi(2.25)(8.85\times10^{-12})}{\ln\left|\frac{1.435}{0.47}\right|} = 1.12\times10^{-10}\ F/m$$

#2

a) classify → loss tangent $\omega = 2\pi f = 2\pi \times 10^6 \times 10 = 20\pi \times 10^6$

$$\frac{\sigma}{\omega\epsilon} = \frac{10^{-6}}{(20\pi \times 10^6)(5)(8.85 \times 10^{-12})} = 3.6 \times 10^{-4}$$

~~lossless dielectric~~ not quite lossless

b) $j\omega\mu(\sigma + j\omega\epsilon) = \gamma^2$ $\gamma = 2.3 \times 10^{-3} + j12.83$

$\beta = 12.83$, $\lambda = \frac{2\pi}{\beta} = 0.4897\ m$

c) $\frac{\Delta\theta}{2\pi} = \frac{d}{\lambda} = \frac{2}{0.4897} = 4.0843$

$\Delta\theta = 25.663^R = 1470.4°$ electrical angle

almost 0 Impedance is real

d) $\eta = \sqrt{\frac{j\omega\mu}{(\sigma + j\omega\epsilon)}} = 4615 \angle 0.01° \ \Omega$

$4.615\ k\Omega$

#6

a) $\frac{\beta}{\omega} = \sqrt{\mu\epsilon} = \frac{\sqrt{\mu_r \epsilon_r}}{c} = \frac{\sqrt{\epsilon_r}}{c}$

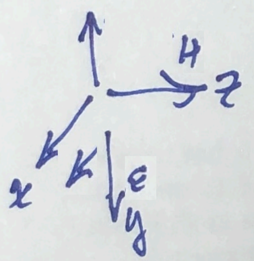
$\frac{c\beta}{\omega} = \sqrt{\epsilon_r} \qquad \epsilon_r = \left(\frac{c\beta}{\omega}\right)^2 = \left(\frac{3\times10^8\,(5)}{2\pi\times10^8}\right)^2 = \left(\frac{15}{2\pi}\right)^2 = 5.7$

b) $\beta = \frac{2\pi}{\lambda} \qquad \lambda = \frac{2\pi}{\beta} = \frac{2\pi}{5} = 1.26\,m$

$v_p = \frac{\omega}{\beta} = \frac{2\pi\times10^8}{5} = 1.26\times10^8\ m/s$

c) $\eta = \sqrt{\frac{\mu}{\epsilon}} = \frac{\eta_0}{\sqrt{\epsilon_r}} = \frac{120\pi}{\sqrt{5.7}} = 158\,\Omega$

d) polarization is direction of $\underline{E}$



$\hat{y}$ is polarization

e) $E = \eta H$

$\underline{E} = 4.74 \sin(2\pi\times10^8 t - 5x)\,(\hat{y})\ V/m$

f) $j\omega\epsilon\underline{E} = \underline{J}_D = j(2\pi\times10^8)(5.7)(8.85\times10^{-12})(4.74)\sin(\,''\,)(\hat{y})\ A/m^2$

$= 1.5\times10^{-1}\sin(2\pi\times10^8 t - 5x + 90^\circ)\,(\hat{y})\ A/m^2$

#4

$1.6\ rad/m = \beta\ ,\ f = 10^7\ Hz$

mag ↓ 60% every 2m

$$e^{-\alpha z} \rightarrow e^{-2\alpha} = 0.4 \qquad -2\alpha = \ln 0.4$$

$$\delta = ? = \frac{1}{\alpha} = -\frac{1}{\ln\sqrt{0.4}} = \underline{1.091\ m} \qquad \alpha = -\ln\sqrt{0.4}$$

$$V_p = ? = \omega/\beta = \frac{2\pi f}{\beta} = \frac{2\pi \times 10^7}{1.6} = \underline{3.93 \times 10^7\ m/s}$$

Skin depth is 1.091 m

phase velocity is 13.1% the speed of light in a vacuum.

#5

$f = 100\,MHz$

$RLGC = ?$

$Z_0 = 18.6 - j\,0.253\,\Omega$

$\gamma = 0.0638 + j\,4.68\ m^{-1}$

$$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)}$$

$$Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}}$$

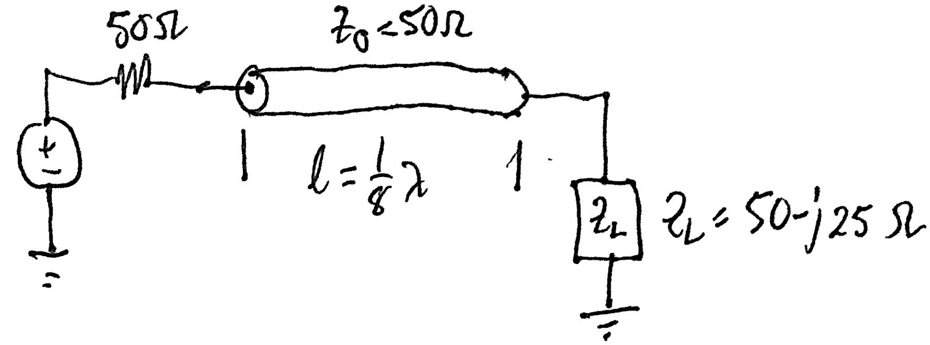
$$\gamma Z_0 = R + j\omega L = \underline{2.37} + j\,87\ \underline{\Omega/m}$$

$$\frac{\gamma}{Z_0} = G + j\omega C = \underline{7.63 \times 10^{-6}} + j\,0.252\ \underline{S/m}$$

$$L = \frac{87}{2\pi \times 100M} = \underline{0.138\,\mu H/m}$$

$$C = \frac{0.252}{2\pi \times 100M} = \underline{401\,pF/m}$$

6.



$$\beta l = \frac{2\pi}{\lambda}\left(\frac{1}{8}\lambda\right) = \frac{\pi}{4} = 45° \qquad \tan \beta l = 1$$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{50 - j25 - 50}{50 + 50 - j25} = \frac{-j25}{100 - j25}$$

$$= 0.2425 \angle -75.96°$$

$$VSWR = \frac{1 + |\Gamma_L|}{1 - |\Gamma_L|} = \frac{1 + 0.2425}{1 - 0.2425} = 1.64$$

$$Z_{in} = Z_0 \left[\frac{Z_L + j Z_0 (1)}{Z_0 + j Z_L (1)}\right] = 31 \angle -7.12°\ \Omega$$

#7

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}} \qquad \eta_{air} = \sqrt{\frac{\mu_0}{\epsilon_0}} = 377\Omega$$

$$\eta_d = \frac{\eta_{air}}{\sqrt{\epsilon_r}} = 188\Omega$$

a) $\Gamma = \dfrac{\eta_d - \eta_{air}}{\eta_d + \eta_{air}} = \dfrac{188-377}{188+377} = -0.3345$

$S = \dfrac{1+|\Gamma|}{1-|\Gamma|} = \dfrac{1+0.3345}{1-0.3345} = 2.005$

b) $f = 100\,MHz \qquad \lambda = ?$

$\gamma = \sqrt{j\omega\mu(\underset{0}{\sigma} + j\omega\epsilon)} = j\omega\sqrt{\mu\epsilon}$

$\beta = \omega\sqrt{\mu\epsilon} = \dfrac{2\pi}{\lambda}$

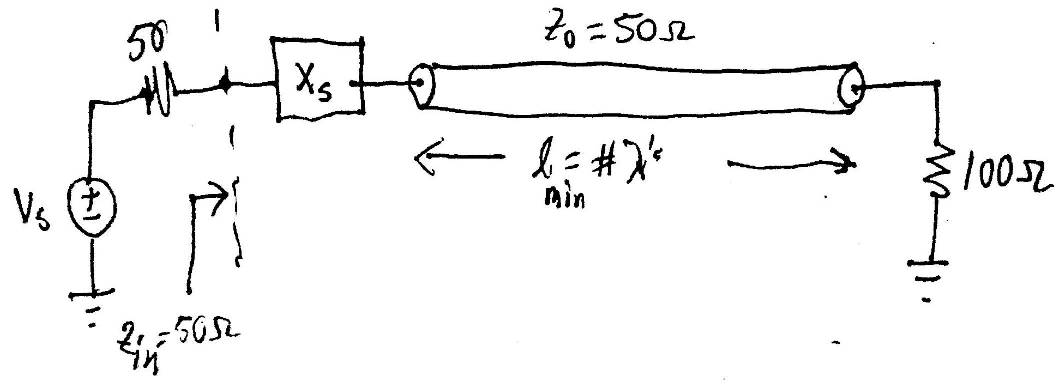
$\lambda = \dfrac{2\pi}{\omega\sqrt{\mu\epsilon}} = \dfrac{1}{f\sqrt{\mu\epsilon}} = \dfrac{c}{f\sqrt{\epsilon_r}}$

$\lambda_{air} = \dfrac{3\times10^8}{10^8} = 3\,m$

$\lambda_d = \dfrac{3\times10^8}{10^8\sqrt{4}} = 1.5\,m$

c) $|\Gamma|^2 \times 100\% = |0.3345|^2 \times 100 = 11.19\%$

#8



$$50 = jX_s + 50\left(\frac{100 + j50\tan\beta l}{50 + j100\tan\beta l}\right)$$

aqui se obtienen dos ecuaciones de la parte real y la parte imaginaria

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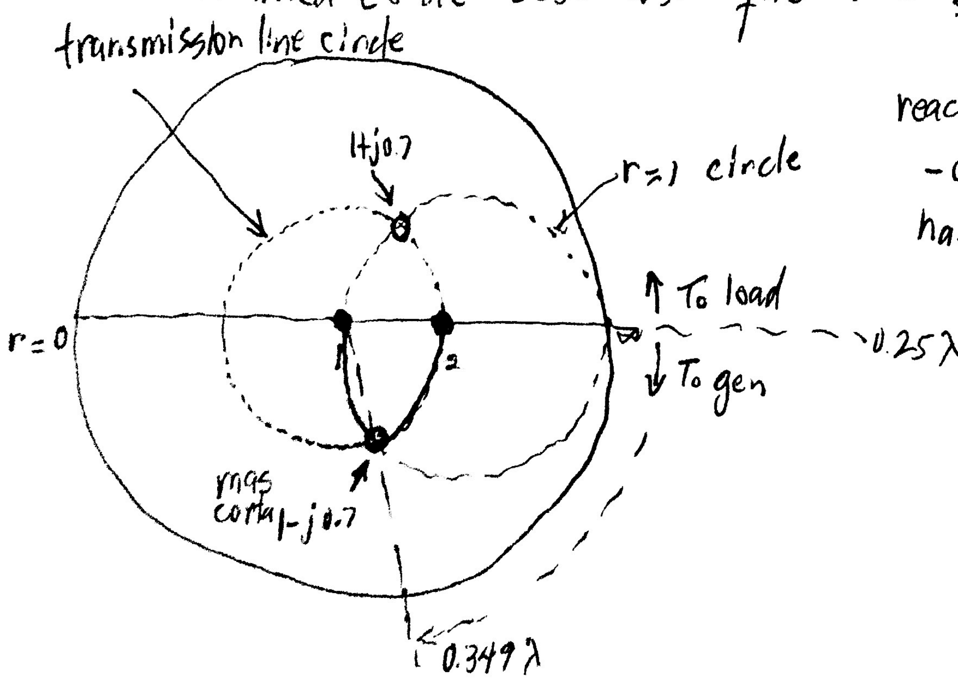
en el smith chart se usan valores normalizados

la linea es de 50Ω asi que $r = \frac{100}{50} = 2$

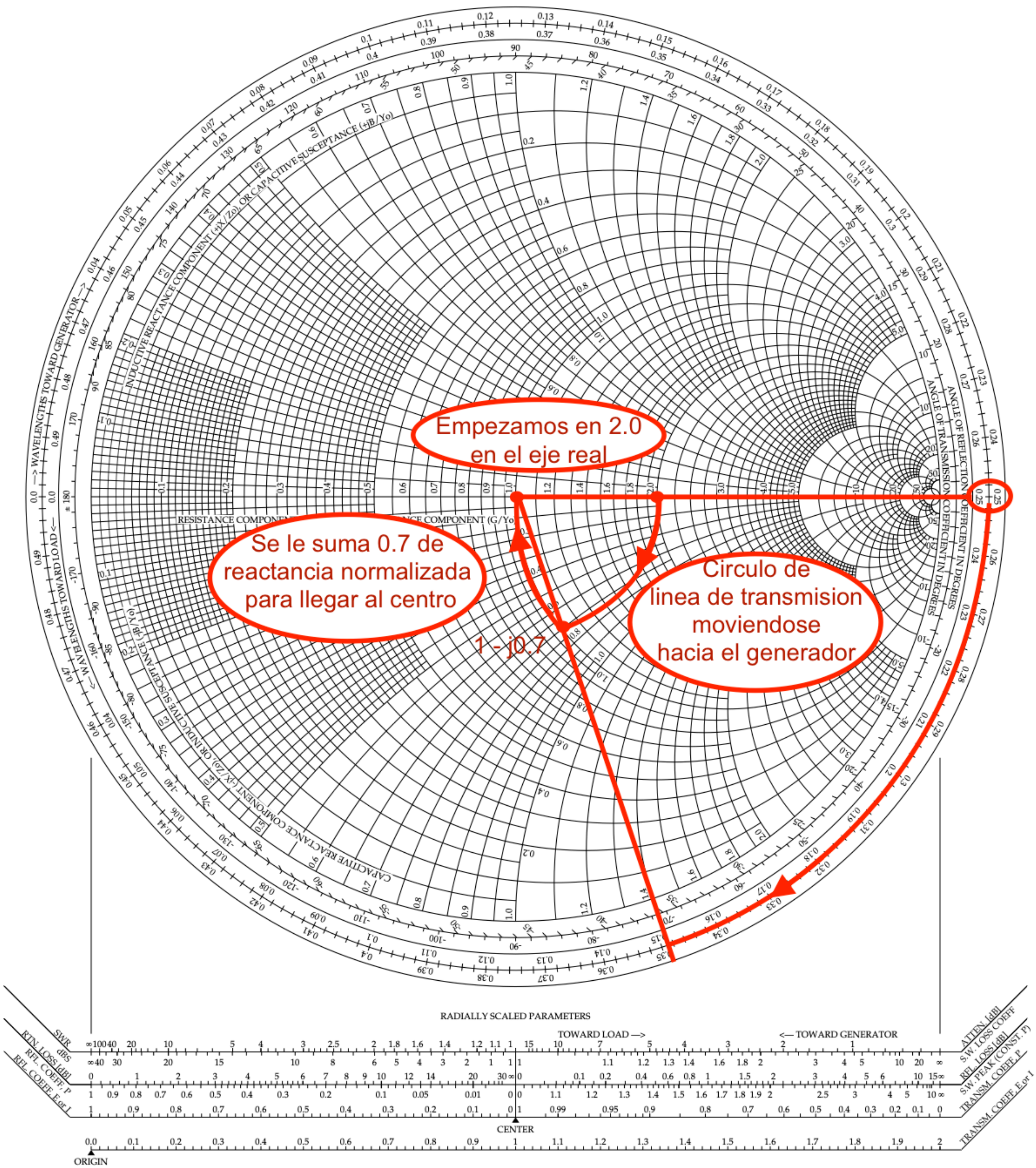


reactancia normalizada de -0.7 en la linea en serie hay que poner $+0.7$

$X_s = (0.7)(50) = \underline{\underline{35\Omega}}$

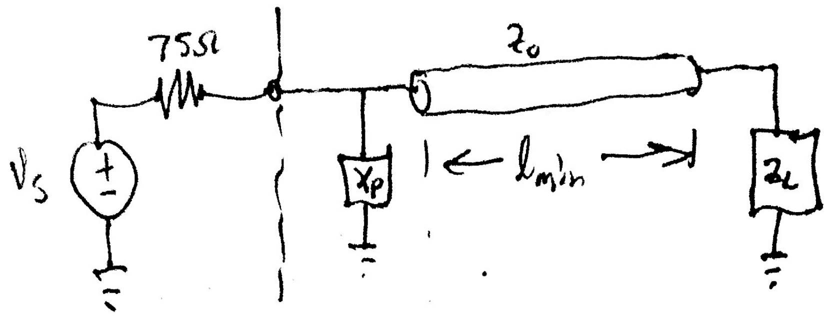
largo de la línea minimo sería $0.349 - 0.25 = \underline{\underline{0.099\lambda}}$

Smith Chart


Empezamos en 2.0
en el eje real
Se le suma 0.7 de
reactancia normalizada
para llegar al centro
1 - j0.7
Circulo de
linea de transmision
moviendose
hacia el generador
RADIALLY SCALED PARAMETERS
TOWARD LOAD —>
<— TOWARD GENERATOR
CENTER
ORIGIN

X

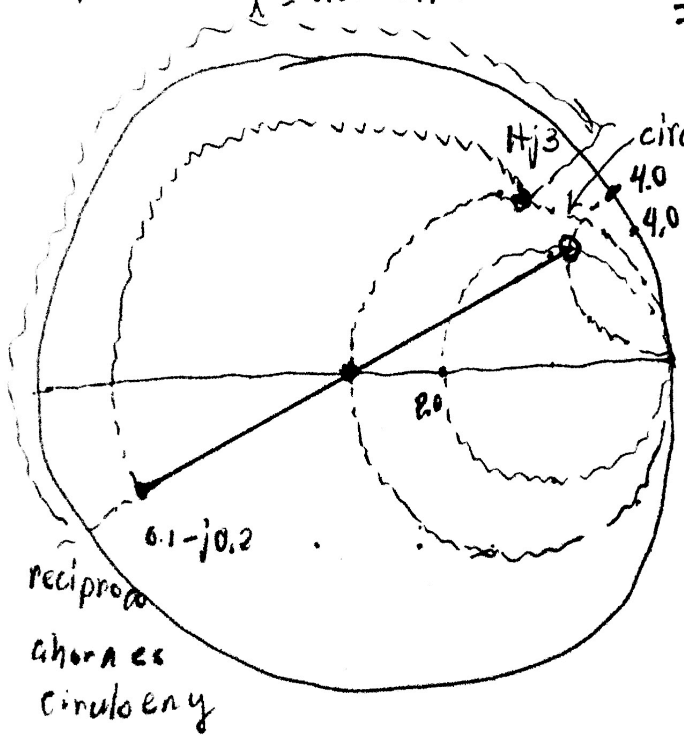
#9 $Z_L = 150 + j300\,\Omega$ $Z_0 = 75\,\Omega$ $X_p = ?$ $l_{min} = \#'s\,\lambda$



quiero paralelo y en paralelo lo que se suma son admitancias así que tengo que tomar el recíproco y usar el Smith Chart invertido porque no tengo círculos de conductancia constante.

$$z = \frac{150 + j300}{75} = 2 + j4 \qquad y = \frac{1}{z} = 0.1 - j0.2$$

$$l = 0.500 - 0.468 + 0.203 = \underline{\underline{0.235\lambda}}$$



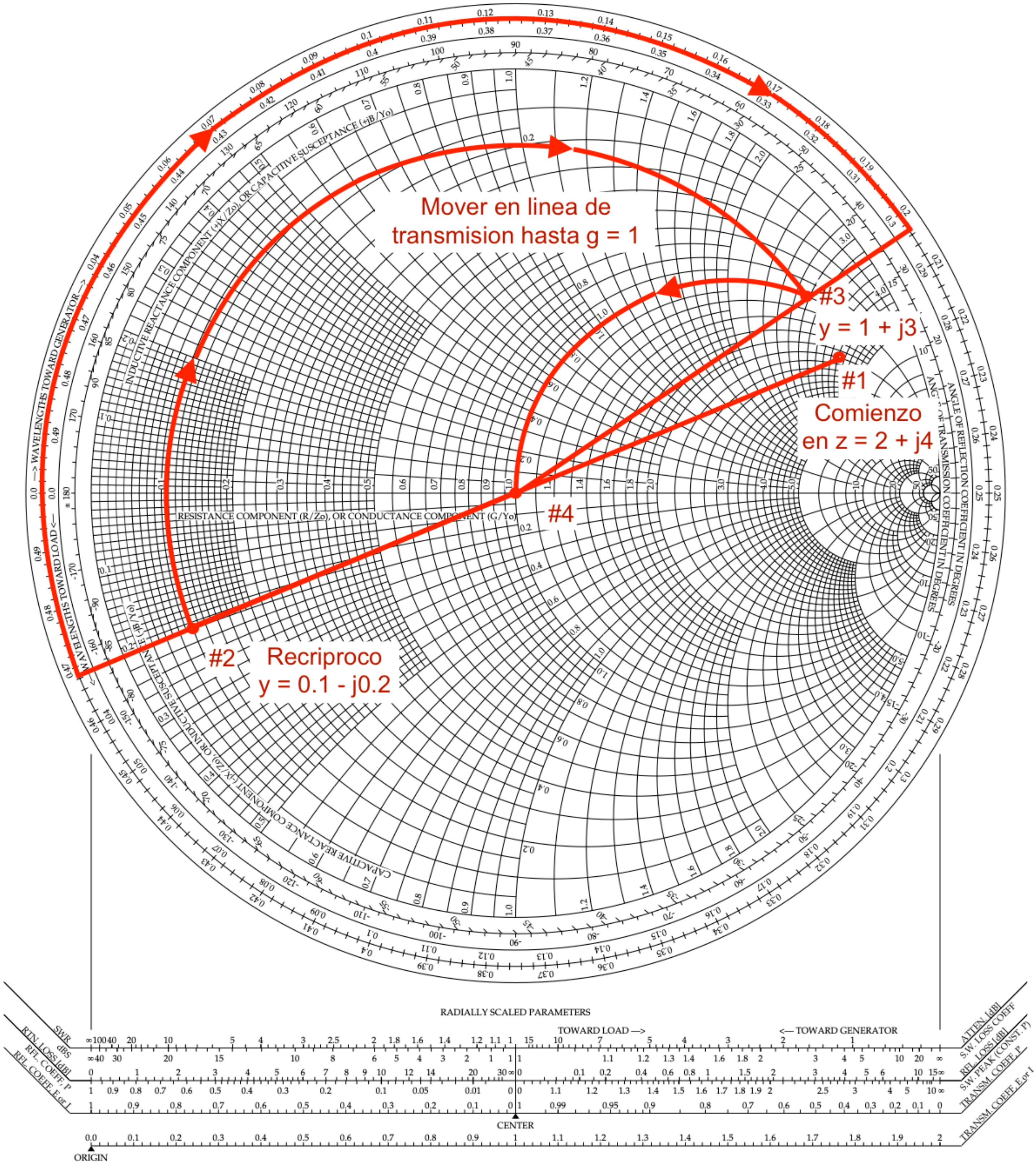
y al final de la línea a la entrada

$y = 1 + j3$ j3 es de una capacitancia
∴ hay que poner un inductor en paralelo
$-j3$ esto es b queremos

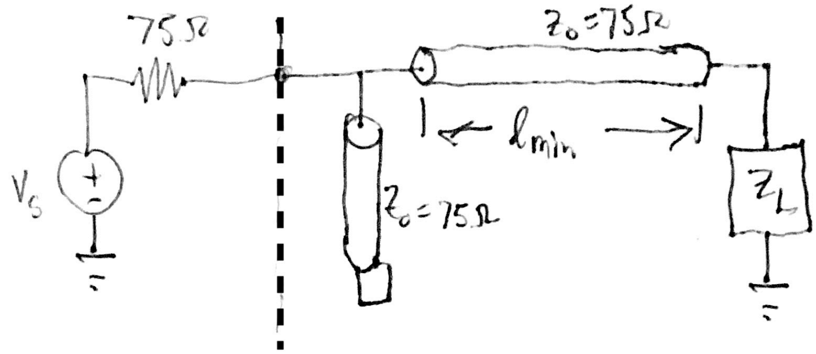
$$x = \frac{1}{-j3} = j\,0.33$$

$$\underline{\underline{X_p = 25\,\Omega}}$$

Smith Chart


Mover en linea de
transmision hasta g = 1
#3
y = 1 + j3
#1
Comienzo
en z = 2 + j4
#4
#2
Recriproco
y = 0.1 - j0.2
RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
INDUCTIVE REACTANCE COMPONENT (+jX/Zo), OR CAPACITIVE SUSCEPTANCE (+jB/Yo)
CAPACITIVE REACTANCE COMPONENT (-jX/Zo), OR INDUCTIVE SUSCEPTANCE (-jB/Yo)
0.0 —> WAVELENGTHS TOWARD GENERATOR —>
<— WAVELENGTHS TOWARD LOAD <—
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
RADIALLY SCALED PARAMETERS
TOWARD LOAD —>
<— TOWARD GENERATOR
SWR
dBS
RTN. LOSS [dB]
RFL. COEFF, P
RFL. COEFF, E or I
ATTEN. [dB]
S.W. LOSS COEFF
RFL. LOSS [dB]
S.W. PEAK (CONST. P)
TRANSM. COEFF, P
TRANSM. COEFF, E or I
CENTER
ORIGIN

#10



$Z_L = 150 + j300\Omega$

en este problema aprovechamos lo ya hecho del #9 hasta $y = 1+j3$, el largo de la línea sigue siendo 0.235λ, $\underline{l_{min} = 0.235\lambda}$.

lo único que ahora el stub en corto tiene que tener una admitancia de $-j3$, $y = -j3$. como es puro imaginario nos movemos en el círculo externo

$l_{stub} = 0.25 + 0.302 - 0.25 = 0.302\lambda$