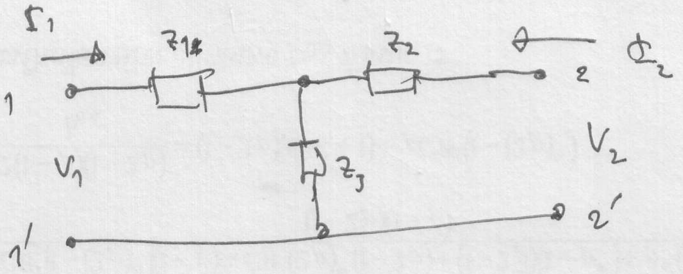
เฉลยข้อสอบ ภาค 2/2558

ข้อ 1

หา Z, Y และ (F) parameter



หา Z - parameter

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \quad \text{---} \quad (1)$$

$$V_2 = Z_{22} I_2 + Z_{21} I_1 \quad \text{---} \quad (2)$$

หา Z_{11} → open V_2 → $I_2 = 0$ (open ที่ 2 - 2')

$$Z_{11} = Z_1 + Z_3 \quad \text{---} \quad Ans$$

และ Z_{12} → open V_1 → $I_1 = 0$

$$Z_{12} = \left. \frac{V_1}{I_2} \right|_{I_1 = 0}$$

Open V_1

$$V_1 = I_2 Z_3$$

$$\therefore \quad Z_{12} = \frac{\cancel{I_2} Z_3}{\cancel{I_2}} = Z_3 \quad \text{---} \quad Ans$$

หา Z_{21} ← open V_2 → $I_2 = 0$

$$Z_{21} = \left. \frac{V_2}{I_1} \right|_{I_2 = 0}$$

ดังนั้น $V_2 = I_1 Z_3$

$$\therefore \quad z_{21} = \frac{\cancel{I_1} Z_3}{\cancel{I_1}} = Z_3$$

$\therefore \quad z_{22} \rightarrow$ open $V_1 \rightarrow I_1 = 0$

$$z_{22} = \left. \frac{V_2}{I_2} \right|_{I_1 = 0}$$

$$V_2 = I_2 Z_2 + I_2 Z_3 = I_2 (Z_2 + Z_3)$$

$$z_{22} = \frac{\cancel{I_2}(Z_2 + Z_3)}{\cancel{I_2}} = Z_2 + Z_3$$

$$[Z] = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} Z_1 + Z_3 & Z_3 \\ Z_3 & Z_2 + Z_3 \end{bmatrix}$$

$\therefore$ [Y] parameter

$$[Y] = [Z]^{-1} \rightarrow \text{invert } [Z]$$

$$\therefore \quad [Z]^{-1} \leftarrow$$

$$[\text{Adjoint } Z] = \begin{bmatrix} {}^{+}\; Z_1 + Z_3 & {}^{-}\; Z_3 \\ {}^{-}\; Z_3 & {}^{+}\; Z_2 + Z_3 \end{bmatrix} \rightarrow \begin{bmatrix} +(Z_2 + Z_3) & -Z_3 \\ -Z_3 & +Z_1 + Z_2 \end{bmatrix}$$

$$\therefore \quad |Z| = (Z_1 + Z_3)(Z_2 + Z_3) - Z_3^2 = Z_1 Z_2 + Z_1 Z_3 + Z_3 Z_2 + \cancel{Z_3^2} - \cancel{Z_3^2}$$

$$|z| = z_1 z_2 + z_1 z_3 + z_3 z_2$$

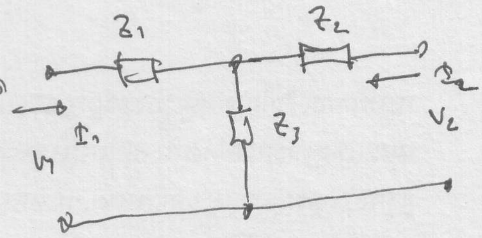
$$[Y] = [Z]^{-1} = \begin{bmatrix} \dfrac{z_2 + z_3}{z_1 z_2 + z_1 z_3 + z_3 z_2} & \dfrac{-z_3}{z_1 z_2 + z_1 z_3 + z_3 z_2} \\[2ex] \dfrac{-z_3}{z_1 z_2 + z_1 z_3 + z_3 z_2} & \dfrac{z_1 + z_2}{z_1 z_2 + z_1 z_7 + z_3 z_2} \end{bmatrix} \longrightarrow \text{Ø}$$

и [F] parameter.

$$V_1 = A V_2 - B I_2$$

$$I_1 = C V_2 - D I_2$$

и $A = \left.\dfrac{V_1}{V_2}\right|_{I_2 = 0}$ ——o



open V_2

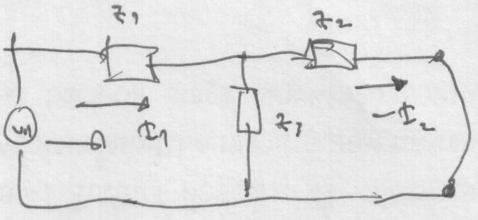
$$V_2 = \frac{V_1 \times z_3}{z_1 + z_3} = \frac{V_1 z_3}{z_1 + z_3}$$

llnuai v_2 → $A = \dfrac{\cancel{V_1}}{\dfrac{\cancel{V_1} z_3}{(z_1 + z_2)}} = \dfrac{z_1 + z_2}{z_3}$

$$A = \frac{z_1 + z_3}{z_3} \longrightarrow \text{Ø}$$

иoí $B = \left.\dfrac{V_1}{-I_2}\right|_{V_2 = 0}$ ——o short

ถ้า V_2 → short



$$Z_T = Z_1 + Z_2 \parallel Z_3 = Z_1 + \frac{Z_2 Z_3}{Z_2 + Z_3}$$

$$Z_T = \frac{Z_1(Z_2+Z_3) + Z_2 Z_3}{Z_2 + Z_3}$$

$$I_1 = \frac{V_1}{Z_T} = \frac{V_1}{\left[\frac{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}{Z_2+Z_3}\right]}$$

$$I_1 = V_1 \left[\frac{Z_2 + Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}\right]$$

หา I_2 → โดยใช้ตัวแบ่ง แบ่ง กร.แส.

$$-I_2 = \frac{I_1 Z_3}{Z_2 + Z_3}$$

แทนค่า I_1 จ. โจ.

$$-I_2 = \frac{V_1 (\cancel{Z_2+Z_3})}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3} \times \frac{Z_3}{(\cancel{Z_2+Z_3})}$$

$$-I_2 = \frac{V_1 Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}.$$

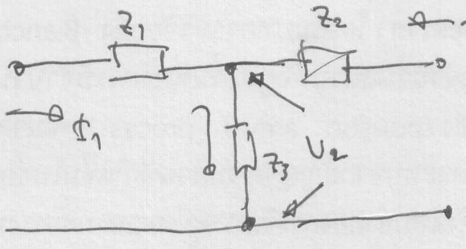
จาก

$$B = \left.\frac{V_1}{-I_2}\right|_{V_2=0} \quad \text{แทนค่า} \quad = \frac{\cancel{V_1}}{\left[\frac{\cancel{V_1} Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}\right]}$$

$$B = \frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_3} \quad \text{———} \; ②$$

หา C จาก

$$C = \left. \frac{I_1}{V_2} \right|_{I_2 = 0} \quad (\text{open } V_2)$$

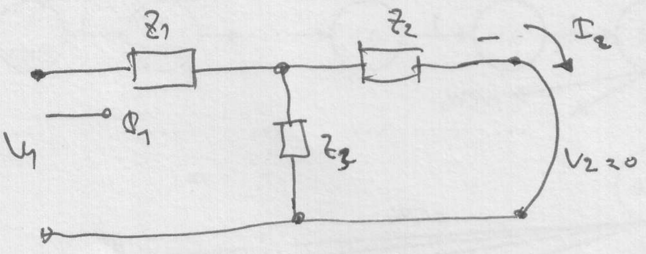


$$V_2 = I_1 Z_3$$

$$\therefore \; C = \frac{I_1}{I_1 Z_3} = \frac{1}{Z_3} \quad \text{———} \; ②$$

หา D จาก[illegible]

$$D = \left. \frac{I_1}{-I_2} \right|_{V_2 = 0} \rightarrow \text{short } V_2$$



มองจาก $V_1 \Rightarrow Z_T = Z_1 + (Z_2 // Z_3)$

ใช้หลักการแบ่งกระแส.

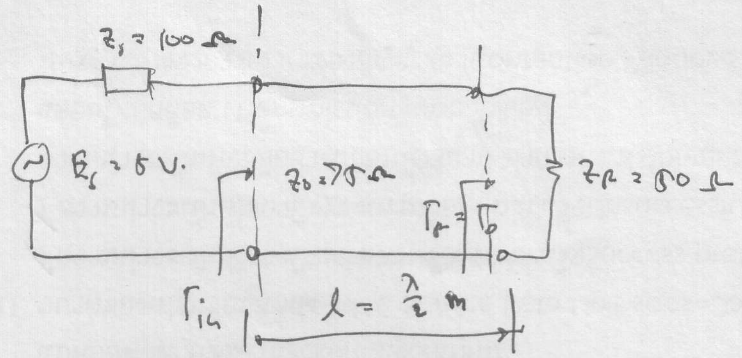
$$-I_2 = \frac{I_1 Z_3}{Z_2 + Z_3}$$

$$\therefore \; D = \frac{I_1}{\left[\frac{I_1 Z_3}{Z_2 + Z_3} \right]} = \frac{Z_2 + Z_3}{Z_3} \quad \text{———} \; ②$$

$$[F] = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

$$[F] = \begin{bmatrix} \frac{Z_1 + Z_3}{Z_3} & \frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_3} \\ \frac{1}{Z_3} & \frac{Z_2 + Z_3}{Z_3} \end{bmatrix}$$

๒ จงหา P_{in}, P_L, P_Σ, Q_L ของวงจรสายส่งดังต่อไปนี้.



จาก $\Gamma_{in} = \dfrac{Z_0 - Z_{in}}{Z_0 + Z_{in}} = \Gamma_0 e^{-j\beta l}$

$$\Gamma_0 = \frac{Z_R - Z_0}{Z_R + Z_0}$$

Sol^n จากสูตร

$$P_{in} = \frac{1}{8} \frac{|E_s|^2 |1 - \Gamma_s|^2}{|1 - \Gamma_s \Gamma_0 e^{-j\beta l}|^2} \left(1 - |\Gamma_0 e^{-2j\beta l}|^2\right)$$

$$\Gamma_s = \frac{Z_s - Z_0}{Z_s + Z_0} = \frac{100 - 75}{100 + 75} = 0.1428$$

$$\Gamma_0 = \frac{Z_R - Z_0}{Z_R + Z_0} = \frac{50 - 75}{50 + 75} = -0.2$$

$$\beta = \frac{2\pi}{\lambda}$$

$$\beta l = \frac{\cancel{2}\pi}{\cancel{\lambda}} \times \frac{\cancel{\lambda}}{\cancel{2}} = \pi$$

$$re^{j\theta} = r\cos\theta + jr\sin\theta = r(\cos\theta + j\sin\theta)$$

$$e^{-2j\beta l} = e^{-2j(\pi)} = e^{j(-2\pi)} = \cos(-2\pi) + j\sin(-2\pi)$$

$$e^{-2j\beta l} = 1 + (0) = 1$$

คิดหา P_{in} จ.1450

$$P_{in} = \frac{1}{8} \frac{|E_s|^2 |1-\Gamma_s|^2}{|1-\Gamma_s\Gamma_0|^2} |1-\Gamma_0|^2$$

$$P_{in} = \frac{1}{8} \frac{5^2 (1-0.1428)^2}{[1-(0.1428)(-0.2)]^2} [1-(-0.2)]^2$$

$$P_{in} = \frac{1}{8} \frac{18.369}{1.05799} (1.2)^2 = 3.125 \text{ W.}$$

$$P_L = P_{in} = 10\log \frac{3.125\text{ W}}{1\text{ W}} = 4.948 \text{ dB}$$

$$\text{Return loss} = (RL) = \cancel{10\log(1/|\Gamma_{in}|^2)} - 10\log(|\Gamma_{in}|)^2$$

$$\Gamma_{in} = \Gamma_0 e^{-j2\beta l} = (-0.2) e^{-j(\pi)}$$

$$\Gamma_{in} = (-0.2)[\cos(-360°) + j\sin(-360°)]$$

$$\Gamma_{in} = (-0.2)(+1+0) = -0.2$$

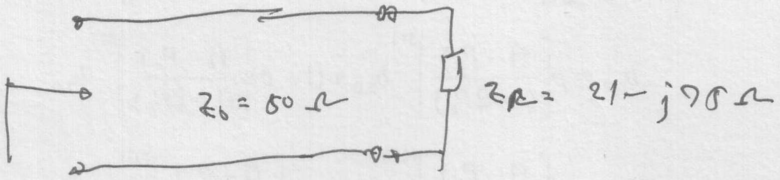
$$\text{Return loss} = -10\log(-0.2^2) = +13.979 \text{ dB}$$

$$\text{Insertion loss} = (IL) = 10\log(1-|\Gamma_{in}|^2)$$

$$= 10\log(1-(0.2)^2) = 10\log 0.96$$

Insertion loss = -0.17728 dB

(3) จงหา SWR และ ค่ากำลังงานสะท้อนกลับ



$P_{in} = 10\,W.$

$$Z_r\ (\text{normallized}) = \frac{21 - j75}{50} = 0.42 - j1.5$$

โดยวิธีคำนวณ

$$\Gamma = \frac{Z_R - Z_0}{Z_R + Z_0} = \frac{21 - j75 - (50)}{21 - j75 + 50}$$

$$\Gamma = \frac{-29 - j75}{71 - j75} = \frac{80.41\angle -111.135^\circ}{103.27\angle -46.56}$$

$$\Gamma = 0.7786\angle -64.575$$

$$|\Gamma| = 0.7786 \longrightarrow \text{ขนาด}$$

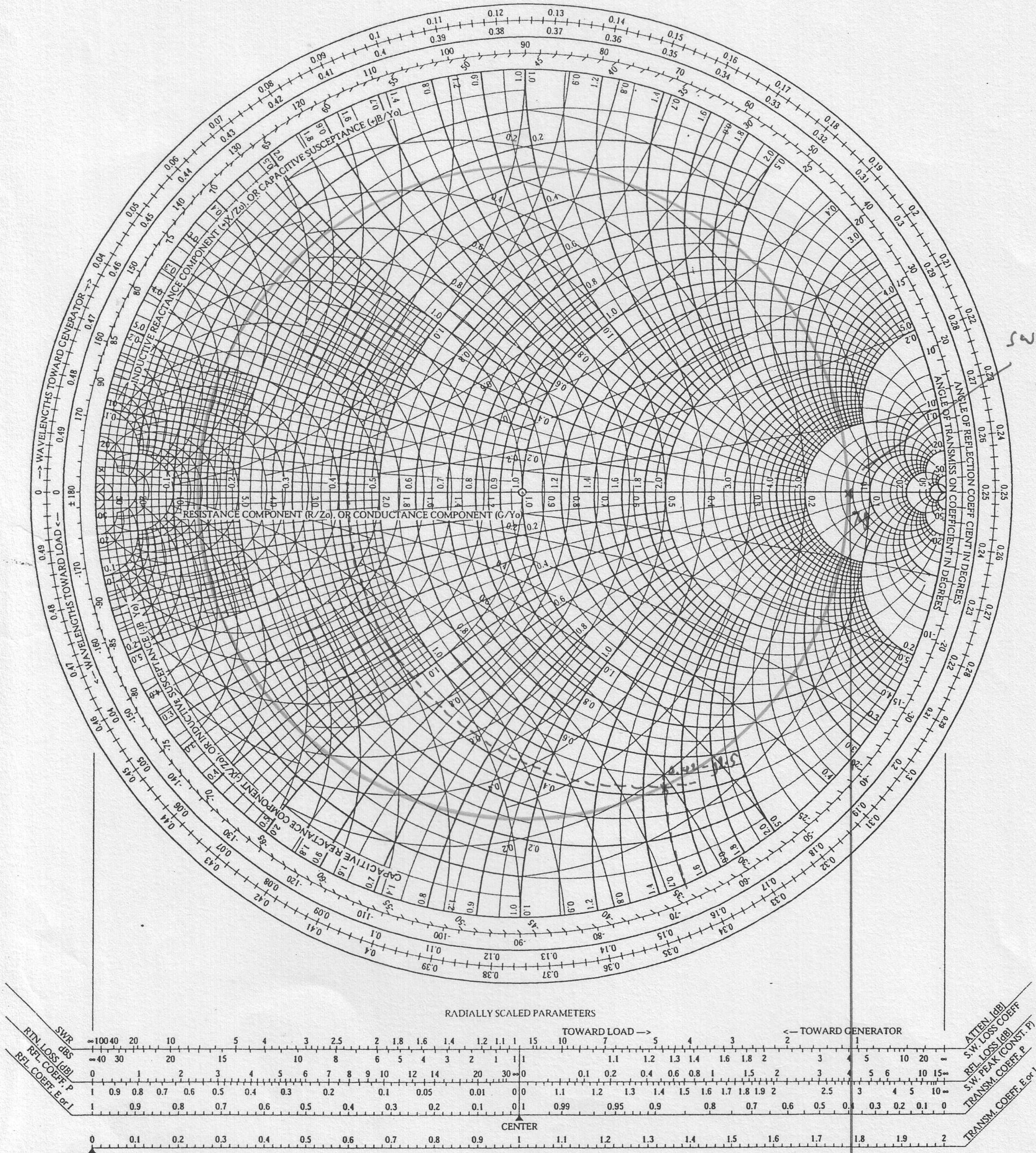
$$SWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} = \frac{1 + 0.7786}{1 - 0.7786}$$

$$SWR = 8.03342 \longrightarrow$$

ใช้ smith chart

NAME	TITLE	DWG. NO.
		DATE
SMITH CHART	Courtesy of Microwaves101.com	

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



SWR = 7.5 – 7.7

SWR — 7.5 — 7.7

$$\eta = \frac{\text{กำลังที่ส่ง}}{\text{กำลังงานที่สะท้อนกลับ}}$$

$$\text{กำลังงานที่สะท้อนกลับ} = \eta \times \text{กำลังส่ง}$$

$$= 0.4 \times 10 \text{ W}$$

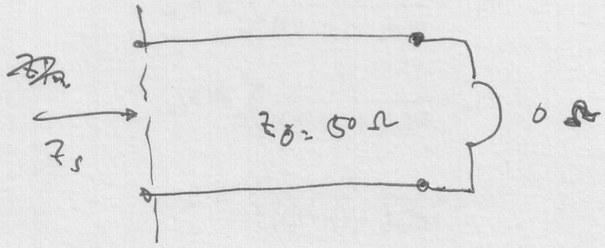
$$= 4 \text{ watt}$$

④ หา Z_{in}. ความยาวของสายส่ง = 0.305 เท่าของความยาวคลื่น

$$l = 0.305\lambda_p \quad \Big| \quad f = 4\text{ GHz}$$

กรณี ① short circuit → $Z_L = 0\ \Omega$

เมื่อโหลดเป็นวงจรลัด



$$Z_s = jZ_0 \tan\beta l$$

$$\beta l = \frac{2\pi}{\cancel{\lambda_p}}(0.305)\cancel{\lambda_p}$$

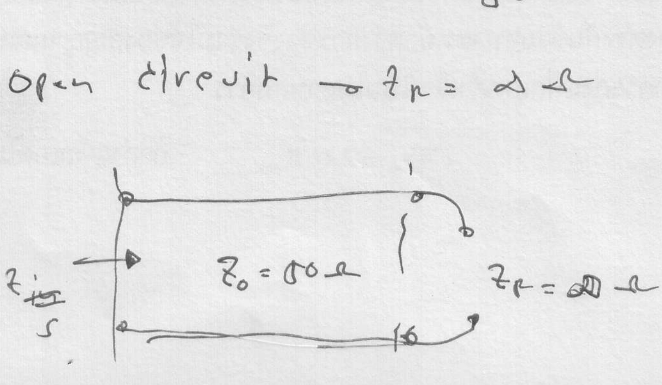
$$\beta l = 109.8$$

$$Z_s = j(50)\tan 109.8$$

$$Z_s = -j138.88\ \Omega$$

$$Z_s\,(\text{normallized}) = \frac{-j138.88}{50} = -j2.77\ \Omega$$

กรณี ② open circuit → $Z_L = \infty\ \Omega$



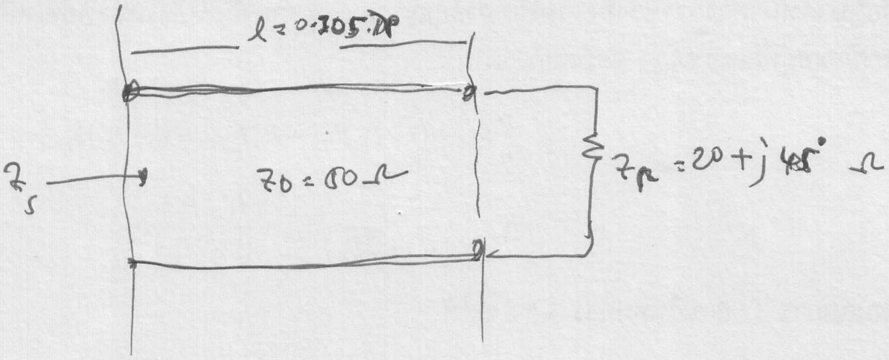
กรณี วงจรเปิด

$$Z_s = \frac{-jZ_0}{\tan \beta l} = \frac{-j50}{\tan \frac{2\pi}{\lambda_p}(0.305\lambda_p)}$$

$$Z_s = \frac{-j50}{-2.777} = +j18.0 \ \Omega$$

$$Z_{(s)} \text{ normallized} = j\frac{18}{50} = +j0.360 \ \Omega$$

กรณี ③ ถ้า $Z_R = 20 + j45$



$$Z_s = \frac{Z_0(Z_R + jZ_0 \tan \beta l)}{(Z_0 + jZ_R \tan \beta l)}$$

$$Z_s = \frac{50\left(20 + j45 + j50\left[\tan \frac{2\pi}{\lambda_p}(0.305\lambda_p)\right]\right)}{50 + j(20+j45)\tan \frac{2\pi}{\lambda_p}(0.305\lambda_p)}$$

$$Z_s = \frac{1000 + j2250 - j6944.01}{50 + j20 + j^2 45(-2.777)}$$

$$Z_s = \frac{1000 - j4694.01}{174.96 + j20} = \frac{4799.3\angle -77.9}{176.09\angle 6.52}$$

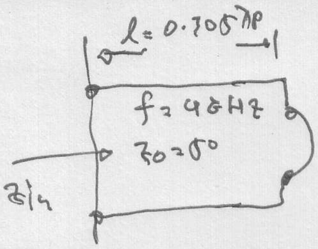
$$Z_s = 27.25 \angle -84.42$$

$$Z_s = 2.649 - j27.12 \quad \Omega$$

$$Z_s \text{ (normallized)} = \frac{Z_s}{Z_0} = \frac{2.649 - j27.12}{50}$$

$$Z_s' = 0.0529 - j0.5424 \quad \text{—— } \boxed{b}$$

To smith chart



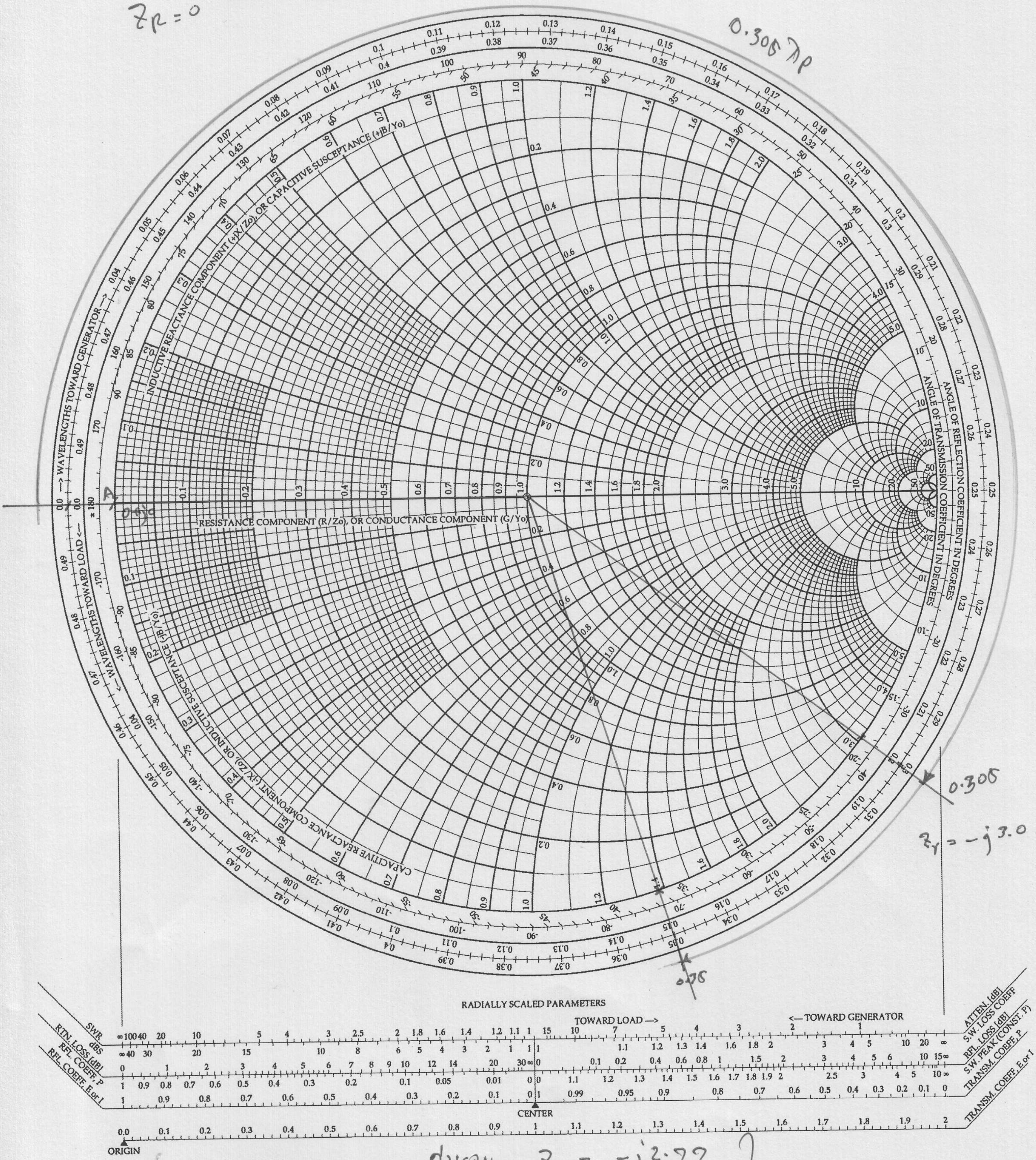
$Z_s' = \frac{Z_R}{Z_0} = \frac{0}{50} = 0\ \Omega \rightarrow 0+j0$

The Complete Smith Chart

Black Magic Design

short c.c.

$Z_R = 0$

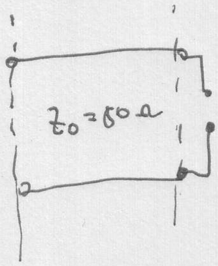


Theory $Z_s = -j2.77$

Smith chart $Z_s = -j3.00$

near $Z_L = \infty$ (open circuits)

(19)



$z_s' = \frac{Z_L}{Z_0} = \frac{\infty}{50} = \infty$

The Complete Smith Chart

Black Magic Design

$z_s' = \infty + j\infty\ \Omega$

$l = 0.305$

$g_1 \delta_r$ $0.25 + 0.305$

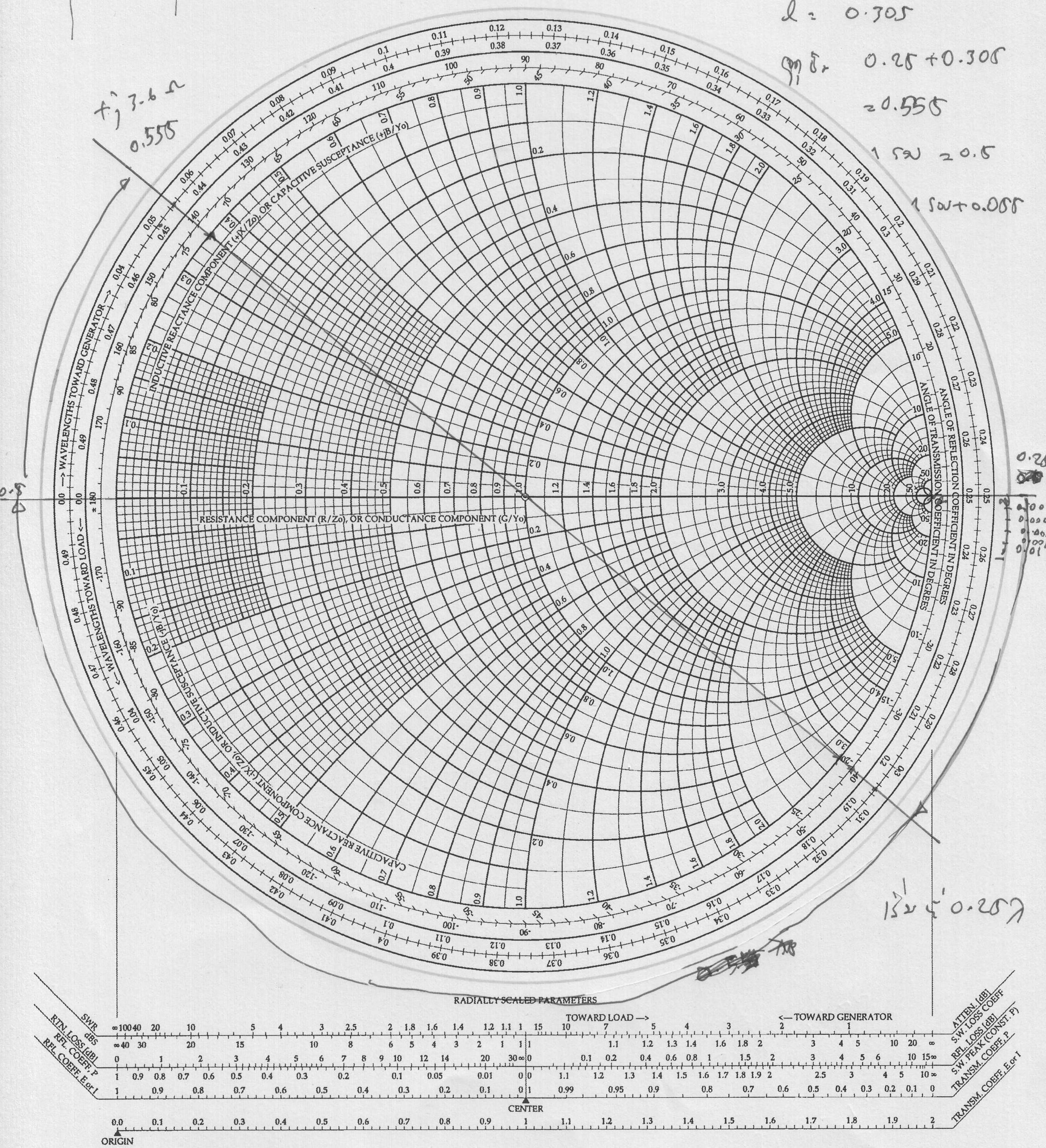
$= 0.555$

1 รอบ $= 0.5$

1 รอบ $+ 0.055$

$+j\,3.6\ \Omega$

0.555



$z_s' = j\,0.257$

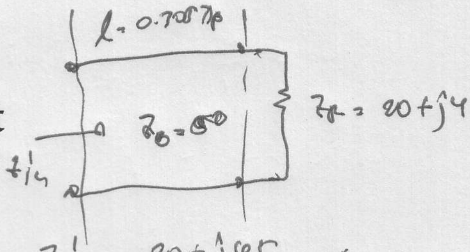
จากรูป $Z_{in} = +j\,0.36$

smith chart $Z_{in} = +j\,0.36\ \Omega$

$Z_L = 20 + j45$

The Complete Smith Chart

Black Magic Design

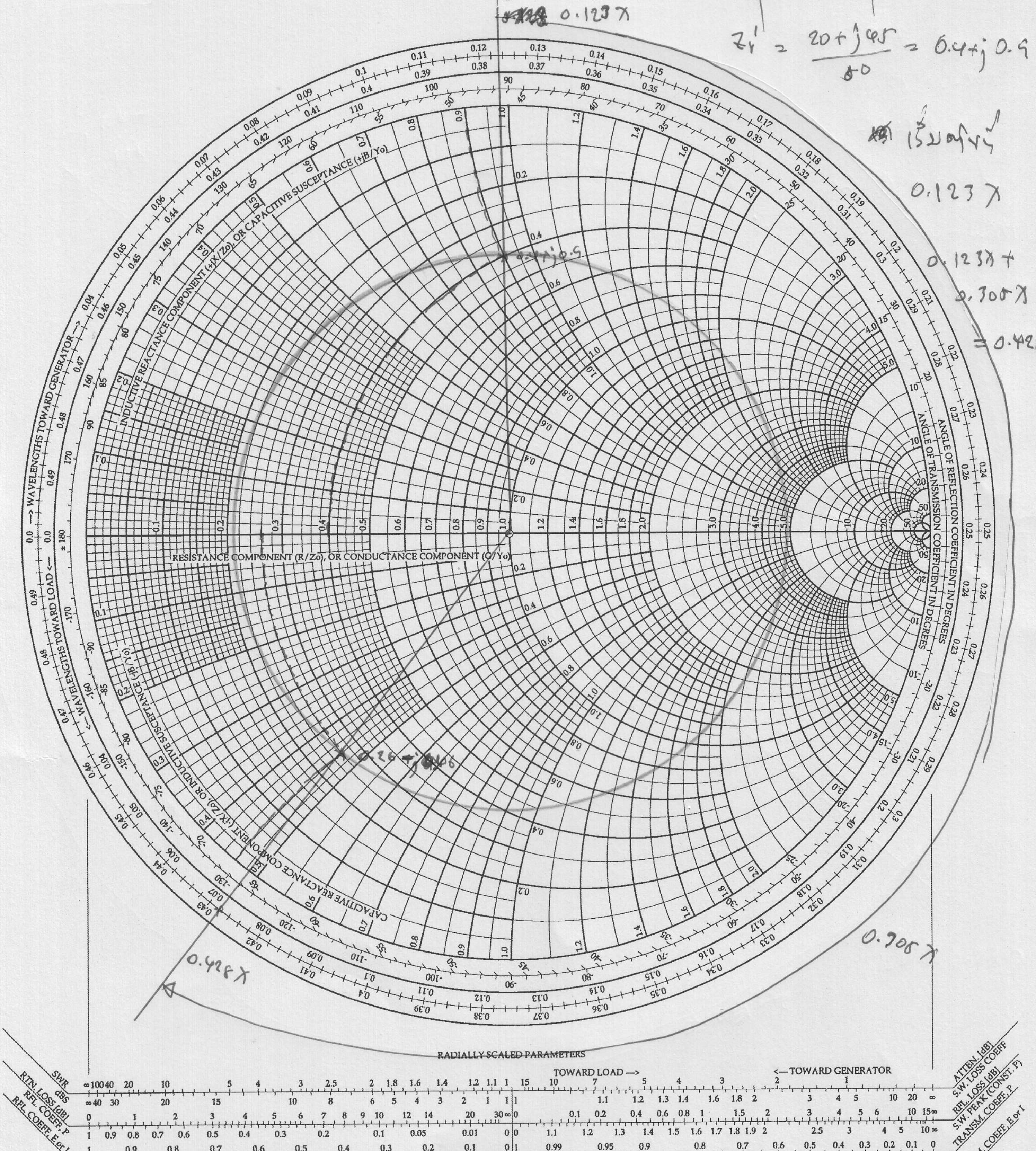


$$z_L' = \frac{20 + j45}{50} = 0.4 + j0.9$$

[illegible]

0.123λ

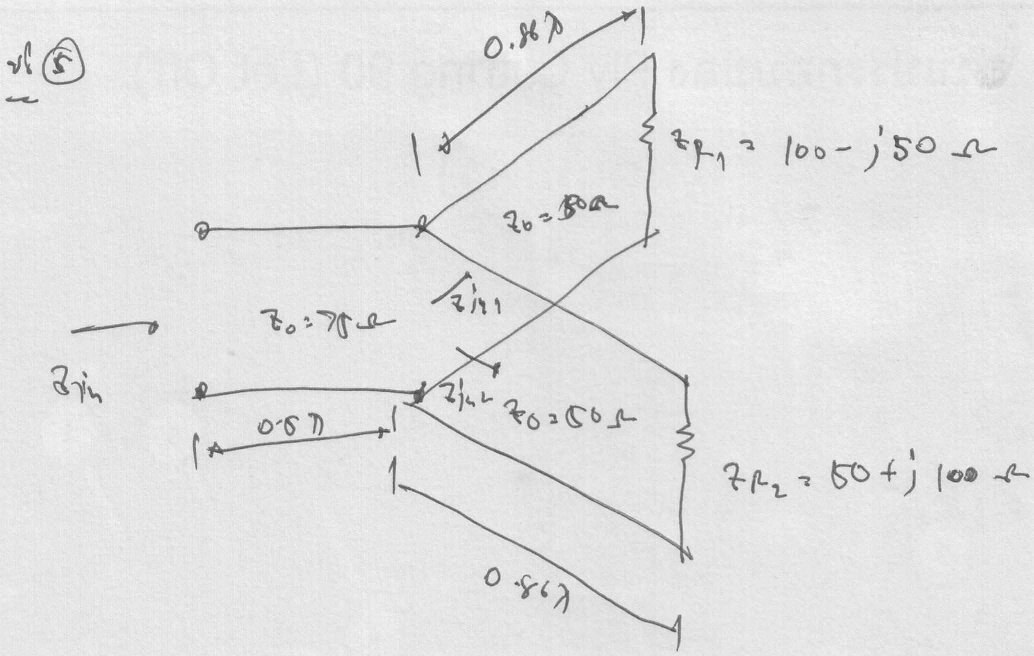
0.123λ + 0.705λ = 0.428λ



$z_r = 0.26 - j0.46$ | [illegible] $= Z_s = 266 - j29.12\ \Omega$

$Z_s = (0.26 - j0.46) \times 50 = 13 - j23\ \Omega$

Q(5)



Soln: Z_{in}

$$Z_{in_1} = \frac{Z_0 (Z_R + j Z_0 \tan\beta l)}{(Z_0 + j Z_R \tan\beta l)}$$

for $\frac{1}{Z_0}$ [illegible]

$$Z_{in_1} = \frac{Z_0 \left(\frac{Z_R}{Z_0} + j \tan\beta l \right)}{\left(1 + \frac{Z_R}{Z_0} \tan\beta l\right)}$$

$$\frac{Z_R}{Z_0} = \cancel{50} \; \frac{100 - j50}{50} = 2 - j1$$

$$\tan\beta l = \tan \frac{2\pi}{\cancel{\lambda}} (0.86\cancel{\lambda}) = \tan(2\pi \times 0.86)$$

$$\tan\beta l = -1.208$$

$$Z_{in_1} = \frac{50\left[2 - j + j(-1.208)\right]}{\left[1 + (2 - j)(-1.208)\right]}$$

$$Z_{in_1} = \frac{100 - j50 - j1.208}{1 + 2 - j(-1.208)}$$

$$Z_{in_1}' = \frac{100 - j\,81.208}{3 + j\,1.208} = \frac{112.348 \angle -29.11}{\cancel{3.234 + j\,21.93}\; 3.234 \angle +21.93}$$

$$Z_{in_1} = 34.73 \angle -49.04 \ \Omega$$

$$Y_{in_1} = \frac{1}{Z_{in_1}} = \frac{1}{34.73 \angle -49.04} = 0.02879 \angle 49.04 \ S.$$

$$Y_{in_1}' = 0.01887 + j\,0.02174 \quad S.$$

$$Z_{in_2} = \frac{Z_0 \left(\frac{Z_R}{Z_0} + j \tan \beta l \right)}{1 + \frac{Z_R}{Z_0} \tan \beta l}$$

$$\frac{Z_R}{Z_0} = \frac{50 + j\,100}{50} = 1 + j2$$

$$\tan \beta l = \tan \frac{2\pi}{\lambda}(0.86\lambda) = \tan 309.6' = -1.2087$$

$$Z_{in\,2} = \frac{50\left[1 + j2 + j(-1.2087)\right]}{1 + (1 + j2)(-1.2087)} = \frac{50 + j100 - j\,1.2087(50)}{}$$

$$= \frac{50 + j100 - j\,60.4}{1 - 1.208 - j\,2.416} = \frac{50 + j\,39.6}{-0.208 - j\,2.416}$$

$$= \frac{63.78 \angle 38.39}{2.424 \angle -94.92}$$

$$= 26.311 \angle 133.29 = -18.04 + j\,19.151$$

$$Y_{in_2} = \frac{1}{26.311\angle 133.29} = 0.038\angle{-133.29}$$

$$Y_{in_2} = 0.038\angle{-133.29} = -0.026 - j0.0276$$

$$Y_{in_3} = Y_{in_1} + Y_{in_2} = 0.01887 + j0.02174 - 0.026 - j0.0296$$

$$Y_{in_3} = -0.00713 - j0.00586$$

$$Y_{in_3} = 0.009229\angle{-140.58^\circ}$$

$$Z_{in_3} = \frac{1}{Y_{in_3}} = \frac{1}{0.009229\angle{-140.58}} = 108.354\angle 140.58^\circ\ \Omega$$

$$Z_R = Z_{in_3}$$

$$Z_{in} = \frac{Z_0\left(\frac{Z_R}{Z_0} + j\tan\beta l\right)}{1 + \frac{Z_R}{Z_0}\tan\beta l}$$

$$\frac{Z_R}{Z_0} = \frac{108.354\angle 140.58^\circ}{75}$$

$$\frac{Z_R}{Z_0} = 1.444\angle 140.58^\circ$$

$$\tan\beta l = \tan\frac{2\pi}{\cancel{\lambda}}(0.5\cancel{\lambda}) = \tan 180^\circ = 0$$

$$Z_{in} = \frac{75\left(1.444\angle 140.58^\circ + j(0)\right)}{1 + \left(1.444\,\cancel{\angle 140.58^\circ}\, j(0)\right)}$$

$$Z_{in} = 108.3\angle 140.58^\circ \quad \Omega$$

$$Z_{in} = -83.\cancel{\ }663 + j\,68.77$$

$$Z_{in}' = \frac{Z_{in}}{Z_0} = \frac{Z_{in}}{75} = -1.1155 + j\,0.916 \quad \Omega$$

(normalized)

โดย Smith chart.

step ① $\frac{Z_1}{Z_0} = \frac{100 - j50}{50} = 2 - j1 = Z_1'$

step ② ~~...~~ กำหนดจุด Z_1' และอ่านค่ากลับ.

ได้ $Y_{in1} = \cancel{1.3\ \pm j\ 1.18}$ $1.3 - j\,1.18$ S

step ③ กำหนด $Z_{in2} = 50 + j100$

$$Z_{in2}' = \frac{50 + j100}{50} = 1 + j2$$

step ④ กำหนด Z_{in2}' → อ่านค่ากลับ ได้

NAME	TITLE	DWG. NO.
SMITH CHART	Courtesy of Microwaves101.com	DATE

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES

0.86λ

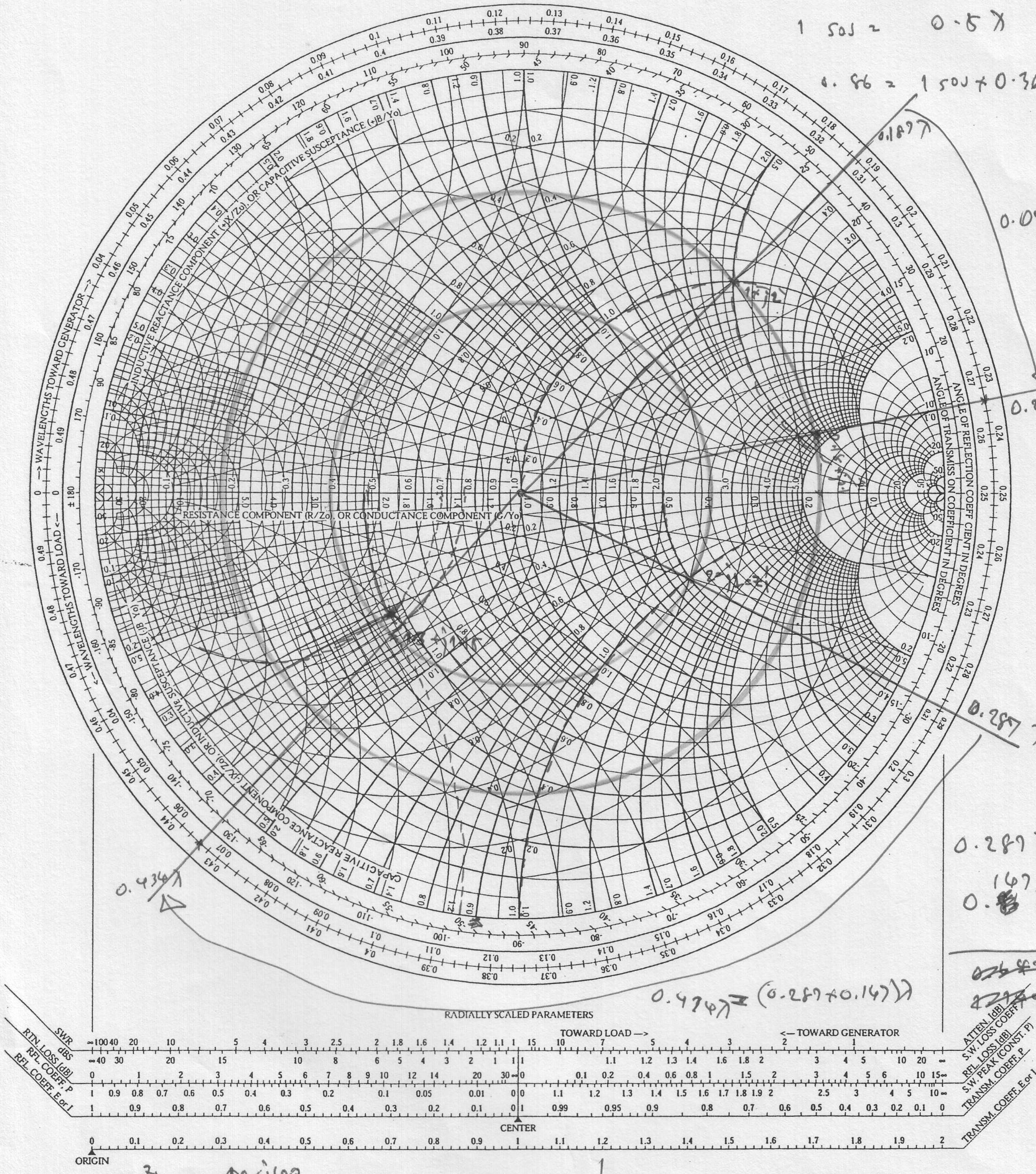
1 50Ω = 0.5λ

0.86 = 1 50Ω + 0.36λ

0.047λ

0.234λ

0.287λ



0.287λ + ~~0.8~~ 0.147λ

~~0.2~~ 0.434λ

0.434λ = (0.287 + 0.147)λ

$Z_{in_2} = 50 + j100$

$z_{in_2}' = \frac{Z_{in_2}}{50} = \frac{50+j100}{50} = 1 + j2$

$l_3 = 0.187\lambda + 0.86\lambda$

$= 1.047\lambda - 250\Omega + 0.047\lambda$

$- 0.187\lambda + 0.047\lambda = 0.234\lambda$

$1.147 = 2\ 50\Omega + 0.147$

$Y_{in_2} = 1.3 + j1.15\ S$

ได้ $Y_{in_2} = 0.18 + j0.1$ S.

$$Y_{in_3} = Y_{in_1} + Y_{in_2} = 1.3 - j1.18 + (0.18 + j0.1)$$

$$Y_{in_3} = 1.48 - j1.08 \quad S$$

Step 6 นำ $Y_{in\,3}$ → แปลงกลับใน Smith chart แล้วคูณด้วย Z.

$$Z_{in_3}' = 0.48 - j0.32 \quad \Omega$$

$$Z_{in_3}\,(\text{จริง}) = Z_{in_3}' \times 50 = (0.48 - j0.32)\,50$$

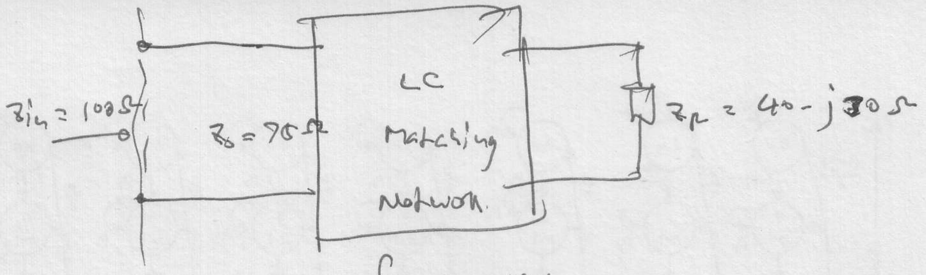
$$Z_{in_3}\,(\text{จริง}) = 24 - j16 \quad \Omega$$

Z_{in_3} → จะเป็นโหลดให้กับ สายส่ง ที่มี $Z_0 = 75\ \Omega$

เนื่องจากสายส่งนี้ยาว $\frac{\lambda}{2}$ → $Z_{in} = Z_{in3}$

$$Z_{in} = 24 - j16 \quad \Omega$$

(b)



$f = 300$ MHz

Sol^n

$$Z_L' = \frac{Z_L}{Z_0} = \frac{40 - j30}{75}$$

$$Z_L' = 0.5333 - j0.4$$

$$Z_{in}' = \frac{Z_{in}}{Z_0} = \frac{100}{75} = 1.333 + j0$$

plot Z_L' และ Z_{in}' → ลงบน smith chart.

โดย Z_L' → เดินบน Z_{in}' → โดยใช้วงกลม resistance และ conductance.

ใช้ L อนุกรม ที่จุด A

$$Z_A = 0.5333 + j0.5$$

$$jX_L = Z_A - Z_L' = 0.5333 + j0.5 - (0.5333 - j0.4)$$

$$jX_L = \cancel{0.5333} + j0.5 - \cancel{0.5333} + j0.4$$

$$jX_L = j0.9$$

$$X_L = \cancel{\quad} = 0.9$$

$$X_{L(\text{จริง})} = 0.9 \times Z_0 = 0.9 \times 75$$

$$X_L(\text{จริง}) = 67.5\ \Omega$$

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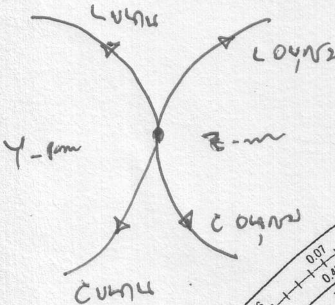
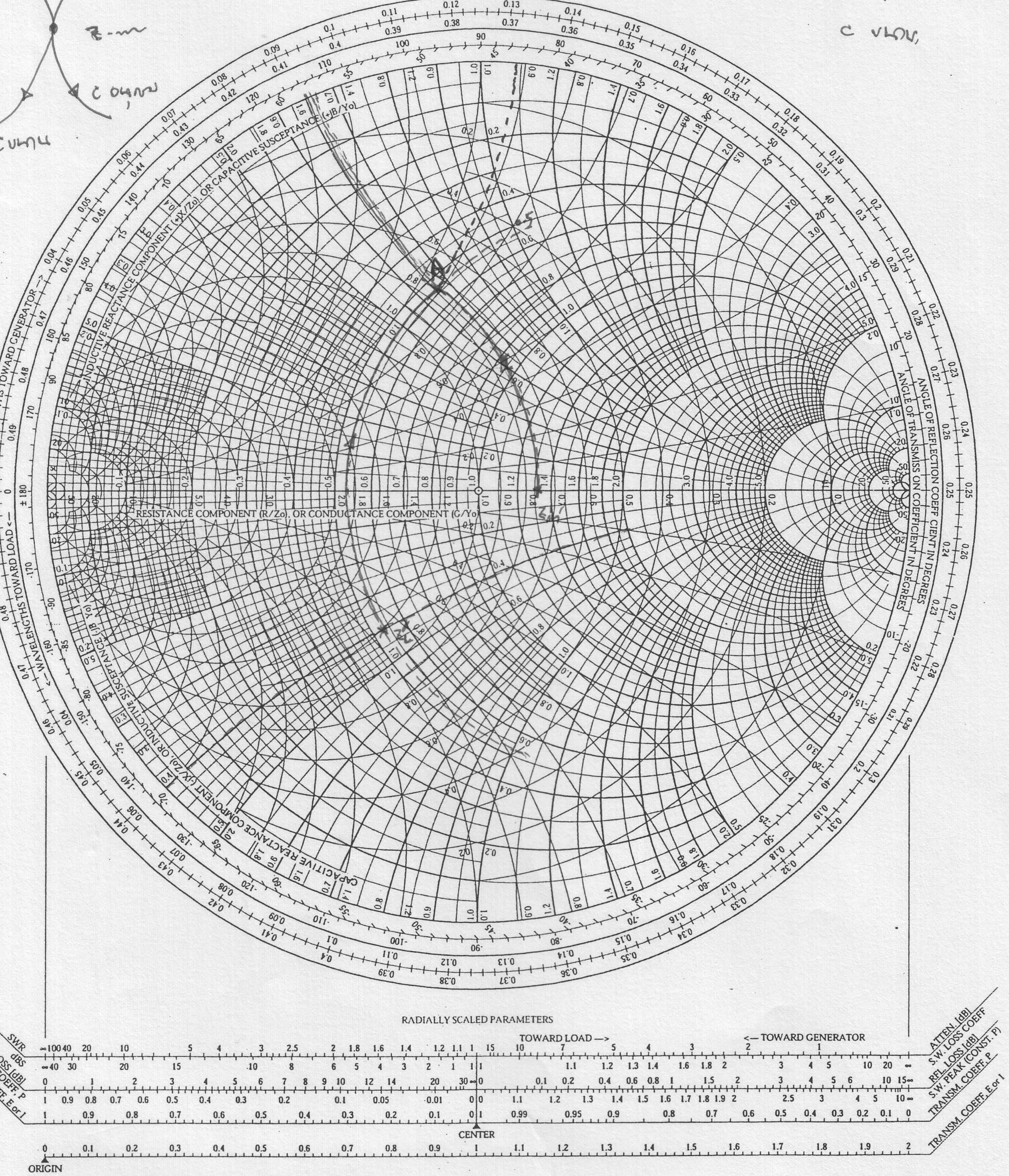


NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



$z_L' = 0.5333 - j0.4 \ \Omega$

$z_{in}' = 1.333 + j0 \ \Omega$

$$2\pi f L = 67.8$$

$$L = \frac{67.8}{2\pi \times 300 \times 10^{6}}$$

$$L = 0.0358 \ \mu H \rightarrow 35.8 \ nH$$

$$Y_A^{*} = 0.75 + j0.93$$

$$Y_{in} = 0.75 + j0$$

$$jb_c = Y_{in} - Y_A = 0.75 - (0.75 + j0.93)$$

$$jb_c = \cancel{0.75 - 0.75} - j0.93$$

$$jb_c = -j0.93$$

$$b_c = 0.93$$

$$\cancel{2\pi f C = \omega C = 0.93}$$

$$b_c = 0.93 \times Y_0 = 0.93 \times \frac{1}{Z_0}$$

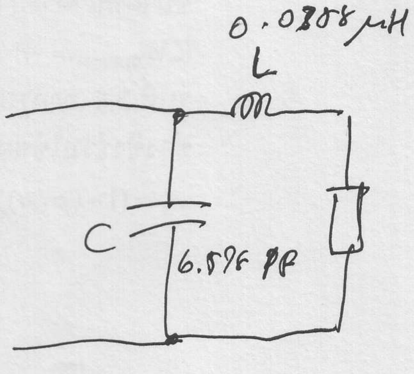
$$= 0.93 \times \frac{1}{75}$$

$$b_c = 0.0124$$

$$2\pi f C = 0.0124$$

$$C = \frac{0.0124}{2 \times \pi \times 300 \times 10^{6}} = 6.578 \times 10^{-12} \ F$$

$$C = 6.578 \ pF$$



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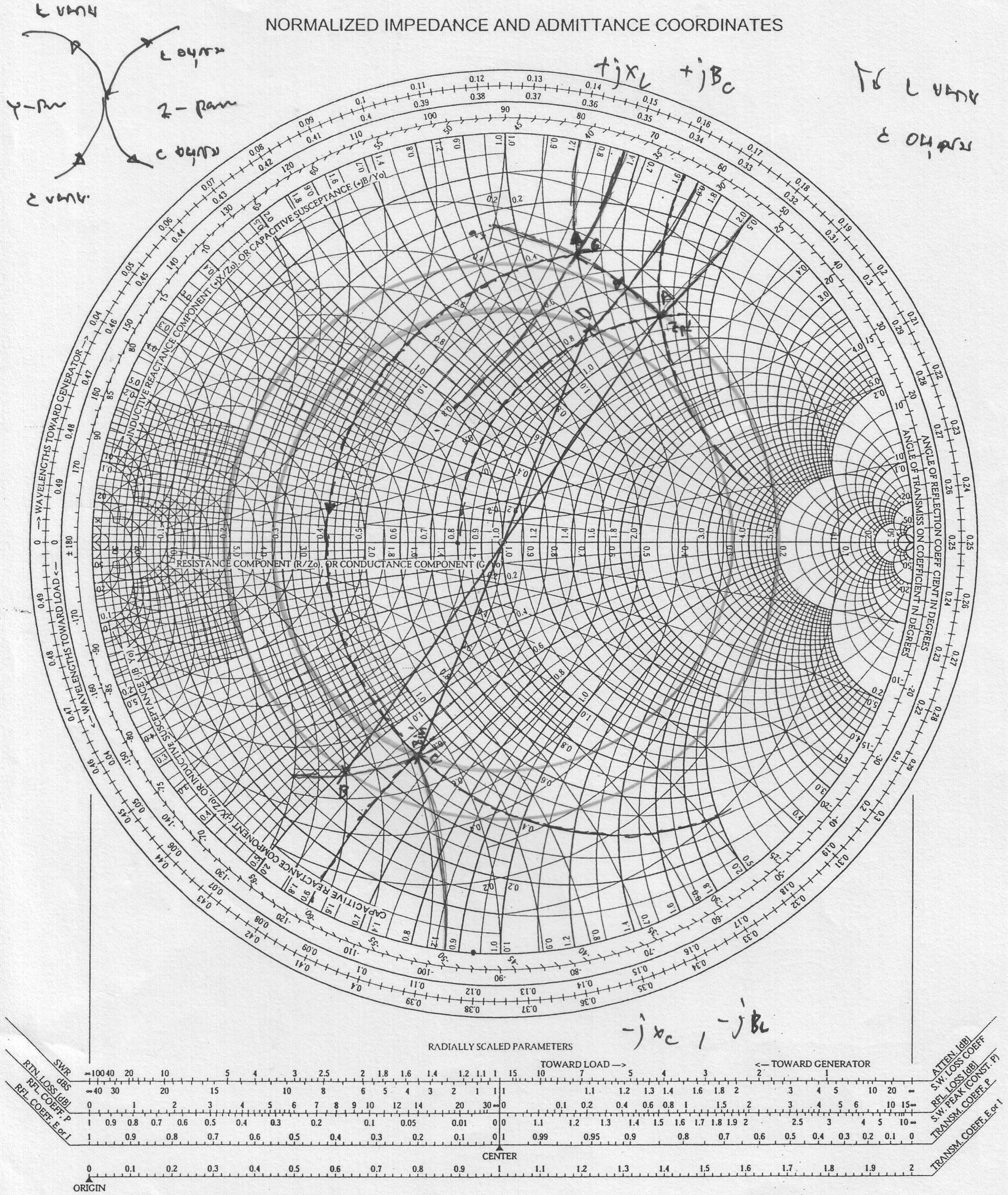
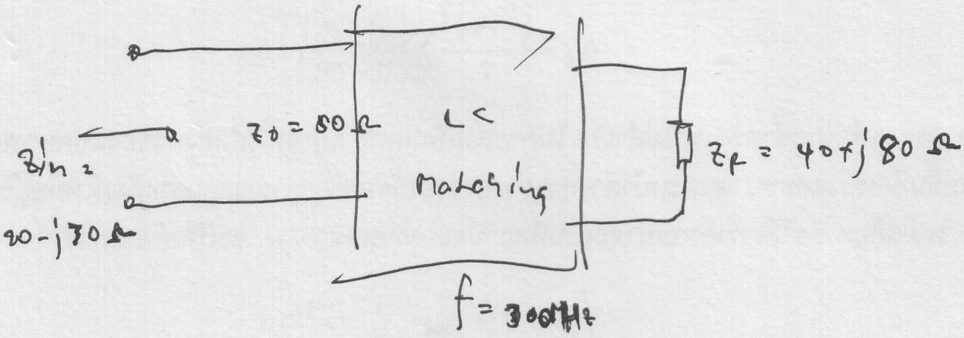
NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



ถ้า C → Z } ค่าที่ได้ scale ใช้ค่าที่ → Z.
D → Y

A → Z } ——— Z
B → Y

ข้อ ⑦



$R + jX_L$

sol^n

$$Z_L' = \frac{Z_L}{Z_0} = \frac{Z_R}{Z_0} = \frac{40+j80}{80} = 0.8 + j1.6$$

① นำ Z_L' plot ลงบน smith chart ได้จุด A แล้วอ่านค่าจากจุด A ได้

$$Y_L' = 0.25 - j0.5 \quad S$$

$$Z_L' = 0.8 + j1.6 \quad \Omega$$

② $$Z_{in}' = \frac{Z_{in}}{Z_0} = \frac{20-j30}{80} = 0.4 - j0.6$$

นำ Z_{in}' → plot ลงบน smith chart ได้จุด B และอ่านค่าจากจุด B

$$Y_{in}' = 0.78 + j1.18 \quad S$$

$$Z_{in}' = 0.4 - j0.6 \quad \Omega$$

③ เคลื่อนย้าย Z_L' → ไปหาจุด Z_{in}' → แนวของวง resistance และ admittance เท่านั้น ตามจุด A → B → C

จาก A → B → เป็น L ขนาน

B → C → เป็น C อนุกรม

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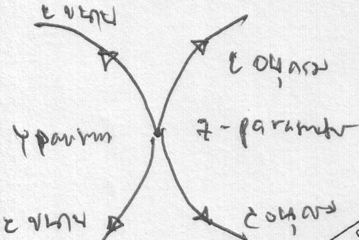
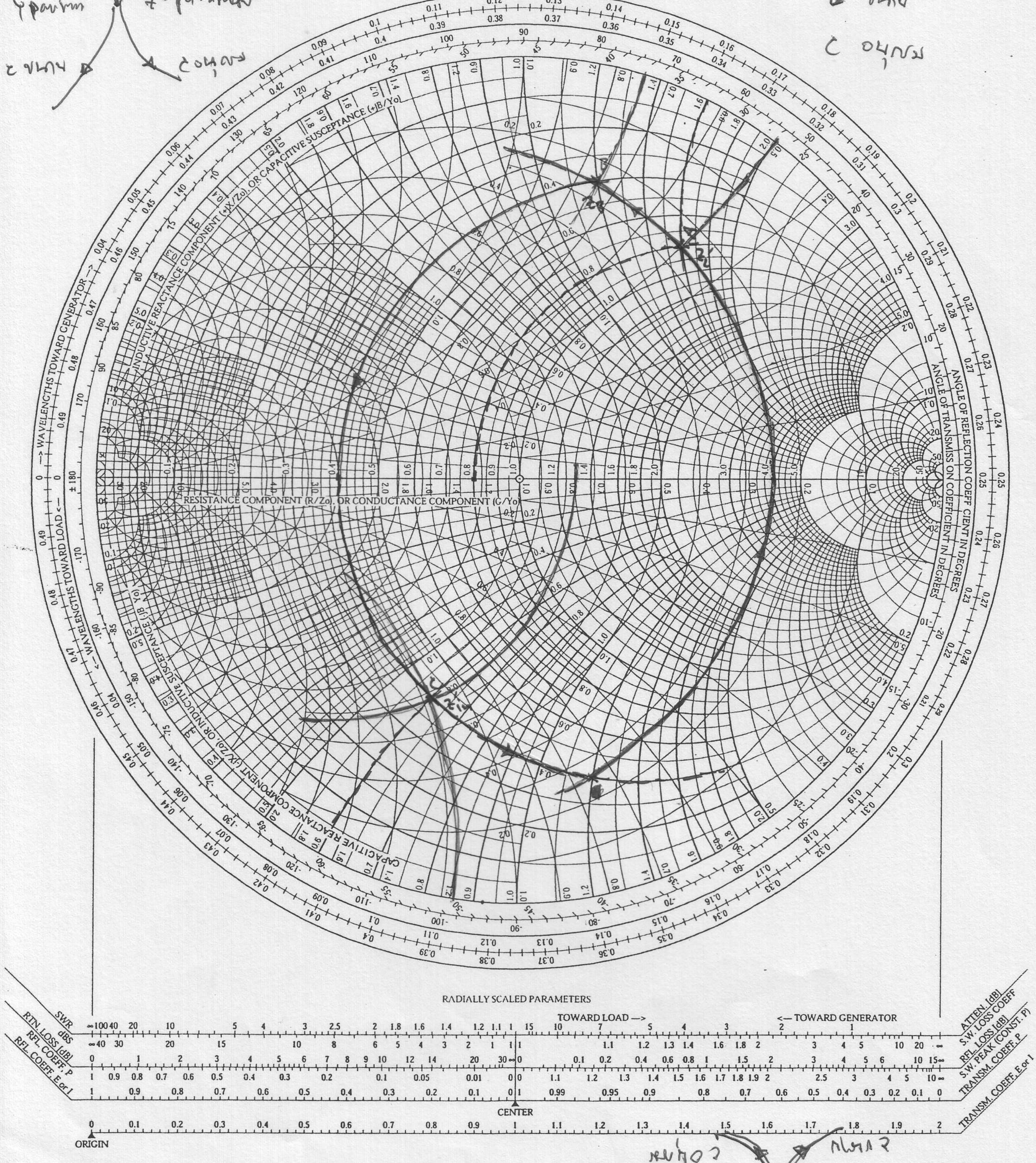
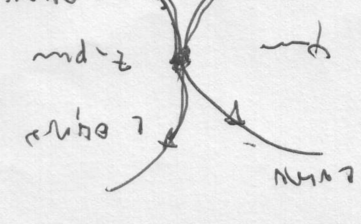


NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES

L shunt

C shunt





ที่จุด B

$$Z_B = 0.4 + j1.2$$

$$Y'_B = \cancel{}\,0.25 - j\,\cancel{}\,0.75$$

หา L ขนาน

$$-jB_L = Y'_B - Y'_L = (0.25 - j\cancel{}\,0.75) - (0.25 - j0.5)$$

$$-jB_L = 0.25 - j0.75 - 0.25 + j0.5$$

$$-jB_L = -j0.25$$

$$B_L = \frac{Z_0}{\omega L} = \frac{Z_0}{2\pi f L} = 0.25$$

$$L = \frac{Z_0}{2\pi f\, 0.25} = \frac{50}{2\pi \times (300\times 10^{6}) \times (0.25)}$$

$$L = 10.61\ \mathrm{nH}$$

หา C อนุกรม

$$-jX_C = Z_{i4} - Z_B = 0.4 - j0.6 - (0.4 + j1.2)$$

$$-jX_C = \cancel{0.4} - j0.6\ \cancel{-0.4} - j1.2$$

$$-jX_C = -j1.8$$

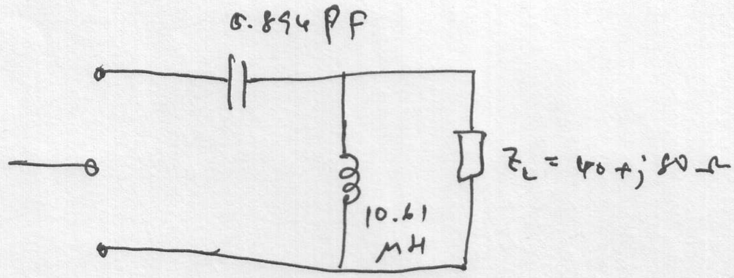
$$X_C = 1.8$$

$$X_C = \frac{1}{\omega C Z_0} = \frac{1}{2\pi f C Z_0} = 1.8$$

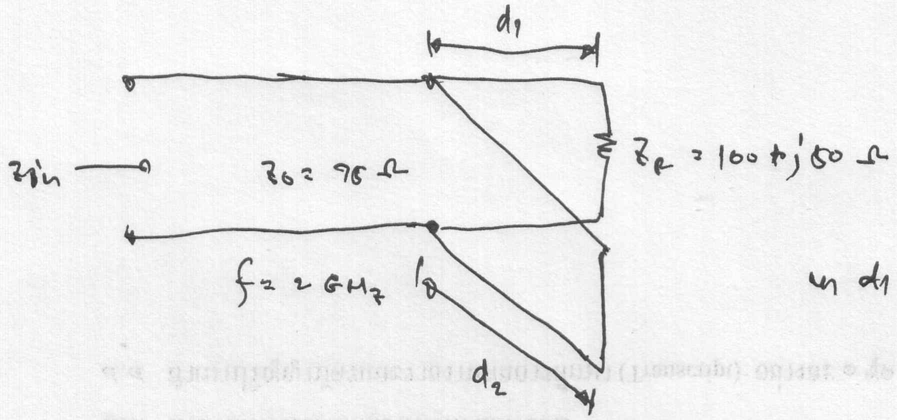
$$C = \frac{1}{2\pi f Z_0 (1.8)}$$

$$C = \frac{1}{2\pi \times (300 \times 10^{6}) \times (50)(1.8)}$$

$$C = 5.894 \text{ pF}$$



ข้อ 8



หา d_1, d_2

sol^n

step 1 $z_r' = \frac{Z_R}{Z_0} = \frac{100+j50}{75} = 1.333+j0.666$

step 2 นำ z_r' → plot ลงใน smith chart ลาก วงกลม SWR

step 3 หา ตำแหน่ง y_r [illegible] ได้ระยะ 0.432λ

$(0.5-0.432)$

step 4 ได้ระยะ $d_1 = 0.068\lambda + 0.15$

$d_1 = 0.218\lambda$

$\lambda = \frac{v}{f} = \frac{3\times10^8}{2\times10^9} = 0.15\ m = 15\ cm.$

$d_1 = 0.218(0.15) = 0.0327\ m$

$d_1 = 3.27\ cm$

step 5 ที่จุด 1 เป็น admittance [illegible]

$y_x = \frac{Y_x}{Y_0} = 1+j0.65$

หา [illegible] input [illegible] $= -j0.65$

step 6 หาความยาว d_2 เริ่มจาก [illegible] $0.00\ \Omega$

อ่าน scale 0.00λ [illegible] $-j0.65$

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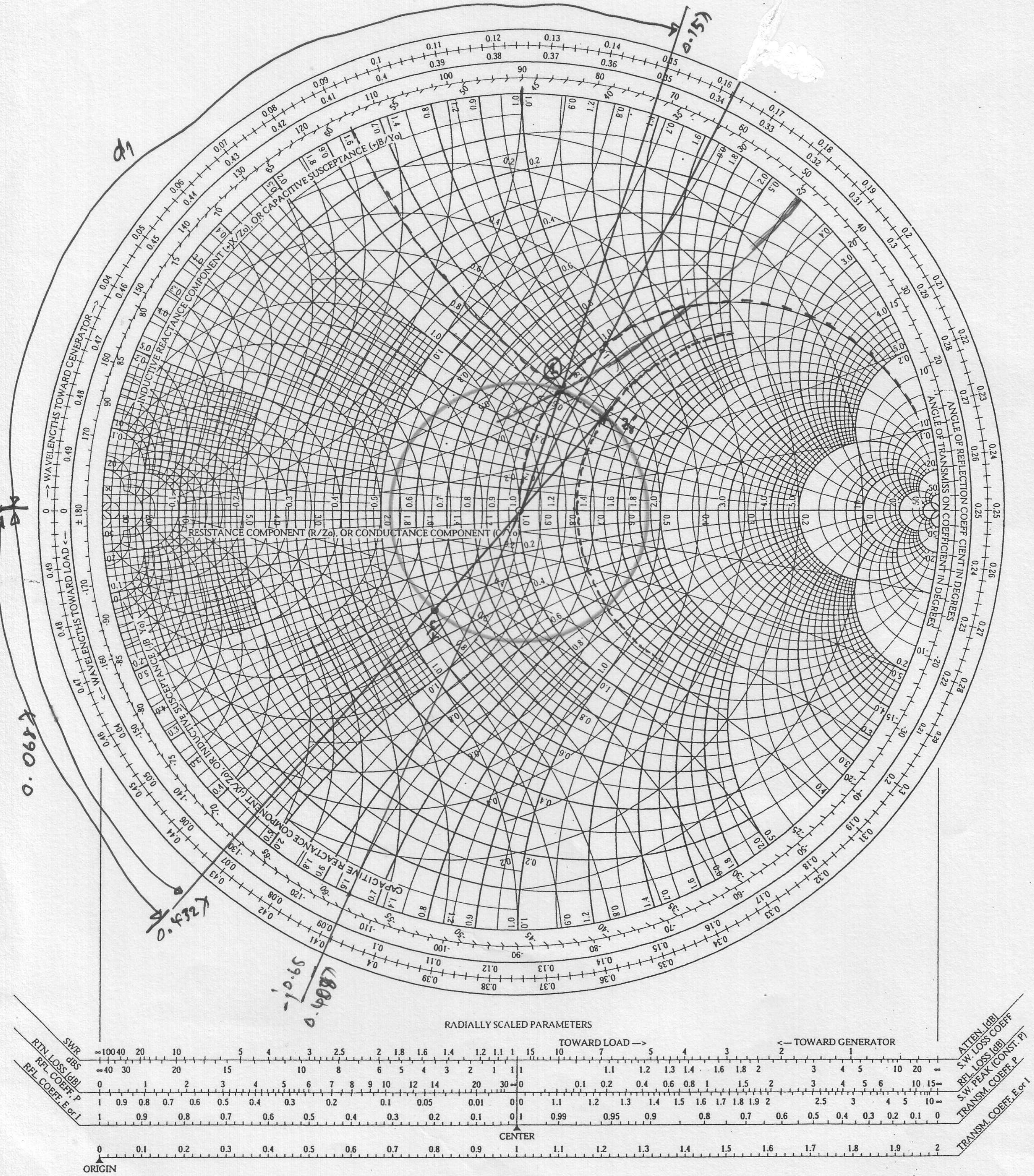

ดัง ระยะ $d_2 = 0.408\ \lambda$

$$d_2 = 0.408\ (15\ cm)$$

$$d_2 = 6.12\ cm$$

$\therefore$ ตอบ $\left.\begin{aligned} d_1 &= 3.27\ cm \\ d_2 &= 6.12\ cm \end{aligned}\right\}$