2021

1.

(a) $Z = R + j\omega L = 0.025 + 15.7j$

$Y = G + j\omega C = 4\times10^{-5} + 0.025j$

$ZY = 0.3925 \angle 179.82^\circ$

$\gamma = 0.628 \angle 89.91^\circ = \underbrace{0.0055}_{(Np/m)} + \underbrace{0.628j}_{(rad/m)}$

$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{628} = \underline{25.06\,\Omega}$

$V_p = \frac{\omega}{\beta} = \underline{1.25\times10^{8}\ m/s}$

(b) $\gamma l = 0.055 + 6.28j$

$\tanh(\gamma l) =$

$Z_{in} = Z_0 \frac{Z_L + Z_0 \tanh(\gamma l)}{Z_0 + Z_L \tanh(\gamma l)} = 46.28 + 0.193j$

$V_{in} = 50\angle 0^\circ, \quad I_{in} = \frac{V_{in}}{Z_{in}} = 1.08 \angle -0.24^\circ$

$P_{in} = \frac{1}{2} Re\{V_{in} I_{in}^*\} = 27\ W$

(c) $\beta l = 6.28\ rad \cong 0^\circ$

$\alpha l = 0.01\ Np = 8.686\times10^{-2}$

$20\log\left(\frac{V_{in}}{V_{out}}\right) = 0.478 \Rightarrow V_{out} = 47.32V$

2. $j0.75$ $j0.5$

$Z_0 = 80$, $Z_L = j60$, $Z_{in} = j40$

$$Z_{in} = Z_0 \frac{Z_L + Z_0 j \tan\beta l}{Z_0 + Z_L j \tan\beta l}$$

$$\Rightarrow \frac{j60 + j80 \tan\beta l}{80 - 60 \tan\beta l} = j0.5$$

$$\Rightarrow 60 + 80 \tan\beta l = 40 - 30 \tan\beta l$$

$$\Rightarrow \tan\beta l = \frac{-20}{110} = -\frac{2}{11}$$

$$\Rightarrow \beta l = -0.18 \text{ (rad)} + \pi = 2.962 \text{ (rad)}$$

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

$$l = \frac{2.962}{2\pi} = 0.471\lambda \ \#$$

$$\Gamma_L = \Gamma(0) = \frac{Z_L - Z_0}{Z_L + Z_0} = -0.28 + 0.96j = 1 \angle 106.26^\circ$$

$$VSWR = \frac{1 + |\Gamma(0)|}{1 - |\Gamma(0)|} = \infty$$

3.

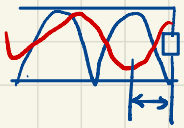
$$|\Gamma(0)| = \frac{VSWR - 1}{VSWR + 1} = 0.524$$

$\lambda = 0.2\,m$

$l = 0.74\,m = 3.7\lambda$

$\downarrow$

0.2λ



$$2\beta l = 2 \times \frac{2\pi}{\lambda} \cdot 0.2\lambda = \frac{4}{5}\pi$$

$\therefore \Gamma(0) = 0.524 \angle -\pi + \frac{4}{5}\pi$

$$\Gamma(0) = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$\Rightarrow \Gamma(0)(Z_L + Z_0) = Z_L - Z_0$$

$$\Rightarrow Z_L = \left(\frac{1 + \Gamma(0)}{1 - \Gamma(0)}\right) \times Z_0$$

$$\Rightarrow Z_L = 85 - 72.18j$$

4. $Z_0 = 100$, $Z_n = 2.5 + j1\,\Omega$

(a) $\Gamma(0) = 0.5 \angle 17^\circ$

(b) 3

(c) 0.2745λ

(d) $62.5 - j77.5\,\Omega$

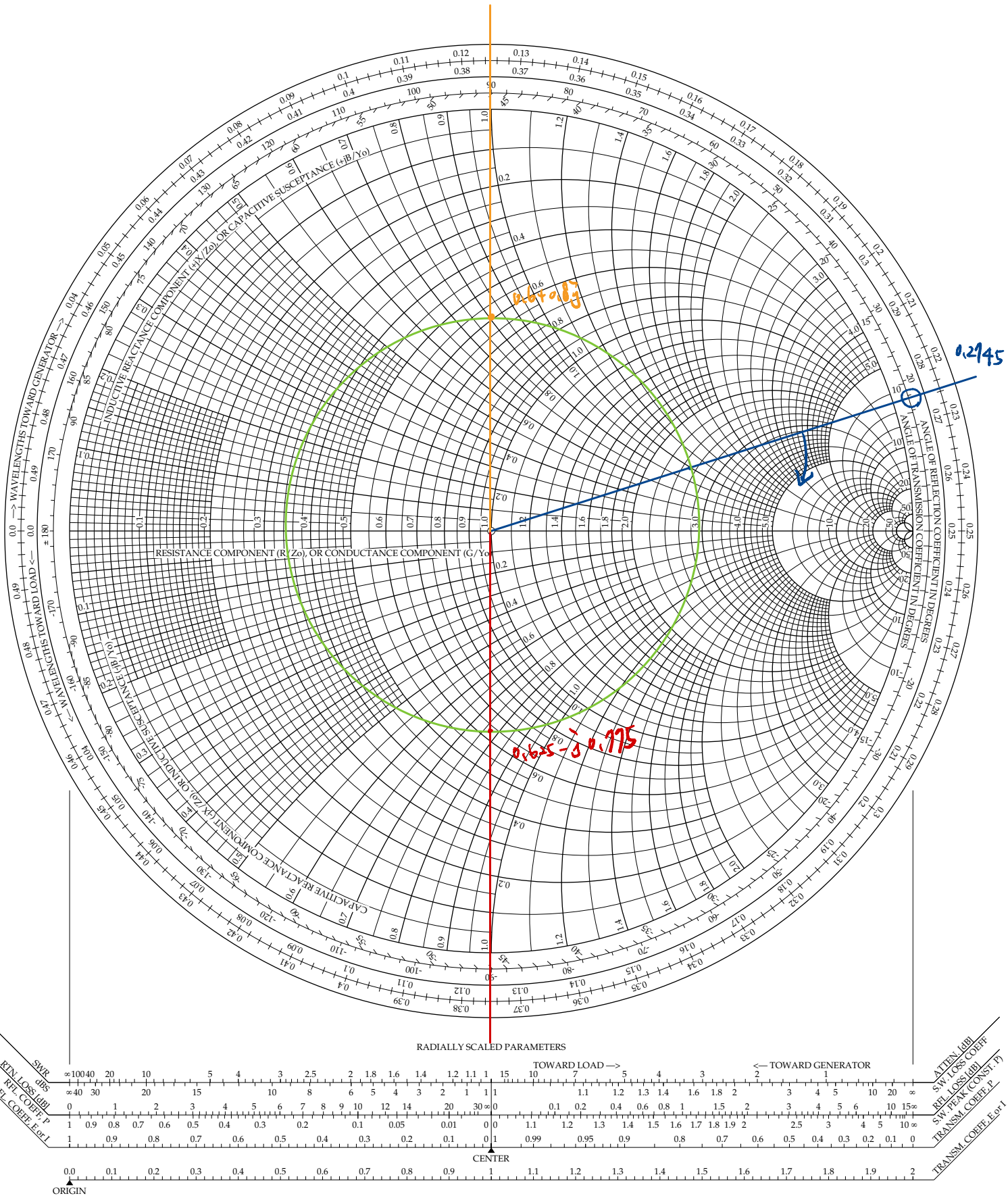
(e) $6 \times 10^{-3} + 8 \times 10^{-3} j\ S$

$\downarrow$

$\frac{1}{Z_0}$

4

Smith Chart



5

$Z_n = 0.5 + j0.5$

(a)

$d = 0$ or 0.3225λ

$a = 0.371\lambda$ or 0.125λ

(b) → admittance

① 補 $-0.95j \xrightarrow{\pm 50} -47.5j$

$\times 75$

$\Rightarrow -1.425j$

$\Rightarrow d = 0,\ l = 0.404\lambda$

② 補 $j1 \Rightarrow j\infty$

$\Rightarrow d = 0.3225\lambda,\ l = 0.0935\lambda$

6.

$Z_{L1}' = 40 - j30\ \Omega$

$Z_{L2}' = \frac{50^2}{100 + j50} = 20 - 10j\ \Omega$

$Z_{L1}' \parallel Z_{L2}' = 13.46 - 1.7j\ \Omega$

$Z_{in} = \frac{50^2}{Z_{L1}' \parallel Z_{L2}'} = 140 + 80j\ \Omega$

$V_{in} = 30 \cdot \frac{140 + 80j}{240 + 80j} = 18.75 + 3.75j\ V$

$I_{in} = \frac{V_{in}}{Z_{in}} = \frac{9}{80} - \frac{3}{80}j \quad \theta = 0.1186$

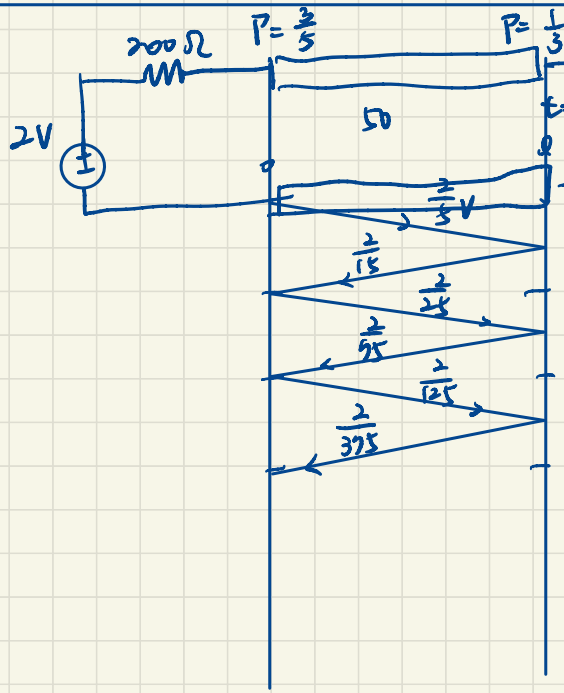
$P_{in} = \frac{1}{2} Re\{V_{in} \cdot I_{in}^*\}$

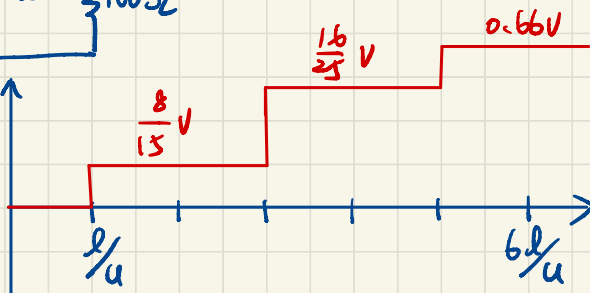
$= \frac{63}{64} W = 0.984\,6$

$P_{L1} = P_{in} \cdot \frac{Z_{L2}'}{Z_{L1}' + Z_{L2}'} = \underline{0.303\ W}$

$P_{L2} = \underline{0.681\ W}$

7.

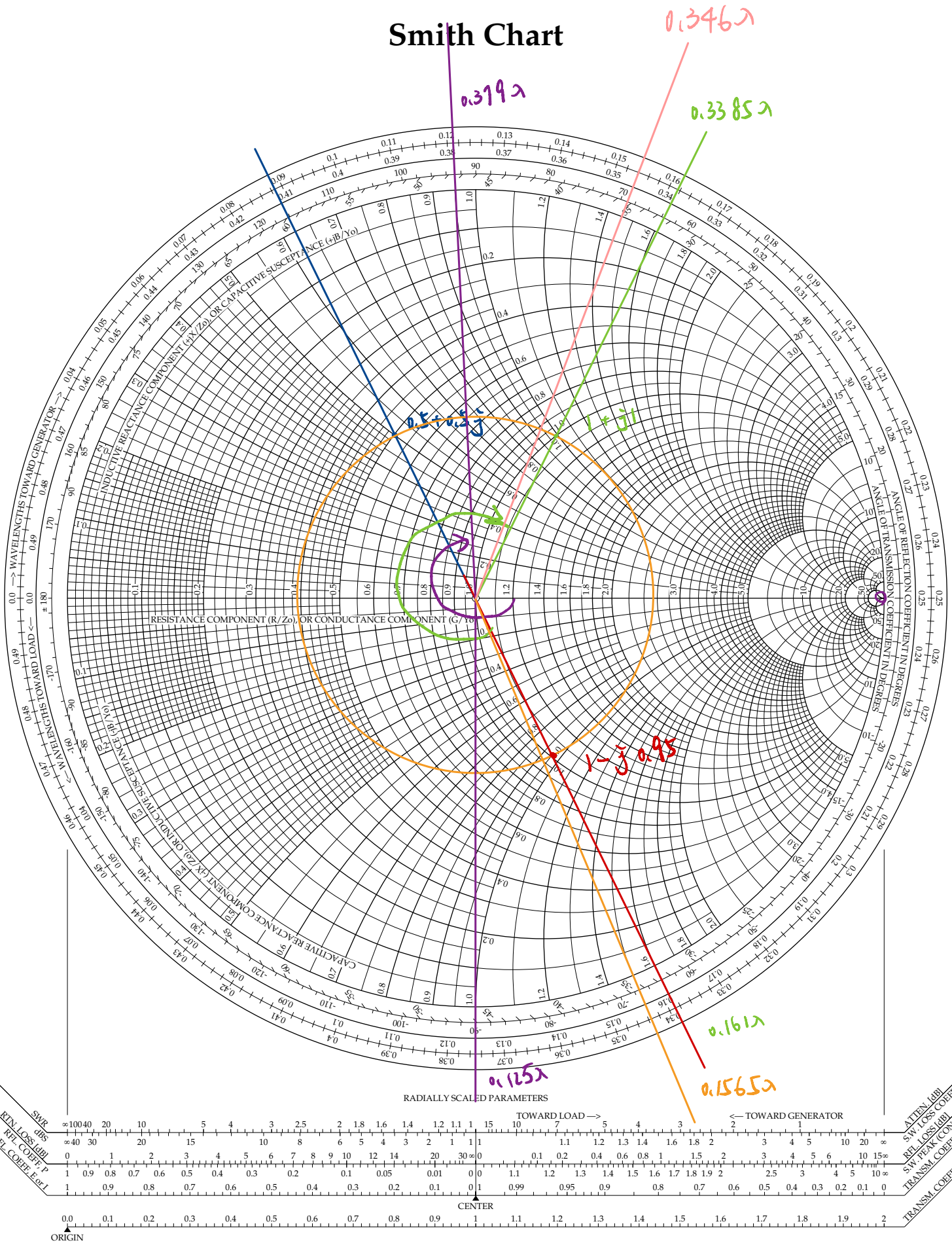




final $= 2 \times \frac{1}{3} = \frac{2}{3} V$

5

Smith Chart



2020

1.

$$\frac{R}{L}=\frac{G}{C} \Rightarrow G=\frac{RC}{L}=9523f\ S$$

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

$$=\sqrt{LC}\cdot\left(\frac{R}{L}+j\omega\right)$$

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

$$=0.29+j3.28\ (1/m)$$

$$u=\frac{\omega}{\beta}=230\times10^{6}\ (m/s)$$

$$Z_0=\sqrt{\frac{Z}{Y}}=\sqrt{\frac{(R+j\omega L)}{(G+j\omega C)}}$$

$$=\sqrt{\frac{L}{C}}=69\ \Omega$$

2.

$$Z_{in}=Z_0\frac{Z_L+Z_0\tanh\gamma l}{Z_0+Z_L\tanh\gamma l} \Rightarrow Z_{oc}=\frac{Z_0}{\tanh(\gamma l)}$$

$$\Rightarrow Z_{OC}=\frac{Z_0}{j\tan\beta l}=\frac{50}{j\tan(\alpha\beta x)}=-16.246j$$

$$Z_{in}=\frac{Z_0^2}{Z_L\,//\,Z_{OC}}=50+j153.88\ \Omega$$

3.

① open

$$Z_1=\frac{50^2}{25}=100\ \Omega$$

$$Z_{in}=Z_1=100\Omega$$

$$V_{in}=10\ \frac{100}{125}=8V$$

$$P_{OFF}=\frac{1}{2}\frac{V_{in}^2}{Z_{in}}=0.32W$$

② close

$$Z_1=100\Omega$$

$$Z_{in}=Z_1\,//\,100=50\ \Omega$$

$$V_{in}=10\times\frac{50}{75}=\frac{20}{3}$$

$$P_{in}=\frac{1}{2}\frac{V_{in}^2}{Z_{in}}=0.444$$

$$P_{ON}=\frac{P_{in}}{2}=0.222\ W$$

4.

$$Z_{sc} \cdot Z_{oc} = Z_0^2 \Rightarrow Z_0 = 50.01\,\Omega$$

$$Z_{in} = Z_0 \frac{Z_L + Z_0 \tanh \gamma l}{Z_0 + Z_L \tanh \gamma l}$$

$$\Rightarrow Z_{sc} = Z_0 \tanh \gamma l$$

$$\Rightarrow \tanh \gamma l = \frac{1}{5} - \frac{49}{50} j$$

$$\Rightarrow \gamma l = \tanh^{-1}\left(\frac{1}{5} - \frac{49}{50} j\right)$$

$$= \frac{1}{2} \ln\left(\frac{\frac{1}{5} + \frac{49}{50} j}{\frac{4}{5} - \frac{49}{50} j}\right)$$

$$= \frac{1}{2} \ln\left(1.225 \cdot e^{j 0.2}\right)$$

$$= \frac{1}{2}(0.203 + j 0.2)$$

$$\Rightarrow \gamma = \underbrace{2.03 \times 10^{-3}}_{(Np/m)} + \underbrace{2 \times 10^{-3}}_{} j$$

$$u = 1.95 \times 10^8$$

$$\Rightarrow \beta = 3.59$$

5.

$$|\Gamma(0)| = \frac{2.8 - 1}{2.8 + 1} = \frac{9}{19}$$

$$\Gamma_{min} = \frac{9}{19} \angle -\pi \qquad x - \frac{1}{5}\lambda$$

$$2\beta l = 2 \times 2\pi \cdot 0.1 = \frac{2}{5}\pi = 72°$$

$$\Gamma(0) = 0.47 \angle -\pi + \frac{2}{5}\pi = 0.47 \angle 252°$$

or $-108°$

$$\Gamma(0) = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$\Rightarrow Z_L = \frac{1 + \Gamma(0)}{1 - \Gamma(0)} Z_0 = 51.1 - 59.4j\,\Omega$$

$$3.59 \times l + 0 = 359$$

$$0.2 + 2n\pi = 359 \Rightarrow n = 57$$

$$\Rightarrow u = 1.953 \times 10^8 \, m/s$$

6.

$$\beta = \frac{\omega}{v_p} = \frac{20}{3}\pi, \qquad Z_n = 2.6 + j1.8\,\Omega$$

(a) $\Gamma_L = 0.6 \angle 22°$

(b) VSWR $= 4$

(c) $\lambda = \frac{v}{f} = 0.3m$,

$20/0.3 = 66.66\lambda \cdots = 0.167\lambda$ $\quad \Gamma = 0.6 \angle -99.5$

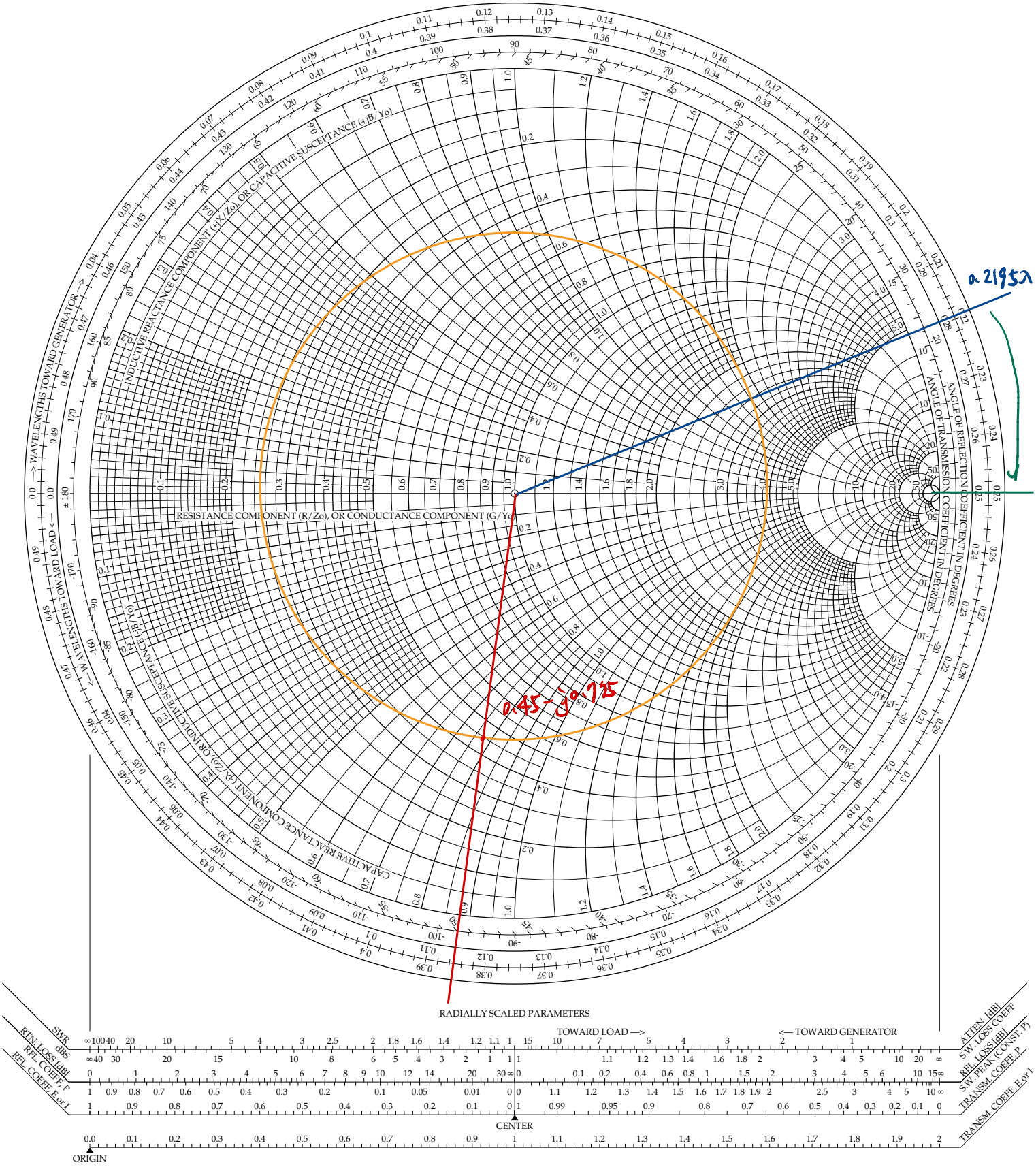
(d) $(0.45 - j0.995) \times 100$

$= 45 - j99.5\,\Omega$

(e) $0.0303\lambda = 9.15 \times 10^{-3} m$

6

Smith Chart



7.

①

$V_S = 1.5 = 3 \times \frac{Z_{in}}{R_S + Z_{in}} \Rightarrow 0.5 = \frac{Z_{in}}{100 + Z_{in}} \Rightarrow 50 = 0.5 Z_{in} \Rightarrow Z_{in} = 100\ \Omega$

$t_{d1} = \frac{3\,ns}{2} = 1.5\,ns$,

∵ 6 ns no wave, Z_{01} and R_S match

∴ $Z_{01} = 100\ \Omega$, $\Gamma_0 = 0$

②

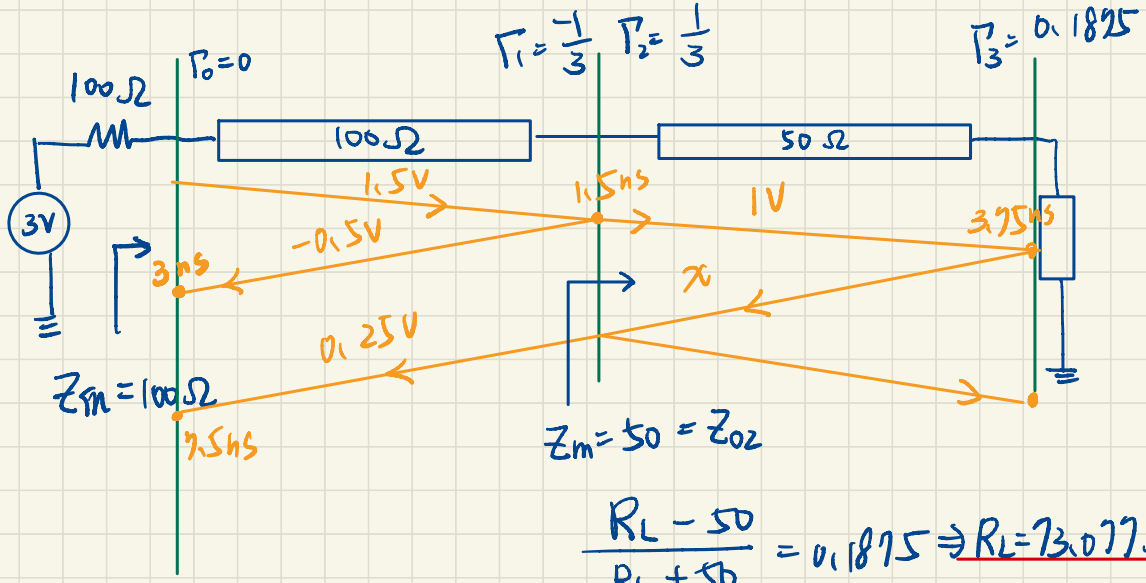
$3 \sim 7.5\ ns$: $1.5 + (-0.5) = 1$, $\Rightarrow \Gamma_1 = \frac{-1}{3}$

∴ $\frac{Z_{in} - Z_{01}}{Z_{in} + Z_{01}} = \frac{-1}{3} \Rightarrow 3Z_{in} - 300 = -Z_{in} - 100 \Rightarrow Z_{in} = 50\ \Omega = Z_{02}$

③ 7.5ns :

$t_{d1} + t_{d2} = \frac{7.5}{2} = 3.75\ ns \Rightarrow t_{d2} = 2.25\ ns$

④ $1.25 - 1 = 0.25\ V$ $\quad x\left(1 + \frac{1}{3}\right) = 0.25 \Rightarrow x = 0.1875\ V$



$\frac{R_L - 50}{R_L + 50} = 0.1875 \Rightarrow R_L = 73.077\ \Omega$

2019

1.

$\alpha l = 0.185 \lambda_p$

(a)

$\gamma l = \alpha l = 0.185$

$$Z_{in} = Z_0 \frac{Z_L + Z_0 \tanh \gamma l}{Z_0 + Z_L \tanh \gamma l}$$

$= 39.34 + 30.86j\ \Omega$

(b)

$$\Gamma(0) = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{1}{2} \angle 90^\circ$$

(c)

$$\Gamma(l/2) = \Gamma(0) e^{2\gamma \frac{l}{2}}$$

$$= \Gamma(0) e^{-2\alpha \frac{l}{2}} = \Gamma(0) e^{-\alpha l}$$

$= 0.416 \angle 90^\circ$

2.

$l_1 = 0.3037 \lambda$

$l_2 = 0.214 \lambda$

3.

$$Z_1 = \frac{50^2}{200} = 12.5$$

$Z_2 = \infty$

$Z_3 = Z_1 \parallel Z_2 = 12.5$

$$Z_{in} = \frac{50^2}{12.5} = 200\ \Omega$$

4.

$Z_n = 1 + j0.6$

(a)

$\Gamma = 0.29 \angle 73^\circ$

(b)

$VSWR = 1.8$

(c)

$$\lambda = \frac{v_p}{f}$$

$d_{min} = 0.101 \lambda$

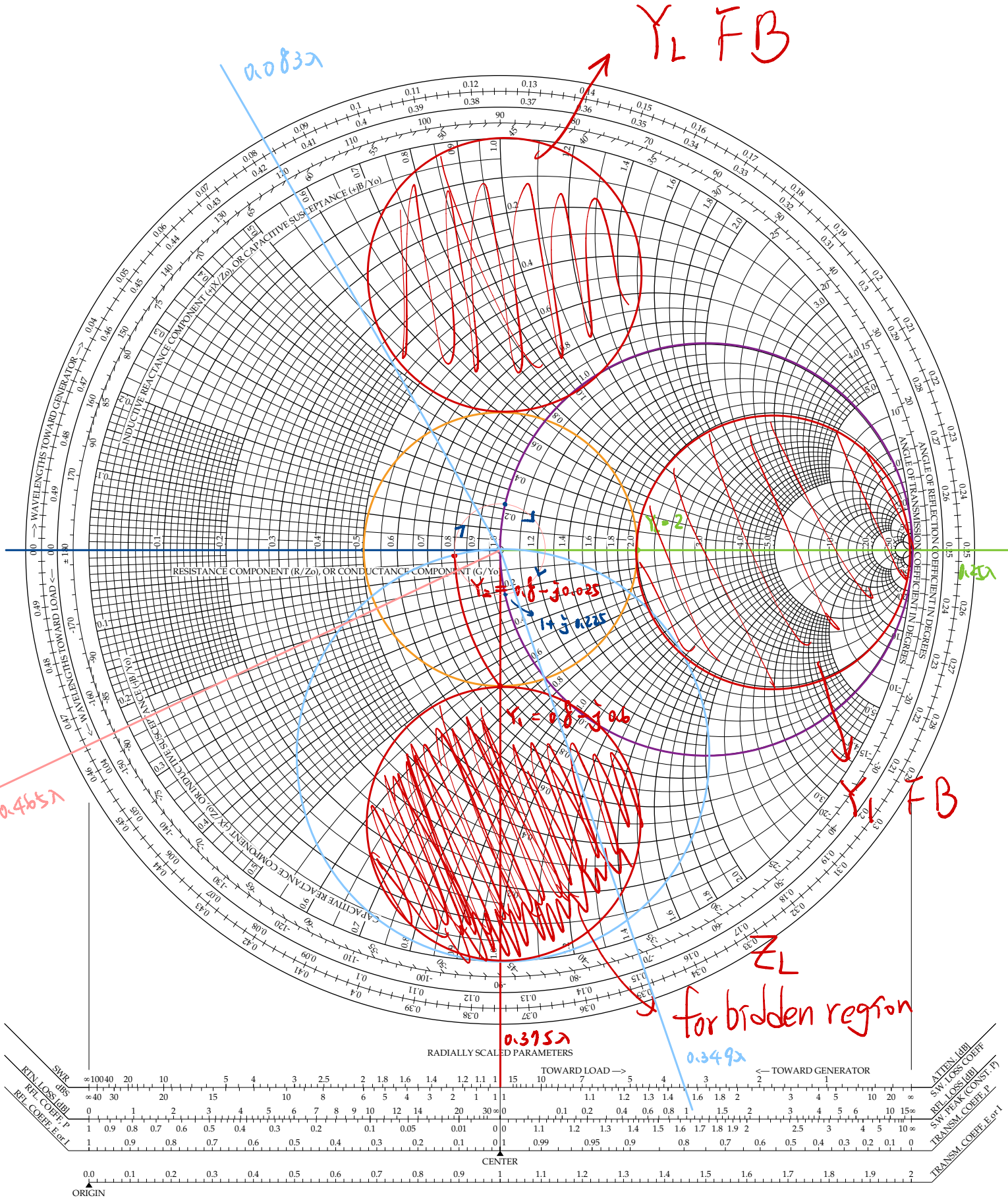
$= 0.0947\ m$

$R_{in} = 1.8 \times 50$

$= 90\ \Omega$

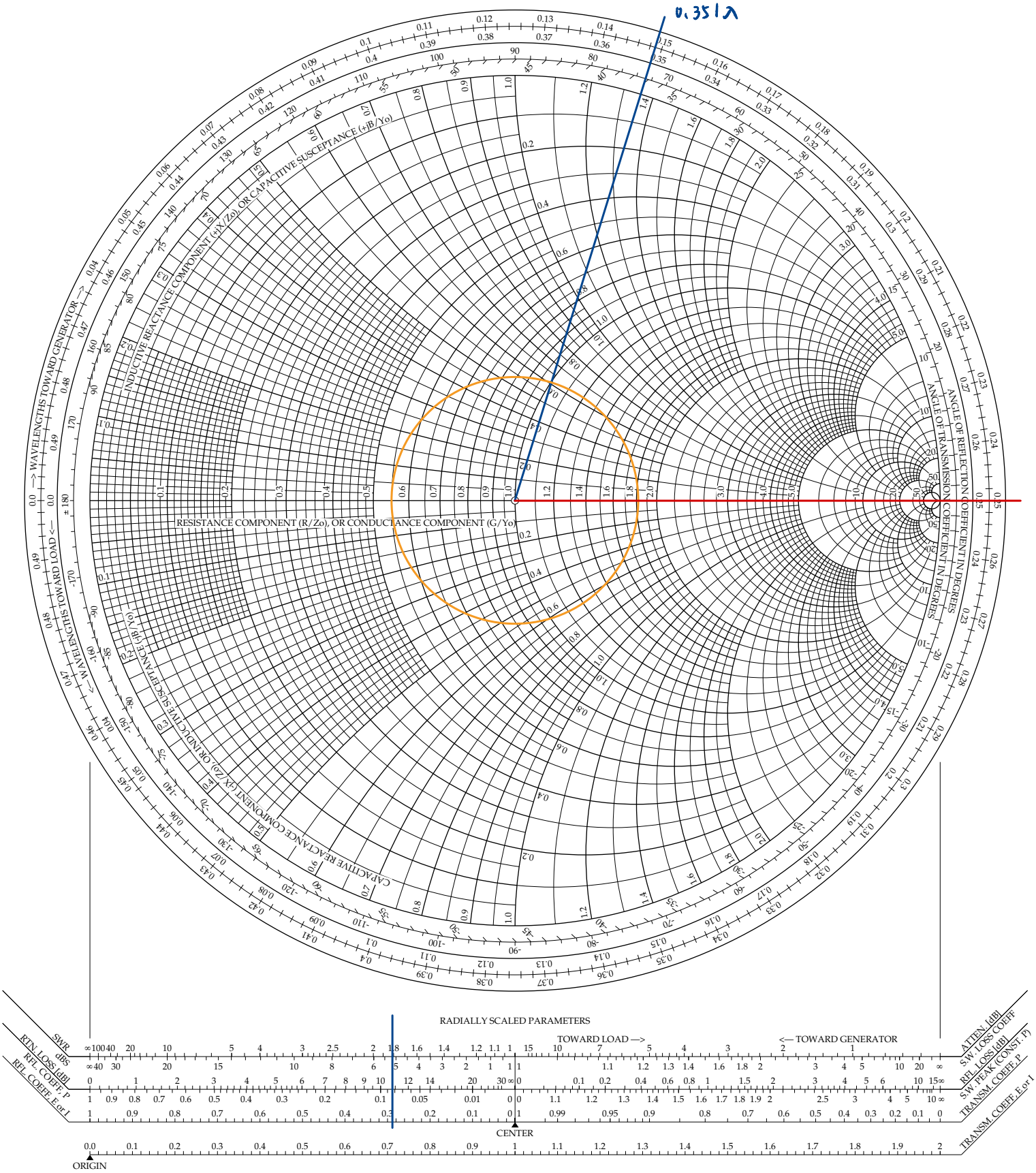
2.

Smith Chart

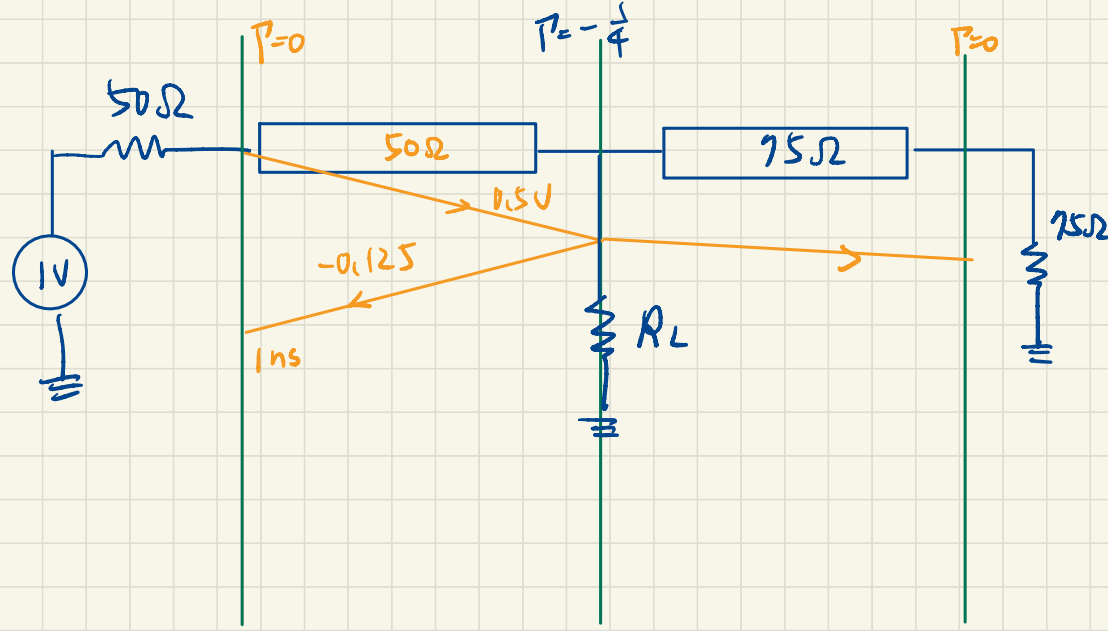


4.

Smith Chart



5.



$$0.5 = \frac{Z_{01}}{50+Z_{01}} \times 1 \Rightarrow 25 + 0.5 Z_{01} = Z_{01} \Rightarrow \underline{Z_{01} = 50\,\Omega}$$

$$t_1 = \frac{1ns}{2} = 0.5ns \Rightarrow \underline{l_1 = 10\,cm}$$

$$\Gamma = \frac{-0.125}{0.5} = \frac{-1}{4} = \frac{R_x - 50}{R_x + 50} \Rightarrow -R_x - 50 = 4R_L - 200$$

$$\Rightarrow R_x = 30\,\Omega$$

$$R_x = R_L \,//\, 75$$

$$\Rightarrow \frac{1}{30} = \frac{1}{R_L} + \frac{1}{75} \Rightarrow \underline{R_L = 50\,\Omega}$$

6.

$V_{in} = 93.338 \angle 31°$,

$V_L = 70.71 \angle 0°$, $I_L = 1.94 \angle -15.95°$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}, \quad \beta l = 310°$$

$V_{in} = A V_L + B I_L \rightarrow \frac{V_L}{Z_L}$

$= \cos(\beta l) V_L + j Z_0 \sin(\beta l) \frac{V_L}{Z_L}$

$\frac{V_{in}}{V_L} Z_L = Z_L \cos(\beta l) + j Z_0 \sin(\beta l)$

$\cos(\beta l) = Re\left\{\frac{k Z_L}{Z_L}\right\} \Rightarrow \beta l = \cos^{-1}\left(Re\left\{\frac{k Z_L}{Z_L}\right\}\right)$

$= \cos^{-1} \frac{32.8}{35} = 20.42°$

$v_p = \frac{\omega}{\beta} = \frac{10^8}{0.0356} = 2.8 \times 10^9 (m/s) = \frac{1}{\sqrt{LC}}$

$Z_0 = \frac{Im\{k Z_L - Z_L \cos\beta l\}}{\sin(\beta l)} = \frac{25.74}{0.35} = 73.77\,\Omega = \sqrt{\frac{L}{C}}$

$LC = 1.2755 \times 10^{-19}$

$\frac{L}{C} = 5442$

$\Rightarrow \begin{cases} L = 2.63 \times 10^{-8}\ H/m \\ C = 4.84 \times 10^{-12}\ C/m \end{cases}$

2018

1.

(a)

$$V_p = \frac{\omega}{\beta} = 150\times10^6 \ m/s$$

(b)

$$\gamma = \alpha + j\beta = 4.6\times10^{-3} + j2.5 \ (1/m)$$

$$= \sqrt{ZY}$$

$$\Rightarrow ZY = -6.25 + 0.023j$$

$$\Rightarrow \frac{Z}{Y} = 2500$$

L: $0.33 \ mH/m$

$$\Rightarrow Z^2 = 15625 \angle 179.8^\circ$$

R

$$Z = 125 \angle 89.9^\circ = 0.218 + j125$$

G

$$Y = 0.05 \angle 89.9^\circ = 8.73\times10^{-5} + j0.05$$

C: $0.13 \ nF/m$

2.

$$Z_{in} = Z_0 \frac{Z_L + Z_0 \tanh(\gamma l)}{Z_0 + Z_L \tanh(\gamma l)}$$

$$\Rightarrow Z_{sc} = \frac{Z_0}{\tanh(\gamma l)}$$

$$\Rightarrow \tanh(\gamma l) = \frac{80 + j60}{30 - j12}$$

$$= 1.61 + 2.644j$$

$$Z_{in} = 92.95 + 119.24j \ \Omega$$

3.

$$Z_n = \frac{40 - j25}{50} = 0.8 - j0.5$$

(a)

$$\Gamma_L = 0.29 \angle -96.25^\circ$$

(b)

$$VSWR = 1.82$$

(c)

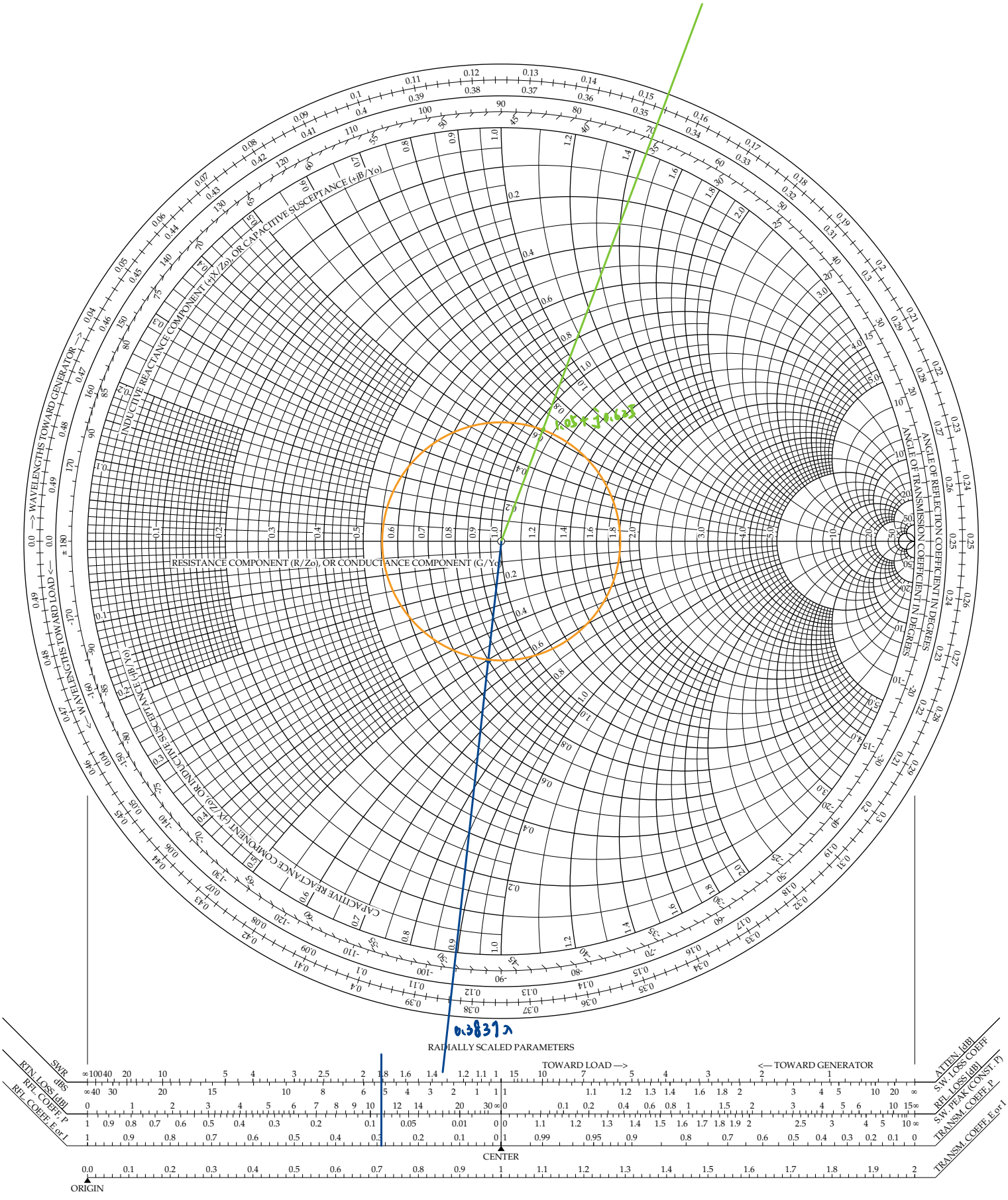
$$Z_{in} = (1.05 + j0.625) \times 50 = 52.5 + 31.25j$$

(d)

$$0.3663\lambda$$

3.

Smith Chart



4.

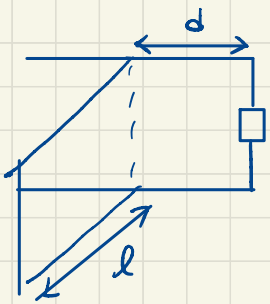
$Z_n = 1.5 + 1.2j$

5.

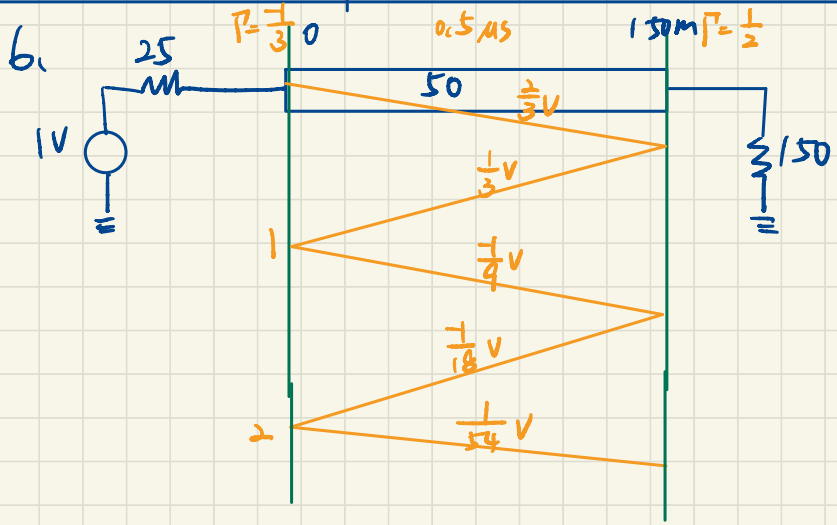
$Z_n = 2 + j1.5$

$d = 0.12175\lambda$

$l = 0.394\lambda$



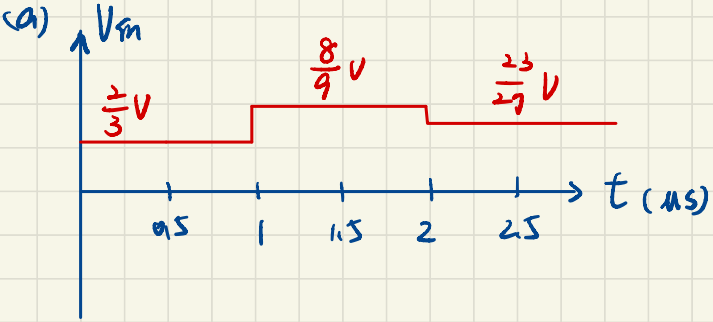
6.



(b)

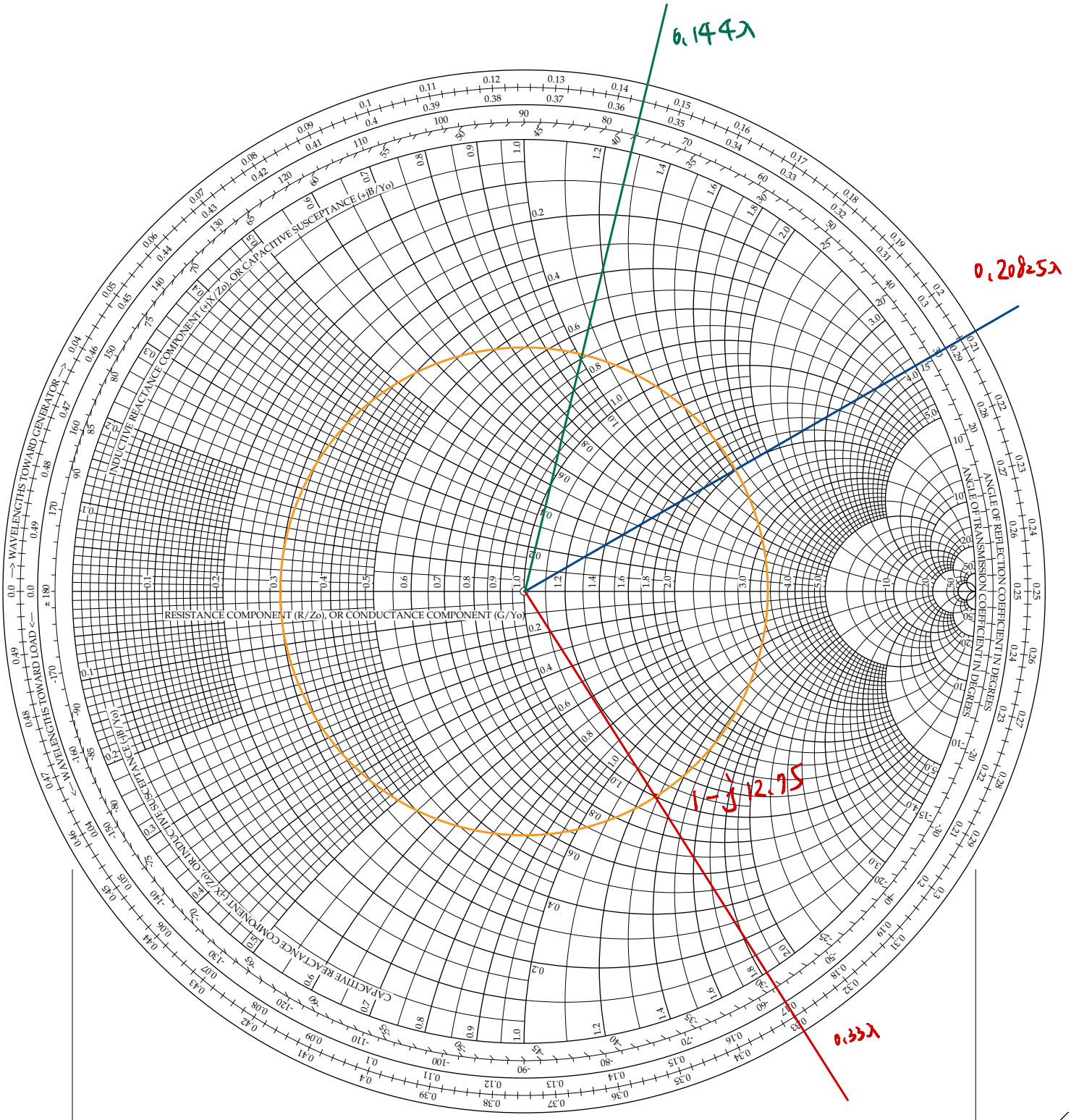
$V_{fin}(t=\infty) = 1 \times \frac{150}{25+150} = 0.857\,V$

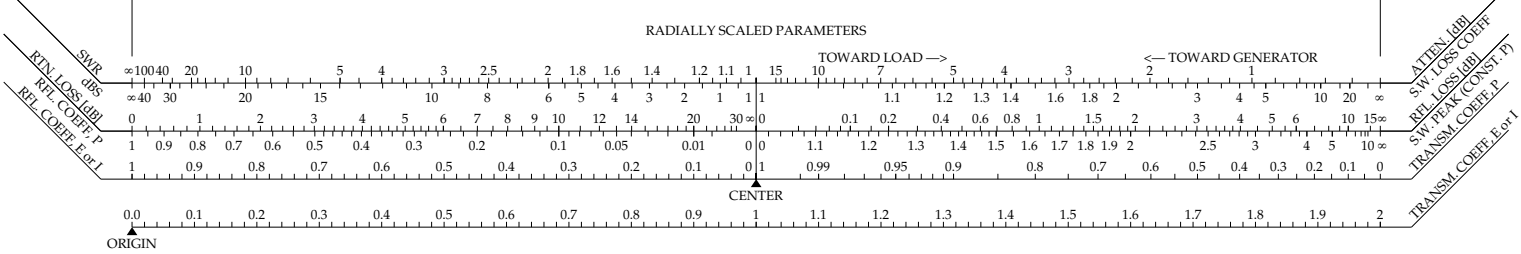
(a)



5

Smith Chart





2017

1.

$$\frac{R}{L} = \frac{G}{C} \Rightarrow G = \frac{RC}{L} = 1.367 \times 10^{-6}\ (S)$$

$$Z_0 = \sqrt{\frac{L}{C}} = 85.54\ \Omega$$

$$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \sqrt{LC}\cdot\left(\frac{R}{L}+j\omega\right) = R\sqrt{\frac{C}{L}} + j\omega\sqrt{LC}$$

$$= 1.17 \times 10^{-4} + j\,3.526\ \left(\frac{1}{m}\right)$$

2.

(a)

$$\Gamma_L = \frac{120-50}{120+50} = 0.412, \quad SWR = \frac{1+|\Gamma_L|}{1-|\Gamma_L|} = 2.401$$

(b)

$$\gamma l = j\beta l = j\frac{2\pi}{\lambda}\cdot\frac{\lambda}{6} = j\frac{\pi}{3}$$

$$Z_{in} = Z_0\frac{Z_L + jZ_0\tan\beta l}{Z_0 + jZ_L\tan\beta l} = 26.26 - 22.55j\ \Omega$$

3.

$$Z_1 = \frac{Z_{02}^2}{R_L} = 12\Omega,$$

$$Z_2 = \frac{Z_{01}^2}{Z_1} = 50\Omega$$

$$\Rightarrow Z_{01} = \sqrt{Z_1 \cdot 50} = 24.5\ \Omega$$

4.

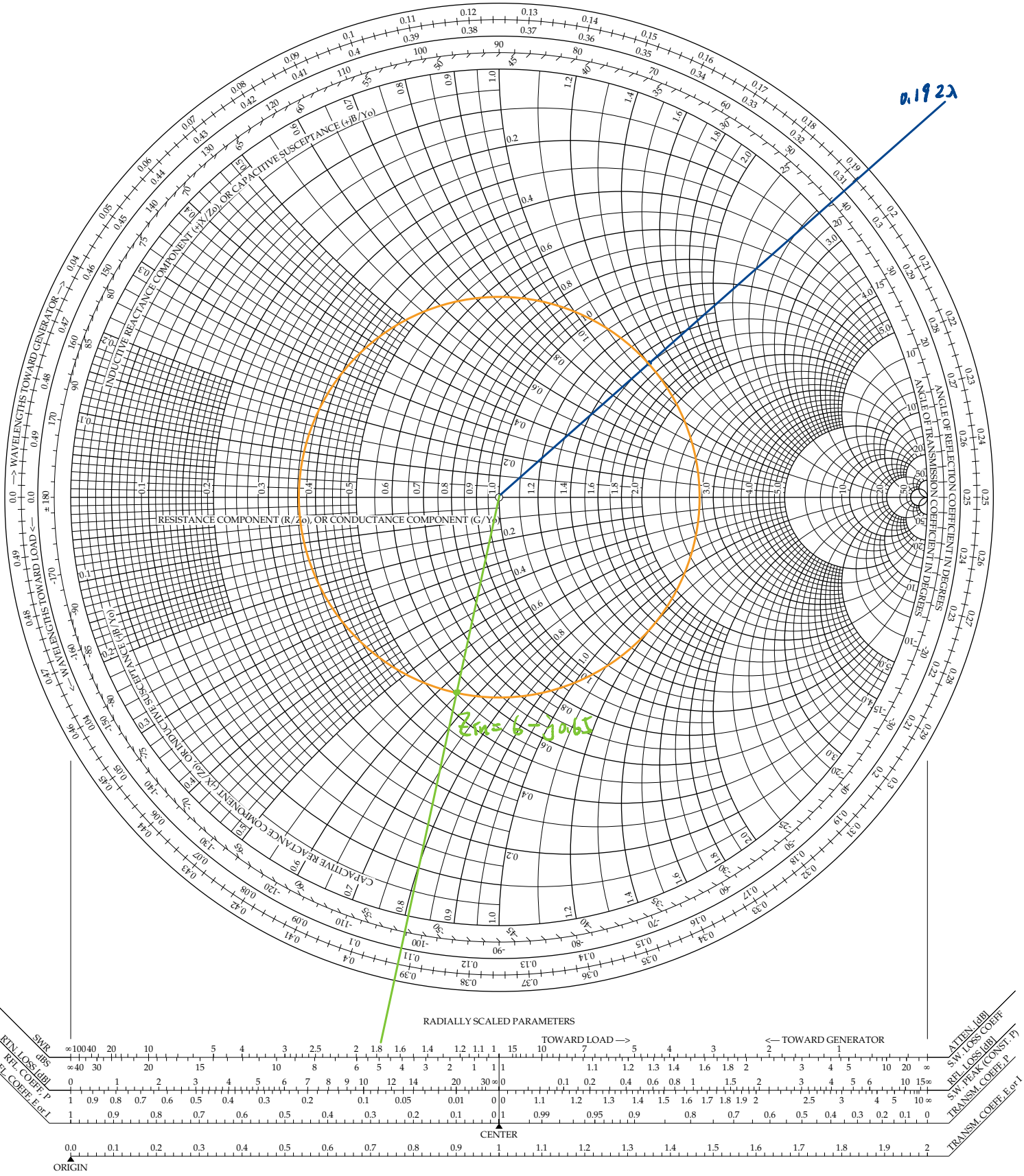
$$\delta V = V_g\frac{50}{60+50} \Rightarrow V_g = 17.6\ V$$

$$TD = \frac{4\mu s}{2} = 2\ \mu s$$

$$l = 3\times10^8 \times 2\mu = 600\ m$$

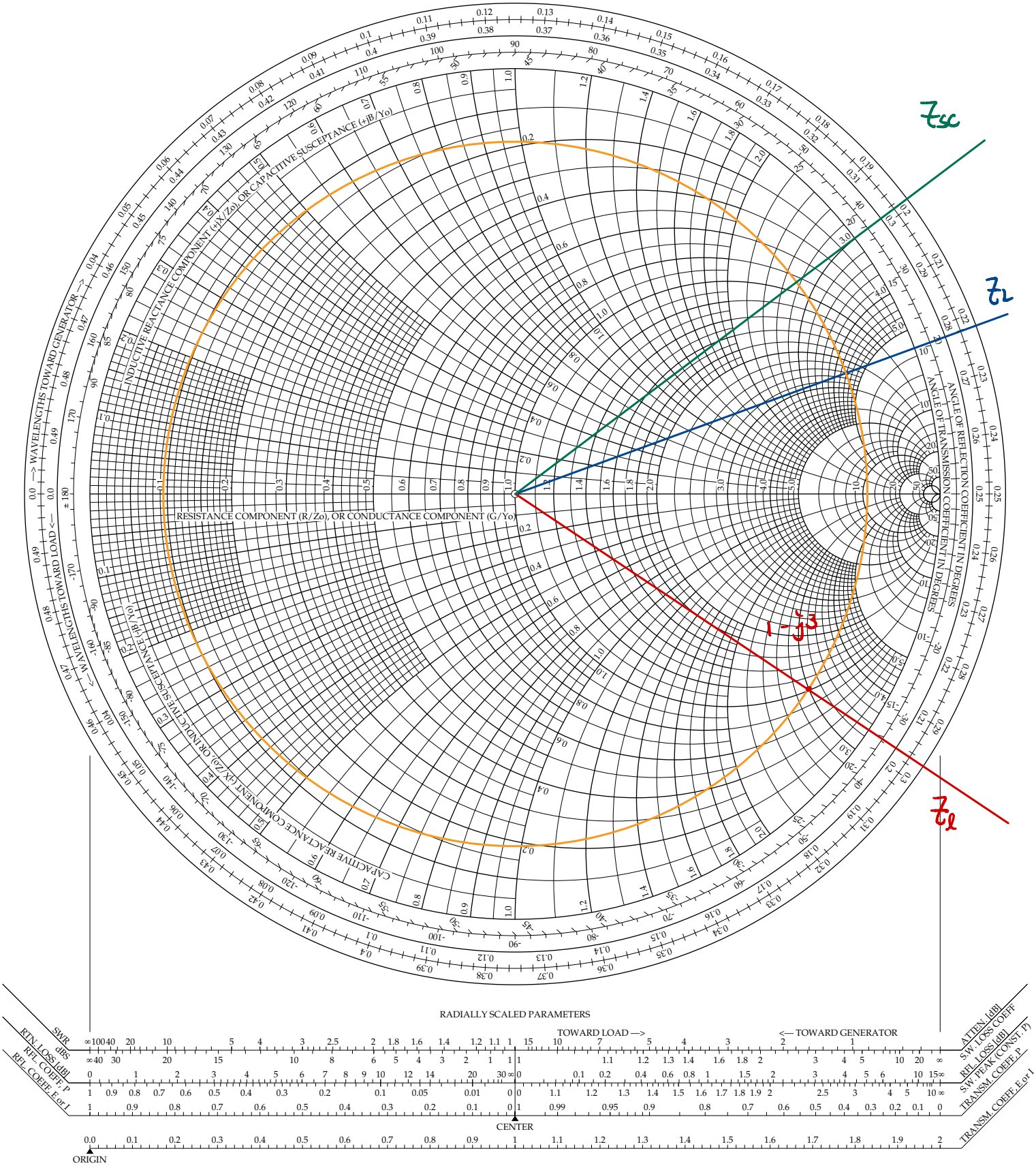
5. $Z_n = 1.5 + 1.2j$

Smith Chart



6. $Z_n = 2.4 + 4.4j$

Smith Chart



2016

1.

$\alpha = 0.0025 \ Np/m$

$\beta = 2 \ rad/m$

$v = \frac{\omega}{\beta} = 5\times10^{7} \ m/s = \frac{1}{\sqrt{LC}}$

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

$= \sqrt{LC}\cdot(\frac{R}{L}+j\omega) = R\sqrt{\frac{C}{L}} + j\omega\sqrt{LC}$

$LC = 4\times10^{-16}$

$Z_0 = \sqrt{\frac{L}{C}}$

2.

(a) $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \sqrt{0.0366\angle 34^\circ}$

$= 0.19\angle 67^\circ = 0.074 + j0.175$

(b)

$v = \frac{\omega}{\beta} = 215\times10^{6} \ (m/s)$

(c)

$Z_0 = \sqrt{\frac{(R+j\omega L)}{(G+j\omega C)}} = \sqrt{15836\angle -30.96^\circ}$

$= 126\angle -15.48^\circ \ \Omega$

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

(d)

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

3.

$Z_{sc} = Z_0 \tanh(\gamma l)$

$\Rightarrow \tanh(\gamma l) = 0.5 + 0.6j$

$\Rightarrow \tanh^{-1}(0.5+0.6j) = \gamma l$

$\Rightarrow \frac{1}{2}\ln\left(\frac{1.5+0.6j}{0.5-0.6j}\right) = \gamma l$

$\Rightarrow \frac{1}{2}\ln(2.068\, e^{j1.257}) = \gamma l$

$\Rightarrow \gamma l = \frac{1}{2}(0.7266 + j1.257)$

$\Rightarrow \gamma = 0.242 + 0.419j$

4.

$$\beta l = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{8} = \frac{\pi}{4},$$

$$Z_{in} = Z_0 \frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l} = \frac{200}{3} - \frac{50}{3}j\ \Omega$$

$$V_{in} = 80 \times \frac{Z_{in}}{Z_g + Z_{in}} = 0.767 \angle 6.8^\circ\ V$$

$$I_{in} = \frac{V_{in}}{Z_{in}} = 0.011 \angle 20.85^\circ$$

$$P = \frac{1}{2} V_{in} I_{in}^* = 4.1\ mW$$

5.