① At an operating frequency of 500 M rad/s, typical circuit values for a certain transmission line are $R = 0.2\ \Omega/m$, $L = 0.25\ \mu H/m$, $G = 10\ \mu S/m$ and $C = 100\ pF/m$ find ①

ⓐ α ⓑ β ⓒ v_p ⓓ λ ⓔ Z_0

→ $Z = R + j\omega L$, $Y = G + j\omega C = 10\times10^{-6} + j\,500\times10^{6}\times100\times10^{-12}$

$= 0.2 + j\,500\times10^{6}\times0.25\times10^{-6}$

$Z = 0.2 + j125 = 125\angle 89.9$

$Y = 10\times10^{-6} + j\,0.05 = 0.05\angle 89.99$

$\gamma = \sqrt{ZY} = 2.5\angle 89.945$

$= 0.0024 + j\,2.5$

$\alpha = 0.0024\ NP/m \quad \beta = 2.5\ rad/m.$

$$v_p = \frac{\omega}{\beta} = \frac{500\times10^{6}}{2.5} = 2\times10^{8}\ m/s.$$

$$\lambda = \frac{v_p}{f} = \frac{2\times10^{8}\times2\pi}{500\times10^{6}} = \frac{4\pi}{5} = 2.513\,m.$$

$$Z_0 = \sqrt{\frac{Z}{Y}} = 50\angle -0.045 = 49.99 - j\,0.03927\ \Omega$$

② Suppose an transmission line is probed and it is found that the distance between minima is 2 cm. The minima position doesnot shift when the actual load is replaced by a short circuit. The standing wave ratio of unknown load is 2. what is the load impedance and operating frequency. (Propagating mode is TEM). Characteristic impedance of the line be $50\,\Omega$.

$\rightarrow$ $\frac{\lambda}{2} = 2cm \Rightarrow \lambda = 4cm$.

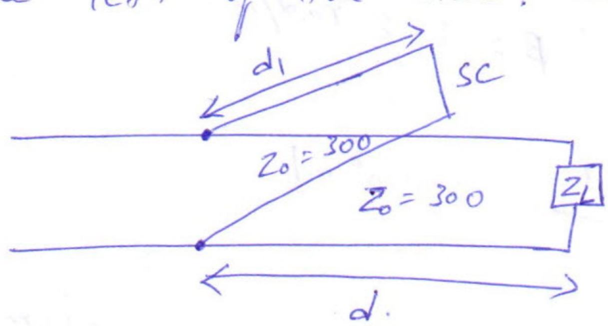
$$\Rightarrow f = \frac{c}{\lambda} = \frac{3\times10^8}{4\times10^{-2}} = \frac{3}{4}\times10^{10}$$

$$= 7.5\,GHz.$$

$Z_{normalised} = 0.5$

$Z_L = 0.5\times50 = 25\,\Omega$

(3) The lossless line shown in the figure is operating with $\lambda = 100cm$, If $d_1 = 10cm$, $d = 25cm$ and the line is matched to the left of the stub, what is Z_L?



Case (1) $d = 25cm$.

Case (2) $d = 20cm$.

(4) A series of measurements are made on a line using an impedance bridge. All measurements are made at the same point on the line. first the input impedance with the unknow load impedance in place is measured as $Z_{in} = 30 + j60\,\Omega$. Since the line is not marked its characteristic resistance is not known. So the load is replaced by a short circuit and the input

impedance is measured as $Z_{in}^{sc} = j53.1\,\Omega$. Repeating the procedure with the load replaced by an open circuit gives $Z_{in}^{oc} = -j48.3\,\Omega$. find Z_0 & Z_L.

$$Z_0 = \sqrt{Z_{sc}\, Z_{oc}} = \sqrt{j53.1 \times -j48.3} = 50.643\,\Omega$$

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}\right]$$

$$= Z_0 \left[\frac{Z_L \cos\beta l + jZ_0 \sin\beta l}{Z_0 \cos\beta l + jZ_L \sin\beta l}\right]$$

$$= Z_0 \frac{\cos\beta l}{\sin\beta l} \left[\frac{Z_L + jZ_0 \tan\beta l}{Z_0 \cot\beta l + jZ_L}\right]$$

$$= -jZ_0 \cot\beta l \left[\frac{Z_L + jZ_0 \tan\beta l}{-jZ_0 \cot\beta l + Z_L}\right] = Z_{oc}\left[\frac{Z_L + Z_{sc}}{Z_L + Z_{oc}}\right]$$

$$Z_L = Z_{oc}\left[\frac{Z_{sc} - Z_{in}}{Z_{in} - Z_{oc}}\right] = -j48.3 \left[\frac{j53.1 - 30 - j60}{30 + j60 + j48.3}\right]$$

$$= 11.634 + j6.3\,\Omega$$

(5) A transmission line has $R = 15\,\Omega/m$, $L = 2\,H/m$, $C = 0.15 \times 10^{-6}\,F/m$, $G = 1 \times 10^{-6}\,℧/m$. find the additional inductance to give a distortionless line. Also find the propagation constant at 1 KHZ.

$\rightarrow \quad \frac{R}{L_1} = \frac{G}{C} \Rightarrow \frac{15}{L_1} = \frac{1\times10^{-6}}{0.15\times10^{-6}} \Rightarrow L_1 = 2.25$

$$L_{ad} = L_1 - L = 2.25 - 2 = 0.25\ H/m$$

$$\gamma = \sqrt{(R+j\omega c)(G+j\omega c)} \qquad \text{since } \frac{R}{L} = \frac{G}{C}$$

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

$$\alpha = R\sqrt{\frac{C}{L}} = 15\sqrt{\frac{0.15\times10^{-6}}{2.25}} = 3.83\times10^{-3}\ NP/m.$$

$$\beta = \omega\sqrt{LC} = 2\pi\times10^{+3}\sqrt{2.25\times0.15\times10^{-6}}$$

$$= 3.65\ rad/m.$$

(6) A lossless line having an air dielectric has a characteristic impedance Z_0 of $200\,\Omega$. The line is operating at 200MHz and input impedance $Z_{in} = (200 - j200)\,\Omega$. Use analytic method and the smith chart to find.

(a) Input ~~impedance~~ admittance.

(b) Input VSWR.

(c) load impedance if the line is 1m ~~large~~ long.

(d) VSWR at the load.

(e) The distance from the load to nearest voltage maximum.

$\rightarrow$ (a) $Y_{in} = \frac{1}{200 - j200} = 2.5\times10^{-3} + j2.5\times10^{-3}\ \mho$

(b) $\Gamma_{in} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0} = \frac{200 - j200 - 200}{200 - j200 + 200} = 0.2 - j0.4$

$$VSWR_{in} = \frac{1+|\Gamma_{in}|}{1-|\Gamma_{in}|} = \frac{1+0.4472}{1-0.4472} = 2.61$$

(c) $$\lambda = \frac{3\times10^8}{200\times10^6} = \frac{3}{2}\,m.$$

$$\beta l = \frac{2\pi}{\lambda}l = \frac{2\pi\times2}{3}\times1 = \frac{4\pi}{3} = 240^\circ$$

$$Z_L = Z_0\left[\frac{Z_{in}-jZ_0\tan\beta l}{Z_0-jZ_{in}\tan\beta l}\right] = 200\left[\frac{200-j200-j200\times\sqrt{3}}{200-j(200-j200)\sqrt{3}}\right]$$

$$= 226.24 + j211.09\ \Omega$$

(d) $$\Gamma_L = \frac{Z_L-Z_0}{Z_L+Z_0} = \frac{226.24+j211.09-200}{226.24+j211.09+200} = 0.447\angle 56.56.$$

(d) $$VSWR_L = \frac{1+|\Gamma_L|}{1-|\Gamma_L|} = \frac{1+0.447}{1-0.447} = 2.61$$

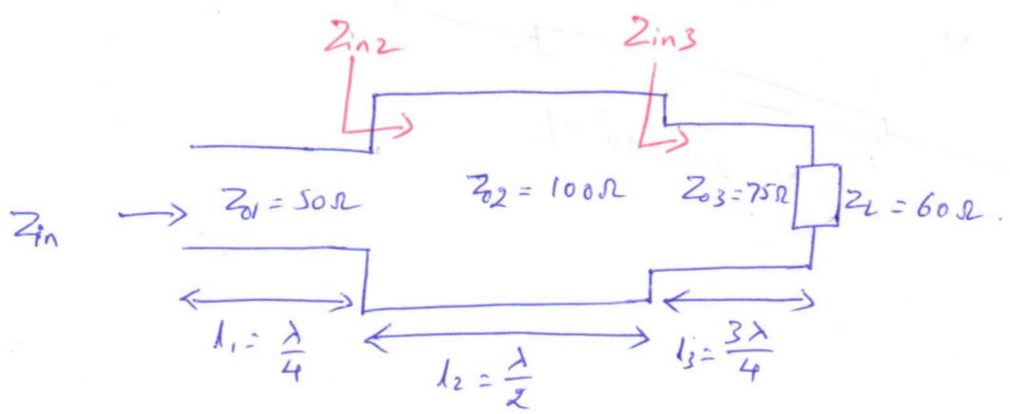
(e) $2\beta y_{max} - \theta = 2\pi m \qquad m = 0, 1, 2, 3 - - -$

$m=0$, first maximum.

$$y_{max} = \frac{\theta}{2\beta}$$

$$= \frac{56.56\times\pi}{180\times2\times\frac{2\pi}{3}\times2} = 0.117\,m$$

(7) Determine the input impedance.



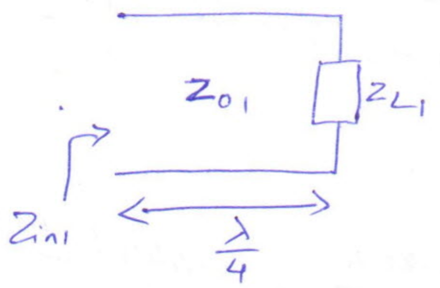
$$Z_{in3} = \frac{75^2}{60} = 93.75\,\Omega \rightarrow \text{Quater wave line.}$$

$$Z_{in2} = 93.75\,\Omega \rightarrow \frac{\lambda}{2} \text{ line}$$

$$Z_{in} = \frac{50^2}{93.72} = 26.67\,\Omega \rightarrow \text{Quater wave line.}$$

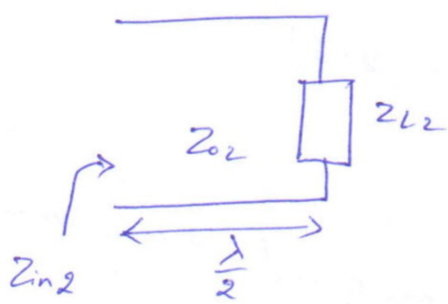
explaination

Quater wave line.



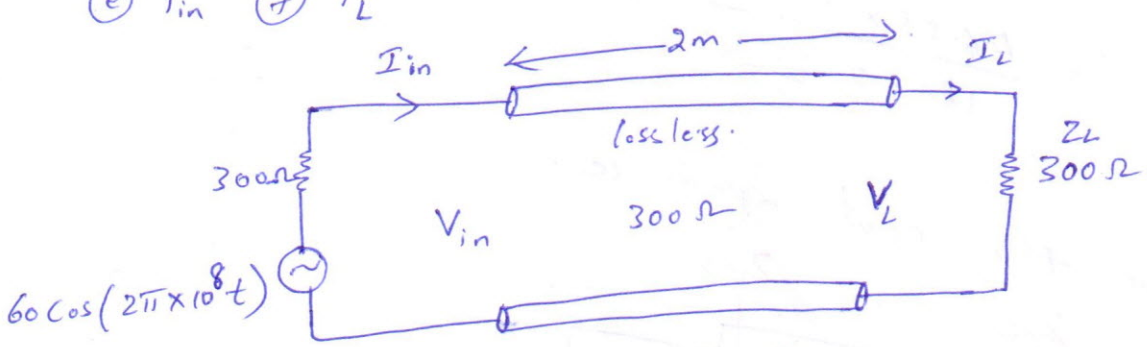
$$Z_{in1} Z_{L1} = Z_{01}^2$$

Half wave line



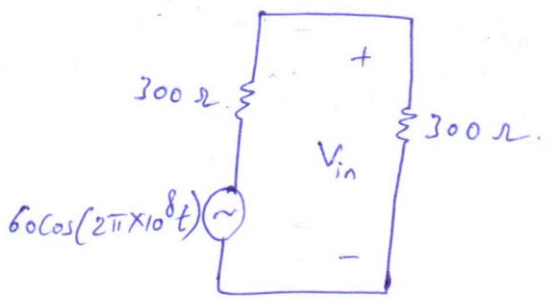
$$Z_{in2} = Z_{L2}$$

(8) for the transmission line. Calculate (a) V_{in} (b) V_L (c) I_{in} (d) I_L (e) P_{in} (f) P_L



$V = 2.5 \times 10^8\ m/s.$

$$\left.\begin{array}{l} Z_L = 300\,\Omega \\ Z_0 = 300\,\Omega \end{array}\right\} \longrightarrow Z_{in} = 300\,\Omega$$



$$V_{in} = \frac{300}{600}\, 60\cos(2\pi\times10^8 t)$$

$$= 30\cos(2\pi\times10^8 t)\ \text{V}$$

Since $Z_L = Z_0$, there is no reflection and also line is lossless therefore voltage at load is same as V_{in} but with delay due to length of the line.

$$\beta l = \frac{2\pi}{\lambda}\, 2 = \frac{2\pi f}{v} \times 2$$

$$= \frac{4\pi\times10^8}{2.5\times10^8} = 1.6\pi \text{ rad.}$$

$$V_L = 30\cos(2\pi\times10^8 t - 1.6\pi)\ \text{V}$$

$$I_{in} = \frac{V_{in}}{300} = 0.1\cos(2\pi\times10^8 t)\ \text{A}$$

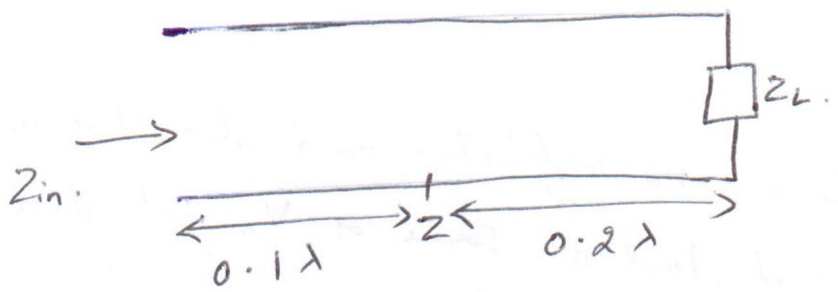
$$I_L = \frac{V_L}{300} = 0.1\cos(2\pi\times10^8 t - 1.6\pi)$$

$$P_{in} = \frac{1}{2} V_{in} I_{in} = \frac{1}{2}\times 30\times 0.1 = 1.5\text{W}$$

$$P_L = 1.5\text{W}$$

(9) A $70\,\Omega$ lossless line has $s = 2$ and $\theta_\Gamma = 200^\circ$. If the line is 0.3λ long obtain. (a) Γ (b) Z_L (c) Z_{in}

(10) If $50\,\Omega$ lossless line has $\Gamma = 0.5\angle 300^\circ$ at a location z. what is the load Impedance and Input impedance, VSWR.



The Complete Smith Chart

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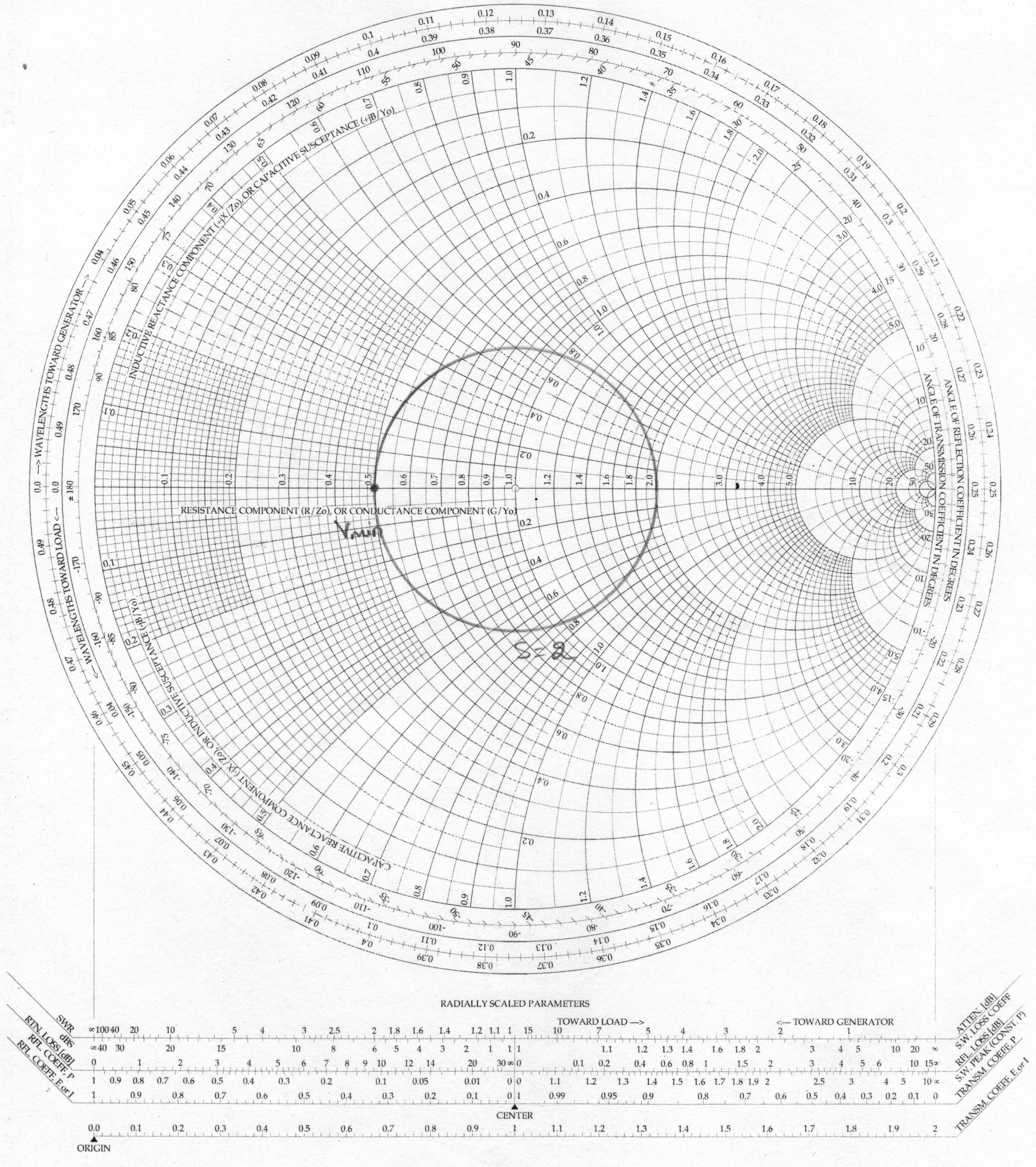
(2)



The Complete Smith Chart

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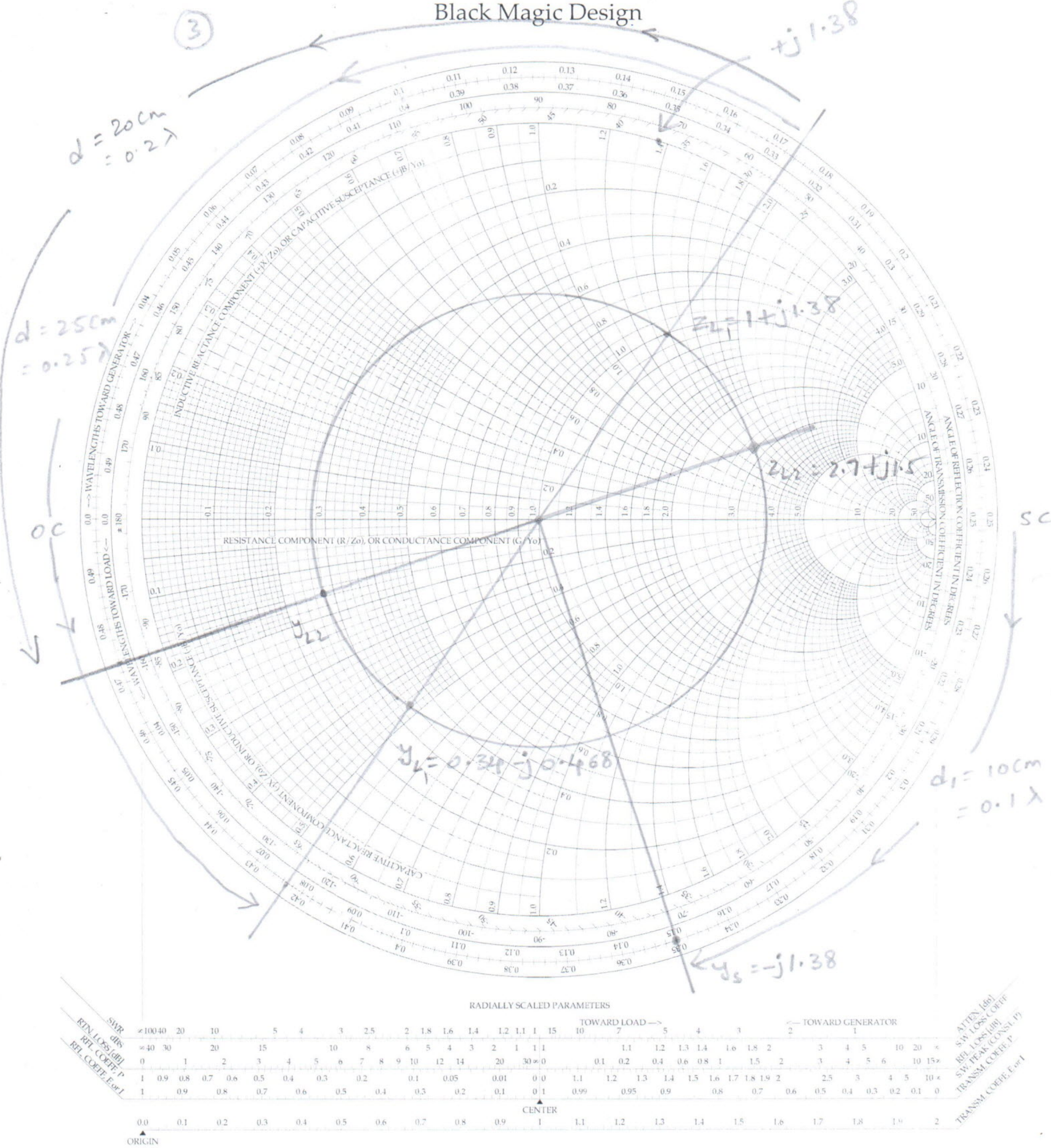

Case ②

$Z_L = 2.7 + j1.5$

$Z_L = (2.7 + j1.5) \times 300$

$= 810 + j450\ \Omega$

Case ①

$Z_L = 1 + j1.38$

$Z_L = (1 + j1.38) \times 300$

$= 300 + j414\ \Omega$

The Complete Smith Chart

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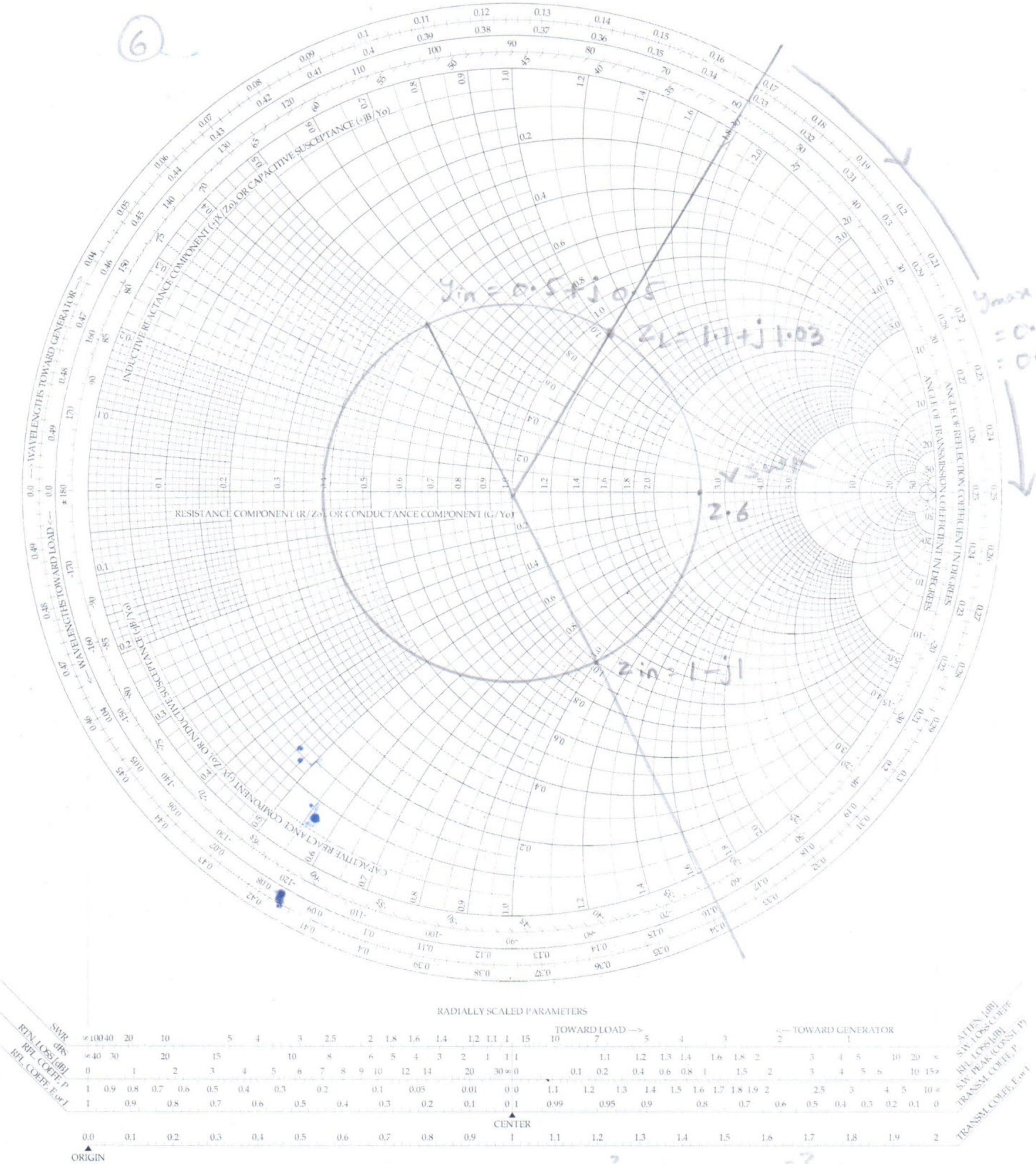

$$Y_{in} = (0.5 + j0.5)\frac{1}{200} = 0.25\times10^{-3} + j\,0.25\times10^{-3} \quad 25$$

$$Z_L = (1.1 + j1.03)\,200 = 220 + j206\ \Omega$$

The Complete Smith Chart

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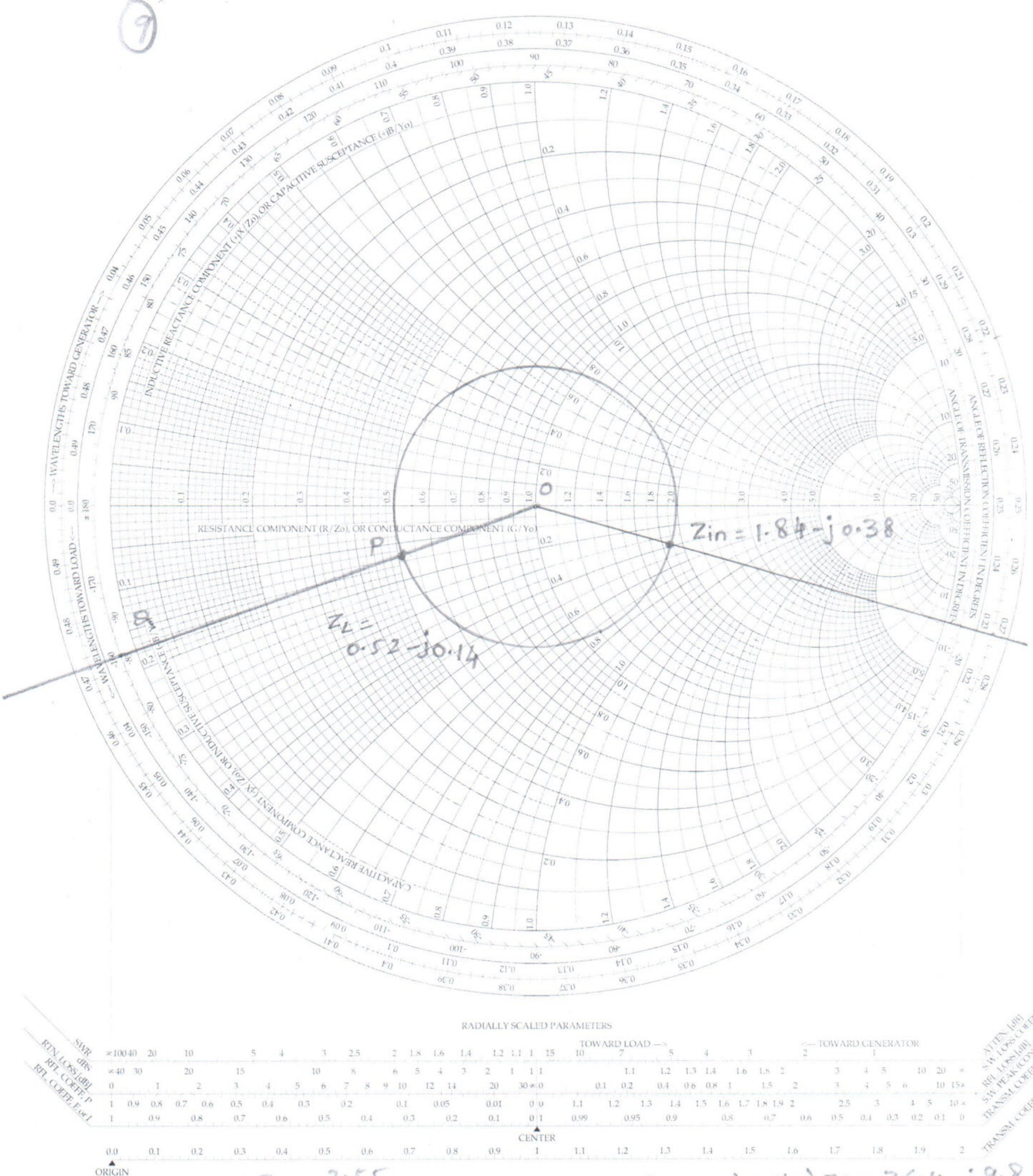
9



$$|\Gamma| = \frac{OP}{OQ} = \frac{2.55}{7.6} = 0.33$$

$$\Gamma = 0.33 \angle 200^\circ$$

$$Z_L = (0.52 - j0.14)70 = 36.4 - j9.8\ \Omega$$

$$Z_{in} = (1.84 - j0.38)70 = 128.8 - j26.6\ \Omega$$

The Complete Smith Chart

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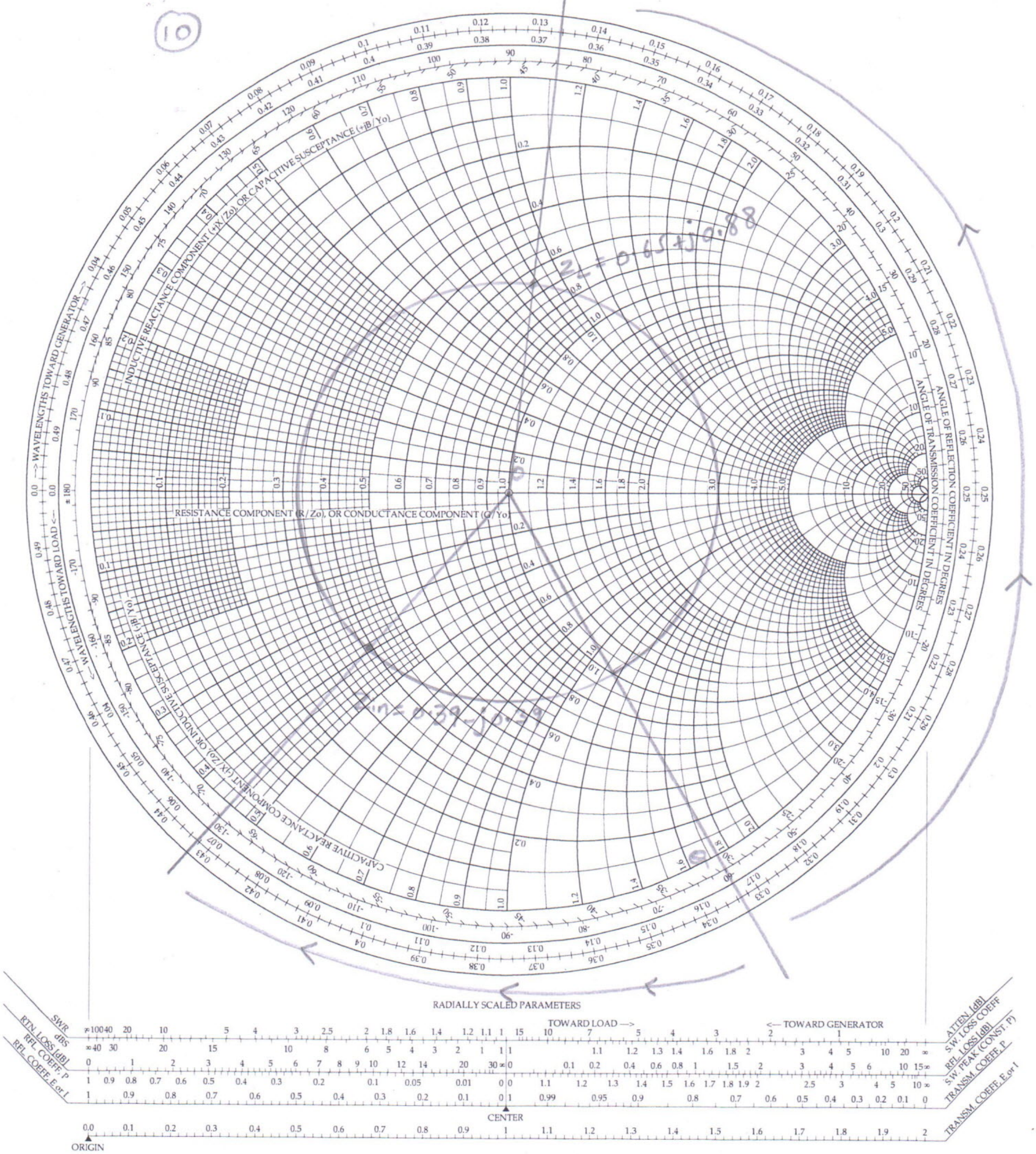

$\frac{OP}{OQ} = 0.5 \Rightarrow OP = 0.5 \times 7.7 = 3.85$ VSWR = 3

$z_{in} = (0.39 - j0.39)50 = 19.5 - j19.5\ \Omega$

$z_L = (0.65 + j0.88)50 = 32.5 + j44\ \Omega$