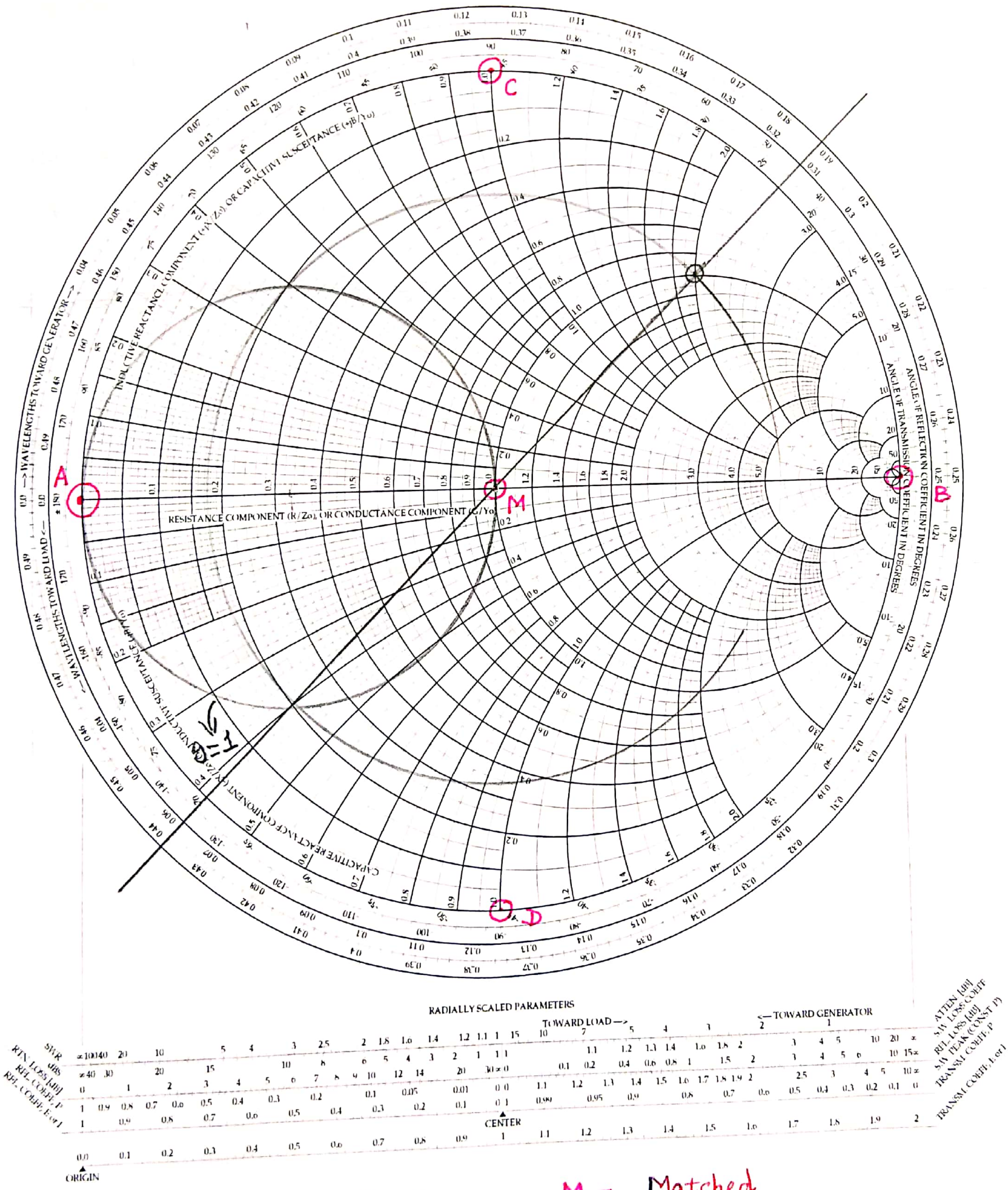
The Complete Smith Chart

Black Magic Design



A – Short Circuit

B – Open Circuit

M – Matched

C – Pure Inductive load equal to Z_o

D – Pure Capacitive load equal to Z_o.

Ⓐ Important points in Smith Chart

Ⓑ How to plot Normalized Impedance $[\bar{z}]$ on Smith Chart

Ⓒ Determining Voltage reflection Coeff (Both Magnitude & phase)

Ⓓ Movement along tx. line

Ⓔ Determing ~~load at~~ impedance at a distance of 0.18λ from load

Ⓕ Determine VSWR

Ⓖ Determine position of Voltage minima, Voltage maxima from the load point

Ⓗ Determine admittance of the load Given.

$Z_R = 25 + j100\ \Omega$

$Z_0 = 50\ \Omega$

$\bar{Z}_R = Z_R / Z_0 = 0.5 + j2$

(0) Origin of the Smith Chart is Called point 'O'

(1) Find $r = 0.5$ circle [r circle], Find $j2$ circle [x circle], find the point of intersection, Call this point as 'A'. The point A is the normalized impedance point.

(2) Draw a St line Connecting point 'O' and point 'A'. The magnitude of this line OA is the Magnitude of Reflection Coefficient and angle line OA makes with horizontal axis gives the phase of the Reflection Coefficient.

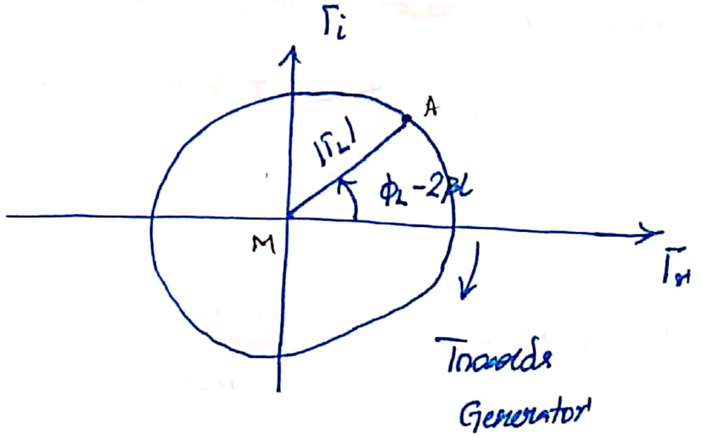
(3) Extend the line OA to outer End of Smith Chart, from angle of Reflection Coeff You Can determine angle of the Ref. Coefficient

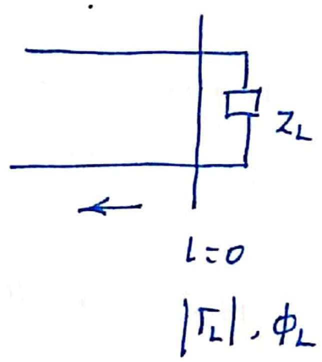
(4) Take Compass and fix one End to 'O' another point to 'A' now in the bottom of the Smith chart You will find Reflection Coeff E or I from there You can determine Magnitude of Reflection Coefficient.

$$\Gamma = \frac{V^- e^{-j\beta l}}{V^+ e^{j\beta l}} = \frac{V^-}{V^+} e^{-j2\beta l}$$

$$\frac{V^-}{V^+} = \Gamma_L = |\Gamma_L| e^{j\phi_L}$$ → Ref. Coeff at load End.

$$\Gamma = |\Gamma_L| e^{j(\phi_L - 2\beta l)}$$

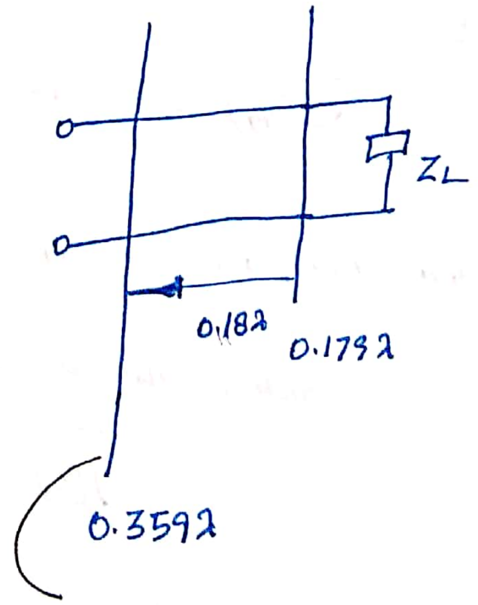




$$\bar{Z} = \frac{1+\Gamma}{1-\Gamma}$$

$$\bar{z}(l) = \frac{1 + |\Gamma_L| e^{j(\phi_L - 2\beta l)}}{1 - |\Gamma_L| e^{j(\phi_L - 2\beta l)}}$$

Load position = 0.179λ



$$\bar{z}(l) = \frac{1 + |\Gamma_L|}{1 - |\Gamma_L|}$$

$\phi_L - 2\beta l = 0$

$\bar{z}(d) = 0.25 - j1.198$

$$\begin{array}{r} 0.179 \\ 0.180 \\ \hline 0.359 \end{array}$$

① Point B $\bar{z}(d)$ at a distance 0.18λ from load.

② Point C, Maximum Value of ~~Char.~~ Normalized impedance. Maxima is at the distance of $\underbrace{(0.25\lambda - 0.179\lambda)}_{0.071\lambda}$ from the load.

③ Point D, minimum Value of ~~Chart~~ Normalized Impedance.

Minima is at the distance of $0.25\lambda + 0.071\lambda = 0.321\lambda$ from the load.

④ Maxima of Normalized Impedance is $\frac{1+|\Gamma_L|}{1-|\Gamma_L|}$ which is nothing but VSWR. So VSWR for this Case = 10.

⑤ ~~Draw a line from point 'O'~~ Extend the line 'OA' mark the point 'E' where it crosses the circle.

Point E is normalized impedance at the position $\lambda/4$ from the load.

$$\bar{z}(\lambda/4) = 0.12 - j0.47$$

$$\begin{array}{r} 0.179 \\ 0.250 \\ \hline 0.429 \end{array}$$

which is nothing but $\bar{z}(\lambda/4) = Z_0/Z_L$.

which is also a normalized Value of Admittance

$$\bar{y}(0) = \bar{z}(\lambda/4) = Z_0/Z_L$$

So 180° opposite point will give you admittance of the that point.

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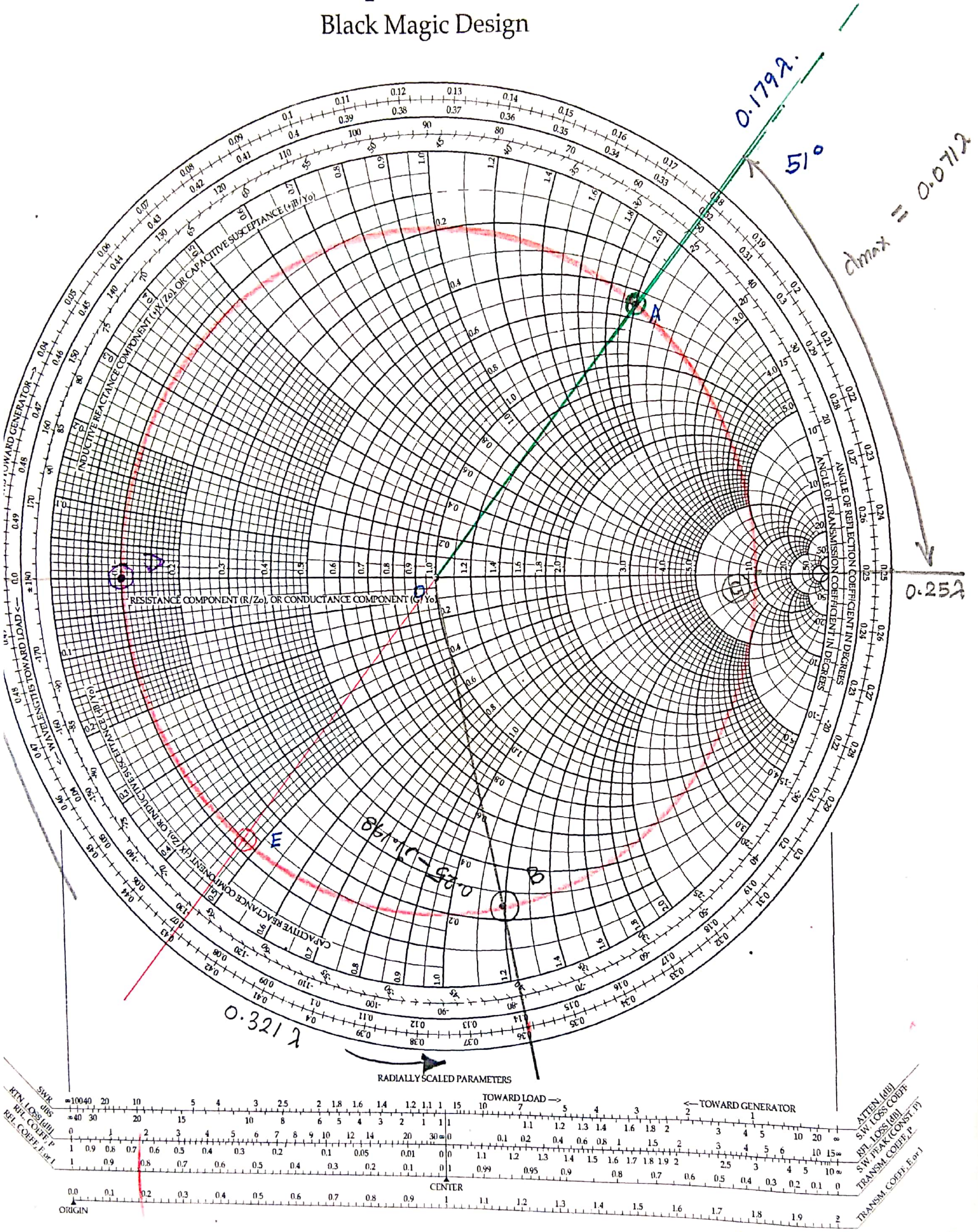


Ⓑ 0.25 − j1.198 $|\Gamma_L| = 0.82$ $\angle\phi_L \cong 51°$ $|\Gamma(d)| = 0.82$ $\angle\Gamma(d) = -78.2°$

Ⓒ 10 Ⓔ $0.12 - j0.47 = \bar{Z}(d)$

Ⓓ 0.1

Determine Voltage Reflection Coeff at load End, VSWR for the load impedance $Z_L = 20 + j30\ \Omega$ terminated in a transmission line of Char. impedance $Z_0 = 50\ \Omega$. Also determine impedance at 0.1λ from the load End, distance of Voltage maxima and Voltage minima from the load end.

$Z_0 = 50\Omega$

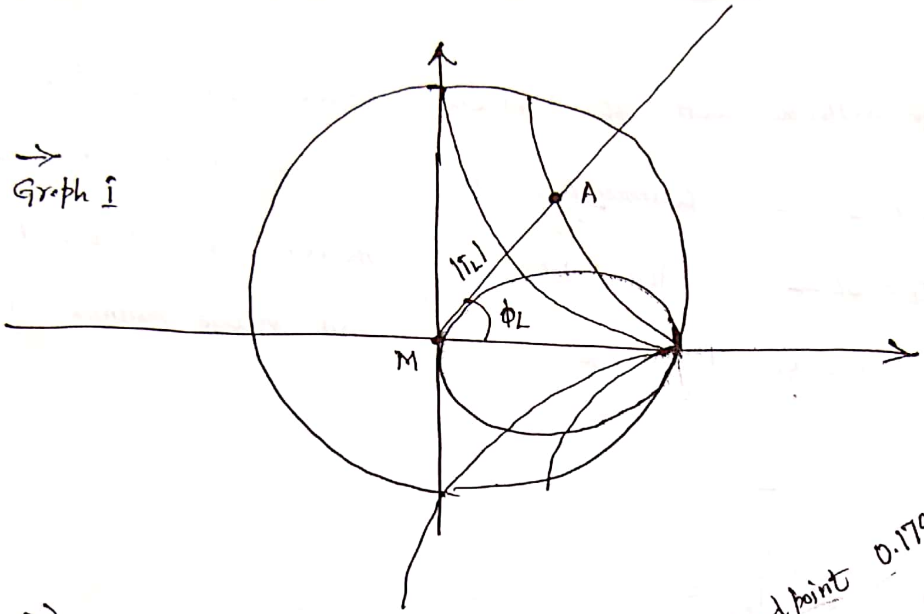
✓ (A) $Z_L = 70 - j100$ $\Gamma_L =$

(B) $Z_L = 100 + j50$ $\Gamma_L =$

(C) $Z_L = 200 - j75$ $\Gamma_L =$

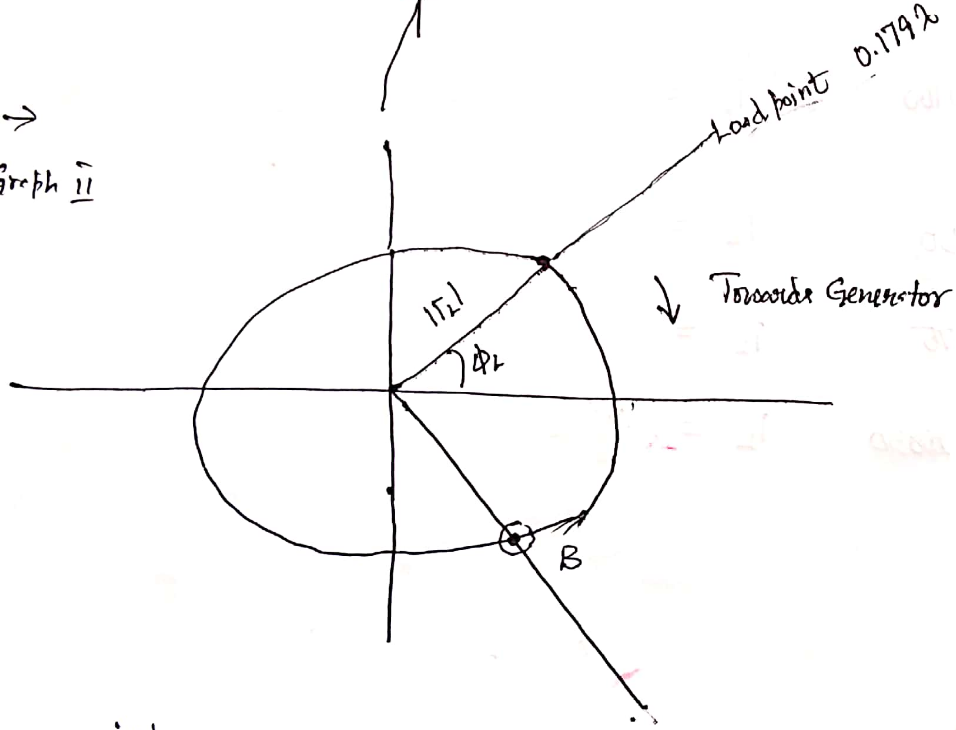
(D) $Z_L = 75 + j\,\cancel{100}50$ $\Gamma_L =$

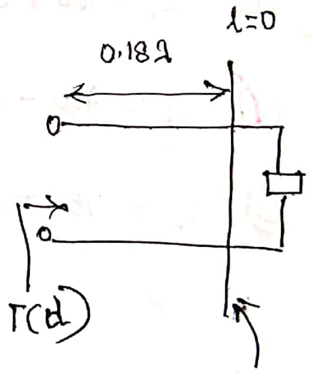
$\vec{\text{Graph I}}$



$A = \bar{Z}_L = 0.5 + j2$

$\vec{\text{Graph II}}$





$$\begin{array}{r} 0.179\lambda \\ 0.180\lambda \\ \hline 0.359\lambda \end{array}$$

$$\Gamma = \frac{V^- e^{-j\beta l}}{V^+ e^{j\beta l}}$$

$$\angle\Gamma_L = -78.2^\circ$$

$$\bar{z}(d) = \frac{1 + \Gamma(d)}{1 - \Gamma(d)}$$

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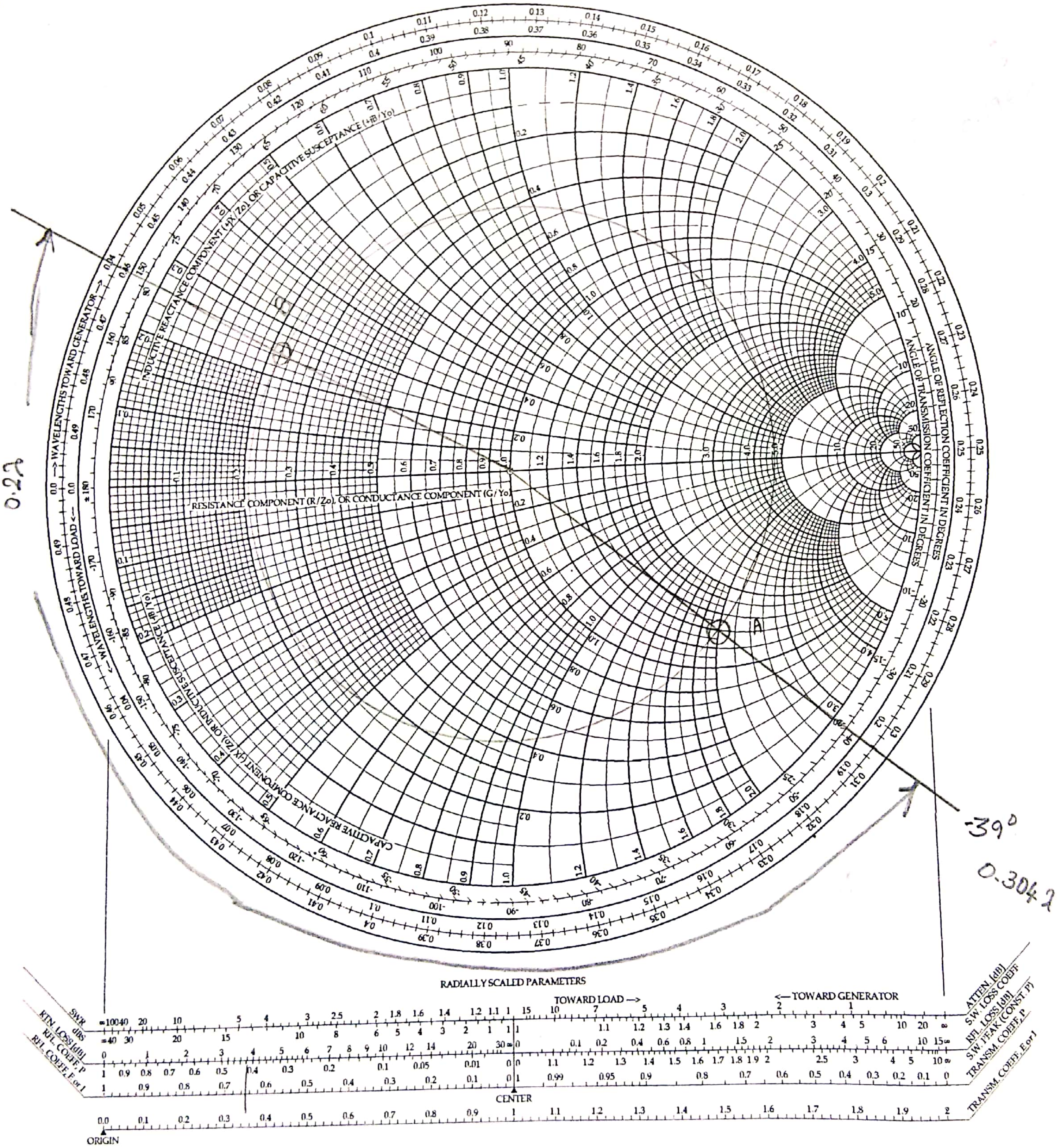

$|\Gamma_L| = 0.65$

$\angle \Gamma_L = -39^\circ$

$Z_L = 70 - j100$ $\quad \bar{Z}_L = \frac{70 - j100}{50} = (1.4 - j2)$

$\rightarrow$ 0.2λ from load

$\bar{z}(d=0.2\lambda) = 0.22 + j0.24$

$\Gamma(d=0.2\lambda) = 0.65 \angle 79^\circ$

$d_{min} = (0.5 - 0.304)\lambda = 0.196\lambda$

$$\begin{array}{r} 0.50 \\ 30 \\ \hline 0.19 \\ 0.25 \\ \hline .44 \end{array}$$

$d_{max} = 0.446\lambda$

VSWR = 4.7

$z_{min} = 0.21$