ICE-3103, Microwave Engineering (Smith Chart)

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We have to find out using Smith chart

a) Voltage reflection coefficient, Γ

b) Voltage standing-wave ratio, **VSWR**

c) Finding input impedance, Z_{in}

d) Finding load impedance, Z_L

e) the distances of the voltage maximum and voltage minimum, d_{max} , d_{min} **OR** l_{max} , l_{min}

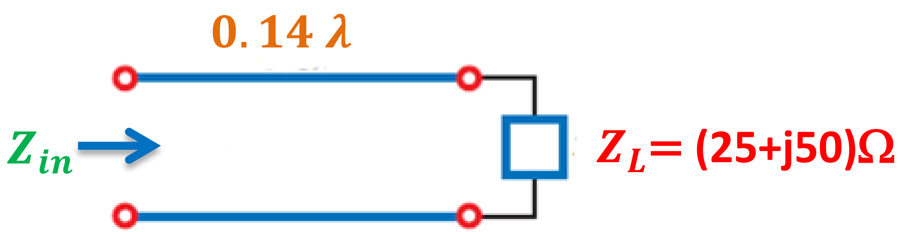
Set: A1 Question

A 50-Ω lossless line is terminated in a load impedance, Z_L = (25+j50)Ω. Use the smith chart to find

a) voltage reflection coefficient,

b) the voltage standing-wave ratio,

c) the input impedance of the line, given the line is **0.14λ**



Solution:

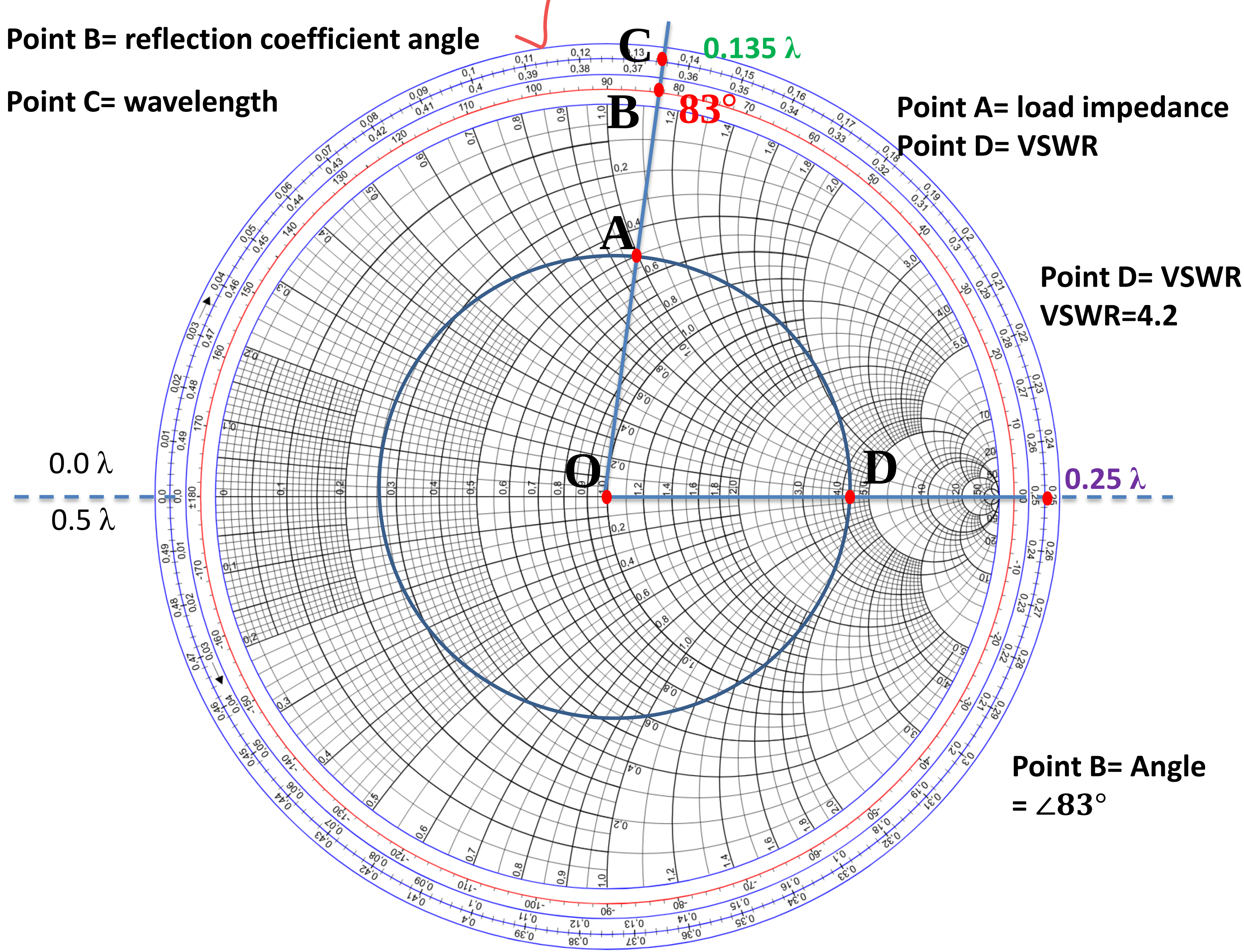
Normalized load impedance, $Z_L = \frac{25\ \Omega}{50\ \Omega} + j\frac{50\ \Omega}{50\ \Omega} = 0.5\ + j1$

Ans: Normalized, $Z_L = 0.5 + j1$

a)$\Gamma = 0.62\ \angle 83°$

b) $\text{VSWR} = 4.2$

c) Normalized $Z_{in} = 03 - \text{j}1.8;$

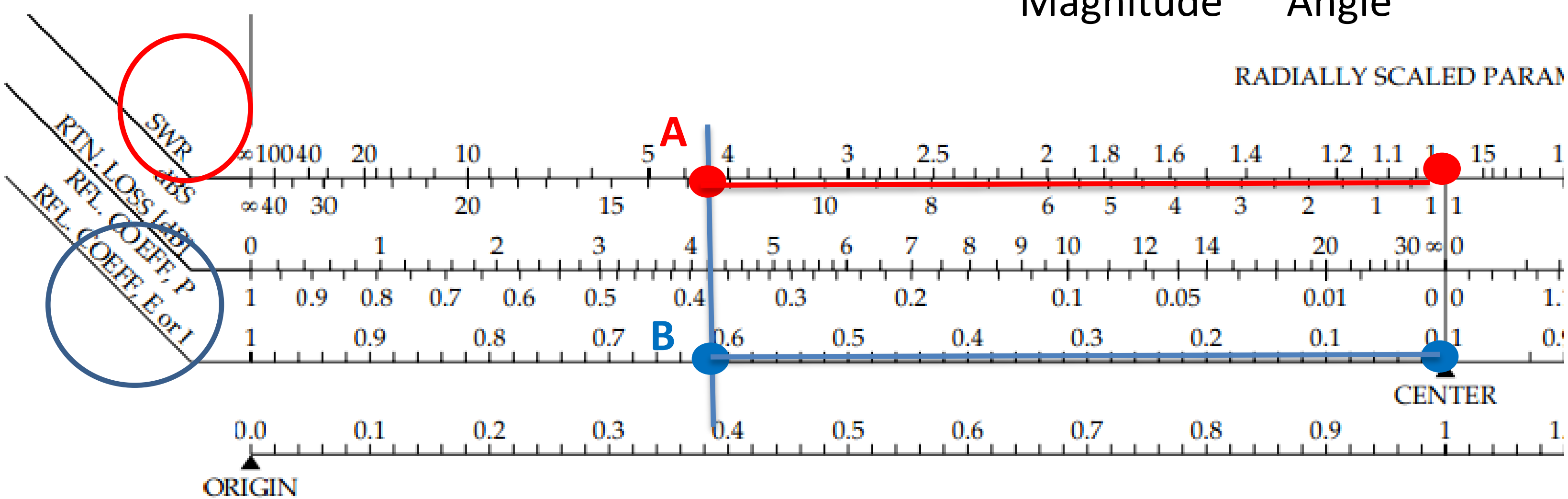


Point B= reflection coefficient angle
Point C= wavelength
Point A= load impedance
Point D= VSWR
Point D= VSWR
VSWR=4.2
Point B= Angle
= ∠83°
C
0.135 λ
B
83°
A
O
D
0.0 λ
0.5 λ
0.25 λ

VSWR = 4.2

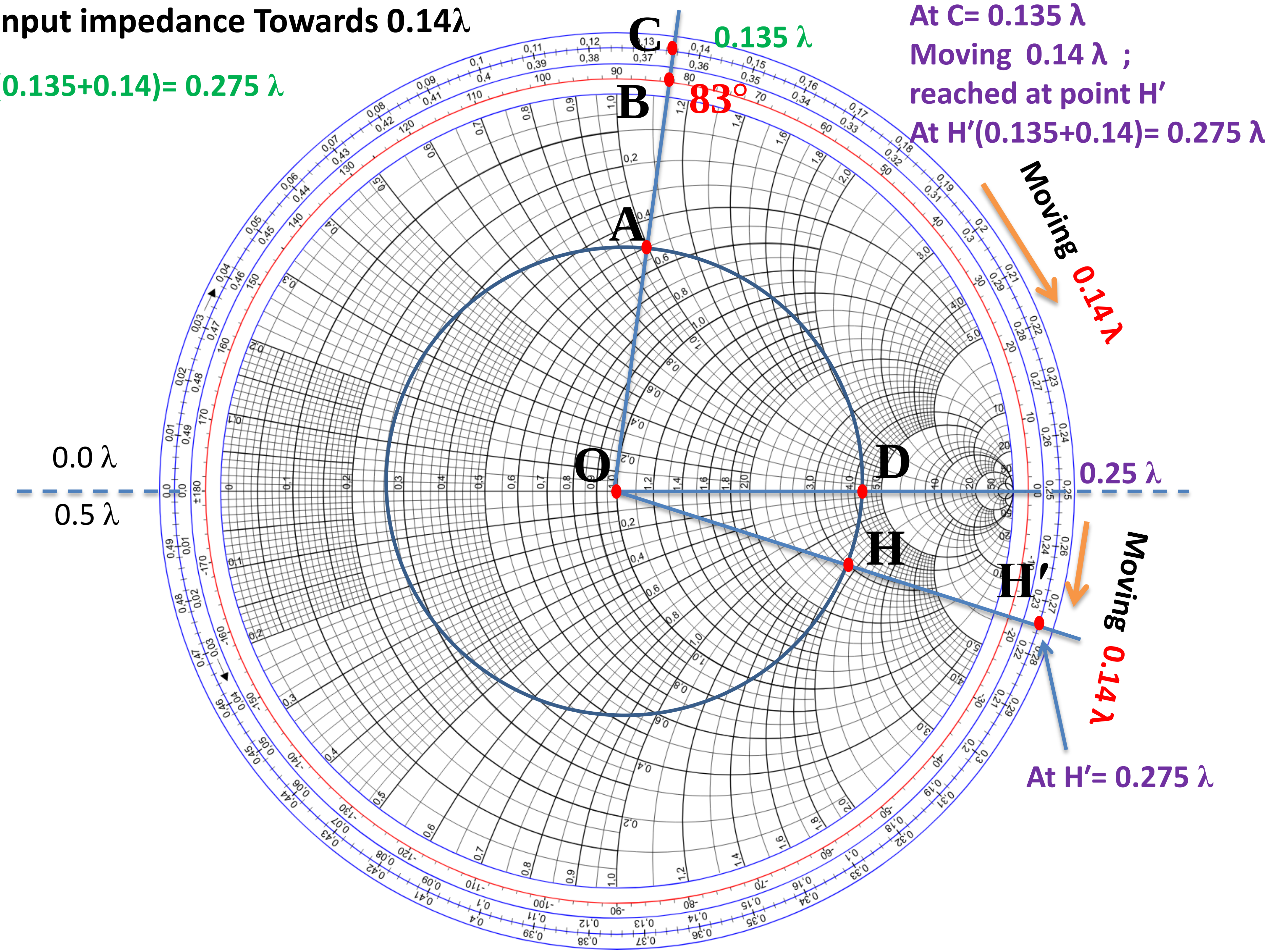
Voltage reflection coefficient, $\Gamma = 0.62\angle 83°$

Magnitude Angle



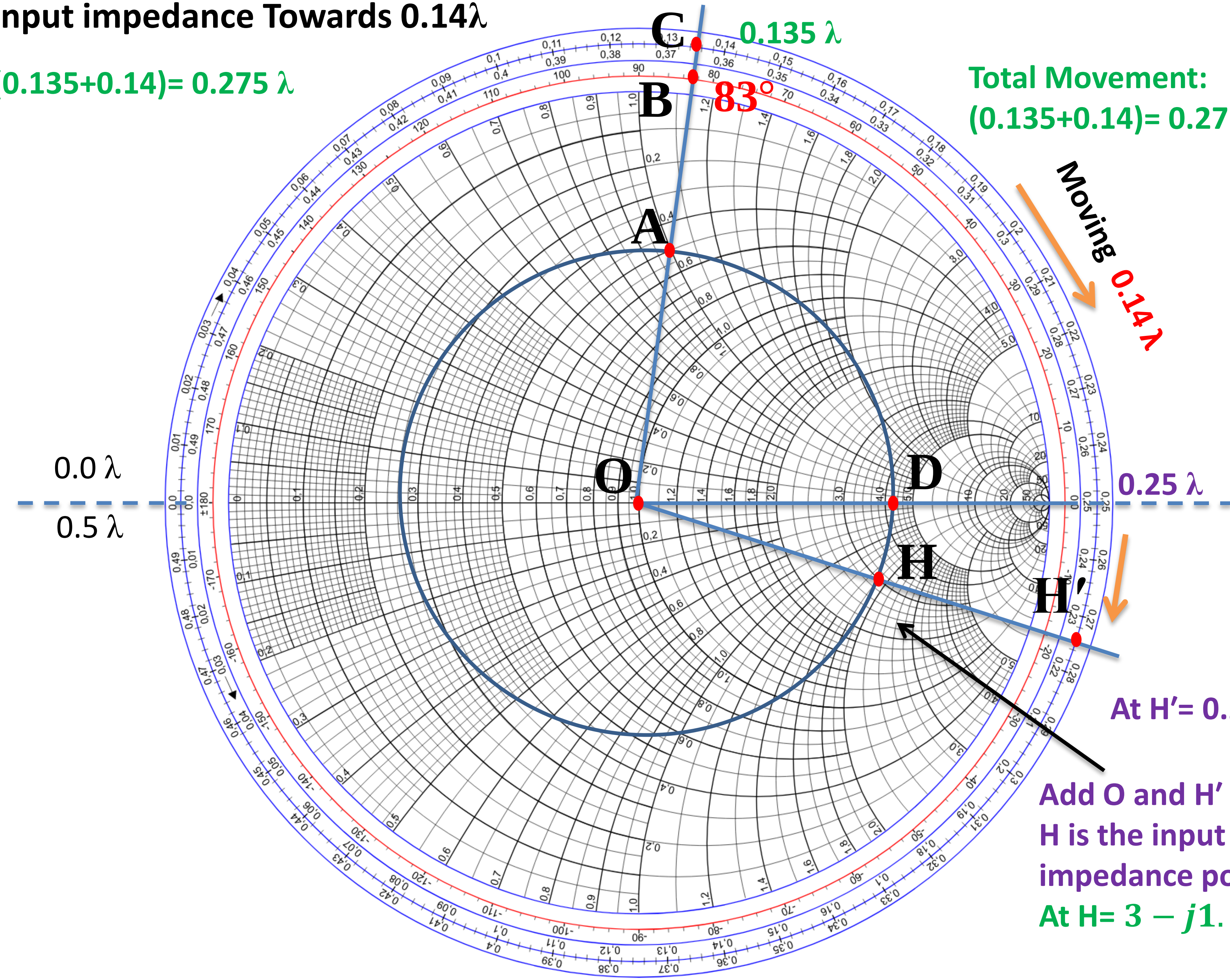
Input impedance Towards 0.14λ

(0.135+0.14)= 0.275 λ



Input impedance Towards 0.14λ

(0.135+0.14)= 0.275 λ



Total Movement:
(0.135+0.14)= 0.275 λ

At H′= 0.275 λ

Add O and H′
H is the input impedance point
At H= $3 - j1.8$

S is numerically equal to the value of r_0 at P_{max}, the point at which the SWR circle intersects the real Γ axis to the right of the chart's center.

S= 4.2

At H= $3 - j1.8$

$\downarrow$ **R** $\downarrow$ **X**

So the input impedance, Z_{in} **at H =** $(3-j1.8)\, Z_0\ \Omega$

= $(3-j1.8)\, 50\ \Omega$

= $(150 - j90)\ \Omega$

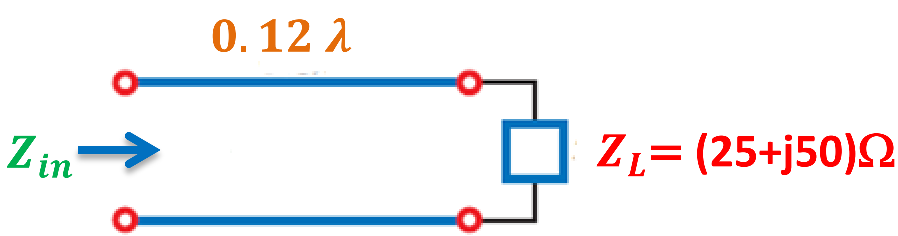
Set: A2 Question

A 50-Ω lossless line is terminated in a load impedance, Z_L = (25+j50)Ω. Use the smith chart to find

a) voltage reflection coefficient,

b) the voltage standing-wave ratio,

c) the input impedance of the line, given the line is **0.12λ**



Solution:

Normalized load impedance, $Z_L = \frac{25\ \Omega}{50\ \Omega} + j\frac{50\ \Omega}{50\ \Omega} = 0.5\ + j1$

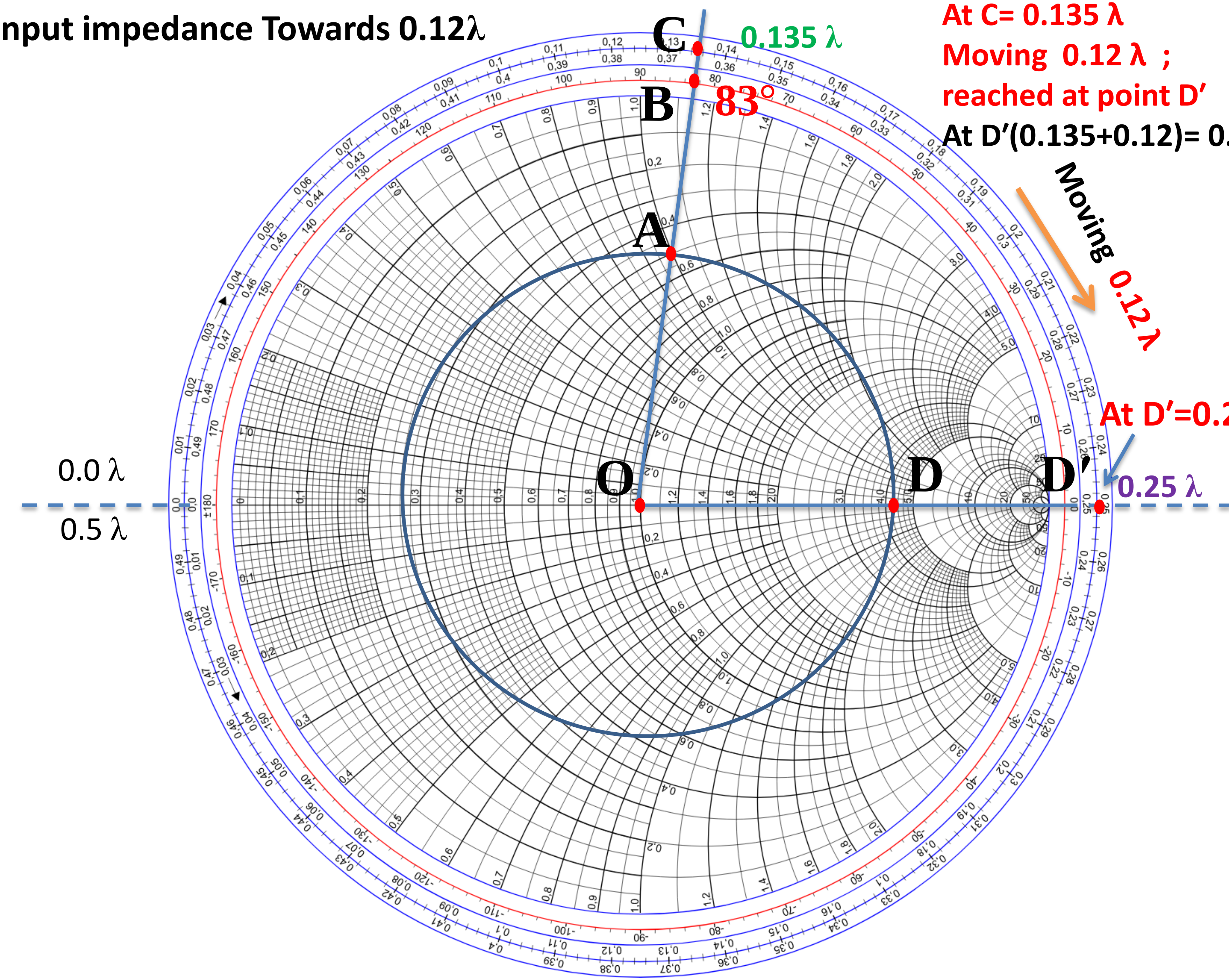
Input impedance Towards 0.12λ

At C= 0.135 λ

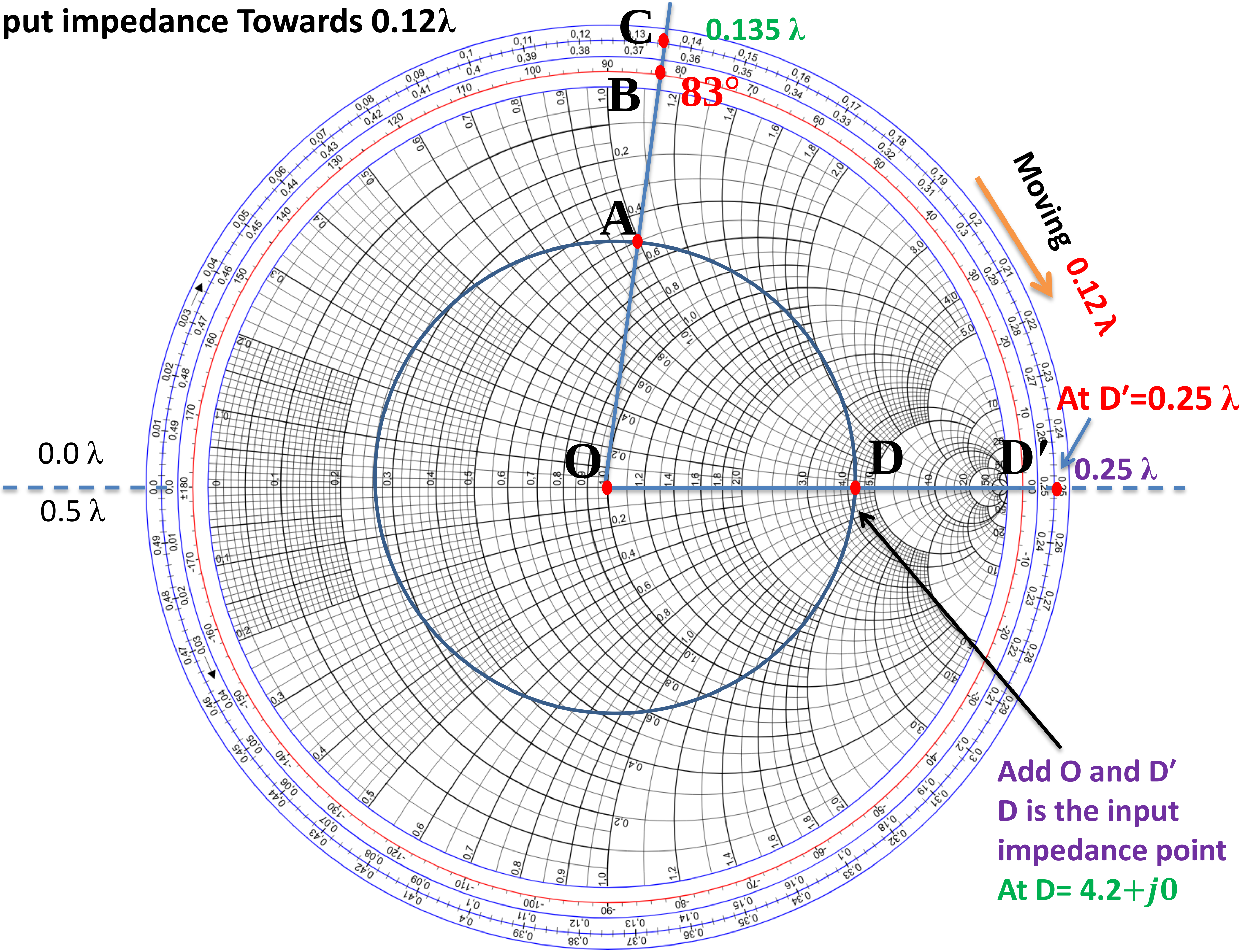
Moving 0.12 λ ;

reached at point D′

At D′(0.135+0.12)= 0.25 λ



Input impedance Towards 0.12λ



S is numerically equal to the value of r_0 at P_{max}, the point at which the SWR circle intersects the real Γ axis to the right of the chart's center.

S= 4.2

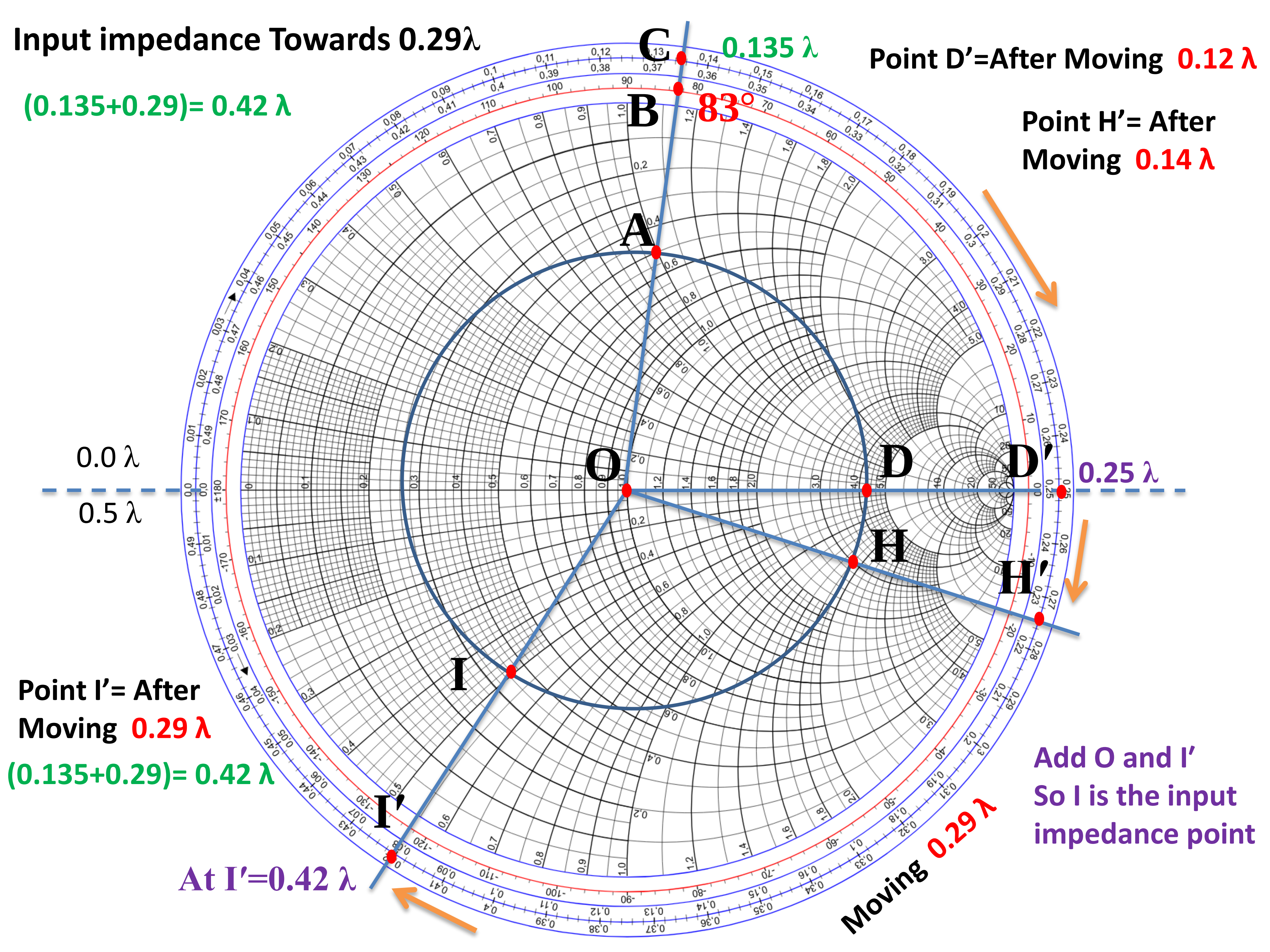
At D= $4.2 + j0$

$$\underset{\textbf{R}}{4.2} + j\underset{\textbf{X}}{0}$$

So the input impedance, Z_{in} at D = $(4.2 + j0\,)Z_0\,\Omega$

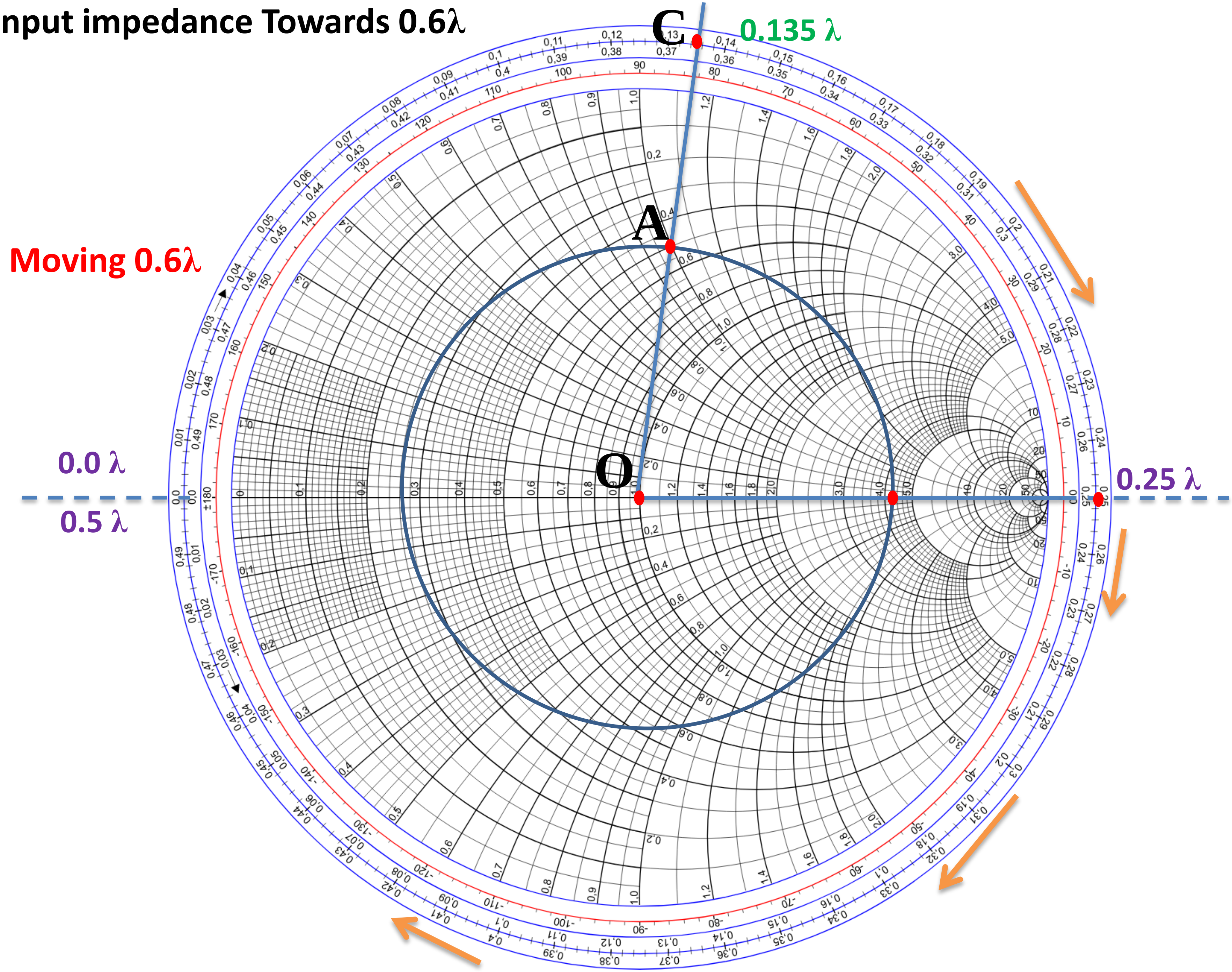
$= (4.2 + j0\,)50\,\Omega$

$= 210\,\Omega$

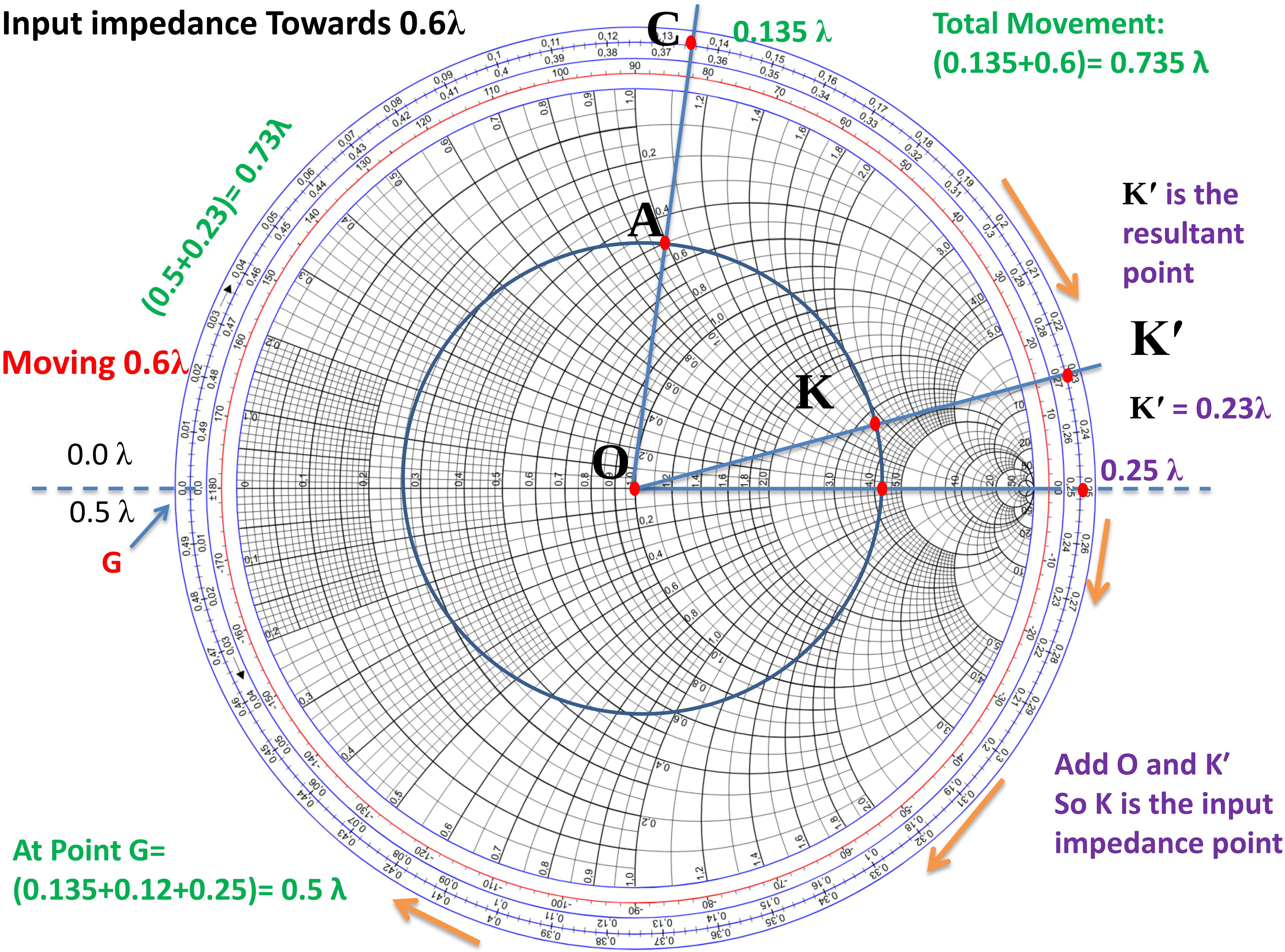


Input impedance Towards 0.29λ
(0.135+0.29)= 0.42 λ
C
0.135 λ
B
83°
A
O
D
D′
0.25 λ
H
H′
I
I′
0.0 λ
0.5 λ
Point D′=After Moving 0.12 λ
Point H′= After Moving 0.14 λ
Point I′= After Moving 0.29 λ
(0.135+0.29)= 0.42 λ
At I′=0.42 λ
Moving 0.29 λ
Add O and I′
So I is the input impedance point

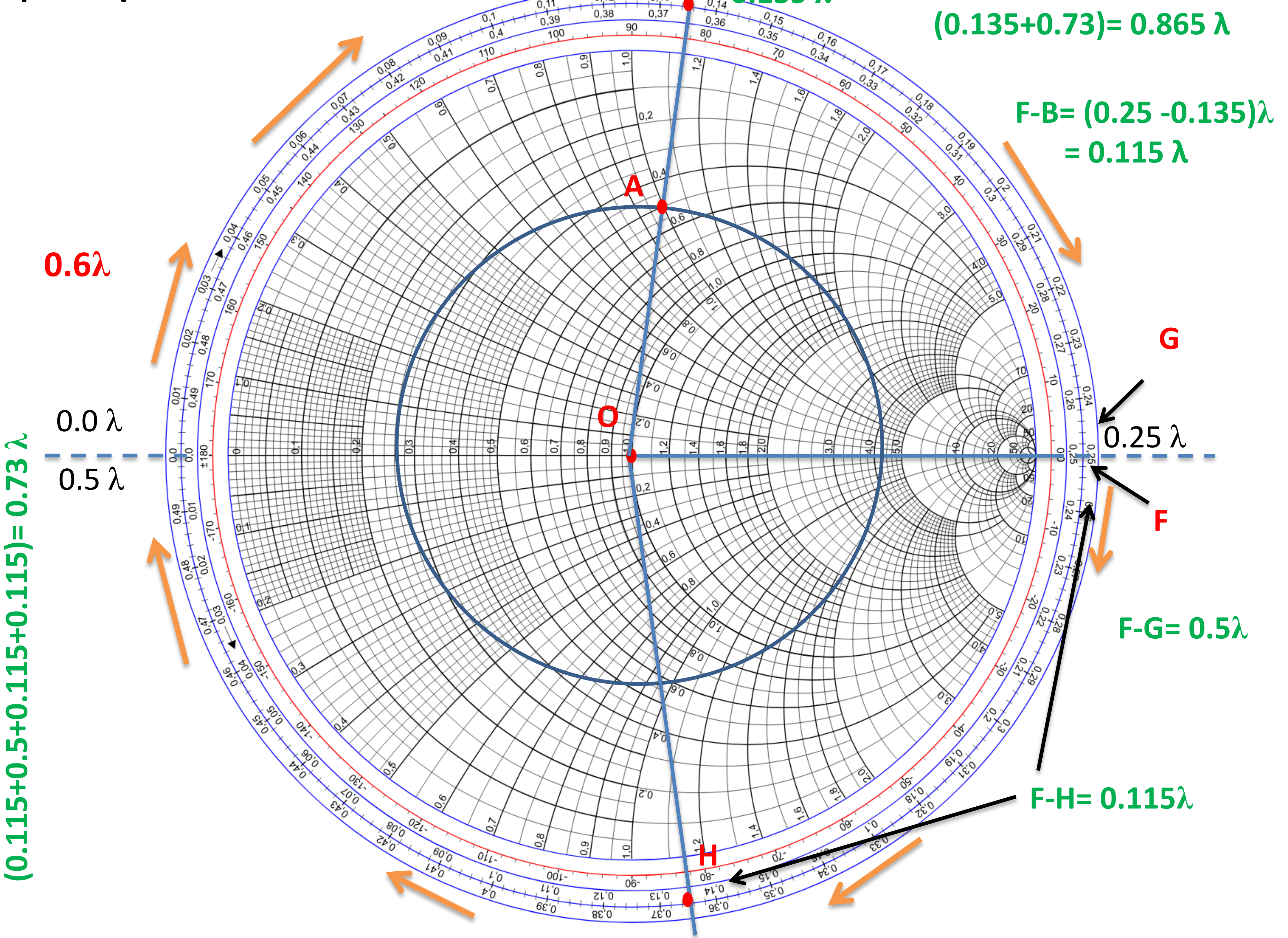
Input impedance Towards 0.6λ



Input impedance Towards 0.6λ



Input impedance Towards 0.73λ



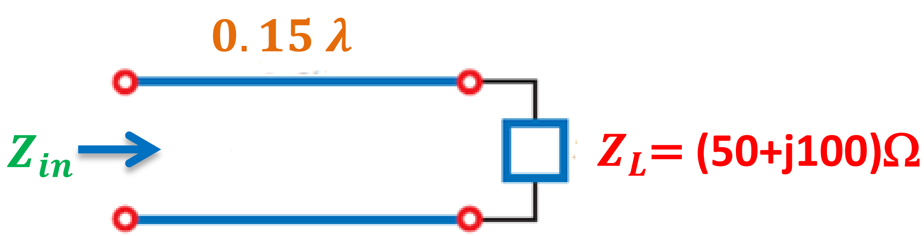
Set: B Question

A 50-Ω lossless line is terminated in a load impedance, **Z_L = (50+j100)Ω**. Use the smith chart to find

a) voltage reflection coefficient,

b) the voltage standing-wave ratio,

c) the input impedance of the line, given the line is **0.15λ**



Normalized load impedance, $Z_L = \frac{50\ \Omega}{50\ \Omega} + j\,\frac{100\ \Omega}{50\ \Omega} = 1 + j2$

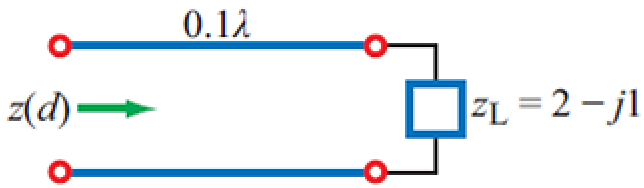
Set: C Question

A lossless transmission line is terminated in a normalized load impedance, Z_L = (2-j1)Ω. Use the smith chart to find

a) voltage reflection coefficient,

b) the voltage standing-wave ratio,

c) the input impedance of the line, given the line is 0.1λ



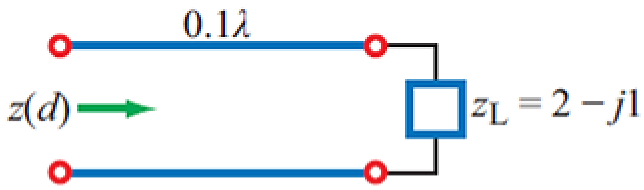
Set: C Question

A lossless transmission line is terminated in a normalized load impedance, Z_L = (2-j1)Ω. Use the smith chart to find

a) voltage reflection coefficient,

b) the voltage standing-wave ratio,

c) the input impedance of the line, given the line is **0.1λ**



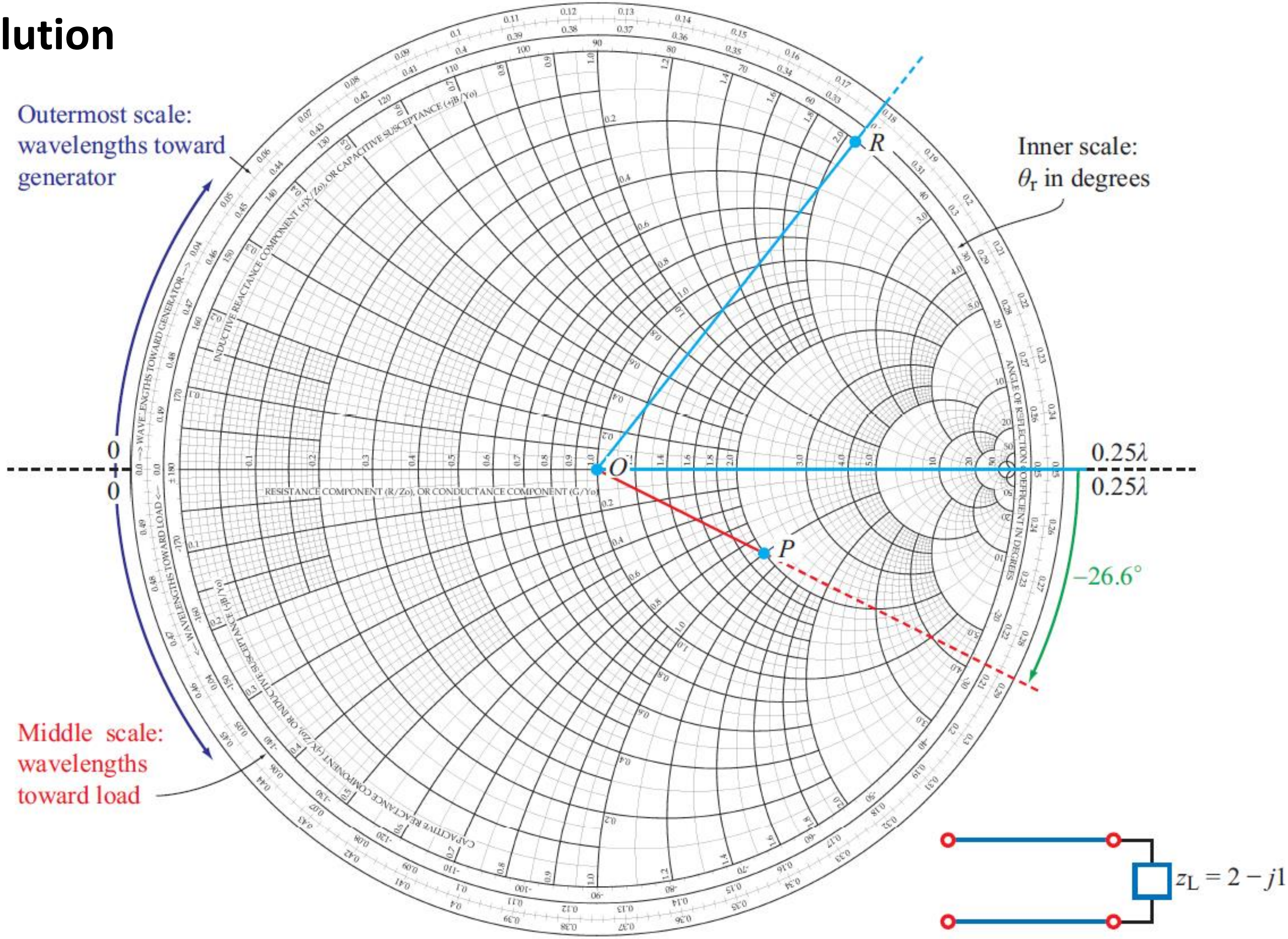
Ans:

a) voltage reflection coefficient= $0.45\angle -26.6°$

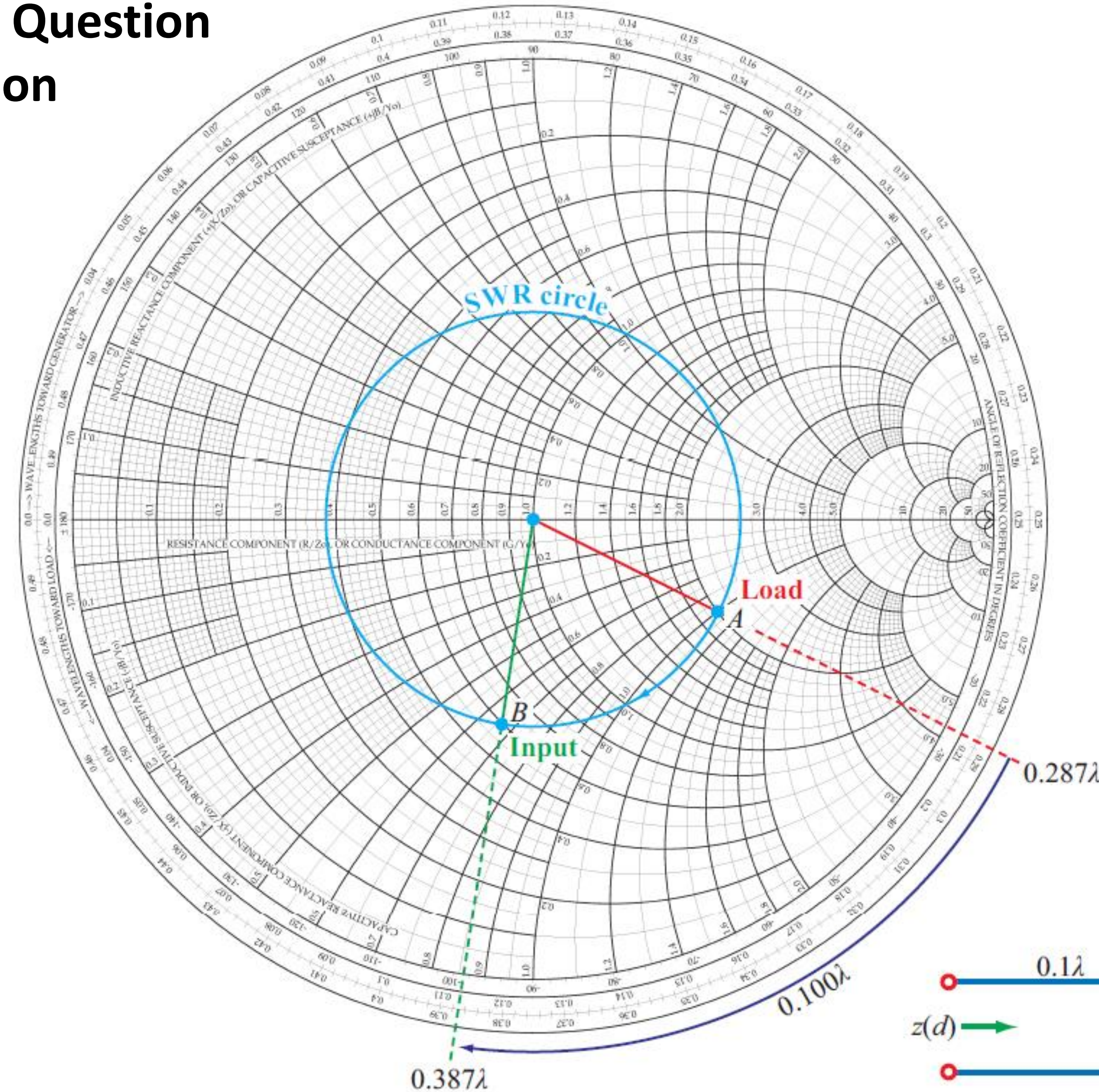
b) the voltage satanding-wave ratio= 2.65

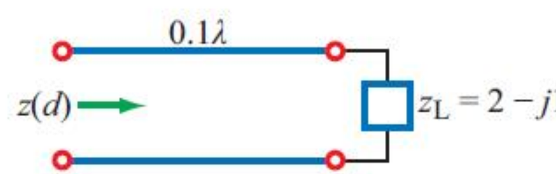
c) the input impedance of the line, given the line is **0.1λ,** = $0.6 - j0.66$

Set: C Question Solution



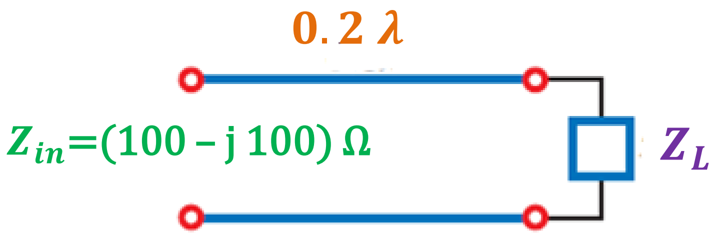
Set: C Question Solution





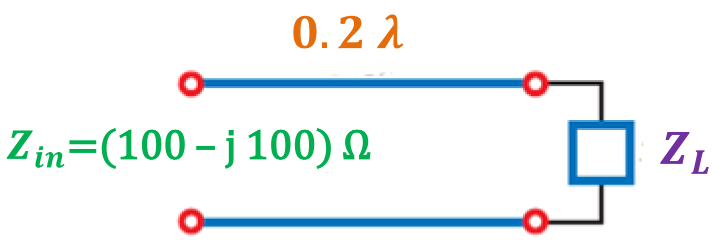
Finding Load Impedance, Z_L

Set: D Question



Finding Load Impedance, Z_L

Set: D Question



Solution:

Given:

Z_{in}= (100 – j 100) Ω

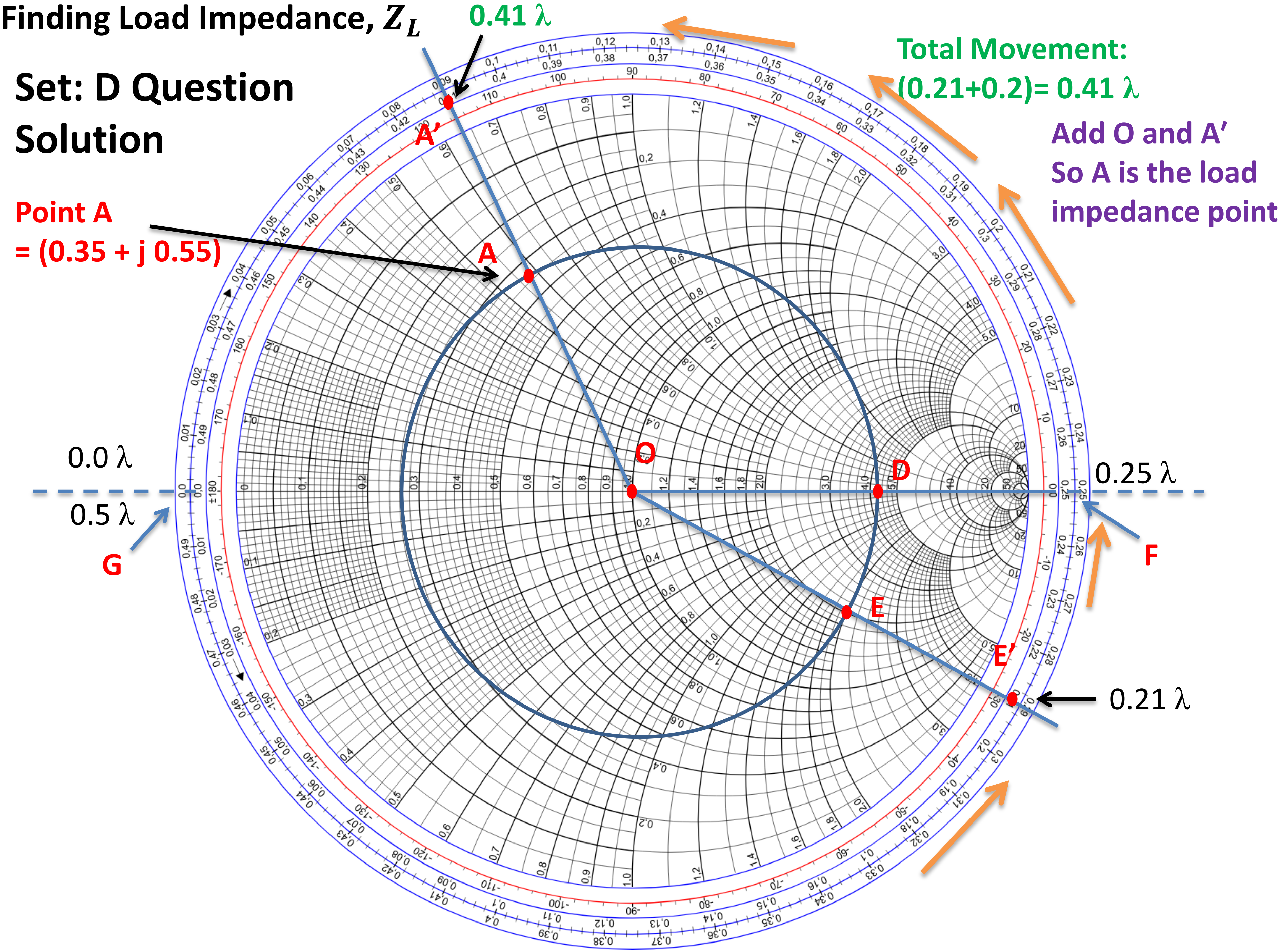
So, Normalized input impedance, $Z_{in} = \frac{100\ \Omega}{50\ \Omega} - \mathrm{j}\,\frac{100\ \Omega}{50\ \Omega}$

$= 2 - j2$

Ans: $Z_L = (0.35 + j0.55)\ Z_0\ \Omega$

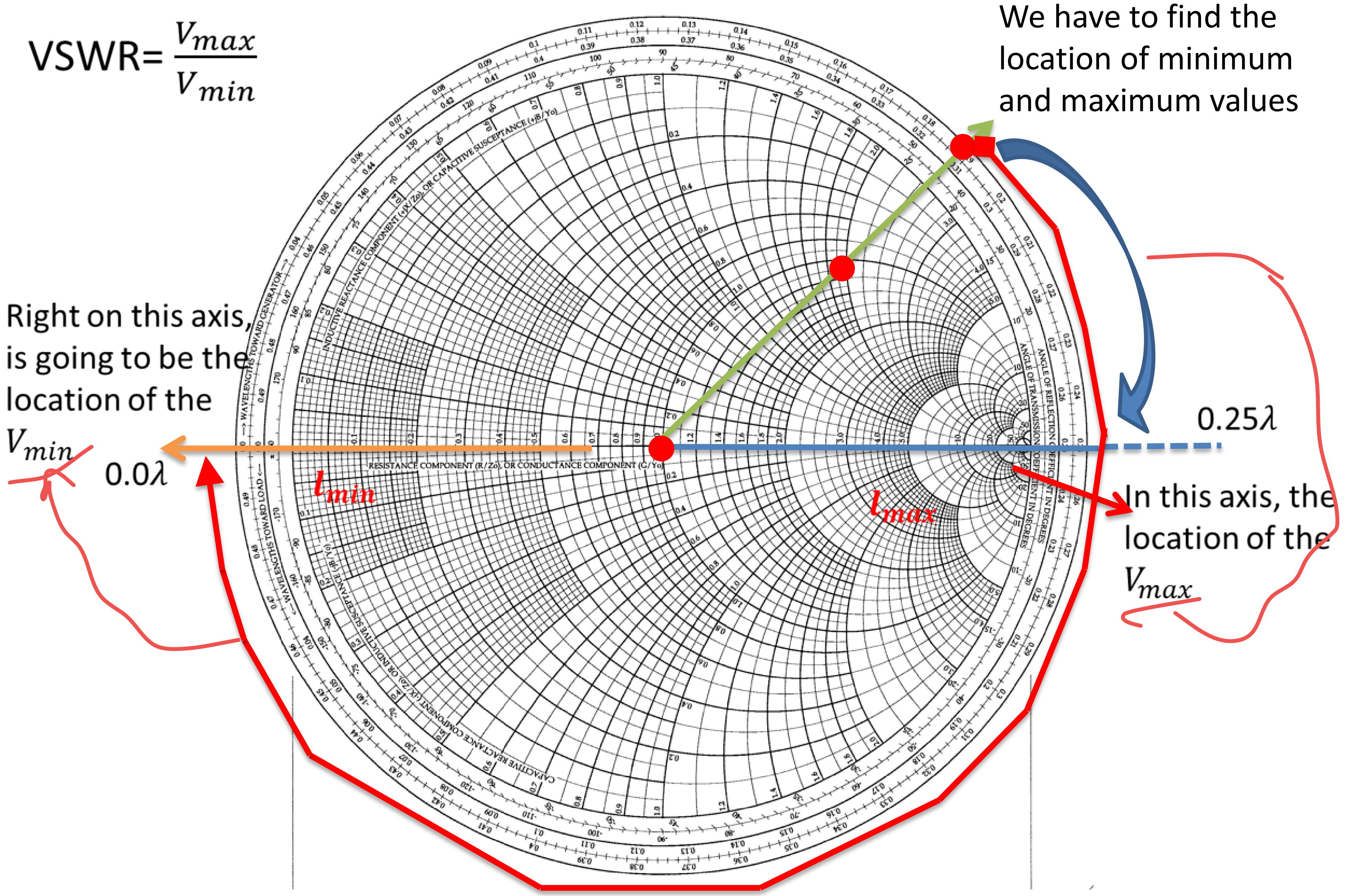
Finding Load Impedance, Z_L

Set: D Question Solution



Maxima and Minima

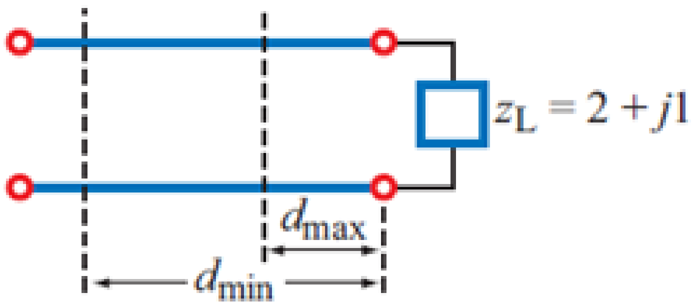
$$VSWR = \frac{V_{max}}{V_{min}}$$



Maxima and Minima

Practice:

Use the smith chart to find the distances of the first voltage maximum and first voltage minimum from the load



Ans:

first voltage maximum= 0.037 λ

first voltage minimum= 0.287 λ

Maxima and Minima

Practice: Solution

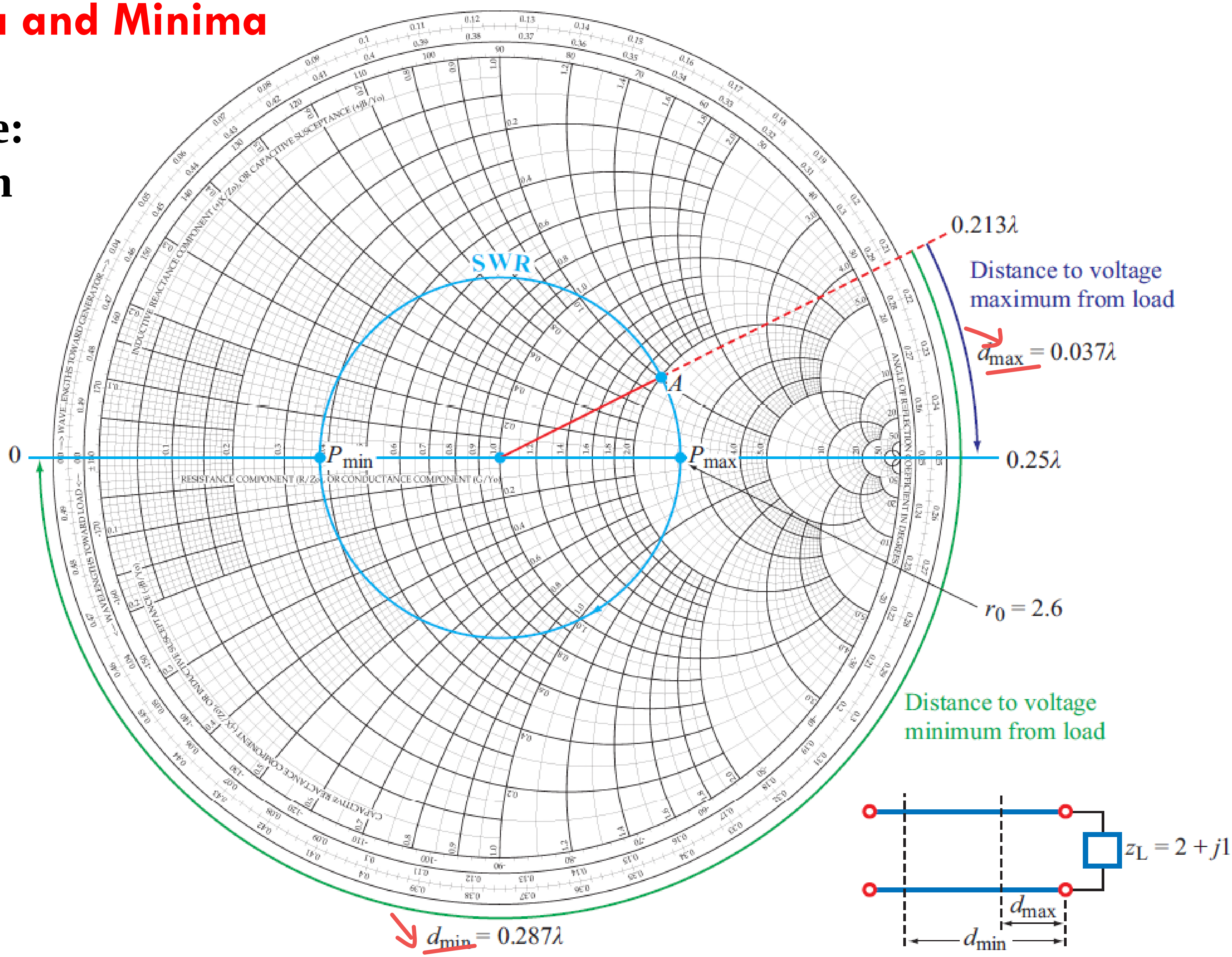


Figure 2-28: Point A represents a normalized load with $z_L = 2 + j1$. The standing wave ratio is $S = 2.6$ (at P_{max}), the distance between the load and the first voltage maximum is $d_{max} = (0.25 - 0.213)\lambda = 0.037\lambda$, and the distance between the load and the first voltage minimum is $d_{min} = (0.037 + 0.25)\lambda = 0.287\lambda$.

Practice:

A 50-Ω lossless line is terminated in a load Z_L = (25+j50)Ω.

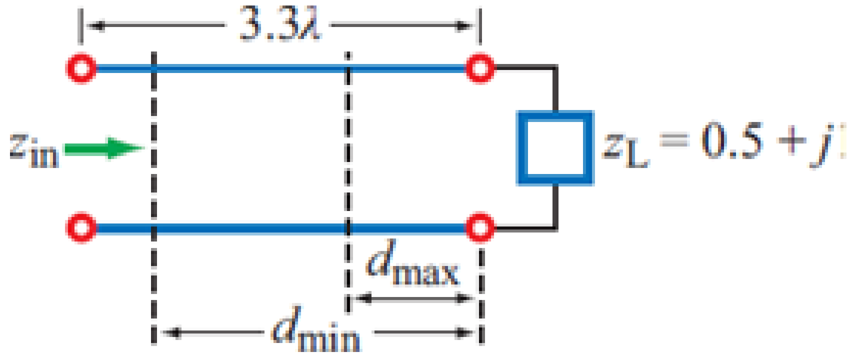
Use the smith chart to find

a) voltage reflection coefficient,

b) the voltage standing-wave ratio,

c) the distances of the first voltage maximum and first voltage minimum from the load,

d) the input impedance of the line, given the line is 3.3λ



Practice:

A 50-Ω lossless line is terminated in a load Z_L = (25+j50)Ω.

Use the smith chart to find

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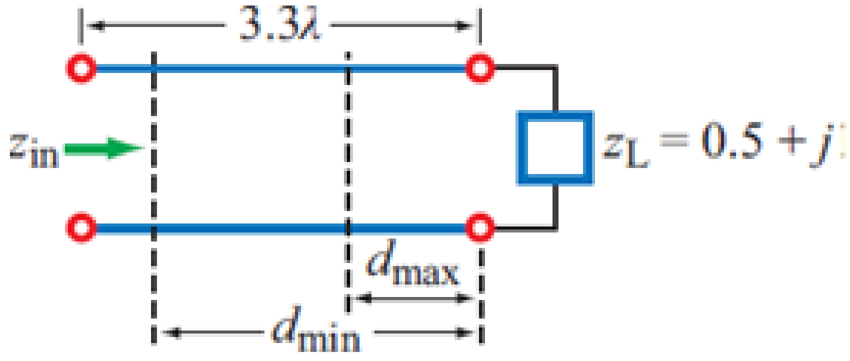


Ans: $Z_L = 0.5 + j1$

a) $\Gamma = 0.62\ \angle 83°$

b) VSWR = 4.26

c) d_{max} = 0.115 λ, d_{min}= 0.365 λ

d) Normalized Z_{in} = 0.28 + j0.40; Z_{in} = (14-j20)Ω

Practice: Solution

A 50-Ω lossless transmission line of length 3.3λ is terminated by a load impedance $Z_L = (25 + j50)$ Ω. Use the Smith

$$z_L = \frac{Z_L}{Z_0} = \frac{25 + j50}{50} = 0.5 + j1$$

(a)

$$d_{max} = (0.25 - 0.135)\lambda = 0.115\lambda$$

$$d_{min} = (0.5 - 0.135)\lambda = 0.365\lambda$$

(b)

$$z_{in} = 0.28 - j0.40$$

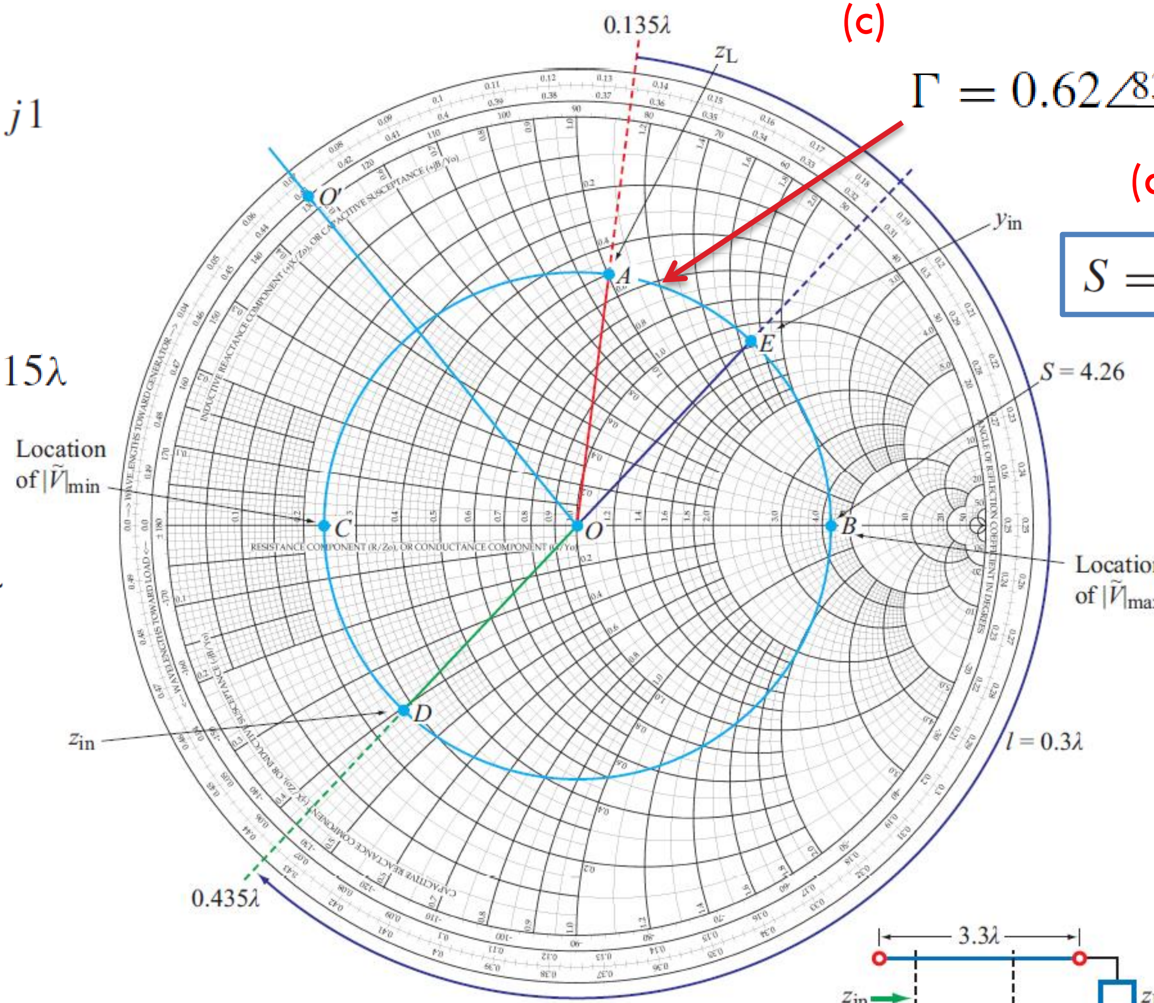
$$Z_{in} = z_{in} Z_0 = (0.28 - j0.40)50 = (14 - j20)\ \Omega$$

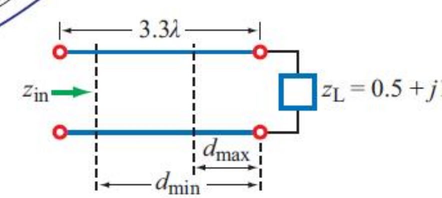
(c)

$$\Gamma = 0.62\angle 83^\circ$$

(d)

$$\boxed{S = 4.26}$$

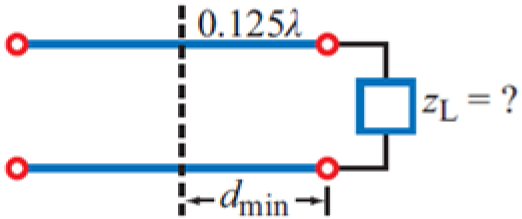




Smith Chart slotted line example:

Given:

$Z_0 = 50\ \Omega$, $SWR = 3$, first voltage min, d_{min} is 5 cm from load and distance between adjacent minima, $\frac{\lambda}{2} = 20$ cm. Find load impedance Z_L



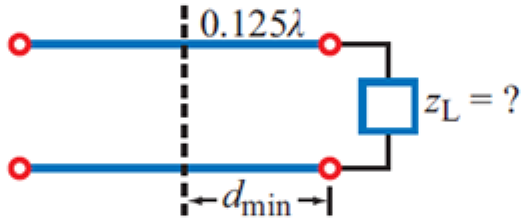
Solution:

Find d_{min} in wavelength format. $d_{min} = \frac{d_{min}\ value\ in\ cm}{\lambda\ value\ in\ cm} = \frac{5\ cm}{40\ cm} = 0.125\ \lambda$

Smith Chart slotted line example.

Given:

Z_0 = 50 Ω, SWR = 3, first voltage min, d_{min} is 5 cm from load and distance between adjacent minima, $\frac{\lambda}{2}$ = 20 cm. Find load impedance Z_L



Solution:

Find d_{min} in wavelength format. $d_{min} = \frac{d_{min}\ value\ in\ cm}{\lambda\ value\ in\ cm} = \frac{5\ cm}{40\ cm} = 0.125\ \lambda$

If λ is given in 0.6m then it should be converted into cm, so λ= 60 cm

$$d_{min} = \frac{d_{min}\ value\ in\ cm}{\lambda\ value\ in\ cm} = \frac{14.2\ cm}{40\ cm} = 0.355\ \lambda$$

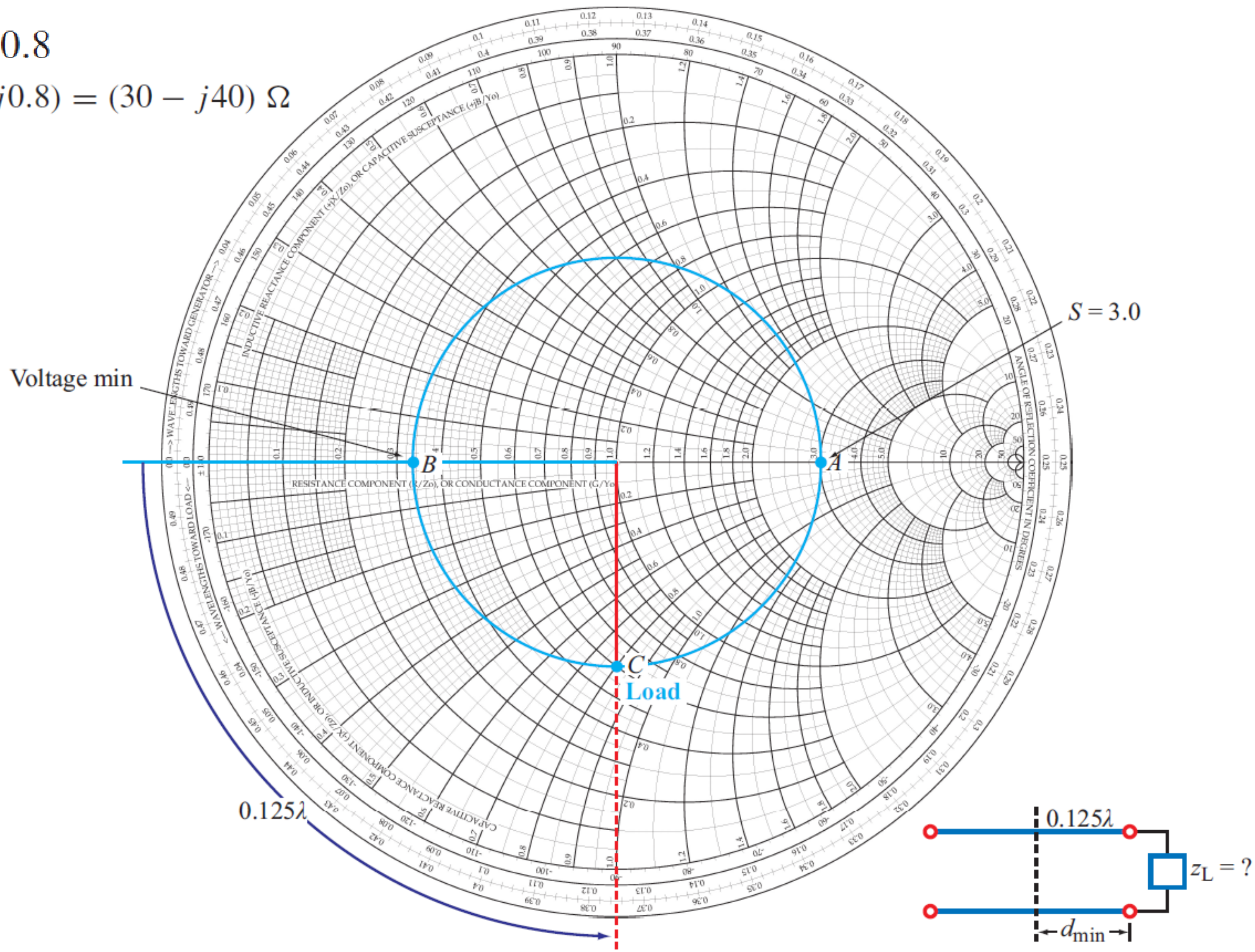
$$d_{min} = \frac{d_{min}\ value\ in\ cm}{\lambda\ value\ in\ cm} = \frac{12\ cm}{60\ cm} = 0.2\ \lambda$$

Smith Chart slotted line example.

$$d_{\min} = \frac{5}{40} = 0.125\lambda$$

$$z_L = 0.6 - j0.8$$

$$Z_L = 50(0.6 - j0.8) = (30 - j40)\ \Omega$$



Determination of Unknown Load Impedance from Standing Wave Data

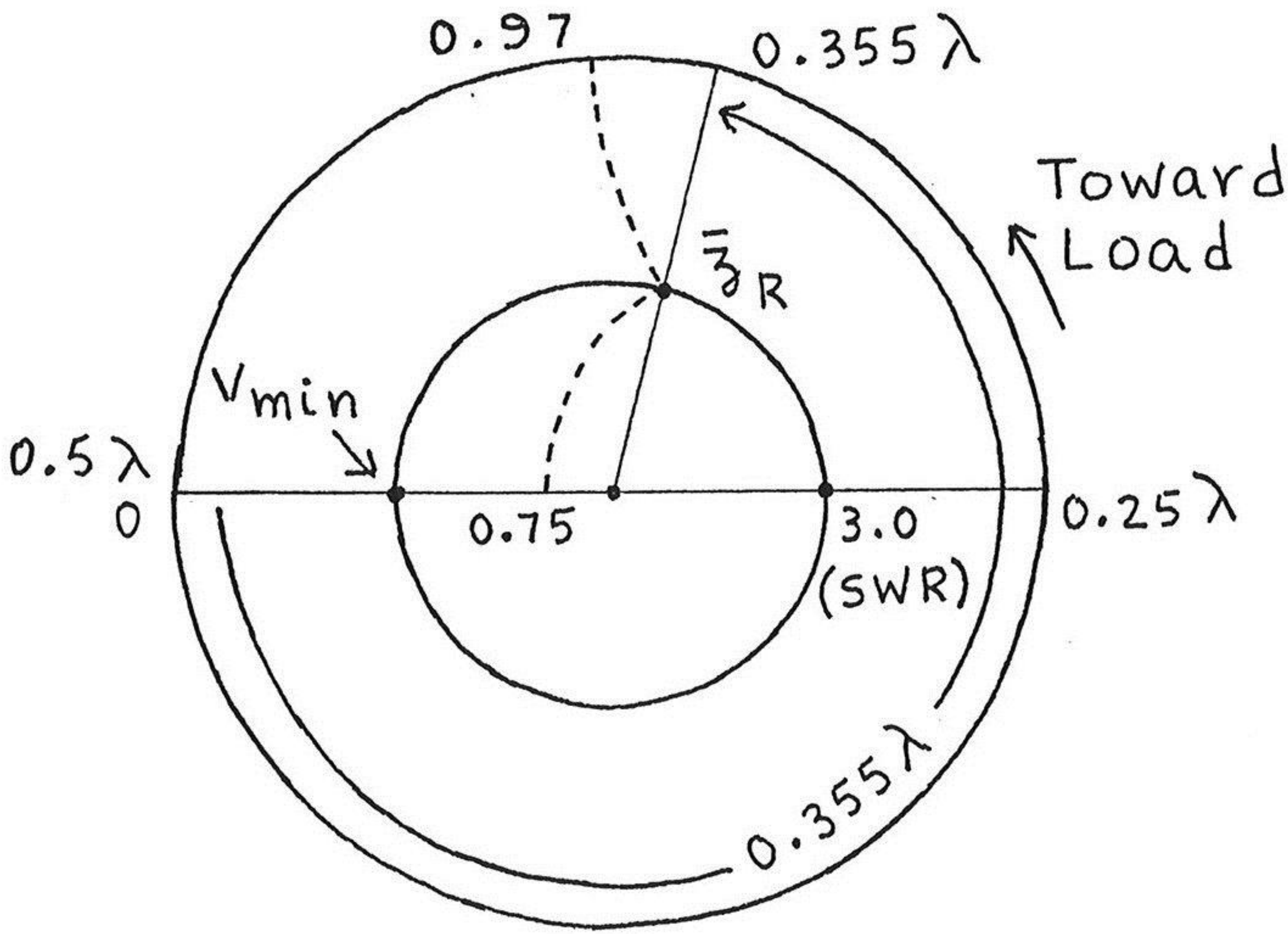
Given $Z_0 = 50\,\Omega$

$SWR = 3.0$

$\lambda/2 = 20$ cm

$d_{min} = 14.2$ cm $= 0.355\,\lambda$

Find $\bar{Z}_R$.



$$\bar{Z}_R = 50(0.75 + j0.97) = (37.5 + j48.5)\,\Omega$$