ECE 344

Microwave Fundamentals

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Example 1(2.2 in the book)

Z_0=100, z_L= 0.4+j0.7 (Zl=40+j70)

l=.3λ

Find Γ_L ,Γ(-*l*), Zin, SWR, Return loss

From smith chart

We can find:

From reflection coefficient E scale

| Γ_L |=.59.θ=104°

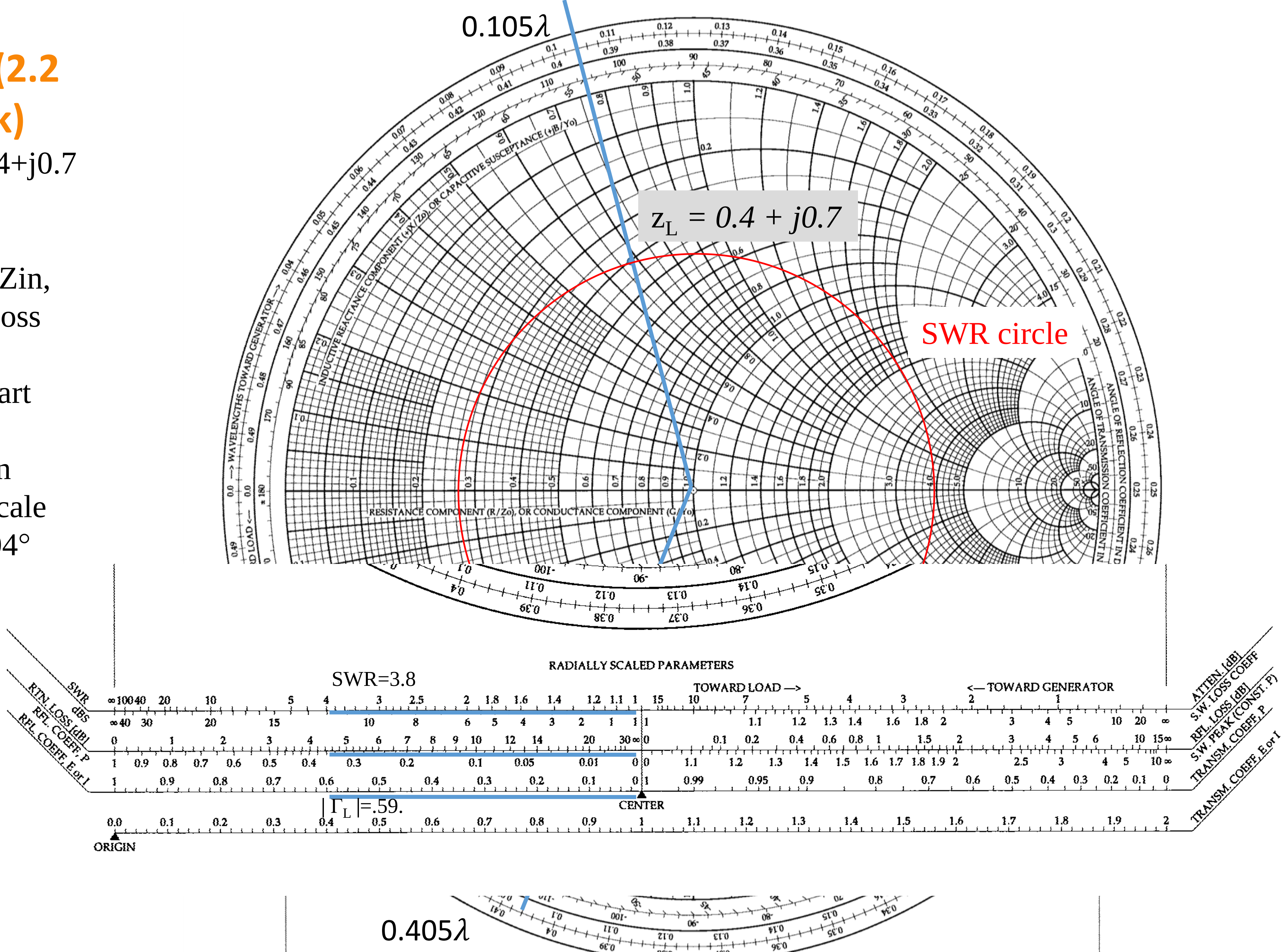
From SWR s

SWR=3.8

From return l

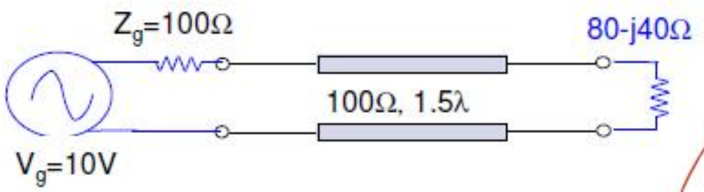
Scale, return loss=4.6dB

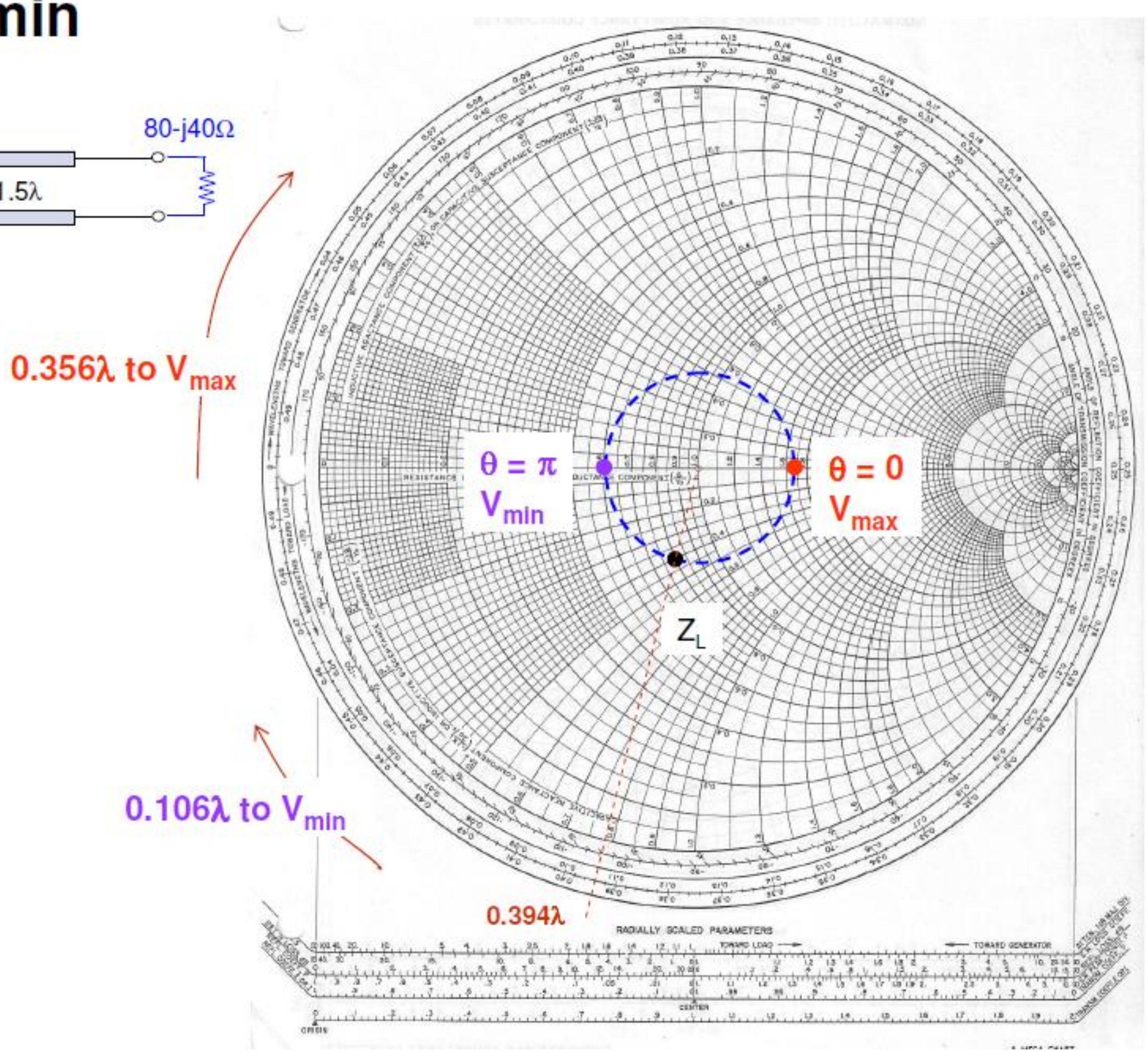
,Γ(-*l*)=.59∠−



V_{max} & V_{min}

Example 2

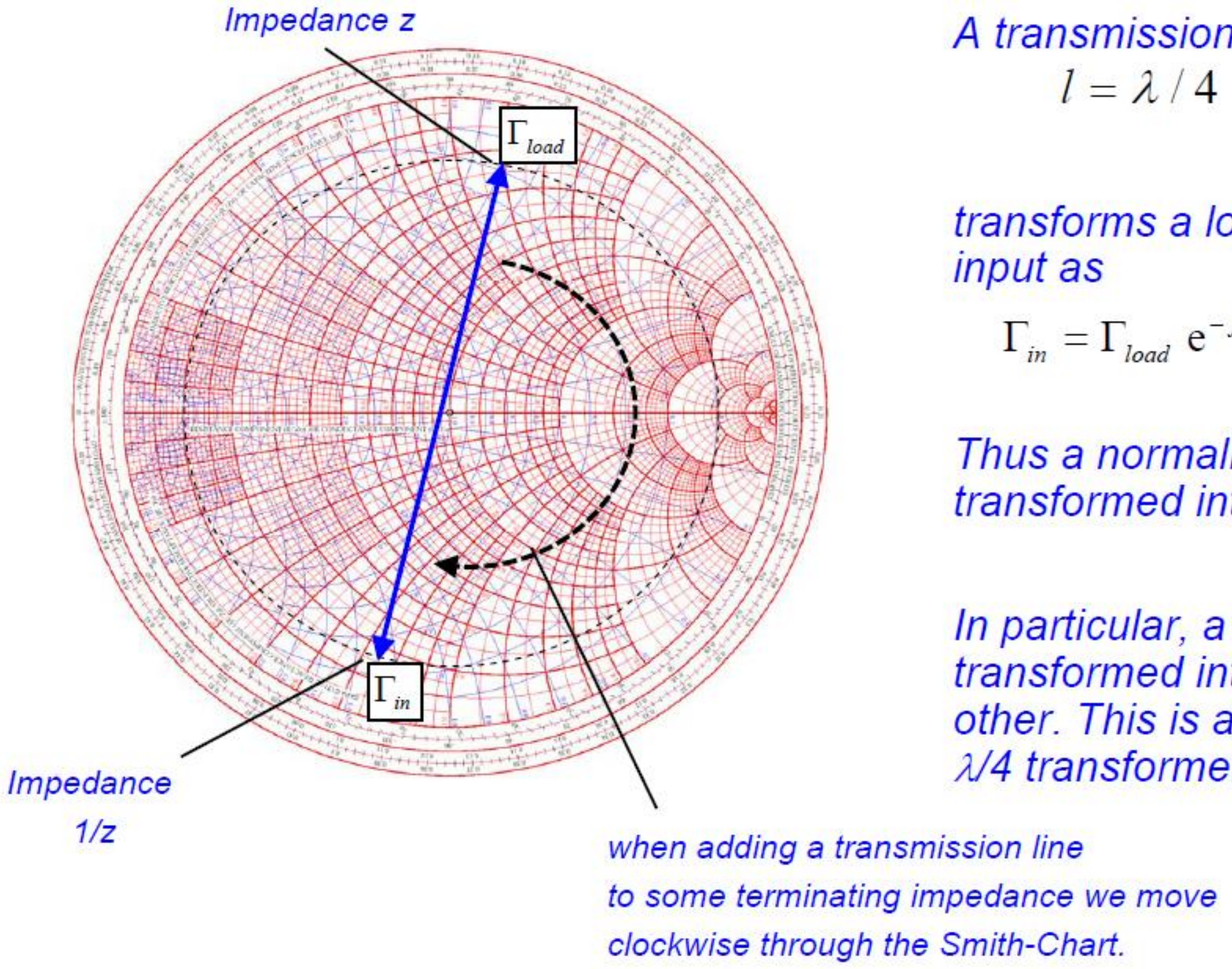




Effect of moving TWG λ/4

$$z_{in}(l=\lambda/4)=\frac{1}{z_L}=y_L \qquad \text{where } z_{in}=\frac{Z_{in}}{z_0},\quad z_L=\frac{Z_L}{z_0},\quad y_L=\frac{Y_L}{y_0}$$

the length $\lambda/4 \rightarrow$ moving π on smith chart $\rightarrow$ gives us admittance of the load



A transmission line of length

$$l=\lambda/4$$

transforms a load reflection Γ_{load} to its input as

$$\Gamma_{in}=\Gamma_{load}\,e^{-j2\beta l}=\Gamma_{load}\,e^{-j\pi}=\underline{-\Gamma_{load}}$$

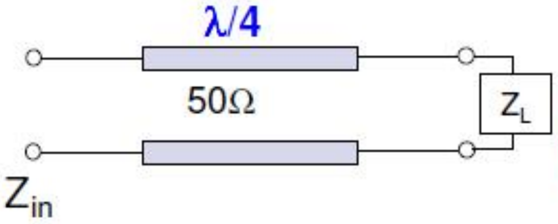
Thus a normalized load impedance z is transformed into 1/z.

In particular, a short circuit at one end is transformed into an open circuit at the other. This is a particular property of the λ/4 transformers.

Effect of moving TWG λ/4

Example3

e.g. $Z_L = 50 + j\,25\ \Omega$



$Z_{in} = 50(0.8 - j\,0.4)\ \Omega$

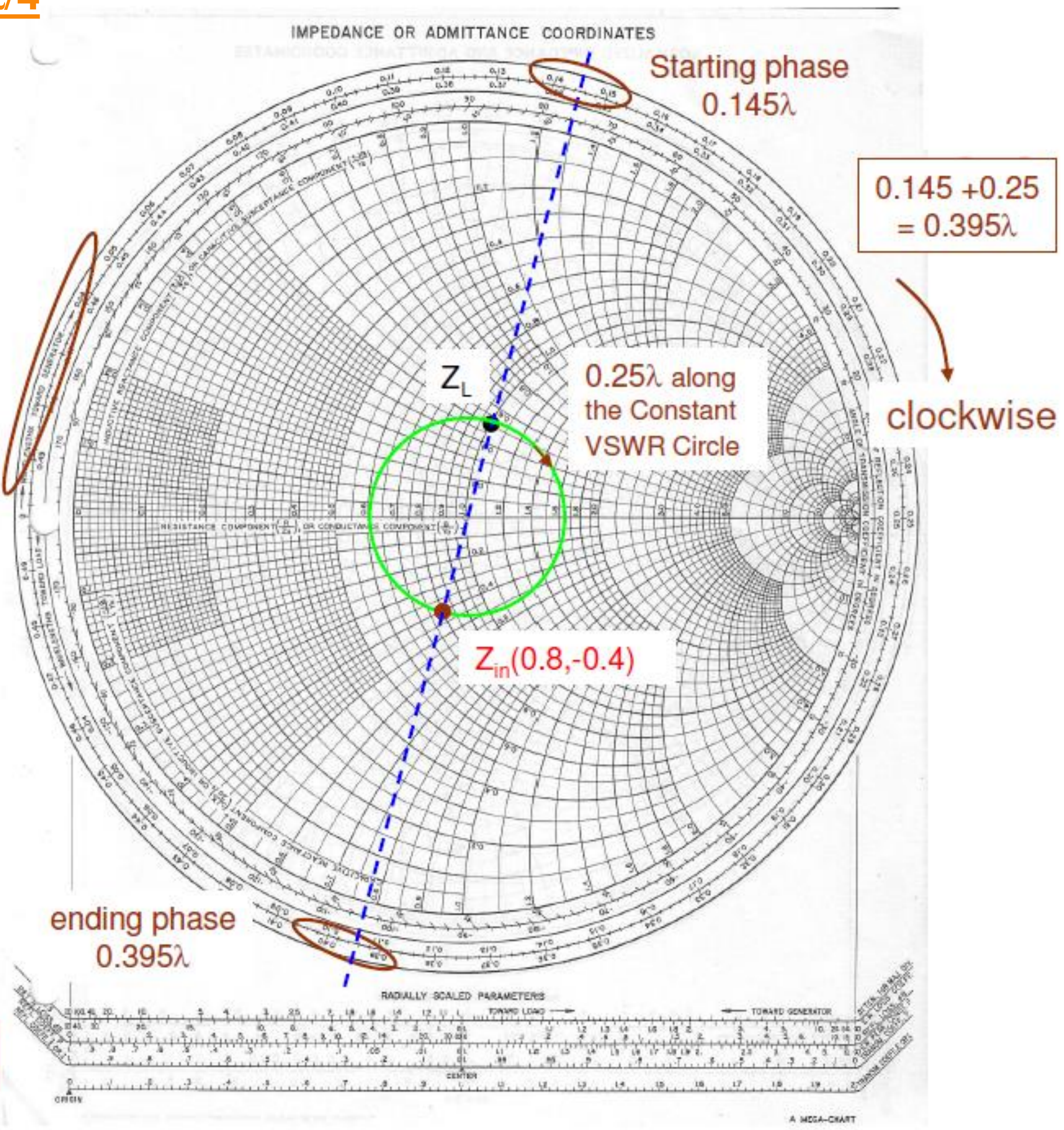
$$Z_o = \sqrt{Z_{in} Z_L}$$

$$1 = \sqrt{\overline{Z}_{in}\overline{Z}_L}$$

$$\overline{Z}_{in} = \frac{1}{\overline{Z}_L} = \overline{Y}_L$$

$Y_L = 0.02(0.8 - j\,0.4)\ \Omega^{-1}$

Convert Z ↔ Y easily !!



Admittance (Y) Calculations

Note:

$$Y(-\ell) = \frac{1}{Z(-\ell)} = \frac{1}{Z_0}\left(\frac{1-\Gamma(-\ell)}{1+\Gamma(-\ell)}\right)$$

$$= Y_0\left(\frac{1+(-\Gamma(-\ell))}{1-(-\Gamma(-\ell))}\right) \qquad Y_0 = \frac{1}{Z_0}$$

$$\Rightarrow Y_n(-\ell) = \frac{Y(-\ell)}{Y_0} = \left(\frac{1+(-\Gamma(-\ell))}{1-(-\Gamma(-\ell))}\right) = G_n(-\ell) + jB_n(-\ell)$$

Define: $\Gamma' = -\Gamma$

$$Y_n(-\ell) = \left(\frac{1+\Gamma'}{1-\Gamma'}\right)$$

Conclusion: The same Smith chart can be used as an admittance calculator.

Same mathematical form as for Z_n:

$$Z_n(-\ell) = \left(\frac{1+\Gamma}{1-\Gamma}\right)$$

Admittance (Y) Chart

As an alternative, we can continue to use the original Γ plane, and add admittance curves to the chart.

$$Y_n(-\ell) = \left(\frac{1 + (-\Gamma(-\ell))}{1 - (-\Gamma(-\ell))} \right) = G_n(-\ell) + jB_n(-\ell)$$

Compare with previous Smith chart derivation, which started with this equation:

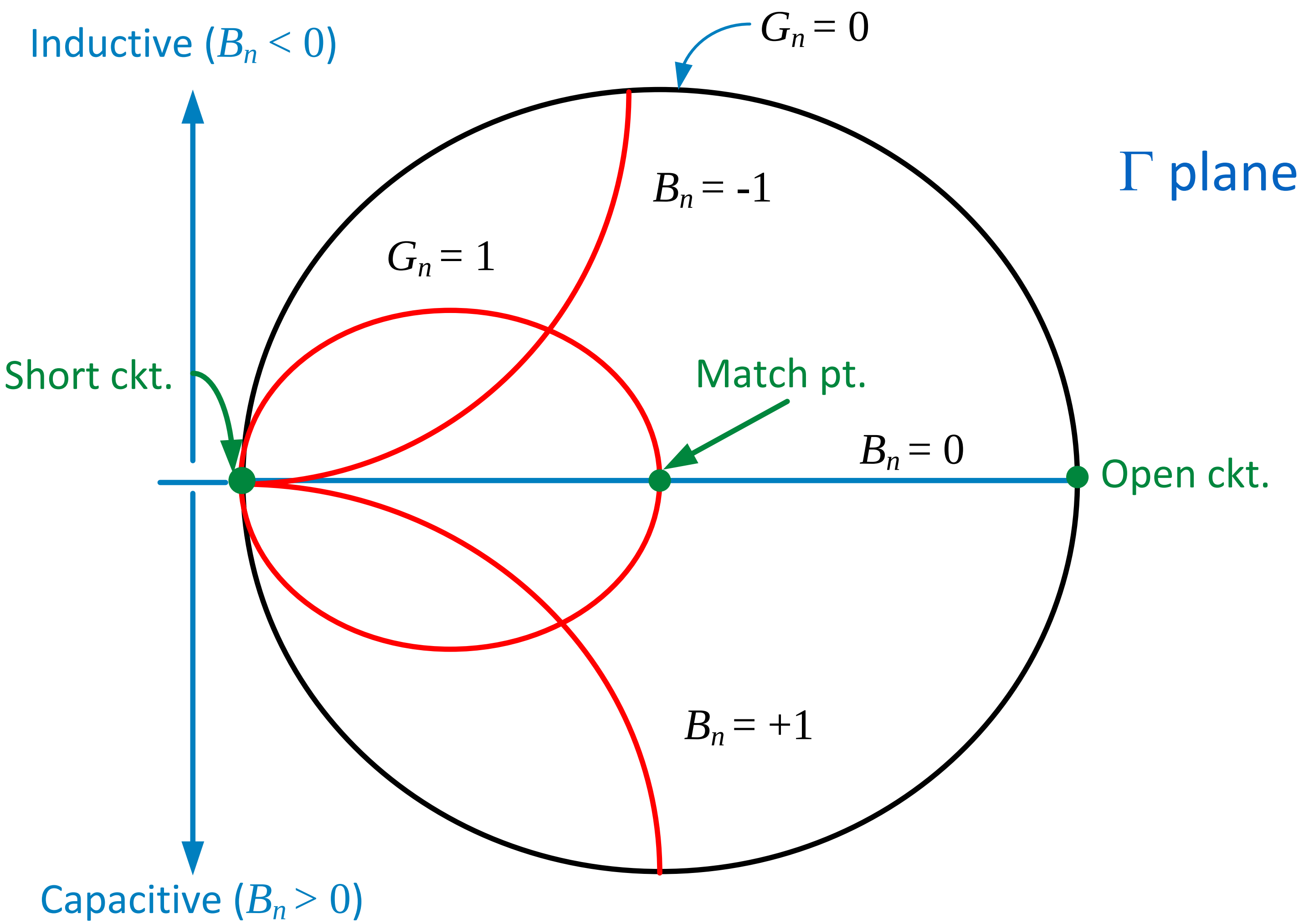
$$Z_n(-\ell) = \left(\frac{1 + (\Gamma(-\ell))}{1 - (\Gamma(-\ell))} \right) = R_n(-\ell) + jX_n(-\ell)$$

If $(R_n\ X_n) = (a, b)$ is some point on the Smith chart corresponding to $\Gamma = \Gamma_0$,
Then $(G_n\ B_n) = (a, b)$ corresponds to a point located at $\Gamma = -\Gamma_0$ (180° rotation).

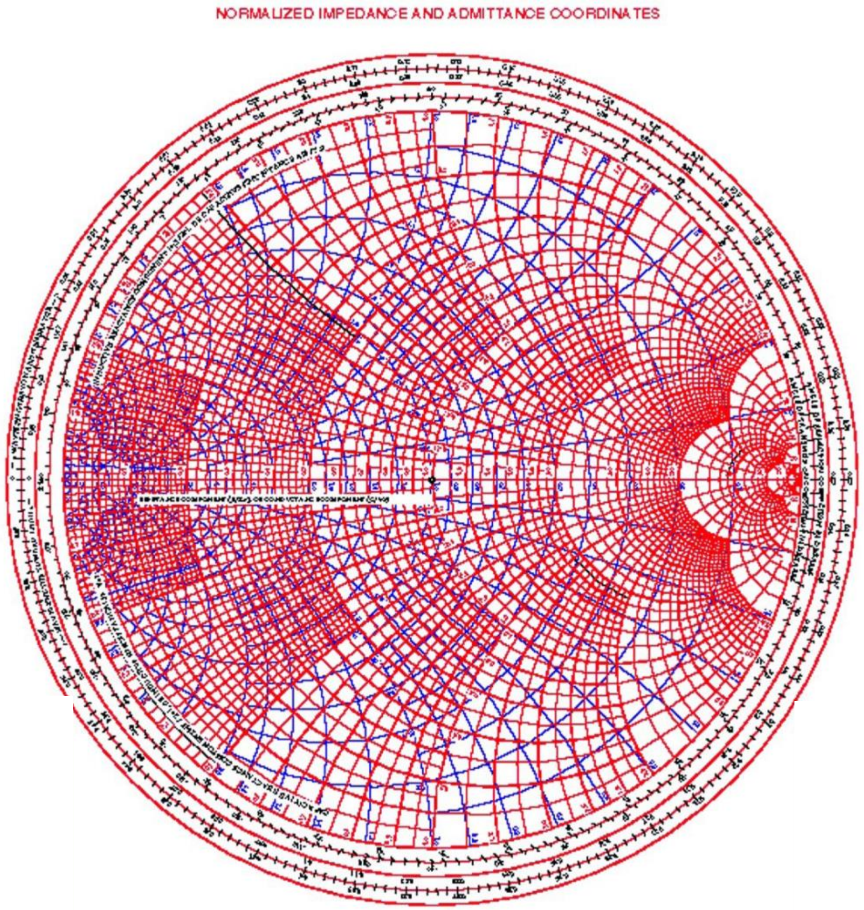
$\Rightarrow$ $R_n = a$ circle, rotated 180°, becomes $G_n = a$ circle.
and $X_n = b$ circle, rotated 180°, becomes $B_n = b$ circle.

Side note: A 180° rotation on a Smith chart makes a normalized impedance become its reciprocal.

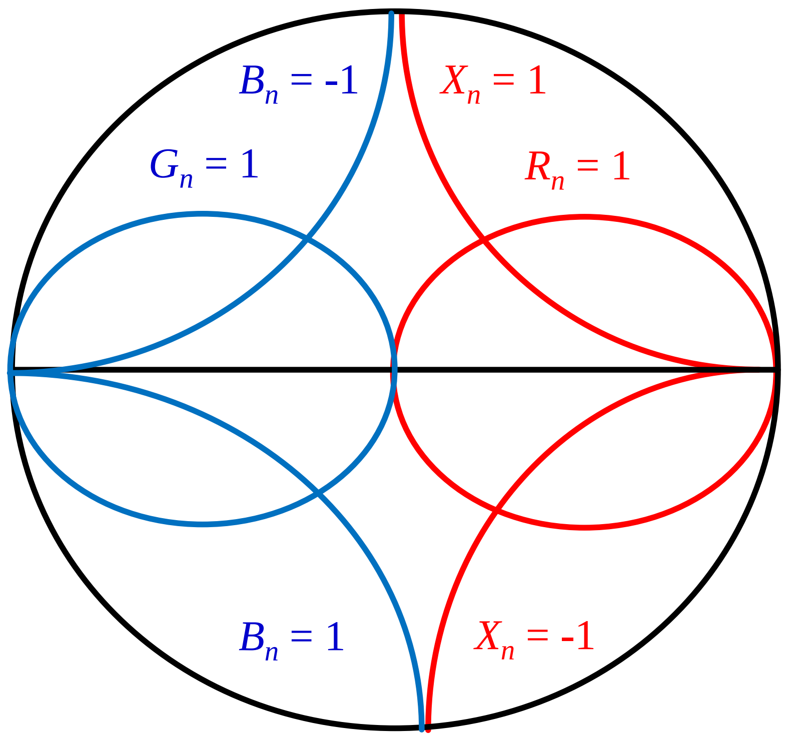
Admittance (Y) Chart (cont.)



Impedance and Admittance (ZY) Chart



Short-hand version



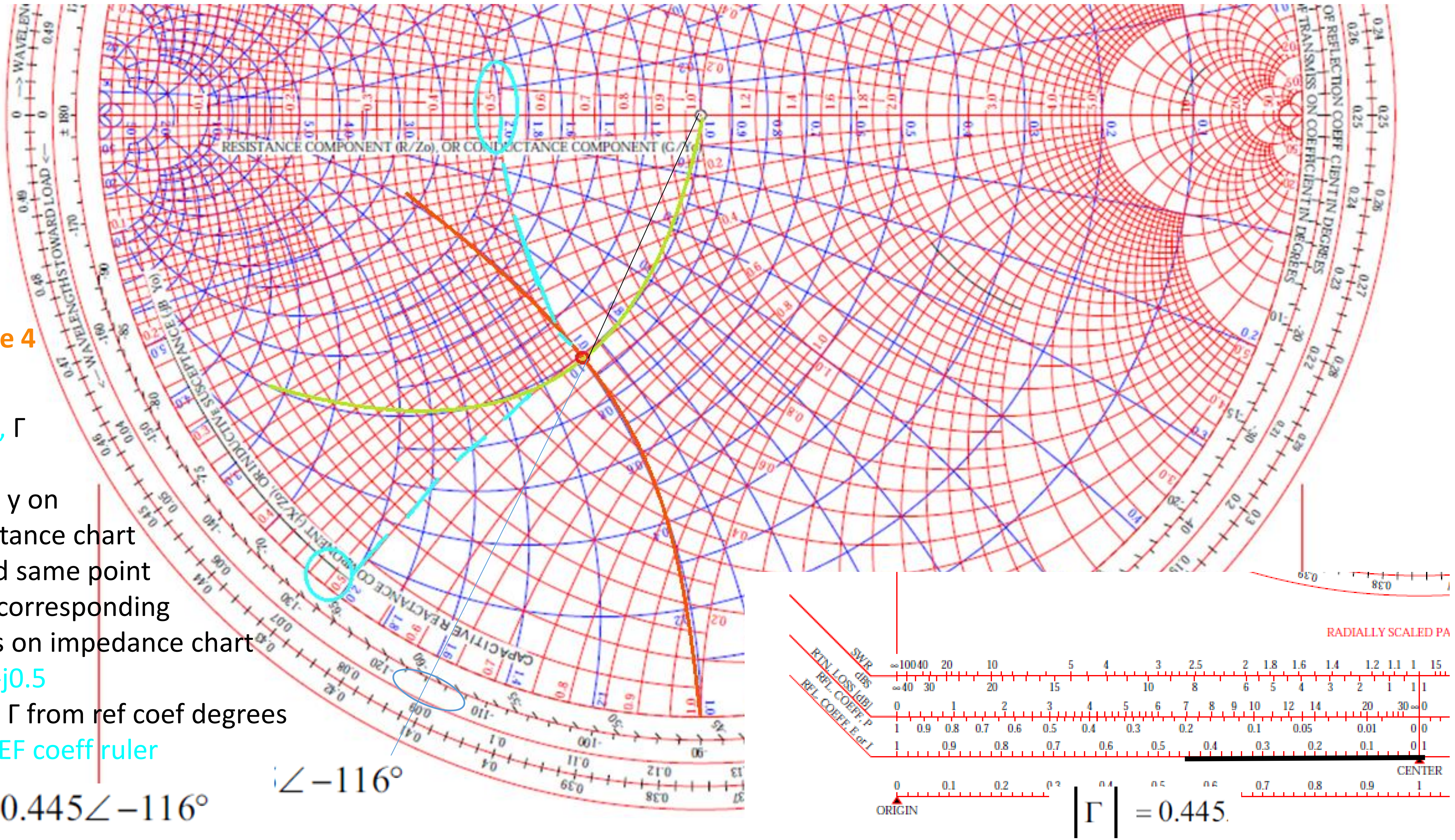
Γ plane

Example 4

Y=1+j

Find Z, Γ

1. Find y on Admittance chart
2. Read same point From corresponding Circles on impedance chart
   Z=0.5-j0.5
3. Find Γ from ref coef degrees And REF coeff ruler



$$\Gamma = 0.445\angle -116°$$

Using impedance-Admittance Smith Chart

Example 5

Given:

$\Gamma = 0.5\angle +45^\circ \quad Z_0 = 50\Omega$

Find Y

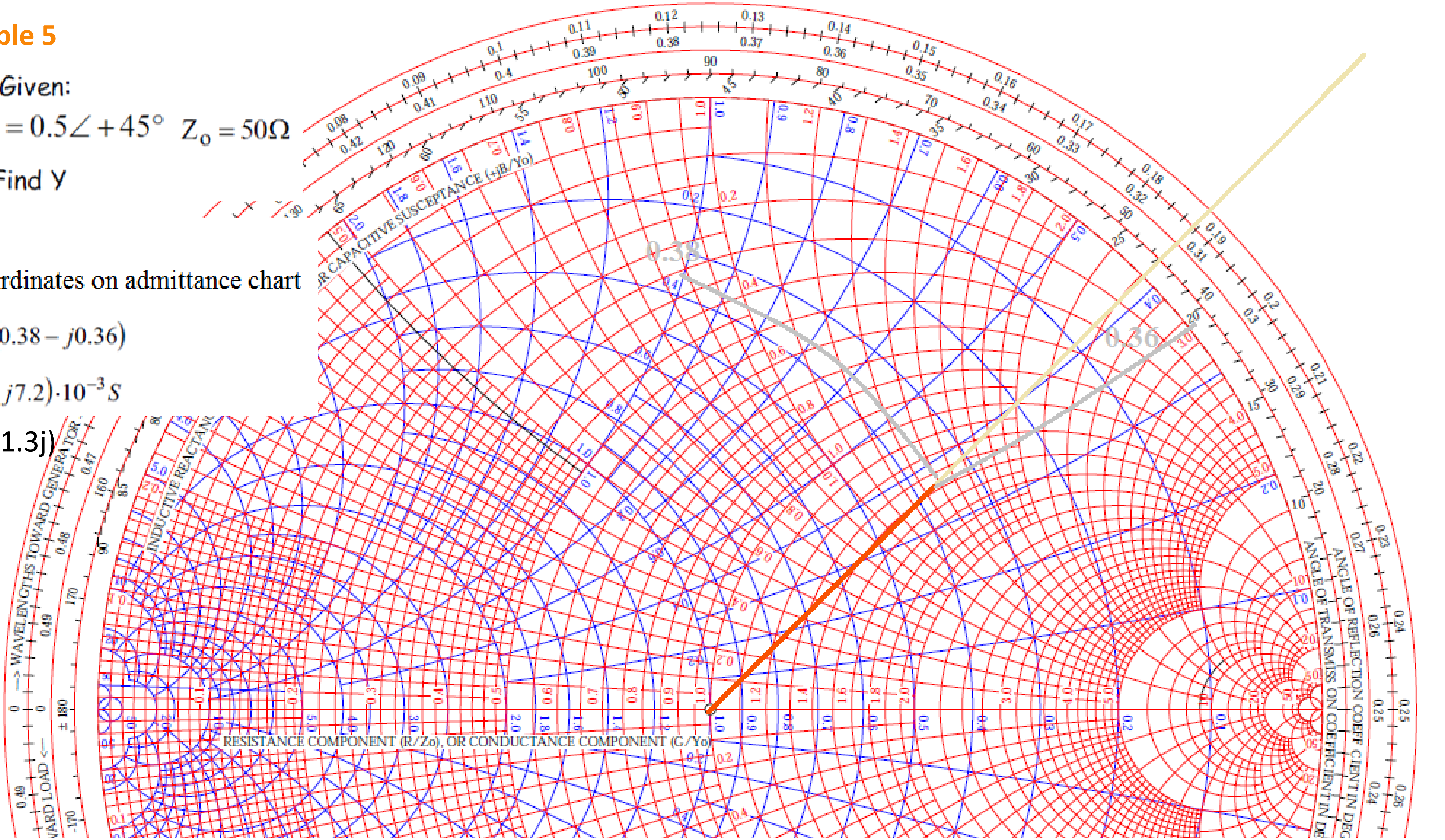
. Plot Γ

. Read coordinates on admittance chart

$$Y = \frac{1}{50\Omega}(0.38 - j0.36)$$

$$= (7.6 - j7.2)\cdot 10^{-3} S$$

Z=50*(1.38+1.3j)

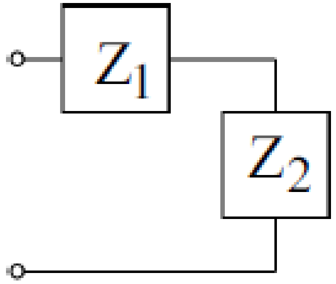


Adding Elements

Admittance

A matching network is going to be a combination of elements connected in series AND parallel.

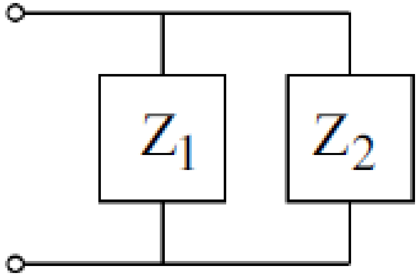
Impedance is well suited when working with series configurations. For example:



$V = ZI$

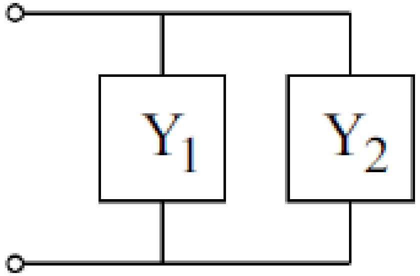
$$Z_L = Z_1 + Z_2$$

Impedance is NOT well suited when working with parallel configurations.



$$Z_L = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

For parallel loads it is better to work with admittance.



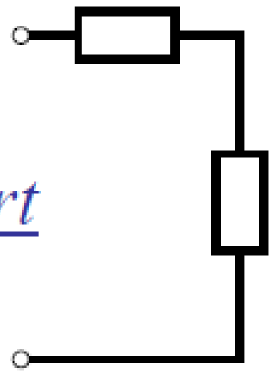
$I = YV$

$$Y_1 = \frac{1}{Z_1} \qquad Y_L = Y_1 + Y_2$$

General Rules

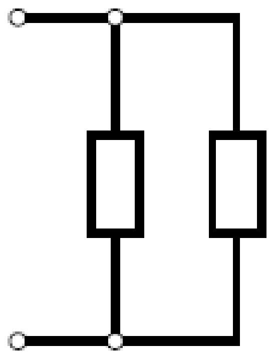
Adding Series Components

→ *Impedance Smith Chart*

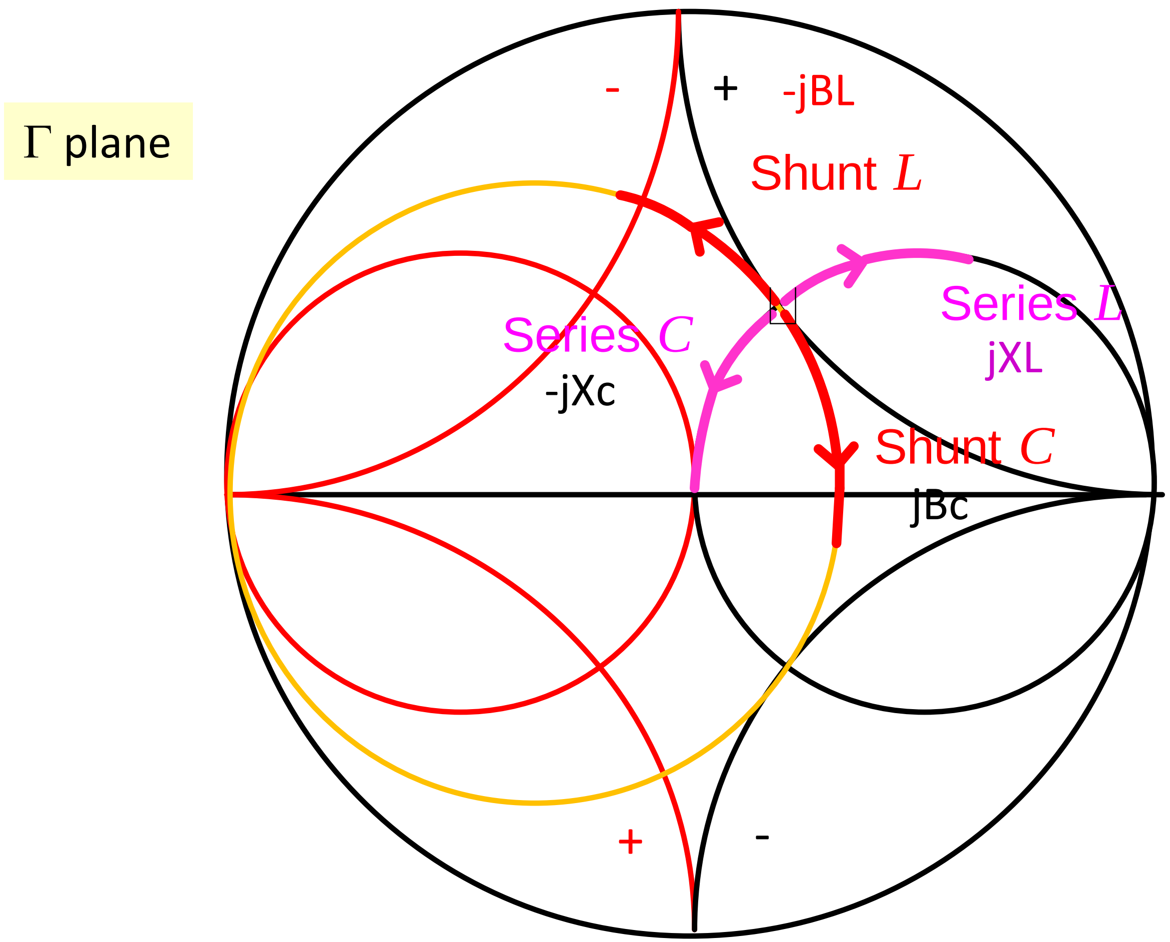


Adding Parallel (Shunt) Components

→ *Admittance Smith Chart*

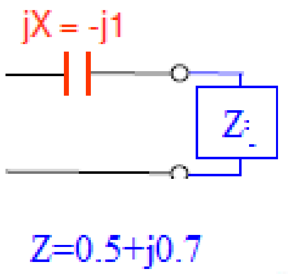


Series and Shunt Elements



Note: The Smith chart is not actually being used as a transmission-line calculator but an impedance/admittance calculator. Hence, the normalizing impedance is arbitrary.

Adding a Series Capacitor

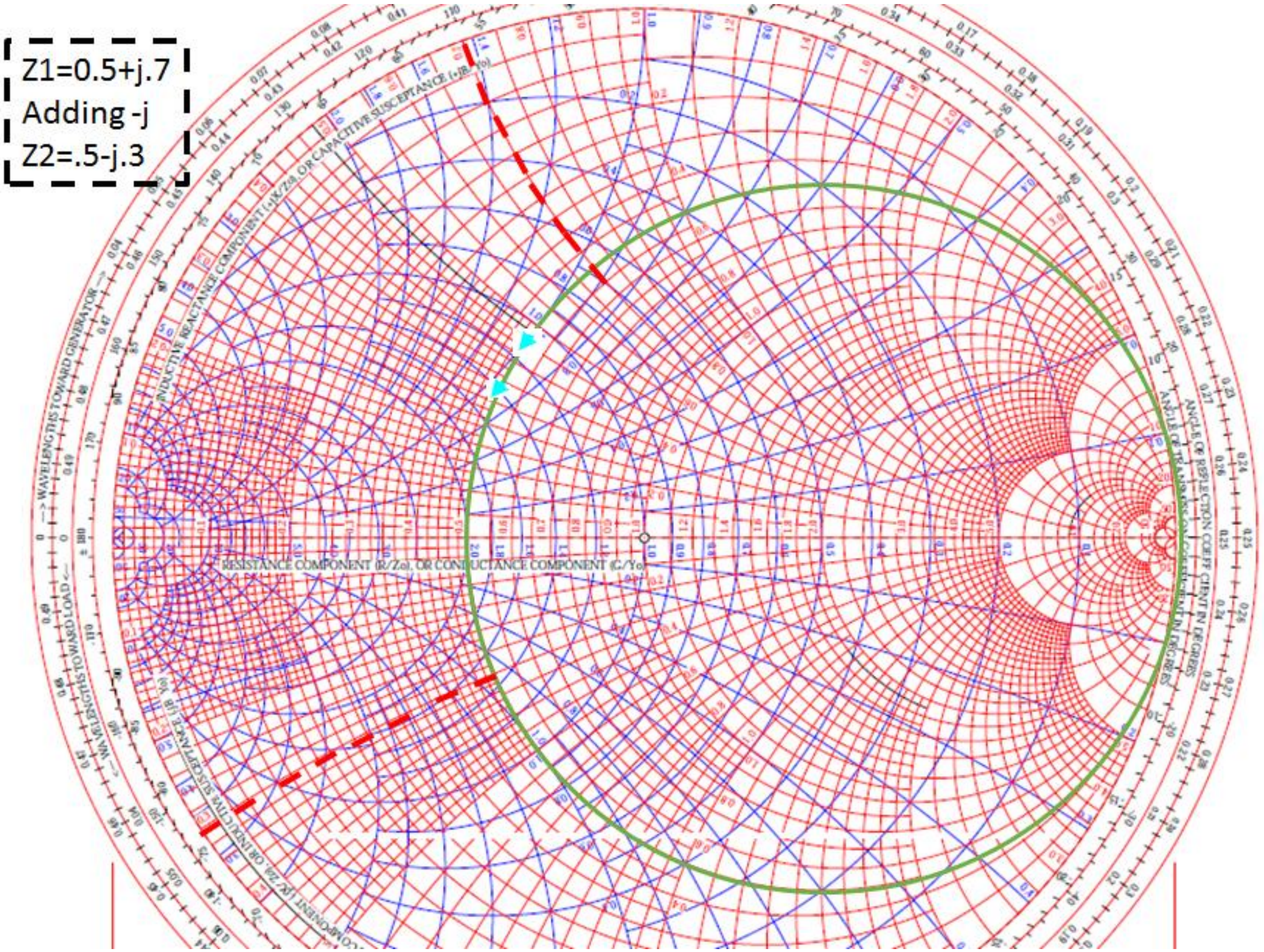


If we have initial impedance
Z=0.5+j0.7
We add a series capacitor

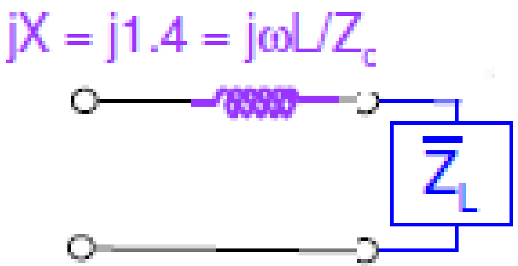
Since resistance does snot change
We move on constant circle from
j0.7 to -j0.3

Z=0.5-j0.3

Values on ADS for f=1GHz
Z=25+j35
Zin=25-j15
1/wc=Zin-Z=50
so C=1/(50*2pi)=3.18pF

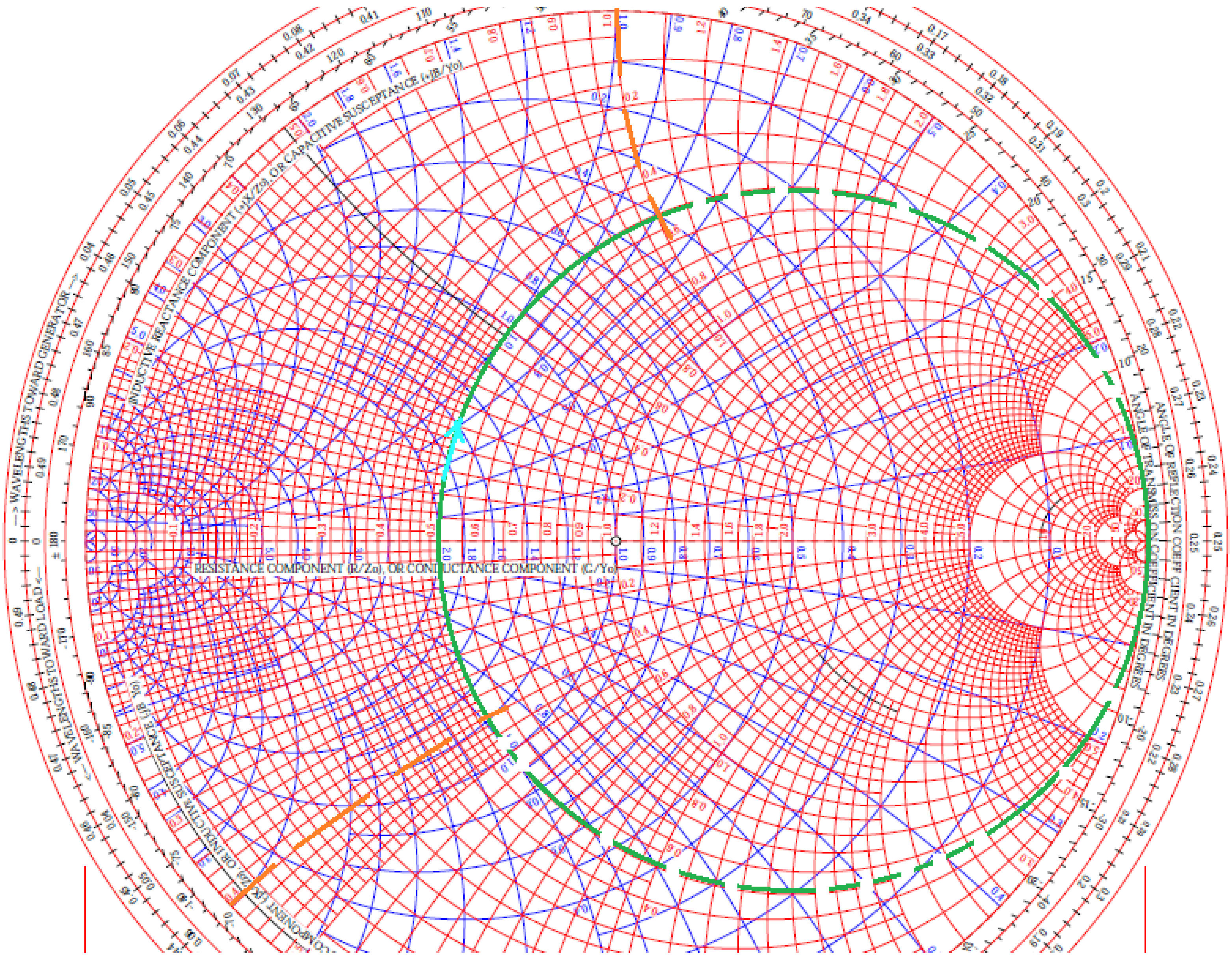


Adding a Series Inductor



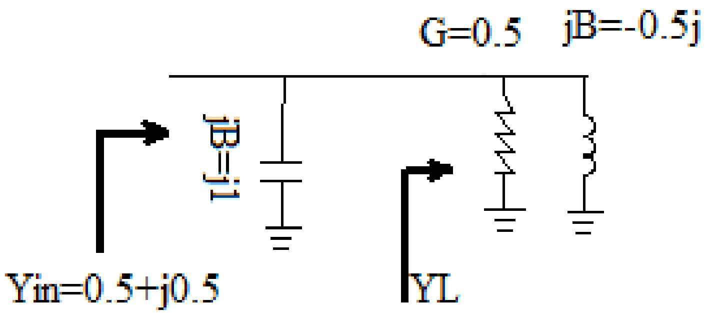
If we have Z=0.5-j0.4
We add series inductor
jX=j1.4

We move on resistance circle
Zin=0.5+j1.0



Values on ADS
Z=25-j20
Zin=25+j50
jwL=j70 so L=70/(2pi)=11.14nH

Adding a Shunt Capacitor



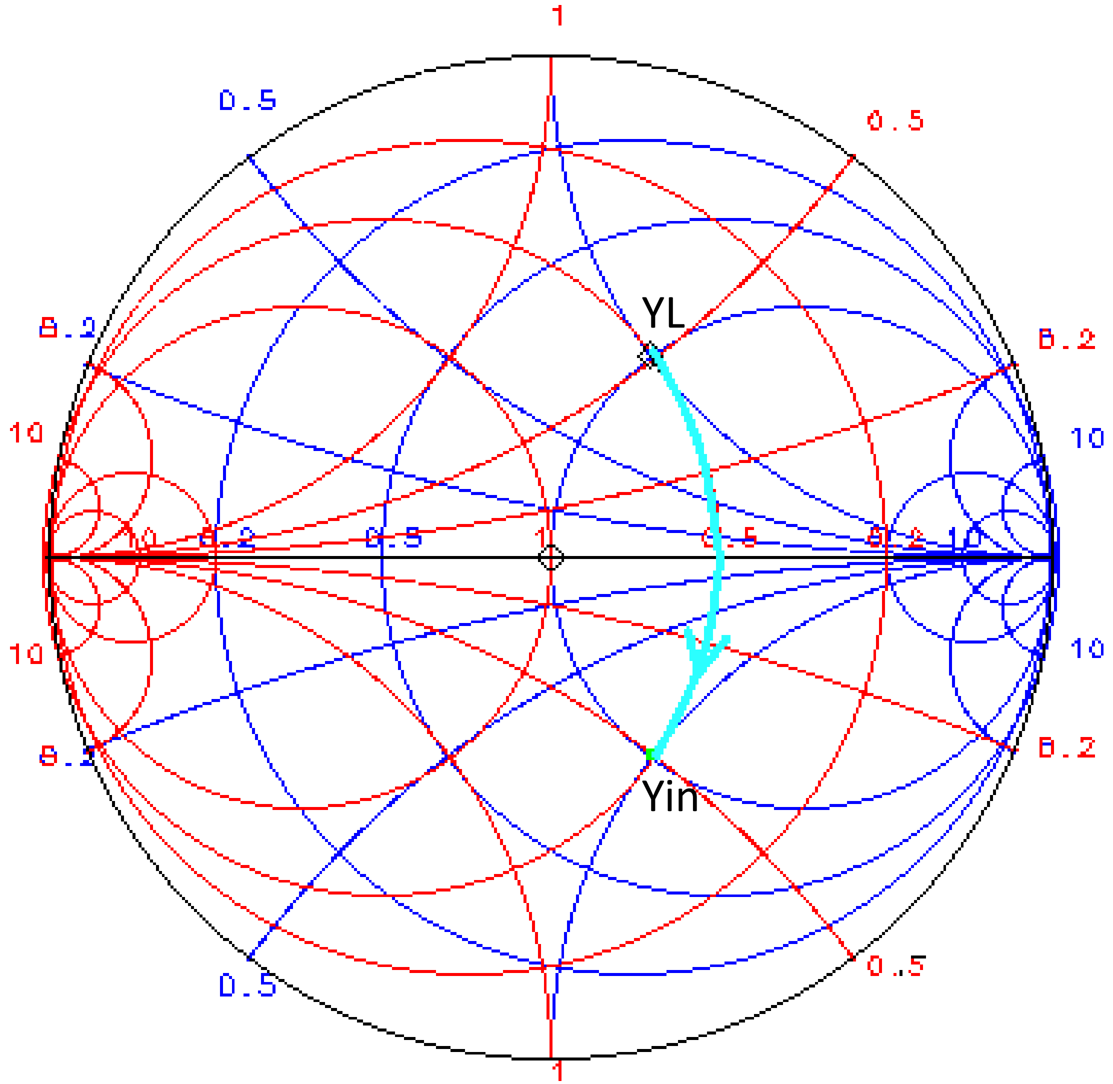
For ZL=1+j1.0
On admittance chart
YL=0.5-j0.5

Adding shunt capacitor
With JB=j1

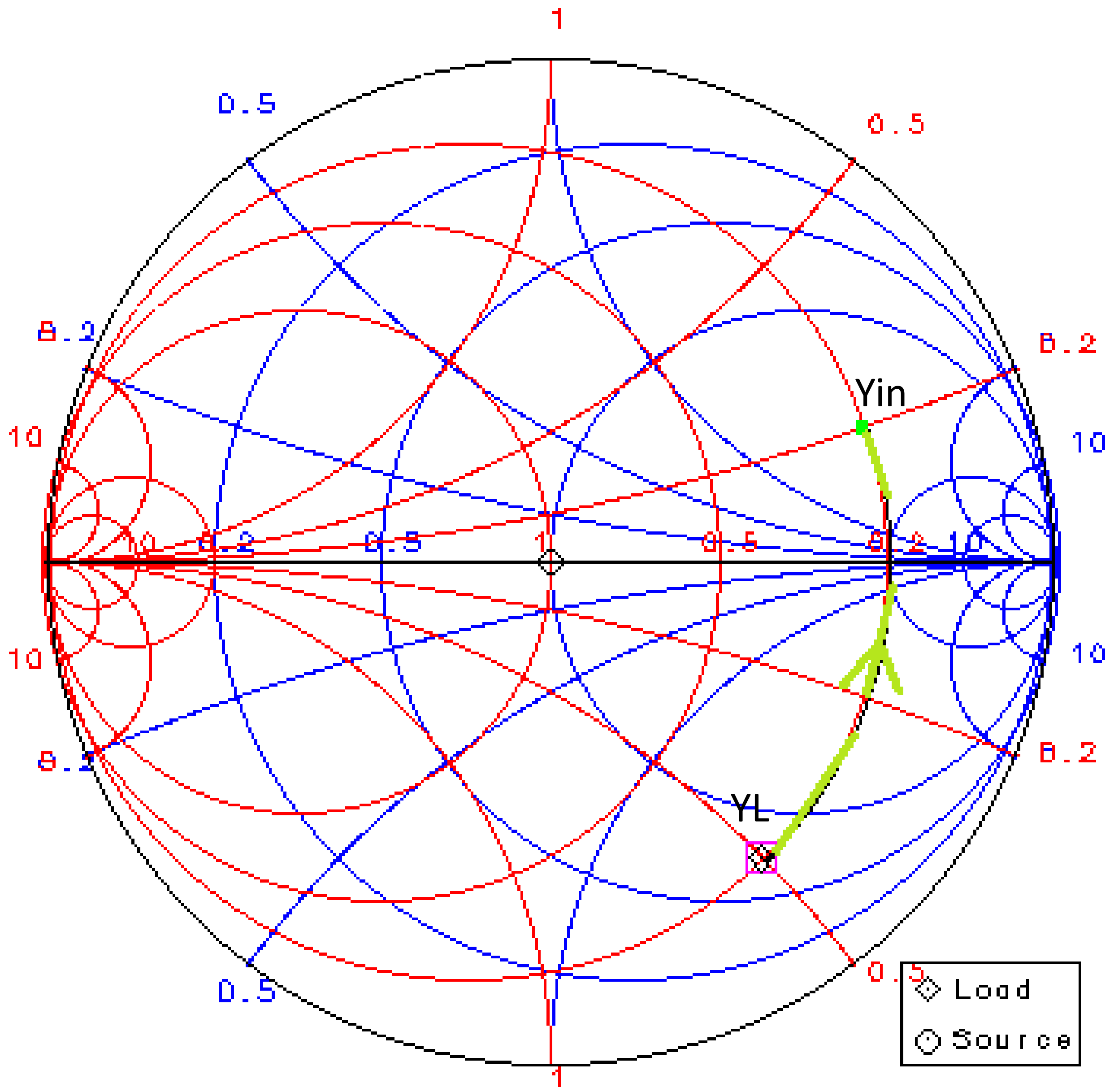
Yin=0.5+j0.5

Read from impedance chart

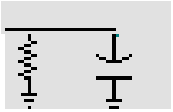
Zin=1-j1.0



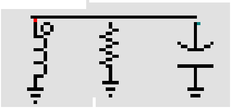
Adding Shunt Inductor



YL=0.2+j0.5



adding shunt inductor
with JB= - j0.7

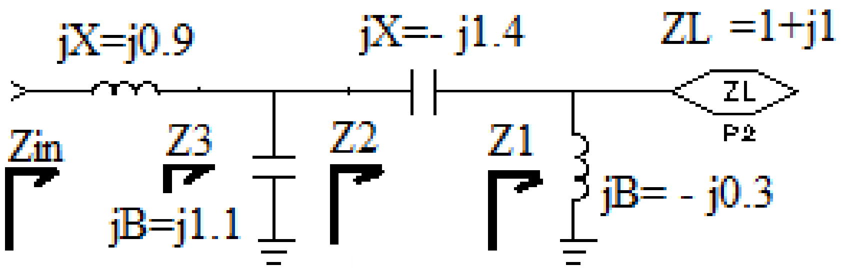


Yin=0.2-j0.2

Read from impedance chart
Zin=2.4+j2.5

Example 6

what is the input impedance of network shown in Fig below



Solution :use impedance admittance smith chart

ZL			
Z:	1.00000	+j	1.00000
Y:	0.50000	+j	-0.50000
Z1,Y1			
Z:	0.55699	+j	0.89652
Y:	0.50000	+j	-0.80479
Z2,Y2			
Z:	0.55699	+j	-0.48811
Y:	1.01549	+j	0.88992
Z3,Y3			
Z:	0.20511	+j	-0.39989
Y:	1.01549	+j	1.97981
Zin,Yin			
Z:	0.20485	+j	0.49905
Y:	0.70391	+j	-1.71486