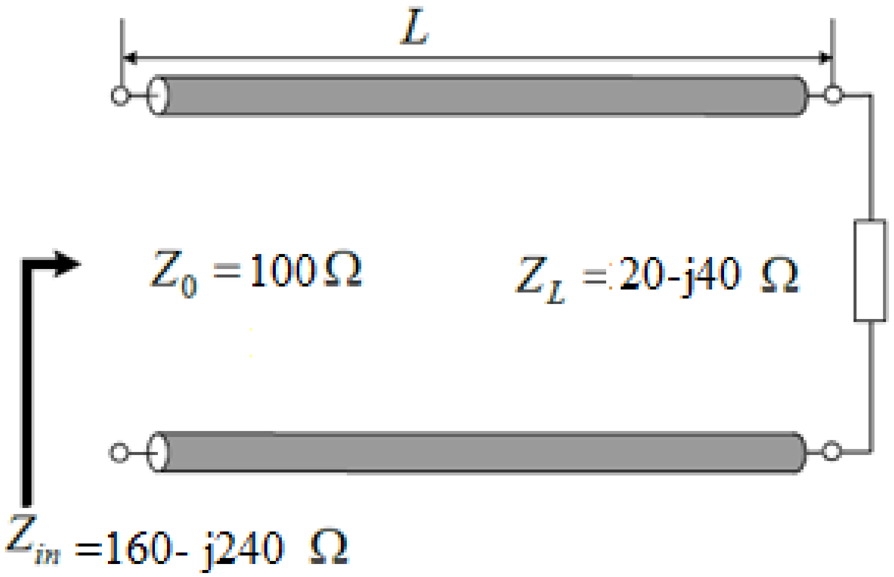
ECE 344

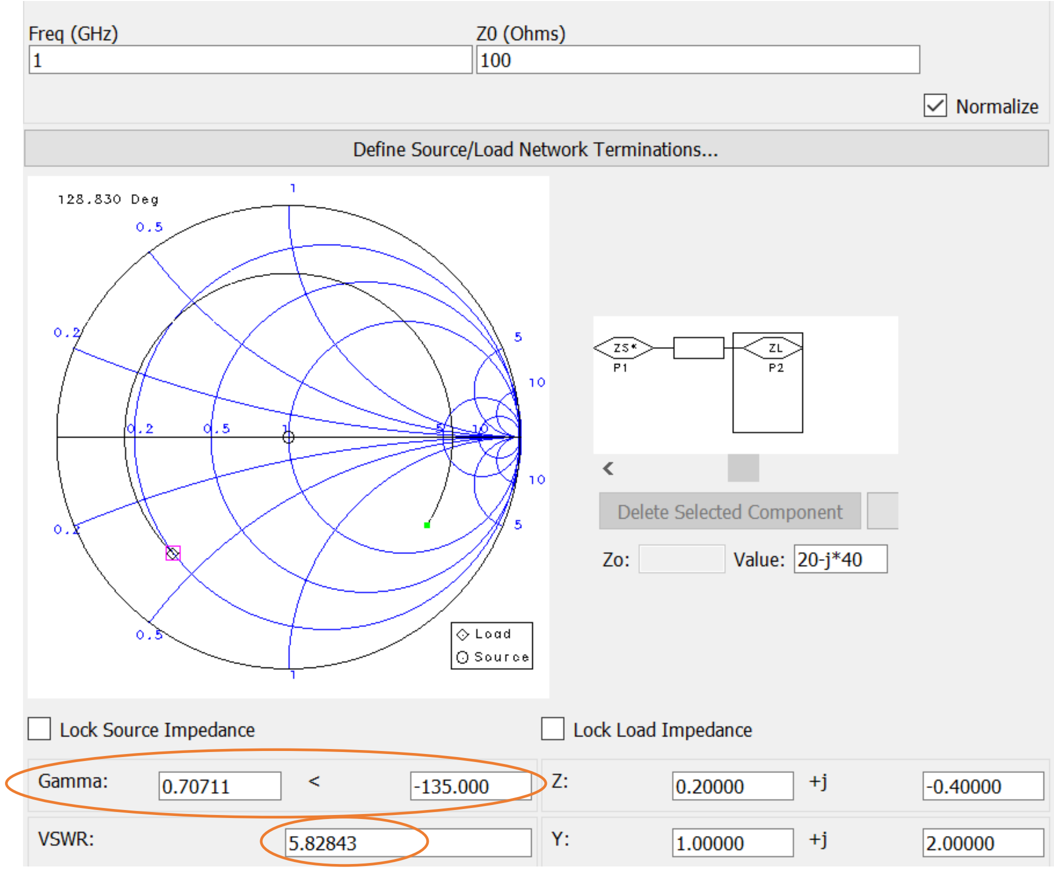
MICROWAVE FUNDAMENTALS
PART1-Lecture 8

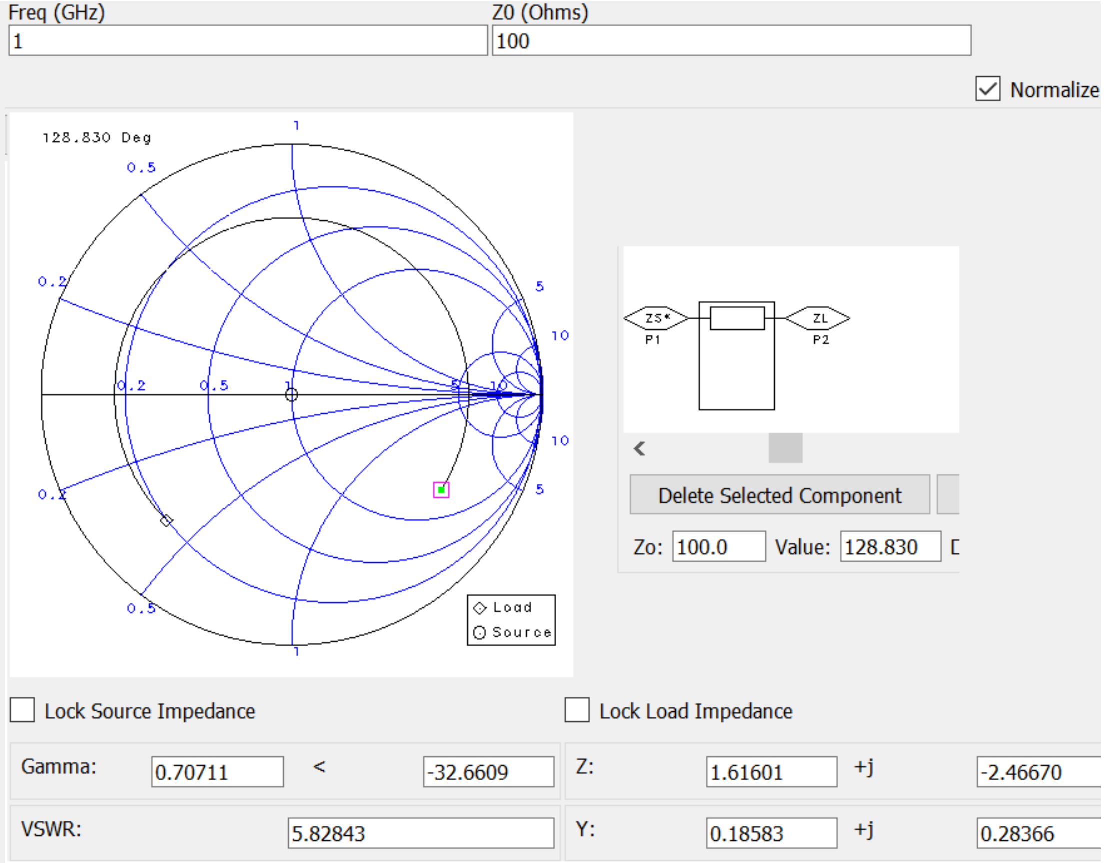
Dr. Gehan Sami

Try to solve:



i. The SWR on the line.
ii. The reflection coefficient at the load, and at the input of the line
iii. The distance from load to the input impedance of the line.
iv. The distance from the load to the first voltage minimum.
v. The distance from the load to the first voltage maximum





At the load:

Swr=5.8

$\Gamma load=0.7\angle -135^{o}$

At the input impedance:

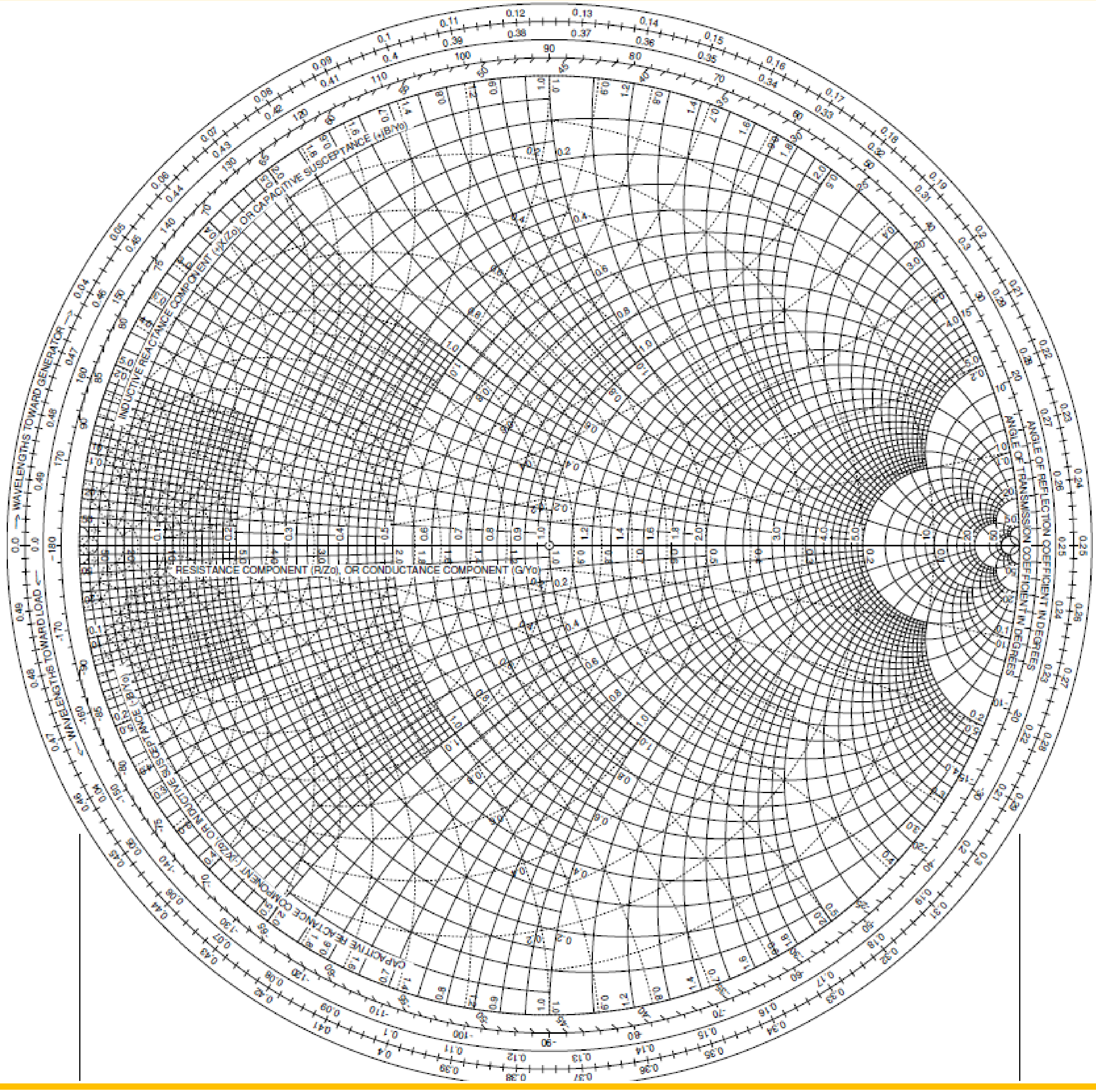
$\Gamma input=0.7\angle -32^{o}$

$\beta l=129^{o}$

L= λ *129/360=0.36λ on smith __>(.5-.438+0.296=.36 λ)

Lmin=(0.5-.438) λ =0.062 λ __>$\beta l=22^{o}$

Lmax= 0.312 λ __> $\beta l=112^{o}$


WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES

$\ell = (0.5 - 0.438)\lambda + 0.296\lambda$

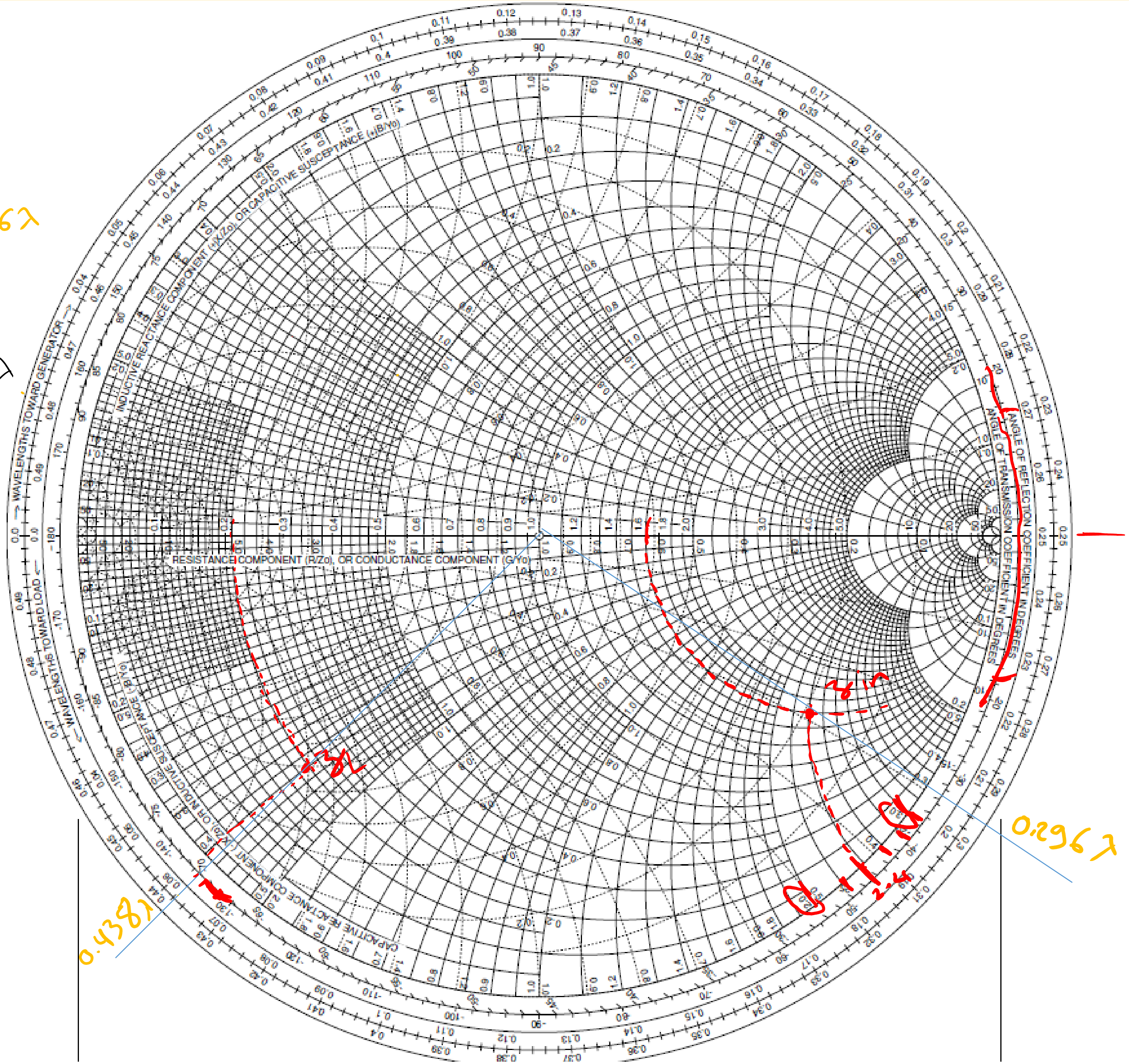
$= 0.358\lambda$

$\ell_{min} = (0.5 - 0.438)\lambda$

$= 0.062\lambda$

$\ell_{max} = \ell_{min} + \lambda/4$

$= 0.312\lambda$



$\Gamma_L = 0.7\angle{-135}$

$\Gamma_{in} = 0.7\angle{-33}$

3ℓ → Get $|\Gamma| = 0.7$

SWR = 5.8

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.

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

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

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

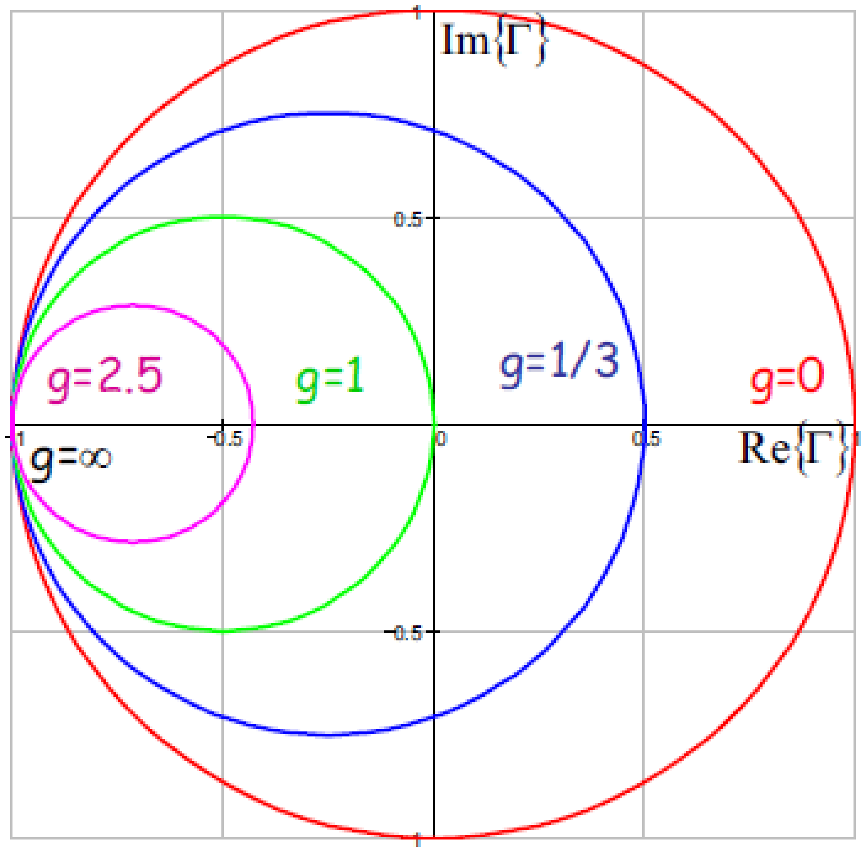
If $(R_n\ X_n) = (a, b)$ is some point on the Smith chart corresponding to $\Gamma = \Gamma_0$,
Then $(G_n\ B_n) = (a, b)$ corresponds to a point located at $\Gamma = -\Gamma_0$ (180° rotation).

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

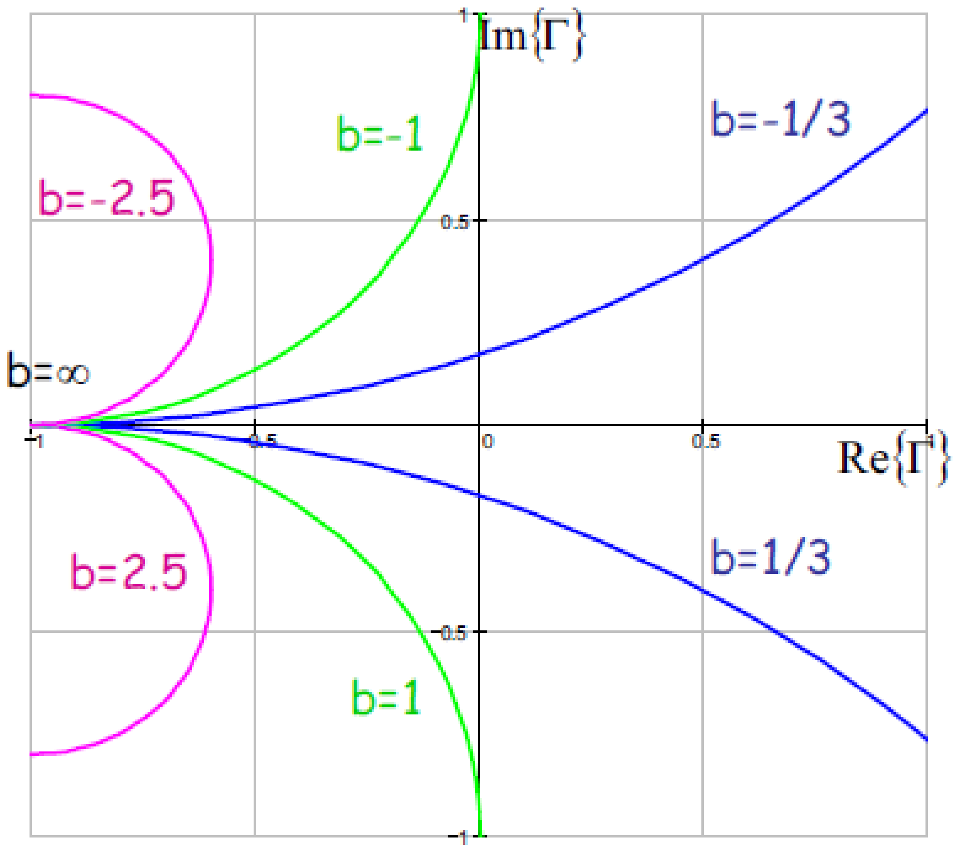
Side note: A 180° rotation on a Smith chart makes a normalized impedance become its reciprocal.

Admittance Smith Chart

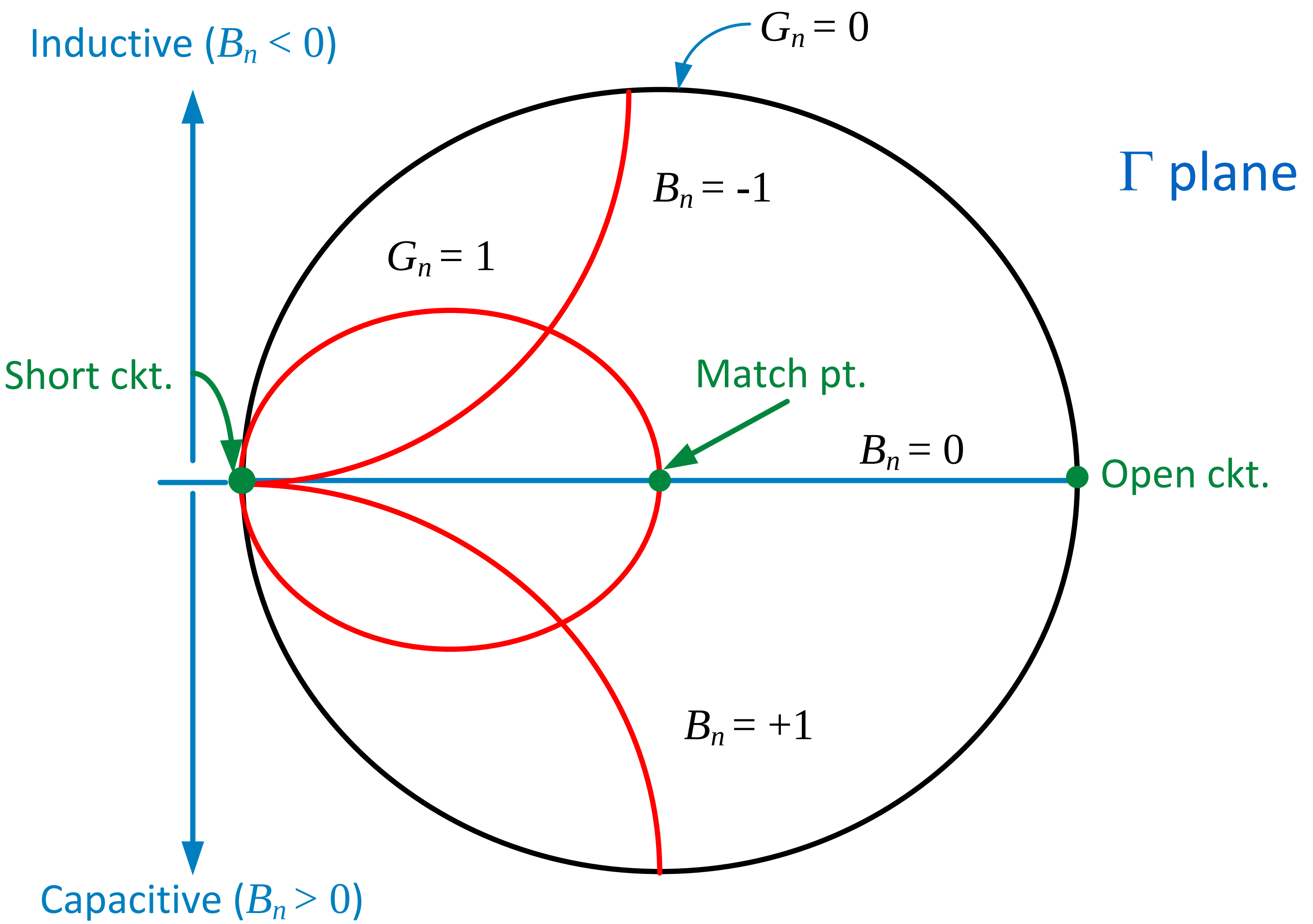
Conductance Circles



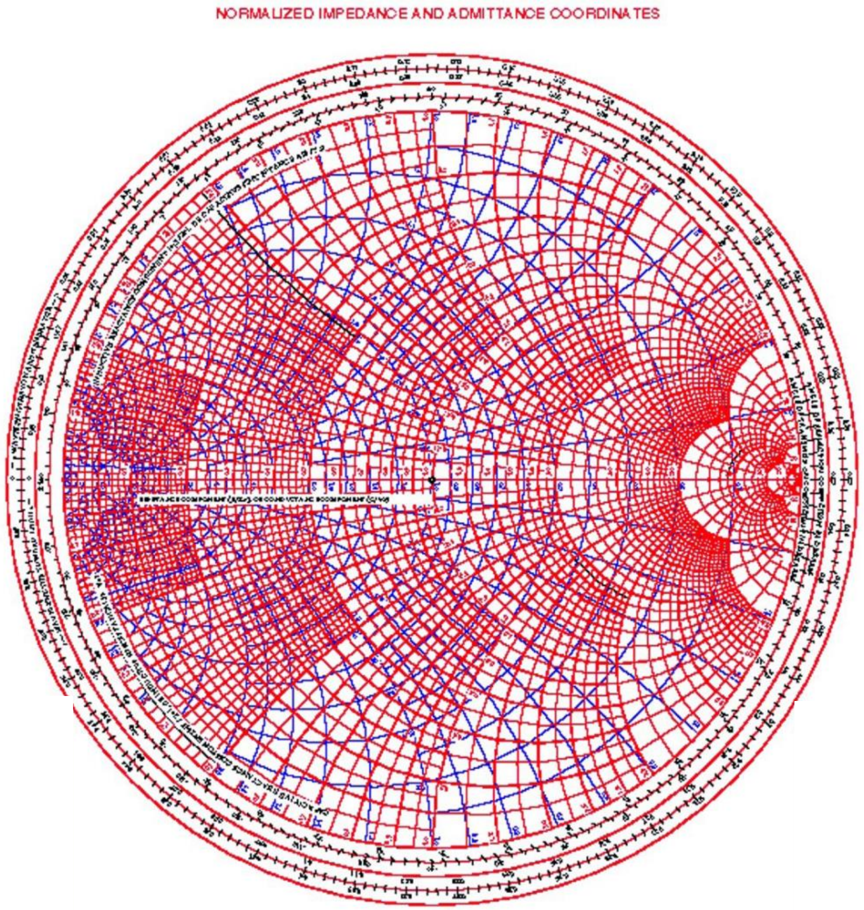
Susceptance Circles



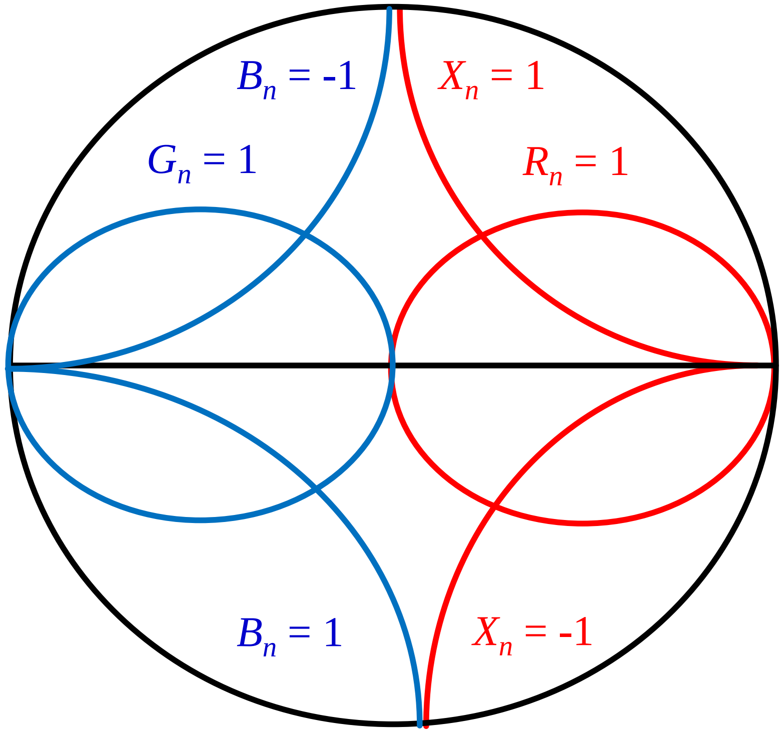
Admittance (Y) Chart (cont.)



Impedance and Admittance (ZY) Chart



Short-hand version



Γ plane

Example 6

Y=1+j

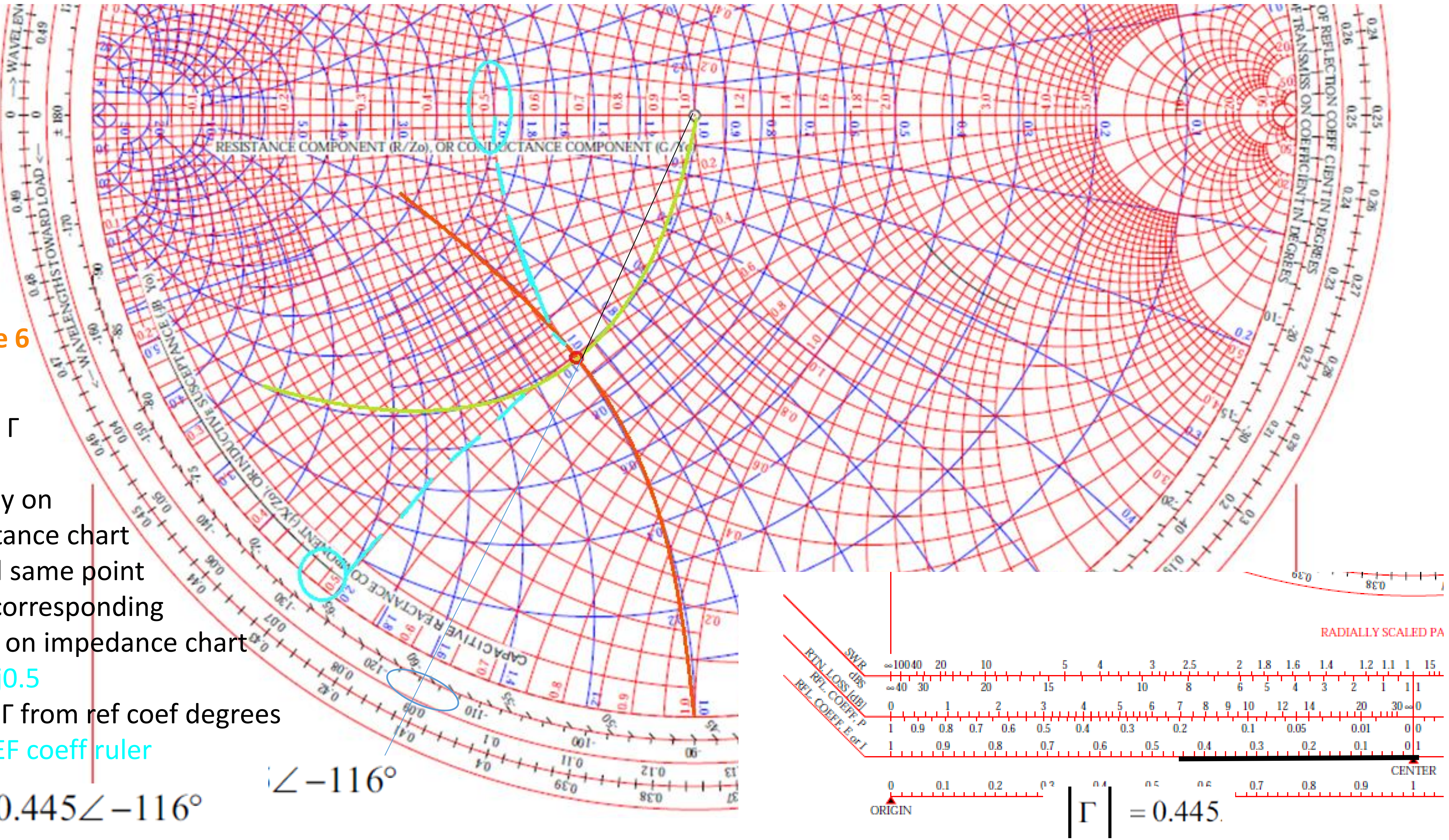
Find Z, Γ

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



$$\Gamma = 0.445\angle -116^\circ$$

Using impedance-Admittance Smith Chart

Example 7

Given:

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

Find Y

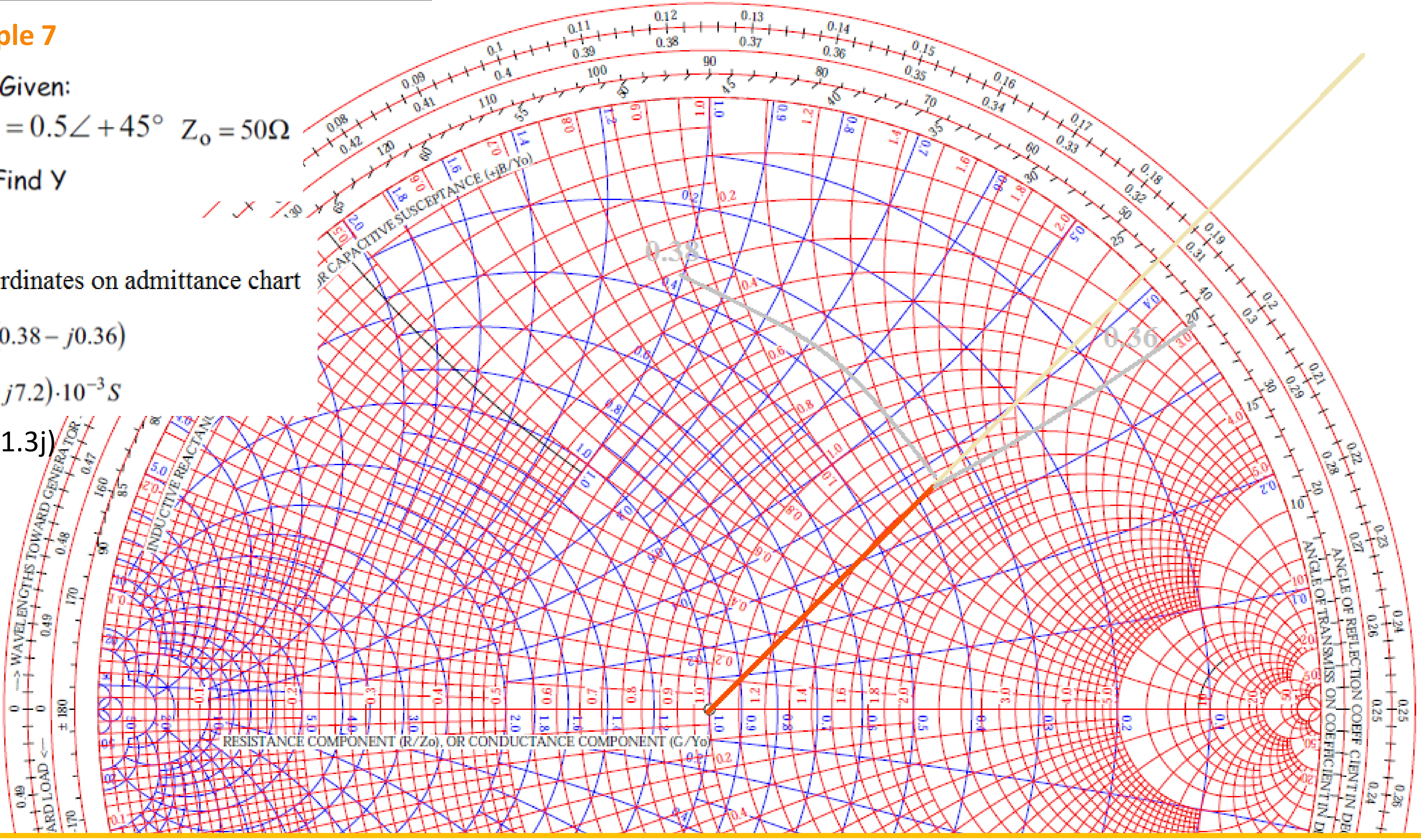
. Plot Γ

. 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)

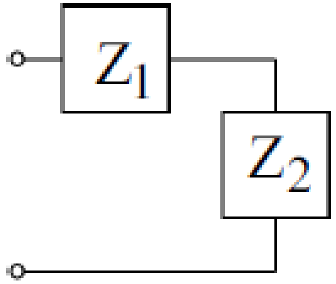


Adding Elements

Admittance

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

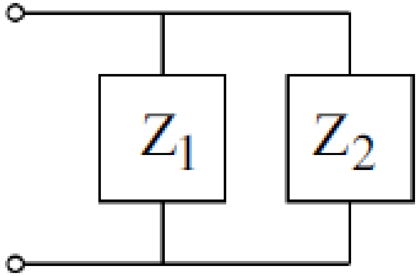
Impedance is well suited when working with series configurations. For example:



$V = ZI$

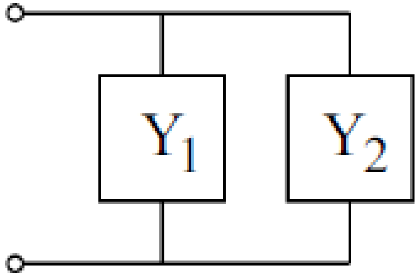
$$Z_L = Z_1 + Z_2$$

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.



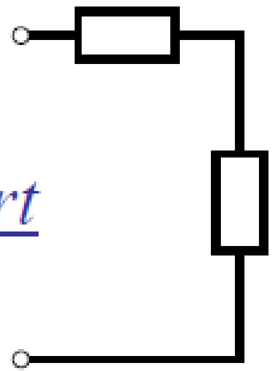
$I = YV$

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

General Rules

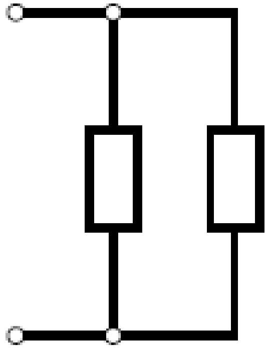
Adding Series Components

→ *Impedance Smith Chart*

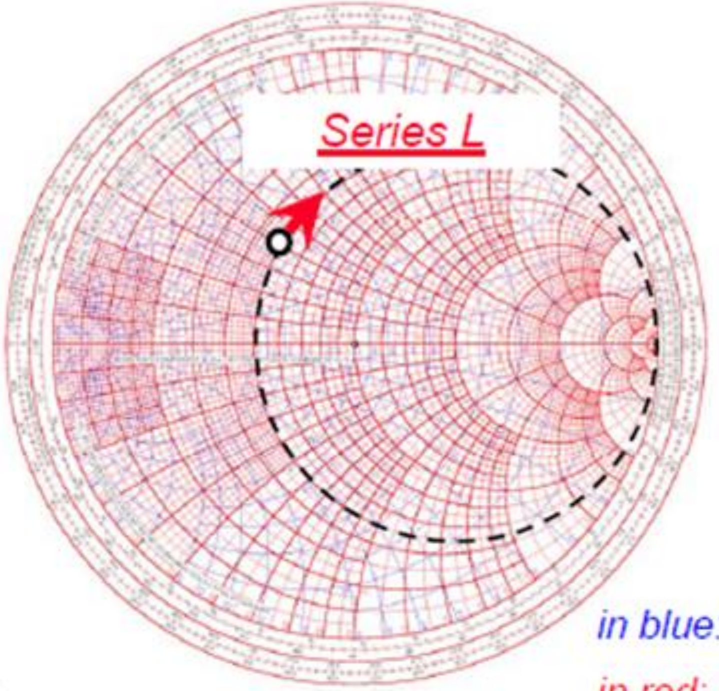


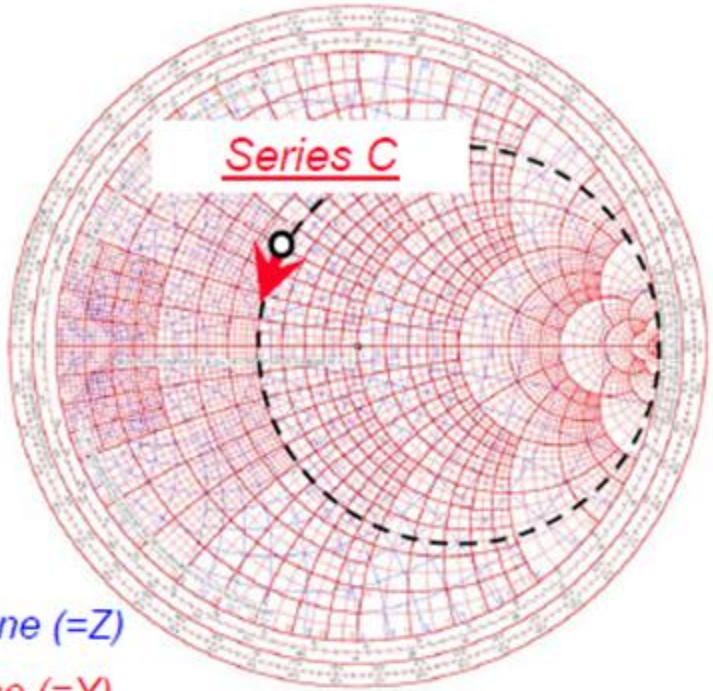
Adding Parallel (Shunt) Components

→ *Admittance Smith Chart*



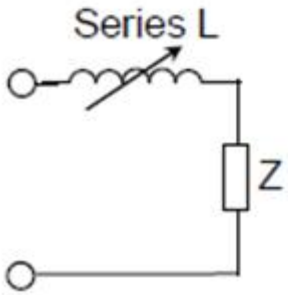
Navigation in the Smith Chart

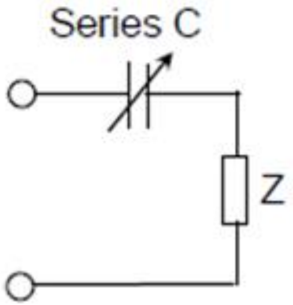




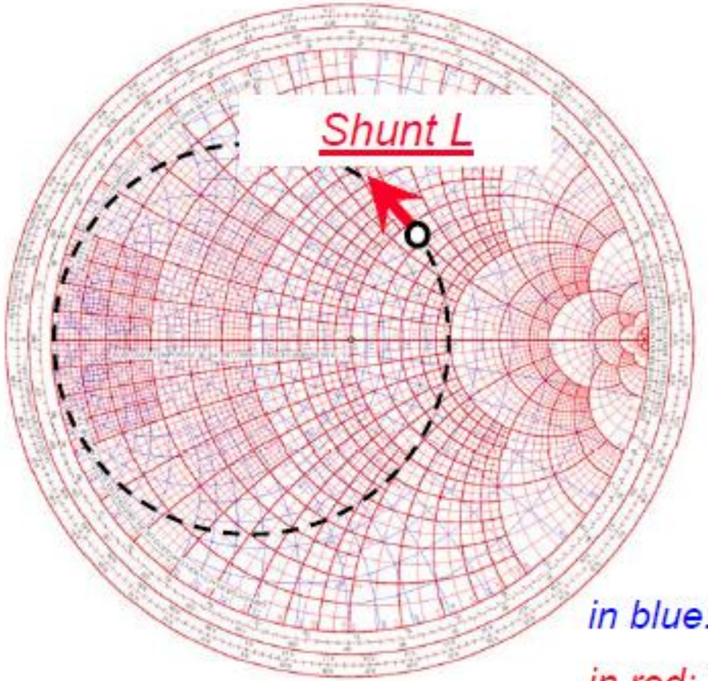
in blue: Impedance plane (=Z)

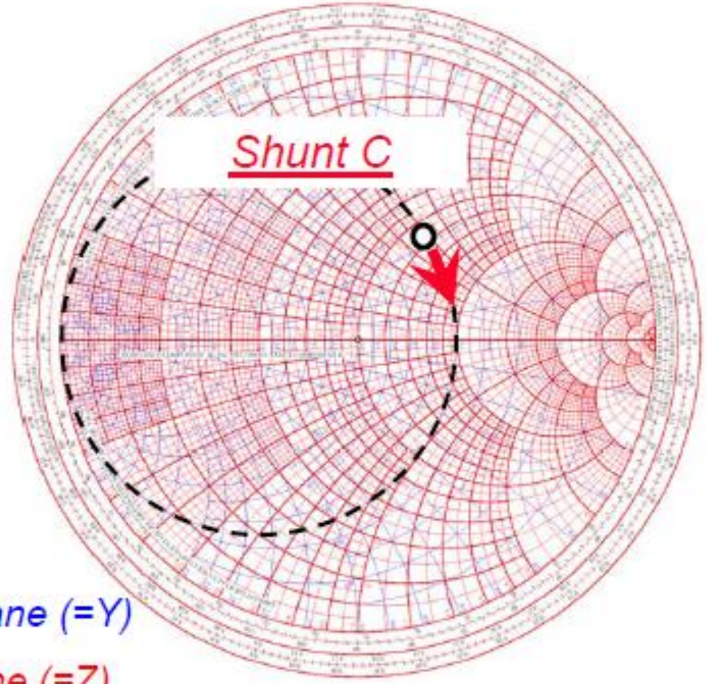
in red: Admittance plane (=Y)





Navigation in the Smith Chart (2)

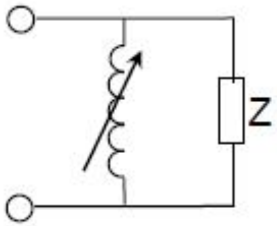




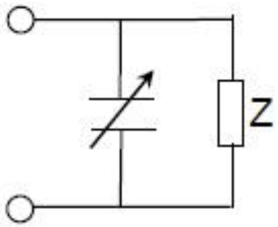
in blue: Admittance plane (=Y)

in red: Impedance plane (=Z)

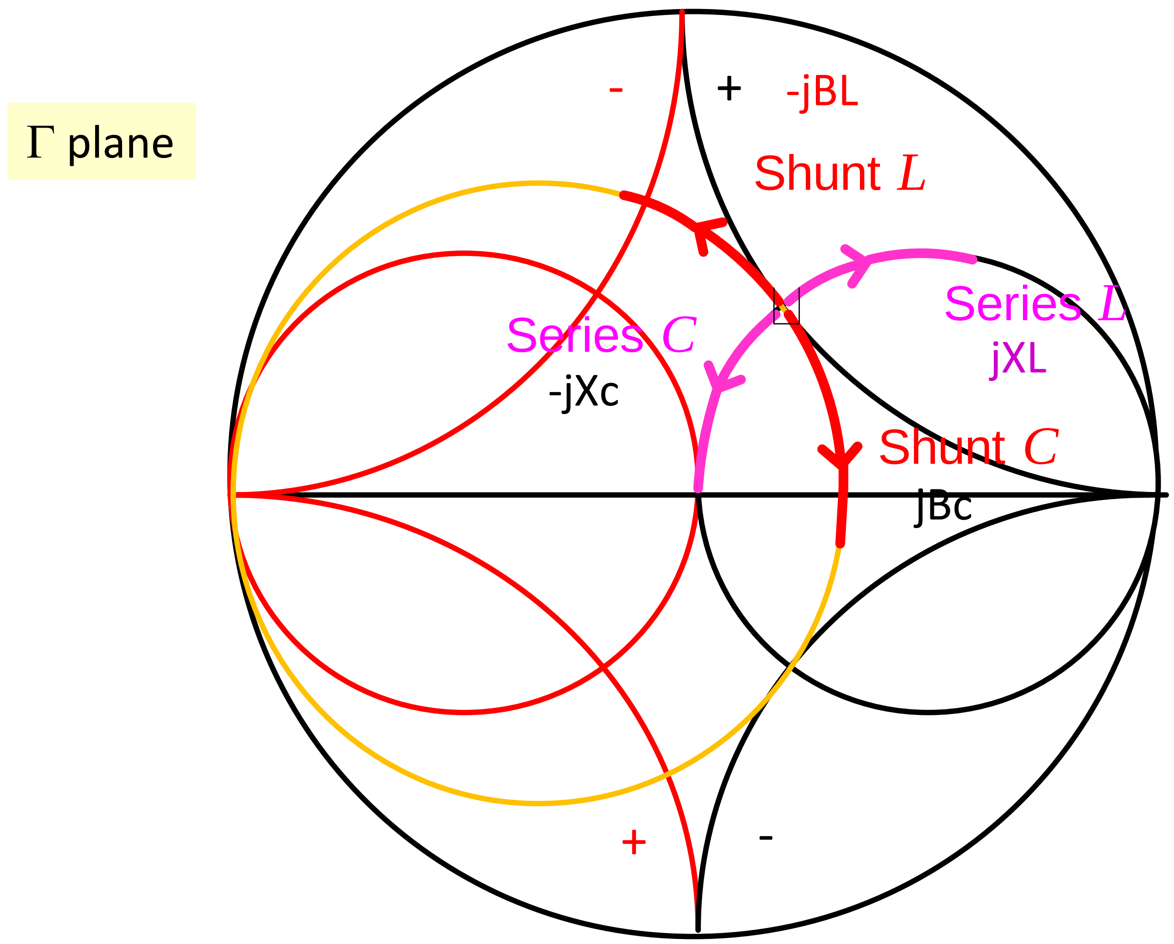
Shunt L



Shunt C

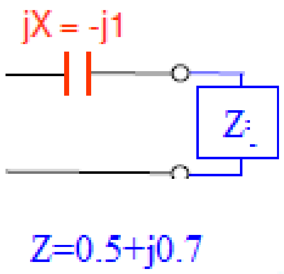


Series and Shunt Elements



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

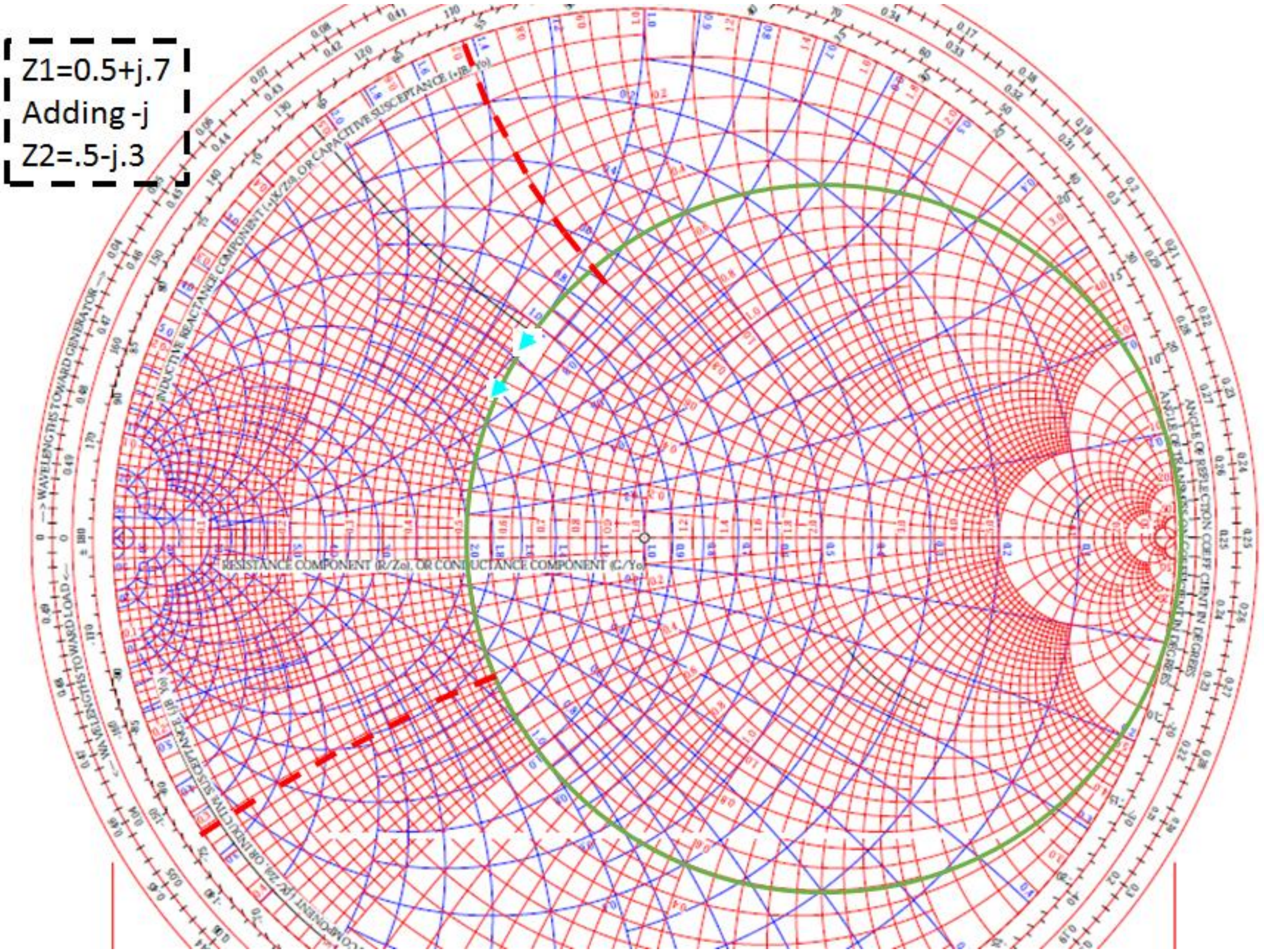


If we have initial impedance
Z=0.5+j0.7
We add a series capacitor

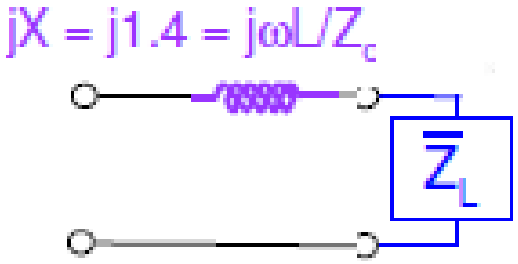
Since resistance does snot change
We move on constant circle from
j0.7 to -j0.3

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

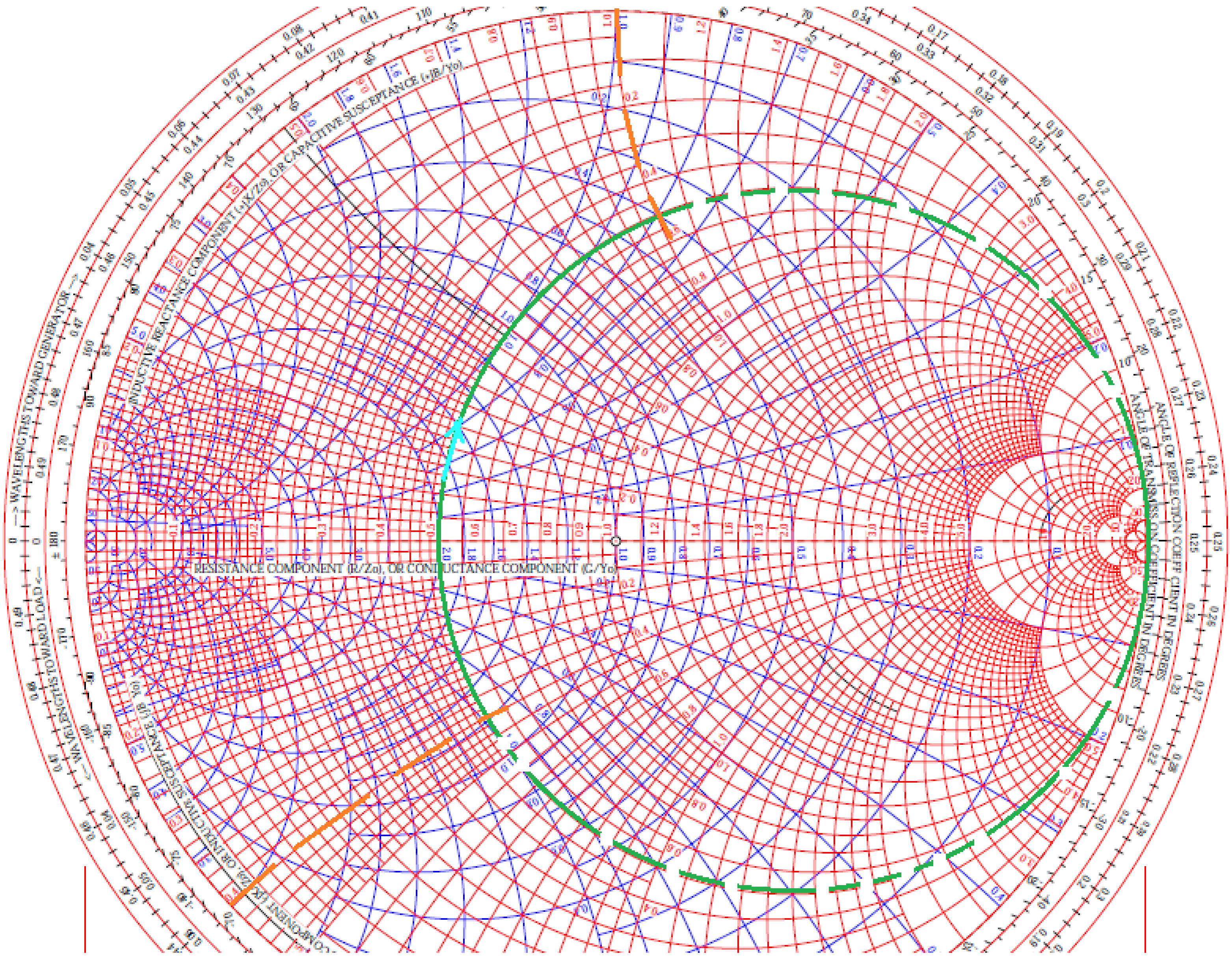


Adding a Series Inductor



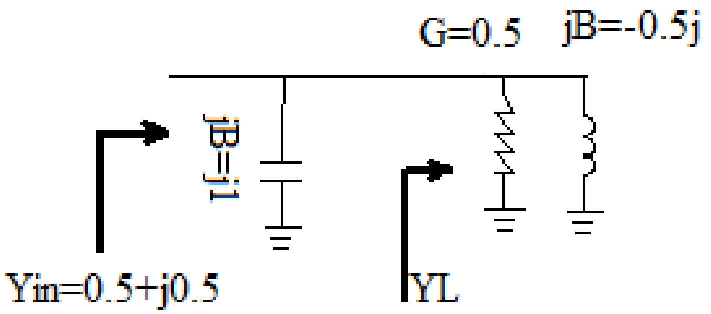
If we have Z=0.5-j0.4
We add series inductor
jX=j1.4

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



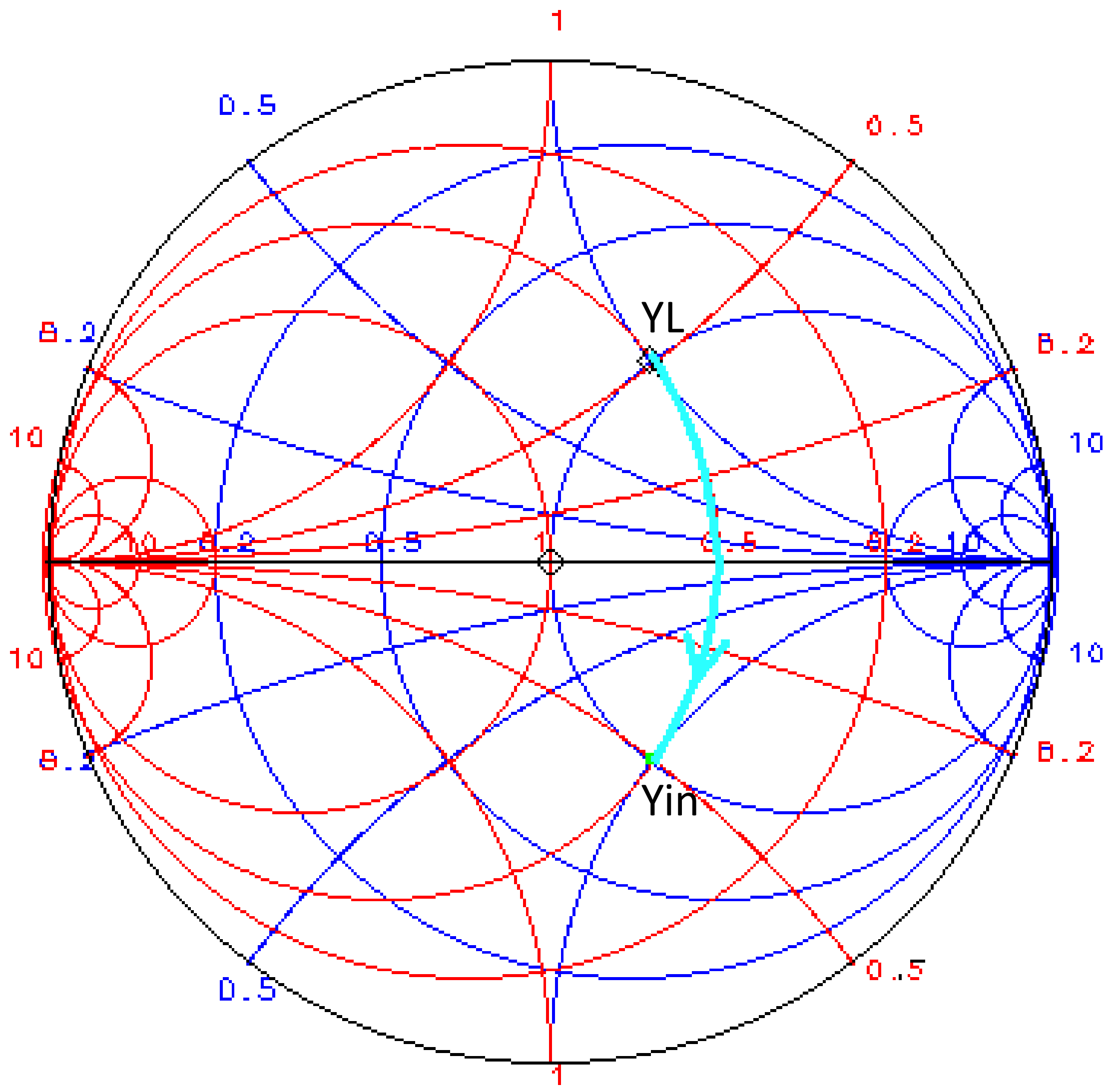
For ZL=1+j1.0
On admittance chart
YL=0.5-j0.5

Adding shunt capacitor
With JB=j1

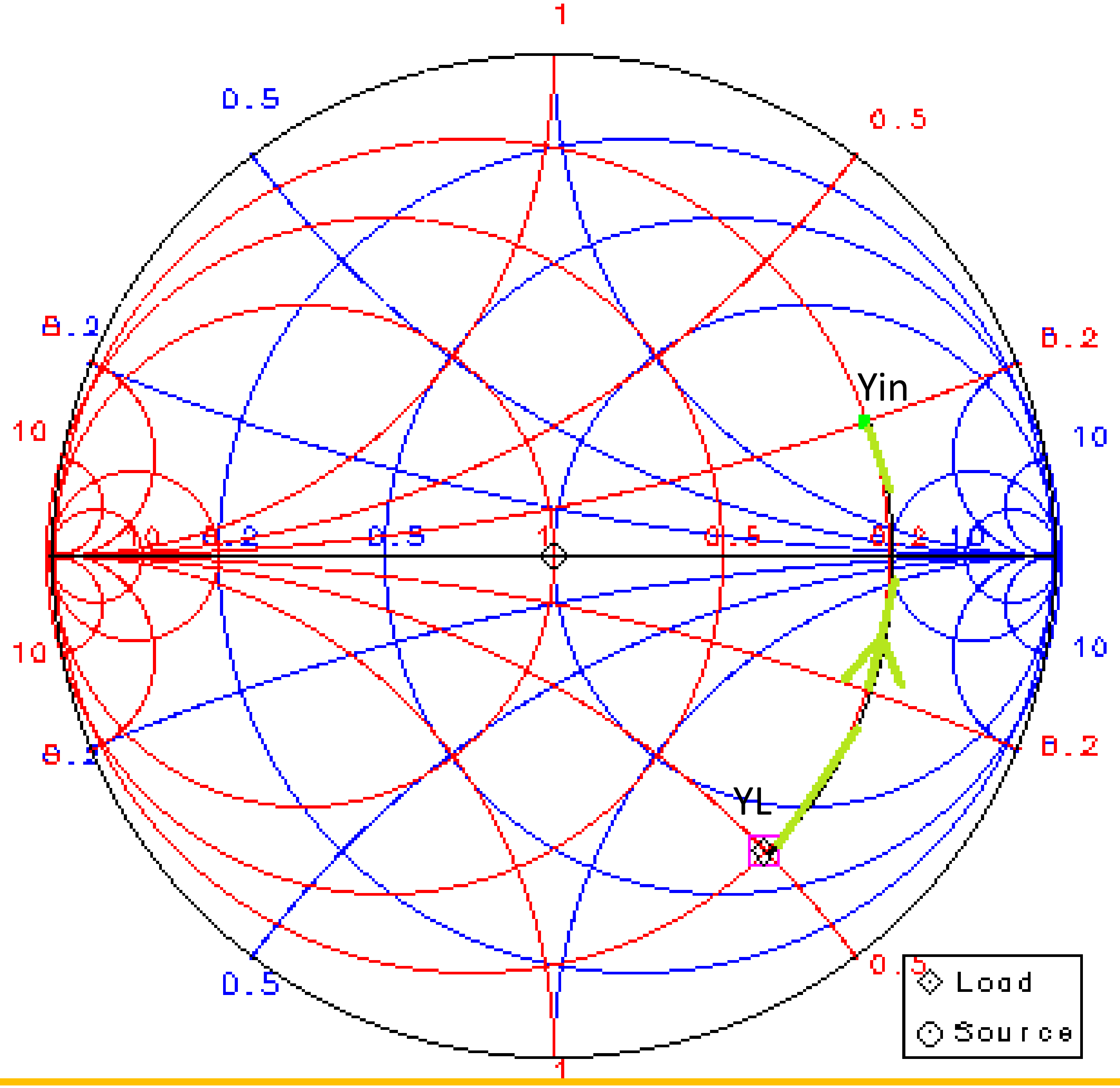
Yin=0.5+j0.5

Read from impedance chart

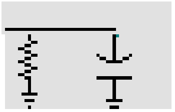
Zin=1-j1.0



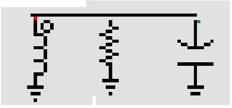
Adding Shunt Inductor



YL=0.2+j0.5



adding shunt inductor with JB= - j0.7

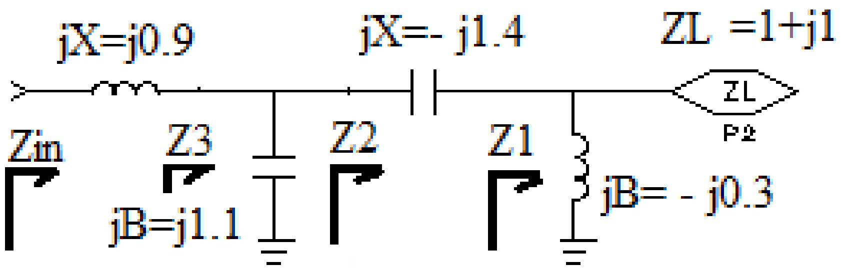


Yin=0.2-j0.2

Read from impedance chart
Zin=2.4+j2.5

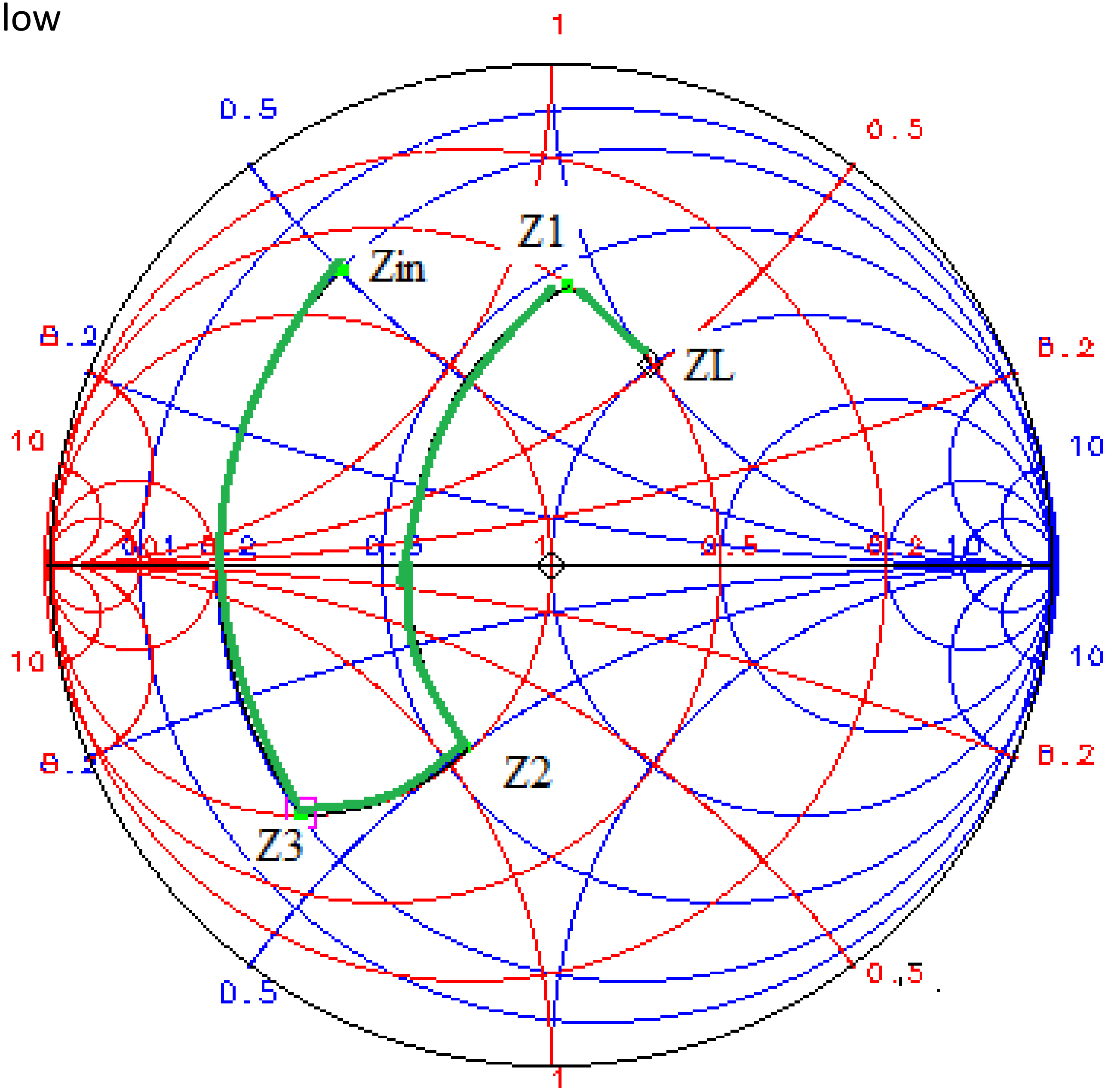
Example 8

what is the input impedance of network shown in Fig below

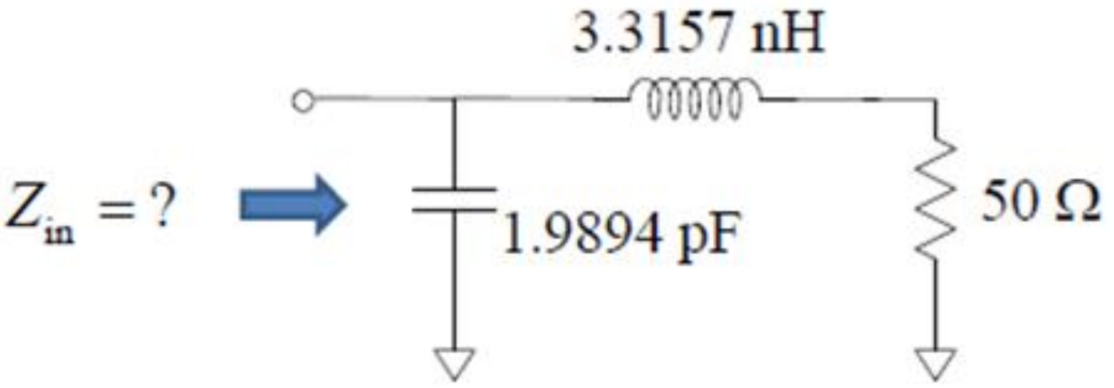


Solution :use impedance admittance smith chart

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



Example 9



$f = 2.4$ GHz

$Z_0 = 50\ \Omega$

$$Z_{in} = \frac{1}{j\omega C} \Big|\Big| (R + j\omega L)$$

$$= \frac{\frac{1}{j\omega C}(R + j\omega L)}{\frac{1}{j\omega C} + (R + j\omega L)}$$

$$= \frac{R + j\omega L}{1 - \omega^2 LC + j\omega RC}$$

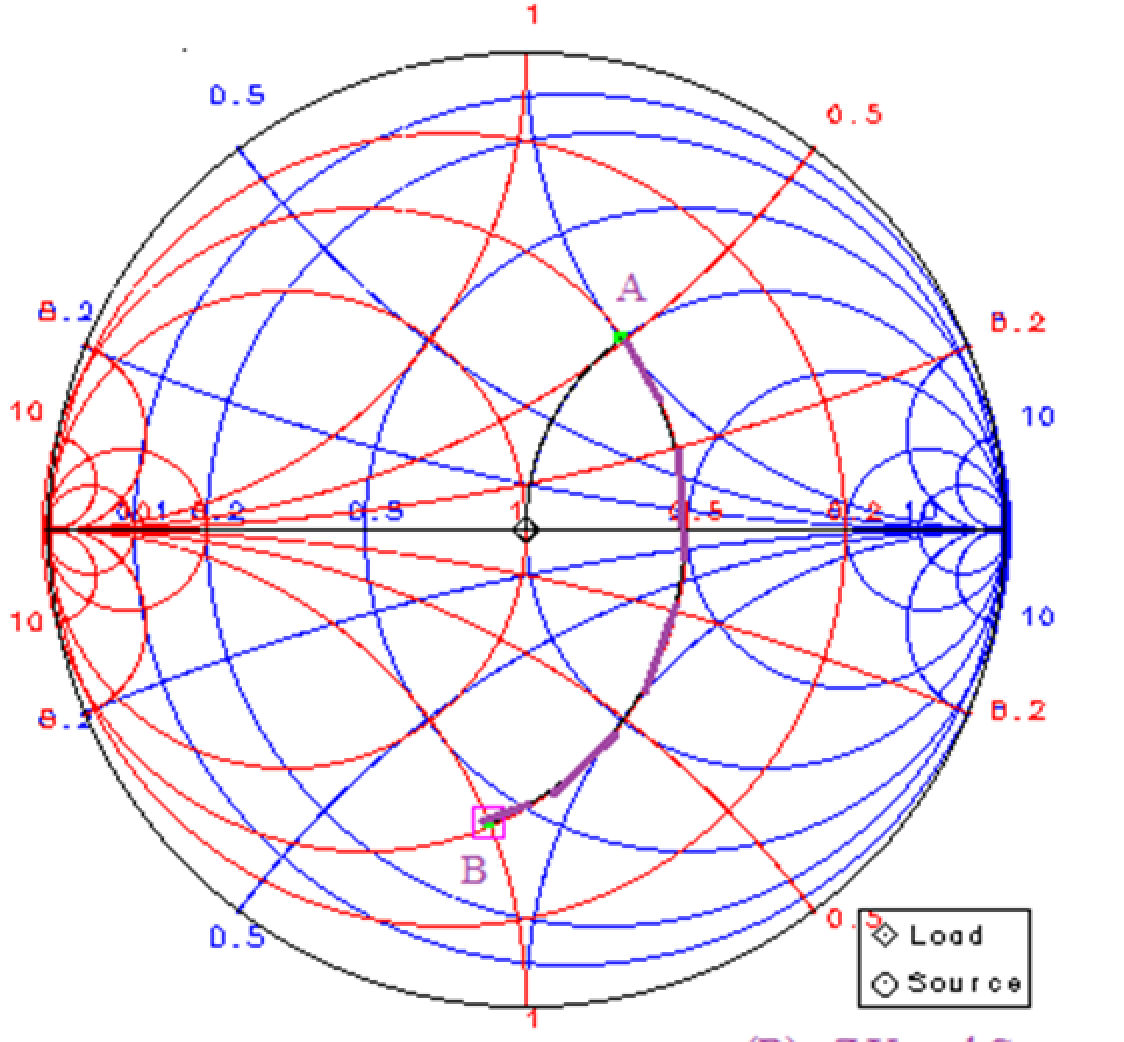
$$= \frac{50 + j(1.5080\times10^{10})(3.3157\times10^{-9})}{1 - (1.5080\times10^{10})^2(3.3157\times10^{-9})(1.9894\times10^{-12}) + j(1.5080\times10^{10})(50)(1.9894\times10^{-12})}$$

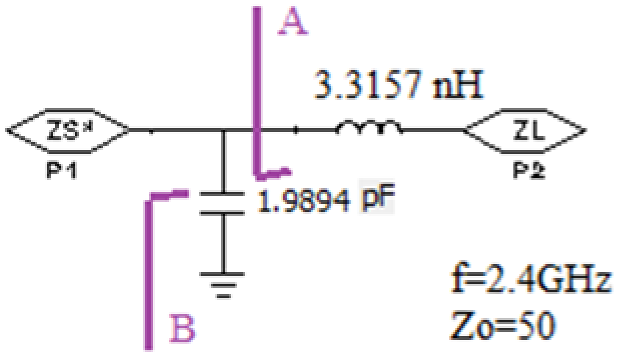
$$= 20 - j40\ \Omega$$

$$\Gamma = \frac{(20 - j40) - 50}{(20 - j40) + 50} = 0.62\measuredangle -98^\circ$$

VSWR = 4.2654

Normalized value is used in impedance admittance smith chart (also using ADS smithchart)





ZL=50

ZA=50+j 2*pi*2.4*3.3157

ZA/Zo=1+j1

Bcn=2*pi*2.4*10^9*1.9894*10^-12*50=1.5

Gamma:	0.62016	<	-97.1237	Z:	0.40002	+j	-0.80001
VSWR:			4.26541	Y:	0.50000	+j	0.99997

← ZB/Zo

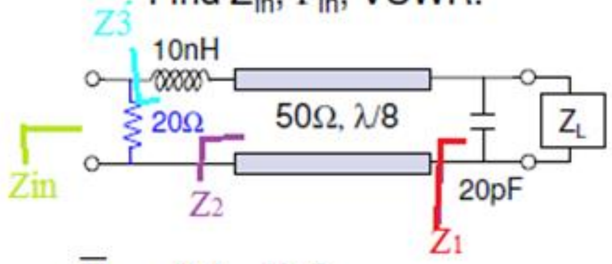
ZB=20-j40

Example 10 **with shunt C, G, series L and TL**

e.g. $Z_L = 20 - j25\ \Omega$

$f = 159$ MHz $(\omega = 10^9)$

Find Z_{in}, Γ_{in}, VSWR.



$$\overline{Z}_L = 0.4 - j0.5$$

$$\overline{B} = \omega C/Y_o = 0.02Z_o = 1$$

$$\overline{X} = \omega L/Z_o = 10/Z_o = 0.2$$

$$\overline{G} = G/Y_o = Z_o/R = 50/20 = 2.5$$

$Z_{in} = 50(0.28+j0.13) = 14 + j7\ \Omega$

$\Gamma_{in} = 0.57\ (164^o)$