
ECE 344

# MICROWAVE FUNDAMENTALS
# PART1-Lecture 9

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*Many Slides from: ECE 5317_6351 Microwave Engineering* *Prof. David R. Jackson*

# Matching Using TL and shunt stub:

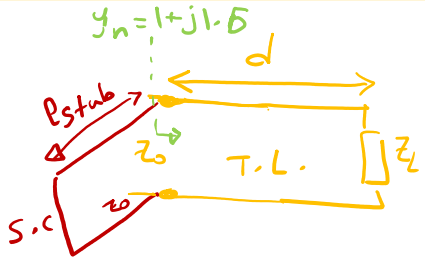
## Example 1

It is desired to match the load **Zl=25+j50Ω to 50Ω TL, f=1GHz**

-use two lumped elements (four connections are possible, previous lecture)

-Use TL and shunt stub
Two solutions are possible , solve for minimum stub length. Declare stub end ( s.c. or o.c.)

-use TL and shunt limped elements (two solutions )




$$d = 0.428\lambda - 0.135\lambda$$
$$= 0.293\lambda$$

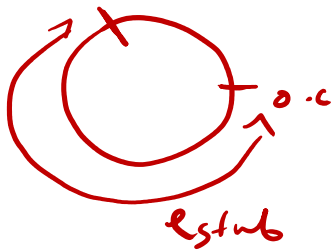
$\because y_n = 1 + j1.5$

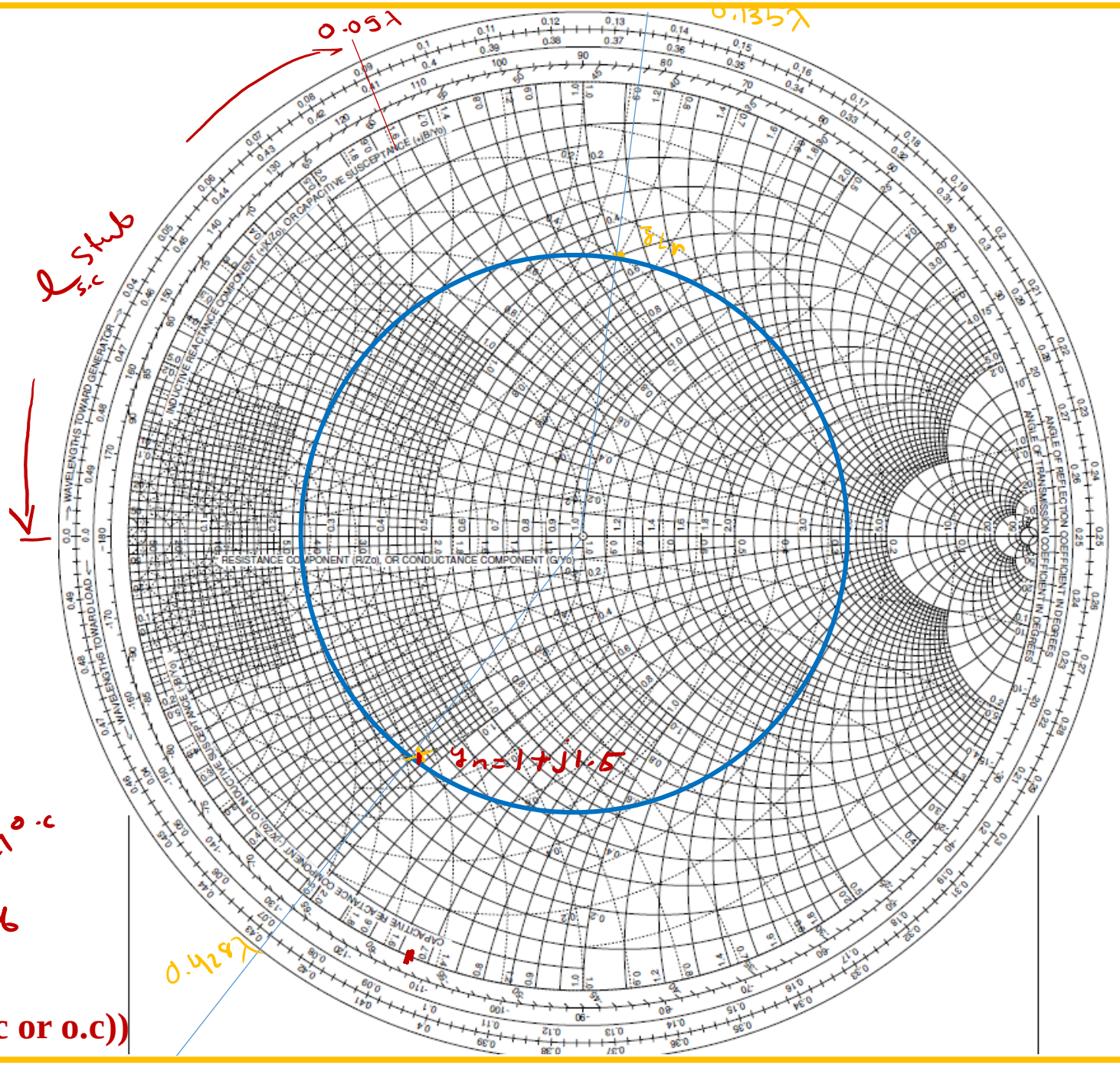
Added Element $y_{stub} = -j1.5$

$$l_{stub}\ {}_{s.c} = 0.09\lambda$$

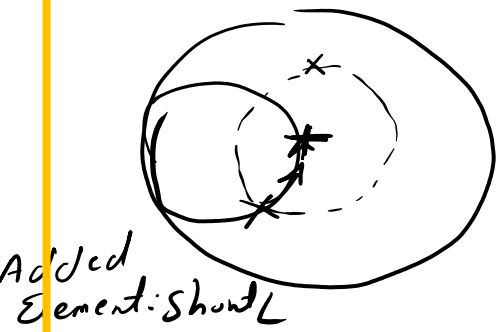
if Added Shunt o.c Stub

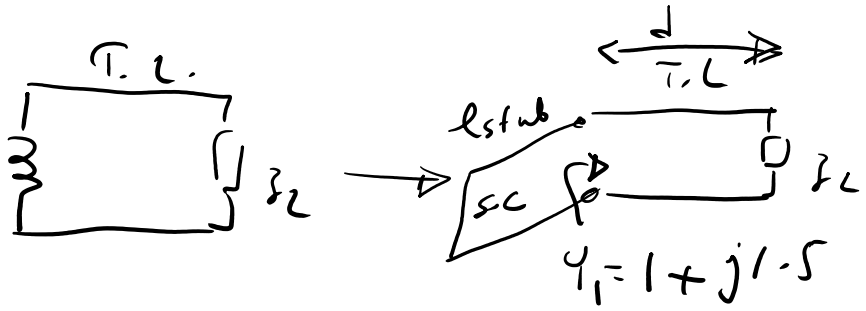
$$l_{stub}\ {}_{o.c} = (0.09 + 0.25)\lambda$$
$$= 0.34\lambda$$

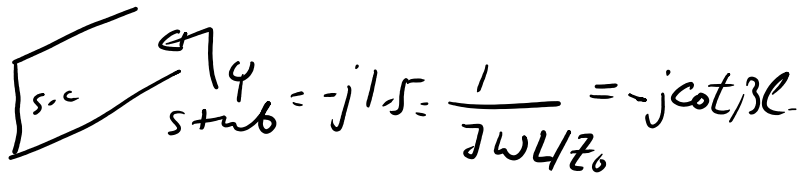



**Using TL (small d then shunt stub( s.c or o.c))**



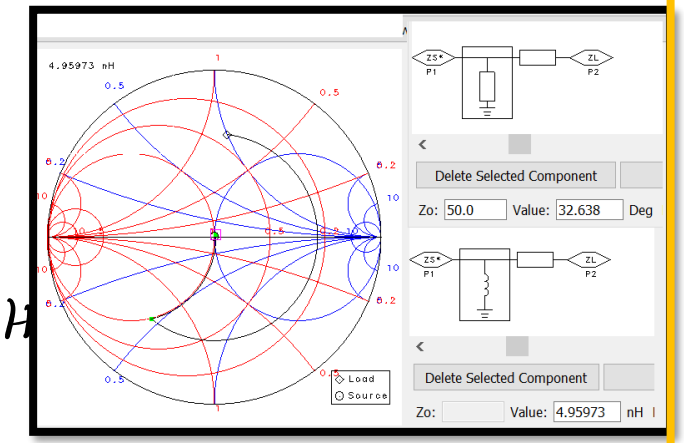

Compute $l_{stub}$ by Equations:

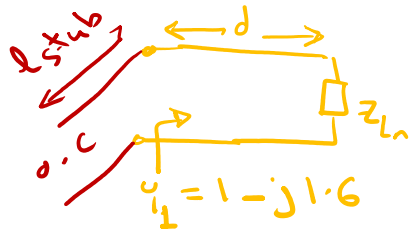
$$y_{stub} = -j1.5 = -j\cot\beta l \rightarrow \beta l = \tan^{-1}\left(\frac{1}{1.5}\right) = 33.69^\circ \rightarrow l_{stub} = \frac{33.69}{360}\lambda = 0.0935\lambda$$

if Matched Network T.L + lumped Element

Compute L

$$1.5 = \frac{1}{\omega L/z_0} \rightarrow L = \frac{50}{1.5 \times 2\pi \times 10^9} = 5.3\ nH$$






**Using TL (large d then shunt stub( s.c or o.c))**

$$d = (0.25 - 0.135)\lambda + 0.25\lambda + 0.072\lambda$$

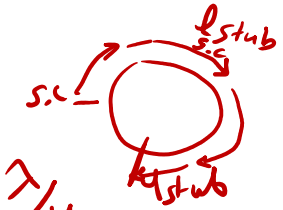
$$= 0.437\lambda \quad \rightarrow \beta l_d = 157.3^\circ$$

Added stub $y_{stub} = j1.6$

$$l_{stub}^{o.c} = 0.412\lambda - 0.25\lambda$$

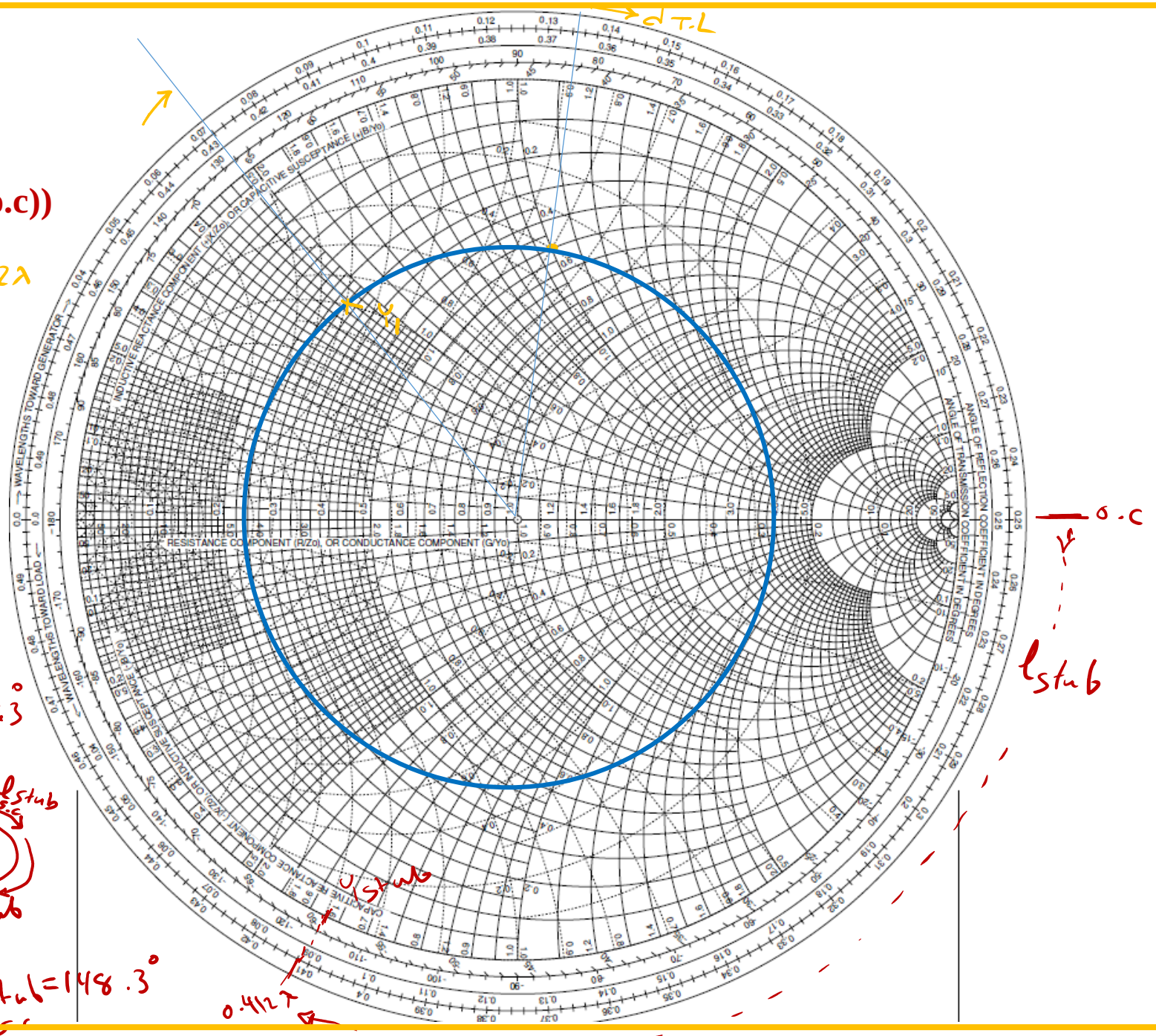
$$= 0.162\lambda \quad \rightarrow \beta l_{stub} = 58.3^\circ$$

if we use s.c stub

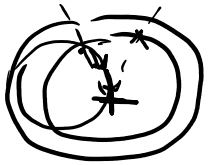


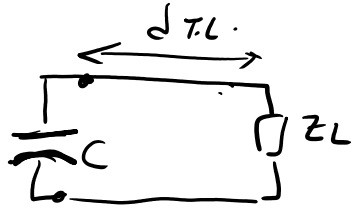

$$l_{stub}^{s.c} = 0.162\lambda + \lambda/4$$

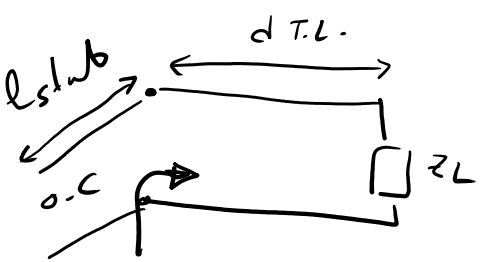
$$= 0.412\lambda \quad \rightarrow \beta l_{stub} = 148.3^\circ$$



Added Shunt Element = C






$f = 1\,GHz$

$Z_0 = 50$

Compute $l_{stub}$ by Equations:

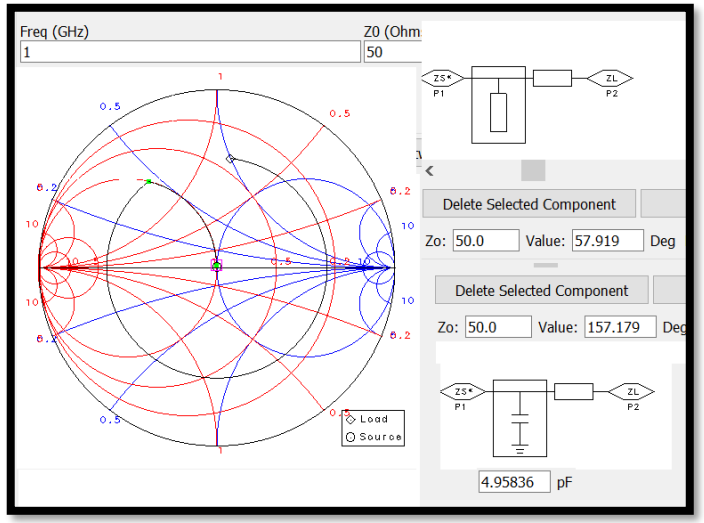
$$Y_{stub} = j1.6 = Y_{n\,o.c.} = j\tan\beta l$$

$Y_1 = 1 - j1.6$

o.c

$Y_{stub} = j1.6$

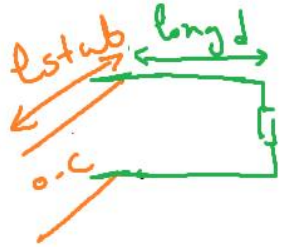
$$\therefore \beta l = \tan^{-1}1.6 \Rightarrow l_{stub\,o.c} = \frac{57.99}{360}\lambda = 0.161\lambda$$




if Matched Network T.L. + Lumped Element :

Compute $C_n$

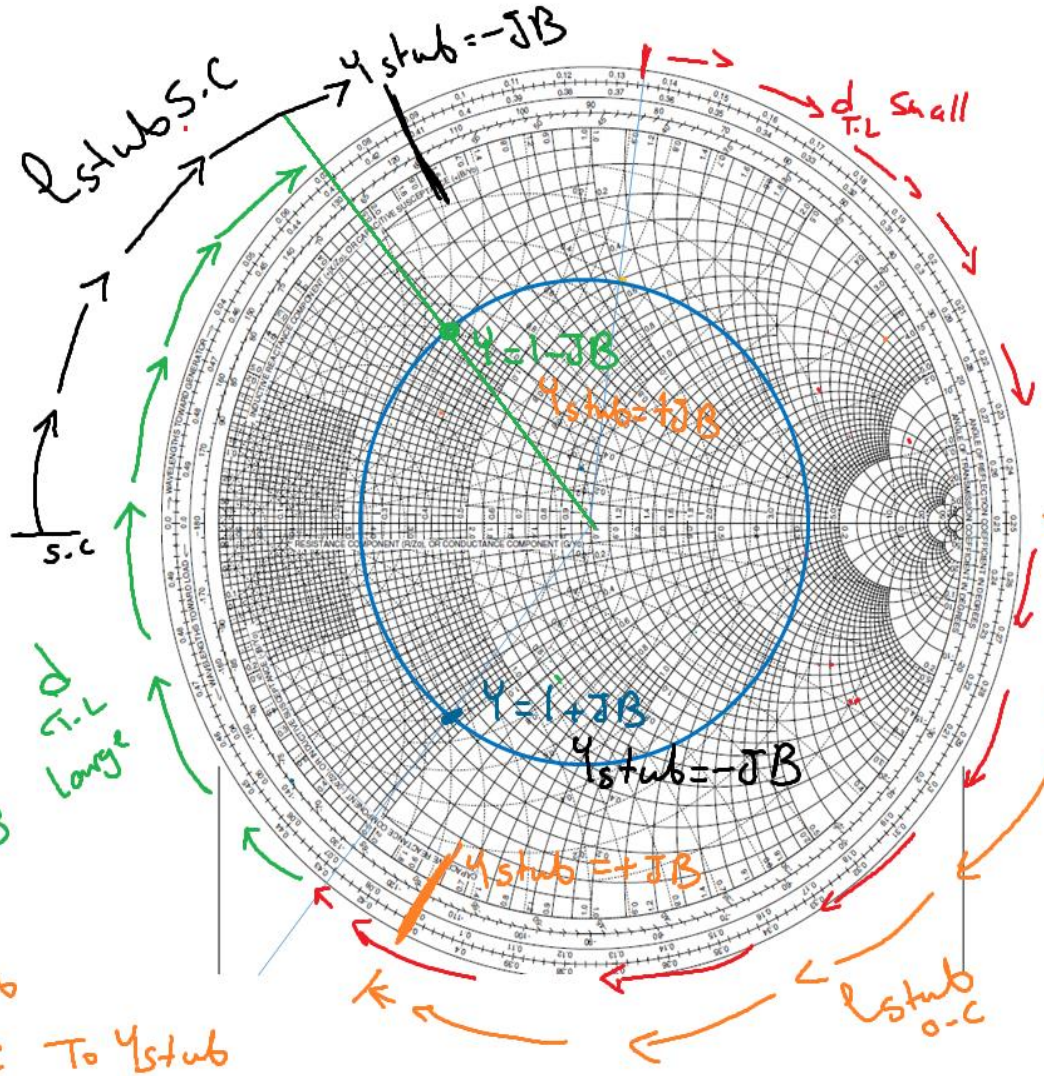
$$Y_{stub} = j1.6 = j\omega C_n Z_0 \rightarrow C_n = \frac{1.6}{2\pi \times 10^9 \times 50} = 5.09\ pF$$

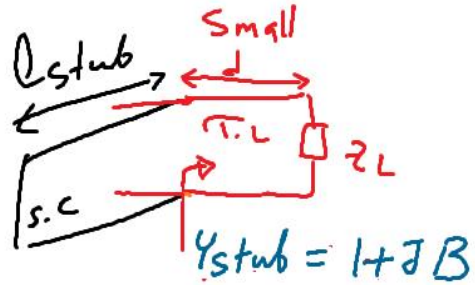



- Add T.L To intercept G=1 Circle
- d From load to Y on G=1 Circle

**Added stub** $Y = 1 - JB$

- $Y_{stub} = +JB$
- locate $Y_{stub}$
- $l_{stub}$ From o.c To $Y_{stub}$




- Add T.L To intercept G=1 Circle
- d From load to Y on G=1 Circle

o-c **Added stub** $Y = 1 + JB$ on G=1 Circle

- $Y_{stub} = -JB$
- locate $Y_{stub}$ Then
- $l_{stub}$ From S.C To $Y_{stub}$

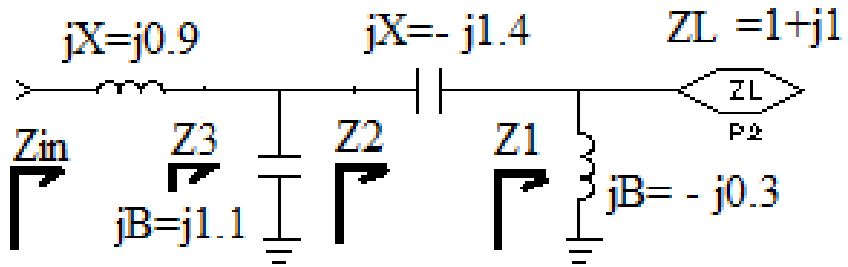
## Example 2

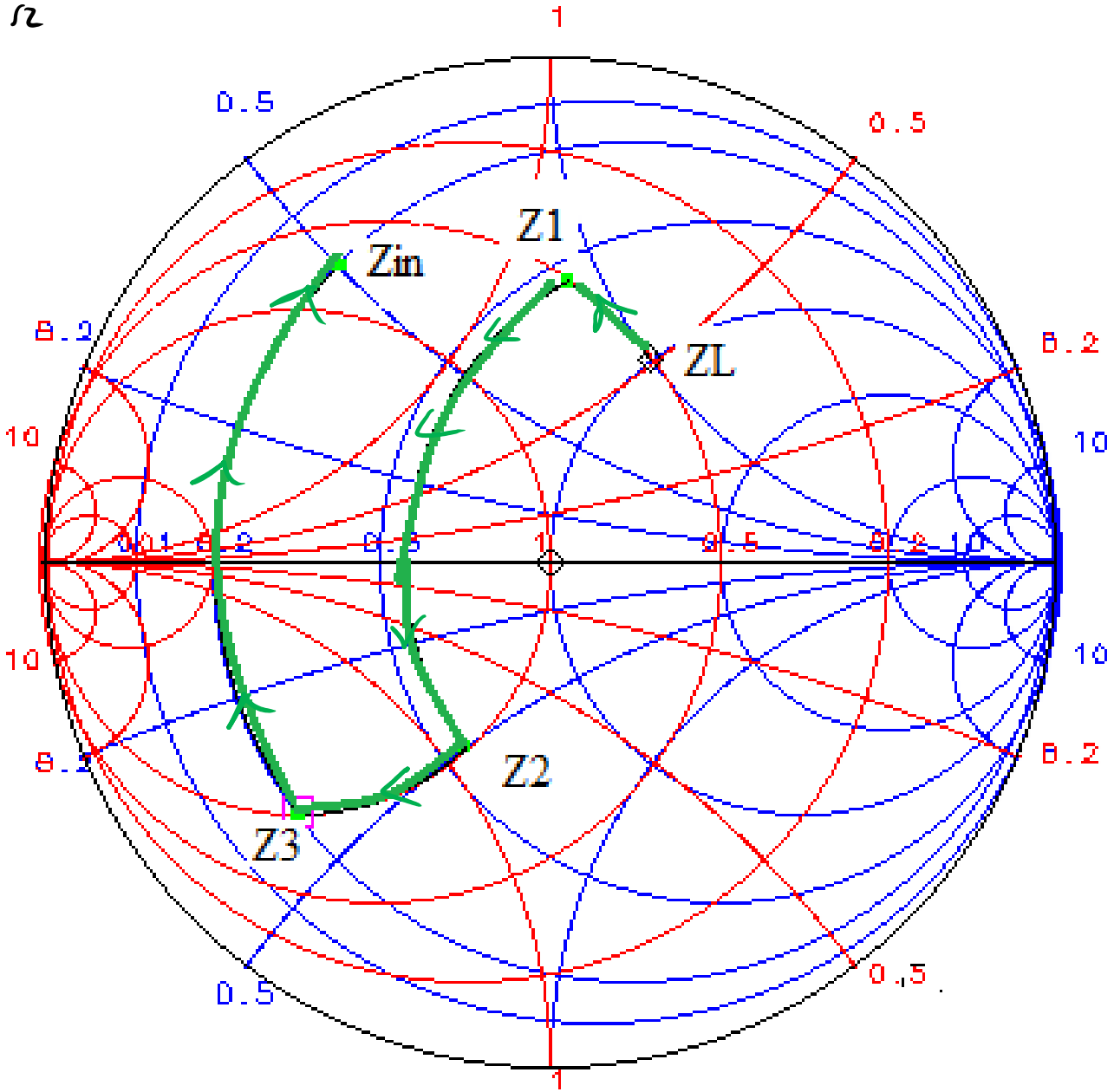
build the circuit from the load for giving track:

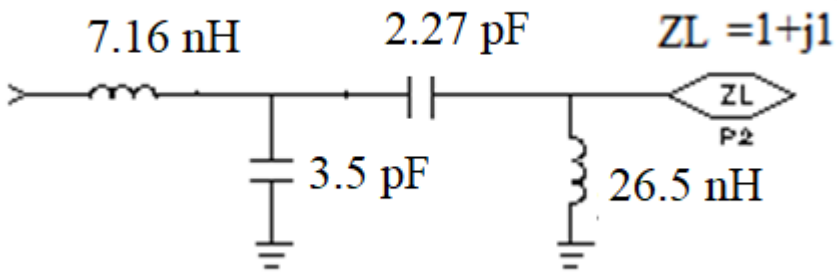
$f = 1\,GHz \quad Z_0 = 50\,\Omega$

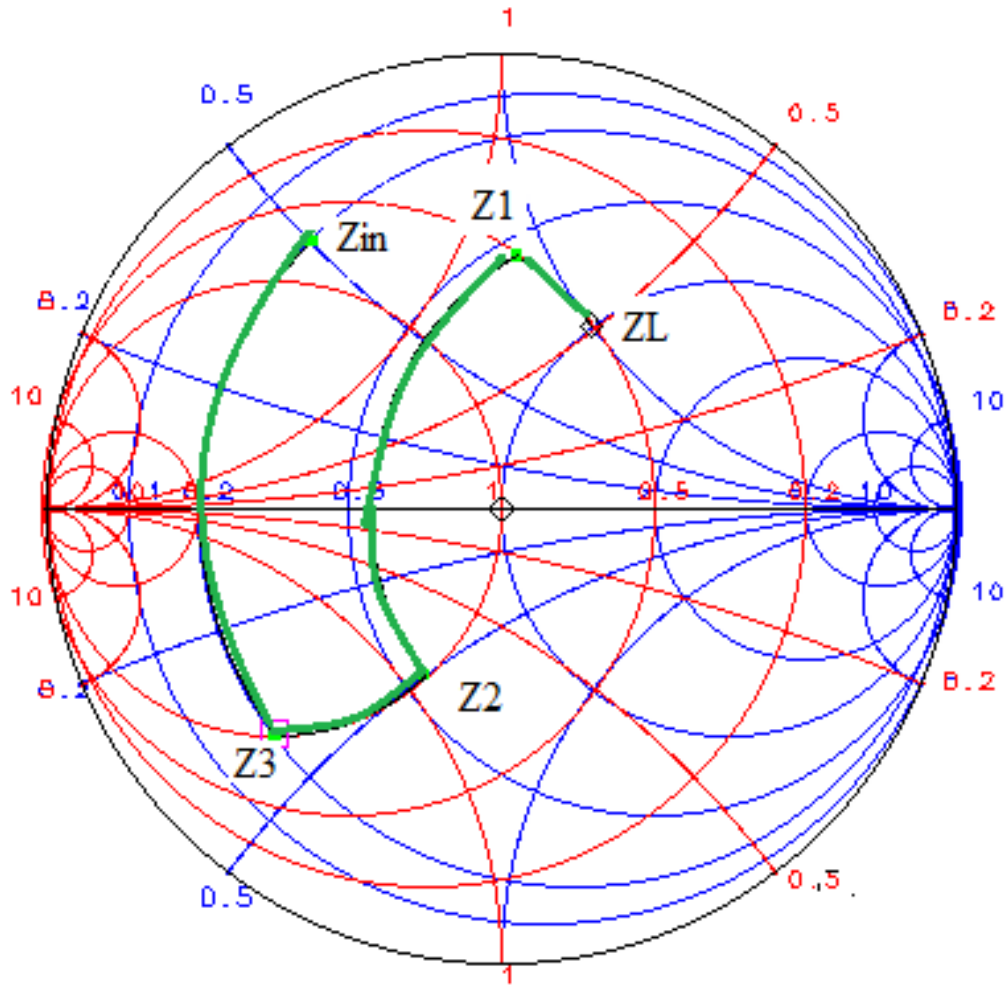
| | | | | |
|---|---|---|---|---|
| ZL | | | | |
| Z: | 1.00000 | +j | 1.00000 | |
| Y: | 0.50000 | +j | -0.50000 | |
| Z1,Y1 | | | | |
| Z: | 0.55699 | +j | 0.89652 | |
| Y: | 0.50000 | +j | -0.80479 | |
| Z2,Y2 | | | | |
| Z: | 0.55699 | +j | -0.48811 | |
| Y: | 1.01549 | +j | 0.88992 | |
| Z3,Y3 | | | | |
| 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 | |

Solution:




7.16 nH
2.27 pF
ZL =1+j1
ZL
P2
3.5 pF
26.5 nH

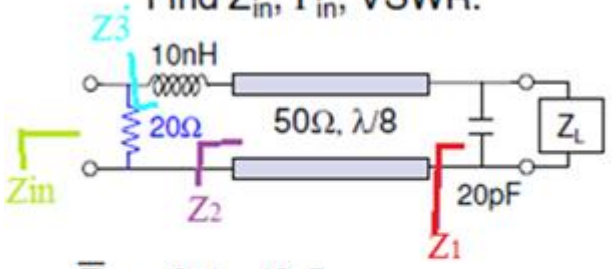

Zin
Z1
ZL
Z2
Z3

## Example 3 with shunt C, G, series L and TL

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

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

Find $Z_{in}$, $\Gamma_{in}$, VSWR.




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

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

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

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

$\Gamma in = 0.58 \angle 163^o$

$Zin = 50(1/(2.93-1.5j)$

$= 13.5+j6.9\Omega$