Intro. to the Smith Chart

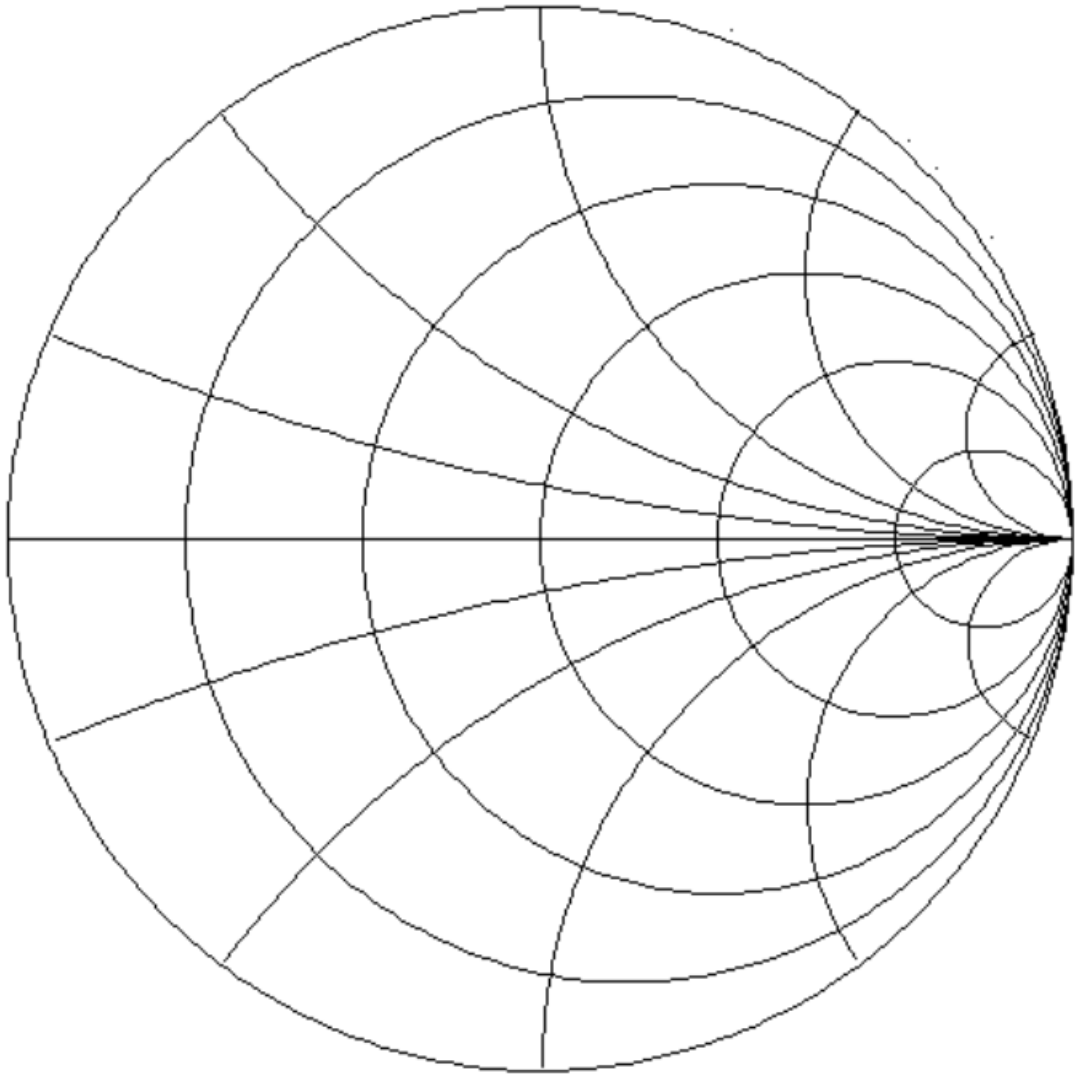
Transmission Line Applications

Background

- Philip Smith of Bell Laboratories developed the “Smith Chart” back in the 1930”s to expedite the tedious and repetative solution of certain rf design problems. These include:
- Transmission line problems
- Rf amplifier design and analysis
- L-C impedance matching networks
- Plotting of antenna impedance
- Etc.

CONSTRUCTION

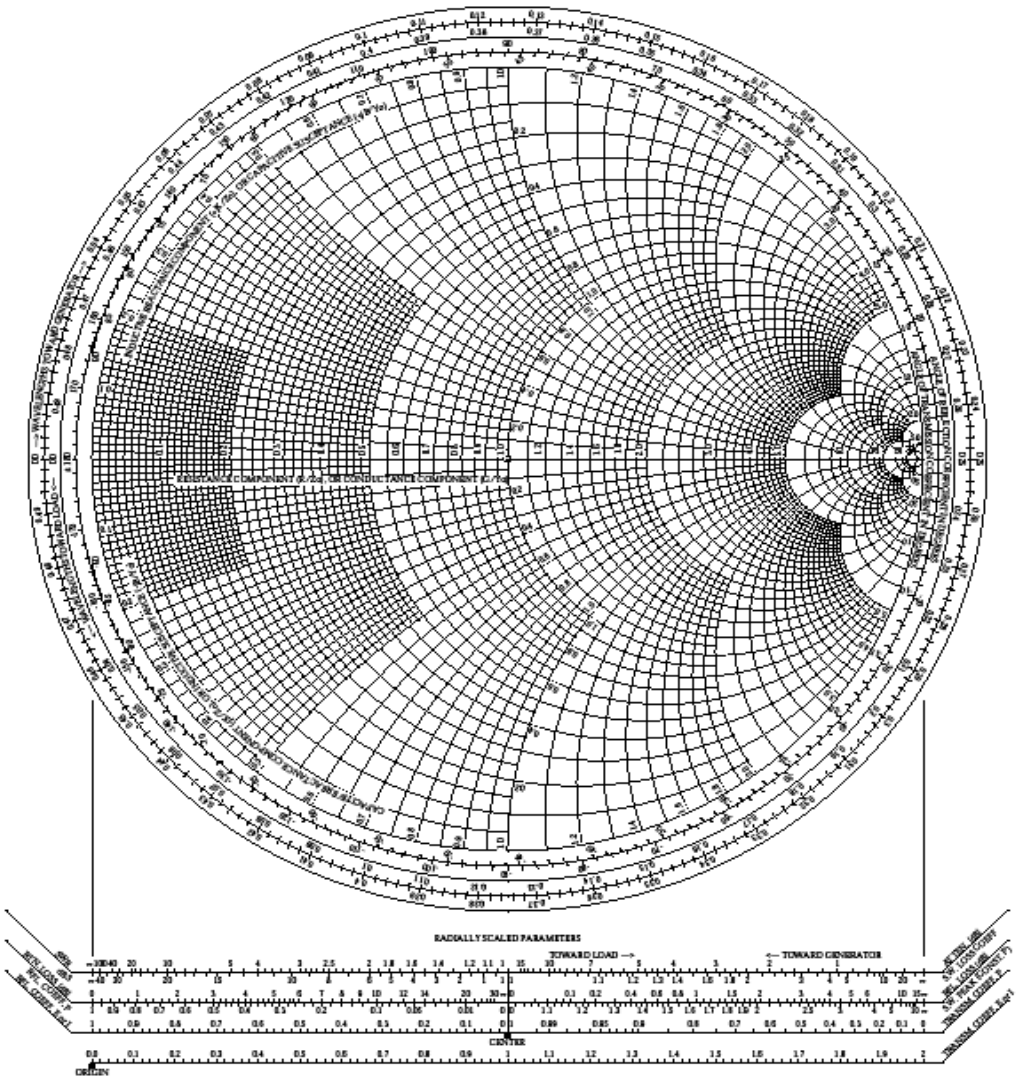
- The Smith Chart is made up of a family of circles and a second family of arcs of circles.
- The circles are called “constant resistance circles”
- The arcs are “constant reactance circles”
- Impedances must be entered in rectangular form – broken down into a real and an imaginary component.
- The real part (resistance) determines the circle to use.
- The imaginary part (reactance) determines the arc to use.
- The intersection of an arc and a circle represents the plotted impedance.



hms.

The Complete Smith Chart

Black Magic Design



Antenna Z known, find Z at transmitter

Assume an antenna impedance (Z_L) of 25 + j50 ohms

Let characteristic impedance of the transmission line = 50 ohms

Let velocity factor of cable (vf) = 0.66

Let physical line length = 100 feet = 30.48 meters

Let the frequency (f) be 14.1 MHz

One electrical wavelength on cable = (983.6)(vf)/f(MHz) = (983.6)(.66)/14.1 = 46.04 ft.

Wavelength of actual cable = 100 ft./46.04 ft. = 2.172 wavelengths or 781.9 degrees

Subtract 0.5 wavelengths until the result is less than or equal to 0.5 wavelengths.

The length to plot is 0.172 wavelengths or 61.9° (toward source).

Normalize Load Z

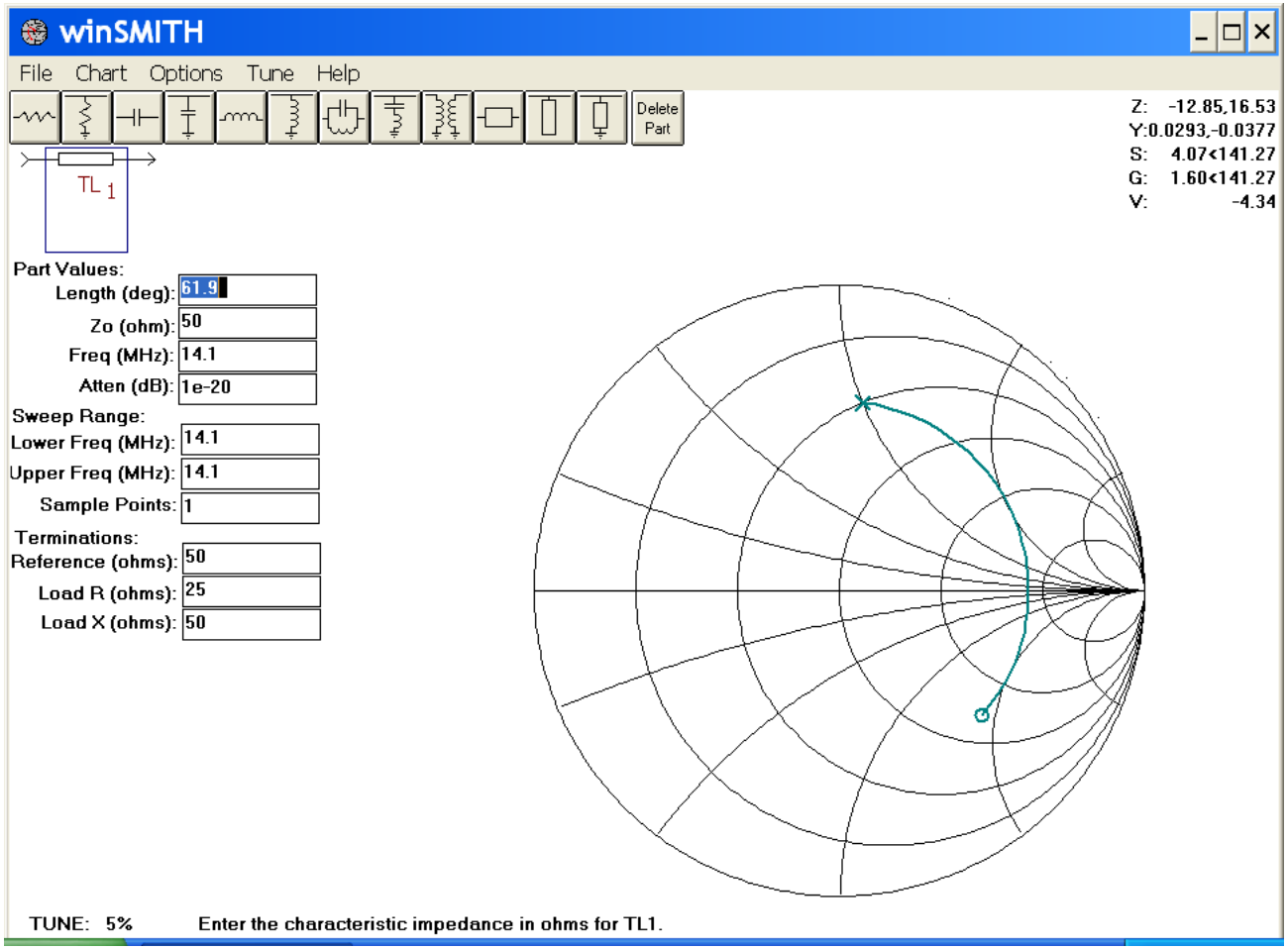
- Since the cable impedance is 50 ohms, we must divide the load impedance by 50 to plot it on the Smith Chart.

- Z_L (normalized) = (25 + j50)/50

- = 0.5 + j1.0

Plotting

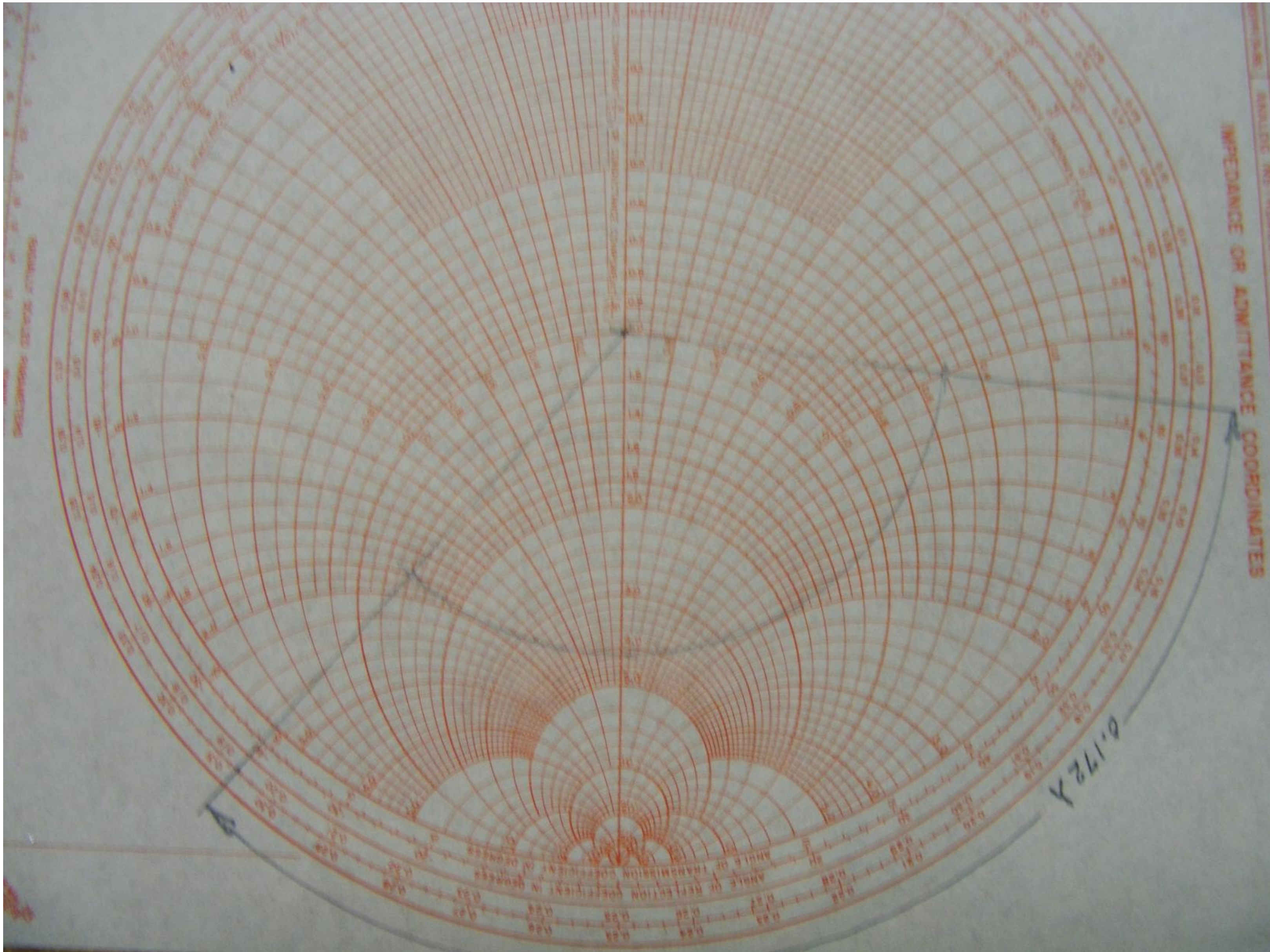
- Place a dot at 0.5+ J1.0
- Extend a radial line from the center through 0.5+j1.0 to the “wavelengths toward generator” scale on the periphery.
- Read approx. 0.1345
- Add 0.172 to get 0.3065
- Extend another radial line from the center through 0.3065 on the “wavelengths toward generator” scale.

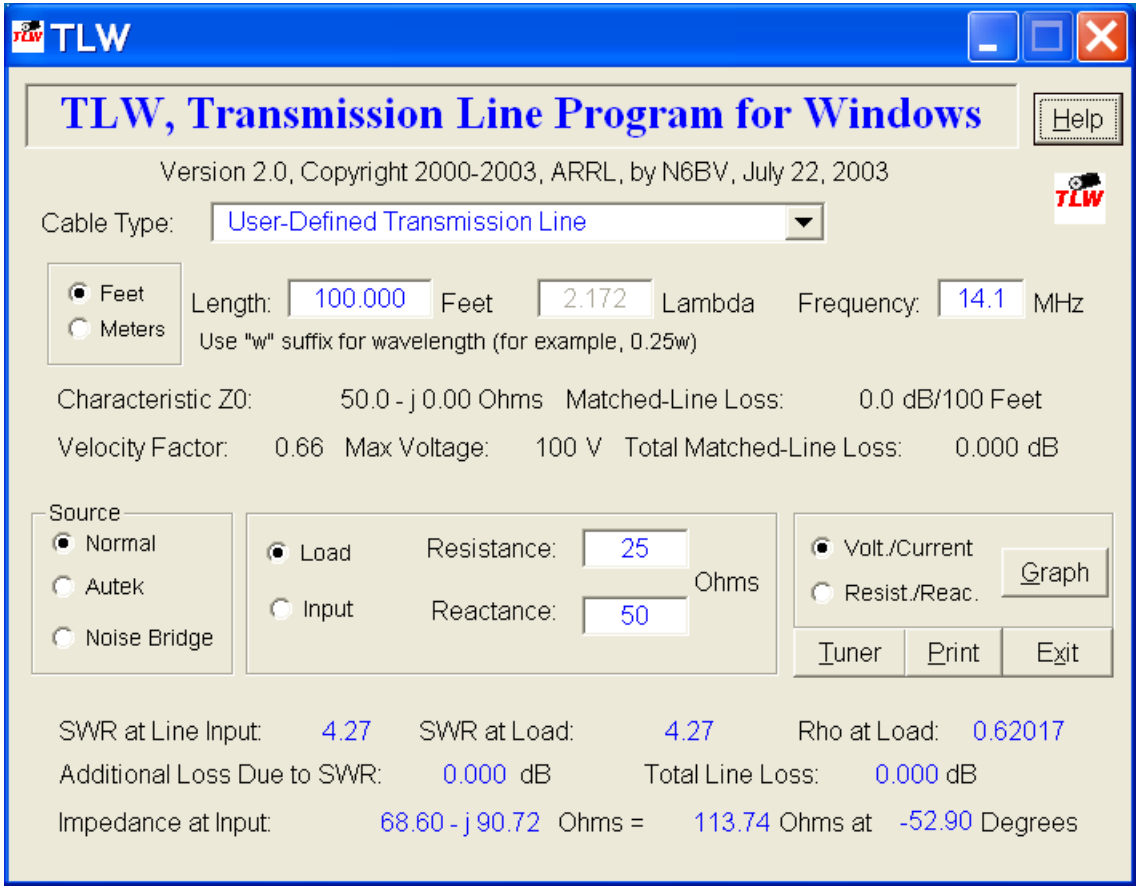

winSMITH
File
Chart
Options
Tune
Help
Delete Part
TL 1
Z: -12.85,16.53
Y:0.0293,-0.0377
S: 4.07<141.27
G: 1.60<141.27
V: -4.34
Part Values:
Length (deg): 61.9
Zo (ohm): 50
Freq (MHz): 14.1
Atten (dB): 1e-20
Sweep Range:
Lower Freq (MHz): 14.1
Upper Freq (MHz): 14.1
Sample Points: 1
Terminations:
Reference (ohms): 50
Load R (ohms): 25
Load X (ohms): 50
TUNE: 5%
Enter the characteristic impedance in ohms for TL1.

Plotting Cont’

- Place one leg of your dividers on the center and the other leg on 0.5+j1.0
- Draw an arc clockwise (0.172 wavelengths) to the second radial.
- Read approx. 1.4 – j1.8 at the intersection.
- Multiple by 50 to un-normalize.
- Z at sending end is approx. 70-j90 ohms

  (An inductive antenna impedance looks capacitive at the transmitter.)


IMPEDANCE OR ADMITTANCE COORDINATES
0.172λ


TLW
TLW, Transmission Line Program for Windows
Help
Version 2.0, Copyright 2000-2003, ARRL, by N6BV, July 22, 2003
Cable Type:
User-Defined Transmission Line
Feet
Meters
Length:
100.000
Feet
2.172
Lambda
Frequency:
14.1
MHz
Use "w" suffix for wavelength (for example, 0.25w)
Characteristic Z0:
50.0 - j 0.00 Ohms
Matched-Line Loss:
0.0 dB/100 Feet
Velocity Factor:
0.66
Max Voltage:
100 V
Total Matched-Line Loss:
0.000 dB
Source
Normal
Autek
Noise Bridge
Load
Input
Resistance:
25
Reactance:
50
Ohms
Volt./Current
Resist./Reac.
Graph
Tuner
Print
Exit
SWR at Line Input:
4.27
SWR at Load:
4.27
Rho at Load:
0.62017
Additional Loss Due to SWR:
0.000 dB
Total Line Loss:
0.000 dB
Impedance at Input:
68.60 - j 90.72 Ohms =
113.74 Ohms at
-52.90 Degrees

Input Impedance (Z_{in}) of a lossless transmission line :

$j := \sqrt{-1}$ define "j"

Problem parameters:

$l := 100\,ft$

$\phi := 61.9\,deg$

$Z_o := 50$

$Z_L := 25 + 50j$

$$Z_{in} := Z_o \cdot \frac{\left[\left(\frac{Z_L}{Z_o}\right)\cdot\cos(\phi) + j\cdot\sin(\phi)\right]}{\cos(\phi) + j\cdot\left(\frac{Z_L}{Z_o}\right)\cdot\sin(\phi)}$$

Answer: $Z_{in} = 68.766 - 90.794i$ OHMS

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