

Introduction to Smith Chart Software

Pacificon '13

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Back in '39

in '39...

Gone With the Wind

The Wizard of Oz

Goodbye Mr. Chips

and

Mr Smith Goes.....

Back in '39

And publishes his famous chart.

The Smith chart was originally used to

- 1) Visualize complex impedances and how they are transformed.
- 2) Calculate complex impedances (using chart ruler, compass, slide rule)
- 3) Used to solve problems associated antennas, filters, impedance matching...

Tutorials

If you look around the net you'll find:

Tutorials which talk about Reflection Coefficients and do ALL the math by hand.

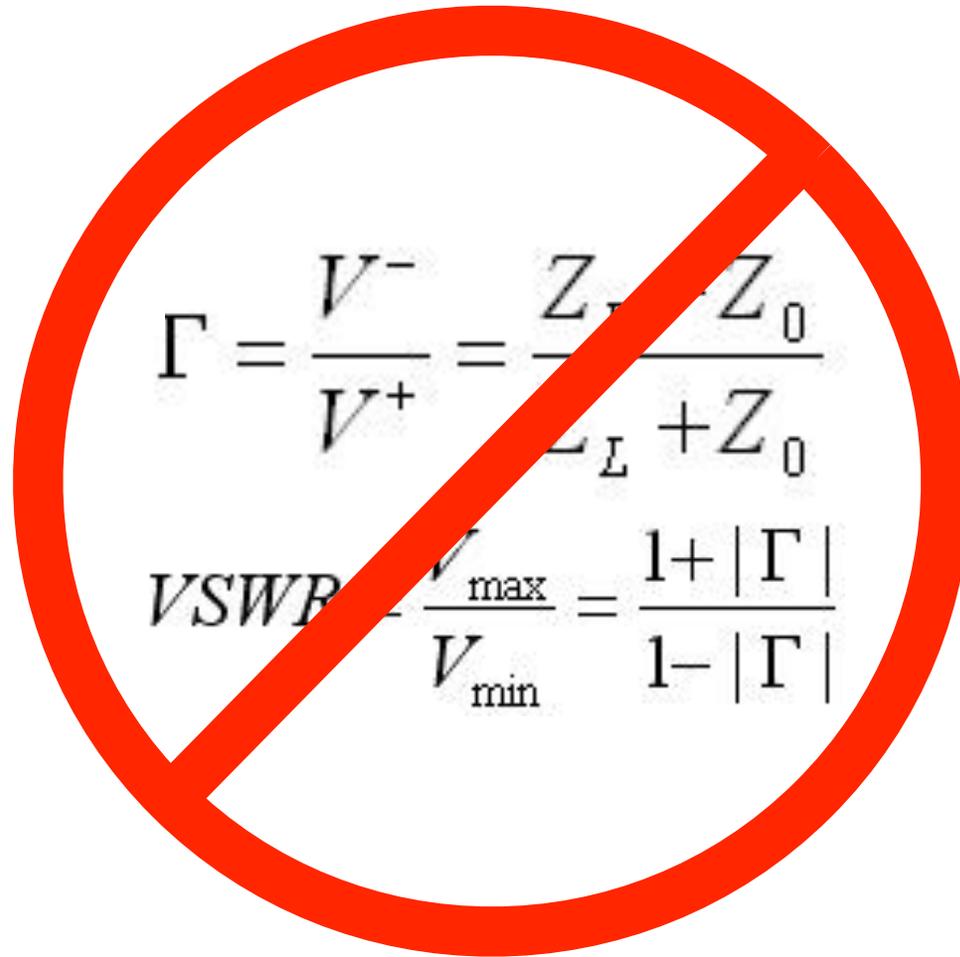
Tutorials which derive the Smith Chart

Most show how to solve a problem...

The SAME WAY THEY DID IN 1939!

The Smith Chart...

A Pragmatic Presentation


$$\Gamma = \frac{V^-}{V^+} = \frac{Z_L - Z_0}{Z_L + Z_0}$$
$$VSWR = \frac{V_{\max}}{V_{\min}} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

Today

Modern computer software can do all the calculations.

Instead of doing calculations by hand which takes minutes, the computer can do tens of thousands a second.

Thus, the Smith chart should be restricted to a visualization tool.

The Smith chart is, simply put, just an unusual form of graph paper!

Today

By using the Smith chart in this way we can:

Use interactive graphics to develop and intuition about impedance transformations and...

Use mathematics to obtain 'precise' answers.

The remainder of this presentation will be done using a program called SimSmith.

Desktop

The SimSmith desktop is divided into four major sections:

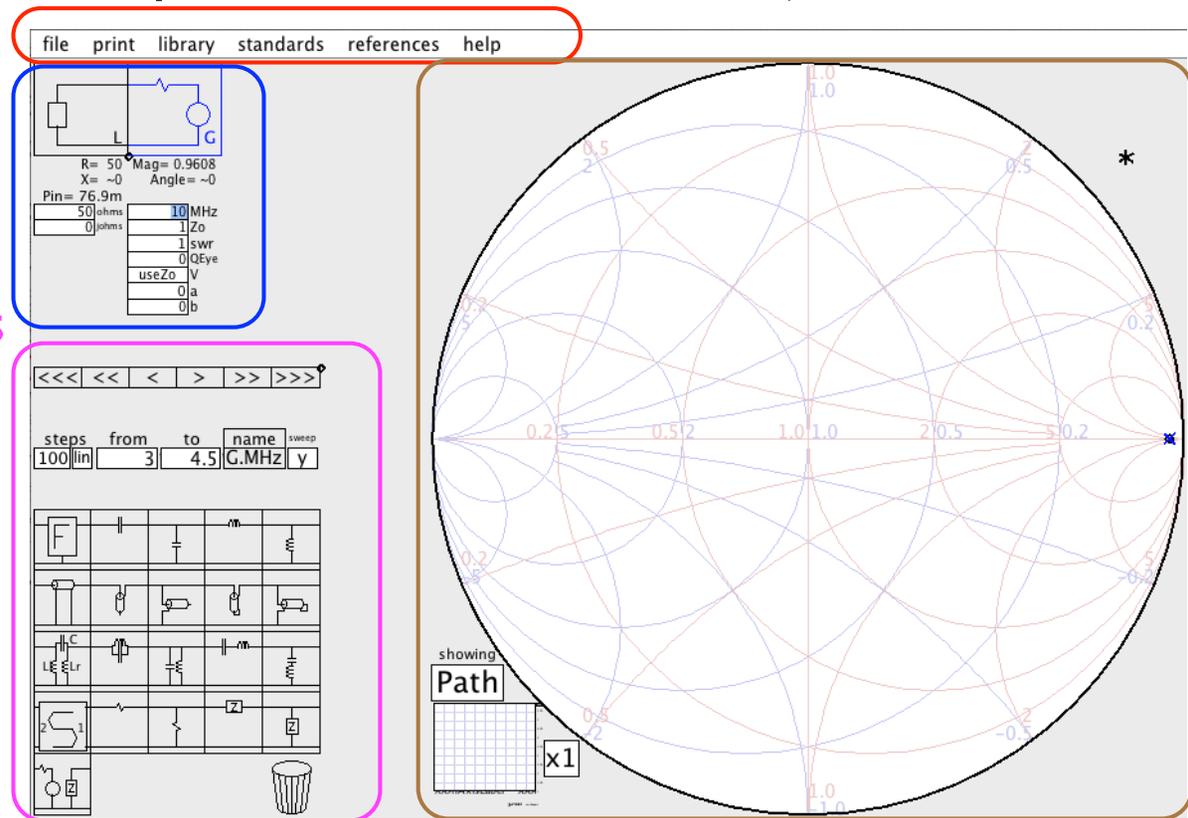
Menu

Circuit

Circuit Elements

Chart

Each area can be subdivided as we will see later



Plotting Impedances

Lets plot a few points to see how things are laid out.

(using SPLAT) to show them...

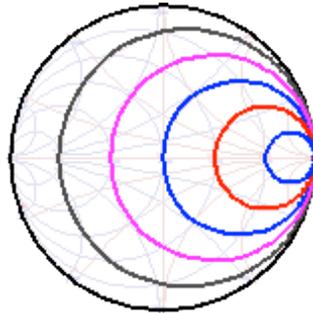
The traditional Smith chart impedances are usually 'normalized'... the center of the graph has impedance '1'.

This means, with the traditional Smith chart you need to multiply or divide all the impedances by your working Z_0 .

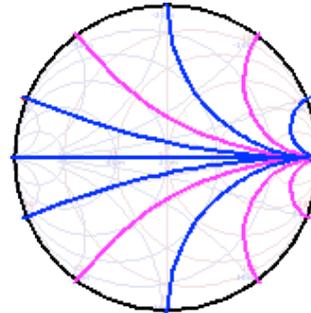
With computer software, this normalization is done automatically. We can set Z_0

Constant curves.

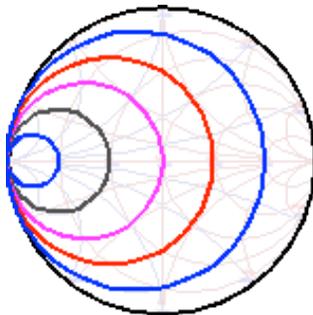
Constant
Resistance



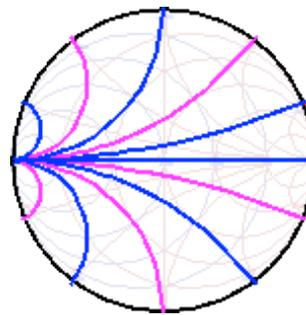
Constant
Reactance



Constant
Admittance



Constant
Susceptance



Analyzing a Circuit

SimSmith is designed to analyze circuits. All circuits have a Load and a Generator.

Uses 'Drag and Drop' paradigm to add, move, and delete elements.

Smith chart shows how an impedance changes as components are added.

Notice 'PATH' taken by impedance.

Each time the circuit changes, SimSmith analyzes the circuit and redraws the chart.

Analyzing a Circuit

Analysis is done at a given frequency specified by G.MHz.

Component values can be changed by:

- 1) Selecting field and typing a new value.
- 2) Selecting a field and using arrows.
- 3) Selecting a path and moving the endpoint.

Explore Effect of Elements

We can explore how elements change the impedance as they are added.

Inductors, Capacitors, resistors, Series and Parallel.

NOTICE: every component moves the impedance along an arc. This is an important observation. (True for lossless components.)

This would be a good time to see how transmission line stubs can modify the impedance.

First Application

Now that we've seen how elements affect impedance, lets solve a problem.

10 \rightarrow 50 ohms.

Many ways: LC, CL, TL, TStub,

Frequency Sweep

We've only analyzed the circuit at a single frequency.

Suppose we'd like to see how the impedance will change as we alter the frequency.

We could just change G.MHz and see how things change or...

SimSmith can show this by sweeping the G.MHz.

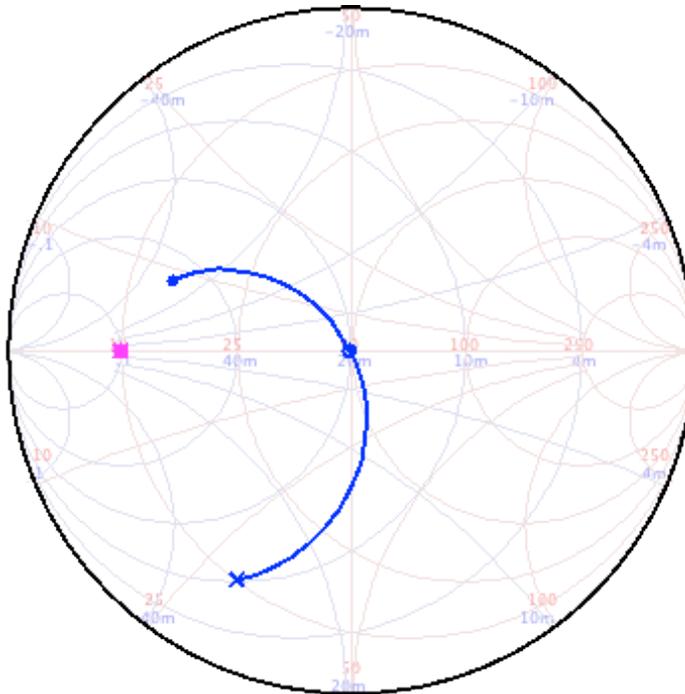
Turn on G.MHz sweep, turn on 'showing SWEEP'.

Frequency Sweep

Here is the sweep of 5 to 15 MHz.

check out splat

See that 'frequency' is reported.



Other Charts

SimSmith can show a couple other pieces of info.

SWR circle

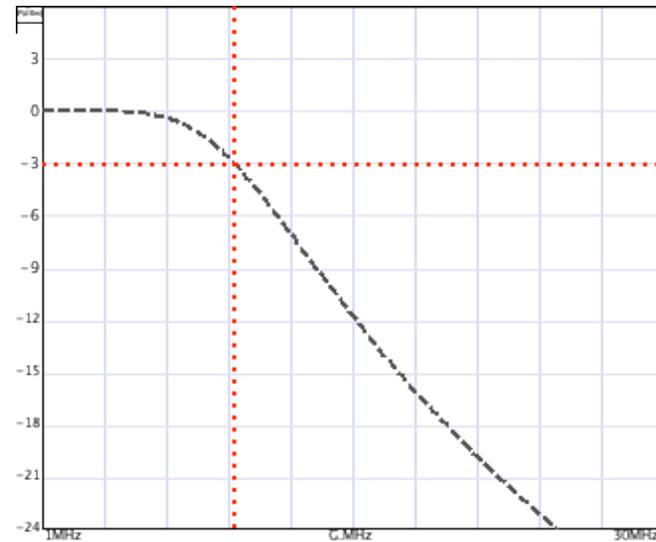
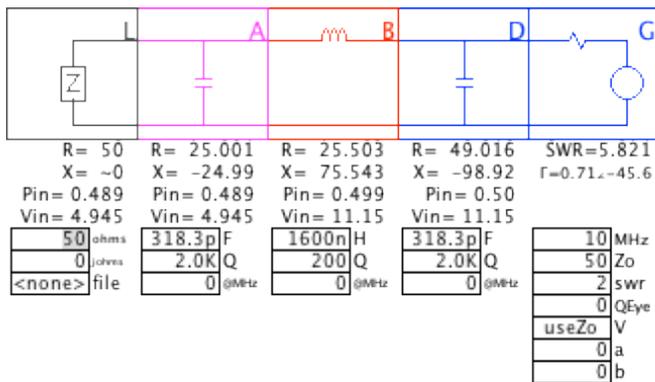
SWR chart (see chart on lower left... click it).

SimSmith can also show the power going into each circuit element. This can be useful for filters.

Here's a low pass filter (Pi).

Filter Example

10 MHz, LPF



9.990 MHz Pwr:-3.09dBw

Variable Loads

So far we've only worked with fixed loads. SimSmith can work with loads that vary with frequency.

Variable loads are specified using files.

These files can be from Antenna Simulators such as 4NEC2, CocoaNEC, EZNEC, etc.

They can also be from various antenna analyzers such as AIM4170, Rig Expert, N2PK VNA, etc.

Load File

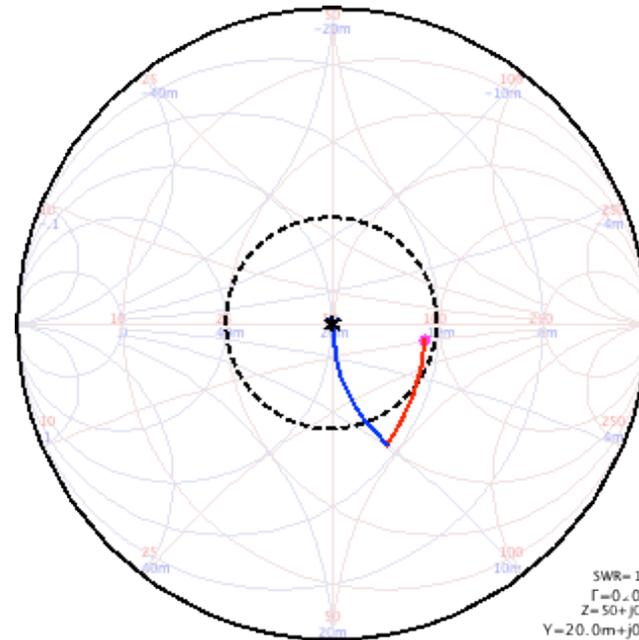
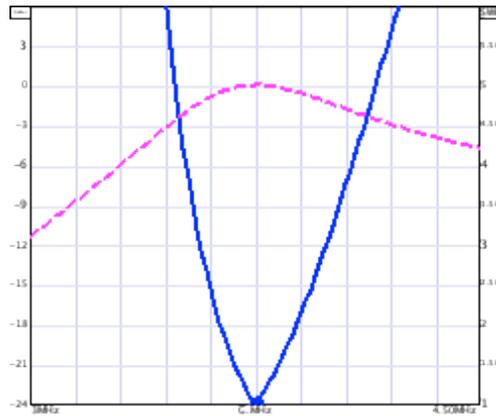
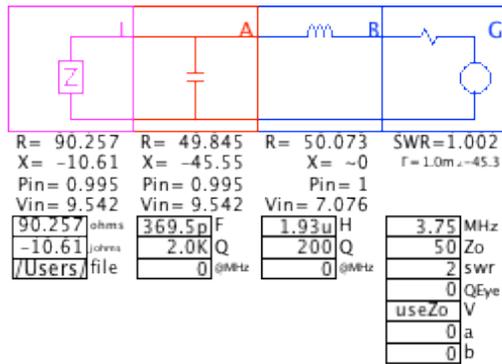
Here is an example of an antenna simulation using EZNEC. It is an 80 meter dipole.

We can sweep the frequency as before. Lets sweep 3.0 to 4.5 MHz.

lets design a matching network for 3.75 MHz

Load File

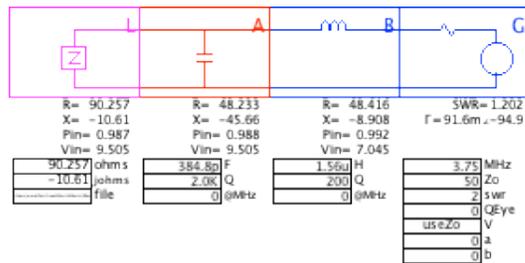
Here is the circuit and the resulting sweep:



Component Variation

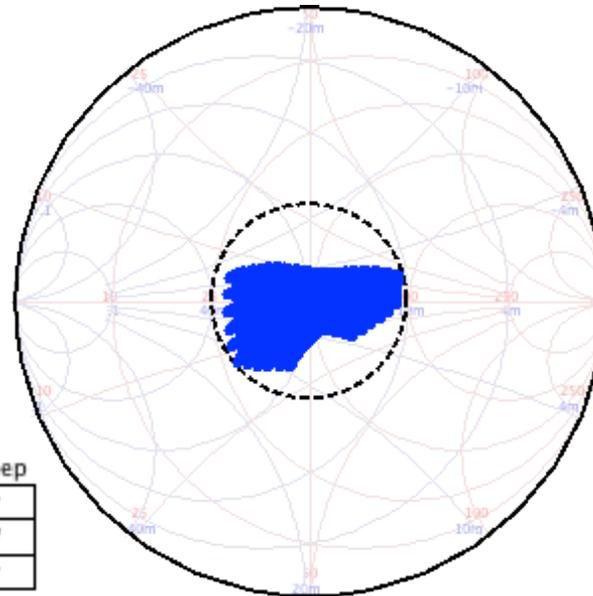
SimSmith allows you to explore how component value variation might affect your results:

Here's the circuit:



Here's the sweep menu

steps		from	to	name	sweep
50	lin	3.6757	3.8317	G.MHz	y
5	lin	296p	444p	A.F	y
5	lin	1.56u	2.34u	B.H	y



Playing with the Feed Line

SimSmith enables you to play with your circuit.

Lets add a feed line. The normal placement is after the matching circuit.

Notice how the feed line has little affect the SWR chart but it **DOES** affect the Smith chart.

(Add feed line and click on feed line.)

Playing with the Feed Line

But you can put the feed line between the antenna and the matching circuit....

And retune the match...

And maximize the SWR bandwidth further....

Backwards Smith Chart

Suppose you want to measure the impedance of an antenna which is already lofted and has a feed line attached.

You can use your antenna analyzer to make the measurement at your rig **THROUGH** the feed line.

Here is a load file with a measurement of an antenna measured through 80 feet of RG-8x

Backwards Smith Chart

We can load up the measurement data as the 'load'...

And then add 80 feet of RG-8X

And then 'subtract it' by making the length negative.

Compare this to the dipole measured at the feed point...

This works for all components in SimSmith.

Summation

Smith chart can be used to visualize complex impedances and how they change.

Modern computers can do all the heavy lifting...

This frees the user from error prone calculations.

This allows the user to explore the insights enabled by the graphic display of data.

This greatly accelerates the learning process.