NanoVNA Beyond SWR

ARRL Rocky Mountain Division Conference

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Roland Smith K7OJL

- First Licensed in February 1959
- Inspired by Sputnik and radio from space
- Hold an Amateur Extra Class license
- Little Pistol contester and DX Chaser
- CW Academy Advisor since 2020
- CW Academy website programmer
- Retired and live with my wife in Utah in the United States

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NanoVNA Saver (https://nanovna.com/?page_id=90)

Connecting a NanoVNA to a computer

NanoVNA Demonstration

- Connecting to NanoVNASaver
- Checking coax cable length
- Measure a random antenna
  - SWR
  - Smith Chart

Remember!

Impedance is a complex number

Part real
Part Imaginary

Resistance

Impedance
Measured in Ohms

$$Z = 25 + j40$$

Reactance

Here's Where Smith Charts Shine!

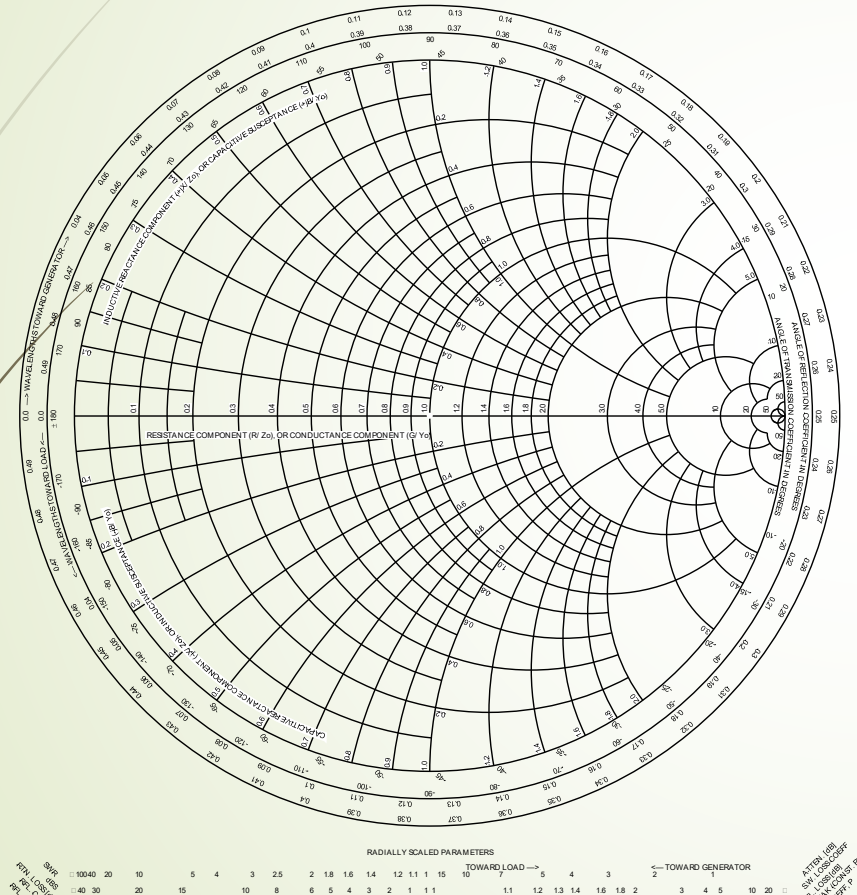
- Invented by Phillip H. Smith in 1936 while working for Bell Labs (published in 1939)
  - A Japanese scientist Mizuhashi Tosaku independently invented a similar chart in 1937 but didn't publish until after Smith's publication
- Developed as a method to graphically represent the RF characteristics of transmission lines and matching circuits
- Displays multiple characteristics at the same time
  - Impedance
  - Admittance
  - Reflection (SWR)
- Very useful to show how RF parameters behave at one or more frequencies

With many thanks to Alan Wolke W2AEW
ARRL NNJ Technical Coordinator

What Does a Smith Chart Look Like?

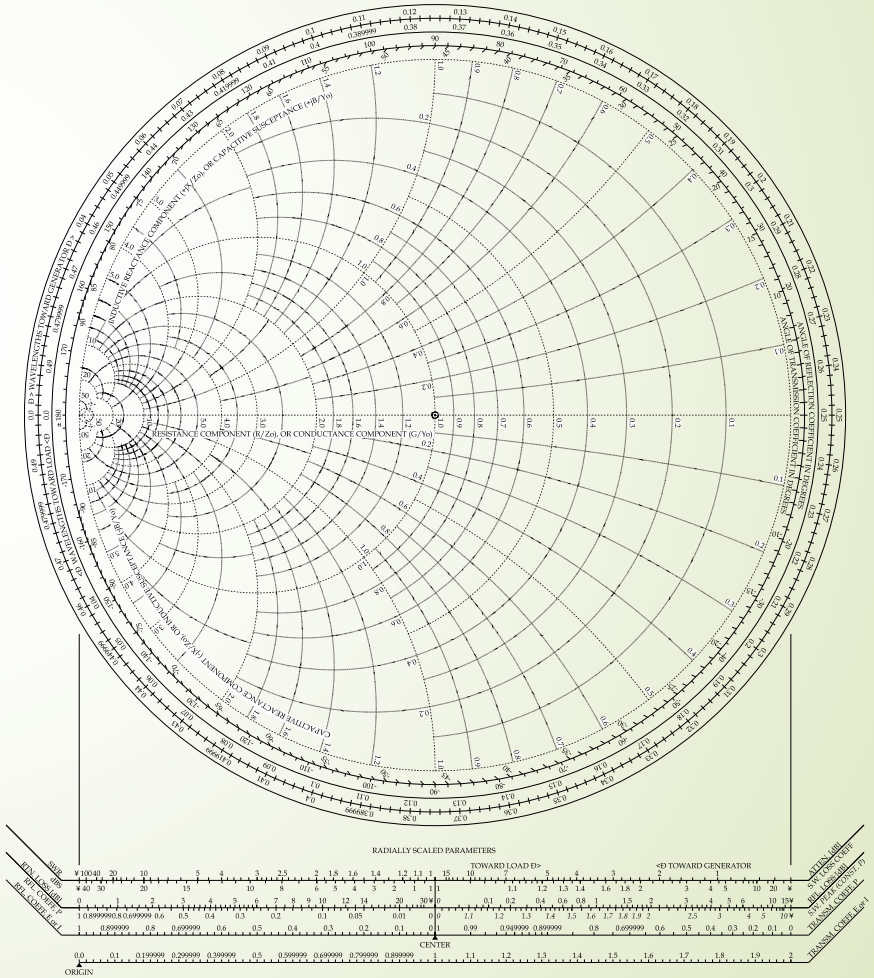
The Complete Smith Chart

Black Magic Design

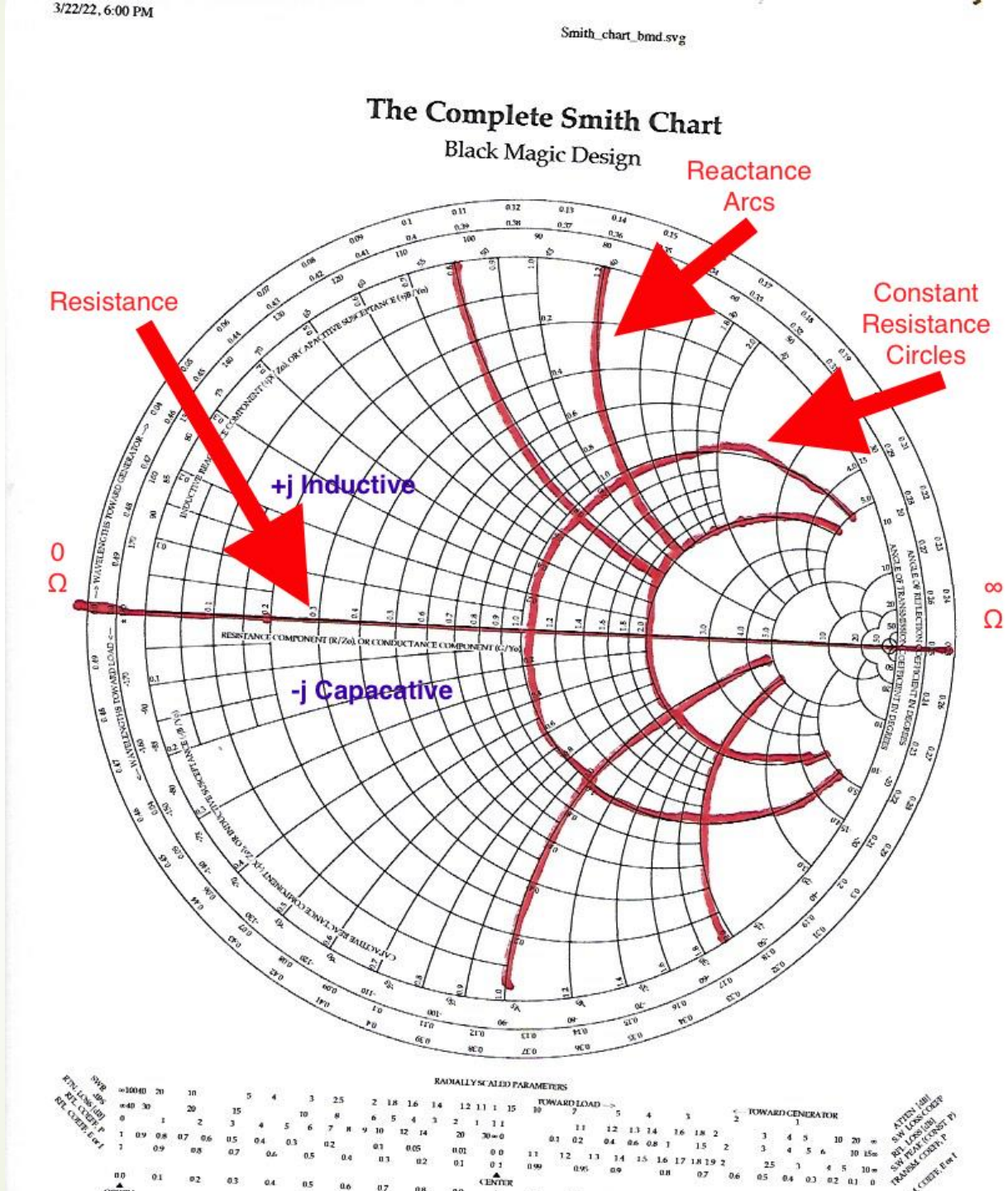


ADMITTANCE SMITH CHART

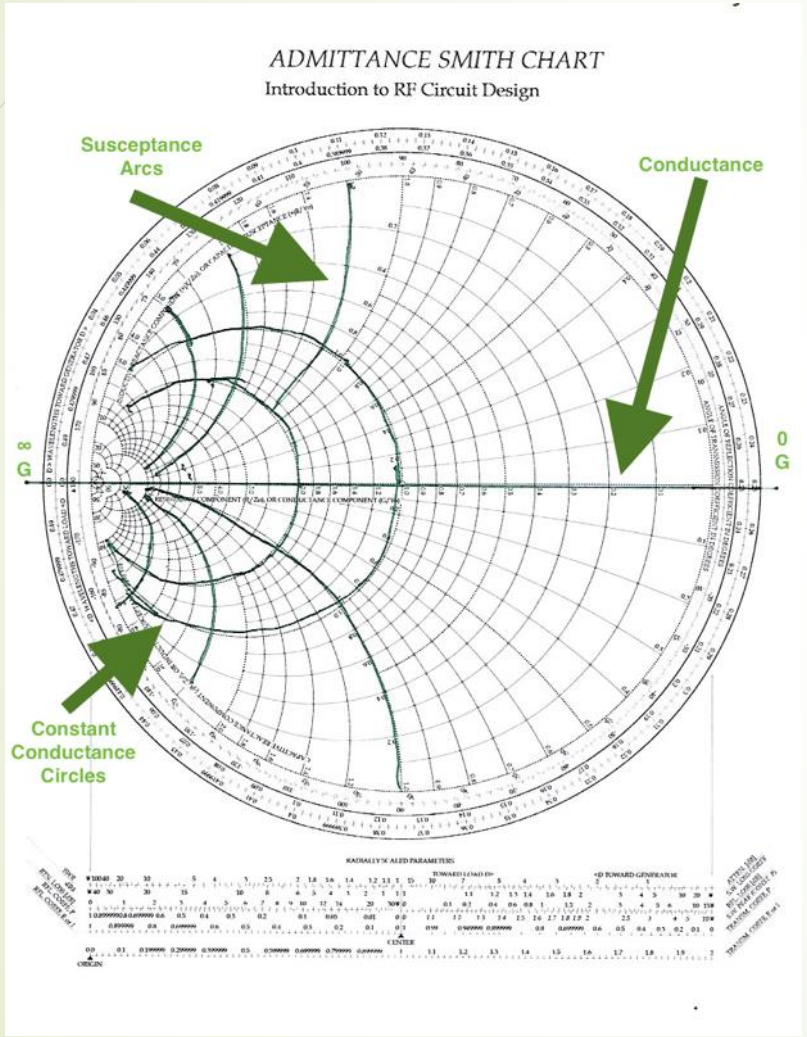
Introduction to RF Circuit Design



How to Interpret a Smith Chart

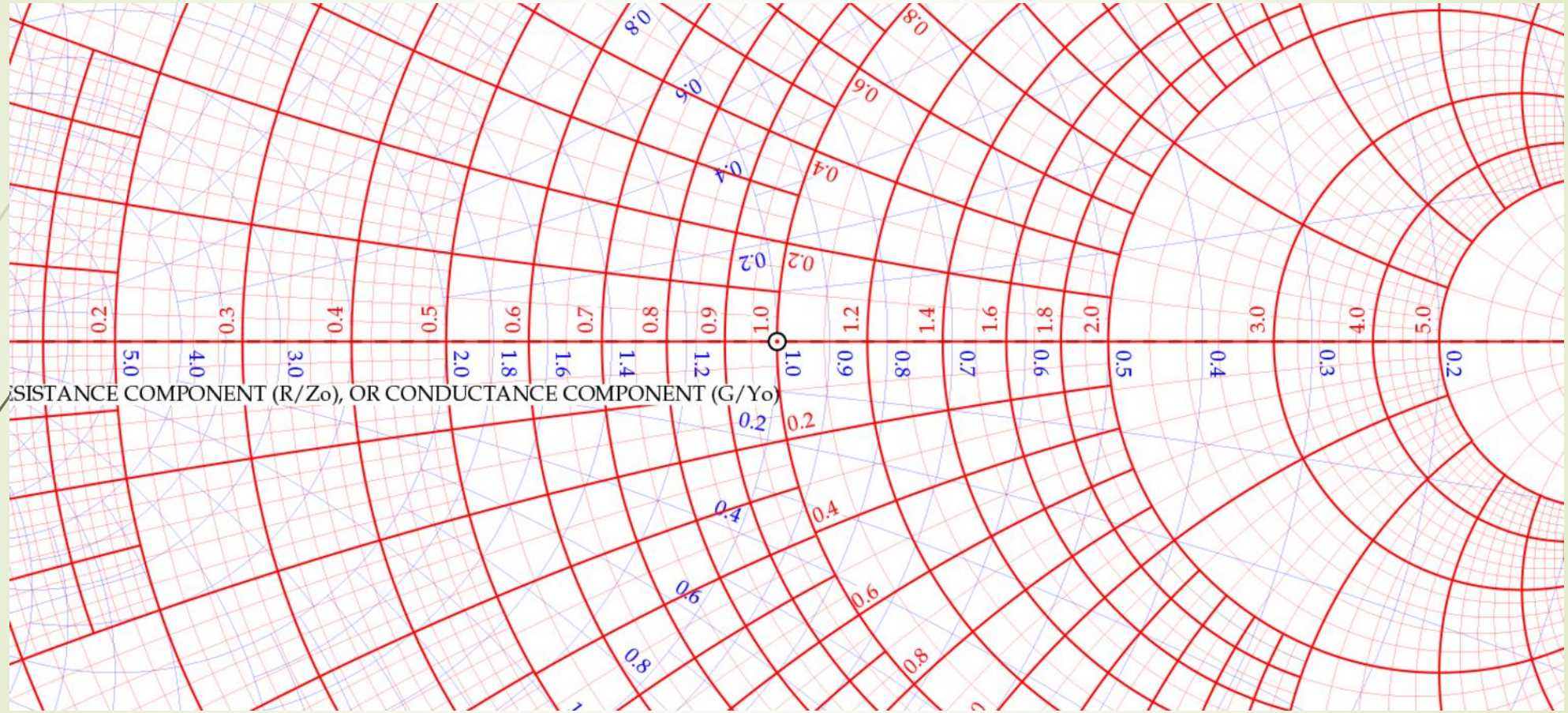


Admittance Smith Chart



- Inverse of Resistance is Conductance (Symbol: G)
- Inverse of Reactance is Susceptance (Symbol B)
- The same data can be plotted on an Admittance chart
- Impedance charts are useful for adding elements in series
- Admittance charts are useful for adding elements in parallel

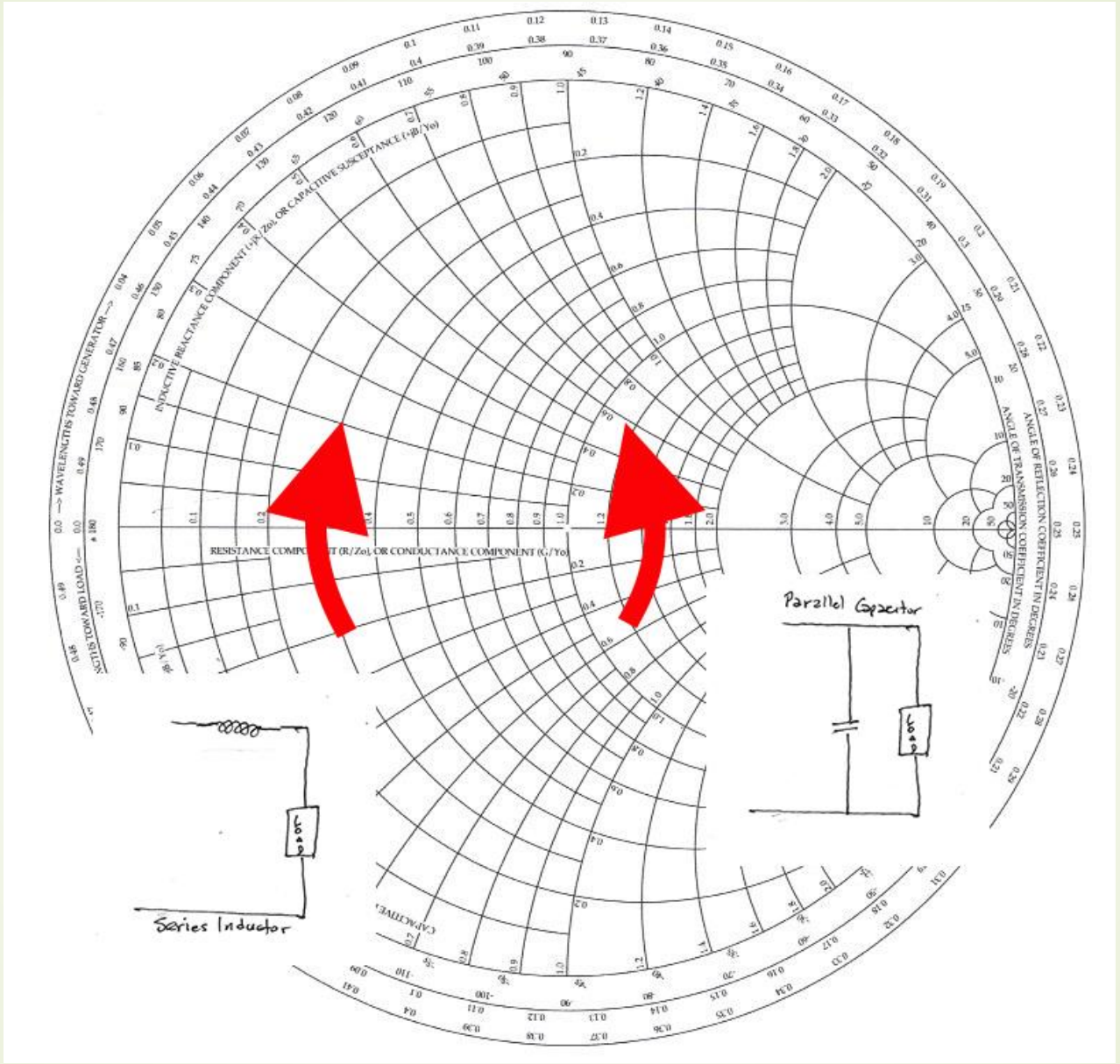
The Combination Chart



Impedance information in Red
Admittance information in Blue

Adding an inductor in series with the antenna will reduce capacitance and increase inductance.

Movement is along a resistance circle

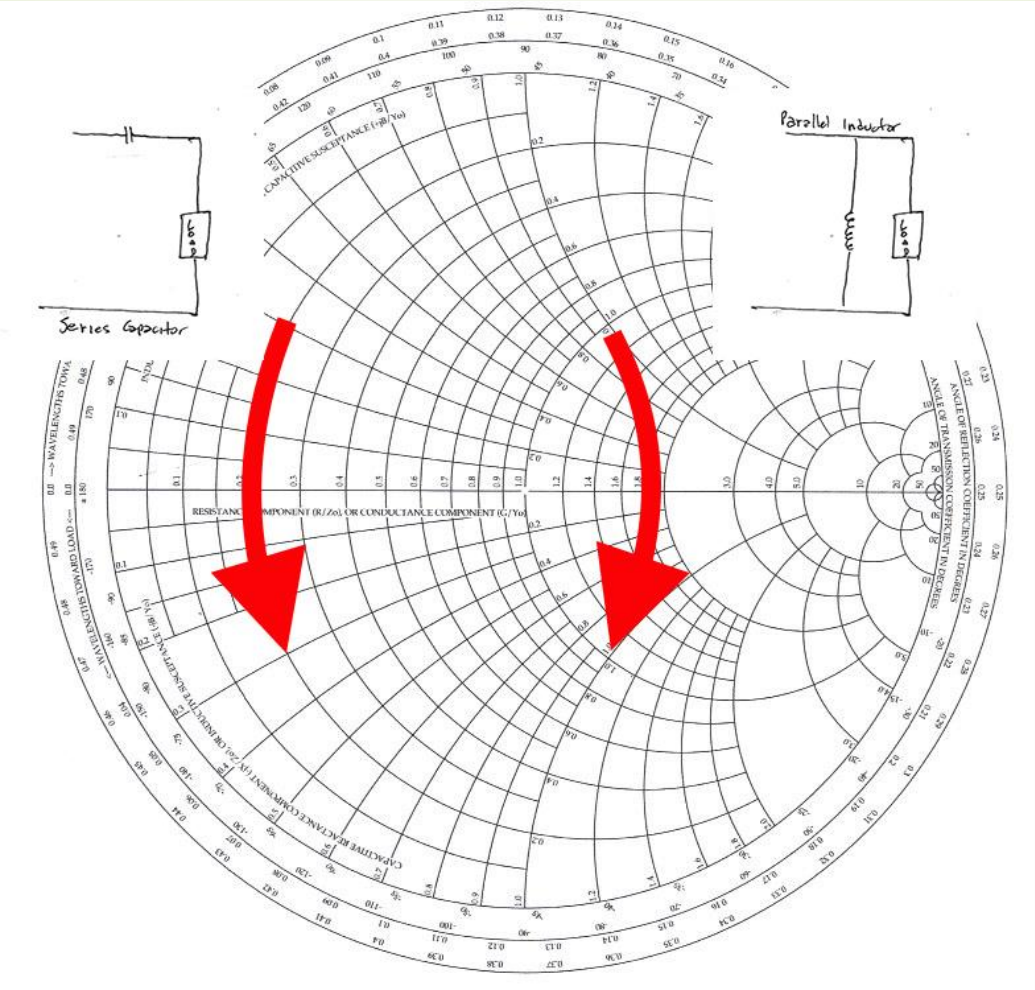


Adding a capacitor in parallel with the antenna will reduce capacitance and increase inductance.

Movement is along a conductance circle

Adding a capacitor in series with the antenna will reduce inductance and increase capacitance.

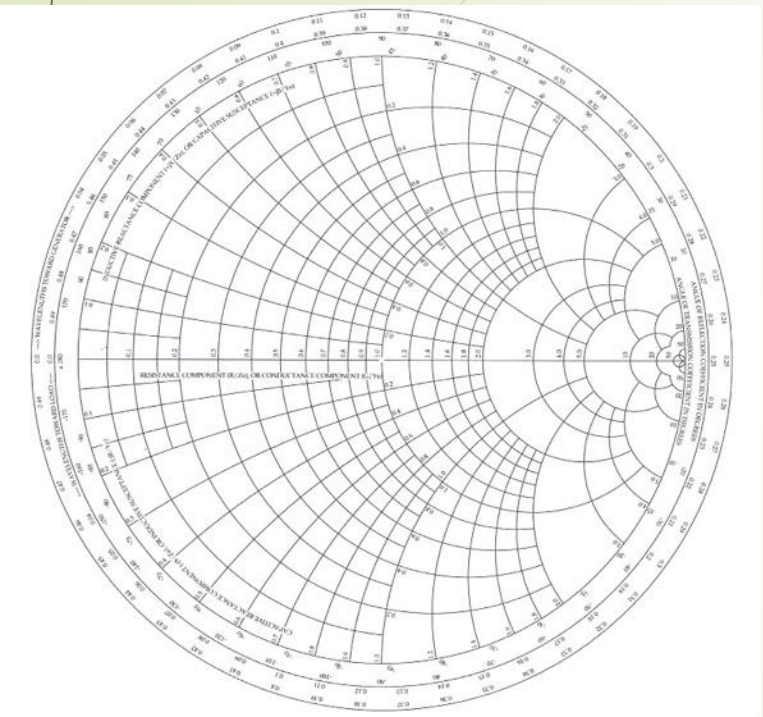
Movement is along a resistance circle



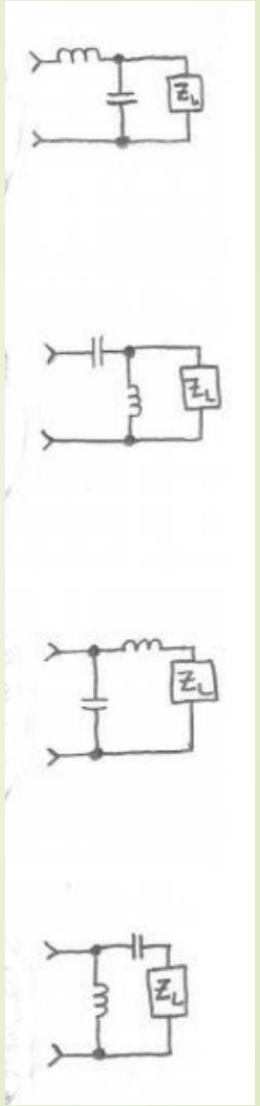
Adding an inductor in parallel with the antenna will reduce capacitance and increase inductance.

Movement is along a conductance circle

Common Topologies



- Top: Series Inductor, Shunt Capacitor
  - Inductor values move CW along the resistance circle
  - Capacitor values move CW along conductance circle
- Second: Series Capacitor, Shunt Inductor
  - Capacitor values move CCW along the resistance circle
  - Inductor values move CCW along conductance circle
- Third: Parallel Capacitor, Series Inductor
  - Capacitor values move CW along conductance circle
  - Inductor values move CCW along resistance circle
- Fourth: Parallel Inductor, Series Capacitor
  - Inductor values move CCW along conductance circle
  - Capacitor values move CW along resistance circle
- There are other less common topologies, such series and parallel inductors, series and parallel capacitors, inductors and resistors, and more

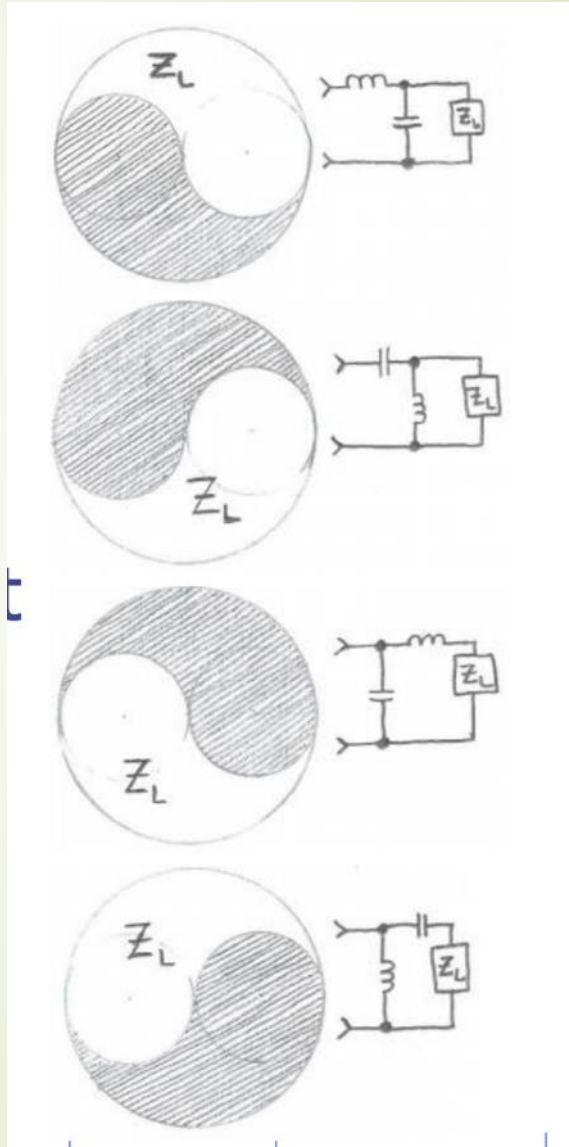


Matching the Load to the Transmitter

- Pick a topology based on where the load is on the Smith chart
  - Sometimes more than one topology works
- Calculate how much move is required on each arc
- Calculate the amount of inductance and capacitance needed
- Adjust accordingly. Calculators available online

Recommend SimSmith

http://www.ae6ty.com/smith_charts.html



SimSmith Demonstration

SimSmith

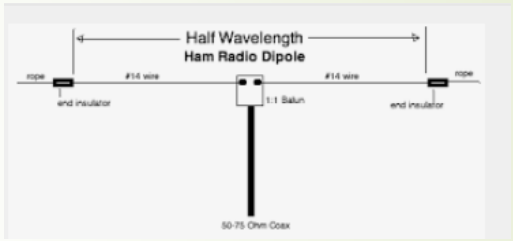
http://www.ae6ty.com/smith_charts.html

Some Considerations

Where to put the matching network?

Here?

Here?



If the feedline is ½ wavelength (or multiple), it doesn't matter

Best is at the antenna feed point?

Do we need to take velocity factor into account?

No

How about feedline loss?

Nope

Questions?