# Hints and Kinks of Antenna Design
(in A Case Study)

Ward Harriman

AE6TY

10-12-12

# Avoid this trap….

The cows on a dairy farm have stopped giving milk. The farmer is at a loss and so calls upon the local university for help.

The university sends out a PhD in veterinary medicine who checks all the cows for diseases but finds nothing.

The university then sends out an environmentalist who checks for pollution, temperature swings, predators… but who, also, finds nothing.

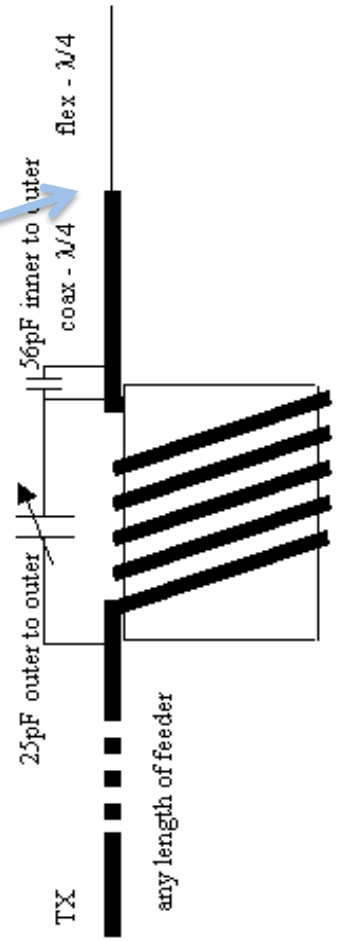
The university then sends out a physicist. He wanders around, measures the cows, the fields, the air, the grass, the barn… everything. Then he starts scribbling madly. After an hour or so he says:

I HAVE A SOLUTION TO YOUR PROBLEM… now if we assume the cows are spherical and in free space…..

# HALF WAVE VERTICAL ANTENNA

This antenna consists of:

- Half Wave Radiator
- Center Fed with Coax
- Trap at Bottom
- Coax feed Line to Rig
- No ATU Required




http://g4oep.atspace.com/endfed/endfed.htm

# Observations:

First Described by James Taylor, W2OZH in ’91

Described on the web in many places but:

- Widely varying reports of success
- Widely varying construction
- Generally non-optimal designs

# Before we look at some results:

It is widely believed that this type of antenna does not need an antenna tuner.

It is widely believed that the trap shouldn't affect operation.

It is widely believed that the trap need not resonate.

# Evolution of a Specific Example

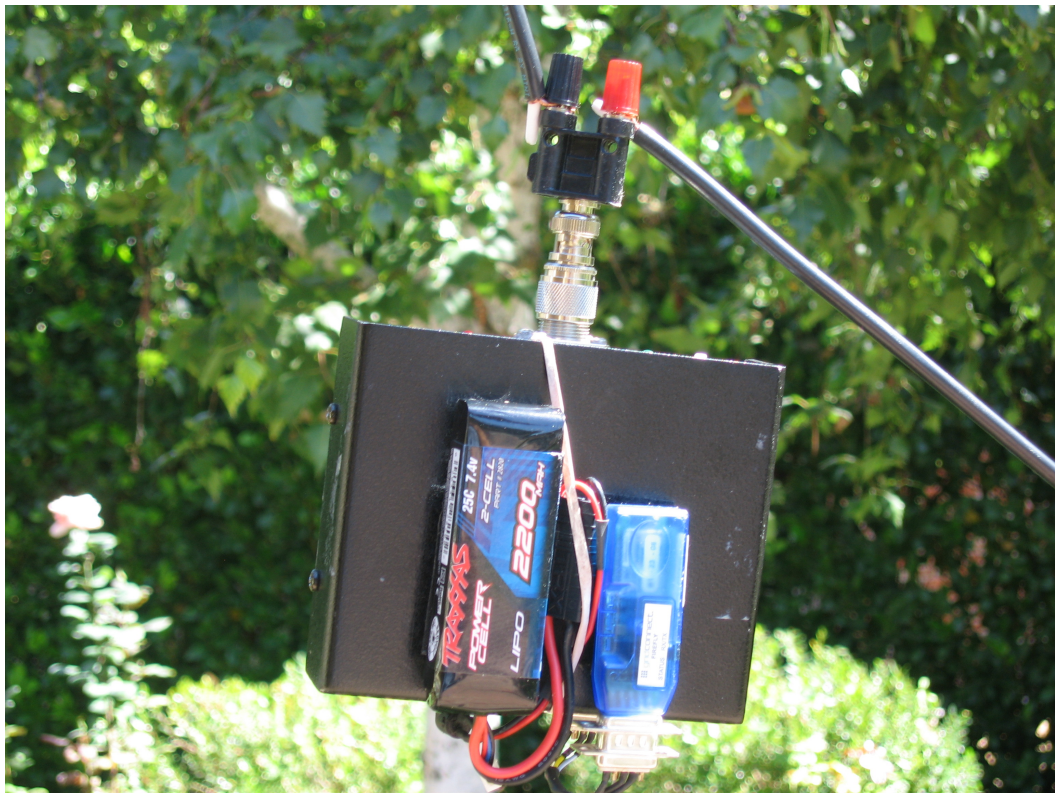
Start with a basic dipole, fed in the center:

# Measure it.

I used an AIM4710B antenna analyzer:

I've modified to be wireless to eliminate feed line effects.

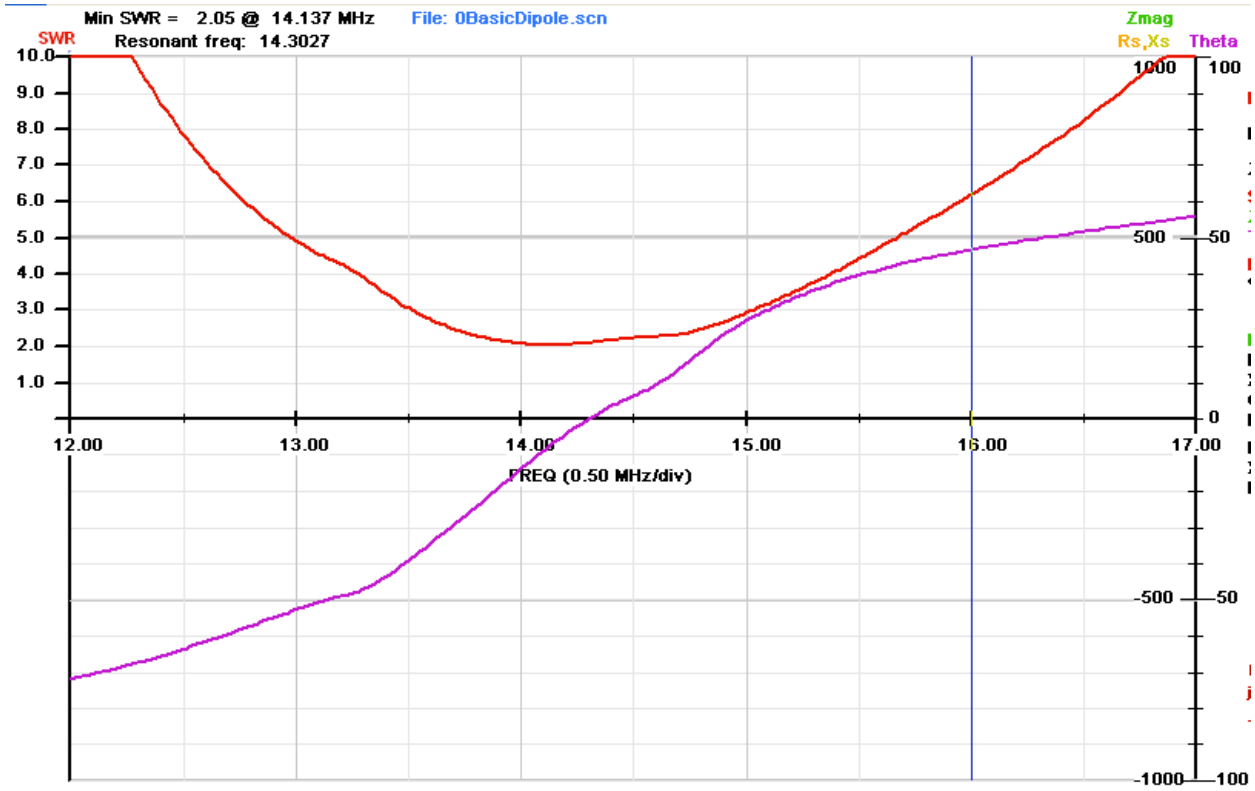
Lithium battery and bluetooth.



# Here's what I Got First

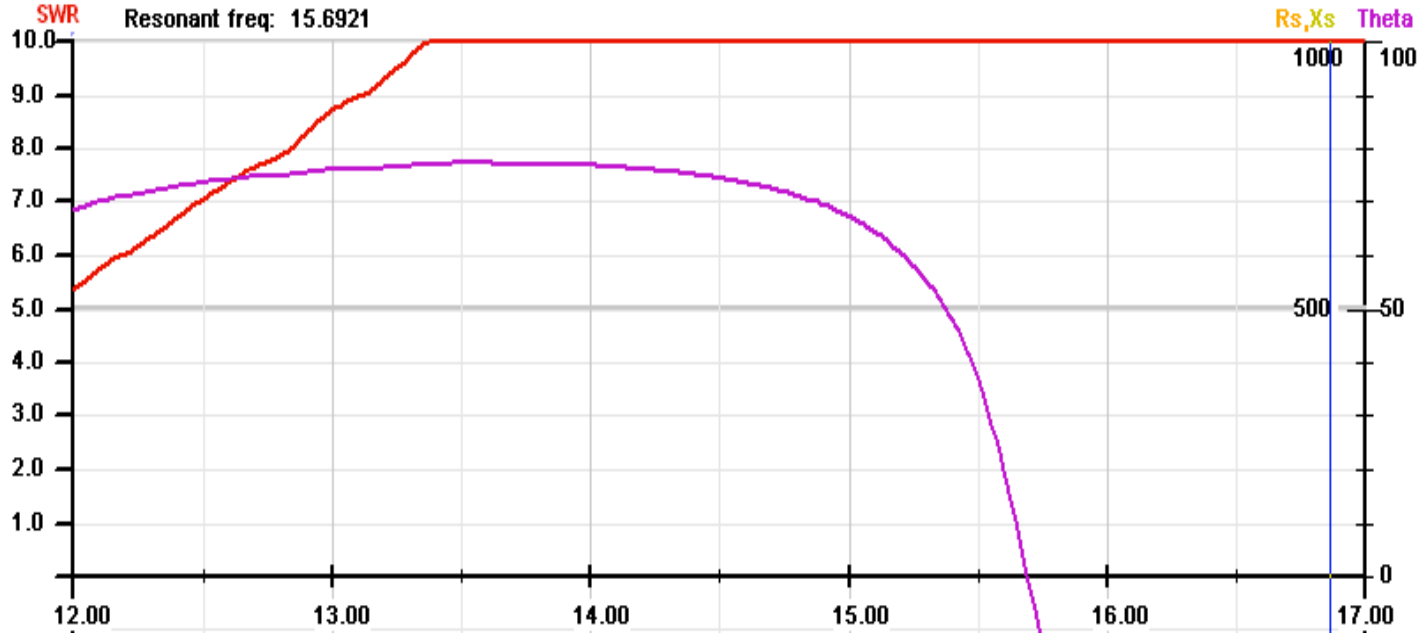
(just the dipole)

Notice: SWR IS NEVER BELOW 2/1.



# Here the trap is just coax coil:

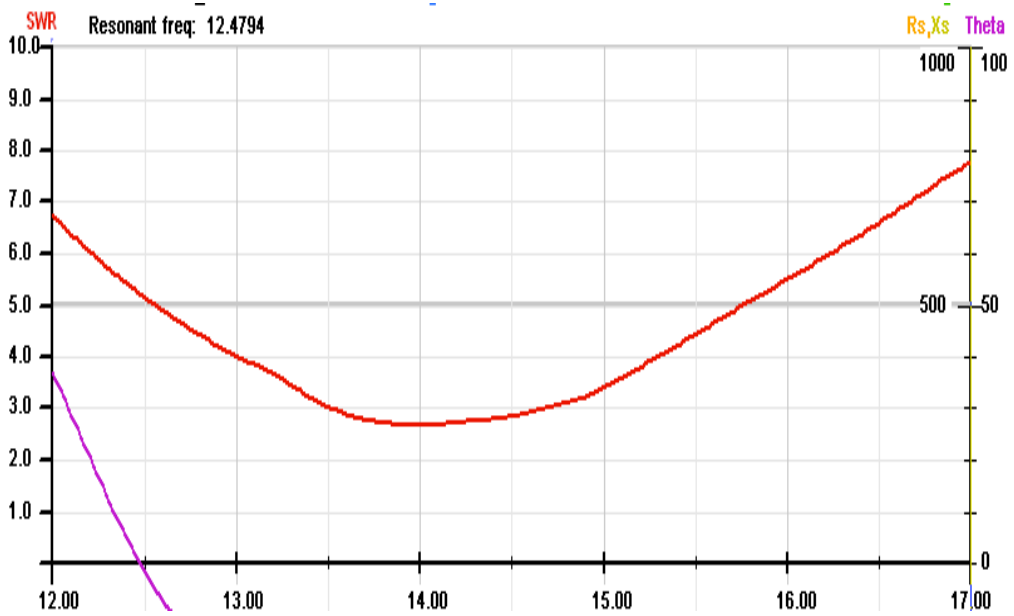
Inductance too small by a factor of 30 or so.




We will need much larger inductance: > 75 uH.

# Here the trap is a 150 uH inductor

## Looks pretty good except for SWR.




16 turns of RG174 over HSC surplus ferrite.

We'll come back to this at the end.

# Now, here's a REAL trap…

RG8X Coax

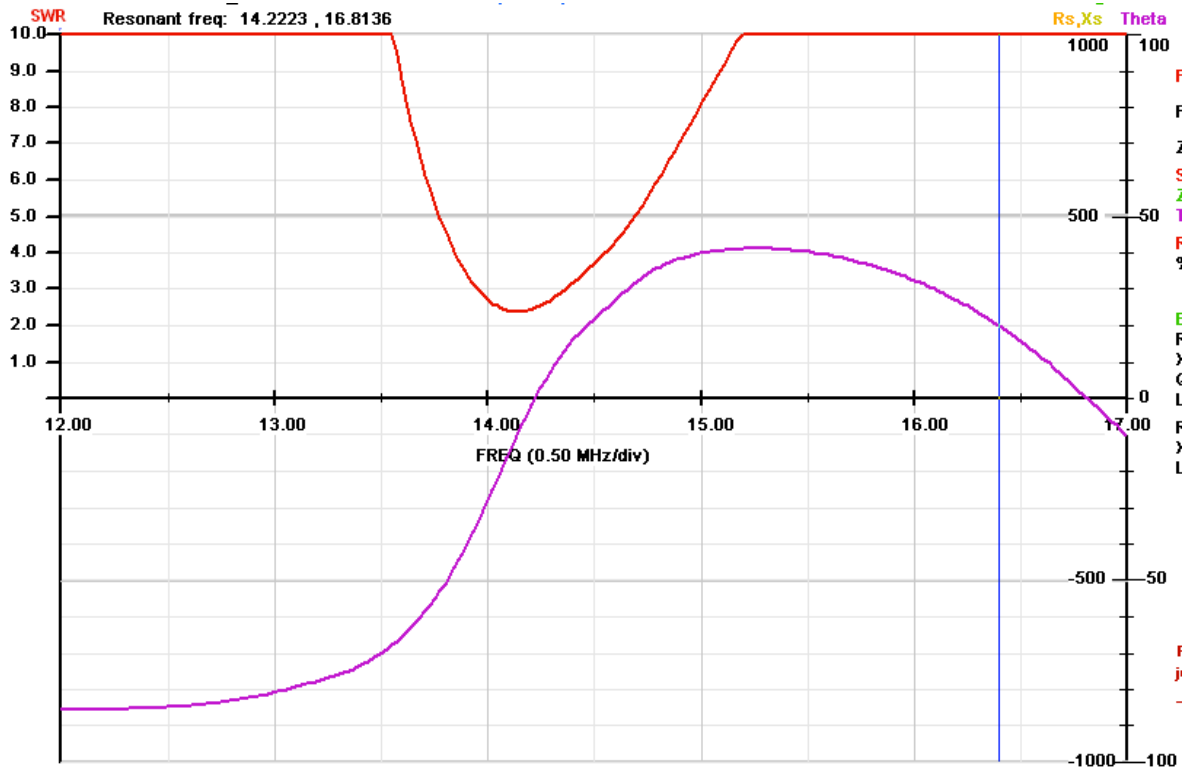
8 turns: 1.5 uH

varCap:  85 pF

(14.1 MHz)

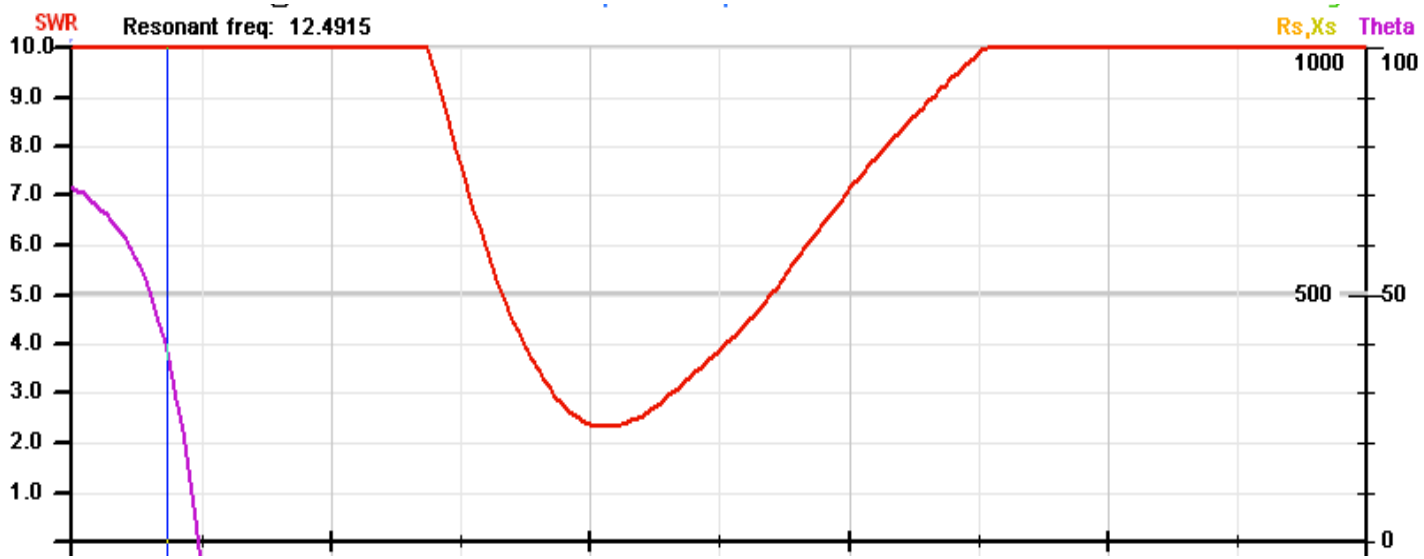
# Here, antenna with Trap

Trap resonance makes impedance higher AND SWR narrower…



# One last step… move feed point.

So far, we've measured the impedance at the center of the dipole. What happens if we move the feed point to below the Trap????



# Whew… not much change.

But still bad…. What do we do?

Could use antenna tuner and declare success…

Could use some 'impedance matching techniques' (we got time……)

# Two Problems to Solve:

First, we want a lower SWR:

- Make sure our expensive rig doesn't fold back.
- Increase power from our simple rig.

Second, we want a wider SWR:

- No 'retuning' over entire band.
- No 'retuning' with change in surroundings.

# Well, how to Match.

Here we will impedance match using a seldom used technique.

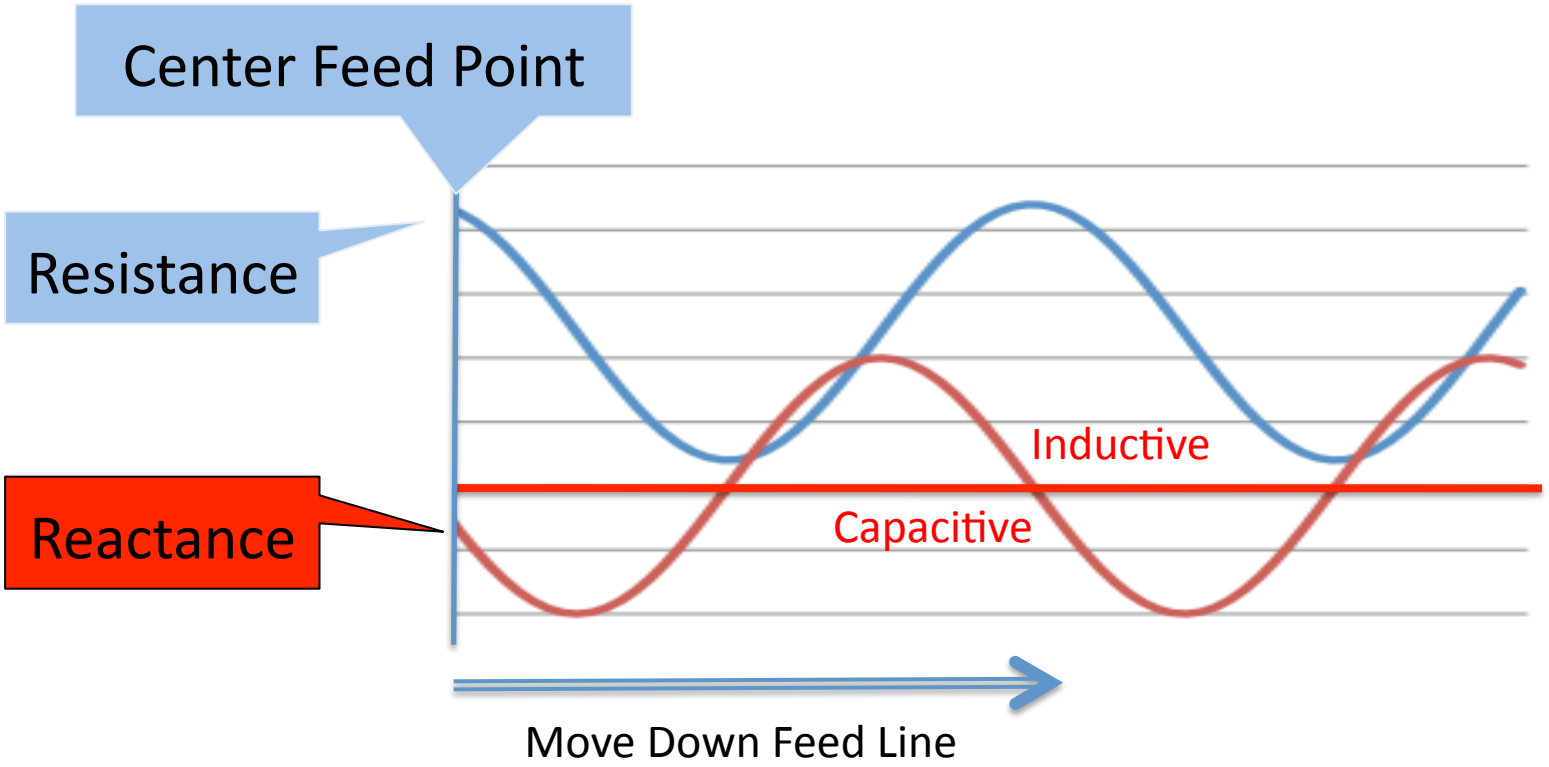
Use RG8X, 50 ohm Coax.

and

Fixed capacitors.

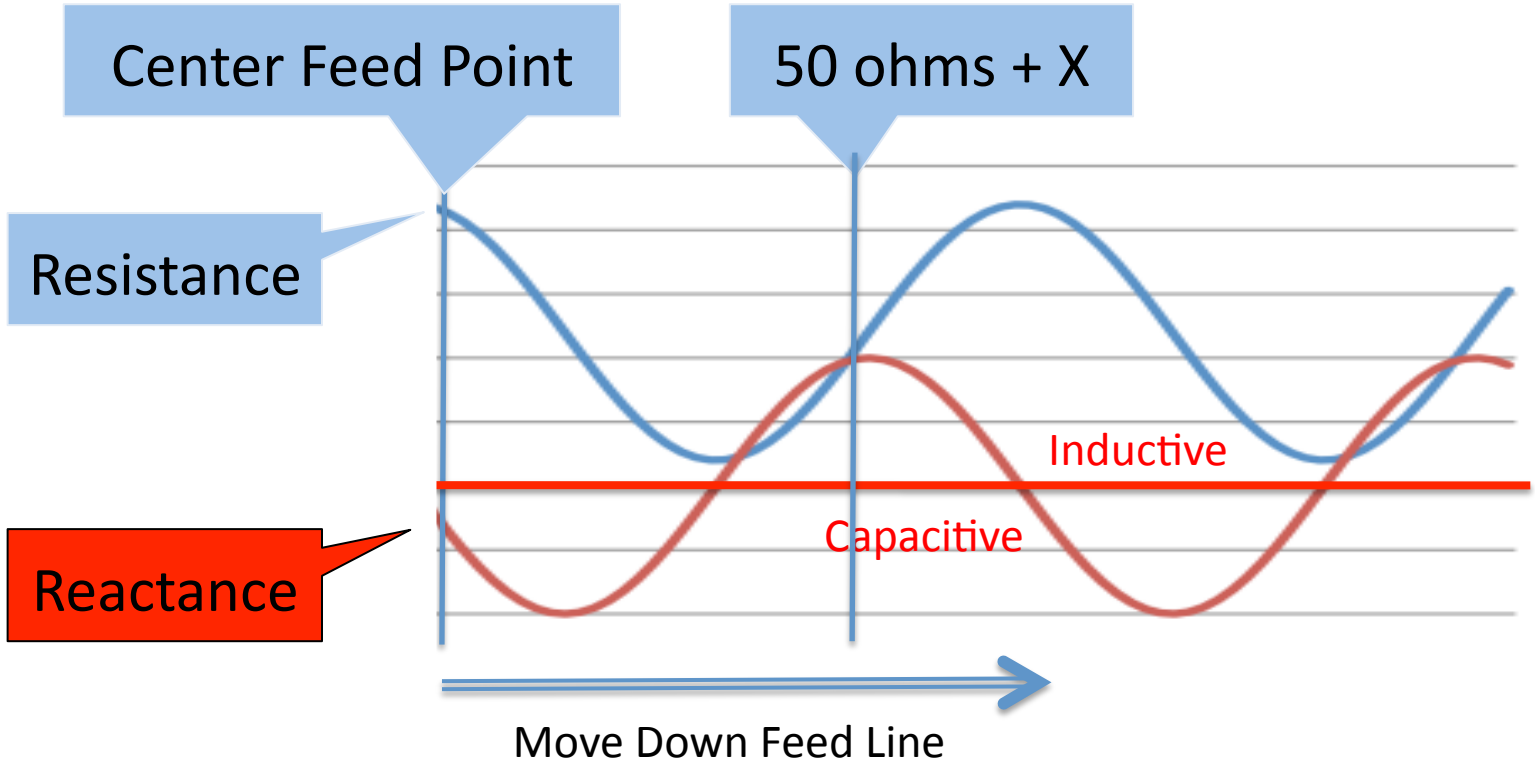
# To Understand Match.

We need to look at the impedance as we move down the feed line from the center feed point:



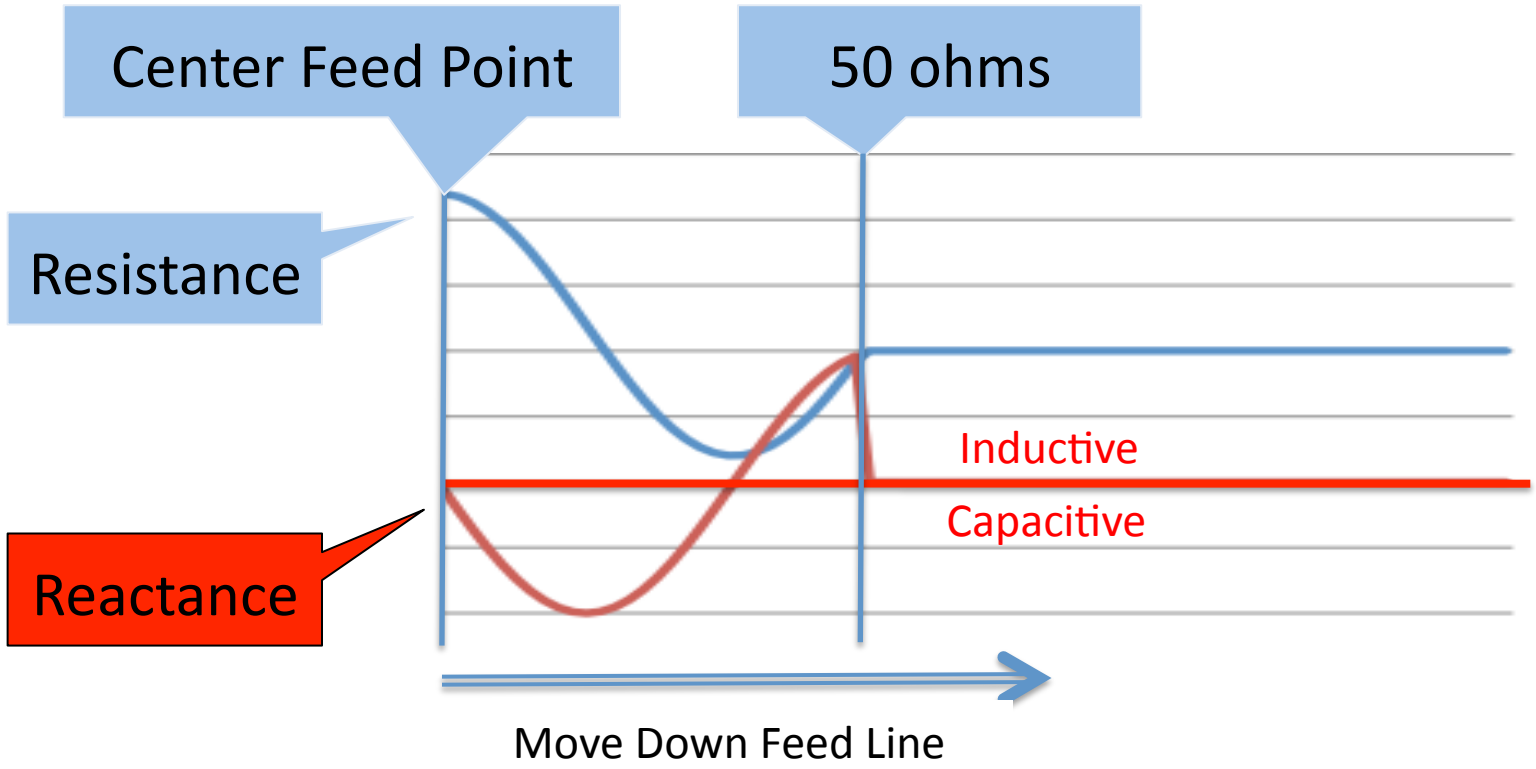
# Pick a Place with 50 Ohms:

As we move to the right, resistance and reactance change… SWR DOES NOT!



# Cancel out Reactance with CAP:

If we add cap of right amount we get this:



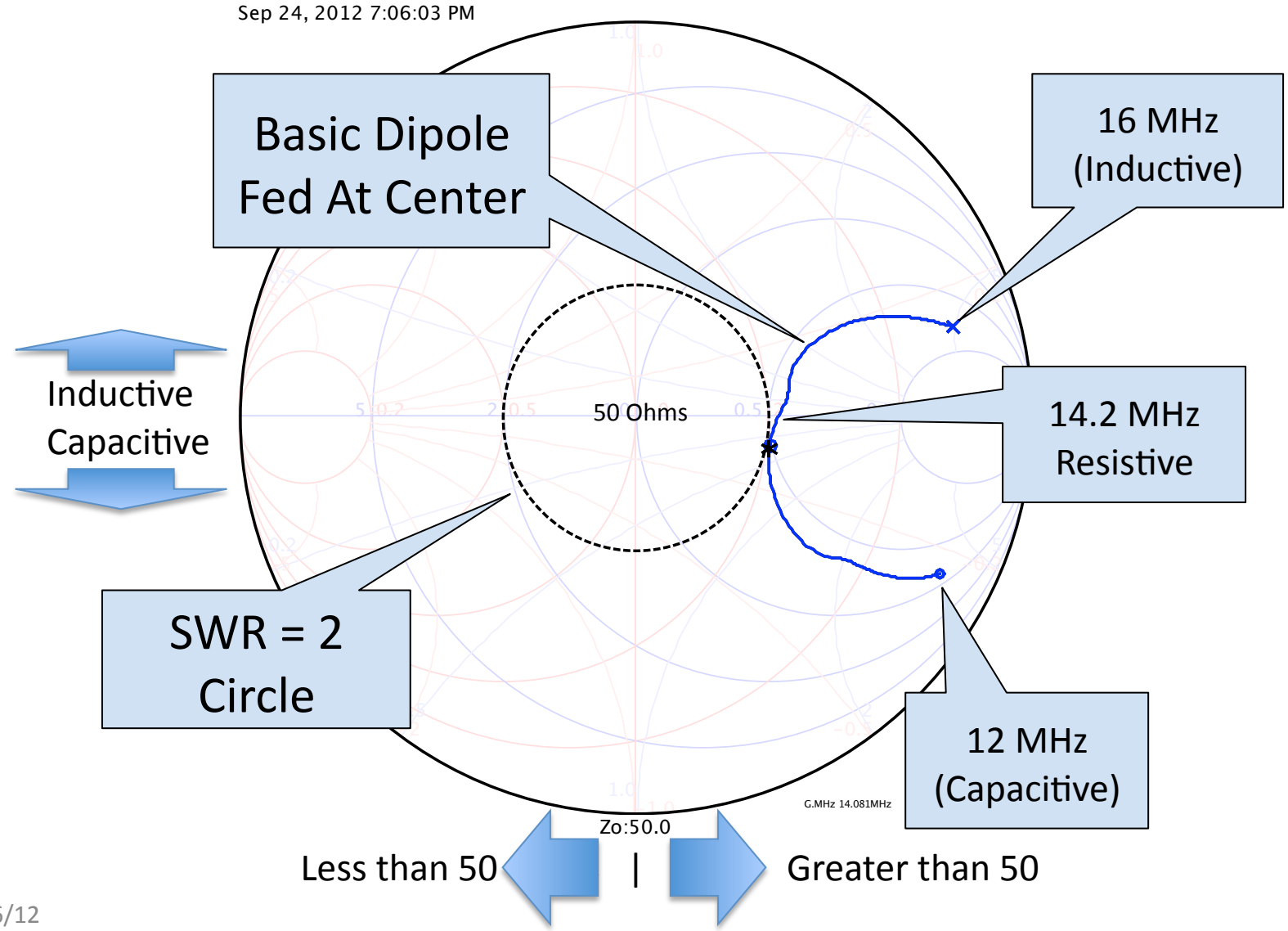
# There is a Special Design Tool

- With the Smith Chart We Can:
  - Read in measured data.
  - Look a the data as Resistance + Reactance

    (Rather than just as SWR)
  - Simulate transmission lines
  - Simulate capacitors

  And See what will happen.

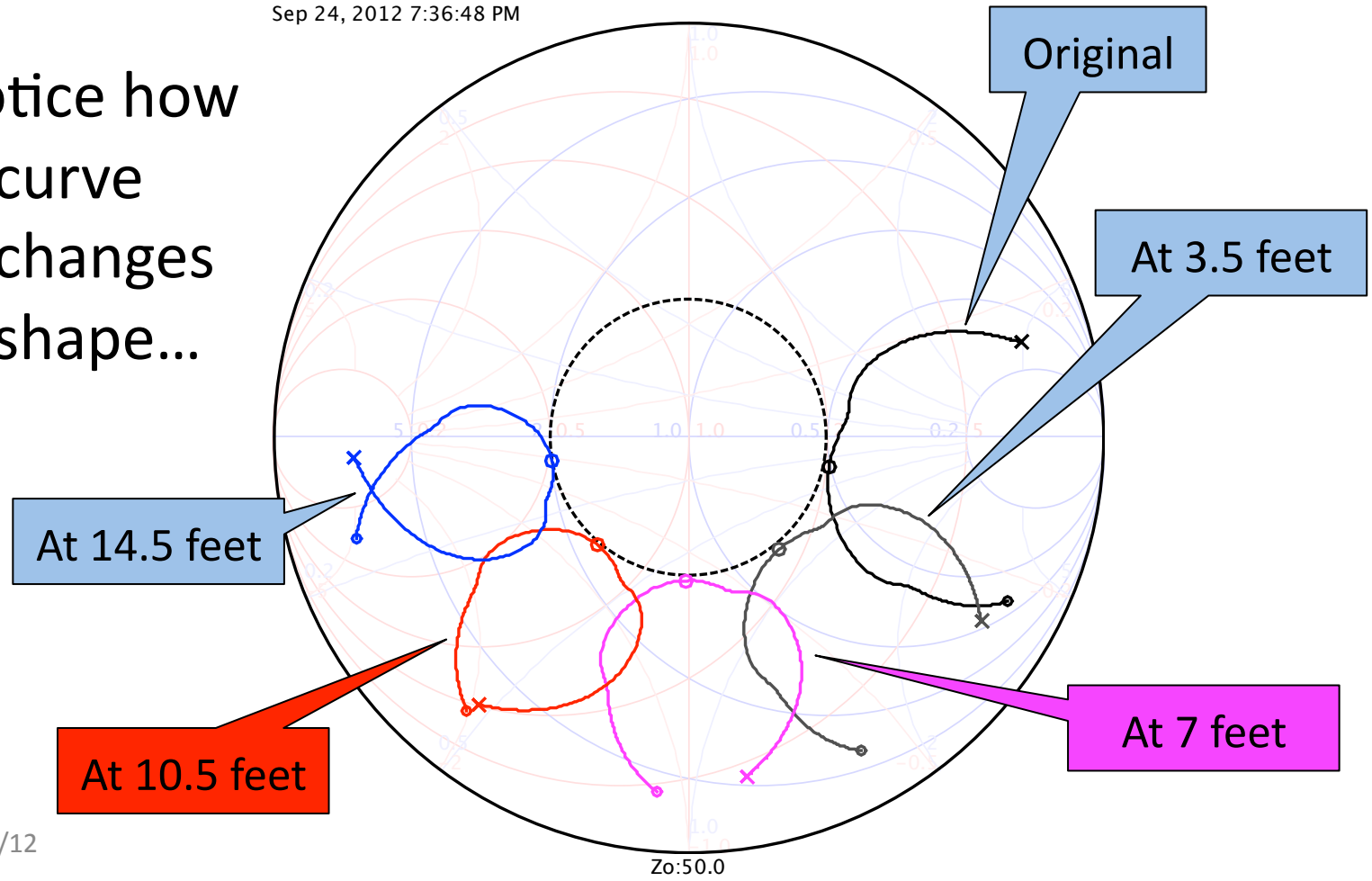
# So, Here's a Smith Chart:



# Yes…. Lots going on.

## But VERY powerful. Lets add a feed line…

Notice how curve changes shape…



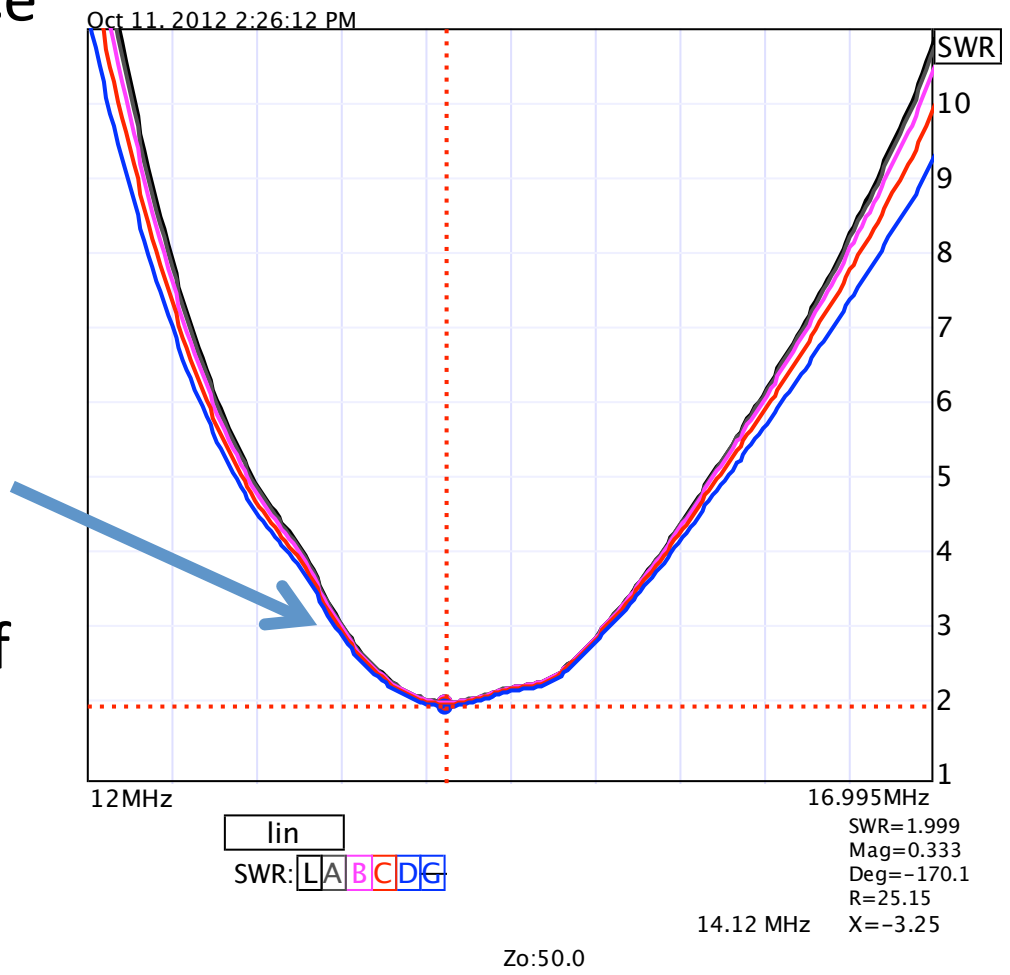
# Just as an aside, how does the SWR change as we add feed line?

Remember: resistance and reactane change…

but SWR does not…

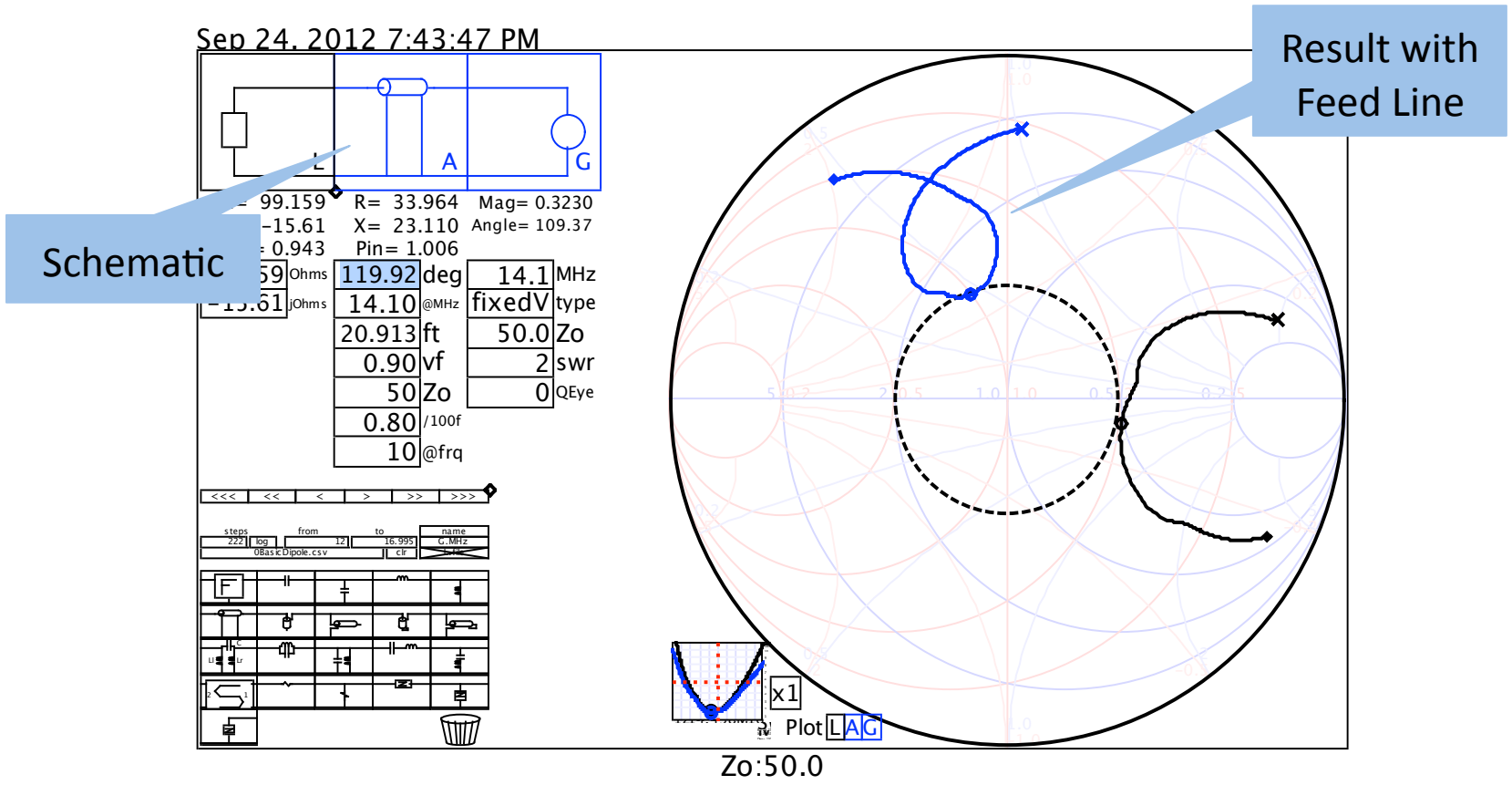
(look at previous slide…. Would you have expect this?)

Therefore: SWR does NOT tell enough of the story!



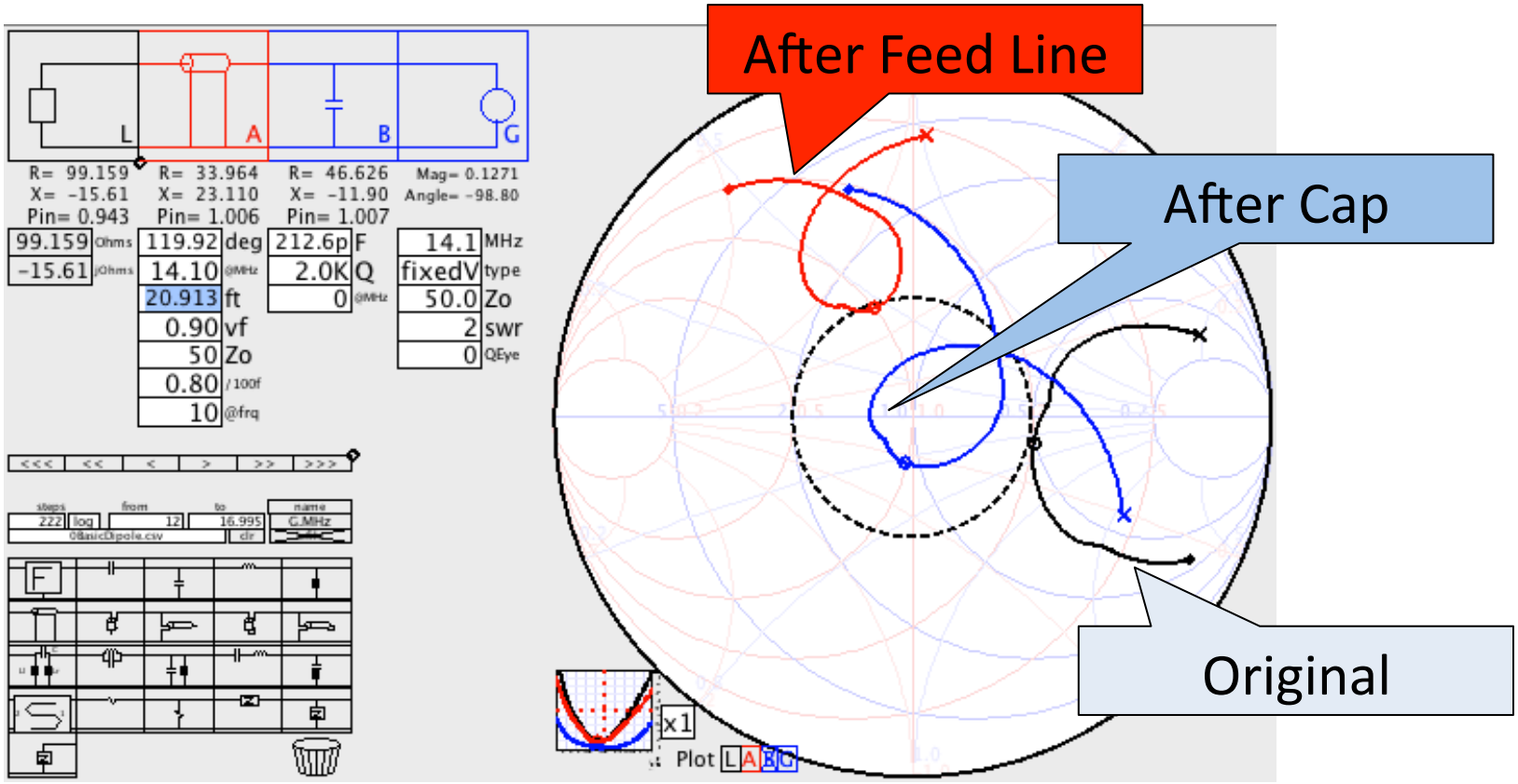
# Using the Smith Chart…
# Lets choose a feed line length:

Here is a screen shot of a Smith chart simulator:



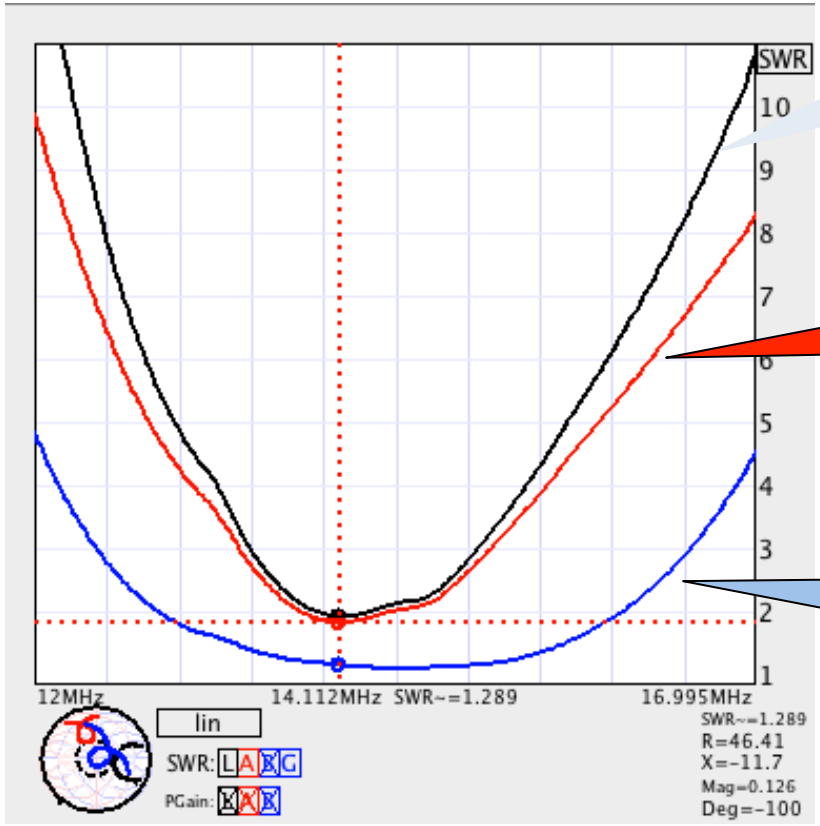
# We can also add our Cap:

## With 20’ feed line and 212 pF Capacitor:



# How's our SWR Look?

Here is the SWR of the previous Smith Chart



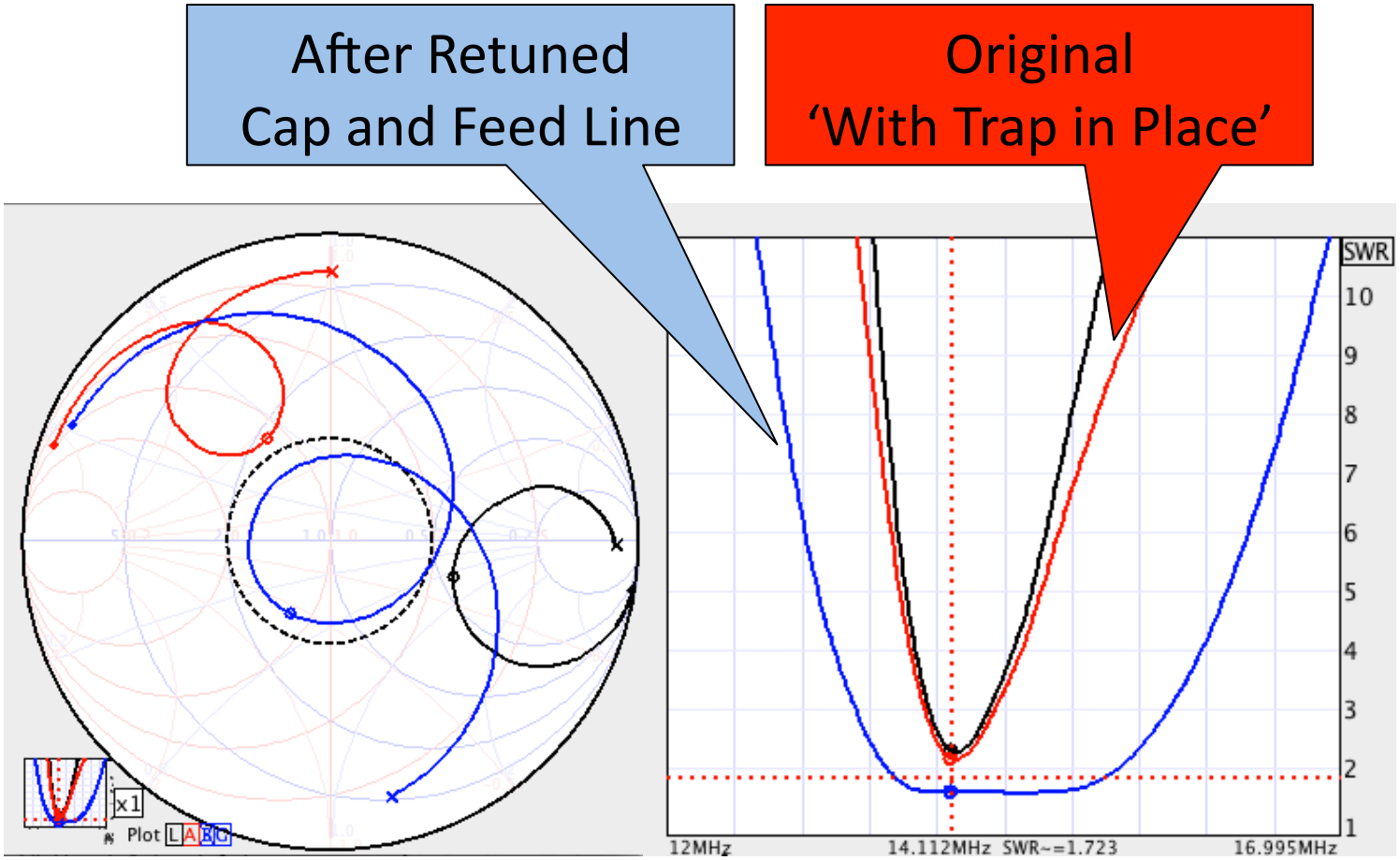

Original

After Feed Line

After Feed Line and CAP

# Lets do all this with the TRAP…

(I Retuned the feed line length and capacitor value)

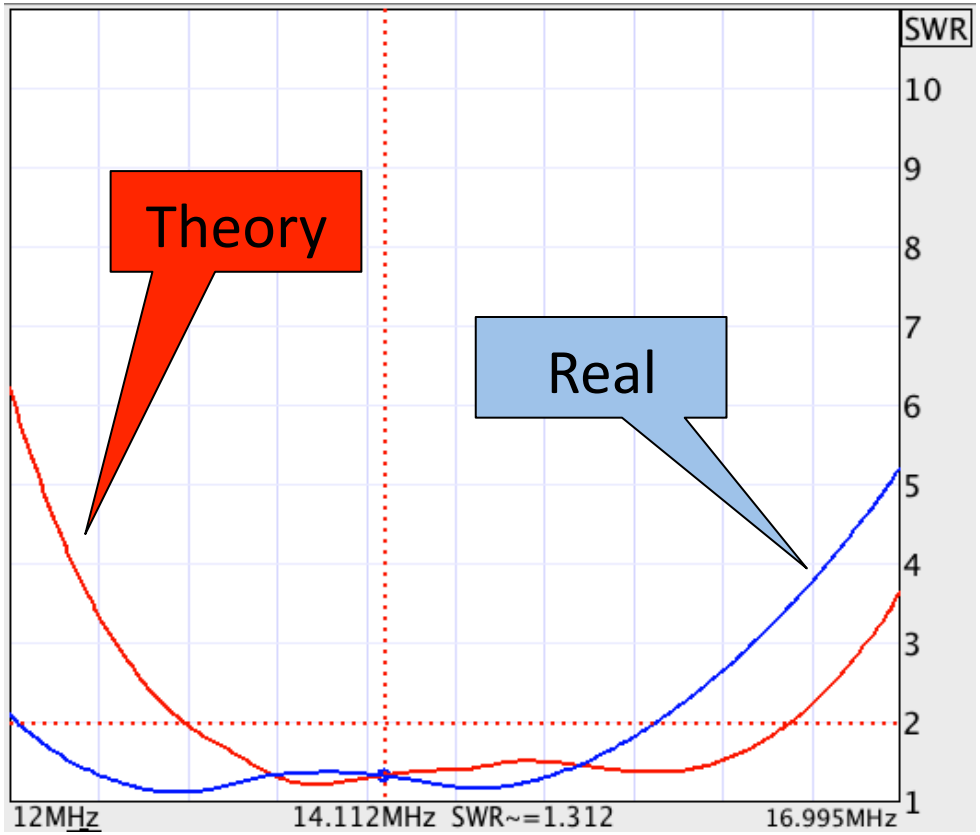


# So… that's theory.
# But does it work out?

Well… almost ☹

I haven't been able to explain the differences….

But the trends are right!



# If We Have Time:

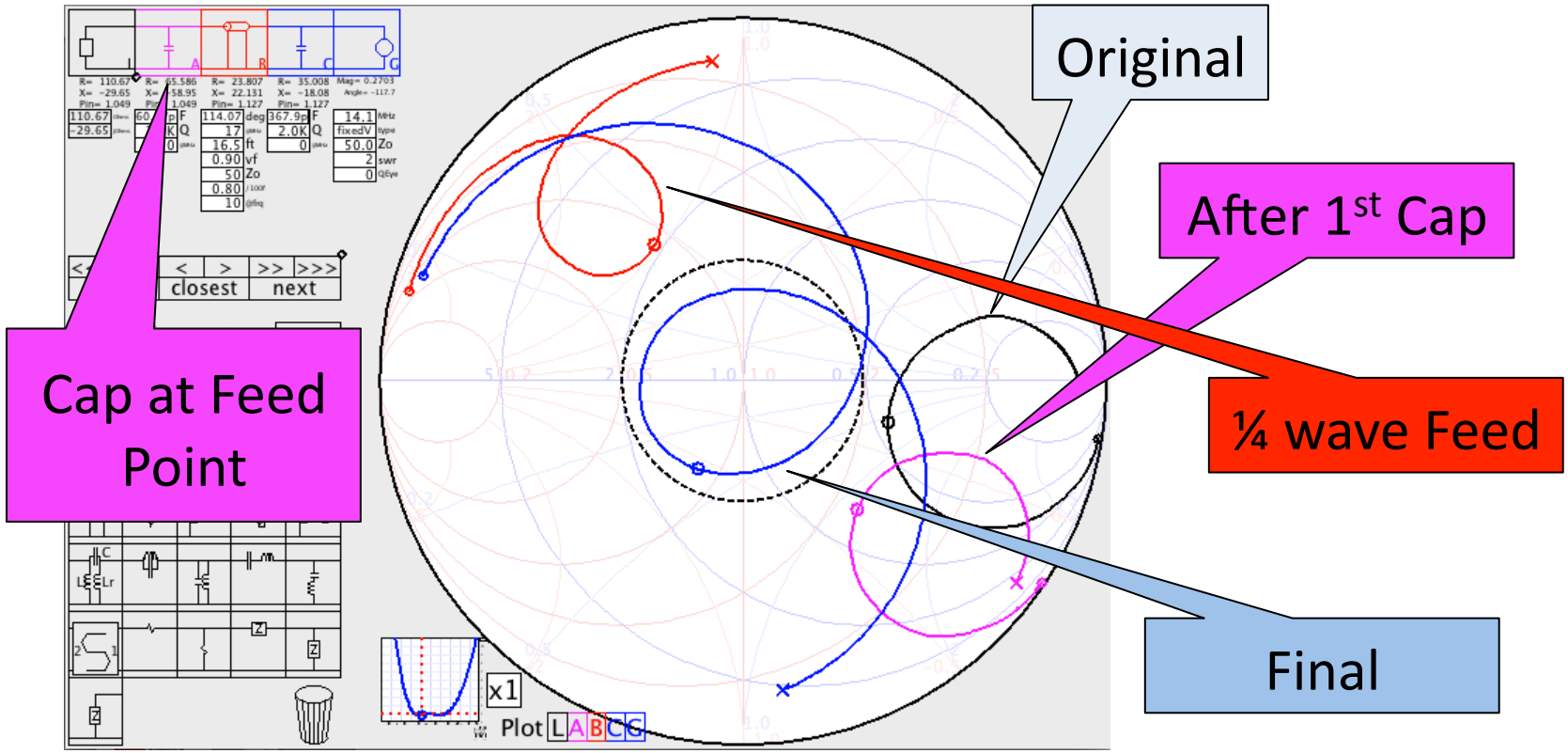
PROBLEM:

the feed line is an inconvenient length: 21 feet. That lands it inside the trap.

Solution: use capacitor to shorten feed line:

# Shorten the Feed line.

Ideally, the feed line would be right length for cap to be ‘right above the trap’… ADD CAP…



# If we have Time:
# One More Thing…

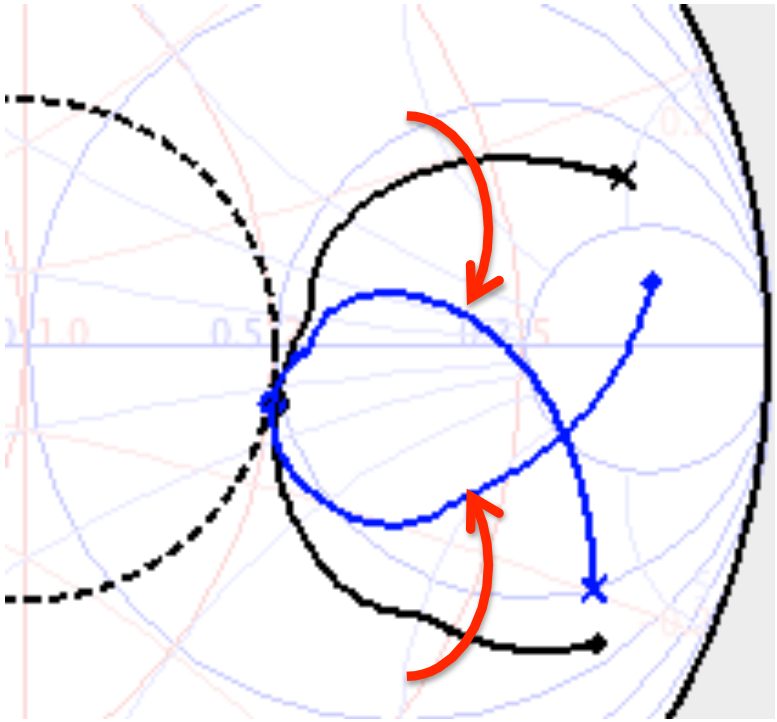
We can improve SWR bandwidth by adding a resonating circuit to the feed point.

Capacitive when

Antenna is inductive…

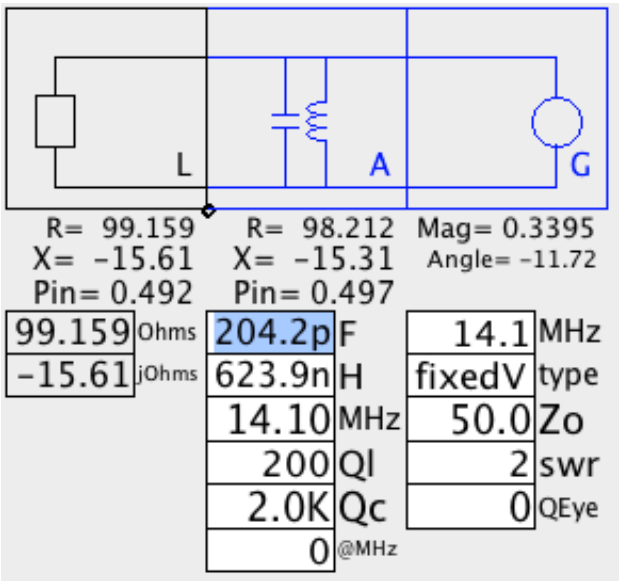
Inductive when

Antenna is Capacitive.

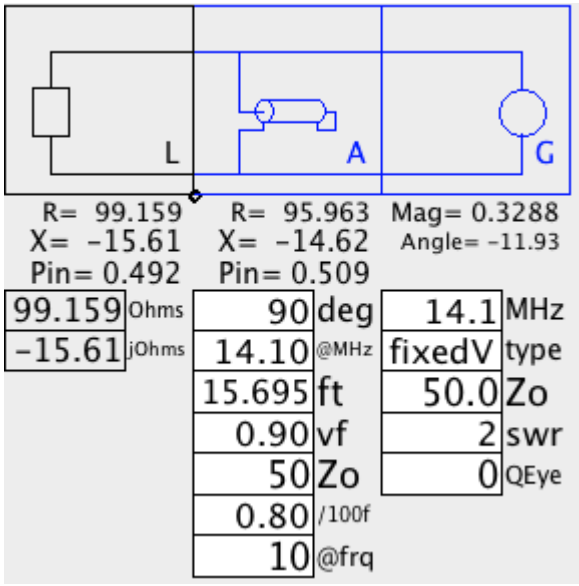


# How do we add this circuit?

LC resonant at 14.1 MHz

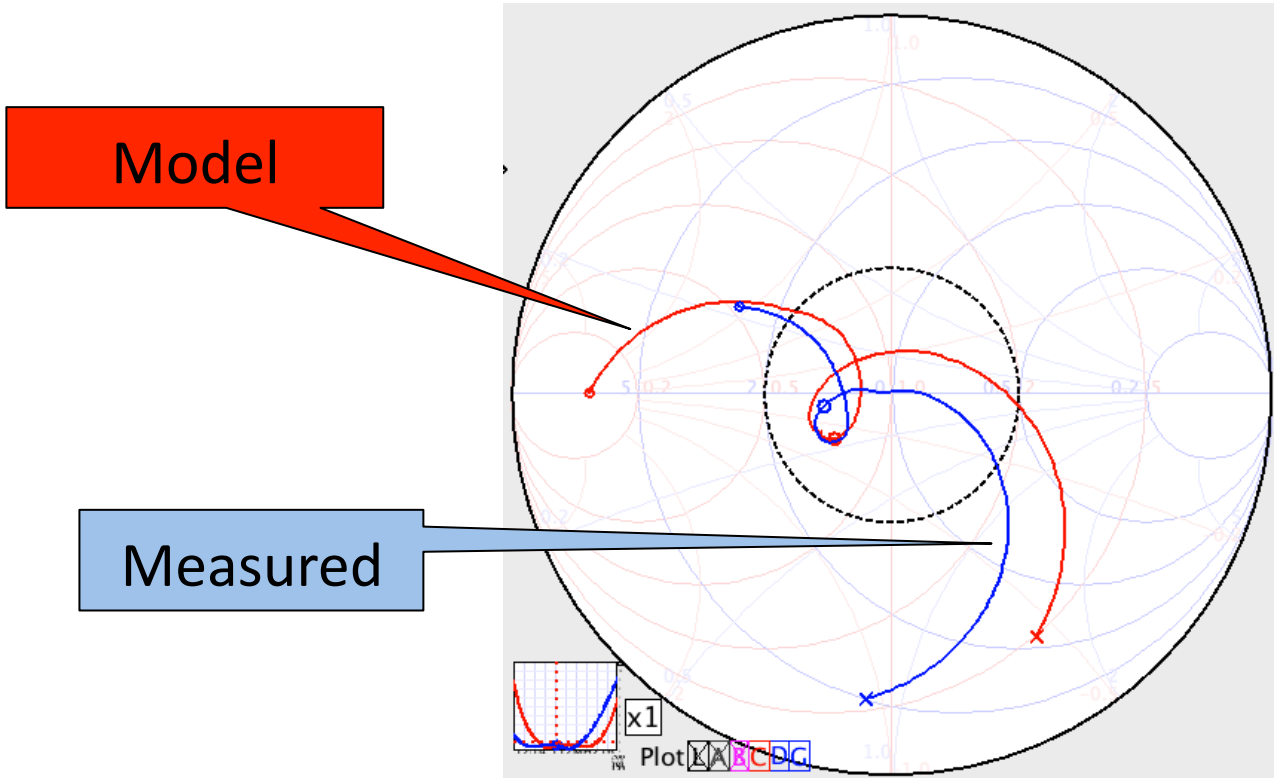



¼ Wave Transmission Line



# Here's what we get either way:

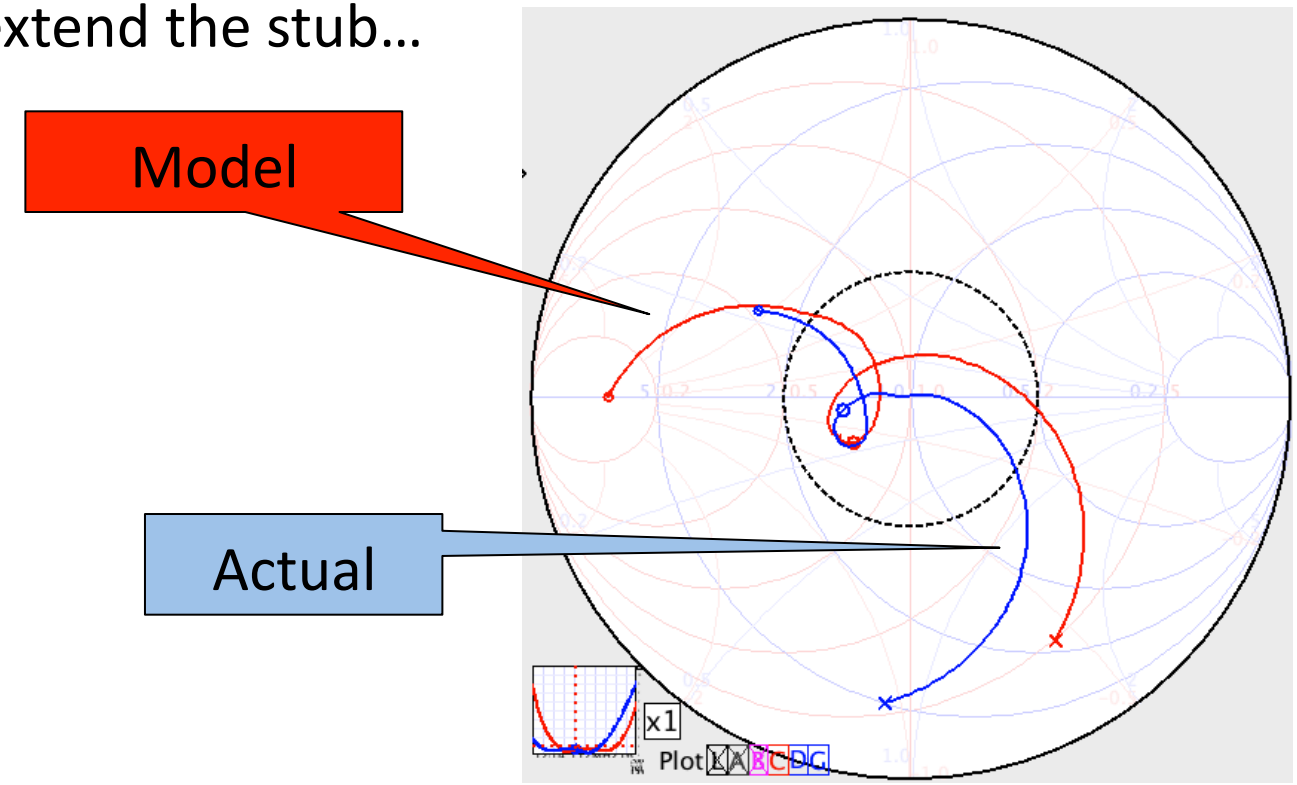
Compare model to real measurements



# Don’t forget the Cap used to shorten the feedline: it is inconvenient.

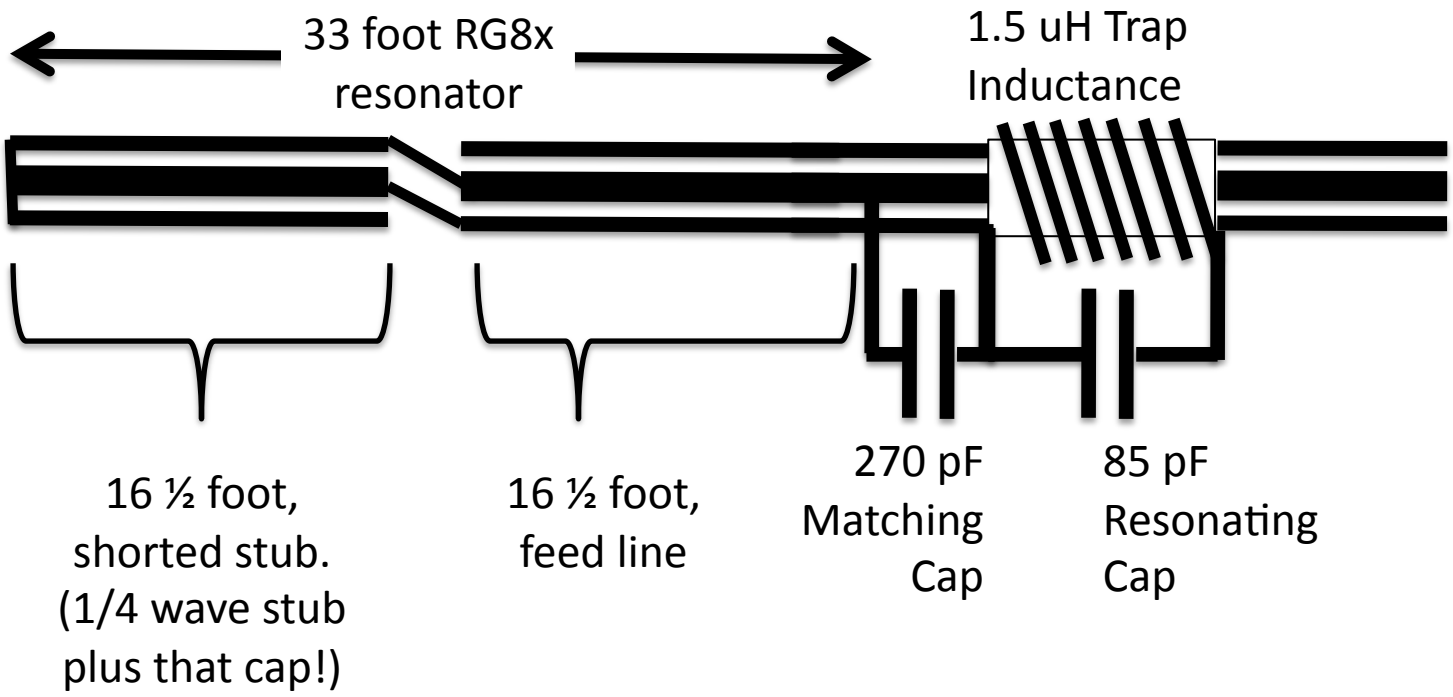
We can combine the ¼ stub with the cap… BECAUSE:

a transmission line Longer than ¼ wave IS CAPACTIVE so we extend the stub…

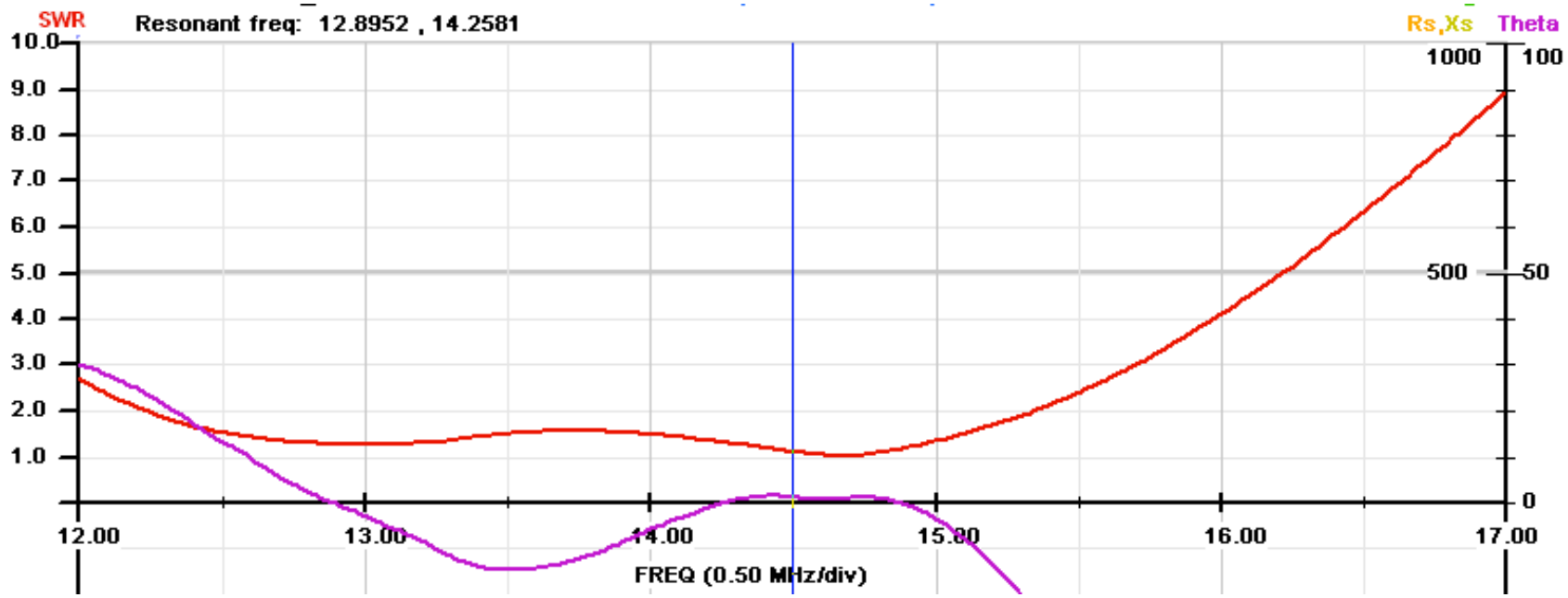


# Final Antenna:

So what does our antenna look like now?



# So, How did we Do?
# Here's the Measured Performance




SWR Less than 2/1 from 12.5 to 15.5 MHz.

# References.

- Smith Charts (ae6ty.com)
- AIM4170B (arraysolutions.com)
- Resonant Feed Line Antenna

  (g4oep.atspace.com)

# The 100 uH inductor version

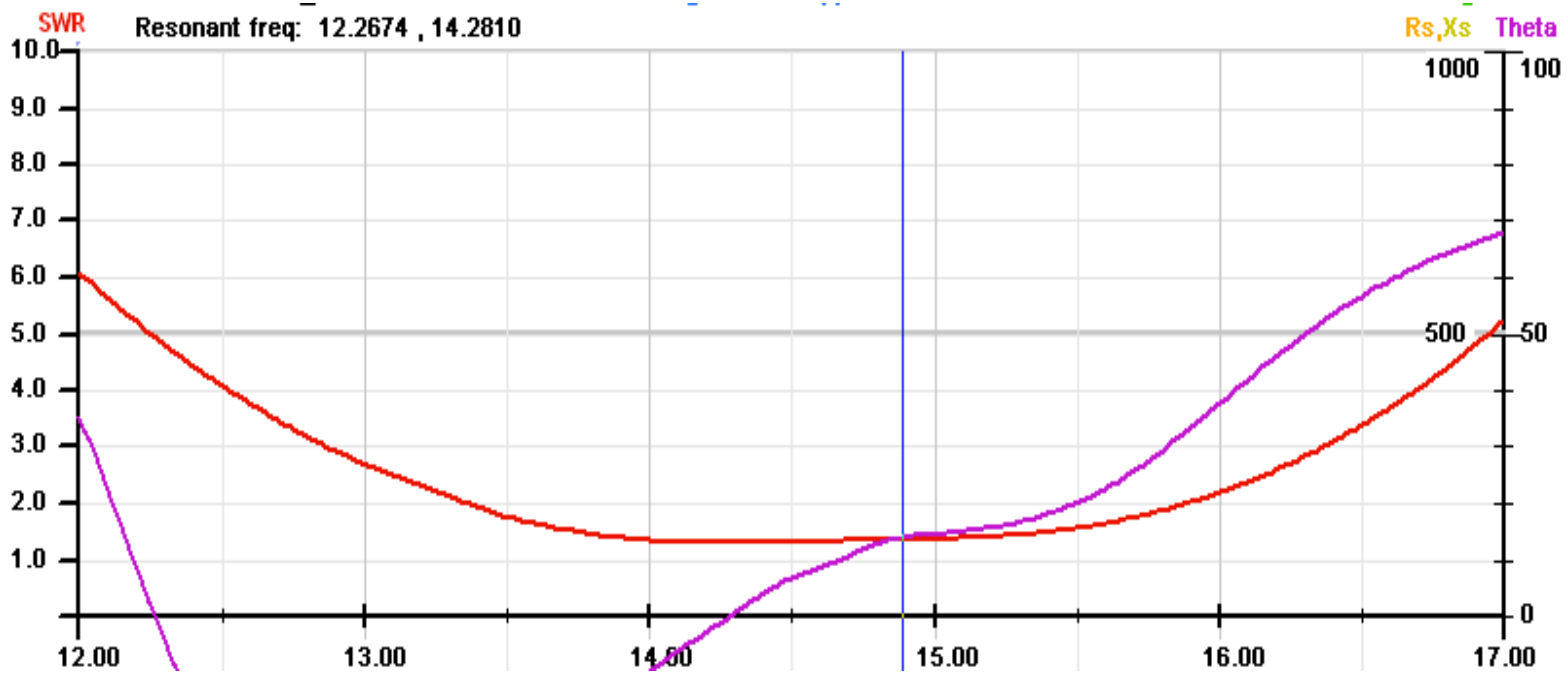
This was easier to construct:

1) inductor value was not critical: >100 uH
2) inductor did not have ‘tuning’ cap.

This was more difficult to ‘tune up’

1) the length of the resonator was affected
2) this moved the ‘right place’ for the matching cap.
3) this changed the length of the resonating section

# Still, after some finagling:




SWR Less than 2/1 from 13.75 to 15.75 MHz.