

TUNING STUBS

THE QUEST FOR TUNING STUBS

Wesley Cardone, N8QM



ABOUT ME

- I am new to amateur radio
- EFFECTIVE DATE
 - 10-27-2019
Extra

Cut Along This Line

UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION
AMATEUR RADIO LICENSE
N8QM

CARDONE, WESLEY M
10626 COOPERSFIELD RD.
CHELSEA, MI 48118

FCC Registration Number (FRN): 0009560111

Special Conditions / Endorsements
NONE

Grant Date	Effective Date	Print Date	Expiration Date
10-27-2019	10-27-2019	10-27-2019	10-27-2023

File Number
0008830364

Station Privileges
PRIMARY

Amateur Extra

THIS LICENSE IS NOT TRANSFERABLE

(Licensee's Signature)

FCC 880 - May 2007

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Call Sign / Number
N8QM

Operator Privileges
Amateur Extra

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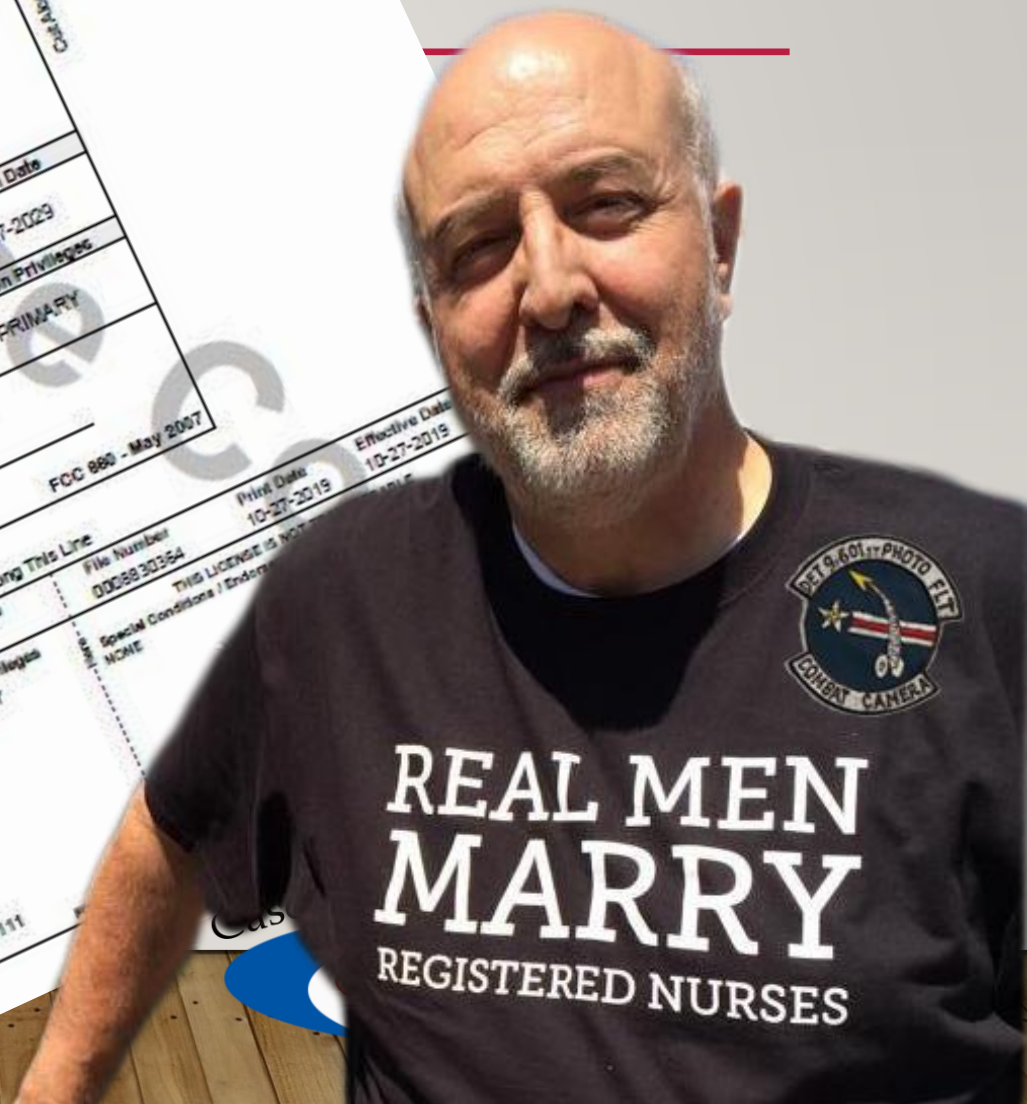
File Number
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document immediately upon receipt. They are not valid until signed.

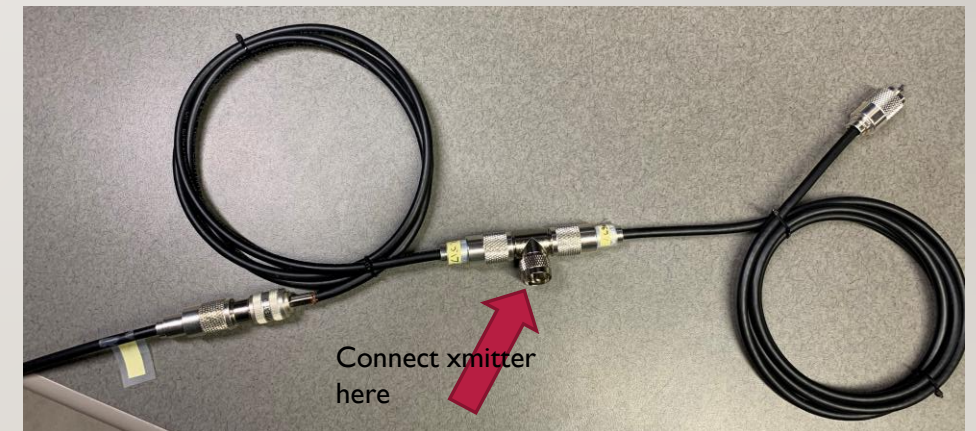
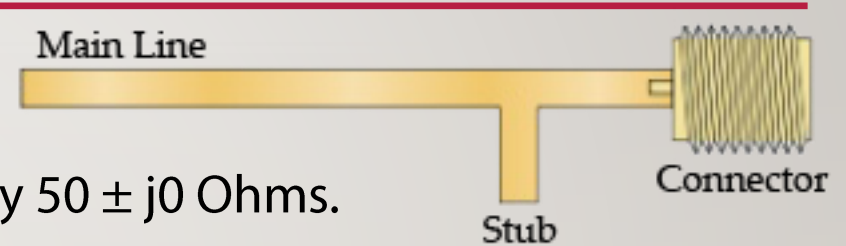
The Commission suggests that the wallet size version be laminated (or another similar document protection process) after signing. The Commission has found under certain circumstances, laser print is subject to displacement.



Wesley Cardone, N8QM

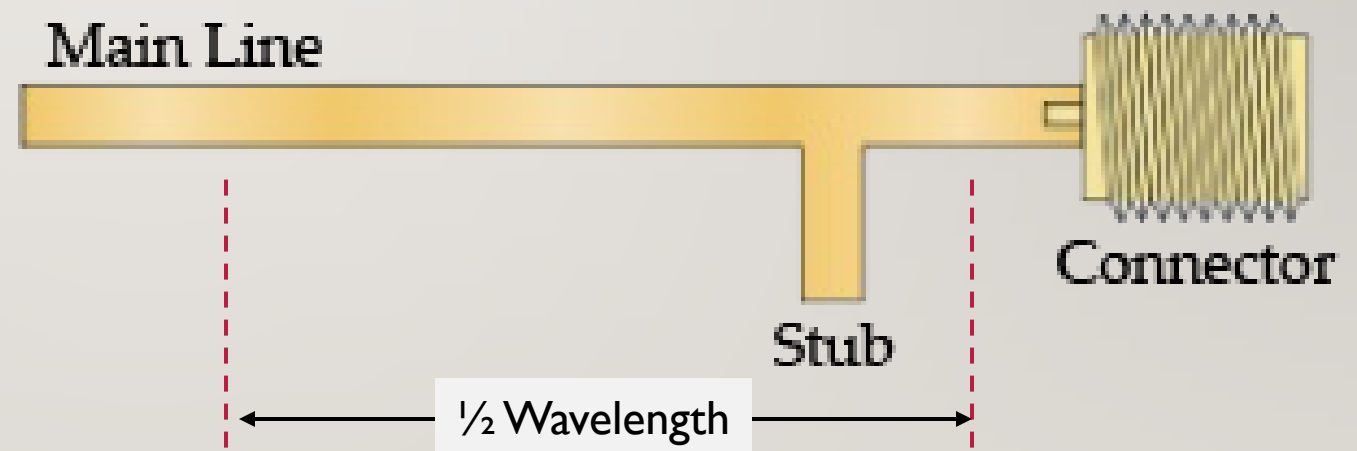
WHAT'S A "TUNING STUB", ANYHOW?

- An impedance transformer
- Every transmitter output has an impedance, typically $50 \pm j0$ Ohms.
 - The coax cable must have a matching impedance.
 - The antenna must have a matching impedance.
This never happens but must be fixed.
- Ways to fix (there are more not listed)
 - antenna tuner
 - Shorten/lengthen antenna
 - Use a tuning stub



WHAT EXACTLY IS A TUNING STUB

- Up to almost a half wavelength is added (or subtracted) to the existing coax feed line.
- A stub is added somewhere within a (not necessarily THAT) half wavelength
- Stub may be
 - Shorted
 - open



WHY HAVE A TUNING STUB?

- You take your best shot at building or erecting a resonant antenna
- Things that could have gone wrong in your build
 - Velocity factor of wire or coax was not what you thought
 - You cut the wire too short
 - Unknown errors preventing it from resonating
- Antenna will be used for one band only
 - Example: Mag-mount mobile for 2 meters
- Fix what an antenna tuner will not fix

WHERE MOST USEFUL

- Implementations
 - By use of ordinary coax
 - Has limitations at wavelengths shorter than likely 100 cm where lengths cannot be cut to a required precision.
 - By use of machined metal bars
 - Has limitations a long wave lengths where machined parts will be too long for practical use.

WHAT YOU WILL NEED TO BUILD A TUNING STUB

- Some PL-259s
- Coax
Use RG-213 or similar with low velocity factor and easy mechanical features to minimize the elbow grease used.
- A Coax Stripping Tool
- Other assorted tools for maybe soldering, crimping, etc.

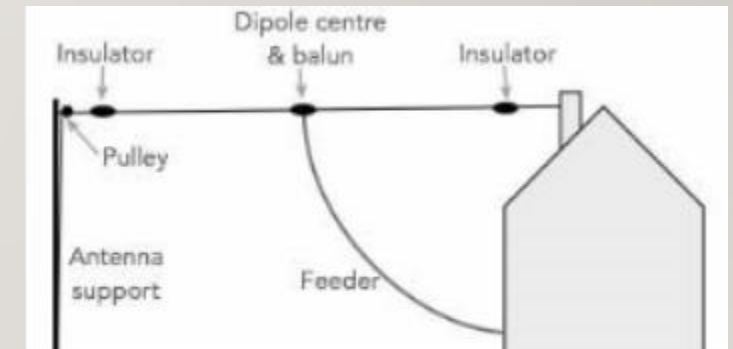
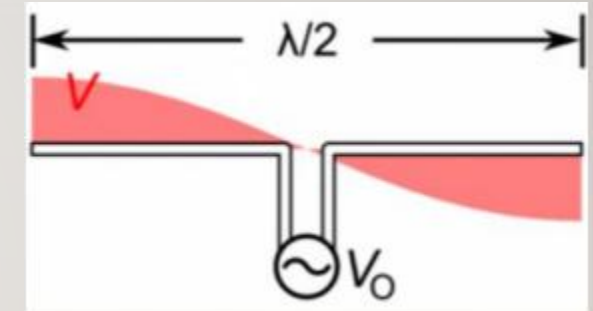


THE OVERALL PROCESS

- Identify the antenna and target frequency it is to resonate at.
- Measure the vector impedance of that antenna at the target frequency.
- Using SimSmith
 - Plot the dot on a Smith Chart representing that vector impedance.
 - Identify 3 or 4 paths to $50 \pm j0$ Ohms (home plate)
- Identify which design is easiest to build.
- Build it

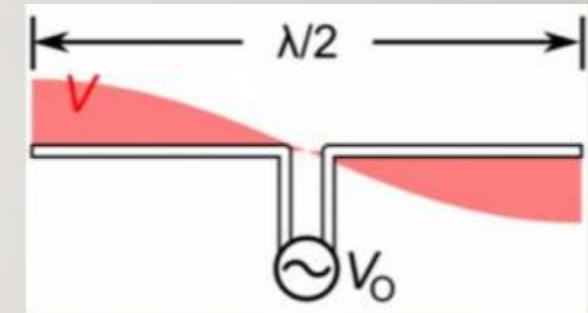
REVIEW: WHAT'S AN ANTENNA, ANYHOW?

- A hunk or two of wires cut to length for a named frequency.
- End-to-end length: a half-wavelength
 - Two wires
 - Usually equal length
 - Fed at the junction of the two wires
- What does length do?
 - Too short: antenna has capacitive reactance
 - Precisely $\lambda/2$: reactance is neutral, *neither* ind nor cap
 - Too long: antenna has inductive reactance



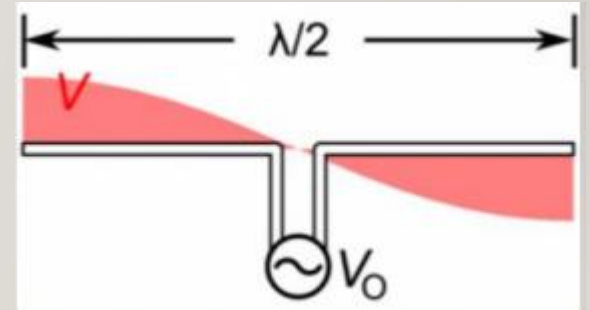
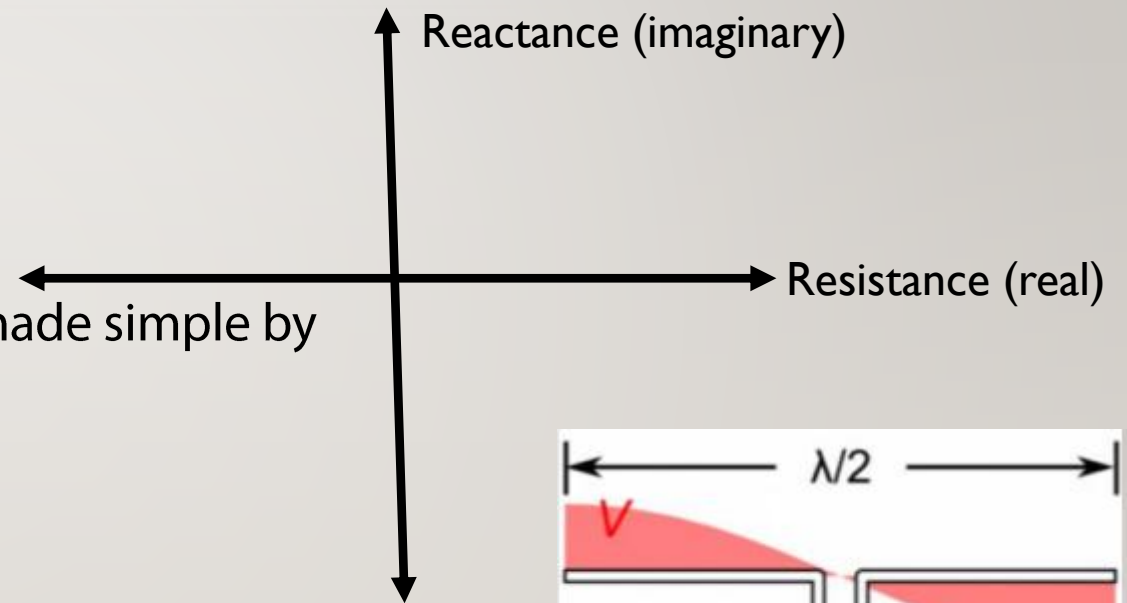
AN ANTENNA HAS IN INPUT IMPEDANCE

- Impedances
 - High is several thousand Ohms
 - Low impedance is anything less than 100 Ohms
- Because you know Ohms Law:
 - What is the impedance at the ends: high or low?
 - What is the impedance at the middle: high or low?
- But simple “impedance” is an oversimplification. Impedance has two components.
 - Resistive (real)
 - Reactive (imaginary)



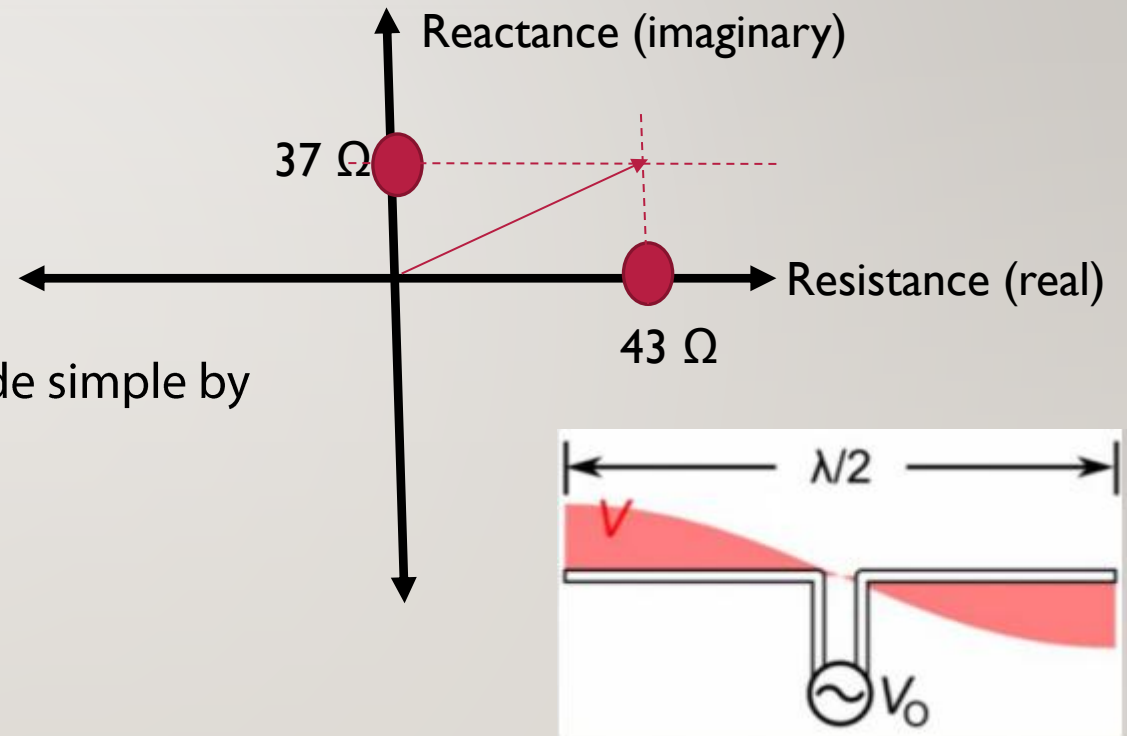
TERMINOLOGY

- Impedance ($Z = R + jX$)
 - Resistance (R) (real)
 - Reactance (X) (imaginary)
- Together called “impedance” but life can be made simple by combining them into a vector quantity.
 - See next slide



TERMINOLOGY

- Impedance ($Z = R + jX$)
- Example: vector quantity $43 + j37 = 57 \Omega$
 - Resistance (R) (real)
 - Reactance (X) (imaginary)
- Together called “impedance” but life can be made simple by combining them into a vector quantity.
- Thus a: “vector impedance”
 - Has a real component (resistance)
 - Has an imaginary component (reactance)



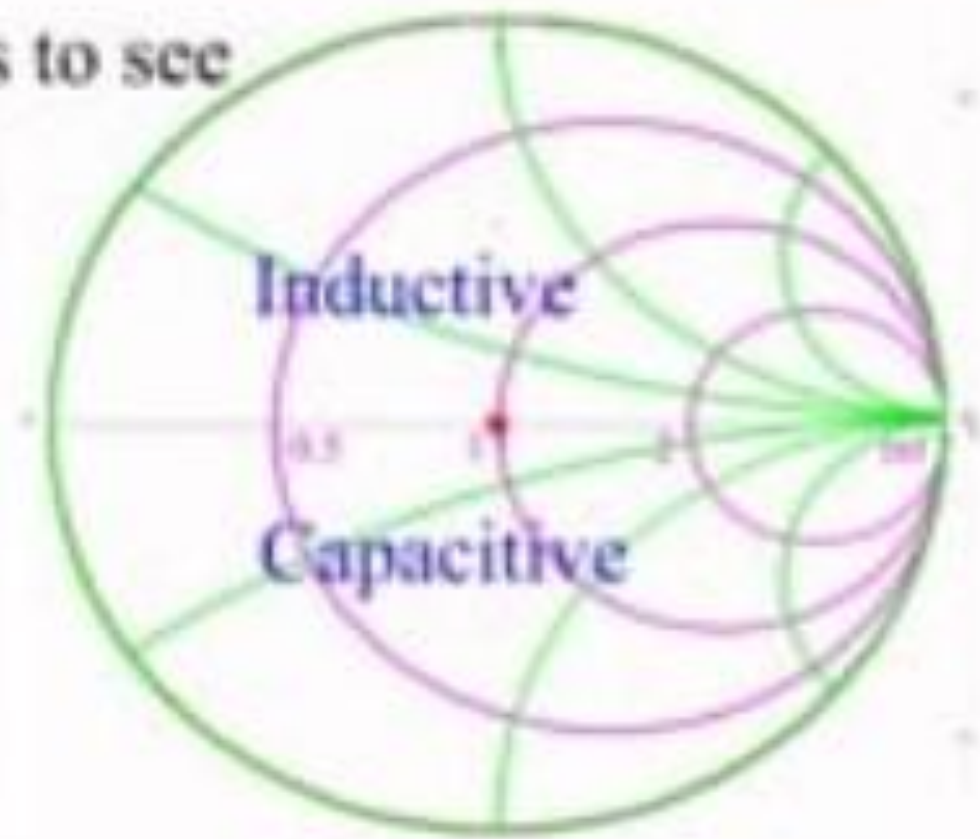
WHAT IS THE HOLY GRAIL FOR IMPEDANCE?

- The Holy Grail is to match your impedance for maximum power transfer.
- Assume your transmitter is specified to have an output impedance of 50 Ohms.
- Antenna must therefore match at 50 Ohms.
 - $50 + j0 = \sqrt{50^2 + 0^2} = 50 \text{ Ohms}$
 - Reactance is neutral if wire lengths are precisely $\lambda/2$.
- Starting point: How do you make $43 + j37$ into $43 + j0$
 - Answer: $43 + j37 - j37 = 43 + j0$
 - Cancel an inductive reactance with an equal capacitive reactance

INTRODUCING: THE SMITH CHART

Let's assign some numbers to see how all this works out.

We already know that home is 1 Ohm normalized.



LET'S INTRODUCE SIMSMITH

- Without computer assistance, the typical amateur radio operator is absolutely lost.
- There are way, way too many ways to go wrong and you never know it.
- You spend the greater part of a day designing and building a tuning stub.
- But it doesn't work.

READING THE SMITH CHART IS ONE THING...

- Making the Smith Chart work for you is a major accomplishment.
- It is easy to read the Smith Chart, but unrealistic for the typical amateur to use it for solutions.
- Enter the free computer application SIMSMITH
 - SimSmith protects you from yourself
 - If you attempt to incorrectly use the Smith Chart, SimSmith refuses to do it or lets you know.
 - For both PC and Mac

SimSmith
for
Interactive RF Circuit Analysis
([Jump down to download options](#))
Please Join the discussion forum at: groups.io/SimSmith



HTTP://WWW.AE6TY.COM/SMITH_CHARTS.HTML

- Scroll down to find the recommended download.

At present, three versions of SimSmith are available.

Please backup your computer before downloading any new software.

Larry Benko has made dozens (a hundred?) videos about using SimSmith to understand RF circuits. Many were made with an older version (15.1) and a few using a somewhat newer version (16.9). Both of these releases are available below. There are some subtle differences in the builds of 16.9 which can cause some confusion. I apologize for this cavaleir behavior on my part.

Finally, the most recent release version 17.3. Significant changes are announced on the SimSmith@groups.io.)

[15.1](#) Useful when following along Larry Benko's older videos

[16.9](#) Useful for Larry's newer videos.

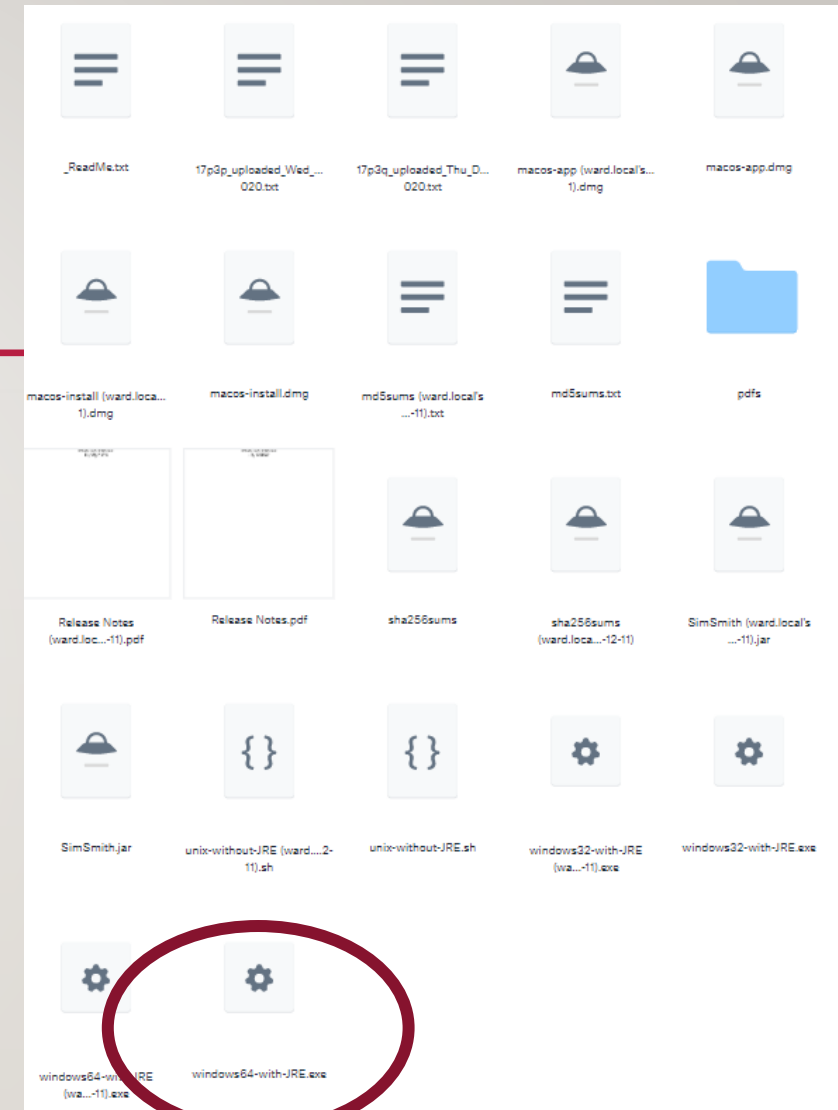
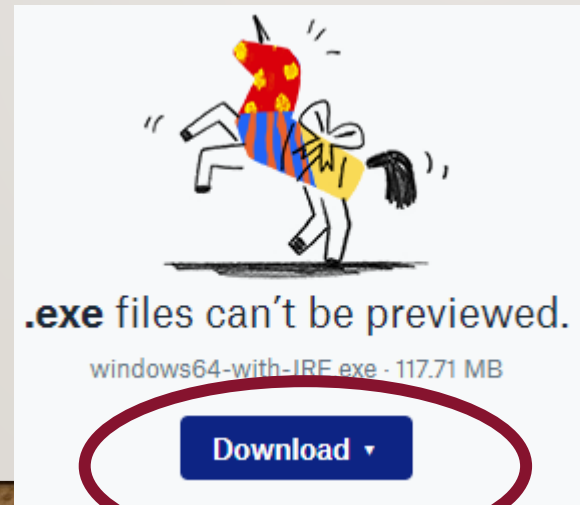
[17.3 Recommended](#). New builds are released here. Please read the latest releast notes (in the download directory) before installing.

Please feel free to contact me with suggestions or questions at ae6ty@ae6ty.com.

Again, please also consider joining the SimSmith group at SimSmith@groups.io

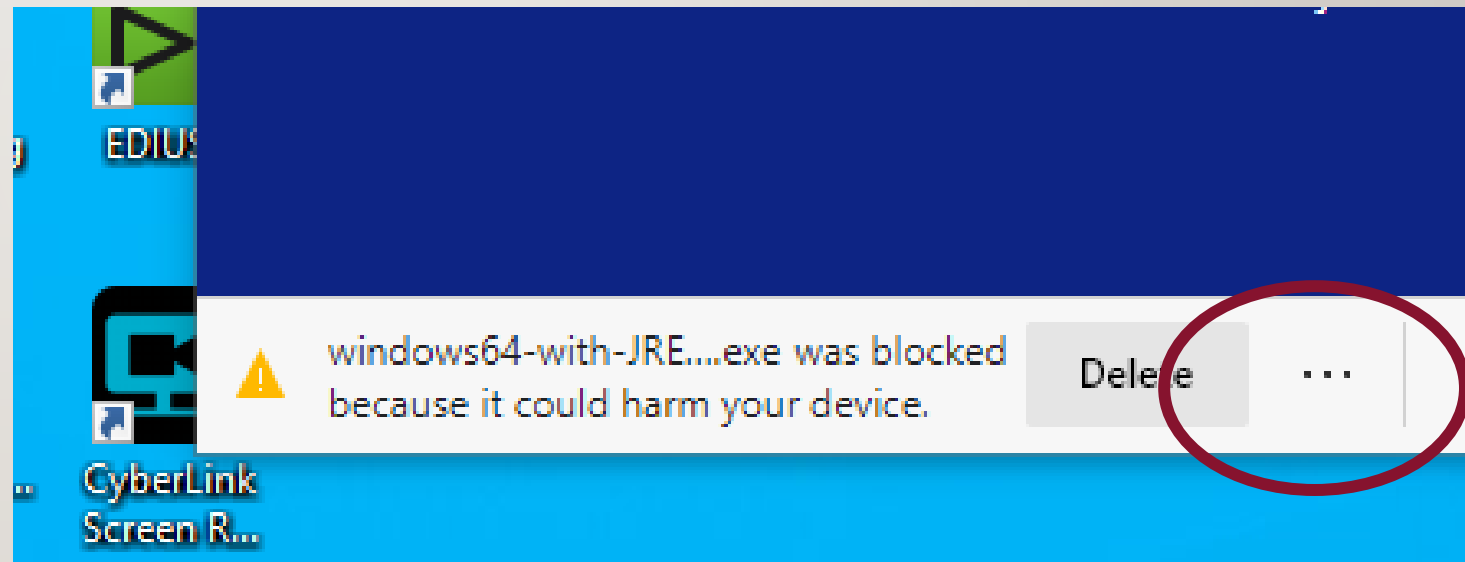
SELECT THE APPLICABLE DOWNLOAD

- I am using Windows 64-bit, therefore...
- I selected the item that was last on the list titled
 - Windows64-with-JRE.exe
- There was a Dropbox invitation which I ignored.
- I chose a direct download rather than Dropbox.
- But Windows blocked it.



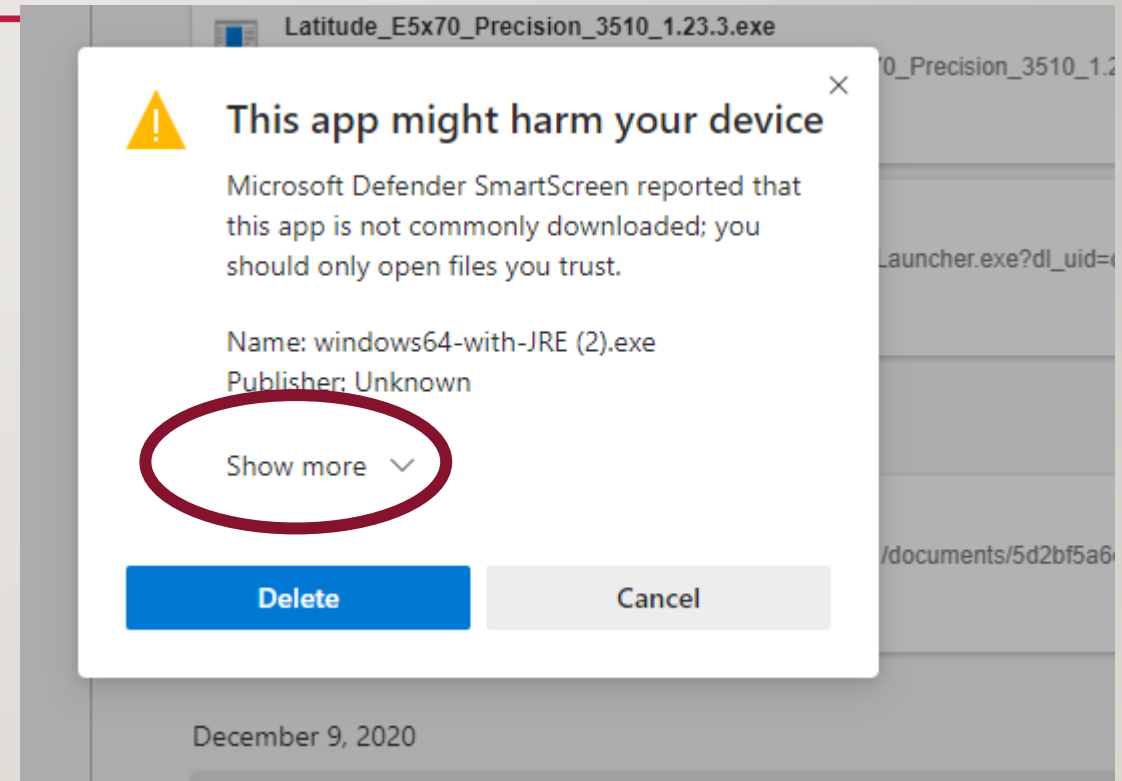
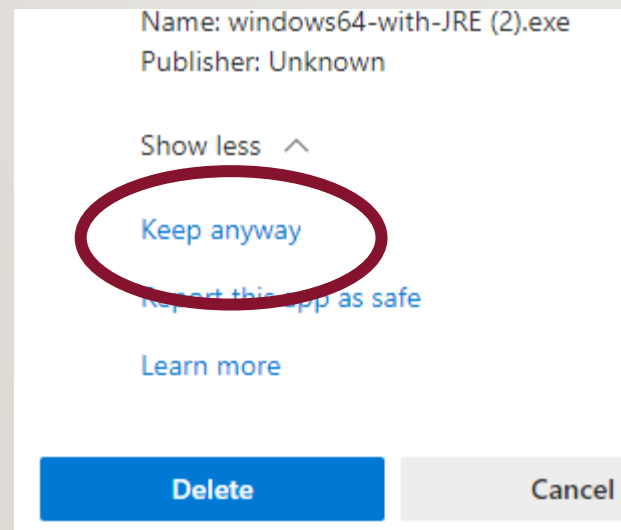
WINDOWS BLOCKED MY DOWNLOAD

- Ignore the message and click on the ellipsis.
- Click “keep.”



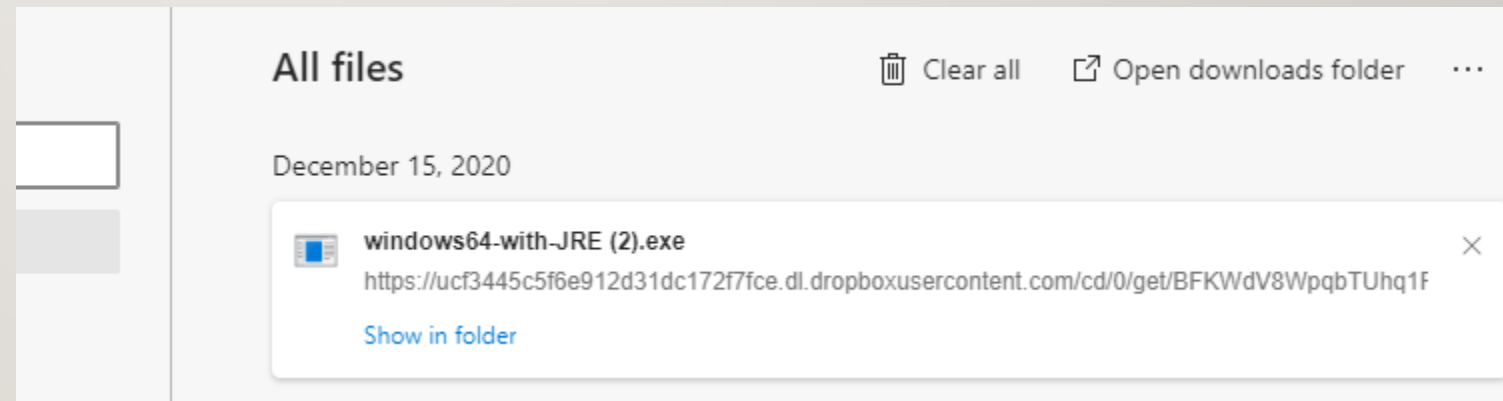
HARM?

- Click "Show more."



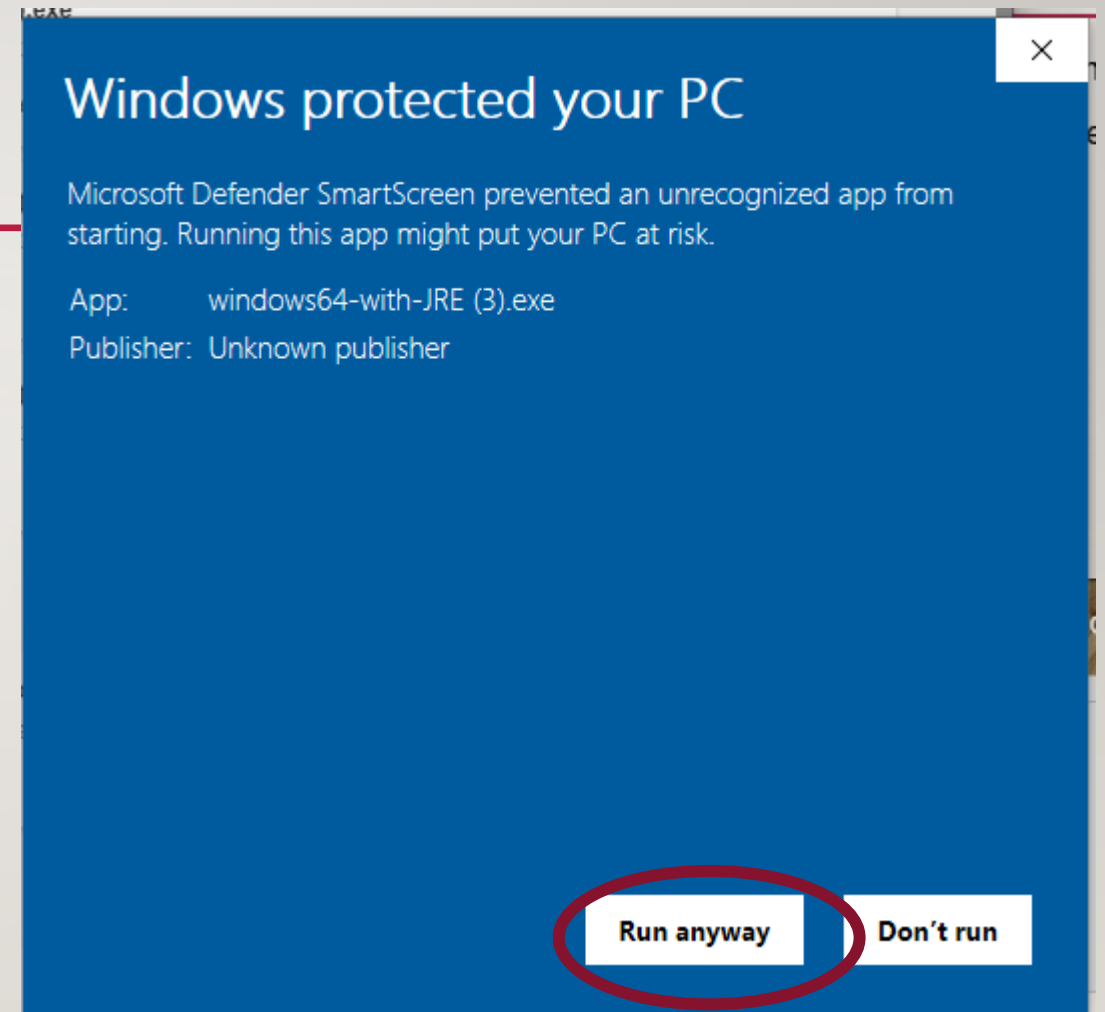
READY TO BOOGIE...ALMOST

- Click on the lower URL text.
- “this file was blocked...”



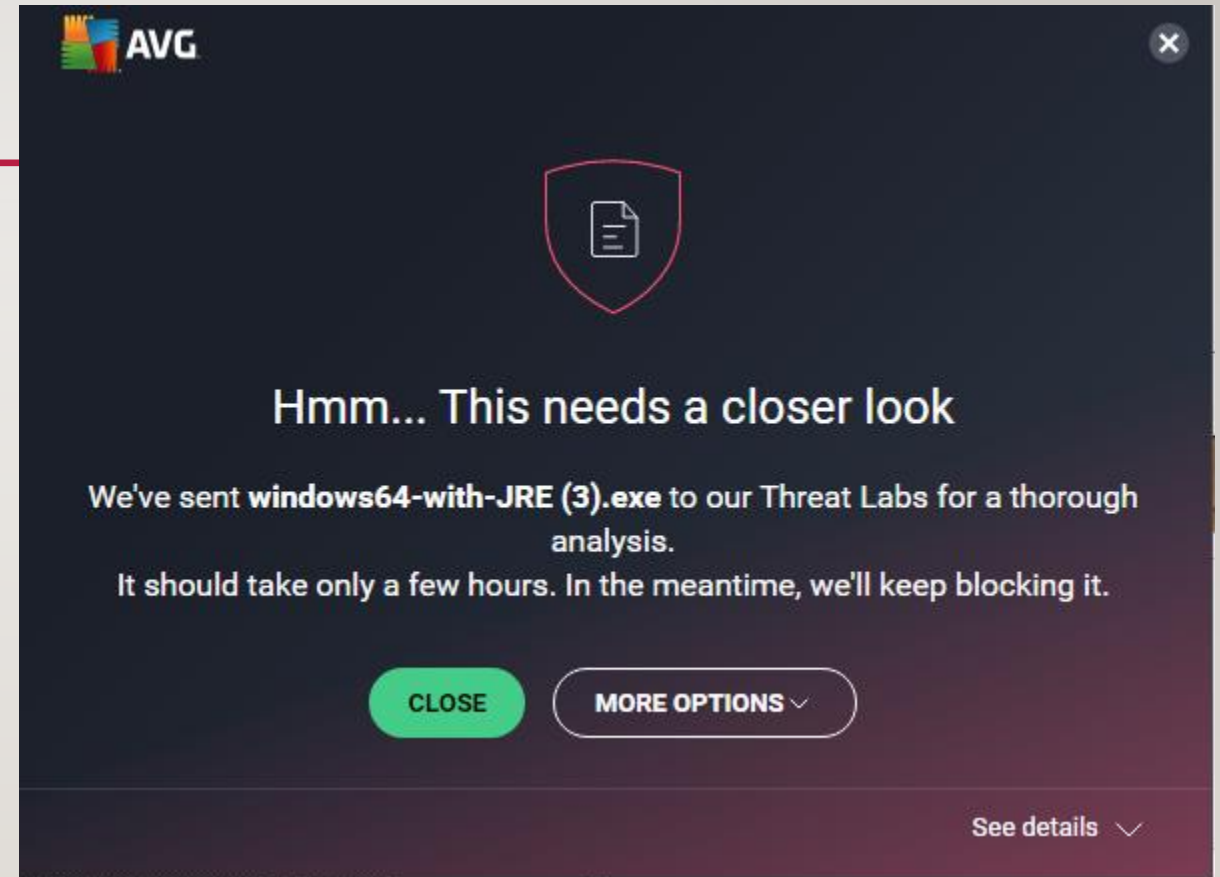
FINALLY!

- This should finally get us home.



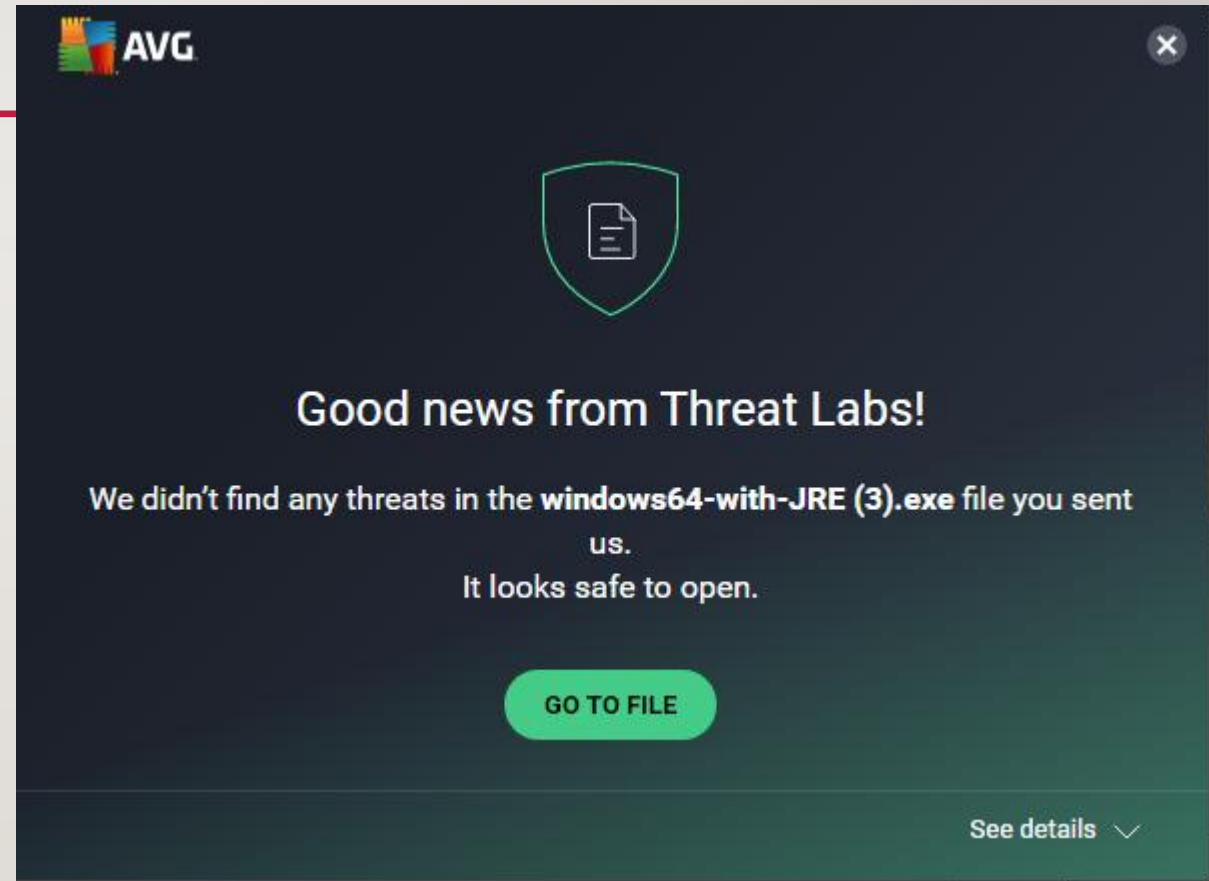
LOCAL ATTENTION

- My own virus monitor called attention to this install.



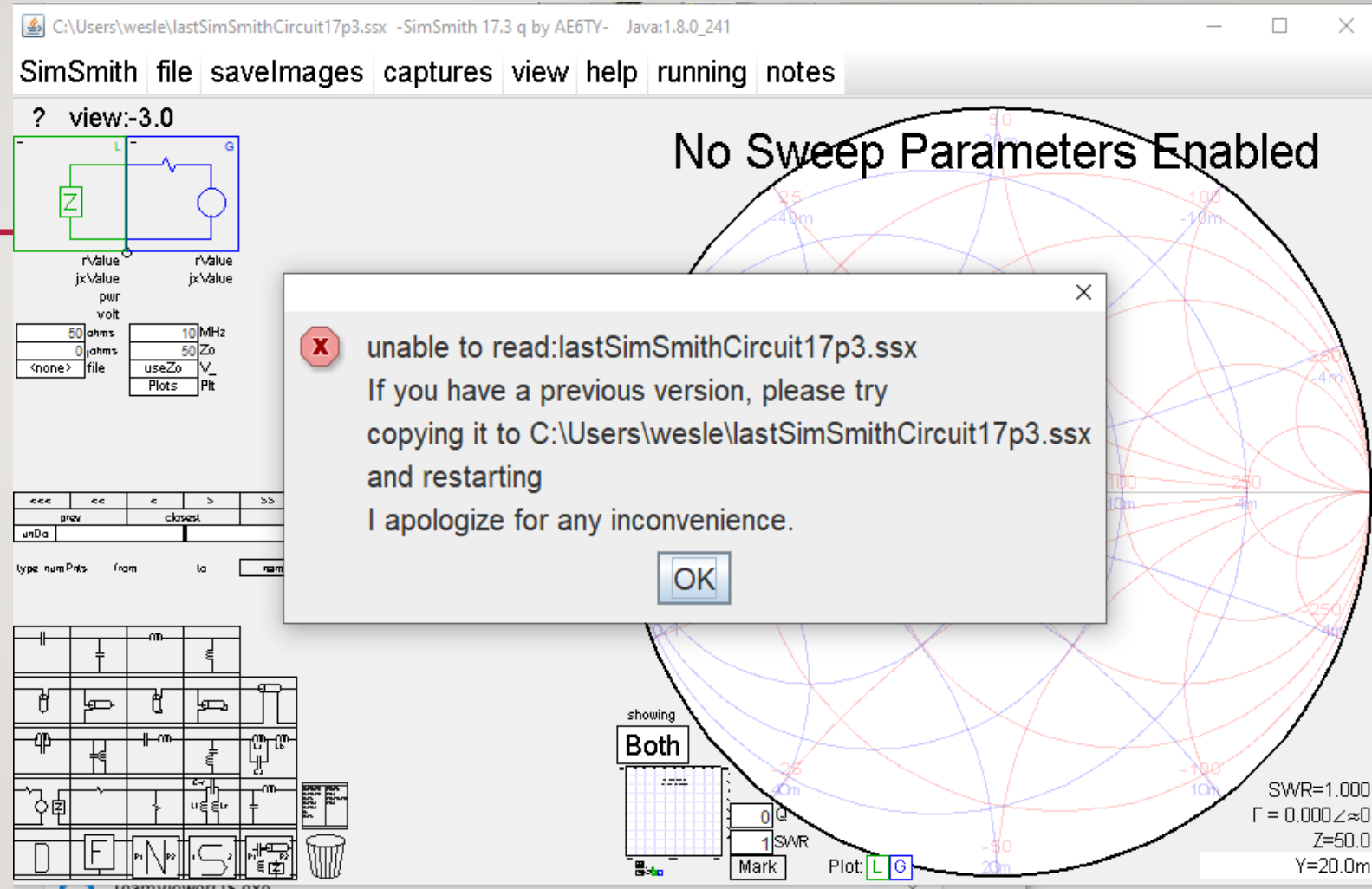
LATER VINDICATION

- My anti virus software came back a few minutes later saying no problem was found.



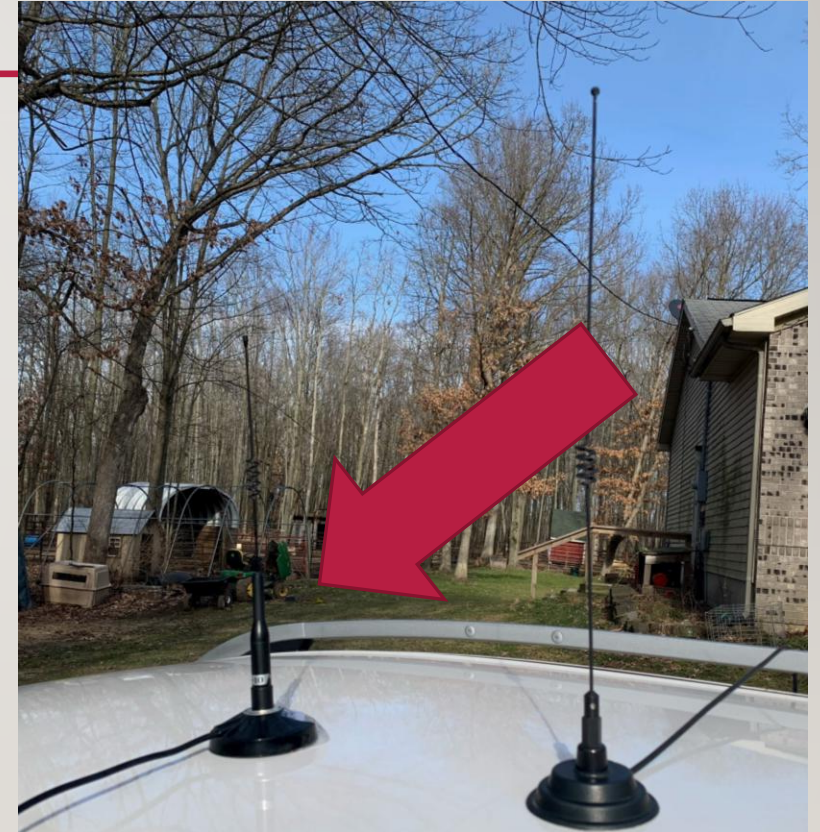
INSTALLED

- Ignore the note. It always appears with a new install because there is no configuration file.



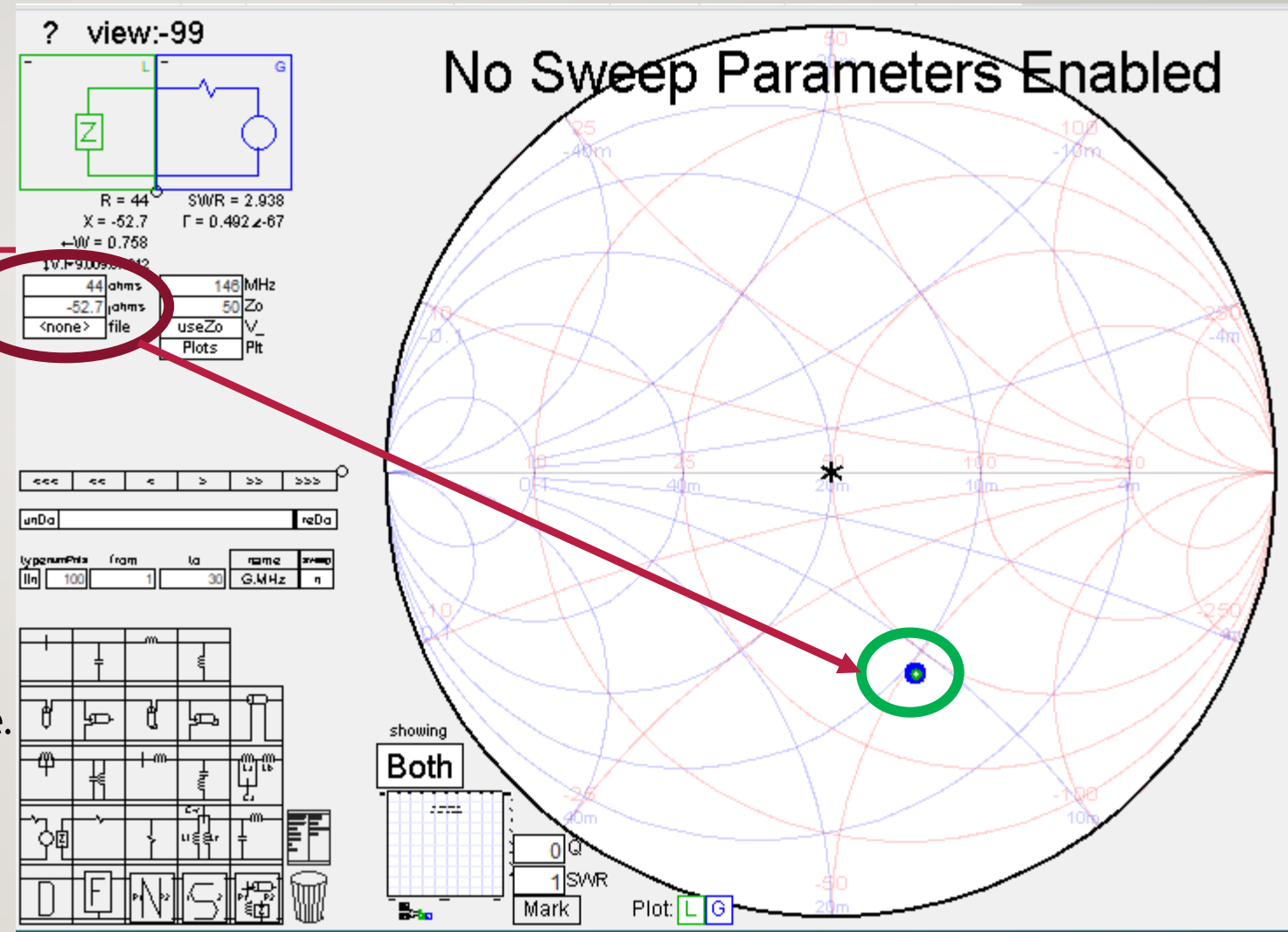
A MAG-MOUNT ANTENNA

- Two antennas shown
 - Right: cut for 2 meters: 146 MHz
 - $Z = 50 - j0$ Ohms @ 146 MHz
 - Left: cut for 2 meters: 155 MHz
 - $Z = 44.0 - j52.7$ @ 146 MHz
- OBJECTIVE:
 - Design & build a tuning stub to fix the left antenna for amateur radio use.



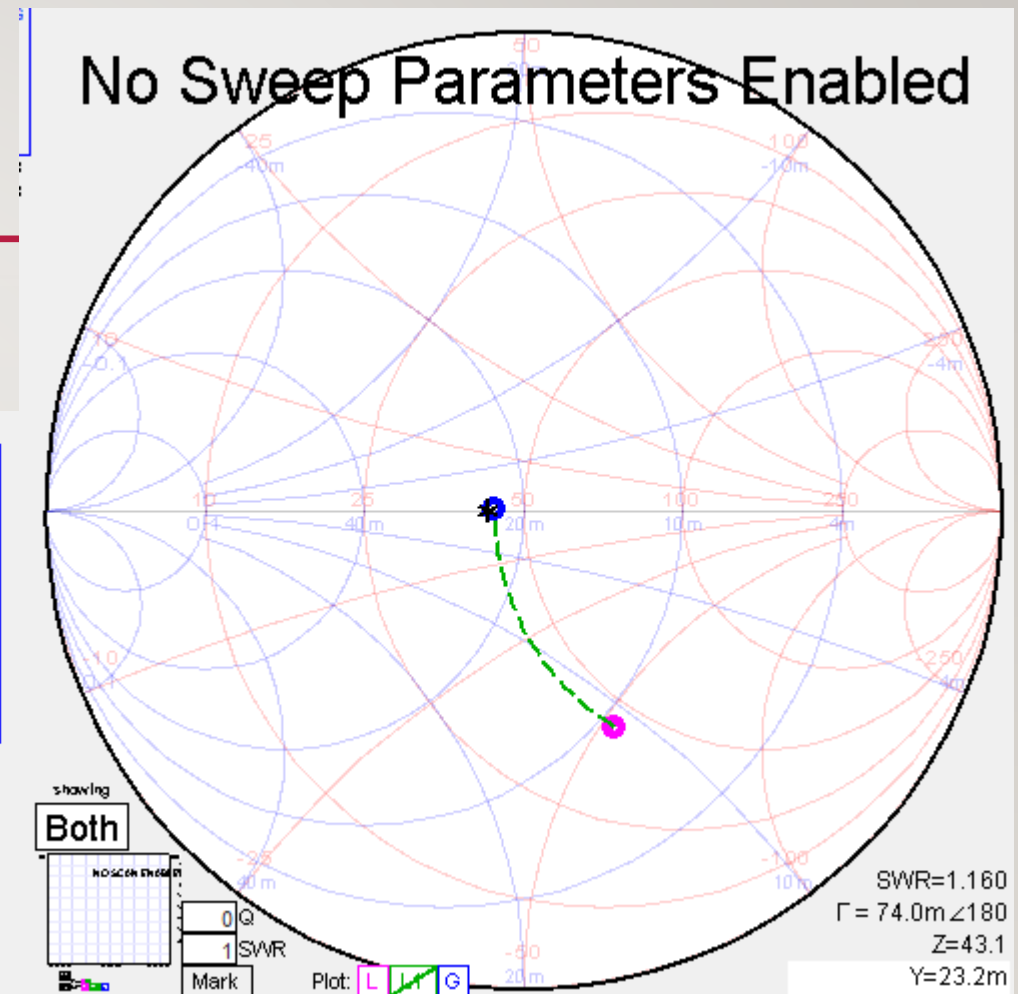
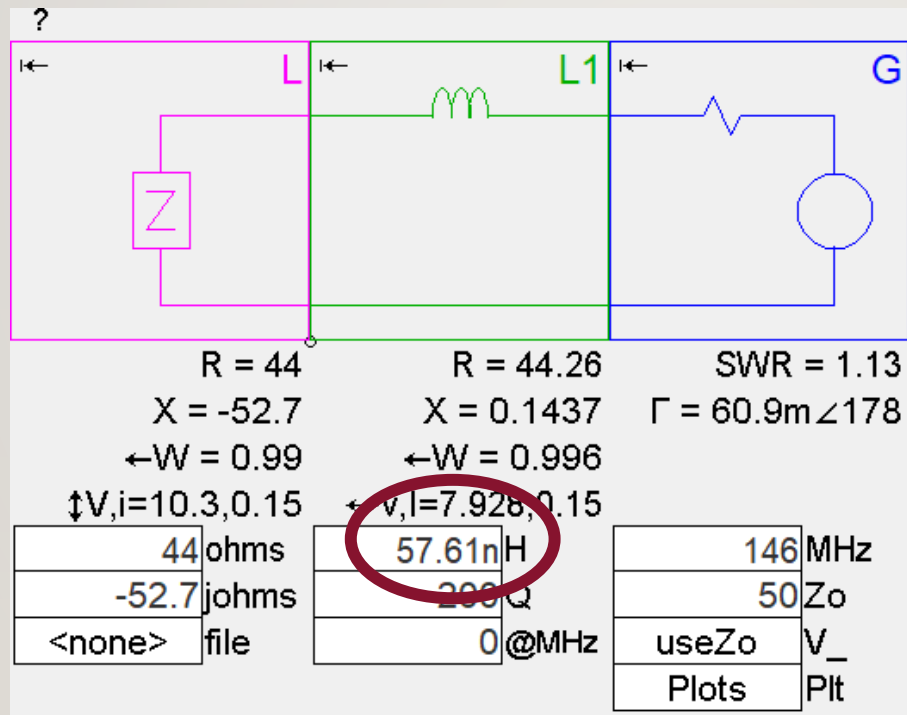
SIMSMITH

- Enter the vector impedance.
- Observe the Smith Chart plot.
- EVALUATION:
 - Is very capacitive
 - But nearly good for resistance.
- Plan: Cancel cap by adding inductance.



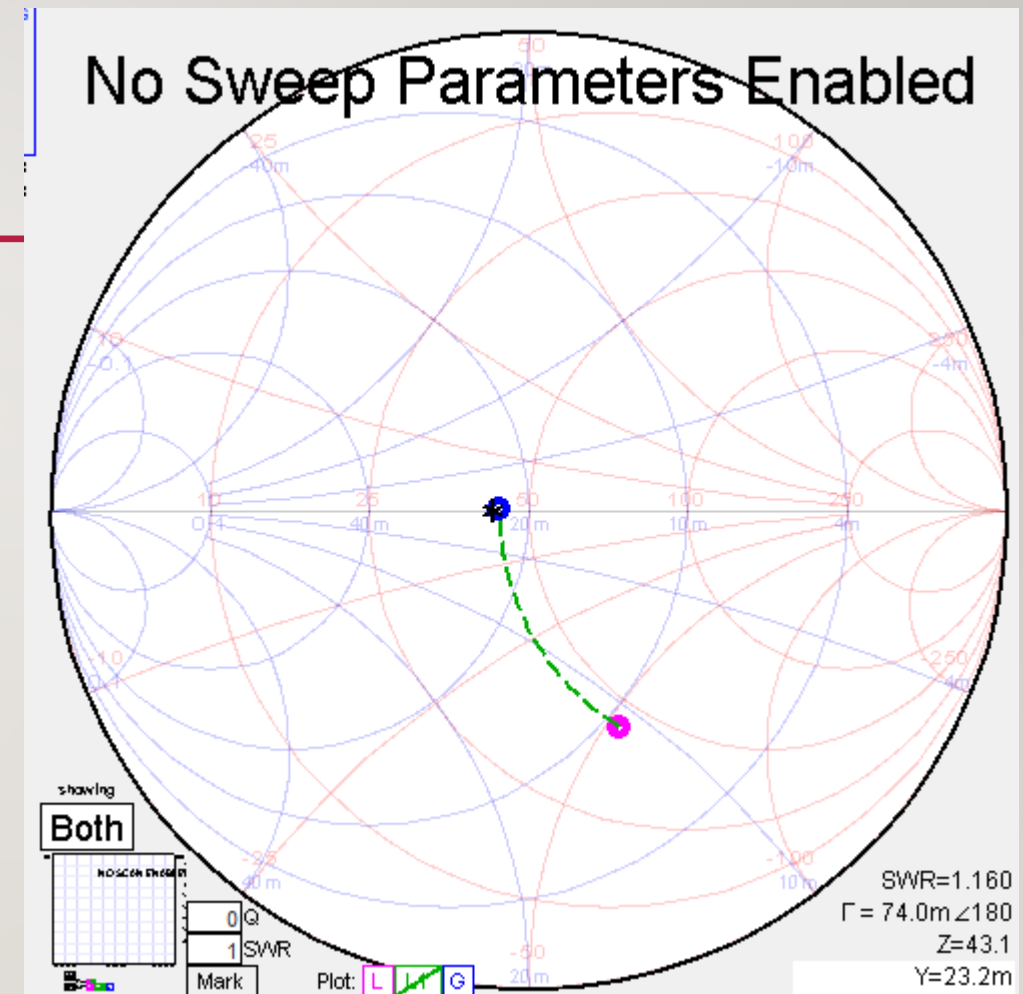
ADD INDUCTANCE

- Add 57.6 nH



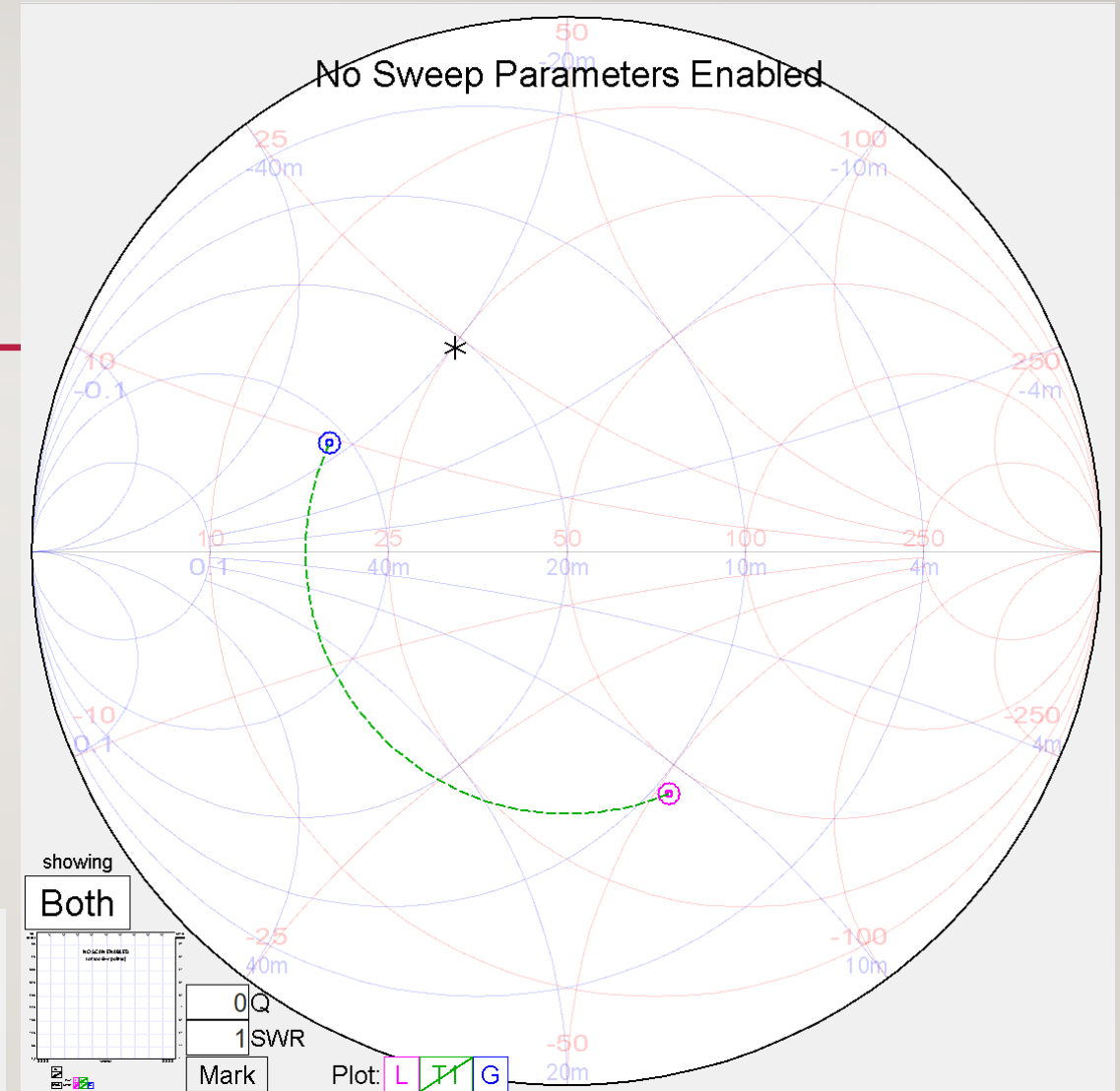
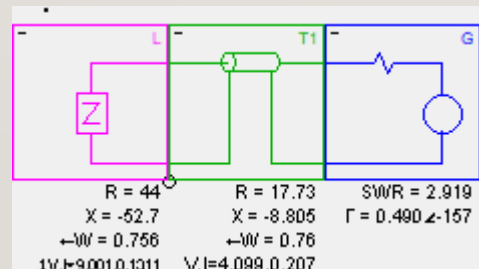
ADD INDUCTANCE

- But still shy of home.
- Need to move slightly to the right. Is this:
 - Increasing the resistance or
 - Decreasing the resistance
- How do we do it?
- Remember from the video what happens to the vector impedance when we add coax length.
- In the next slide we will add 1 foot of RG-8X coax ($v_f=0.78$) after removing the inductor.



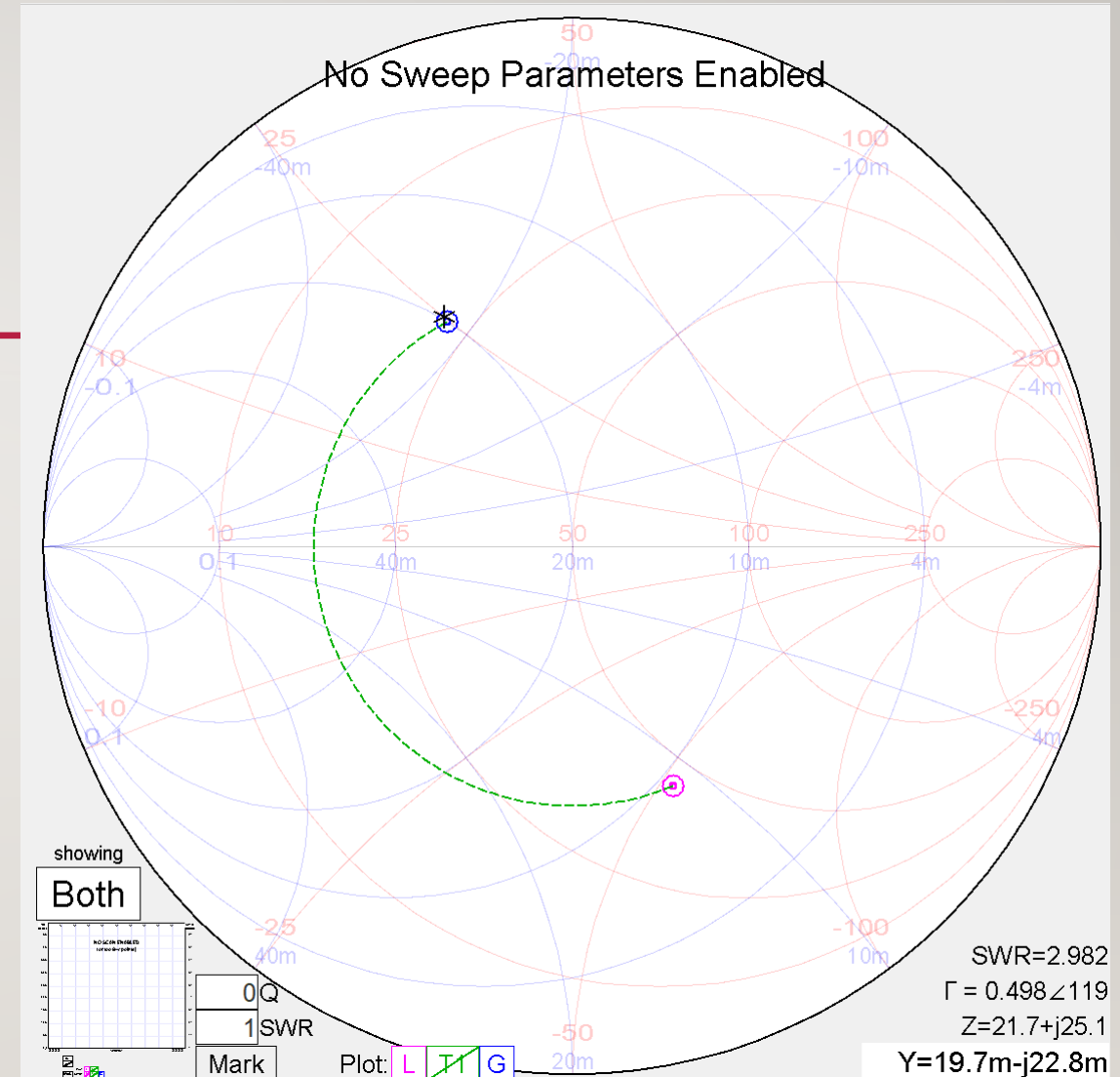
ADD 1 FT COAX, IND GONE

- We removed the 57 nH inductor.
- Then added 1.0 ft of RG-8X coax.
- Describe the effect caused.
 - Is the vector impedance now
 - Capacitive or
 - Inductive?



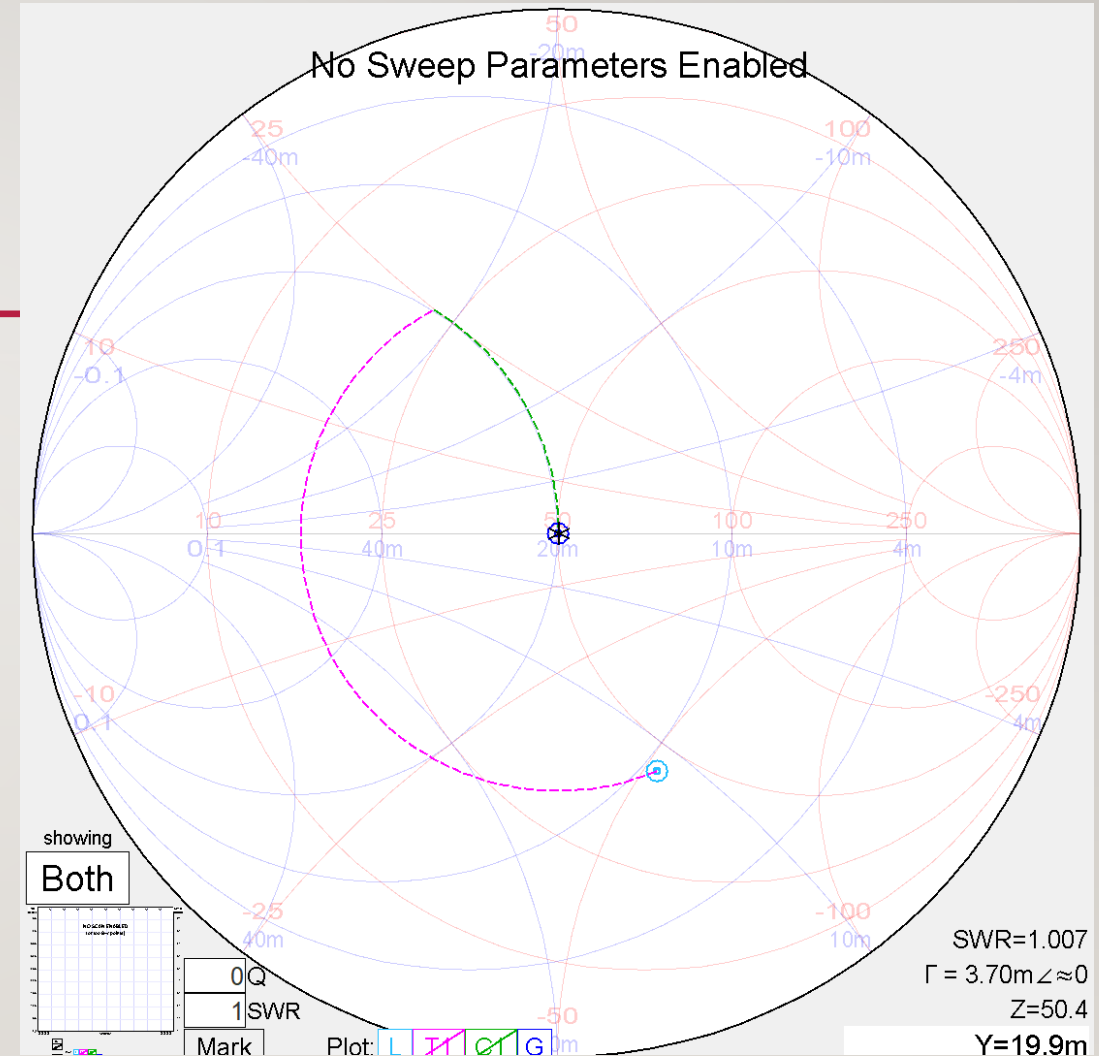
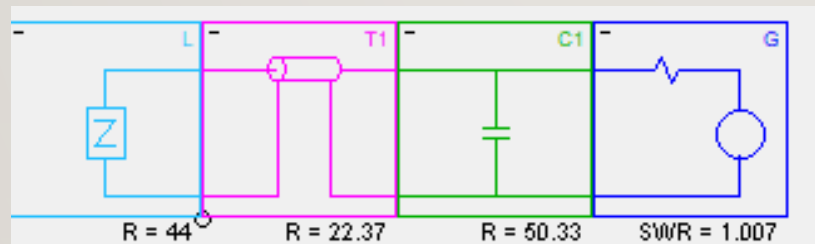
ADD MORE FEED LINE

- So now we add another 3 inches for a total of 15 inches.
- Why is this additional 3 inches critical?



ADD CAPACITANCE

- We add 24 pF of capacitor instead of an inductor. Why?
- This takes us to the Holy Grail—home plate.
- But who has a 24 pF capacitor handy and what a headache attaching it.



COAX TO IMPLEMENT REQUIRED REACTANCE

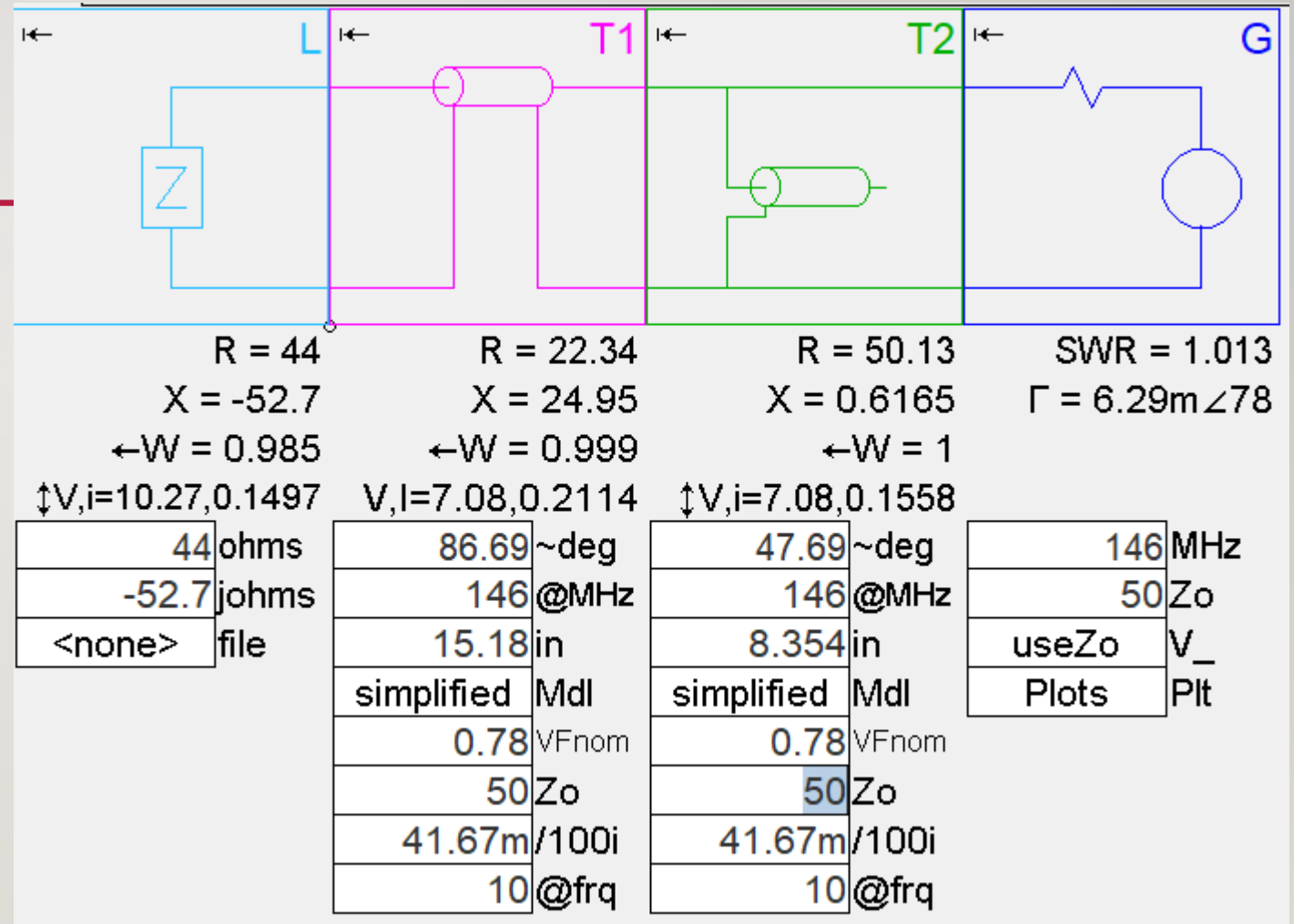


- Series-Open stub adds capacitance while decreasing resistance
- **Parallel-Open stub adds capacitance while increasing resistance**
- Series-Shorted stub adds inductance while increasing resistance
- Parallel-Shorted stub adds inductance while decreasing resistance
- Adding coax extension increases resistance and affects reactance in varied manners.



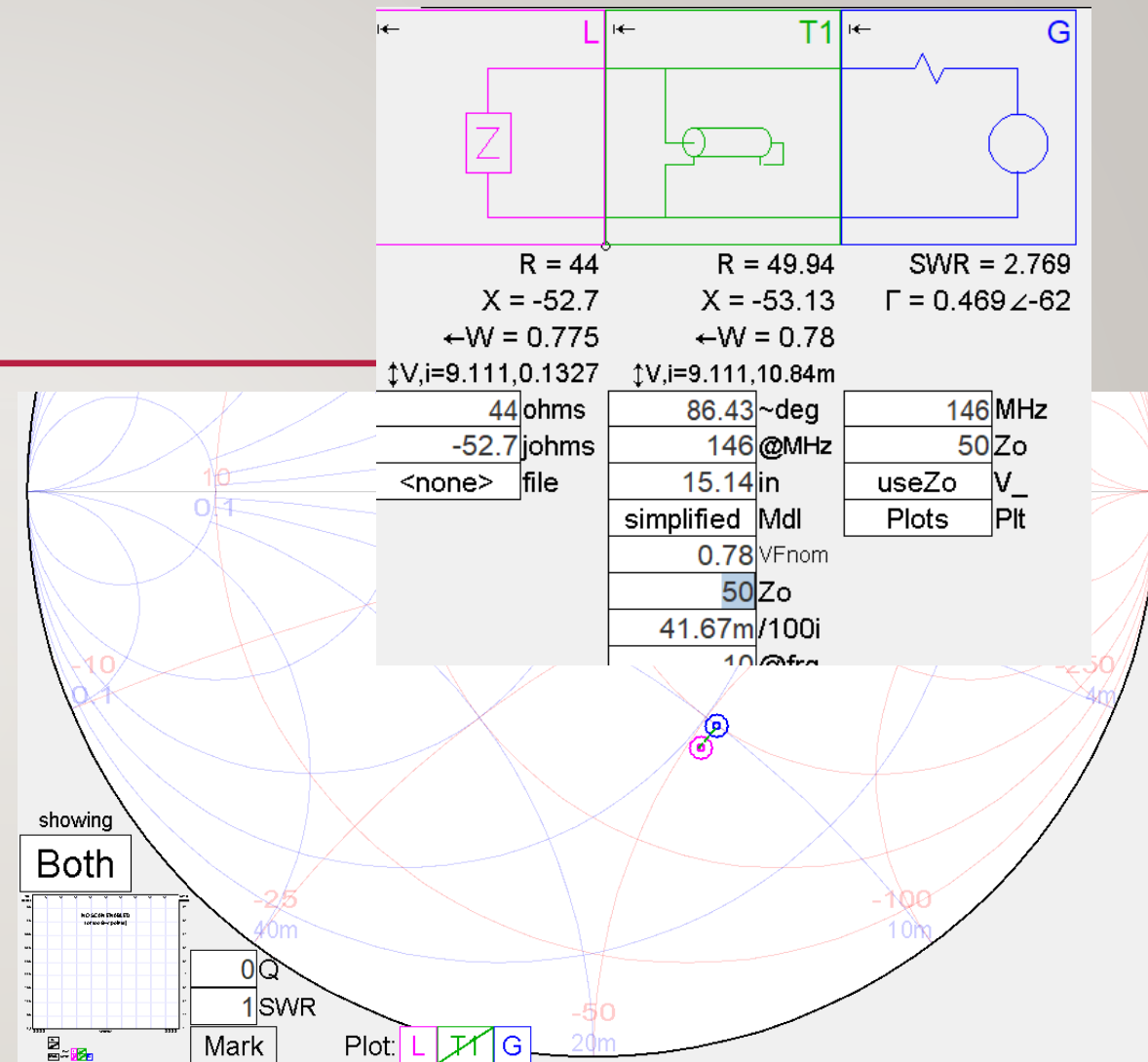
OPEN STUB COAX

- An open stub coax acts like a capacitor.
- Add 8" and 1/3" yields precisely 24 pF.



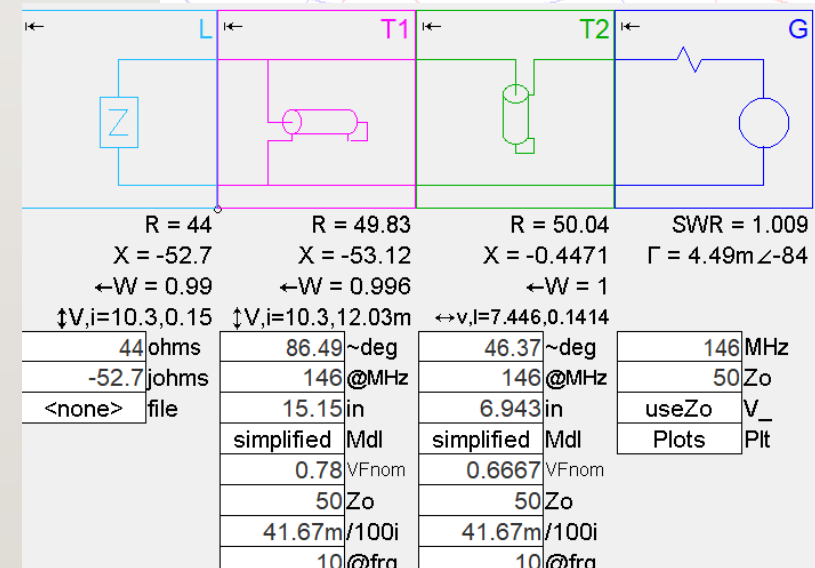
METHOD #2 STEP 1

- Add a shorted step to move counter-clockwise
- Added 15" and 1/8" in parallel

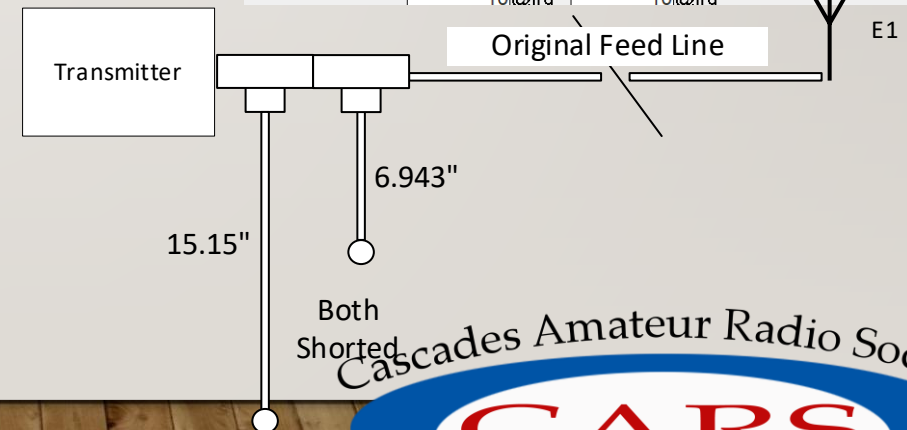
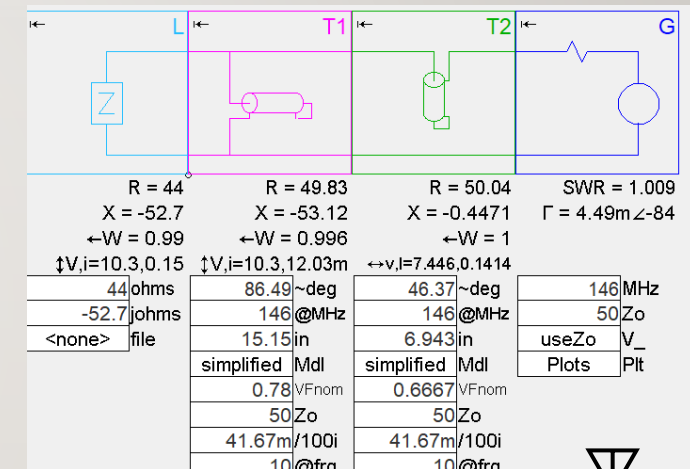
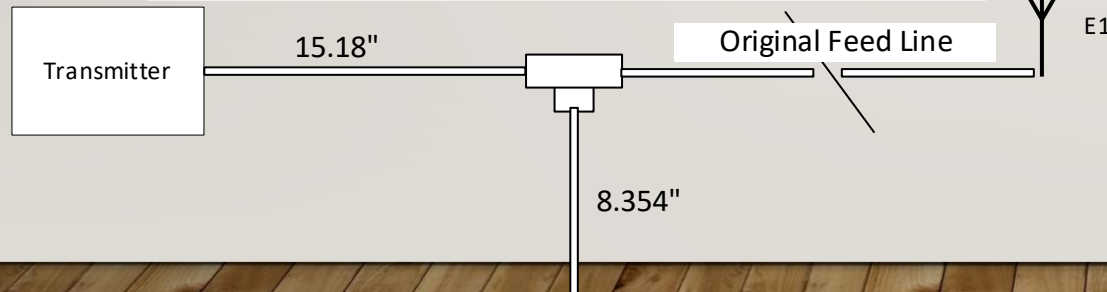
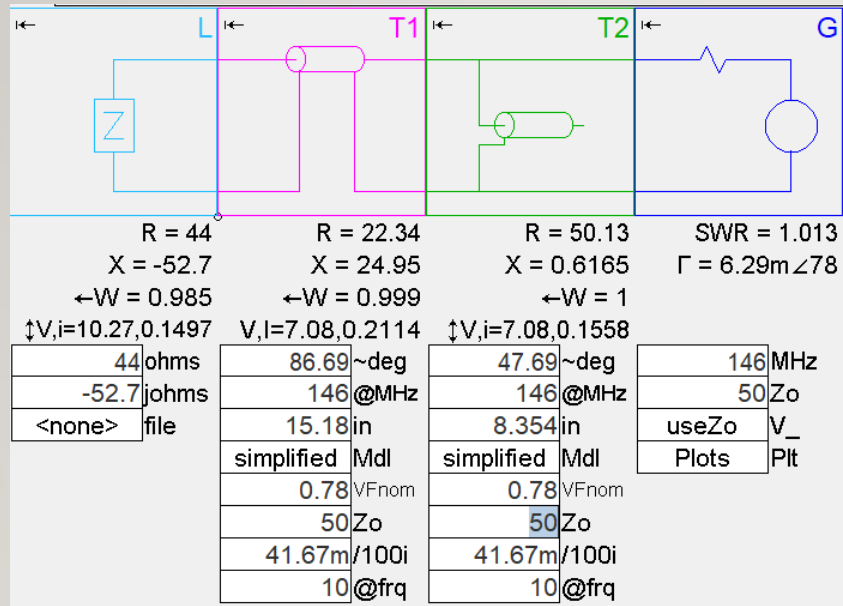


METHOD #2, STEP 2

- Add a series shorted step of length 8" and 1/8" RG-8X coax.



TWO METHODS: WHICH ONE TO BUILD



CONCLUDING QUESTIONS FOR YOU

- Why is it an advantage to use a coax with a low velocity factor?
- Would someone please explain to me what happens to the vector impedance when you add feed line?