

Revisiting Slot Antennas

Chris Hamilton AE5IT

Rocky Mountain Ham Radio

NerdFest 2021

Who am I?

- AE5IT, formerly KD0ZYF
- Licensed 2014 to call for help in the woods
- Immediately became a weird RF nerd
- Slot antennas captured attention early, but no real use cases

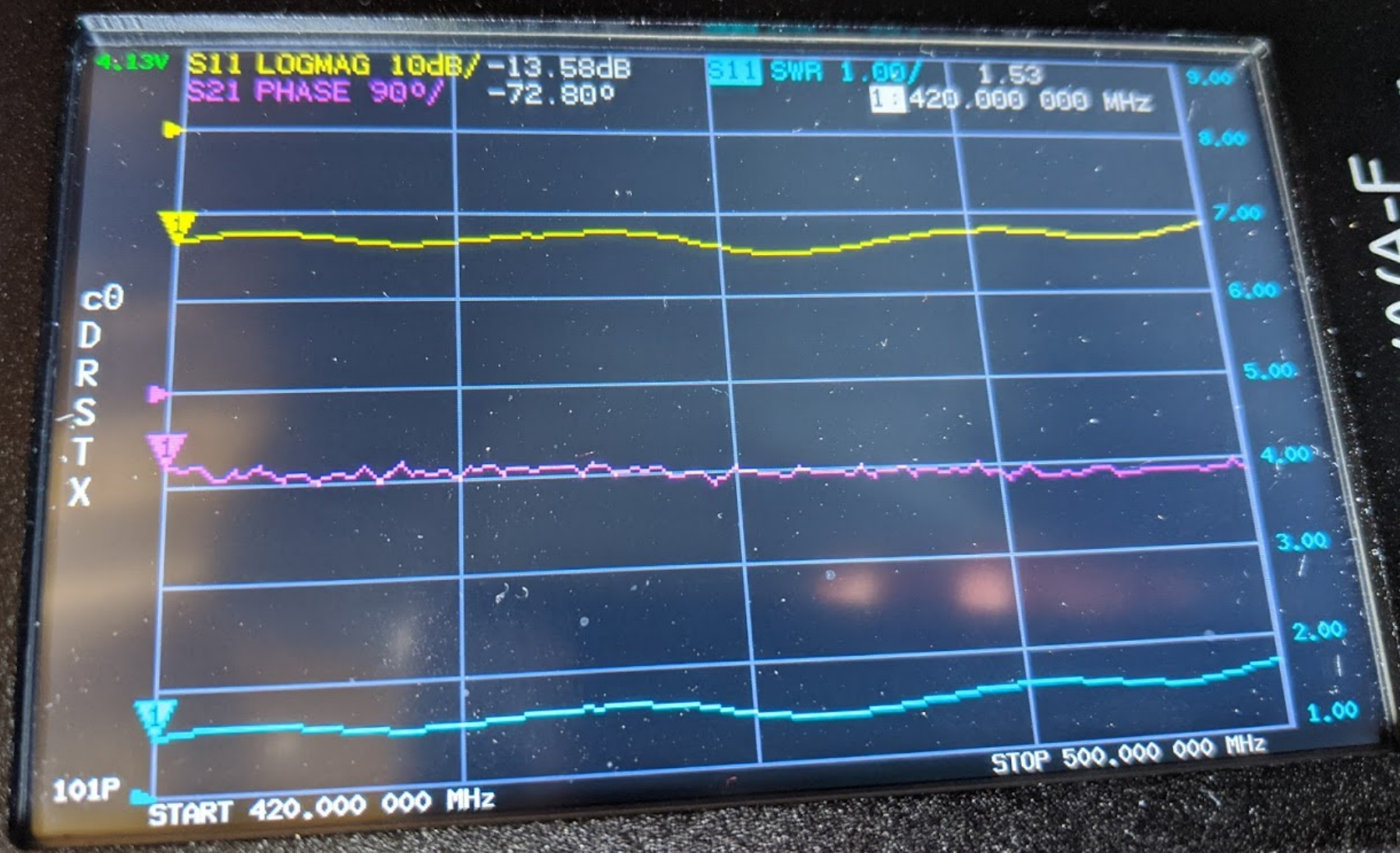
Early 2020 – no-drill mobile

- Could I load the gap between body panels as a slot antenna?
- Construction & waterproofing challenges
- Working without a VNA, lots of guessing
- Surprisingly difficult to load
- Radiation pattern and polarization not ideal (pretty good for overhead ISS passes)
- Went directly for 2m / 70cm dual-band





PORT 2 S21 PORT 1





The rest of 2020 & early 2021

- EVERYTHING WAS NORMAL AND FINE AND NOTHING AT ALL WEIRD HAPPENED
- Returning to ham projects after a lost year
- Coincidentally a recent increased interest in slot antennas among hams

So what *is* a slot antenna?

- Literally a slot cut into a large metal sheet
- Mathematical & physical complement to a dipole antenna
- Radiation pattern resembles a dipole, but with E & H planes swapped -- *a vertical slot is horizontally polarized*
- Feedpoint impedances inverse of dipole

Where & why are they used?

- Practical at V/UHF and above
- Common in aviation, TV broadcast, telecom
- Used for cell towers & microwave arrays
- The metal plane can be a waveguide – *the support structure is the antenna*
- Allows for *electrically* steerable beams in compact & robust packages

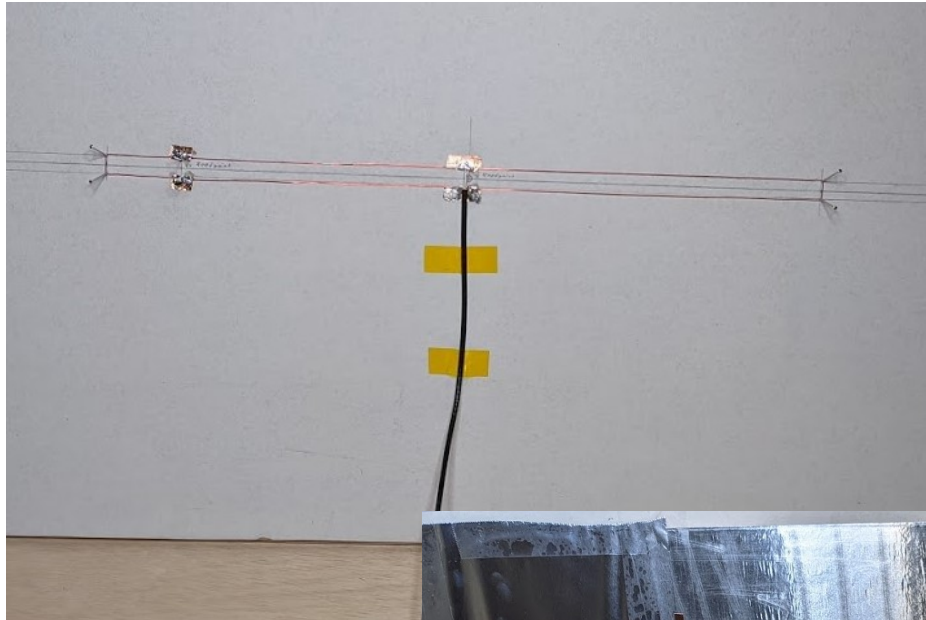
Largely unknown by hams

- Wildly impractical at HF
- Horns and dishes give more gain in smaller packages
- Applications for V/UHF weak signal?
- Some applications for stealth antennas in restrictive neighborhoods
- Some new designs seem to contradict the literature, or my understanding of it

Current work

- Fundamentals
- Build from reference designs: Kraus, Johnson & Jasik
- Measure & compare performance
- Figure out my weird VNA
- Perform replication studies of recent popular designs

Let's build antennas!



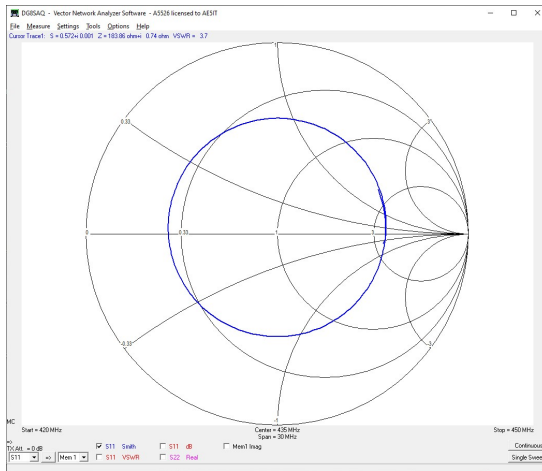
Minimal resonant slot
26 AWG copper wire
Center-fed



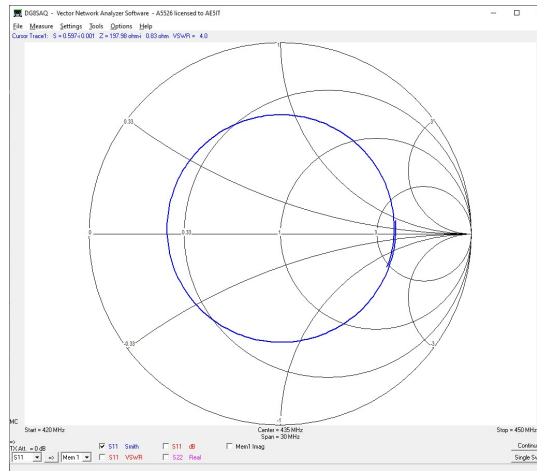
Textbook slot
 $\lambda \times \lambda/2$ Aluminum sheet
 $\lambda/20$ -fed

This is not a test & measurement talk.

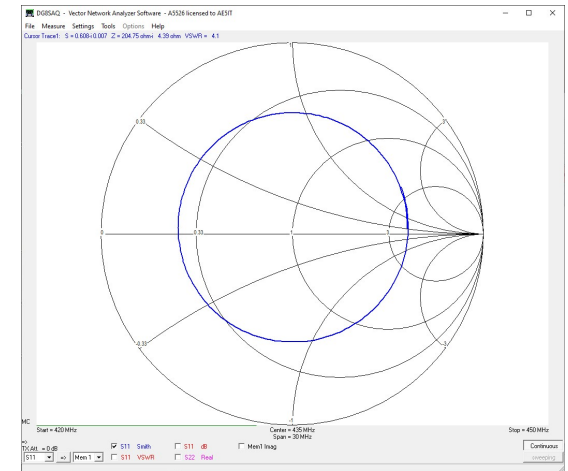
- BUT THESE ARE ALL BAD -



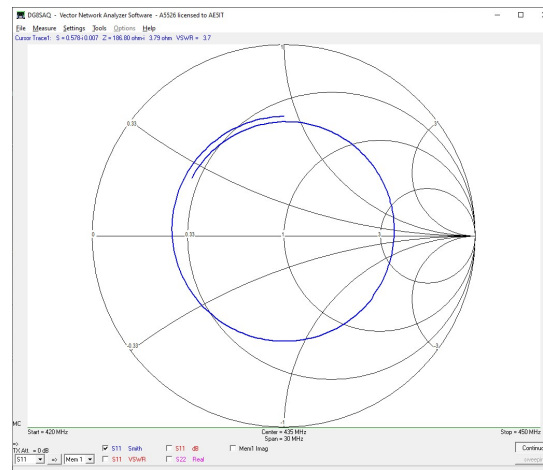
Resonant, wire, center fed



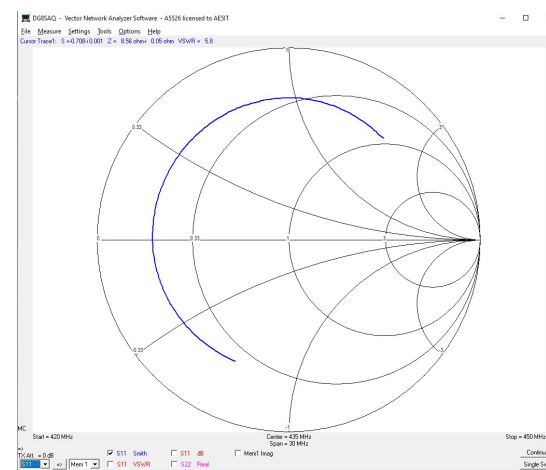
Resonant, wire, $\lambda/20$ fed



Open

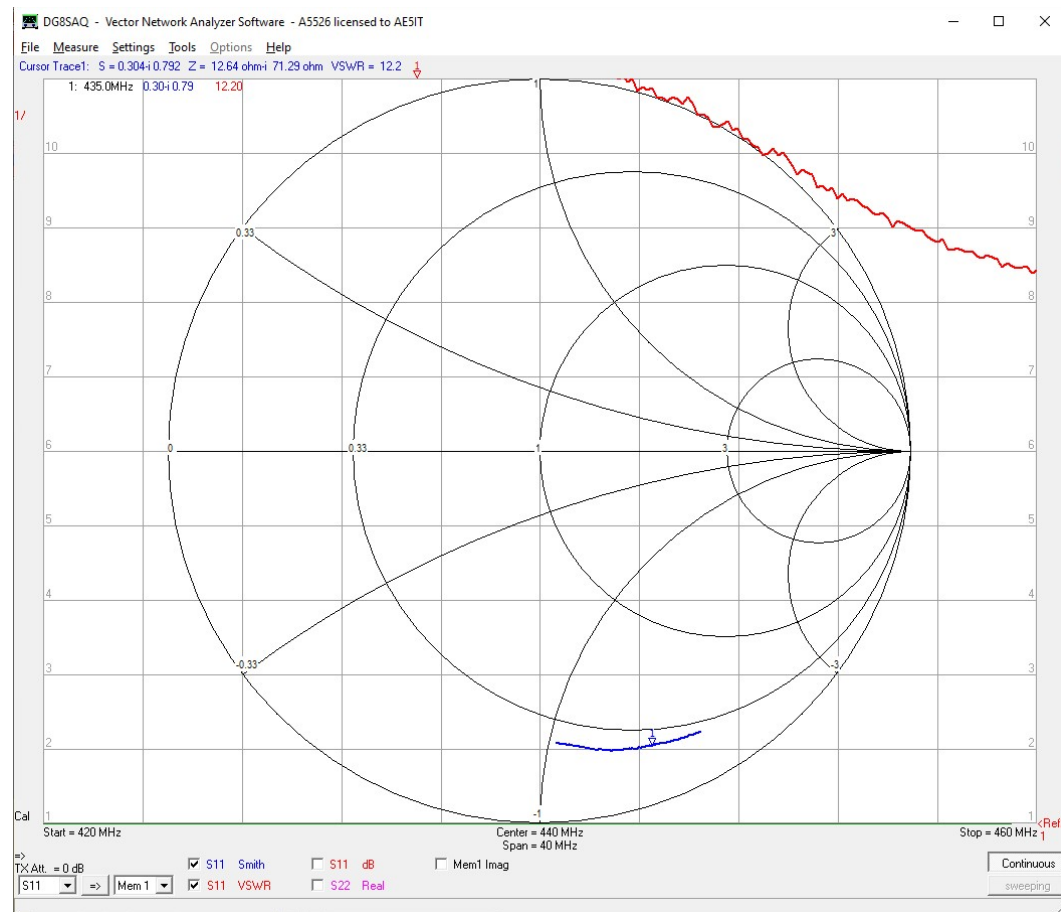


Resonant Cu tape, $\lambda/20$ fed

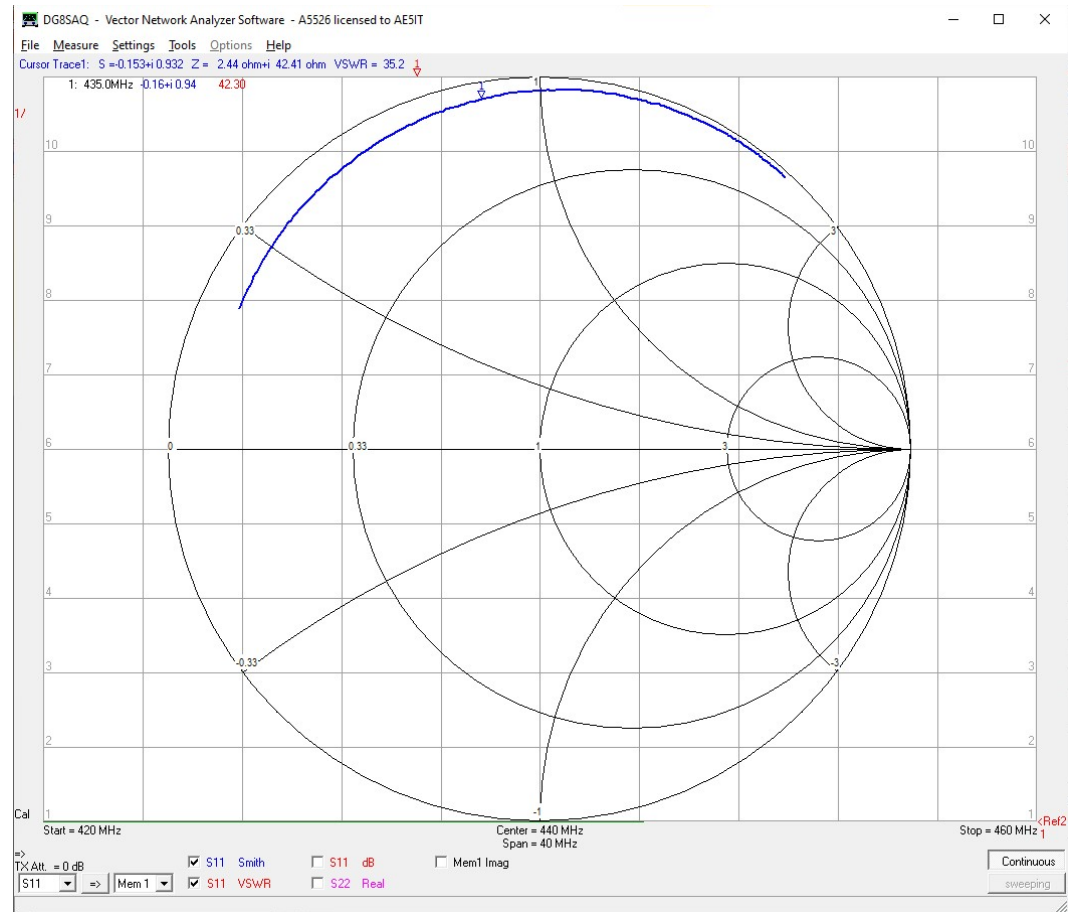


Resonant, Al sheet, center fed

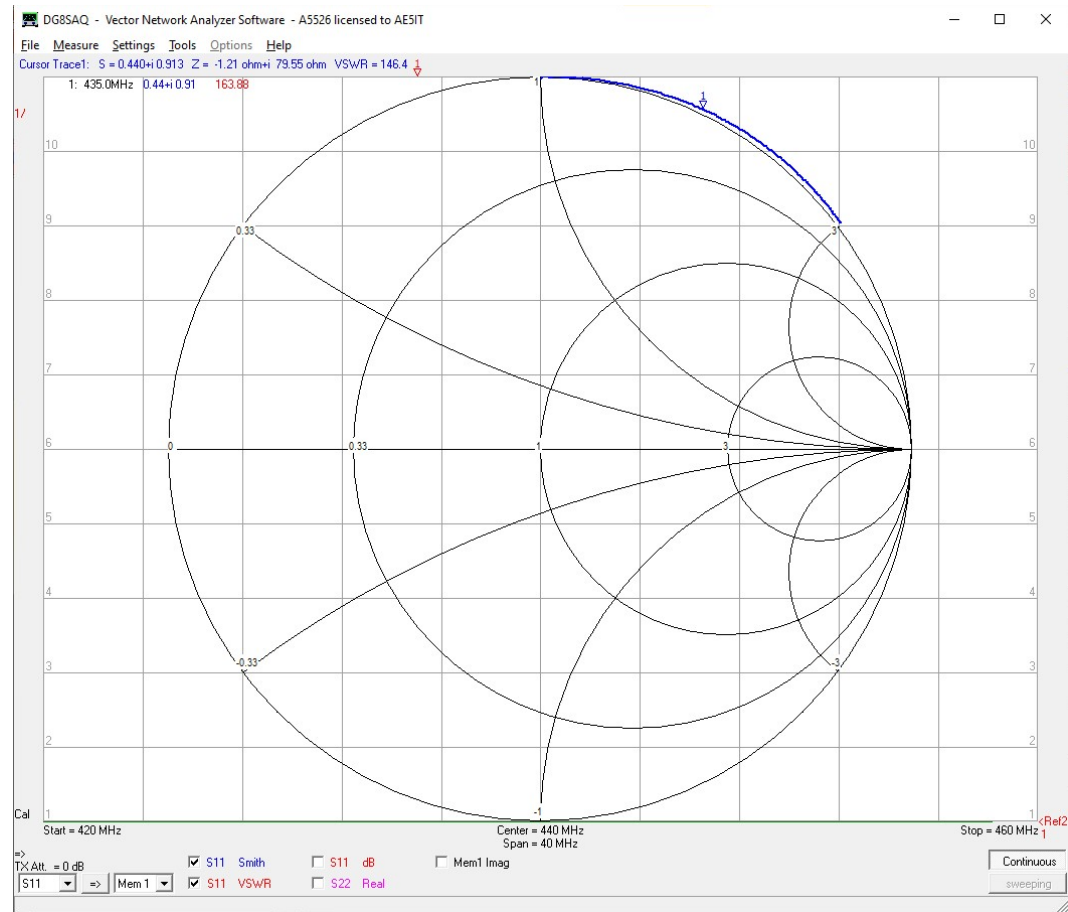
Finally figured out my funky VNA



Resonant, AI sheet, center fed
Expected ~10:1 SWR at 435MHz, seeing about 12:1
Better, but not great.

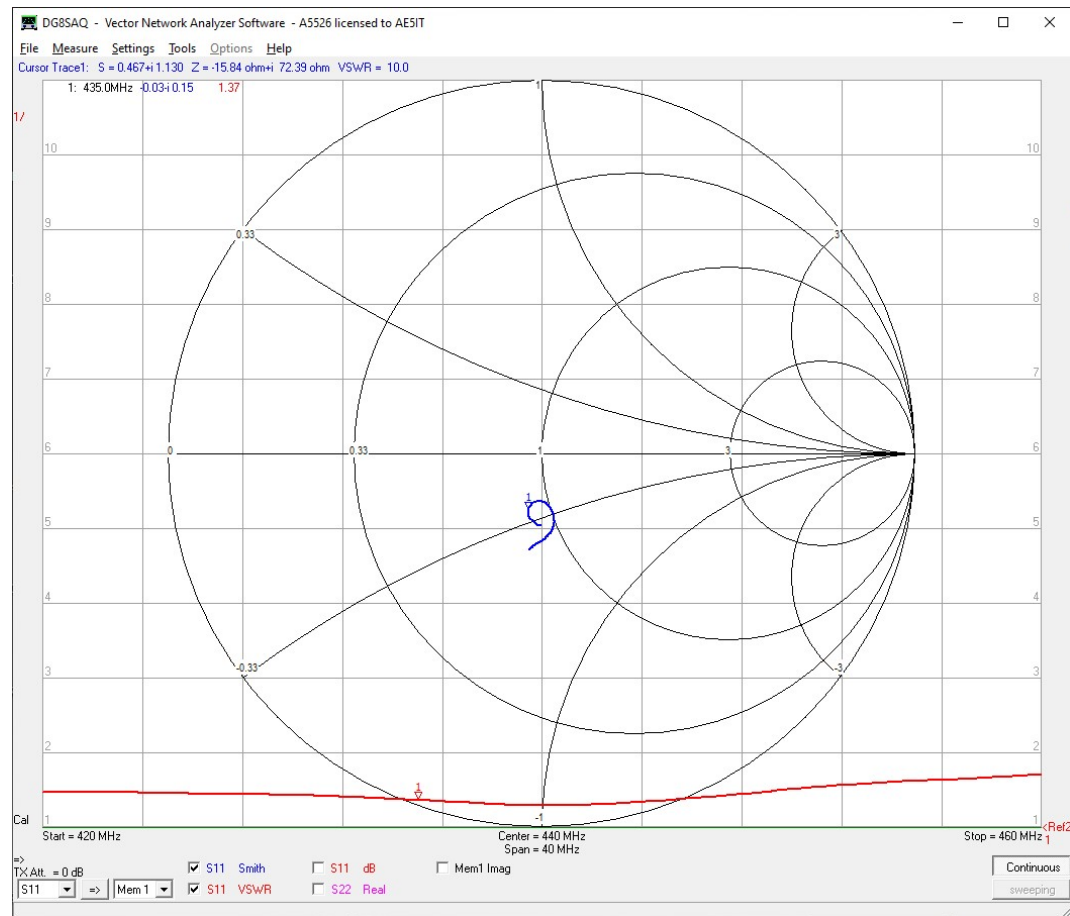


Resonant, AI sheet, $\lambda/20$ -fed
Expected 1:1 SWR at 435MHz, actually closer to 40:1
Hmm.



Resonant, AI sheet, $\lambda/10$ -fed
~ 160:1 SWR
Even worse

Time for another sanity check



Resonant, center-fed dipole
1.5:1 SWR
Finally, something behaves as expected

Will it antenna?

Something unexpected is happening, just ditch the VNA for now, get some signal data

	Repeater output Rx (dBm)	1 W @ repeater (dBm)
Rubber Duck	-60	-94
Resonant center-fed dipole	-78	-110
Resonant center-fed Al sheet	-76	-98
Resonant $\lambda/20$ -fed Al sheet	-90	-117
Resonant $\lambda/10$ -fed Al sheet	-83	-105

Motorola XPR 6550 RSSI mode; RMHam Lookout Local DMR

Lessons learned

- (Re)learn my equipment
- Don't abandon a project for an entire year
- Don't jump directly to the hard stuff
- Build & verify the basics first
- RF is fun, keep doing it

References

- John Kraus, *Antennas* 2ed, ch 13
- Richard Johnson & Henry Jasik, *Antenna Engineering Handbook* 2ed, ch 8 & 9
- Joseph Carr, George Hippisley, *Practical Antenna Handbook* 5ed, ch 18 & 19
- Peter Joseph Bevelacqua, Antenna-theory.com
<https://www.antenna-theory.com/antennas/aperture/slot.php>