A SHORTENED HF ANTENNA

FROM OPEN RESEARCH INSTITUTE
PRESENTED BY
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OCTOBER 2025

ELEMENTS

- The Past
- The Present
- The Future

SHORTENED HF ANTENNAS

WHAT DO WE KNOW?

WHAT CAN WE LEARN FROM THE PAST?

TRADE OFFS

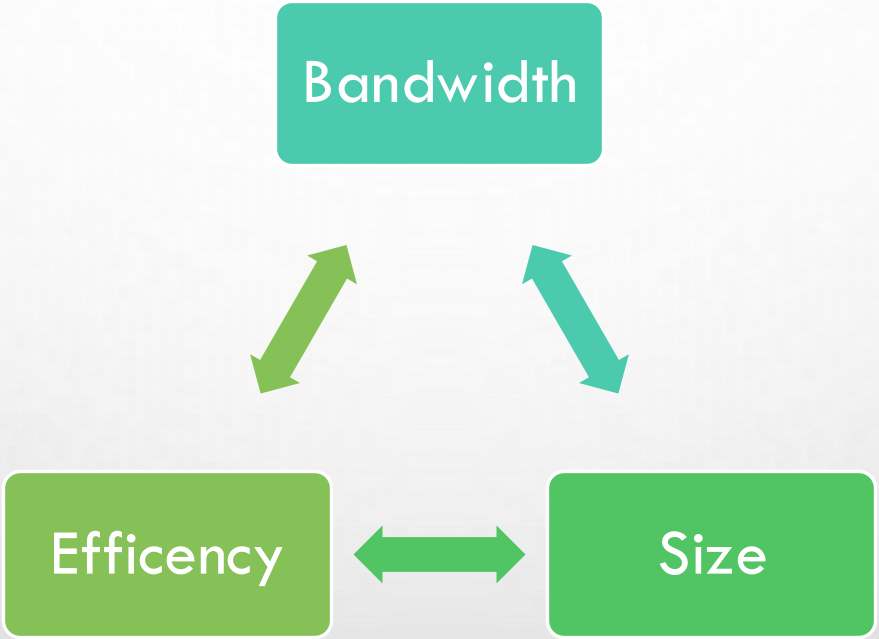
TRADE OFFS

"EFFECT OF ANTENNA SIZE ON GAIN, BANDWIDTH, AND EFFICIENCY" ROGER F. HARRINGTON

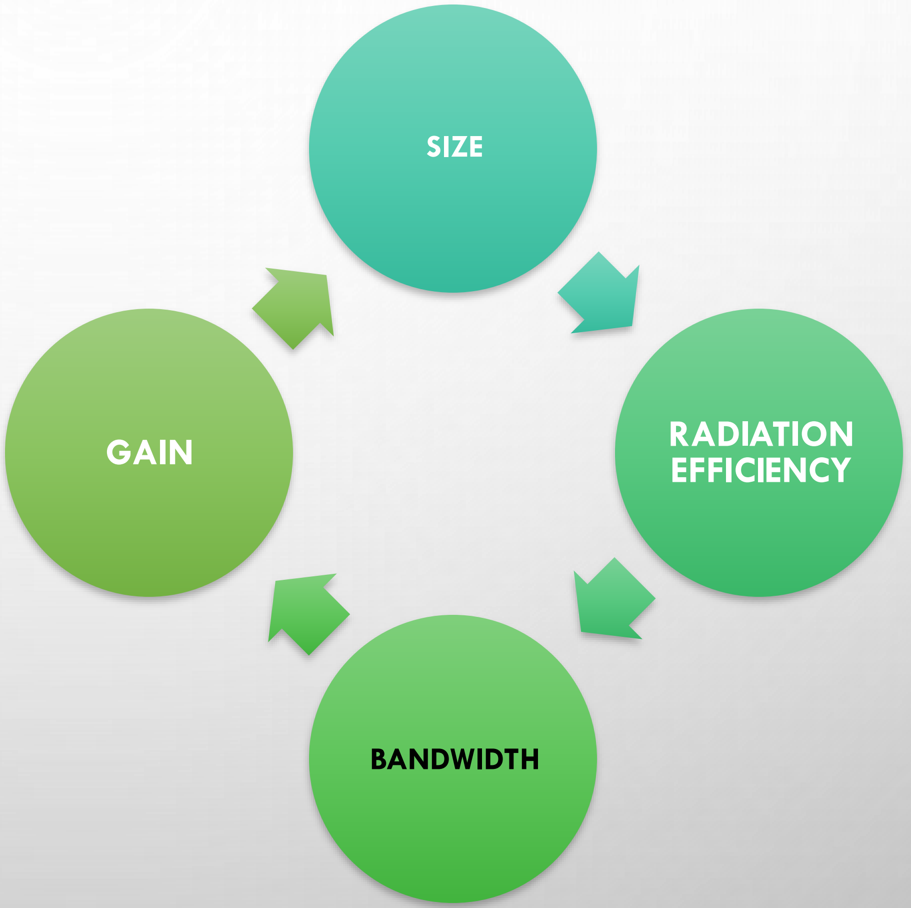
JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS D. RADIO PROPAGATION
VOL. 64D, NO.1, JANUARY- FEBRUARY 1960

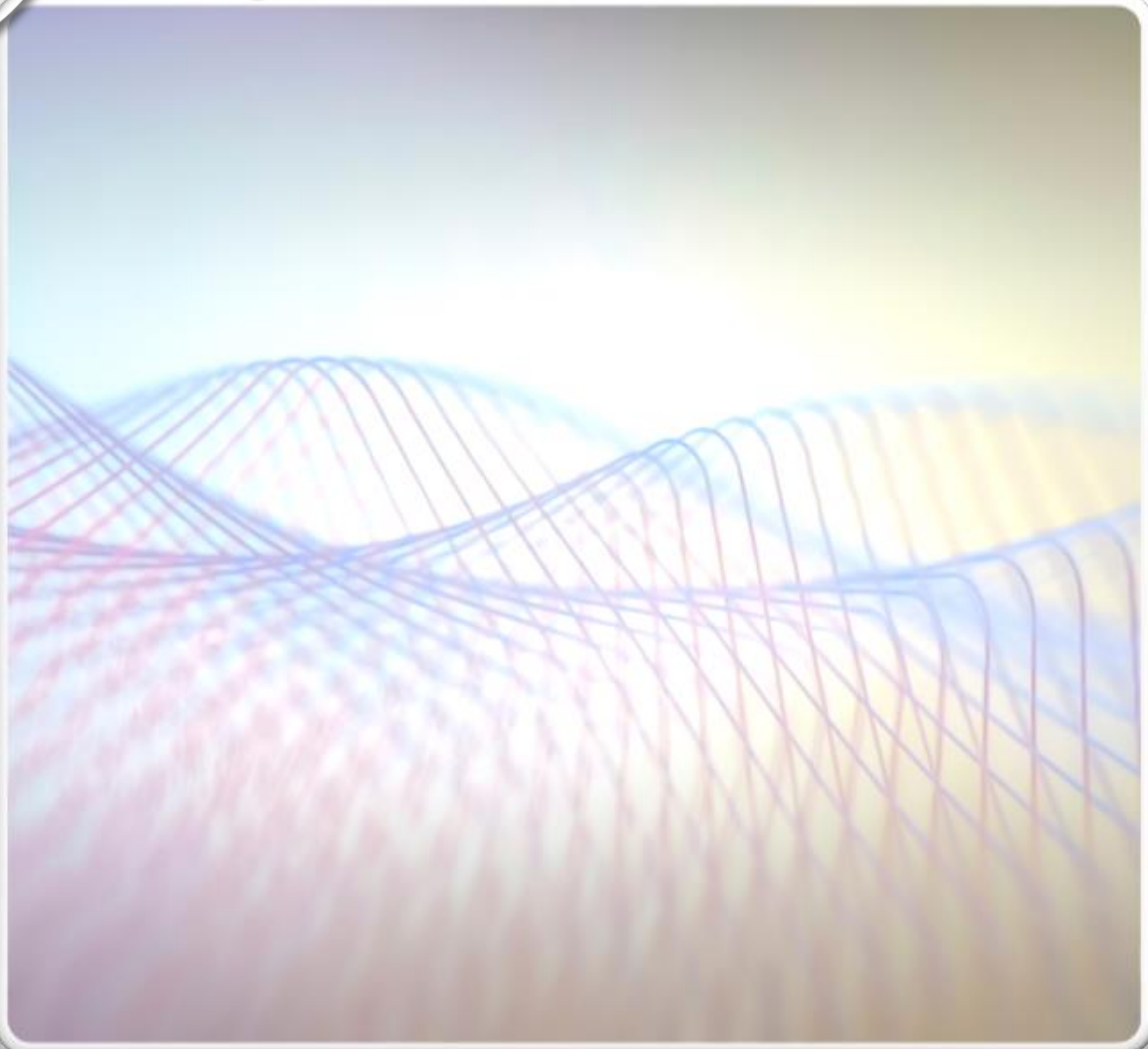
"THE MAXIMUM GAIN OBTAINABLE FROM A BROAD-BAND ANTENNA IS APPROXIMATELY EQUAL TO THAT OF THE UNIFORMLY ILLUMINATED APERTURE. IF HIGHER GAIN IS DESIRED , THE ANTENNA MUST NECESSARILY BE A NARROW-BAND DEVICE. IN FACT, THE INPUT IMPEDANCE BECOMES FREQUENCY SENSITIVE SO RAPIDLY THAT, FOR LARGE ANTENNAS, NO SIGNIFICANT INCREASE IN GAIN OVER THAT OF THE UNIFORMLY ILLUMINATED APERTURE IS POSSIBLE."

"THE ANTENNA TRIANGLE" PICK ANY TWO!



BALANCING ACT





MINIATURIZATION TECHNIQUES

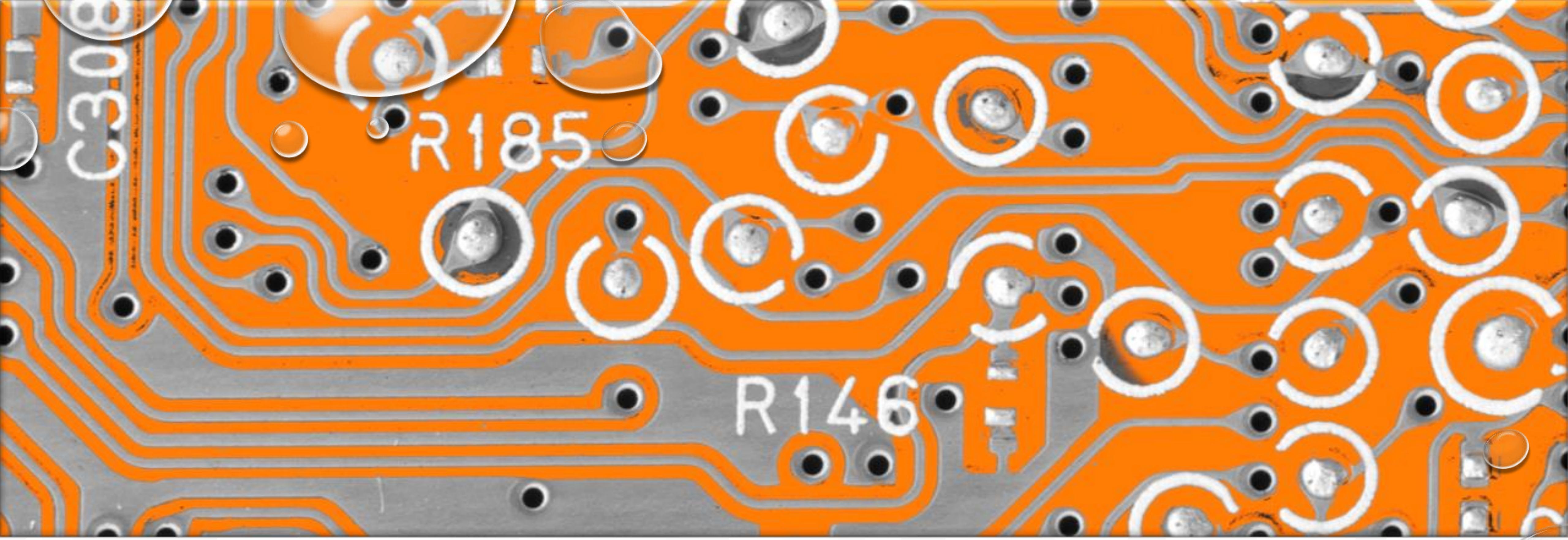
- Structural modifications
- Lumped elements
- High permittivity materials

STRUCTURAL MODIFICATIONS

- Slots/Slits
- Fractals
- Meanders

LUMPED ELEMENTS

L	Inductors
C	Capacitors
R	Resistors



HIGH PERMITTIVITY MATERIALS

LINEAR LOADING

(meanders!)

HTTPS://WWW.M0PZT.COM/

THE METHOD OF "LINEAR-LOADING" IS A FANCY WAY OF SAYING "FOLD THE WIRE BACK ON ITSELF"

LINEAR LOADING REDUCES THE OVERALL LENGTH OF AN ANTENNA WITHOUT USING LOADING COILS.

1958 RSGB ARTICLE

HTTPS://GITHUB.COM/OPENRESEARCHINSTITUTE/DUMBBELL/

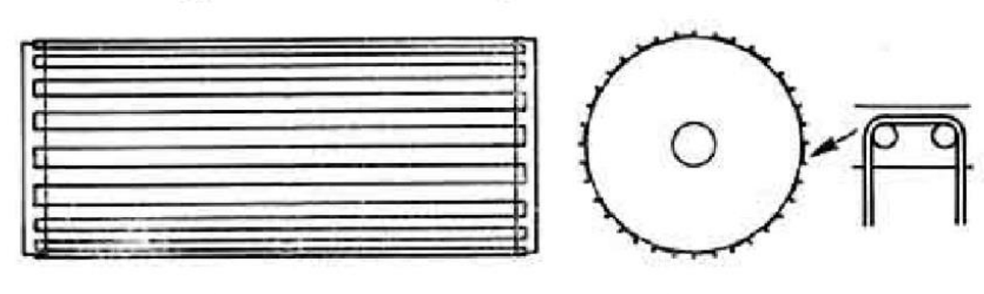


Fig. 2. Method of winding a loading coil for outside use.

Aerials for Confined Spaces

By M. J. HEAVYSIDE, B.Sc. (Hons.), M.Ed., Ph.D. (G2QM)*

IT is assumed that a length of wire suitably placed, insulated and fed with alternating current from a transmitter acts as an aerial and that the amount of radiation from any portion of it is proportional to the square of the current in that portion.

Radiation Resistance

As a measure of the amount of radiating power of an aerial a fictitious resistance, called the "radiation resistance," is assumed. This must not be confused with the impedance at the feed point, for only in the special case of centre-fed dipoles are these two almost alike in amount. A comparison of the radiation resistance of an aerial with the loss resistance gives an idea of its efficiency as a radiator, though this does not take into account the direction of radiation.

Aerials are usually compared with a half-wave aerial in free space as a standard and this provides a useful starting point for the consideration of aerials shorter than a half-wave. A half-wave aerial can be considered in two ways. First, it acts as a tuned coil so that its spread inductance and capacitance tune to the frequency for which it is designed. Secondly, it is of such a length that when the travelling wave supplied by the transmitter is reflected out of phase at the far end, the point of maximum current is in the centre, the feeding end being a point of high impedance.

The power radiated by a short section of a half-wave aerial (and hence the contribution of that section to the radiation resistance) is proportional to $\sin^2 \theta$ where θ is the electrical distance from the free end. To use this to arrive at an approximation to the radiation resistance of a short aerial, without using advanced mathematics, we can plot a curve, letting each 14 ft and a little over represent 10° of a 256 ft half-wave aerial. The area between any part of the curve and the line on which it stands represents the radiation resistance of the part of the aerial represented by that part of the curve.

Efficiency

"What is the value of this gain in radiation resistance?" might be asked. The value is in the increase in efficiency as the radiation resistance rises compared with the loss resistance. If the radiation resistance is 2 ohms and the loss resistance is also 2 ohms, as it might be for a 40 ft length of wire, only half the power supplied is radiated. If the radiation

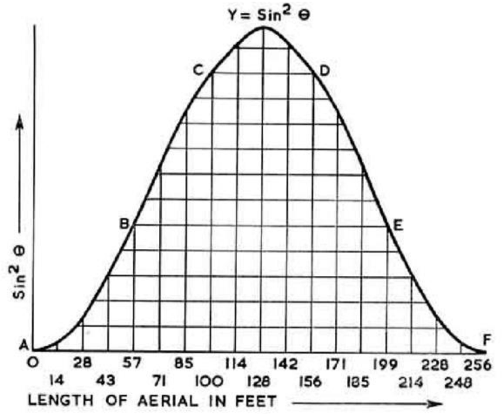


Fig. 1. Curve plotting $\sin \theta$ versus aerial length.

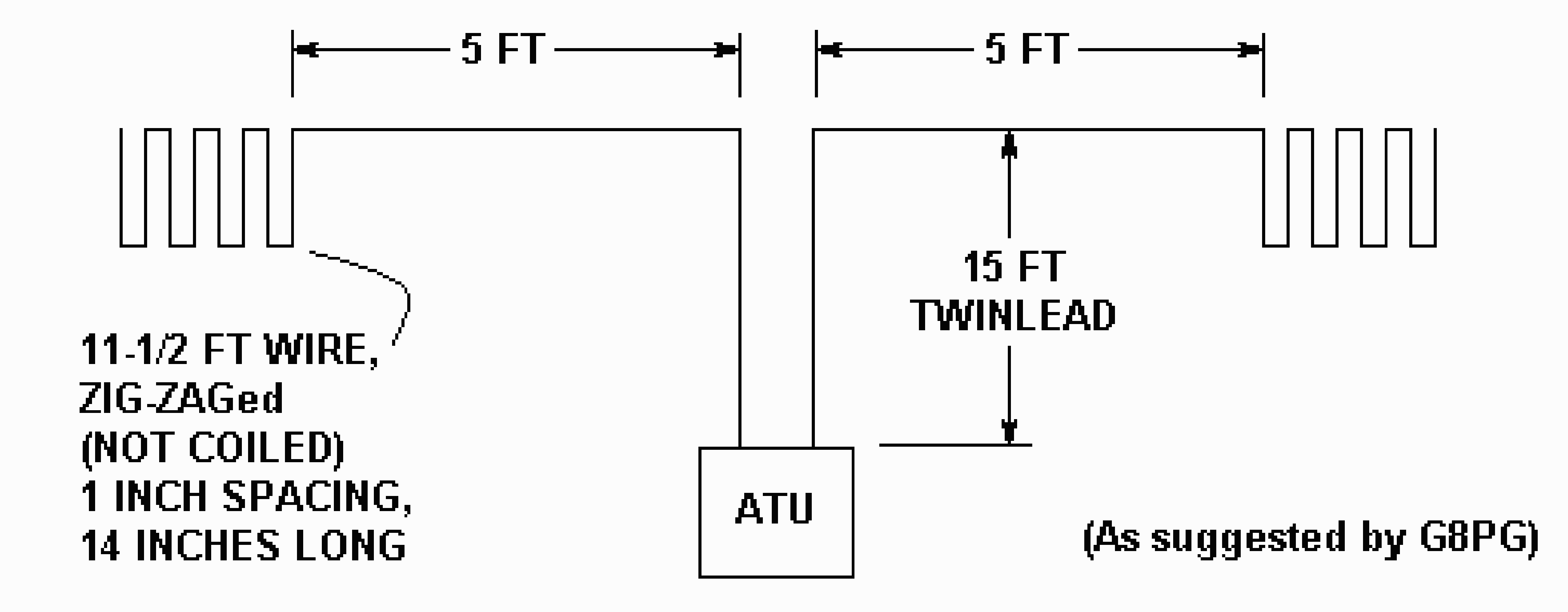
resistance is raised to 40 ohms by increasing the loss resistance only to 4 ohms, then only one eleventh of the power supplied is lost and ten elevenths radiated.

Aerials on the 160 metre band tend to have low radiation

TABLE I

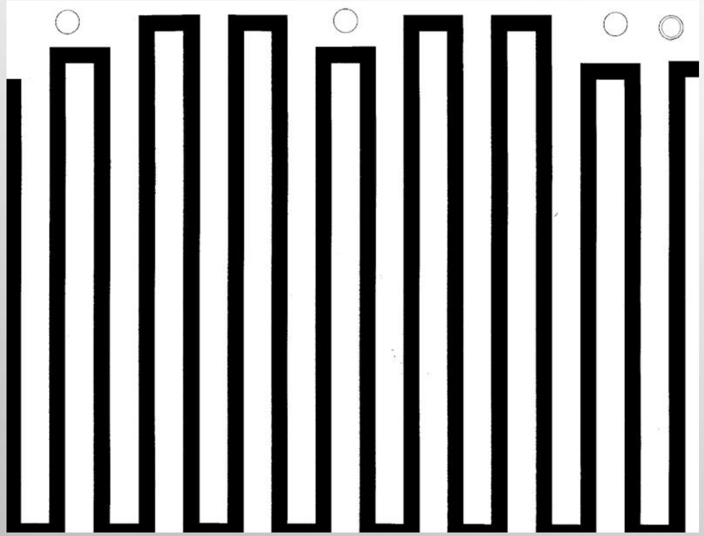
Portion to	14ft	28ft	43ft	57ft	71ft	85ft	100ft	114ft	128ft
Area under	$\frac{1}{8}$	$\frac{7}{8}$	$2\frac{1}{4}$	4	$6\frac{1}{4}$	$8\frac{1}{2}$	$10\frac{1}{4}$	$11\frac{1}{2}$	$12\frac{1}{4}$
Radiation resistance in ohms of each portion	0·08	0·56	1·45	2·57	4	5·5	6·6	7·4	7·9
Radiation resistance in ohms of length from end	0·08	0·64	2·1	4·6	8·6	14·1	20·7	28·1	36
Radiation resistance in ohms of length at centre	8	15·8	23·4	30·6	37·5	43·8	49·5	54·8	59·1
Times gain	100	12·4	11·1	6·7	4·4	3·1	2·4	1·9	1·6

NOTEBOOK ANTENNA FROM N5ESE

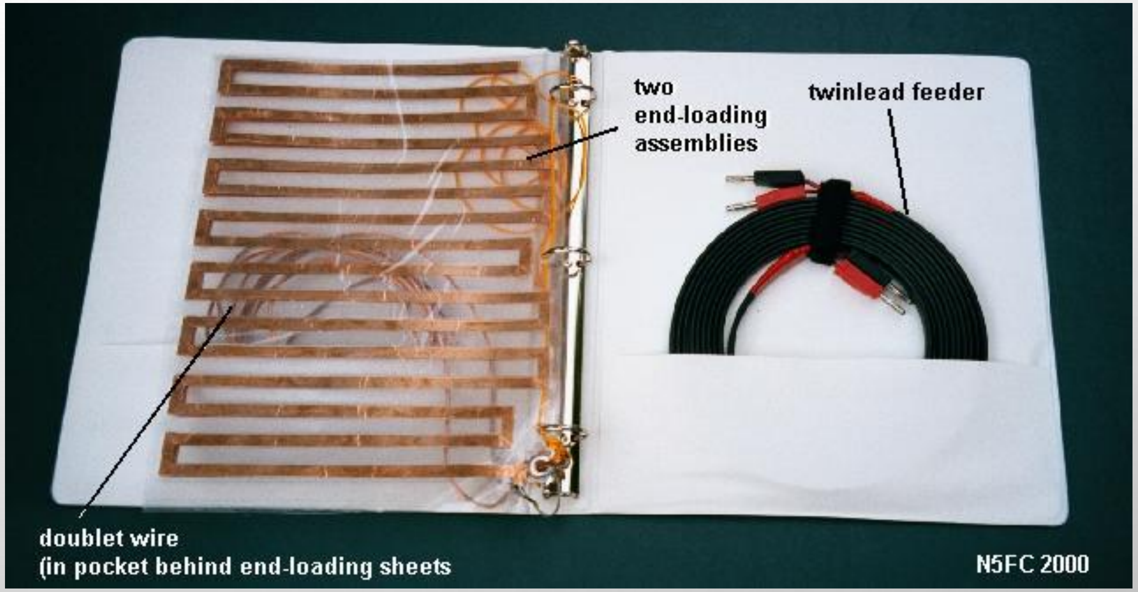


NOTEBOOK ANTENNA FROM N5ESE

COPPER TAPE TEMPLATE



ANTENNA ASSEMBLED



SHORTENED HF ANTENNAS

WHAT HAVE WE DONE?

SOME RECENT WORK

PROCESS AND HIGH-LEVEL RESULTS

SIMULATE

INITIAL RESULTS IN MMANA WERE GOOD, SO A MODEL IN MATLAB WAS WRITTEN AND PUBLISHED.

CONSTRUCT

AN ANTENNA WAS CONSTRUCTED ON USING THE DIMENSIONS FROM N5ESE'S DOCUMENTATION, WHICH USES THE CONCEPTS ESTABLISHED IN EARLIER PAPERS.

TEST

THE PROTOTYPE ANTENNA WAS TESTED, AND PERFORMANCE MATCHED SIMULATION.

PUBLICLY AVAILABLE REPOSITORY

MATLAB MODEL

MATLAB SIMULATION AND FIELD TESTING RESULTS ARE IN THE **MATLAB_MODEL_AND_RESULTS** FOLDER.

EAST COAST TEAM

SIMULATIONS AND PHOTOGRAPHS OF FIELD TESTING, FROM THE WASHINGTON DC TEAM LEAD BY SAMUDRA HAQUE, ARE IN THE **WASHINGTON_DC_EFFORTS** FOLDER

PAPERS AND ARTICLES

TECHNICAL ARTICLES AND PAPERS ABOUT THIS DESIGN CAN BE FOUND IN THE **PAPERS** FOLDER.

https://github.com/OpenResearchInstitute/dumbbell/

MATLAB SCRIPT

A WALKTHROUGH OF THE SIMULATION

THE BASICS

WE START OUT DUPLICATING THE MODEL IN THE 1958 PAPER.

THE MODEL SETS AN AERIAL LENGTH OF 256 FEET AND USES SIN(X) SQUARED TO REPRESENT THE RADIATED POWER OF SHORT SECTIONS OF A HALF WAVE AERIAL. X IS THE ELECTRICAL DISTANCE FROM THE FREE END.

```
% Create a dipoleMeander antenna
% Generated by MATLAB(R) 9.14 and Antenna Toolbox 5.4.
% Started on: 13-May-2023 08:00:20
%% radiation resistance and efficiency model
% from the 1958 Heaviside paper
% sin(x) squared graph, over 256 foot aerial
aerial_length = 256;
x = 0:pi/18:pi;
y = sin(x).*sin(x);
```

FIGURES FROM PAPER

THE CURVE IS EASY, BUT LABELING THE GRAPH TAKES SOME EFFORT.

WE SET UP INDICES FOR THE LOCATION OF THE LABELS, MAKE A SET OF LABELS, AND FIGURE OUT HOW TO OFFSET THE LABELS FROM THE CURVE SO THEY DON'T CRASH INTO THE CURVE.

WE PLOT THE CURVE AND THEN DISTRIBUTE THE LABELS HERE.

```
% recreate the A, B, C, D points on the graph in the paper
idx = [1, 5, 8, 12, 15, 19]   % the index of the location of the labels
labels = {'A', 'B', 'C', 'D', 'E', 'F'};   % list of the labels in the paper
x_offset = [0, -0.05, -0.075, 0.075, 0.05, 0]   % makes the labels much prettier
figure
p = plot(x, y, "-o", "Color", "k", "LineWidth", 2)
for ind = 1:length(labels)
   disp(x(idx(ind)))
text((x(idx(ind))) + x_offset(ind), y(idx(ind)) + 0.05, labels(ind), "Color", "b","FontSize", 18,
"HorizontalAlignment", "center")
end
```

VISUALIZATIONS

WE COLOR IN THE SECTIONS OF THE GRAPH BY DESIGNATING THE RANGES ON THE X AND Y AXES AND THEN USE THE AREA FUNCTION TO FILL THEM IN.

```
% Let's do some animation?
ABx = x(1:5)
ABy = y(1:5)
CDx = x(8:12)
CDy = y(8:12)
centerx = x(1:10)
centery = y(1:10)
hold on
area(ABx, ABy,"FaceColor","c" )
area(CDx, CDy, "FaceColor","g")
hold off
```

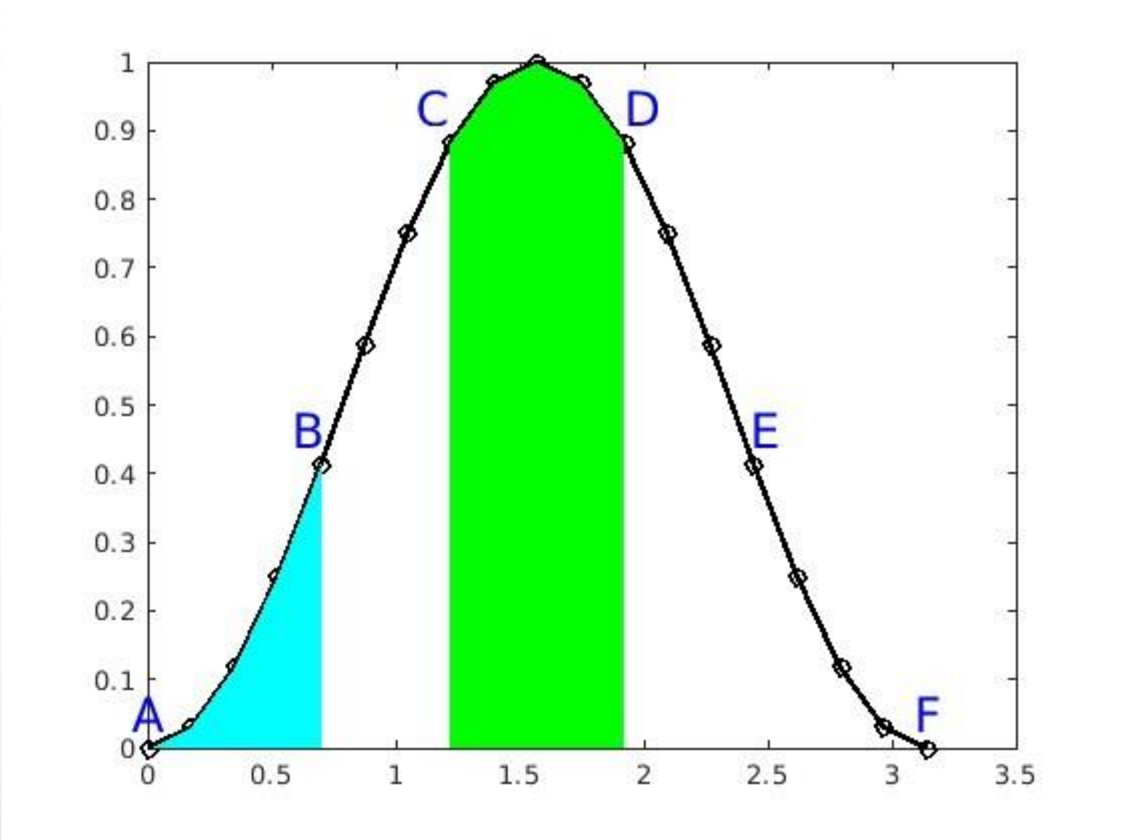
FIGURE 1

WHAT IF WE COULD MAKE THE END PIECE IN CYAN ACT LIKE THE MIDDLE PIECE IN GREEN? MUCH BETTER **RADIATION RESISTANCE**.

In Fig. 1 the curve is drawn. Table I shows the number of squares under each portion of the aerial, but as the curve is symmetrical, only the first quarter wave is shown.

If we take a length of 57 ft of wire, shown in Fig. 1 as AB on the curve, this acts as a length of 57 ft at the end of an aerial, if suitably fed; that is, the portion EF of the curve. It will be seen that the radiation resistance of this portion, even if in free space, would be only 4·6 ohms.

If it could be moved to the centre, to be represented by the curve CD, the radiation resistance would be changed to 30·6 ohms, and the 57 ft would be nearly as good a radiator as 120 ft of wire used ordinarily. A 28 ft length of wire would show a greater gain in radiation resistance, from 0·6 ohm at the end to 15·8 ohms at the centre.



x axis is expressed in radians.

RADIATION RESISTANCE

THE COMPONENT OF ANTENNA RESISTANCE THAT ACCOUNTS FOR THE POWER RADIATED INTO SPACE AND IS EQUAL IN OHMS TO THE RADIATED POWER IN WATTS DIVIDED BY THE SQUARE OF THE EFFECTIVE CURRENT IN AMPERES AT THE POINT OF POWER SUPPLY.

ML = ANTENNA'S LOSS DUE TO IMPEDANCE MISMATCH.

$$\varepsilon_R = \frac{P_{radiated}}{P_{input}}$$

$$\varepsilon_T = M_L \cdot \varepsilon_R$$

COMPARING AREAS UNDER THE CURVE

"THE 57 FT (GREEN, IN THE CENTER) WOULD BE NEARLY AS GOOD A RADIATOR AS 120 FT OF WIRE USED ORDINARILY (BLUE)"

In Fig. 1 the curve is drawn. Table I shows the number of squares under each portion of the aerial, but as the curve is symmetrical, only the first quarter wave is shown.

If we take a length of 57 ft of wire, shown in Fig. 1 as AB on the curve, this acts as a length of 57 ft at the end of an aerial, if suitably fed; that is, the portion EF of the curve. It will be seen that the radiation resistance of this portion, even if in free space, would be only 4·6 ohms.

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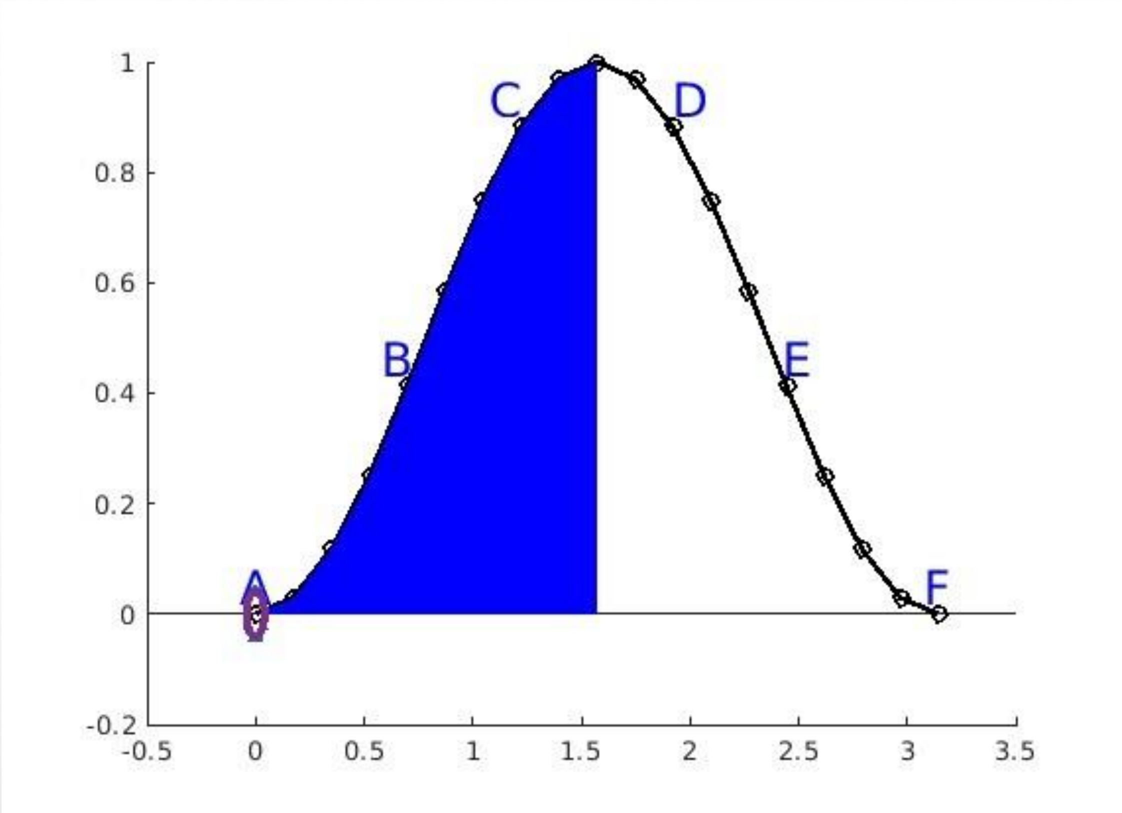


x axis is expressed in radians.

SIMULATE THE N5ESE ANTENNA

I COPIED OVER N5ESE'S COMMENTS FROM HIS PAGE TO THE MATLAB SCRIPT AND CAPTURED THE ANTENNA LENGTH IN A VARIABLE "JUST IN CASE".

THIS IS A PRETTY GOOD EXPLANATION OF WHAT THE ZIG ZAG IS DOING, WHICH IS TO MAKE OUR AERIAL HAVE HIGHER RADIATION RESISTANCE WHILE BEING SHORTER.

```
%% N5ESE antenna calculations
% But there is a method by which the portion acting as an aerial can be
% made to act as the center portion. This method causes the current, after
% reflection at the insulator, to build up to maximum in the aerial by
% putting the required length of wire between the aerial proper and the
% insulator. This special length of wire must be wound non-inductively and
% spaced at least 1 inch and of a length equal to a quarter wavelength for
% the band in use, minus one half the length of the aerial top.
% This "loading coil" can be wound around a cylinder or flattened out in in
% a tab or wing or two-dimensional area.
% 12 foot 7 band "doublet" has 11.5 feet in each loading coil, and 5 feet
% of radiator on each side.
n5ese_length_ft = 11.5+11.5+5+5;
```

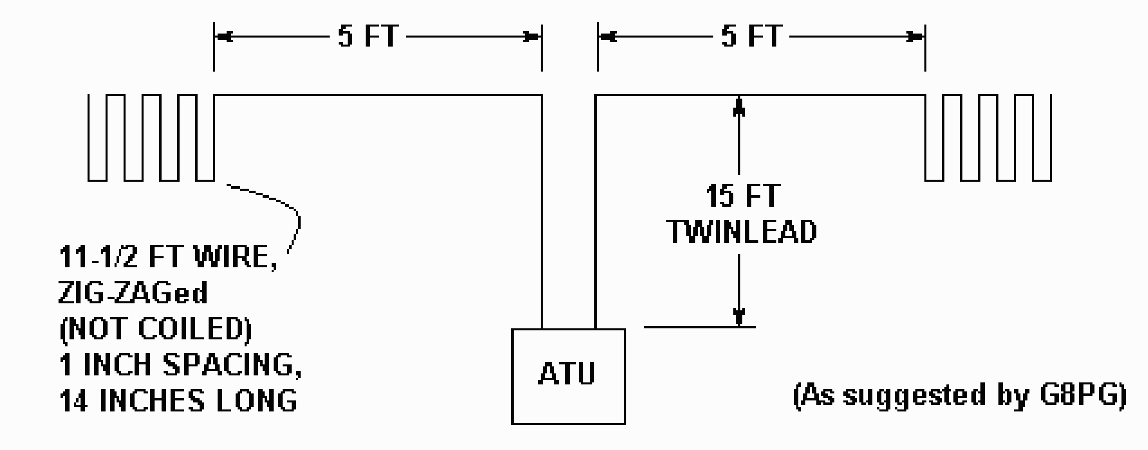
SIMULATE THE N5ESE ANTENNA (WITH PARAMETERIZATION)

I PICKED A FREQUENCY TO START WITH, GOT A FULL WAVELENGTH, AND DIVIDED IT UP INTO 6 PARTS. I STARTED WITH A HALF-WAVE DIPOLE AND FOLDED THE OUTER ONE THIRDS OF THE ENTIRE WIRE UP INTO ZIG ZAGGED SECTIONS.

WE NOW HAVE THE LENGTH OF THE WIRE FOR EACH OF THE TWO FOLDED SECTIONS AND THE CENTER AERIAL.

I CONVERTED IT TO FEET FOR DISPLAY BECAUSE I STILL HAVE A DIFFICULT TIME WORKING IN METERS.

```
% take the middle one third of the structure for the radiating element
frequency = 14.2e6  % in Hz
c = 299792458   % speed of light in m/s
wavelength = c/frequency
radiatorLength = wavelength/6 % one third of a half wave dipole in meters
u = symunit;
radiatorLength_ft = unitConvert(radiatorLength*u.m, u.ft)
[len units] = separateUnits(radiatorLength_ft);
len = double(len) % one third of a half wave dipole in feet.
```



Overall design idea above.

PARAMETERIZE THE ZIG ZAGS

```
NotchLength = 0.0254;
```

WE GOT THIS!

IF THE FOLDED ELEMENTS ARE EXECUTED WITH A ONE INCH GAP, THEN SET THE ANTENNA NOTCH LENGTH = 0.0254 M (ONE INCH).

WE SEE THE "AT LEAST ONE INCH GAP" IN THE PAPERS. WE CAN SIMULATE DIFFERENT GAPS IN FUTURE WORK TO FIND OUT HOW MUCH IT MATTERS. WANT TO HELP? WELCOME ABOARD.

NOTCH LENGTH IS A TERM FROM THE MATLAB MODEL FOR A MEANDER DIPOLE, WHICH WE WANT TO USE.

QUADRATIC EQUATION FOR THE WIN

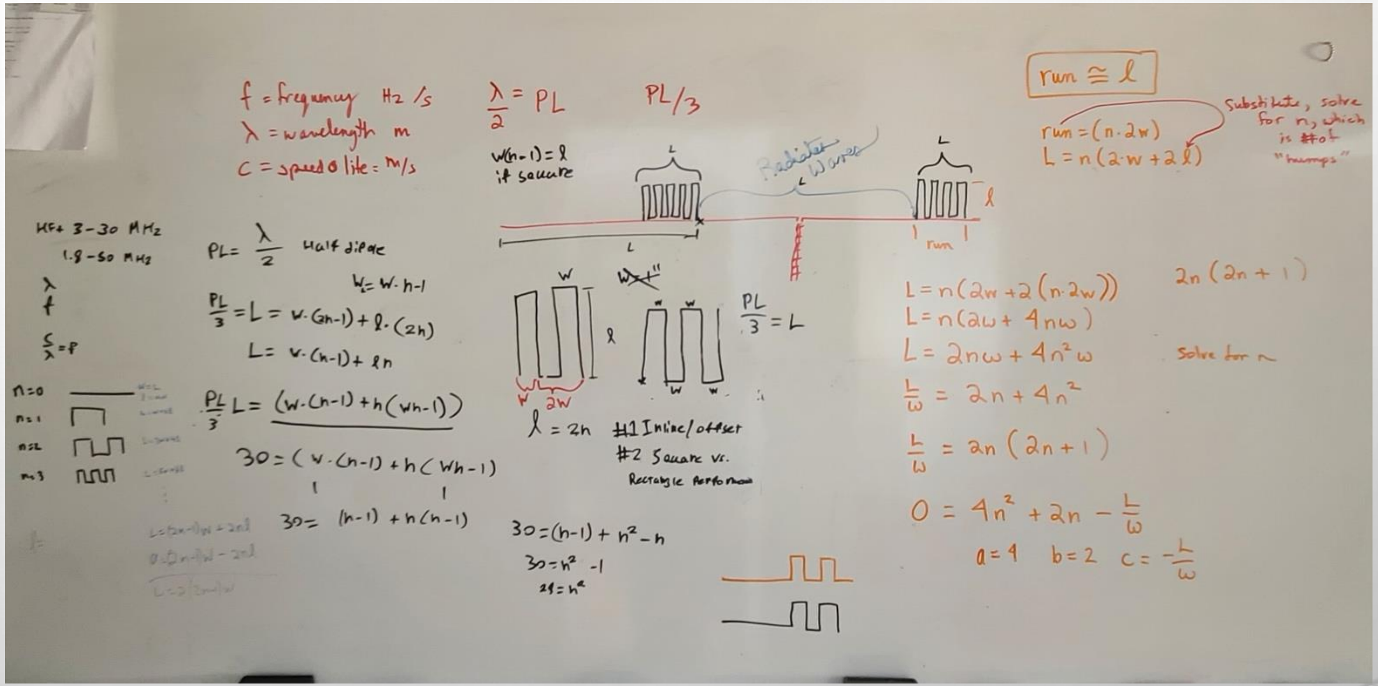
WE KNOW WE NEED A ONE INCH GAP BETWEEN ZIG ZAGS AND WE KNOW HOW MUCH WIRE WE HAVE TO FOLD UP.

SO, HOW MANY TIMES CAN WE GO BACK AND FORTH IF WE ZIG ZAG WITH A ONE INCH GAP?

THIS IS THE NUMBER OF HUMPS IN OUR ZIG ZAG.

THE QUADRATIC EQUATION CAN GIVE US THIS ANSWER.

```
A = 4*NotchLength;
B = 2*NotchLength;
C = -radiatorLength;
numHumps = ((-B)+((B^2-4*A*C))^0.5)/(2*A)
numHumps_2= ((-B)-((B^2-4*A*C))^0.5)/(2*A);
```



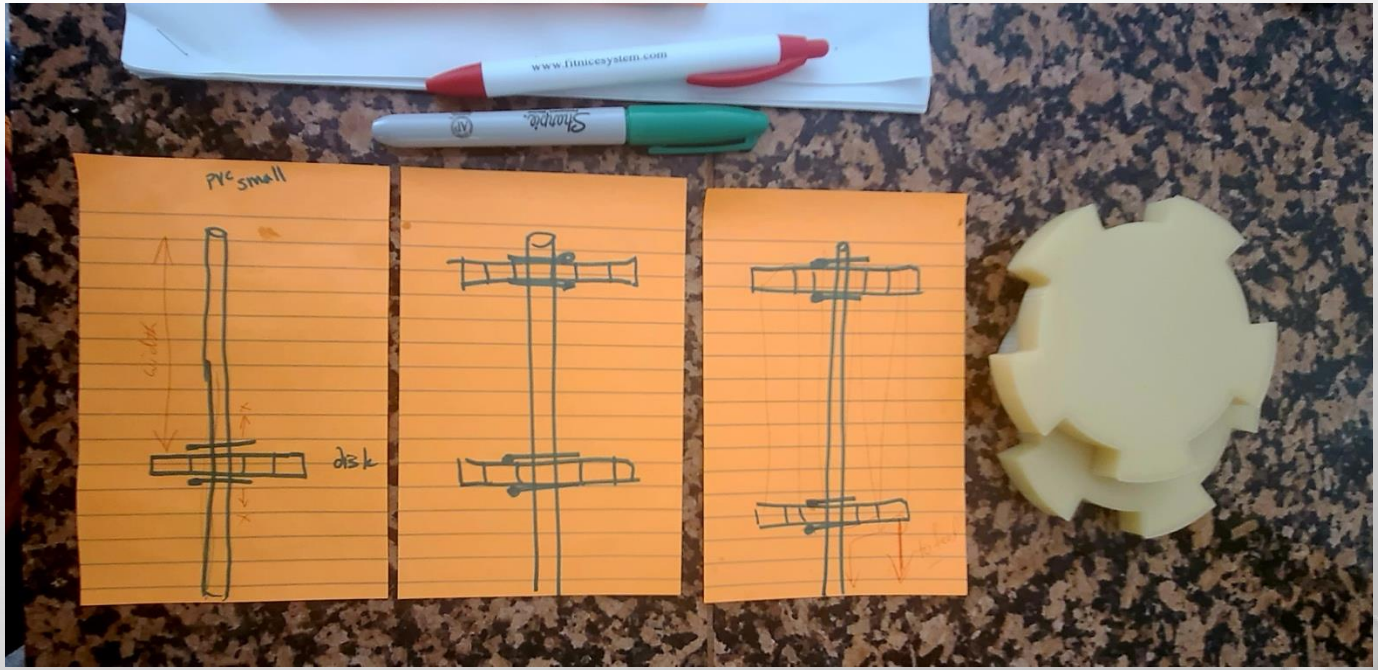
Thank you to ORI's Lab Tech One for nailing this down in a whiteboard session.

```
integerNumHumps = floor(numHumps)
%radiatorLength = numHumps*(2*NotchWidth + 2*NotchLength)
finalNotchWidth = (radiatorLength - 2*integerNumHumps*NotchLength)/(integerNumHumps*2)
% for an outdoor installation, put the inductive load around a cylinder. Do
% this with acrylic disks or somethign like that. We have the NotchRun,
% which is notch length times the integral number of humps.
NotchRun = integerNumHumps*NotchLength*2
```

WE NEED AN INTEGER NUMBER OF HUMPS

NOTCH RUN IS THE HORIZONTAL LENGTH OF THE FOLDED SECTION. NOTCH WIDTH IS THE VERTICAL LENGTH OF THE FOLDED SECTION.

WE SET THE NUMBER OF HUMPS TO THE FLOOR OF THE VALUE WE CALCULATED, AND THEN RECALCULATE THE NOTCH WIDTH. THIS SETS HOW FAR APART THE SUPPORT STRUCTURES NEED TO BE TO WIND THE ZIG ZAGS. ALSO, RECALCULATE THE NOTCH RUN. THIS IS IMPORTANT TOO, FOR THE DIAMETER OF THE COWLINGS (SPACING PLATES).



CALCULATE COWLING DIAMETER

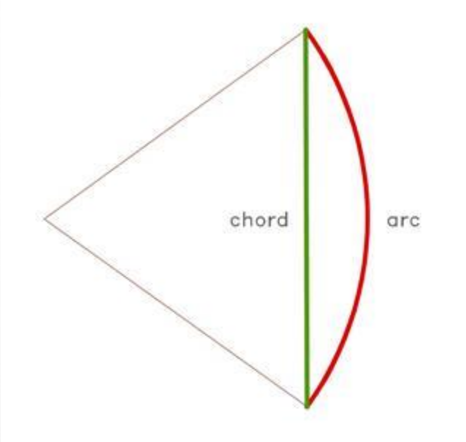
RELATIVELY SIMPLE CALCULATION. ADD TEETH EVERY OTHER INCH AND THEN LASER CUT AN ACRYLIC DISK OR 3D PRINT A SPACER.

WELL, WE AREN'T DONE QUITE YET.

THE SPACER GETS MORE COMPLEX WHEN YOU THINK ABOUT HOW TO WIND REAL WIRE AROUND A TOOTHED DISK. WE CALCULATED IT AS IF THE WIRE FOLLOWED THE ARC OF THE DISK, BUT WHEN IT PASSES OVER THE TEETH, IT WILL MAKE A CHORD INSTEAD.

SO, WE COMPENSATE FOR THAT IN THE MODEL AND RECALCULATE THE OPTIMIZED DIAMETER.

```
NotchRun = integerNumHumps*NotchLength*2
cowlingDiameter = NotchRun/pi
cowlingDiameter_in = unitConvert(cowlingDiameter*u.m, u.in)
[dia units] = separateUnits(cowlingDiameter_in);
dia = double(dia) % diameter of the two disks in inches to make the cowling
```




```
% we know the angle, chord length = 2*r*sin(theta/2)
% calculate arc length, circumference/(2*pi/10) <== use this number to
% calculate a new radius for the chord length.
arc_length = (cowlingDiameter*pi)*(2*pi/(2*integerNumHumps))/(2*pi)
chord_length = 2*(cowlingDiameter/2)*sin((2*pi/(2*integerNumHumps))/2)
optimized_cowlingDiameter = arc_length/sin((2*pi/(2*integerNumHumps))/2)
outside_diameter = optimized_cowlingDiameter + NotchLength
```

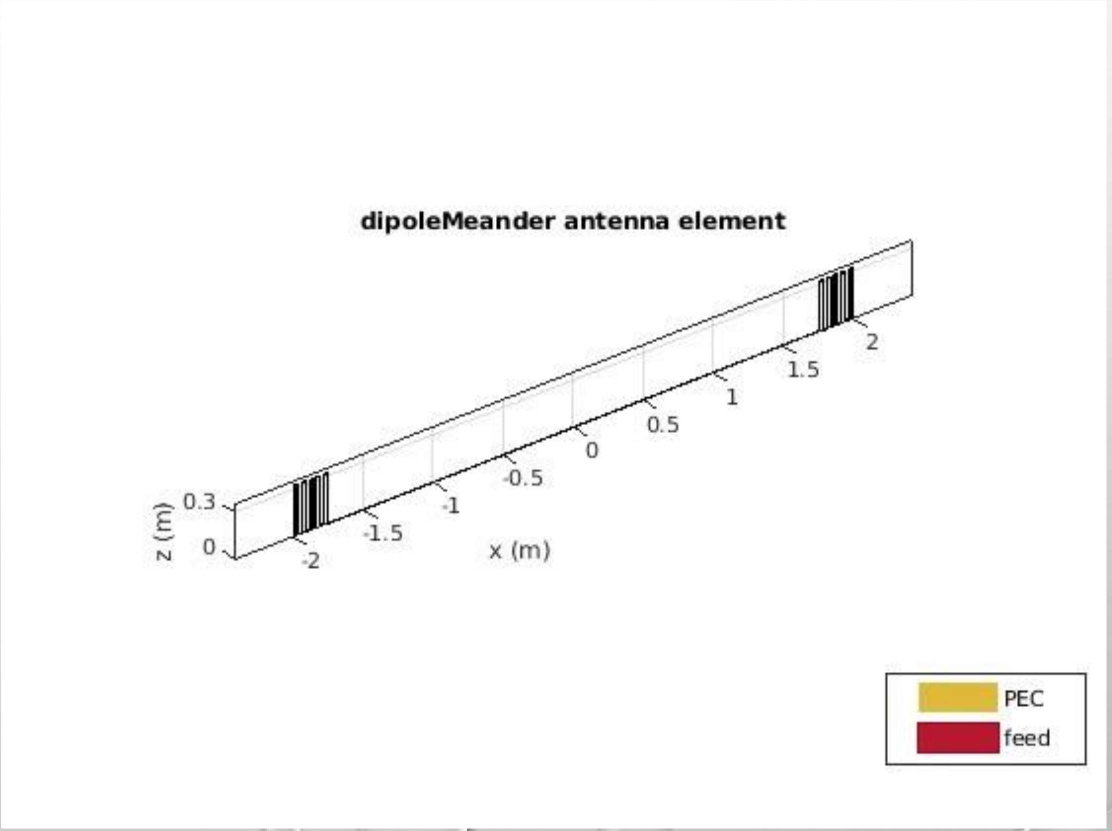
TAKE OUR CALCULATIONS TO MATLAB ANTENNA DESIGNER

THE MEANDER DIPOLE MODEL IN MATLAB'S ANTENNA BUILDER IS THE SHAPE WE NEED.

WE CONFIGURE THIS MODEL WITH OUR CALCULATED MEASUREMENTS AND SHOW THE RESULTS SO FAR.

Today

```
%% Antenna Properties
antennaObject = dipoleMeander;
antennaObject.Width = 0.002623;
%antennaObject.ArmLength = [7.3152, 0.0254, 0.0254, 0.0254, 0.0254, 0.0254, 0.0254, 0.0254,
0.0254, 0.0254, 0.0254, 0.0254];
antennaObject.ArmLength = [radiatorLength, repmat(NotchLength, 1, integerNumHumps)]
antennaObject.NotchLength = 0.0254;
antennaObject.NotchWidth = finalNotchWidth;
```



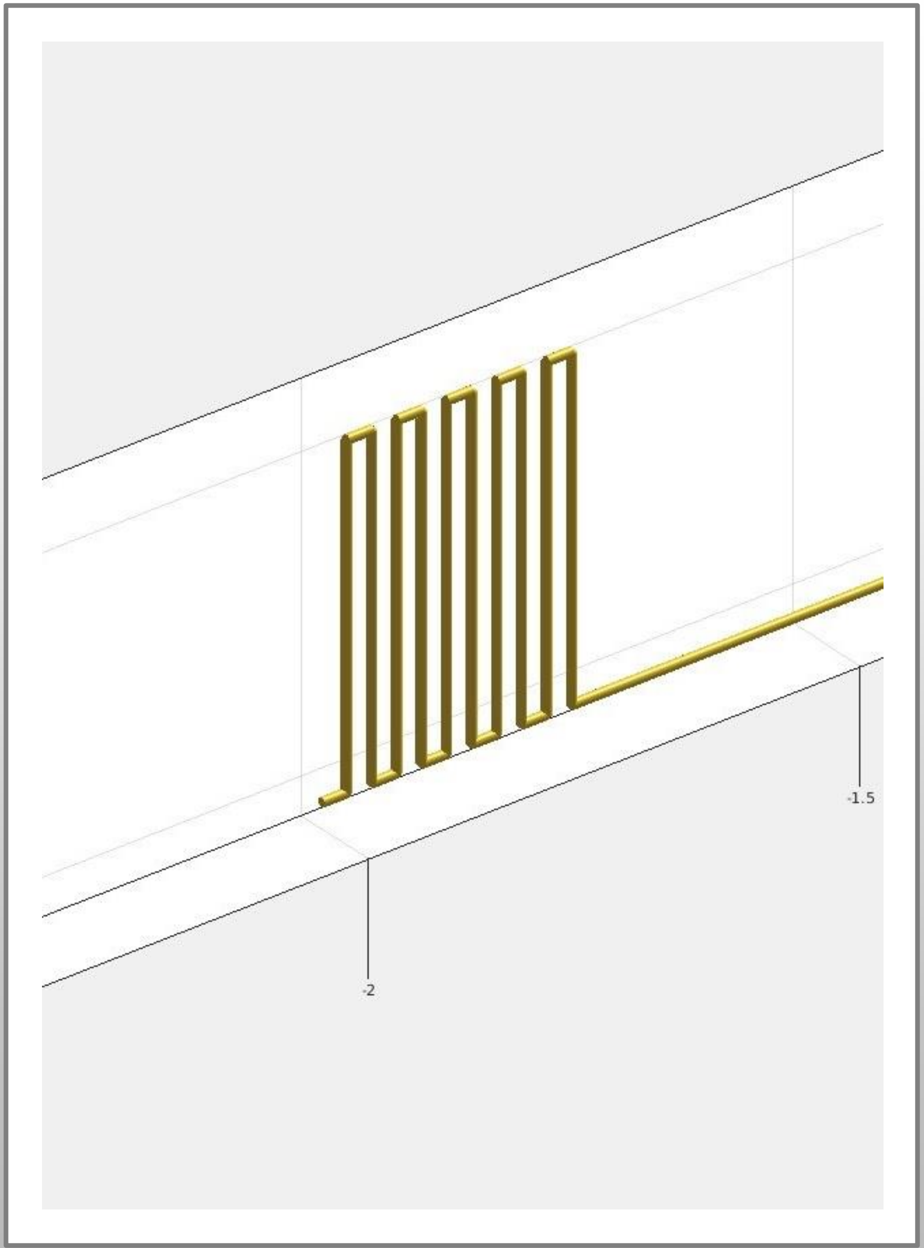
SET UP THINGS FOR ANTENNA ANALYSIS

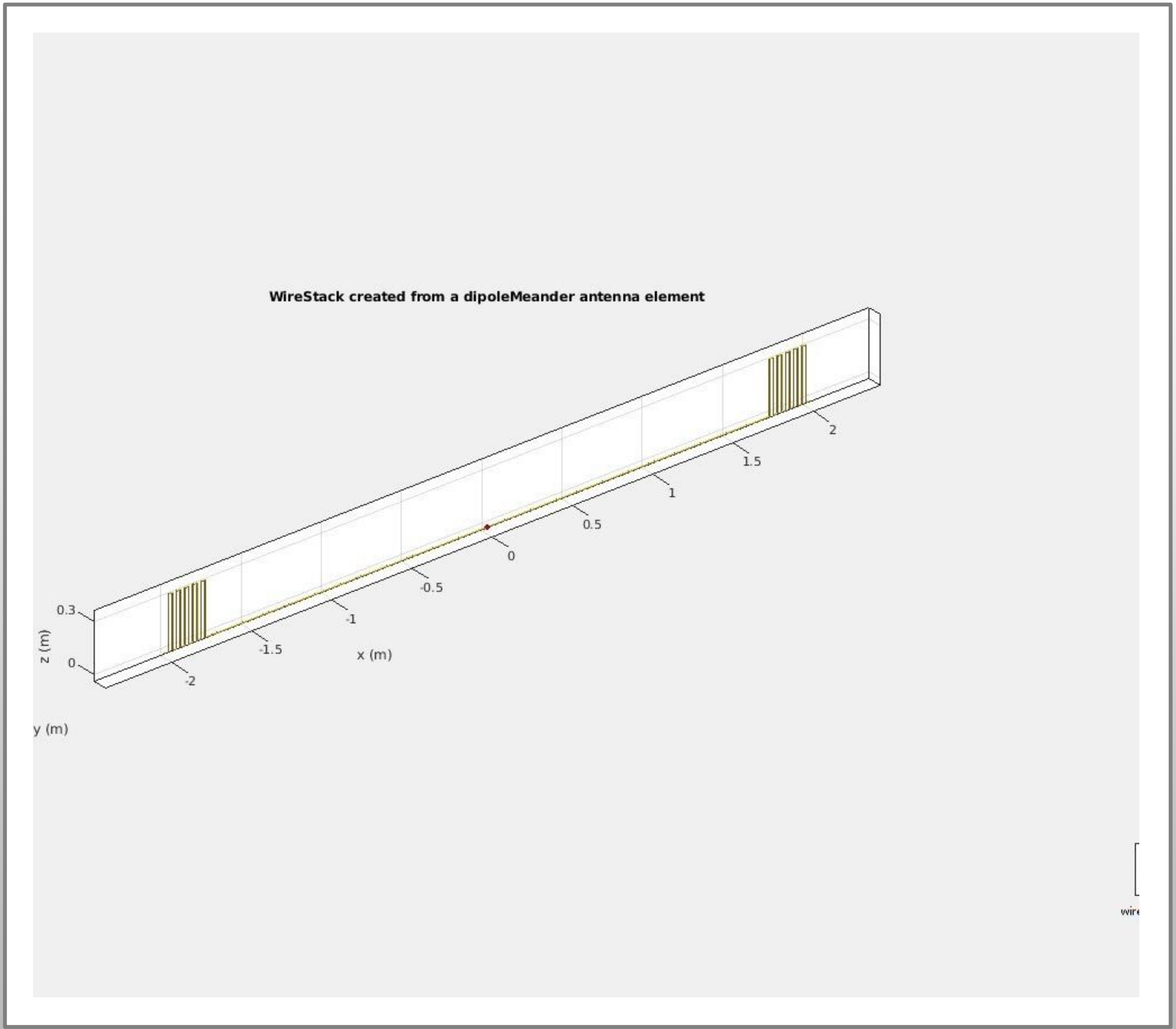
NEXT, WE CONVERT TO A "WIRESTACK". THIS MOVES THE MODEL FROM THE ORIGINAL PCB TRACE MODEL STYLE TO A WIRE ANTENNA MODEL WITH THE RIGHT TYPE OF FEEDPOINT.

Today

```
%% Antenna Analysis
% Define plot frequency
plotFrequency = frequency;
% Define frequency range
freqRange = (0.8*frequency:0.1*frequency:1.2*frequency);
testFreqRange = (1.6*frequency: 0.01*frequency:2*frequency);
% Reference Impedance
refImpedance = 50;
```

```
wireAntennaObject = wireStack(antennaObject)
% show the antenna
figure
show(wireAntennaObject)
```


-1.5
-2

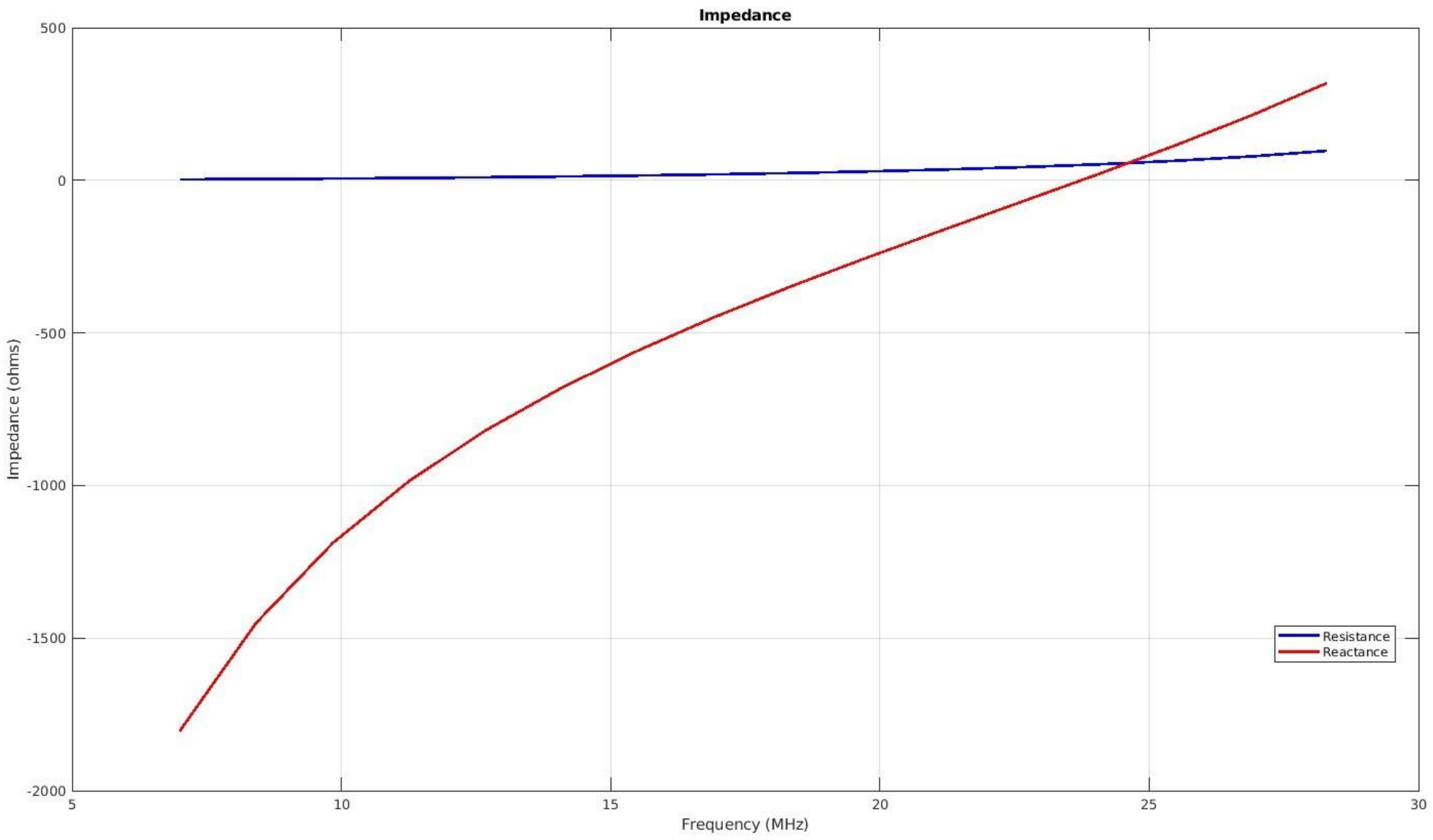

WireStack created from a dipoleMeander antenna element
0.3
0
z (m)
y (m)
x (m)
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

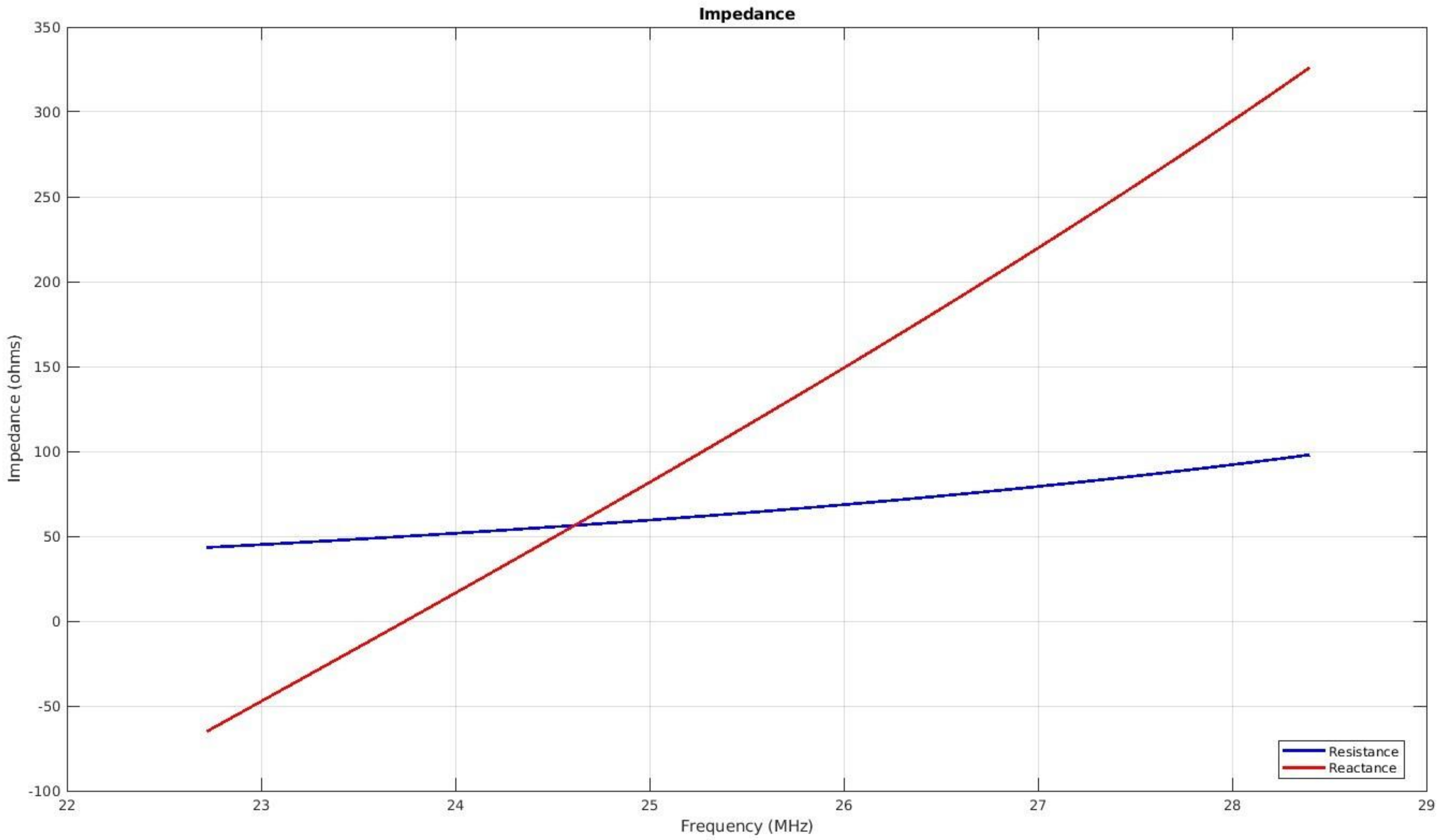
VISUALIZATIONS

- IMPEDANCE
- ANTENNA PATTERN
- ANTENNA EFFICIENCY
- CHARGE DISTRIBUTION
- CURRENT DISTRIBUTION

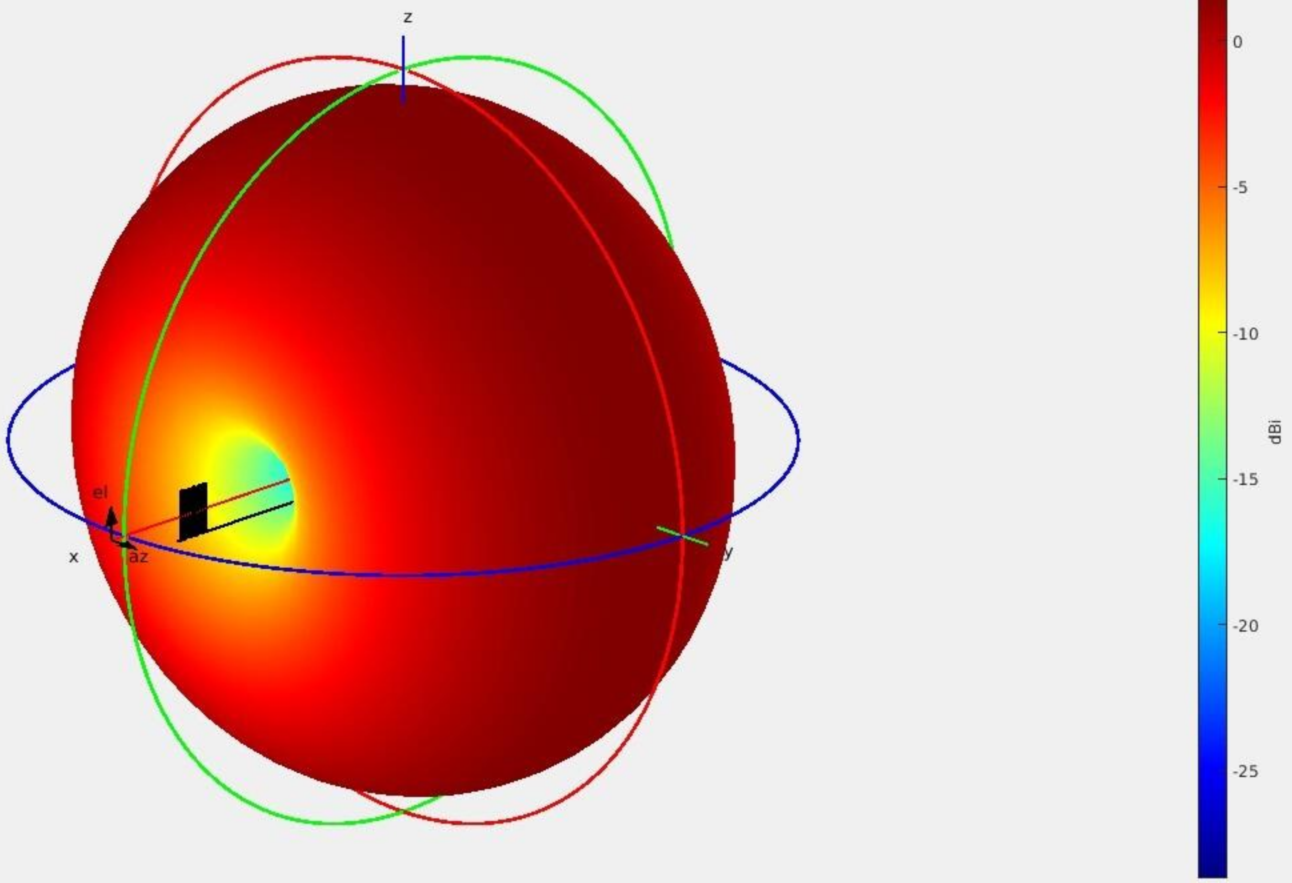
```
% impedance of wire antenna
figure
impedance(wireAntennaObject, testFreqRange)
% produce antenna pattern
figure
pattern(wireAntennaObject, frequency)
% Antenna efficiency of microstrip antenna
figure
efficiency(antennaObject, freqRange)
% Charge distribution on antenna
figure
charge(wireAntennaObject, frequency)
% Current distribution on antenna
figure
current(wireAntennaObject, frequency)
```

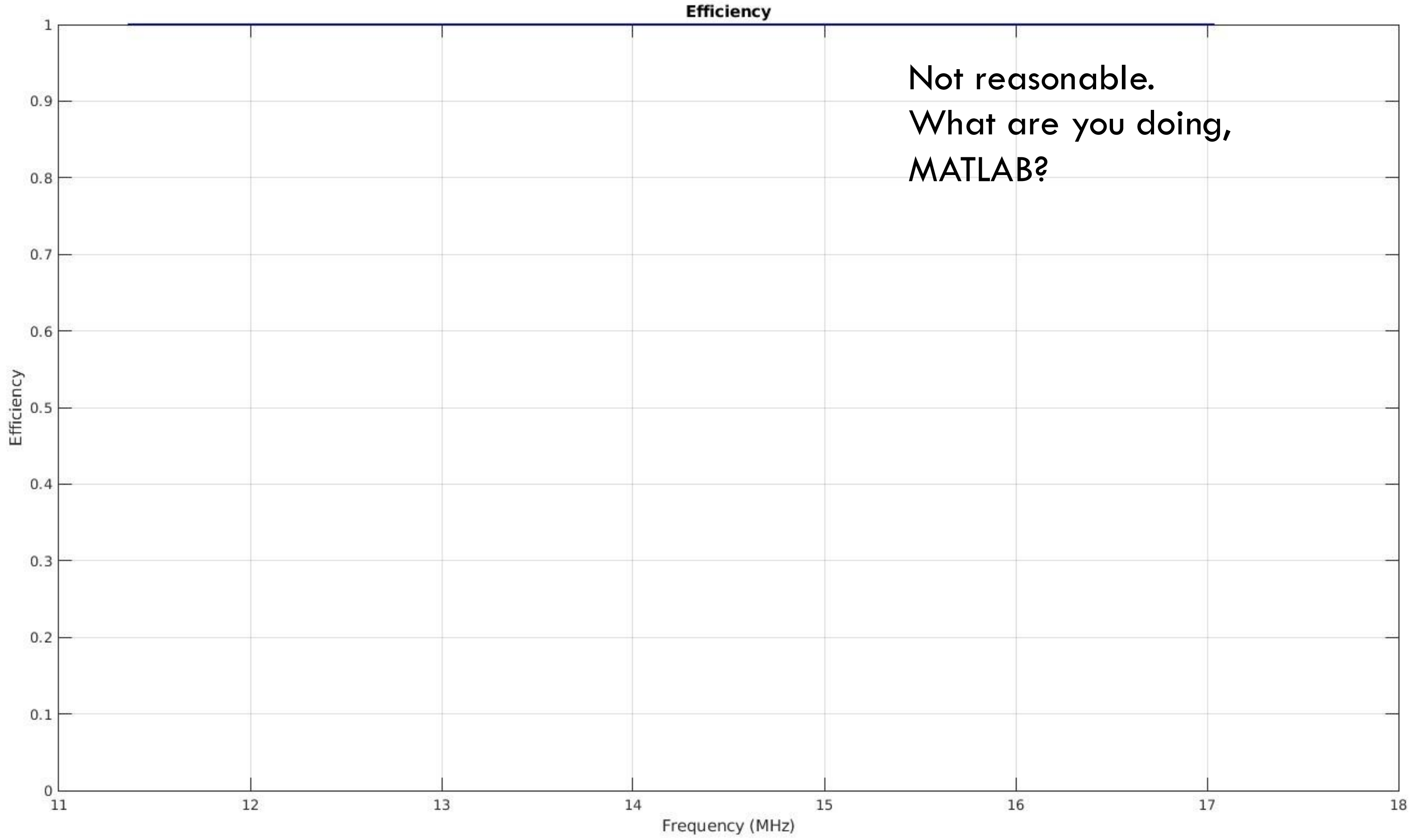
Today


Impedance
500
0
-500
-1000
-1500
-2000
Impedance (ohms)
5
10
15
20
25
30
Frequency (MHz)
Resistance
Reactance

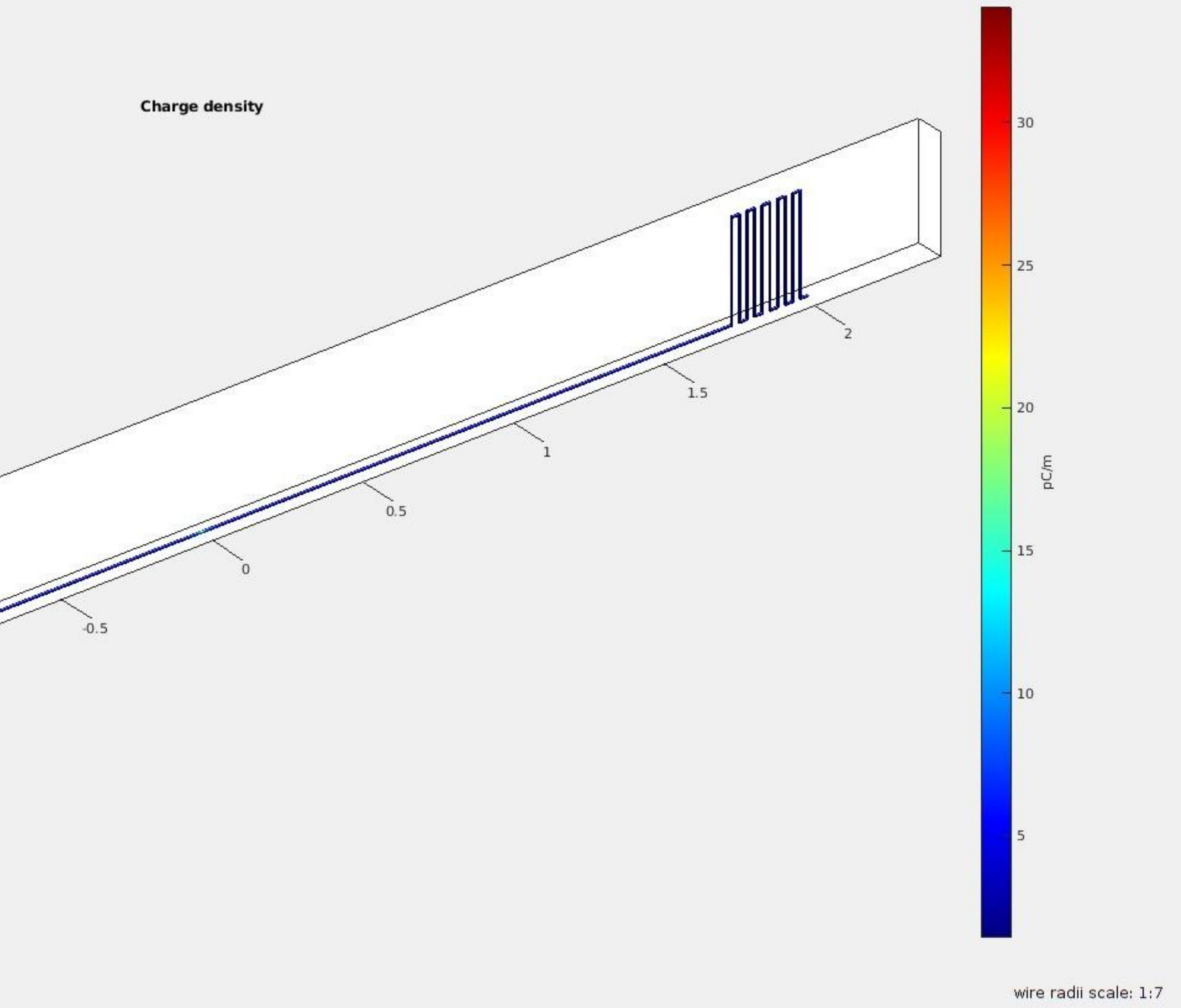

Impedance
Impedance (ohms)
Frequency (MHz)
Resistance
Reactance
350
300
250
200
150
100
50
0
-50
-100
22
23
24
25
26
27
28
29

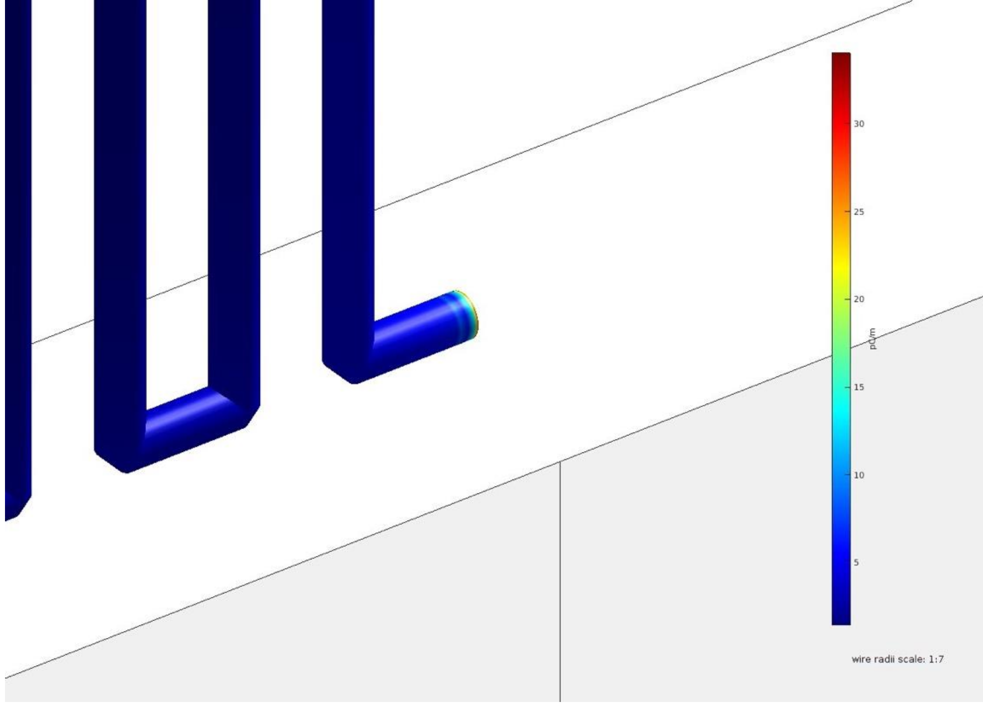
Output : Directivity
Frequency : 14.2 MHz
Max value : 1.8 dBi
Min value : -28.6 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]

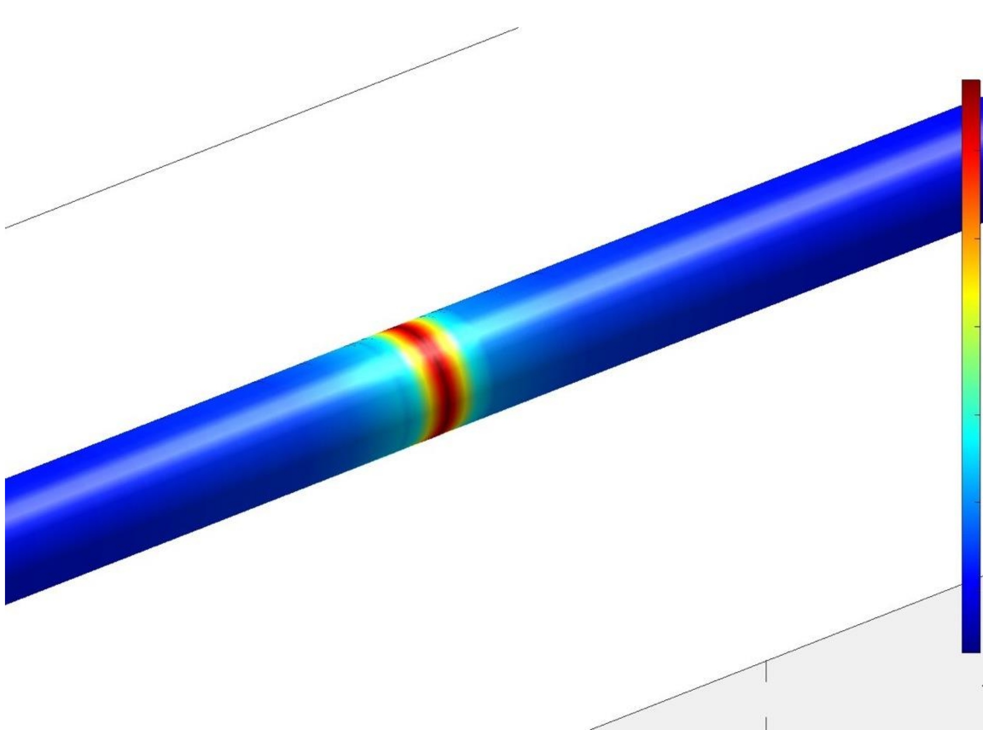


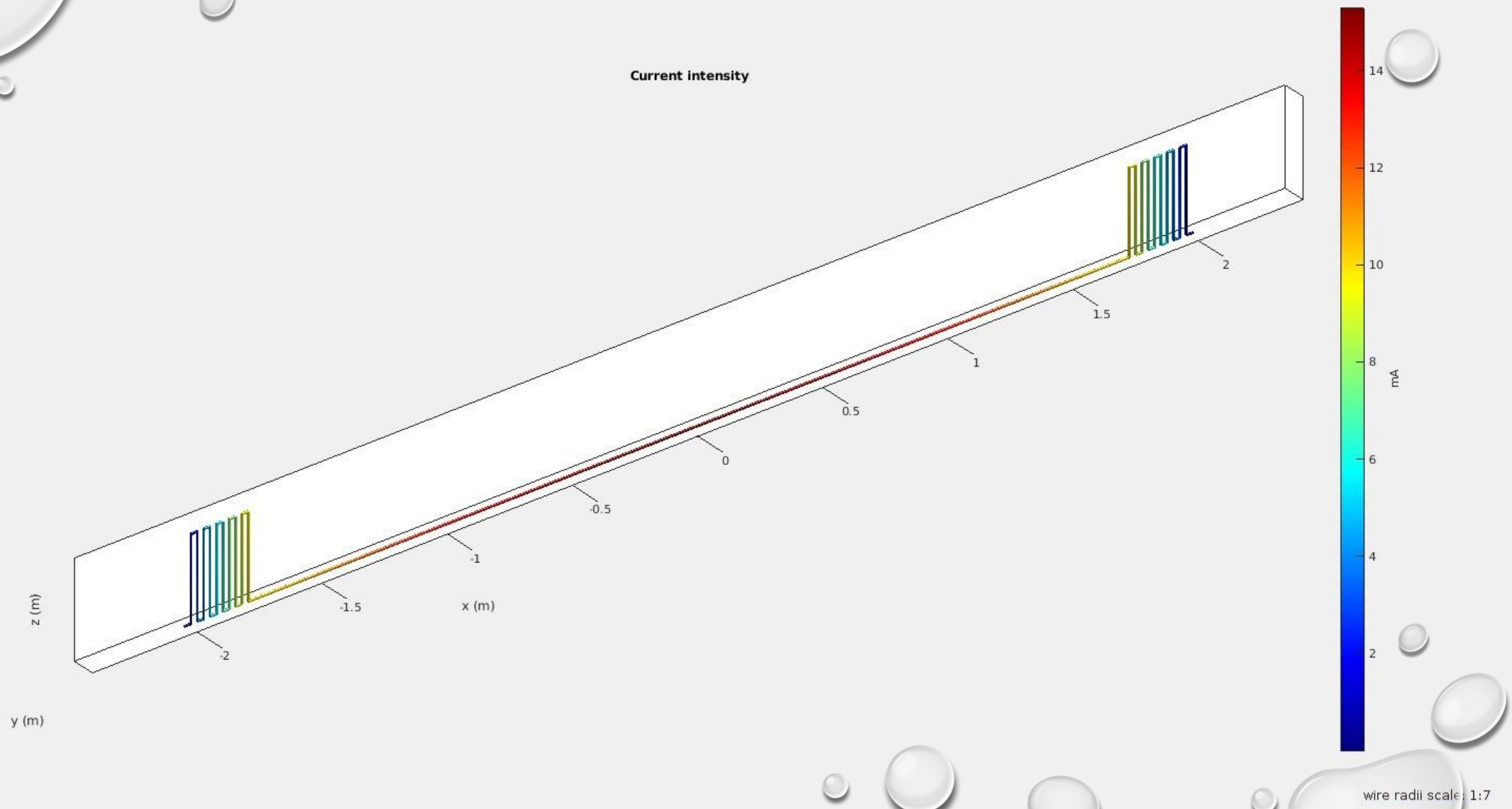


Not reasonable.
What are you doing,
MATLAB?

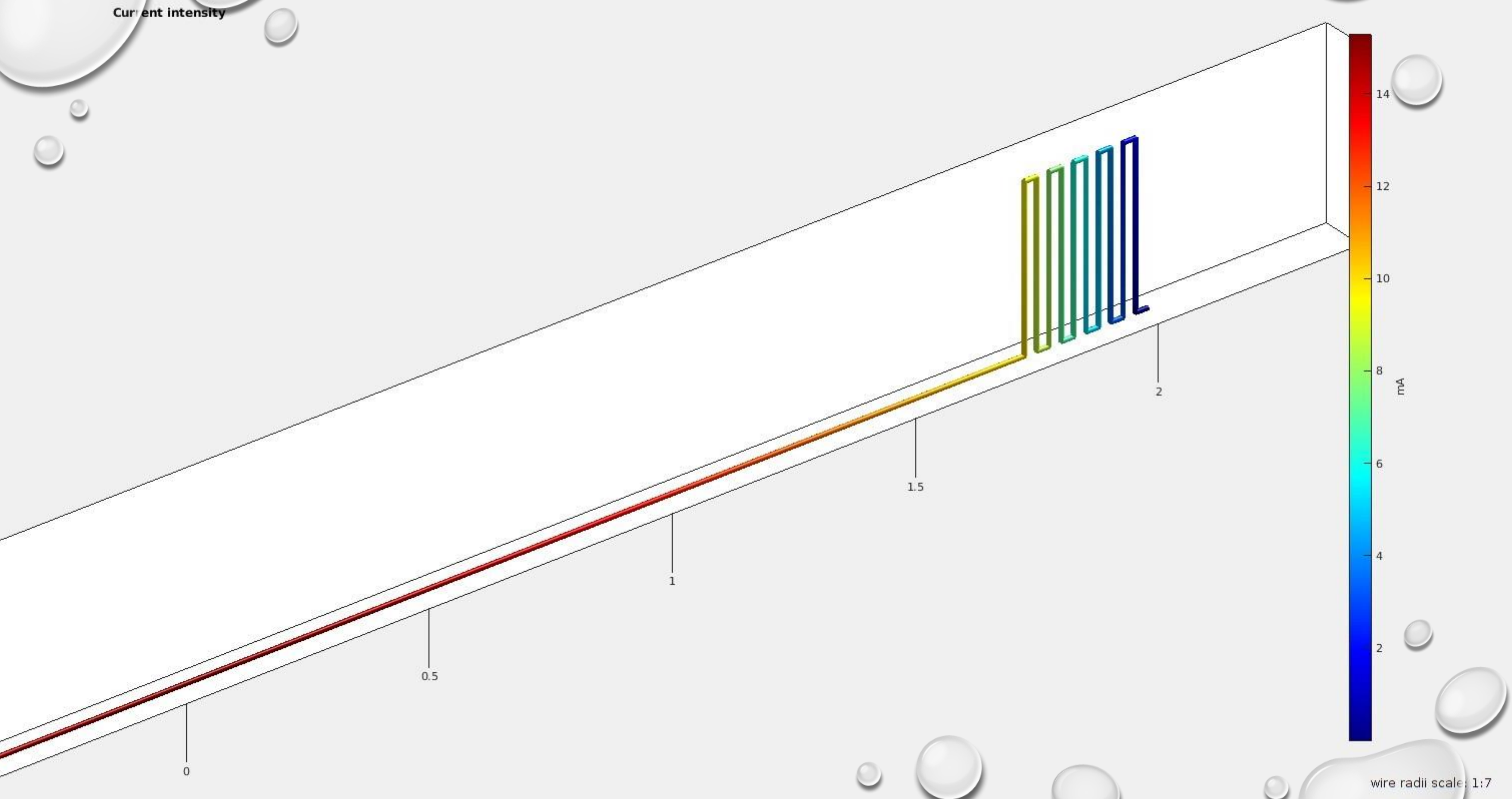

Charge density
-0.5
0
0.5
1
1.5
2
30
25
20
15
10
5
pC/m
wire radii scale: 1:7


30
25
20
15
10
5
wire radii scale: 1:7





Current intensity
z (m)
x (m)
y (m)
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
mA
14
12
10
8
6
4
2
wire radii scale: 1:7


Current intensity
0
0.5
1
1.5
2
14
12
10
8
6
4
2
mA
wire radii scale: 1:7

SMITH CHART?

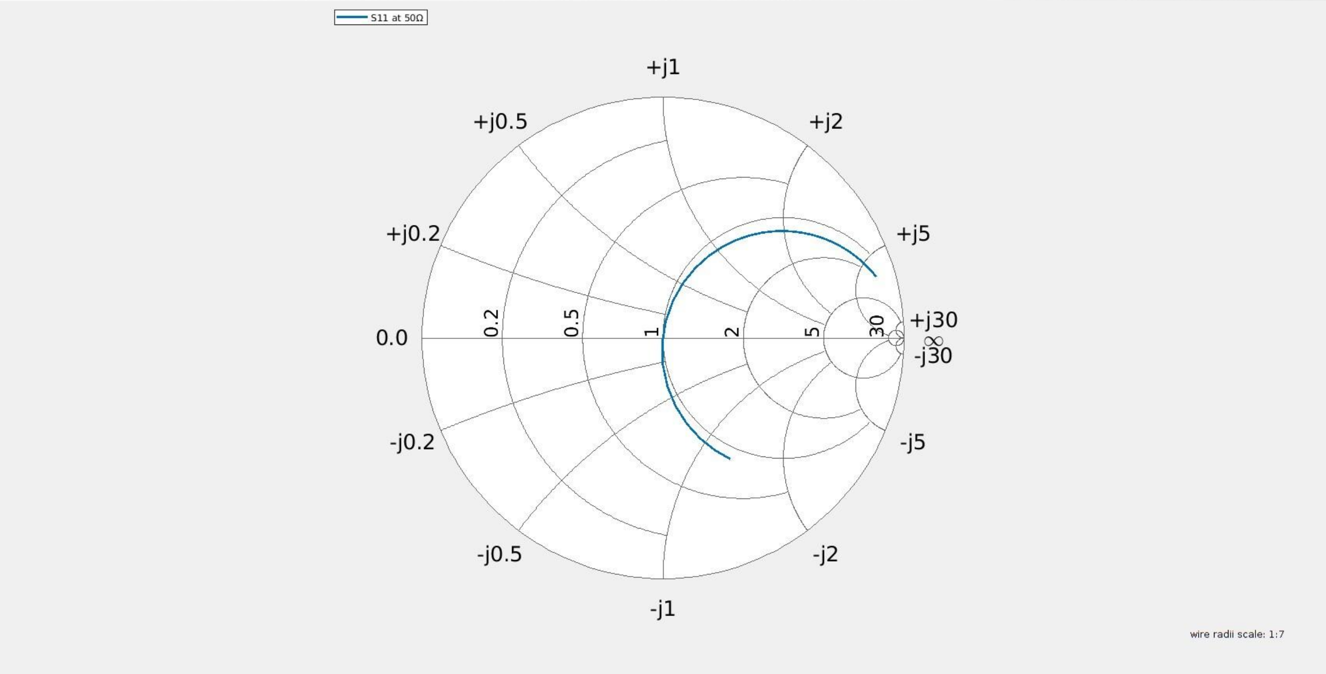
KB5MU ASKED FOR ONE, SO I LEARNED HOW TO DO IT IN MATLAB.

THIS IS OVER

TESTFREQRANGE = (1.6*FREQUENCY: 0.01*FREQUENCY:2*FREQUENCY);

23-28 MHZ

```
%% Attempt Smith chart
%d = dipole;  % we have a wireAntennaObject
%freq = linspace(60e6, 90e6, 200); % we have testFreqRange
s_50 = sparameters(wireAntennaObject, testFreqRange, 50);
hg = smithplot(s_50,[1,1]);
hg.LegendLabels = {"S11 at 50#ohm"};
hg.LineWidth = 2;
```



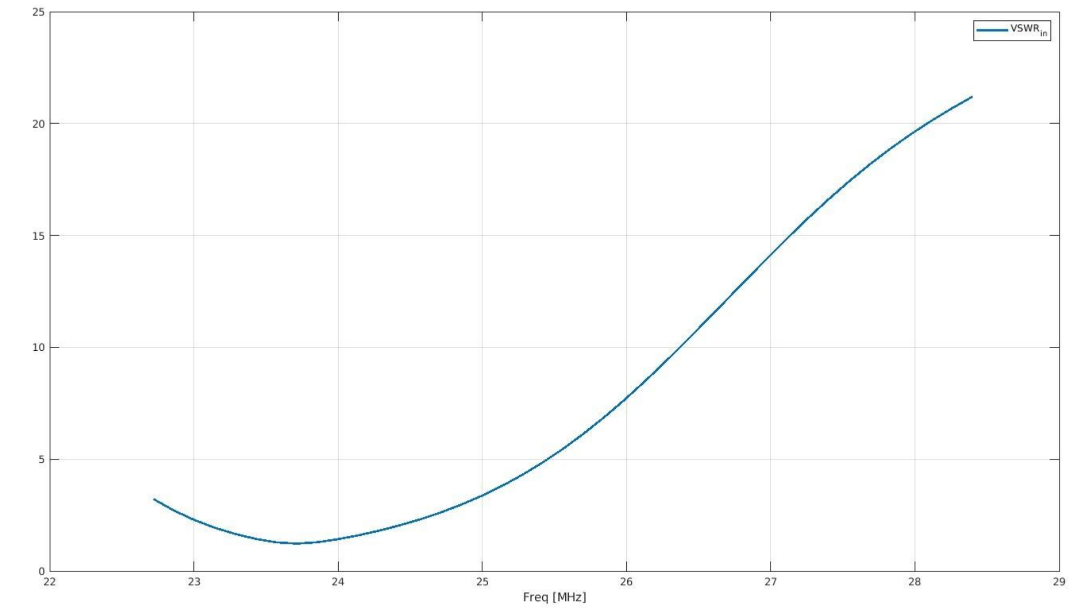
ADD COAX TO THE MODEL

WE CONSTRUCTED THE FIRST ANTENNA WITH COAX BECAUSE WE DIDN'T HAVE ANY TWIN LEAD IN STOCK.

SO, WE MODELED THE ANTENNA WITH COAX TO LEARN HOW TO DO THIS IN MATLAB. WE THEN LOOKED AT THE VSWR.

```
%% Attempt to add coax cable to analysis
%Model the Effect of Coaxial Cable
%The coaxial cable connected to the fabricated dumbell antenna is a LMR-400 with a
% characteristic impedance of 50 Ω. Create a model of this coaxial cable using RF Toolbox.
out_radius = 0.0813/2; %Overall Braid Diameter: 0.320in (8.13mm). function wants meters!
in_radius = 0.0274/2; % 2.74mm is the inner conductor diameter. function wants meters!
eps_r = 1.38; % we think it's 1.38 for LMR400. This is close to the default.
line_length = 23.8; % in meters
coax_cable = rfckt.coaxial;
coax_cable.OuterRadius = out_radius;
coax_cable.InnerRadius = in_radius;
coax_cable.EpsilonR = eps_r;
coax_cable.LossTangent = 2e-4;
coax_cable.LineLength = line_length;
```

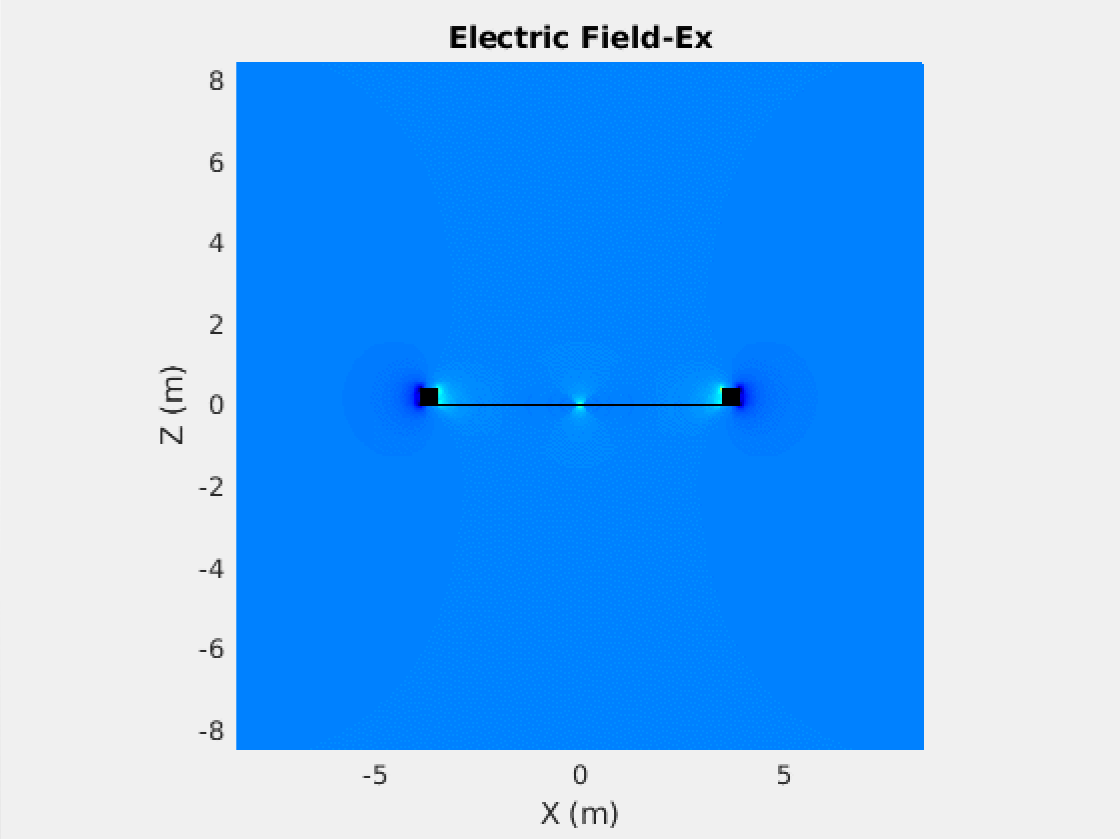
```
% Analyze the coaxial cable at the range of frequencies intended for operation
% and use the antenna's impedance as the load.
% Compute the input VSWR for the coaxial cable and dumbbell antenna.
Zantenna =impedance(wireAntennaObject, testFreqRange);
analyze(coax_cable, testFreqRange, Zantenna);
figure
hline = plot(coax_cable,'VSWRin','None');
hline.LineWidth = 2;
```



ELECTRIC FIELD ANIMATION

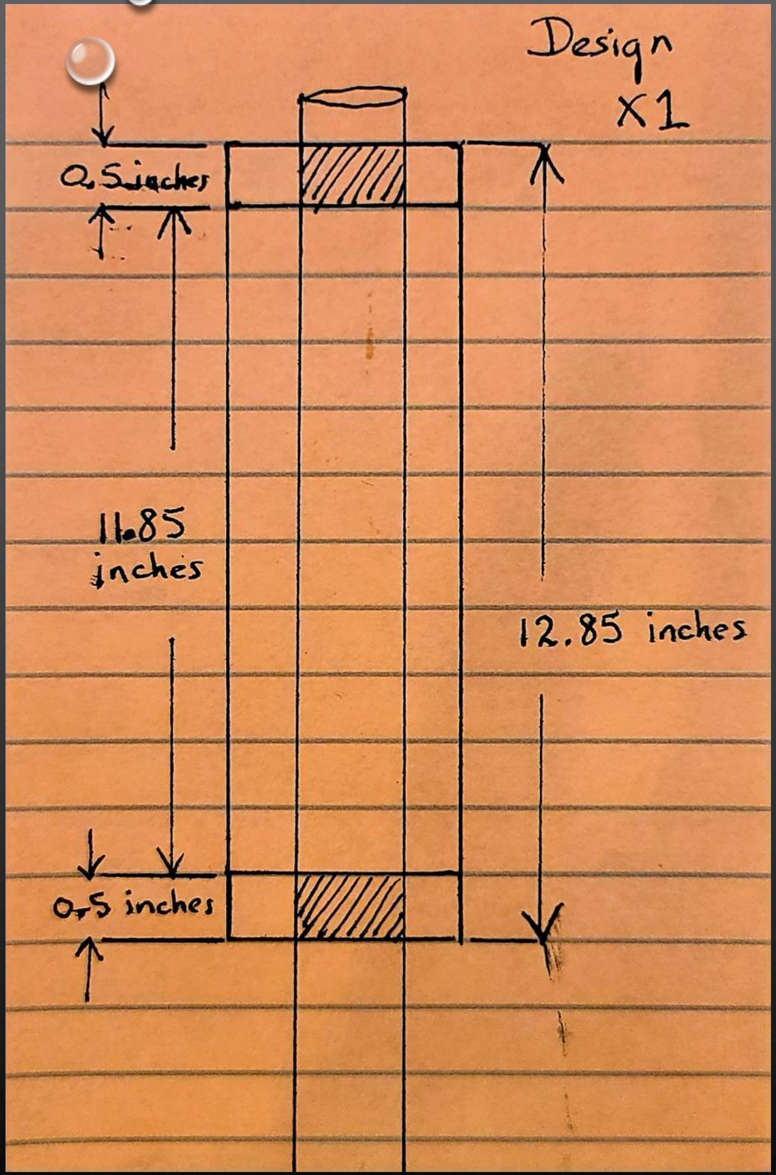
IF A PICTURE IS WORTH 1000 WORDS, THEN AN ANIMATION IS WORTH 1000 PICTURES. HERE'S THE ELECTRIC FIELD OF THE ANTENNA MODEL.

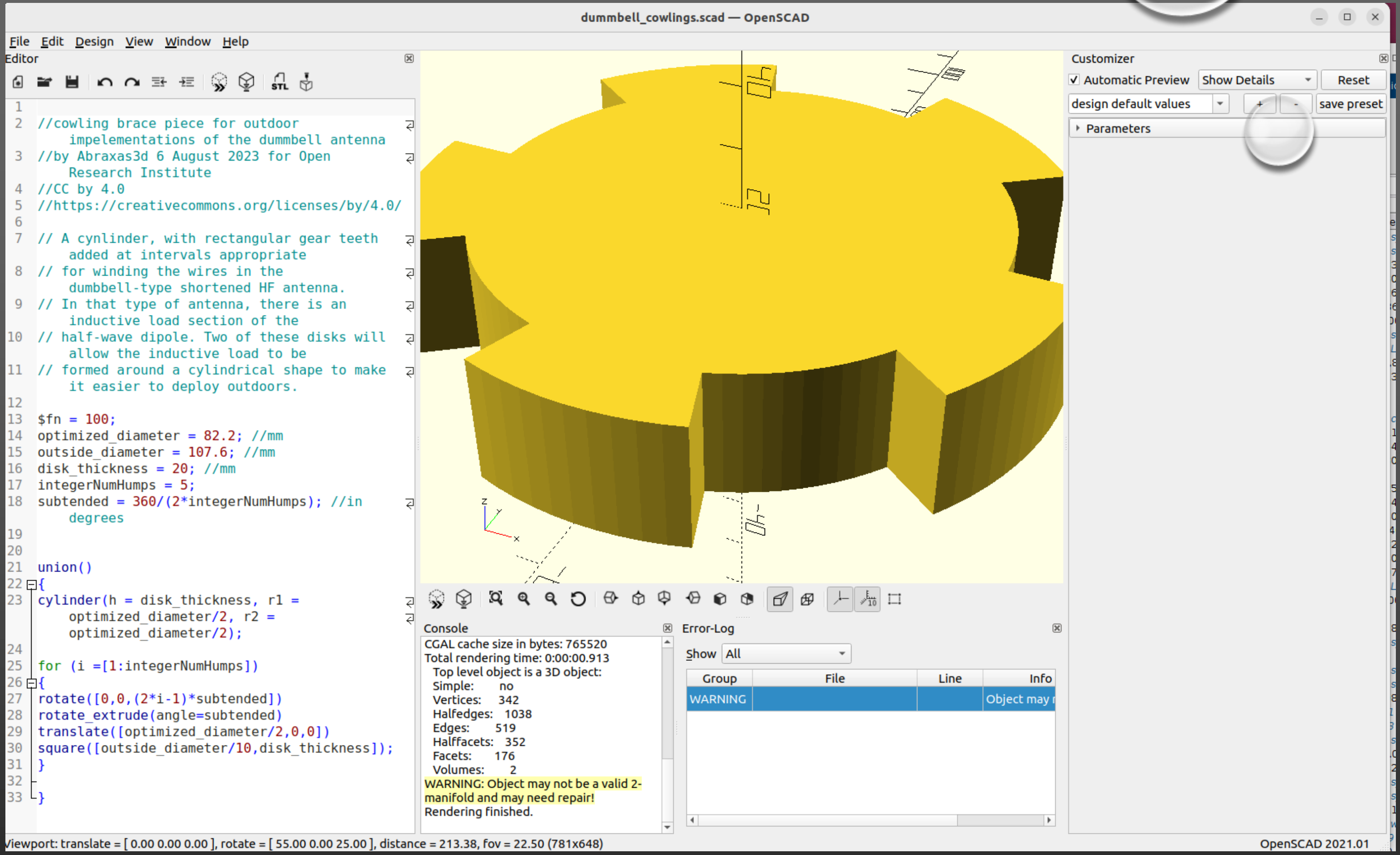
SEE THE REPOSITORY FOR THE CODE AND HELPER FUNCTION SOURCED FROM THE MATLAB COMMUNITY.



SHORTENED HF ANTENNAS

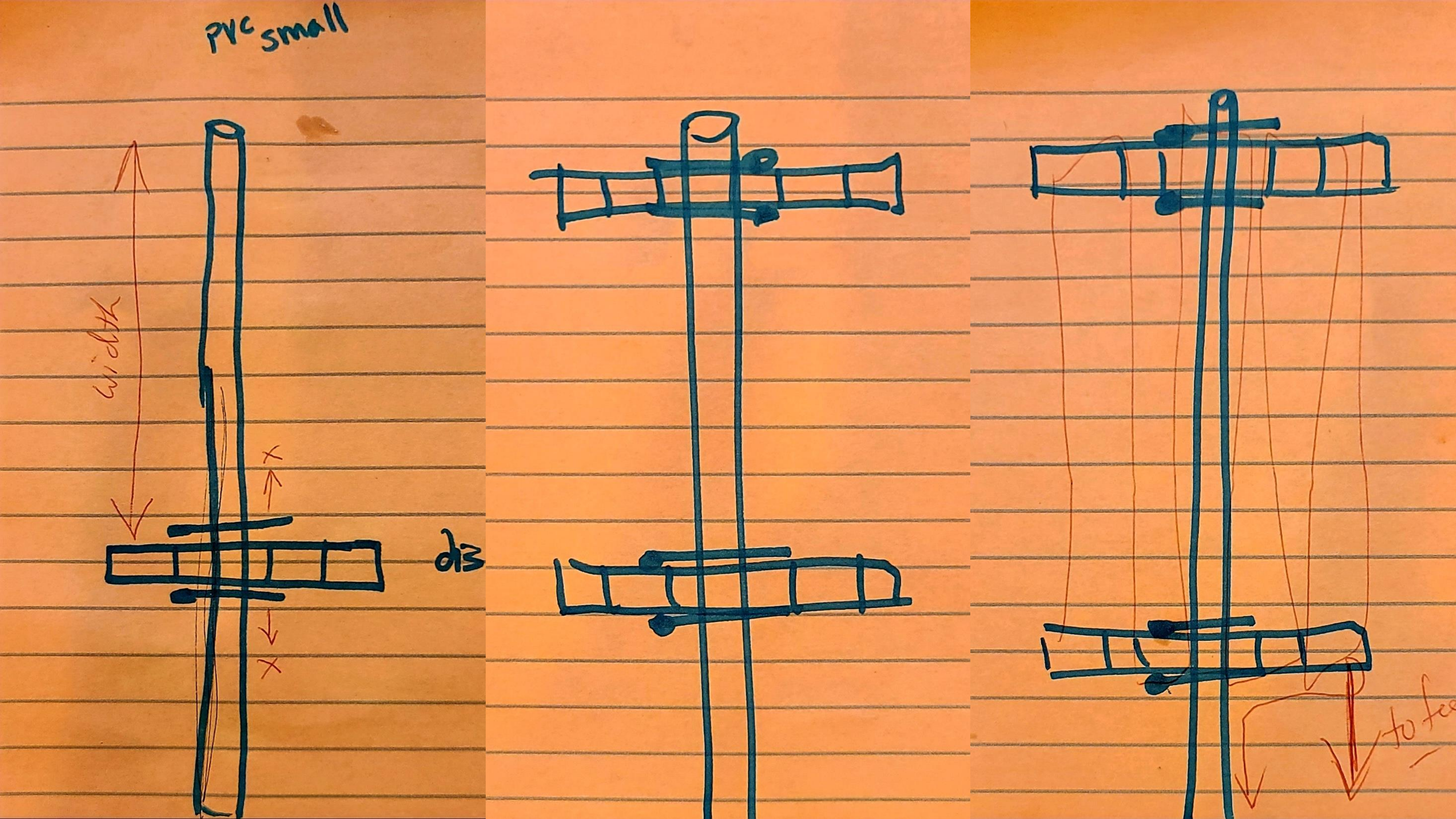
ENOUGH TALK! LET'S BUILD IT!



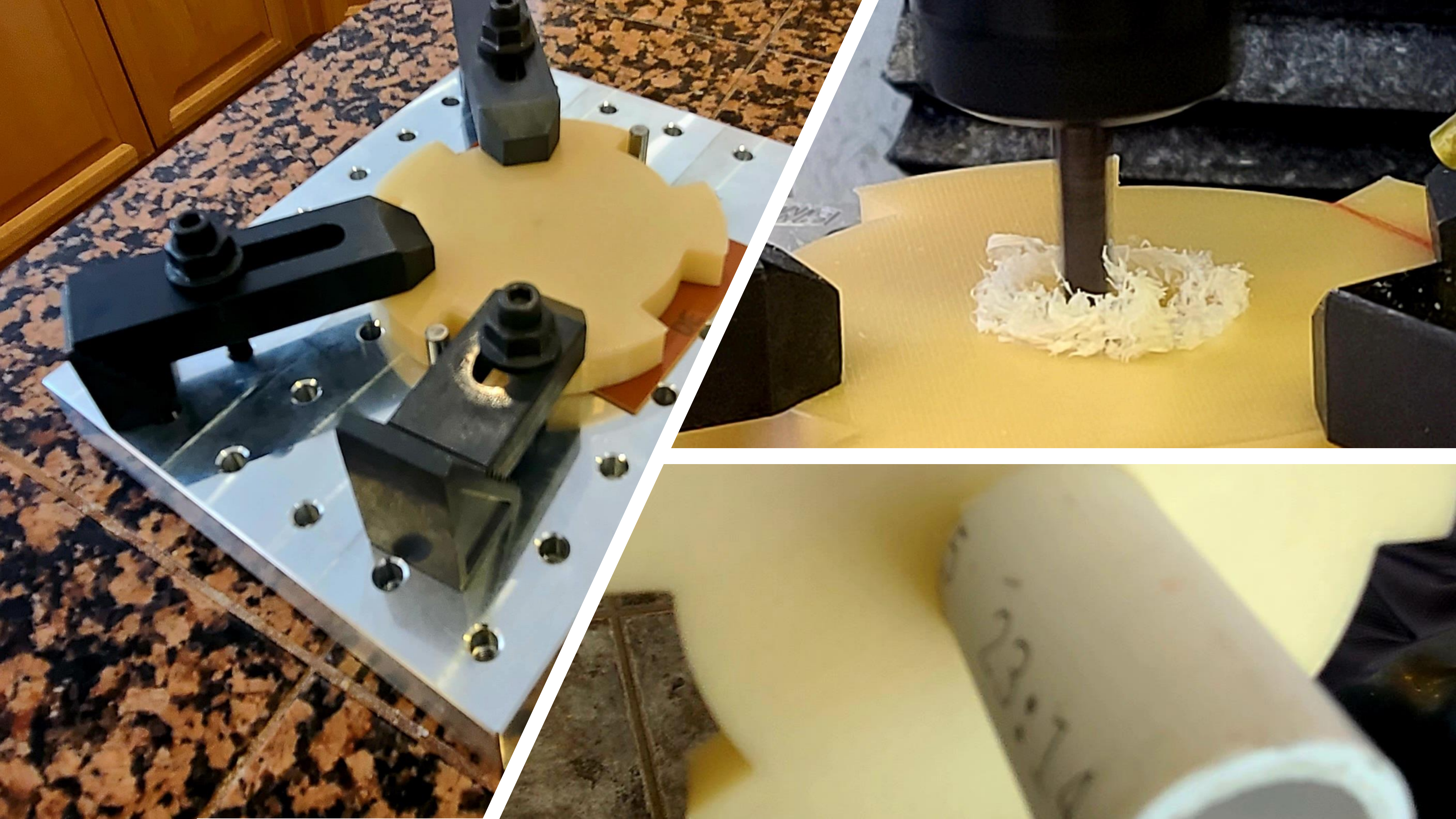


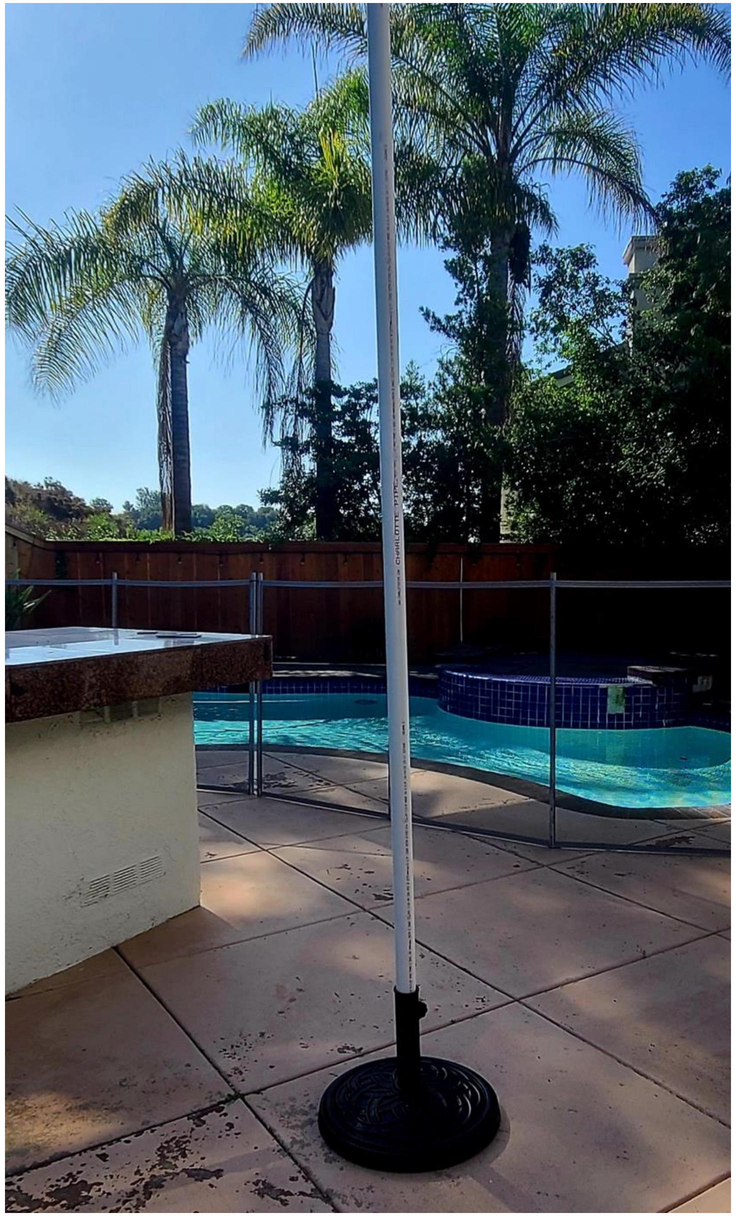
Version X1 in OpenSCAD and STL model exported.

Thank you to Mark Whittington for 3d printing a set of cowlings!

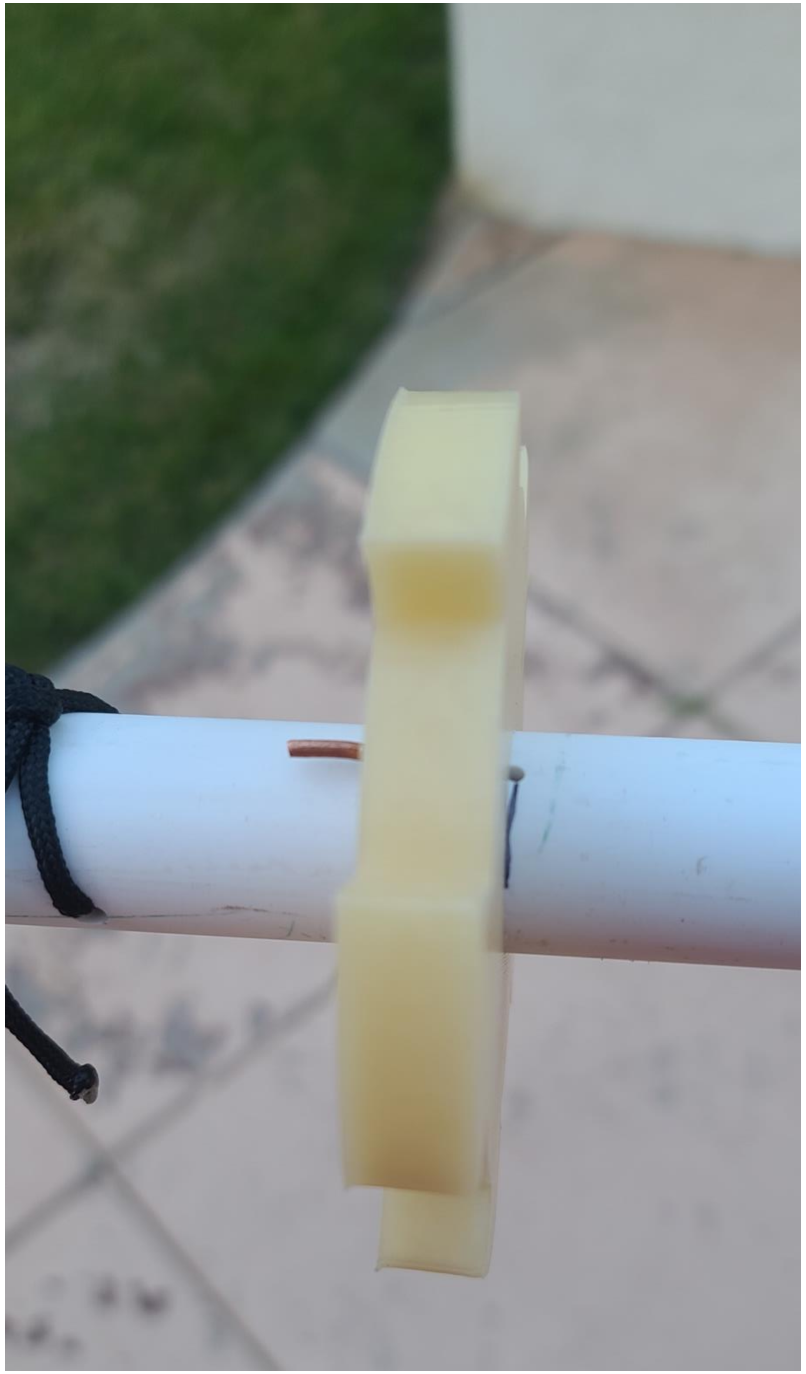
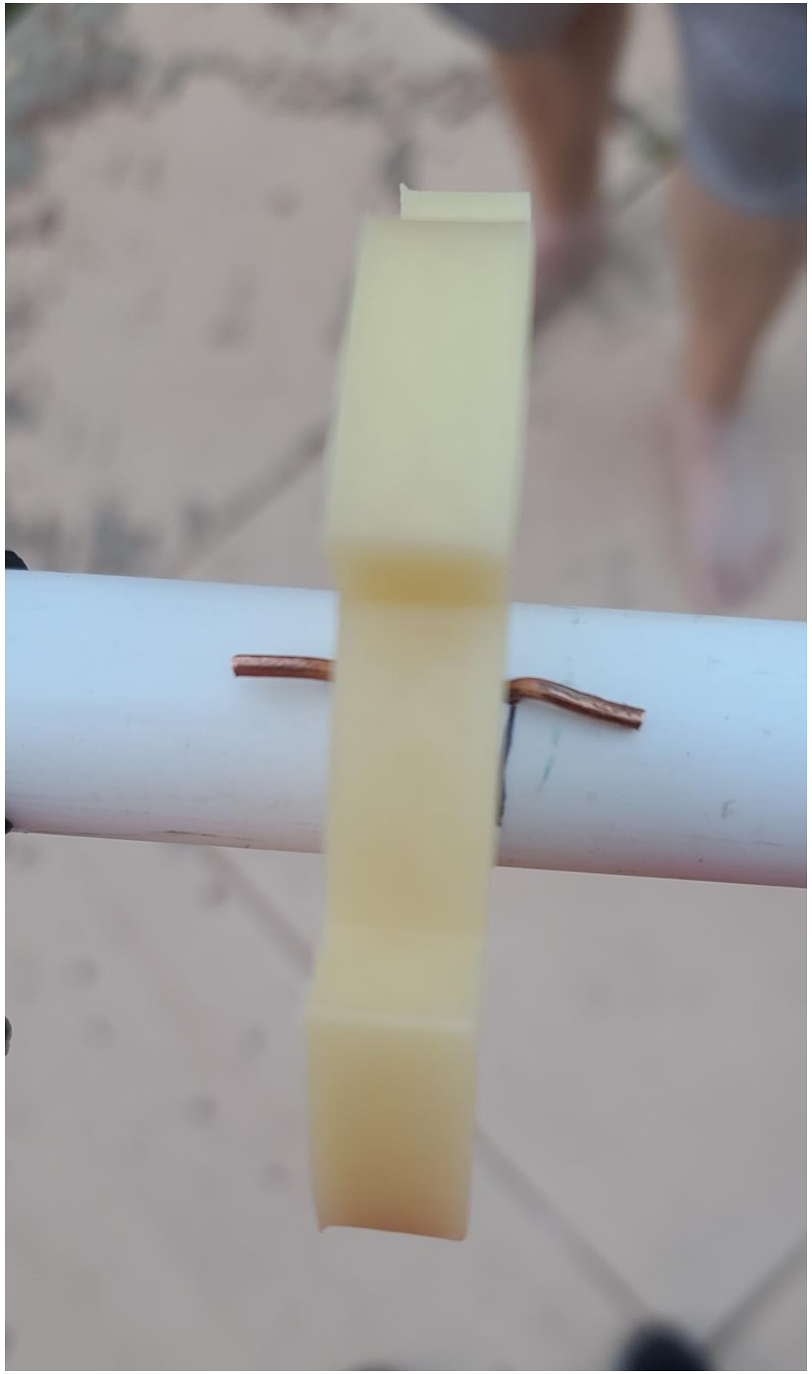


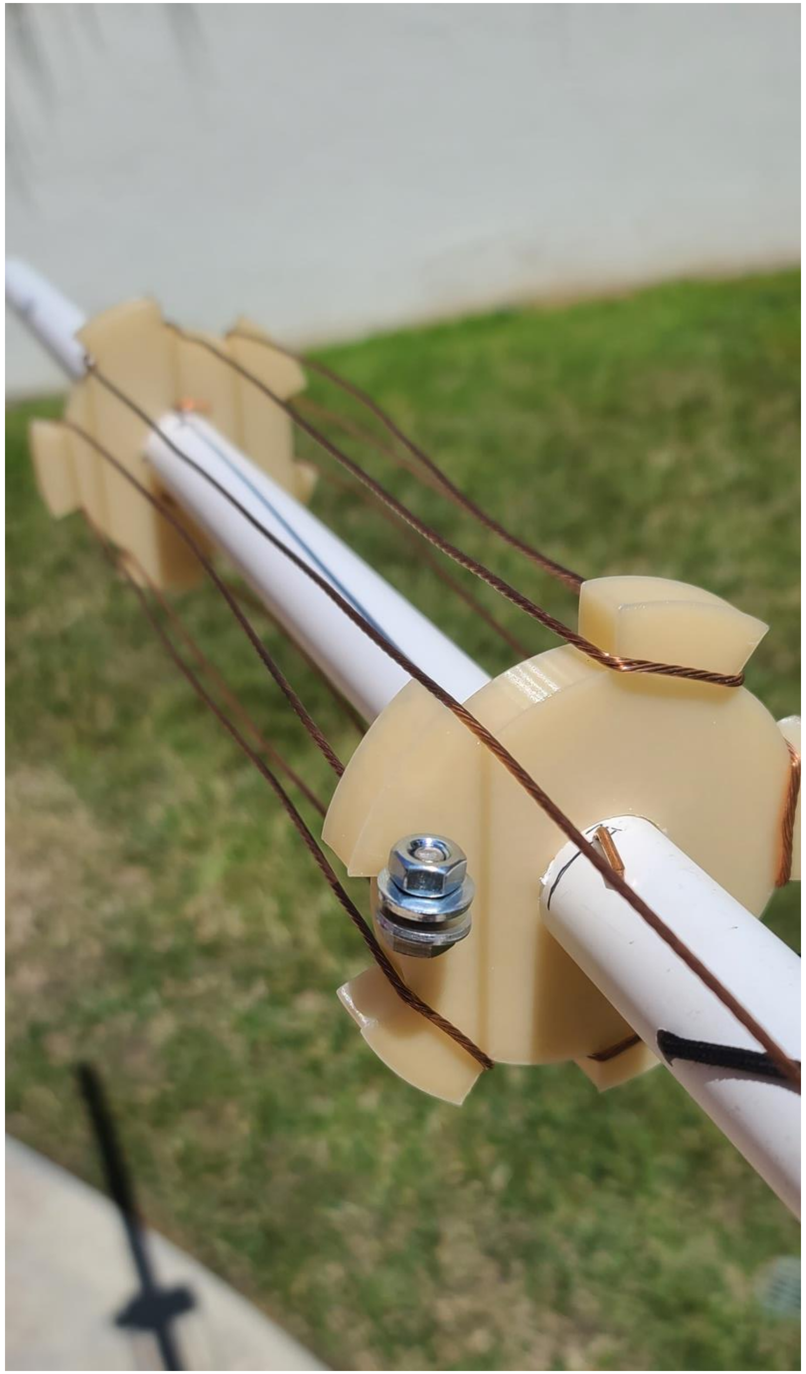
pvc small
width
x
x
d3
to fee



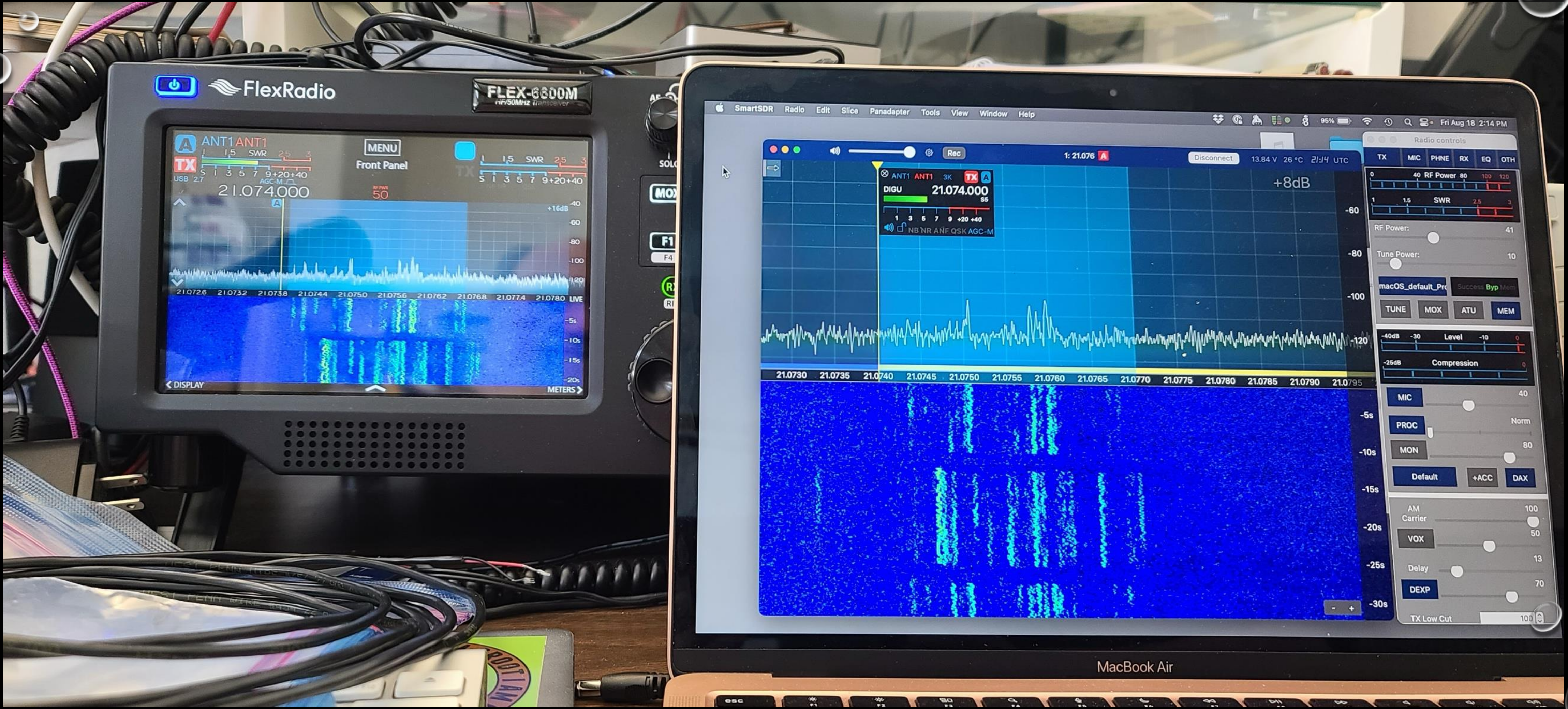


Test fit the cowlings and construct the support truss for the boom.

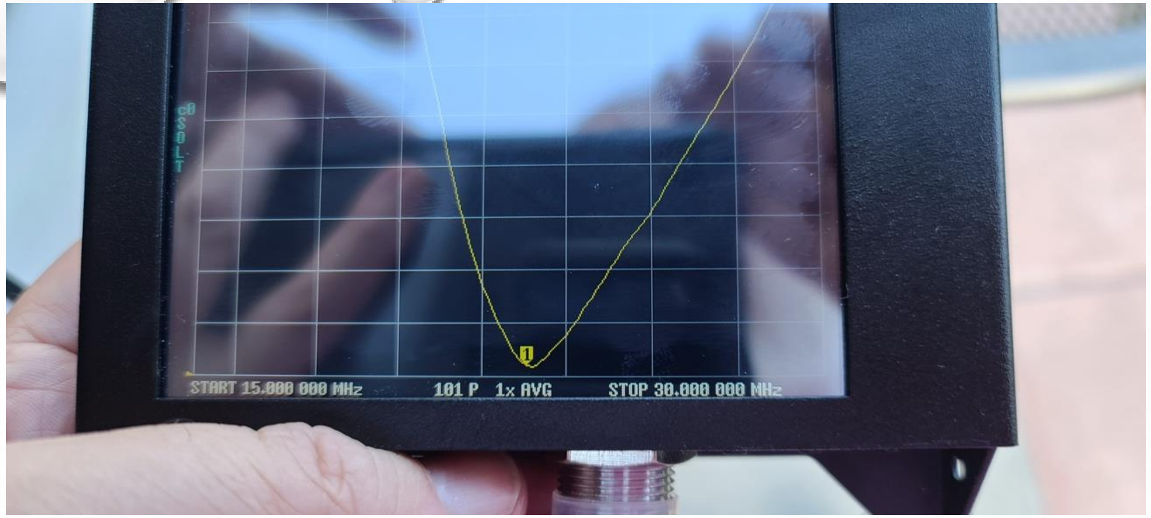




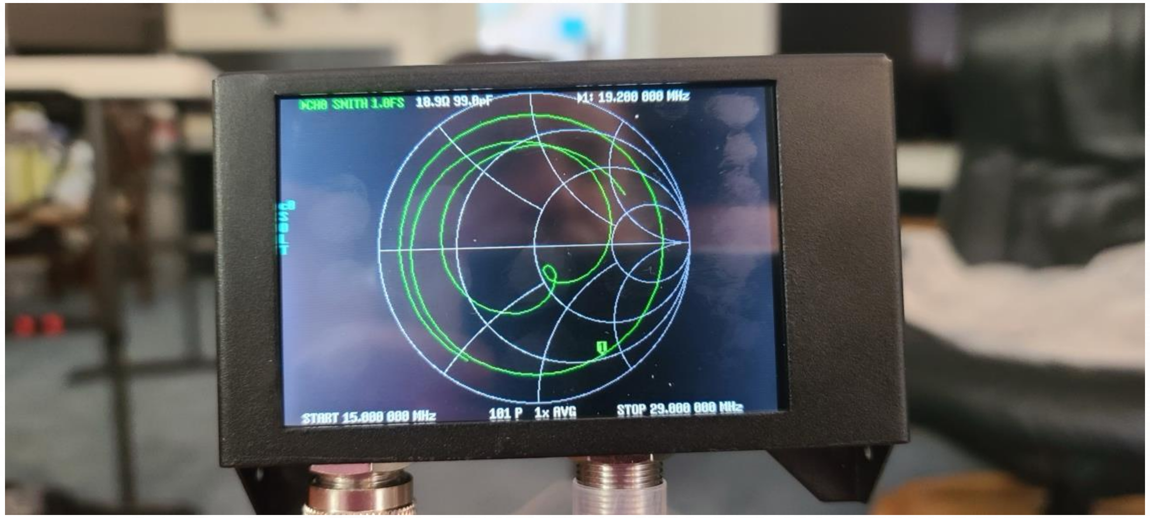


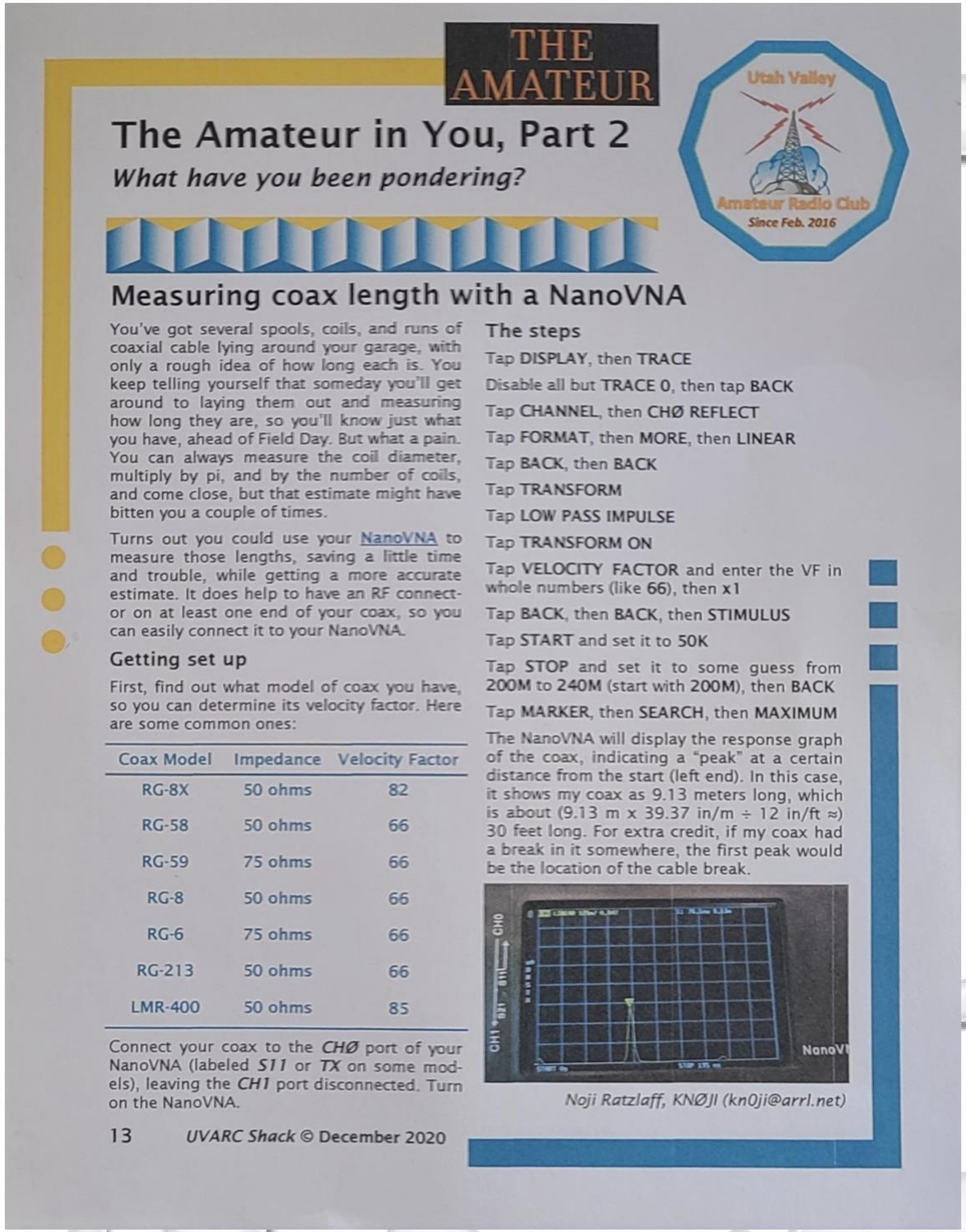
Antenna was put up and tested first with coax.



40ft no-radial vertical on left, dumbbell prototype on right.







THE AMATEUR

Utah Valley Amateur Radio Club Since Feb. 2016

The Amateur in You, Part 2

What have you been pondering?

Measuring coax length with a NanoVNA

You've got several spools, coils, and runs of coaxial cable lying around your garage, with only a rough idea of how long each is. You keep telling yourself that someday you'll get around to laying them out and measuring how long they are, so you'll know just what you have, ahead of Field Day. But what a pain. You can always measure the coil diameter, multiply by pi, and by the number of coils, and come close, but that estimate might have bitten you a couple of times.

Turns out you could use your NanoVNA to measure those lengths, saving a little time and trouble, while getting a more accurate estimate. It does help to have an RF connector on at least one end of your coax, so you can easily connect it to your NanoVNA.

Getting set up

First, find out what model of coax you have, so you can determine its velocity factor. Here are some common ones:

Coax Model	Impedance	Velocity Factor
RG-8X	50 ohms	82
RG-58	50 ohms	66
RG-59	75 ohms	66
RG-8	50 ohms	66
RG-6	75 ohms	66
RG-213	50 ohms	66
LMR-400	50 ohms	85

Connect your coax to the *CHØ* port of your NanoVNA (labeled *S11* or *TX* on some models), leaving the *CH1* port disconnected. Turn on the NanoVNA.

The steps

Tap **DISPLAY**, then **TRACE**

Disable all but **TRACE 0**, then tap **BACK**

Tap **CHANNEL**, then **CHØ REFLECT**

Tap **FORMAT**, then **MORE**, then **LINEAR**

Tap **BACK**, then **BACK**

Tap **TRANSFORM**

Tap **LOW PASS IMPULSE**

Tap **TRANSFORM ON**

Tap **VELOCITY FACTOR** and enter the VF in whole numbers (like **66**), then **x1**

Tap **BACK**, then **BACK**, then **STIMULUS**

Tap **START** and set it to **50K**

Tap **STOP** and set it to some guess from **200M** to **240M** (start with **200M**), then **BACK**

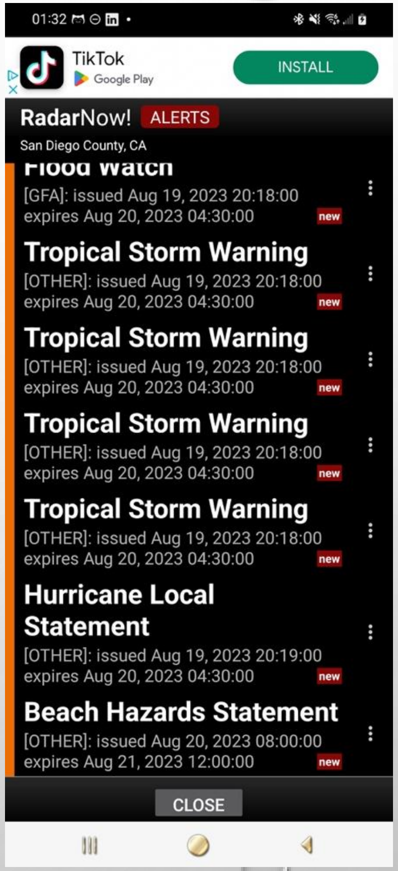
Tap **MARKER**, then **SEARCH**, then **MAXIMUM**

The NanoVNA will display the response graph of the coax, indicating a "peak" at a certain distance from the start (left end). In this case, it shows my coax as 9.13 meters long, which is about (9.13 m x 39.37 in/m ÷ 12 in/ft ≈) 30 feet long. For extra credit, if my coax had a break in it somewhere, the first peak would be the location of the cable break.

Noji Ratzlaff, KNØJI (kn0ji@arrl.net)

13 *UVARC Shack* © December 2020

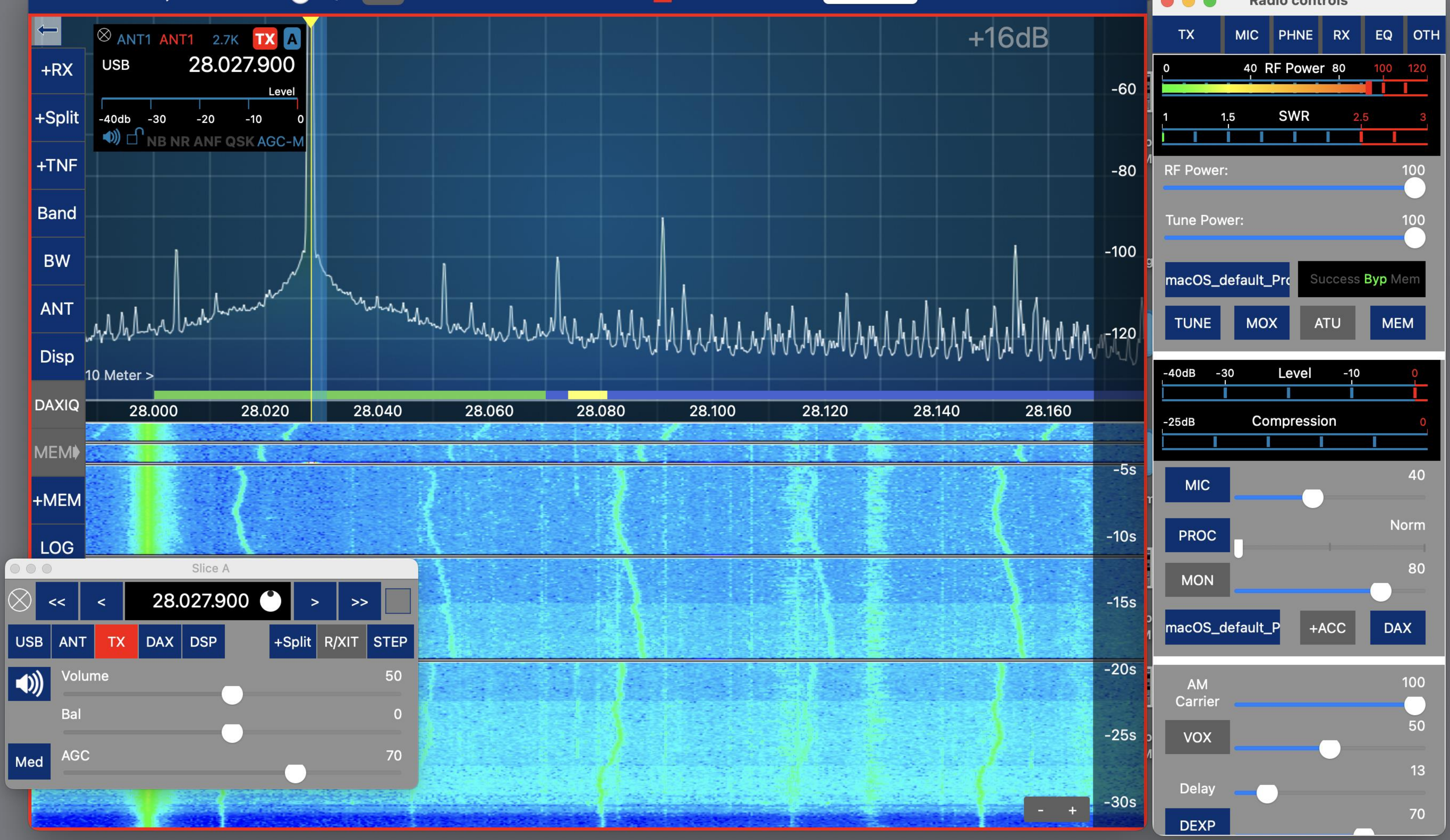
Hurricane Hilary Intermission



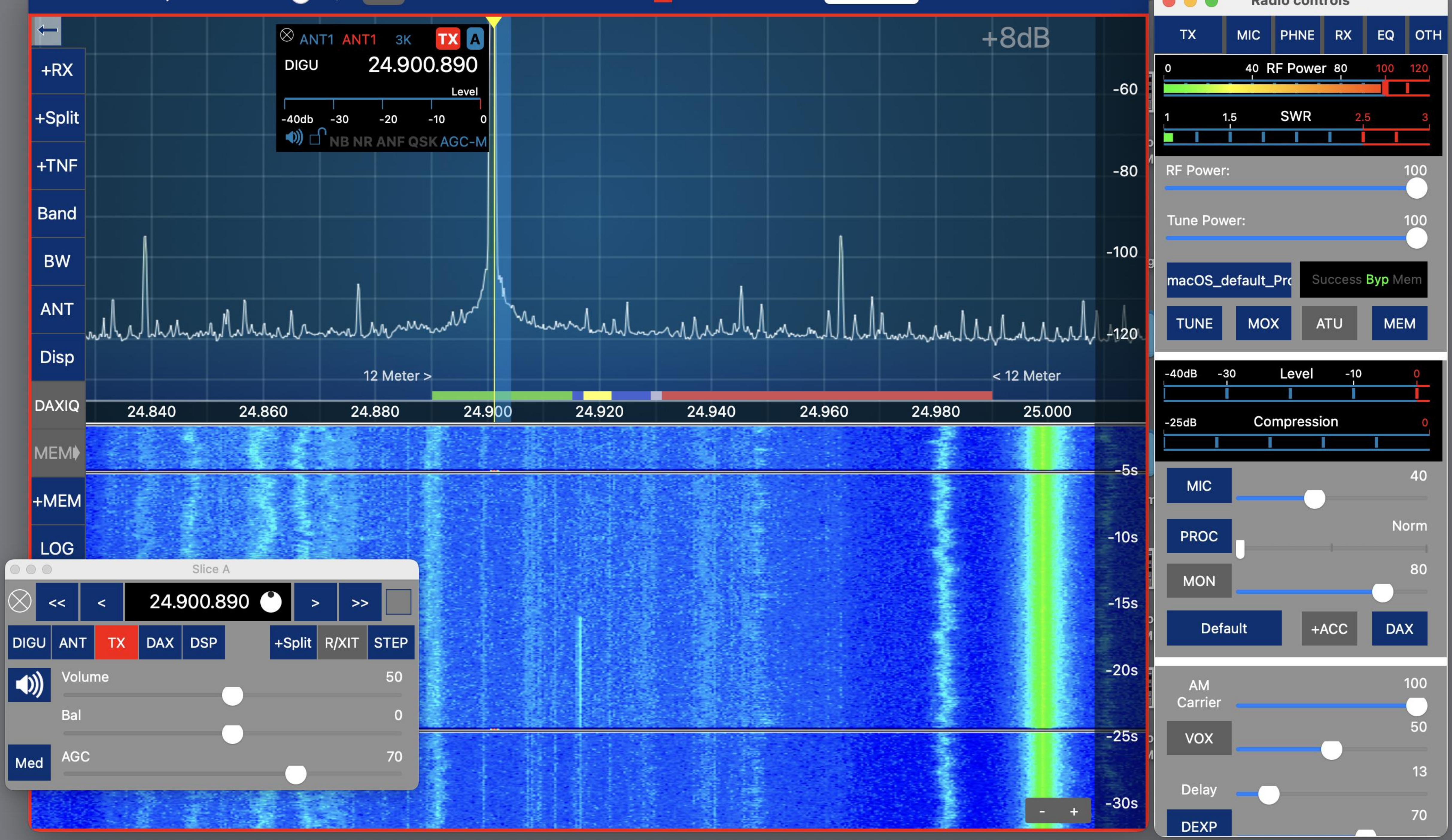
Thank you to Paul Williamson KB5MU for construction and test support.
Thank you to John Barcroft K6AM for twin lead to replace the coax.



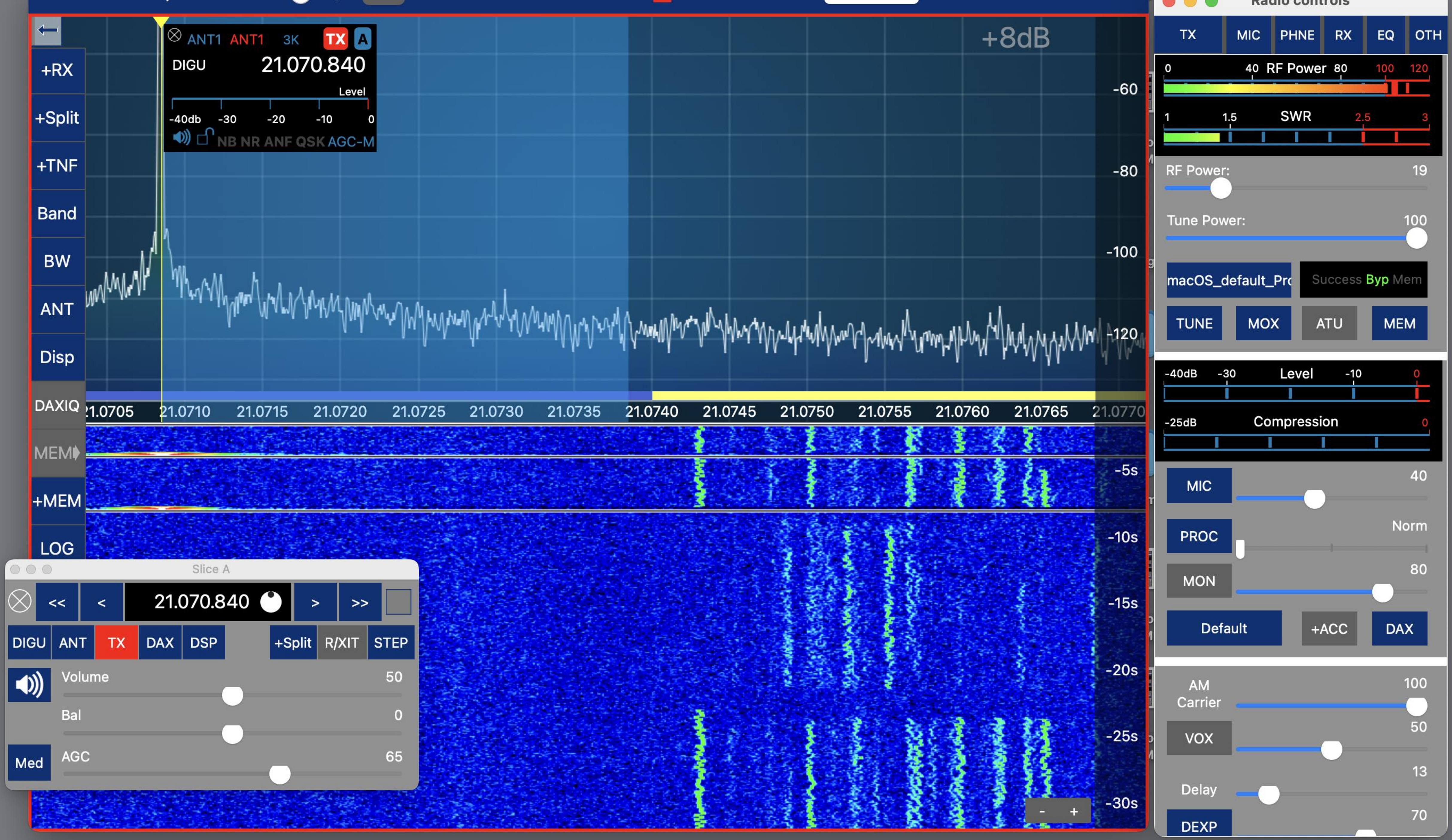

ANTENNA
FREQUENCY
XMTR MATCHING
INDUCTOR
ANT MATCHING



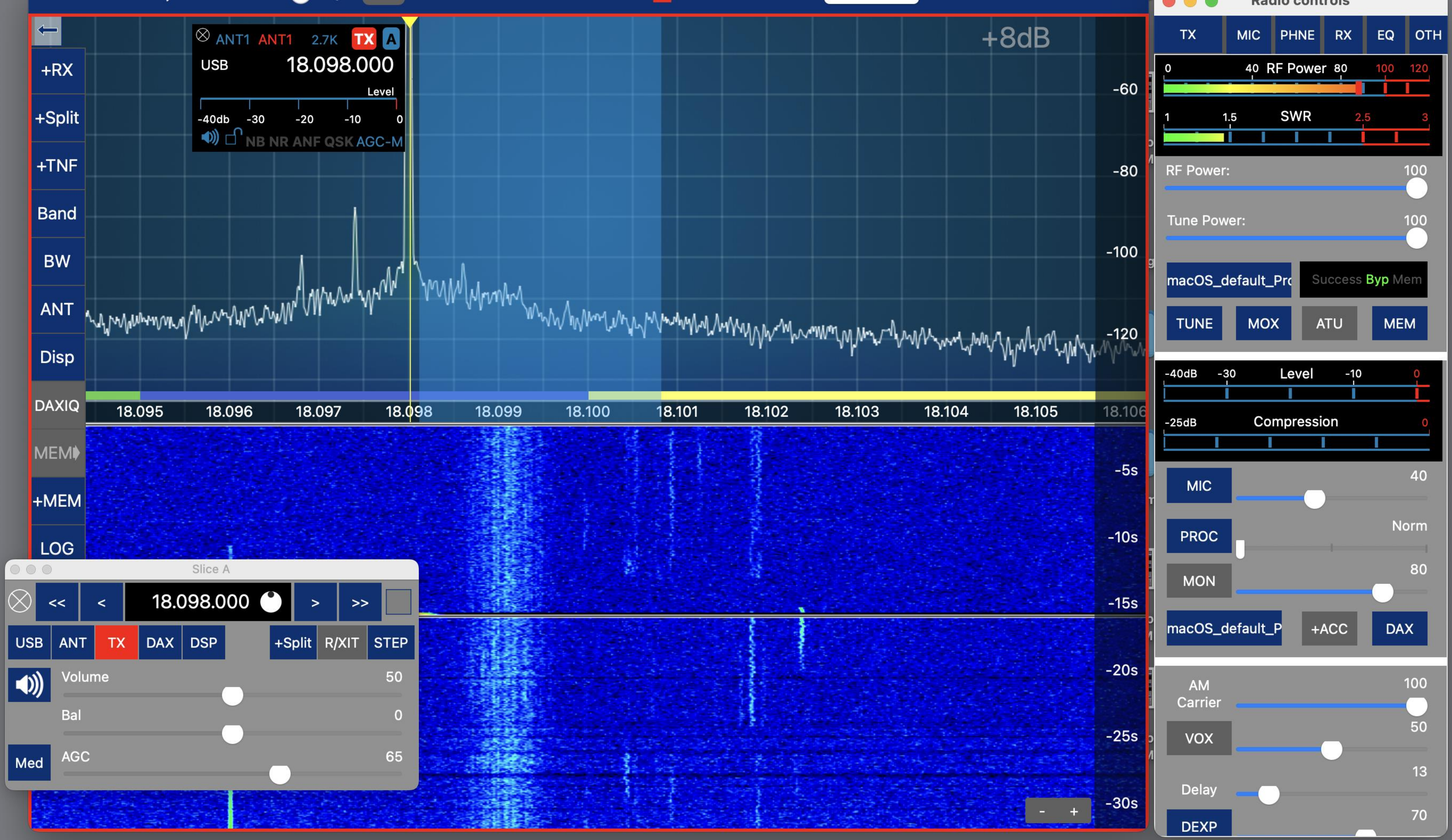
Radio controls
+RX
+Split
+TNF
Band
BW
ANT
Disp
DAXIQ
MEM
+MEM
LOG
ANT1 ANT1 2.7K TX A
USB 28.027.900
Level
-40db -30 -20 -10 0
NB NR ANF QSK AGC-M
+16dB
-60
-80
-100
-120
10 Meter >
28.000 28.020 28.040 28.060 28.080 28.100 28.120 28.140 28.160
-5s
-10s
-15s
-20s
-25s
-30s
Slice A
<< < 28.027.900 > >>
USB ANT TX DAX DSP +Split R/XIT STEP
Volume 50
Bal 0
Med
AGC 70
TX MIC PHNE RX EQ OTH
0 40 RF Power 80 100 120
1 1.5 SWR 2.5 3
RF Power: 100
Tune Power: 100
macOS_default_Pro
Success Byp Mem
TUNE MOX ATU MEM
-40dB -30 Level -10 0
-25dB Compression 0
MIC 40
PROC Norm
MON 80
macOS_default_P +ACC DAX
AM Carrier 100
VOX 50
Delay 13
DEXP 70

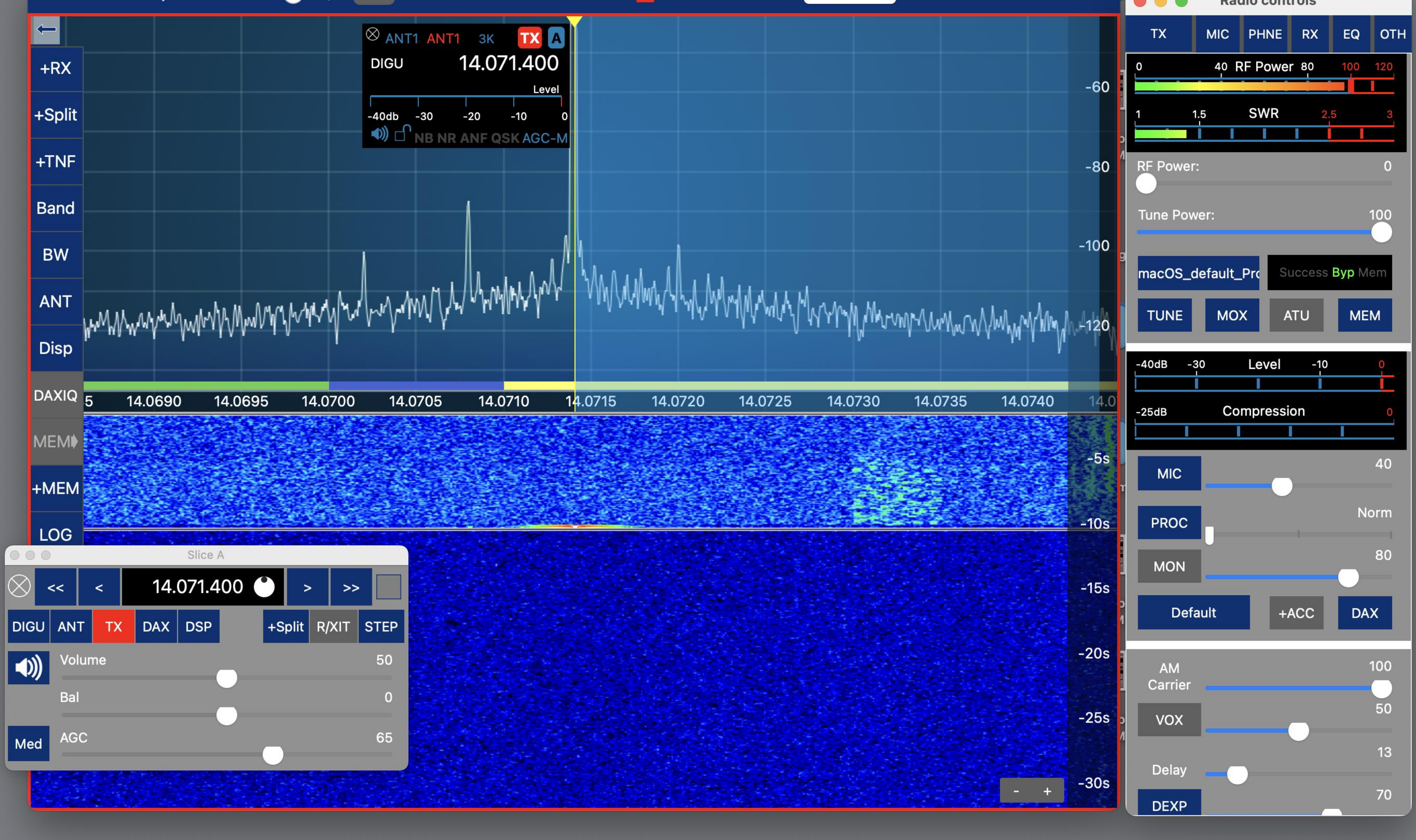


Radio controls
TX
MIC
PHNE
RX
EQ
OTH
+8dB
ANT1 ANT1 3K TX A
DIGU 24.900.890
Level
-40db -30 -20 -10 0
NB NR ANF QSK AGC-M
+RX
+Split
+TNF
Band
BW
ANT
Disp
DAXIQ
MEM
+MEM
LOG
-60
-80
-100
-120
12 Meter >
< 12 Meter
24.840 24.860 24.880 24.900 24.920 24.940 24.960 24.980 25.000
-5s
-10s
-15s
-20s
-25s
-30s
Slice A
<< < 24.900.890 > >>
DIGU ANT TX DAX DSP +Split R/XIT STEP
Volume 50
Bal 0
Med
AGC 70
0 40 RF Power 80 100 120
1 1.5 SWR 2.5 3
RF Power: 100
Tune Power: 100
macOS_default_Pro
Success Byp Mem
TUNE
MOX
ATU
MEM
-40dB -30 Level -10 0
-25dB Compression 0
MIC 40
PROC Norm
MON 80
Default
+ACC
DAX
AM Carrier 100
VOX 50
Delay 13
DEXP 70

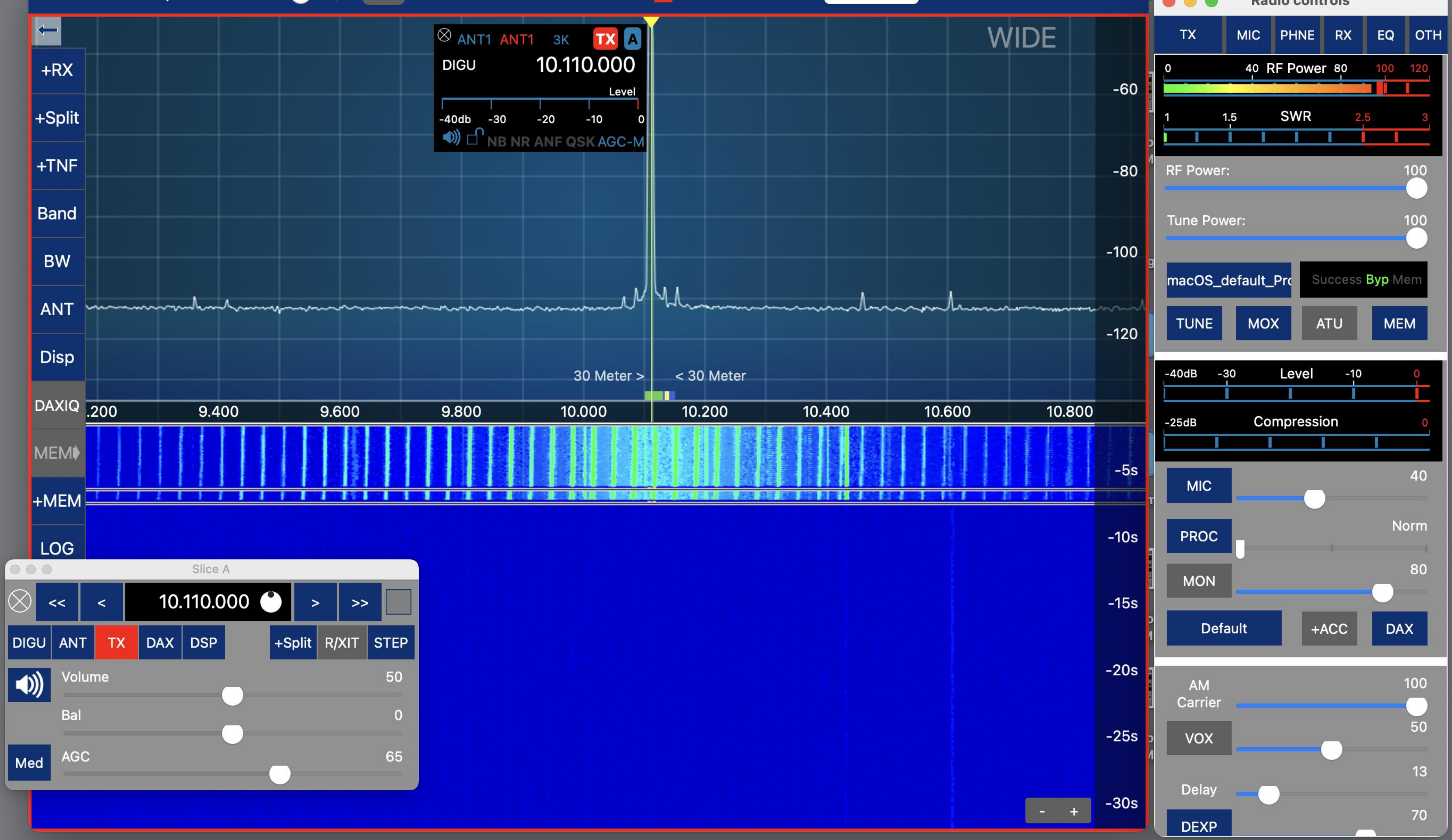


ANT1 ANT1 3K TX A
DIGU 21.070.840
Level
-40db -30 -20 -10 0
NB NR ANF QSK AGC-M
+8dB
+RX
+Split
+TNF
Band
BW
ANT
Disp
DAXIQ
MEM
+MEM
LOG
-60
-80
-100
-120
21.0705 21.0710 21.0715 21.0720 21.0725 21.0730 21.0735 21.0740 21.0745 21.0750 21.0755 21.0760 21.0765 21.0770
-5s
-10s
-15s
-20s
-25s
-30s
Slice A
<< < 21.070.840 > >>
DIGU ANT TX DAX DSP +Split R/XIT STEP
Volume 50
Bal 0
Med
AGC 65
Radio controls
TX MIC PHNE RX EQ OTH
0 40 RF Power 80 100 120
1 1.5 SWR 2.5 3
RF Power: 19
Tune Power: 100
macOS_default_Pro
Success Byp Mem
TUNE MOX ATU MEM
-40dB -30 Level -10 0
-25dB Compression 0
MIC 40
PROC Norm
MON 80
Default +ACC DAX
AM Carrier 100
VOX 50
Delay 13
DEXP 70

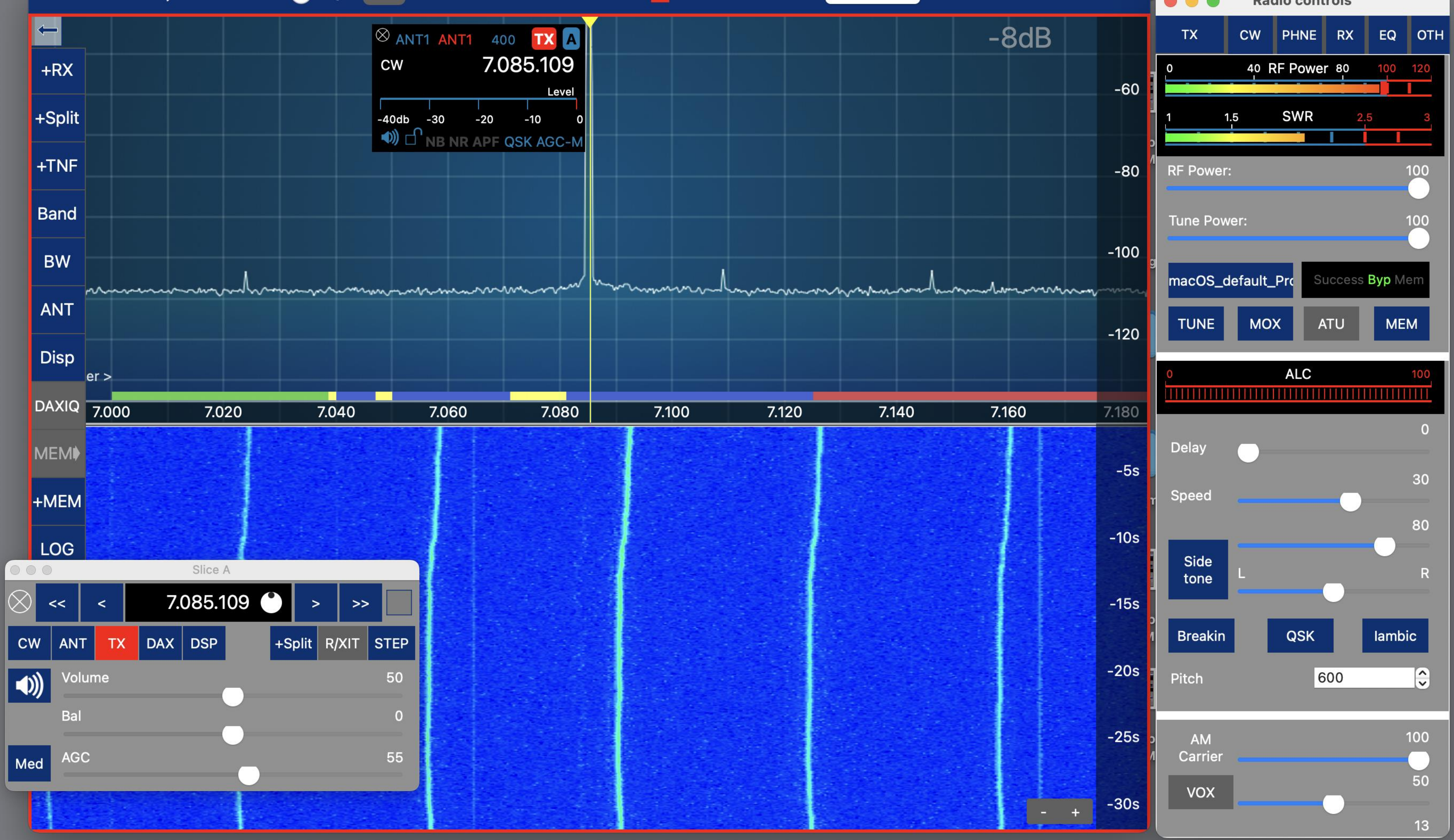

ANT1 ANT1 2.7K TX A
USB 18.098.000
Level
-40db -30 -20 -10 0
NB NR ANF QSK AGC-M
+8dB
+RX
+Split
+TNF
Band
BW
ANT
Disp
DAXIQ
MEM
+MEM
LOG
-60
-80
-100
-120
18.095 18.096 18.097 18.098 18.099 18.100 18.101 18.102 18.103 18.104 18.105 18.106
-5s
-10s
-15s
-20s
-25s
-30s
Slice A
<< < 18.098.000 > >>
USB ANT TX DAX DSP +Split R/XIT STEP
Volume 50
Bal 0
Med
AGC 65
Radio controls
TX MIC PHNE RX EQ OTH
0 40 RF Power 80 100 120
1 1.5 SWR 2.5 3
RF Power: 100
Tune Power: 100
macOS_default_Pro
Success Byp Mem
TUNE MOX ATU MEM
-40dB -30 Level -10 0
-25dB Compression 0
MIC 40
PROC Norm
MON 80
macOS_default_P +ACC DAX
AM Carrier 100
VOX 50
Delay 13
DEXP 70



ANT1 ANT1 3K TX A
DIGU 14.071.400
Level
-40db -30 -20 -10 0
NB NR ANF QSK AGC-M
+RX
+Split
+TNF
Band
BW
ANT
Disp
DAXIQ
MEM
+MEM
LOG
-60
-80
-100
-120
14.0690 14.0695 14.0700 14.0705 14.0710 14.0715 14.0720 14.0725 14.0730 14.0735 14.0740
-5s
-10s
-15s
-20s
-25s
-30s
Slice A
<< < 14.071.400 > >>
DIGU ANT TX DAX DSP +Split R/XIT STEP
Volume 50
Bal 0
Med AGC 65
Radio controls
TX MIC PHNE RX EQ OTH
0 40 RF Power 80 100 120
1 1.5 SWR 2.5 3
RF Power: 0
Tune Power: 100
macOS_default_Pro
Success Byp Mem
TUNE MOX ATU MEM
-40dB -30 Level -10 0
-25dB Compression 0
MIC 40
PROC Norm
MON 80
Default +ACC DAX
AM Carrier 100
VOX 50
Delay 13
DEXP 70



ANT1 ANT1 3K TX A
DIGU 10.110.000
Level
-40db -30 -20 -10 0
NB NR ANF QSK AGC-M
WIDE
+RX
+Split
+TNF
Band
BW
ANT
Disp
DAXIQ
MEM
+MEM
LOG
-60
-80
-100
-120
30 Meter >
< 30 Meter
.200 9.400 9.600 9.800 10.000 10.200 10.400 10.600 10.800
-5s
-10s
-15s
-20s
-25s
-30s
Slice A
<< < 10.110.000 > >>
DIGU ANT TX DAX DSP +Split R/XIT STEP
Volume 50
Bal 0
Med AGC 65
Radio controls
TX MIC PHNE RX EQ OTH
0 40 RF Power 80 100 120
1 1.5 SWR 2.5 3
RF Power: 100
Tune Power: 100
macOS_default_Pro
Success Byp Mem
TUNE MOX ATU MEM
-40dB -30 Level -10 0
-25dB Compression 0
MIC 40
PROC Norm
MON 80
Default +ACC DAX
AM Carrier 100
VOX 50
Delay 13
DEXP 70



Radio controls
TX
CW
PHNE
RX
EQ
OTH
RF Power
SWR
RF Power:
100
Tune Power:
100
macOS_default_Pro
Success Byp Mem
TUNE
MOX
ATU
MEM
ALC
Delay
Speed
Side tone
Breakin
QSK
Iambic
Pitch
600
AM Carrier
VOX
+RX
+Split
+TNF
Band
BW
ANT
Disp
DAXIQ
MEM
+MEM
LOG
ANT1 ANT1 400 TX A
CW
7.085.109
Level
-40db -30 -20 -10 0
NB NR APF QSK AGC-M
-8dB
-60
-80
-100
-120
7.000
7.020
7.040
7.060
7.080
7.100
7.120
7.140
7.160
7.180
-5s
-10s
-15s
-20s
-25s
-30s
Slice A
<<
<
7.085.109
>
>>
CW
ANT
TX
DAX
DSP
+Split
R/XIT
STEP
Volume
50
Bal
0
AGC
55
Med

SWR CHART

Frequency	SWR
28 MHz	1
24.9 MHz	1.1
21.070 MHz	1.4
18.098 MHz	1.4
14.071 MHz	1.4
10.110 MHz	1
7.085 MHz	2

HOW MUCH DID THIS COST?

- LESS THAN $100 TRIP TO HARDWARE STORE

10 FOOT OF PVC PIPE AND FITTINGS
PORCH UMBRELLA STAND

- IN STOCK OR DONATED

SPOOL OF STRANDED WIRE
COAX
HEAVY COPPER WIRE FOR PINS
3D PRINTED COWLINGS
CNC FOR EDITING PARTS
~15 FEET OF TWIN LEAD
RF CONNECTORS
FLEX RADIOS
HEATHKIT TUNER
HAND TOOLS
SOLDERING GUN
SOLDERING IRON
PVC MAST
CORD AND TINY TURNBUCKLE FOR TRUSS
PORTABLE VNA AND SPECTRUM ANALYZER
MATLAB
OPENSCAD

INTEREST GREW! THANK YOU TO:

- N0MQL

INTERESTED IN BUILDING A 160M VERSION, AND SHARED EXPERIENCE AND ADVICE FROM PRIOR ANTENNA DEPLOYMENTS.

- N6CTA

GREAT ADVICE AND ENCOURAGEMENT. MIGHT BE INTERESTED IN BUILDING ONE OF THESE.

SHORTENED HF ANTENNAS

WHAT ARE WE GOING TO TRY NEXT?

THERE IS A LOT TO DO!

GO BIG AND GO HOME!

- Small size
- Good efficiency
- Good bandwidth
- How about 160m?

NEXT STEPS

EFFICIENCY?

THE MATLAB MODEL RAILED AT 1 AND WE DIDN'T STOP TO FIGURE OUT WHY.

A MORE REASONABLE SET OF RESULTS FOR EFFICIENCY, BOTH SIMULATED AND MEASURED, IS ON THE LIST.

ACHIEVABLE 160M

BUILD A VERSION THAT CAN DO 160M. COLLABORATE WITH THE ACTIVE FEDIHAMS THAT ARE INTERESTED IN CONSTRUCTING FOR THIS BAND. MOST OF US HAVE NEVER HAD A 160M ANTENNA BECAUSE OF THE SPACE REQUIREMENTS.

REVISE THE SPACERS

LACING WIRE AROUND TEETH IS OK FOR A PROTOTYPE, BUT A NON-CONDUCTIVE DISK WITH HOLES IN IT FOR THE WIRE MIGHT BE AN IMPROVEMENT.

PUT IN A RECESS FOR A PIN TO PREVENT ROTATION ON THE BOOM. ALTHOUGH, THEY SEEM STABLE SO FAR.

YOU DO NOT HAVE TO BE AN EXPERT TO JOIN. YOU JUST HAVE TO BE WILLING TO BECOME MORE OF ONE ALONG THE WAY.

HTTPS://OPENRESEARCH.INSTITUTE/GETTING-STARTED

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