



LWA Antenna & FEE Measurements

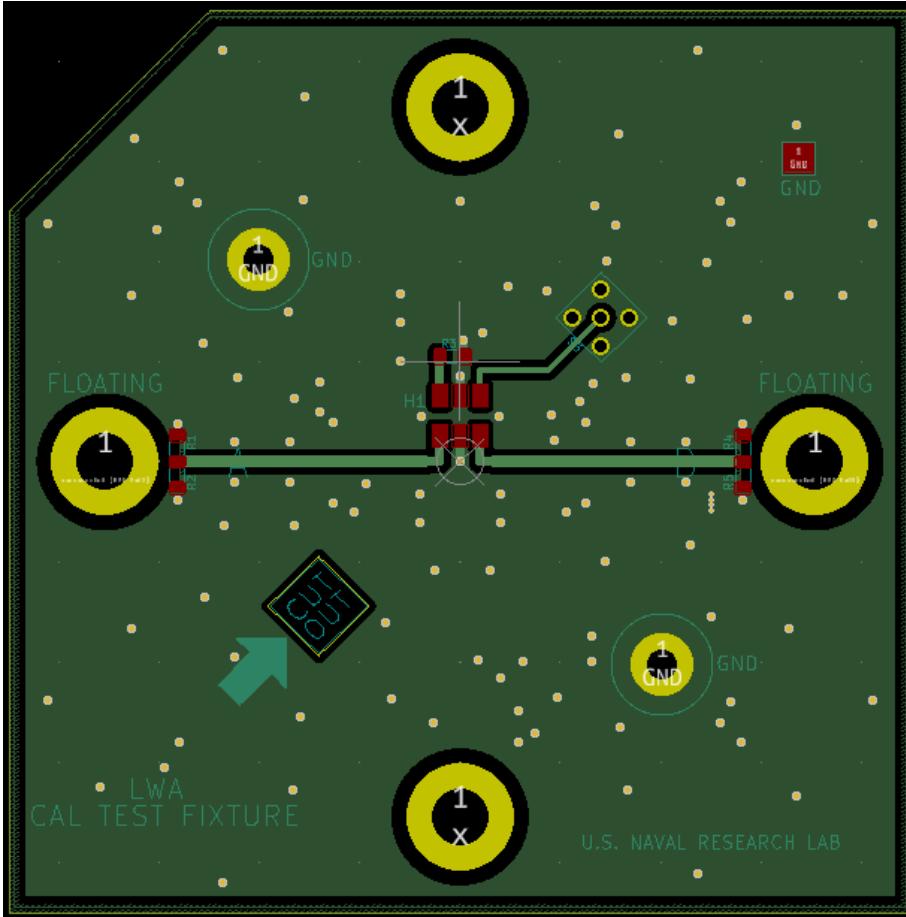
Whitham D. Reeve, Brian Hicks
Chris DiLullo, Jayce Dowell

Dipole Impedance Measurements

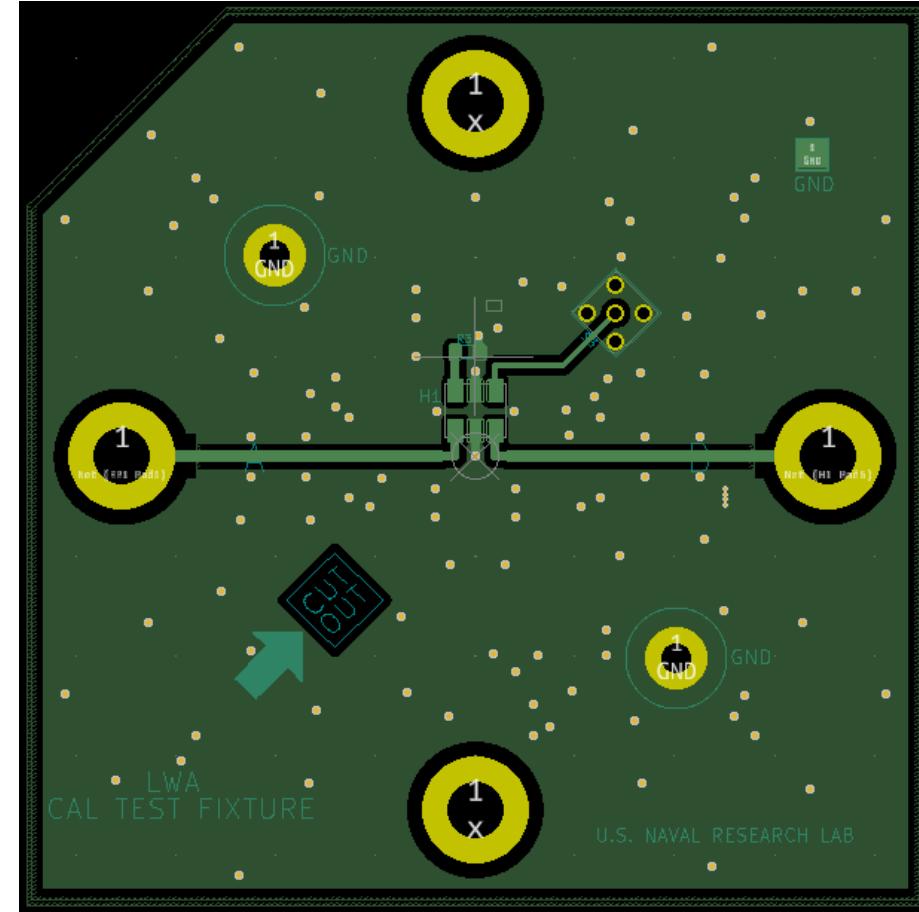
- Equipment
 - Keysight N9917A Microwave Analyzer in *Network Analyzer* mode
 - ✓ S/N MY56071016
 - ✓ Calibration due 23 Dec 2023
 - Test cables, LMR-240 with N-M and SMA-M, 37 ft (11 m), 2X
 - 50 ohm termination, N-F
 - Calibration Fixtures (custom, Brian Hicks)
 - Test Fixtures (custom, Brian Hicks)

Calibration & Test Fixtures, V2

V2 Calibration Fixture

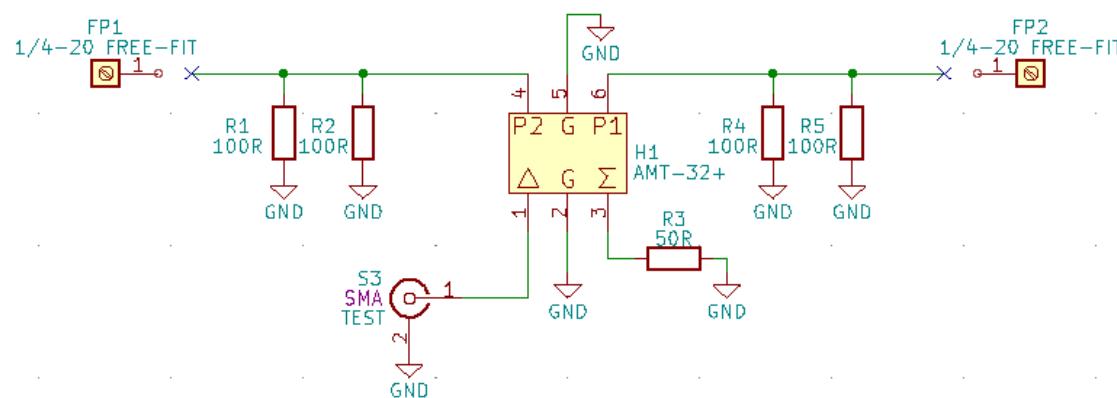


V2 Test Fixture

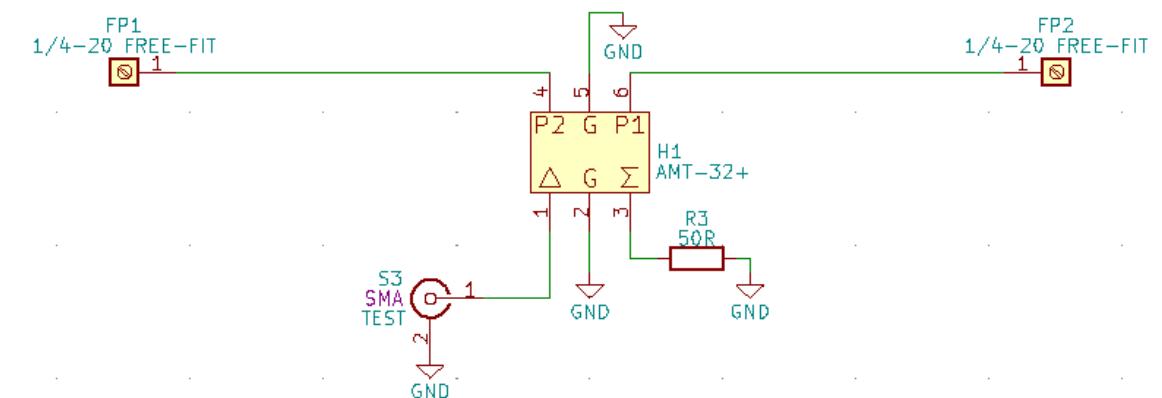


Calibration & Test Fixtures, V2

V2 Calibration Fixture

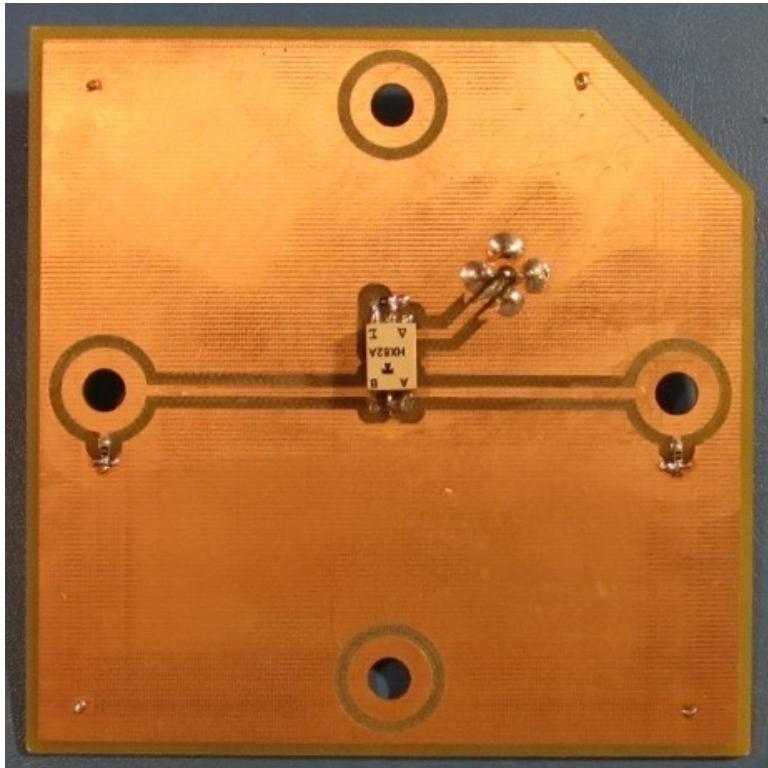


V2 Test Fixture

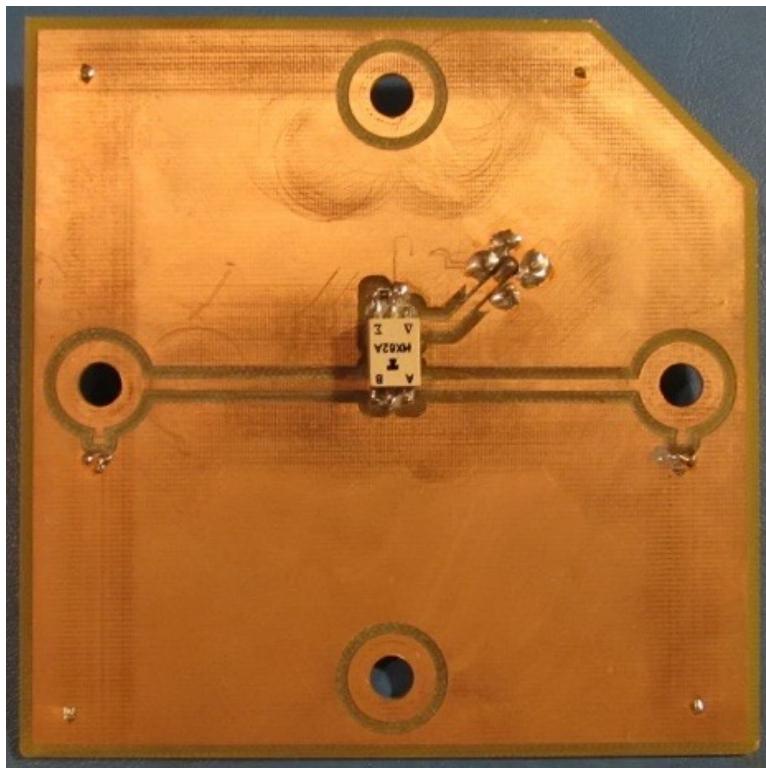


Calibration & Test Fixtures, V1

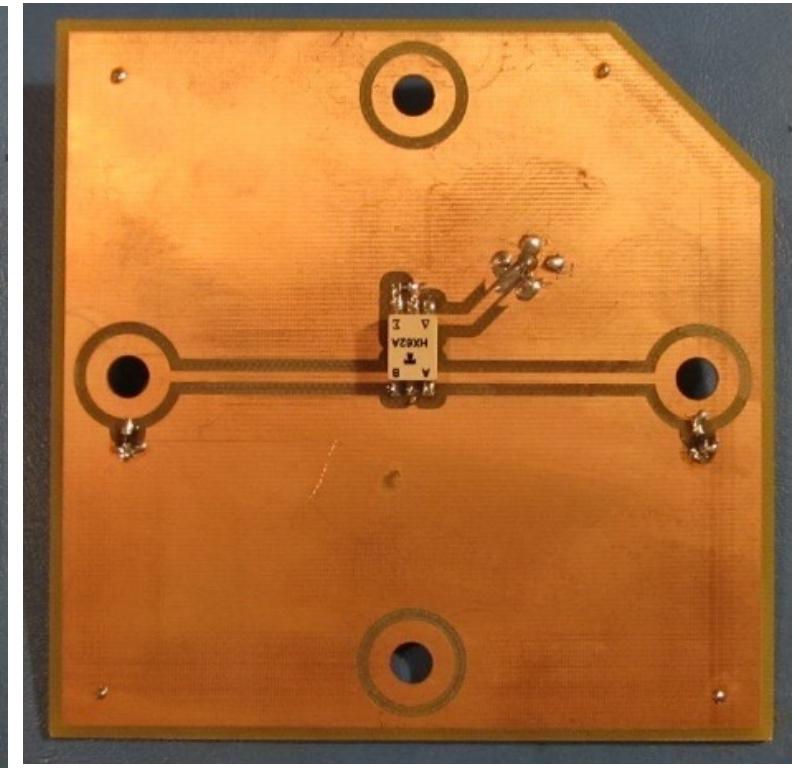
V1 SHORT



V1 OPEN

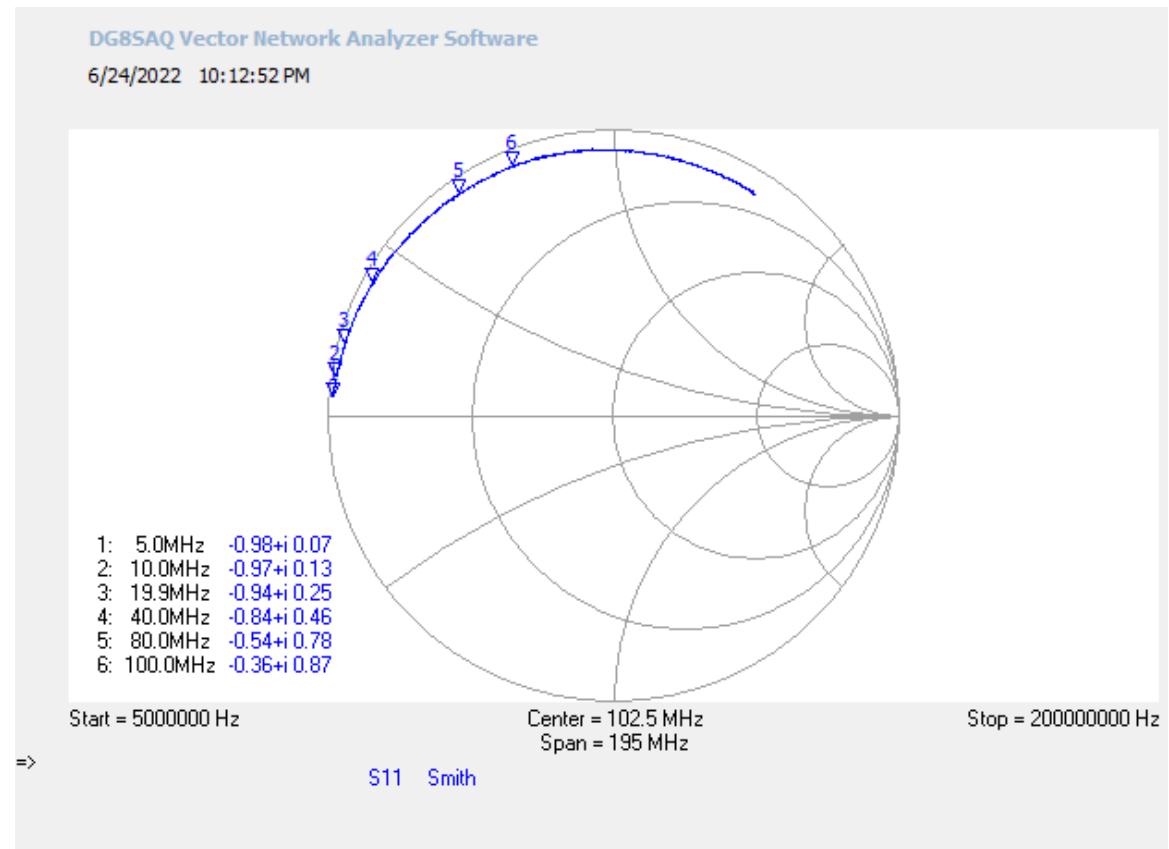
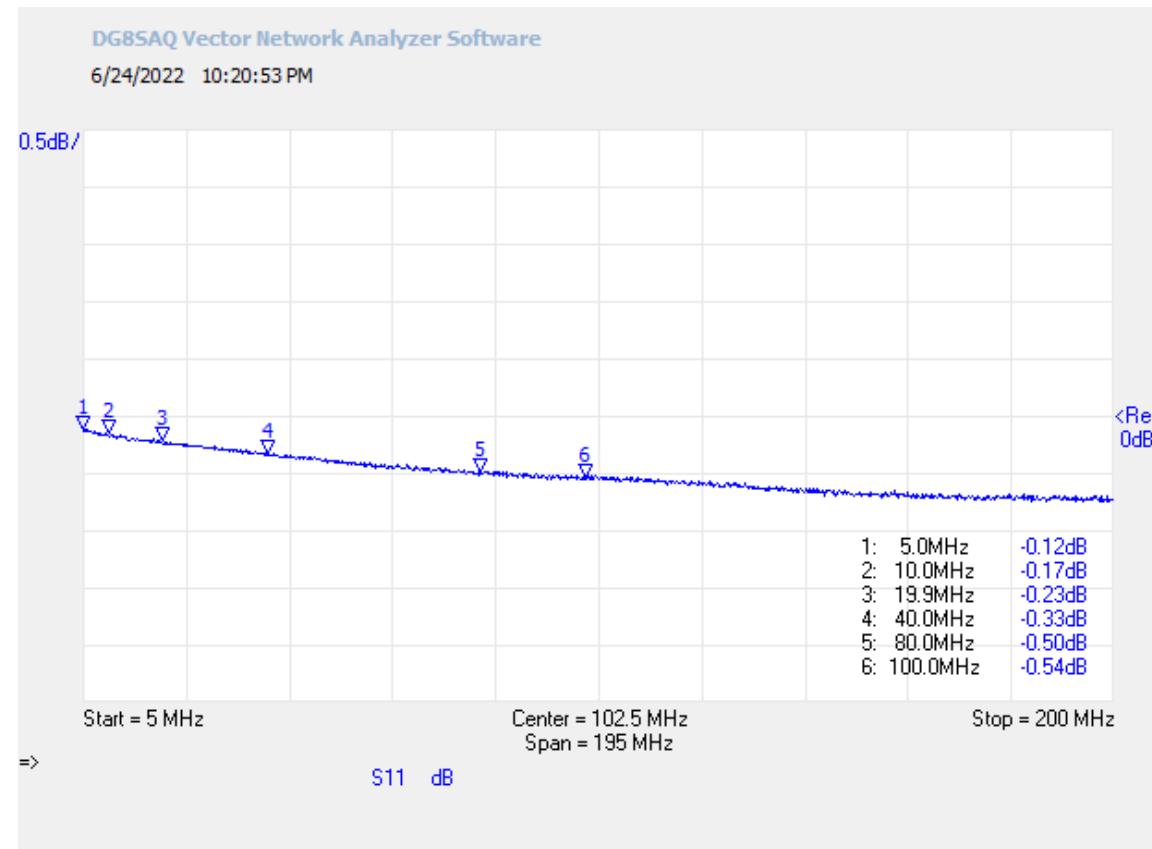


V1 LOAD



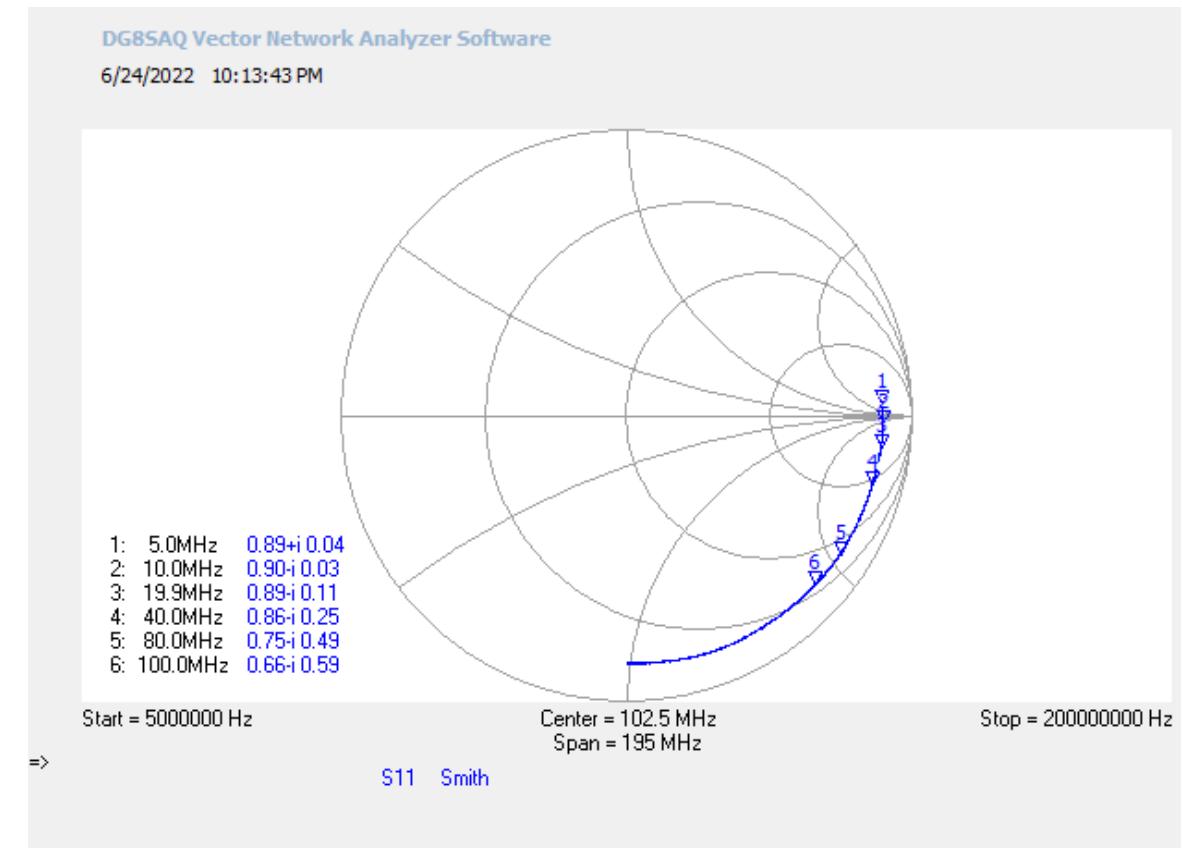
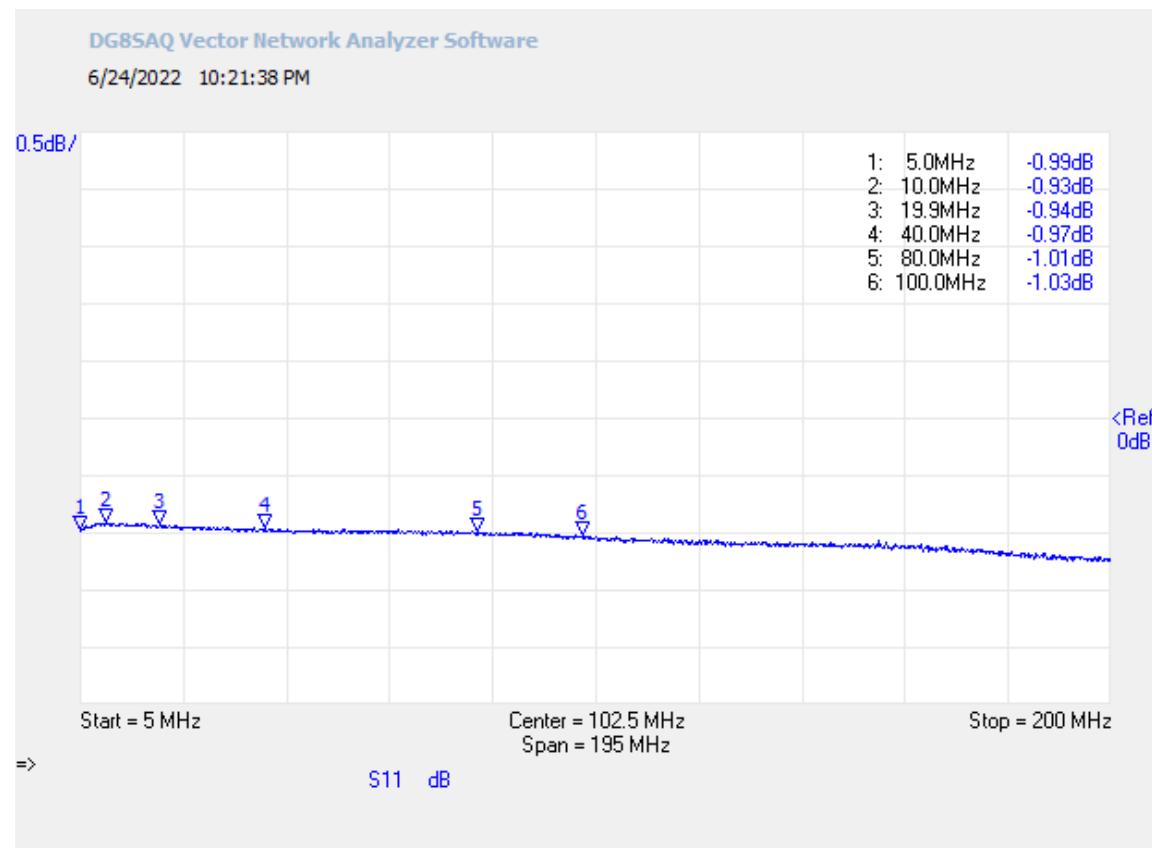
Calibration Fixture Measurements, V2

Short



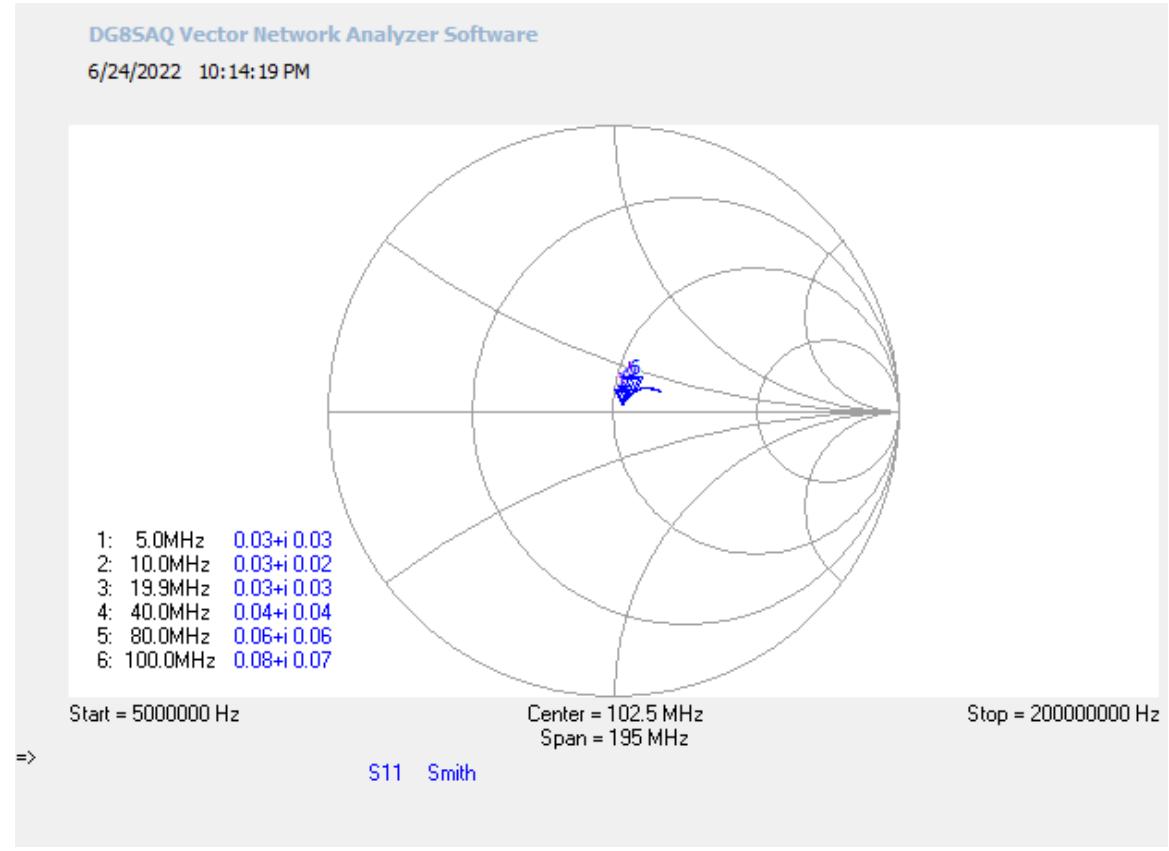
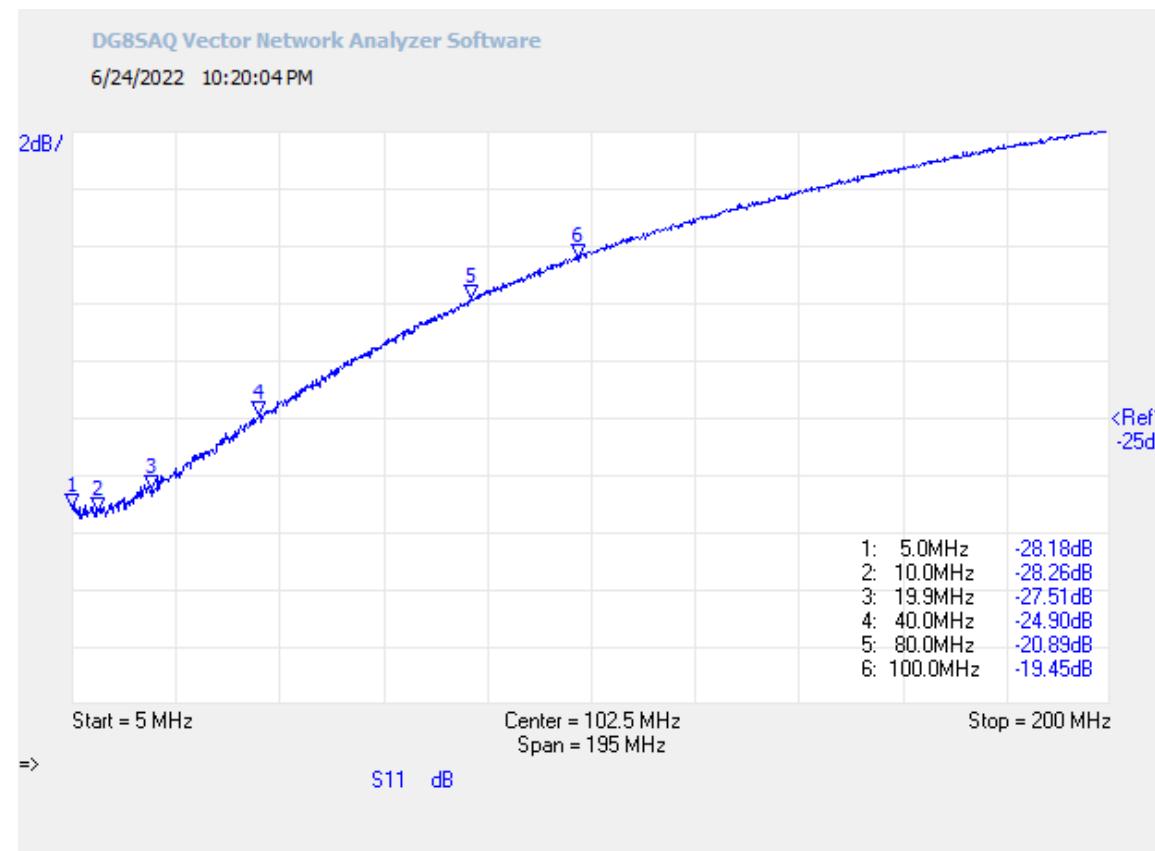
Calibration Fixture Measurements, V2

Open



Calibration Fixture Measurements, V2

Load



Antenna Installation

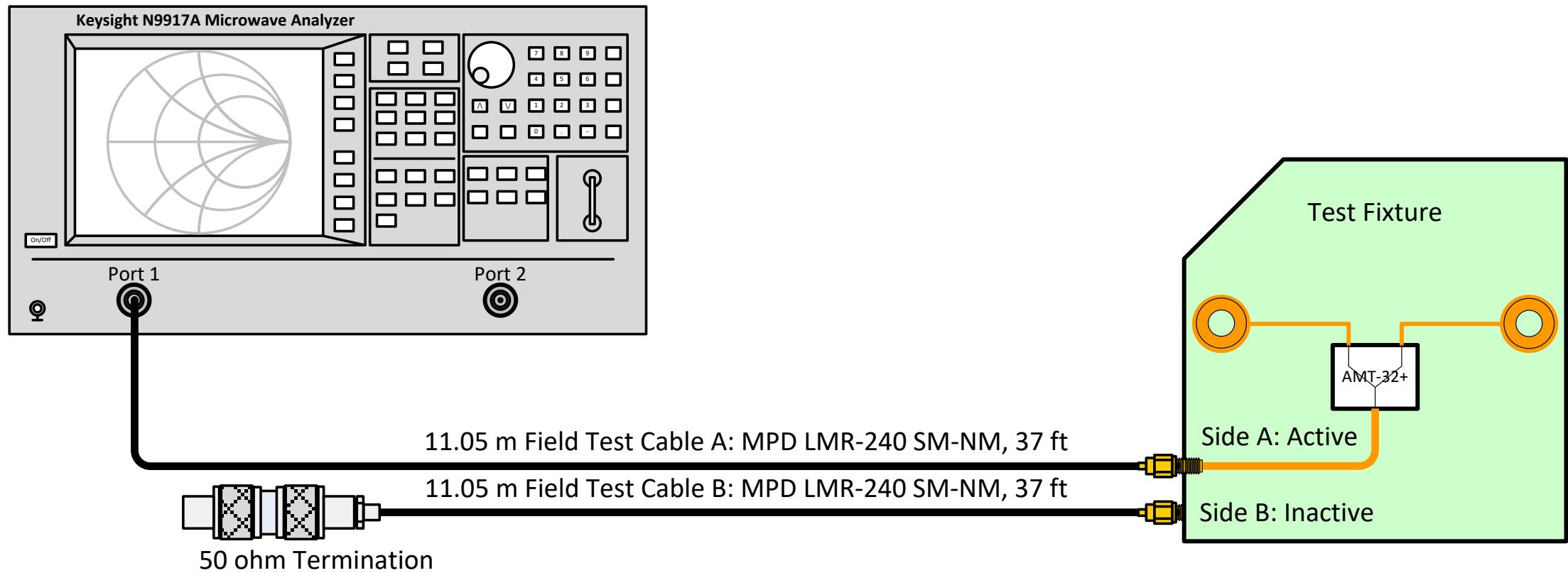


Marauding Wildlife

Moose admiring a quality installation



Dipole Impedance Measurements

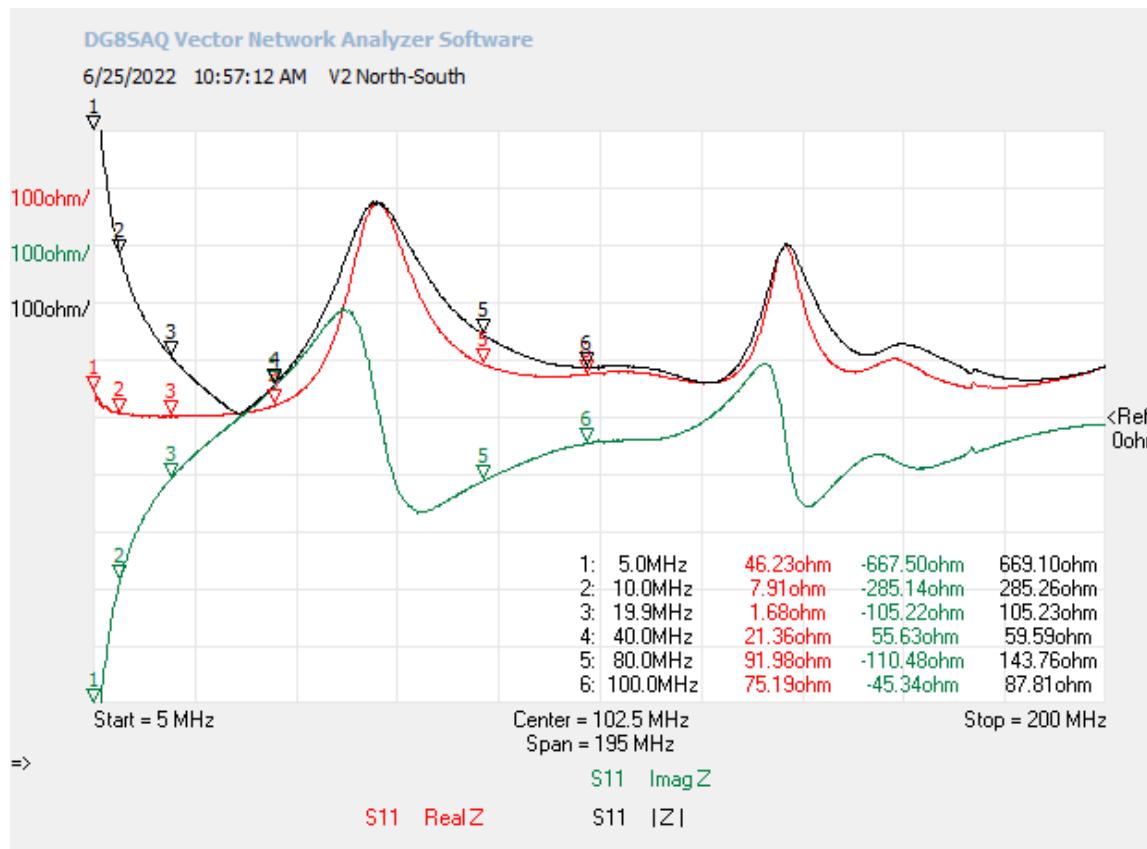


Dipole Impedance Measurements

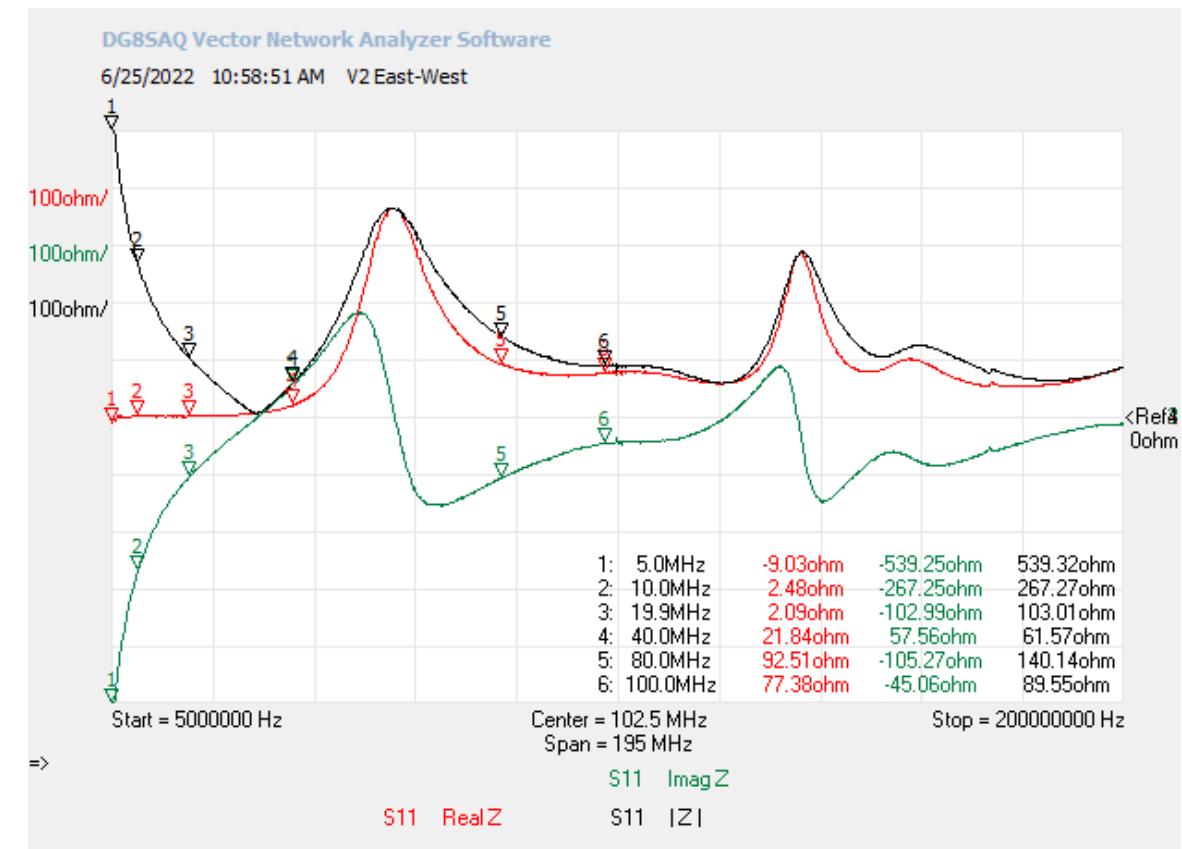
- All measurement data saved as S1P Touchstone files
 - Reflection coefficient S11 → .s1p
 - ASCII text in 3-column tabular format
 - Frequency | Mag(dB) | Phase(degrees)
- Convert to R + jX format and plotted as impedances

Dipole Impedance Measurements, V2

North-South Dipole, V2

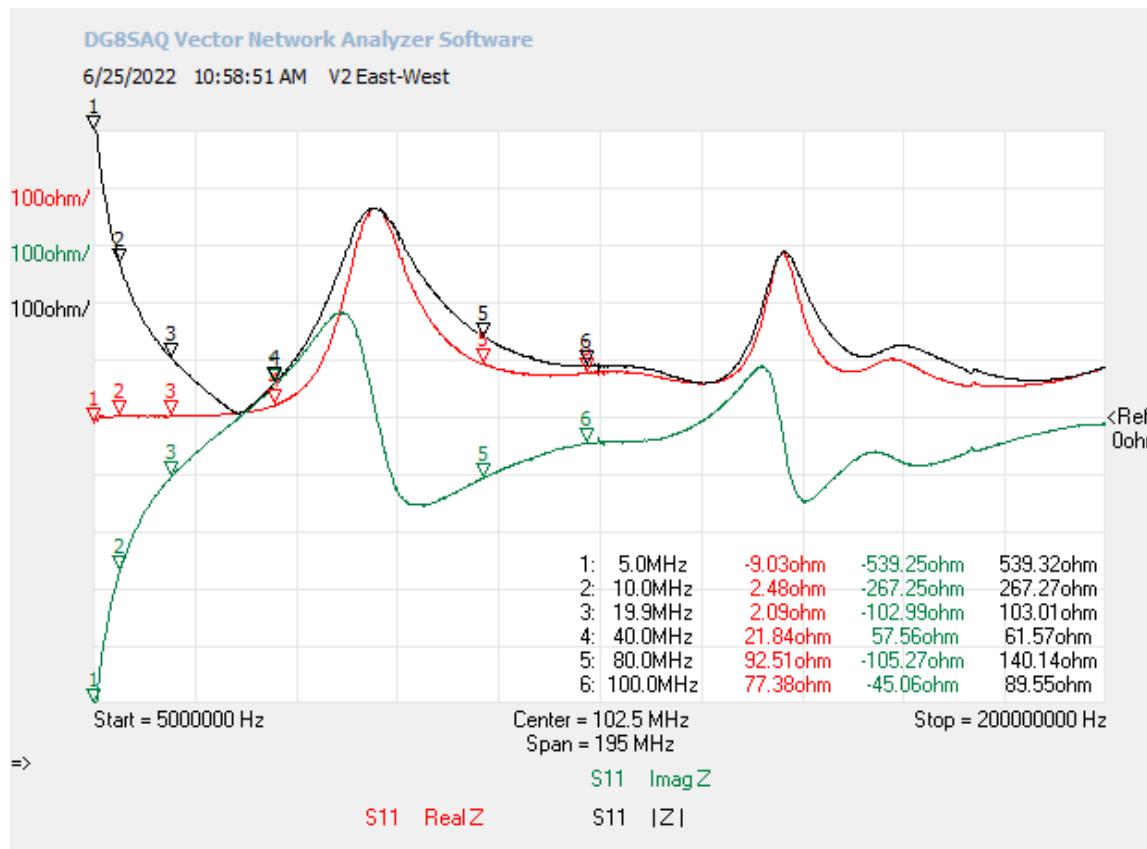


East-West Dipole, V2

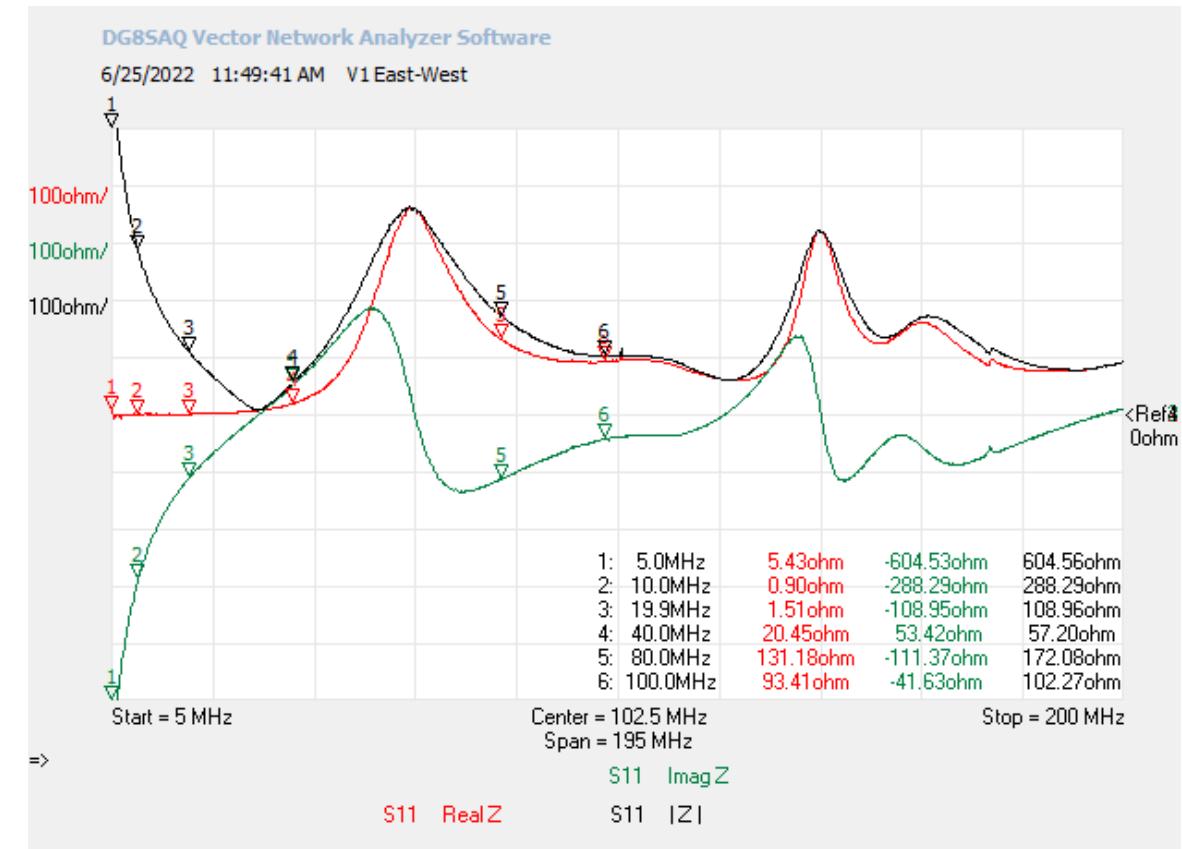


Dipole Impedance Measurements, V1 & V2

East-West Dipole, V2



East-West Dipole, V1



Impedance Matching Efficiency

- Reflection Coefficient S₁₁

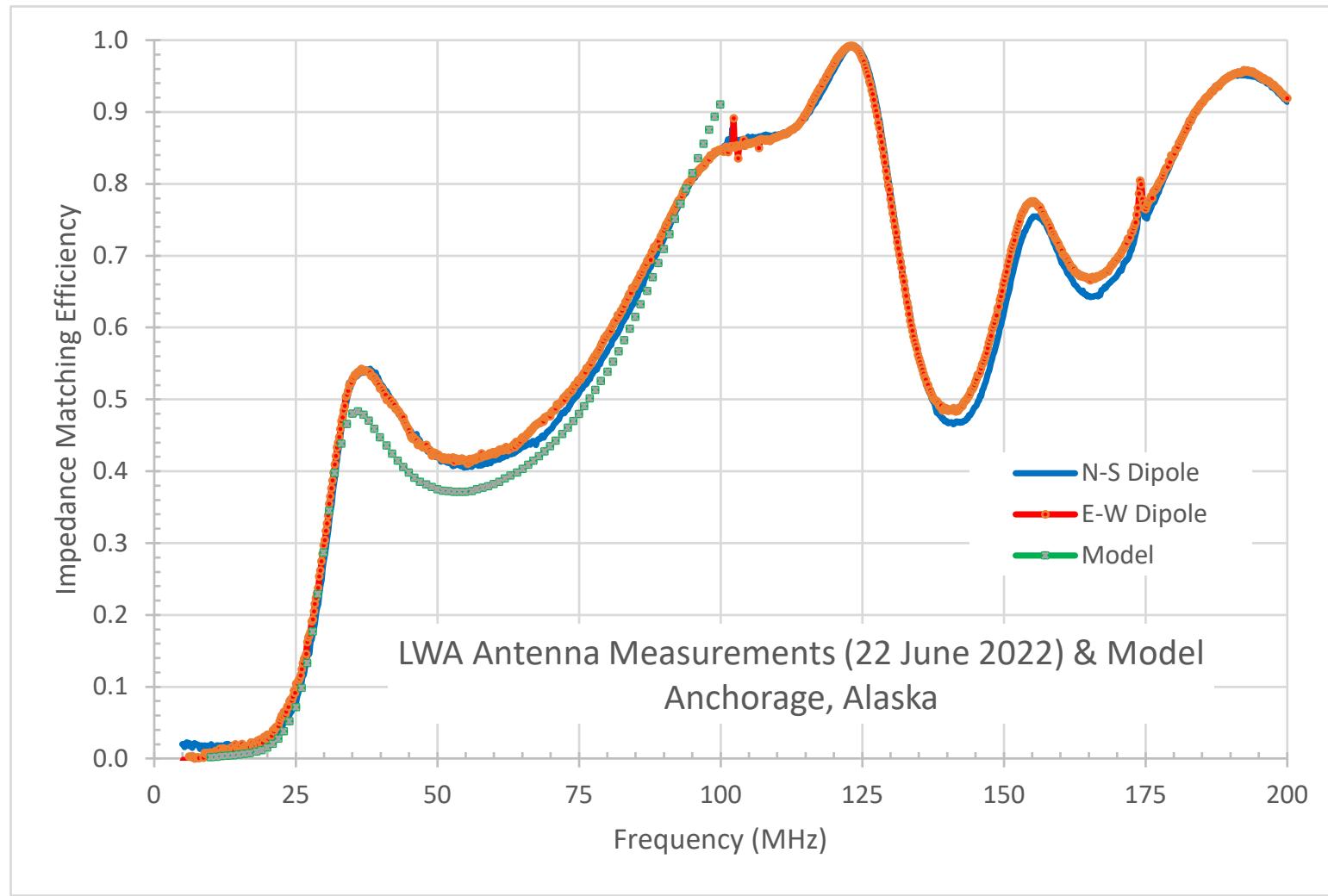
$$S_{11} = A(\text{dB}) \cdot e^{j \cdot \phi(\text{deg.})}$$

where A(dB) is the measured (reflected/incident) voltage ratio in dB and $\phi(\text{deg.})$ is the measured phase in degrees at each frequency point. A is converted to a linear ratio and ϕ to radians

$$A = 10^{A(\text{dB})/20} \quad \phi = \phi(\text{deg.}) \cdot (\pi/180)$$

- Impedance Matching Efficiency $IME = 1 - |S_{11}|^2 = 1 - |A \cdot e^{j \cdot \phi}|^2$

Impedance Matching Efficiency



FEE Measurements

- Foregoing IME assumes perfect $Z_0 = 100 + j0$ ohms

$$IME = 1 - \left| \frac{(Z - Z_0)}{(Z + Z_0)} \right|^2 = 1 - |\Gamma|^2$$

- It may be better to use actual FEE impedance measurements

FEE Measurements

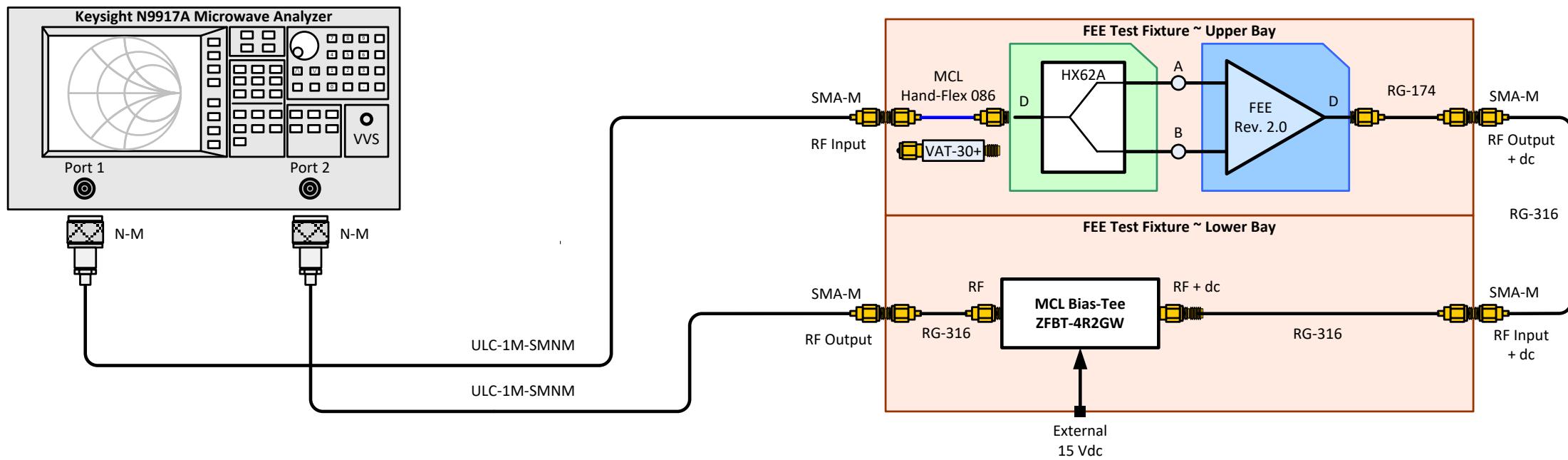
- Alternate form called Impedance Matching Factor, IMF, takes into account actual FEE reflection coefficient

$$IMF = \frac{(1 - |\Gamma_{ANT}|^2)(1 - |\Gamma_{RX}|^2)}{|1 - \Gamma_{ANT}\Gamma_{RX}|^2}$$

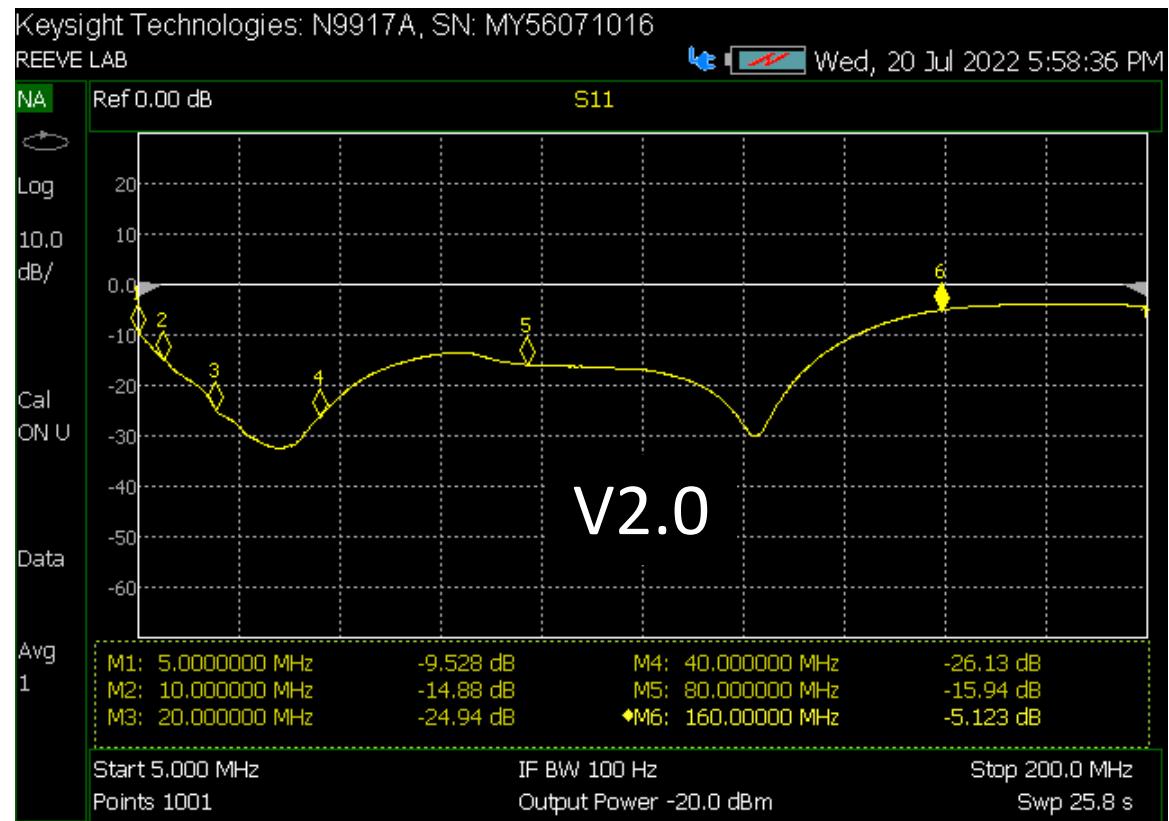
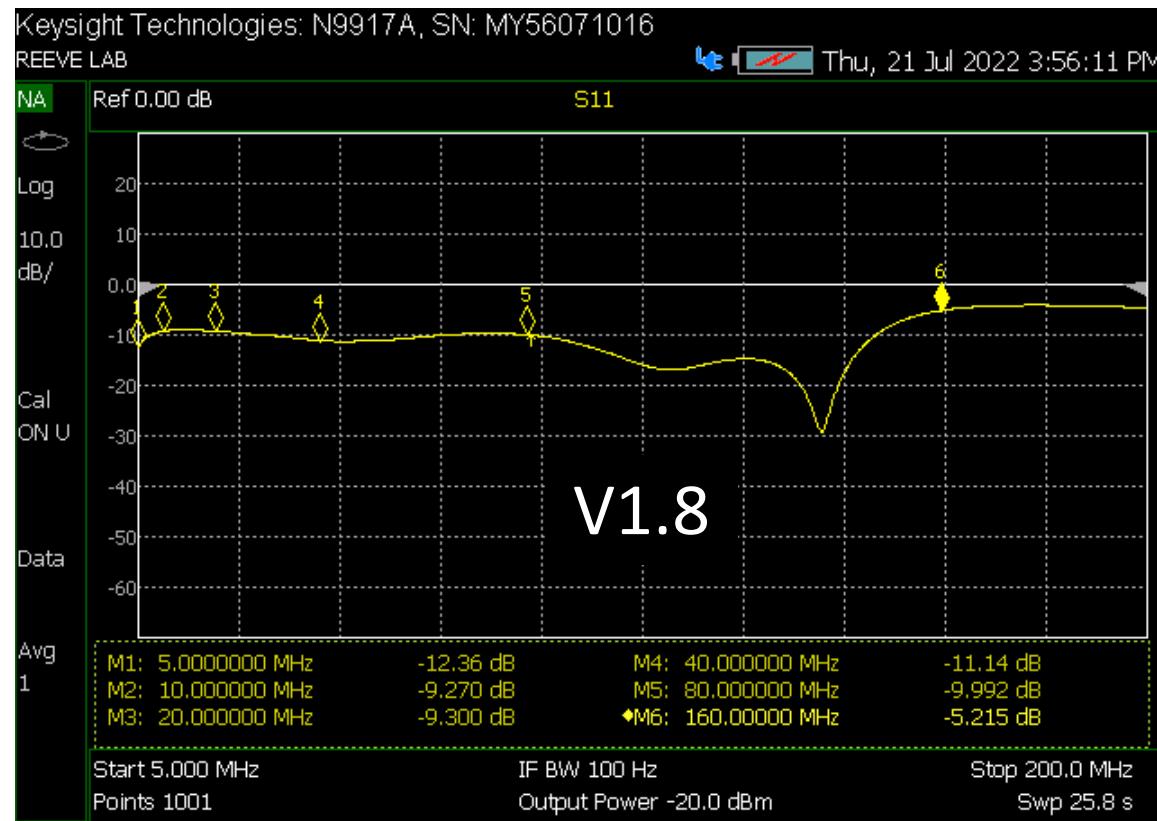
Rudge, A., Milne, K., Olver, A., Knight, P., The Handbook of Antenna Design, Vol. 1 and 2, Peter Peregrinus Ltd, 1986

- Reduces to IME when FEE reflection coefficient $\Gamma_{RX} = 0$

FEE Measurements



FEE Reflection Coefficient, V1.8 & V2.0



FEE Impedance, V1.8 & V2.0

