A DUAL-BAND CIRCULARLY POLARIZED PRINTED ANTENNA FOR DEEP SPACE CUBESAT COMMUNICATION

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global skyware
completing the picture

OUTLINE

- CUBESAT AT DEEP SPACE
- NASA DEEP SPACE NETWORK
- CIRCULARLY POLARIZED ANTENNA FOR CUBESAT
- PROPOSED ANTENNA
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CUBESAT AT DEEP SPACE

- NASA'S MARS CUBE ONE – MARCO - The first interplanetary nanospacecraft mission, may 2018 [1].
- M-ARGO by ESA, expected to launch, 2023 [2].
- BEYOND ATLAS to explore the mini moon, 2016HO3, initiative started 2017 [3].

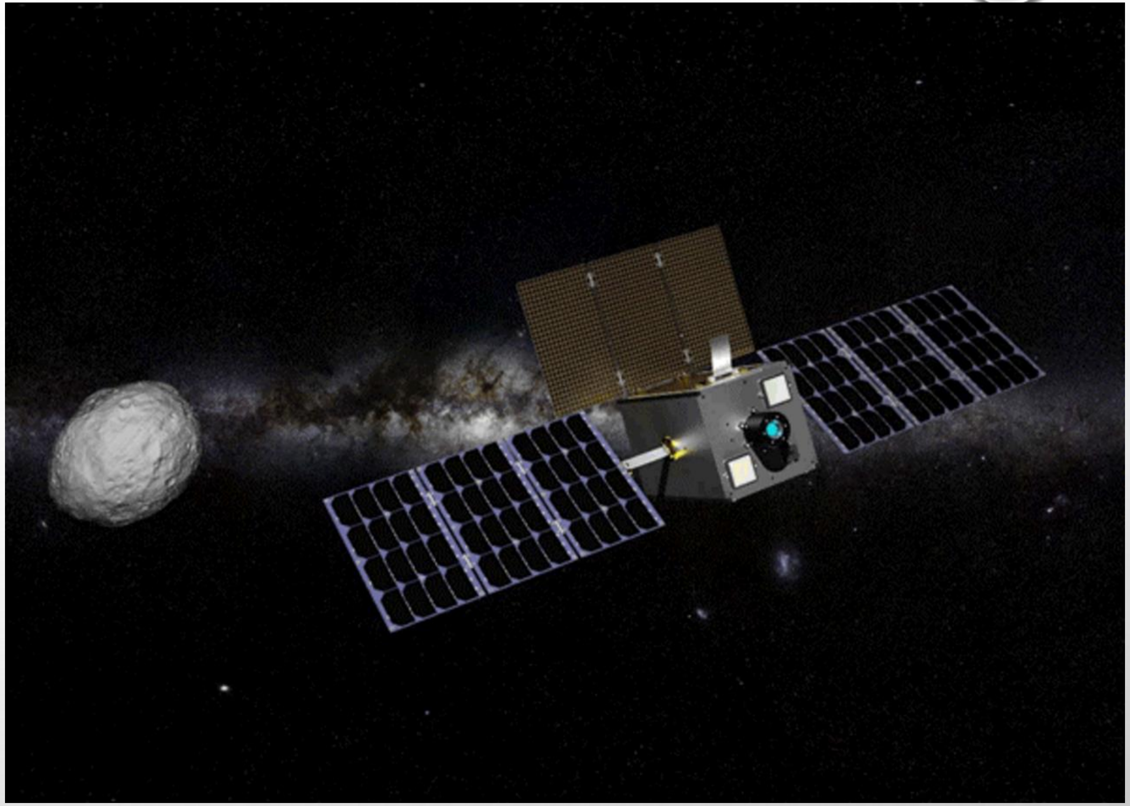


Fig. 1: M-Argo nanosatellite [2]

NASA DEEP SPACE NETWORK

- Supports spacecraft missions orbiting at deep space.
- Have three 70-m long most sensitive and largest antenna system.
- Located 120^{o} apart from each other around the world.
- X-Band transmitting frequencies coherent to deep space are 7145 MHz to 7188 MHz.
- X-band receiving frequencies allocated for deep space are 8400 MHz to 8450 MHz

Fig. 2: Deep Space Network Antenna, Goldstone, California, USA [4]

CIRCULARLY POLARIZED ANTENNA FOR CUBESAT

- Most satellite communication system use circularly polarized antennas.
- Doesn’t need strict orientation like linear antennas.
- Can radiate energy in every plane
- Two types: RHCP – clockwise pattern and LHCP – counterclockwise pattern

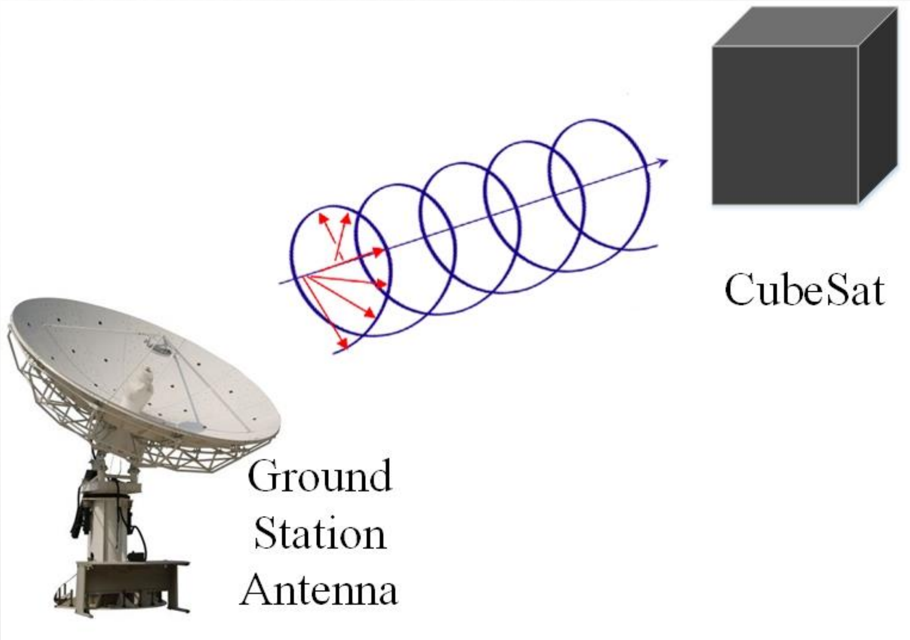
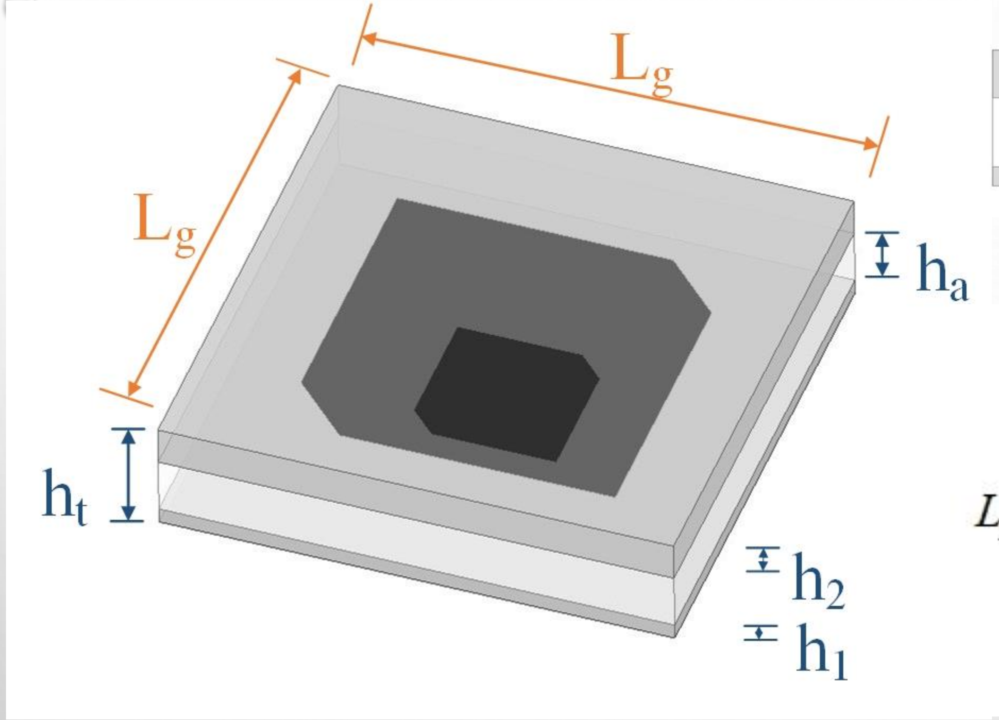
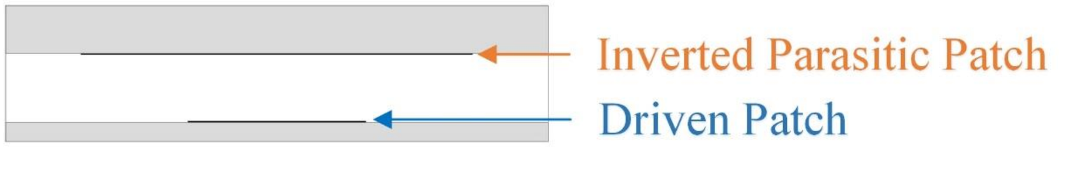


Fig. 3: Circularly polarized wave propagation between ground station antenna [5] and CubeSat.

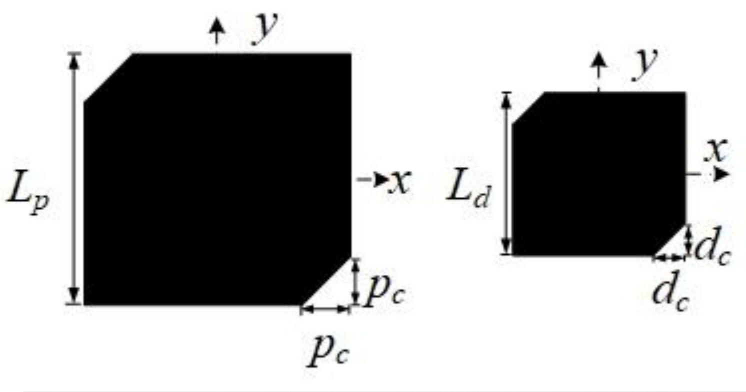
ANTENNA GEOMETRY



(a)



(b)



(c)

Fig. 4: (a) 3D View of the Proposed Antenna, (b) Side View, (c) Geometry of the Parasitic and the Driven Patches with Negative Perturbations

Driven Patch Size, L_d	5.9 mm × 5.9 mm
Driven Patch Corner Cut, d_c	1.05 mm
Parasitic Patch, L_p	13 mm × 13 mm
Parasitic Patch Corner Cut, p_c	2.3 mm
Air Gap, h_a	2.3 mm
Total Antenna Thickness, h_t	4.6 mm
Ground Plane, L_g	18 mm × 18 mm

Table 1: Design Parameters of the Stacked Patch Antenna with Negative Perturbations For CubeSats

VSWR AND AXIAL RATIO

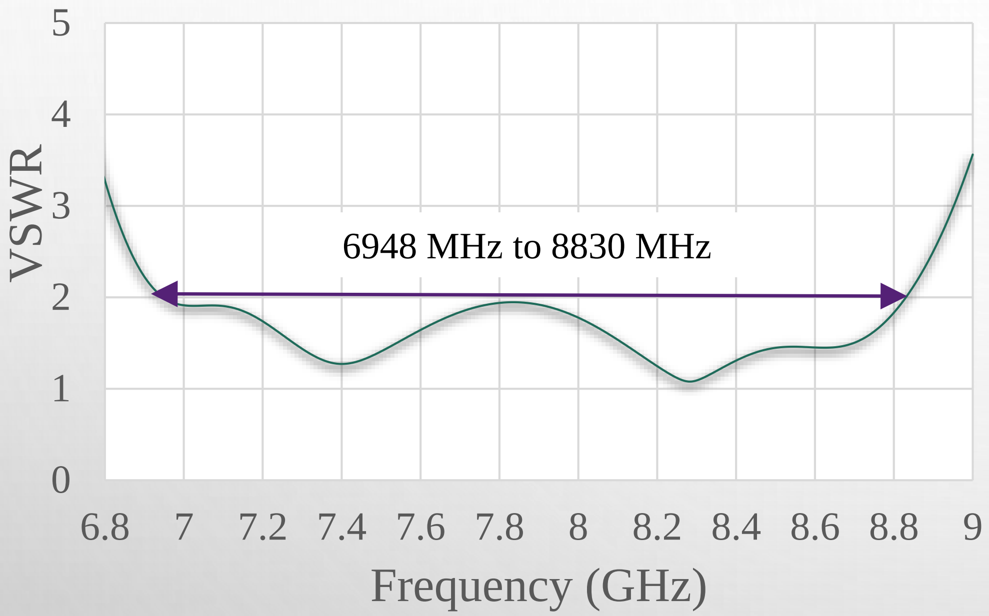


Fig. 5: VSWR Versus Frequency, VSWR < 2: 1.88 GHz or 23.86%

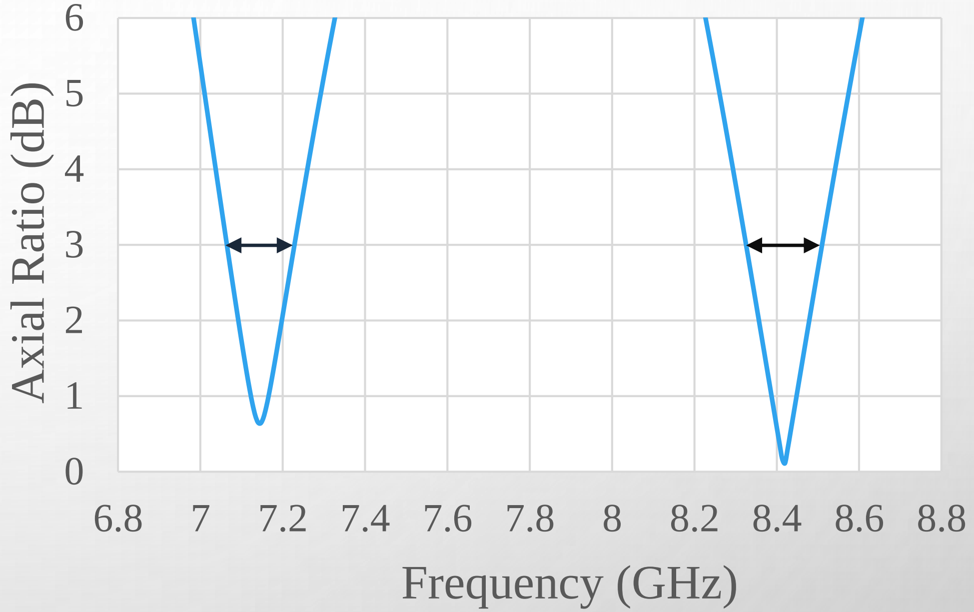


Fig. 6: Simulated Axial Ratio Versus Frequency Plot of the Proposed CP Antenna

AR ~ 3 dB bandwidth

Uplink: 7064 MHz to 7229 MHz

Downlink: 8325 MHz to 8508 MHz

3-DB AXIAL RATIO BEAMWIDTHS

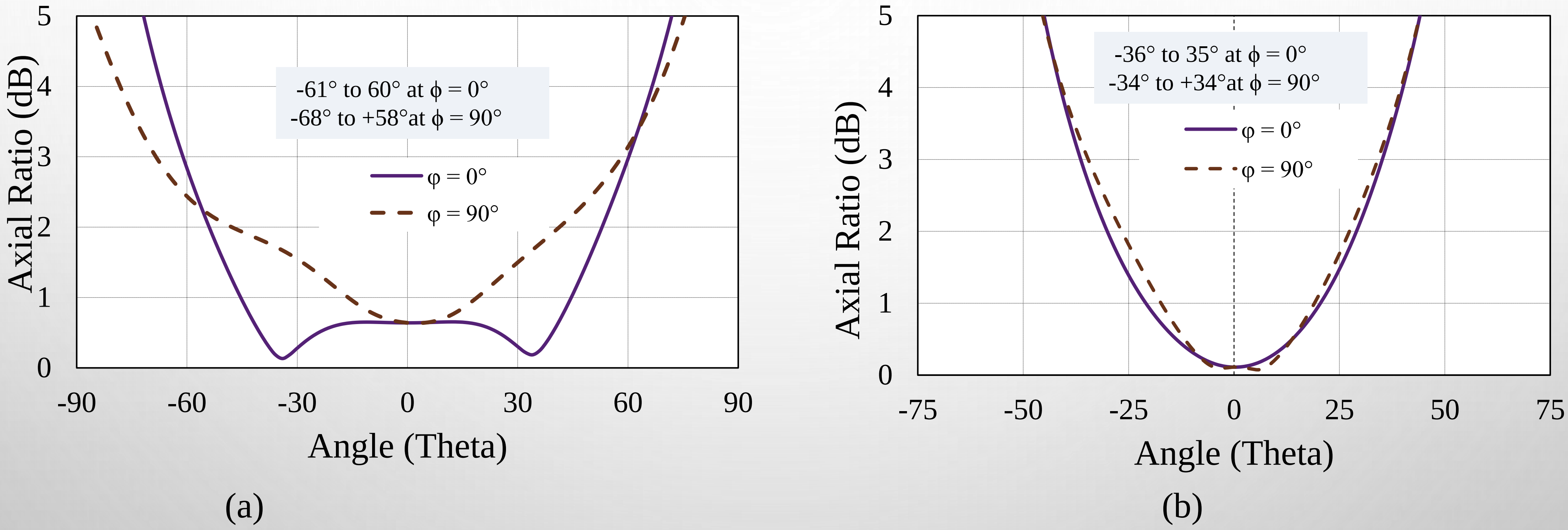


Fig. 7: Axial Ratio Versus Elevation Angle Plots in ϕ = 0° and 90° Planes at (a) 7146 MHz, and (b) 8420 MHz

RHCP GAIN VS. FREQUENCY

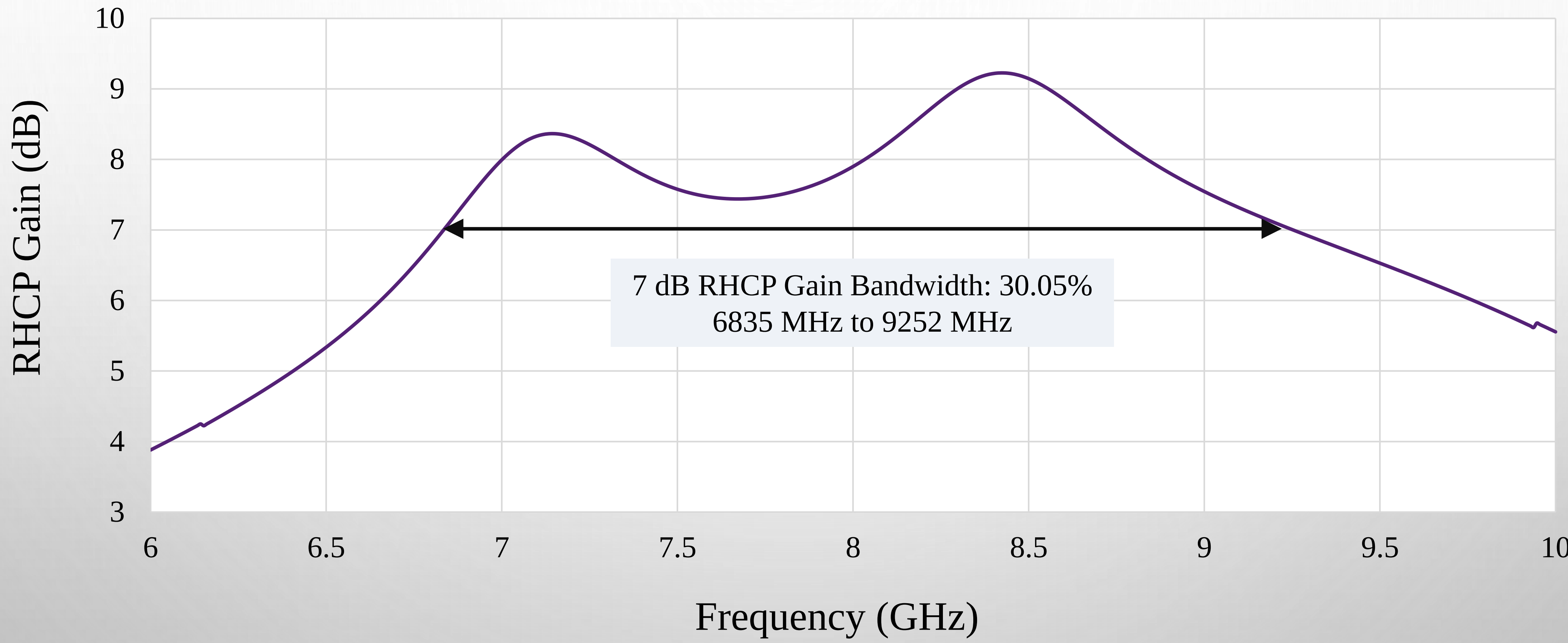


Fig. 8: RHCP Gain Versus Frequency, peak gains are achieved at 7146 MHz (8.37 dBic) and 8420 MHz (9.24 dBic)

PARAMETRIC STUDY

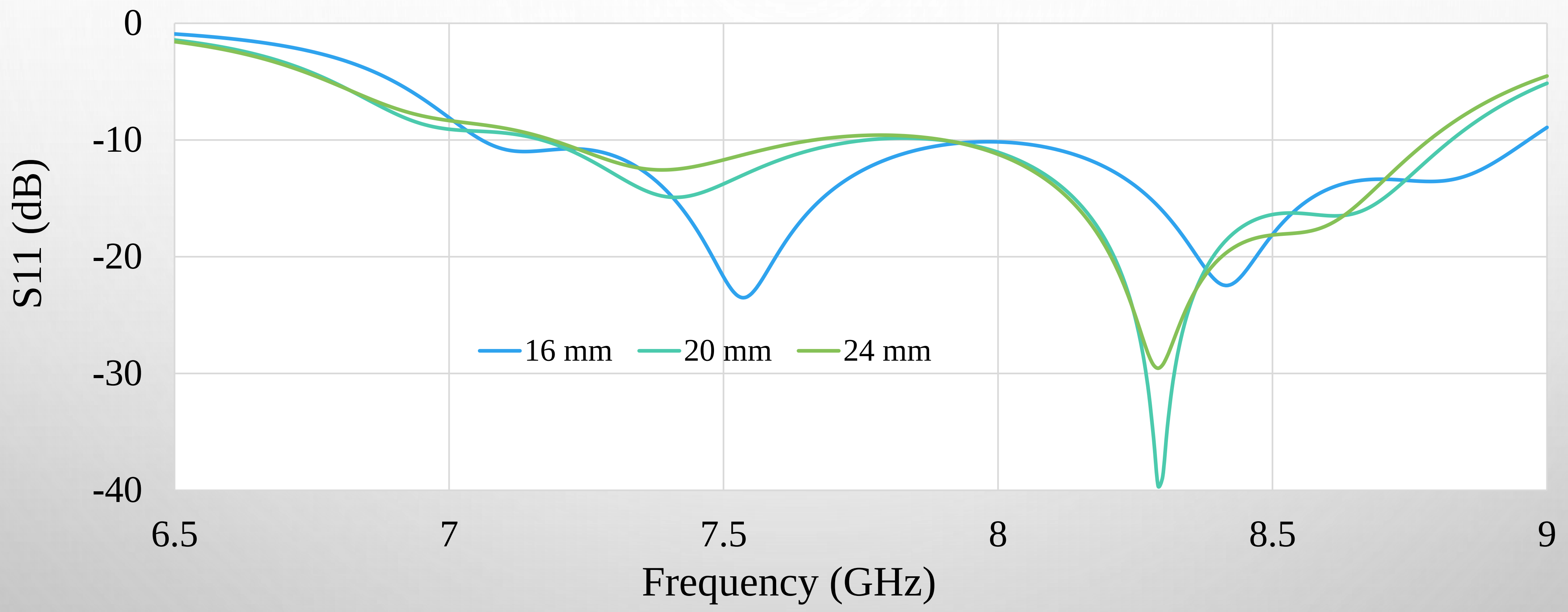


Fig. 9: S_{11} Versus Frequency for Different Ground Plane Sizes. Till a minimum value, lower the plane size, better the return loss performance

PARAMETRIC STUDY (CONT.)

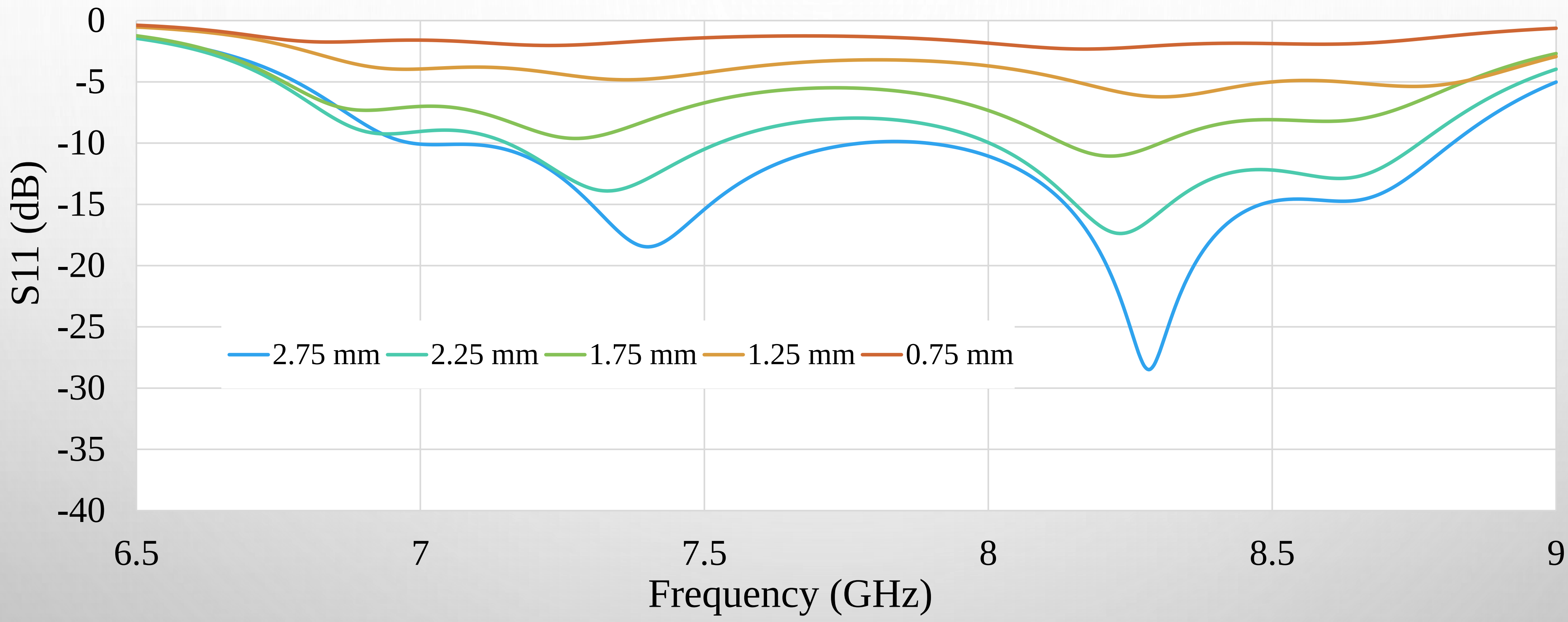


Fig. 10: S_{11} Versus Frequency for Different Probe Feed Locations (All Distances are Calculated from the Center Point of the Driven Patch). Impedance matching point for 50 Ω can be found near the edge.

CONCLUSION

- Achieved wideband VSWR < 2
- Achieved < 3 dB axial ratio values at the required frequencies
- Peak RHCP gain of 9.3 dBi achieved from the single element
- Need an array if higher gain is required

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THANK YOU