UHF PATCH ANTENNA DESIGN

***Design of UHF Rectangular Patch Antenna with Inset Feeding Strip*:** Rectangular patch design, with an inset feeding strip at one edge of the patch, on a 1.6mm standard FR-4 substrate with double copper layer of 50µm each. Patch dimensions are 6cm (length) by 7.825cm (width), and full substrate dimensions are 8.5cm (length) by 9cm (width), which is the smallest size achieved considering the CubeSat size constraints and without compromising more realized gain. Simulations performed with CST Studio Suite 2017 ©.

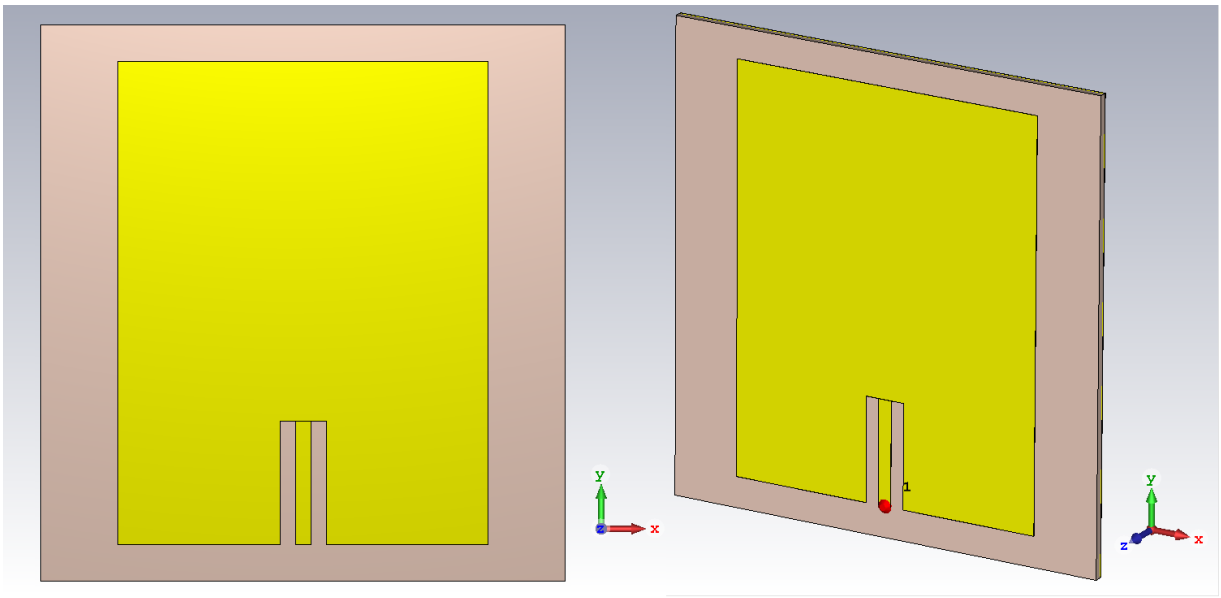

Figure 1. 1. UHF Rectangular Patch Antenna. Perspective and Front Views

Parameter List

Name	Expression	Value	Description	Type
f	0.915	0.915	Frequency [GHz]	Frequency
Lambda	327.8688	327.8688	Wavelength [mm]	Length
LambdaG	80.35484984	80.35484984	Guided Wavelength [mm]	Length
Lpatch	60	60	Patch Length (X Axis) [mm]	Length
Lsubs	Lpatch+25	85	Substrate Length (X Axis) [mm]	Length
Tpatch	0.05	0.05	Patch Thickness (Z Axis) [mm]	Length
Tsubs	1.6	1.6	Substrate Thickness (Z Axis) [mm]	Length
Wpatch	78.25	78.25	Patch Width (Y Axis) [mm]	Length
Wstrip	2.5	2.5	Feed Strip Width (X Axis) [mm]	Length
Wsubs	Wpatch+15.75 - 4	90	Substrate Width (Y Axis) [mm]	Length
x0	Wstrip	2.5	Inset Gap - Width (X Axis) [mm]	Length
y0	20	20	Inset Gap - Length (Y Axis) [mm]	Length

Figure 1. 2. Parameter List for Structure design

Juan Sebastián Hincapié Tarquino
Electronic Engineer, Universidad Nacional de Colombia
M.Sc. Astronomy (C), Observatorio Astronómico Nacional - Universidad Nacional de Colombia

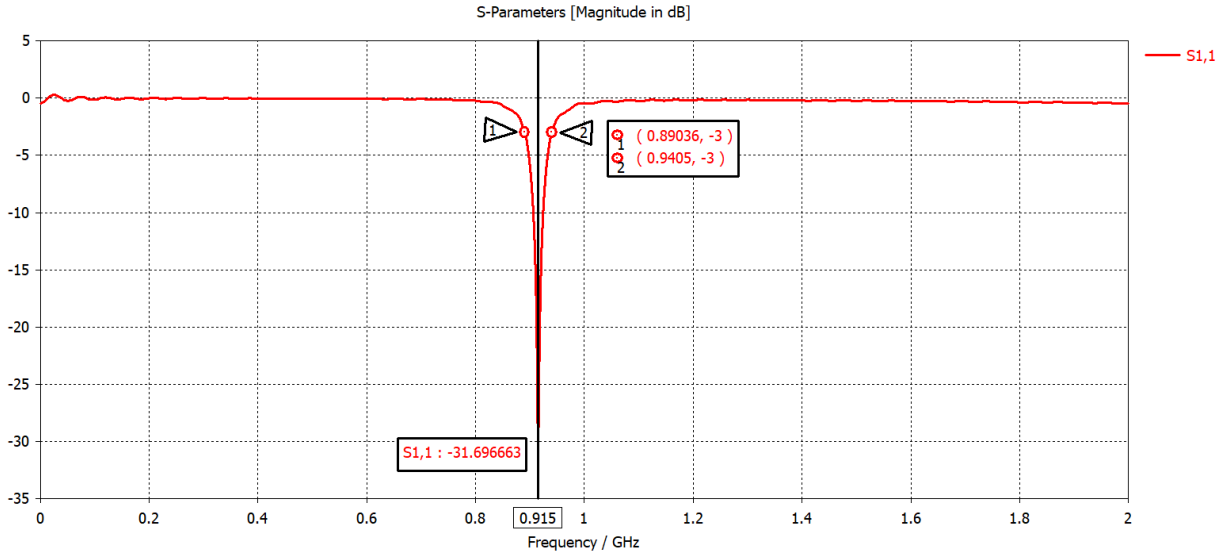

Figure 1. 3. Input reflection coefficient (S11 Parameter) for UHF Rectangular Patch Antenna

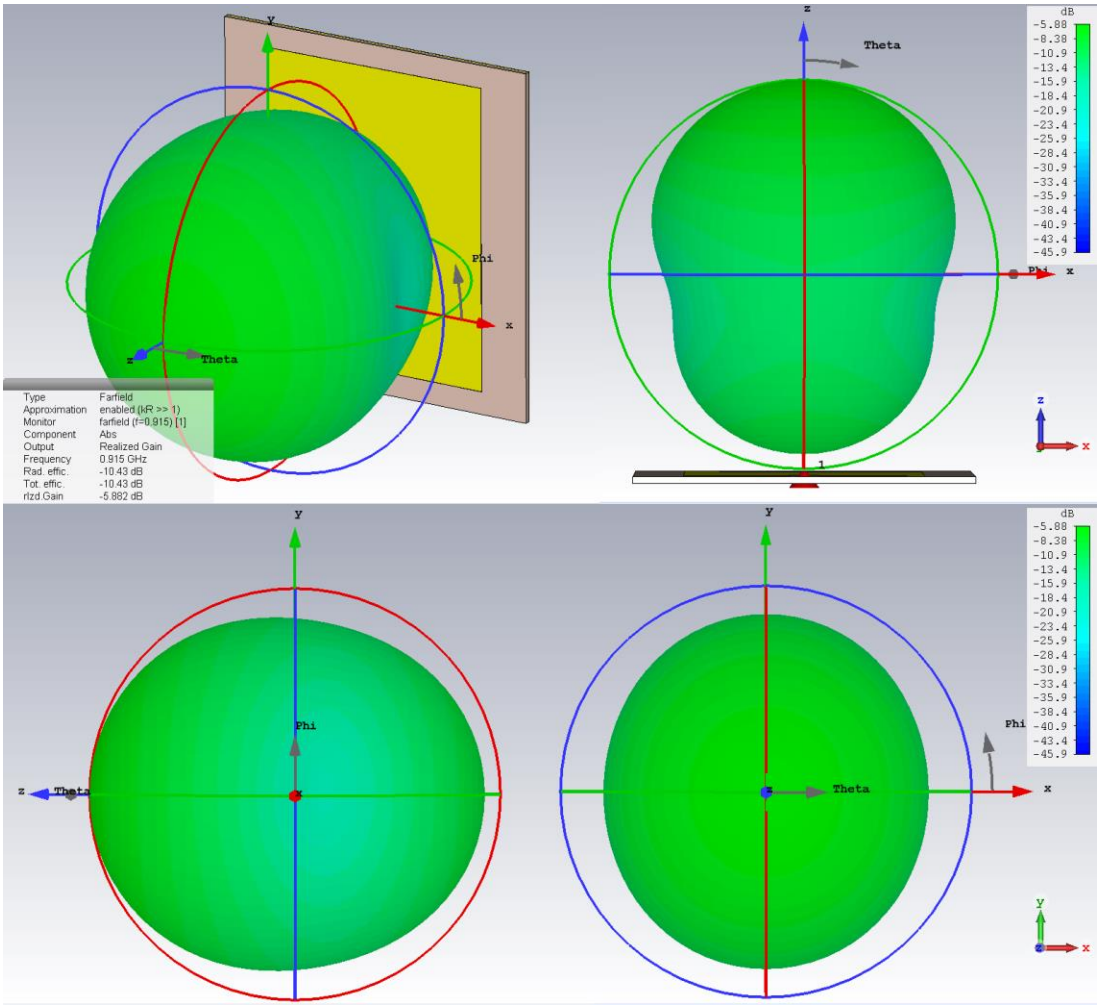

Figure 1. 4. Far-field Radiation Pattern for UHF Rectangular Patch Antenna. Realized Gain.

Juan Sebastián Hincapié Tarquino
Electronic Engineer, Universidad Nacional de Colombia
M.Sc. Astronomy (C), Observatorio Astronómico Nacional - Universidad Nacional de Colombia

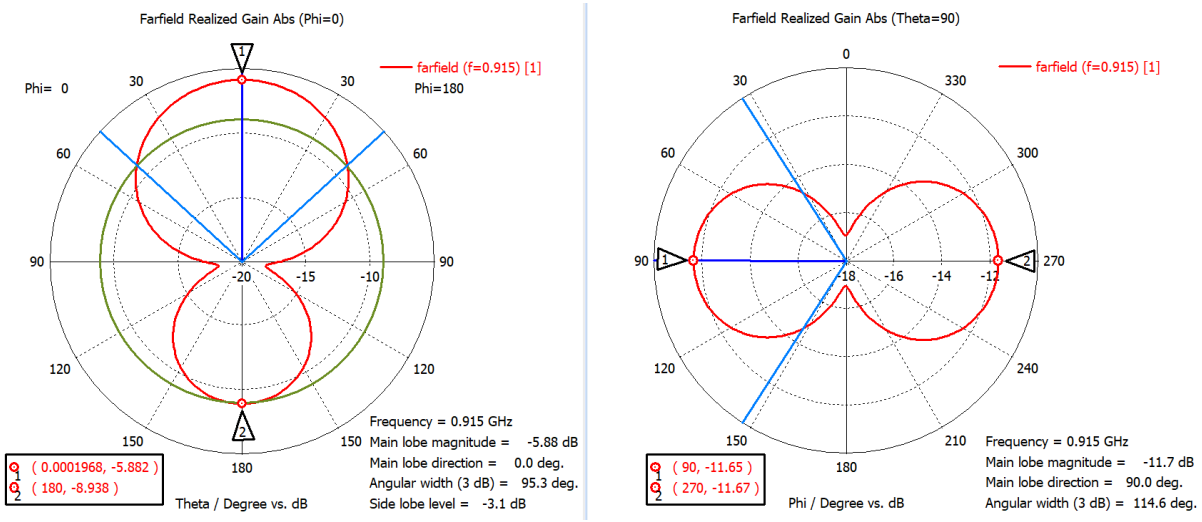

Figure 1. 5. Far-field Radiation Pattern for UHF Rectangular Patch Antenna. Realized Gain. (Polar View)

Resonance is achieved with this design at the desired UHF frequency of 915 MHz, with a reasonable directivity, as expected from microstrip planar (patch) antennas. However, realized gain has negative value. The highest value achieved at realized gain for such design was of -2.053 dB, but with FR-4 substrate size of 10cm (length) by 11.775cm (width), which exceeded the size constraint for the antenna design.

UHF Patch added to Structure – No 2.5m Wire Antennas: UHF Patch antenna design is added to the CubeSat structure, one at each side of the cube, just behind the S-Band patch arrays. Simulations performed with CST Studio Suite 2017 ©.

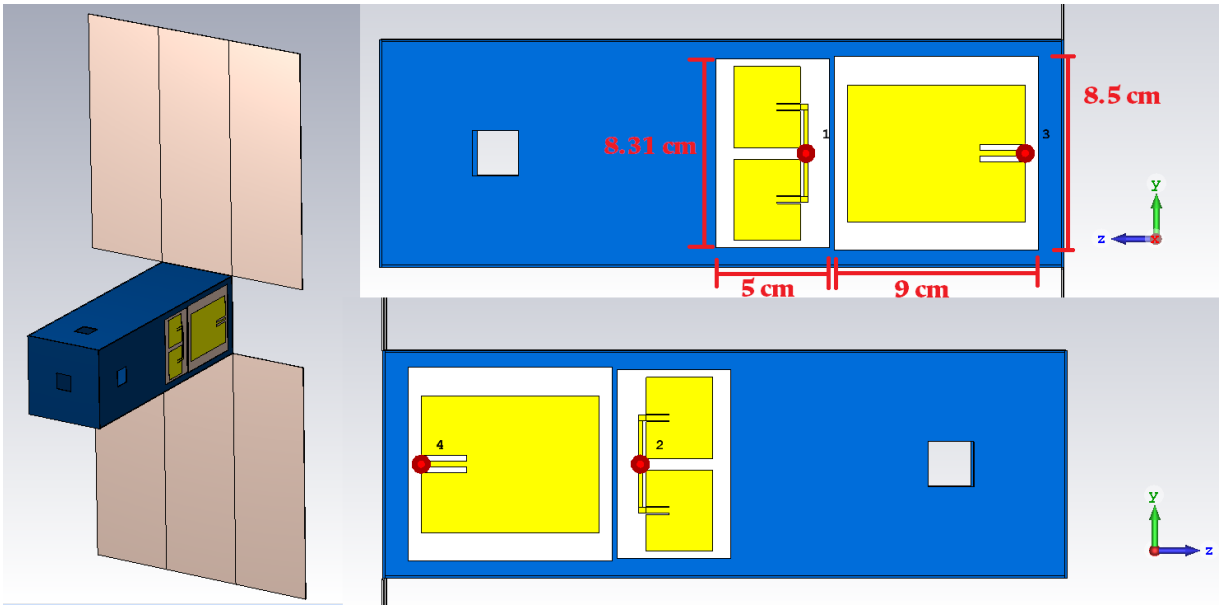

Figura 2. 1. UHF Patch Antenna added to CubeSat structure. Perspective, Left- and Right-side Views. Also shown, 2x1 S-Band Patch Array antenna.

Juan Sebastián Hincapié Tarquino
Electronic Engineer, Universidad Nacional de Colombia
M.Sc. Astronomy (C), Observatorio Astronómico Nacional - Universidad Nacional de Colombia

Parameter List

Name	Expression	Value	Description	Type
freq_S	= 2.4	2.4	Frequency - S-Band [GHz]	Frequency
freq_UHF	= 0.915	0.915	Frequency - UHF [GHz]	Frequency
Gpatch_S	= 1 + Gpatch_U + Wsubs_U - 0.8	10.3	Distance From UHF Edge to S-Band Patch [cm]	Length
Hbox	= 10	10	Box Height (Y Axis) [cm]	Length
Hpan	= 10	10	Panel Height/Width (X Axis) [cm]	Length
Lambda	= 68.49315	68.49315	Wavelength [cm]	Length
Lbox	= 30	30	Box Length (Z Axis) [cm]	Length
Lpan	= 30	30	Panel Length (Y Axis) [cm]	Length
Lpatch_S	= 2.935705	2.935705	S-Band Patch Length (Z Axis) [cm] (Orig = 2.8579)	Length
Lsubs_S	= 4 + 1	5	S-Band Substrate Length (Z Axis) [cm]	Length
Lwire	= 240	240	Wire Antenna Length [cm]	Length
MPHole	= 2	2	Wire Antenna Box Hole	Length
Rwire	= 0.016	0.016	Wire Antenna Radius [cm]	Length
Tbox	= 0.1	0.1	Box Thickness [cm]	Length
Tpan	= 0.08	0.08	Panel Thickness [cm]	Length
Tpatch	= 0.005	0.005	Patch Thickness (X Axis) [cm]	Length
Tsubs	= 0.16	0.16	Substrate Thickness (X Axis) [cm]	Length
Wconn_S	= 2*Wstrip_S/3	0.16666666666...	S-Band Patch - Width - Connector Strip between Patches [cm]	Length
Wpatch_S	= 3.65779 - 0.09849	3.5593	S-Band Patch Width (Y Axis) [cm] (Orig = 3.5593)	Length
Wposc	= Hbox/2	5	Wire Antena Central Position [cm]	Length
Wstrip_S	= 0.25	0.25	S-Band Patch - Feed Strip Width (X Axis) [cm]	Length
Wsubs_S	= 2*(2*Wstrip_S + Wpatch_S) + 0.19	8.3086	S-Band Substrate Width (Y Axis) [cm]	Length
x0_S	= 0.05	0.05	Space between S-Band Patch & Feed Strip (Y Axis) [cm]	Length
y0_S	= 1.025	1.025	Space between S-Band Patch & Feed Strip End (Z Axis) [cm]	Length
Gpatch_U	= Tbox + 1	1.1	Distance From Box Edge to UHF Patch [cm]	Length
Lpatch_U	= 6	6	UHF Patch Length (Z Axis) [cm]	Length
Lsubs_U	= Lpatch_U+2.5	8.5	UHF Substrate Length (Z Axis) [cm]	Length
Wpatch_U	= 7.825	7.825	UHF Patch Width (Y Axis) [cm]	Length
Wstrip_U	= 0.25	0.25	UHF Feed Strip Width (X Axis) [cm]	Length
Wsubs_U	= Wpatch_U+1.575 - 0.4	9	UHF Substrate Width (Y Axis) [cm]	Length
x0_U	= Wstrip_U	0.25	UHF Patch - Inset Gap - Width (X Axis) [cm]	Length
y0_U	= 2	2	UHF Patch - Inset Gap - Length (Y Axis) [cm]	Length

Figura 2. 2. Parameter List for Structure design

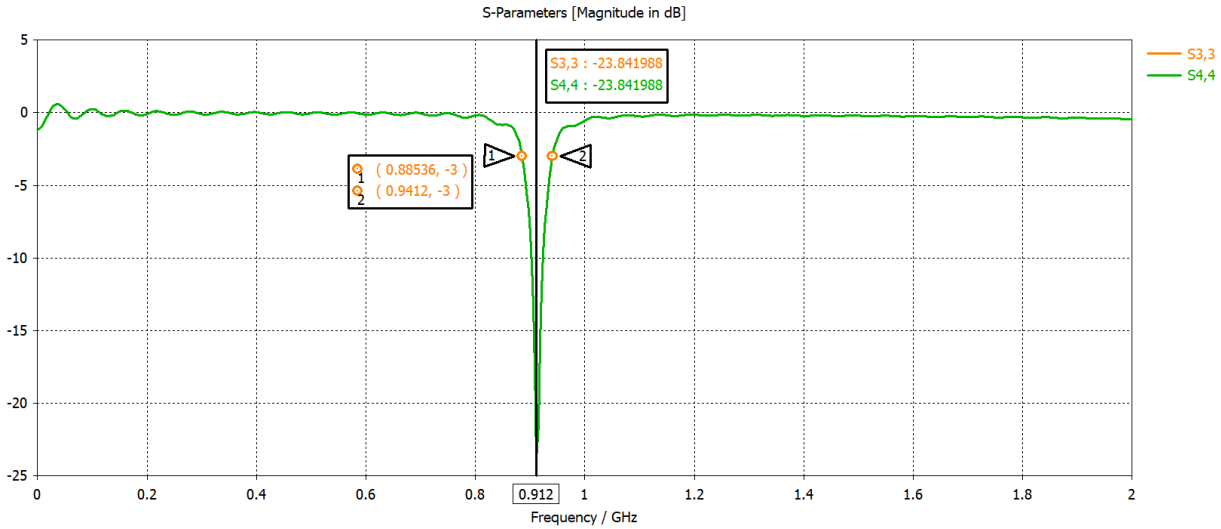

Figura 2. 3. Input reflection coefficient (S11 Parameter) for UHF Patch Antennas

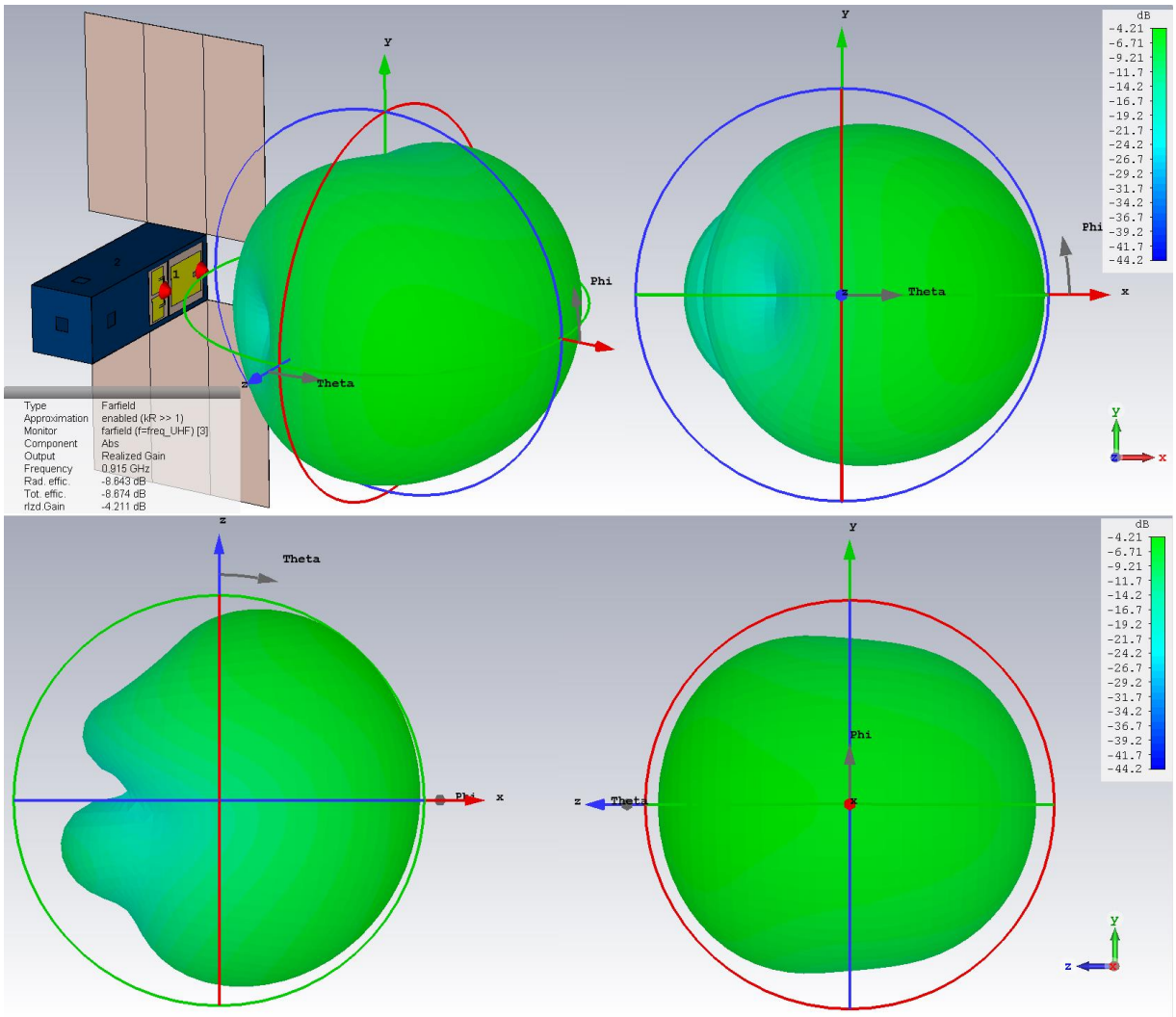

Figura 2. 4. Far-field Radiation Pattern for UHF Patch Antenna. Realized Gain.

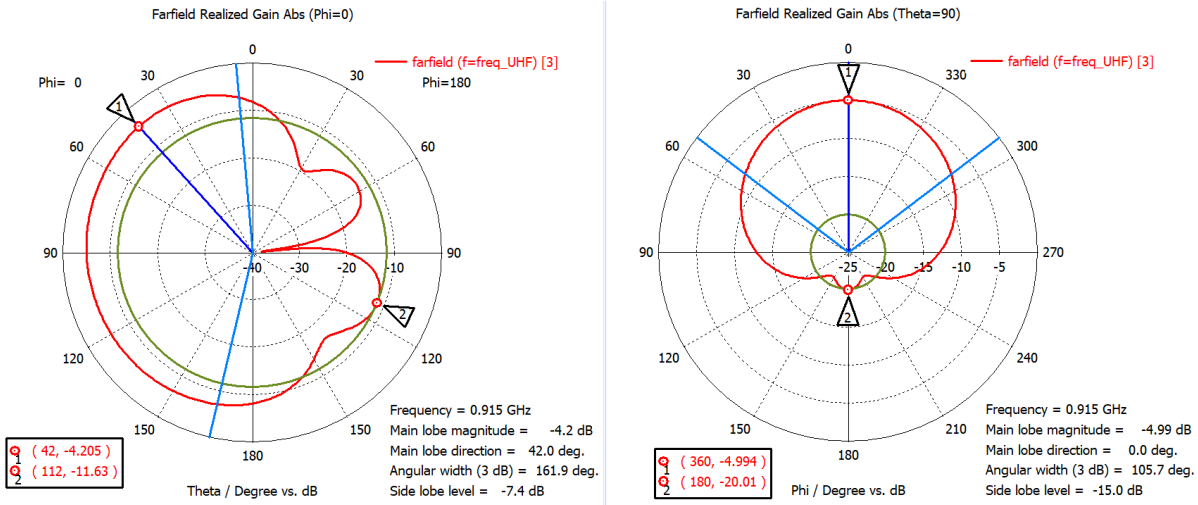

Figura 2. 5. Far-field Radiation Pattern for UHF Patch Antenna. Realized Gain. (Polar View)

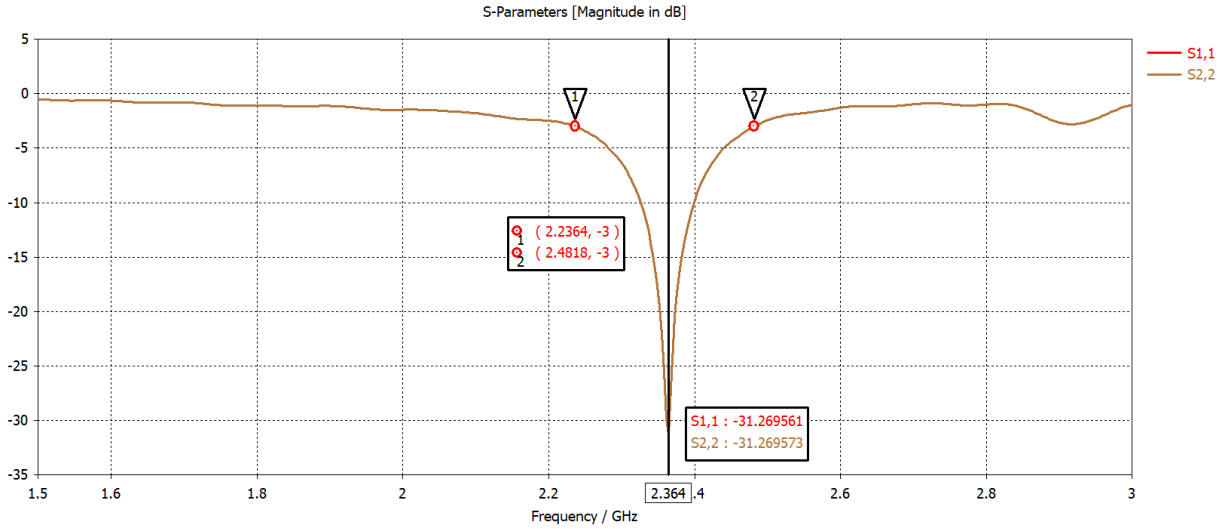

Figura 2. 6. Input reflection coefficient (S11 Parameter) for S-Band Patch Array Antennas

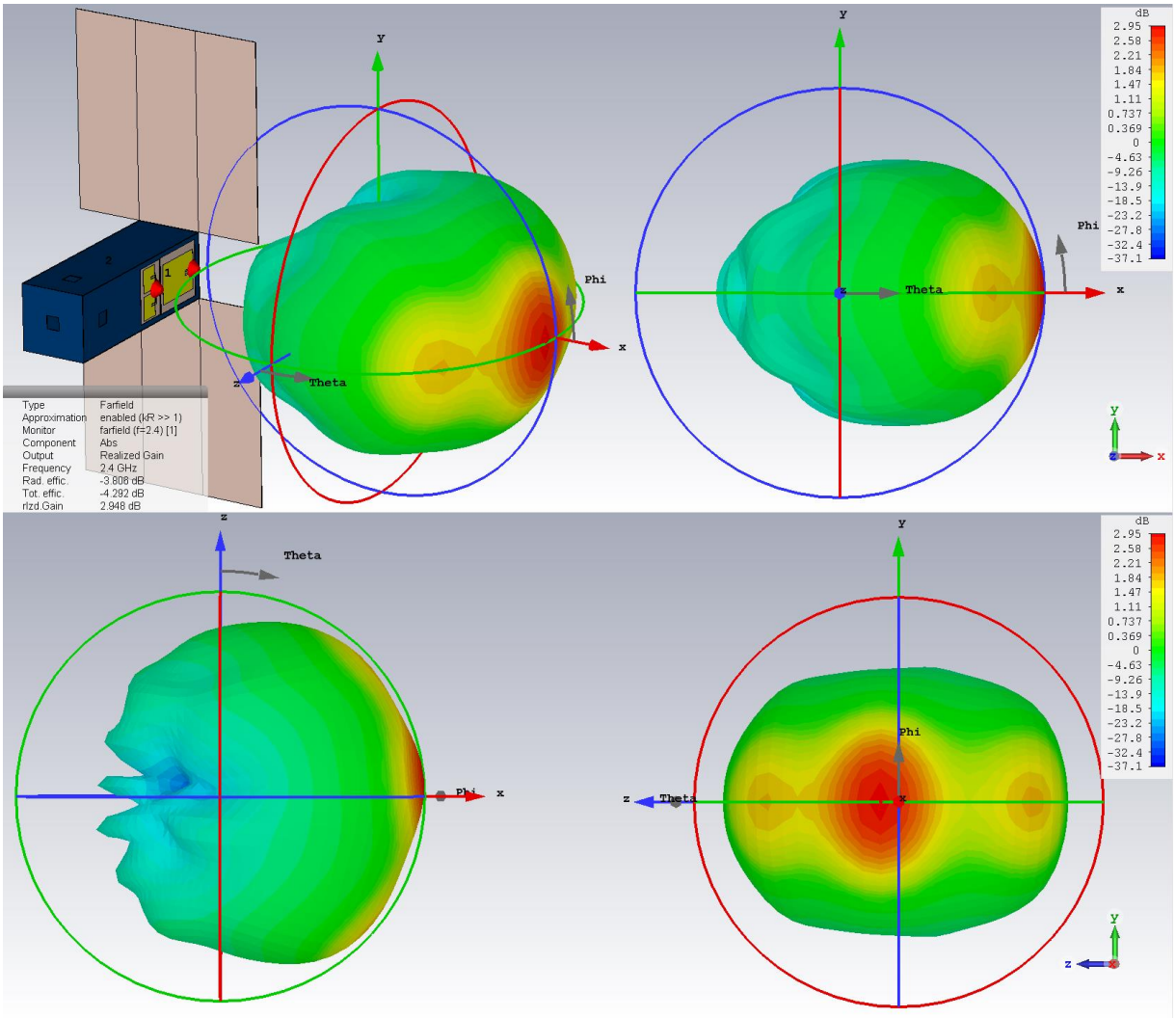

Figura 2. 7. Far-field Radiation Pattern for S-Band Patch Array Antennas. Realized Gain.

Juan Sebastián Hincapié Tarquino
Electronic Engineer, Universidad Nacional de Colombia
M.Sc. Astronomy (C), Observatorio Astronómico Nacional - Universidad Nacional de Colombia

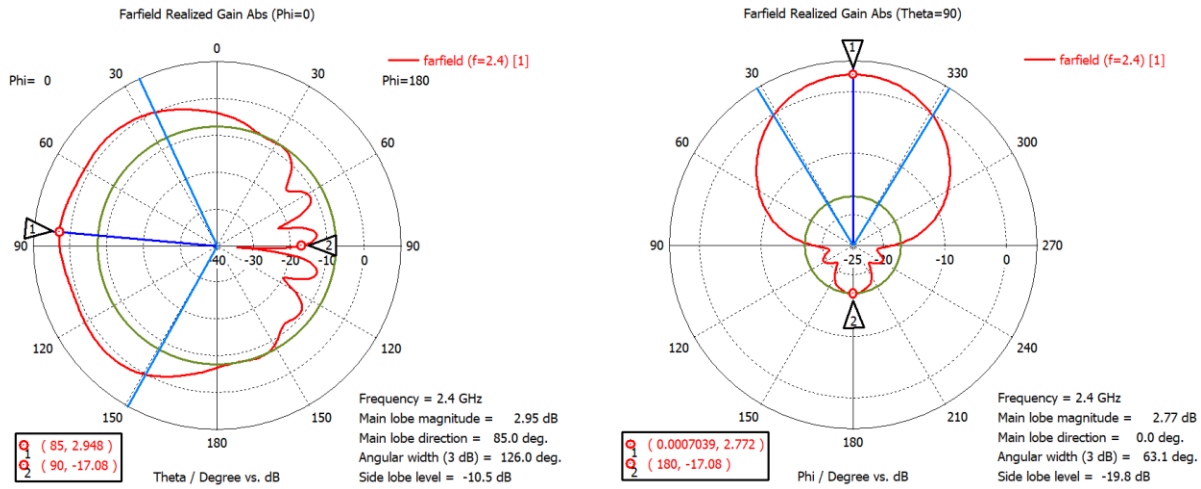

Figura 2. 8. Far-field Radiation Pattern for S-Band Patch Array Antennas. Realized Gain. (Polar View)

Adding the UHF patch antenna to the CubeSat structure, including the previously designed S-Band 2x1 Patch Antenna Array, shows a small enhancement in terms of UHF realized gain, with a operation frequency of 912MHz (shift down of 3MHz). Considering the current location of both communication antenna systems, the UHF antenna has a small interference effect on the S-Band patch behavior and Radiation Pattern.

Also, size of the FR4 substrate is enlarged in 1cm length and 2mm width giving space for the screws that will hold the final antenna implementation to the CubeSat structure. With respect to the previous report, there's a small compromise in gain, due to both enlargement of substrate and interference with UHF antenna. (Pending verifications and a new simulation including 2.4m Wire antennas).

PARAMETER	UHF Rectangular Patch Antenna	UHF Patch added to CubeSat Structure with S-Band Array	UHF Patch with S-Band Array and 2.4m Wire Antennas
Input Reflection Coefficient (S11 Parameter)	**-31.696 dB (at 915 MHz)**	**-23.842 dB (at 912 MHz)**	
Half-Power (-3 dB Bandwidth)	50.14 MHz	55.84 MHz	
Directivity	4.550 dBi	4.464 dBi	
Gain (IEEE)	-5.879 dB	-4.180 dB	
Realized Gain	-5.882 dB	-4.211 dB	
Half-Power Beamwidth (HPBW)	95.3 deg	161.9 deg	
Front-to-Back Ratio	3.056 dB	7.425 dB	

Table 1.1. Results Summary for UHF Patch Antenna.

PARAMETER	Simulation without UHF Antenna or 2.4m Wire antennas (Previous Report)	Simulation only with 2.4m Wire antennas (Previous Report)	Simulation only with UHF Patch	Simulation adding UHF Antenna and 2.4m Wire antennas
Input Reflection Coefficient (S11 Parameter)	**-7.705 dB (at 2.397 GHz)**	**-11.895 dB (at 2.425 GHz)**	**-31.269 dB (at 2.364 GHz)**	
Half-Power (-3 dB Bandwidth)	121.7 MHz	279.8 MHz	245.4 MHz	
Directivity	8.379 dBi	10.13 dBi	7.240 dBi	
Gain (IEEE)	3.626 dB	5.542 dB	3.434 dB	
Realized Gain	2.812 dB	5.118 dB	2.948 dB	
Half-Power Beamwidth (HPBW)	2.81 dB	1.29 dB	126 deg	
Front-to-Back Ratio	16.193 dB	17.616 dB	20.028 dB	

Table 1.2. Results Summary for S-Band 2x1 Patch Array Antenna on CubeSat Structure with different companion antennas.