S-BAND PATCH ANTENNA DESIGN: COMPARISON BETWEEN SINGLE PATCH AND 2x1 PATCH ARRAY

1. ***Single Patch Antennas at Left- and Right-side of CubeSat structure:*** S-Band rectangular patch antenna, for operation at 2.4GHz, at Left- and Right-side of CubeSat structure. Design stage performed without 2.4 m Wire Antennas. Simulations performed with CST Studio Suite 2017 ©.

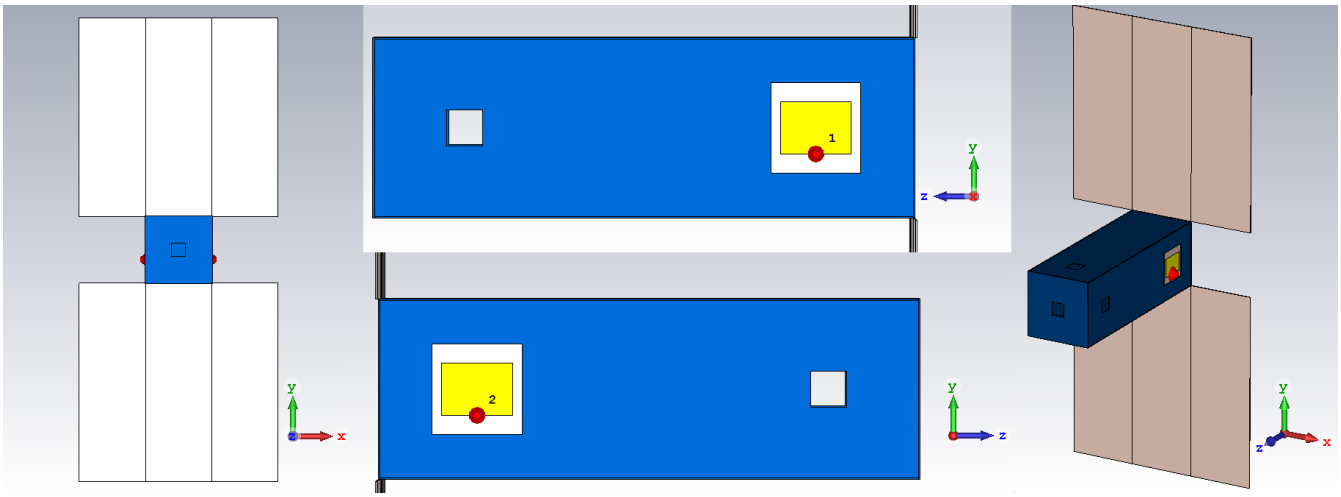

Figure 1. 1. Cube-Sat structure. Perspective, Front, Right- and Left-side Views

Parameter List

Name	Expression	Value	Description	Type
f	= 2.4	2.4	Frequency [GHz]	Frequency
Gpatch	= 3	3	Distance From Box Edge to Patch [cm]	Length
Hbox	= 10	10	Box Height (Y Axis) [cm]	Length
Hpan	= 10	10	Panel Height/Width (X Axis) [cm]	Length
Lambda	= 12.5	12.5	Wavelength [cm]	Length
LambdaG	= 6.1808	6.1808	Guided Wavelength [cm]	Length
Lbox	= 30	30	Box Length (Z Axis) [cm]	Length
Lpan	= 30	30	Panel Length (Y Axis) [cm]	Length
Lpatch	= 2.8973	2.8973	Patch Length (Y Axis) [cm]	Length
Lsubs	= 5	5	Substrate Length (Y Axis) [cm]	Length
MPHole	= 2	2	Wire Antenna Box Hole	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	= Tbox	0.1	Substrate Thickness (X Axis) [cm]	Length
Wpatch	= 3.9393	3.9393	Patch Width (Z Axis) [cm]	Length
Wposc	= Hbox/2	5	Wire Antena Central Position [cm]	Length
Wsubs	= Lsubs	5	Substrate Width (Z Axis) [cm]	Length
Lwire	= 240	240	Wire Antenna Length [cm]	Length
Rwire	= 0.16	0.16	Wire Antenna Radius [cm]	Length

Figure 1. 2. Parameter List for Structure design

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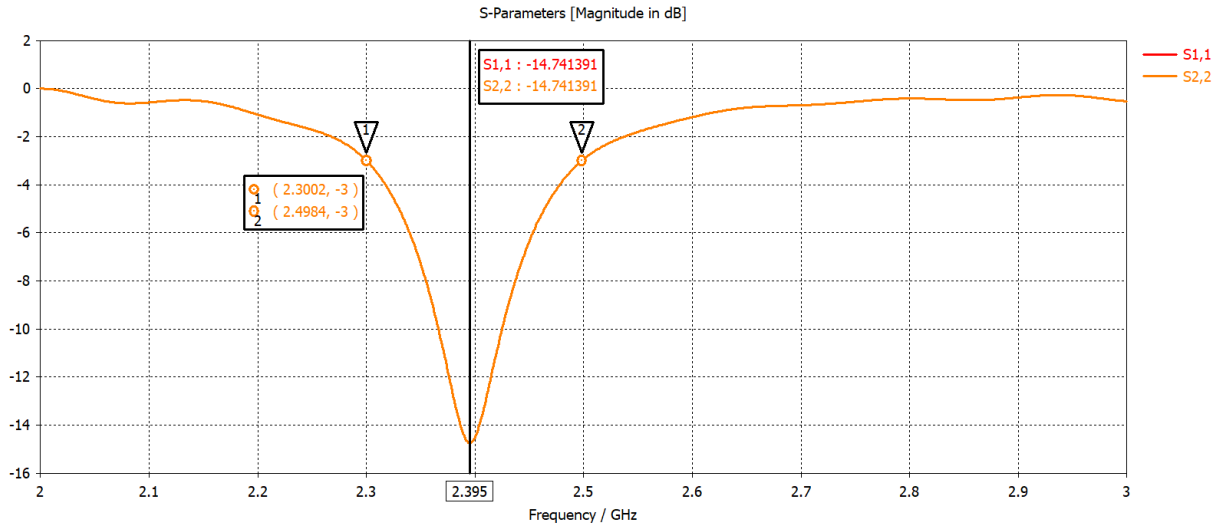

Figure 1. 3. Input reflection coefficients (S11 and S22 Parameters) for both S-Band Patch Antennas

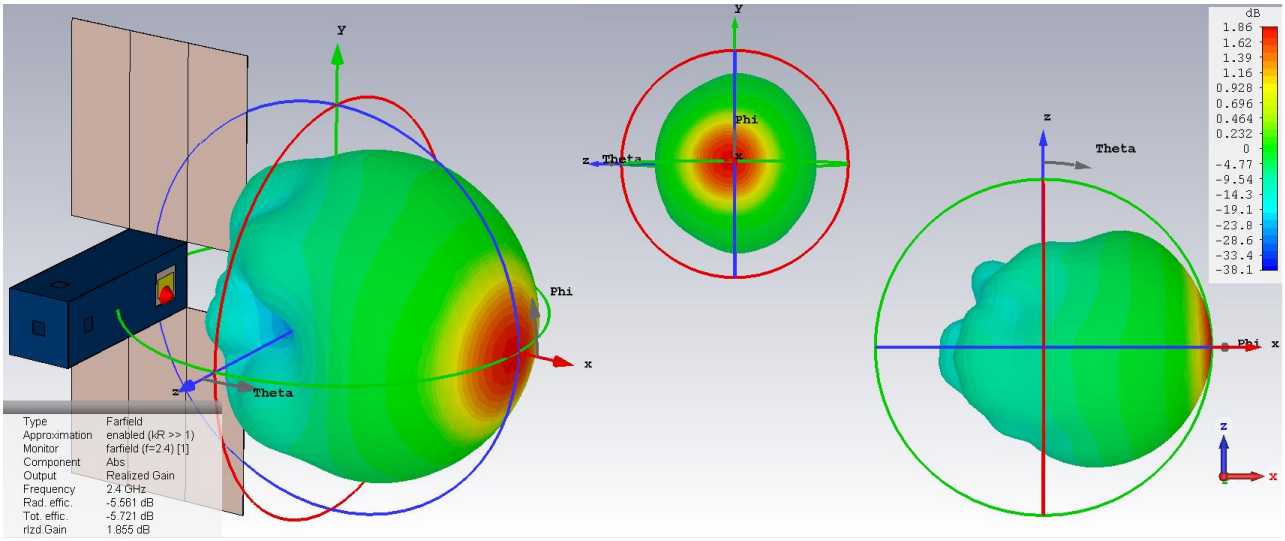

Figure 1. 4. Far-field Radiation Pattern for Left-Side Patch Antenna Design. Realized Gain.

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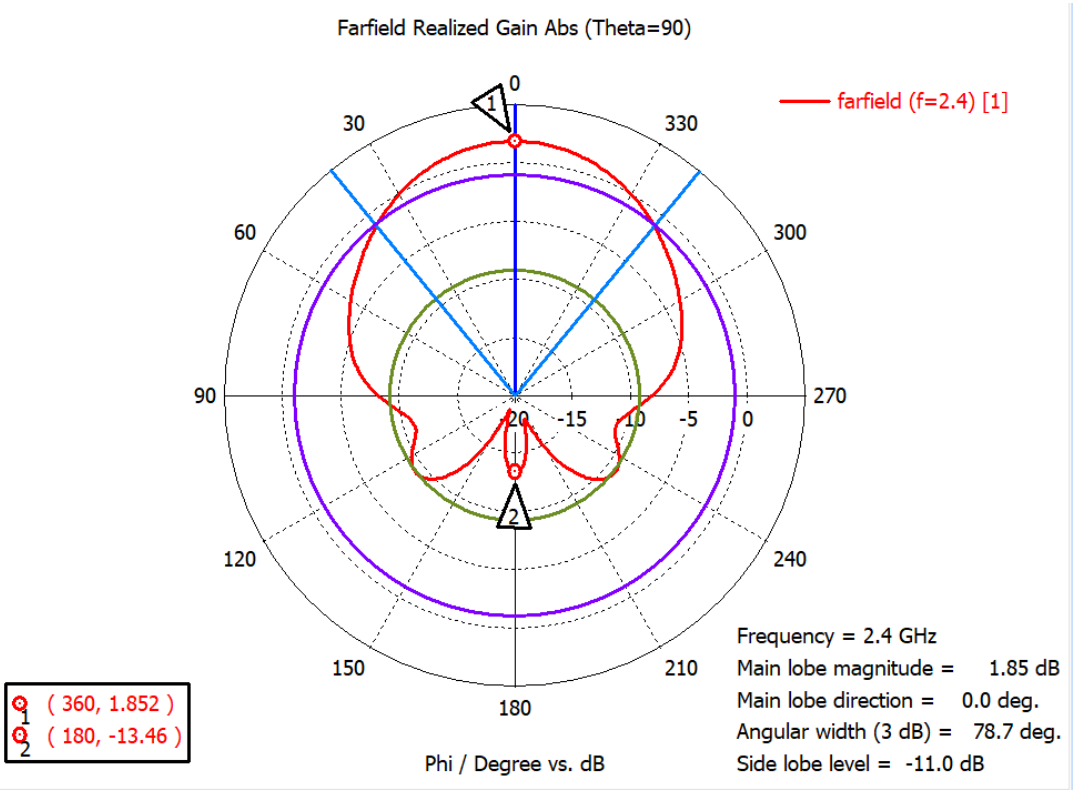

Figure 1. 5. Far-field Radiation Pattern for Left-Side Patch Antenna Design. Realized Gain. (Polar View)

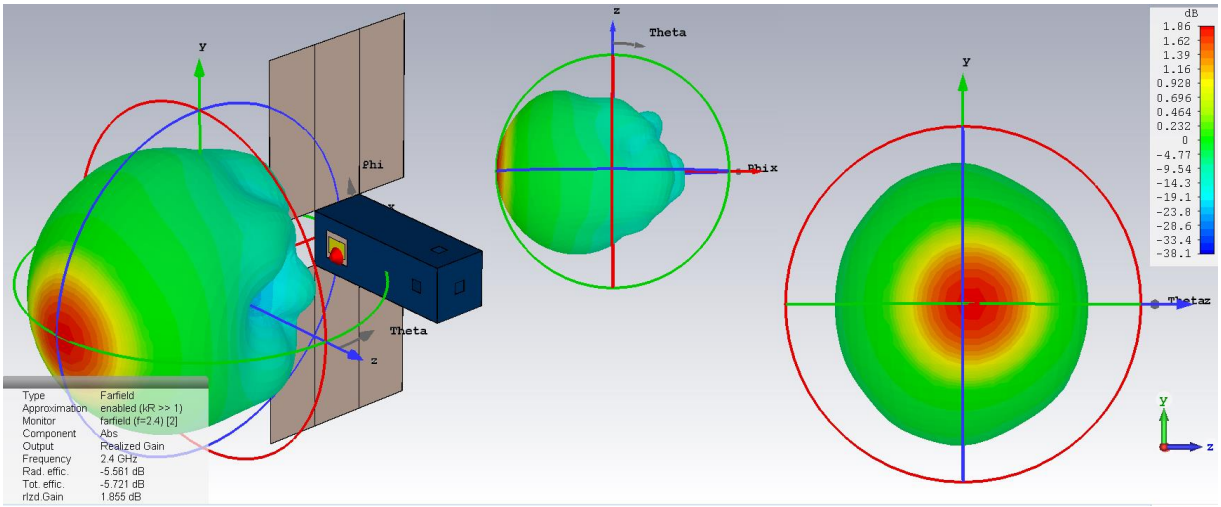

Figure 1. 6. Far-field Radiation Pattern for Right-Side Patch Antenna Design. Realized Gain.

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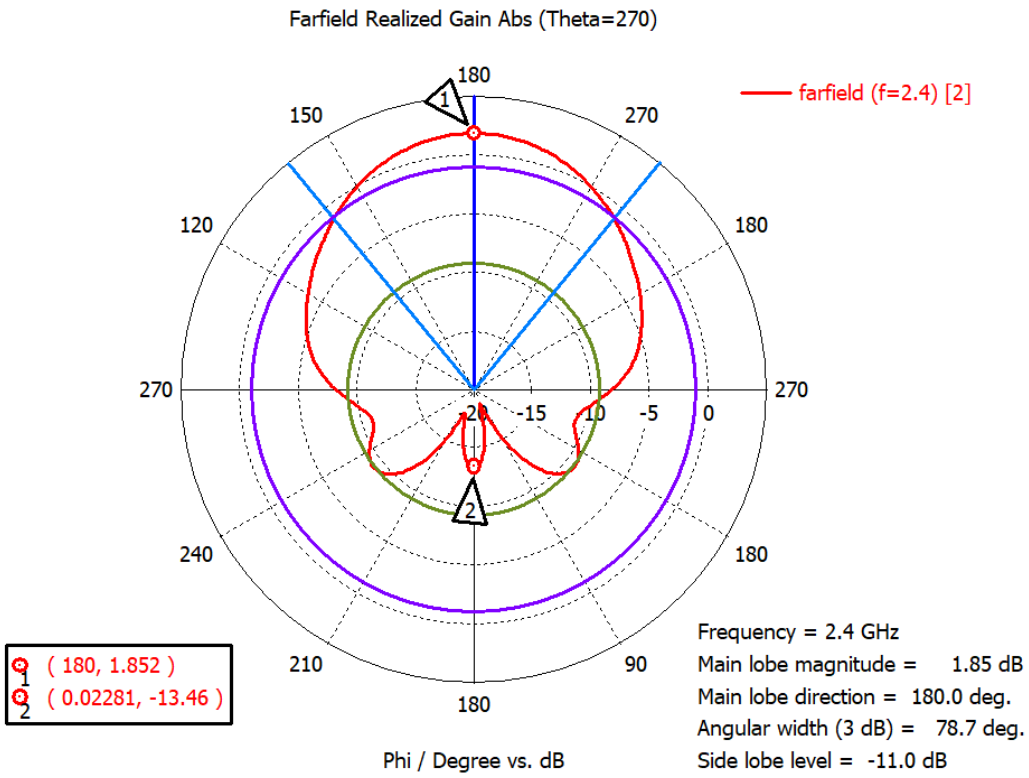

Figure 1. 7. Far-field Radiation Pattern for Right-Side Patch Antenna Design. Realized Gain. (Polar View)

2. ***2x1 Patch Array Antennas at Left- and Right-side of CubeSat structure:*** S-Band rectangular 2x1 patch antenna, for operation at 2.4GHz, at Left- and Right-side of CubeSat structure. Design stage performed without 2.4 m Wire Antennas. Simulations performed with CST Studio Suite 2017 ©. When adding the 2x1 array to the structure operation is shifted up to 2.451GHz.

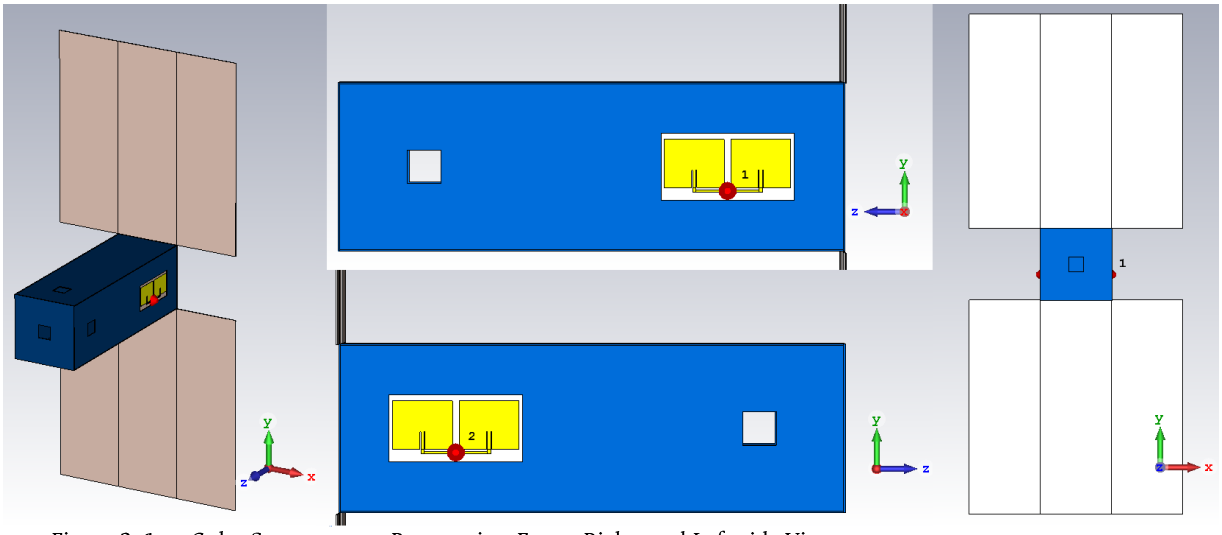

Figure 2. 1. Cube-Sat structure. Perspective, Front, Right- and Left-side Views

Parameter List

Name	Expression	Value	Description	Type
f	= 2.4	2.4	Frequency [GHz]	Frequency
Gpatch	= 3	3	Distance From Box Edge to Patch [cm]	Length
Hbox	= 10	10	Box Height (Y Axis) [cm]	Length
Hpan	= 10	10	Panel Height/Width (X Axis) [cm]	Length
Lambda	= 12.5	12.5	Wavelength [cm]	Length
LambdaG	= 6.1808	6.1808	Guided Wavelength [cm]	Length
Lbox	= 30	30	Box Length (Z Axis) [cm]	Length
Lpan	= 30	30	Panel Length (Y Axis) [cm]	Length
Lpatch	= 2.8579	2.8579	Patch Length (Y Axis) [cm]	Length
Lsubs	= 4	4	Substrate Length (Y Axis) [cm]	Length
MPHole	= 2	2	Wire Antenna Box Hole	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
Wpatch	= 3.5593	3.5593	Patch Width (Z Axis) [cm]	Length
Wposc	= Hbox/2	5	Wire Antena Central Position [cm]	Length
Wsubs	= 2*(2*Wstrip + Wpatch)	7.9186	Substrate Width (Y Axis) [mm]	Length
Wconn	= 2*Wstrip/3	0.133333333...	Width - Connector Strip between Patches [mm]	Undefined
Wstrip	= 0.20	0.20	Feed Strip Width (X Axis) [mm]	Length
x0	= 0.05	0.05	Space between Patch & Feed Strip (X Axis) [mm]	Length
y0	= 1.025	1.025	Space between Patch & Feed Strip End (Y Axis) [mm]	Length

Figure 2. 2. Parameter List for Structure design

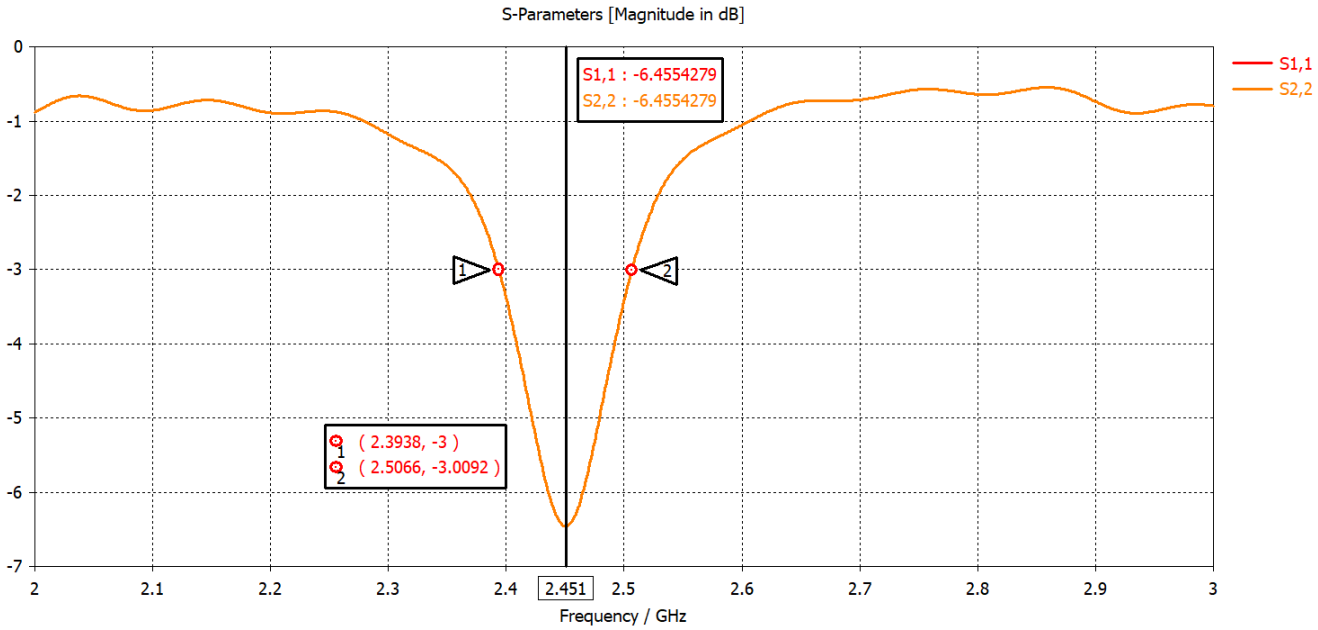

Figure 2. 3. Input reflection coefficients (S11 and S22 Parameters) for both 2x1 S-Band Patch Array Antennas

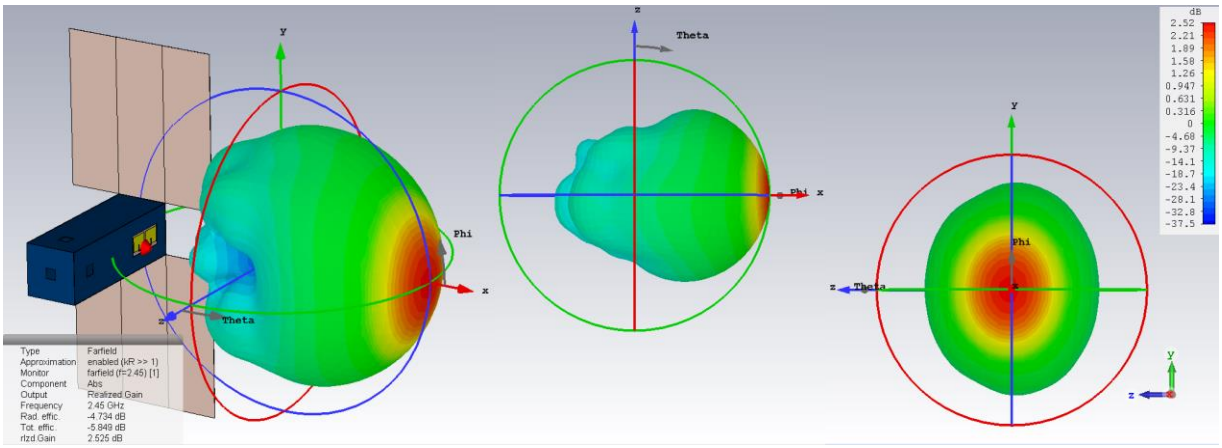

Figure 2. 4. Far-field Radiation Pattern for Left-Side 2x1 Patch Array Antenna Design at 2.45 GHz. Realized Gain.

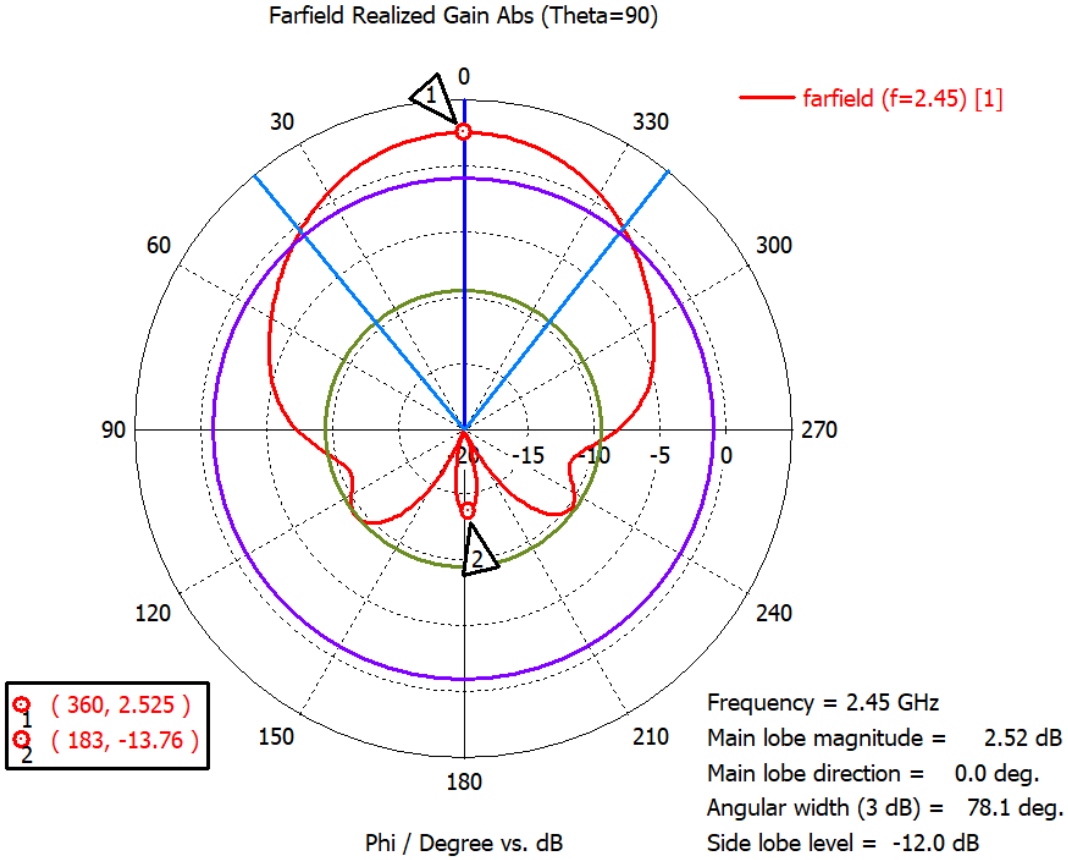

Figure 2. 5. Far-field Radiation Pattern for Left-Side 2x1 Patch Array Antenna Design at 2.45 GHz. Realized Gain. (Polar View)

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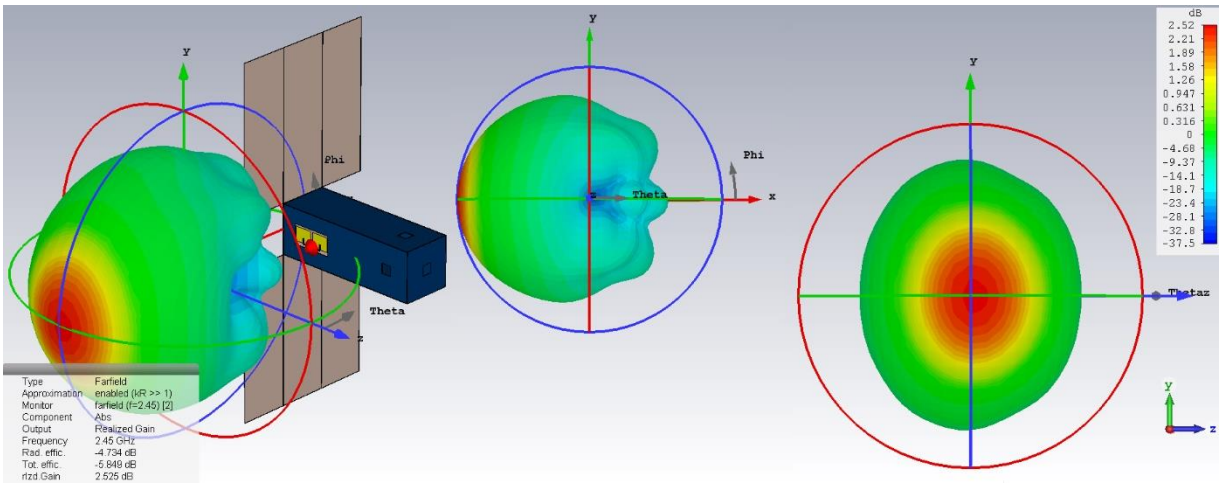

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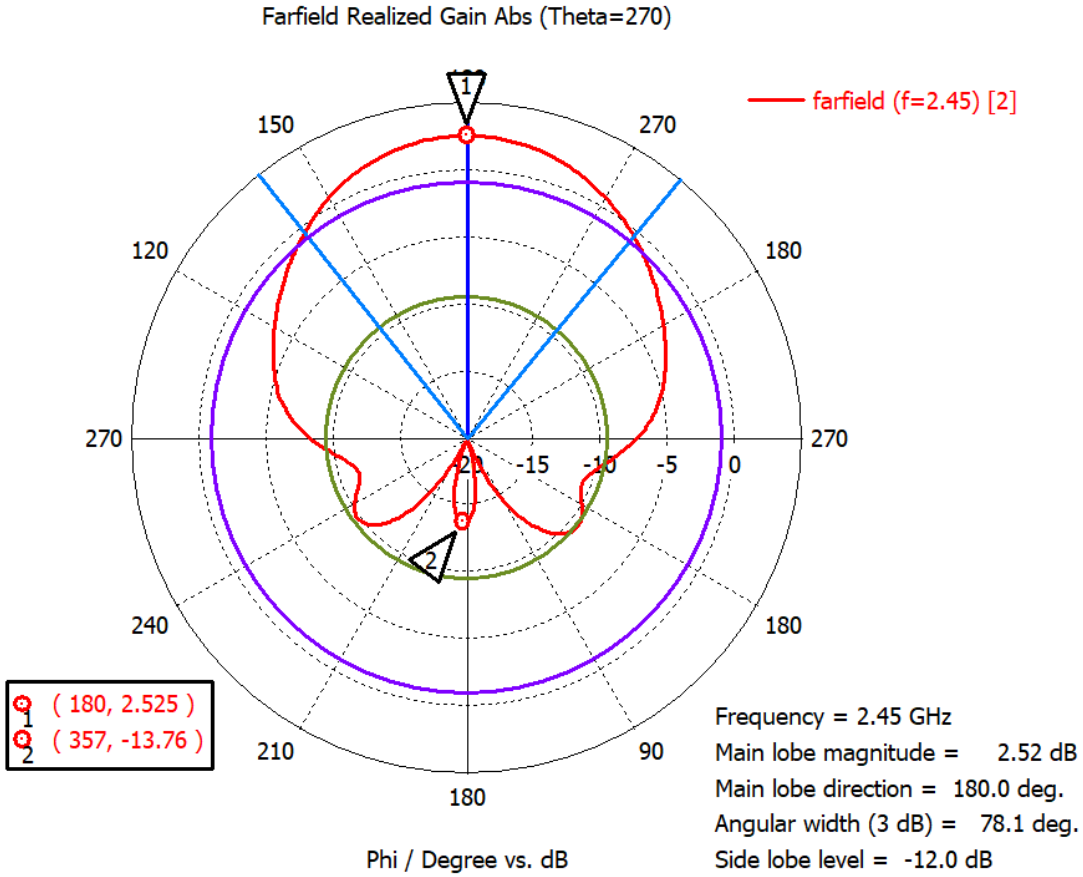

Figure 2. 7. Far-field Radiation Pattern for Right-Side 2x1 Patch Array Antenna Design at 2.45 GHz. Realized Gain. (Polar View)

PARAMETER	Single Patch	2x1 Patch Array
Input Reflection Coefficient (S11 Parameter)	**-14.7414 dB (at 2.395 GHz)**	**-6.4554 dB (at 2.451 GHz)**
Half-Power (-3 dB Bandwidth)	198.2 MHz	112.8 MHz
Directivity	7.576 dBi	8.373 dBi
Gain (IEEE)	2.015 dB	3.639 dB
Realized Gain	1.855 dB	2.525 dB
Half-Power Beamwidth (HPBW)	78.7°	78.1°
Front-to-Back Ratio	15.312 dB	16.285 dB

Table 1.1. Results Summary.

As expected, 2x1 patch array has a higher gain, directivity and Front-to-Back Ratio, however its bandwidth, HPBW and Input Reflection Coefficient are lower in magnitude in comparison to Single Patch. So far, there is no significant improvement switching from single patch to 2x1 array.

There are pending results, which will be shown in subsequent simulations adding 2.4m Wire Antennas and the 2 back-side dipoles, as well as performing corrections to the 2x1 patch array for operation at 2.4GHz (51MHz below current operation), which will be discussed in the next report.