Electromagnetic Waves Project

Dual-Pol 30-GHz Microstrip Patch Antenna

Submitted to:

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Submitted by:

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1. Abstract

The use of a low profile microstrip patch antenna is a good choice for 5G Mobile communication, due to its capacity to operate in the millimeter waveband, and also enhances the overall antenna gain and bandwidth. This report presents the design and simulation of a dual polarized microstrip patch antenna on a Duroid 5870 substrate for 5G mobile Network communication at 30GHz using CST software [1].

2. Introduction:

The most common type of microstrip antenna is the Microstrip patch antennas (MPA), they are a class of planar antennas which have been researched and developed extensively in the last four decades. They have become favorites among antenna designers and have been used in many applications in wireless communication systems, both in the military sector and in the commercial sector.

A Microstrip patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to a dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

The implementation of the microstrip patch antenna is a milestone in wireless communication systems and is continuing to fulfill the changing demands of the new generation of antenna technology. Microstrip patch antennas are widely used in wireless communication systems because they are low profile, of light weight, of low cost, of conformal design, and easy to fabricate and integrate. The patch is the dominant figure of a microstrip antenna; the other components are the substrate and ground, which are the two sides of the patch [2]. The proposed patch antenna has a compact structure of 2.8229mm × 2.8229mm × 0.035mm including the ground plane, which is suitable to be used in handheld devices. The proposed design at 30GHz frequency achieves high gain, energy efficiency and better bandwidth. In this report geometry of the antenna and various parameters such as return loss plot, gain plot and radiation pattern plot that are presented & discussed.

3. Problem Description

In this project, it is required to design a Dual-Pol 30-GHz Microstrip Patch Antenna.

4. Design Procedure

At first, a microstrip patch antenna calculator (hfss software) has been used to get the initial dimensions of the Antenna.we use data sheet of Rogars5870 to know the value of ϵ which equal to 2.33 and substrate thickness which equal to 1.575mm, After optimization in (CST Studio suite) for the dimensions of antenna that taken from calculator, we obtain this parameter as Shown in below figures.

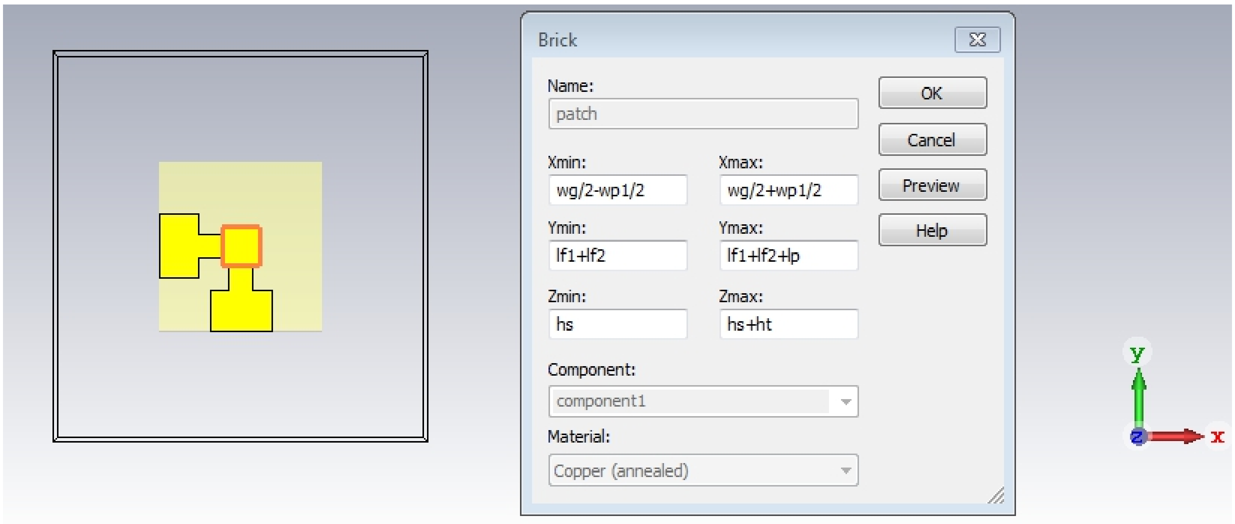

Figure 1: dimension of patch

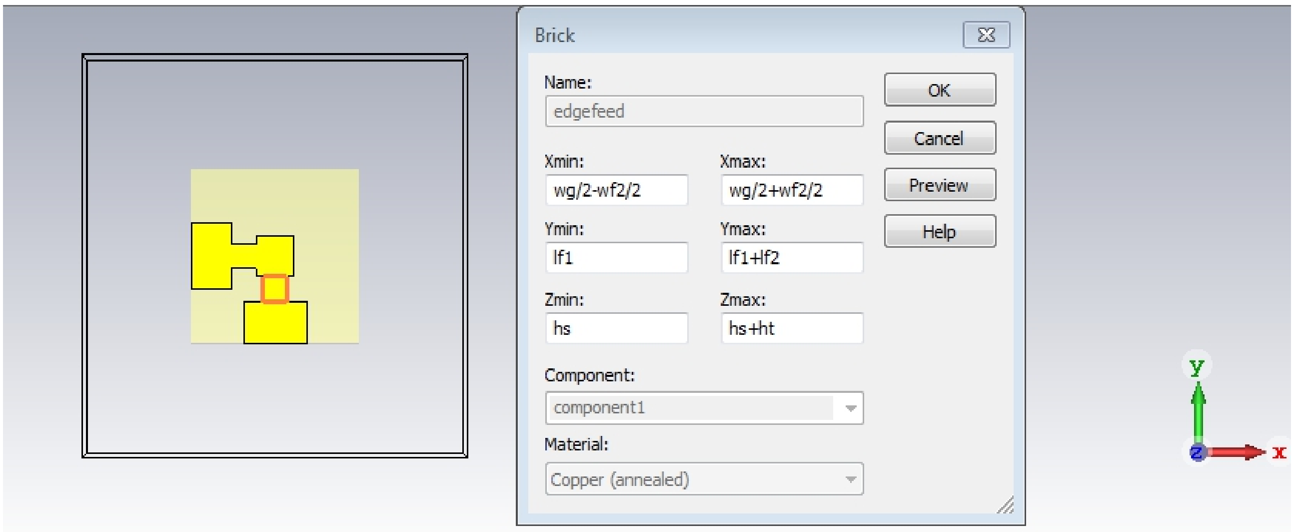

Figure 2:dimension of edge feed of port 1

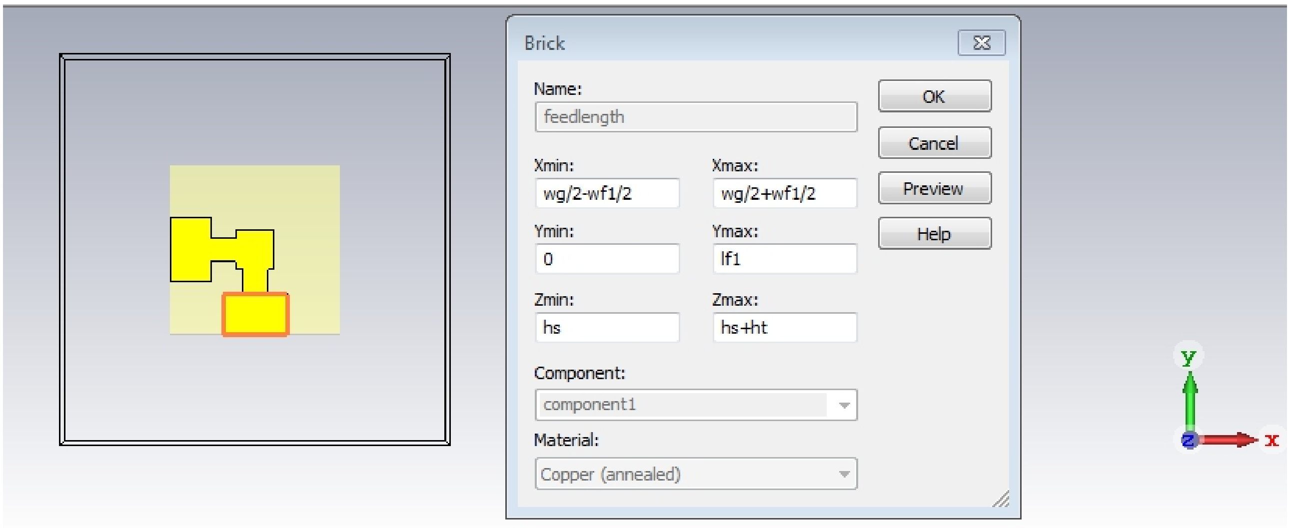

Figure 3:dimension of feed length of port 1

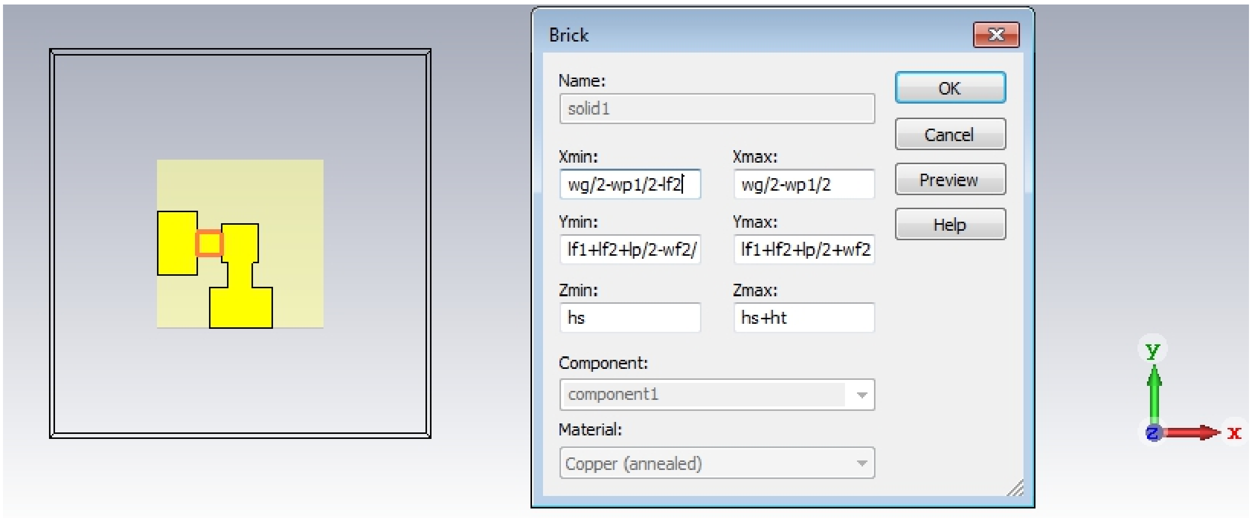

Figure 4:dimension of edge feed of port 2

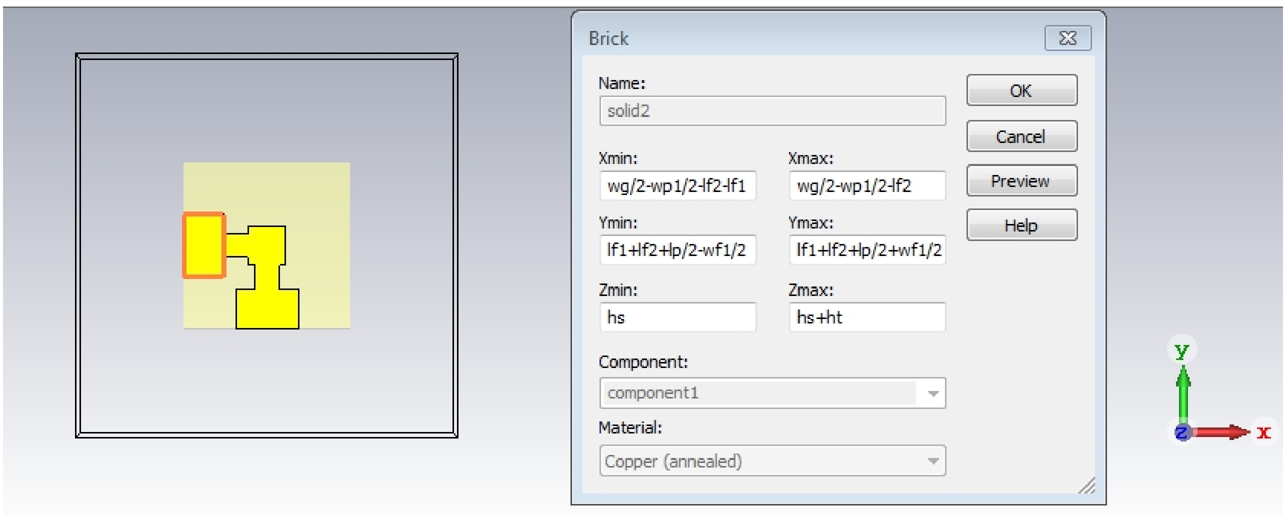

Figure 5:dimension of feed length of port 2

3D Schematic

arameter List

Name	Expression	Value
wg	= 2*(lf1+lf2)+wp1	12.4388572207118
lg	= 2*(lf1+lf2)+lp	12.4388572207027
ht	= 0.035	0.035
hs	= 1.575	1.575
wf1	= 4.678	4.678
lf1	= 2.975	2.975
wf2	= 1.764	1.764
lf2	= 1.833	1.833
wp1	= 2.8228572207118	2.8228572207118
lp	= 2.8228572207027	2.8228572207027
wv	= 5*wf1	23.39

Figure 6:Parameters of antenna

5. Different views of the antenna

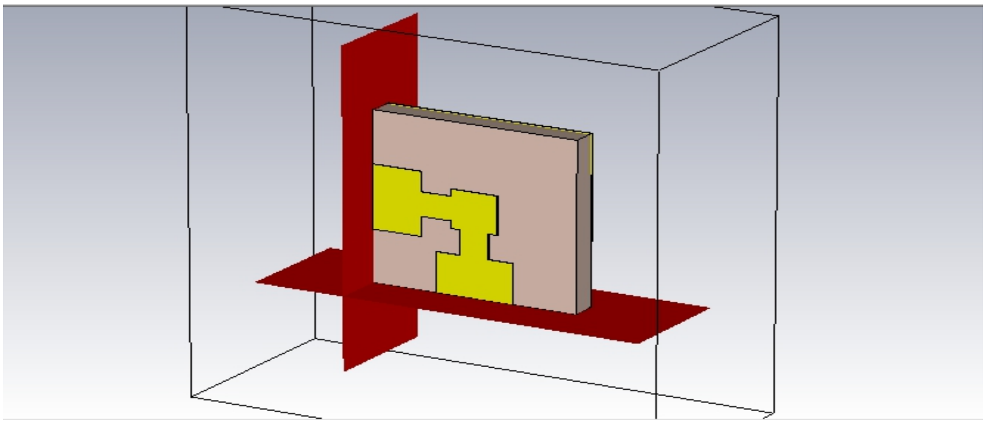

Figure 7: 3D view of antenna layout

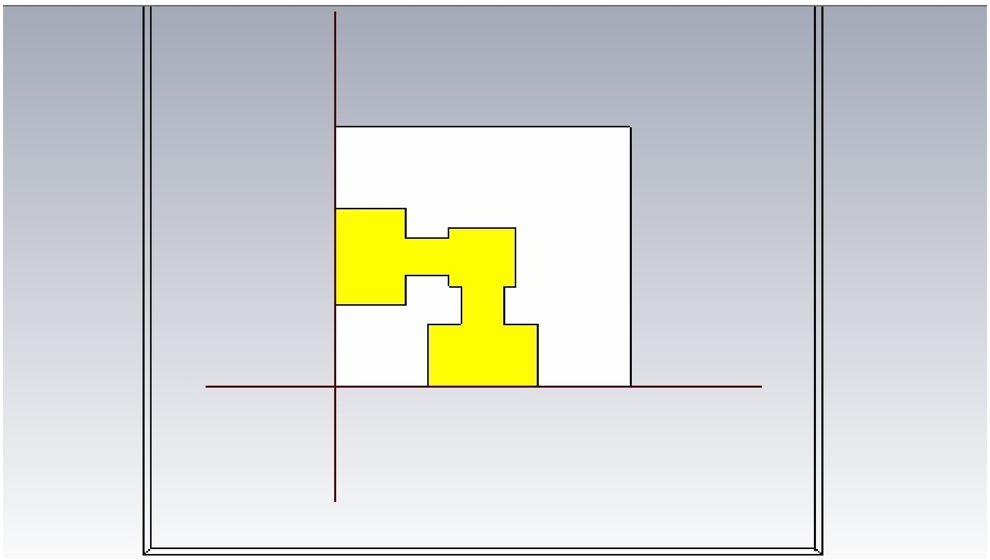

Figure 8: front view of antenna layout

6. Results and Discussion of designed antenna @ 30 GHz

6.1. Return Loss

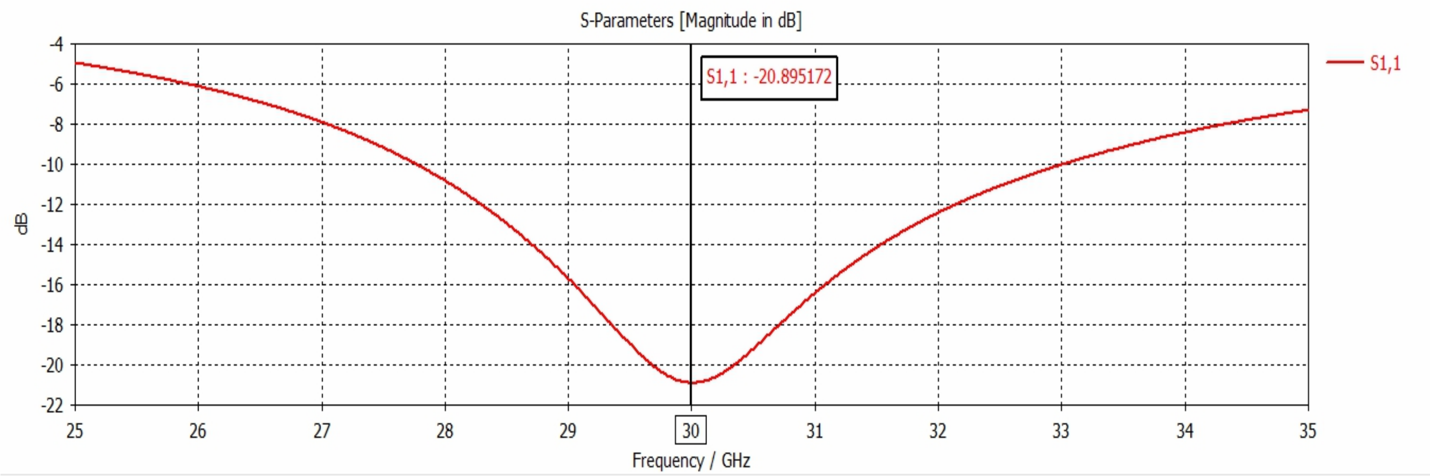

Figure 9: Return loss of the designed antenna Vs. Frequency @ operating Frequency

- Return loss of the designed antenna @ 30 GHz ~ -21 dB which is acceptable value to use for the antenna

6.2. S-Parameters

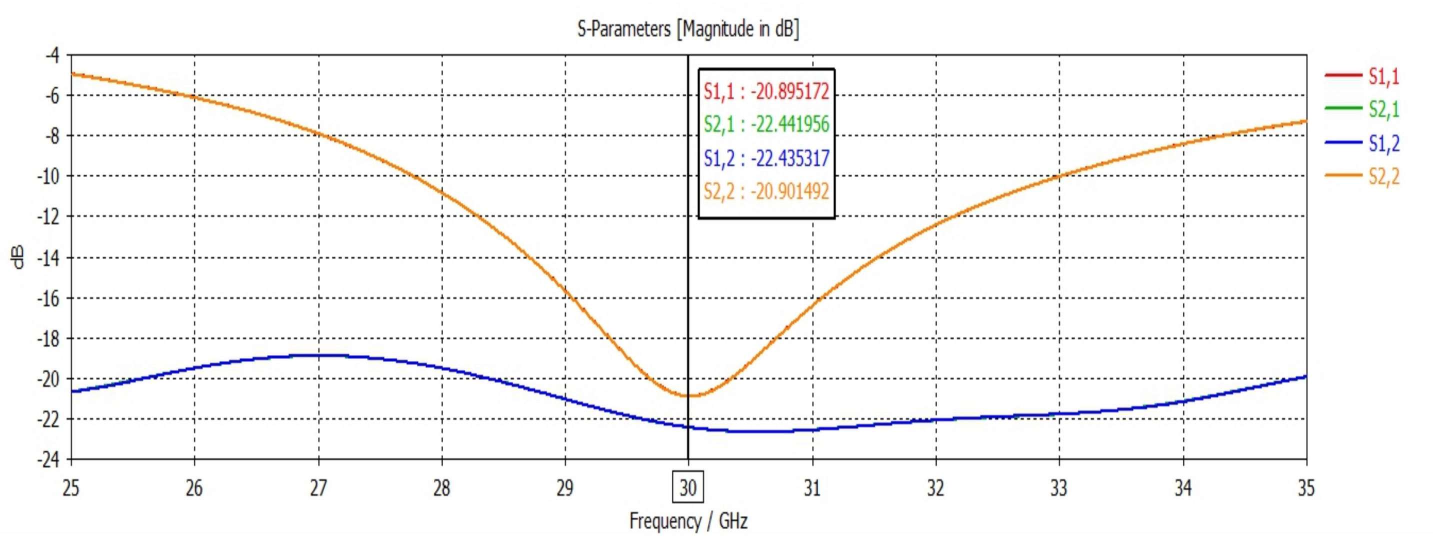

Figure 10: S-Parameters of antenna

6.3. Input impedance on Smith chart

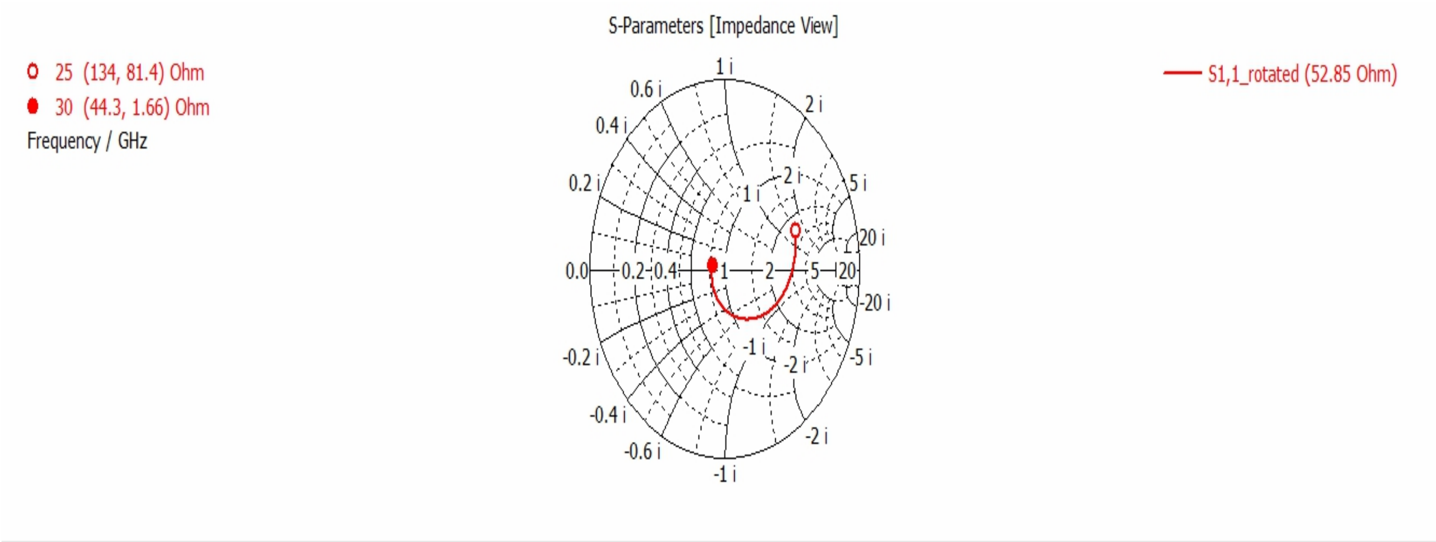

Figure 11: Input impedance on Smith chart of port 1

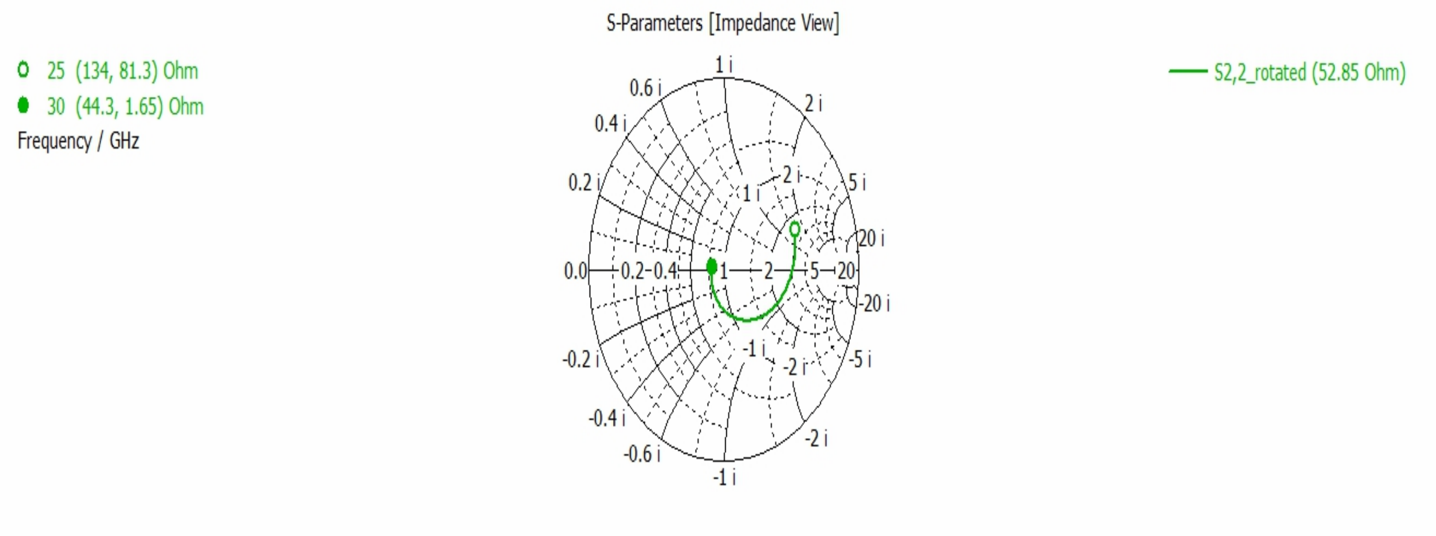

Figure 12: Input impedance on Smith chart of port 2

- Input impedance for port 1 equals 44.3 Ω
- Input impedance for port 2 equals 44.3 Ω

6.4. Radiation pattern

6.4.1. Radiation pattern of port 1

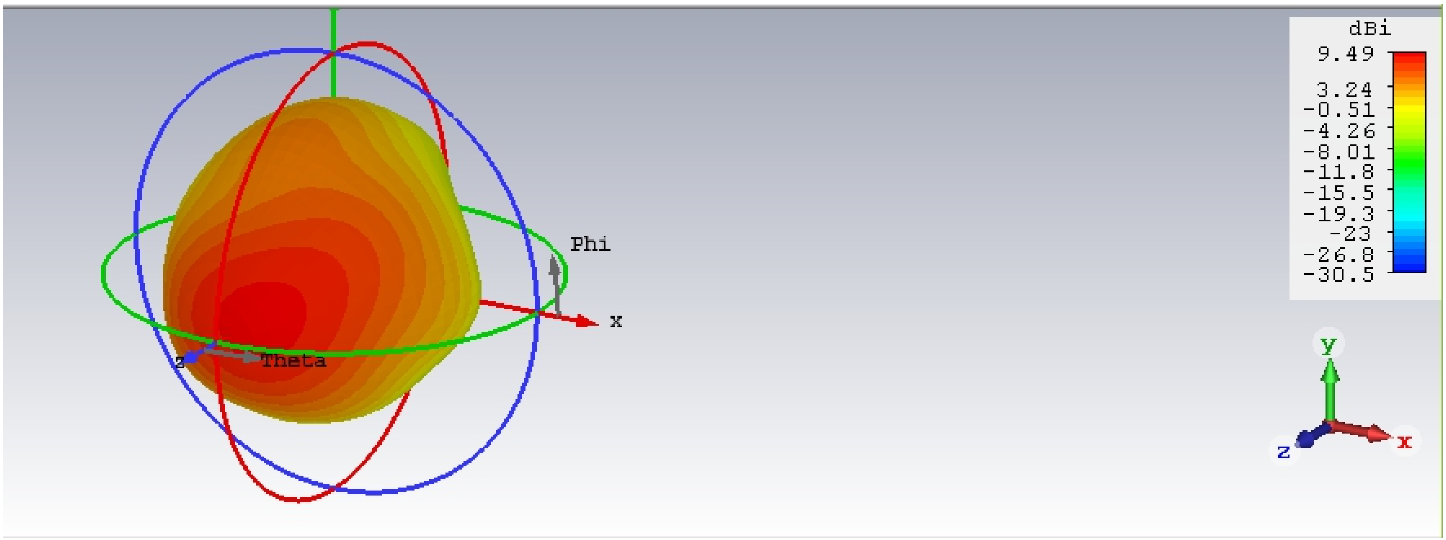

Figure 13: 3D Radiation pattern for port 1

6.4.1.1. E-Plane

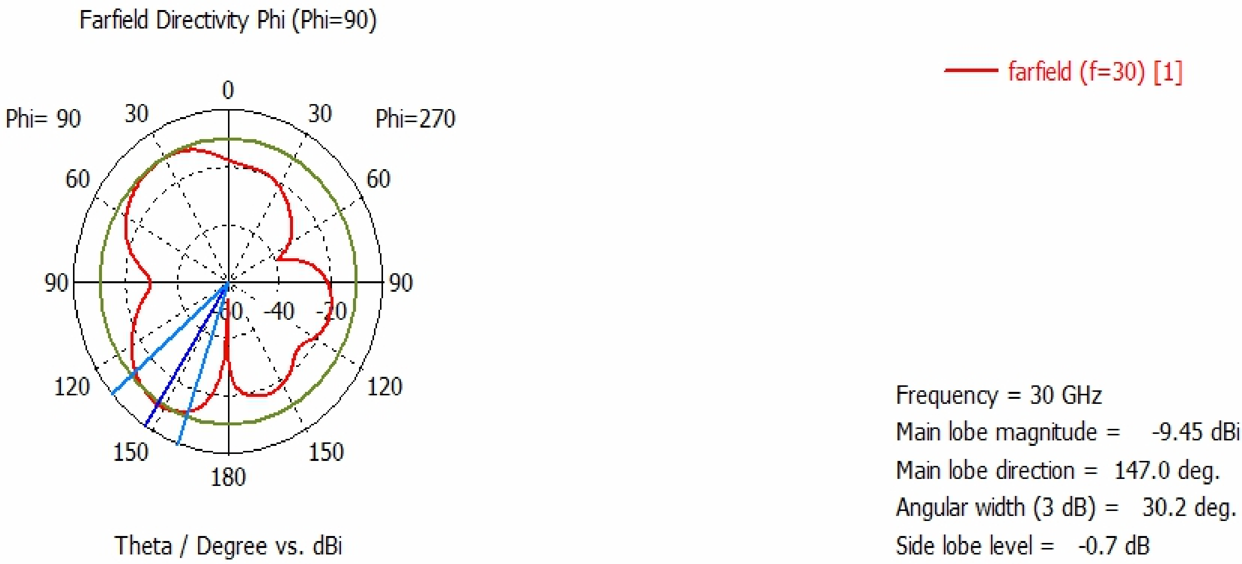

Figure 14: The Co-polarized radiation pattern of E-Plane for port 1

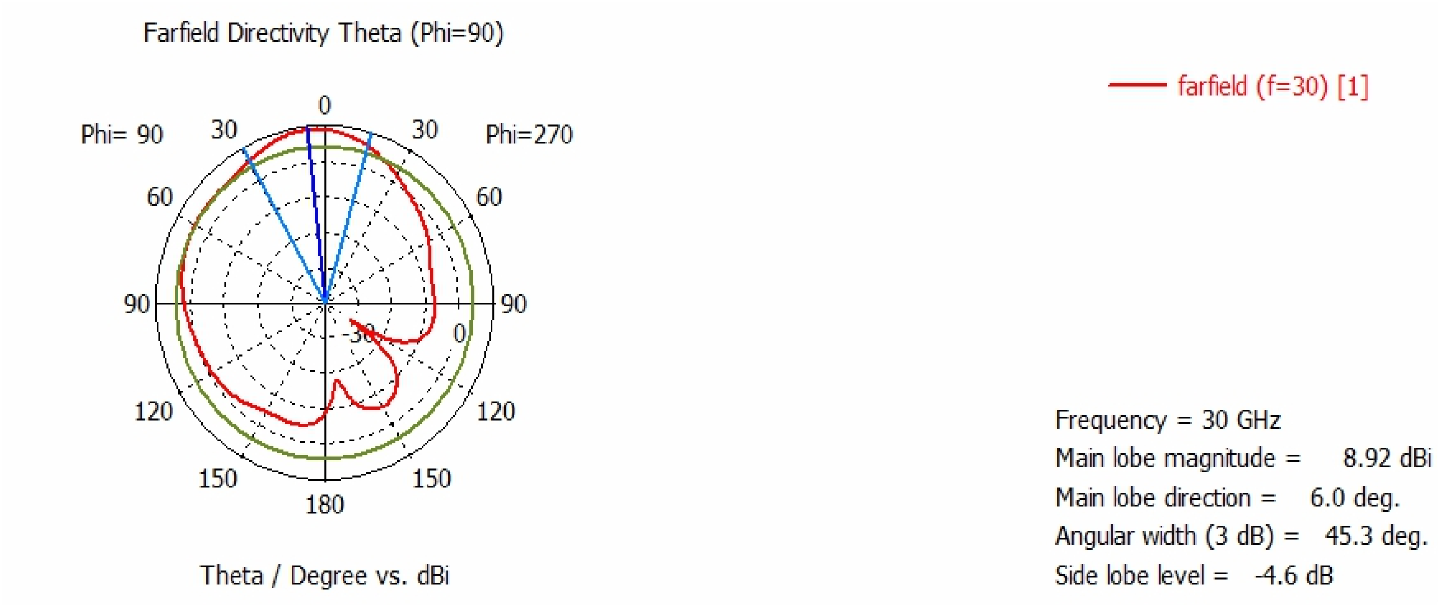

Figure 15: The Cross- polarized radiation pattern of E-Plane for port 1

6.4.1.2. H-Plane

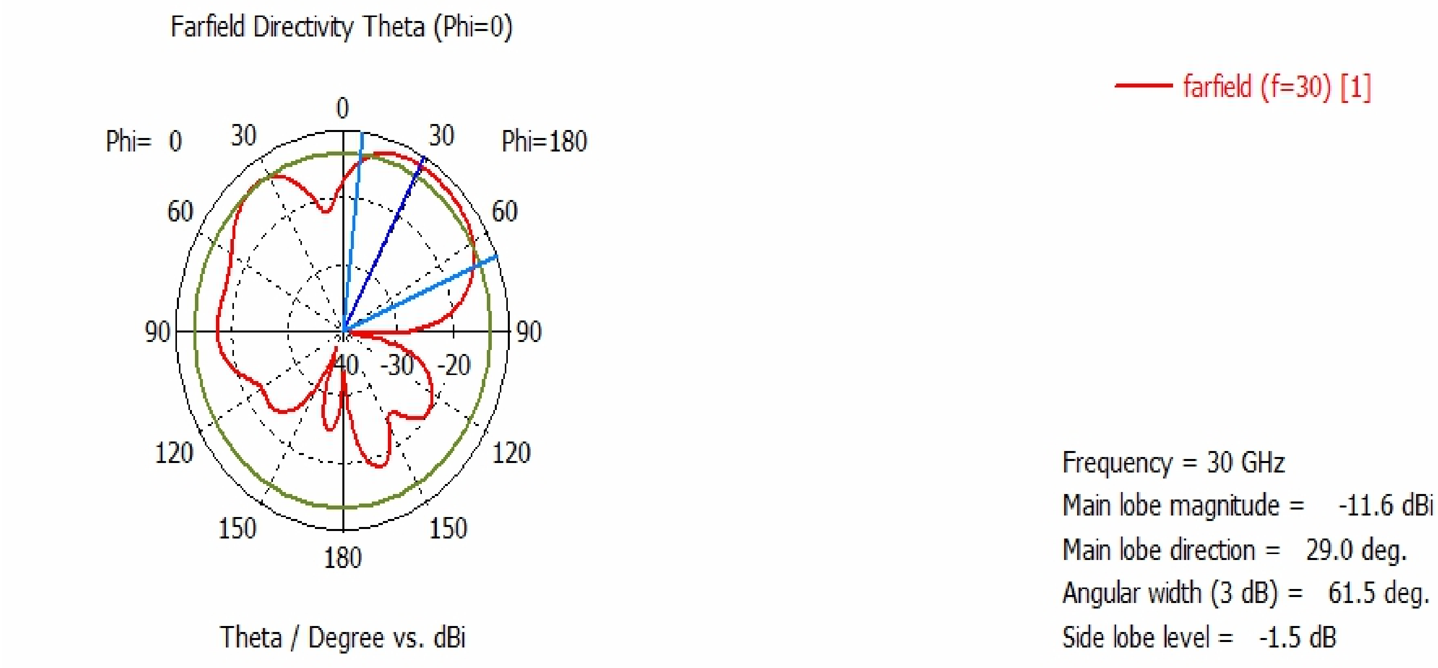

Figure 16: The Co-polarized radiation pattern of H-Plane for port 1

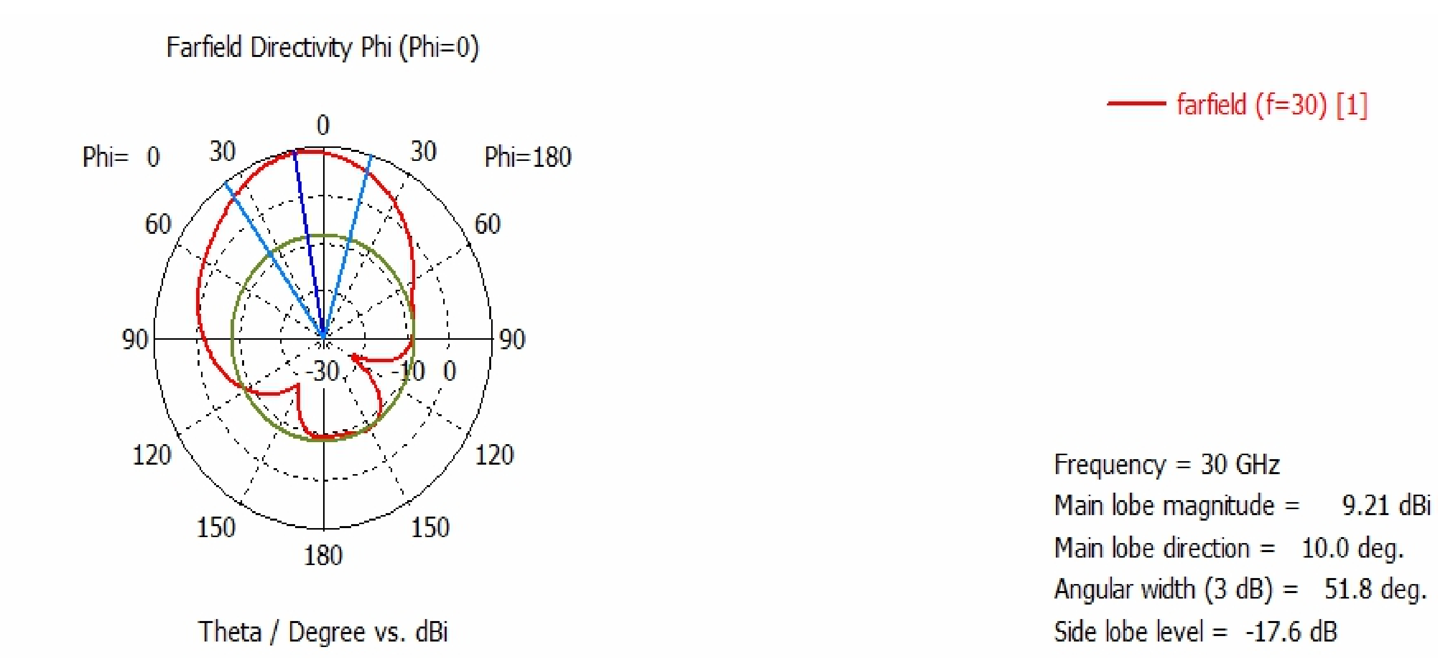

Figure 17: The Cross-polarized radiation pattern of H-Plane for port 1

6.4.2. Radiation pattern of port 2

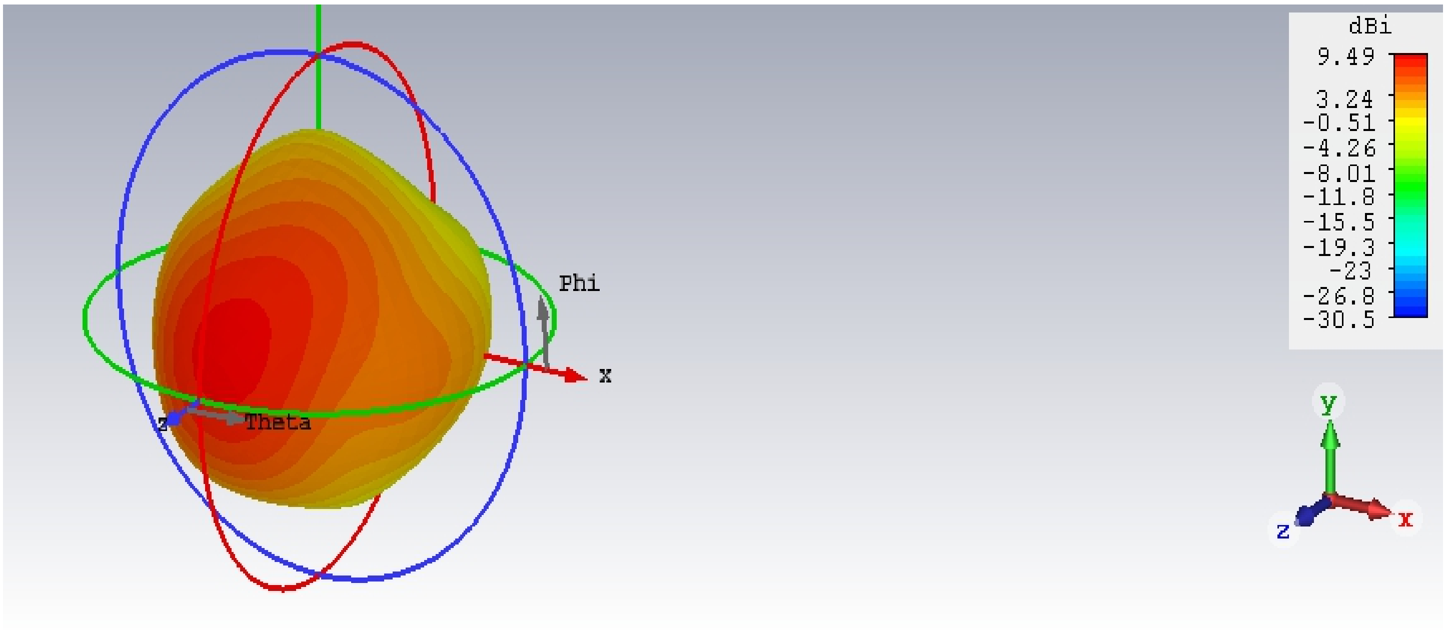

Figure 18: 3D Radiation pattern for port 2

6.4.2.1. E-Plane

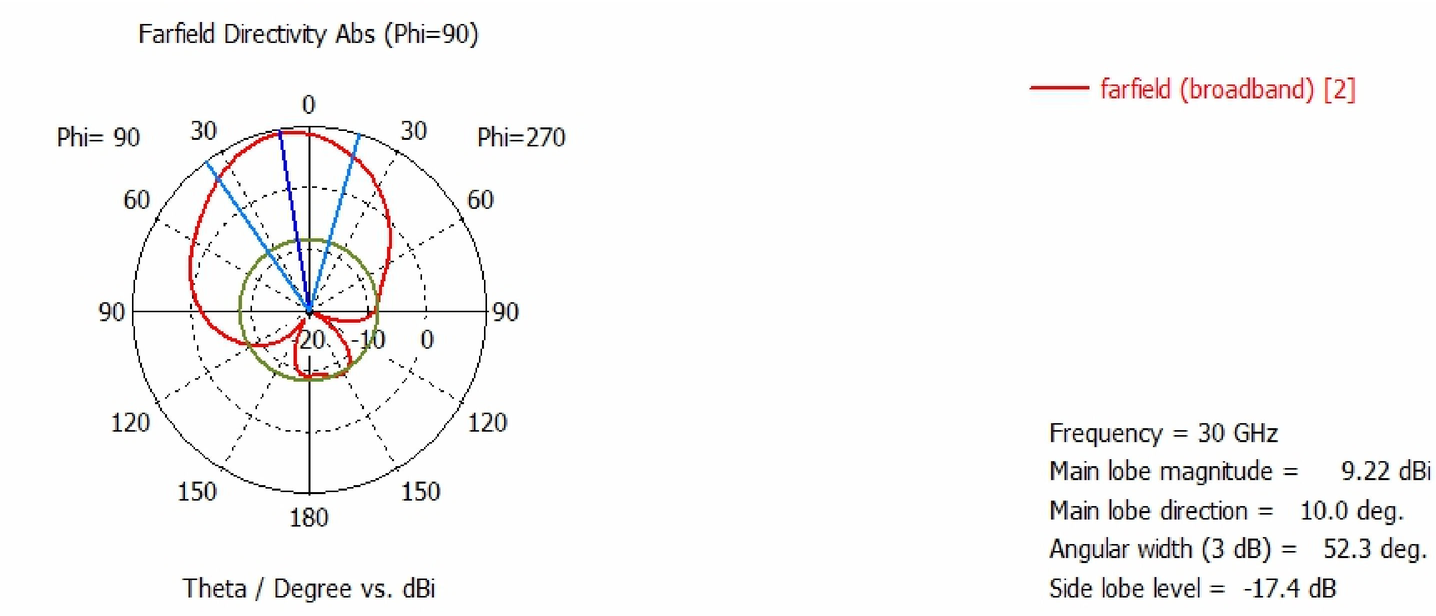

Figure 19: The Co-polarized radiation pattern of E-Plane for port 2

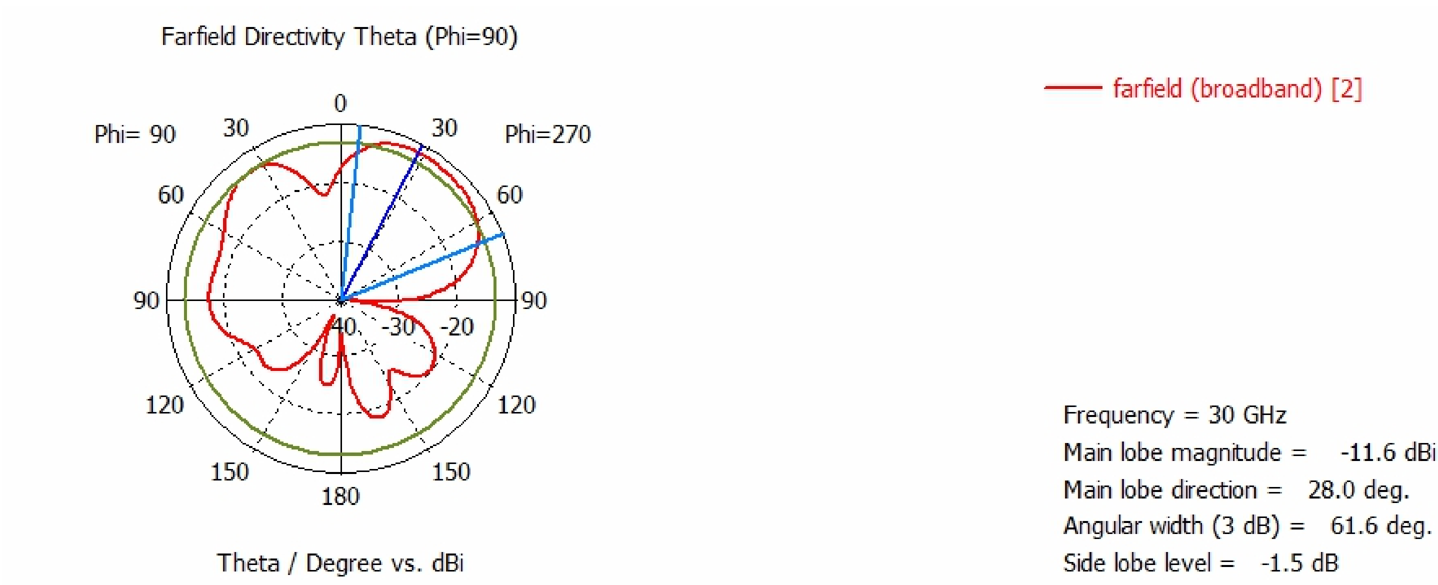

Figure 20: The Cross- polarized radiation pattern of E-Plane for port 2

6.4.2.2. H-Plane

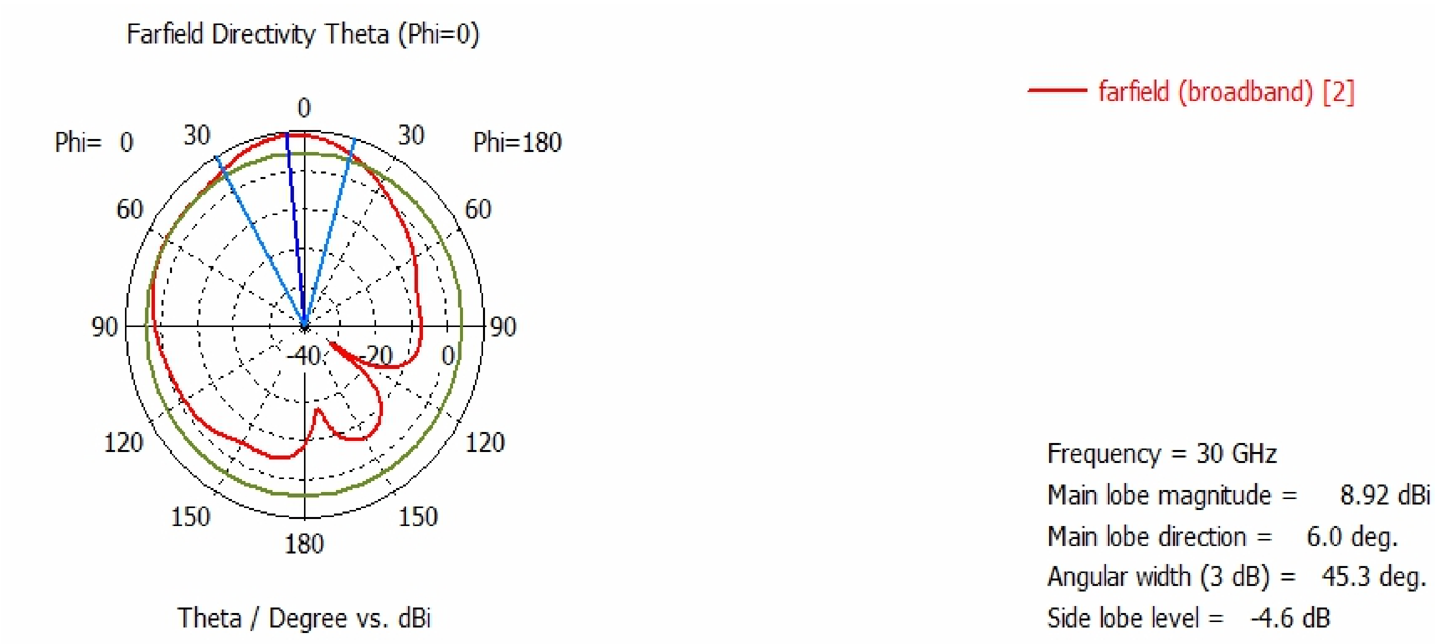

Figure 21: The Co-polarized radiation pattern of H-Plane for port 2

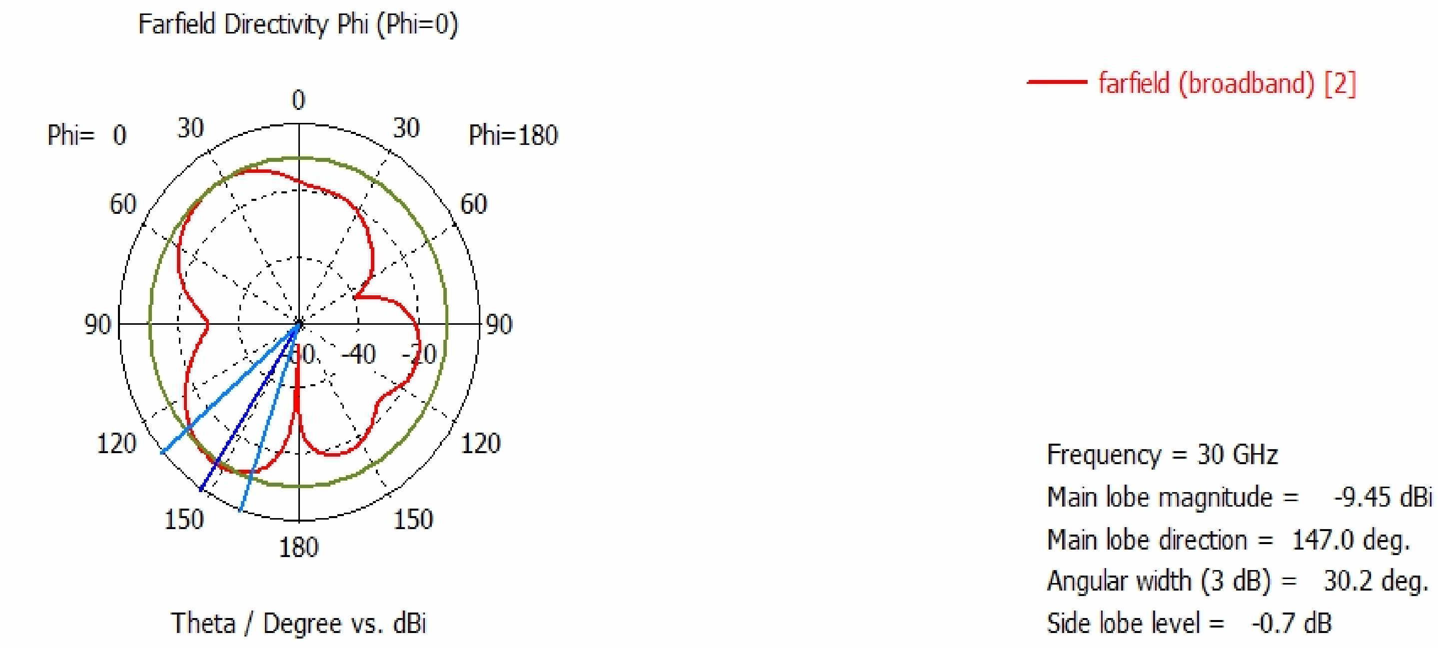

Figure 22: The Cross-polarized radiation pattern of H-Plane for port 2

6.5. Gain

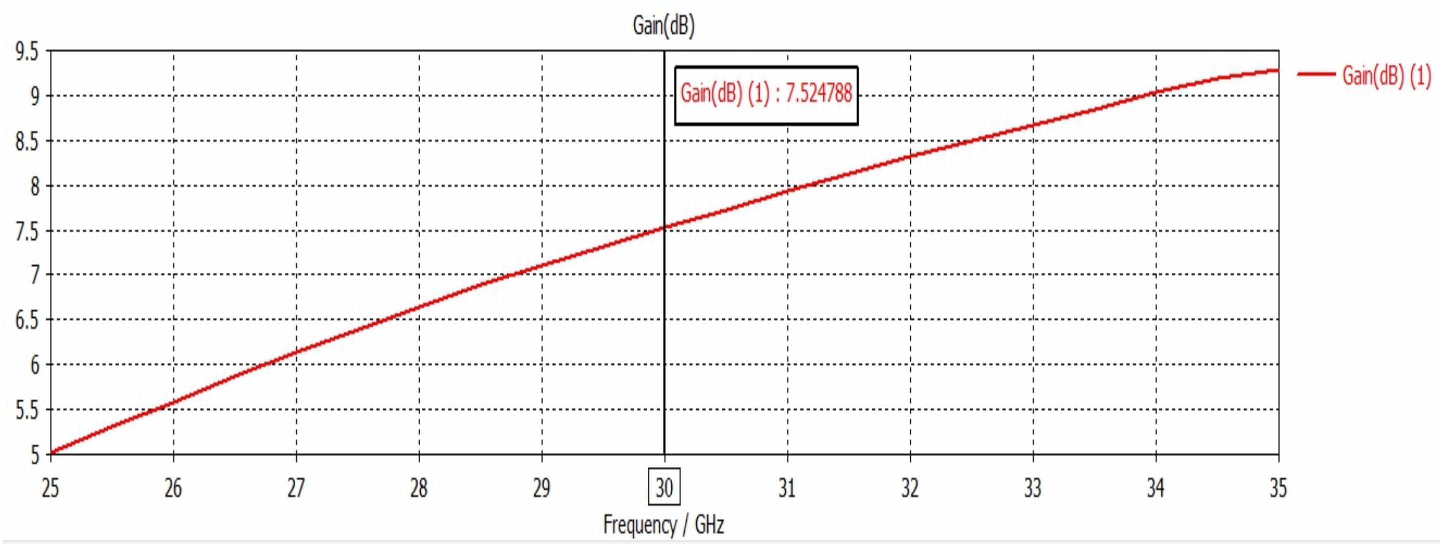

Figure 23: Gain of designed antenna

✧ The Gain @ 30 GHz =7.524788 dB which is considered acceptable gain for microstrip patch antenna

6.6. Radiation Efficiency

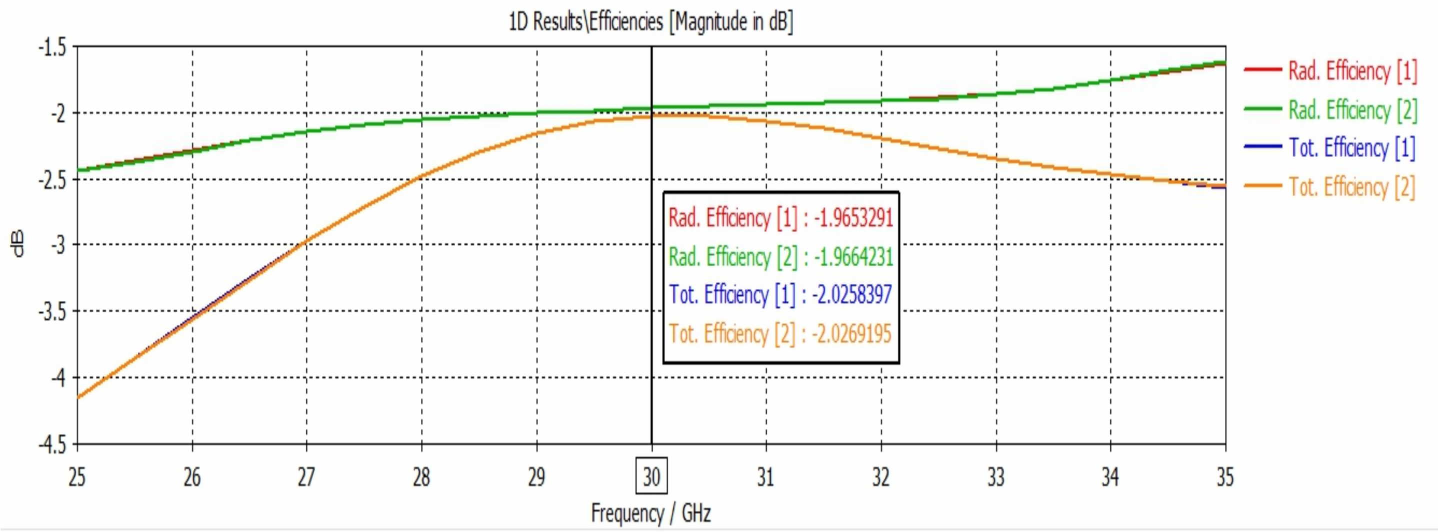

Figure 24: Radiation Efficiency of designed antenna

✧ Radiation Efficiency @ 30 GHZ = 63.6%

✧ Total Efficiency @ 30 GHZ = 62.7%

6.7. Bandwidth

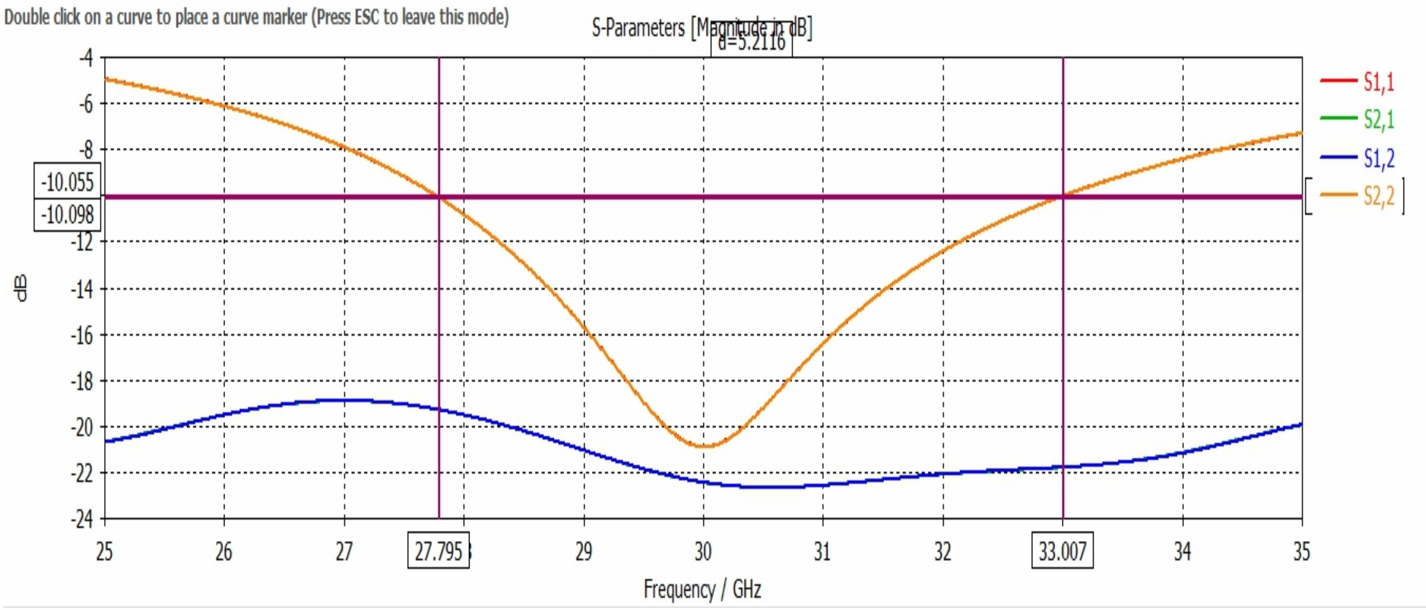

Figure 25: Bandwidth of designed antenna

✧ Bandwidth of antenna is equal to 5.2116 GHz.

7. Layout of Antenna

PCB antennas require the proper size ground plane for optimal performance. From a simple design perspective. Larger ground planes increase capacitance and decrease the resonant frequency. Better grounding also achieves better return loss. Establishing the correct ground allows the PCB antenna to have better performance.
We used online software which is called (Online Gerber Viewer) to generate the Layout.

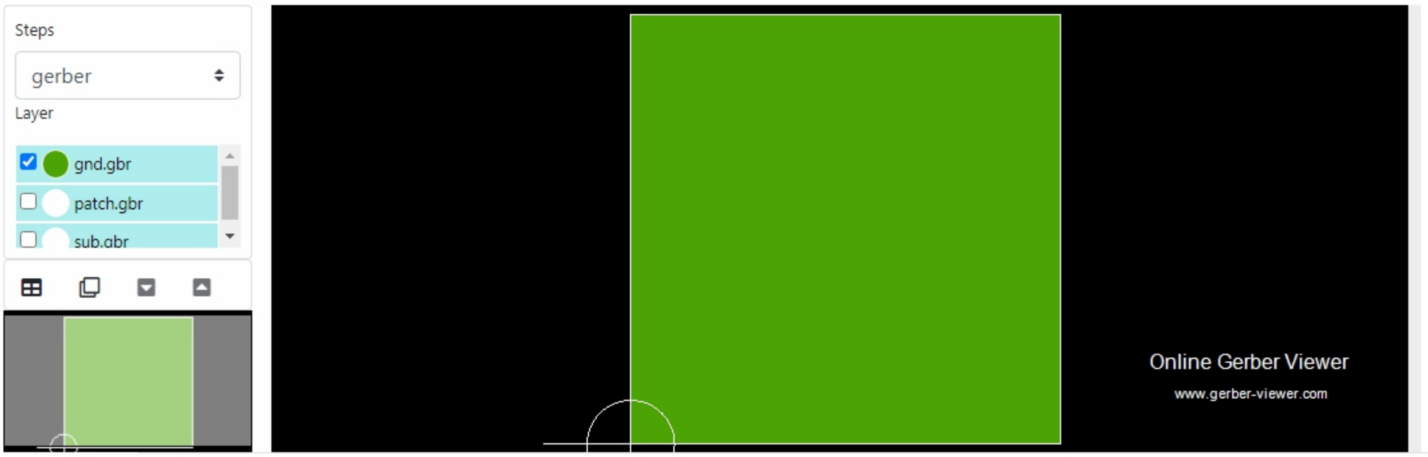

Figure 26:Ground Layout

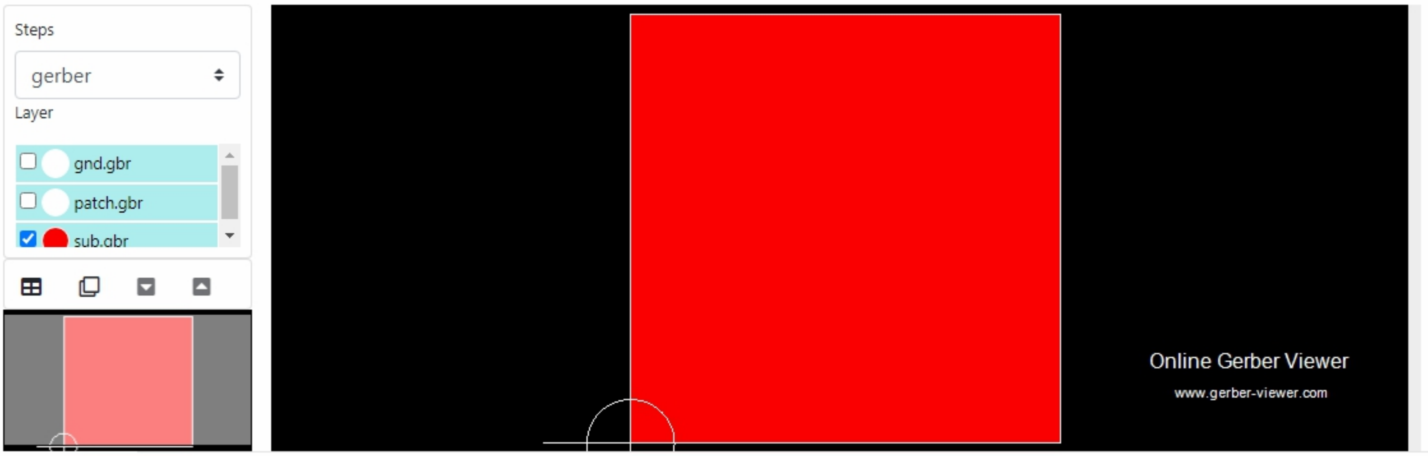

Figure 27: Substrate Layout

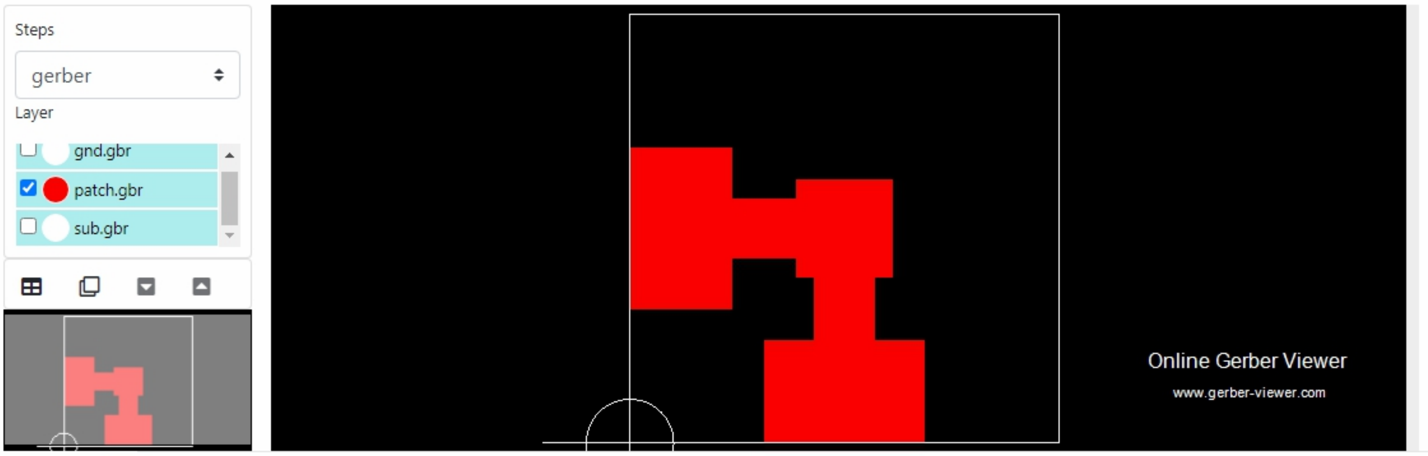

Figure 28: Patch Layout

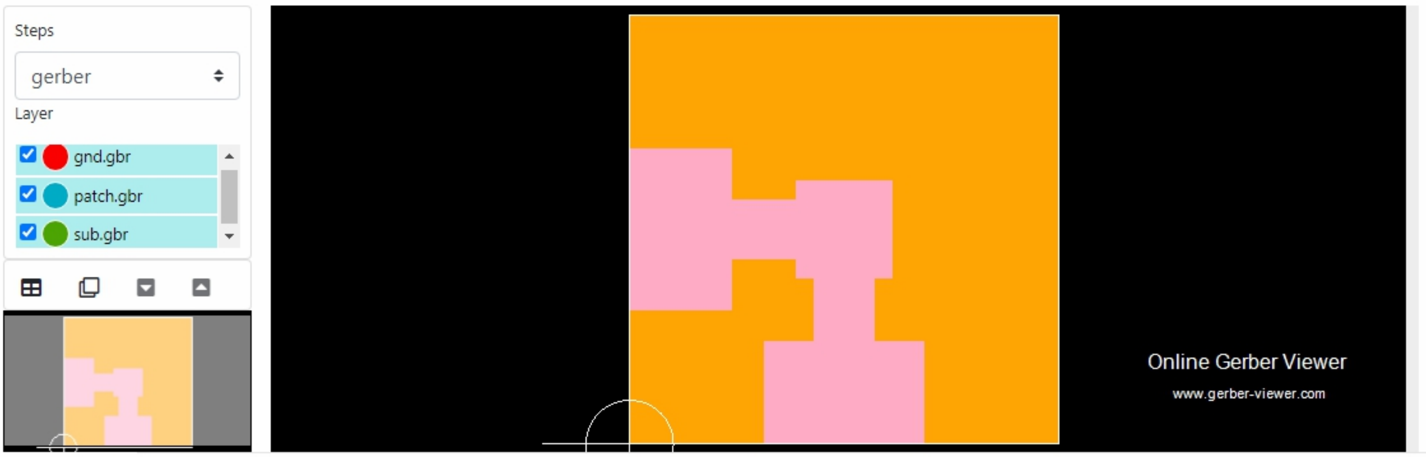

Figure 29: Final Layout of antenna

8. Designed Antenna with connector

8.1. Mini-SMP Connector [3]

Mini-SMP	RIGHT ANGLE PLUG PCB FULL DETENT	**18S203-40ML5**

Electrical data	
Impedance	50 Ω
Frequency	DC to 65 GHz
Return loss	≥ 26 dB @ DC to 6 GHz
	≥ 19 dB @ 6 GHz to 18 GHz
	≥ 14 dB @ 18 GHz to 26.5 GHz
Insertion loss	$\leq 0.1 \times \sqrt{f\,[\mathrm{GHz}]}$ dB
Insulation resistance	≥ 5 GΩ
Center contact resistance	≤ 6 mΩ
Outer contact resistance	≤ 2 mΩ
Working voltage (at sea level)	325 V rms
(at 70000 feet)	125 V rms

Return loss in application depends decisive on PCB layout

Figure 30:MSMP 18S203-40ML5 specification

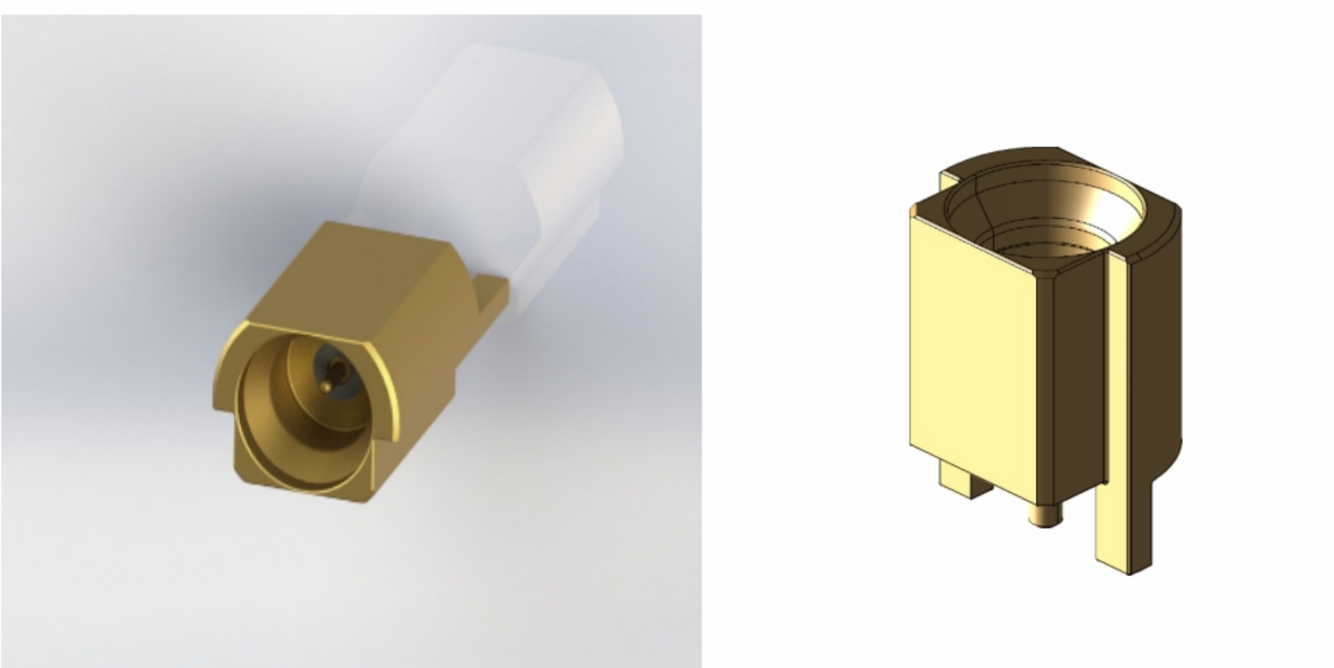

Figure 31:MSMP 18S203-40ML5 Connector

Model of MSMP connector was used in the design with its footprint,MSMP 18S203-40ML5 can operate in a frequency range from 0 to 65 GHz which suits our operating frequency of 30 GHz [4].

8.2. Final Design of antenna with connector

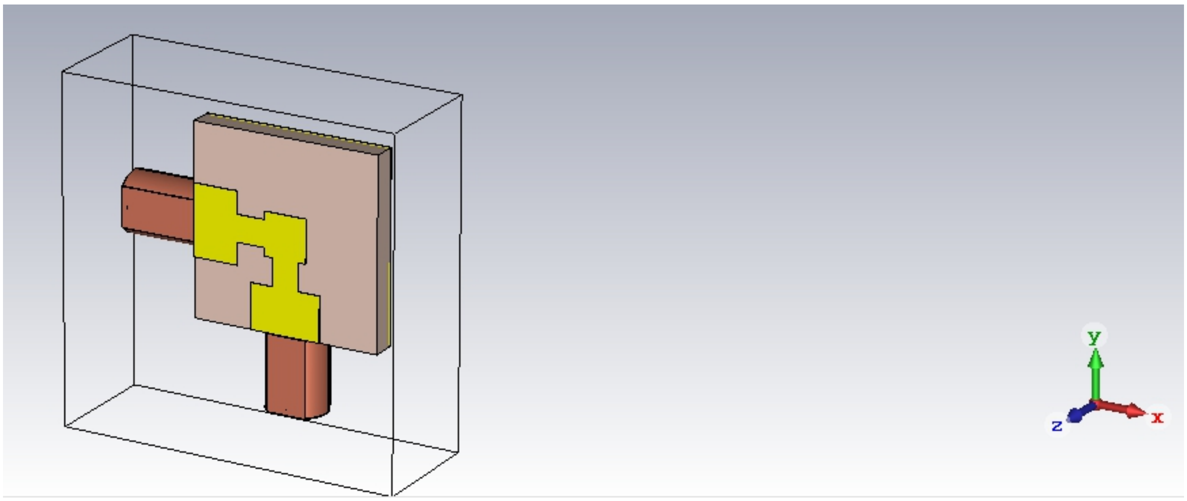

Figure 32 : 3D View of antenna with connector

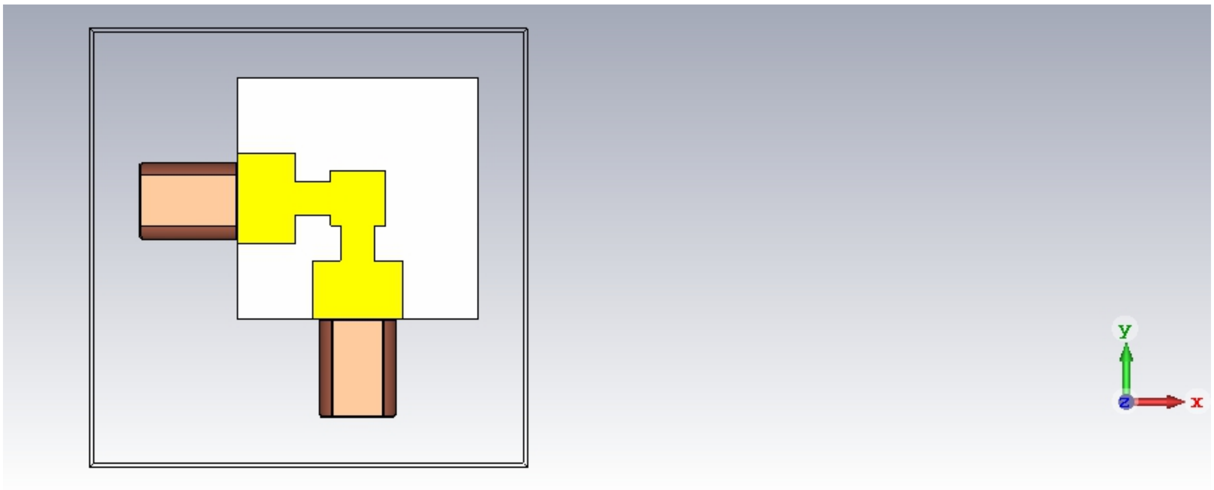

Figure 33 :Front View of antenna with connector

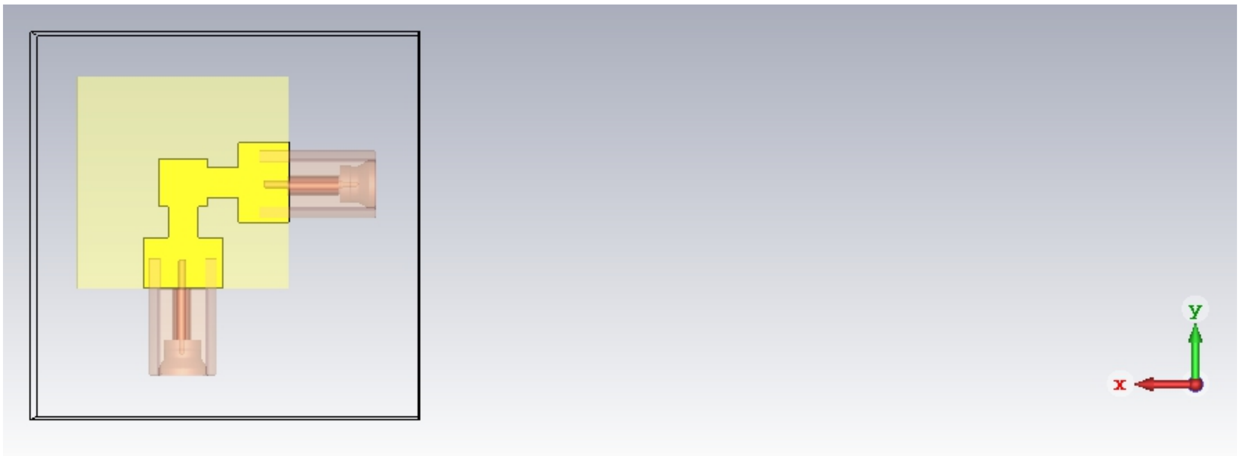

Figure 34 : Back View of antenna with connector

9. Conclusion

This report covers the Design of a Dual-Pol 30-GHz Microstrip Patch Antenna. The designed antenna is simulated on CST studio suite to analyze the required parameters such as input impedance, return loss,S-parameters , gain, efficiency,Bandwidth and radiation pattern of E and H planes at a frequency 30GHZ. The antenna achieved a 5.2116 GHz bandwidth, Input impedance is 44.3 Ω , gain of peak 7.524788 dB and efficiency of 63.6% at the required frequency 30 GHz.

10. References

[1] David okwum, Joshua Abolarinwa, Opeyemi Osanaiye ,"A 30GHz Microstrip Square Patch Antenna Array for 5G Network". Published in: 2020 International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS) , Published by IEEE.

[2] L. H. Weng, Y. C. Guo, X. W. Shi, and X. Q. Chen, "An overview on defected ground structure," Progress in Electromagnetics Research B, vol. 7, pp. 173–189, 2008.View at: Google Scholar

[3]https://docs.rs-online.com/577e/0900766b814f70d5.pdf

[4]Model of 65 GHz 1-Port Edge-Mount Mini-SMP (MSMP) Semi-Rigid Coaxial Connector Socket