DESIGN AND ANALYSIS OF CIRCULAR ARRAYS FOR S - BAND APPLICATIONS

N. Naveen Kumar[1], Pamisetty Chandana[2], Dr. Y.L. Ajay Kumar[3]

[1]Assistant Professor, [2]Assistant Professor, [3]Associate Professor, ECE Department, Anantha Lakshmi Institute of Technology and Sciences, Ananthapuramu, Andhra Pradesh, India.

Abstract: In modern wireless communication systems, it requires large bandwidth, high gain, high directivity, and reduced size to provide better performance. Firstly, in this paper we designed single element micro strip patch antenna array which results low gain and low directivity. As we increase the number of arrays of antenna elements such as 2×1, 2×2, 4×2, the gain and directivity are improved. In the proposed design coaxial feed is used because of very easy fabrication and low radiation. The substrate used for this design is RT/Duroid 5880(tm) with dielectric constant of 2.2 and loss tangent of 0.09. It was simulated by using Ansoft HFSS17.0 software tool. The operating frequency of the antenna is 2.25GHz which is suitable for S-Band Applications.

Keywords: micro strip patch antenna, coaxial feed, wireless communication, S-Band, Directivity, Gain, HFSS17.0.

I. INTRODUCTION

Antennas are the key components of any wireless communication [1-2] systems. An antenna is a device that transmits and/or receives the electromagnetic waves. Micro strip antennas are often used where thickness and conformability to the host surfaces are the primary requirements. Since the patch antennas [3-4] can be directly printed onto a circuit board, these are becoming increasingly popular within the mobile phone market. They are low cost, have a low profile, ease of installation and are easily fabricated. Over the last few years, the circularly polarized micro strip antennas are widely used in the wireless communication applications, because they can be able to reduce the loss which is caused by the polarization misalignment between the receiver and transmitter antennas.

Micro strip patch antenna [4-8] is a metallic strip or patch mounted on a substrate which is supported by ground plane. In its simplest form, consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The patch which is to be radiated can be designed with a variety of shapes such as circular, triangular, square, semi-circular, sectroal, and annular rings shaped. But circular and rectangular configurations are the most commonly used configuration because of ease of analysis and fabrication. In this proposed system circular micro strip patch antenna is configured.

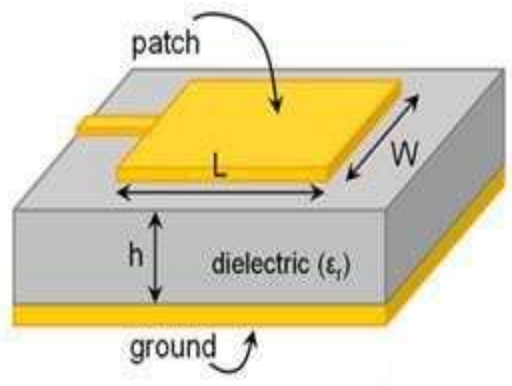

Fig 1: Micro Strip Patch Antenna.

The micro strip antenna had proved to be an excellent radiator for many applications because of its several advantages such as low fabrication cost, they support both circular and linear polarizations. But it also has some disadvantages such as low gain ,low efficiency; however some of them can be overcome using new techniques of feeding, configuration of the patch,etc.In order to obtain a more gain ,wide bandwidth and more directivity , we designed array of micro strip patch elements. Here in the proposed design coaxial feed [9-12] is used because it is easy to fabricate and has low spurious radiation. And it was simulated by HFSS V17 (High Frequency Structure Simulator) software tool. The proposed array of micro strip antenna operates on a frequency of 2.25GHz that supports S-band applications.

II. DESIGN SPECIFICATIONS

In order to design an antenna, our first step is to consider the specification of the antenna based on its application. The proposed antenna was designed for an operating frequency of 2.25GHz. FR4 substrate has a high loss tangent which will reduce the antenna efficiency .so in order to overcome this disadvantage we have chosen RT/ Duroid 5880 (tm)as a substrate for the proposed design which will have a low loss tangent of 0.009, so that it will not reduce the antenna efficiency. The dielectric constant is 2.2 for the proposed array of antenna design. From the following equations the proposed antenna dimensions are calculated

The width of antenna element:

$$w = \frac{c}{2 f_0 \sqrt{(\frac{\epsilon_r + 1}{2})}} ----(1)$$

Where, $c =$ Speed of light in free space

The length of antenna element:

$$L = L_{eff} - 2\nabla L ----(2)$$

Where,

$L_{eff} =$ The effective length $= \frac{c}{2 f_0 \sqrt{(\epsilon_{reff})}}$

$\epsilon_{reff} =$ The effective $\epsilon_r = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2\sqrt{(1+12\frac{h}{w})}}$

The various design parameters are listed in below table.

TABLE 1: SUMMARY OF DESIGN SPECIFICATIONS

DESIGN PARAMETER	VALUE
1.Frequency	2.25GHz
2.substrate	RT Duroid 5880(tm)
3.dielectric constant	2.2
4.Loss Tangent	0.009
5.Patch Length	40.5mm
6.Patch Width	48.4mm
7. Insert gap	2.434mm

III. ANTENNA ARRAY DESIGN

A. 1×1 Antenna Array Design

Here the single element micro strip patch antenna is designed. The width of the patch is 48.4mm and the length of the patch is 40.5mm. The insert gap is 2.434mm here coaxial feed is used. The design antenna is operated at 2.25GHz. After simulation the Return loss in dB, VSWR, Gain in dB, Directivity in dB are obtained which are shown in the below figures.

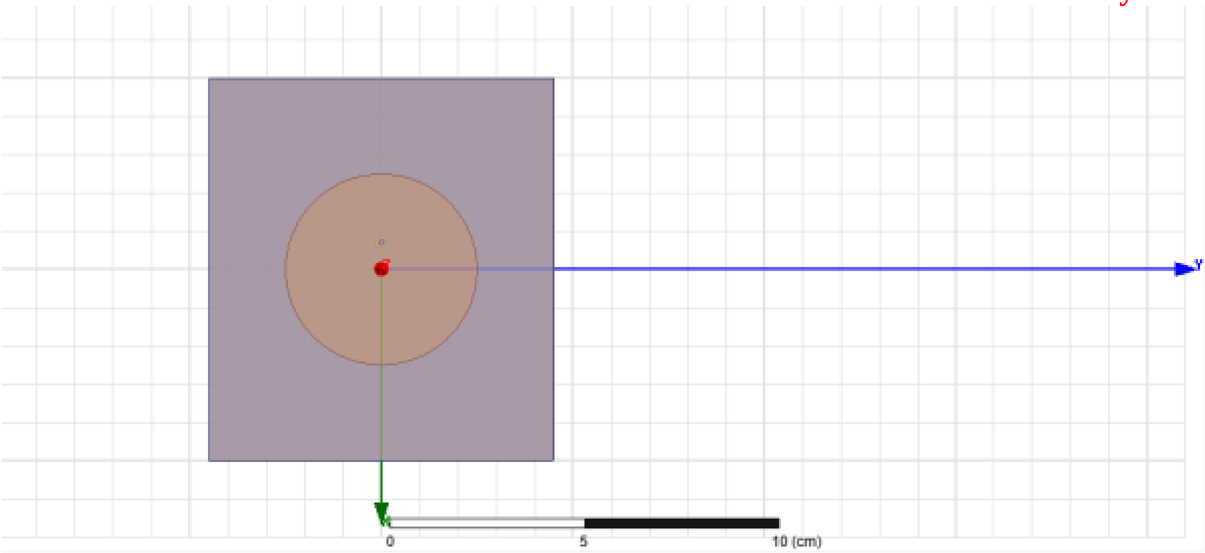

Fig 2: 1×1 Antenna Array

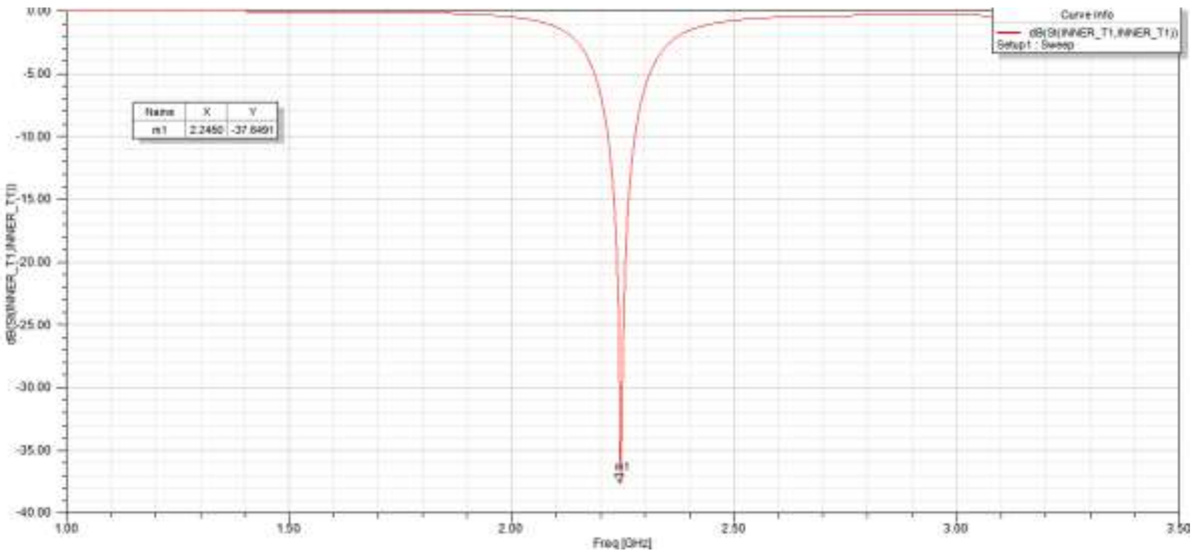

Fig 3: Return Loss of 1×1 Antenna Array

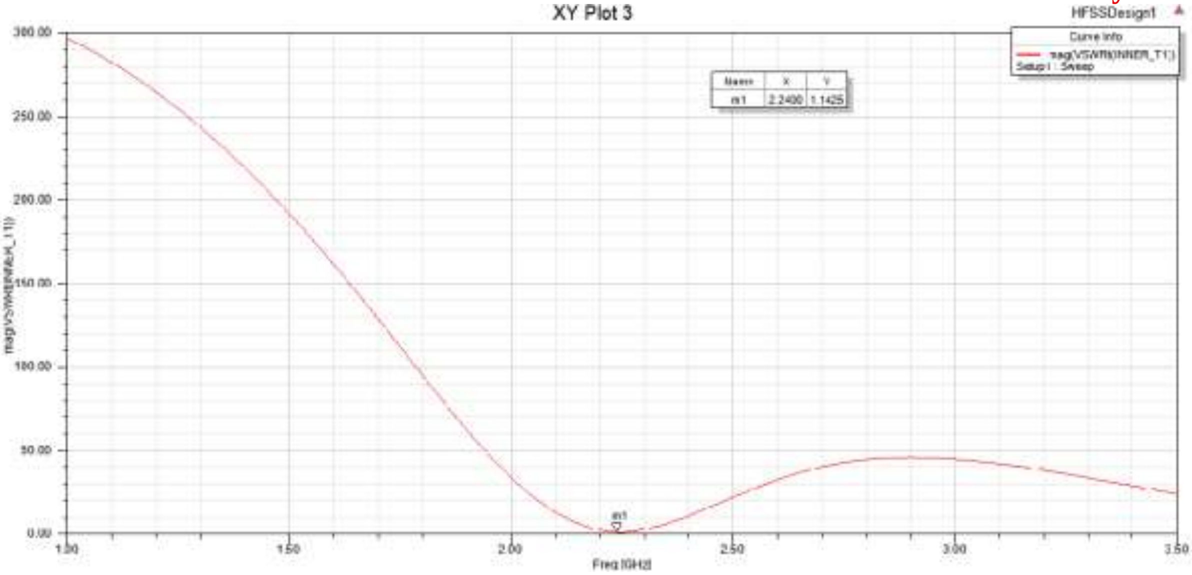

Fig 4: VSWR of 1×1 Antenna Array

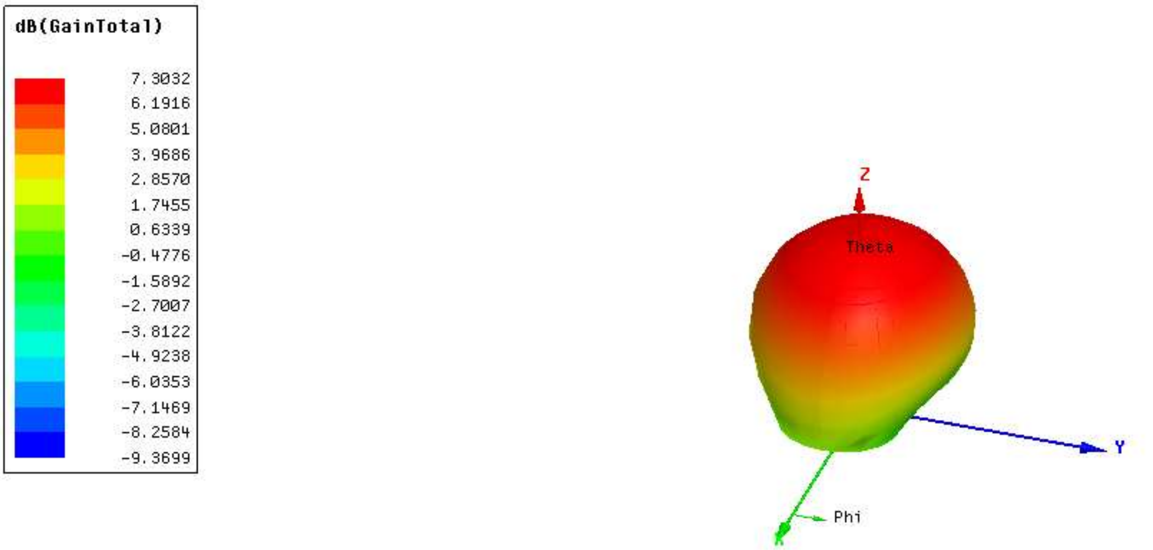

Fig 5: Gain of 1×1 Antenna Array

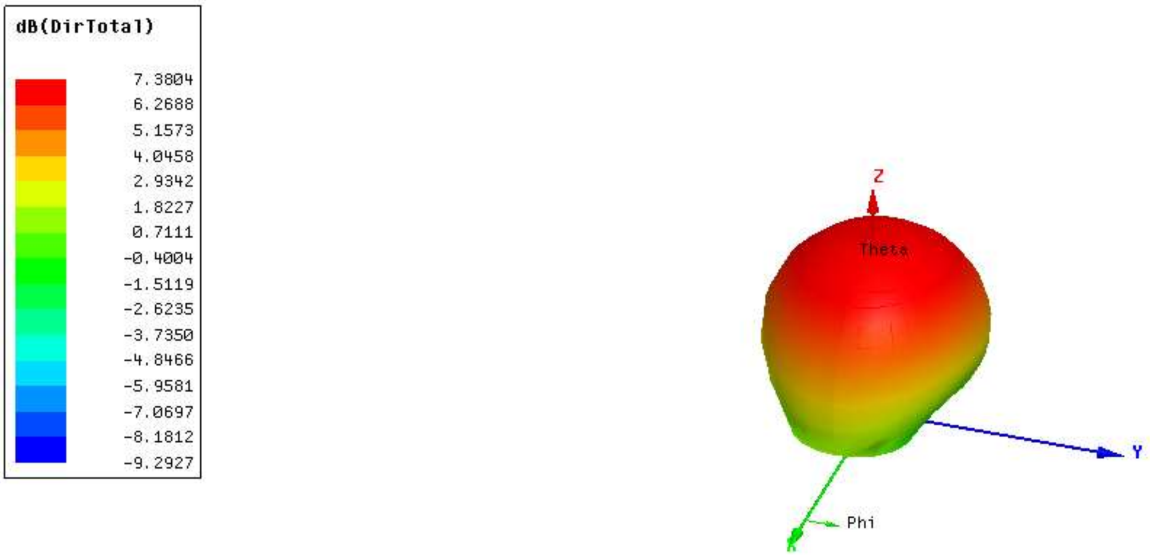

Fig 6: Directivity of 1×1 Antenna Array

B. 2×1 Antenna Array Design

Here two elements are used and each element has same dimensions which is mentioned above in order to increase the antenna performance. Width is 48.4mm and length is 40.5mm. Insert gap is 2.434mm. Here coaxial feed is used. The design antenna is operated at 2.25GHz. After simulation the Return loss in dB, VSWR, Gain in dB, Directivity in dB are obtained which are shown in the below figures.

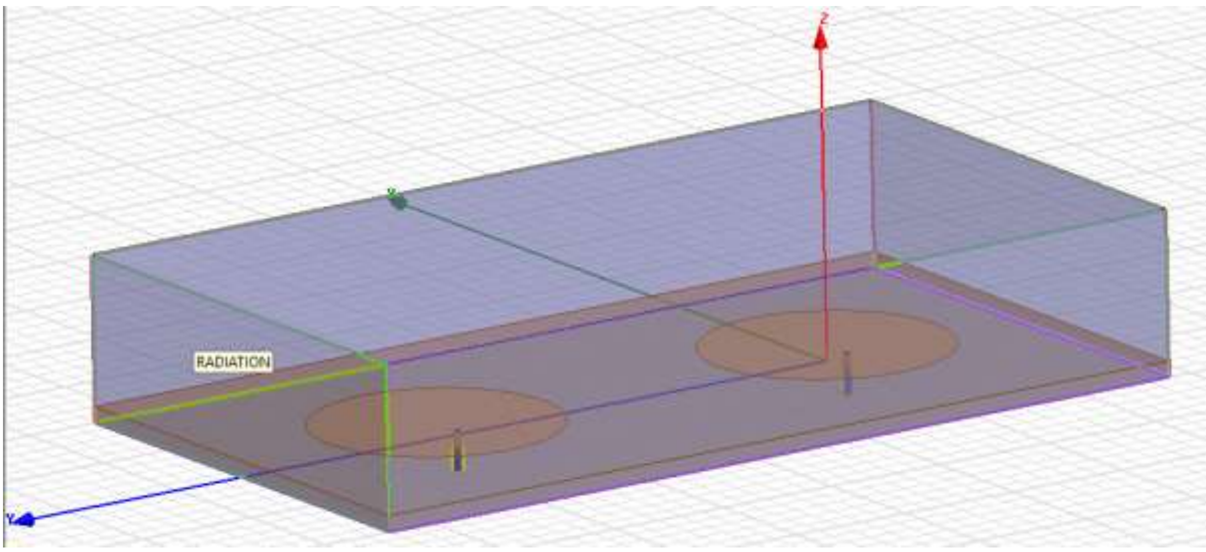

Fig 7: 2×1 Antenna Array

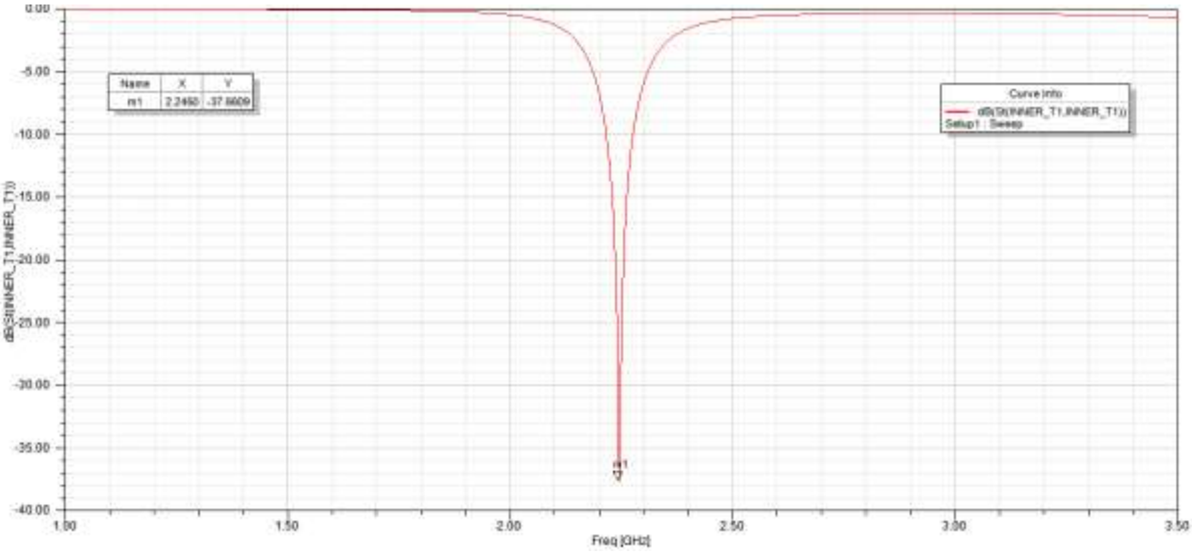

Fig 8: Return Loss of 2×1 Antenna Array

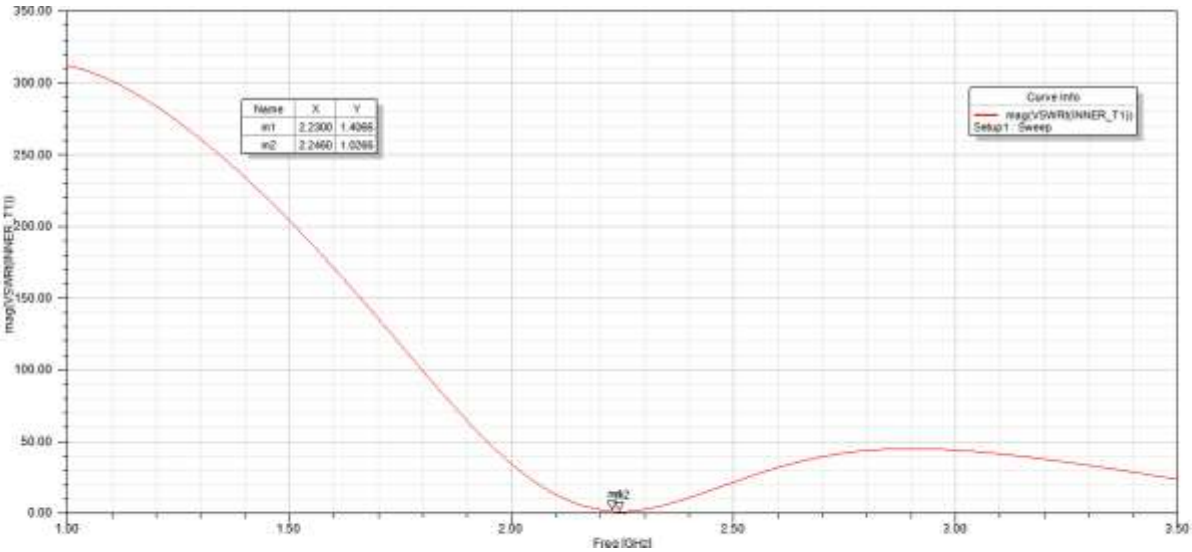

Fig 9: VSWR of 2×1 Antenna Array

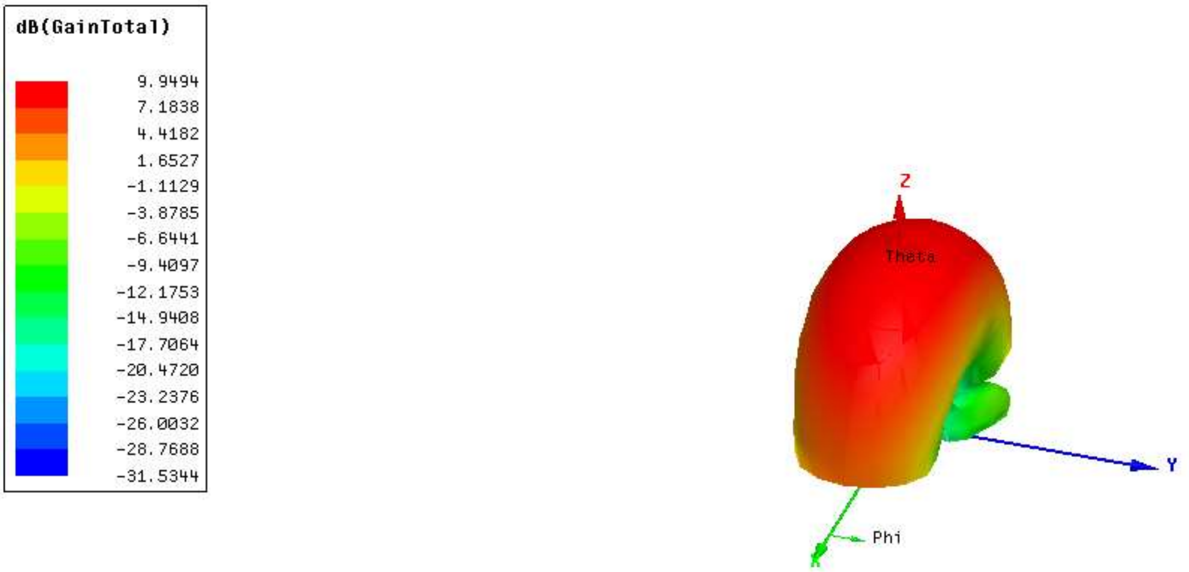

Fig 10: Gain of 2×1 Antenna Array

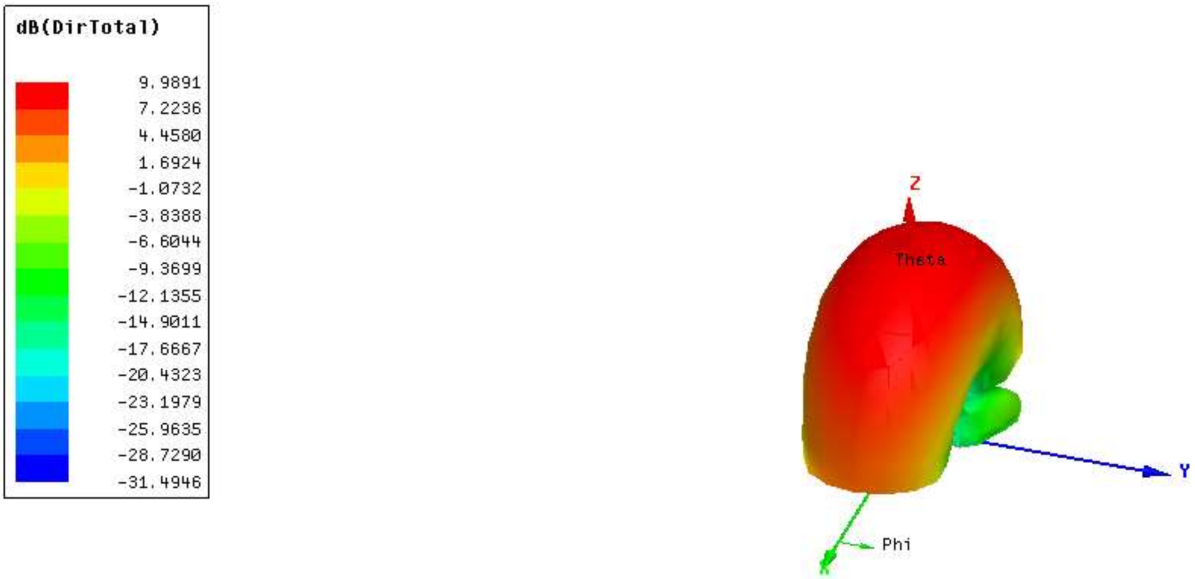

Fig 11: Directivity of 2×1 Antenna Array.

C. 2×2 Antenna Array Design

Here four elements are used and each element has same dimensions which is mentioned above in order to increase the antenna performance. Width is 48.4mm and length is 40.5mm. Insert gap is 2.434mm. Here coaxial feed is used. The design antenna is operated at 2.25GHz. After simulation the Return loss in dB, VSWR, Gain in dB, Directivity in dB are obtained which are shown in the below figures.

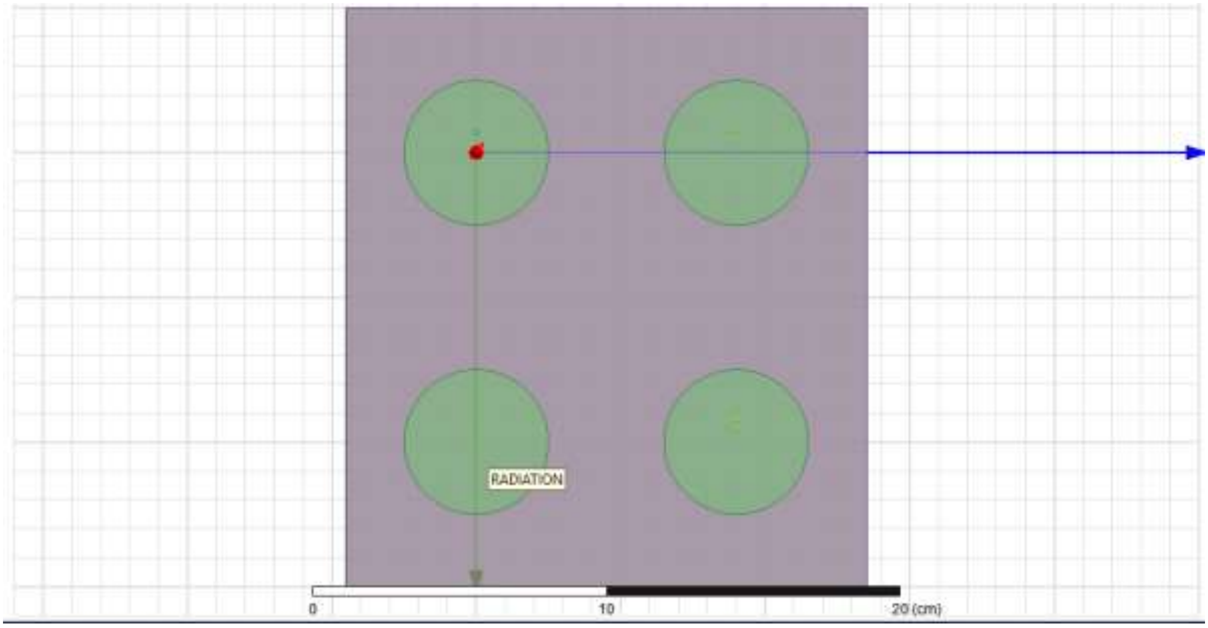

Fig 12: 2×2 Antenna Array

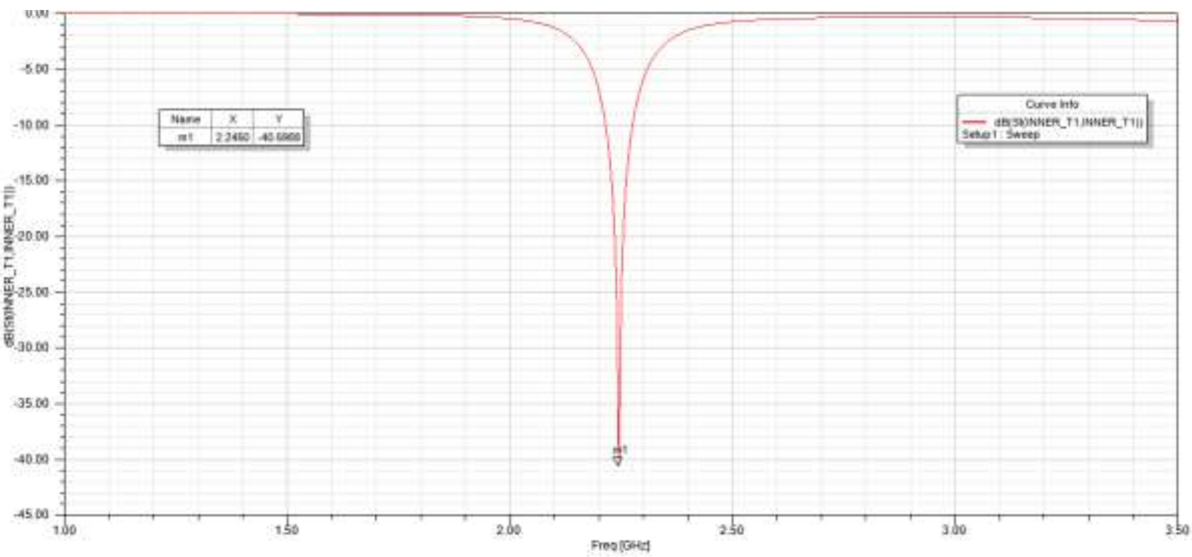

Fig 13: Return Loss of 2×2 Antenna Array

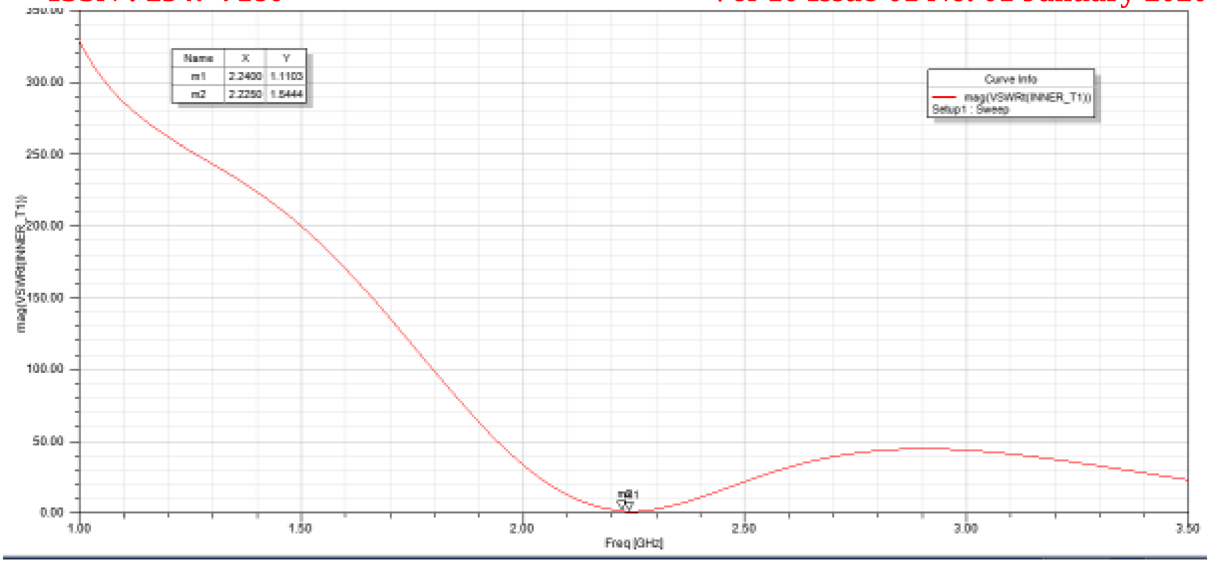

Fig 14: VSWR of 2×2 Antenna Array

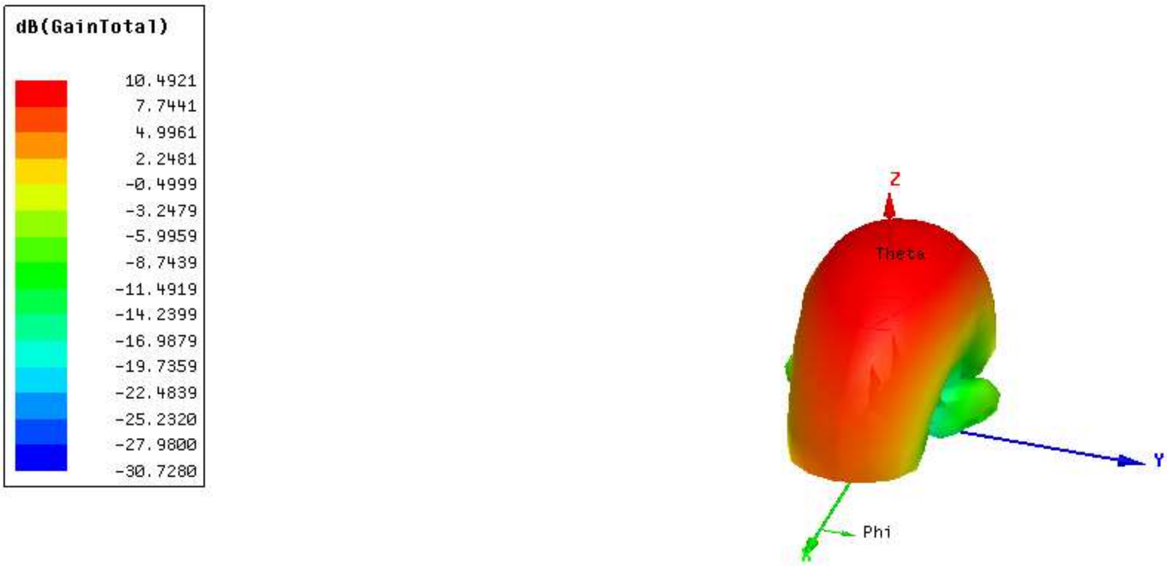

Fig 15: Gain of 2×2 Antenna Array

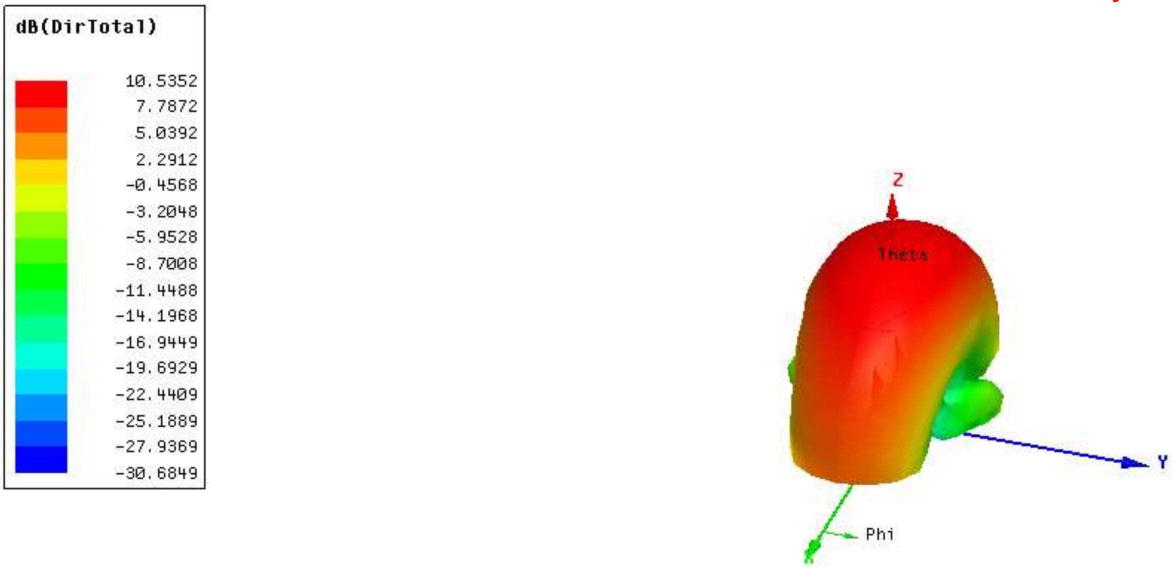

Fig 16: Directivity of 2×2 Antenna Array

D. 4×2 Antenna Array Design

Here eight elements are used and each element has same dimensions which is mentioned above in order to increase the antenna performance. Width is 48.4mm and length is 40.5mm. Insert gap is 2.434mm. Here coaxial feed is used. The design antenna is operated at 2.25GHz. After simulation the Return loss in dB, VSWR, Gain in dB, Directivity in dB are obtained which are shown in the below figures.

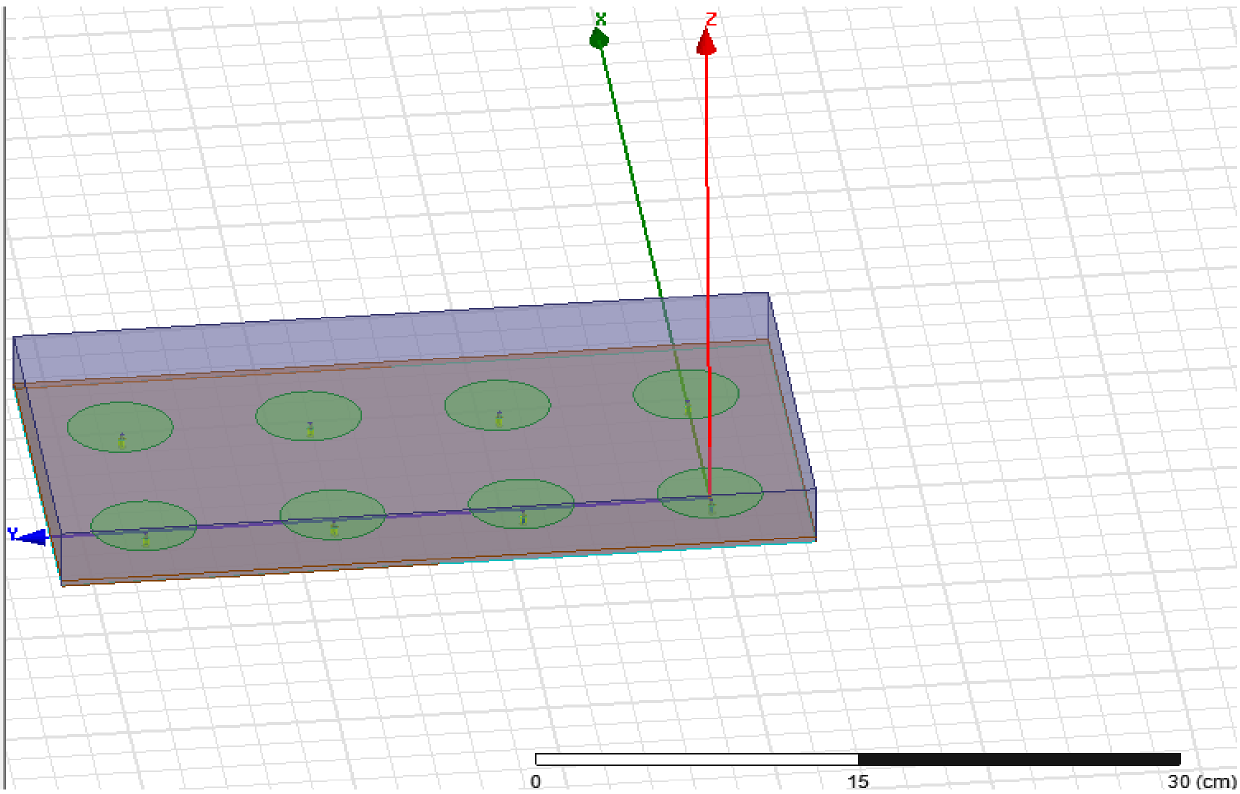

Fig 17: 4×2 Antenna Array

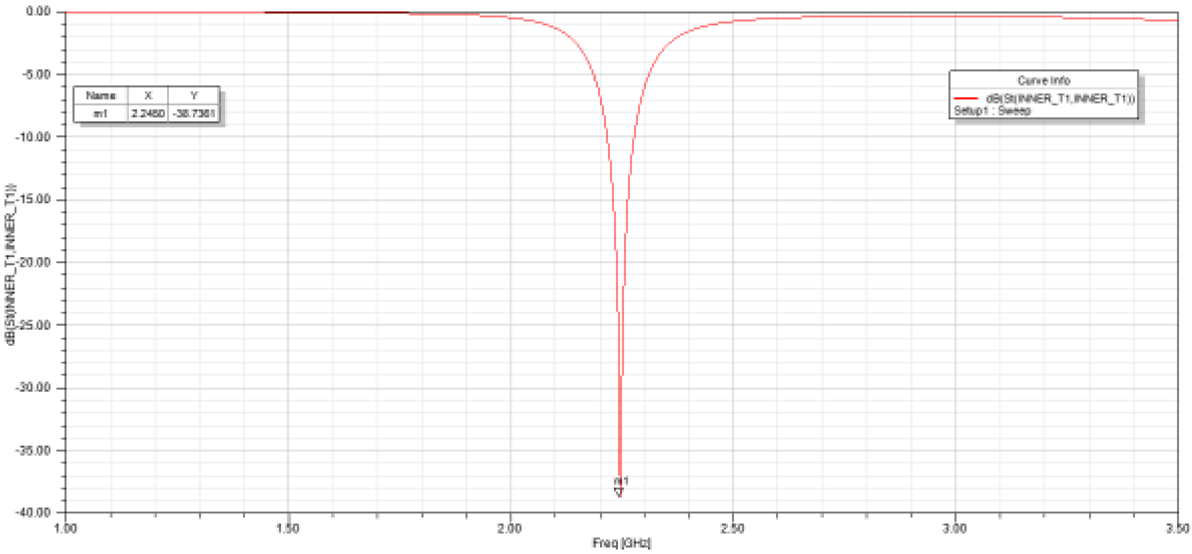

Fig 18: Return Loss of 4×2 Antenna Array

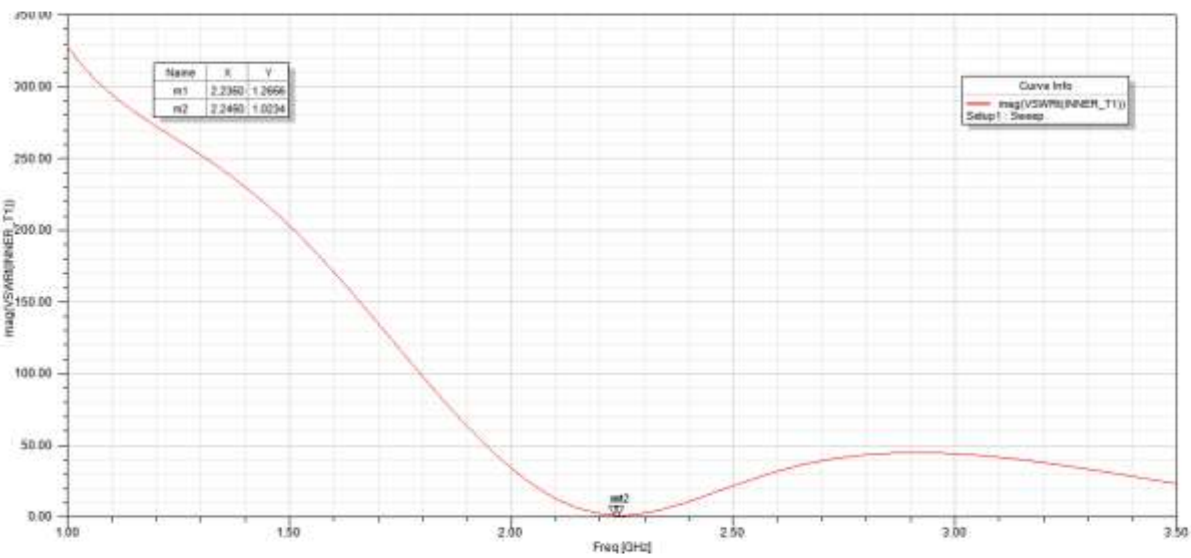

Fig 19: VSWR of 4×2 Antenna Array

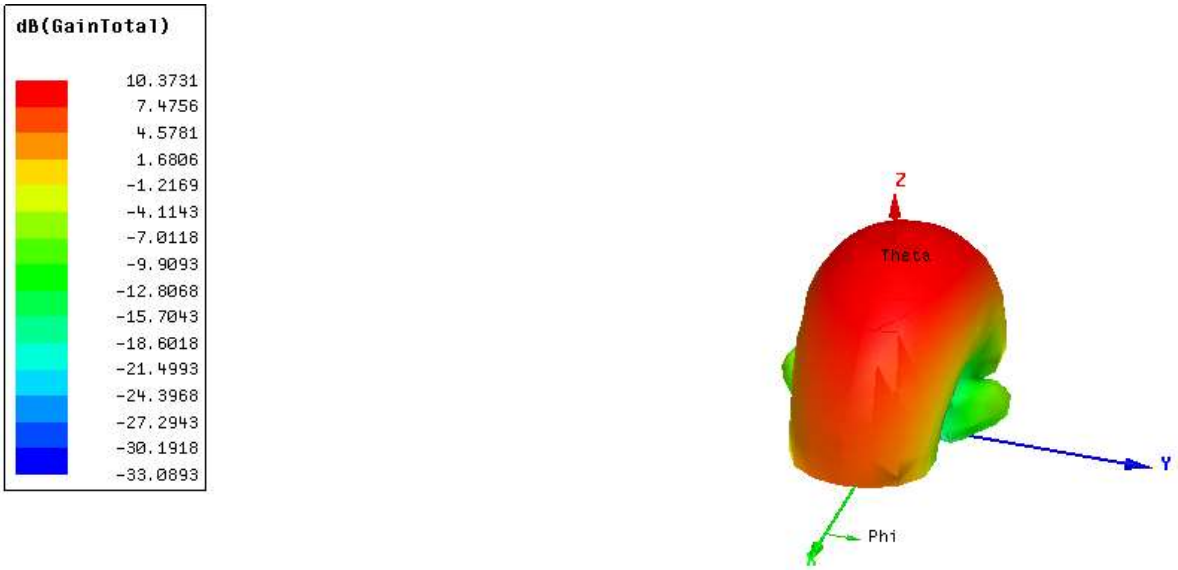

Fig 20: Gain of 4×2 Antenna Array

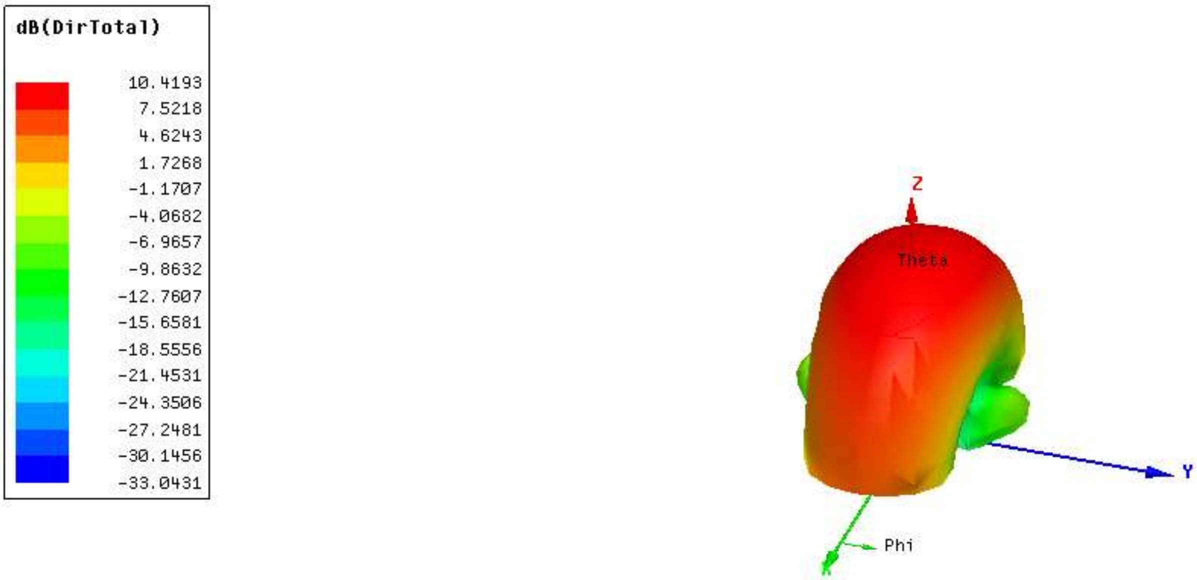

Fig 21: Directivity of 4×2 Antenna Array

IV. COMPARATIVE STUDY OF VARIOUS ANTENNA ARRAY DESIGNS.

After simulation of the designs, we got Return loss as -37.64dB, VSWR as 1.1425, Gain as 7.30dB, Directivity as 7.38dB for single element antenna at 2.25GHz. We got Return loss as -37.66dB, VSWR as 1.0265, Gain as 9.949dB, Directivity as 9.989dB for 2×1 Array element antenna at

2.25GHz. We got Return loss as -40.59dB, VSWR as 1.1103, Gain as 10.49dB, Directivity as 10.53dB for 2×2Array element antenna at 2.25GHz. We got Return loss as -38.7631dB, VSWR as 1.0234, Gain as 10.37dB, Directivity as 10.41dB for 4×2 Array element antenna at 2.25GHz.

TABLE 2: SUMMARY OF RESULTS OF MICROSTRIP ANTENNA ARRAY DESIGNS

Parameters	1×1	2×1	2×2	4×2
1.Return loss(dB)	-37.64	-37.66	-40.59	-38.7631
2.VSWR	1.1425	1.0265	1.1103	1.0234
3.Gain(dB)	7.3032	9.949	10.49	10.37
4.Directivity(dB)	7.3804	9.989	10.53	10.41

V. CONCLUSION

From the above results it is shown that the single element micro strip patch antenna has low gain and low directivity. In order to overcome this, the design of antenna arrays is proposed. As the number of elements is increasing, gain and directivity of antenna array is improved. The Micro strip patch array antenna is the convenience solution to enhance the performance of the antenna. The proposed array of micros trip antenna operates on a frequency of 2.25GHz that supports S-band applications.

REFERENCES

[1] J. C. Liberti, T. S. Rappaport, “Smart Antennas for Wireless Communications: IS-95 and Third Generation CDMA Applications”, Prentice Hall, New Jersey, 2020.

[2] H. F. AbuTarboush, H. S. Al-Raweshidy, “A Connected E Shape and U-Shape Dual-Band Patch Antenna for Different Wireless Applications”, the Second International EURASIP Workshop on RFID Technology, July, 2019.

[3] F. Yang, X. Zhang, Y. Rahmat-Samii, “Wide-band E-shaped patch antennas for wireless communications,” IEEE Trans. Antennas Propagation, vol. 49, 2018, pp. 1094-1100

[4] Kazi Tofayel Ahmed, Md. Bellal Hossain, Md. Javed Hossain, “Designing a high band width Patch Antenna and comparison with the former Patch Antennas”, Canadian Journal on Multimedia and Wireless Networks Vol. 2, No. 2, April 2017.

[5] Shackelford, A.K., Lee, K.F., and Luk, K.M.: “Design of small-size wide bandwidth

microstrip-patch antennas”, IEEE Antennas Propag. Mag.,AP-45, (1), pp.75– 83, 2013.

[6] AngYu, XuexiaZhang, “A Method to Enhance the Bandwidth of Microstrip Antennas Using a Modified E shaped patch,” Radio and Wireless Conference, pp. 261 – 264, August 2013.

[7] G.Kumar&K.P.Ray,“Broadband microstrip antennas”,Artech House,London, pp.11–14 2013,.

[8] D. M. Pozar, and D. H. Schaubert, “ Microstrip Antennas, the Analysis and Design of Microstrip Antennas and Arrays,” IEEE Press, New York, USA, 1995.

[9] Balanis C. A., “Antenna Theory, Analysis and Design,” 3rd ed. Hoboken, NJ: Wiley, 2005.

[10] J. R. James and P. S. Hall, “Handbook of microstrip antennas”, Peter Peregrinus, London, UK, 1985.

[11] MATLAB User Guide, The Math Works.

[12] Yikai Chen, Shiwen Yang, and Zaiping Nie, “Bandwidth enhancement method for low profile E-shaped microstrip patch antennas,” IEEE transactions on antennas and propagation, vol. 58, no. 7, July 2010.

[13] J. Huang, “The finite ground plane effect on the Microstrip Antenna radiation pattern,” IEEE Trans. Antennas Propagate, vol. AP-31, no. 7, pp. 649-653, 1983.

[14] Milligan, T. A.,“Modern Antenna Design”, John Wiley & New Jersey, 2005.