DESIGN AND ANALYSIS OF SINGEL AND 2X2 MICROSTRIP PATCH ARRAY ANTENNA FOR HIGH GAIN WIFI APPLICATIONS

[1]Dr. R PRASAD RAO, [2]S. PHANI VARAPRASAD, [3]A RAMANA BABU, [4]A HEMA KIRAN
[1]Professor, [2,3]Assistant Professor, [4]Student, B.Tech.
Department of Electronics & Communication Engineering, Avanthi Institute of Engineering & Technology - Autonomous, Tamaram , Makavarapalem, Anakapalli Dist., AP., India.

Abstract:

Microstrip patch antenna arrays play important role in aircraft, spacecraft and missile applications because of their lighter weight, low volume, low cost, low profile, smaller in dimensions besides easy installation and aerodynamic profile are constrains. This project presents a single and 2x2 Microstrip Patch array antenna of rectangular topology is designed to operate at S Band. The operating frequency of array is from 2 to 4 GHz. The antenna array has been designed and simulated using HFSS. The array antenna design at operating frequency 2.4 GHz, FR4 Substrate with dielectric constant of 4.4 and thickness of substrate 1.6mm. The designed antenna provides a return loss less than −10 dB and high gain 7.44 dB. The antenna performance using normal patch and with slits on patch are also compared in terms of Return loss, VSWR, Gain are measured to finalize the antenna design. The resonant frequency is chosen at 2.4GHz which is suitable for High Gain Wi-fi Application. HFSS is used to the software environment to design and compare the performance of the antennas. Based on the result analysis, it is noted that slit on rectangular patch array antenna offers higher bandwidth, higher radiation efficiency and directivity as compared with the rectangular Microstrip patch antenna shows smaller than the return loss of corporate feed rectangular patch array.

Keywords: Single and 2x2 microstrip patch Array antenna, , FR4_Epoxy substrate material, HFSS tool.

I. Introduction to Rectangular Microstrip Patch Antenna:

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. Various mathematical models were developed for this antenna and its applications were extended to many other fields. The number of papers, articles published in the journals for the last ten years, on these antennas shows the importance gained by them. The micro strip antennas are the present day antenna designer's choice. Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns. Various parameters of the microstrip antenna and its design considerations were discussed in the subsequent chapters. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch.

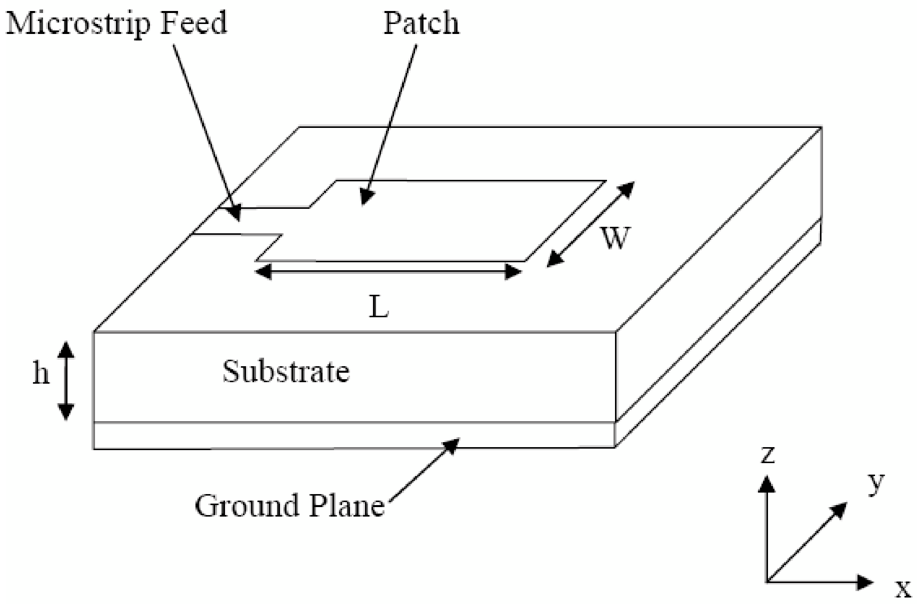


Fig. Single Microstrip Patch Antenna

Microstrip antenna array design: The performance of microstrip antenna increases based on the count of patch elements placed on the substrate.

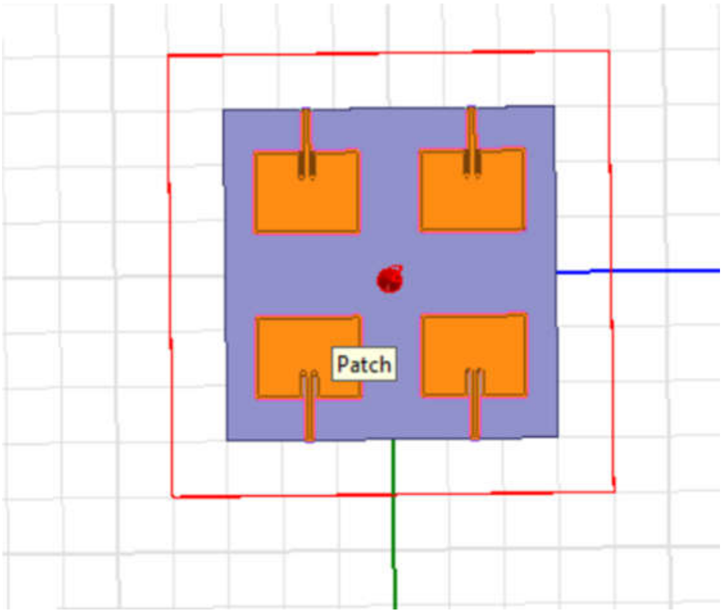


Fig. 2x2 Microstrip Patch Array Antenna

II. Designing of Rectangular Microstrip antenna:

To design a Rectangular microstrip patch antenna the Essential parameters are
1. The operating frequency (f0).
2. Dielectric Constant of substrate (Ɛr)
3. The height of the dielectric substrate (h).

Rectangular microstrip antenna designed based on the following equations

Step 1: Calculation of the width(W): $W = \frac{c}{2fr\sqrt{\frac{\varepsilon r+1}{2}}}$

 ISSN NO : 2347-3150

Step 2: calculation of effective dielectric constant ($Eeff$):

$$Eeff = \frac{(\epsilon r+1)}{2} + \frac{(\epsilon r-1)}{2}\sqrt{\frac{1}{\left(1+\frac{12h}{W}\right)}}$$

Step 3: calculation of extension length(ΔL):

$$\Delta L = 0.412h\frac{(Eeff+0.3)(\frac{W}{h}+0.264)}{(Eeff-0.258)(\frac{W}{h}+0.813)}$$

step 4: calculation of effective length (Leff):

$$Leff = \frac{c}{2fr\sqrt{Eeff}}$$

step 5: calculation of original length(L):

$$L = Leff - 2\Delta L$$

Step 6: calculation of length of the ground plane (Lg):

$$Lg = 6h + L$$

Step 7: calculation of width of the ground plane (Wg):

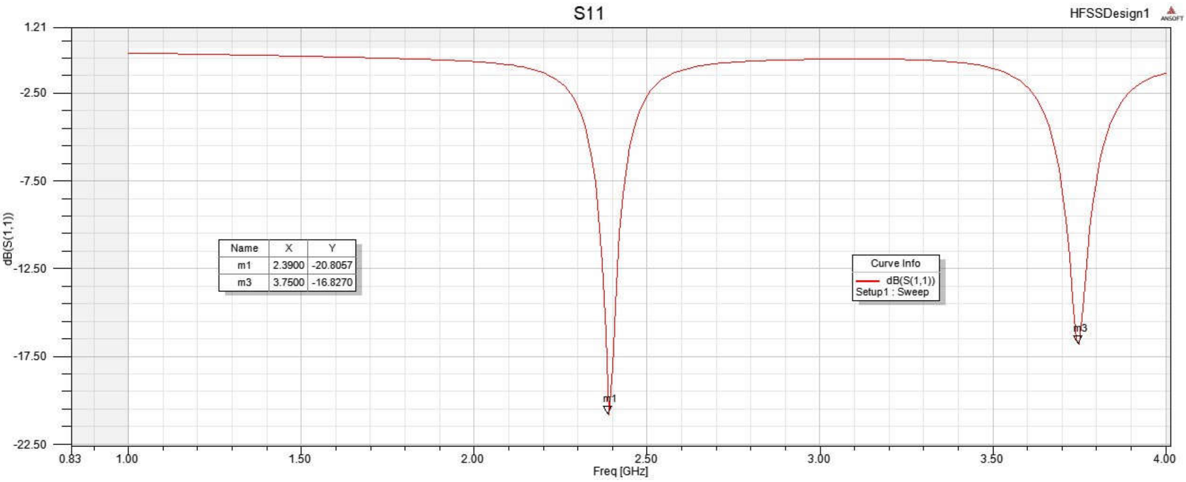
$$Wg = 6h + W$$

Step 8: Return Loss = -S11 = -10log*(|S11|)

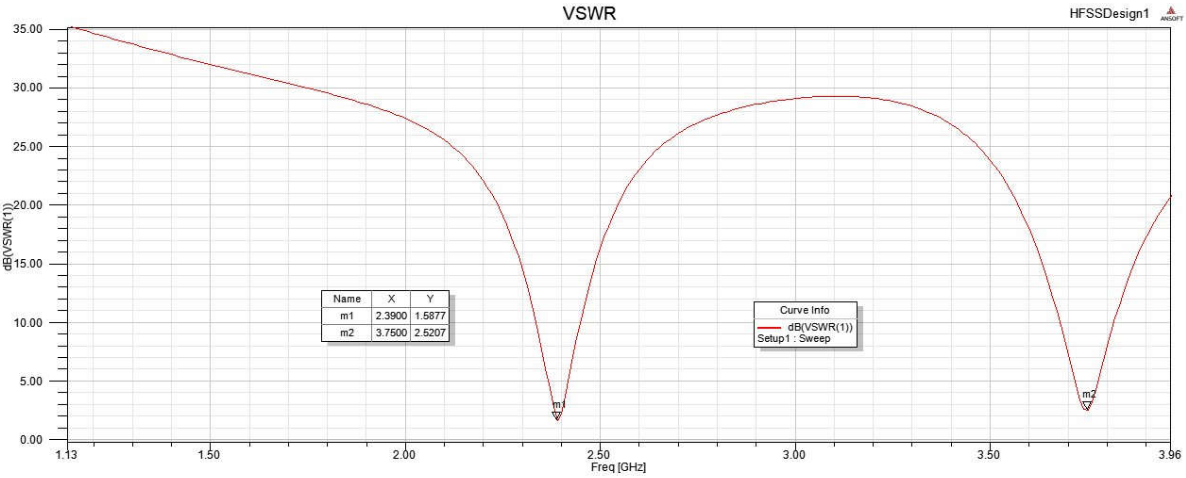
Design Parameters:

Parameter	Value
Width(W)	38.04 mm
Effective Dielectric Constant (E eff)	4.08 mm
Extension Length(ΔL)	0.73 mm
Effective Length (L eff)	30.92 mm
Original Length(L)	29.44 mm
Length of Ground Plane (L g)	39.04 mm
Width of Ground Plane (W g)	47.63 mm

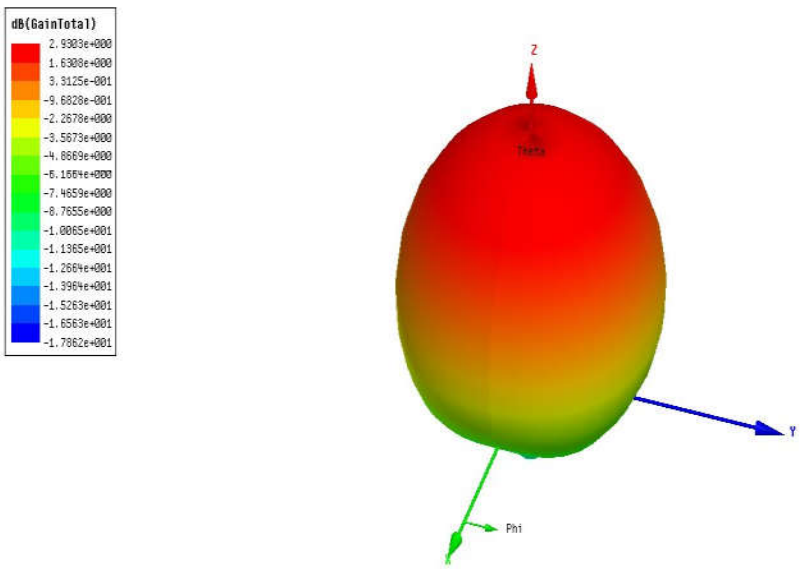
i). Return Losses: It is a parameter used to measure the power reflected by the antenna due to the mismatch of the transmission line and antenna. Lower value of the return loss provides the high efficiency of antenna.



ii). VSWR: VSWR stands for voltage standing wave ratio. It is defined as the ratio between the maximum value of standing wave voltage to its minimum value. The antenna with less VSWR has the better return loss compared to the other antenna.



iii). GAIN:



SIMULATION RESULTS

PARAMETER	SINGLE ANTENNA	CUTTING HOLES IN SINGLE PATCH	MICROSTRIP ARRAY	CUTTING HOLES IN MICROSTRIP ARRAY
RETURN LOSS (S11)	-17.16	-19.79	-26.56	-37.01
GAIN	2.93	1.88	7.44	1.89
VSWR (dB)	2.42	1.78	0.81	0.24

Table: Comparison of single Microstrip Patch and 2x2 Microstrip Patch Array Antenna with and without cutting holes on patch with different parameters

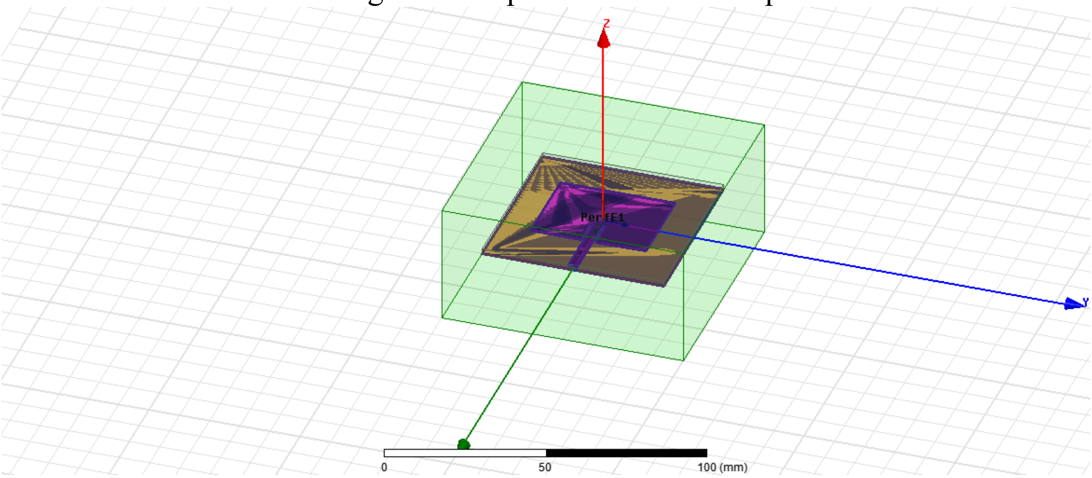


Fig. Designed Rectangular patch using HFSS

i). Return Losses:

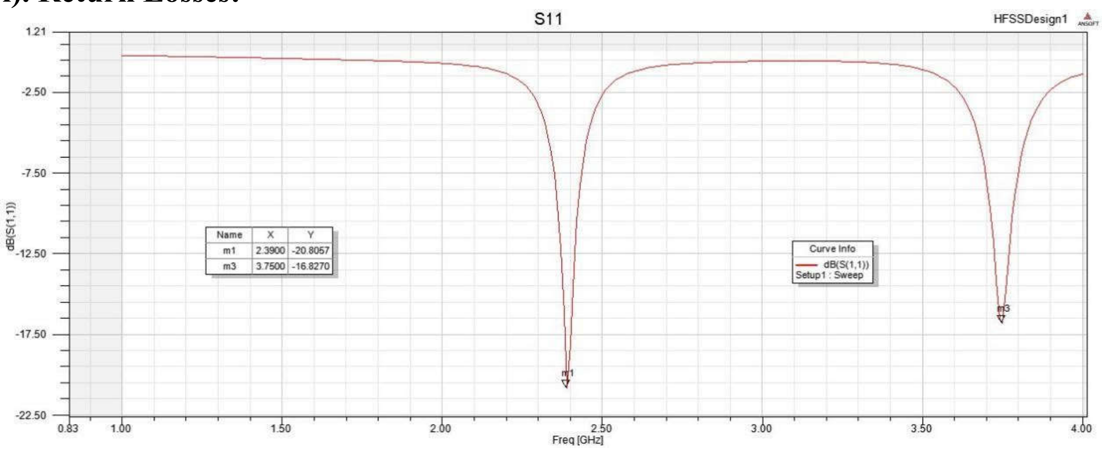


Fig. Return losses for Single patch MSPA

ii). VSWR:

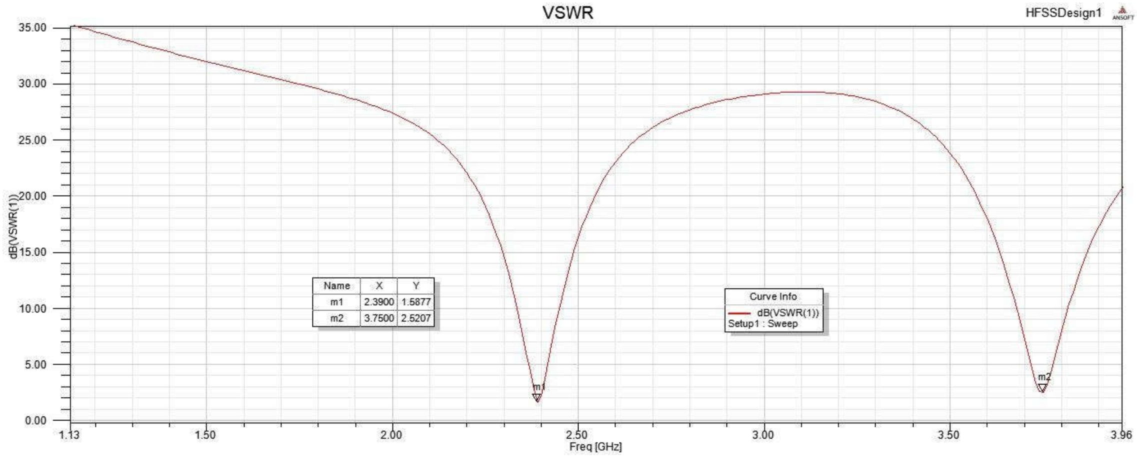


Fig. VSWR for Single patch MSPA

iii) Gain:

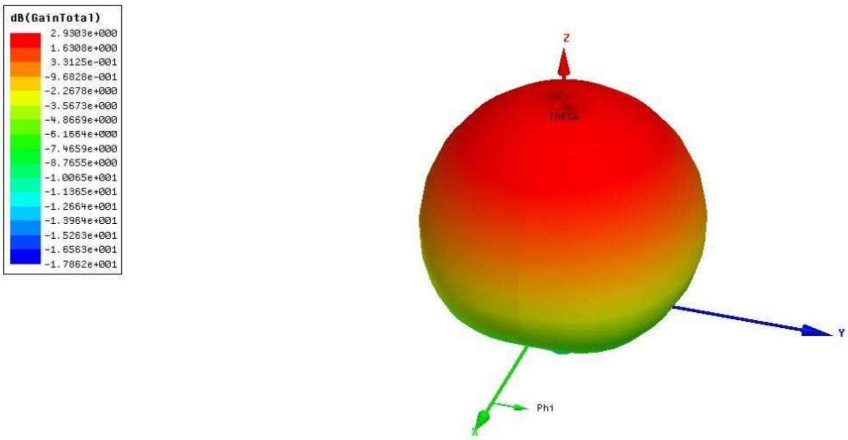


Fig. Gain for Single patch MSPA

Simulation Results of cutting holes on the patch

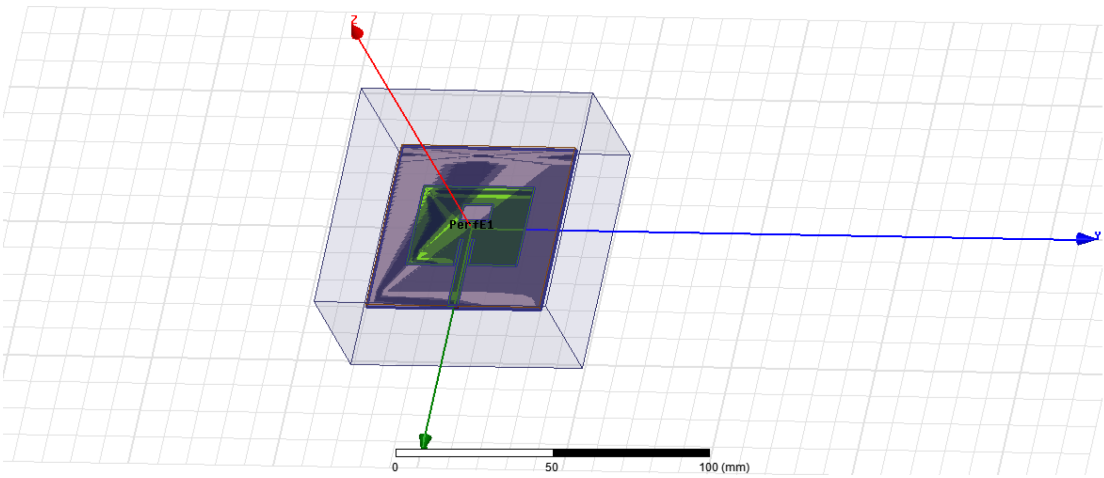


Fig. cutting holes on the patch for Single MSPA

i). Return Losses:

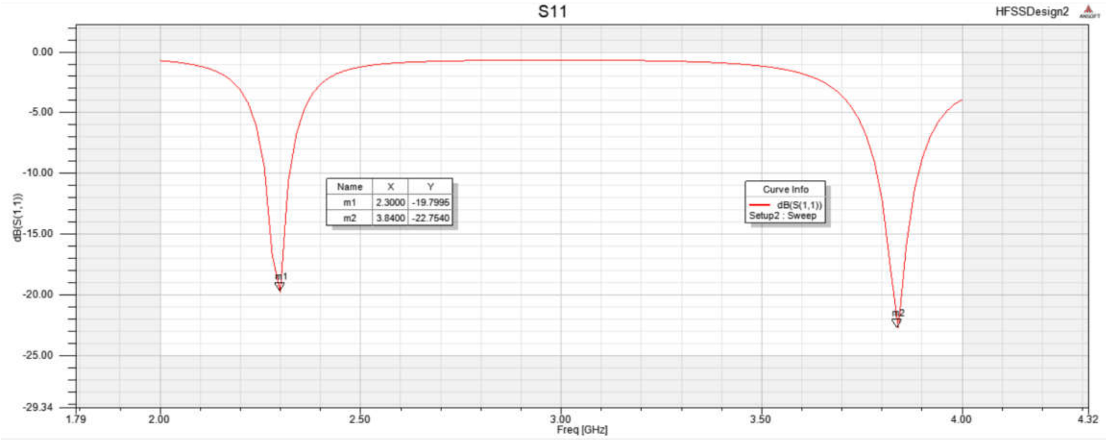


Fig. Return losses for Hole on patch for single MSPA

ii). VSWR:

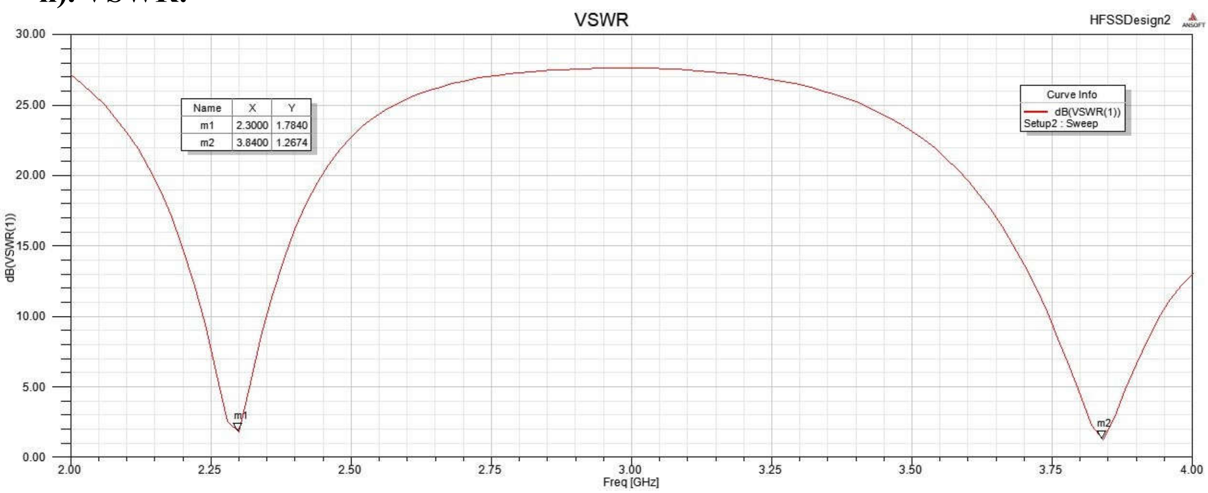


Fig. VSWR for Hole on patch for single MSPA

iii). Gain:

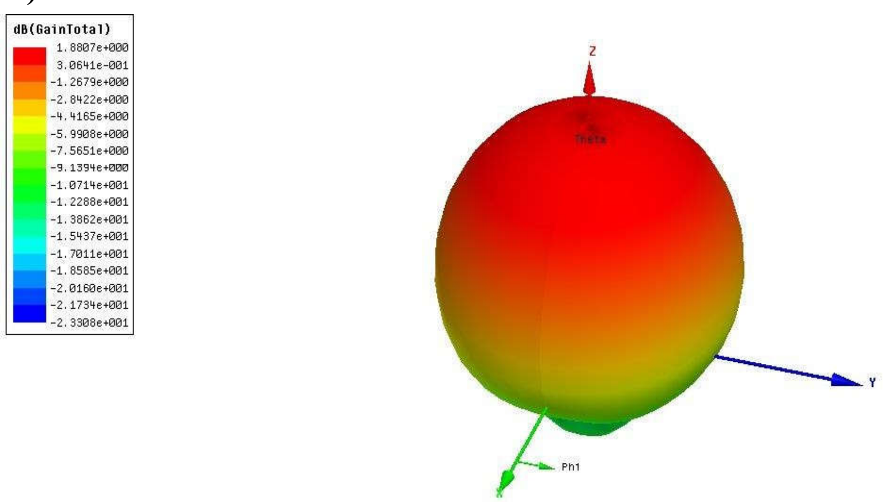


Fig. Gain for Hole on patch for single MSPA

Simulation Results for 2x2 Microstrip Patch Array Antenna

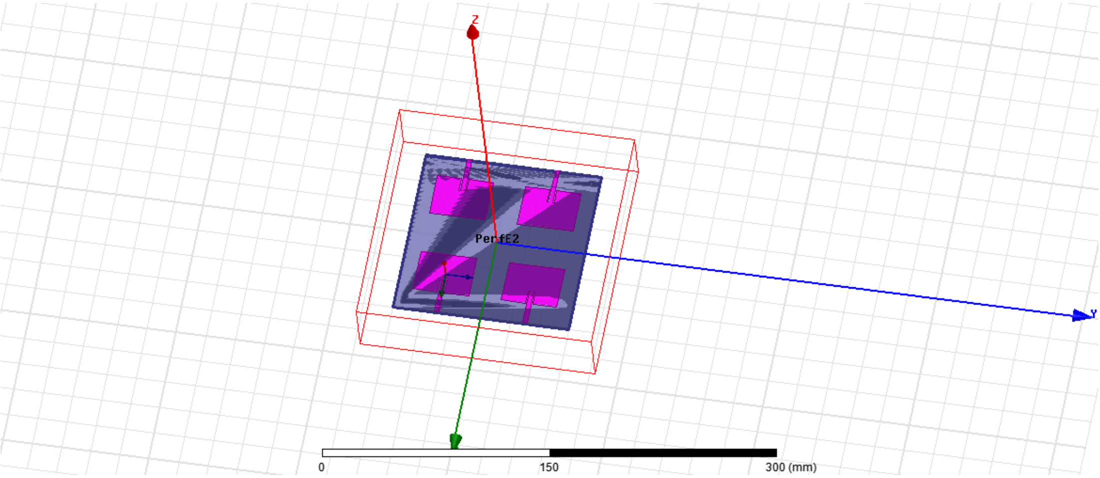


Fig. Designed patch 2x2 Microstrip Patch Array Antenna

i). Return Losses:

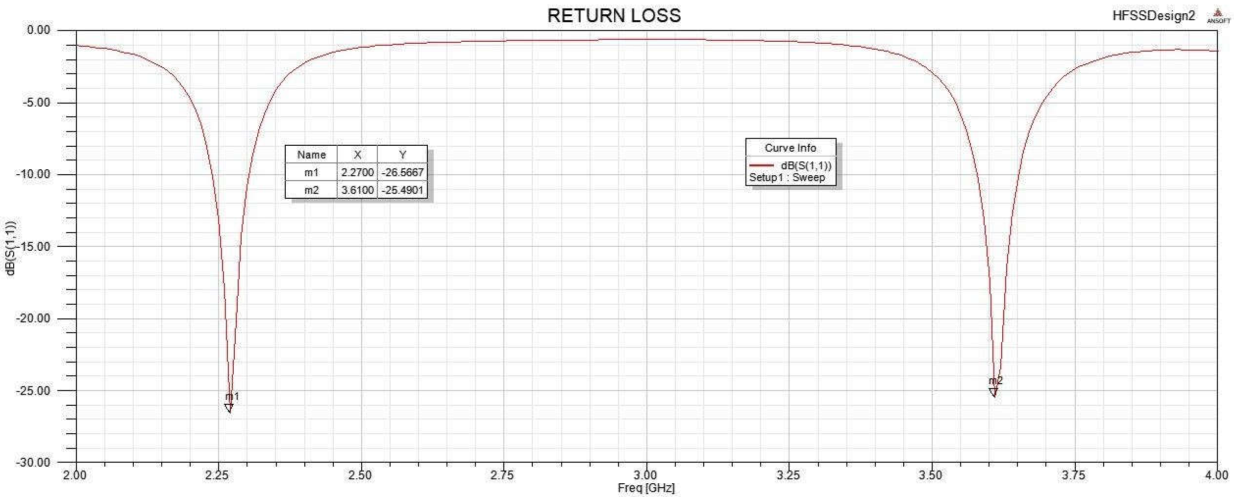


Fig. Return Losses for 2x2 Microstrip Patch Array Antenna

ii). VSWR:

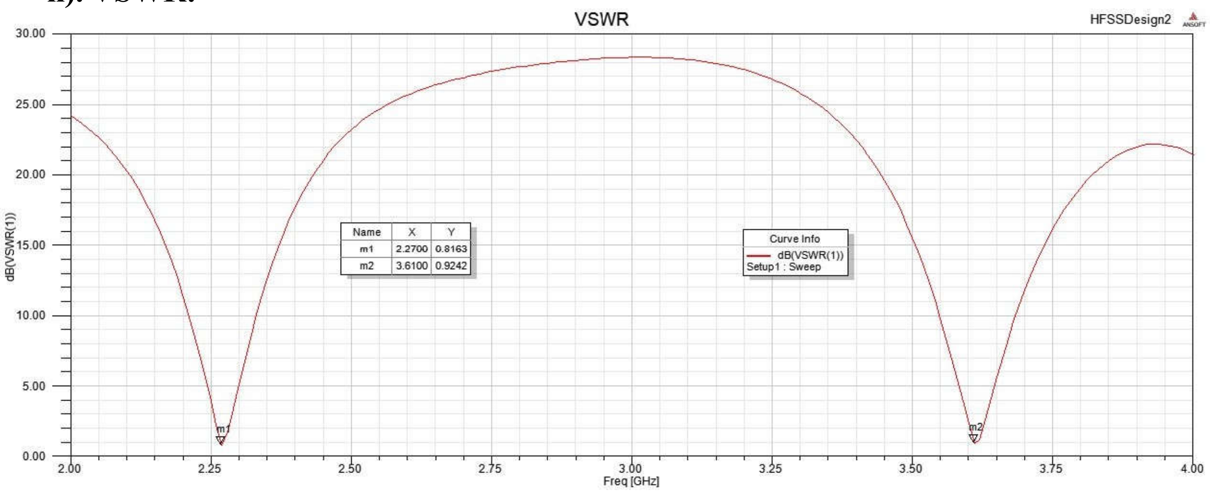


Fig. VSWR Losses for 2x2 Microstrip Patch Array Antenna

iii). Gain:

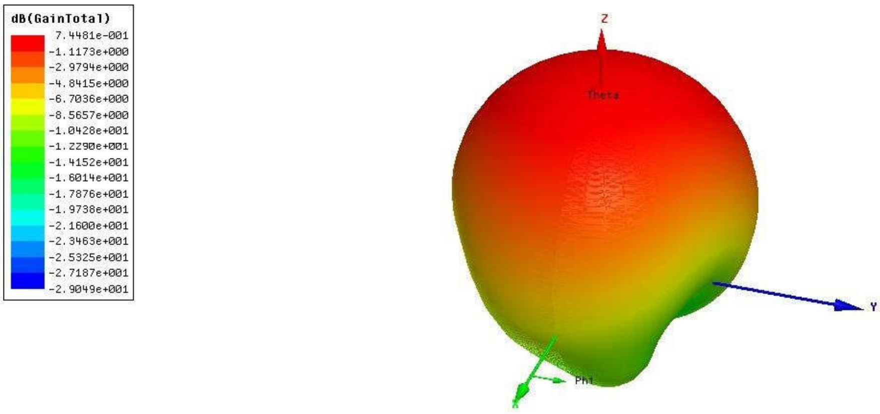


Fig. Gain for 2x2 Microstrip Patch Array Antenna

Simulation Results of Hole on patch of 2x2 Microstrip Patch Array Antenna

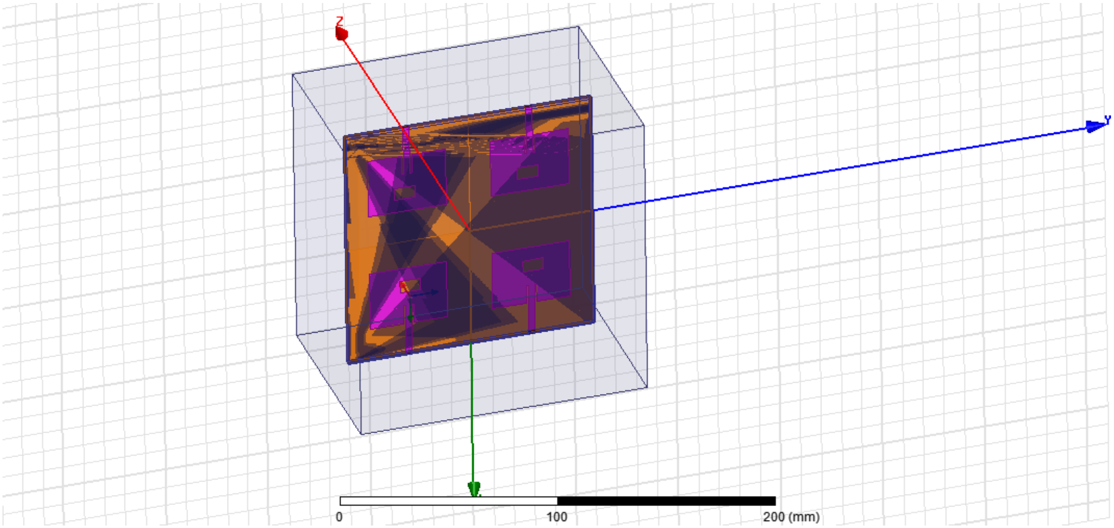


Fig. Designed cutting holes on patch 2x2 for Microstrip Patch Array Antenna

i). Return Loss:

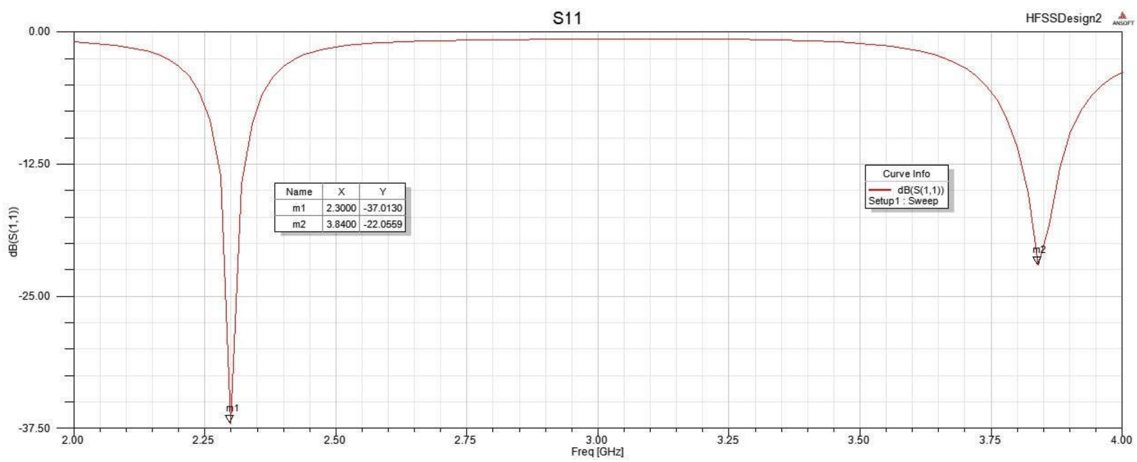


Fig. Return Losses for cutting holes on patch for 2x2 Microstrip Patch Array Antenna

ii). VSWR:

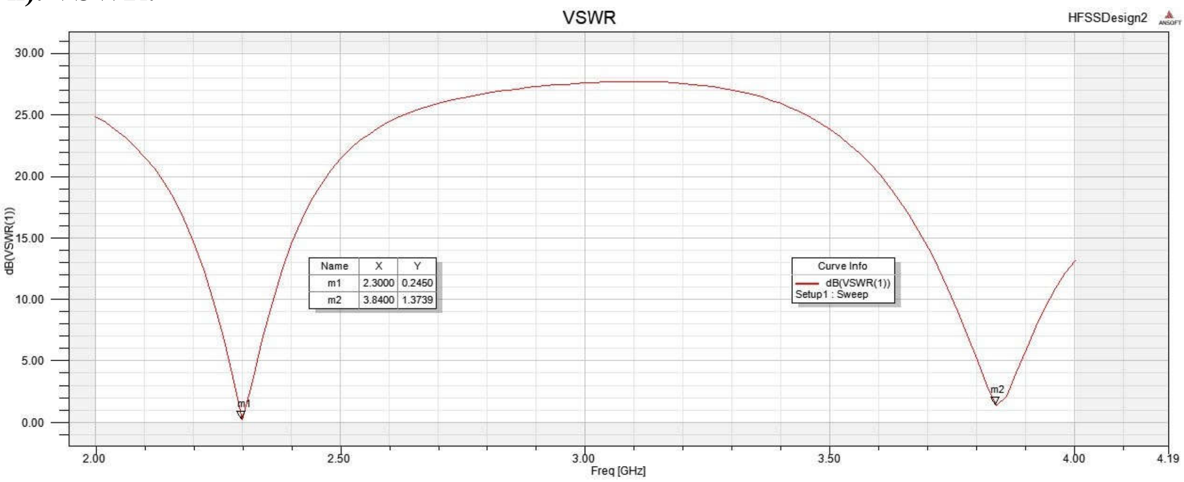


Fig. VSWR Losses for cutting holes on patch 2x2 for Microstrip Patch Array Antenna

iii). Gain:

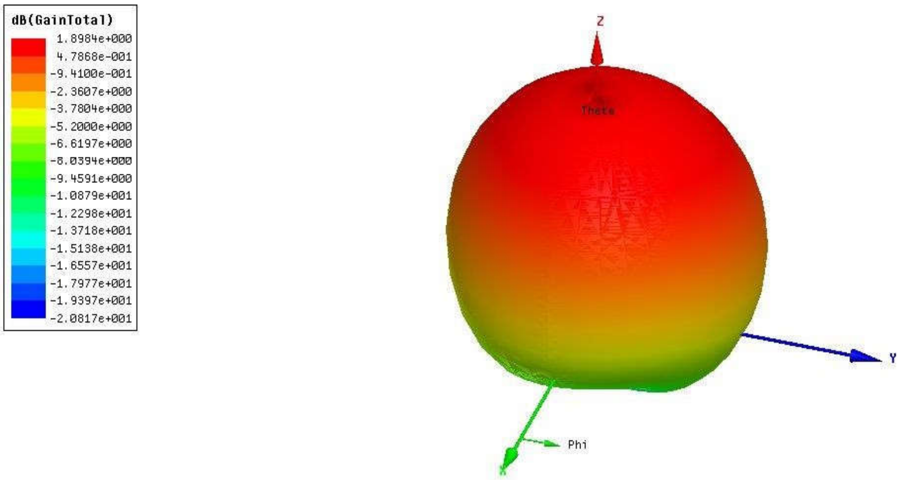


Fig. Gain Losses for cutting holes on patch 2x2 for Microstrip Patch Array Antenna

CONCLUSION

In this paper, comparison between a Single Microstrip Patch Antenna and 2x2 Microstrip Patch Array Antenna and also cutting holes on single Microstrip Patch Antenna and 2x2 Microstrip Patch Array Antenna, using the simulation results obtained from HFSS has been carried out. These three antenna configurations show quite good results on perspectives of Return Loss, VSWR, Gain for high gain Wi-Fi applications. In designing single and 2x2 array antennas for high gain Wi-Fi applications, the presence of holes on the patch significantly impacts performance. Antennas without holes tend to exhibit higher gain and lower VSWR compared to those with holes. The absence of holes contributes to better impedance matching, resulting in lower S11 values. However, antennas with holes might offer advantages in terms of size reduction or specific radiation pattern requirements. Ultimately, the choice between the two designs depends on the trade-offs between gain, VSWR, and other application specific factors such as size constraints and desired radiation characteristics.

REFERENCES

[1] Dr. R. Prasad Rao, "Design of Advanced Encryption Standard (AES) Algorithm for secure Applications", The International journal of analytical and experimental model analysis, May 2023.

[2] S. Phani varaprasad & R. Prasad raodesign and analysis of a multi layer substrate single patch microstrip patch antenna for enhancing the beam width with control on directivity iaset: International Journal of Electronics and Communication Engineering (IJECE) ISSN (P): 2278-9901; ISSN (E): 2278-991X Vol. 6, Issue 1, Dec - Jan 2017; 47-52 © IASET

[3] J. Shang ,Y. Yu "Efficient power Management and Delay Reduction in positive Feedback Comparator Design", Industrial Engineering Journal, May 2023.

[4] A . B.Mustafa, T.Rajendra "Design and analysis of U shape MSP Array Antenna for Satellite Applications using CST", JAC: A Journal of Composition Theory, May 2023.

[5] S. Phani varaprasad & p. Ashok kumar design and performance analysis of various parameters of single and multi layer of mspas International Journal of Electronics and Communication Engineering (ijece) issn (p): 2278–9901; issn (e): 2278–991x vol. 6, issue 6, oct–nov 2019, 1–6 © iaset

[6] Dr. R. Prasad Rao, "Design and Analysis of Rectangular & Circular Patch Array Antenna Using HFSS", Industrial Engineering Journal, April 2023.

[7] Dr. R. Prasad Rao, "Design and Analysis of Rectangular Patch Array Antenna Using HFSS", Industrial Engineering Journal, April 2023.

[8] Dr. R prasad rao, S. Phani varaprasad, R. ramana babu, N.manasa design and analysis of rectangular patch array antenna using hfss industrial engineering journal issn: 0970-2555 volume : 52, issue 4, april : 2023

[9] M.A.Afridi, A.B.Mustafa, "Antenna Array Synthesis for Controlled Side Lobes and Nulls Using Evolutionary Modified Differential Evolution", Jour of Adv Research in Dynamical and Control Systems, Vol. 12, No. 1, 2020.

[10] Dr. R. Prasad Rao, "Side Lobe Reduction of Micro Strip Array Antenna for Environmentally Safe Application Based on Modified Differential Evaluation Algorithm", pp: 5250-5264, Journal of Green Engineering (JGE), Volume-10, Issue-9,

2020.

[11] S. Phani varaprasad, CH. Vijayalakshmi Design and Analysis of A Multilayer Substrate Single Patch MSPA for Improving the Angular Width and Directivity for Mobile Applications© 2019 ijrar june 2019, volume 6, issue 2

[12] T.Rajendran ,J.G.Santas, “Synthesis of A periodic Antenna Array with Minimum Side lobe Levels Using Modified Differential Evolution”, International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-8 Issue-5, March, 2019.

[13] A. Alomainy “Minimization of Side Lobe Level for Linear Antenna Arrays Using Improved Particle Swarm Optimization, 247- 252”, International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-8 Issue-5, 2017.

[14] Dr. R. Prasad Rao,“Design and Analysis of a Multilayer Substrate Single Patch Microstrip Patch Antenna for Enhancing the Beamwidth with Control on Directivity, Vol. 6, Issue 1”, IASET: International Journal of Electronics and Communication Engineering, Volume-8 Issue-5, 2017.

[15] Y.C.Guo, Q.Y. Song, “Implementation of Efficient CSLA using D-LATCH approach, 781-785”, International Journal of VLSI System Design and Communication Systems 2017.

[16] Dr. R. Prasad Rao, “Design and Analysis of Multi Substrate Microstrip Patch Antenna, 733-739”, 2017.

[17] C.Ahumada,A.Alominy, “High Speed Architecture Design of Viterbi Decoder using Verilog HDL, 4650-4656”, International Journal of Engineering Trends and Technology (IJETT), Vol. 4 No.10, 2017.

[18] Dr. R. Prasad Rao,“Design and analysis of 16-bit Full Adder using Spartan-3 FPGA”, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), Vol.1, No.7, 2013.