International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

Design of Inset Feed Rectangular Microstrip Patch Antenna with Different Dielectric Substrates

V. Saidulu

Abstract: ***Microstrip antennas find wide applications in high-speed vehicles, and missiles, tanks, satellite communications, mobile communications and wireless communications etc. The main advantage of these antennas over conventional microwave antenna is light weight, low volume, low cost, planar structure and compatibility with integrated circuits. The present paper deals with the design and simulation of an inset feed rectangular microstrip patch antenna using different dielectric substrate materials such as Arlon AD320, FR4 (Epoxy glass) and Vaccum (Air) and having dielectric constant (ϵ_r)= 3.2, 4.4 and 1.0 respectively and also comparing their performance characteristics. The resonant frequency of the proposed antenna is designed at frequency of 1.9 GHz, which is lying in the L-band region. The antenna software such as High Frequency Structure Simulator is used for designing of proposed antenna. The simulation results shows the maximum bandwidth is 40MHz and minimum gain is 2dB is obtained using FR4 (Epoxy-glass) substrate whose dielectric constant (ϵ_r) = 4.4, at which return loss is -35.67dB. Maximum gain is 9.72dB and bandwidth is 39MHz obtained using Vaccum (Air), whose dielectric constant (ϵ_r) = 1.0. However, 6 dB gain and 25MHz bandwidth is obtained using Arlon AD 320A substrate, whose dielectric constant (ϵ_r) = 2.2 at which return loss is obtained -24.57dB. The proposed antenna can be used for military telemetry, GPS, mobile phone (GSM) and amateur radio applications.***

Keywords: Bandwidth, beam-width, Gain, Inset feed, Patch antenna, Radiation pattern, Return loss.

I. INTRODUCTION

Microstrip patch antenna is popularly called a printed antenna. Microstrip antenna is used for satellite, military, aerospace, command control, mobile and wireless communication applications. Because of smaller size, light weight, low profile [1]. The microstrip antenna as compared over conventional microwave antennas is easy to design and fabricated on printed circuit board (PCB) [2]. The microstrip patch antenna is also have some disadvantages compared over conventional microwave antennas such as low gain due to loss and also low bandwidth.

Revised Manuscript Received on March 30, 2020.
* Correspondence Author
V. Saidulu, Associate Professor ECE Department Mahatma Gandhi Institute of Technology Gandipet, Hyderabad. saiduluvadtya@gmail.com.

The bandwidth of microstrip patch antenna is increasing by stacking method [1]-[2]. Stacking means antenna consists of driven element and one or more parasitic elements. This paper mainly focused on the design and simulation of inset feed rectangular microstrip patch antenna using different dielectric substrates and also comparing their performance characteristics. The simulation results shows the maximum bandwidth is 40MHz and minimum gain is 2dB is obtained using FR4 (Epoxy-glass) substrate whose dielectric constant (ϵ_r) = 4.4, at which return loss is found -35.67dB and maximum gain and bandwidth 9.72dB and 39MHz is obtained at Vaccum (Air), whose dielectric constant (ϵ_r) = 1.0. However, 6 dB gain and 25MHz bandwidth is obtained at Arlon AD 320A, whose dielectric constant (ϵ_r) = 2.2 at which return loss is -24.57dB. Geometry of rectangular microstrip patch antenna is shown in Fig.1. The proposed antenna can be used for military telemetry, GPS, mobile phone (GSM) and amateur radio applications.

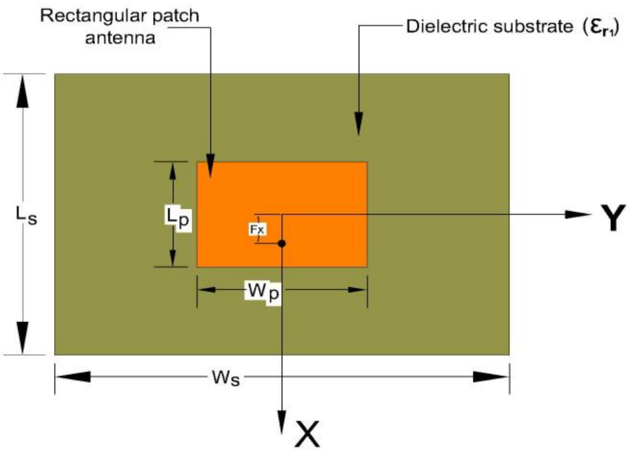
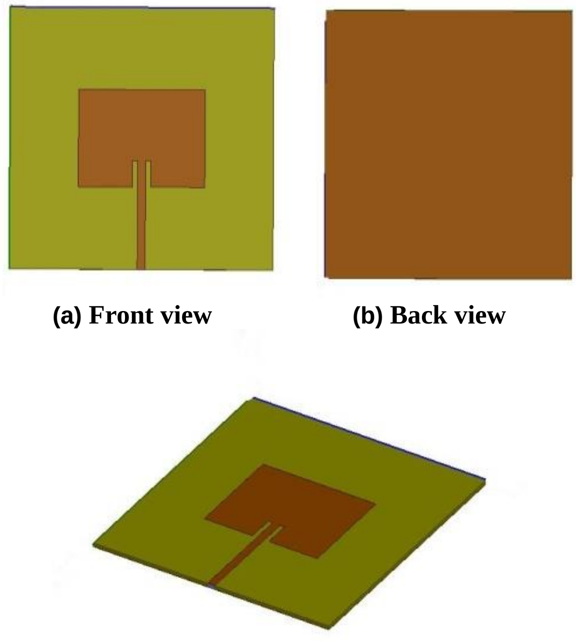


Fig. 1 Geometry of rectangular microstrip patch antenna with FR4 substrate (W_P= 48 mm, L_P=37.2 mm, F_X=10.5 mm, F_Y=0)

II. INSET FEED MICROSTRIP ANTENNA DESIGN

The transmission line model is used for designing of inset feed rectangular microstrip patch [2], the layout structure of microstrip patch antenna is shown in Fig.2. The selection of dielectric substrate and operating frequency is most important for designing of any antenna. Frequency operation of proposed antenna is designed at frequency of 1.9GHz .

The higher the dielectric constant material gives more losses and low efficiency as compared with low dielectric constant of the substrate materials [1]-[5]. The three different dielectric substrate materials such as Arlon AD320A, FR4 (Epoxy glass) and Vaccum (Air) is used for designing of inset feed microstrip patch antenna and corresponding their dielectric constant (ϵ_r) =3.2, 4.4 and 1.0 respectively. The material used for ground plane and patch is copper, which is a good conductor [6]-[13]. The designing dimension of rectangular microstrip patch antenna using different substrate materials is shown in Table 1.



(a) Front view (b) Back view

(c) 3D view

Fig.2 Layout structure of inset feed microstrip patch antenna

Table -1: Design of antenna parameters

Parameters	FR4_epoxy	Arlon AD320A	Vaccum(AIR)
Ground width(W_g)	100mm	100mm	120mm
Ground length(L_g)	100mm	100mm	120mm
Height(h)	1.6mm	1.6mm	3mm
Patch width(W_p)	48mm	52mm	84.5mm
Patch length(L_p)	37.2mm	44.3mm	74.5mm
Relative permittivity	4.4	3.2	1

III. RESULTS AND DISCUSSION

The designs of a rectangular microstrip patch antenna using High Frequency Simulation Software. The radiation pattern, half power beam width, gain and return loss of the proposed antennas are shown for different substrates. The proposed rectangular microstrip antenna of single element is designed. The performance of inset feed rectangular microstrip patch antenna has been studied using three different substrate materials for following the case.

A. Antenna performance with FR4 (Epoxy-Glass) substrate

The proposed rectangular microstrip antenna of single element is designed with FR4 (Epoxy glass) substrate material whose permittivity of 4.4 and loss tangent is 0.02. The return loss and VSWR plot is shown in Figs.3 and 4. From Fig.3, observed return loss, resonating frequency and bandwidth. Simulations are carried out at a frequency range of 1.9GHz with a frequency step size of 5 GHz. Fig. 3, shows the simulated return loss plots of microstrip patch antenna with FR4 (Epoxy glass) substrate. As depicted by the simulation results, antenna resonates at a frequency of 1.9GHz, exhibits a return loss of -35.67dB and bandwidth of 40MHz.

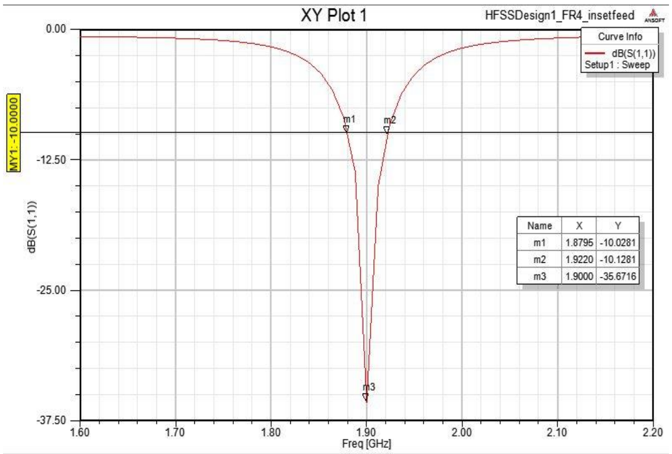


Fig.3 Return loss of Antenna

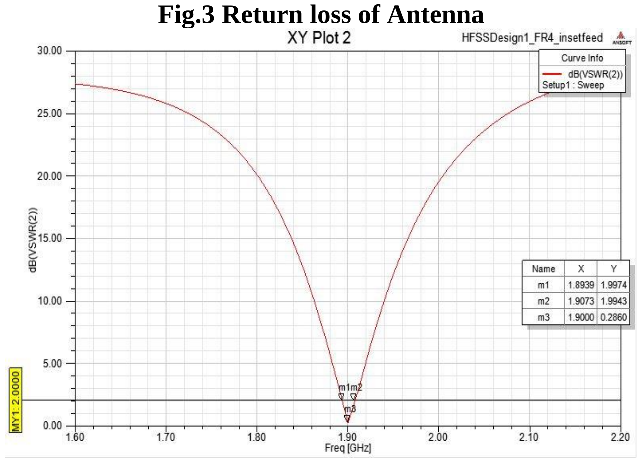


Fig.4 VSWR of single element

The simulated VSWR characteristics of the proposed antenna are presented in Fig 4. It can be seen that the proposed antenna is tuned with excellent impedance matching at the required frequency i.e. at 1.9GHz and impedance bandwidth is approximately 1- 10 MHz for the proposed antenna.

Radiation pattern at 0 deg:

Radiation patter defines the variation of the power radiated by an antenna as a function of the direction away from the antenna.

This power variation as a function of the arrival angle is observed in the antenna far field. Radiation Pattern for proposed antenna for Phi=0 deg. is shown in Fig.5. The gain and beam width can be calculated from Fig.5. The total radiation patterns of the single element microstrip antenna at the resonant frequency 1.9GHz for phi=0deg are shown in Fig.5. The gain of the antenna in elevation plane is 2.77dB.

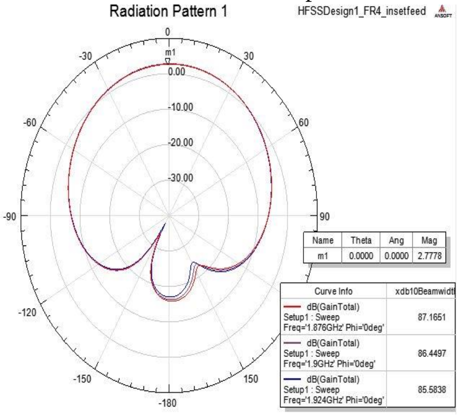


Fig. 5 Radiation pattern of single element at 0 deg

Radiation pattern at 90 deg:

The antenna gain and beam width can be calculated from Fig. 6. Radiation pattern for proposed antenna for Phi=90 deg. is shown in Fig.6.

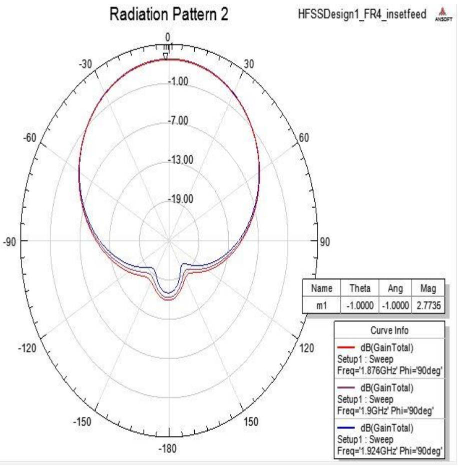


Fig. 6 Radiation pattern of single element at 90 deg

The total radiation patterns of the single element microstrip antenna at the resonant frequencies 1.9GHz for phi=90deg. are shown in Fig.6, The gain of the antenna is 2.77 dB in azimuthal plane. The simulated 3D radiation pattern with and without antenna is shown in Figs. 7 and 8.

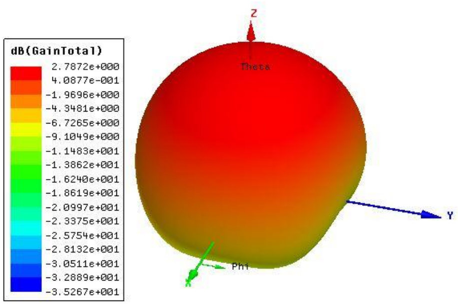


Fig.7 3D Radiation pattern without Antenna

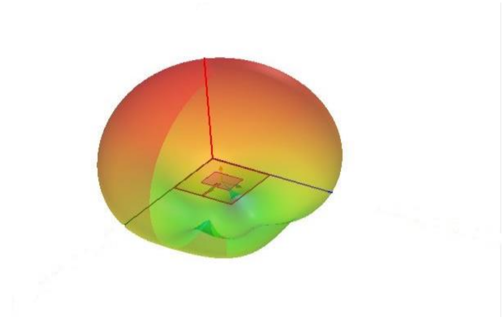


Fig.8 3D Radiation pattern with Antenna

B. Antenna performance with Arlon AD320A subsrate

The proposed rectangular microstrip antenna of single element is designed with Arlon AD320A substrate material whose permittivity of 3.2 and loss tangent is 0.0032. The material used for ground plane and patch is copper, which is a good conductor. From Fig. 9 observe return loss, resonating frequency and bandwidth.

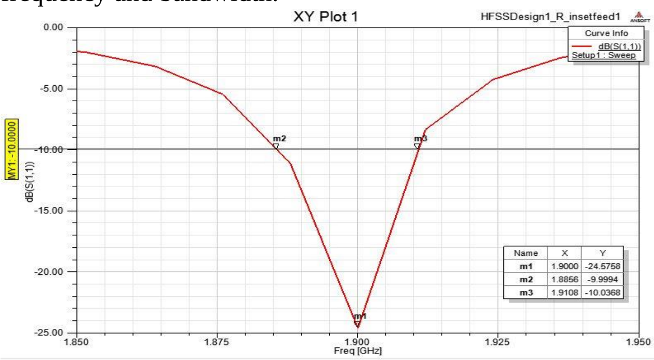


Fig. 9 Return loss of Antenna

Simulations are carried out over the frequency range of 1.9GHz with a frequency step size of 5 GHz. Fig. 9 shows the simulated return loss plots of microstrip antenna. As depicted by the simulation results, this antenna resonates at a frequency of 1.9GHz, exhibits a return loss of -24.57dB and bandwidth of 25MHz.

VSWR

The simulated VSWR characteristics of the proposed antenna are presented in Fig. 10. It can be seen that the proposed antenna is tuned with excellent impedance matching at the required frequency i.e. at 1.9GHz and impedance bandwidth is approximately 1- 10 MHz for the proposed antenna.

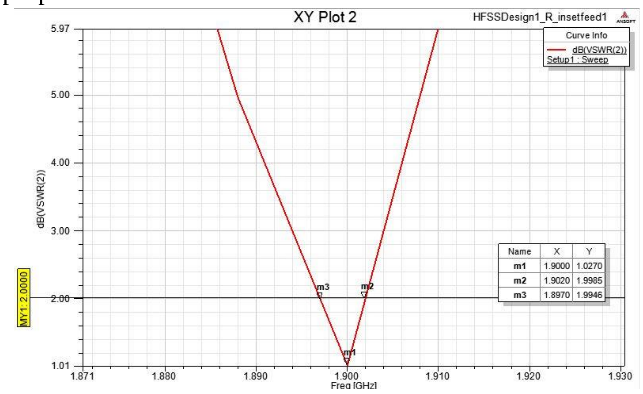


Fig. 10 VSWR of single element

Radiation Pattern at 0 deg

Radiation patter defines the variation of the power radiated by an antenna as a function of the direction away from the antenna. The radiation pattern for proposed antenna for Phi=0 deg. is shown in Fig.11. From Fig. 11, the antenna gain and beam width can be calculated.

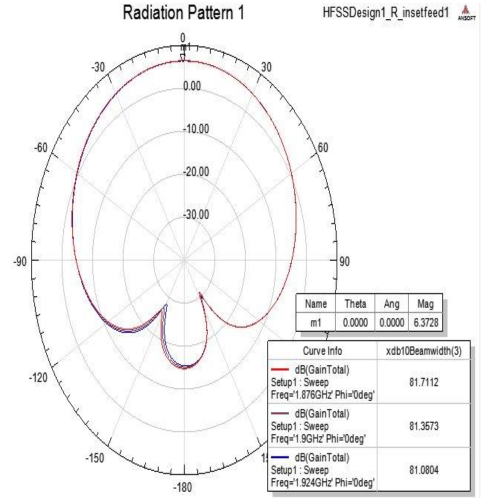


Fig.11 Radiation pattern of single element at 0 deg

The total radiation patterns of the single element microstrip antenna at the corresponding resonant frequencies are shown in Fig. 11, for phi=0deg. The gain of antenna in elevation plane is 6.37dB.

Radiation Pattern at 90 deg

From Fig. 12, The antenna gain and beam width can be observed from Fig.12. Radiation Pattern for proposed antenna for Phi=90 deg. is shown in Fig.12.

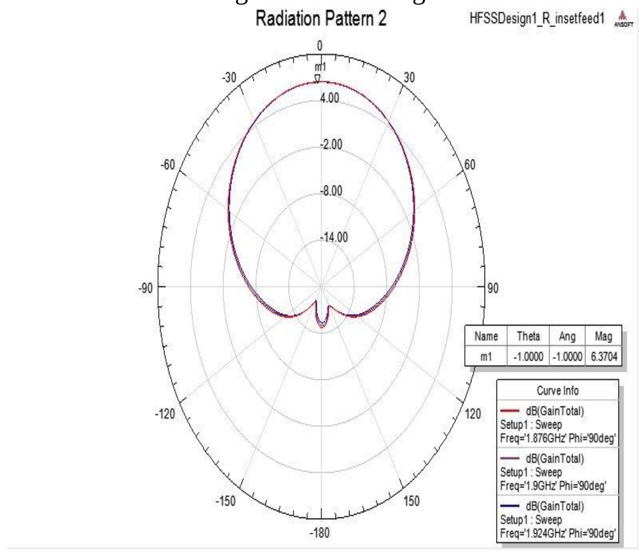


Fig. 12 Radiation pattern of single element at 90 deg

The total radiation patterns of the single element microstrip antenna at the corresponding resonant frequencies 1.9GHz for phi=90deg. are shown in Fig.12. The gain of antenna is 6.37 dB in azimuthal plane. The 3 D radiation pattern with and without substrate is shown in Fig. 13 and Fig.14.

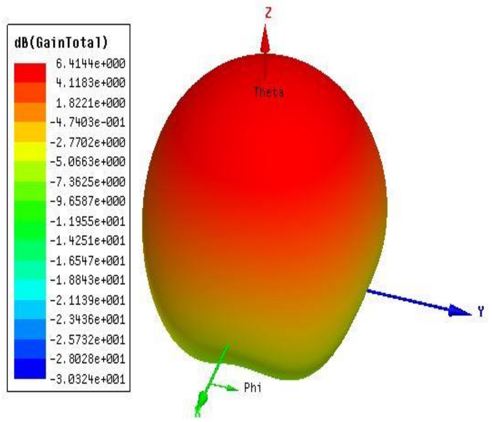


Fig. 13 3D Radiation pattern without Antenna

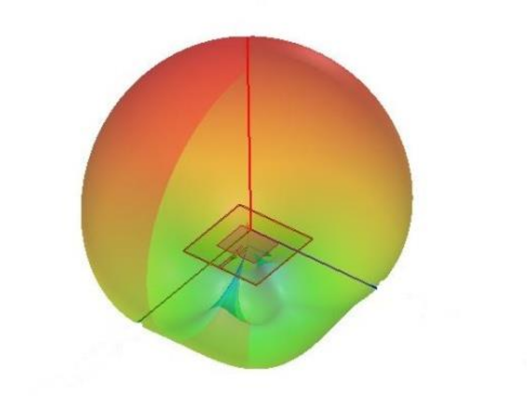


Fig. 14 3D Radiation pattern with Antenna

C. Antenna with Vaccum (Air) Subsrate

The proposed rectangular microstrip antenna of single element is designed. The used substrate is Air material with permittivity of 1 and loss tangent is 0. The material used for ground plane and patch is copper, which is a good conductor.

Return Loss

From Fig. 15, we can observe return loss, resonating frequency and bandwidth.

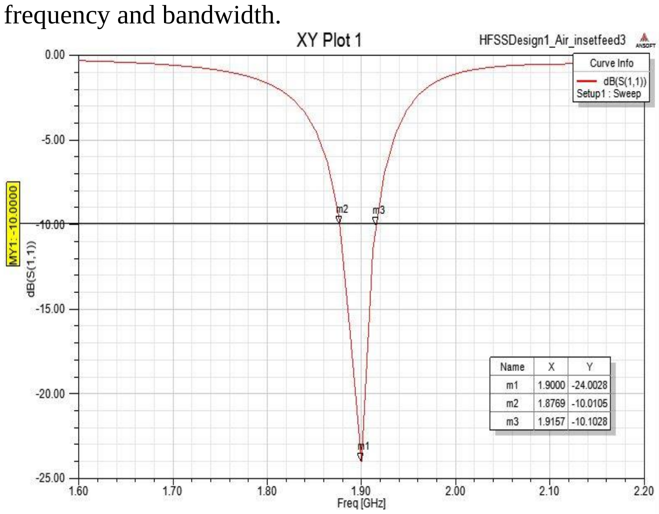


Fig 15 Return loss of Antenna

Simulations are carried out over the frequency range of 1.9 GHz with a frequency step size of 5 GHz. Fig. 15, shows the simulated return loss plots of microstrip antenna. As depicted by the simulation results, antenna resonates at a frequency of 1.9GHz, exhibits a return loss of -24dB and bandwidth of 39MHz.

VSWR

The simulated VSWR characteristics of the proposed antenna are presented in Fig 16.

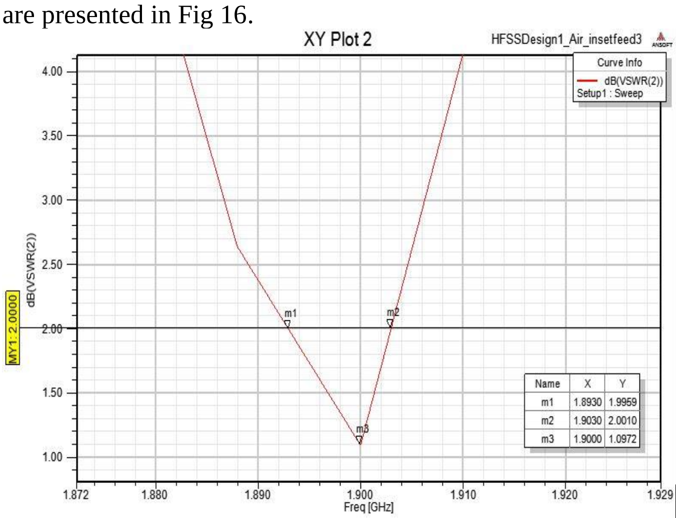


Fig 16 VSWR of single element

It can be seen that the proposed antenna is tuned with excellent impedance matching at the required frequency i.e. at 1.9GHz and impedance bandwidth is approximately 1-10 MHz for the proposed antenna.

Radiation Pattern at 0 deg:

Radiation patter defines the variation of the power radiated by an antenna as a function of the direction away from the antenna. The total radiation patterns of the single element microstrip antenna at the corresponding resonant frequencies are shown in Fig. 17 for phi=0deg. The gain of antenna in elevation plane is 9.72dB .

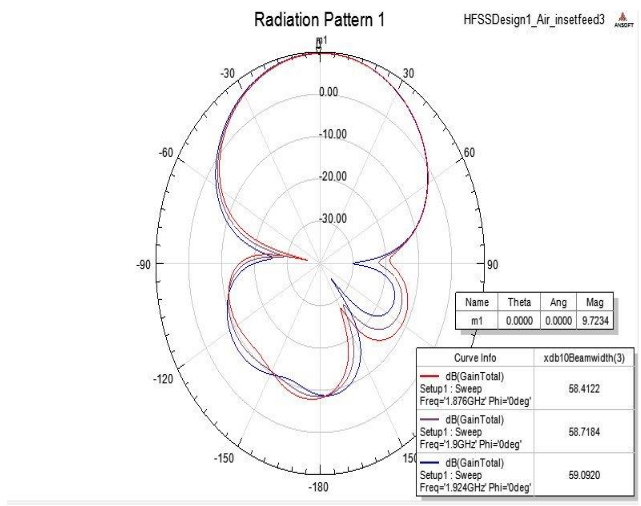


Fig 17 Radiation pattern of single element at 0 deg

Radiation Pattern at 90 deg:

The antenna gain and beamwidth can be observed from the radiation pattern plot. Radiation Pattern for proposed antenna for Phi=90 deg.is shown in Fig.18. The total radiation patterns of the single element microstrip antenna at the corresponding resonant frequencies 1.9GHz for phi=90deg. are shown in Fig. 18.

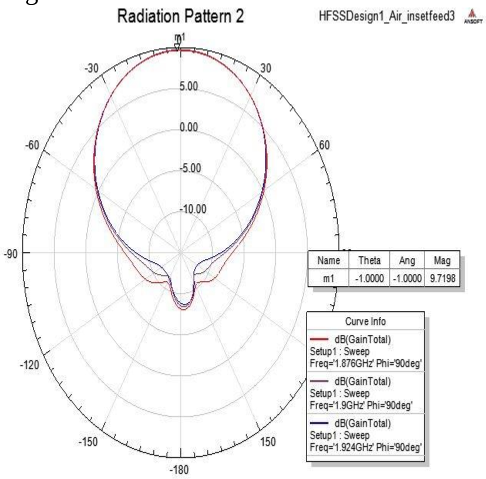


Fig 18 Radiation pattern of single element at 90 deg

The gain of antenna is 9.71 dB in azimuthal plane. The simulation results of microstrip patch antenna for different materials are compared as shown in Table 2,

Table -2: Comparisons of results of inset feed rectangular microstrip patch with different substrate materials

.SNO	Parameters	FR4 (Epoxy glass)	Arlon AD 320A	Vaccum (Air)
1	Gain (dB)	2	6	9.72
2	Bandwidth (MHz)	40	25	39
3	Return loss (dB)	-35.67	-25.57	-24.0
4	Beamwidth (Degree)	87.67	81.71	58.41

IV. CONCLUSION

The resonant frequency of the proposed antenna is 1.9 GHz, which is lying in the L-band region and designed on different dielectric substrate materials such as Arlon AD320, FR4 (Epoxy glass) and vaccum (air) and having dielectric constant (ϵ_r) = 3.2, 4.4 and 1.0 respectively. The High frequency Simulation Software is used for designing of proposed antenna and compared their performance characteristics. The simulation results shows the maximum bandwidth is 40MHz and minimum gain is 2dB is obtained using FR4 (Epoxy-glass) substrate whose dielectric constant (ϵ_r) = 4.4, at which return loss is -35.67dB. Maximum gain is 9.72dB and bandwidth is 39MHz obtained using vaccum (air), whose dielectric constant (ϵ_r) = 1.0. However, 6 dB gain and 25MHz bandwidth is obtained using Arlon AD 320A substrate, whose dielectric constant (ϵ_r) = 2.2 at which return loss is obtained -24.57dB. The proposed antenna can be used for military telemetry, GPS, mobile phone (GSM) and amateur radio applications.

ACKNOWLEDGMENT

The author expresses his deep gratitude to the Department of ECE, MGIT, for their encouragement during this work

REFERENCE

1. IJ Bhal and P Bhartia, "Microstrip antennas", Artech house, 1980
2. Balanis, C.A., Antenna Theory: Analysis and Design, John Wiley& Sons.
3. Inder Prakash, Stuchly "Design of Microstrip Antennas Covered with Dielectric layer", IEEE Trans. Antennas Propagate. Vol.A.P-30, NO.2, March 1992.
4. O.M.Ramahi, Y.T.LO, "Superstrate effect on the Resonant frequency of Microstrip Antennas", Microwave Opt. Technol. Lett. Vol.5, p.p. 254 – 257, June 1992.
5. J.R. James P.S Hall, Wood & A. Hounderron, "some recent development in microstrip antenna desing", IEEE Trans. AP, VoL. AP-29, Jan. 1981, pp. 124-27
6. E.O. Hammerstad, "Eauations for microstrip circuit design, "5th European microwave conference, 1975, pp. 268 – 272.
7. H. Gutton, G. Baizzinot, "Flat –aerial for ultra high frequencies", French Patent No. 703113, 1955
8. L. Lewin. "Radiation from strip line discontinuities". Proc. IEEE Vol. 107, Pt. C. Feb.1960, pp. 163 – 170.
9. J.R. Howell, "Microstrip antennas, "' IEEE Trans, AP, - 23, Jan 1975, pp. 90 – 93.
10. E.O. Hammerstad, "Eauations for microstrip circuit design, "5th European microwave conference, 1975, pp. 268 – 272.
11. X.L. Sun, S.W.Cheung, and T.I.Yuk, "Dual band monopole antenna with frequency unable feature for WiMAX Applications, "IEEE Antennas wireless Propagat. Lett. Vol.12, pp.100-103, 2013.
12. C.H. Chang and K.L. Wong, "Printed λ/8 PIFA for pentaband WAN operation in mobile phone, " IEEE Trans. Antennas Propagat, Vol.57, no.5, pp. 1373-1381, May, 2009.
13. Harshit Srivastava and Usha Tiwari "Design, Simulation & Analysis of Rectangular & Circular Microstrip patch antenna for Wireless Applications, International Journal of Recent Technology and Engineering, ISSN. 2277-3878,Volume.8, Issue. 4, November 2019.

AUTHOR'S PROFILE

Dr V. Saidulu received B.Tech and M.Tech degree from Nagarjuna University, A.P and Banaras Hindu University, U.P.respectively. He received his Ph.D degree from JNTUH, Hyderabad. Currently he is working as Associate Prof. in ECE Department, MGIT, Hyderabad. His research area is antennas and mobile communications. He has more than 25 papers published to his credit.