Analysis of Circular Microstrip Patch Antenna using Three Different Shapes of Substrate

[1]Divyesh K. Patel,
[1]M.TECH. [Digital Communication]
Patel College of Science and Technology,
Bhopal, M.P.

[2]Sameena Zafar
[2] Asst.Professor and Head of Department
Patel College of Science and Technology,
Bhopal, M.P.

ABSTRACT
In this paper analysis has been carried out for a circular microstrip patch antenna and software based design using three different shapes of substrate. Three individual antennas are designed and compared. A circular patch where radius 8.58 mm and thickness 0.02 mm put on three different substrate shapes like square, rectangular and circular. This type of design uses Roger RT/Duriod 5880 substrate material based on HFSSTM EM Simulator Software. The results of three antennas are compared in terms of return loss, VSWR and return loss bandwidth at particular frequency.

KEYWORDS
Circular Microstrip Antennas, Return Loss, VSWR

1. INTRODUCTION

In telecommunication, there are several types of the micro strip antennas (also known as printed antennas) the most common of which is the micro strip patch antenna or patch antenna. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating 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 micro strip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. The micro strip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane [1]. [2-3].Circular microstrip patch antennas have been much attracted due to their simple structure. Circular microstrip patch antenna is one of the simplest patch configurations. The circular microstrip antenna offers a number of radiation pattern options not really implemented using a rectangular patch. Circular patches were reported to lose less energy by radiation and thus it provides larger quality factors than other configurations for example rectangular patches. Basically a circular micro strip antenna can only be analyzed via the cavity model and full-wave analysis. The cavity model also provides the method that the normalized fields within the dielectric substrate can be found more accurately and it does not radiate any power. Due to the fringing fields between the patch and the ground plane, the effective dimensions of the antenna are greater than the actual dimensions. The fringing effect was larger due to the fact that some of the waves travel in the substrate and some in the air. The feed line used was directly connected to the edge of the micro strip patch. Such feeding technique provides match impedance between the patch and the feed. This matching circuit was very important in order to ensure the maximum power can be transferred to the micro strip antenna and thus increasing the overall performances.

2. ANTENNA DESIGN

The antenna used is based on circular microstrip patch antenna. The designed antenna operates in C-band [4-8 GHz].Based on the cavity model formulation; a design procedure is outlined for practical designs of circular microstrip antenna. Micro strip antennas basically consist of a radiating patch on one side of a dielectric substrate, which has a ground plane on the other side. The patch is generally made of conducting material such as copper. In today market there are many substrate materials with dielectric constant or relative Permittivity in range from 1.17 to 25 is available. Generally substrate chosen in range of $2.2< \varepsilon_r <25$[4].It is assumed that the specified information includes the dielectric constant of the substrate (ε_r), the height of the substrate h (in cm) and the resonant frequency(f_r). Then the physical radius of the patch can be calculated by [5],

$$a = \frac{F}{\left\{1+\left(\frac{2h}{\pi \epsilon_r F}\right)\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \quad \text{------(2)}$$

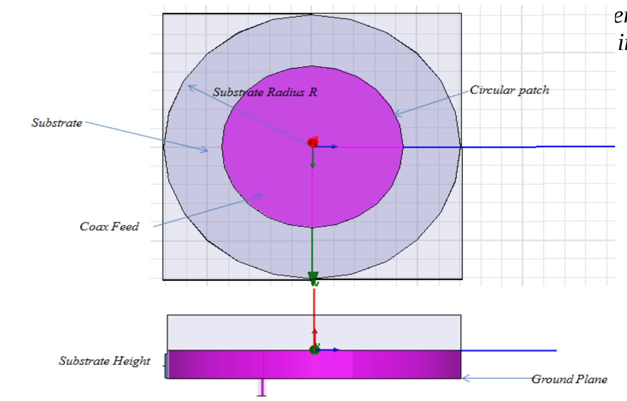
Where,

$$F = \frac{8.791\times 10^9}{f_r\sqrt{\epsilon_r}}$$

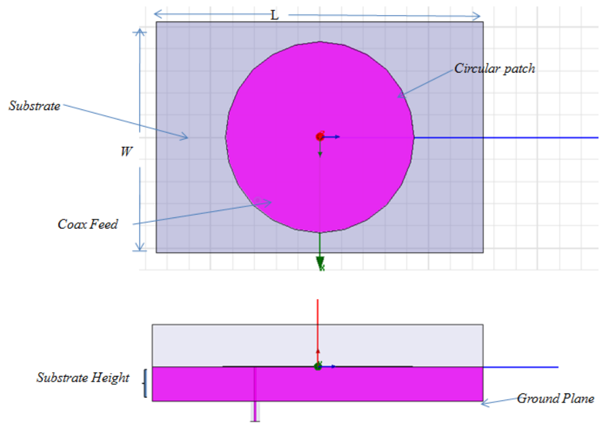
The design uses Roger RT/Duriod 5880 substrate material (dielectric constant εr= 2.2 and loss tangent tan δ = 0.009) with thickness/height (h) of 3.122 mm.The radius of circular patch calculated from equation (1) for perfect circular microstrip patch antenna operating at resonant frequency 5.90 GHz is 8.61 mm. Table 1 shows antenna parameters of three designed antennas using three different types of substrate shapes. Circular patch is mounted on substrate shapes like square, rectangular and circular. The area of all antennas is kept nearly same to same.The antennas are fed by probe-feeding technique or coaxial feeding. The location of feed is optimized to get desired frequency response. Excitation to patch conductor is given using wave port. The figure 1 depicts the geometry of three proposed antennas with dimensions as given in Table 1.

ANTENNA ELEMENT	ANTENNA-A [CMSA WITH CIRCULAR SUBSTRATE]	ANTENNA-B [CMSA WITH SQUARE *SUBSTRATE]*	ANTENNA-C [CMSA WITH RECTANGULAR SUBSTRATE]
Substrate	RT/Duroid 5880	RT/Duroid 5880	RT/Duroid 5880
	Radius =14.05 mm	Length =24 mm	Length =29.45 mm
	-	Width =24 mm	Width =20.20 mm
	Thickness =3.122 mm	Thickness =3.122 mm	Thickness =3.122 mm
Circular Patch	Copper	Copper	Copper
	Radius =8.61 mm	Radius =8.61 mm	Radius =8.61 mm
	Thickness =0.02 mm	Thickness =0.02 mm	Thickness =0.02 mm
Ground Plane	Copper	Copper	Copper
	Radius =14.05 mm	Length =24 mm	Length =29.45 mm
	-	Width =24 mm	Width =20.20 mm
	Thickness =0.02 mm	Thickness =0.02 mm	Thickness =0.02 mm

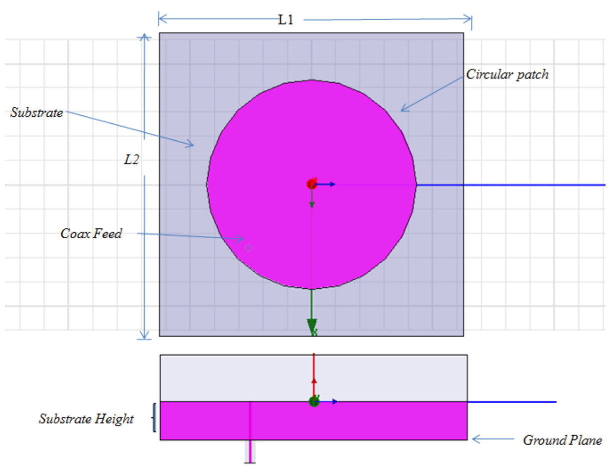
Table 1: Antenna Mechanical Parameters.



(A)



(B)



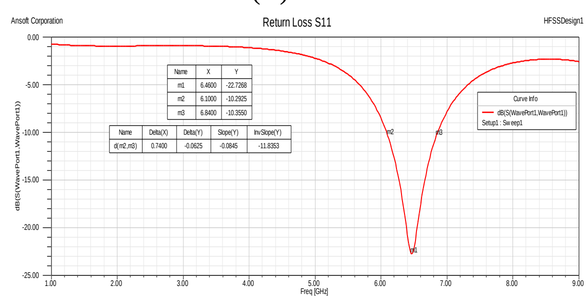
(C)

Fig 1: Geometry of proposed antennas
(a) Antenna-A.CMSA with circular Substrate
(b) Antenna-B.CMSA with Square substrate
(c) Antenna-C.CMSA with rectangular substrate.

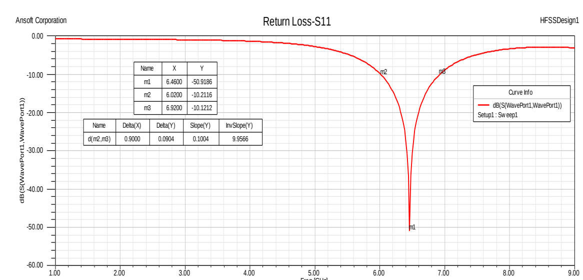
3. SIMULATION RESULTS

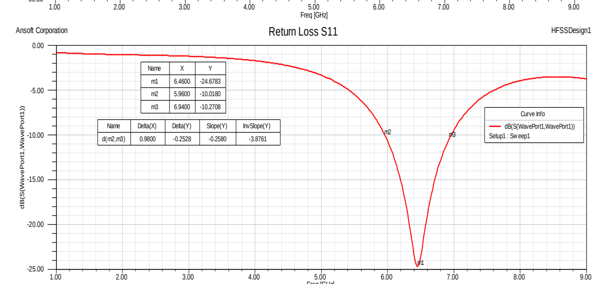
The results of simulation three different antennas are performed by Ansoft HFSS^{TM}v11.HFSS stands for High Frequency Structure Simulator. It is full-wave electromagnetic (EM) simulator used to analyze 3D volumetric models, high speed and high-frequency component designs. By using this software we can calculate antenna parameters such as S Parameters, Resonant Frequency, Fields,VSWR and field patterns [6]. The figure 2 shows return loss (S11) vs. frequency (GHz) plots of three designed antenns.Maxiamum return loss is obtianed at 6.46 GHz as shown in figure.

(A)



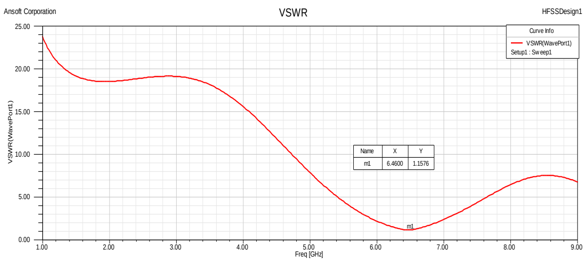
(B)



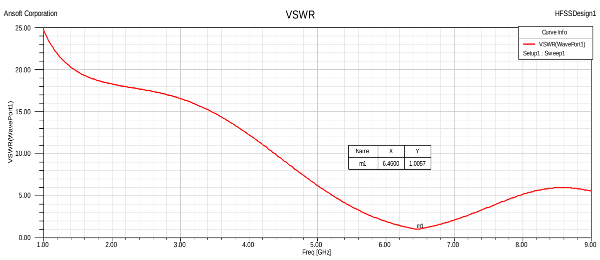


(C)

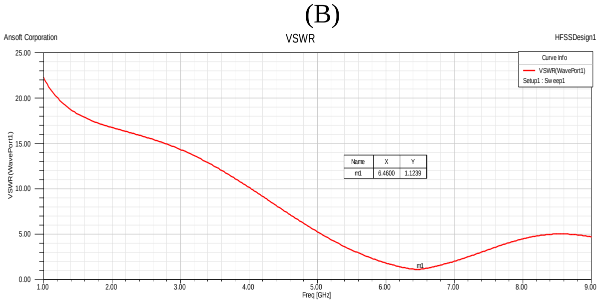
Fig 2: Rerturn Loss vs Frequency plots of
(a) Antenna- A (b) Antenna – B (c) Antenna - C



(A)

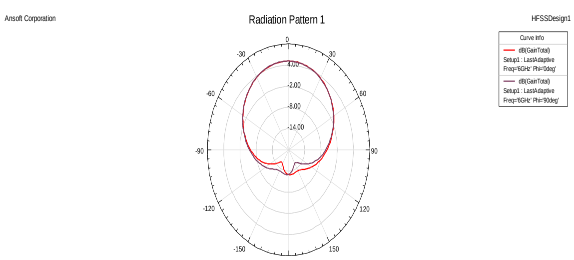


(B)

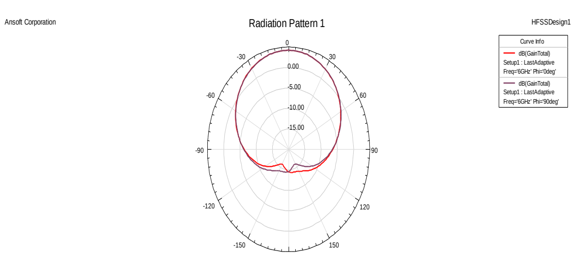


(C)

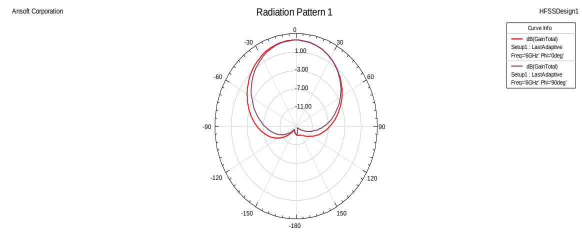
Fig 3: VSWR Plots of (a) Antenna- A (b) Antenna- B and (c) Antenna- C.



(A)

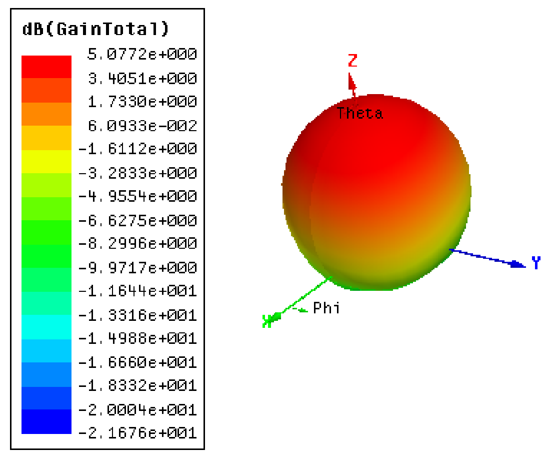


(B)

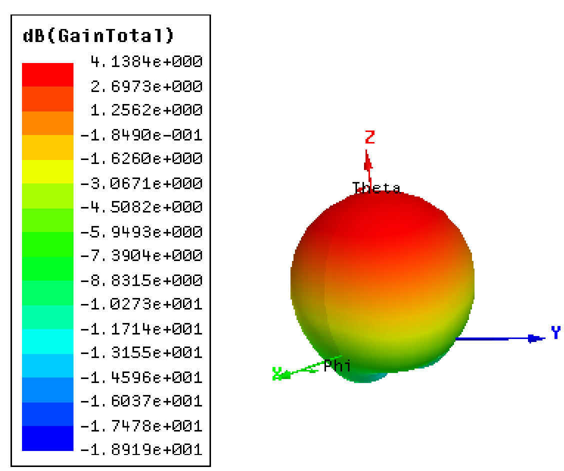


(C)

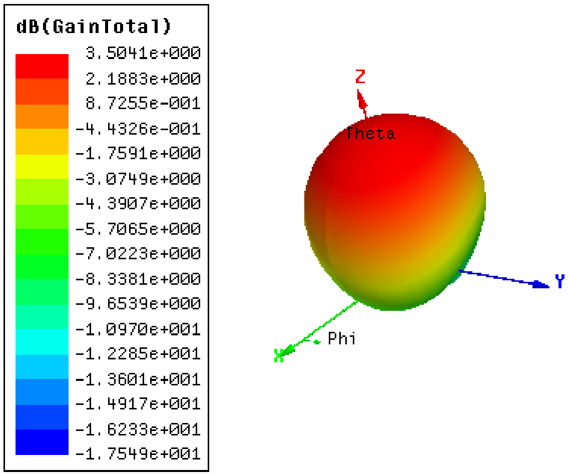
Fig 4: Radiation Patterns at phi=0 deg (E-Plane) and phi= 90 deg (H-plane) of (a) Antenna- A (b) Antenna- B and (c) Antenna- C.



(A)



(B)



(C)

Fig 5: 3D plots for total gain of (a) Antenna- A (b) Antenna- B and (c) Antenna- C.

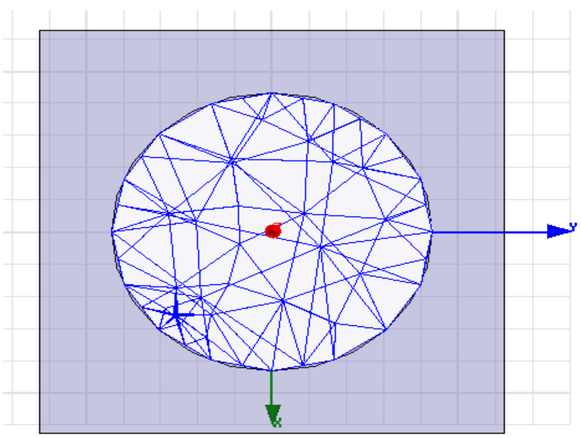


Fig 6: Mesh Refinement of Antenna-B

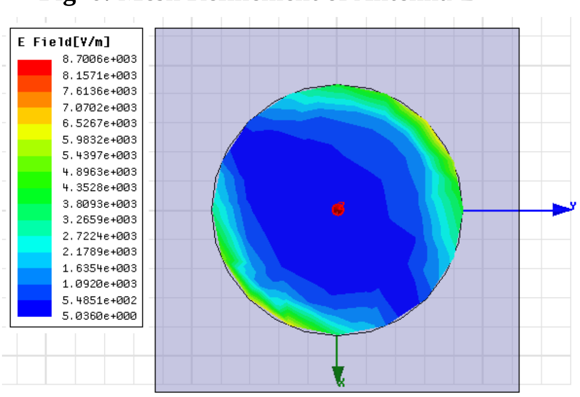


Fig 7: E-Field Distribution of Antenna-B

PARAMET-ER	ANT -A	ANT -B	ANT -C
Centre Frequency	6.46 GHz	6.46 GHz	6.46 GHz
Return Loss	-22.72 dB	-50.91 dB	-24.67 dB
VSWR	1.15	1.00	1.12
Return Loss Bandwidth	11.45 %	13.93 %	15.17 %

Table 2: Comparison of antenna electrical parameters

The figure 3 shows VSWR (Voltage Standing Wave Ratio) plots of antennas.As shown VSWR is near to 1.Figure 4 shows radiation pattern of three antennas at phi=0 deg (E-plane) and at phi=90 deg (H-plane).Figure 5 shows far field distributions at 6.46 GHz of antennas.

The Comparison of three designed antenna is given in Table 2.Comparisions were done using antenna electrical parameters.From results Antenna B can give better performance.Figure 6 and 7 shows mesh refinement and E-field distribution in circular patch respectively.

4. CONCLUSION AND FUTURE WORK

In this paper the design and simulation of circular disk microstrip patch antennas using three different shapes of substrates are presented.At one particular center frequency (6.46 GHz) Antenna- B gives better return loss and VSWR because of good E-Field distribution in patch radiator.It's total volumetric area is smaller then Antenna-C and Antenna-A so possible reduction in size can be achived. In future the goal is to make the Antenna-B circularly polarized by intoducing slots or perturbation in patch with dual-frequency response in C-band.This is a research work being carried out by 1st author for fulfillment of dissertation work.

5. ACKNOWLEDGMENTS

The Authors would like to thanks HOD of Electronics and Communication Department of PCST, PATEL COLLEGE OF SCIENCE AND TECHNOLOGY, RATIBAD, BHOPAL (M.P.) for their support and encouragements and for give testing and development facility for this work.

6. REFRENCES

[1] B.J. Kwaha, N Inyang & P. Amalu, "The circular microstrip patch antenna – design and implementation", *IJRRAS*, VOL. 8 Issue 1, July 2011.

[2] Ramesh Garg, Prakash Bhartia and Inder J. Bahl,"Microstrip Antenna Design Handbook", (Artech House,Inc.,Boston,London, 2001)

[3] James R. James, Peter S. Hall, "Handbook of Microstrip Antennas", (Peter Peregrinus Ltd., London, UK), IEE Electromagnetic Waves Series 28, 1989.

[4] Keith R. Carver and James Mink, "Microstrip Antenna Technology", *IEEE Transactions on Antennas and Propagation* , Vol. 29, No. 1, Page.2-22, 1981.

[5] Constantine A. Balanis, "Antenna Theory, Analysis and Design", 2nd ed., John Wiley & Sons, Inc., New York, 1997.

[6] Ansoft High Frequency Structure Simulator (HFSSTM) v11 User's Guide, 2007, A