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Design of Planar and Conformal Microstrip Patch Antenna for Avionics Applications

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***Abstract:** Microstrip patch antennas have an important role on Communication applications on satellites, aircrafts, missiles and other vehicles comparing to other types of antenna because of their conformability nature. In this paper several EM simulations performed on planar and conformal antenna for avionic applications. The design of the proposed planar antenna configuration is analyzed by using IE3D simulation software, it is MOM (Method of Moments) based and conformal antenna is analyzed by using HFSS simulator which is finite element method.In addition we are achieving circular polarization.*

***keywords:** planar microstrip patch, conformability, Method of Moment,IE3D,HFSS.*

I. INTRODUCTION

Now a day's mobile communication and other defence, aircraft and satellite communication systems need a compact MSA [1]. Microstrip antennas are some advantages with reference to other types such as low profile, small size and less fabrication costs. The flexibility afforded by microstrip antenna technology has led to a wide usage in avionics applications, low efficiency and narrow bandwidth and less gain are the limitations. A comparative analysis between planar and conformal antenna determines advantages and limitations of radiation characteristics. Planar microstrip antennas can be reached its maturity [2].

There can be as many as 15 different antennas or more, it gives aerodynamic drag. Placement of the antennas into the host surface is highly considerable. The conformal antenna is highly desirable on variety platforms, such as missile, rocket, UAV, satellite and aircraft. Conformal antennas are almost any geometry of the cylindrical, conical and spherical structures. The other important feature of conformal antenna is aerodynamic drag is less, integration of antenna on host surface is simple, and conformal antenna reduces the errors caused by the superstate i.e. radome.The simple conformable design is antennas on single curved surfaces; the main purpose of such design is to improve azimuth plane coverage. A vision of a future conformal antenna consists a complete RF system, including power dividers, feed network, phase shifters, etc.the main drawback of conformal antenna is negative effect on pattern of radiation because of curvature and the beam will be changed from one direction to other [3]. The directivity of conformal antenna also reduced because of surface change of antenna.

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To meet the requirements and to overcome the limitations of linear polarization implementation of circular polarization is more advantage compared to linear polarization. The most important of circular polarization is less polarization loss and more resistive to signal degradation due to bad weather conditions for reflectivity, phasing issue, absorption and multipath issues [4].

II. ARRAY ANTENNA DESIGN

For achieving circular polarization, two orthogonal standing waves, 90^0 out of phase are required for microstrip antenna. We have two different techniques for achieving circular polarization. One is to feed a square patch on two adjacent sides,one of the feed is delayed by 90^0. This technique is difficult to get circular polarization.

The second method for achieving circular polarization through feeding one side of the patch and truncate the square patch corners. If the square patch corners are truncated perfectly the right amount of size, there will be variance in frequencies cause the ninety degrees phase shift, a lower output impedance is achieved in this criteria [5].

The empirical equations had shown below gives the truncated size of corners and modes of circular polarized signals [6] .

$$\Delta s/S = 1/2Q \quad \text{.........(eq1)}$$

$$f_1 = f_0\,[1\text{-}(2\Delta s)/S] \quad \text{....(eq2)}$$

$$f_2 = f_0. \quad \text{.................(eq3)}$$

Where Δs is perturbationarea,S denotes patch area, and quality factor of patch is Q. The patch lengthis L, then area $S = L^2$ and Δs is equal to c^2, where c is the perturbation length.

The four element array consists of four corner truncated microstrippatch antennas with a feed network consists of hybrid T-junction for equal amplitude distribution RT/Duroid 5880 dielectric substrate with 1.6 mm thickness.

The radius of the patch determined by a systematic approach taking into account of €r, Frequency (fr) and height of substrate (h) to be taken [14]:

Practical Radius can be calculated as:

$$a = \frac{F}{\left\{1+\frac{2h}{\pi \epsilon r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \text{....(eq4)}$$

$$F = \frac{8.791\times10^9}{fr\sqrt{\epsilon r}} \quad \text{.................(eq5)}$$

The patch effective radius as:

$$a_e = a\{1 + 2h/(\pi \epsilon r a)\ \ [\ln\,(\pi a/2h) + 1.7726]\}^{1/2}$$
...............(eq 6)

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The schematic of proposed conformal antenaa as shown in Fig.1.

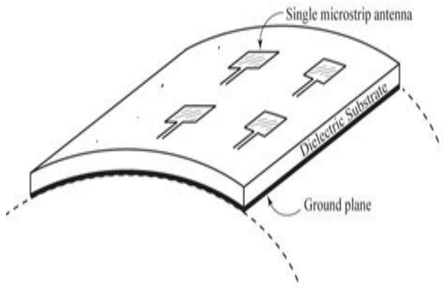

Fig.1. Schematic of Conformal antenna

For TM wave the resonant frequency TM110 gives :

$$(f_r)_{110} = \frac{1.8412 v_0}{2\pi a_{e\sqrt{\epsilon r}}} \text{..........(eq7)}$$

III. 2×2 ARRAY RESULTS: COMPARISON AND ANALYSIS

Figure 2 shows thesimulated plannar MSP antenna array with 1,6 mm thickness using RT/Duroid 5870 with 2.33 dielectric constant with dimensions of 74.4mm×74.4mm and square patch with 16.4mm×16.4mm. Figure 3 is simulated conformal antenna 3D view designed in HFSS with same antenna dimensions.

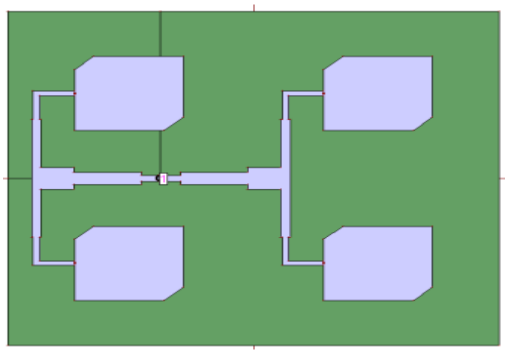

Fig.2. Antenna Geometry in IE3D

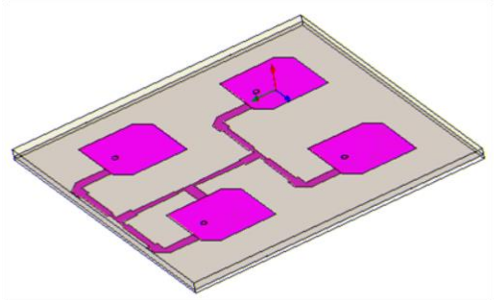

Fig.3. 3D View of Conformal antenna Design in HFSS

Figure 4 shows the simulated VSWR vs Frequency plot for planar antenna, it shows the value of VSWR < 2. The theoretical value is unity; in practical case we have losses, so VSWR must less than two. The bandwidth is seen to be more than 200MHz for 2:1 of the centre frequency. Figure5 shows simulated conformal antenna VSWR vs Frequency plot it also shows more than 300MHz band width for 2:1.

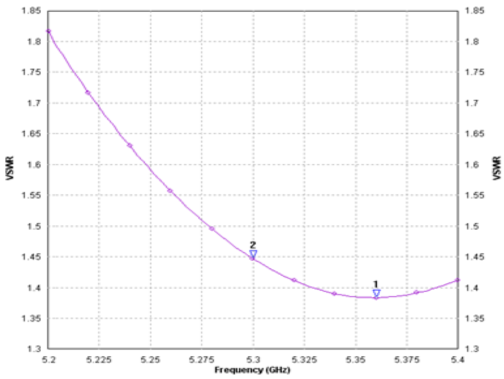

Fig 4. VSWR plot for Planara Antenna

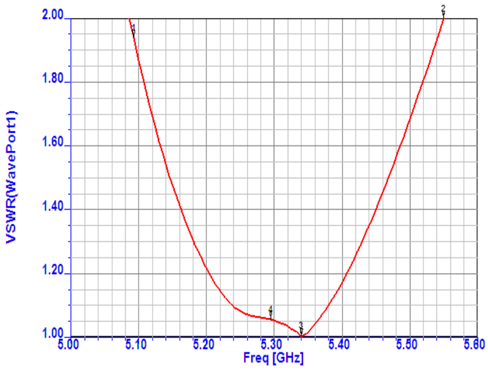

Fig.5. VSWR Plot for Conformal Antenna

Figure6& Figure7 represents the radiation characteristics of planar and conformal microstrip antennas Radiation characteristics respectively,the minimum half power beam width is 53ofor planar array and 570 beam width for conformal array.

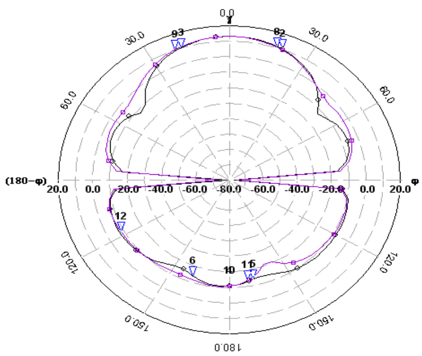

Fig 6.Radiation pattern for Planar Antenna

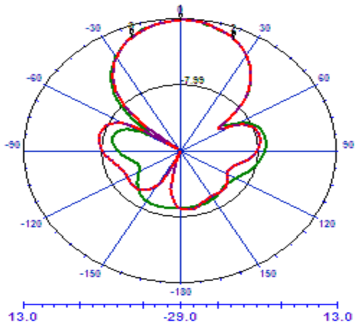

Fig 7.Radiation pattern for conformal Antenna

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Figure8 & 9 shows the axial ratio plot of planar & conformal array antennas respectively. In general the axial ratio for circular polarization is 1, for linear polarization infinite and for elliptical axial ratio in between 1 and infinite. So here the axial ratio plot for both planar and conformal arrays shows 1 for the entire band of frequency, and then we conclude that the designed antennas achieved circular polarization.

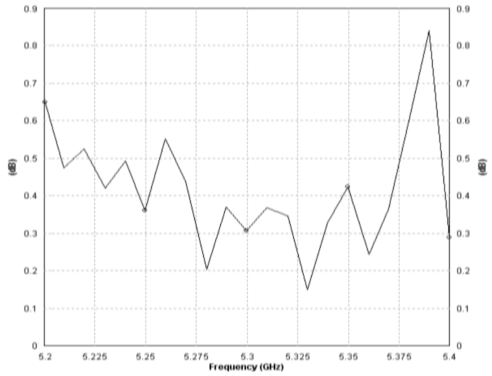

Fig.8. Axial ratio plot for planar array antenna

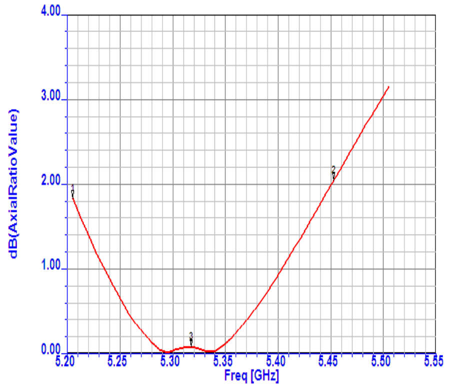

Fig.9. Axial ratio plot for conformal array antenna

Table- I: Simulated antenna parameters for planar array & conformal array antenna

SL.NO	Parameter	Planar array in IE3D	Conformal array in HFSS
1	VSWR	1.45	1.25
2	Band width (at VSWR $\leq$2:1)	200MHz	200MHz
3	Axial Ratio	< 1dB	< 1dB
4	Half power beam width	53^0	57^0

IV. CONCLUSION

In this paper 2×2 microstrip patch antenna array were designed and simulated at C-band for both planar and conformal cases. It has the bandwidth of more than 0.3 GHz, VSWR < 2, beam width of 57^0 and resonating frequency 5.3 GHz is achieved. The simulated results shows good return loss and VSWR and more compact in size. These initial simulation results will be used to guide the development of fabricated arrays on conformal substrates for avionics applications.

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