DESIGN OF MICROSTRIP PATCH ANTENNA ARRAY FOR S-BAND APPLICATIONS

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***Abstract* -This paper presents rectangular micro strip patch antenna array. The antenna array is designed using easily available and low cost substrate material FR4 with dielectric constantof 4.4. The operating frequency of antenna array is 3GHz with coaxial feeding technique. The proposed design is used in many applications like space craft, air craft, and mobile satellite communications. This antenna is designed by using HFSS software.The obtained parameters of the array are S_{11} -24.1dB,VSWR 1.07, gain 3.91 and radiation pattern are observed.**

Keywords- FR4 epoxy, Return loss, VSWR, Gain.

I. INTRODUCTION

In the modern wireless communication system the most important aspect is to develop compact wireless communication antennas. The Micro strip patch antennas fulfill these requirements. The patch antenna has low profile easy to fabricate, minimal cost and light weight. Many techniques have been examined for accomplishing wide bandwidth and great performance [1].At the center of the patch electric field is zero because fields at the center due to them will be equal and opposite at that position the field will be canceled. Patches are having high magnitude in the edges and maximum current distribution on center of patch at the resonant frequency.

The S-band frequency is used by radars which monitor the weather, surface ship radars and NASA and ISRO to communicate with the space shuttle and the international space station. In India the s band is used for direct to home (DTH) which falls between (2.5 to2.7 GHz) .The ISM band (used for unlicensed spectrum devices like Bluetooth, cordless phone) operate between 2.402 GHz to 2.480 GHz. The s band frequency is defined by IEEE as it lies in the range from 2GHz to 4GHzconsisting of wave length range of 15-7.5cm. This is significant for WiMAX applications.

A 2x2 linear antenna array is designed to using the s band frequency. This array antenna is used to increase the signal strength directivity and gain.

II. ANTENNA DESIGN

The designed patch antenna with feeding technique is coaxial probe feeding and it has and input impedance is 50ohm at S – band frequency of 3 GHz. This design the patch is placed above the substrate with the thickness of 3.2mm. The structure of patch antenna with 3 axes X, Y, Z. The design having the 3 layers top layer is patch, middle layer is substrate and bottom layer is the ground. The below figure shown the single element patch antenna.

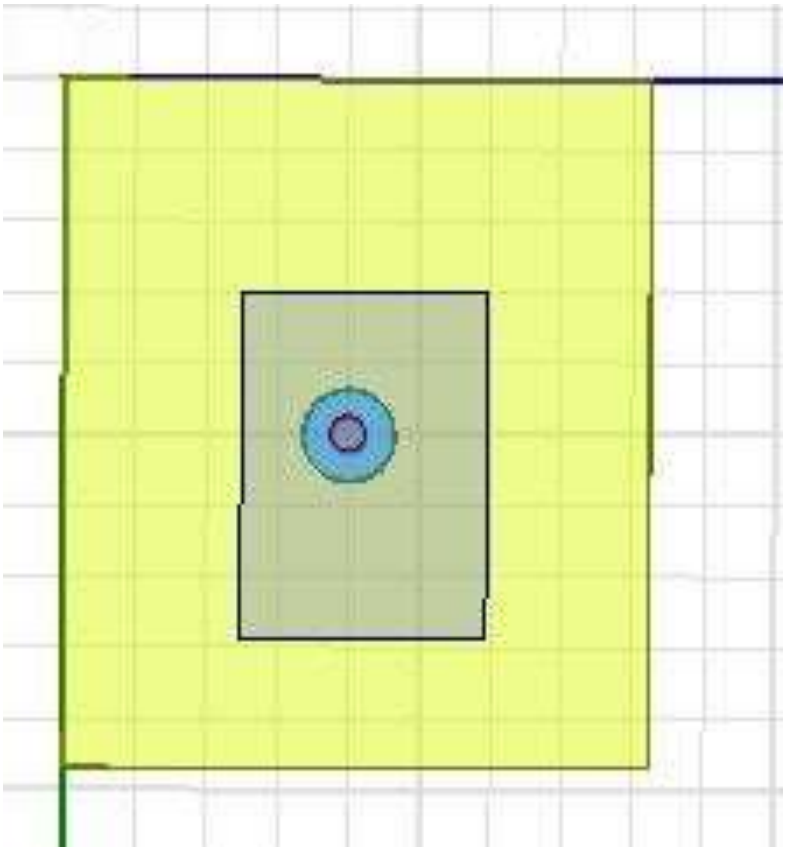

Fig. 1Front viewof single element patch antenna

A. Design specifications:TABLE I

Design parameters of microstrip patch antenna

S.No.	Parameters	Details
1.	Substrate	FR-4 epoxy
2.	Dielectric constant	4.4
3.	Operating frequency	3GHz

The parameters of the patch antenna design that are as follows:

Width of micro strip patch antenna

$$W = \frac{C}{2f\sqrt{\frac{\epsilon_r+1}{2}}}[1]$$

Effective dielectric constant

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r+1}{2}\left(1+12\frac{h}{w}\right)^{-1/2}[2]$$

Effective length

$$\Delta L = 0.412 \times h \frac{[\epsilon_{eff}+0.3]\left[\frac{w}{h}+0.264\right]}{[\epsilon_{eff}-0.258]\left[\frac{w}{h}+0.8\right]} \quad [3]$$

Actual length

$$L = L_{\text{eff}} - 2x\Delta l \quad [4]$$

W is the width of the patch
f is the center of frequency
∈ris the dielectric constant of the substrate
h is the thickness of the substrate
$\in_{eff}$ is the effective dielectric constant
L is the actual length of patch antenna

Ground is placed below the substrate material and the ground is six times greater than the patch antenna and the patch is generally made of conducting material such as copper or gold. The ground also made of various materials such as copper,silver, and gold.The equations of the ground plane shown in below.

Length of the ground Lg,

$$L_g = 6h + P_l \quad [5]$$

Width of the ground Wg,

$$w_g = 6h + P_w [6]$$

Where,
h is the thickness of dielectric constant
P_l is the length of the patch
P_w is the width of the patch

Using the above formulas all the parameters are obtained for the antenna design. The below table shows the calculated values of the rectangular micro strip patch antenna.

TABLE II

Dimensions of micro strip patch antenna

S.No.	Parameters	Dimensions (mm)
1.	Patch length	22.8
2.	Patch width	30.6
3.	Ground length	41.5
4.	Ground width	49.2
5.	Substrate length	41.5
6.	Substrate width	49.2

B. Design of Array antenna

A 2x2 array antenna is designed to using the HFSS software. This design to using the dimensions of the substrate is 41.5x49.2mm and the length and width of the patch antenna is 22.8x30.6mm with coaxial probe feeding technique.

In the coaxial probe feeding use the different material like Teflon and Pec. The outer conductor material is Teflon the outer conductor of the cable is connected to ground plane. The pin is extended up to the patch antenna. Pin material is pec. Pec is the perfect electric conductor. Feed can be placed any where inside the patch to match with its input impedance. Substrate material as fr4 epoxy is not reliable for high frequency applications like more than 4GHz. Thedistance of separation between the patches$\frac{\lambda}{2} = 22.5$. This is the 4 element array antenna is designed for better performance. This array antenna increases the signal strength and reduces the power wastage.

The figure 2 represents the 2x2 rectangular micro strip patch array antenna

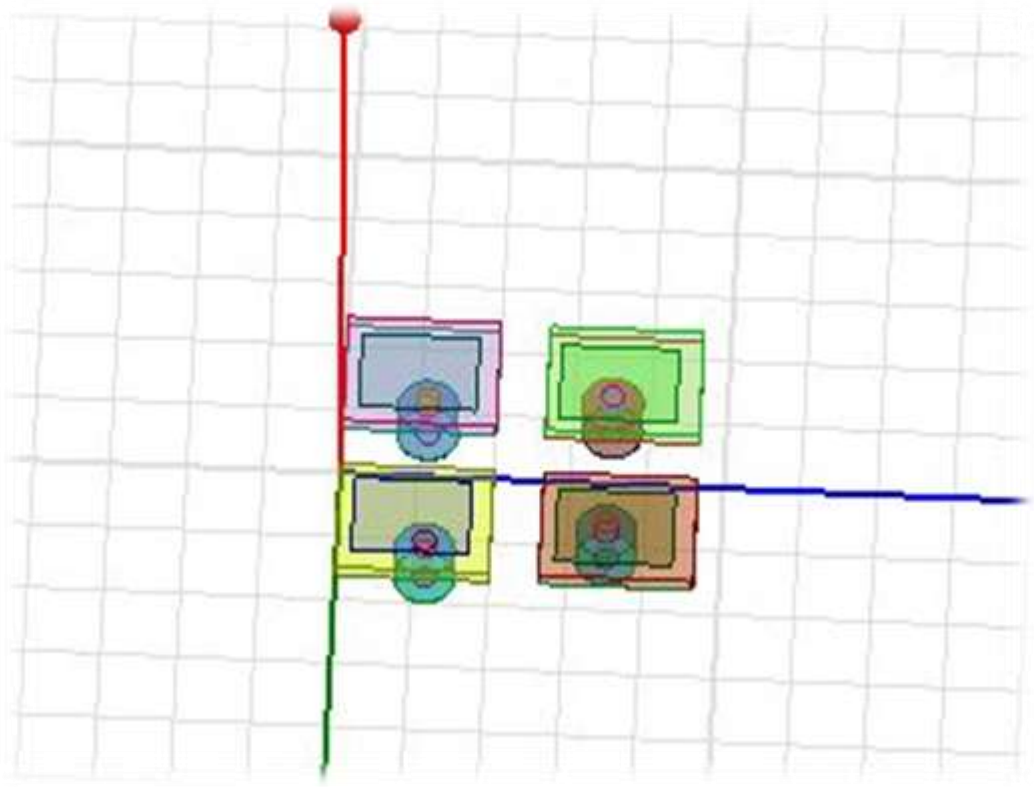

Fig.2 2x2 Array antenna design

III. SIMULATED RESULTS

This 2x2 rectangular patch antenna array simulated to using the HFSS 13.o version software. The input impedance of the antenna is 50 ohms. This array antenna is used for various applications.

A. Return Loss

The return loss graph at S – Band frequency range 2- 4GHz. Figure 3 shows the 2x2 rectangular array return loss at3.4GHz.

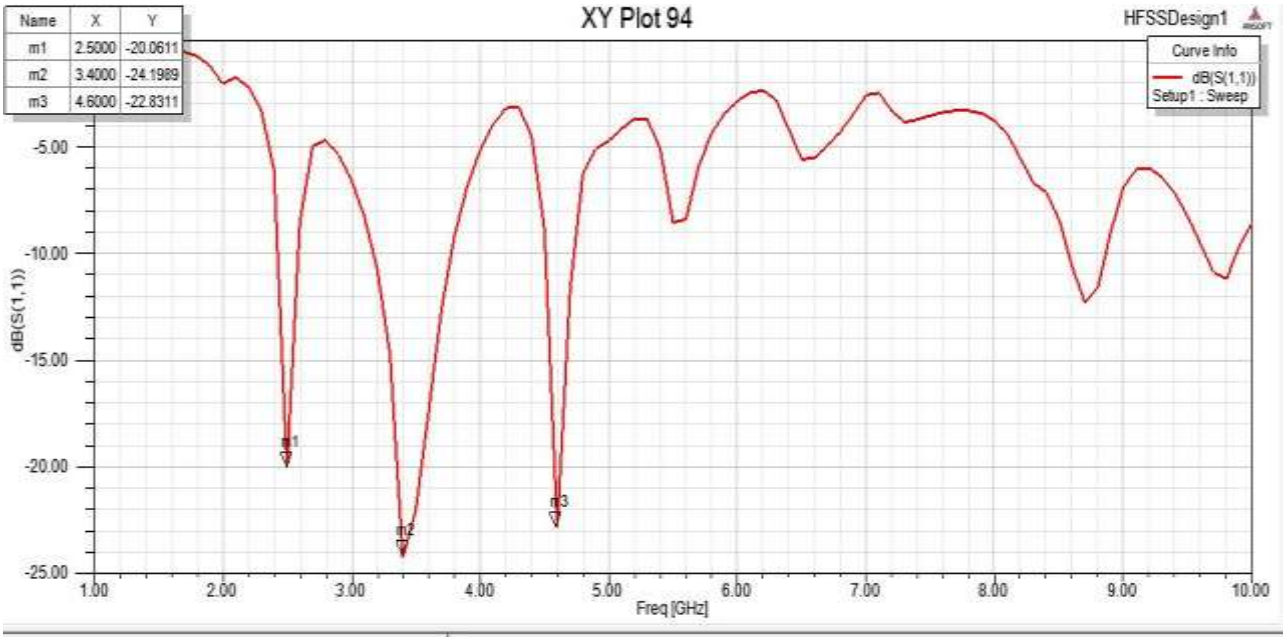

Fig.3Return loss of antenna array at 3.4GHz

B. VSWR:

VSWR stands for voltage standing wave ratio and is also referred to as standing wave ratio. The value lies between the 1 and 2.VSWR is always a real and positive numbers for antennas. Figure 4 shows the VSWR graph of 2x2 array antenna.

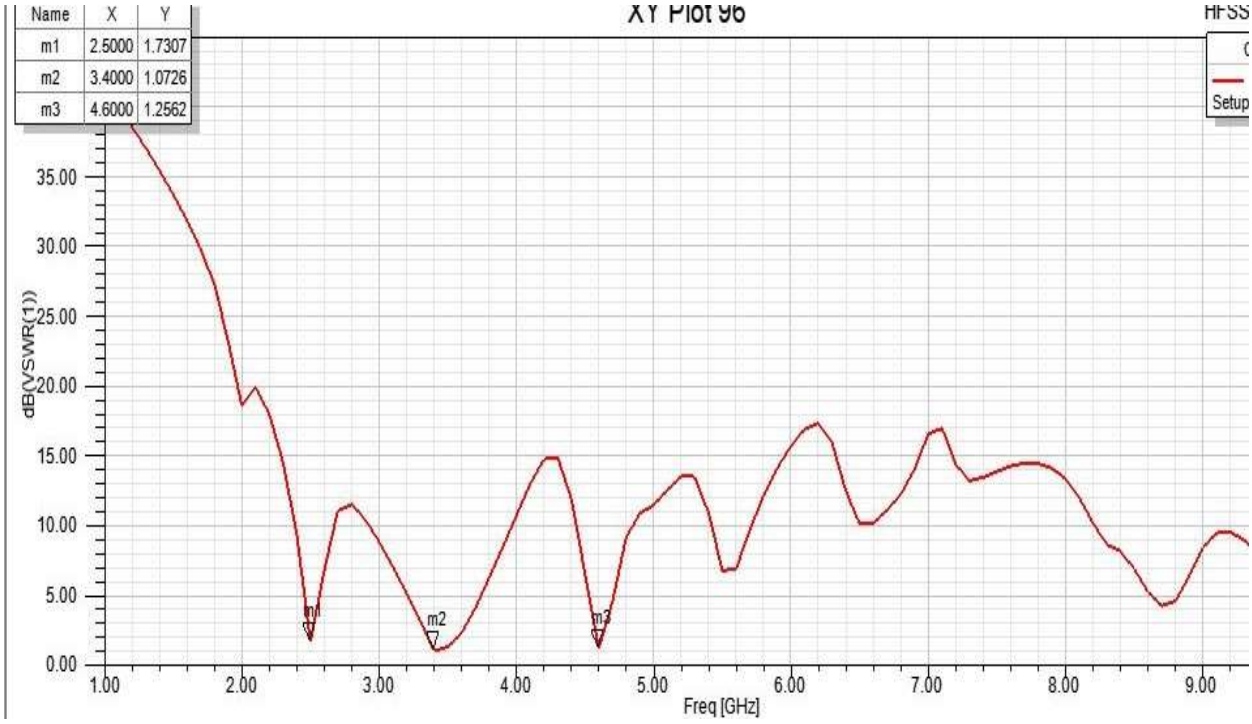

Fig.4 VSWR Plot at 3.4GHz

C. Gain:

The gain ofthe antenna represents the efficiency and directional capabilities of the antenna. The graph given below shows the gain of 4 element array.

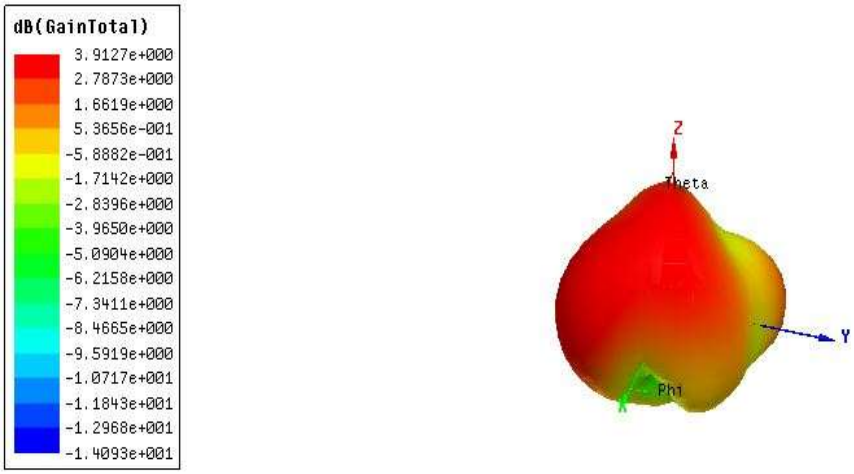

Fig. 5Gain at 3.4GHz

D. Radiation Pattern:

The strength of radio waves that provides the antenna for transmitting and receiving is depicted with the help of radiation pattern.

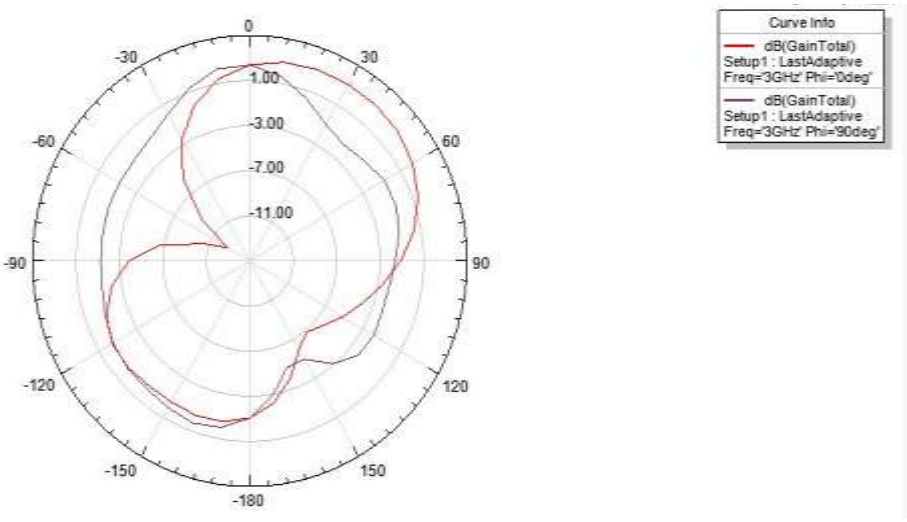

Fig.6.Radiation pattern

This can be achieved with the help of the operating frequency of antenna with 3GHz with coaxial feeding technique and it is observed that the proposed antenna is better when compared to other references in terms of $S_{11,}$ VSWR and are shown in table III.

TABLE III

Comparison between the proposed antenna and 2x2 and 2x3 array antenna [2] and 1x2 array [3] and 2x1,2x2 [4].

Reference	**S_{11} Parameter**		**VSWR**		**GAIN**		**Operating frequency**	**Feeding technique**
[2]	2x2	2x3	2x2	2x3	2x2	2x3	2.4GHz	Microstrip line
	-10.9	-16.00	1.4	1.7	10	12		
[3]	1x2		1x2		1x2		2.4GHz	Microstrip line
	-23.05		1.54		8.75			
[4]	2x1	2x2	2x1	2x2	2x1	2x2	2.4GHz	Microstrip line
	-17.03	-19.31	1.67	1.65	7.58	11.42		
Proposed antenna	-24.1		1.07		3.91		3GHz	Coaxial probe

IV. CONCLUSION

A 2x2 rectangular patch antenna array is designed successfully. It designed at the frequency at frequency of 3GHz for wireless applications. The coaxial probe feeding technique is used for the four element antenna array. Simulation is carried out using the HFSS 13.0 software. This array antenna gives better return loss, gain and Vswr. The proposed antenna can be further improved by implementing different slots on the patch to improve gain and bandwidth.

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