Design of Rectangular Microstrip Patch Antenna Array with Coaxial Feeding for X – Band Communications

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***Abstract*- This thesis presents rectangular microstrip patch antenna array. The operating frequency at 9.3 GHz and designed by using coaxial feed technique. The antenna array designed iscost effective and easily available FR4 substrate material of relative permittivity 4.4, thickness 1.6, and impedance 50 ohms. This antenna is simulated using HFSS software.The antenna parameters such as return loss, VSWR, gain, and radiation pattern are studied,whichcan be used for X- band applications**.

*Keywords-**Microstrip patch antenna, FR4 epoxy, Return, VSWR, Gain***

I.INTRODUCTION

Microstrip patch antennas (MPAs) are rapidly gaining more attention due to the proliferation of communication devices and systems with frequencies becoming more suitable for the size and performance of this type of antenna. The patch is usually made of a conducting material (gold or copper) and it can be designed to assume different shapes (square, rectangular, triangular, dipolar, circular, circular ring, elliptical, disc sector, ring sector). The patch acts as the radiator and it is etched together with the feed lines on the substrate are used for improved electrical and mechanical stability. Microstrip patch antenna widely used in wireless communications applications such as telemetry and communications, aviation, naval communications, automatic guidance of intelligent weaponry, satellite, biomedical, radar, GPS systems.

In this paper two antenna array were proposed with same shapes for the radiating elements. FR4 substrate has been used to design the antennas for the X-Band frequency of 9.7 GHz which is useful for the radiolocation services. To maintain the compact nature of the antenna array interelement spacing in the antenna array is chosen the space wavelength.

X-band is used in radar applications including continuous-wave, pulsed, single-polarization, dual-polarization, synthetic aperture radar, and phased array. X-band radar frequency sub-bands are used in civil, military, and government institutions for weather monitoring, air traffic control, maritime vessel traffic control, defense tracking, and vehicle speed detection for law enforcement.

II.DESIGN OF ARRAY ANTENNA

Proposed antenna are two element antenna array aligned in 2x2 matrix format. The antennas are been designed on a low cost easily available FR4 glass epoxy substrate which is having a thickness of 1.6mm. The designed rectangular microstrip patch antenna having the substrate material is FR4 with relative permittivity 4.4, with the feeding technique is coaxial probe feeding and it has input impedance is 50 ohm by using the x-band frequency. Rectangular microstrip resonant patches have been used extensively in a variety of array configurations. It is very easy to analyze a rectangular microstrip antenna. The frequency range is specified by the IEEE at 8.0 to 12.0GHz. For military and satellites communications. Coaxial feed has been used to excite the antenna element and each element of the antenna array is fed by a independent coaxial feed. Commercial available 3D model simulator tool Ansys HFSS has been used to simulate the antenna array.

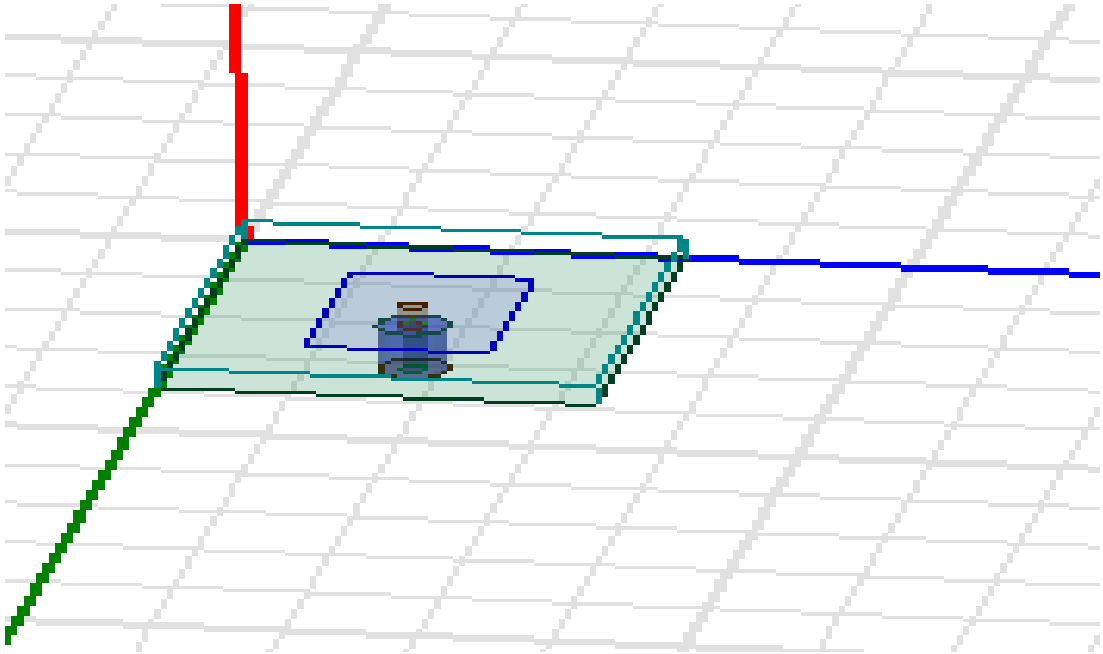

Fig . 1. Single Antenna using Coaxial Feeding

The designed patch antenna array using the following parameters:

Width of micro strip patch antenna

$$W = \frac{C}{2f\sqrt{\frac{\epsilon r+1}{2}}} \quad (1)$$

Effective dielectric constant

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

Effective length

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

Actual length

$$L = L_{eff} - 2x\Delta l (4)$$

Where,

W is the width of the patch

f is center of the frequency

$\in_r$is 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

The equations of the ground plane are as follows:

Length of the groundL_g

$$L_g = 6h + Pl \quad (5)$$

Width of the ground W_g

$$W_g = 6h + Pw \ (6)$$

Where,

h is the thickness of dielectric constant

Pl is the length of the patch

Pw is the width of the patch

TABLE 1

Parameters of the rectangular micro strip patch antenna

S. No.	Parameters	Dimensions (mm)
1.	Substrate material	FR4 epoxy
2.	Dielectric cont	4.4
3.	Operating frequency	9.3
4.	Thickness	1.6
5.	Patch length	16.4
6.	Patch width	19.5
7.	Ground length	16.4
8.	Ground width	19.5

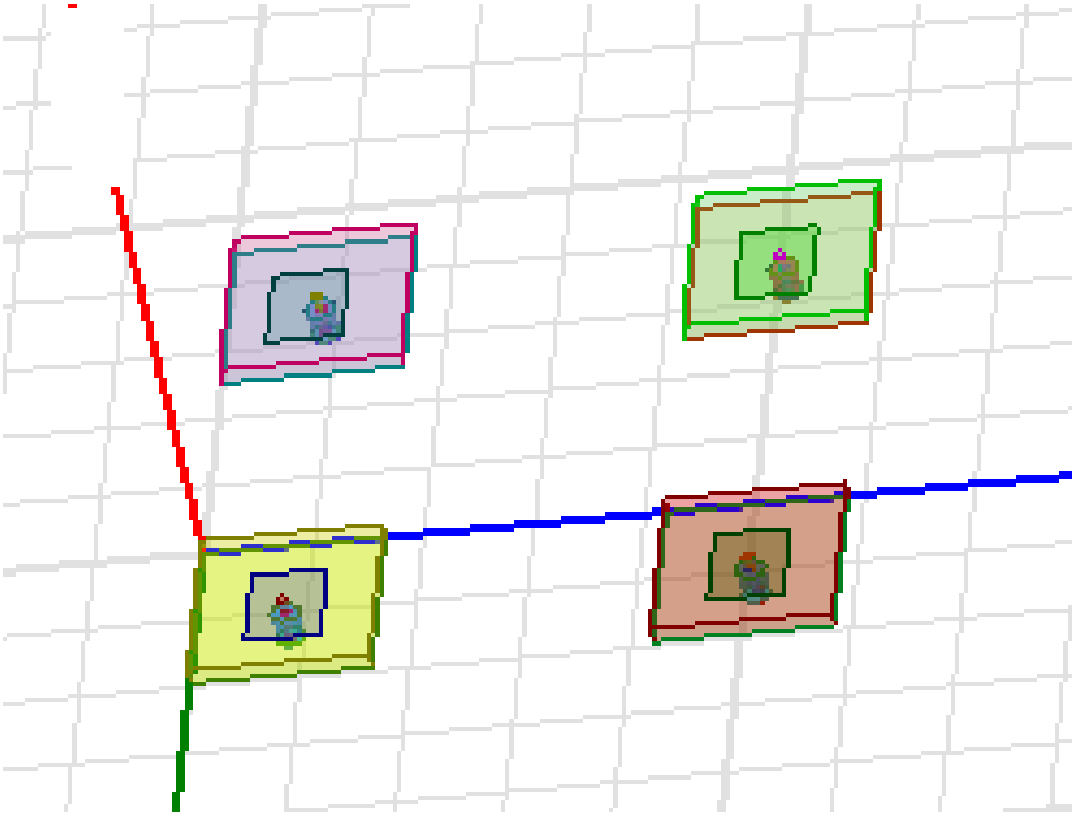

Fig. 2. 2x2 Array Antenna Design

III. ARRAY ANTENNA RESULTS

A. Returnloss:

Return loss for array antenna : Antenna has the return loss of -16 dB at 9.7 GHz

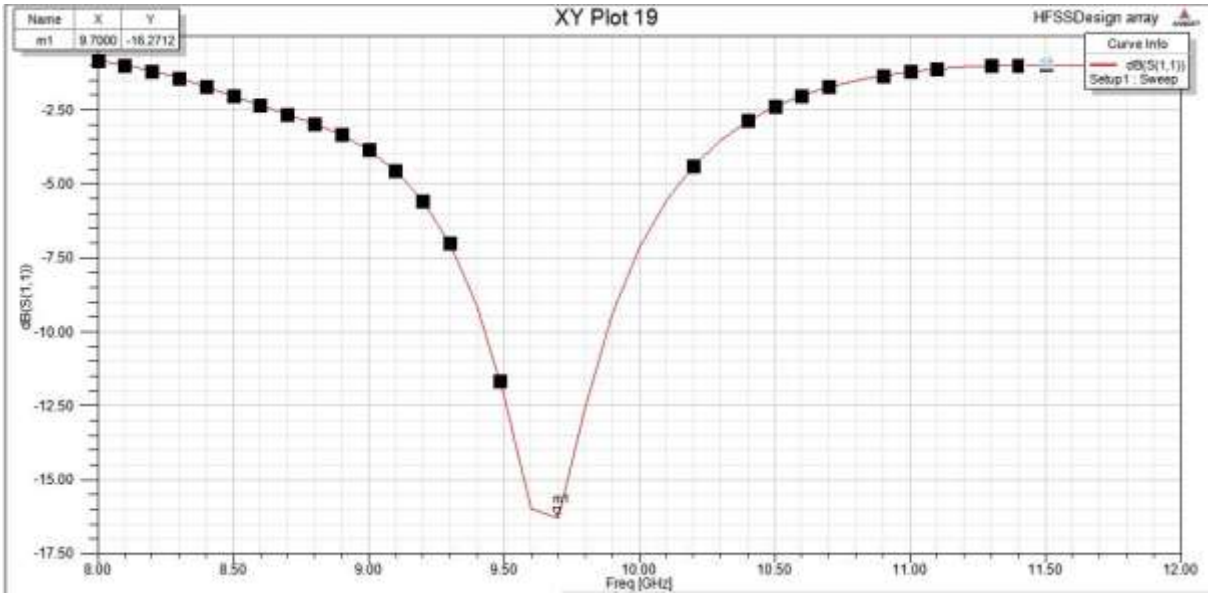

Fig. 3. Return loss

B. VSWR (Voltage Standing Wave Ratio):

VSWR for array antenna : Antenna has the VSWR of 1.36 dB at 9.7 GHz

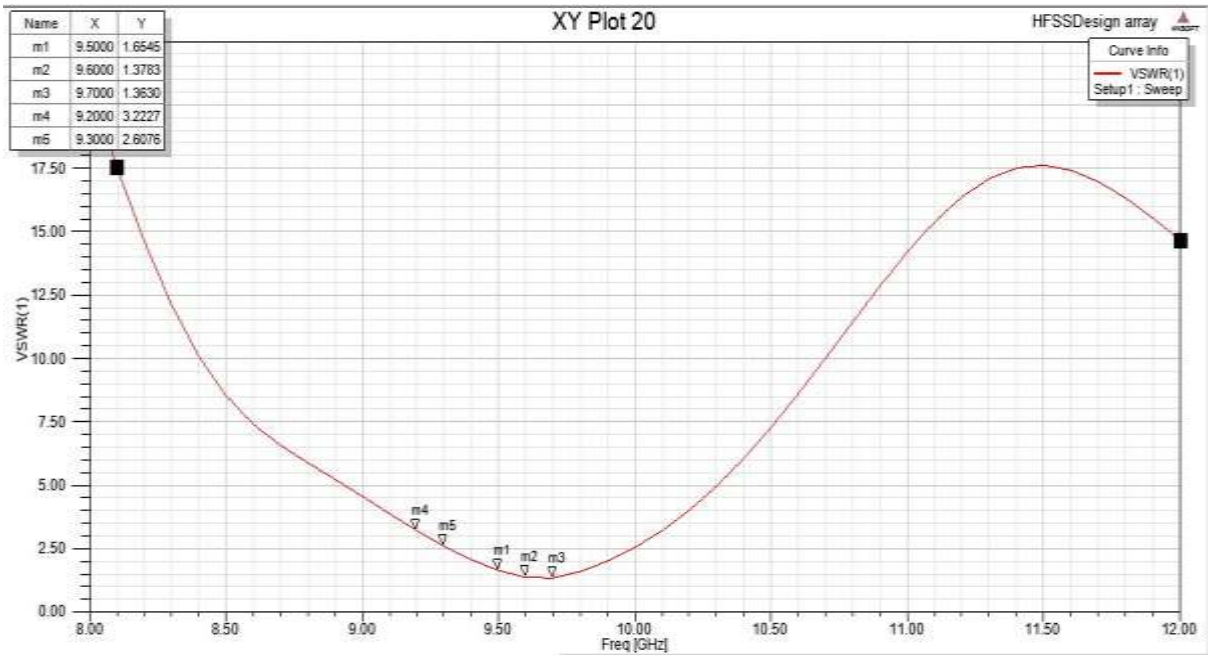

Fig. 4. VSWR

C. Gain:

A total Gain of 3.57 dB is observed in the 3D – Polar plot

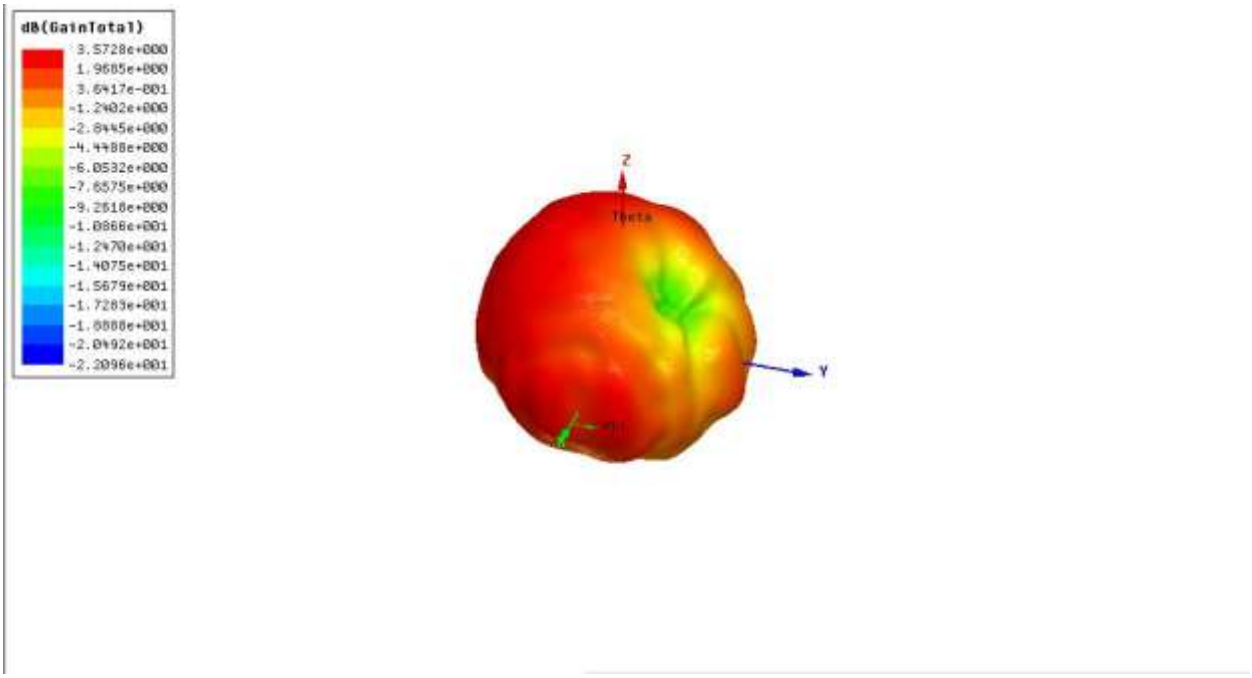

Fig . 5. 3D – Polar plot

D. Radiation pattern :

The radiation pattern of the antenna at 9.7 GHz shown below

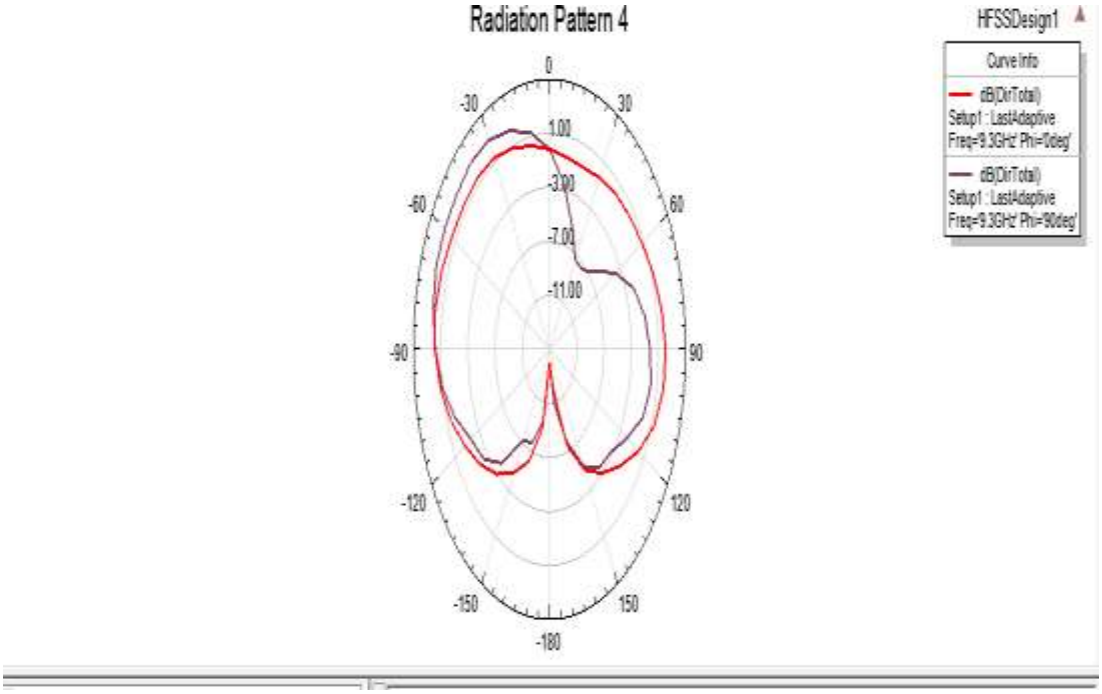

Fig. 6. Radiation pattern

TABLE II

Comparison between the single element and 2x2 array antenna

S. No.	Parameters	Single antenna	2x2 array antenna
1.	Operating frequency	9.3 GHz	9.3GHz
2.	S11 parameter(dB)	-19	-16
3.	VSWR	1.35	1.56
4.	GAIN (dB)	2.9	3.57

TABLE III

Comparison between the proposed antenna and 2x2 array antenna

Reference	S11 parameter	VSWR	Gain	Operating frequency	Feeding technique
Madhukant Patel PiyushKuchhal KanhiyaLlal Ranjan mishra[1]	1X8 -17.61 dB	1X8 1.30	1X8 12.30	1X8 10 GHz	Strip line feed Array
Proposed antenna	2x2 -16 dB	2x2 1.56	2x2 3.57	2x2 9.3 GHz	Coaxial FeedingAdrray

The antenna array is designed using easily available and low cost substrate material FR4 with dielectric constant of 4.4. The operating frequency of antenna array is 9.3GHZ with coaxial feeding technique.

IV. CONCLUSION

The 2X2 rectangular microstrip patch array antenna is designed frequency at 9.3 GHz, then return loss -16dBand VSWR 1.56 at 9.7 GHz, gain 3.57dB. These results are observing at 9.7 GHz. Array antennadesigning is suitable for x- band applications like satellite communications, these results are observing at 9.7 GHz Radars, Terrestrial communication and Networking. The proposed antenna can be applied for different patch shapes rectangular, circular and ring slots for other frequency bands. In this 2x2 array antenna we are using coaxial feeding technique by using the HFSS 13. 0.

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