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Design and Simulation of 4 Element MIMO antennas for Wireless Application

Snehal Surwase, Dhanashree Yadav, Shraddha Shinde, Prof. Ashish Jadhav

B. E Students, Dept. of ENTC, SVERI's COE, Pandharpur, India

B. E Students, Dept. of ENTC, SVERI's COE, Pandharpur, India

B. E Students, Dept. of ENTC, SVERI's COE, Pandharpur, India

Assistant Professor, Dept. of ENTC, SVERI's COE, Pandharpur, India

ABSTRACT: This paper expresses the design of different microstrip MIMO antennas for the wireless application. MIMO is a key factor in the advanced wireless communication standards such as WiFi, WiMAX, Long Term Evolution (LTE), 4G and 5G systems. The proposed design resonating at three frequencies and that are 1.8GHz, 2.8GHz and 3.3GHz, which has ground plane dimension130mm x130mm. Increase in the number of patch, results in an improved pattern of radiation in the MIMO system. The simulation results show improvement in VSWR (1.59dB), S-Parameter (-12dB) and radiation pattern**.**

KEYWORDS: MIMO, WiMAX, LTE, Flame Retardant 4 (FR4);

I. INTRODUCTION

The microstrip antennas and their different shapes are mostly chosen for the design of MIMO systems for the wireless application. MIMO is nothing but multiple antennas which are present at not only transmitter, but also the receiver to development communication performance. MIMO systems employing a wide band phenomenon are the best ever growing field of technology which has acquired the attention recently in the further Wireless Communications.
The multiple-input multiple-output (MIMO) technology made a better quality of mobile communication services by justifying the multipath fading which is required in various wireless applications like WiFi, WiMAX and LTE provide multimedia service. In wireless communications there has been always growing demand for capacity, data rate, coverage and reliability. So that MIMO system widely used in the different technologies.

II. RELATED WORK

In this paper author designed the antenna for application of WLAN with resonance Freq of 5.2GHz [1].This antenna is operating in the range of 4.8GHz-5.4GHz with bandwidth 600MHz. The return loss at 5.2 GHz frequency is below -10 dB, which shows that there is good matching at these points. This micro strip patch can be feed by different feed technique like transmission line, co-axial transmission line, but the author has used the inset feed technique. They also worked on radiation pattern and other important parameters like gain, efficiency as well as return loss.
In this paper author give information that an original two element MIMO system with modified isolation is intended and physically realized. The mutual coupling in the developed MIMO system is analyzed without consideration of patch and also with patch element among the antennas. The MIMO system with patch element among the antennas is given away to advance the isolation of 14 dB. A skilled technique is proposed to ease the mutual coupling developed in the antenna structure by employing a simple micro strip patch element in between the antennas [2].
A compressed design of 2 element Multiple Input Multiple Output (MIMO) system is planned of patch antenna with an inverted U-shape. A superior design of the antenna may boost performance of the system. The feeding of antenna has done with a coaxial feeding method print on a dielectric FR-4 substrate. In this paper author suggested MIMO patch antenna with a shape of an inverted U, which generate a dual band of frequency resonates at 2.8GHz and 6.4GHz with outstanding return loss of <-25dB. Hence, from the above conclusion author reduce that this MIMO antenna is well

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outfitted for wireless (WLAN) and satellite communications. The simulation result of return loss, mutual coupling as well as radiation pattern are shown [3].

III. ANTENNAS DESIGN

Design constraint of antenna:
A Microstrip patch antenna contains of a delicate metallic patch above a ground plane. Proposed design consists of the microstrip antenna which has patched dimensions as 24mm X 41mm and ground dimension as 65mm X 47mm.The overall performance of patch depends additionally on its size, but also the shape.The dielectric material chosen for our design is FR4 which has a constant of dielectric is 4.4. The dielectric substrate has height (Thickness) equal to 1.6mm
To design a Rectangular Microstrip patch antenna the necessary parameters are:

1. The operating frequency (Fo).
2. Dielectric constant of substrate *(εreff)*.
3. Effective dielectric constant *(εreff)*
4. The height of the dielectric substrate (hs)
5. The height of the conductor (t).
6. The width of the patch (W).
7. The Length of the patch (L).
8. The length and width of the ground plane (Wg) and (Lg).

Formulation:

Step1: Calculation of the width (W):

$$W = \frac{c}{2fo\sqrt{\varepsilon r+1}}$$

Step2: Calculation of effective dielectric constant (*εreff*):

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1 + 12\frac{h}{W}\right]^{1/2}$$

Step3: Calculation of extension length (ΔL):

$$\Delta L = \frac{\left(\frac{W}{h}+0.264\right)(\varepsilon reff+0.3)}{(\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)}$$

Step4: Calculation of effective length *(Leff)*:-

$$Leff = \frac{c}{fo\sqrt{\varepsilon reff}}$$

Step5: Calculation of actual length of patch (L):

$$L = Leff - 2\Delta L$$

Step6: Calculation of ground plane dimensions (Lg and Wg):

$$Lg = 6h+L;\ Wg = 6h+W$$

Design of simple microstrip antenna:-
The above design is of straight forward microstrip patch antenna which has dimensions given in below. This antenna is resonating at three frequencies that are 1.8GHz, 2.8GHz and 3.3 GHz respectively. It is a distinctive, comfortable design which having the higher accuracy and less complexity.

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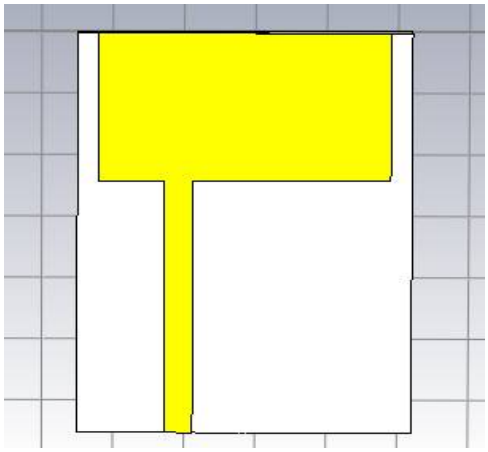

Fig (1.1) Simple microstrip patch antenna design

Table (1.1) Dimensions of the Proposed Antenna

PARAMETER	VALUES
Patch width (Wp)	41mm
Patch length (Lp)	24mm
Ground width (Wg)	47mm
Ground length(Lg)	65mm
Height of substrate (Hs)	1.6mm
Height of ground (Ht)	0.035
Dielectric constant	4.4

The above table gives the design specification of simple microstrip patch antenna. With above design specifications, simulation of antenna is carried out and gives the result shown below in Fig. (1.2).As S parameter should be less than -10 dB. So that the design gives the following results that are mentioned below.

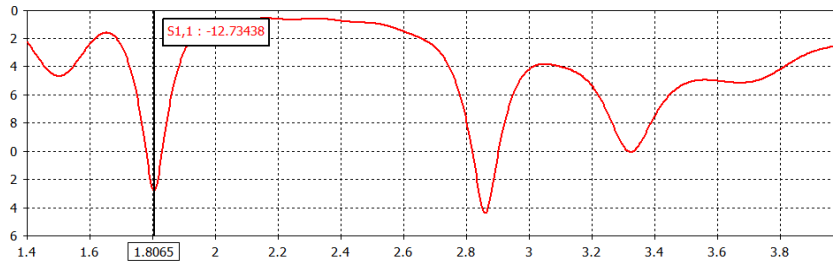

Fig (1.2) S-parameter

S-parameters characterize the input-output relation among ports (either terminal) in an electrical system. The S11, S22 parameters have the meaning of reflection coefficients.S11 and S22 represents the power reflected from the antenna. At 1.8 GHz frequency, S11= -12.75dB, VSWR= 1.59, Directivity=5.14dBi. At 2.8 GHz frequency, S11=-14.37dB, VSWR= 1.48, Directivity=6.34dBi. At 3.3GHz frequency, S11=-10.08dB, VSWR= 1.91, Directivity=6dBi and also reference impedance is very close to 50 ohms.

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Design of 2 element MIMO antenna:-

To improve the parameters such as directivity, VSWR and Bandwidth, 2 element MIMO antennas designed. The 2 element antenna increases the radiation pattern which has the ground length of 130mm and width 65mm. This antenna is also operating at the frequencies 1.8GHz, 2.8GHz and 3.3 GHz respectively.

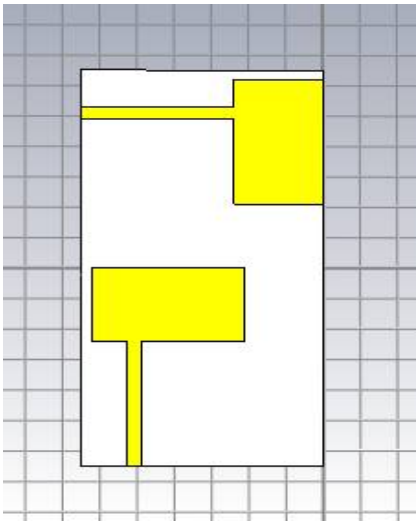

Fig (1.3) 2 element MIMO antenna

The simulation result of above antenna is given below:

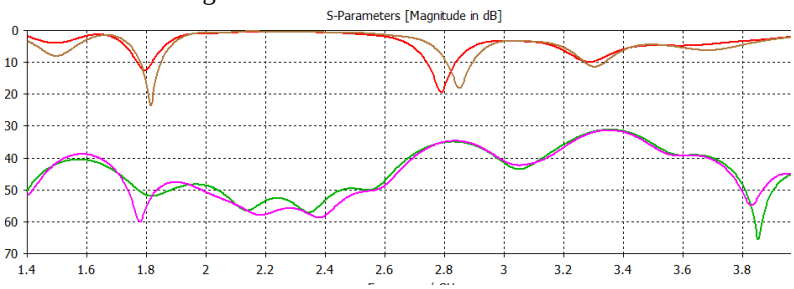

Fig (1.4) S parameter

At 1.8 GHz frequency, S11=-12.37dB, S22=-17.16dB, VSWR= 1.32, Directivity=7.05dBi.At 2.8 GHz frequency, S11=-13.07dB, S22= -12.5dB, VSWR= 1.5, Directivity=6.5dBi.At 3.3 GHz frequency, S11= -10.03dB, S22= -11.30dB, VSWR= 1.8, Directivity=6.1dBi which shows improvement in the results.

Design of 4 element MIMO antenna:-

To get further improvement in the parameters of 2 element MIMO antenna design we go for the 4 element MIMO antenna design which has the ground dimension of 130 X 130 mm..The 4 element MIMO antenna is shown below. As increase in the number of elements on the substrate, improvement in results takes place. The above antenna is operating at the frequencies 1.8GHz, 2.8GHz and 3.3GHz respectively.

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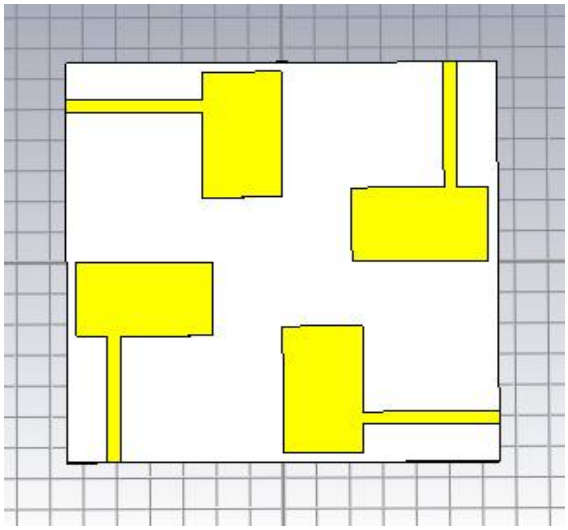

Fig (1.4) 4 element MIMO antenna.

The improved parameter during the simulation as shown below:

a) S parameter :-

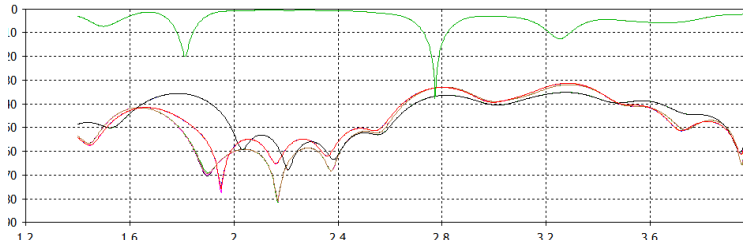

Fig (1.5) S parameter

From the simulation result, S parameters at 1.8 GHz as S11=-20.11dB, S22=20.12dB, S33=20.12dB S44=20.12dB. At 2.77GHz S11=-36.53dB, S22=-29.99dB, S33=-36.65dB, S44=-29.91dBand at 3.33GHz, S11=-12.61dB, S22=12.60dB, S33=-12.61dB, S44=-12.61dB

b) VSWR:-

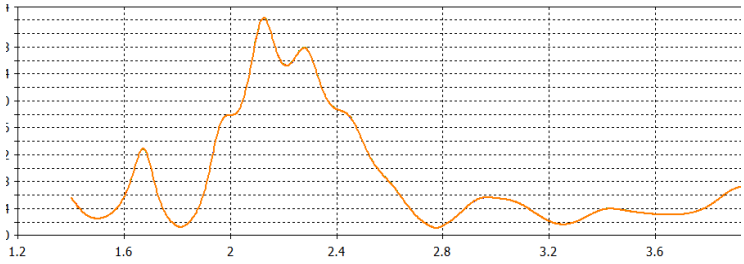

Fig (1.6) VSWR

VSWR is decided from the voltage measured together a transmission line leading to an antenna. VSWR is defined as the ratio of the peak amplitude of a standing wave to the minimum amplitude of a standing wave. From the simulation result, VSWR are obtained at three frequencies i.e.1.8GHz, 2.8GHz and 3.3GHz which have values of 1.23, 1.02, and 1.6 respectively. In such way the value of VSWR is lies between in the Range of 1.02 to 1.6.

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c) Reference Impedance:-

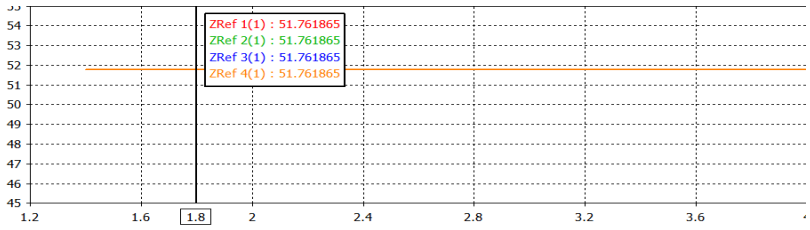

Fig (1.7) Reference impedance

Impedance matching is the most important parameter for improving the performance of the system. Its application is used in excessive frequency circuit design. The reference impendence obtained for this design which has a value of 51.76ohm. When reference impedance matched to Standard value of reference impedance (i.e.50 ohm) then maximum power gets transferred.

IV. SIMULATION RESULTS

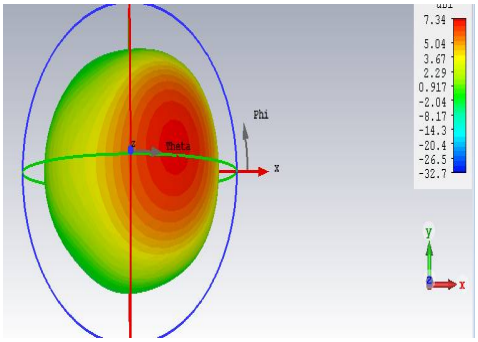

Fig (1.8) radiation pattern at 1.8 GHz

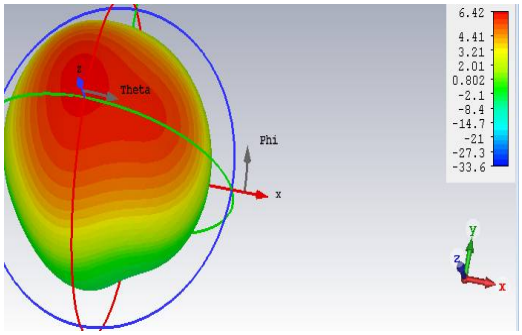

fig (1.9) radiation pattern at 2.7GHz

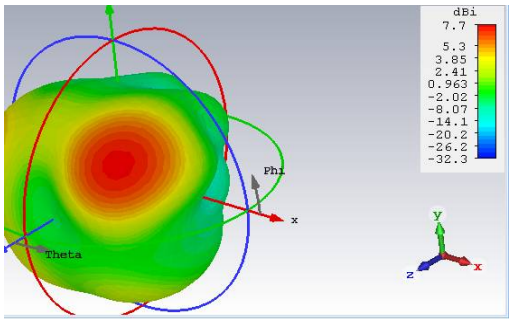

Fig (1.10) radiation pattern at 3.3GHz

The 4 element MIMO antenna has a different radiation pattern at different frequencies that are shown in the above figures. It indicates energy radiated by the antenna. It is a diagrammatical representation of the distribution of radiated energy into space, as a function of direction

a. At the 1.8 GHz, radiation pattern is 7.34 dBi (fig.1.8)
b. At the 2.7 GHz, radiation pattern is 6.42 dBi (fig.1.9)
c. At the 3.3 GHz, radiation pattern is 7.70 dBi (fig.7.7)

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So at 3.3 GHz, the proposed antenna gives maximum radiation (7.7 dBi) which is important for the MIMO system. Due to that data rate and also efficiency get increased.

V. CONCLUSION

From above simulation results, the design concludes that the increase in the number of patches on the substrate, data rate and radiation pattern get increased. The Proposed design resonating at three frequencies and that are 1.8GHz, 2.8GHz and 3.3GHz and it gives VSWR in the range of 1 to 2 and the values of S Parameters which are less than -10 dB. In such way the designed antennas which give good results in the range of 1.8 to 3.3GHz frequencies which are used for different wireless application.

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