Fabrication of 4 Element MIMO Antenna for Wireless Applications

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Abstract— A Design and Simulation of 4 element Multiple Input Multiple output (MIMO) Microstrip Patch Antenna that has 4 ports, been designed and implemented. The proposed antenna consists of four ports with all the four patches operates at LTE and WLAN frequencies 1.8GHz, 2.8GHz, 3.3 GHz. The antenna is fabricated on an inexpensive FR4 material of a dielectric constant of ε = 4.4, with thickness of substrate that is 1.6 mm and the thickness of patch is 0.035 mm. The measured results represents that the proposed antenna obtained a reasonable bandwidth for LTE and WLAN applications defined by return loss less than -10dB. And the S Parameters of antenna and Voltage Standing Wave Ratio of an antenna are simulated and measured. In this project, structure of the four ports MIMO antenna has been designed to have broad bandwidth. Since MIMO antenna having good gain and directivity can be achieved. The simulation is carried out by using CST microwave studio program. The simulation results show improvement in VSWR, S- Parameter and radiation pattern when we increase the number of patches.

Key words: MIMO, Multiband, WLAN, WiMAX, LTE, Flame Retardant 4 (FR4)

I. INTRODUCTION

The microstrip antennas and their different shapes are effectively used for the design of MIMO systems for the wireless applications. MIMO is nothing but multiple antennas present at the transmitter as well as at the receiver to improve the 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 is responsible for a better quality of communication services by justifying the multipath fading which is required in various wireless applications like WiFi, WLAN, WiMAX and LTE which provide multimedia communication services. The MIMO technology is widely used in the different systems to improve the need of datarates, coverage area and reliability of the system for the wireless communication.

II. RELATED WORK

The author has designed the antenna for application of WLAN with resonance Frequency of 5.2GHz. 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. This microstrip 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 [1].

The author gives information of a 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 microstrip patch element in between the antennas [2].

A compressed design of 2 element Multiple Input Multiple Output (MIMO) system has planned for patch antenna with an inverted U-shape. A superior design of the antenna may boost performance of the system. The coaxial feeding technique is proposed to print on a dielectric FR-4 substrate. The author suggested inverted U shaped MIMO patch antenna, 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 has concluded that this MIMO antenna is well outfitted for wireless (WLAN) and satellite communication [3].

III. ANTENNA DESIGN

A. Design Constraints 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 essential 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).

1) Formulation:

Step 1: Width (W):

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

Step 2: Effective dielectric constant (εreff):

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

Step 3: Extension length (ΔL):

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

Step 4: Effective length (Leff):

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

Step 5: Actual length of patch (L):

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

Step 6: Ground plane dimensions (Lg and Wg):

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

B. 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.

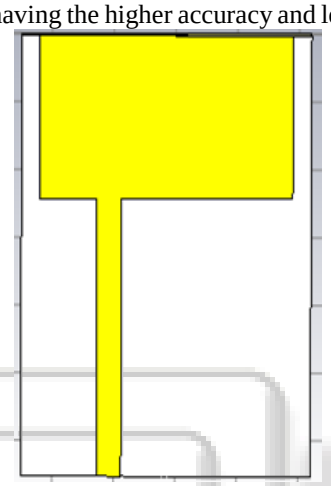

Fig. 1: Simple microstrip patch antenna design

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)	0.035mm
Dielectric constant	4.4

Table 1: Dimensions of the Proposed Antenna

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.

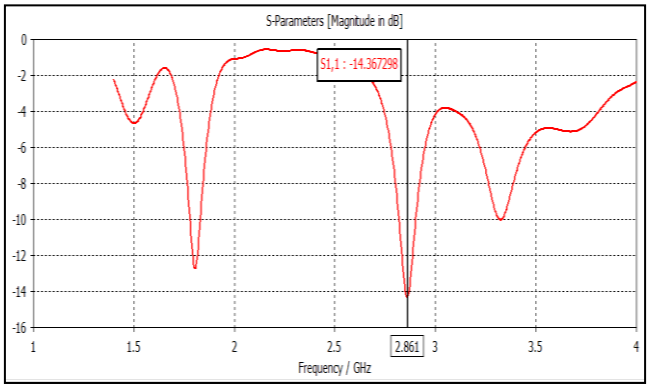

Fig. 2: S-parameter

S-parameters characterize the input-output relation among ports in an electrical system. The S11 and S22 represents the power reflected from the port of an antenna.

At 1.8 GHz, S11= -12.75dB, VSWR = 1.59, Directivity = 5.14dBi.

At 2.8GHz, S11=-14.37dB, VSWR=1.48, Directivity= 6.34dBi.

At 3.3GHz, S11=-10.08dB, VSWR= 1.91, Directivity= 6dBi.

C. Design of 2 Element MIMO Antenna:

For the improvement in parameters of an antenna such as directivity, VSWR and Bandwidth, 2 element MIMO antenna is designed. The 2 element antenna improves the radiation pattern of an antenna. The antenna has the ground length of 130mm and width 65mm. This antenna is also a multiband antenna which is operating at the frequencies 1.8GHz, 2.8GHz and 3.3 GHz.

Fig. 3: Fabricated 2 element MIMO antenna

The simulation result of above antenna is given below:

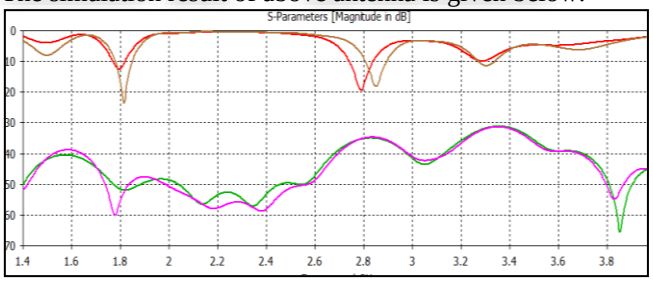

Fig. 4: S parameter

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.

D. Design of 4 Element MIMO Antenna:

To get future 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.

Fig. 5: Fabricated 4 element MIMO antenna.

The improved parameter during the simulation as shown below:

1) S parameter:

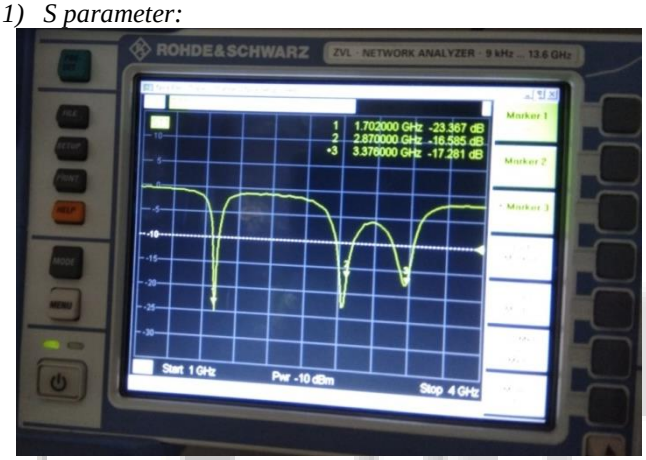

Fig. 6: Reflection coefficient practical result on VNA

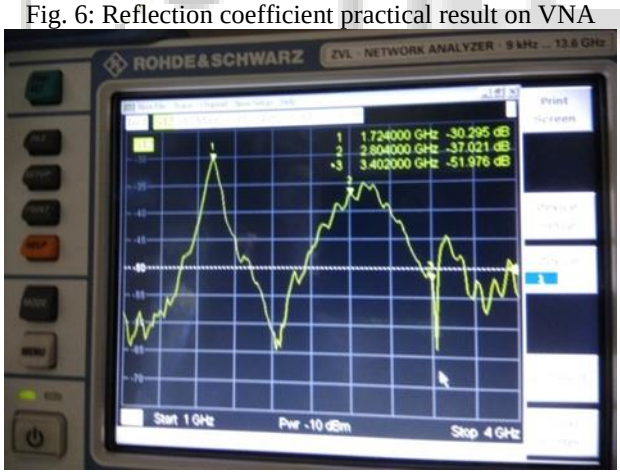

Fig. 7: Transmission coefficient practical result on VNA

From the simulation result, S parameters

At 1.8GHz, 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=-29.91dB and

At 3.33GHz, S11=-12.61dB, S22=12.60dB, S33=-12.61dB, S44=-12.61dB.

2) VSWR:

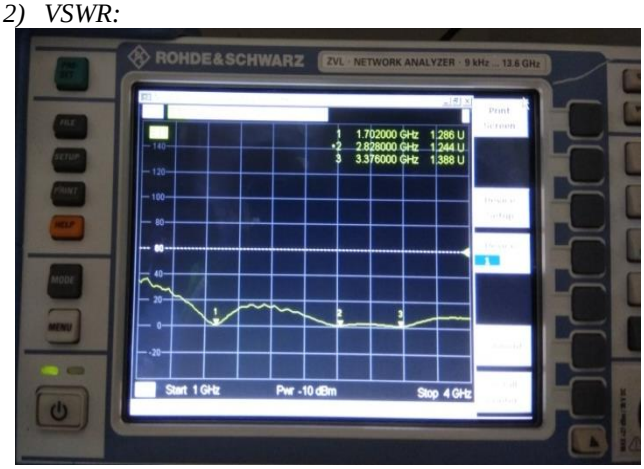

Fig. 8: VSWR practical result on VNA

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.

3) Reference Impedance:

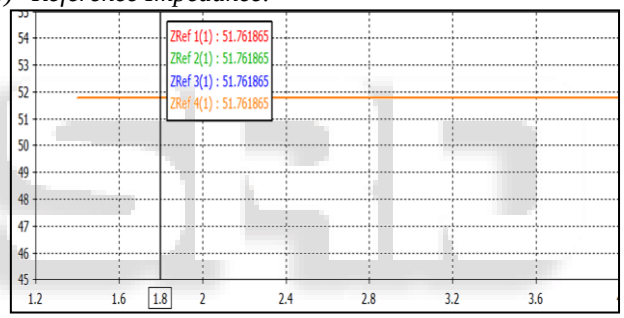

Fig. 9: Reference impedance

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

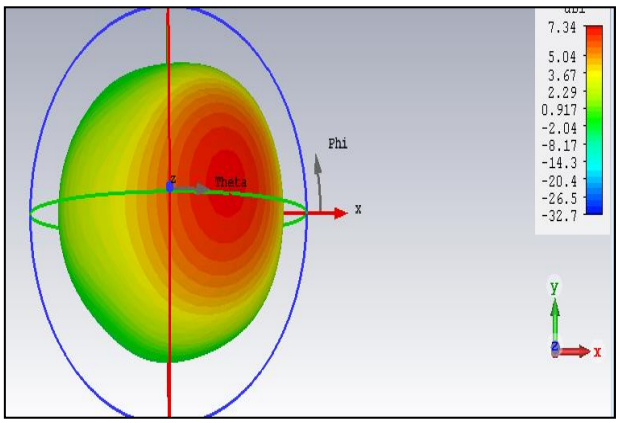

Fig. 10: radiation pattern at 1.8 GHz

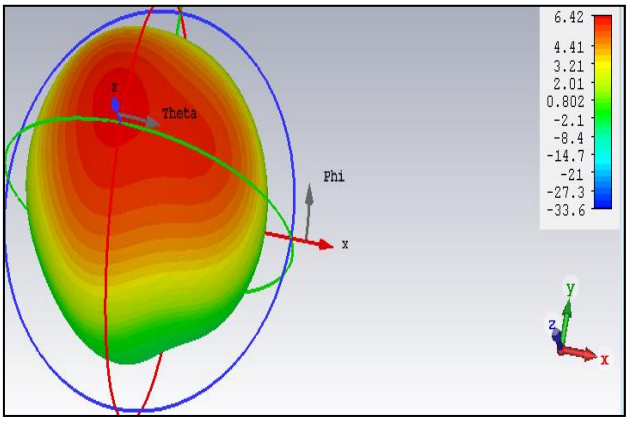

Fig. 11: radiation pattern at 2.7GHz

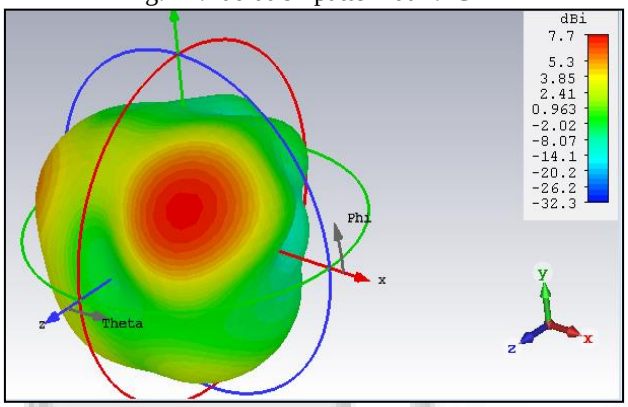

Fig. 12: radiation pattern at 3.3GHz

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

1) At the 1.8 GHz, radiation pattern is 7.34 dBi (fig.10)
2) At the 2.7 GHz, radiation pattern is 6.42 dBi (fig.11)
3) At the 3.3 GHz, radiation pattern is 7.70 dBi (fig.12)

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 this simulation and practical 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 is of 3 bands which is 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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