Design of Multilayer Micro Strip Antenna Array for Fixed Wimax Application

Nivedita Shankar Mahadik
ExTC
Saraswati College of Engg.
Mumbai, India

Sheetal Bhujade
ExTC
Saraswati College of
Mumbai, India

ABSTRACT
This paper presents the design of Multi layer parasitic MSA Array concerned on enhancement of gain at 5.8 GHz for Wi-Max application. Micro strip patch antenna array is designed by using different substrates. First layer element is made of FR4 substrate while other layers are of different substrates. The antenna provides better gain after adding the patch elements.

Keywords
Micro strip Antenna, Rectangular Patch, Square Patch, Co-axial feeding, Return Loss , VSWR, Directivity, Gain, Radiation Pattern.

1. INTRODUCTION
Recently, the development of communication technology is highly increased & still continues to grow. This increases the technology & their services applications which are very popular in everyday life, with variety of advantages at anytime & anywhere for the users. With such increase in demand for wireless digital applications are used. There are different frequencies for different applications like Wi-Fi, Wi MAX. In Wi Max also there are different types like Mobile Wi MAX and Fixed Wi MAX. In this paper the resonant frequency is 5.8 GHz it can be also used for Fixed Wi Max application [5].

Antennas which are used for these applications should be of low profile, light weight, low volume. All these requirements are overcome by using Micro strip antennas. The structure of patch antenna consists of dielectric substrate on optically planar ground plane, radiating element on other side of substrate which is prepared with conducting materials [1]. Micro strip Antennas has several advantages & several disadvantages. Disadvantages such as height, gain & bandwidth which are overcome by constructing patch antennas in array configuration.

2. DI ELECTRIC MATERIAL
While selecting the substrate or dielectric material cost of material, dielectric constant, loss tangent are the parameters need to be considered. In this paper Roger RT/ Duroid 5880 with permittivity 2.2 and loss tangent 0.009 and FR-4 with permittivity 4.4 and loss tangent 0.022 are used.

3. DESIGN OF RECTANGULAR & SQUARE PATCH ANTENNA
The Rectangular and square patch Micro strip antenna can be designed at frequency of 5.8 GHz using transmission line model whose dielectric constants are 2.2 and 4.4 .

A. Designing steps at 5.8 GHz frequency:

1. Calculation of the Width (W)

$$W = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

2. Calculation of Effective Dielectric constant (ε_{eff}) :

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]\wedge(-\frac{1}{2}\ ) \qquad (2)$$

3. Calculation of Effective length (L_{eff}):

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{eff}}} \qquad (3)$$

4. Calculation of Length Extension (ΔL) :

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\,(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)\,(\frac{W}{h}+0.8)} \qquad (4)$$

5. Calculation of the resonant length of patch (L):

$$L = L_{eff} - 2\Delta L \qquad (5)$$

4. FEED METHOD
The co- axial feed method is adopted for this paper. The outer conductor of co-axial probe is connected to ground plane. Inner conductor is extended through dielectric and soldered to patch. Inner conductor transfers power from strip line to Micro strip antenna from slot in ground plane. Position of feed is also effects the radiation characteristics in order to have best matching with input impedance.

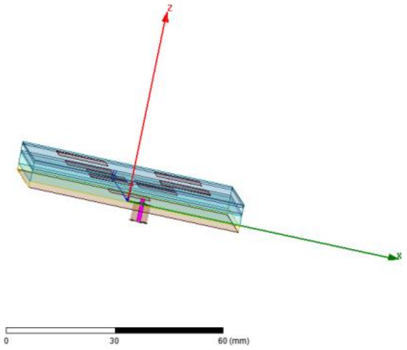

Fig 1. Co axial feeding in Multilayer Parasitic Antenna

5. NUMERICAL DESIGN
This antenna is designed with Multilayer Micro strip patch antenna which has one patch on first layer of substrate. It consists of ground plane, first layer of FR-4 substrate, second and third layer are of RT-Duroid. The antenna is proposed at 5.8 GHz frequency. Patch of first layer is designed according to characteristics of FR-4 substrate which is having length 11.5mm and width of 11.5mm. Another two layers consists of four patches of 11mmx11mm size.

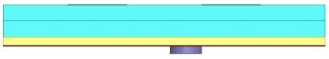

Fig 2. Schematic of proposed Multilayer Parasitic Antenna

6. SIMULATION SETUP

Now days, by the availability of latest simulation software, it has become very easy to implement our ideas or proposals insisted of real time implementation. Present project work of co axial feed square patch antenna is designed by using Ansoft HFSS and CST software. And results return loss, gain , VSWR & directivity are presented.

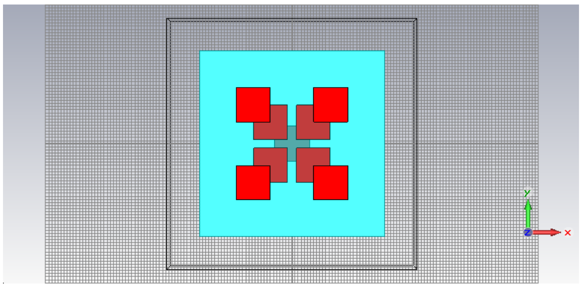

Fig 3. Top view of Multilayer Parasitic Antenna

7. RESULTS & DISCUSSION

7.1. Return loss

It is the reflection of signal power resulting from the insertion of a device in a transmission line and measures the reflected power of the system compared to the input power.

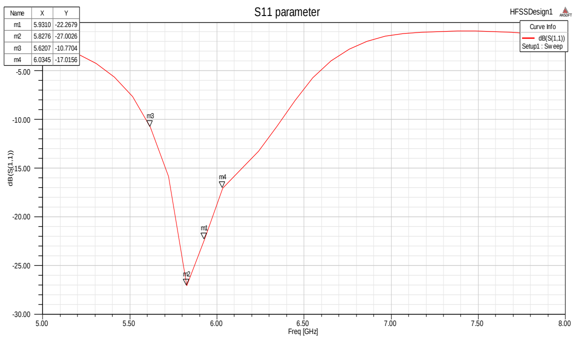

Fig 4. Return loss of Multilayer antenna for 11mmx11mm patch

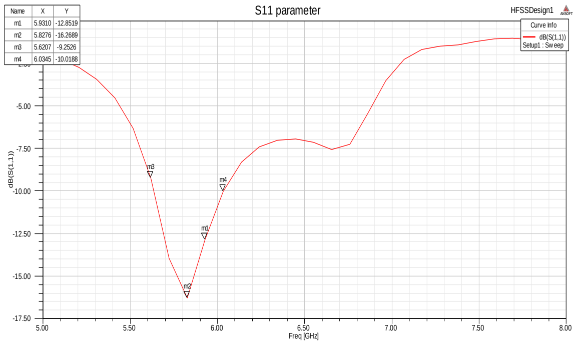

Fig 5. Return loss of Multilayer antenna 13mmx14mm patch

It is usually expressed as the ratio in dB relative to the transmitted signal power. Return loss is caused by impedance mismatch between two or more circuits. Plot of return loss is shown in Fig.4 & Fig.5. Here, return loss in Fig.4 is -16.26dB for 11mmx11mm patch & for 13mmx14mm patch size it is -27dB which is shown in Fig 5.

7.2. VSWR

It is the ratio of minimum and maximum voltage on transmission line.

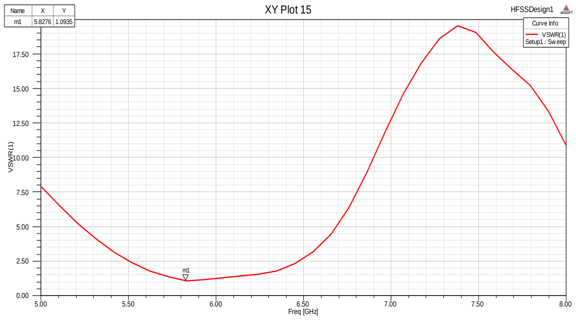

Fig 6. VSWR of Multilayer antenna 11mm x 11mmpatch

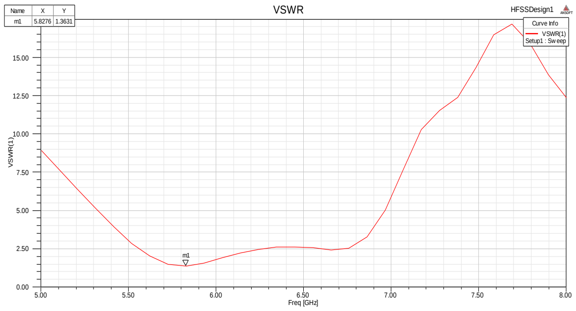

Fig 7. VSWR of Multilayer antenna 13mm x 14mm patch

Fig. 6 & 7 shows VSWR value 1.3:1 which denotes a maximum standing wave amplitude that is 1.3 times greater than the minimum standing wave value.

7.3. Gain

Gain of antenna is actual realized quantity which is less than directivity due to Ohmic losses in antenna.

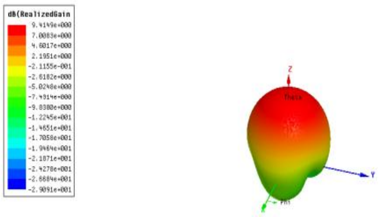

Fig 8. Gain of Multilayer antenna for 13mmx14mm patch

It can also be defined as the ratio of maximum radiation intensity in given direction to the maximum radiation intensity from a reference antenna produced in the same direction with same power input. Here the gain of an antenna is 9.8dB which is more sufficient for this multi layer antenna as shown in Fig.8.

7.4 . Directivity

The maximum directive gain is called as directivity of an antenna. It is the ratio of maximum radiation intensity of the subject antenna to the radiation intensity of an isotropic or reference antenna radiating the same total power.

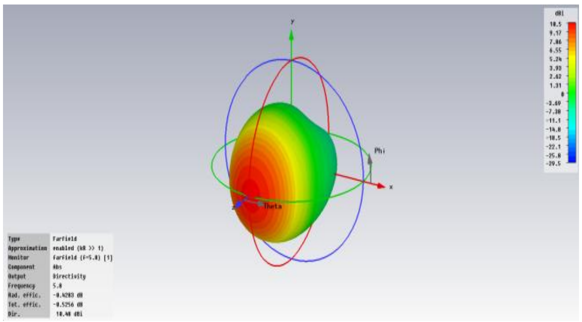

Fig 9. Directivity of Multilayer antenna for 13mmx14mm size patch

In this antenna design it is 10.40 dBi as shown in above Fig. 9.

7.5. Radiation Pattern

Radiated energy from an antenna is not of the same strength in all directions. It is more in one direction and less or zero is other direction. It is the graph which shows the variation in actual field strength of electromagnetic field at all points which are at equal distance from the antenna.

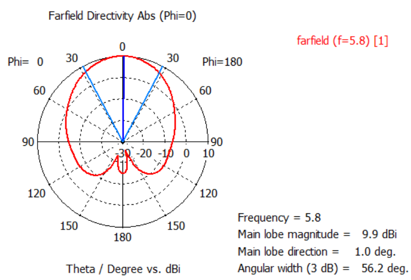

Fig 10. Radiation Pattern of Multilayer antenna for 13mmx14mm size of patch at Phi-0^0

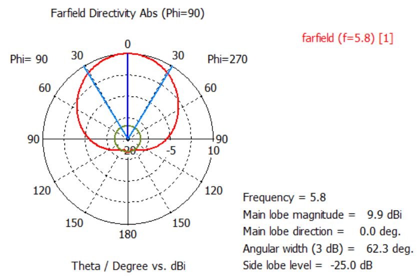

Fig 11. Radiation Pattern of Multilayer antenna for 13mmx14mm size of patch at Phi-90^0

Fig 10 shows angular width at 3dB when Phi=0 is 56.2 deg. & Fig 11 shows angular width at 3dB when Phi=90^0 is 62.3 deg. It is unidirectional radiation pattern..

Table 1 Outputs of HFSS and CST software by keeping the size of patch 11mmx11mm

Parameters	HFSS	CST
Return Loss	-16.26dB	-16.56dB
Gain	4.8	5
VSWR	1.3	1.3
Directivity	5	5.26

Table 1 shows the simulation results in HFSS & CST software. Here the patch size is 11mmx11mm.Table shows Directivity which is 5.26dBi which is half after increasing the patch size up to 13mmx14mm.

Table 2 Outputs of HFSS and CST software by varying the patch size to 12mmx12mm

Parameters	HFSS	CST
Return Loss	-15.40dB	-15.40dB
Gain	4	5.2
VSWR	1.4	1.4
Directivity	4.5	5.8

Table 2 shows simulation results after increasing the patch size by 12mmx12mm. Here there is quite change in Return loss, Gain & Directivity.

Table 3 Outputs of HFSS and CST software after by varying the patch size to 13mmx13mm

Parameters	HFSS	CST
Return Loss	-21.77dB	-21.77dB
Gain	9	9.3
VSWR	1.17	1.1
Directivity	9.8	10

Table 3 shows simulation results by changing the patch size from 12mmx12mm to 13mmx13mm. It gives better results as compared to others. There is improvement in all parameters.

Table 4 Outputs of HFSS and CST software after by varying the patch size to 13mmx14mm

Parameters	HFSS	CST
Return Loss	-27dB	-26.9dB
Gain	9.8	9.8
VSWR	1.09	1.09
Directivity	10.40	10.40

Table No 4 shows better results in both software's after increasing patch size by 13mmx14mm. It gives better Return loss, Gain, VSWR is 1.09 which is good.

8. CONCLUSION

Simulation results shows effects after increasing the size of patch in upper layer of an antenna. There is change in VSWR, return loss, gain & directivity. In this paper the first simulation is carried out for 11mm x 11mm patch and it is changed up to 13mm x 14mm to get good response of antenna. The patch of first layer is square for FR-4 substrate. The second layer is of RT-5880 substrate having square patches & third layer patches changed from square to the rectangular. It means after changing the length and width of patches the resulting output gets changes from broad bandwidth to narrow bandwidth. It means after increasing the area of metallic plate the total performance of antenna has been improved. It is because the patch is radiating element of antenna. And after increasing the height of an antenna there is an enhancement of bandwidth. There is air gap between all three layers.

In this paper the simulation is carried out by using High Frequency Simulation Software & Computer Simulation Tools. Table No.1,2,3 & 4 shows the outputs by using both software's by varying the size of upper layer patch antenna[1]. Table No.1 shows 11mm x 11mm size of upper layer patch whose Return loss is -16.26 dB for HFSS software & -16.56 dB for CST software. Table No.4 shows Return loss for 13mm x 14mm patch in HFSS it is -27dB & in CST it is -26.9dB. It means after changing the size of a patch return loss, gain, directivity & VSWR all these parameters changes. In future work all these parameters can be varied by using different substrates for different layers & for different Dielectric Constants.

9. REFERENCES

[1] Girish Kumar and K.P.Ray , Broadband Microstrip Antenna, Boston : Artech House , 2003.

[2] C.A.Balanis, Antenna Theory, 2nd ed. New York : John Wiley & Sons, Inc, 1997.

[3] Tomohiro Seki,Naoki Honna, Kenjiro Nishikawa and Kouichi Tsunekawa " Milimeter- Wave high efficiency Multilayer parasitic Micro strip Antenna Array on Teflon Substrate" IEEE TRANSACTIONS On Microwave Theory And Techniques, Vol.53, No.6, June 2005.

[4] D.Bhardwaj, D.Bhatnagar, S. Sancheti , B. Soni " Design of Square Patch Antenna with a Notch On FR4 Substrate" in Proc. Asia Pacific Microwave Conference, 2007. ISSN 1751-8725.

[5] Jeffrey G.Andrews, Arunabha Ghosh, Rias Muhamed, Fundamentals of WiMAX: Prentice Hall, 2007.

[6] M.M.Sharma, N.C Bajia, Vinita Agarwal, Shilpi Kumawat, Swati Gupta and R.P.Yadav " Compact Micro strip Circular Patch Antenna For Wi Max Double Layered Substrate " in *Proc. International Conference On Microwave*, 2008.

[7] M.T.Ali, M.K.M Salleh, N.Ramli and H.Alias " Truncated Rhomic Micro strip Patch Array Antenna With Frequency Reconfigurability " *IEEE Asia Pacific Conference On* Applied *Electromagnetics (AMCE 2012)* , December 11-13, 2012, Melaka, Malaysia.

[8] Khalid Ali, Sultan Jasim " Compact Dual Band Monopole Antenna for WLAN/ Wi Max Applications" *International Conference On Micro electronics, Communication and Renewable energy (ICMiCR-2013).*

[9] George Casu, Catalin Marau, Andrei Kovacs " Design & Implementation of Micro strip Patch Antenna Array" IEEE 2014.

[10] V Srinivasa Rao, Dr. DR Jahangirdar, Prof. Girish Kumar " Design And Development of Broadband Circularly Polarized C- Band Micro Strip Antenna Array " *Annual IEEE India Conference (INDICON)*, 2014.