Low Profile, High Gain Microstrip Patch Antenna

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ABSTRACT
Wireless technology is one of the main areas of research in the world of communication and a study of communication system is incomplete without understanding the operation of an antenna. Recent trends of wireless mobile communication technology are towards the miniaturization and demand for more robust and compact designs. This paper proposed a low cost, efficient, high gain and wideband Microstrip Antenna (MSA) using rectangular patch for wireless applications. In this paper an attempt is made to implement the line feed and probe feed MSA with a low cost, easily available FR4 substrate with permittivity 4.4, substrate height of 1.59mm and loss tangent of 0.02. The proposed Antenna is also optimised by using air as a dielectric substrate. An attempt is also made to optimised MSA using double layer with airgap. Double layer consisted of double sided copper ensure using one side as ground plane and other side as feed network. The air gap reduces both the electric field concentration on the lossy epoxy and the effective dielectric constant of the radiating plane. The structure is optimised using Zeland IE3D version 14.10. The optimised MSA with air as a dielectric substrate provides a maximum gain of about 9.3 dB, RL<-10dB and efficiency >90% at resonance frequency at 2.4 GHz.

Keywords
MSA, FR4, probe feed, line feed, R.L

1. INTRODUCTION
Nowadays, due to their several key advantages over conventional wire and metallic antennas, Microstrip Aantennas have been used for many applications, such as Direct Broadcasting Satellite (DBS) Systems, mobile communications, Global Positioning System and various radar systems .Their advantages include low profile, light weight, low cost, ease of fabrication and integration. [1] But Microstrip patch antennas also possess major disadvantages such as narrow impedance bandwidth, low efficiency and gain, which seriously limit the application of the Microstrip patch antennas. These limitations are due to the impedance mismatch of the feeding circuitry. In order to match the element the simplest matching method involves choosing the feed location where the resonant resistance is equal to feed-line impedance. In most application, the Microstrip patch antenna is fed using either coaxial probe feed or inset Microstrip line as both are direct contact methods providing high efficiency [2].Generally, both the bandwidth and gain will increase with substrate thickness (up to certain limit), but decrease with increasing dielectric constant. One common method for bandwidth enhancement is using parasitic patches, either in co-planar or stacked geometry. The gain can also be increased in co-planar geometry by placing the parasitic patches adjacent to fed patch to form an array [3].The performance of Microstrip patch antennas greatly depends on substrate parameters i.e. their dielectric constant and tangent loss. Means that, the efficiency and gain are low when the dielectric constant and tangent loss are high [4] In designing a Microstrip Antenna, numerous substrates can be used to achieve good response [5]. Utilization of thick substrate with low dielectric constant is considered as a method of bandwidth enhancement technique [6]. Further to increase the efficiency and to decrease the high substrate loss, an airgap is inserted between radiating element and the ground plane. This air gap reduces both the electric field concentration on the lossy epoxy and the effective dielectric constant of the radiating plane. [7]. In comparison to a normal Microstrip patch antenna, antenna loaded with metamaterial structure has the capability to increase the gain and reduce the return loss as its dielectric constant reduces because of the structure[8]. Patch antennas are feasible for both on–body and off-body communication due to the low profile they utilize. The ground plane of such antenna effectively shields both the antenna (from the influence of the human body) and the user (from negative effects of electromagnetic field) [9]. The size, the patch and hence the patch array and also the integrability of the patch array with RF front end can be improved by using GaAs substrate and employing micro matching [10]

In this paper, optimised high gain Microstrip patch Antenna, in which air is used as a dielectric substrate and MSA using Double layer with air gap at 2.4GHz. .The method of feeding used is Probe feed technique, with the advantage that the feed can be placed at any place in the patch to match with its input impedance (usually 50 ohm)

2. ANTENNA DESIGN

2.1 MSA Design with Finite Ground Plane
The Microstrip patch Antenna is designed and optimised using a finite ground plane since there are various disadvantages using an infinite ground plane. The main advantage of using finite ground plane is that it is designed practically. It increases the gain and reduces the unwanted radiations.

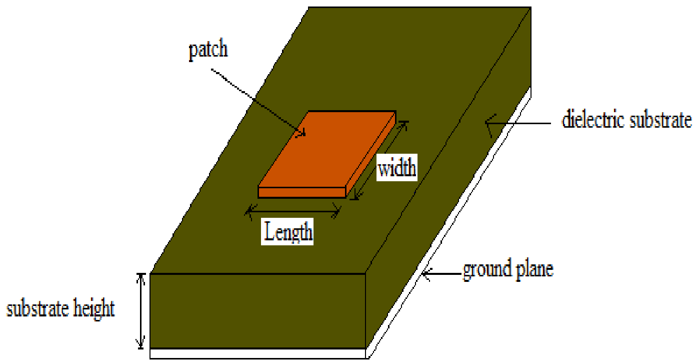

Fig.1 RSMA structure as shown above.

The geometry of the standard rectangular patch Antenna is shown in figure 1.

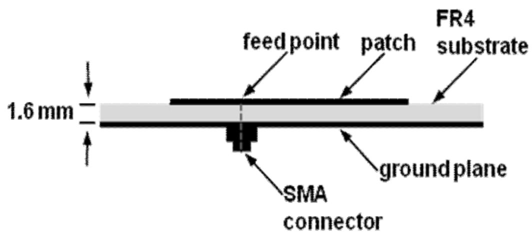

Fig2. side view of probe feed rectangular patch Antenna with dimensions, patch width (w) = 38mm, patch length (L) =29.5mm, feed distance 7.5mm and finite ground plane 60x60mm.

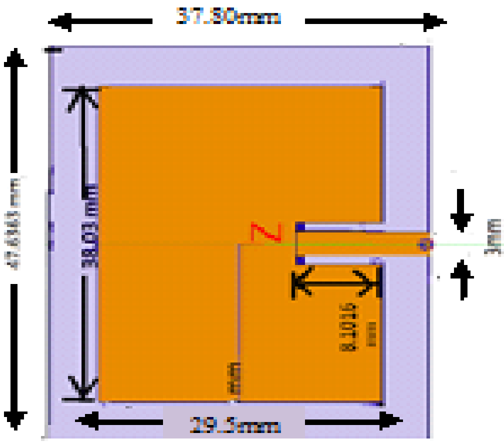

Fig 3. Dimension of patch for rectangular patch antenna.

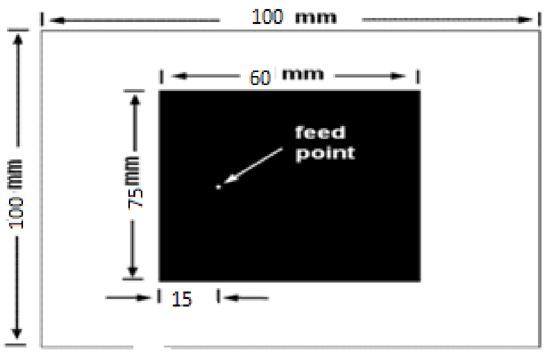

Fig 4.Geometry of top view the high gain Microstrip Rectangular patch Antenna with air 1.5mm as a dielectric substrate height, loss tangent 0, permittivity1.

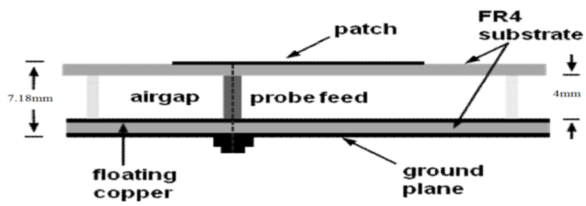

Fig.5.Geometry of side view Double layer Microstrip Rectangular patch Antenna with air gap 4mm,patch length (L)=46.5mm, Patch width (w)=51mm, probe feed distance 12.5mm, and finite ground plane 60x60mm.

An air gap 4mm is inserted between radiating element and ground plane as shown in fig.5.

3. SIMULATED RESULTS

The effect of change in Antenna dimensions on radiation parameters such as Gain, Bandwidth, Return loss and Efficiency etc is studied. The effect of change in patch length, width, and feed position on radiation characteristics is also studied.

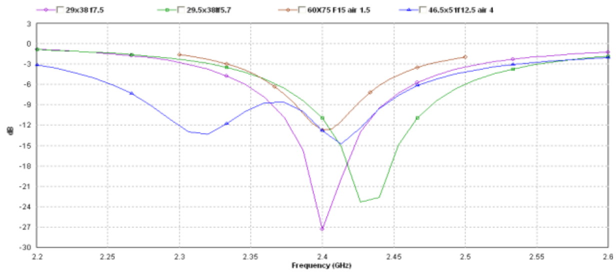

Fig 6 Return loss vs. Frequency

The return loss (R.L) is parameter indicate the amount of power that is lost to load and does not return as a reflection. The MSA with air as dielectric, MSA using double layer with air gap and also with FR4 as a dielectric substrate is optimised at 2.4GHz with probe feed & line feed. The optimised structure provided R.L<-10dB. As shown in Fig .6

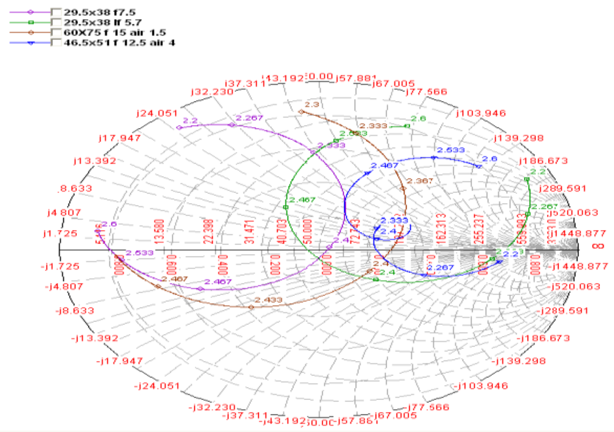

Fig.7. Smith chart

Impedance variation is observed from smith chart fig. 7.

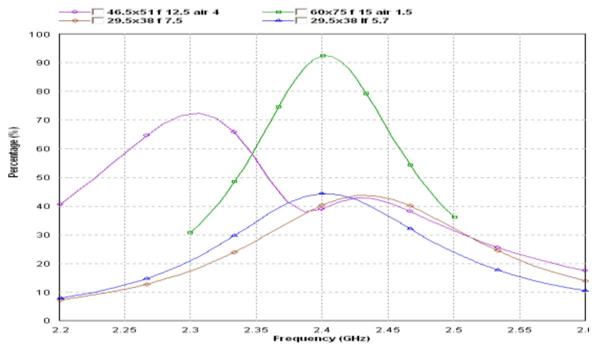

Fig 8. Antenna efficiency vs. Frequency

As shown in Fig 8.the optimised MSA with air as a dielectric provided a maximum efficiency of 92.74%.MSA using double layer with air gap efficiency 40.41%. MSA using FR4 substrate with probe feed and line feed provide efficiency 40.42%, 44.31% respectively.

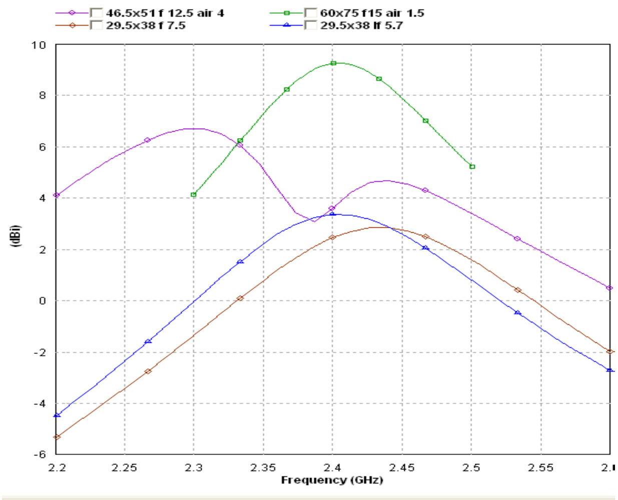

Fig 9 Total gain vs. Frequency

As shown in Fig 9.the optimised MSA with air as a dielectric provided a maximum gain 9.247dB, MSA using double layer with airgap, MSA using FR4 substrate with probe feed and line Feed Provide gain 3.36dB, 2.46dB, 3.36dB respectively.

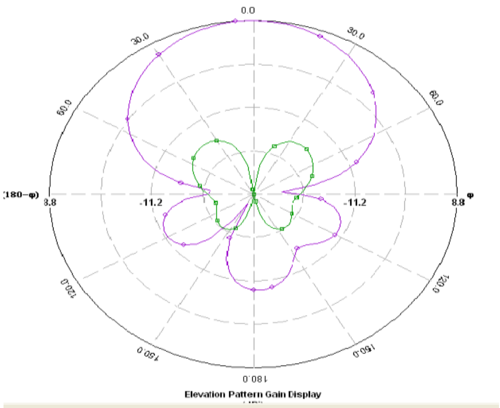

Fig.10. Antenna 2D Radiation Pattern

This radiation pattern shows that the antenna radiates more power in a broadside direction and less in other direction. As shown in Fig.10 (Side Lobe Level) S.L.L<-20dB, (Front to back ratio) F/B>15dB.

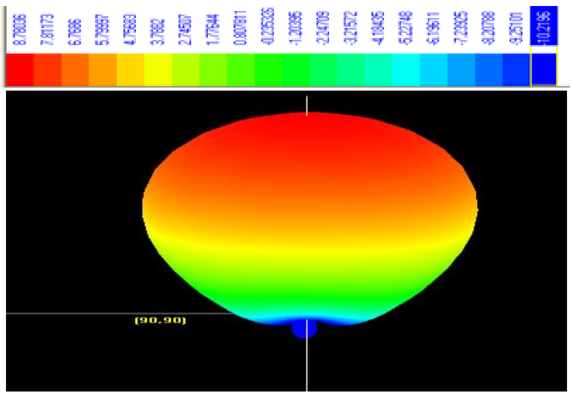

Fig.11. 3D Radiation pattern for air as a dielectric substrate

Current density variation scale as shown in Fig.11

4. RESULT AND DISCUTIONS

The graphs discussed above have been tabulated as follows:

Sr. No.	Length x Width (mm)	Feeding Techniques	Frequency (GHz)	Gain (dB)	Efficiency (%)	Return Loss (dB)
1	29.5 X 38	Probe Feed	2.4	2.46	40.42	-27.31
2	29.5 X 38	Line Feed	2.4	3.36	44.31	-11.01
3	60 X 75	Air as a Dielectric Substrate	2.4	9.247	92.74	-12.4
4	46.5X51	Double layer with air gap	2.4	3.36	40.41	-14.13

The gain, efficiency is improved by using air as a dielectric substrate. MSA using double layer with airgap provided R.L-14.13dB and gain, efficiency can be improved by change in Antenna parameters .But for above antenna, it is inconvenient to use a Microstrip line feed from the point of optimization. Hence for the above designed Antenna, used coaxial probe feeding.

5. CONCLUSION

In this paper an attempt is made to optimised MSA using double layer with airgap, using air and FR4 as a dielectric substrate at resonance frequency 2.4GHz and optimised structure provided a maximum gain of 9.3dB, efficiency>90%, R.L<-10dB, S.S.L<-20dB and F/b>15 dB, also the effect of change in antenna dimensions on the radiation parameters of the antenna is studied.

Antenna parameters can be further improved using double layer with air-gap by change in antenna dimensions.

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