Microstrip U-Slot Aperture Coupled Antenna for Wimax Application

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Abstract— The micro strip antenna has become a rapidly growing area of research with their potential application like mobiles and satellite communication. The antenna exhibits wideband characteristics that depends on various parameters such as U slot dimensions, coupling slot feed etc. In this project, the proposed antenna design shows the measured return loss within acceptable range throughout band (3.15 GHz – 3.6 GHz). Feeding technique adapted in aperture coupled. This design is simulated using CST microwave studio software. The main aim of this project is to optimize the gain of 2 dB using a superstreet layer i.e. λ/2 distance from ground level and thickness of layer is λ/4. The computer simulated results showing VSWR value below 2 in middle frequency band range of WIMAX enhances the adoption of this antenna for WIMAX application. The results are analyzed, estimated and discussed in terms of VSWR and radiation pattern.

Key words: VSWR, WIMAX, CST

I. INTRODUCTION

The concept of micro strip antenna was first proposed by Deschamps [1] in 1951. However, it took nearly 2 decades to practically implement this antenna, when Munson and Howell [2] developed it in 1970's. The advantages of micro strip antenna make them popular is many applications that require a low profile and relatively light weight. In addition, micro strip antenna are manufactured using printed circuit technology, so that mass production can be achieved in low cost. Unfortunately, a classical micro strip antenna has a very narrow impedance bandwidth (1-3%) that precludes its use in military application and variety of typical communication systems. However, if the frequency bandwidth would be widened, a broadband micro strip antenna would prove very useful in commercial applications such as mobile satellite communications, 2.5G and 3G wireless systems, direct broadcast system, global positioning systems, wireless local area networks, remote sensing, Bluetooth personal networks and WIMAX.

Much intensive research has been done in last decade to develop Novell bandwidth enhancement techniques. These techniques include the utilization of multilayer structure consisting of several parasitic radiating elements with slightly different sizes above the driven element (A stack patch antenna), planar patch antenna surrounded by closely spaced parasitic patches (A co-planar parasitic sub- array) and incorporation of a dissipative load to lower the quality of patch. The stack patch antenna increases the thickness of the antenna while the co-planar geometry increases the lateral size of the antenna. Incorporation of the dissipative load in the single layer single patch antenna through addition of high loss material or resistors also increases bandwidth but compromises the antennas efficiency and gain. The bandwidth of the single patch antenna can also be increased by implementing internal structures such as shorting pins or slots.

In 1995, Huynh and Lee [19] presented an experimental study of a new kind of broadband antenna with impedance bandwidth of 47%. The new antenna was a probe feed rectangular microstrip antenna on a unity permittivity substrate with an internal U shaped slot. Since then, a number of experimental and theoretical papers have been published for this antenna. Recently, researches have proposed a similar design of antenna with U slot on micro wave substrate. However, most of the authors have used the co- axial feed, which has the disadvantage that the patch and the supporting material must be physically drilled and soldered at the feed point; this is especially inconvenient in array design. Feeding methods, which do not have the aforementioned drawback, are proximity coupling, aperture coupling and micro strip line feed. Omer in a recent paper reported that U-Slot antenna fed by a micro strip line gives better return loss characteristics and bandwidth than the antenna without U-Slot. Lee et al have used a proximity coupled micro strip fed in rectangular patch antenna with U slot and obtained over 20% impedance bandwidth with a complicated pi shaped stub. However, no work has been reported in the open literature on aperture coupled antenna with U-Slot either theoretical or experimental.

The aperture coupled feed is especially attractive, since, the ground plane of feed line shields the antenna half space from spurious radiation emitted by coplanar feed lines. Further in array application, the feed circuitry will be located behind the ground plain of the antenna, which eliminates competition for precious real estate between the antenna elements and feed network. With bi-layer design we can mount the antenna element on thick and low dielectric constant substrate and then feeding network on thin and high dielectric constant substrate to get optimum and good performance. These advantages have provided the motivation for the work presented in this dissertation.

II. ANTENNA DESIGN

In this section, the antenna design steps of micro strip slot antenna with a slot are presented ans same in compared with superstrate layer added to it. The structure of micro strip slot antenna in this paper utilizes dielectric material of Rogers Duriod 5880 with permittivity value of 2.2.

Fig 1(a) and Fig 1(b) Depicts the geometry of micro strip antenna with and without superstrate layer. The performance of these antennas is analyzed and compared but using simulation and testing results. The length and width of the patch could considerably affect the performance of the patch. So these parameters are chosen by the formulae [3] to achieve the compact structure. This is analyzed by computer simulation technology microwave tool.

The geometry of proposed antenna for WIMAX application is shown in fig 1(b). The dimension of antenna is 51.456mm x 62mm x 80mm. The width and length of feed line is 1.6mm and 29mm respectively is fixed in such a way that it should achieve the characteristics impedance of 50Ω. The micro strip feed line is present below the lower substrate layer, which feeds the patch present on upper layer of substrate. There is an aperture slot in between ground plane and upper substrate. The ground plane has a coupling slot on it with width and length of 186mm and 17mm respectively. There is an air gap of 3mm between those

The geometry of the aperture-coupled patch antenna with U-slot. The U-slot is\ located at the top of the upper dielectric substrate, which as a relative permittivity €r1 and thickness H1, the lower substrate has relative permittivity €r2 with thickness H2, and these two are separated by an air gap AG. The patch is electromagnetically coupled to a 50 Ω micro strip line through a rectangular slot in the common ground plane. The length of the micro strip line extending beyond the centre of the coupling slot acts as an open-circuited stub, which can be used to maximize the impedance bandwidth of the antenna

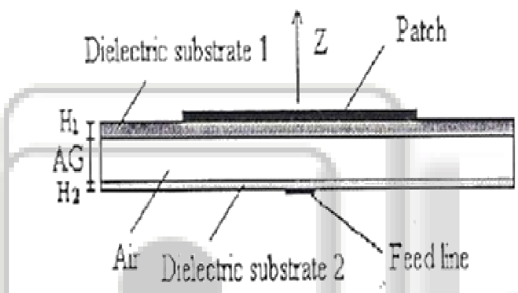

Fig. 1 (a): side look of antenna without superstrate

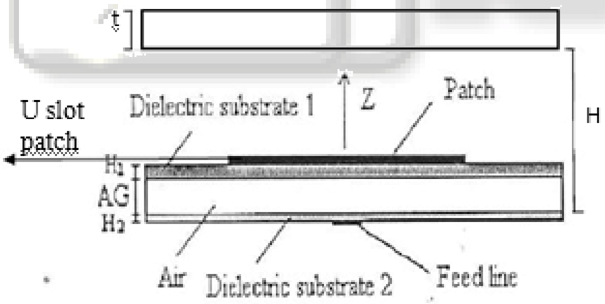

Fig. 1(b) : side look of antenna with superstarte layer

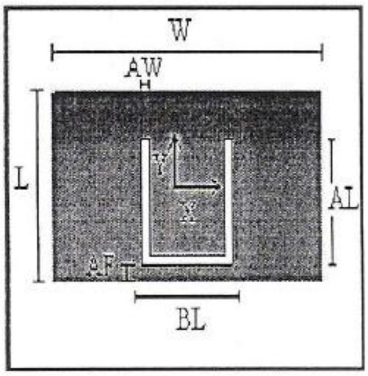

Fig. 1(c): top view of U slot antenna

III. SIMULATED RESULTS

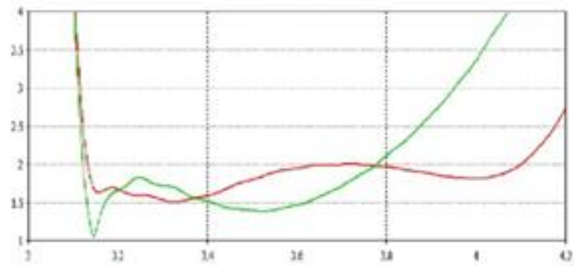

Fig.1 (d): VSWR comparison of antennas with and without superstrate.

To verify the simulation results, 2 antennas were simulated with the dimensions given in Table 1. In each design, the percentage bandwidth was calculated by dividing the frequency bandwidth defined by a VSWR of 2 or less by the centre frequency defined as the arithmetic mean of the VSWR<2 frequencies of the band. This chapter first describes the simulated results obtained with antenna A and then reports the simulated results obtained with antenna B and at last compares the results obtained by the 2 antennas simulated results. The results include simulation of bandwidth, gain and radiation characteristics of the antennas in the desired frequency band having VSWR <2.

A. Simulated Results of Radiation Characteristic

Tables written below tell the complete simulated results of E Plane radiation pattern and H plane radiation pattern.

Frequency (GHz)	3- dB beam width	Cross polarization level (below main lobe level)	Back lobe level (below main lobe level)
3.13	57.7	> 35 dB	16 dB
3.3725	51.5	> 35 dB	14 dB
3.615	46.2	> 40 dB	7 dB
3.8575	43.2	> 35 dB	6 dB
4.1	41.2	> 35 dB	9 dB

Table 1: E Plane radiation pattern at various frequencies

Frequency (GHz)	3 dB beam width	Cross polarization level (below main lobe level)
3.13	95.8	> 20 dB
3.3725	112.8	> 20 dB
3.615	114.7	> 20 dB
3.8575	115.6	> 20 dB
4.1	104.8	> 20 dB

Table 2: H plane radiation pattern at various frequencies

B. Simulated Gain

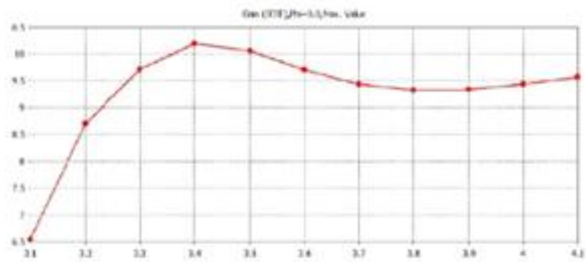

Fig. 1(e): simulated gain of antenna with superstrate

Reference antenna A shows an average gain of 8.1 dBi in the desired frequency band. Simulated gain characteristics

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of antenna B in 10.2 in desired frequency band from 3.13 to 4.1 GHz. It is shown in fig 1(e).

IV. TESTED RESULTS

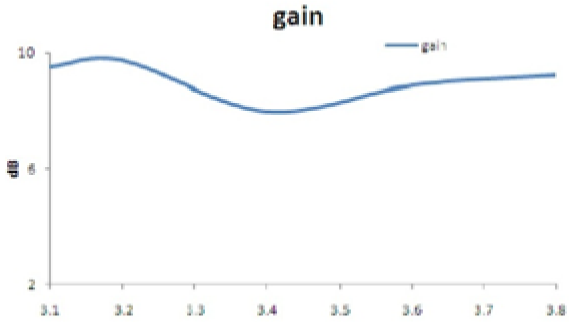

Fig 1(f): Tested results of microstrip antenna with superstrate layer.

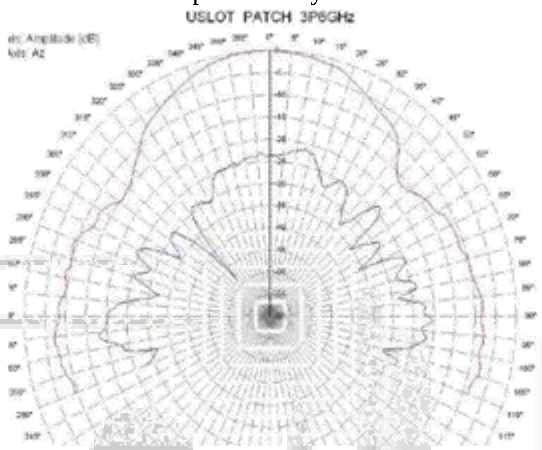

Fig. 1(g): E plane Pattern at 3.2 GHz

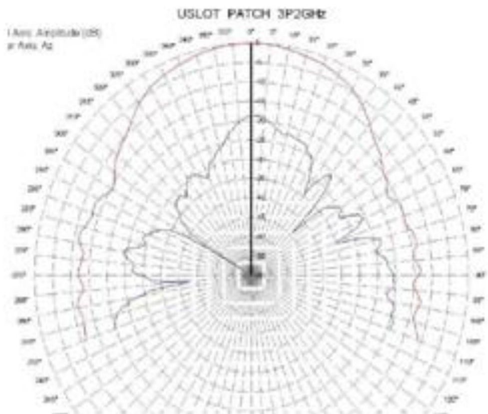

Fig. 1(h): E Plane Pattern at 3.4 GHz

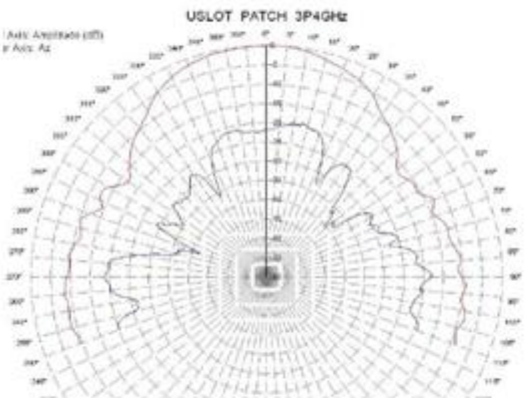

Fig 1(i): Eplane pattern at 3.6 GHz.

Fig. 1(j): return loss of fabricated antenna over a range of frequency.

V. CONCLUSION

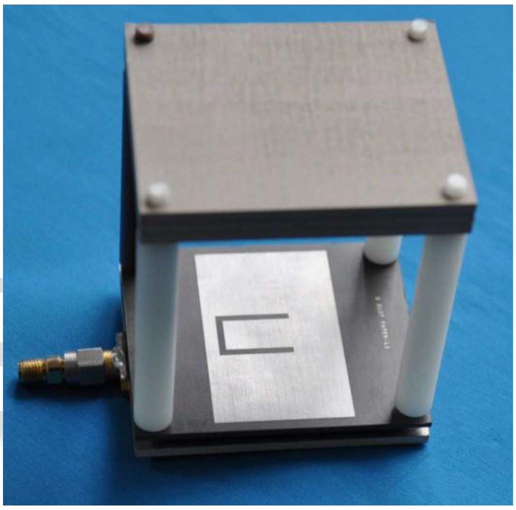

Fig. 1(k): fabricated antenna model.

Comparing the measurements results obtained we can say that addition of superstrate layer to U slot patch antenna is enhancing the bandwidth of aperture coupled microstrip antenna, but this result is not as encouraging as in the case of probe fed microstrip antenna with U slot and addition of superstrate layer on it. This may be due to the fact that disturbance in the impedance characteristics by adding the U slot is compensated by larger probe inductance of probe feed antenna **o**ver wide frequency band, but this disturbance is not compensated by the simple rectangular stub in the case of aperture coupled microstrip antenna. However, this design is much better than proximity coupled microstrip antenna, which is giving only 15% impedance bandwidth, that to with a complicated π shaped stub. This design is also having advantage wide beam width. In no other feeding method, addition of superstrate layer affects the gain characteristics as much as in this case, this shows an enhancement of 2 dBi in gain near resonant frequency. This phenomenon can be utilized in making wide band microstrip antenna with high gain at particular frequency range of WIMAX from 3.2 to 3.6 GHz

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