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SIMULATION OF MICROSTRIP SLOTTED PATCH ANTENNA AT FREQUENCY IN UPPER BAND (5.2-5.8 GHz) FOR WIMAX APPLICATION IN IE3D SOFTWARE

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Abstract
Microstrip patch antennas are strong candidates for use in many wireless communication applications. This article introduces some of the basic concepts of patch antennas. The main focus will be on Simulation and optimizing the slotted I patch antenna for WIMAX application with resonance frequency of (5.2-5.8) GHz. This band is currently being used for industrial, medical and scientific applications. This design is simulated with IE3D software that based on finite element method. FR4 glass epoxy resin has been used as a dielectric material. Slit in the ground plane of the proposed antenna has been employed to enhance the bandwidth and increase the bandwidth of the antenna. The proposed antenna gives -15dB return loss, VSWR of 1.41, Gain of 4dBi and radiation efficiency of 50% is achieved.

Keywords
Patch Antenna, Finite Ground, WIMAX, IE3D software

1. INTRODUCTION

The concept of microstrip antenna dates back to the 1950's, but it was not until the 1970's that greater emphasis was given to develop this technology. This is mainly due to the availability of good substrates. Since then, extensive research and development of microstrip antenna and arrays, exploiting the numerous advantages such as light weight, low volume, low cost, planar configuration, compatibility with integrated circuits, have led to diversified applications and to the establishment of the topic as a separate entity within the broad field of microwave antennas [1].

Microstrip patch antenna is widely considered to be suitable for many wireless applications, even though it usually has a narrow bandwidth [2]. To meet the above requirements, two individually challenging modifications may have to be combined to design a microstrip antenna with wideband operation [2]. Several broad banding techniques for microstrip antennas are widely known, prominent among them are the use of stacked patches or use of parasitic patches. The stacked patch antennas have multilayer structure consisting of several parasitic radiating elements placed one above the other and above the driven element. However this approach has the inherent disadvantage of increased overall thickness and issues related to aligning various layers precisely. The second approach uses patch antenna closely surrounded by parasitic patches. The structure looks like a coplanar parasitic sub-array. This approach, although thin, the antenna occupies considerable lateral area.

Microstrip antennas (MSA) have some good features, like low cost, low profile. Due to this microstrip antennas (MSA) are well suited for WLAN/WIMAX application systems. Microstrip antennas (MSA) have some disadvantages, like narrow bandwidth, low gain etc. Broad banding is the main problem, for solving this problem we propose new structures for devices that require more than one frequency band of operation [2].

A new standard known as WIMAX (Worldwide Interoperability for Microwave access) has been established by the IEEE 802.16 working group. WIMAX theoretically can have coverage of up to 50 km radius. WIMAX antennas have aroused high interest in recent years [3] [4]. The name WIMAX was created by the WIMAX forum which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes WIMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL".

There is no uniform global licensed spectrum for WIMAX, although the WIMAX Forum has published three licensed spectrum profiles: 2.5GHz (2.5-2.69 GHZ), 3.5 GHz (3.4-3.69 GHZ) and 5.5 GHz (5.25-5.85 GHZ). WIMAX[5][6][7] provide the data rate upto70 Mbps over 50 Km. IEEE 802.16-2004 is often called IEEE 802.16d, since that was the working party that developed the standard. It is also frequently referred to

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as "fixed WIMAX" since it has no support for mobility. It replaced IEEE Standards 802.16-2001, 802.16c-2002, and 802.16a-2003. 802.16e-2005 is an amendment to 802.16-2004 and is often referred to in shortened form as 802.16e. It introduced support for mobility, amongst other things and is therefore also known as "mobile WIMAX".

2. FEEDING METHODS

There are many configurations that can be used to feed micro strip antennas. The most popular and the widely used is the coaxial probe. The Coaxial feed or probe feed is a very common technique used for feeding Micro strip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. Probe feeding a micro strip patch antenna is another form of the original excitation methods propose in the mid-1970s. The probe or feeding pin is usually the inner conductor of a coaxial line; hence, probe feeding is often referred to as a coaxial feed. The advantage of this technique is that it provides independent optimization of each layer and due to its direct interaction it avoids spurious radiation. [8], [9], [10], [11].

3. ANTENNA DESIGN

3.1. DESIGN PRINCIPLE

A microstrip patch antenna in its basic form consists of a metallic radiating patch on one side of dielectric substrate, which has a ground plane on other side. The radiating elements and feed lines are usually photo etched on the dielectric substrate.
A strip line to feed the patch antenna from its radiating edge with the highest gain achievable and minimum antenna return loss has been employed [12]. The first part of the design is to estimate the length (L) and width (w) of the antenna. The length and width of the patch antenna were calculated using equations [13]:-

Width of the MSA is:

$$W = \frac{C}{2f0\sqrt{\frac{(\epsilon r+1)}{2}}} \qquad \text{eqn. (1)}$$

Effective dielectric length of antenna is:

$$L_{eff} = \frac{c}{2f0\sqrt{\epsilon reff}} \qquad \text{eqn. (2)}$$

Effective dielectric constant of antenna is:

$$\epsilon_{reff} = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}[1 + 12\frac{h}{w}]^{1/2} \qquad \text{eqn. (3)}$$

Length extension is:

$$\Delta L = \frac{(\epsilon reff +0.3)(\frac{w}{h} + 0.264)}{(\epsilon reff -0.258)(\frac{w}{h} +0.8)} \qquad \text{eqn. (4)}$$

Actual length is:

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

3.2. GROUND PLANE

Essentially the transmission line model is applicable to an infinite ground plane only. However, it has been shown that a finite ground plane can be used for if the ground plane is 6 times larger than the height of the dielectric substrate plus the used length or width.
The length and width of the ground plane is given by [13]:

$$W_g = 6\,h + W \qquad \text{eqn. (6)}$$

$$L_g = 6\,h + L \qquad \text{eqn. (7)}$$

3.3. ANTENNA CONFIGURATION

A slotted I patch antenna in upper band of frequency (5.2-5.8GHz) for WIMAX applications is designed by using direct contact probe fed technique. By replacing a pair of horizontal slots and a single vertical slot on the patch with the probe fed mechanism on a FR4 substrate suspended through air as dielectric substrate between patch and ground plane are the design constraints. The proposed antenna is constructed with dielectric permittivity (ϵr) = 4.36, centre operating frequency (f_0) = 5.4GHz, substrate of thickness (h) = 2.4mm and loss tangent(δ) = 0.001.

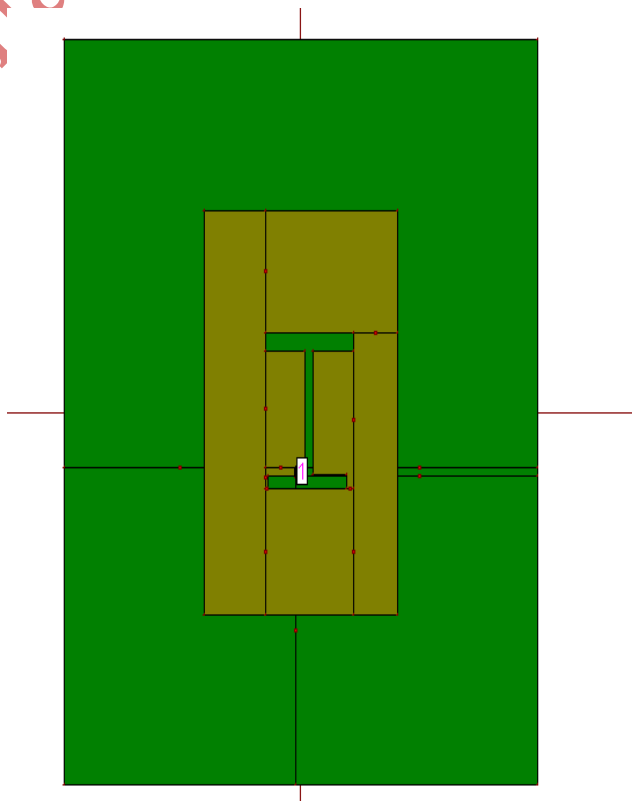

Fig1: Design of proposed antenna

TABLE 1.1 Dimensions of proposed antenna

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Antenna Parameter	Dimensions
Resonant frequency	5.4GHz
Dielectric constant	4.36
Loss Tangent	0.001
Length of antenna	9.8582mm
Width of antenna	17.04mm
Thickness of substrate	2.4mm

4. SIMULATION AND RESULTS

The antenna in upper band of WIMAX (5.2-5.8GHz) is designed using IE3D software. IE3D is a full-wave electromagnetic simulator based on the method of moments. It is to analyze and simulate various parameters of antenna such as return loss, VSWR, radiation pattern, current distribution current density, and efficiency and bandwidth calculation.

4.1. RETURN LOSS

The center frequency 5.4GHz is selected as the one at which the return loss is minimum. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -9.5 dB (-9.5 dB corresponds to a VSWR of 2 which is an acceptable figure). Using IE3D, the RL of - 15dB is obtained.

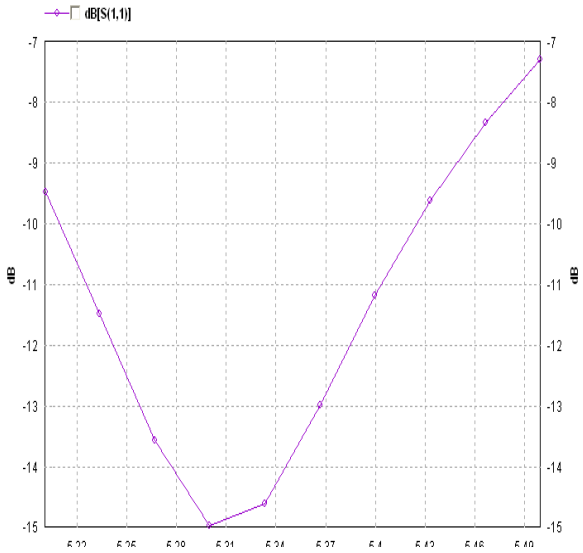

Fig 2: Return loss

4.2. VSWR

When an antenna and feed line do not have matching impedances, some of the electrical energy cannot be transferred from the feed line to the antenna. Energy not transferred to the antenna is reflected back towards the transmitter. It is the interaction of these reflected waves with forward waves which causes standing wave patterns (VSWR).

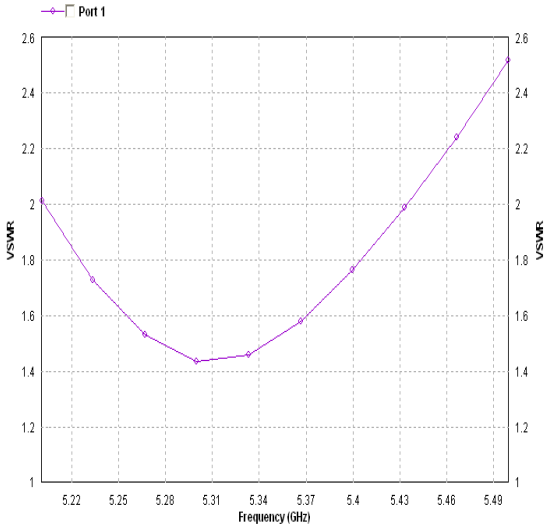

Fig 3: VSWR

4.3. GAIN V/S FREQUENCY GRAPH

The gain of this slotted antenna is 4dB

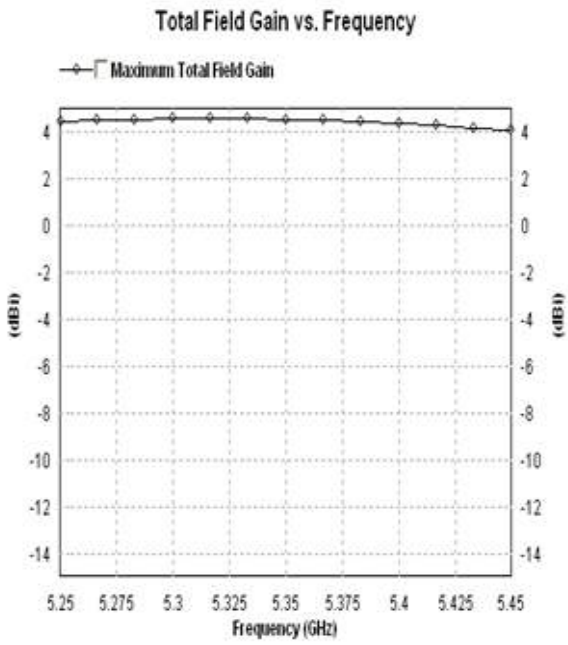

Fig 4: Gain vs Frequency

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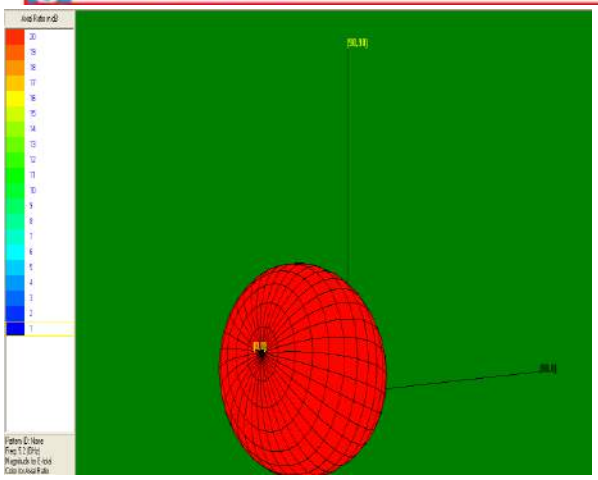

Fig 5: 3-D Radiation pattern

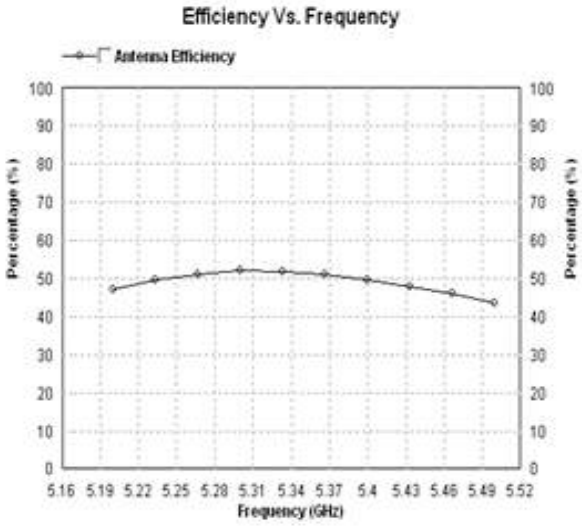

Fig 6: Efficiency vs Frequency

5. CONCLUSION

In design and simulation of microstrip, I slotted patch antenna for WIMAX applications by using IE3D software are discussed.

In this work, we obtained a reflection coefficient S_{11} of -15 dB, a standing wave ratio equal to 1.41, a gain of 4dBi, and an efficiency of 50% at the resonant frequency of 5.4 GHz. The proposed design has simple design structure and can easily be fabricated at low cost thus being a good solution for many WIMAX applications.

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