MICROSTRIP LINE FED STACKED LAYER E-SHAPED PATCH ANTENNA FOR WLAN AND WIMAX APPLICATIONS

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ABSTRACT

The design of stacked layer E-shaped microstrip patch antenna for wideband operation in the 5-6 GHz frequency range has been presented in this paper. The antenna is Microstrip line fed. The Roger RO4350 of 1.6 mm height with relative permittivity of 3.66 and dielectric loss tangent of 0.004 has been used as the substrate on which the patch is placed. An air box of 2mm height has been introduced between substrate and the ground. The ANSOFT HFSS software has been used for designing the antenna. High performance characteristics and good impedance matching have been obtained. The antenna is resonating at 5.36 GHz with a return loss of -56.5 dB. A maximum gain of 5.3 dB has been obtained in E-plane. The proposed antenna is suitable for WLAN and WiMax applications operating within 5.15-5.85 GHz frequency band.

Keywords: E-shaped, Line Feed, Stacked Layers, WLAN and WiMax.

I. INTRODUCTION

Due to the inherent advantages of low profile, less weight, low cost, and ease of integration with microstrip circuits, the Microstrip patch antennas are widely used in wireless communications [1]. However, the main disadvantage of microstrip antennas is their small bandwidth. Many methods have been proposed to improve the bandwidth. These include the use of a thick substrate and cutting slots in the design [2-5]. Improvement of broader bandwidth becomes an important need for many applications such as for high speed networks.

High-speed wireless computer networks have attracted the attention of researchers, especially in the 5-6 GHz band (e.g. WiMax and IEEE 802.11a Indoor and Outdoor WLAN). These networks have the ability to provide high speed connectivity between notebook computers, PCs, personal organizers and other wireless digital appliances. Many novel
Antenna designs have been proposed to suit the standards for high-speed wireless computer networks. Some approaches have resulted in the probe-fed U-slot patch antennas [6-10], the E-shaped patch antennas [11-17] and many others.

The E-shape has been an attraction for antenna designers. An E-shaped patch antenna has been presented in [11]. However, this antenna is a coaxial probe fed antenna and covers the 5-6 GHz frequency band. This antenna design is a bit complex and contains many slots in the patch. In [12], a parametric study of this E-shaped patch antenna has been presented. In [13], an E-shaped patch antenna which operates at 1.9 GHz and 2.4 GHz frequency bands has been presented. The E-shaped patch antenna presented in [14] is a coaxial probe feeded antenna. In this antenna, the substrate material used is having a dielectric constant of 2.2 and a height of 3.2 mm. A microstrip line feed tri-band E-shaped antenna has been reported in [15]. This is a monopole antenna. In [16], a multilayer substrate microstrip line feed E-shaped antenna has been reported. This antenna is designed to cover 5 GHz to 6 GHz band. However, Glass and Silicon are the two substrate materials used as antenna substrate which are different than the substrates used in proposed antenna.

In this paper, a simple design of E-shaped patch antenna with an air box of 2 mm inserted between ground plane and the substrate has been presented which can cover the frequency range of 5.15-5.85 GHz. The same technique of stacked layers structure using an air box sandwiched between substrate and the ground has been reported in [11], [17-20]. Ansoft HFSS which is the industry standard simulation tool for 3D full-wave electromagnetic field simulation based on Finite Element Method (FEM) has been used for simulation purposes [21], [22].

II. ANTENNA DESIGN

The side view of the proposed antenna structure has been shown in Fig. 1. The broad banding technique of stacked layers is used to improve the bandwidth. An air box of 2 mm height has been inserted between substrate and the ground. The Roger RO4350 of 1.6 mm thickness having relative permittivity of 3.66 and dielectric loss tangent of 0.004 has been used as the substrate. The substrate and ground size has been considered as 47.6 mm x 46.6 mm. The antenna is feeded by a microstrip line. The feeding method is easy to fabricate but difficult to model accurately and have low spurious radiation and narrow bandwidth of impedance matching [23]. The location of the feed element with respect to the patch also plays a role in the antenna performance. The patch geometry has been shown in Fig. 2. The corresponding dimensions are listed in Table I. The E-shaped design has been obtained by removing two rectangular patches of dimensions L1 x W1 from one side of the main rectangular patch of dimensions L x W at W3 distance apart from the two opposite sides. L2 and W2 are the dimensions of the feed of the antenna.
Fig. 3 shows the return loss plot of the proposed antenna. The antenna is resonating at 5.43 GHz with a return loss of -58.2 dB. The lower -10 dB frequency at 4.96 GHz and upper -10 dB frequencies at 5.95 GHz have been obtained which covers the entire range of WiMax and WLAN applications. Fig. 4 presents the E-plane and H-plane radiation patterns which are almost omnidirectional in shape. The maximum gain of 5.5 dB has been obtained in the E-plane. The smith chart has been shown in Fig. 5 which presents the impedance characteristics of the antenna at the entire observing frequency range of 3.5 GHz to 8 GHz. Fig. 6 presents the 3D polar plot obtained at 5.5 GHz. Fig. 7 shows the variations in the gain with respect to frequency. Fig. 8 and Fig. 9 are showing the E-field and H-field respectively. It has revealed that the gain performance of the proposed antenna is satisfactory within the desired frequency range. The other parameters such as peak directivity, peak gain and radiation efficiency are shown in Table II.

### TABLE I

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Dimensions (mm)</th>
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<tr>
<td>L</td>
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<tr>
<td>W</td>
<td>37</td>
</tr>
<tr>
<td>L1</td>
<td>17.5</td>
</tr>
<tr>
<td>W1</td>
<td>15.5</td>
</tr>
<tr>
<td>L2</td>
<td>4.8</td>
</tr>
<tr>
<td>W2</td>
<td>11</td>
</tr>
<tr>
<td>W3</td>
<td>2</td>
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</table>

III. RESULTS AND DISCUSSION

Fig. 2. E-shaped patch geometry with line feed
Fig. 3. Return loss plot

Fig. 4. E and H plane radiations patterns

Fig. 5. Smith chart
Fig. 6. Polar plot

Fig. 7. Gain v/s frequency curve

Fig. 8. E-field distribution on the patch
TABLE III
OTHER SIMULATED RESULTS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Simulated Results</th>
</tr>
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<tr>
<td>Peak Directivity</td>
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<tr>
<td>Peak Gain</td>
<td>3.4399</td>
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<tr>
<td>Radiation Efficiency</td>
<td>0.98682</td>
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</table>

IV. CONCLUSION AND FUTURE SCOPE

A simple stacked layers E-shaped microstrip patch antenna fed with microstrip line has been designed for WiMax, WLAN and other high-speed wireless communication systems operating within 5.15 GHz to 5.85 GHz frequency band. The simulated results have shown satisfactory radiation performance of the antenna across the entire operating frequency range. These features are very useful for worldwide portability of wireless communication equipments. The proposed antenna design will be helpful for antenna design engineers to design and optimize the antennas for other wireless applications. The future works include fabrication of the antenna, measurements of antenna performance parameters with the industry standard equipments and comparison of simulated and measured results.

REFERENCES


