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Article

Dual-band Umbrella Shape Slotted Patch Antenna for WLAN and WiMAX Applications

Nidhi Sharma[1] Vikas Soni[2]

[1,2]Electronics and Communication Engineering Department, Modi Institute of Technology, Kota (Rajasthan), India.

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Corresponding Author:
Nidhi Sharma, Electronics and Communication Engineering Department, Modi Institute of Technology, Kota (Rajasthan), India.
E-mail Id:
nidhi650sharma@gmail.com
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A B S T R A C T

This article indicates the designing and result observation of compact umbrella shape slotted patch antenna regarding dual-band applications resonating at WLAN (2.4 GHz) and Lower WiMAX (2.9 GHz). The design is simulated on simulator software with FR4 substrate dimensions of 30×30×0.82 mm^3. The simulated S-parameters and VSWR parameters are analysed for operating range 2.35-2.62 GHz and 2.81-2.99 GHz concerning S-band applications. The simulated results identified the stable realisation of efficiency, gain, and patterns.

Keywords: Dual-Band, Umbrella Shape Slotted Patch Antenna, Wimax, Wlan

Introduction

In the present scenario, MPA (microstrip patch antenna) are demanded regarding applications in the field of wireless communication because of various characteristics of MPA such as compactness, broadband, stable gain, and efficiency. Wireless communication is more popular and demanding over wired network communication due to various advantages such as ease of mobility, affordable cost, sharing the band with multiple users, data transmission by utilizing the radio waves, ease of installation, flexibility in use and virtual access. Many common applications of wireless communication in daily life are Bluetooth, cordless and mobile phones, ad hoc networks, WLAN, Wi-Fi and Wi-MAX.[1] Multiband antennas are widely used in the field of various wireless communication technologies. To cover all the desired wireless communication frequencies, multiband antennas can be used which function in multiple frequencies simultaneously. Multi radio platforms require multiband antennas for obstacle-free communication.[2] A multi-band antenna is demonstrated by utilizing a triangular microstrip patch for many applications. The antenna consists of a fragment of capacitor and groove having the shape of T - input reactance of demonstrated structure varying with T grooved fragmented capacitor. The multiple resonant modes are achieved with an elemental frequency range of 1.97–2.16 GHz.[3]

A dual-band antenna is framed by using a rectangular microstrip patch which consists of an internal radiating patch of pentagonal shape built on glass epoxy dielectric material because it is easily available at a lower price. For the applications of Wi-Fi to maintain the linear polarization, dual-band operation is considered. The pentagonal patches were used to attain the respective resonator of circular shape. The designed multiband antennas are embedded on a router. A good agreement with the operating frequency is achieved. It has been observed that the antenna functions satisfactorily in the dual-band mode for WLAN and WiMAX Applications. The measured results are compared with monopolar radiation patterns.[4,5]

In this article, a dual-band antenna structure has been proposed to cover the wireless standards at WLAN and

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lower WiMAX at 2.4 and 2.9 GHz respectively. An umbrella shape radiating section is chosen to improve the radiation characteristics at the desired resonant modes.

Designing of Proposed Antenna

This part focuses on the designing of the proposed umbrella shape slotted dual-band antenna. Figure 1 represents the layouts of the proposed structure with front, side, and bottom view. The antenna is designed on FR4 dielectric material having a depth of 0.82 mm, εr = 4.4, and dissipation factor tanδ = 0.02. The dimension of the design is 30 × 30 × 0.82 mm^3. The proposed design is fed by a rectangular shape feed line (characteristics impedance of 50 ohms). The antenna consists of a radiating part of a slotted circular shape (radius 7.5 mm) attached with a circular ring (radius 6 mm) in the upward direction which makes an umbrella shape with radiating section as shown in Figure 1(a).

The extracted values (in mm) of the recognized structure are: L_S = 30, W_S = 30, h = 0.82, R = 7.5, R_1 = 5, R_2 = 6, L_{SL1} = 0.25, W_{SL1} = 8, L_{SL2} = 2.25, W_{SL2} = 4, L_1 = 9, W_1 = 1.5, L_2 = 5, L_{SLT} =1.4 , W_{SLT} = 4 , W_f = 4, and L_f = 18. The antenna parameters used in simulation are analysed by applying transient solver of simulator CST Microwave Studio (MWS-version 2014).[6]

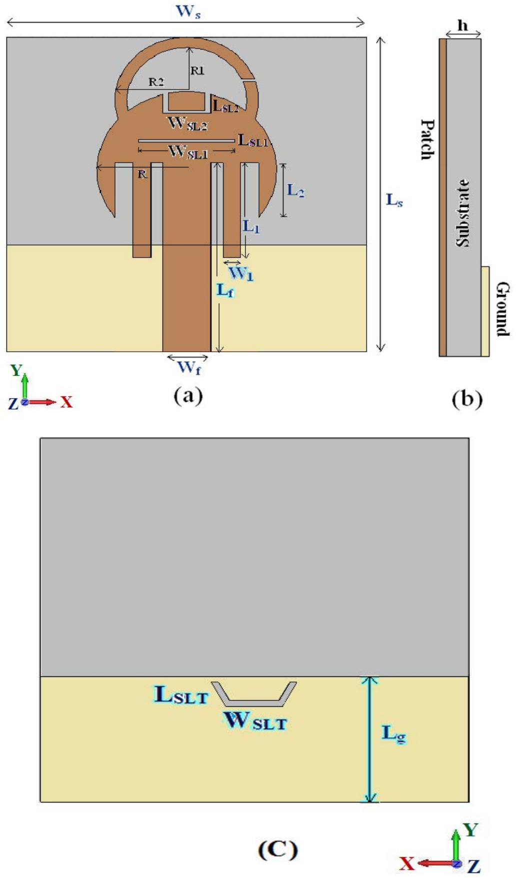

Figure 1.Layout of Proposed Design of Umbrella Shape Slotted Dual-band antenna (a) Top view, (b) Side view, (c) Bottom view

In the proposed design, the radiating section is circular, so the required parameters are obtained by using the following equations:

The radius of a circular patch can be calculated as

$$a = \left[\frac{F}{\left\{1+\frac{2h}{\pi \varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.17726\right]\right\}^{1/2}} \right] \quad (1)$$

Where

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

h is the depth of the dielectric material (in mm).

ε_r is the relative permeability of the dielectric material.

f_r is the fundamental frequency.

Result Analysis

The proposed configured antenna indicates the dual operating bands with impedance bandwidth of 5.43% (2.35-2.62 GHz) and 3.10% (2.81-2.99 GHz) during simulation mode as represented in S-parameter and VSWR analysis as shown in Figure 2 and Figure 3.

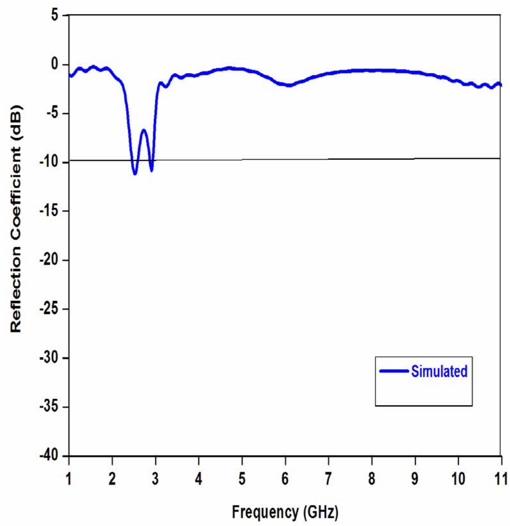

Figure 2.S_{11} versus Frequency Observation during Simulation Proces

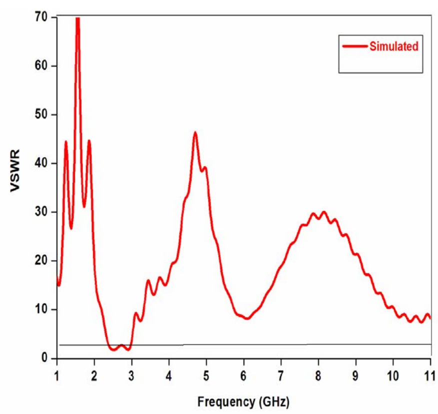

Figure 3.VSWR versus Frequency Observation during Simulation Process

Figure 4 represents the variation in the radiation efficiency with respect to the operating frequency for the proposed antenna. The maximum efficiency of 78% and 88% is achieved at resonant frequency band at 2.41 GHz and 2.92 GHz respectively.

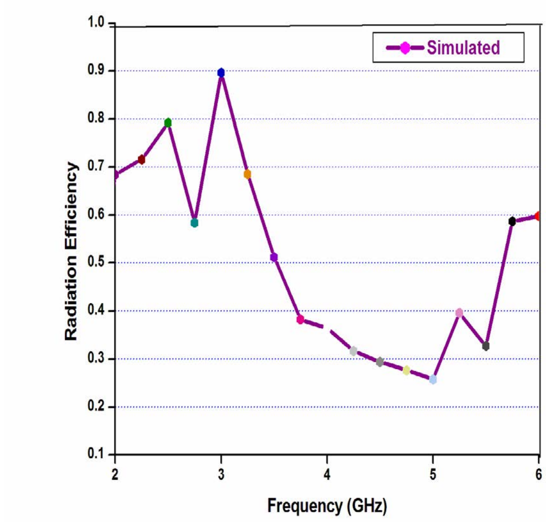

Figure 4.Simulated Antenna Radiation Efficiency

The simulated antenna gain is indicated in Figure 5, which represents the variation in the antenna gain with respect to the operating frequency for the proposed antenna. The peak gain of 2.49 dBi and 3.52 dBi is observed at wireless communication mode at 2.41 GHz and 2.92 GHz respectively. Figure 6 shows the 3D plot of proposed structure at resonant frequencies 2.42 GHz and 2.91 GHz. It is identified that at a higher frequency side, gain is improved.

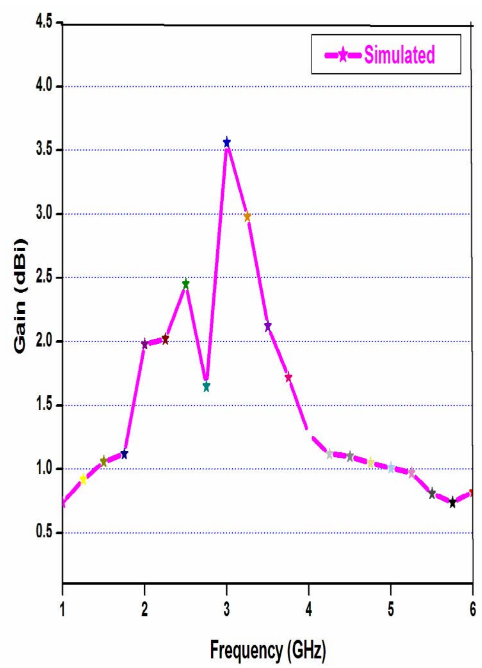

Figure 5.Simulated Antenna Gain

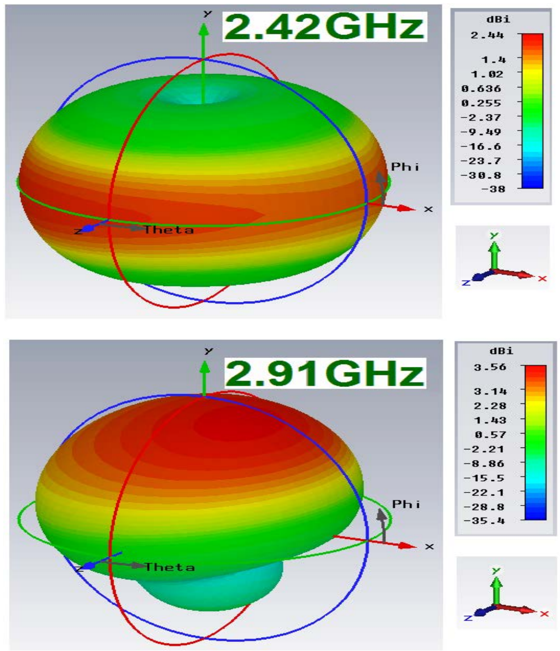

Figure 6.Simulated 3D Polar Gain Plot at 2.42 GHz and 2.91 GHz

For better observation of the proposed design, other parameter radiation patterns are studied. Patterns are investigated for E and H plane in simulation as well as measurement mode. There is a fair matching between the simulated and experimented analysed parameters. Figure 7 represents the comparison of patterns regarding the proposed design at distinct resonant frequencies 2.42 and 2.91 GHz. As observed from Figure 7, the patterns are like Omni directional and dipole like/ bi-directional in H and E plane respectively.[7,8]

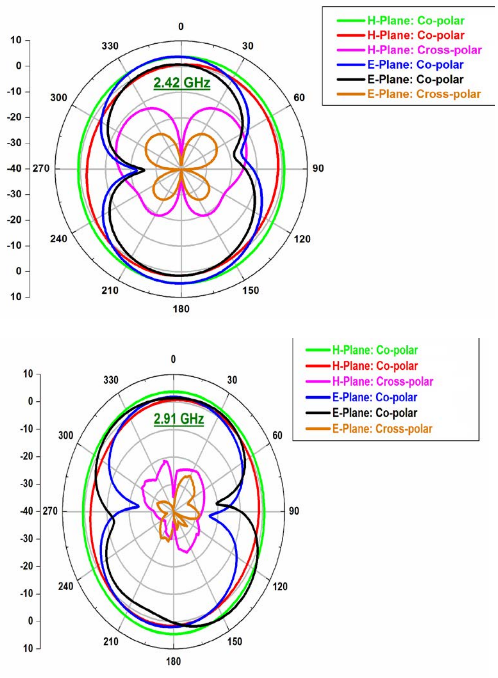

Figure 7.Radiation Patterns at 2.42 and 2.91 GHz

The simulated surface current distribution of proposed umbrella shape dual-band antenna at wireless standards 2.4 GHz and 2.9 GHz is anticipated in Figure 8. It is noticed that the current exists around the periphery of U shaped slot on the ground plane for resonant frequency 2.4 GHz for WLAN application. For upper resonant band 2.9 GHz (Lower Wi-MAX), the current is present across the part of the slotted circular shape radiating section and umbrella shape section, providing the enhanced radiation parameters.[9]

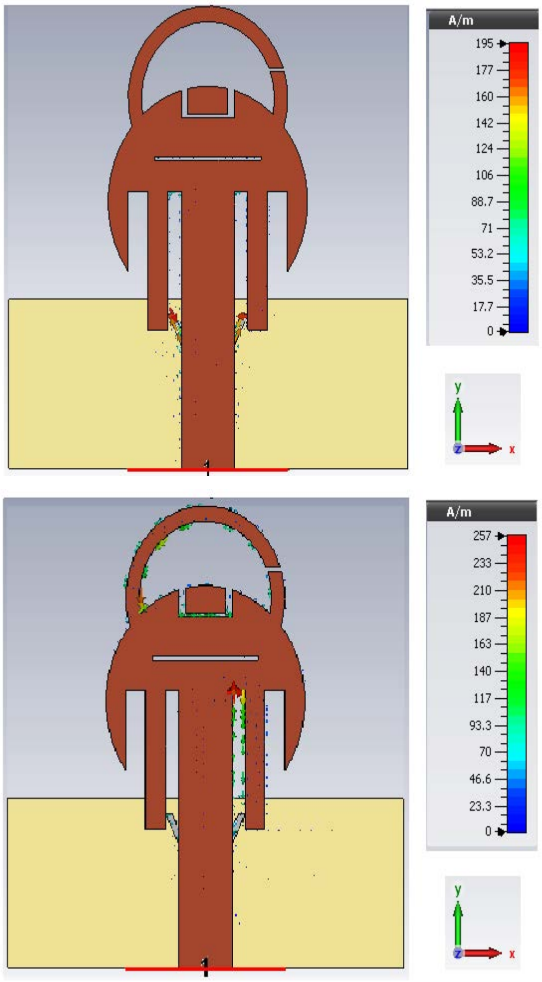

Figure 8.Current Distributions at 2.42 and 2.91GHz

Conclusion

The proposed antenna is designed/ analysed for wireless application standards at 2.4 GHz and 2.9 GHz to facilitate various wireless frequency band applications. The above bands are useful for the following applications in wireless communications: WLAN (2.4 GHz) and Lower WiMAX (2.9 GHz) for RFID services. The radiating part comprises the slotted circular shape with the integration of umbrella shape circular part and defected ground plane which results in the dual resonating band configuration for wireless applications. The proposed design specifies the radiation characteristics in consistency and improved formation.

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