IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Compact Microstrip Patch Antenna with Comb-Like Slot for WLAN Applications

P. Prasanna Kumar*1, R. Nakkeeran2

*1,2 Department of Electronics Engineering, School of Engineering and Technology, Pondicherry University, Pondicherry, India

pallepogu.prasanna96@gmail.com

Abstract

A technique to design a compact microstrip patch antenna is presented in this paper. The proposed antenna consists of a comb-like slot patch with inset feeding microstrip line. The proposed antenna shows good impedance bandwidth at the center frequencies 2.44 GHz and 5.61 GHz with good impedance matching. The proposed antenna provides the size reduction of 94.6% while comparing literature one, maximum gains of 2.88 dBi and 4.3 dBi, antenna efficiency of 88% and 98% for both center frequencies, respectively.

Keywords: Microstrip patch antenna, comb-like-slot patch, WLAN,dual-band.

Introduction

The main goal is to design antenna for wireless communication applications where the space value of the antenna is quite limited while it reserves the characteristics of multiband, light weight and low cost. Microstrip antennas are the most rapidly developing field in the last twenty years. Currently these antennas have a large number of applications in mobile radio systems, integrated antennas, satellite navigation receivers, satellite communications, direct broadcast radio, television etc. are reported in [1]. To reduce the size of the antenna while achieving dual band and wide bandwidth, numerous designs of various types of slots on patch have been proposed in literature, the U-slot and E-shaped patch antennas are proposed in [2], [3]. Wideband microstrip antennas with tooth like slot on patch are introduced in [4]-[6]. Dual broadband toothbrush-shaped and comb shaped slot antennas are reported in [7], [8]. In wireless communication applications, the demand for low profile compact size planar antennas is increasing day by day. In reference [2]-[8], the main drawback is the large size of antenna.

In this communication, a new compact microstrip patch antenna with comb-like slot is presented. The desired bands are obtained by tuning the dimensions of comb-like slots, length and width of inset feed and the size of patch. The proposed antenna shows less than -10 dB return loss both at 2.44 GHz (2.41-2.48 GHz) and 5.61 GHz (5.43-5.82 GHz).

The rest of paper is organized as follows. Antenna design is presented in Section II. Section III deals with the results and discussion. Conclusion given at section IV.

Antenna Design

The geometry of the proposed antenna is shown in Fig. 1. The design of the proposed antenna follows the described guidelines followed by the optimization with the commercially available software IE3D. In the design, the antenna is printed on a 1.574 mm thick FR4 substrate of dielectric constant 4.2 and loss tangent 0.0245.

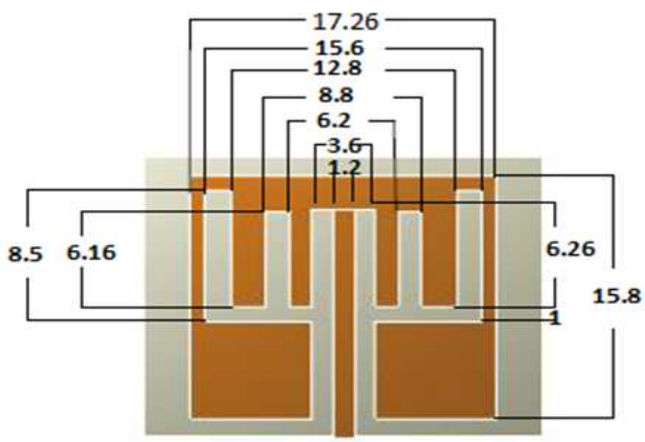


Fig. 1. The geometry of the proposed antenna with detailed dimensions (Unit: mm).

The following design procedure is used to design this antenna with good radiation characteristics.

Specify: ε_r, f_r (in Hz) and h (in mm).

Here f_r is the resonance frequency

ε_r is the dielectric constant

h is the thickness of substrate

Determine: width and length of patch and slot.

Design procedure:

1. The actual length of the patch can now be determined by solving the equation (1) for L.

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_{reff}}} - 2\Delta L + L_{slot}$$

(1) Where,

L_{slot} is length of horizontal slot

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

(2)

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{ref} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

(3)

2. For an efficient radiator, a practical width that leads to good radiation efficiency is $W \approx 1.5L$
3. Design the slot with slot length is equal to $\frac{\lambda}{2}$ or $\frac{\lambda}{4}$ and the width of slot is calculated as $1/(0.065L_{vslot})$.
4. To excite the antenna, inset feed technique is used. The inset feed having a strip width 1.2 mm, a gap width of 1.2 mm (between the strip and the patch) and inset depth 13.5 mm is considered.

Values of the design parameters calculated using the presented method and the design parameters optimized using IE3D software. The detailed dimensions of microstrip patch antenna with comb-like slot on patch are shown in Fig. 1.

Results and Discussion

The simulated reflection coefficient of the antenna is shown in Fig. 2. The simulated gain and antenna efficiency is shown in Fig. 3 and Fig. 4, respectively.

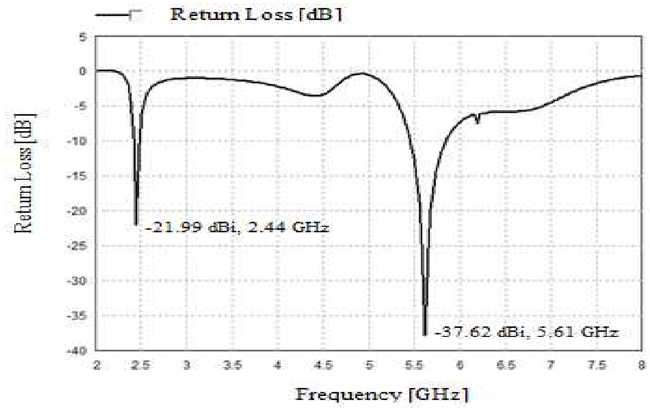


Fig. 2. The simulated return loss of the proposed antenna

In the proposed antenna, the center frequencies 2.44 GHz and 5.61 GHz are obtained by considering the width of the patch 17.26 mm and the length of main slot 7.5 mm. The good impedance matching is obtained by considering the location of the end of feed line (0 , 3.94) mm. By doing this,the better return loss obtained at the required operating frequency, as shown in Fig.2.

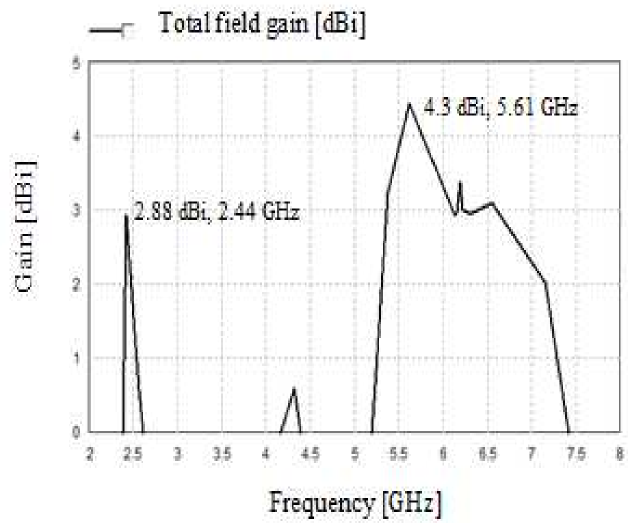


Fig. 3. Simulated gain of the proposed antenna

The radiation patterns of the antenna are symmetric and omnidirectional due to the geometrical symmetry of the antenna structure, the stable radiation patterns are achieved with maximum gains of 2.88 dBi and 4.3 dBi for both bands of the proposed antenna are shown in the Fig. 5 and Fig. 6. It is seen from the results that two operating bands centered at about 2.44 GHz and 5.6 GHz are excited with good impedance matching. The -10 dB impedance bandwidth for the lower and upper bands comes around 70 MHz (2.41–2.48 GHz) and 430 MHz (5.41–5.84 GHz), respectively, which are able to cover outdoor Wireless Local Area Network (WLAN) bands.

ISSN: 2277-9655
Impact Factor: 1.852

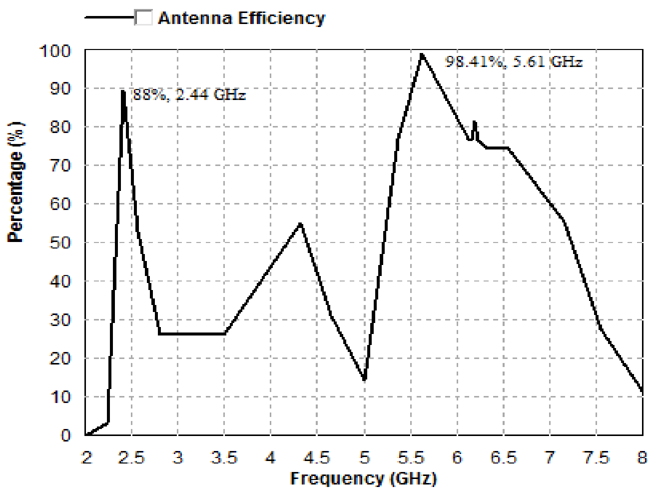


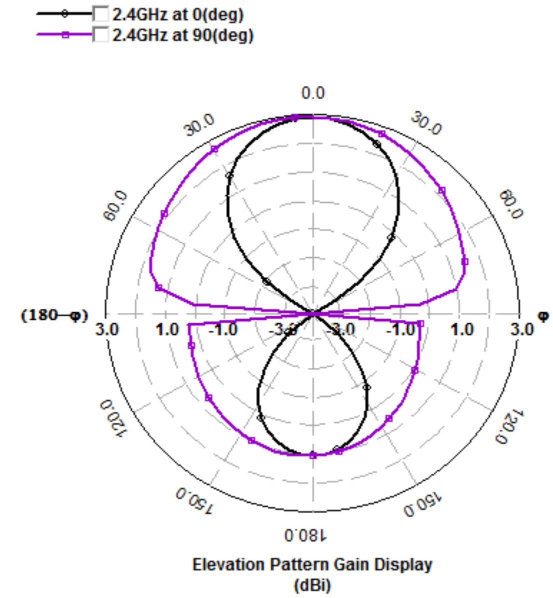
Fig. 4. Simulated antenna efficiency of the proposed antenna

The comparison between proposed antenna and reference [2], Hsing-Yi Chen *et.al*, is shown in Table I.

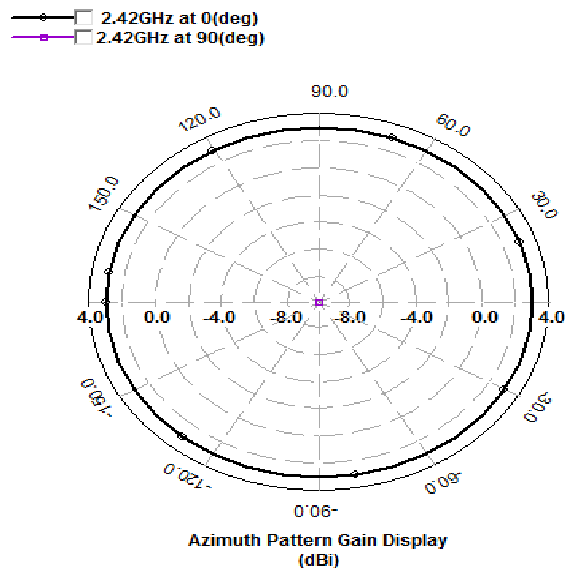
Table I

Parameters	Reference [2]	Proposed antenna
Operating Frequency (GHz)	2.40 -2.48 5.72-5.82	2.41-2.48 5.45-5.84
Ground plane dimension (L x W) in mm^2	64 x 68	19 x 23
Patch dimension (L x W) in mm^2	30 x 54	15.8 x 17.26
Dielectric Constant	4.4	4.2
Dielectric Material	FR4	FR4
Dielectric Substrate height in mm	4.4	1.574 (0.062")
Volume (L x W x h) in mm^3	64 x 68 x 4.4	19 x 23 x 1.574

The size reduction done through the proposed antenna is 96.40%. So, the antenna has a simple structure and is easy to be printed on FR4 substrate with small volume of about 19 mm x 23 mm x 1.574 mm. In addition, although the antenna shows a simple structure and compact size, it can generate two bands centered at about 2.4GHz and 5.61 GHz to cover the outdoor WLAN bands.

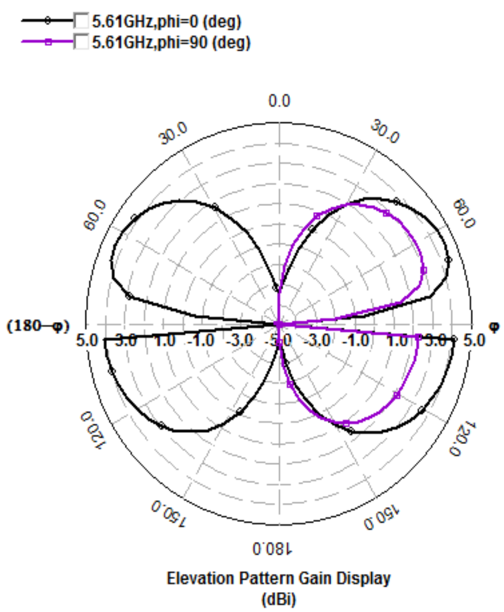


(a)

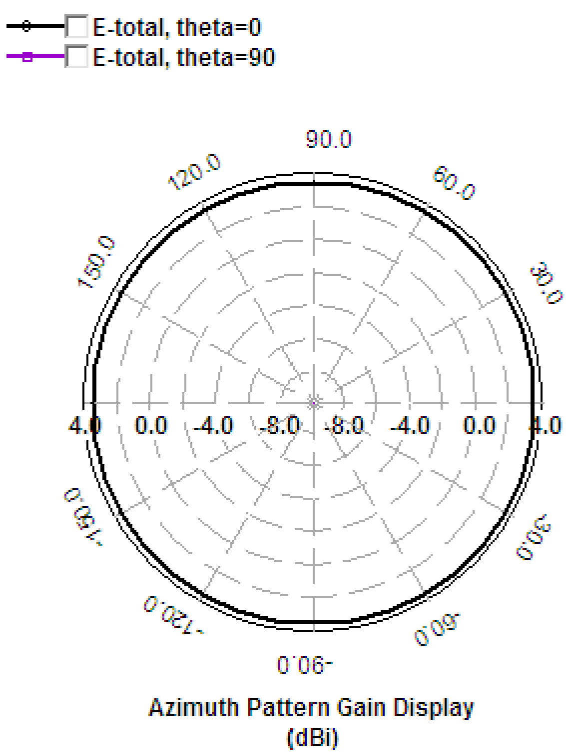


(b)

Fig. 5.(a) Elevation pattern at 2.44 GHz, (b) Azimuthal pattern at 2.44 GHz.



(a)



(b)

Fig. 6.(a) Elevation pattern at 5.6 GHz, (b) Azimuthal pattern at 5.6 GHz.

Conclusion

In this paper, a new compact microstrip patch antenna with comb-like slot is designed using IE3D software. The proposed antenna having return loss -21.99 dB at 2.44 GHz, -37.62 dB at 5.61 GHz and provides good impedance bandwidth 70 MHz (2.41–2.48 GHz), 430 MHz (5.41–5.84 GHz) with compact size and low cost. The radiation patterns of the antenna are symmetric and omnidirectional due to the geometrical symmetry of the antenna structure. It can be preferred for outdoor WLAN applications.

References

[1] J.D. Kraus, "*Antennas for All Applications*" 3rd Ed., McGraw Hill, inc., New York.

[2] Hsing-Yi Chen and Yu Tao, "Performance Improvement of a U-Slot Patch Antenna Using a Dual-Band Frequency Selective Surface With Modified Jerusalem Cross Elements" IEEE Trans. Antennas Propag., vol. 59,No. 9. September. 2011.

[3] Y. Ge, K. P. Esselle, and T. S. Bird, "*E-shaped patch antennas for high-speed wireless networks*," IEEE Trans. Antennas Propag., vol. 52, pp. 3213-3219, Dec. 2004.

[4] G. B. Han, D. G. Fang, and H. Wang, "*Design of the LTCC tooth like-slot antenna*," in Proc. ICMMT 4th Int. Conf. on Microwave and Millimeter Wave Technology, Aug. 2004, pp. 23–26.

[5] H. Wang, X. B. Huang, D. G. Fang, and G. B. Han, "*A microstrip antenna array formed by microstrip line fed tooth-like-slot patches*," IEEE Trans. Antennas Propag.,vol. 55, pp. 1210-1214, Apr. 2007

[6] Wen Yang, Jianyi Zhou "A Single Layer Wideband Low Profile Tooth-like-slot Microstrip Patch Antenna Fed by Inset Microstrip Line, "International workshop on antenna technology (iWAT), Aug. 2013, pp. 23-26.

[7] J: Y. Sze and K.-L. Wong, "Broadband rectangular microstrip antenna with a pair of toothbrush-shaped slots," Electron Lett 34 (1998), 2186-2187.

[8] Jui-Han Lu, "Dual-Frequency Operation of A Single-feed Rectangular Microstrip patch antenna with A Pair of COMB-SHAPED slots," Microwave and Optical Technology Letters: vol. 23, No. 3, Nov. 1999.