Two Compact Microstrip Patch Antennas for 2.4 GHz Band – A Comparison

Vibha Rani Gupta and Nisha Gupta

Abstract - **Two low profile patch antennas for Wireless LAN 802.11b communication standard are proposed and investigated. In the first structure, the radiating structure consists of a square patch with four equal length slits cut along the diagonal of the patch and four angular grooves cut along the edges of the patch. The second structure consists of a fractal microstrip patch configuration. Both the structures provide an optimized patch area resulting into a substantial reduction in size compared to a typical microstrip square patch designed at the same frequency of operation. It is found that the characteristics of the Grooved patch antenna are comparable to the Fractal patch antenna.**

Keywords - **Compact microstrip antenna, Size reduction, Antenna for wireless LAN, Stacked patches**

I. Introduction

Rapid progress in wireless communication promises to replace wired communication networks in the near future in which antennas play a more important role. Microstrip Antennas (MSAs) are used in a broad range of applications from communication systems to biomedical systems, primarily due to several attractive properties such as light weight, low profile, low production cost, conformability, reproducibility, reliability, and ease in fabrication and integration with solid state devices. In recent years the rapid decrease in size of personal communication devices has lead to the need for more compact antennas. As communication devices become smaller due to greater integration of electronics, the antenna becomes a significantly larger part of the overall package volume. This results in a demand for similar reductions in antenna size. The size of a conventional microstrip antenna is somewhat large when designed at lower microwave frequency spectrum. Sometimes the size of the antenna even exceeds the dimension of the receiver or repeater system and thus is unsuitable for mounting conformably on the existing receiver/repeater system. For many antenna applications, such as handheld transceivers, small size is extremely important. In addition to this, low profile antenna designs are also important for fixed wireless application.

Several techniques for reducing the size of the patch have been presented in the literature such as using a substrate with high dielectric constant [1], incorporating a shorting pin in a microstrip patch [2], use of short circuit [3], cutting slots in radiating patch [4-6] and by partially filled high permittivity substrate [7]. Indeed, it remains quite difficult to miniaturize such radiating elements because these efforts generally conflict with electrical limitations or cost considerations.

In this paper, a square microstrip patch antenna, a similar slotted patch configuration with four equal lengths slits along the diagonal of the patch together with four angular grooves along the edges of the patch and a fractal microstrip patch antennas are investigated and compared. Finally, a scheme for gain and bandwidth enhancement is presented.

The simulations are carried out with IE3D from Zeland Software, which is based on the method of moments. The proposed antennas are compact, having a patch area less than that of a conventional square microstrip patch antenna fabricated on the same substrate and resonating at the same frequency. These antennas can find application in the WLAN 802.11b communication standard operating at 2.4 GHz and, in linear phased arrays, to realize more elements tightly packed into a linear array. This configuration of linear array further reduces the amount of mutual coupling between the elements which otherwise would lead to a degradation in the radiation pattern.

II. Antenna Design

Fig.1 shows the conventional square microstrip patch antenna with patch dimension L x W as 28.2 mm x 28.2 mm. Due to the unavailability of the commercial microwave laminates with a dielectric constant of 2.2 the solution was sought utilizing standard PCB (FR-4, $\varepsilon_r = 4.4$) as the dielectric material with a backplane conductor to form a microstrip antenna. The thickness of the substrate is assumed to be 1.6 mm. However, the same configuration when realized with other low loss substrate gives better performance. The antenna is probe fed which is the most widely used feeding method in microstrip antenna. The coaxial feed position is determined to give optimal matching at 4.8 mm. The patch is found to resonate at 2.46 GHz.

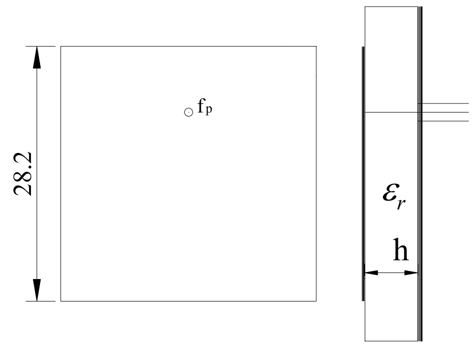

Fig. 1 Geometry of conventional square microstrip patch L = W = 28.2 mm

Vibha Rani Gupta and Nisha Gupta are the faculty of Department of Electronics and Communication Engineering, Birla Institute of Technology, Mesra, Ranchi-835215, Jharkhand, INDIA, E-mail: vrgupta@bitmesra.ac.in, ngupta@bitmesra.ac.in.

Fig. 2 illustrates the variation of the conventional square microstrip patch antenna under investigation. The proposed slotted patch antenna uses four equal length slits cut diagonally in the patch and four angular grooves cut along the four edges of the radiating element, printed on same substrate. The purpose of the slots is to lengthen the effective radiating current path of the patch. Thus the effective size of the patch may be reduced relative to a given frequency of operation. The feed is a coaxial feed with a new feed position as 2.1 mm. for optimal feed matching.

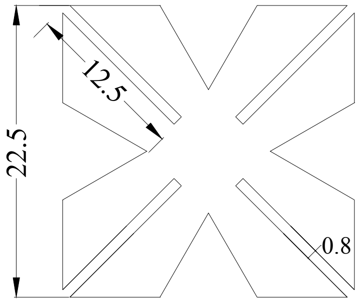

Fig.2 Geometry of the proposed antenna 1
L= W = 22.5 mm

The fractal patch is generated by applying an iterative sequence to the starting structure as shown in Fig. 3. The starting structure in the present case is a square patch (28.2 mm x 28.2 mm). Fig. 4 shows the fractal patch configuration after third iteration, printed on the same substrate. As evident from this figure, the area occupied by the fractal patch decreases with the increase in iteration. Next, the new feed position is determined by the iterative method for best possible impedance matching as 2.8 mm.

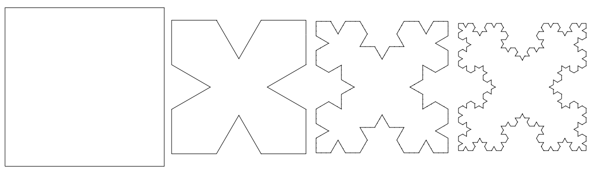

Fig. 3 Fractal patch antenna generation

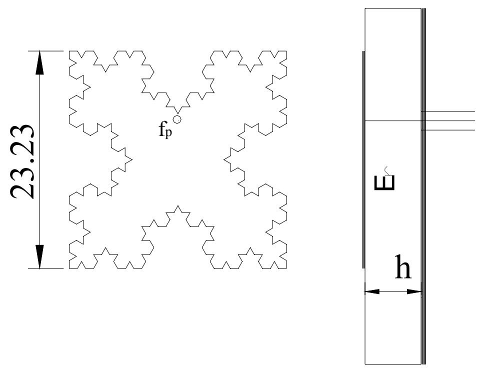

Fig. 4 Proposed antennas 2 (Fractal patch Antenna)
L = W = 23.23

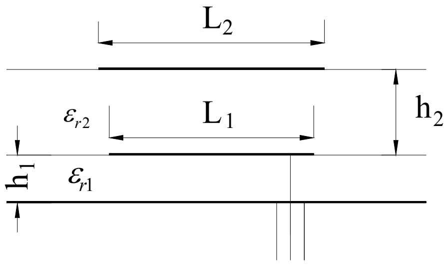

Fig.5 Geometry of the proposed antenna 1 in stacked configuration
L1 = 22.28 mm, L2 =22.59 mm, h1 = 4.8mm, h2 = 7 mm.

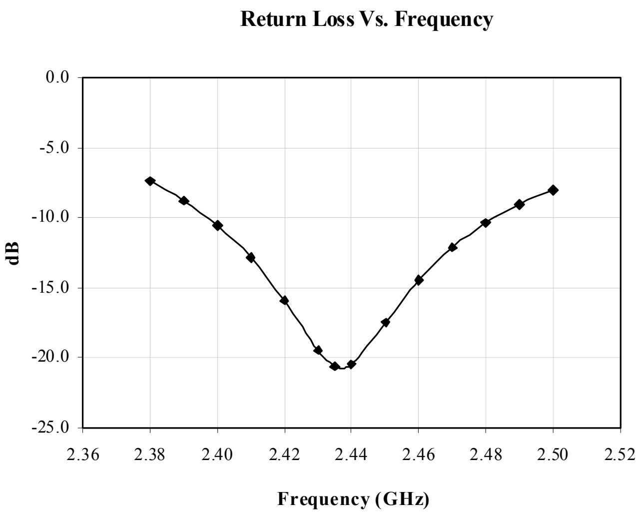

Fig. 6 Return Loss Vs. Frequency of proposed antenna 1
in stacked configuration

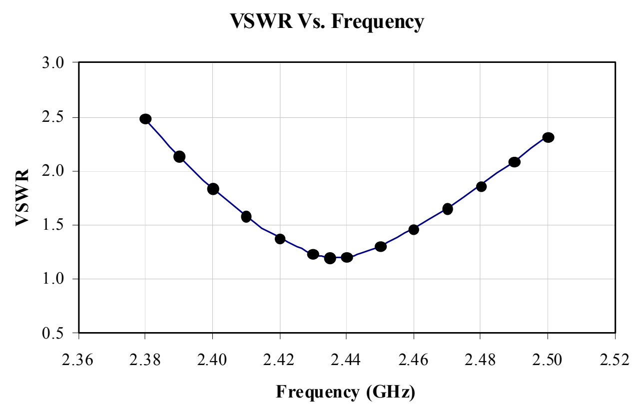

Fig. 7 VSWR Vs. Frequency of proposed antenna 1
in stacked configuration

One problem associated with the slotted patch is diminished antenna gain and bandwidth. The gain reduction is caused by the overall reduction in the antenna size. It can also be attributed to the substrate characteristics which may lead to surface wave excitation and hence a reduction in gain. A design modification proposed using stacked configuration [8] could significantly improve the gain and bandwidth of the slotted patch. Figure 5 shows the stacked patch configuration proposed for the gain and bandwidth enhancement. The return loss, VSWR and gain are plotted in Fig. 6, Fig. 7 and Fig. 8 respectively for the stacked patch configuration of proposed antenna 1. A measured return loss characteristic is also shown in Fig. 9. A comparison of the result is summarized in Table I.

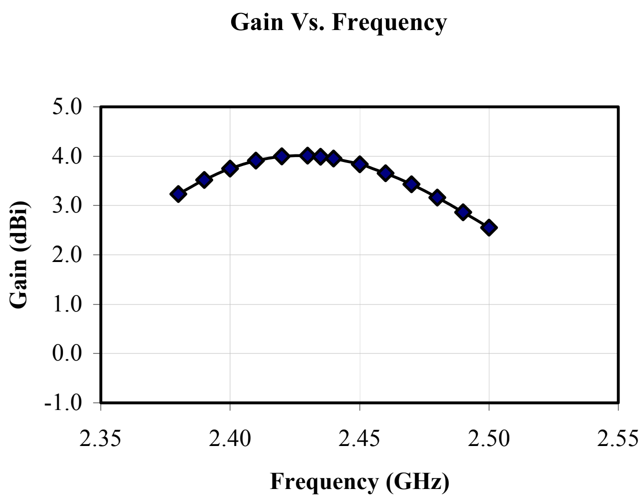

Fig. 8 Gain Vs. Frequency of proposed antenna 1 in stacked configuration

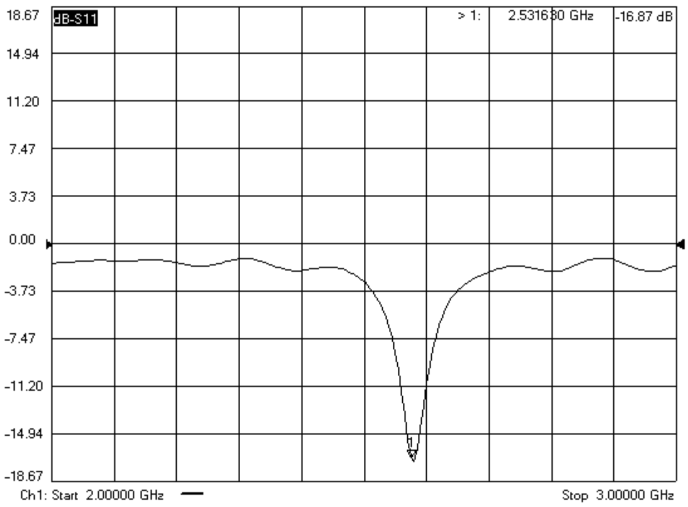

Fig.9 Measured Return loss characteristic of proposed antenna 1 in stacked configuraion

III. CONCLUSION

Two compact microstrip patch antennas are proposed for WLAN 802.11b communication standard at 2.4 GHz. band. The characteristics of the proposed compact microstrip patch antennas are compared with each other and with that of a simple square patch antenna. The proposed patch antennas show a significant size reduction compared to the simple square patch antenna. The gain and bandwidth of the proposed antennas can be increased significantly using stacked configuration

TABLE I
COMPARISON OF PROPOSED ANTENNAS WITH CONVENTIONAL SQUARE PATCH ANTENNA

Type of Antenna	Resonant Freq. (GHz)	% Reduction in size	% Reduction in area	VSWR BW (MHz)	Gain (dBi)
Conv. Square patch Antenna	2.46	-	-	43	3.14
Proposed Antenna 1	2.46	20.45%	54%	26	0.542
Proposed Antenna 2 (Fractal)	2.46	17.85%	54%	26.8	0.878
Stacked Config. of Proposed Antenna 1	2.44	19.89%	53%	91.46	4.0

ACKNOWLEDGEMENT

The authors acknowledge the financial support granted under the Self-Assistance Program (SAP) of University Grants Commission, Government of India, New Delhi.

REFERENCES

[1] T. K. Lo, C. O. Ho, Y. Hwang, E. K. W. Lam, and B. Lee, "Miniature aperture-coupled microstrip antenna of very high permittivity," *Electronics Letters*, 33, pp. 9-10, 1997.

[2] R. B. Waterhouse, S. D. Targonski and D. M. Kokotoff, "Design and performance of small printed antennas," *IEEE Transactions on Antennas and Propagation*, 46, pp. 1629-1633, 1998.

[3] S. Pinhas and S. Shtrikman, "Comparison between computed and measured bandwidth of quarter-wave microstrip radiators," *IEEE Transactions on Antennas and Propagation*, 36, pp. 1615-1616, 1988.

[4] K. L. Wong and K. P. Yang, "Small dual frequency microstrip antenna with a cross slot," *Electronics letters*, 33, pp. 1916-1917, 1997.

[5] H. Iwasaki, "A circularly polarizated small- size antenna with a cross slot," *IEEE Transactions on Antennas and Propagation*, 44, pp. 1399-1401, 1996.

[6] V. R. Gupta and N. Gupta, "*Characteristics of a Compact Microstrip Antenna*," *Microwave and Optical Technology Letters*, 40, pp. 158-160, 2004.

[7] B. Lee and F. J. Harackiewicz, "Miniature microstrip antenna with a partially filled high -permittivity substrate," *IEEE Transactions on Antennas and Propagation*, 50, pp. 1160-1162, 2002.

[8] R. B. Waterhouse, "Design of probe-fed stacked patches", *IEEE Transactions on Antennas and Propagation*', 47, pp. 1780-1784, 1999.