# Wideband Printed Microstrip Antenna for Wireless Communications

V. P. Sarin, Nisha Nassar, V Deepu, C. K Aanandan, P Mohanan, *Senior Member, IEEE*, and Kesavath Vasudevan, *Senior Member, IEEE*

***Abstract*—A simple electromagnetically coupled wideband printed microstrip antenna having a 2:1 VSWR bandwidth of 38% covering the 5.2/5.8-GHz WLAN, HIPERLAN2, and HiSWANa communication bands is presented. The large bandwidth is obtained by adding a rectangular metal strip on a slotted square microstrip antenna. The antenna occupies an overall dimension of $42 \times 55 \times 3.2$ mm$^3$ when printed on a substrate of dielectric constant 4. It exhibits good radiation characteristics and moderate gain in the entire operating band. Details of the design along with experimental and simulation results are presented and discussed.**

***Index Terms*—5.2/5.8-GHz WLAN, broadband microstrip antenna, HiSWANa, wideband antennas.**

## I. Introduction

Due to the rapid progress in wireless communication systems, high-gain broadband antennas are of great demand. Even though microstrip antennas have a lot of advantages like high gain, low profile, and ease of fabrication, their usage is limited by their inherent narrow bandwidth. Various techniques like aperture coupling [1], use of coupled parasites [2], stacking [3], [4], E-shaped patch [5], and modifications in the feed [6]–[8] have been proposed to enhance the bandwidth of microstrip antennas. Compact broadband operation has also been implemented using microstrip ring antennas [9], [10]. Garg *et al.* have reported a single-band microstrip ring antenna [11] in which impedance matching is brought about by loading a metal strip on the ring structure without affecting the cross-polarization characteristics. Implementation of wideband transmission line matching network to the end of the feed line proposed in [12] and [13] increases the fabrication complexities. Lee *et al.* have proposed a microstrip line-fed patch antenna in which broadband matching is achieved by using an inverted L-strip fabricated on a foam substrate connected to the end of the feed line [14].

In this letter, a new broadband, planar impedance-matching scheme is achieved by using a simple rectangular strip without any structural complexities. The antenna has a 2:1 VSWR bandwidth of 38% from 4.3-6.33 GHz covering IEEE 802.11a (5.15-5.35, 5.725-5.825 GHz), HIPERLAN2 (5.45-5.725 GHz), and HiSWANa (5.15-5.25 GHz) communication bands.

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The authors are with Centre for Research in Electromagnetics and Antennas (CREMA), Department of Electronics, Cochin University of Science and Technology, Kerala 682022, India (e-mail: vasudevan@cusat.ac.in).

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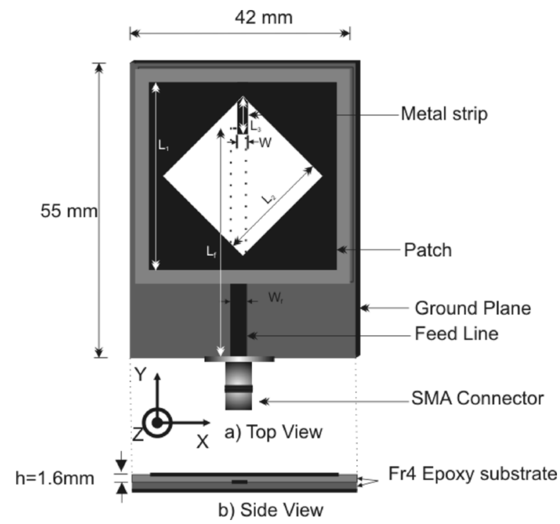


Fig. 1. Geometry of the proposed antenna. ($L_1 = 35$ mm, $L_2 = 17.5$ mm, $L_3 = 7.8$ mm, $W = 2$ mm, $L_f = 43$ mm, and $W_f = 3$ mm).

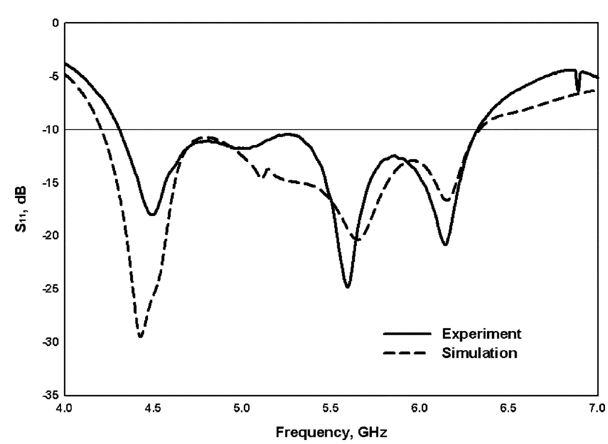


Fig. 2. Return loss characteristics of the proposed antenna. ($L_1 = 35$ mm, $L_2 = 17.5$ mm, $L_3 = 7.8$ mm, $W = 2$ mm, $L_f = 43$ mm, and $W_f = 3$ mm).

## II. Geometry of the Antenna

The geometry of the proposed antenna is shown in Fig. 1. A square microstrip patch antenna of dimension $L_1 \times L_1$ mm$^2$ is fabricated on a substrate of dielectric constant 4 with a loss tangent 0.02 and height 1.6 mm. A 45° tilted square slot of dimension $L_2 \times L_2$ mm$^2$ is etched on the center of the square patch. For achieving good impedance-matching characteristics,

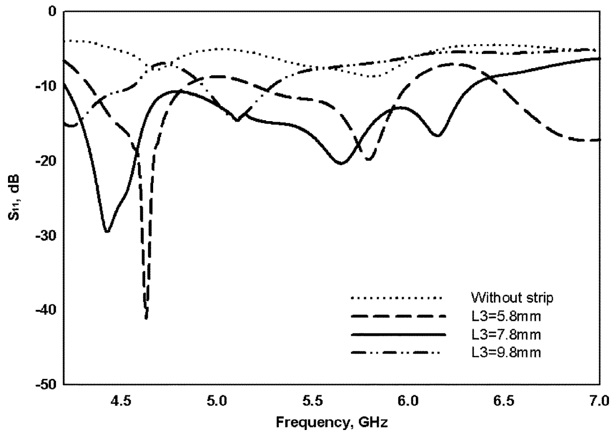


Fig. 3. Effect of strip length $L_3$. ($L_1 = 35$ mm, $L_2 = 17.5$ mm, $W = 2$ mm, $L_f = 43$ mm, and $W_f = 3$ mm).

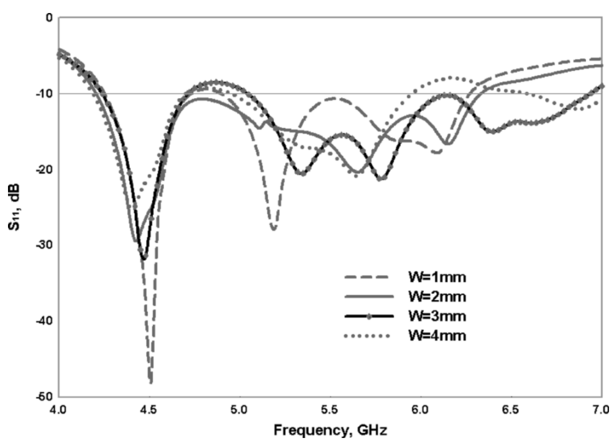


Fig. 4. Effect of strip width W. ($L_1 = 35$ mm, $L_2 = 17.5$ mm, $L_3 = 7.8$ mm, $L_f = 43$ mm, and $W_f = 3$ mm).

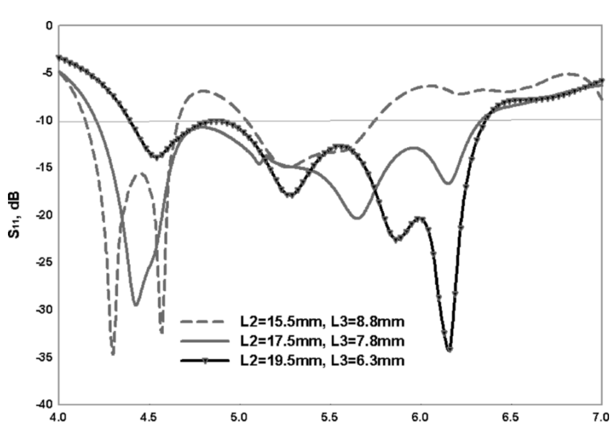


Fig. 5. Effect of slot length $L_2$. ($L_1 = 35$ mm, $L_3 = 7.8$ mm, $L_f = 43$ mm, $W = 2$ mm, $L_f = 43$ mm, and $W_f = 3$ mm).

a rectangular strip of dimension $L_3 \times W$ mm$^2$ is incorporated symmetrically at the top corner of the slot. The antenna is electromagnetically coupled using a 50-$\Omega$ microstrip transmission line fabricated on the same substrate. The ground plane dimension is optimized as $42 \times 55$ mm$^2$.

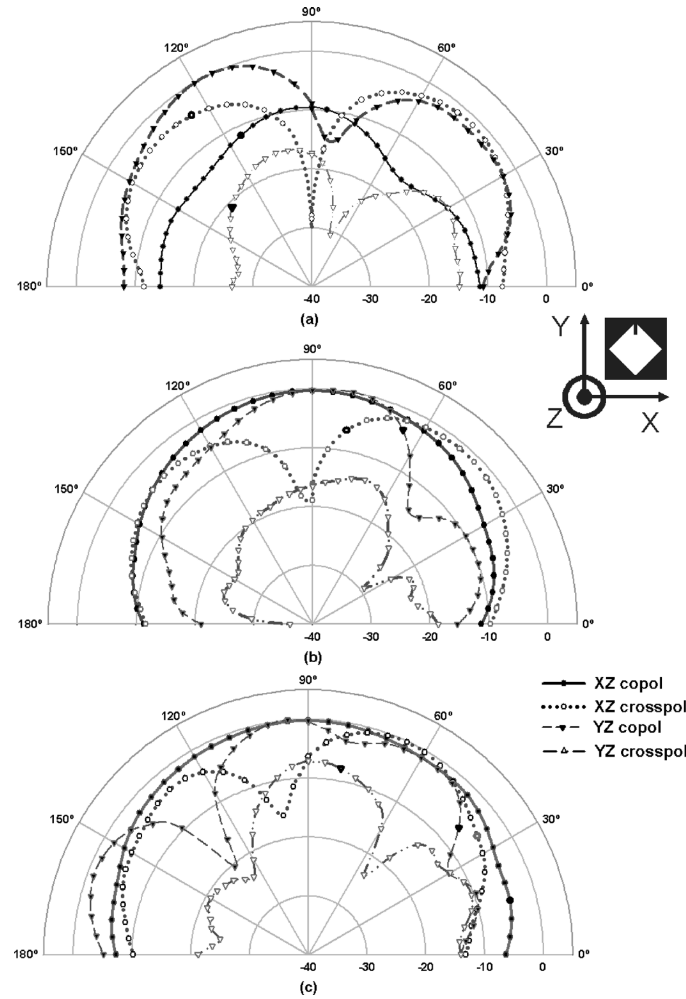


Fig. 6. Measured radiation patterns of the antenna at (a) 4.5, (b) 5.6, and (c) 6.14 GHz.

## III. Results and Discussions

The simulation and the experimental studies of the antenna are done using Ansoft HFSS and HP8510C Network Analyzer, respectively. Fig. 2 shows the simulated and experimental return loss characteristics of the antenna. Bandwidth enhancement is achieved by merging three major resonances centered at 4.5, 5.6, and 6.14 GHz, respectively.

Fig. 3 shows the return loss characteristics of the antenna with and without the strip. It is evident from the graph that without the strip, there exist only two poorly matched resonances. As length of the strip $L_3$ increases, impedance matching also increases, and the maximum bandwidth is obtained when $L_3 = 7.8$ mm. Also, the resonant frequencies shift toward the lower side with increase in $L_3$. The strip creates an additional resonance at 6.14 GHz, and it is verified using the surface current patterns.

Fig. 4 shows the effect of strip width on return loss characteristics of the antenna. An optimum width of $W = 2$ mm is selected for achieving the maximum bandwidth of the antenna.

The effect of slot length on the return loss characteristics is shown in Fig. 5. As the slot dimension $L_2$ decreases, the first and second resonances shift toward the lower side, and a higher strip length is required for impedance matching.

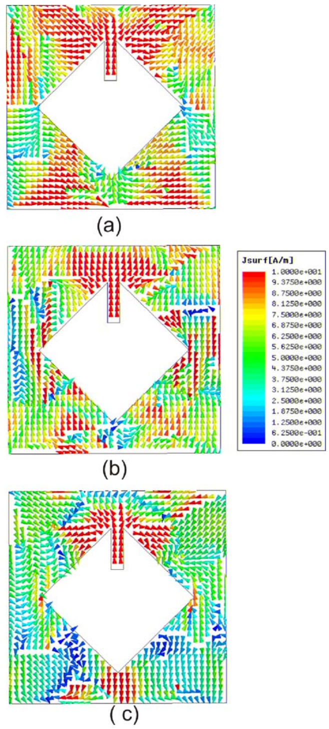


Fig. 7. Simulated surface current distribution of the antenna at (a) 4.5, (b) 5.6, and (c) 6.14 GHz.

The polarization of the antenna is also verified. The antenna is linearly polarized along the $Y$-axis. The normalized $XZ$ and $YZ$ plane radiation patterns of the antenna are shown in Fig. 6. The simulated surface current distributions of the antenna at the three resonant frequencies are shown in Fig. 7. Corresponding to the resonance at 4.5 GHz, a full-wave variation is noted on the top edge of the patch along the strip. Also, a similar variation is noted along the two edges in the $Y$-direction. This produces two resonances around 4.5 GHz, which coalesce to give the first resonance. However, the polarization is found to be along the $Y$-axis. This is because the opposing currents on either sides of the strip cancel the fields along the axis at the far-field. The second resonance is due to the three half-wave variations along the sides of the patch in the $Y$-direction, resulting in almost steady $XZ$-copolar and $YZ$-copolar patterns. A symmetric full-wave variation from the strip to the right and left edges of the patch causes the third resonance.

The measured gain of the antenna is shown in Fig. 8. The antenna has a peak gain of 5.9 dBi at 4.7 GHz and lowest of 2.5 dBi at 6.37 GHz. It can be seen from Fig. 7(c) that the opposing currents on either sides of the strip cause field cancellation along the axis at the far-field, giving a reduced gain for the third resonance.

From the simulation studies using HFSS, the optimum parameters of the antenna are found to be $\mathrm{L}_1 = 1.24\lambda_{\mathrm{g}}$, $\mathrm{L}_2 = 0.62\lambda_{\mathrm{g}}$, $\mathrm{L}_3 = 0.46\lambda_{\mathrm{g}}$, and $\mathrm{W} = 0.07\lambda_{\mathrm{g}}$, where $\lambda_{\mathrm{g}}$ is the guided wavelength corresponding to the center frequency. The design parameters are validated for different frequencies.

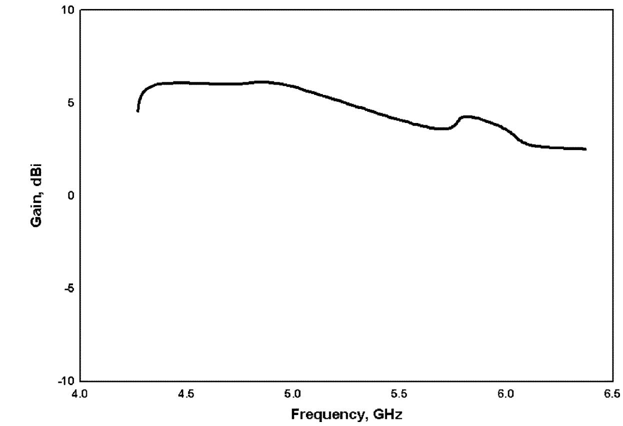


Fig. 8. Measured gain of the antenna.

## IV. Conclusion

A wideband, electromagnetically coupled, printed microstrip antenna suitable for 5.2/5.8-GHz WLAN, HIPERLAN2, and HiSWANa applications is presented. Bandwidth enhancement is achieved due to the employment of a matching metal strip on the slotted square microstrip antenna. The antenna has a 2:1 VSWR bandwidth of 38% from 4.3 to 6.33 GHz, with good radiation and impedance-matching characteristics.

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