

Research Article

Compact and Broadband Microstrip Antennas for Next Generation High-Speed Wireless Communication Using HIPERLAN/2

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The investigations on rectangular-slot-loaded and V-slot-loaded proximity-coupled microstrip antennas are reported. The performances of two antennas are investigated for the application in wireless local area network 2 (HIPERLAN/2) using IE3D software and the computed results are verified by measurement. Results show that the antennas have wide bandwidth and moderate gain and may be used as small, compact antennas for HIPERLAN/2 communication.

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1. INTRODUCTION

The need for wireless broadband communications has increased rapidly in recent years demanding quality of service, security, handover, and increased throughput for the wireless local area networks (WLANs). The main aim of next-generation wireless communication is high-speed networking service for multimedia communication. The most important high-data-rate wireless broadband networking systems for next generation wireless communications are European Telecommunications Standards Institutes (ETSI) High Performance Local Area Network type 1 (HIPERLAN/1), and High Performance Local Area Network type 2 (HIPERLAN/2) which uses the frequency bands 5.150 GHz–5.350 GHz and 5.470 GHz–5.725 GHz, respectively, with omnidirectional antennas [1]. The modern wireless communication systems require the antennas for different systems and standards with characteristics like compact, broadband, multiple resonant frequencies and moderate gain. Because of many attractive features, microstrip patch antennas have received considerable attention for wireless communication applications [2–8]. Single-layer microstrip antennas have very narrow bandwidth, but using two-layer proximity-coupled microstrip antennas higher bandwidth can be achieved [9–13]. The input impedance of a proximity-coupled microstrip antenna is a sensitive function of length and width of the microstrip feed line. Since radiation pattern of a microstrip antenna has wide beamwidth in one hemisphere, two back-to-back microstrip antennas in the same

module can be used to produce nearly omnidirectional radiation pattern required for LAN applications. In proximity-coupled microstrip antenna, the radiating patch, fabricated on a dielectric substrate, is excited by a microstrip line on another substrate as shown in Figure 1. The dielectric constant and height of the substrates, used for microstrip patch and microstrip line, may be different. Investigations on slot loaded single-layer microstrip antennas are reported, but research work on slot-loaded proximity-coupled microstrip antennas are insufficient [4, 12, 13]. Compact microstrip can be designed by embedding suitable slots on the radiating patch. The loading can be varied by varying the length and width of the slot. Slots can be of different shapes and some slots or combination of two slots on the patch can produce dual frequencies.

In this paper, the theoretical and experimental studies on two new types of proximity-coupled microstrip antennas are reported. Both proximity-coupled microstrip antennas were rectangular type, but one antenna was loaded by cutting rectangular-shaped slot on the patch and other was loaded by V-shaped slot on the patch. Cutting slot on the microstrip patch, reduced size, compact antenna can be designed [12, 13]. The geometry of rectangular-slot-loaded and V-slot-loaded microstrip radiating patches are shown in Figures 2 and 3, respectively. Results show that the proposed microstrip patch antennas have very small size, wide bandwidth, and moderate gain for the application in HIPERLAN/2.

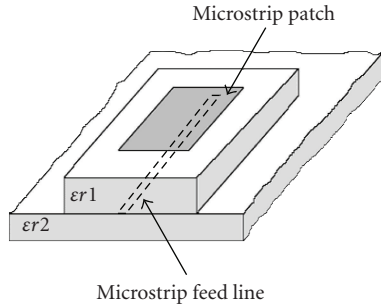


FIGURE 1: Proximity-coupled microstrip patch antenna.

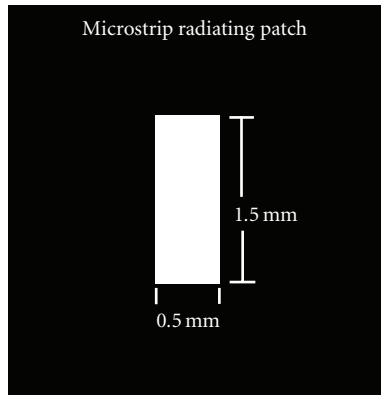


FIGURE 2: Rectangular-slot-loaded microstrip patch.

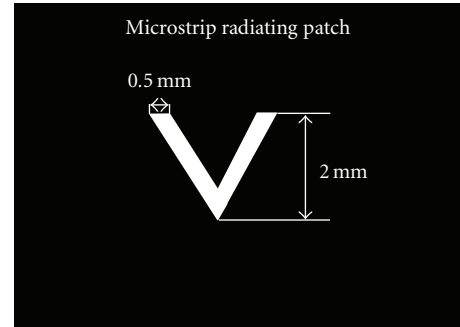


FIGURE 3: V-slot-loaded microstrip patch.

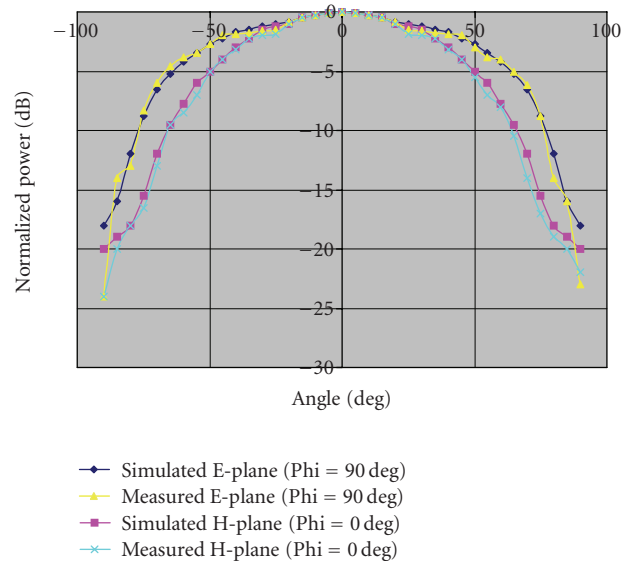


FIGURE 4: Computed and measured radiation patterns of rectangular-slot-loaded proximity-coupled microstrip antenna at 5.56 GHz.

2. COMPUTED AND MEASURED RESULTS

The method of moment using IE3D software is used for the design of the proximity-coupled microstrip antennas. The antennas were fabricated on glass epoxy substrate with dielectric constant 4.36, substrate thickness 1.57 mm, and measurements were done using vector network analyzer (N5230A, Agilent Technologies, USA). The radiation patterns of the antennas were measured using C-band microwave test bench (consisting of Gunn oscillator, PIN modulator, isolator, variable attenuator, and direct-reading-absorption-type frequency meter), Gunn power supply, standard pyramidal Horn antenna (of gain 17 dB), and HP power meter.

Two microstrip antennas, with V-slot and rectangular-slot on the center of the rectangular patches, were fed by SMA connectors via very small microstrip lines. The microstrip feed lines were placed below the centers of the V-slot and rectangular-slot. The dimension of the V-slot-loaded microstrip antenna was 12 mm × 4 mm and the dimension of the rectangular-slot-loaded microstrip antenna was 12 mm × 4.4 mm. The dimensions of the rectangular-slot and V-slot are shown in Figures 2 and 3. The dimension of the feed line was 5 mm × 1 mm. These optimum dimensions of the patches, slots, and feed line were determined using IE3D computation to obtain required frequency for HIPERLAN/2 and to achieve best impedance matching.

The computed return loss of the rectangular-slot-loaded proximity-coupled microstrip patch antenna shows that it

resonates at 5.56 GHz. The antenna shows broadside radiation pattern as shown in Figure 4, where computed and measured results are plotted. The computed gain at 5.56 GHz is 5.3 dBi and minimum gain at the frequency band of 5.470 GHz–5.725 GHz is 4.5 dBi. The computed 10 dB return loss bandwidth of the antenna is 190 MHz. The simulated and measured return losses of the rectangular-slot-loaded proximity-coupled microstrip patch antenna are compared in Figure 5. The computed return loss of the V-slot-loaded proximity-coupled microstrip patch antenna shows that it resonates at 5.565 GHz. The antenna shows broadside radiation pattern and shown in Figure 6, where computed and measured results are plotted. The computed gain at 5.565 GHz is 5.3 dBi and minimum gain at the frequency band of 5.470 GHz–5.725 GHz is 4.7 dBi. The computed 10 dB return loss bandwidth of the antenna is 210 MHz. The simulated and measured return losses of the V-slot-loaded proximity-coupled microstrip patch antenna are compared in Figure 7. Microstrip antenna simulation using IE3D software assumes infinite ground plane, whereas in practice, the ground plane is finite. For fabricated rectangular-slot-loaded

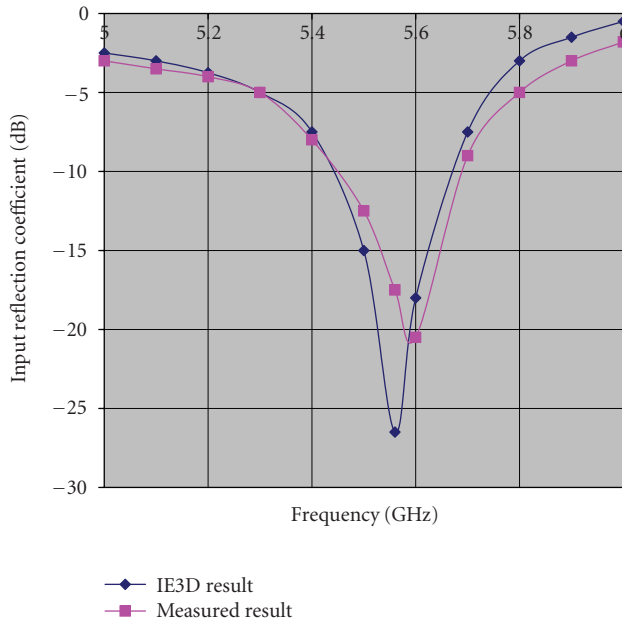


FIGURE 5: Comparison between simulated and measured return losses for rectangular-slot-loaded proximity-coupled microstrip antenna.

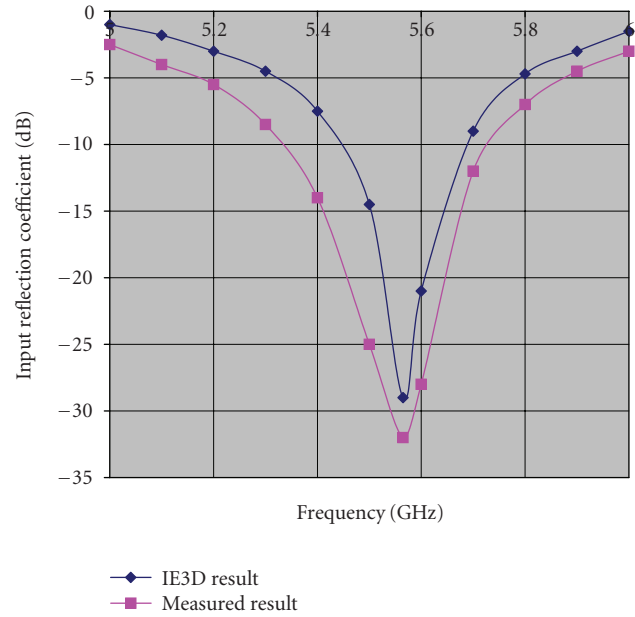


FIGURE 7: Comparison between simulated and measured return losses for V-slot-loaded proximity-coupled microstrip antenna.

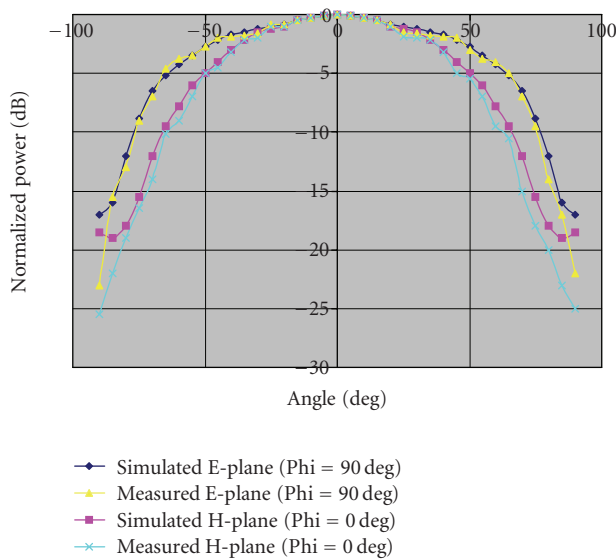


FIGURE 6: Computed and measured radiation patterns of V-slot-loaded proximity-coupled microstrip antenna at 5.56 GHz.

and V-slot-loaded proximity-coupled microstrip patch antennas, measured here, the dimensions of the ground plane were 25 mm × 25 mm. The small differences between computed and measured radiation patterns, as shown in Figures 4 and 6, are due to the fact that measurements were not performed in anechoic chamber and also simulation using IE3D software considers infinite ground plane, whereas in measurement the ground plane is finite. Due to small ground plane, the diffracted field from the edge, modified the radiation patterns resulting in some ripples. Polarization has not

been studied in this paper. In mobile communications and in WLAN applications, polarization is not critical. Especially, in urban scenarios, intense reflections and scattering change the polarization of the incoming electromagnetic waves. It is evident from Figures 5 and 7 that there are small differences between simulated and measured results. This is because of the fact that the antennas were not fabricated using multilayered etching technique. The slot-loaded microstrip patch was fabricated on one substrate and microstripline was fabricated on other substrate and these two were joined together by thin gum before measurement. The difference between simulated and measured return loss bandwidths, shown in Figures 5 and 7 may be due to the effect of thin layer of gum. Another reason of this difference is that perhaps the feed line was not exactly below the centres of the V-slot and rectangular-slot-loaded patches at the time of measurements, because during measurements it was found that if the feed line is shifted very little, laterally from the centre, bandwidth changes.

3. CONCLUSION

The performances of very reduced size broadband microstrip antennas for the application in HIPERLAN/2 communication are reported here. The computation using IE3D shows that in order to achieve same characteristics, in the frequency range of HIPERLAN/2, using proximity-coupled rectangular microstrip antenna without loading by any slot, the required dimension of patch should be 12 mm × 10 mm and for proper impedance matching the dimension of the feed line should be 15 mm × 4 mm. Therefore, using the proposed rectangular-slot-loaded proximity-coupled microstrip antenna the peripheral area of the patch is reduced by 65% and using V-slot-loaded proximity-coupled microstrip antenna the peripheral area of the patch is reduced by 60%. The feed

line dimension is reduced by about 90%. The V-slot-loaded proximity-coupled microstrip antenna has more impedance bandwidth than rectangular-slot-loaded proximity-coupled microstrip antenna. Thus, these proposed antennas are truly compact and broadband antennas.

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