Design of a Multiple U-shaped Slot Microstrip Patch Antenna in the Hiper-LAN Band

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Abstract: In this study, a multiple U-shaped slot microstrip patch antenna for application to the Hiper-LAN band is designed and fabricated. To obtain sufficient bandwidth in the operating band, the foam is inserted between the substrate and ground plane, the coaxial probe source is used, and the position of the probe shift is adjusted from the center to the left. The measured result of the fabricated antenna satisfies the conditions of VSWR<1.5 in the Hiper-LAN band, gain of 3.88 ~ 9.28 dBi, and broad radiation pattern.

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1. Introduction

Resolving the existing defect of a wired LAN, the wireless LAN has been studied since 1990. The wireless LAN enhances the environment where a wired LAN installation is difficult. Accordingly, the application field has maximized the wireless LAN's advantages of portability and simplicity [1].

In today's information society, transmitting enormous information at a 2Mbps transmission rate of the wireless LAN in a 2.4GHz frequency band is difficult. As such, demand for a new frequency band has increased. Wireless Local Area Network (5.15GHz~5.35GHz, 5.47GHz~5.725GHz) and Unlicensed National Information Infrastructure (UNII, 5.725GHz~5.825GHz) and High Performance Radio Local Area Network (Hiper-LAN, 5.15GHz~5.35GHz, 5.47GHz~5.725GHz) have been discussed in relation to this new frequency band [2]. Therefore, the development of a system that enables utility is expanded. Accordingly, the development of the antenna that matches the requirements of the new wireless communication system is being pursued.

A microstrip antenna is used chiefly in a wireless LAN. The advantages of microstrip antennas make them popular in many applications requiring a low profile and relatively lightweight antenna. Nonetheless, the inherent narrow impedance bandwidth of the antenna (2~3%) is a major barrier to its use in today's communication systems. The use of parasitic patches, either in multi-layer geometry or coplanar geometry, has been suggested to increase the bandwidth of the microstrip antenna [3]-[6]. One of the common parasitic patch antennas is the U-shaped slot antenna proposed by Huynh and Lee [7]. Since then, several experimental and theoretical papers on the U-slot antenna have been presented. This study was introduced the U-slot antenna to determine the broadband characteristic [8]-[14].

In this study, a multiple U-shaped slot microstrip patch antenna is designed and fabricated in the Hiper-LAN band. The four U-slots are injected in the patch to determine the broadband characteristic. Unlike the existing U-shaped slot antenna, the position of the probe is located on the left lower column from the center. A coaxial cable feed is used for manufacturing convenience. All simulations are carried out using Ensemble 5.0 of Ansoft. Inc. The details of the proposed antenna and experimental results are presented and discussed.

2. Antenna Configuration and Results

Figure 1 shows the configuration of the multiple U-shaped slot antenna. A prototype design is done using Ensemble 5.0 from Ansoft, Inc., based on the method of moment in frequency domain. The antenna is designed to work in the 5GHz frequency band, with VSWR of 2:1 over the designated frequency range. A radiating patch occupying an area of $27 \times 39.5\ mm^2$ is printed on a thin Taconic TLY-5A-0620-C1/C1 substrate with thickness of 1.57mm and relative permittivity of 2.17. The ground plane has a size of $40 \times 50\, mm^2$. An airgap is inserted between the substrate and the ground to improve bandwidth. Through simulation, return loss is measured and observed according to the change in the length, thickness, location of the U-shaped slot, location of the coaxial probe source, and thickness of the airgap. The antenna is then designed using optimal conditions. The optimum design parameters of the proposed antenna are set as follows: W_0 =27mm; W_1=1.5mm; W_2=3.3mm; W_3=2.0mm; W_4=6.0mm; Y_1=4.0mm; Y_2=3.5mm; F=10mm; L_0=39.5mm; L_1=11.0mm; L_2=15.0mm; X_1=2.1mm; X_2=3.5mm; X_3=7.0mm, and; X_4 =3.6mm.

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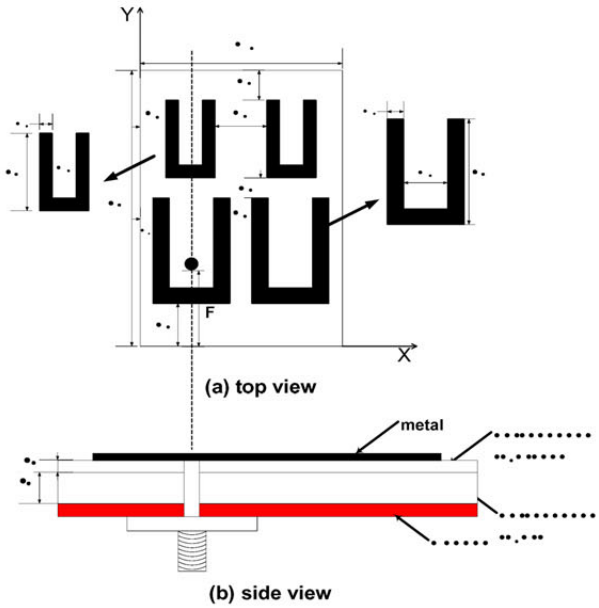


Figure 1. Geometry of the triple U-shaped slot antenna

(a) Top view of the proposed U-shaped slot antenna

(b) Side view of the proposed U-shaped slot antenna

Based on the proposed design described earlier, this study designs, fabricates, and measures a multiple U-shaped slot microstrip patch antenna in the Hiper-LAN band. The return loss of the antenna is measured using an HP8510 network analyzer, with the far-field patterns and gain measured inside an available compact range at the RFIC Center of Kwangwoon University. Figure 2 shows the measured return loss versus frequency for the proposed antenna; Figure 3 illustrates the VSWR versus frequency at the starting point of 4.5GHz and stop point of 6.5GHz with an interval of 200MHz. The impedance bandwidth (2:1 VSWR) of the proposed antenna reaches approximately 730MHz (5.05-5.61GHz, 5.92-6.09GHz). Likewise, the bandwidth of the proposed antenna satisfies the conditions of VSWR<1.5 in the operating band (Hiper-LAN band).

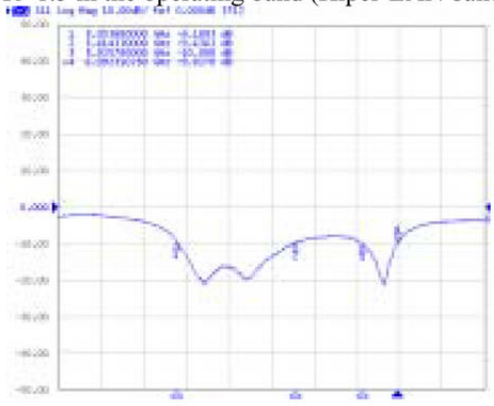


Figure 2. Measured return loss vs. frequency for the proposed antenna.

The radiation characteristics of the proposed antenna are also studied. Figure 10 shows the measured radiation patterns of the proposed antenna at 5.1, 5.3, 5.5, 5.7, and 5.9GHz. Good broadband radiation patterns are obtained. Slight asymmetry in the radiation patterns is also observed, which is largely due to the fringe and coupling effects of the four U-shaped slots.

Figure 11 shows the measured antenna gain versus frequency for the proposed antenna for five frequencies across the 5GHz band. Gain is measured at 3.45-9.28dBi. The antenna gain has a peak value of 9.28dBi, with gain variation at 5.4dBi.

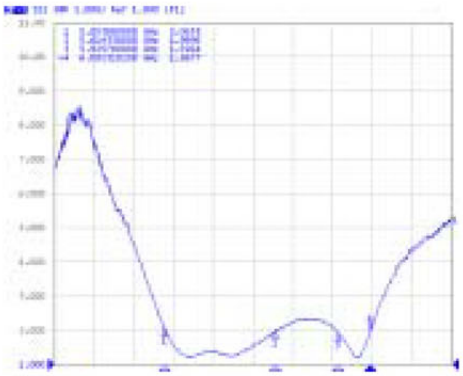
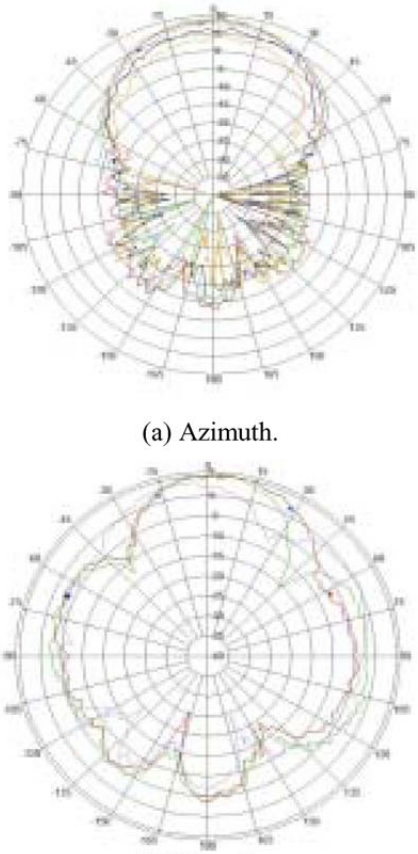


Figure 3. Measured VSWR vs. frequency for the proposed antenna.



(a) Azimuth.

(b) Elevation.

Figure 4. Radiation pattern. (a) Azimuth; (b) Elevation.

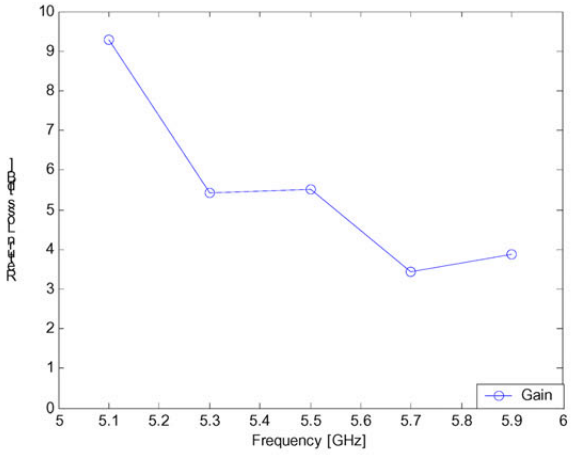


Figure 5. Measured antenna gain for the operating frequencies.

3. Conclusion

A multiple U-shaped slot microstrip antenna is proposed, described, and experimentally investigated for the Hiper-LAN band. By varying the U-slot width, the position of U-slot sections, the thickness of the foam, and the position of the feeding point, optimizing parameters are obtained to determine the good characteristic in the operating band. The obtained impedance bandwidth (2:1 VSWR) coveres 730MHz (5.05~5.61GHz, 5.92~6.09GHz). Across the 5GHz band, the proposed antenna also shows broadband radiation pattern. Gain is measured at 3.88-9.28dBi. Therefore, the antenna is suitable for practical applications requiring broadband antennas in the Hiper-LAN band.

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