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Studies of Triangular Slot Antenna for Dual-Band Antenna with Various Tuning Stub

J. H. Yoon*, G. H. Han, D. H. Kim, J. C. Lee, S. M. Woo, H. H. Kim

Research & Development Team, Antenna Group, Wireless Solutions Division, Samsung Electro-Mechanics Co., Ltd.
314, Maetan-3 Dong, Yeongtong-Gu, Suwon, Kyunggi-Do, Korea, 443-743
E-mail: joonghan.yoon@samsung.com

1. INTRODUCTION

In recent years, the introduction of new indoor communication wireless protocols such as Bluetooth, IEEE 802.11b, and wireless local area networks (WLANs) has led to enormous challenges with respect to antenna designs for wireless communications. The newer WLANs, however, have to provide high-speed wireless connectivity between PCs, laptops, and other equipment in corporate, public, and home environments. In practice, IEEE 802.11b is one of the WLANs, with frequency bands ranging from 2.4 to 2.484 GHz for the ISM band. HIPERLAN 2 was developed for the frequency band ranges of 5.15–5.35 GHz, 5.470–5.725 GHz, and 5.725–5.925 GHz. The required frequency for 5-GHz WLANs is 5.15–5.35 GHz / 5.725–5.825 GHz for the IEEE 802.11a. U-NII covers the frequency band of 5.725–5.825 GHz. In addition to individual approaches for 2.4 GHz and 5 GHz bands, triple-band antennas are necessary for many applications, driving a demand for them.

For the WLAN, dual- or triple-slot antennas have been proposed using a stair-shaped slot [1], a triangular slot [2], a rectangular slot [3], and a double-ring slot [4]. Compared with the regular patch antenna, the slot antenna fed by a microstip line has better characteristics, including a wider bandwidth, less conductor loss, and better isolation between the radiating element and feeding network. In particular, wide-slot antennas have an attractive property of providing a wide operating bandwidth, especially for those having a modified tuning stub, such as the rectangular stub [5]–[9]. However, although many microstrip-fed wide-slot antennas have been proposed for triple-band applications, studies on the triangular-slot antenna with various tuning stub for the triple band are rare.

In this paper, we report a new design of microstrip printed triangular-slot antenna with various tuning stub for triple-band operation. The tuning stub is positioned within the slot region on the opposite side of the printed triangular slot. By choosing suitable parameters, we obtained a significantly enhanced triple-band impedance bandwidth. The results of the experiment that were conducted on the antenna’s impedance bandwidth, radiation pattern, and gain are discussed in detail in the succeeding section.

2. ANTENNA DESIGN

The schematic configuration of the proposed antenna design for a triangular-slot antenna with fork-like and a rectangular tuning stub is shown in Fig. 1. The proposed slot antenna has an area of 65 mm × 55 mm. The printed triangular slot has dimensions of 46 mm × 39.5 mm and is printed on a thin FR-4 substrate 0.8 mm thick and 4.4, permittivity. The fork-like tuning stub is composed of a straight section of length W_2 and two branch sections of equal lengths W_1 and the spacing between the edges of the two branch sections is L_4. These sections have similar widths and equal to that of L_5 of the 50 Ω microstrip line. The length (L_1=L_2) of the triangular slot, the length (W_1) of the two branch sections in the fork-like tuning stub, the gap (L_4) between the two branch sections of the fork-like tuning stub, and the small gap (W_2) between the fork-like tuning stub and slot region in the opposite side of the printed

ISBN: 978-4-88552-223-9 C3055©IEICE

triangular slot were made to vary in steps, with the bandwidth calculated at each step until the maximum bandwidth has been obtained and optimized for broadband use.

Also, the rectangular tuning stub is composed of a rectangular section of length W_1 and width L_3. By selecting proper dimensions L_3, W_1, length and width of the rectangular tuning stub, the length of the triangular slot length (L_1=L_2), and the feed gap (W_2) between the rectangular tuning stub and slot region on the opposite side of the printed triangular slot, good impedance matching of the printed triangular-slot antenna across a much-enhanced bandwidth for triple-band application can be obtained. After a thorough parametric study of the triangular slot antenna with fork-like stub, the optimum design parameters of the proposed antenna were set as follows: L_1 = 46 mm; L_2 = 46 mm; L_3 = 10.1 mm; L_4 = 7.1 mm; L_5 = 1.5 mm; L_6 = 1.5 mm; width of lines W_1 = 11.5 mm; W_2 = 1.4 mm; W_3=1.5 mm. Also, in case of a rectangular tuning stub, the optimum design parameters were set as follows: L_1 = 46 mm; L_2 = 46 mm; L_3 = 7.5 mm; L_4 = 1.5 mm; width of lines W_1 = 10.5 mm; W_2 = 2.2 mm. The optimum parameters were obtained with the aid of the commercially available software Ensemble 5.0 [10].

3. MEASUREMENT

Fig. 2 shows the simulation and measurement of the test antenna of fork-like and rectangular tuning stub. From the measured results, based on the 2:1 VSWR impedance bandwidth definition, which is acceptable for practical applications, the lower mode has an impedance bandwidth of 550 MHz (2.27–2.82 GHz) or about 21.6%, 423 MHz (2.237–2.66 GHz) or about 17.27%, which covers the 2.4 GHz WLAN band. On the other hand, the upper mode has an impedance bandwidth of 1.736 GHz (4.346–6.082 GHz), or about 33.29%, 1.92 GHz (4.13–6.05 GHz), or about 37.72%, which covers the required bandwidths for WLAN operation in the 5.2 GHz and 5.8 GHz bands. The first case is fork-like tuning stub and the second case is rectangular tuning stub, respectively.

The radiation characteristics of the proposed antenna were also studied. Fig. 3,4 plots the measured radiation pattern at 2.4 GHz and 5.2GHz. The red line represents the radiation patterns for fork-like tuning stub and the blue line represents the radiation patterns for rectangular tuning stub, respectively. Good radiation pattern characteristics and gain for the proposed antenna are observed.

We simulated and measured antenna gain for frequencies across the 2.4- and 5-GHz bands for rectangular tuning stub. In case of fork-like tuning stub, The 2.4 GHz band had an antenna gain level of about 2.02 to 3.74 dBi. And the measured antenna gain levels obtained were about 2.12–3.24 dBi in the 5.2 GHz band and about 4.63–5.69 dBi in the 5.8 GHz bands, respectively. In case of rectangular tuning stub, The 2.4-GHz band has an antenna gain level of about 2.66 to 4.18 dBi and the measured antenna gain levels obtained are about 2.28–3.81 dBi in the 5.2-GHz band and about 5.36–6.22 dBi in the 5.8-GHz band, respectively.

4. CONCLUSION

A triangular-slot antenna with fork-like and a rectangular tuning stub is proposed for the triple band (2.4/5.25/5.8 GHz band), and a prototype is successfully implemented. Optimum parameters are produced by varying various parameters and using the commercially available software. Experimental results show that two separate wide resonant modes with good impedance matching has been obtained, which cover required bandwidths for WLAN operation in the 2.4/5.2/5.8 GHz bands. Good radiation pattern characteristics and gain for the proposed antenna are observed and exhibited.

ACKNOWLEDGEMENT

The author would like to express his sincere gratitude to Prof. Kyeong Sik Min, Korea Maritime University, and Prof. Hiroyuki Arai, Yokohama National University, for their support during the author's stay in Japan. This work was undertaken with the support of the Post-doctoral Fellowship Program of the Korea Science & Engineering Foundation (KOSEF).

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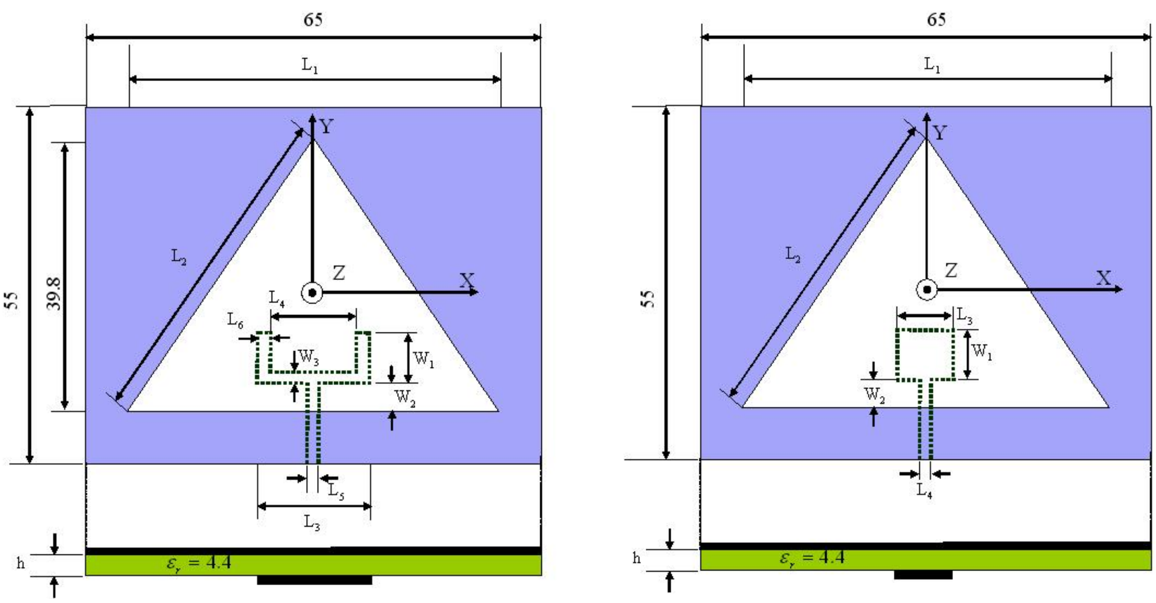
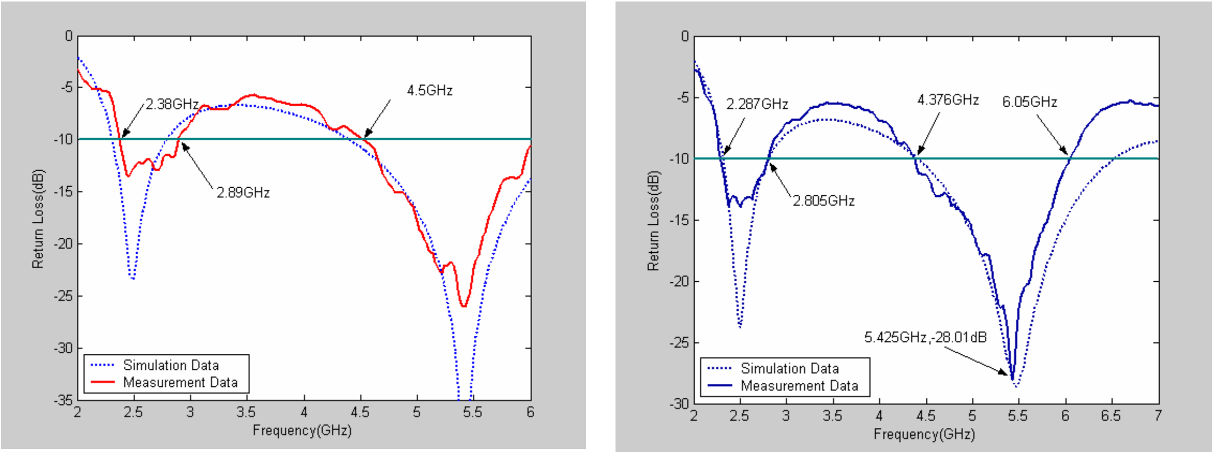


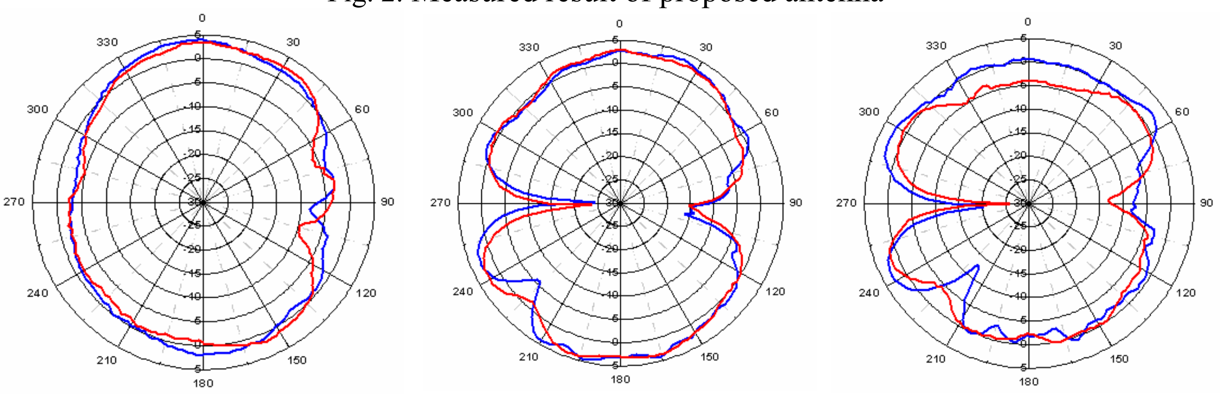
(a) fork-like tuning stub (b)rectangular tuning stub

Fig. 1. Configuration of the triangular-slot antenna with rectangular tuning stub



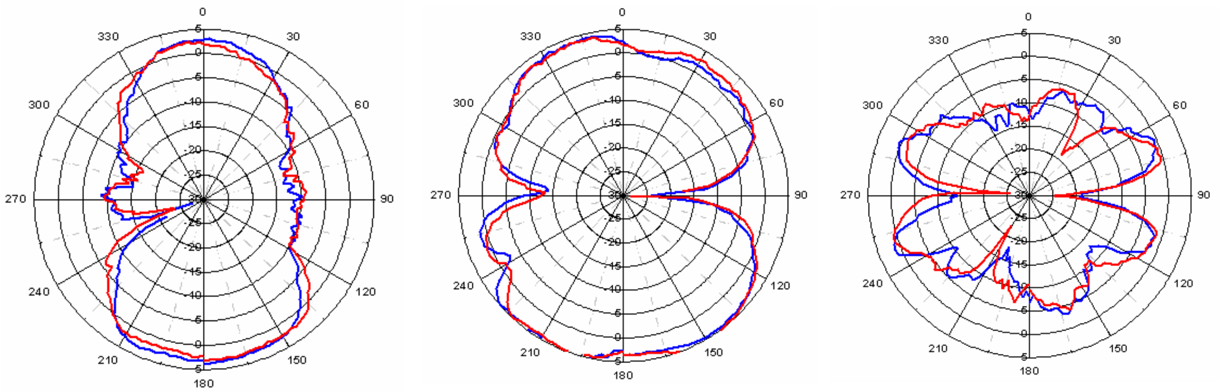
(a) fork-like tuning stub (b) rectangular tuning stub

Fig. 2. Measured result of proposed antenna



(a) x-z plane (a) y-z plane (a) x-y plane

Fig. 3. Measured radiation patterns at 2.44GHz



(a) x-z plane (a) y-z plane (a) x-y plane

Fig. 4. Measured radiation patterns at 5.2GHz