A BROADBAND BALANCED-FED DUAL-BAND BUILT-IN ANTENNA FOR 5 GHz WIDEBAND WIRELESS LAN SYSTEMS

Tadahiko MAEDA*, Yoshitaka NAKAMURA**, and Masao ASAKAWA***
Graduate School of Science and Engineering at Ritsumeikan University
1-1-1 Nojihigashi, Kusatsu-shi, Shiga, 525-8577 Japan
**Email* :*tmaeda@is.ritsumei.ac.jp, **rs029004@se.ritsumei.ac.jp, and ***rs000006@se.ritsumei.ac.jp

1. INTRODUCTION

While the 2.4 GHz frequency band is widely used for current wireless LAN systems, the IEEE 802.11a system, which uses a 5GHz frequency band is one of the promising options for the high-speed wireless data exchange. In order to realize a stable high-speed operation with small handheld wireless terminals, there are two important requirements for the built-in type antennas: 1) Reduction of the undesired leakage of RF current on the metallic case for stable radiation characteristics and 2) Dual-band operation for both 2.4 GHz and 5 GHz for efficient space utilization. In order to meet the requirements, a novel configuration of a three-dimensional structure for a balanced-fed dual-band antenna has been proposed. While the operating bandwidth of the proposed antenna covers the originally assigned bandwidth of the 5 GHz wireless LAN in Japan, it does not cover the newly expanded frequency band for outdoor service in Japan, nor the overseas frequency bands assigned in the U. S. and Europe. This paper describes the design and overall performance of the improved balanced-fed dual-band antenna.

2. ANTENNA STRUCTURE

To date, several studies on unbalanced-fed dual-band antennas have been conducted for several mobile systems [1] [2] including wireless LAN systems [3]. While the idea of balanced-fed antennas has been proposed [4], with several modified configurations, these antennas have not been studied for dual-band operation. Thus, a novel configuration for a balanced-fed dual-band built-in antenna has been proposed [6]. To reduce the total size of the antenna, a particular folded structure has been introduced. Figure 1 shows the entire structure of the radiating element which consists of the upper and lower radiating elements where the feed-point is located at the center of the lower radiating element, as indicated by a small circle. Several structural parameters of the lower radiating element are also shown in Fig. 2.

3. OPTIMIZATION OF STRUCTURAL PARAMETERS

As shown in Fig. 3, the antenna is placed over the 120 X 36.5 [mm] metallic plate which simulates the metallic ground plate of wireless terminals, like a PCMCIA card or a small PDA terminal. Due to the complexity of the antenna structure, a novel simulation algorithm is implemented in the PC cluster system that consists of 16 parallel dual processors, with a Myrinet-2000 data bus, which enables cross-bus data exchange of, up to 2 G bps, between those processors. Also, to increase the efficiency of the calculation by the Method of Moment using the PC cluster system, two efficient techniques [5] are introduced, which dramatically reduce the duration of the wide-band impedance matrix computation, bringing it down to 5% of the original duration: 1) Efficient impedance calculation using the symmetrical relationship for the physical structure of a target antenna, and 2) Efficient interpolation for the impedance matrix of the antenna in the frequency domain.

The antenna is placed above the metallic plate in the position where the distance between the lower portion of the radiating element and the metallic plate is equal to 1 [mm]. The initial structural parameter set (Configuration 1) [6] is as follows: a=18, b=10, c=6, d=4, e=13, f=8, g=7, h1=8, h2=4, s1=1, s2=1, s3=2, w1=3, w2=5, w3=3, w4=1, w5=2 [mm]. The VSWR plot for this parameter set is shown in Fig. 4. While the operating bandwidth of this antenna covers the originally assigned bandwidth of 5 GHz wireless LAN in Japan, it does not cover the newly expanded frequency band for outdoor service in Japan nor the overseas frequency bands assigned in the U. S. and Europe.

Of all the structural parameters, the tilt angle parameter u (shown in Fig. 5), three additional vertical

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position parameters (shown in Fig. 6), and a length parameter f (shown in Fig. 1) were selected, based on the preliminary simulation results, in order to improve the impedance characteristics for the 5 GHz band. As shown in Fig 7, the parameter u influences mainly the higher frequency response and is fixed to 5 [deg] where the VSWRs for both lower and higher frequency bands are well balanced.

In the next step, the effects of the parameter P1 were examined, combined with parameters P2 and P3. Based on the simulation results (shown in figures 8 and 9) for several combinations of these three parameters, the configuration with P1=2, P2=3, P3=1 [mm] was selected to improve the input impedance characteristics, as well as to reduce the total size of the antenna. In addition, the parameter f was fixed to 12 [mm] for wider bandwidth at the 5 GHz band based on the results shown in Fig. 10. This selection brought an upward shift in the resonant frequencies for both frequency bands. To compensate two center frequencies for both the 2.4 GHz and 5 GHz bands, a scaling factor for the entire physical size of the antenna was introduced. Figure 11 demonstrates the VSWRs as a parameter of the scaling factor after fixing other parameters. Finally, the scaling factor was fixed at 1.1 and all the structural parameters have been fixed as the optimized structure (Configuration 2).

As shown in Figures 12 and 13, the radiation patterns for both configurations at 2.4 GHz are the same, whereas the radiation pattern at 5 GHz for configuration 2 shows a wider pattern than that of configuration 1. To assess the key advantage of the balanced-fed antenna, the amplitude of the RF current has been confirmed at less than -20 dB (taking the current amplitude reference of 0 dB at the feeding point) over the entire area of the metallic plate, which is sufficiently lower than that of the unbalanced-fed antennas and is helpful for stable radiation when the antenna is used with several different grounding conditions.

4. MEASUREMENT RESULTS

To assess the validity of the simulation results, measurements were carried out for the optimized antenna structure. Measurement results of the input impedance for the optimized antenna structure are shown in Fig. 14 with the calculated results. While there is a slight difference in the frequency characteristics shown in the figure, the measurement results of the VSWR agree with the calculated results. The bandwidth of 38.2% for the 5 GHz band with a center frequency of 6180 MHz has been confirmed experimentally, which fully covers the assigned frequency bands for the 5 GHz wireless LAN systems worldwide.

5. CONCLUSIONS

This paper describes the basic design, optimization, and overall performance of the balanced-fed dual-band built-in antenna. The five major key structural parameters of this antenna were optimized in order to meet multiple bandwidth requirements by using the efficient parallel Method of Moment. The measured bandwidth exceeds 2360 MHz, which is sufficiently wide for all the frequency bands assigned for the 5 GHz wireless LAN systems worldwide.

ACKNOWLEDGEMENTS

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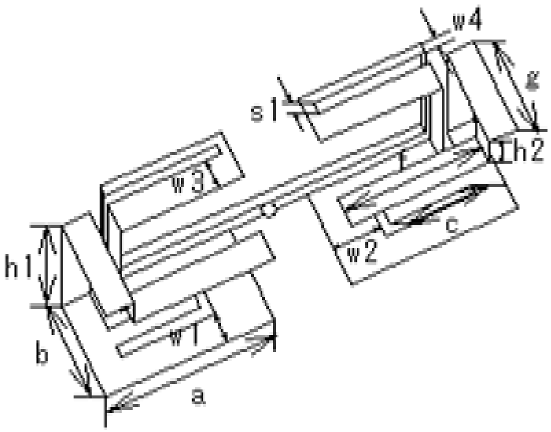

Fig. 1: Antenna structure: Entire radiating element.

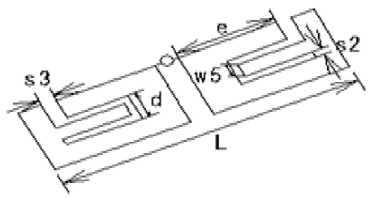

Fig. 2: Antenna structure: Lower portion of the radiating element.

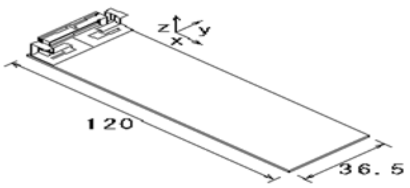

Fig. 3: Antenna structure: Placed on the metallic plate.

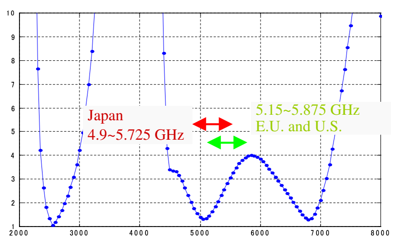

Fig. 4: Calculated VSWR for Configuration 1 and assigned frequency bands for IEEE 802.11a.

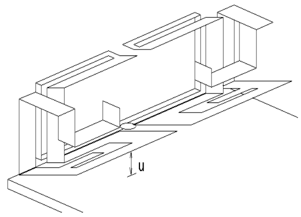

Fig. 5: Tilt angle parameter u.

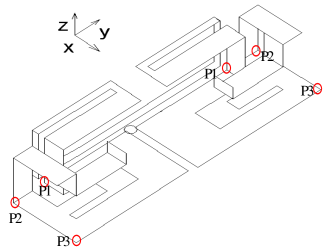

Fig. 6: Additional vertical position parameters: P1, P2, and P3: Distance between point P* and the metallic plate.

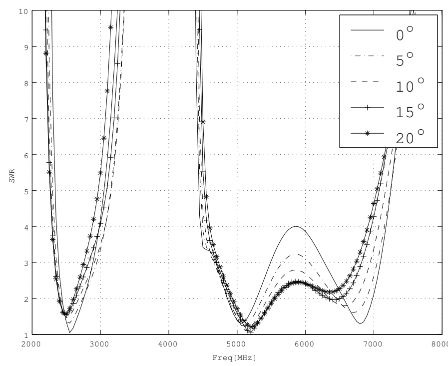

Fig. 7: VSWR as a parameter of u.

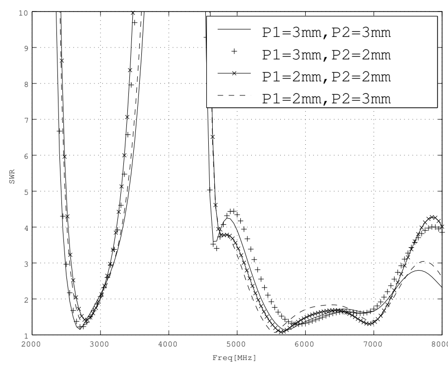

Fig. 8: VSWR as parameters of P1 and P2 where P3=1 [mm].

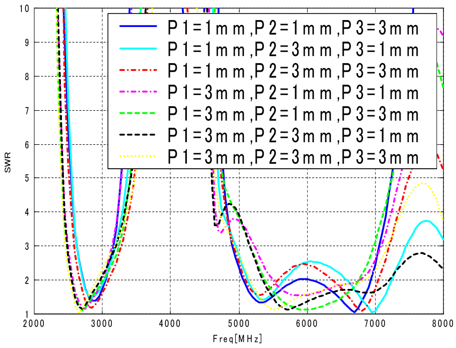

Fig. 9: VSWR as parameters of P1, P2, and P3.

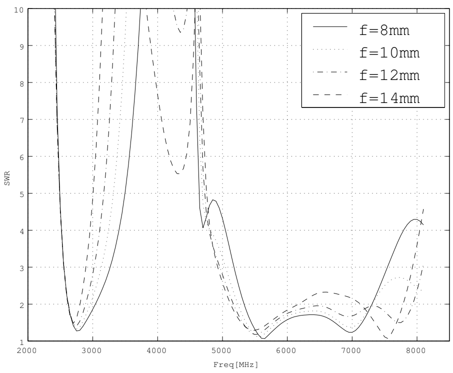

Fig. 10: VSWR as a parameter of f.

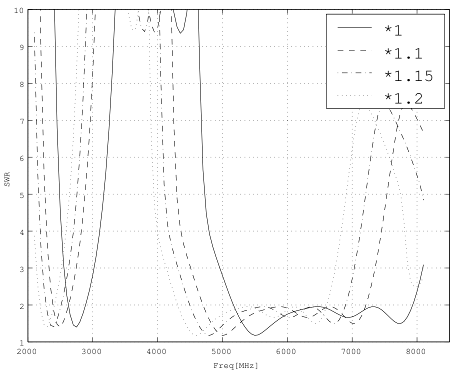

Fig. 11: VSWR as a parameter of the size scaling factor.

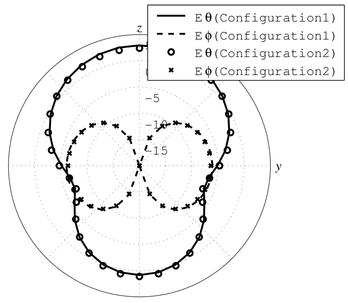

Fig. 12: Radiation patterns for 2.4GHz band.

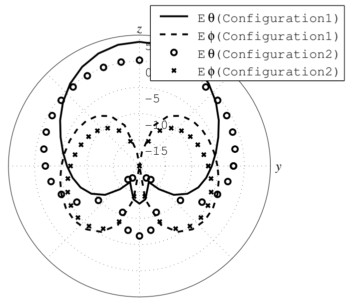

Fig. 13: Radiation patterns for 5GHz band.

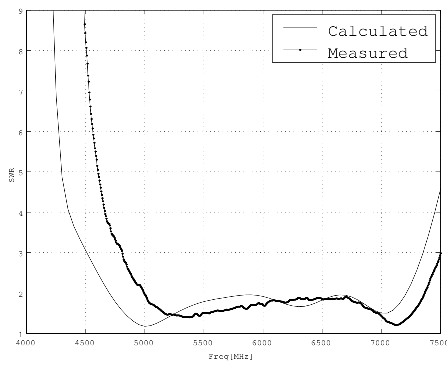

Fig. 14: Comparison of calculated and measured results for configuration 2.