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Analysis of decoupling method between J-shaped folded monopole antennas for IEEE 802.11 b/g on handset

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Abstract: This letter presents a mutual coupling reduction method between two J-shaped folded monopole antennas (JFMA), which cover Wireless Local Area Network (WLAN), especially for IEEE 802.11 b/g band on handset. IEEE 802.11 b/g is used to 2.4 GHz (2400-2484 MHz) band. We proposed an effective method to reduce mutual coupling by using a bridge line that links two antennas. As the analytical results, by linking the shorting strips of two JFMA elements with a bridge line, we obtained a sufficiently reduced mutual coupling and improved total antenna efficiency.

Keywords: small antenna for handset, mutual coupling reduction
Classification: Microwave and millimeter wave devices, circuits, and systems

References

[1] R. G. Vaughan and J. B. Anderson, "Antenna diversity in mobile communications," *IEEE Trans. Veh. Technol.*, vol. VT-36, no. 4, pp. 147–172, Nov. 1987.
[2] D. Gesbert, M. Shafi, D. S. Shiu, P. Smith, and A. Naguib, "From theory to practice: An overview of MIMO space-time coded wireless systems," *IEEE J. Sel. Areas Commun.*, vol. 21, no. 3, pp. 281–302, April 2003.
[3] Y. Gai, X. Chen, C. Parini, and Z. Ying, "Study of a dual-element PIFA array for MIMO Terminals," *Proc. IEEE AP-S Int. Symp.*, Albuquerque, NM USA, pp. 309–312, July 2006.
[4] A. Diallo, C. Luxey, P. Thuc, R. Staraj, and G. Kossiavas, "Study and reduction of the mutual coupling between two mobile phone PIFAs operating in the DCS1800 and UMTS bands," *IEEE Trans. Antennas Propag.*, vol. 54, pp. 3063–3074, Nov. 2006.
[5] J. Kim, K. Chung, Y. Ho, and M. Kim, "An LTE-band dual-antenna design with an enhanced antenna efficiency," *IEICE Trans. Commun. Lett.*, vol. E92-B, no. 11, pp. 3554–3556, Nov. 2009.
[6] Y. Kim, J. Ito, and H. Morishita, "Study on the reduction of the mutual coupling between two L-shaped folded monopole antennas for handset," *Proc. IEEE AP-S Int. Symp.*, San Diego, CA USA, pp. 1–4, June 2008.

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[7] IE3D, Release 14.0 Zeland Software, 2009.

1 Introduction

The recent increase of needs for wireless communication quality has induced the development of multi-antenna system for handset. Diversity and multiple-input multiple-output (MIMO) applications [1, 2] are considered as the potential technologies for enhancing the performances and capacity with a high-speed transmission rate. In these applications, even though well-matched compact antennas are co-located on the same ground plane of a handset, improving their isolation still remains a big task, since mutual coupling occurring between the radiators affects the antenna performances, especially the antenna efficiency [3]. The method of linking between two antennas using a bridge line is introduced as one of the promising mutual coupling reduction method [4, 5, 6]. The idea is to compensate the effect of the existing coupling by introducing an opposite coupling by linking two antennas with a suspended microstrip line. However, antenna elements used for these papers are wide arrangement interval of two antenna elements, and disadvantageous for the miniaturization of the entire antenna volume. In this paper, the mutual coupling reduction between two J-shaped folded monopole antennas (JFMAs) on a finite ground plane operating at 2.4 GHz (2400-2484 MHz) band for IEEE 802. 11 b/g is investigated using this decoupling method. JFMA has a simple structure, and it is effective for the miniaturization of the entire antenna volume because the interval of two JFMA elements can be narrowed to 1 mm. In addition, it is shown that the linking location of the bridge line is different compared with L-shaped folded monopole antenna (LFMA) that has already been introduced [6]. In the analysis, the electromagnetic simulator IE3D by Zeland software has been used for the simulation [7], and several prototypes are fabricated and measured for comparison with the simulation results.

2 Antenna structure and decoupling method

The two JFMA elements are mounted adjacent to the upper edge of a rectangular ground plane of size 40 × 100 mm^2, which represents a shielding plate in the handset unit, as shown in Fig. 1 (a). The antenna parameters have been adjusted so that the antennas operate at the frequency of nearly 2.4 GHz band, and the height of these antennas is 7 mm from ground plane. These antennas are composed of the wire of 1 mm in the diameter. Two JFMAs consist of symmetrically installed on the top of ground plane and separated by a small spacing 1 mm. The antenna element and ground plane are made up of copper strips with thicknesses of 0.2 mm and 0.5 mm, respectively. The conductivity of the metal structures are 5.7×10^7 [S/m].

The idea is to compensate for the existing coupling between radiators by

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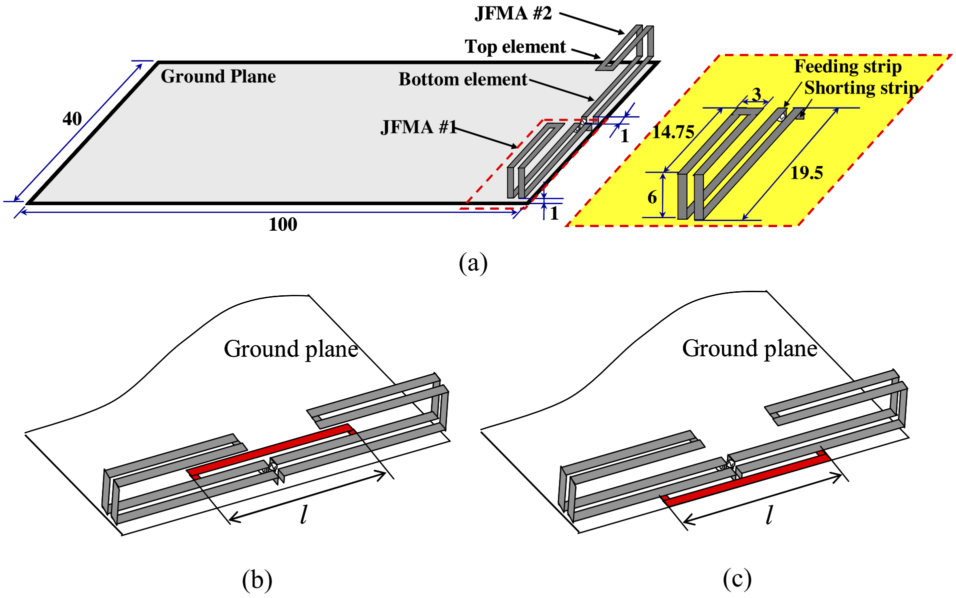

Fig. 1. Configuration of the proposed antenna. (a) normal JFMA (b) Installation of the bridge line linking two feeding strips (f-f Bridge) (c) Installation of the bridge line linking two shorting strips (s-s Bridge)

introducing an opposite coupling. It is supposed that this can be done by linking the two antennas, and two attempts are made by linking feeding strips (f-f Bridge) or shorting strips (s-s Bridge) at the bottom of the antenna element using 1 mm width bridge line as shown in Fig. 1 (b),(c).

3 Simulation results and measurements

Fig. 2 (a) shows the mutual coupling at the resonance frequency (2.45 GHz) with two types of bridge line when the length$l$ of the bridge line is varied. The lowest mutual coupling becomes −21.24 dB, when the length of bridge line $l=$ 24 mm on linking the s-s Bridge. On the other hand, f-f Bridge can not be obtained effect of mutual coupling reduction. Therefore, JFMAs and LFMAs [6] differ from each other in the linking location of the bridge line. It is because the relative position of feeding strip and shorting strip is different between JFMA and LFMA. Fig. 2 (b, c) shows the S-parameters of modified JFMA (with s-s Bridge, l = 24 mm), and they are compared with normal model (Fig. 1 (a)). The mutual coupling at the resonance frequency is reduced from −9.23 dB to −21.24 dB, while the bandwidth ($S_{11} \leq -10$ dB) becomes slightly narrower. In addition, the mutual coupling can be reduced over a wideband in modified JFMA. Fig. 2 (d) shows the comparison of the total efficiencies of normal JFMA and modified JFMA. As expected, the total efficiencies are improved, as the mutual coupling is reduced with s-s bridge line. Fig. 3 shows the comparison of the average current distributions of normal JFMA and modified JFMA. JFMA#1 is exited and JFMA#2 is terminated with the terminal impedance of 50 Ω. The current of the shorting

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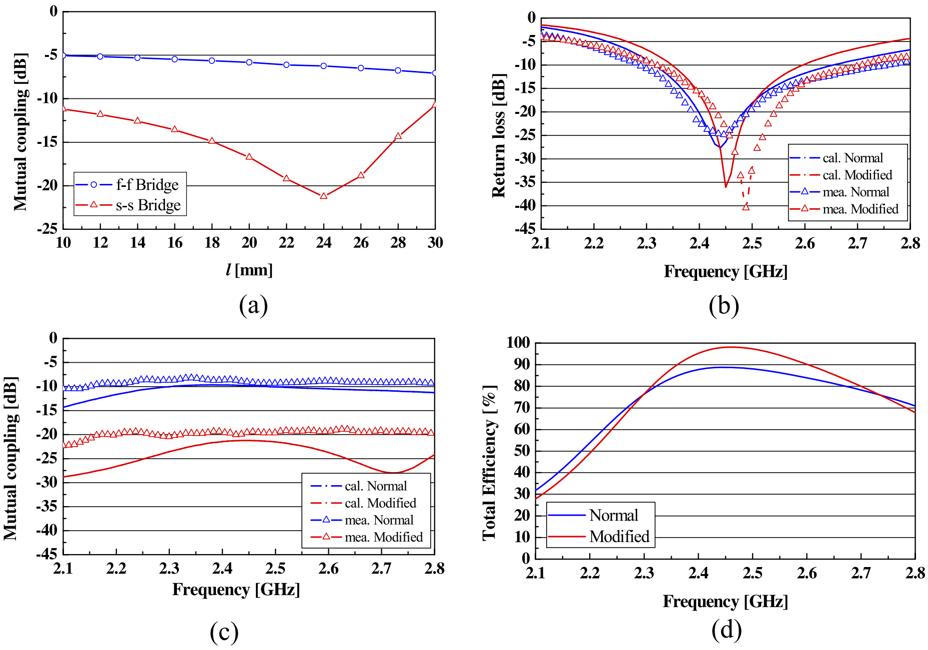

Fig. 2. S-parameters Characteristics and total efficiency. (a) Mutual coupling S21 at 2.45 GHz when length of bridge line l is varied (b) Simulated and measured return loss S11 (c) Simulated and measured mutual coupling S21 (d) Simulated total efficiency

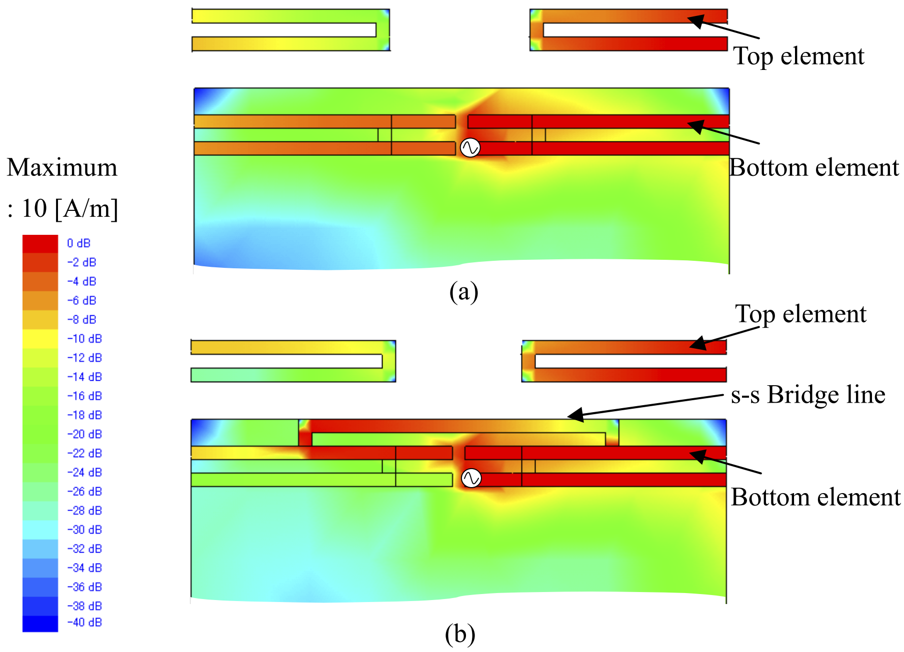

Fig. 3. Average current distributions. (a) Without Bridge line (b) Bridge line between shorting strips

strip of JFMA#2 flows to not the JFMA#2 element side but the bridge line side. And, it becomes small around the link of bridge line and JFMA#1. Therefore, the current distribution of JFMA#1 is equivalent to those of the case the link of bridge line and JFMA#1 is disconnected at the resonance

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frequency. As a result, the current flow on the non exited antenna (JFMA#2) is reduced greatly by using s-s bridge line in comparison with normal JFMA. Therefore, it is considered that the mutual coupling is reduced in the modified antenna (Fig. 3 (b)).

4 Conclusions

In this paper, we proposed J-shaped folded monopole antenna (JFMA) for IEEE 802.11 b/g on handset and analyzed the effective method to reduce the mutual coupling by using a bridge line linking two JFMAs. As the analytical results, by linking the shorting lines of two JFMA elements with a bridge line, we obtained a sufficiently reduced mutual coupling and improved total antenna efficiency. Even when two JFMAs are arranged at narrow interval, the mutual coupling reduction is possible. Therefore, it is also possible to miniaturize the entire volume of the antenna. In addition, it is found that the linking location of the bridge line leads to a different result, although the same type of folded monopole antenna such as JFMA and LFMA is used. It is because the relative position of feeding strip and shorting strip is different between JFMA and LFMA. Finally, by the experiment using a prototype, we confirmed the analytical validity of the calculation.

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