A Printed Multi-Band Antenna for 2.4/5GHz WLAN and Satellite DMB Applications

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1. Introduction

As portable wireless devices become smaller and have required high efficient performance, the antenna volume including the ground substrates should be reduced. And the rapid development of wireless applications has promoted the antenna to be designed as a small ground plane for covering two more different frequency bands. Since the folded dipole arms including the ground plane act as a primary source of radiation, the small size ground strongly influences the antenna performance such as return loss and radiation efficiency [1-4]. In this paper, the proposed antenna covers dual ISM (2400-2483MHz and 5150-5350MHz/5725-5875MHz) and satellite DMB (2535-2655MHz) bands. This novel antenna is the folded printed dipole type antenna with a small ground plane while retaining the similar antenna performances with the conventional PIFA. This folded dipole arms are designed to operate at two resonant modes, 2GHz and 5GHz bands. This proposed antenna has a small volume of $11 \times 36 \times 1$ mm^3, and it is very suitable for WLAN and DMB applications.

2. Antenna Design

The geometry of the proposed antenna is shown in Fig. 1. The geometrical parameters of the length and width of striplines are optimized in an attempt to achieve design goals at both 2GHz/5GHz band. This novel antenna is mounted on the FR-4 substrate with a permittivity value of 4.6. The ground conductor of opposite side in antenna substrate is removed. The antenna is fed by a 50 Ω coaxial cable. As shown in Fig. 1, part A is a feeding point and part F is a ground plane. The outer conductor of coaxial feeding cable is directly connected to part F. And part B, C, D, and E are radiating elements.

In order to have broad bandwidth covering 2GHz band at 2.4GHz ISM band and DMB band, part D and E are induced together from part C. The length from part A (a feeding point) to part D and E is about 30 mm, which approximately corresponds to an electrical quarter wave length at 2 GHz band resonant mode. And the bandwidth is about 500MHz starting from 2300MHz to 2800MHz for VSWR < 2.0. In case of 5GHz band for 5.2/5.8 GHz, the length of part C, D, and E is 12 mm which is the same as an electrical quarter wave length at 5GHz band resonant mode. The total length starting from part A to the end point of part B also has 12 mm corresponding to an electrical quarter wave length at 5GHz. At 5GHz mode, the folded radiating elements (part C, D, and E) change the phase of

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currents, so it leads to 5GHz resonant mode. And the bandwidth is over 3000MHz starting from 4700MHz to 7700MHz for VSWR < 2.0. The stripline width of part B is broader than other parts because it plays a key role to have high radiation efficiency. The small ground plane of part F acts also an important role to radiate 2GHz band as well as 5GHz band.

3. Results

Computed and measured return losses data versus frequency are compared in Fig. 2. In order to optimize the proper parameters, Ansoft HFSS is used. The measurements are performed with Agilent 8722ES Network Analyzer. It shows that the proposed antenna covers 2.4/5GHz ISM band and 2.6GHz DMB band. The experimental results have a good agreement with the simulated results. In order to check the operating mechanism of the proposed antenna, Fig. 3 shows the surface current distributions at the operating frequency. Basically, the radiating mechanism is similar to those of dipole antenna. Through the modification of dipole antenna branch like part D and E, this proposed antenna can achieve the resonance frequency. And asymmetric dipole arms like this proposed antenna lead to the harmonic dual resonant frequency band. As shown in Fig. 3, asymmetric and folded dipole arms change the current phase and distributions, so the proposed antenna resonated at both 2GHz and 5 GHz frequency bands.

The maximum measured radiation gains are 2.91 dBi and 4.46 dBi at 2GHz and 5GHz bands, respectively. Fig. 4 shows the measured radiation gains at each associated frequencies bands. And the simulated and measured radiation patterns for the designed antenna at resonant frequencies of 2.5GHz and 5.5GHz are plotted in Fig. 5 and 6, respectively. The simulated and measured results agree well with each other.

4. Conclusion

A printed and compact multi-band antenna has been proposed and implemented. The proposed antenna indicates not only a broad impedance bandwidth but also a good radiation gain performance in spite of the very small volume with the dimensions, $11 \times 36 \times 1$ mm^3 (FR-4). Moreover, DMB service, which provides high quality and various broadcasting channel services by satellites, is commercialized in 2005. It is expected that the DMB service market is going to be dramatically expanded to a couple of times in a few years. So, this antenna can be very attractive for next generation wireless communication services such as 2.4/5GHz ISM and satellite DMB applications.

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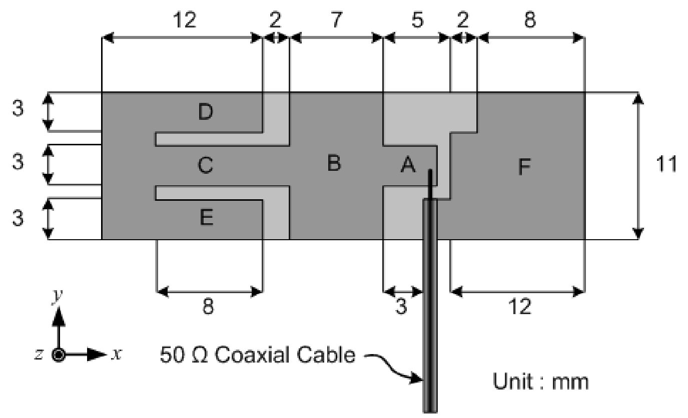


Fig.1 Geometries of the Proposed Antenna

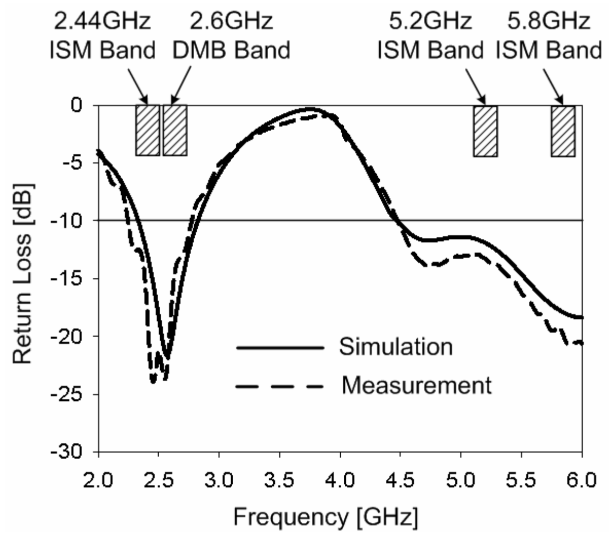
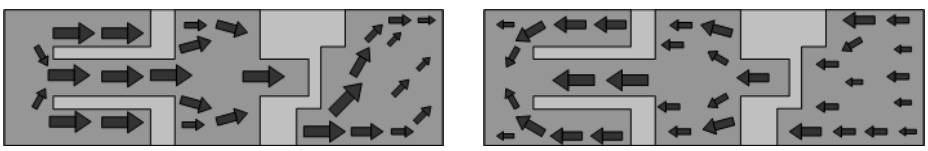
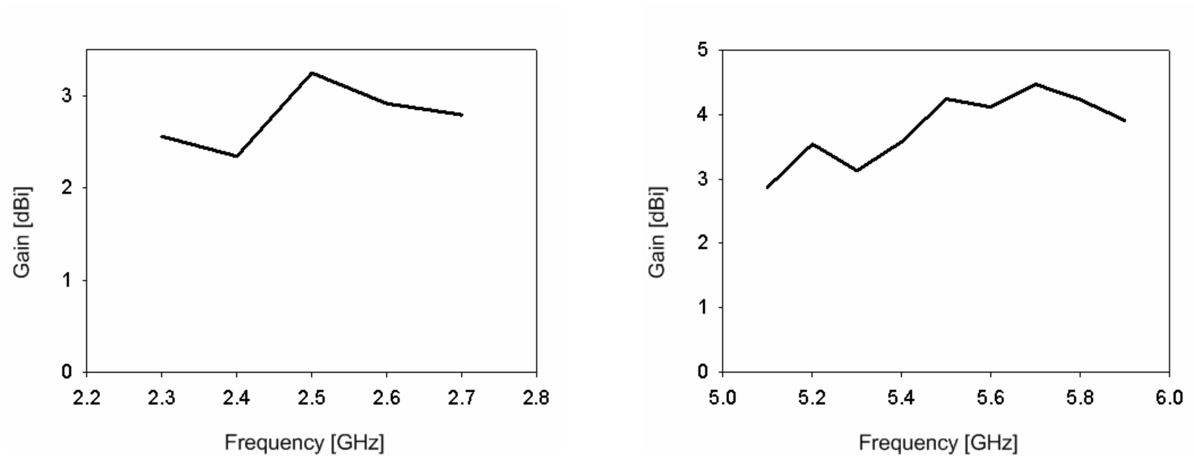


Fig.2 The Measured and Simulated Return Losses of the Proposed Antenna



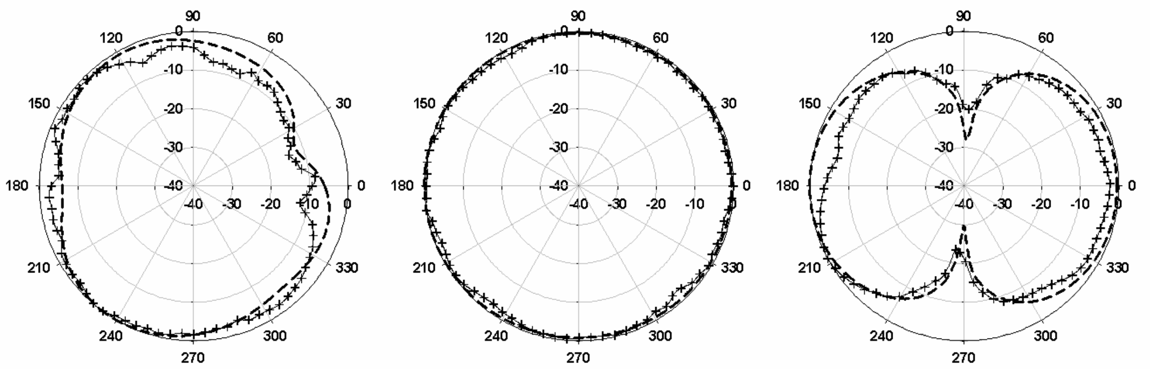
(a) 2.5 GHz (b) 5.5 GHz

Fig.3 The Surface Current Distributions



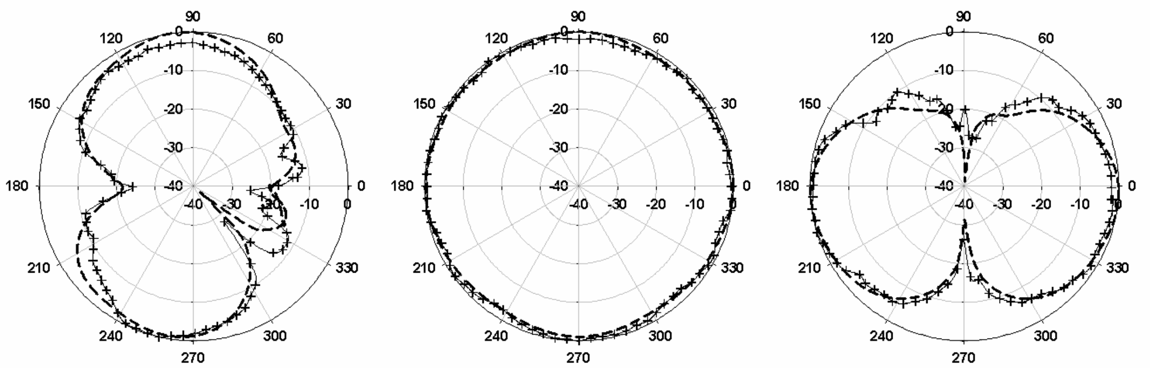
(a) At 2 GHz Band　　　　　　　(b) At 5 GHz Band

Fig.4 The Measured Radiation Gains



(a) xy plane(E_{Φ})　　　(b) yz plane (E_{Φ})　　　(c) zx plane (E_{θ})

Fig. 5 Measured and Simulated Radiation Patterns at 2.5GHz (++++ Measurement, ----- Simulation)



(b) xy plane(E_{Φ})　　　(b) yz plane (E_{Φ})　　　(c) zx plane (E_{θ})

Fig. 6 Measured and Simulated Radiation Patterns at 5.5GHz (++++ Measurement, ----- Simulation)