Design and Analysis of Printed Dipole Slot Antenna for WLAN and RFID Applications

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Abstract

A printed dipole slot antenna for 2.4GHz RFID band and 5.2GHz WLAN band application is designed fabricated on FR4 substrate and measured using Agilent network analyzer. This antenna effectively covers both 2.4GHz and 5.2GHz bands. The return losses of the measured results are in agreement with simulated results, the measured S parameters and radiation pattern showed that the proposed design is suitable for RFID and WLAN frequency regions. The measured return loss (S parameter) of is -14.8 dB at 2.4GHz and simulated return loss is -31.61dB at 5.2GHz which is most suitable for RFID and wireless LAN applications.

Keywords: Printed dipole antenna, WLAN, RFID, substrate, gain, radiation pattern

1.  Introduction

Radio frequency identification (RFID) system is a wireless communication system in which objects can be identified without having any physical contact with it [1]. Due to the rapid growth in the radio frequency technology, very small size RFID antennas are manufactured and these antennas are operating in ultra high frequency
Design of antennas for this wireless communication systems should have low cost, compact design and multiband tuning. Since dipole antennas are low profile and etched on a single substrate, can be used in wireless applications. Multi-branched strips are used to achieve multiband operation but it needs large ground plane [3-4]. The proposed antenna is designed to be operated in the 2.45 GHz (2.4 GHz - 2.484 GHz) for RFID band and 5.25 GHz (5.15 - 5.35 GHz) for WLAN bands.

There are many antenna designs for WLAN systems such as a dual-band dipole antenna operated in WLAN systems [5], or the patch antenna with double L-slits [2]. It is well known that a dipole slot antenna usually operates at the half-wavelength mode. To reduce the size of the antenna, the geometry can be designed to a monopole antenna [3] or designed to an antenna with one or more open-ended slots, which operate at the quarter wavelength mode. The printed dipole slot antenna is easy to fabricate using simple photolithography [5]. A prototype antenna was fabricated and tested. The measured S parameters and radiation patterns are given and discussed. This antenna simultaneously resonates at 2.41 GHz and 5.2 GHz, which operates in the frequency bands for RFID and WLAN systems. It allows us to use a single antenna for dual band resonant frequencies.

2. Antenna Design

The geometry of the dipole antenna with slot is shown in fig.1. The designed dimensions of the proposed antenna are L1 = 17.5 mm, L2 = 9.0 mm, L3 = 11.0 mm, L4 = 18.0 mm, Lg = 8.45 mm, Ws = 2.0 mm, and Wa = 1.0 mm. The slot antenna is fabricated on an FR4 substrate with a thickness of 1.6 mm and a relative permittivity of 4.4.
The proposed antenna has a length $L = 40.0 \text{ mm}$ and width $W = 15.0 \text{ mm}$ only. The dual folded slots are symmetric to the microstrip fed line [6]. The proposed slot antenna is excited by a T-shape microstrip which is connected to a $50\Omega$ standard miniature adapter (SMA). The pictures of the designed proposed antenna fabricated on an FR4 substrate are shown in Fig. 2. This fabricated antenna is more suitable for WLAN and RFID frequency range applications.

3. Result and Discussion

The simulation of the design is carried out by the method of moment’s technique using ADS software [7]. Fig. 3 shows simulated electric current distribution of printed dipole antenna at 2.4 GHz, in which red color indicates the maximum electric current density distribution of an antenna. Fig. 4 shows the simulated return losses of the dipole slot antenna.
The first simulated resonance frequency (f1) occurs at 2.41 GHz at the return loss value of -8.85 dB. The second simulated resonance frequency (f2) occurs at 5.2 GHz at the return loss value of -32.96 dB. The return loss is measured by Agilent 100MHz - 3.5GHz network analyzer. The measured return loss of the dipole antenna is shown in fig.5. It shows -16.11dB return loss at 2.4 GHz frequency which can be used for RFID application and -26dB loss at 5.25GHz for WLAN application.
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Fig. 7 Simulated circularly polarized H plane and E plane electric field pattern at 2.4GHz

Fig. 8 Simulated E plane co-polarized, cross-polarized radiation pattern at 2.4GHz and 5.2GHz

Fig. 9 Absolute electric field components of dual band dipole antenna

Fig. 10 Efficiency of dual band dipole slot antenna
The simulated radiation pattern and directivity of dipole at 2.4GHz is shown in fig.6. This radiation pattern is similar to that of a conventional half-wavelength dipole antenna which has a figure eight radiation pattern in the H-plane and directivity at 2.4 GHz is 2.32 dBi, which is the required gain characteristic for WLAN frequency spectrum. Fig. 7 shows simulated H plane and E plane circularly polarized pattern at 2.4GHz. This pattern shape is purely omni-directional and its level is around -12 dB. The normalized co-polarized, cross-polarized E-plane radiation pattern of the proposed antenna at 2.4 GHz and 5.2GHz is shown in Fig. 8. It can be observed that the E-plane co-polar radiation pattern is in the shape of figure eight and cross-polar radiation pattern is -10dB at 2.4 GHz.

Polarization describes the direction of the electric field. All electromagnetic waves propagating in free space have electric and magnetic fields perpendicular to the direction of propagation. When considering polarization, the electric field vector is usually described and the magnetic field is ignored because it is perpendicular and proportional to the electric field. To obtain optimum performance, the receiving and transmitting antenna should have the same polarization. In practice, most antennas in short-range applications will produce a field with polarization in more than one direction. Reflections change the polarization of an electromagnetic wave. Since indoor equipment experiences a lot of reflections, polarization is not as critical as it is with equipment operating outside with line-of-sight limitations. An absolute electric field component of an antenna is shown in Fig.9. Here $E_\theta$ and $E_\phi$ field components are mutual perpendicular to each other and produces the figure eight pattern. The simulated efficiency of an antenna is shown in fig.10.

4. Summary and Concluding Remarks

A dual band dipole slot antenna is designed, fabricated and tested for WLAN and RFID applications. The measured and simulated results of return loss proved that this proposed antennas can be applied to 2.4 GHz and 5.2GHz wireless systems. It affords consistent radiation pattern and appropriate gain characteristics in the WLAN and RFID frequency bands. The peak antenna gain at 2.4 GHz is 2.32 dBi and at 5.2 GHz is 2.45 dBi. Hence this proposed antenna might be suitable for WLAN and RFID applications.

References


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