A Slot Loop Antenna with a pair of patches for Dual-Band Operation

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Abstract:

This article presents a new printed slot loop antenna with a pair of patches for wireless communication systems in 2.4 GHz (2.4 – 2.484 GHz) and 5 GHz (5.15 – 5.95 GHz) bands. With the use of a pair of the patches inset at the center of the slot loop antenna, the obtained impedance bandwidths for two main operating bands can reach about 100 MHz bandwidth for the 2.4 GHz band and 1550 MHz bandwidth for the 5 GHz band, which cover the required operations of the IEEE 802.11a/b/g. Several properties of the proposed antenna design results such as impedance bandwidth, radiation pattern and measured gain have been confirmed experimental in detail.

1. Introduction

Designing components of the wireless communication system have been developed exponentially over the last year because they display low profile, lightweight, low manufacturing cost, and easy integrating circuit boards. Several interesting antenna designs with diverse geometric configurations for wireless local area network (WLAN) band have been widely studied, such as a monopole antenna, a dipole antenna, an inverted-F antenna, and a slot antenna etc. The slot loop antennas for the wireless communication applications have been published, owing to their dual-band and low profile characteristics [1]-[6]. However, the slot loop antenna is used the multi-way on the metal to improve multi-band applications. The slot loop antenna type based on slot configuration and the loop design has been developed to obtain satisfied operation bandwidth over the required bands. In this paper, we proposed a slot loop antenna with a pair of patches and obtained to meet the impedance bandwidth requirements of WLAN application. To verify the validation of the proposed antenna, the simulated and measured return losses against frequency are presented. Also, measured radiation patterns and gains of over 2.4 and 5 GHz operations are shown and discussed.

2. Antenna Design

The configuration of the slot loop antenna has a single layer metallic structure is shown in Fig. 1. The dimensions of the antenna were firstly studied by Ansoft HFSS simulation electromagnetic software, and then verified by experiment. The radiator structures are composed of the loop antenna by slot for dual-band operation and a pair of dipole-shaped patches for the higher band operation and the operating impedance matching. The feed has a 50Ω coaxial line structure is applied to interface the antenna to the test equipment. The proposed antenna is printed on the FR4 substrate with thickness of 1.6mm, relative permittivity of 4.3 and loss tangent of 0.0245 and has dimensions of 80 mm × 15 mm. The optimum dimensions of the proposed antenna are L_1 = 47.5 mm, L_2 = 43 mm, L_3 = 6.5 mm, L_4 = 20.2 mm, L_5 = 14 mm, L_6 = 2.8 mm, W_1 = 1 mm, W_2 = 1.5 mm, W_3 = 5.5 mm, W_4 = 9.5 mm, W_5 = 1 mm, and W_6 = 1 mm.

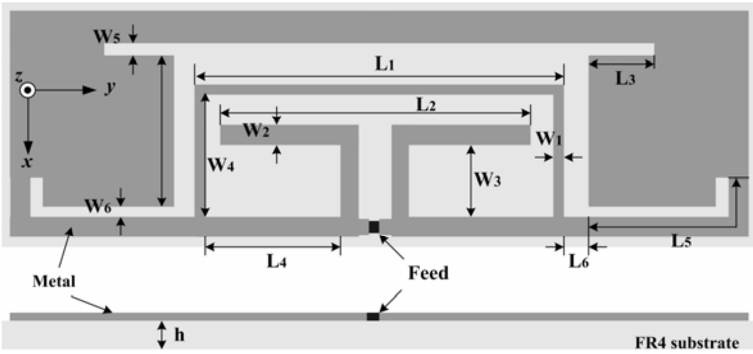


Figure 1: The configuration of the proposed antenna

3. Results and Discussions

The effects of design parameter have been shown in the simulation that the impedance matching and the operating resonance modes of the proposed antenna with a pair of patches is critically dependent on the slot length at the radiator metal plane (L_5) and the length of the patches (L_2). So these parameters could be optimized for the multi-band WLAN applications.

Fig. 2 shows the simulated return loss curves with different length of the slot at metal plane (L_5) when other parameters are fixed. We could design slot and modify the length of slot of the proposed antenna, and get multi-resonance modes of return loss. Fig. 2 shows the simulated return loss curves for different slot length of the proposed antenna with their respective optimal designs. It is observed from Fig. 2 that the first resonant frequency is markedly increased with the decrease of the slot length of proposed antenna. However, the middle resonant frequency goes downward move when slot length decreases at the same time. The optimized length of the slot is found to be at L_5= 14 mm.

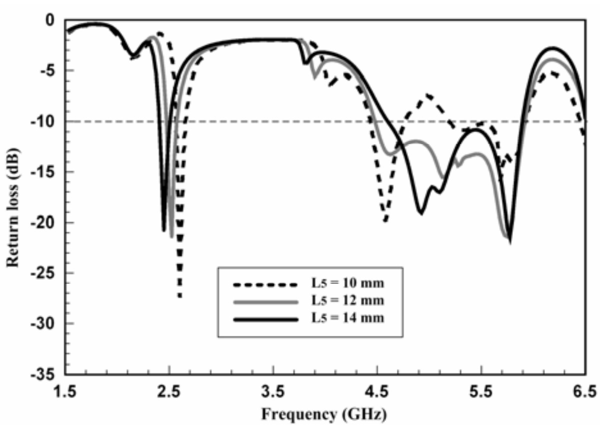
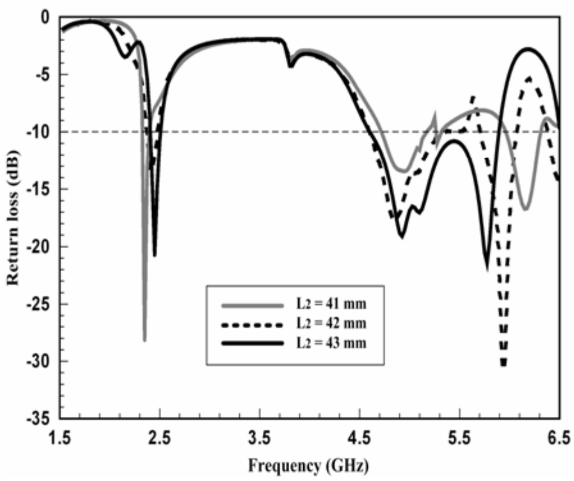


Figure 2: The simulated return loss curves with different slot length (L_5) of proposed antenna

We studied to modify dimension of the length of patches radiator and obtained the results in Fig. 3. Other parameters are fixed at the optimized state. If the antenna has completed the length of a pair of the patches, the performance of impedance bandwidth will be broadband situation in upper band. By decreasing the length of a pair of patches, the lower band operation downward moves. The effect of the length of the patches influences all operation. The impedance bandwidth of the antenna changes significantly with the variation of L_2.

Fig. 4 shows the simulated and the measured return loss curves of proposed antenna with/without a pair of patches. The measured return loss curves aggress well with the simulated one in most of the frequency band range except in 2.4 and 5 GHz. It is shown that the different resonance occurs at 2.45 GHz, 4.8 GHz and 5.8 GHz in the simulation; this resonance also appears in the measurement, but it is not apparent, this could be due to the effect of the SMA port. The measured impedance bandwidth has 100 MHz from 2.4 to 2.5 GHz operation in lower band and 1550 MHz from 4.35 to 5.9 GHz operation in upper band. Moreover, compared to the with and the without a pair of patches, the impedance matching of the newly proposed antenna can be obtained, which is desirable since the impedance bandwidth covers 2.4 and 5 GHz WLAN operation. The measurements of return loss and radiation performances are obtained with the 8720C Network Analyzer.



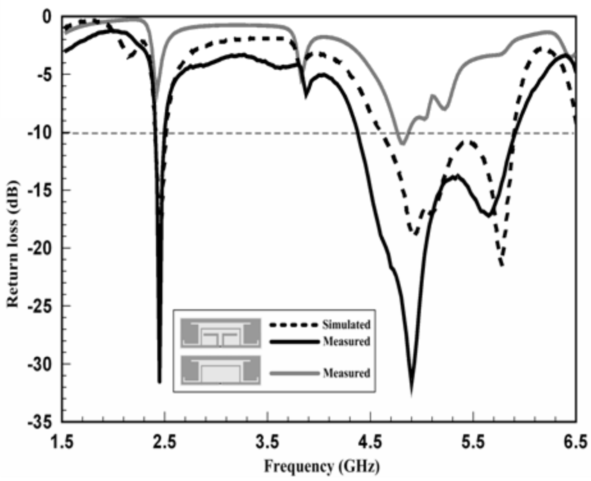


Figure 3: The simulated return loss curves with curves different stub length (L2) of proposed antenna

Figure 4: Simulated and measured return loss

Figs. 5 and 6 show the measured far-field radiation patterns at two purpose frequencies of 2.45 and 5.2 GHz for slot loop antenna with a pair of patches. It is shown that three planes of this proposed antenna. The experiment results show the patterns in horizontal plane have closed omni-directional for 2.45 and 5.2 GHz. Besides, the radiation patterns of vertical plane are similar to dipole in lower band. It can also be seen that the peak gain is above 2.8 dBi from 2.4 to 2.5 GHz in the lower frequency range. When the frequency increases from 4.3 to 5.9 GHz, the peak gain is higher than 3.7 dBi, other frequencies does not change much and fixed at around 4.5 dBi.

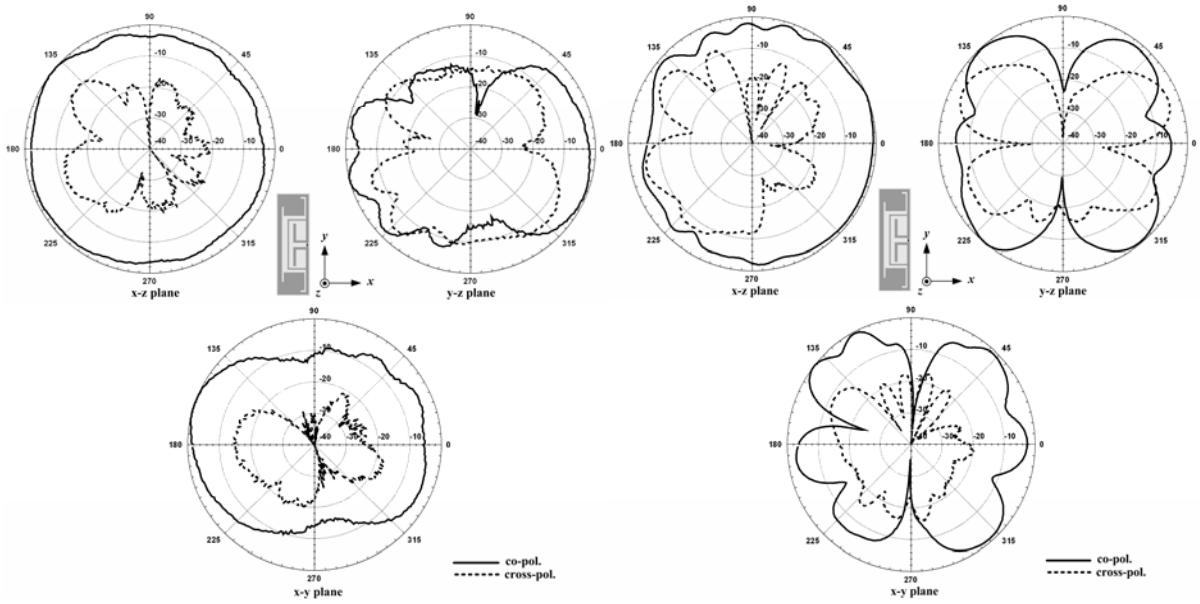


Figure 5: Measured radiation patterns of the proposed antenna at 2.45 GHz

Figure 6: Measured radiation patterns of the proposed antenna at 5.2 GHz

4. Conclusion

The new printed slot loop antenna with a pair of patches for the WLAN wireless communication systems is successful demonstrated. In the proposed antenna, using slot structure and a pair of patches has accepted impedance bandwidth and impedance matching, which covers 2.4 and 5 GHz bands for WLAN operation. Measured results of the proposed antenna exhibit fairly good omni-directional patterns at x-z plane for the main operating band. The measured results of the designed antenna exhibit fairly good agreements with these simulated ones. It shows good performances for 2.4 and 5 GHz WLAN applications.

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