

Dual Band MIMO Antenna Using a Decoupling Network for WLAN Application

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Abstract— A dual band MIMO antenna using a decoupling network for WLAN application is proposed. The proposed MIMO antenna consists of two planar inverted F antennas and a decoupling network. In order to improve the isolation characteristic between the two radiating elements, a decoupling network was added at the feeding line of each antenna element. The proposed MIMO antenna has the isolation of about 20 dB at the lower band and over 18 dB at the upper band. It is observed that the antenna can cover 2.4/5.2 GHz WLAN operation, simultaneously. Design considerations and experimental results of the dual band MIMO antenna using a decoupling network are presented.

Keywords— Multiple-input multiple-output antenna, Decoupling Network, planar inverted-F antennas, Isolation, WLAN

I. INTRODUCTION

Future wireless communication system requires high data rates to accommodate various multimedia services. Multiple input multiple output (MIMO) system has been regarded as one of practical approaches to fulfill such requirements by increasing channel capacity and improving the reliability [1]-[2]. To implement a MIMO antenna system, two or more antenna elements are required. However, the available space for an antenna in a recent wireless device is limited, so it is very challenging to an antenna designer to decouple closely-packed multi-antenna elements while maintaining high isolation characteristic between antenna elements [3]-[4]. In order to improve the isolation performance between antenna elements within a wireless terminal, many researchers have been trying to find new techniques. In [5], to reduce the mutual coupling, the folded resonator is placed above the antenna. However, since the antenna requires a large space it can hardly be integrated into wireless devices such as PDAs or mobile phones. In [6], a suspended microstrip line is connecting the feeding strip of two PIFAs to improve the isolation between the two ports. Although several techniques have been reported for high isolation characteristics, it is still quite difficult for antennas to obtain the good isolation at dual band when two antennas are very closely placed.

In this paper, a dual band MIMO antenna using a decoupling network for WLAN application is proposed. The

antenna can cover 2.4/5.2 GHz WLAN operations, simultaneously. The designed dual band MIMO antenna has been successfully implemented and experimental results are presented and discussed.

II. MIMO Antenna Design

Figure 1 shows the configuration of the proposed MIMO antenna using a decoupling network for WLAN application. The proposed MIMO antenna consists of two planar inverted F antennas and a decoupling network. The overall size of the proposed MIMO antenna is 40 mm × 5 mm. The antenna was printed on the FR4 substrate with a volume of 40 mm × 80 mm × 1 mm and relative permittivity of 4.4. Two symmetry antennas are placed at the corner of the top edge of the system ground.

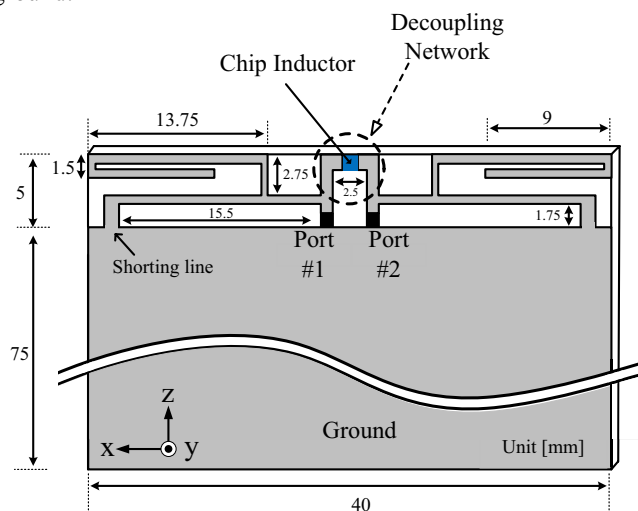


Figure 1. Configuration of the proposed MIMO antenna

The 50 Ω feed lines are used to excite the two radiators. The first resonant frequency is determined by the total length (about 30 mm) of the planar inverted F antennas, which is about quarter wavelengths of the operating frequency at 2.4 GHz. In addition, a second order resonant mode at about 5 GHz is generated to cover the 5.2GHz WLAN band.

Figure 2 shows the S-parameter characteristics with and without a decoupling network. The proposed antenna was

designed and analyzed by using the Ansys's high frequency structure simulator (HFSS V12.1.0) [7]. In order to improve the isolation as well as to enhance the impedance matching characteristic for the desired dual frequency band, a decoupling network was added at the feeding line of each antenna element. When a decoupling network is added, the band width at lower resonance frequency is widened and lower band isolation characteristic is increased up to 28dB. Isolation characteristic at the upper band is also improved.

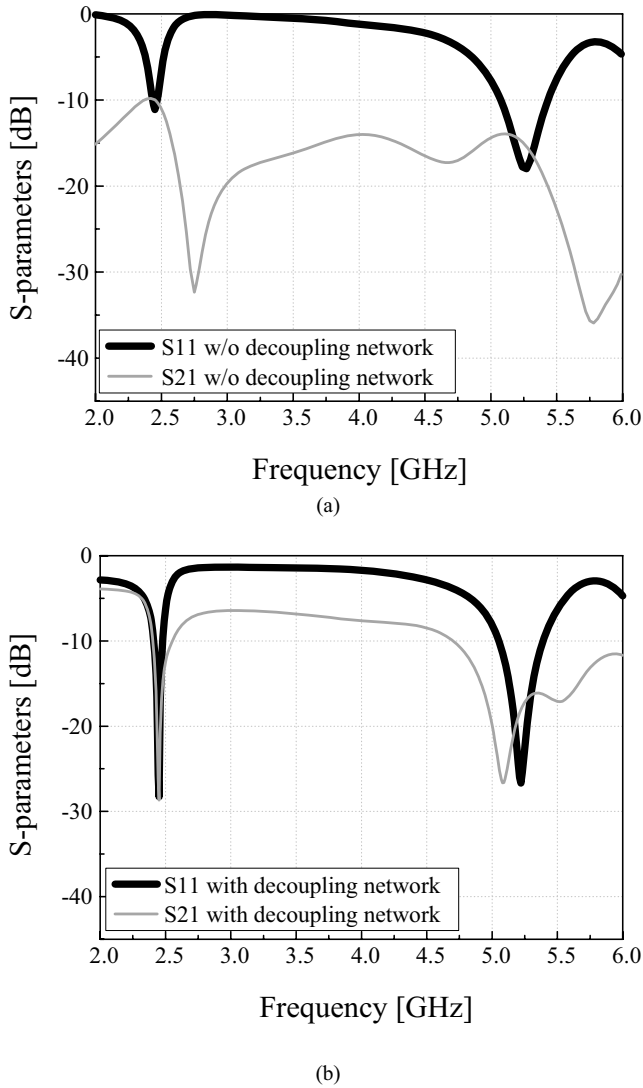


Figure 2. Simulated S-parameter characteristics with and without a decoupling network
(a) without decoupling network, (b) with decoupling network

Figure 3 shows the simulated isolation characteristic of the proposed antenna for various values of chip inductor and without chip inductor. The result indicates that the resonance frequencies for both lower and upper bands are lowered as L increases. The optimized chip inductor value is chosen as 2.7nH.

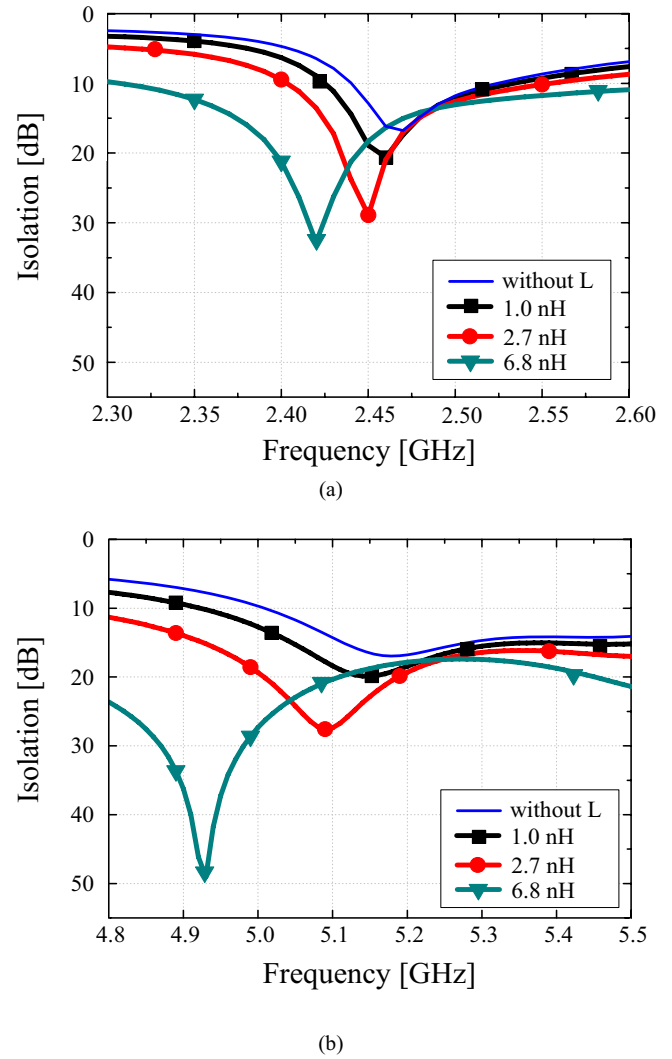


Figure 3. Simulated isolation characteristic of the proposed antenna for various values of chip inductor
(a) 2.4 GHz band, (b) 5.2 GHz band

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

Figure 4 shows the measured S-parameter characteristics of the proposed MIMO antenna. Results show that the proposed antenna simultaneously satisfied the -10 dB s-parameter requirement from 2.4 GHz to 2.5 GHz and from 5.05 GHz to 5.4 GHz. The measured isolation characteristics are about 20 dB at the lower band and over 18 dB at the upper band. Figure 5 shows the measured 3D radiation patterns of the fabricated MIMO antenna at 2.44 GHz and 5.25 GHz, respectively. Figure 6 shows the measured antenna gain against frequency. The antenna gain is varying from about 1.94 to 5.34 dBi at the desired frequency band.

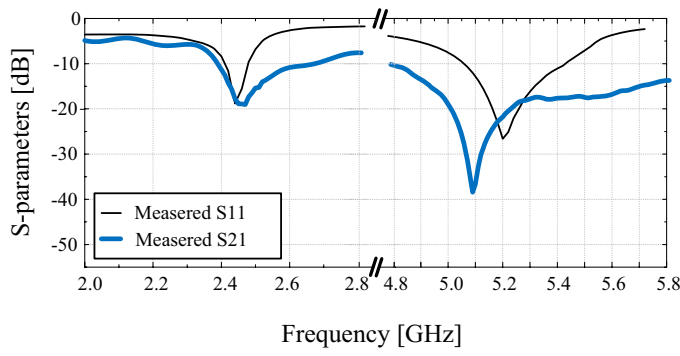


Figure 4. Measured S-parameter characteristics of proposed MIMO antenna

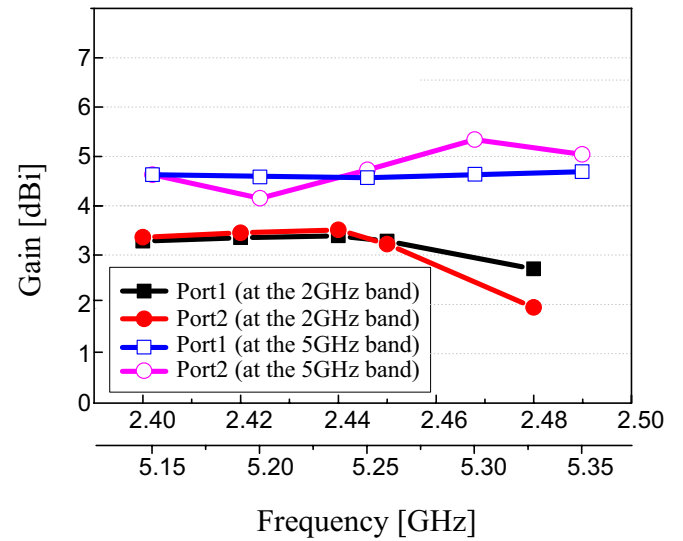


Figure 6. Measured antenna gain characteristics

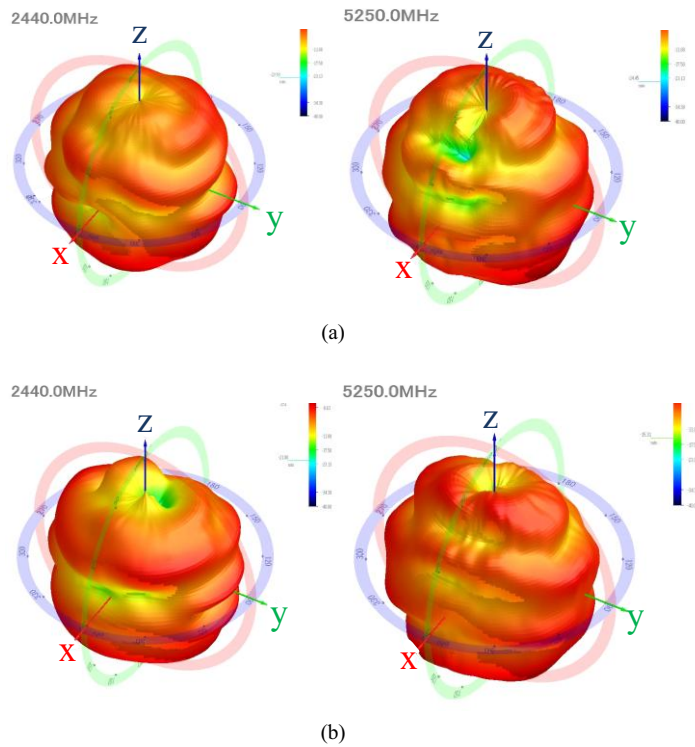


Figure 5. Measured 3D radiation patterns of the fabricated MIMO antenna: (a) Antenna #1, (b) antenna #2

The measured peak gains of antenna #1 are 3.39 dBi at 2.4 GHz and 4.73 dBi at 5.2 GHz WLAN bands. Those of antenna #2 are 3.51 dBi and 4.57 dBi, respectively. The maximum gain variation is about 0.7 dB over the lower frequency band and 0.35 dB over the upper frequency band, respectively.

Generally, the envelope correlation coefficient (ECC) is used to evaluate the diversity capability of a multi-antenna system. Under the assumption that the MIMO system operates in an uniform multipath environment, the envelope correlation coefficient (ECC) of two antennas is given by [8]

$$\rho_{12} = \frac{|S_{11}^* S_{12} + S_{12}^* S_{22}|^2}{(1 - |S_{11}|^2 - |S_{21}|^2)(1 - |S_{22}|^2 - |S_{12}|^2)} \quad (1)$$

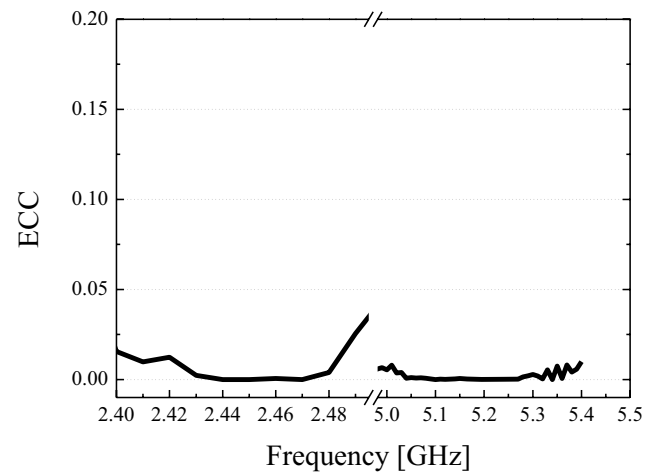


Figure 7. Envelope correlation coefficient characteristics

The ECCs of the proposed antenna using equation (1) are illustrated in Figure 7. They are maintained below 0.05 over the frequency bands of interest.

IV. CONCLUSIONS

A dual band MIMO antenna using a decoupling network for 2.4 GHz and 5.2 GHz WLAN application is proposed. The proposed MIMO antenna consists of two planar inverted F antennas and a decoupling network. The MIMO antenna has the isolation of about 20 dB at the lower band and over 18 dB at the upper band. Furthermore, the ECC of the two antennas is maintained below 0.05 over the entire frequency bands of interest. The proposed antenna can be a good candidate for future wireless applications such as a mobile phone, laptop, etc.

ACKNOWLEDGMENT

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