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A Closely-Packed MIMO Antenna for USB Dongle Application at WLAN Band

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1. Introduction

A MIMO(Multiple Input Multiple Output) antenna system is a technique to improve the performance of wireless communication systems. In order to design a MIMO antenna system for USB(Universal Serial BUS) dongle application , two or more antenna elements are required to dispose within a small space. Due to the sophisticated and small structure of a USB dongle, the space allowed for antenna is extremely limited.

So far, many researchers have been trying to find new techniques for isolation improvement between antenna elements. Mushroom-like EBG structures can suppress the surface wave between antenna elements so that the mutual coupling between antenna elements is reduced[1]. However, mushroom-like structure occupies a huge area. A compact integrated diversity antenna with two feed ports has been introduced[2]. However, the antenna element is too large to be used for USB dongle application. In [3], the mutual coupling is reduced by etching multiple slots on the ground plane to realize a LC band-stop filter. However, such antenna design cannot be utilized for a USB dongle with other electronic units, meanwhile a large ground plane size is needed for sufficient isolation. In [4], the method using lumped circuit networks on the input ports is proposed to decouple two closely spaced PIFAs. However, this technique requires implementations of several capacitors, inductors and significantly increases the cost and complexities. In [5], an additional folded resonator with electrical length of about half a guided wavelength is placed above the two PIFAs, but the return loss achieved is only 12 dB at the desired band. In [6], a metamaterial directional coupler is introduced to improve the isolation. However, the bandwidth is very narrow.

In this paper, a compact MIMO antenna for USB dongle application at WLAN band is proposed. The proposed MIMO antenna consists of two identical meander line antennas connected through a common metallic strip. To improve the isolation performance, suspended lines were inserted between the two antenna elements. The suspended line acts as a band stop filter and provides a good isolation between the two ports despite of very close distance. The measured isolation characteristics between the two antenna elements is higher than 18 dB.

2. Antenna design

The structure of the proposed MIMO antenna is depicted in Fig.1 The MIMO antenna is printed on 1.6 mm FR4 substrate (ε_r =4.4) with the total size of 60 mm $\times$ 15 mm and antenna size of 12 mm $\times$ 15 mm. The proposed MIMO antenna is composed of two identical meander line antennas together through a common metallic strip. Each of antenna elements has the size of 6.2 mm $\times$ 12 mm. The distance between the two antenna elements is 2.6 mm. The suspended line connects the two antenna elements and has the distance (D) of 4.75 mm away from the feed points. The metallic strip not only operates as a common part of the two antenna elements but also contributes as an additional path for the coupling current between them. Placement of a slot having the size of 1 mm $\times$ 9.5 mm within each antenna element can control the impedance matching and isolation characteristics and. Fig. 2 shows the simulated isolation characteristics for various values of distance D. Fig. 3 shows the simulated return loss characteristics for various values of length L.

3. Results and Discussion

Fig. 4 shows the simulated S-parameter characteristics for the proposed antenna with and without suspended line. Without suspended line, the MIMO antenna has the isolation of about 12 dB at WLAN band. When a suspended line is added, the simulated isolation at WLAN band is increased up to 30 dB. Meanwhile, the return loss at the resonance frequency is significantly improved from 11 dB to 20 dB. Fig. 5 shows the measured S-parameter characteristics of proposed antenna. The measured maximum isolation is almost 20 dB and 10 dB return loss bandwidth is wide enough to cover the whole WLAN band. Fig. 6 shows the measured radiation patterns of the fabricated MIMO antenna at 2.44 GHz. The radiation pattern of each antenna element in X-Z plane is very similar while the radiation pattern of each antenna element in Y-Z plane shows opposite direction. Fig.7 shows the measured peak gains and radiation efficiencies of each antenna element. The measured peak gain and radiation efficiency of antenna #1 at 2.45 GHz are 0.35 dBi and 38 %, respectively. The measured peak gain and radiation efficiency of antenna #2 at 2.45 GHz are 0.54 dBi and 44.6 %, respectively. The measured ECC and diversity gain around the center frequency are shown in Table 1. The measured ECC results reveal that good far-field decoupling is achieved by the proposed MIMO antenna.

4. Conclusion

In this paper, a MIMO antenna for USB dongle application operating at WLAN band is proposed. The proposed MIMO antenna consists of two identical meander line antennas connected through a common metallic strip. To obtain the high isolation characteristics, a suspended strip is added and works as a new path for the coupling current between the two antenna elements. The S-parameter characteristics and radiation patterns are examined and they show reasonable agreements with the simulated results. In addition, the measured low ECC values prove that it works well with low coupling in the far-field.

Acknowledgments

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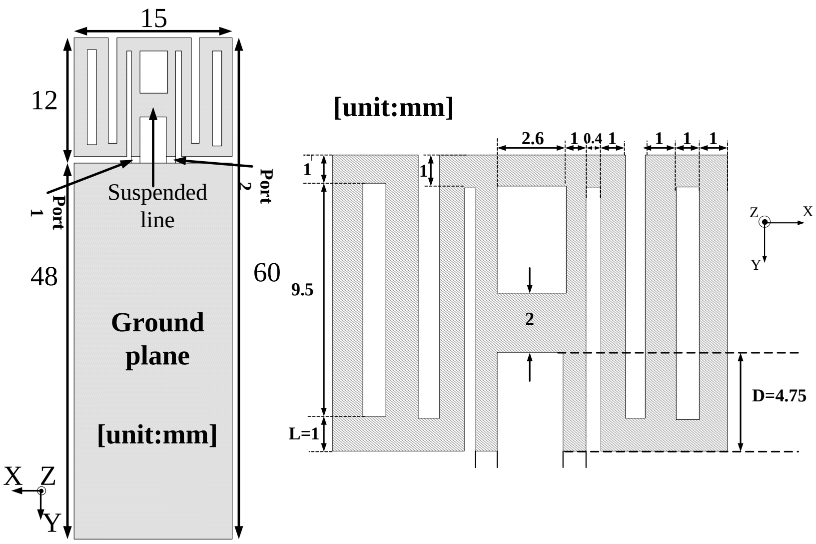


(a) (b)

Fig.1 Geometry of the proposed MIMO antenna. (a) configuration of the whole antenna, (b) structure of radiating elements.

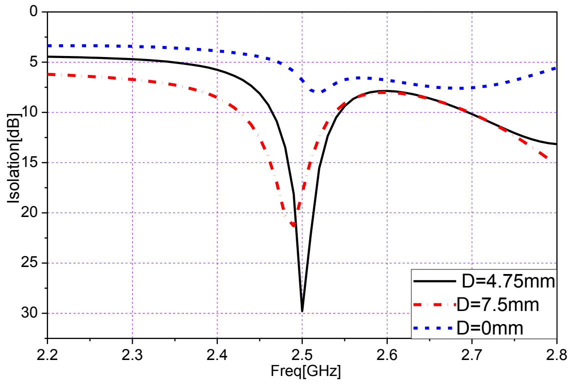


Fig. 2 The simulated isolation characteristics for various distances D

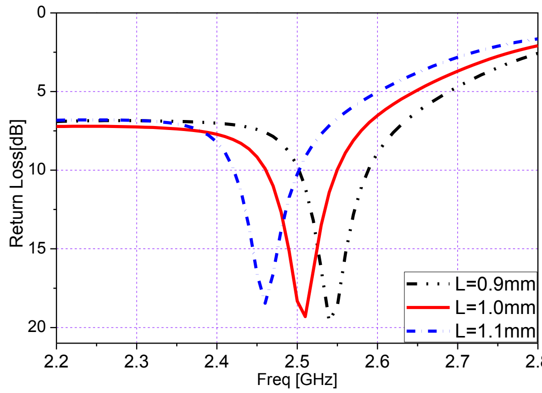


Fig.3 The simulated return loss characteristics for various lengthes L

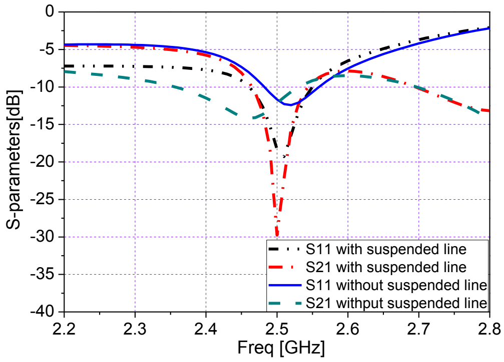


Fig. 4 Simulated S-parameter characteristics with and without a suspended line

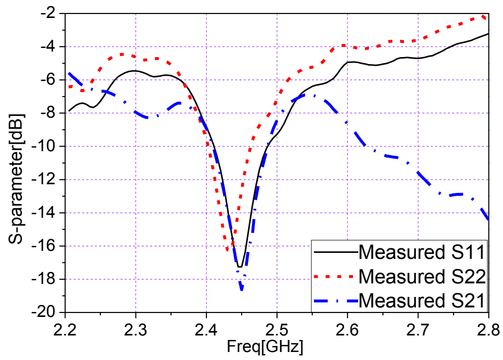
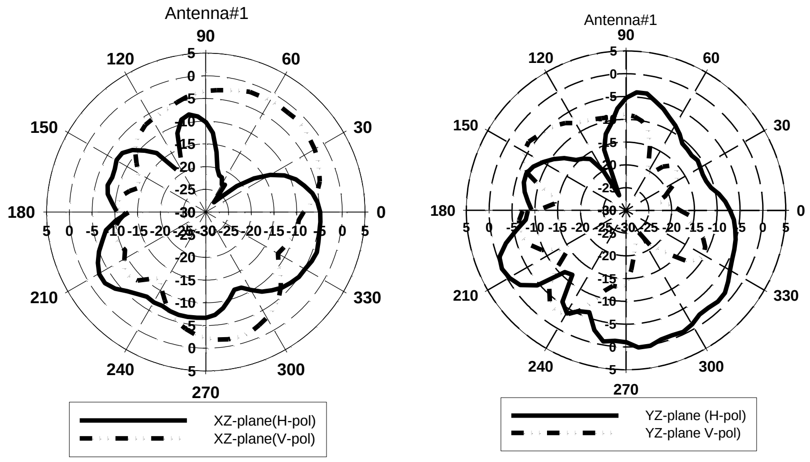
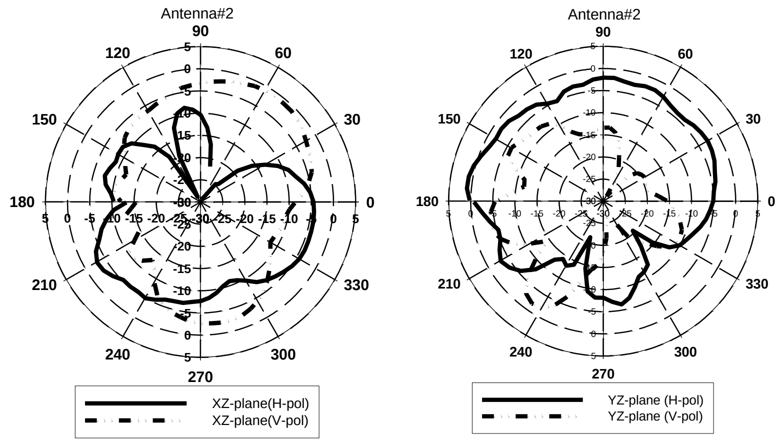


Fig. 5 Measured S-parameter characteristics of the proposed MIMO antenna



(a)



(b)

Fig. 6 Measured radiation patterns at 2.44 GHz. (a)antenna#1, (b)antenna#2.

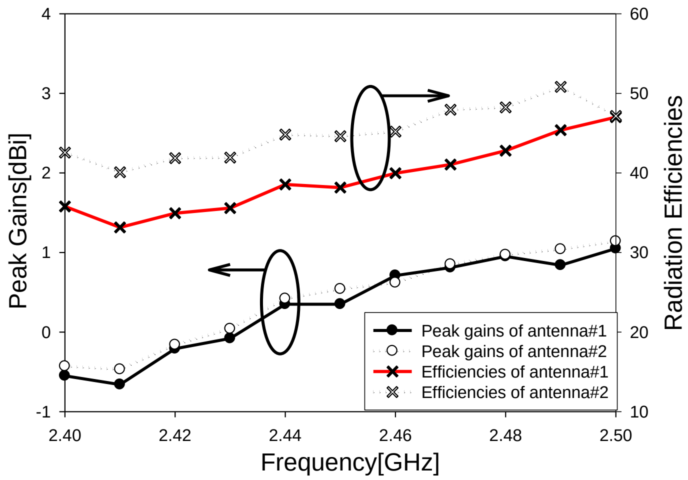


Fig. 7 Measured peak gains and radiation efficiencies of antennas

Table 1:Measured Far-Field Performance

Frequency [MHz]	ECC	Actual Diversity Gain [dB]
2430	0.01512	2.51
2440	0.01085	3.48
2450	0.05966	3.78
2460	0.03711	3.97