High Gain Directional Hybrid Dipole Antenna Array

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Abstract – In this paper, we propose the high gain directional hybrid antenna array for point-to-point WLAN application. This antenna is designed by using combo of 1.25-λ dipole and folded dipole in parallel. The reactance of antennas (1.25-λ dipole and folded dipole) are complementary and obtains good impedance matching in ISM 2.45-GHz band. BTW, the operating band of folded dipole is a little higher than 1.25-λ dipole. This design method can achieve better antenna gain and efficiency compare with general antenna design. For the purpose to enhance the antenna gain, we apply the skill of 1 × 2 array and add reflector behind the radiators. Details of the antenna design and the experimental results are presented.

Index Terms — Antenna array, Directional antenna. 1.25-λ dipole, folded dipole

I. Introduction

High Gain and directional pattern antenna has been extensively used in long distance transmission for point-to-point wireless system application. In high gain antenna array design, the 0.5-λ length of antenna radiator is usually used, such as dipole antenna or patch antenna [1, 2]. And the spacing of array is 0.8λ [3] to obtain high gain performance. Therefore, the more transmission line loss and poor space usage efficiency will be designed issues.

This paper proposes hybrid dipole array design. The radiator length of dipole and folded dipole are 1.25λ and 1λ, respectively. The antenna array is operated in ISM 2.4-GHz band and printed on two side of FR4 substrate (permittivity = 4.4, loss tangent = 0.02). For the purpose to achieve the performance of high directivity (1.25-λ dipole) and high efficiency (folded dipole) at the same time. We combine both antenna (1.25-λ dipole and folded dipole) in parallel and obtain complementary reactance, high directivity, high efficiency antenna array design.

II. Proposed Antenna Design

The structure of proposed antenna is shown in Fig.1. This is 1 × 2 antenna array design. The antenna array is printed on FR4 substrate. The reflector is added behind the antenna array and the radiation power could be reflected to certain direction and enhanced the antenna directivity. And the distance of antenna and reflector is 10 mm (~0.08λ). It's less than the traditional design (~0.25λ). The array element is designed by combo of 1.25-λ dipole and folded dipole. For the purpose to achieve high directivity and high efficiency performances of antenna, the 1.25-λ dipole is main radiator and the functions of folded dipole are radiator and feed (excite the 1.25-λ dipole mode). The length of folded dipole is close and less than one wavelength. The operating band is a little higher than ISM 2.4-GHz band. It's because we want to keep the high directivity characteristic of 1.25-λ dipole and generate a capacitance effect to compensate the inductance of 1.25-λ dipole. The spacing of array is 36 mm (~0.3λ). The other features of this antenna design describes as below. It includes one dipole antenna that the radiator length is 1.25 wavelength (item A) and one folded dipole antenna (item B) in parallel. The item A and item B combine to one hybrid antenna used as one array element. Two hybrid antenna elements are connected by the parallel transmission line (item C). The descriptions and dimensions of this antenna design are shown as table 1.

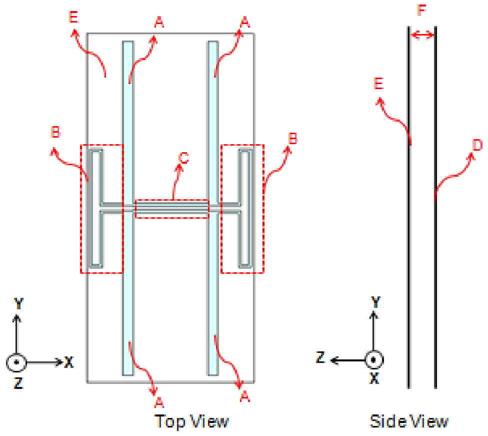


Fig.1. Structure of proposed antenna.

Item	Description	Dimension L × W × T (mm)
A	Radiator length	62 × 4
B	folded dipole antenna	110 × 1
C	parallel transmission line	29 × 13
D	Reflector	136 × 65 × 1
E	PCB substrate (FR4)	136 × 65 × 0.6
F	Gap between FR4 and reflector	10

Table.1 High gain antenna parameters

There is high directivity radiation pattern, if the radiator length of dipole antenna is 1.25λ. However, the input impedance isn't 50 ohm in this condition. The relation of input impedance and radiator length of dipole (include reflector) is shown in Fig.2. We could find that the reactance of 1.25λ dipole antenna is capacitive and the value of reactance is around 100 ohm. It is difficult to have good impedance matching for 1.25-λ dipole antenna design.

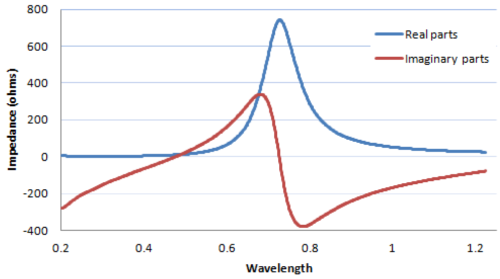
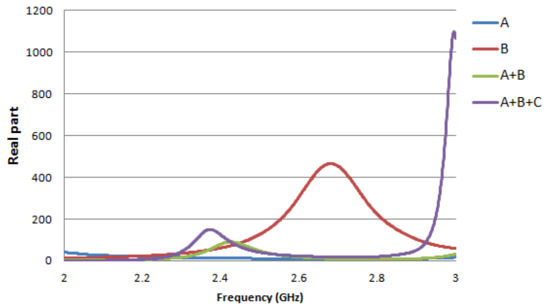
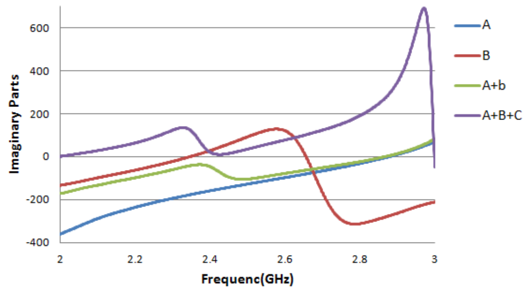


Fig.2 Input impedance versus radiator length of dipole antenna

In order to keep high directivity radiation pattern of 1.25-λ dipole antenna, we add a folded dipole antenna in parallel. The main reason we selected folded dipole to be 1.25-λ dipole's feed is inductive reactance of folded dipole in 2.4-GHz band. And it can compensate the capacitive reactance of 1.25 wavelength dipole antenna. All impedance curves of this antenna are shown in Fig.3.



(a)



(b)

Fig.3. Input impedance of dipole antenna (a) resistance (b) reactance.

III. Result and Discussion

The Return loss of proposed antenna is shown as Fig.4. In ISM 2.4-GHz band, the result of return loss is meet general specification which is larger than 10dB.

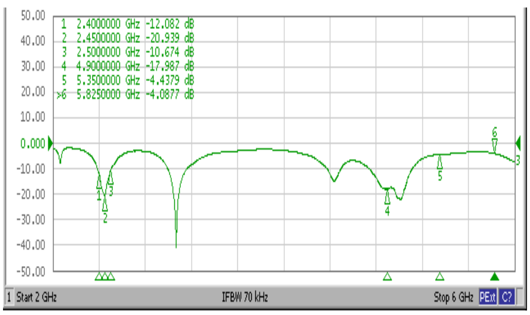


Fig.4. Return loss of proposed antenna

The radiation pattern of this antenna design is broadside. The antenna efficiency and gain are 65% and 10 dBi in 2.4-GHz band, respectively. In addition, the 3-dB beamwidth of E-plane and H-plane are 50 degree and 64 degree. The radiation patterns are shown in Fig.5.

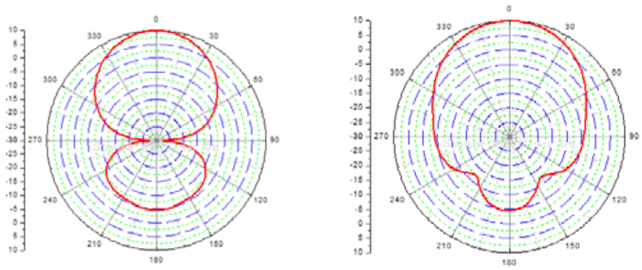

(a) E-plane (b) H-plane

Fig5. Radiation patterns of proposed antenna

Due to this antenna design will radiate power in 3-GHz and 5.2-GHz band. It might impact WLAN system at 5-GHz band and WIMAX at 3-GHz band performance. Therefore, it can suppress the out-band noise by adding low pass filter in the proposed antenna. The antenna structure is shown in Fig.6 and measurement result of return loss is shown as Fig.7.


Fig.6. Structure of antenna with low pass filter

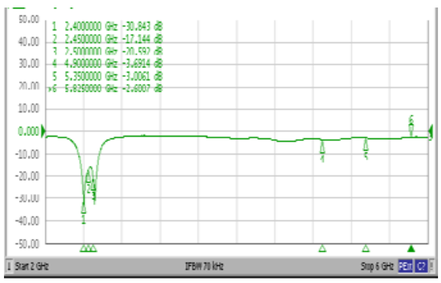


Fig.7. Return loss of antenna with low pass filter

IV. Conclusion

This paper proposes new 1 × 2 antenna array design. The array element is used combo of 1.25-λ dipole and folded dipole. The antenna gain and efficiency of proposed antenna are better than traditional antenna array which is used half-wavelength radiator. The space of proposed antenna is just only 136 mm × 65 mm × 11.6 mm. The antenna gain achieves 10 dBi.

References

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