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Antenna Design for 4-Sector Node in WLAN Applications

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Abstract. This paper introduces an antenna design which is compatible with 4-sector node in WLAN systems. The designed antenna operating in 2.4-GHz band provides 90-degree beamwidth for each sector and also a high front-to-back ratio so that the interference between beams can be avoided. The proposed antenna is low of complexity as it can be fabricated on a single-layer FR4.

Keywords: Patch antenna, Sector node, WLAN; Front-to-back ratio.

1. Introduction

Wireless Local Area Networks or WLANs allow people to access Internet in anywhere at anytime employing radio signal. Lots of standards based on IEEE 802.11 have been developed to increase data transmission speed for WLAN systems. Usually, the systems consist of 2 major equipment: access point and client station. The client station includes computer desktop, laptop and communication gadgets. Those client stations access the networks all the time as users trend to constantly send or receive information from Internet. This circumstance introduces one problem, namely hidden node. While two nodes (e.g., 1st and 2nd nodes) are communicating to each other, the other nodes (e.g., 3rd node) cannot send data to those 2 nodes. So, the 3rd node is considered as a hidden node. As a result, some information from the 3rd node is lost and also the system average throughput is low. According to the mentioned impairment, sector antenna design for WLANs is proposed in this paper in order to allow simultaneous cross communication between 4 nodes.

From literatures, the authors of [1] have revealed that the use of 4 or 8-sector antenna can tackle the problem of hidden nodes and also increase the system gain and coverage area. However, the realization of sector antenna has not been demonstrated. From [2]-[9], the authors have proposed microstrip antennas which is suitable for indoor communication and they are light in weight and low of cost. Unfortunately, those proposed antennas cannot be applied for 4-sector node as their beamwidth is not 90-degree and their front-to-back ratio is too low, which can introduce interference among 4-beams when they are simultaneously operating. For the issue of self-interference between beams, the authors of [10] have indicated that the ratio between desired to undesired signals (at the same frequency) for a full duplex communication system must be at least 20 dB to guarantee the bit error rate. Therefore, this ratio is adopted to be one the criteria for the front-to-back ratio of the proposed design.

According to the above motivations, this paper introduces the antenna design using a single layer FR4 operating at 2.4-GHz band for WLANs. The antenna has 90-degree in half-power beamwidth and also provides 20-dB front-to-back ratio. The remainder of the paper is as follows. After introduction, the antenna

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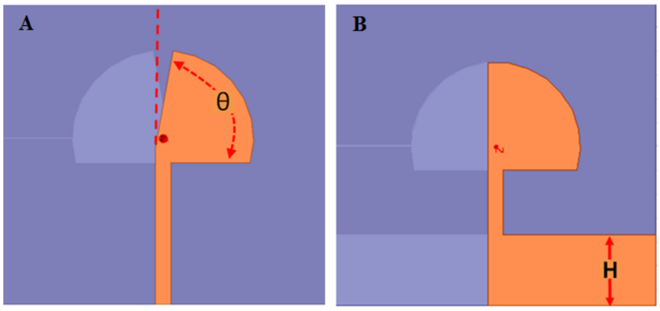
design is discussed in Section II. Then, Section III presents the simulation and measurement results including discussions. Finally, Section IV concludes the paper.

2. Antenna Designs

From the beginning, the antenna design starts from Fig. 1 a). The antenna was designed on a single-layer FR4 having dielectric constant of 4.4 and substrate thickness of 1.6 mm. The overall size is 6.7×6.7 cm2. As shown in the figure, θ is the flare angle of designed antenna. Note that the antenna was fabricated on two sides as shown in the figure.



a) b)

Fig. 1: Antenna design development a) flare angle b) reflector section.

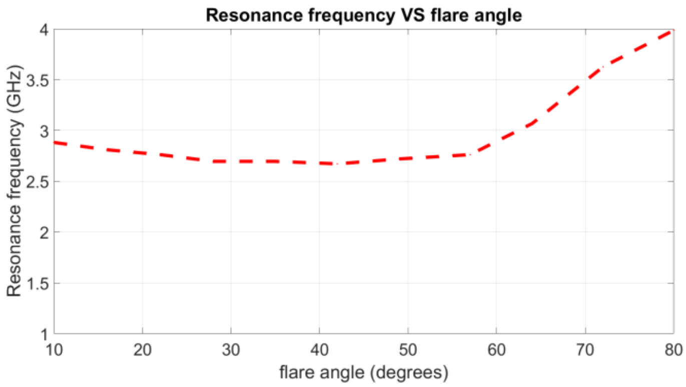


Fig. 2: Resonance frequency vs. flare angle for the antenna design shown in Fig. 1 a).

Fig. 2 shows the resonance frequency when varying the angle θ. As we can see, changing the flare angle affects the resonance frequency. Then, metal in rectangular shape was added on right-handed side of the antenna as shown in Fig. 1 b). The concept of this addition is as we would like to make the main beam narrower and also to rise up front-to-back ratio by adding the reflector section. The simulated results showing the effect of the mentioned addition are presented in Figs. 3 a) and b), respectively. Afterwards, the height of sided metal was adjusted again to see beamwidth and front-to-back ratio.

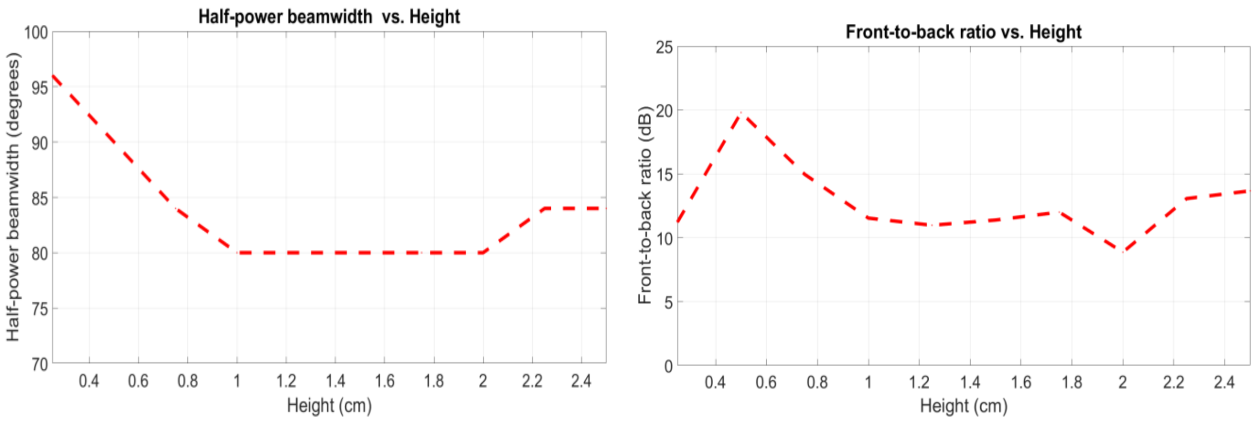


Fig. 3: Response for the antenna design shown in Fig. 1 b) in terms of a) half-power beamwidth vs. height and b) front-to-back ratio vs. height.

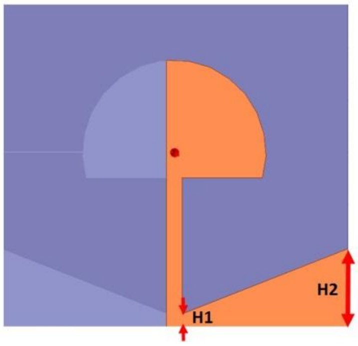
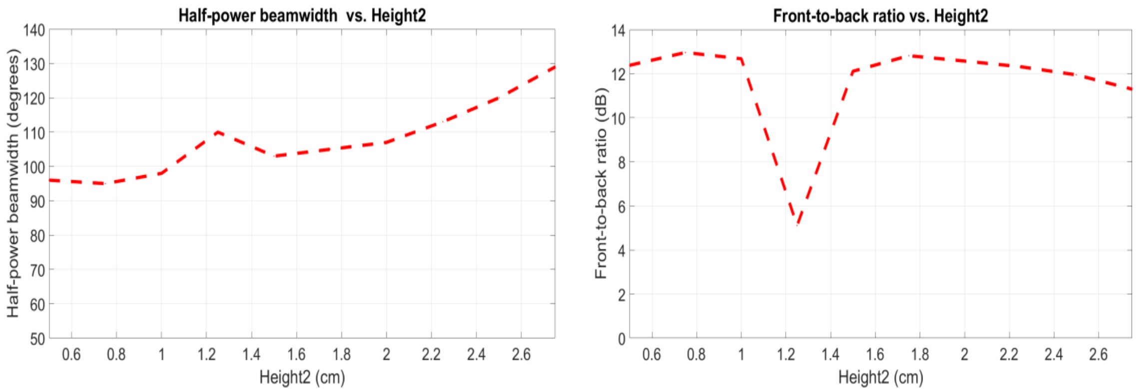


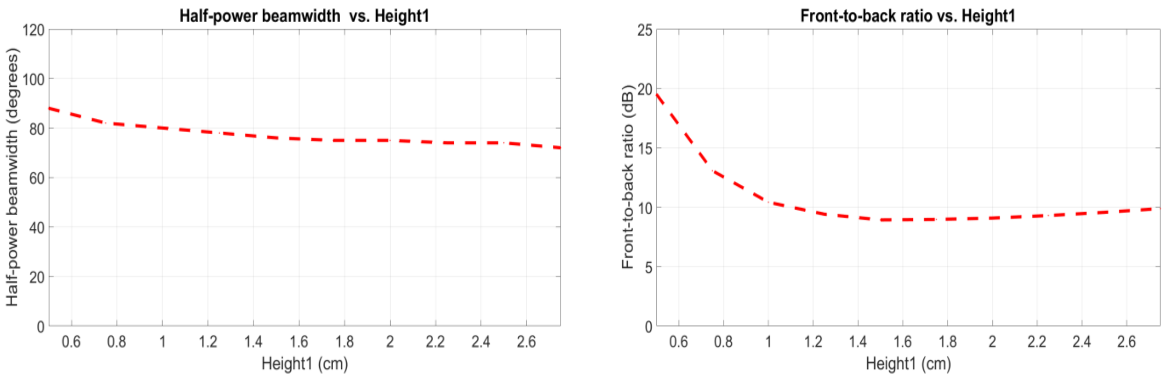
Fig. 4: Antenna design when varying H1 and H2.

Fig. 4 defines the meaning of left-handed side height (H1) and right-handed side height (H2). Figs. 5 a) and b) show the changes of beamwidth and front-to-back ratio respectively, when H1 is constant at 0.25 cm but varying H2. On the other hand, Figs. 6 a) and b) show the changes of beamwidth and front-to-back ratio respectively, when H2 is constant at 0.25 cm but varying H1. As we can see, changing H1 is different from changing H2. However, a number of computer simulations using CST microwave studio were done to achieve a half-power beamwidth of 90-degree and front-to-back ratio of 20-dB.



(a) (b)

Fig. 5: Response when varying H2 in terms of a) half-power beamwidth vs. height and b) front-to-back ratio vs. height.



(a) (b)

Fig. 6: Response when varying H1 in terms of a) half-power beamwidth vs. height and b) front-to-back ratio vs. Height.

Fig. 7 shows the dimension of final antenna design. This antenna can be fabricated on two-sided FR4 with dielectric constant of 4.4 and substrate thickness of 1.6 mm. The overall size of antenna is 6.7×6.7 cm2. The antenna testing is presented in next section including simulation and experimental results in terms of return loss and radiation pattern. The photographs of designed antenna are presented in Fig. 7 b) and c).

(a) (b) (c)

Fig. 7: Final antenna design a) dimension illustration b) front view and c) back view.

3. Experimental Results and Discussions

The factors indicating the radiation performance in this paper are return loss (S11) and radiation pattern. Fig. 8 show simulated and measured S11 for the antenna shown in Fig. 7. As we can see, they are in good agreement. The S11 values are below -10 dB from frequencies 2.08 to 2.73 GHz for simulation. In addition, these values are below -10 from 1.8 to 2.86 GHz for measurement. Figs. 9 a) and b) show both simulated and measured radiation pattern at 2.4 GHz for E-plane and H-plane, respectively. As we can see, they are in good agreement as we can have 90-degree beamwidth from simulation and 89.63-degree beamwidth from measurement. Also, the front-to-back ratio is 21.58 dB from simulation and 20.22 dB from measurement.

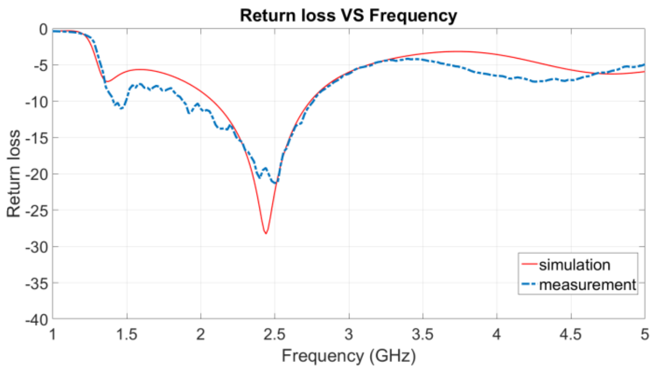
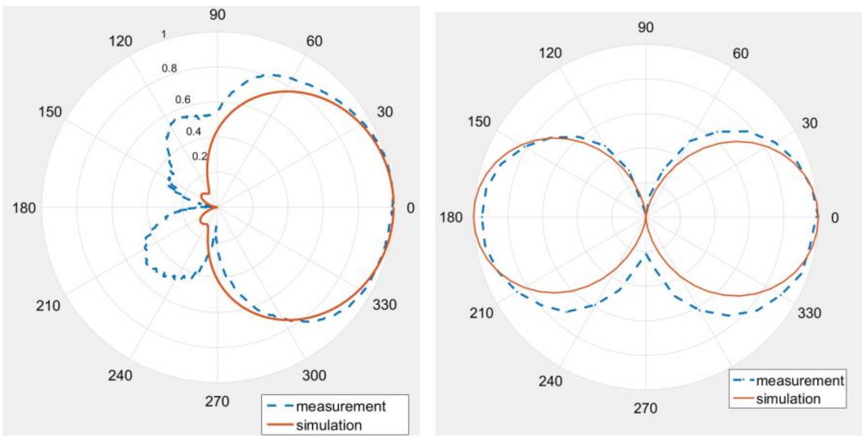


Fig.8: S11 of designed antenna from simulation and measurement.



(a) (b)

Fig.9: Radiation pattern from simulation and measurement at 2.4 GHz a) E-plane and b) H-plane.

According to the obtained results in terms of S11 and radiation pattern, the designed antenna proposed in this paper can be utilized for 4-sector node in WLANs. As they can cover throughout 360-degree coverage and also have less self-interference between beams.

4. Conclusion

This paper has presented an antenna design employing a printed dipole antenna which can be easily fabricated on single-layer FR4. The proposed antenna is small of size as 6.7×6.7 cm2. The antenna has been proposed for 4-sector node in WLANs, which provides half-power beamwidth of 90 degrees and low front-to-back ratio of 20 dB.

5. References

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