Jurnal
Teknologi

Full Paper

A DUAL BAND MIMO DIELECTRIC RESONATOR ANTENNA FOR WLAN APPLICATION

Article history
Received
31March 2015
Received in revised form
30June 2015
Accepted
20 August 2015

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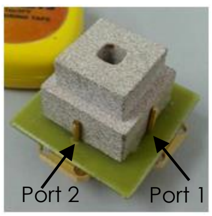
Graphical abstract



Abstract

In this paper, a dual band multiple-input-multiple-output dielectric resonator antenna for wireless local area network application is presented. Two identical feeding techniques are used to feed the proposed antenna. The simulated impedance bandwidth for both port are the same which are 6.5% at 2.45 GHz and 3% at 5.2 GHz. The DRA also has an acceptable value of isolation over the operating frequency. The simulated S-parameter and other multiple-input-multiple-output parameters are studied and observed.

Keywords: WLAN,DRA,MIMO

Abstrak

Di dalam kertas ini, dua jalur berbilang masukan, berbilang keluaran (MIMO) dielektrik resonator antenna (DRA) bagi kegunaan sistem komunikasi tanpa wayar telah diperkenalkan. Antenna ini menggunakan dua teknik suapan yang sama. Simulasi galangan jalur lebar bagi kedua liang adalah sama, 6.5% pada 2.45 GHz dan 3% pada 5.2 GHz. Dilektrik resonator antenna ini juga mempunyai nilai pengasian ke atas frekuensi operasi yang boleh diterima. Simulasi s-parameter dan parameter berbilang masukan, berbilang keluaran yang lain telah dikaji dan diperhatikan.

Kata kunci: WLAN, DRA, MIMO

1.0 INTRODUCTION

In recent years, a tremendous growth has been noticed in wireless communication technologies. Increasing demand on high capacity communication services has made a multiple-input-multiple-output (MIMO) antenna as a center of interest in research area. By having a several advantages, MIMO antennas are capable to improve the capacity of the channel, data rates, link reliability as well as the network coverage [1]. As reported in [2-3], WLAN systems which employ a MIMO technology are able to achieve a data transmission speed of greater than 100 Mbits/s. Commonly known that the WLAN network systems are designed to operate at 2.45 GHz, 5.2 GHz, and 5.8 GHz [4-6]. It requires a low cost and compact antenna with sufficient bandwidth for its application.

Previously, most of the research used microstrip antennas and monopole antenna for WLAN application [7-10]. Even though it suits the feature well, but microstrip antenna still suffers from a narrow bandwidth and need a large size to make it operate. In order to solve this problem, a dielectric material which made up from a ceramic material is introduced to replace the conventional antenna. It is then known as dielectric resonator antenna (DRA) which capable to give more antenna advantage compare to microstrip antenna. Some of the benefits by implementing DRAs in communication systems are high radiation efficiency, small conductive loss, light weight, small in size, and ease of excitation and fabrication [11]. Besides that, DRAs are also very versatile and ease in term of the shape and feeding mechanisms [12-13].

Some of the work on DRA for WLAN application is found in [14-15]. However, the DRA only operate at single frequency. Here, a dual band MIMO DRA for WLAN application is proposed. The DRA will be operating at frequency of 2.45 GHz and 5.2 GHz.

2.0 ANTENNA DESIGN AND ANALYSIS

The design of dual frequency DRA for WLAN application starts with a single element antenna. This design is based on a combination of two different sizes of single DRA. Both DRAs operate at two different frequencies which are at 2.45GHz and 5.2 GHz. Both of DRAs have been stacked and dual frequency could be achieved by performing marginally optimization. Hole is introduced at the center of DRA in order to make it fully operating at two frequencies.

Figure 1 shows the geometry of the proposed antenna. The rectangular DRA has a dimension of a, b and d. the antenna is made up from high permittivity Eccostcok material with dielectric constant, $\varepsilon_r = 30$. Coaxial probe is chosen as the coupling mechanism for the antenna so that it can be easily coupled directly into a 50Ω system. Both probes are located adjacent to the DRA's wall as presented in Figure 2. The DRA was mounted at the center of substrate which has a size of 30 x 30 x 1.6 mm^3 (Length x Width x Height). Table 1 represents the dimension value of the overall antenna.

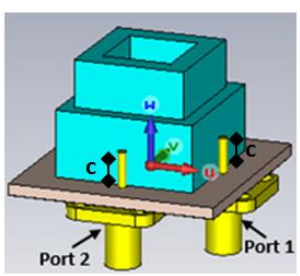


Figure 1 Geometry of the proposed antenna

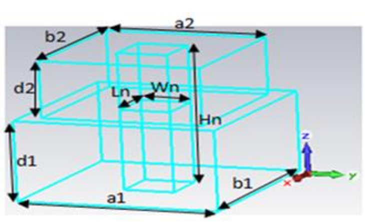


Figure 2 Dimension of the proposed antenna

Table 1 Optimized parameter of the proposed DRA

Parameter	Description	Value (mm)
W	Width of substrate	30
L	Length of substrate	30
a1	Width of DRA 1	20
b1	Length of DRA 1	20
d1	Height of DRA 1	9.6
a2	Width of DRA 2	16
b2	Length of DRA 2	16
d2	Height of DRA 2	6.8
Wn	Width of hole	5
Ln	Length of hole	5
Hn	Height of hole	16.4
h	Height of substrate	1.6
Mt	Thickness of copper	0.035
ε_r	Dielectric constant of DRA	30

In order to achieve optimal performance, parametric studies are performed on several parameters. These include the height and width of DRA and the dimension of the hole when both DRA's is stacked. However in this paper, the height of the connector and position of the probe variation is shown to see the effect on antenna performance. The parametric study is done by using CST Microwave Studio 2013.

2.1 Study the Connector Height Variation

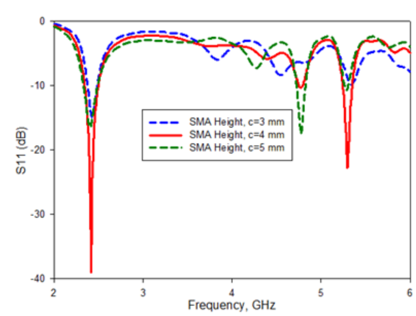


Figure 3 Simulated S_{11} of the proposed antenna for different height of SMA

As can be seen the reflection coefficient plot in Figure 3, the results of the S_{11} are affected when the height of the connector is varied. In the same time, the reflection coefficient value is degraded and some extra resonant frequency exists. However, noted that at the height of 4 mm is chosen and remains fixed. After that the position of the probe is varied in order to study the effect on the antenna performance.

2.2 Study the Probe Position Variation

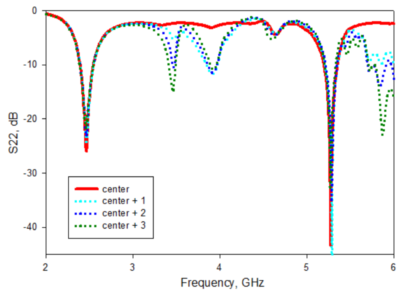


Figure 4 Simulated S_{22} of the proposed antenna for different location of probe

The position of the probe is varied after fixing the height of the connectors at 4 mm. The result of S_{22} is shown in Figure 4. When the position of both probes changed to the right side, more resonant frequencies are introduced. The desired resonant frequency is obtained when the probe is at the center position of the DRA's wall which is at a1/2 and b1/2 for respectively ports. By choosing a proper position of the probe will help to obtain the best antenna performance for WLAN application. Thus probe is chosen to be at the center position which is next to DRA wall.

3.0 SIMULATION RESULTS

Several antenna parameters have been taken into consideration, which are reflection coefficient, isolation, correlation coefficient, diversity gain as well as the efficiency and radiation pattern. Fig. 5 shows the simulated S-parameters of the proposed antenna. The reference level of the reflection coefficient (S_{11} and S_{22}) is -10 dB. Note that the DRA is capable to operate at dual frequencies which are at 2.45 GHz and 5.2 GHz with satisfactory value of reflection coefficient. The S_{11} and S_{22} curve are almost similar because both ports are symmetry.

The impedance bandwidth at both frequencies is 6.5% and 3% respectively. Besides that, the isolation at both frequencies is also acceptable which is above 20 dB at 2.45 GHz and 10 dB at 5.2 GHz. As can be seen in Fig. 6, the value of correlation coefficient is maintained below 0.01 over the frequency band of WLAN. This also can be calculated by using the S-parameters and the formula for correlation coefficient is expressed as below

$$\rho_e = \frac{|S11^{*}S22 + S12^{*}S22|^2}{|(1-|S11|^2-|S21|^2)(1-|S22|^2-|S21|^2)|} \qquad (1)$$

Other than that, the diversity gain, G is also calculated to evaluate the diversity characteristics and MIMO performance of the proposed antenna. The equation is expressed as

$$G = 10ep = 10(\sqrt{(1-|1-0.99|^2)}) \qquad (2)$$

The simulated diversity gain is approximately 10 dB at both frequencies. While for the simulated total efficiency, η for both port of the antenna are shown in Table 2. The values are obtained from the equation shown below

$$\text{For port 1: } \eta1,\text{total} = \eta1,\text{rad}(1-|S11|^2-|S21|^2) \qquad (3)$$

$$\text{For port 2: } \eta2,\text{total} = \eta2,\text{rad}(1-|S22|^2-|S12|^2) \qquad (4)$$

In addition, the simulated radiation pattern for both frequencies is shown in Fig. 7 and Fig. 8. Since the position of the port for the proposed antenna is symmetrical, thus the radiation at both ports is identical. Overall, the radiation pattern at both frequencies is omnidirectional except at the H-plane of 5.2 GHz which more towards directional pattern. This is due to the different modes excited in the DRA at 5.2 GHz.

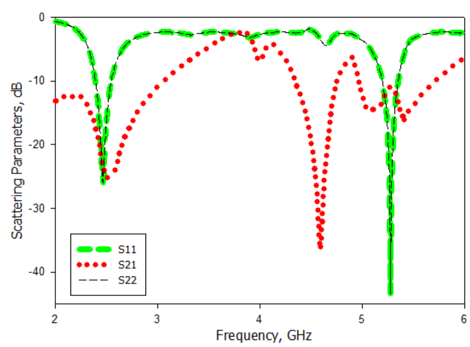


Figure 5 Simulated S-parameters of the proposed antenna

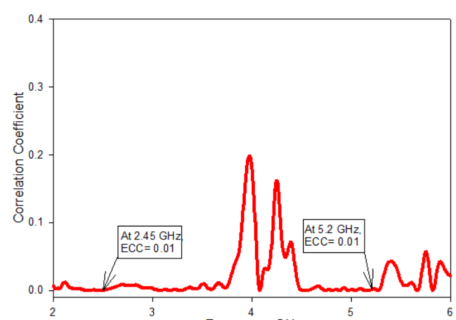
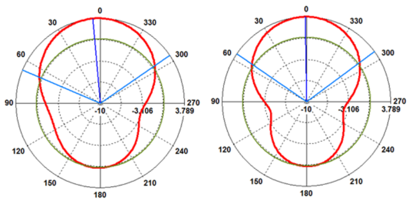


Figure 6 Simulated correlation coefficient

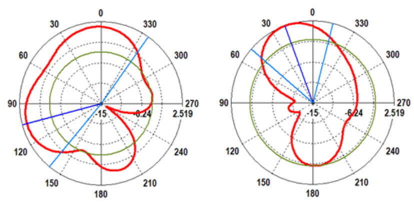
Table 2 Simulated total efficiency

Frequency	Port 1	Port2
2.45 GHz	93 %	93 %
5.2 GHz	25%	25%



(a) (b)

Figure 7 Simulated 2-D radiation pattern of proposed antenna at 2.45 GHz. (a) E-plane (b) H-plane



(a) (b)

Figure 8 Simulated 2-D radiation pattern of proposed antenna at 5.2 GHz. (a) E-plane (b) H-plane

4.0 CONCLUSION

In this paper a dual band MIMO DRA for WLAN application is proposed. The proposed antenna has been simulated using CST Microwave Studio 2013 and able to operate at dual band (2.45 GHz and 5.2 GHz) with an acceptable value of isolation. The simulated S-parameters results and other MIMO parameters have been discussed in detail. The presented simulation results provides satisfactory for WLAN application.

Acknowledgement

The authors would like to thank the Ministry of Education (MOE) and UTM GUP (votes 04H36) and Ministry of Science Technology and Innovation (MOSTI) (vote 4S056) for sponsoring this work.

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