Multiband Dielectric Resonator Antenna for WLAN Application

N. M. Nor[1], M. H. Jamaluddin[1], J. Nasir[1], S. F. Roslan[1], H. Mohamad[2] and N. Ramli[2]

[1]Wireless Communication Center, Universiti Teknologi Malaysia, JohorBahru, Johor, Malaysia
[2]Wireless Communication Cluster, MIMOS Berhad, Kuala Lumpur, Malaysia.

***Abstract*—In this paper, a rectangular dielectric resonator antenna for wireless local area network application is presented. By using a single DRA block, multiple modes can be generated by introducing a notch on the DRA thus producing multiple frequencies. The proposed rectangular DRA with a notch is made up from high permittivity (ε_r=30) Eccostcok HiK material which can operate at 2.45GHz, 5.2GHz and 5.8GHz. The antenna has been fabricated and tested. A good measurement and simulation results in term of reflection coefficient and radiation pattern are achieved.**

Keywords—DRA, WLAN, Multiband.

I. INTRODUCTION

Wireless Local Area Network (WLAN) has undergone a rapid development in recent years. The network systems are designed to operate at 2.45GHz, 5.2GHz, and 5.8GHz [1]-[3]. WLAN requires low cost and compact antenna with sufficient bandwidth for its application. There are many papers in the literature which work in WLAN application using a microstrip antenna and monopole antenna [4]-[8]. Previously, microstrip antenna is used because it suits the features well. However microstrip antenna suffers from narrow bandwidth and need a large size to make it operate.

Among possible antenna solution, DRA is a good candidate to replace the conventional antenna. It is commonly understandable that dielectric resonator antenna (DRA) has given more advantages compare to microstrip antenna. DRA offers several attractive features which able to meet the requirement for WLAN [9]-[13]. Some work on DRA for WLAN application is found in [14]-[15]. However, the DRA only operate in single frequency. In order to improve, dual-band DRA is introduced in [16]. It is based on the slot hybrid antenna. However the works only have been done at dual frequency.

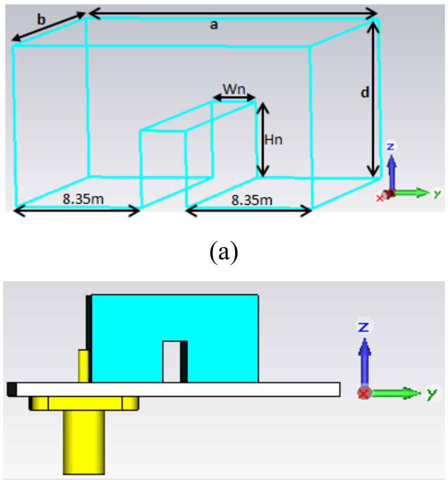
Here we proposed a single DRA with a notch that can operate at multiple frequencies which are 2.45GHz, 5.2GHz, and 5.8GHz.

II. ANTENNA DESIGN

Fig. 1 shows the geometry of the rectangular dielectric resonator antenna (DRA). This proposed antenna has a dimension of 19.7 x 19.7 x 10.5 mm^3 (a x b x d) with dielectric constant of 30. It is mounted on FR4 substrate with dielectric constant of 4.6 and it has a thickness of 1.6mm. The size of the substrate and copper metallic ground plane is 38 x 38 mm^2.

The notch is created in the middle of DRA (along the x-axis) to introduce multiple modes which resulted with multiple frequencies. The notch parameter (W_n and H_n) plays an important role to control the resonant frequency as well as the bandwidth of the antenna.

This rectangular DRA is coupled directly into a 50Ω system since it is fed by a coaxial probe located at axis of DRA wall. In the following, the parametric study of DRA has been carried out.



(a)

(b)

Fig. 1. The proposed Notched DRA (a) Geometry of the proposed antenna (b) Side view

III. PARAMETRIC STUDY

In order to produce multiple frequencies antenna and further enhance the result of reflection coefficient, extensive optimizations are conducted. The commercial Computer Simulation Technology (CST) Microwave Studio package is used for the analysis. It used finite integral technique (FIT) -based electromagnetic (EM) simulation. The effect of tuning the notch parameter is discussed.

A. Notch Width Variation

Fig. 2 shows the reflection coefficient for different notch width. The value of W_n is increased from 2mm to 4mm. As can be seen from the figure, increasing the notch width will result in frequency shifting especially at the upper frequency. When W_n is equal to 3mm, it gives the best reflection coefficient plot compare to the others. In this situation, the antenna able to operate at 2.45GHz, 5.2GHz and 5.8GHz.

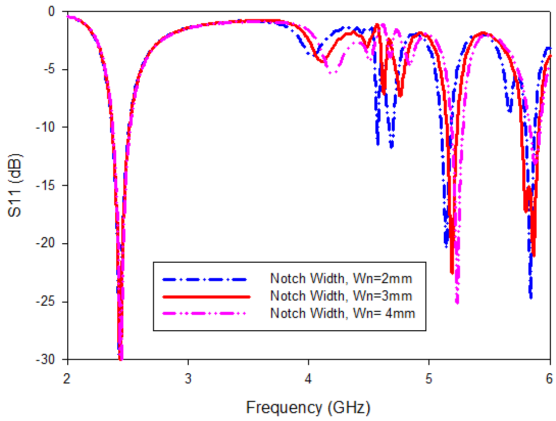


Fig. 2. Reflection coefficient as a function of frequency for W_n = 2mm, 3mm, and 4 mm.

B. Notch Height Variation

In the next step, the effect of notch height on the reflection coefficient is analyzed. Fig. 3 shows that by increasing the value of H_n from 4.5mm to 6.5mm, only the higher frequencies are changed while at the lower frequency remains the same. It can be seen that the best value of H_n (5.5mm) provides the antenna to operate at the interested WLAN application which are 2.45GHz, 5.2GHz and 5.8GHz.

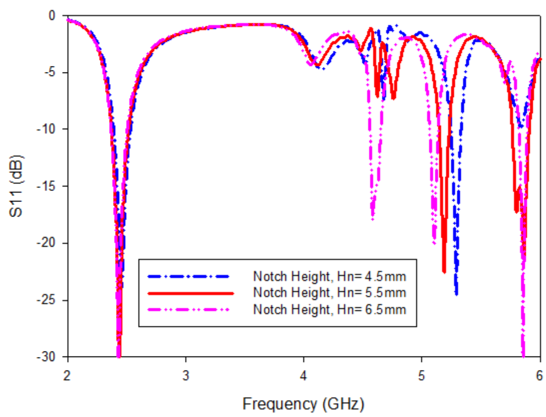


Fig. 3. Reflection coefficient as a function of frequency for H_n = 4.5mm, 5.5mm, and 6.5mm.

C. SMA Connector Height Variation

Since the DRA is fed with coaxial probe, the height of the SMA connector will also affect the reflection coefficient of the antenna. Fig. 4 presented the reflection coefficient plot when SMA height is increased from 3.635mm to 5.635mm. It was found that when SMA height is equal to 3.635mm, the reflection coefficient plot is degraded and more resonant frequency appears. The result for the rest value of SMA height shows some similarity. Fortunately, SMA height equal to 5.635mm is chosen which able to make the notch DRA operates at the interested WLAN frequencies.

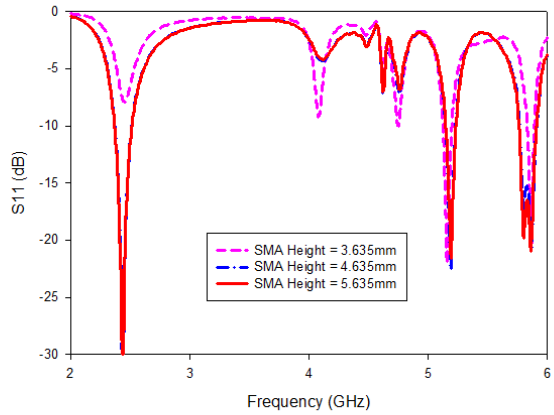


Fig. 4. Reflection coefficient as a function of frequency for SMA height = 3.635mm, 4.635mm, and 5.635mm.

IV. RESULT AND DISCUSSION

Table 1 represents the final dimension of the proposed antenna after the optimization process. The DRA prototype is fabricated and measured and the photograph of the DRA is shown in Fig. 5.

Fig. 6 shows the measured and simulated reflection coefficient of the DRA. A reasonable agreement can be observed between the results. However, there is slightly frequency shifting at 5.2GHz, which might come from fabrication uncertainties.

The antenna can operate at 2.45GHz, 5GHz and 5.8GHz, which the measured 10dB impedance bandwidths are 6.02%, 2.7%, and 2.6% respectively.

Fig. 5. Fabricated prototyped DRA.

Table 1. Fabricated prototyped DRA.

Parameter	**Description**	**Value (mm)**
W	Width of substrate	38.0
L	Length of substrate	38.0
a	Width of DRA	19.7
b	Length of DRA	19.7
d	Height of DRA	10.5
Wn	Width of notch	3.0
Hn	Height of notch	5.5
h	Height of substrate	1.6
Mt	Thickness of copper	0.035
ε_r	Dielectric constant of DRA	30.0

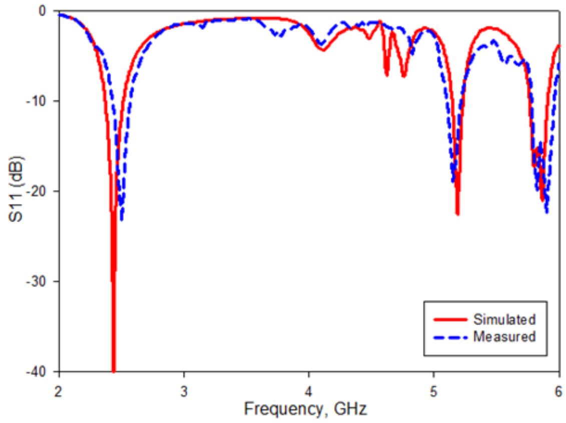
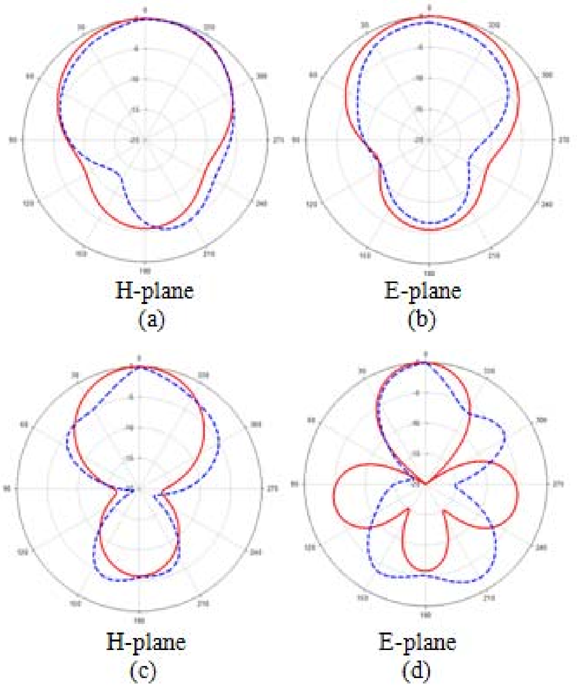


Fig. 6. Measured and simulated reflection coefficient of DRA.

The radiation pattern of the DRA was measured inside an anechoic chamber with the transmitting field provided by the horn antenna. Fig. 7 shows the H-plane and E-plane radiation pattern of the DRA.

The simulated and measured radiation pattern agrees with each other well. At the frequency of 2.45GHz and 5.8GHz the radiation pattern is almost omnidirectional with both gain of 4.7dBi while at 5.2GHz the gain is 6.9dBi.



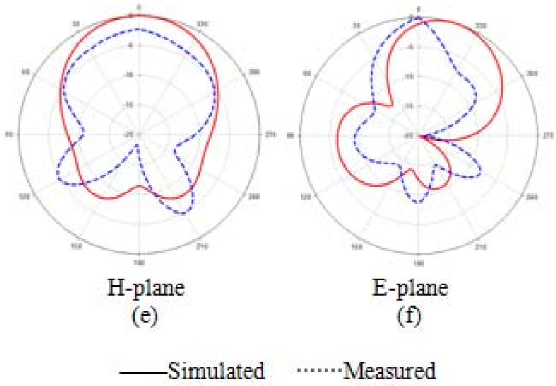


Fig. 7. Measured and simulated radiation pattern of DRA for: 2.45GHz (a) and (b); 5.2GHz (c) and (d); 5.8GHz (e) and (f).

V. CONCLUSION

Triple-band DRA for WLAN application has been proposed and fabricated. The DRA is able to operate at multiple frequencies which are 2.45GHz, 5.2GHz, and 5.8GHz. This paper presents a design for novel multiple frequencies DRA for WLAN application. It is shown that by introducing a notch on the rectangular DRA, triple-band frequencies can be achieved, which are 2.45GHz, 5.2GHz and 5.8GHz. A prototype of the antenna was fabricated. This notched DRA can give a monopole-like radiation pattern at 2.45GHz and 5.2GHz. While at 5.2GHz, the pattern is more like a dipole.

ACKNOWLEDGMENT

The authors would like to thank the Ministry of Education (MOE) and UTM GUP (votes 05H62) and Ministry of Science Technology and Innovation (MOSTI) (vote 4S056) for sponsoring this work.

REFERENCES

[1] H. Zhai, Z. Ma, Y. Han, and C. Liang, "A Compact Printed Antenna for Triple-Band WLAN/WiMAX Applications," *IEEE Antennas Wireless Propag. Lett.,* vol. 12, pp. 65-68, 2013.

[2] H. W. Lui, C.H. Ku, and C. F. Yang, "Novel CPW-fed planar monopole antenna for WiMAX/WLAN applications," *IEEE Antennas Wireless Propa. Lett.*, vol 9, pp. 240-242, 2010.

[3] M. Khalily, M. R. Kamarudin, M. Mokayef, and M. H.Jamaluddin, "Omnidirectional Circularly Polarized Dielectric Resonator Antenna for 5.2GHz Wlan Application," *IEEE Antennas Wireless Propa. Lett.*, vol 13, pp. 443-446, 2014.

[4] A. Khaleghi, A. Azoulay, and J. C. Bolomey, "A Dual Band Back Coupled Meanderline Antenna for Wireless LAN Applications," *Vehicular Technology Conference*, vol. 1, pp. 226-229, 2005.

[5] Zhong, Y. Li, H. jiang and Y. Long, "Design of a Novel Dual-Frequency Microstrip Patch Antenna for WLAN Applications," *IEEE International Symposium on Antennas and propagation Society*, vol. 1, pp. 277-280, 2004.

[6] W. C. Liu, "Wideband Dual-Frequency Double Inverted -L CPW-fed Monopole Antenna for WLAN application," *IEE Proceeding on Microwave, Antennas and Propagation,* vol. 152, pp. 505-510, 2005.

[7] R. Devi, and D. K. Neong, “Wideband Dual-Frequency Antenna for WLAN Applications,” *IEEE International Symposium on Antennas and propagation Society*, vol. 3, pp. 1-4, Dec. 2011.

[8] C-Y. Pan, J-Y. Jan, and L-C.Wang, “Compact and Broadband Microstrip-Line-Fed Modified Rhombus Slot Antenna”, Radioengineering,, Vol. 22, No. 3, Sept. 2013.

[9] A. Petosa, *Dielectric Resonator Antenna Handbook*, Norwood, MA, Artech House, 2007.

[10] K. M. Luk and K. W. Leung, *Dielectric Resonator Antennas*, Hertfordshire, England, Research Studies Press Ltd, 2003.

[11] S.F. Roslan, M.R. Kamarudin, M. Khalily, and M.H. Jamaluddin, “An MIMO Rectangular Dielectric Resonator Antenna for 4G Applications,” *IEEE Antennas Wireless Propag. Lett*., vol. 13, pp. 321-324, 2014.

[12] M. Khalily, M. K. A. Rahim, A. Kish, and, S. Danesh, “Wideband P-Shaped Dielectric Resonator Antenna”, Radioengineering,, Vol. 22, No. 1, Apr. 2013.

[13] M. Khalily, M. R. Kamarudin, and M. H. Jamaluddin, “A Novel Square Dielectric Resonator Antenna with Two Unequal Inclined Slits for Wideband Circular Polarization,” *IEEE Antennas and Wireless Propag. Lett.*, vol. 12, pp. 1256-1259, 2013.

[14] D. Cornos, A. Laisne, R. Gillard, F. Le Bolzer, and C. Nicolas, “Compact Dielectric Resonator Antenna for WLAN Applications,” *IEE Electronics Letters,* vol. 39, pp. 588-590, 2003.

[15] Z. Wang, C. C. Chiau, X. Chen, B. S. Collin, and S. P. Kingsley, “A Miniature Broadband Dielectric Resonator Antenna (DRA) Operating at 2.4 GHz,” *IEEE International Workshop on Antenna Technology Small Antennas and Novel Metamaterials*, pp. 104-107, 2006.

[16] Y. Ding, and K.W. Leung, “On the Dual-Band DRA-Slot Hybrid Antenna,” *IEEE Transactions on Antennas and Propagation,* vol. 57, pp. 624- 630, 2009.