ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

A COMPARISON BETWEEN RECTANGULAR AND C-SHAPEP PATCH ANTENNA FOR BANDWIDTH IMPROVEMENT AT 5.2 GHZ FOR WLAN APPLICATIONS

Adel Y.I. Ashyap, Waddah A. M. A, Abdirahman M. S, M. Z. M. Jenu, Z. Z. Abidin and S. H. Dahlan
Center for Electromagnetic Compatibility Faculty of Electrical and Electronic Engineering Universiti Tun Hussein Onn Malaysia Batu Pahat, Johor, Malaysia
E-Mail: ashyap2007@gmail.com

ABSTRACT

A comparison between rectangular microstrip patch and C-shaped patch antennas are proposed in this paper for wireless local area networks (WLANs) applications operating at the frequency band of 5.2 GHz. The rectangular patch antenna has a return loss of -40.951 dB and bandwidth of 7.9% at 5.2 GHz. The patch antenna has an Omni-directional radiation pattern with maximum gain of 6.5 dBi. The C-shaped patch antenna has shown a bandwidth improvement of more than 13% at a return loss of -43.859 dB better than -10 dB. Similarly, the C-shaped antenna has shown a size reduction of more than 16% compared to the rectangular microstrip patch antenna. However, the antenna's radiation pattern is more to unidirectional pattern with reduced gain of 4.830 dBi compared to the rectangular microstrip patch antenna. Both antennas were printed on a FR4 substrate with dielectric constant of 4.7. The simulated results were verified through measurement in which a good agreement between the simulated and measured result were documented.

Keywords: antennas, WLAN, bandwidth improvement, antenna's radiation pattern.

INTRODUCTION

The huge growth and improvement in the ear of wireless communication technology increases the call for extremely efficient compact devices. It is a challenge to be compatible with a wide range of small scale applications while maintaining good performance. In the RF and microwave studies field, microstrip patch antennas are considered as a smart solution for compact and cost effective wireless communication systems that used in many applications and have been used in wireless communication systems for a long time due to their convenient feeding mechanisms, simple structures, low volume, low profile, light weight, low fabrication cost, ease of mounting on the host surface and convenient integration with RF devices. These types of characteristics of microstrip patch antennas have made them attractive candidates for numerous applications (Alam, Islam and Misran, 2012), (Nashaat Elsheakh *et al*., 2010), (Ojaroudi, Ghobadi and Nourinia, 2009).

As with new developments, there has been an augmented requirement for high data rate and compact sized antennas. Microstrip antenna is the ideal choice for such an application due to their characteristic that mention above. However, standard rectangular microstrip patch antenna has the drawback of narrow bandwidth. Enhancement of the performance to cover the demanding bandwidth is necessary (Ang and Chung, 2007). A few approaches can be applied to improve the microstrip antenna bandwidth. These include introducing cutting notches and slots in the conventional rectangular, square etc, increasing the substrate thickness, introducing slits in the patch geometry, introducing parasitic element either in coplanar or stack configuration, using different dielectric materials using air gap structure, using different feeding methods, using different patch shape such as E shape , U-slot patch antennas, V-slot patch antennas ,W shape ,etc and modifying the shape of a common radiator patch by incorporating slots. The last approach is particularly attractive because it can provide excellent bandwidth improvement and maintain a single-layer radiating structure to preserve the antenna's thin profile characteristic (Ang and Chung, 2007), (Ge, Esselle and Bird, 2006), (Kin-Lu Wong and Wen-Hsis Hsu, 2001), (Lee *et al*., 1997), (Rafi and Shafai, 2004), (Lotfi Neyestanak, Hojjat Kashani and Barkeshli, 2007).

Wireless local area networks (WLAN) are broadly used worldwide. The IEEE 802.11b and 802.11g standards utilize the 2.4 GHz ISM band. The frequency band is license-free; hence the WLAN equipment will suffer interference from cordless phone, microwave ovens, wireless routers, Bluetooth devices, wireless access point facilitates wireless connection between PCs, laptops, and other appliances that use the same band. The 802.11a standard uses the 5 GHz band which is cleaner to support high-speed WLAN (Ang and Chung, 2007). Therefore a comparison between rectangular and C-shaped patch antennas is introduced to investigate the difference between them in terms of bandwidth improvement, radiation pattern with maximum gain and return loss at frequency band 5.2 GHz for WLAN applications and to show how C-shaped antenna can participate for bandwidth enhancement compare to rectangular microstrip patch antenna.

ARPN Journal of Engineering and Applied Sciences

Antenna geometry

Both antennas have been designed to fit in WLAN applications. The next is a summary of the details of both antennas design.

A. Rectangular patch antenna

Patch antenna, as shown in Figure-1 has been designed at the frequency band of 5.2 GHz. In the purposed antenna follow transmission line model design technique. According to this model a rectangular patch of length L and width W can be viewed as a very wide transmission line that is transversely resonating, with the electric field is varying sinusoidal under the patch along its resonant length L. The electric field is assumed to be invariant along the width W of the patch. The most important parameters for the design of a rectangular microstrip patch antenna is the resonant frequency (f) of the antenna, the dielectric constant of the substrate (ε_r) and the substrate thickness (h). For the design of rectangular microstrip patch antenna, the following mathematical approach illustrated in Figure-2 was used to calculate the dimension. The dimension has been optimized to get the required resonant frequency.

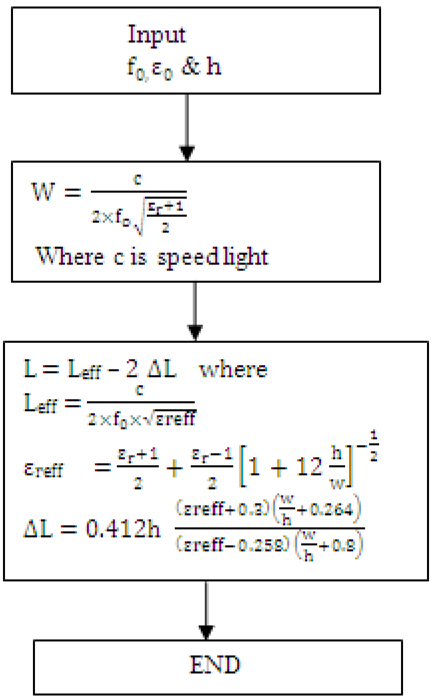


Figure-1. Process of dimensions calculation for the rectangular patch antenna.

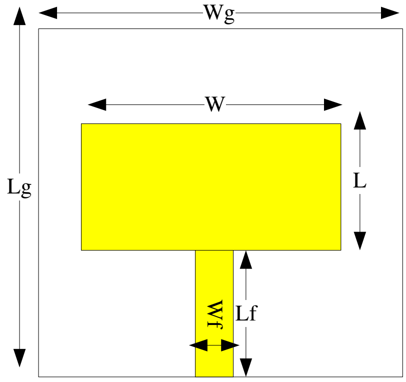


Figure-2. Geometry of the rectangular patch antenna.

In the design of this antenna, as shown in the Figure-1, the FR4 substrate is used because of its ease of fabrication, availability, low cost etc and has thickens of h=1.6 mm with loss tangent = 0.005 and a relative permittivity ε_r= 4.7. The length and width of patch are L=12.8 mm and W=17.1 mm respectively. The length and width of ground are Lg = Wg = 28.9 mm. The width of the feeding line is Lf= 3 mm. The edges along the length are called none radiating and along the width are called radiating edges (Girase *et al.*, 2014). There are different techniques of feeding such as coaxial probe feed, microstrip line feed, aperture coupling and coplanar waveguide (CPW). In this paper, microstrip line (50 ohm) feed has been used; it is considered to be the simplest methods to fabricate as it is a conducting strip connected to the patch and therefore can be considered as extension of the patch. The antenna was designed and analyzed using CST Microwave Studio software.

The fabricated antenna is shown in Figure-3.

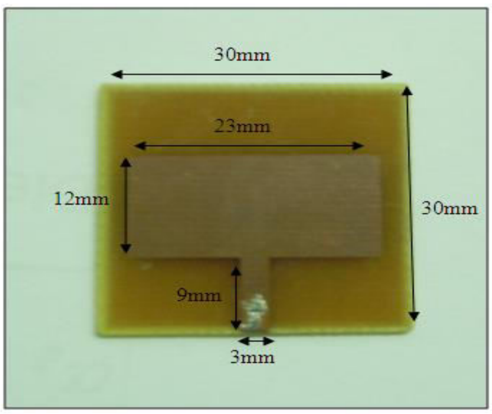


Figure-3. Prototype of the fabricated rectangular antenna.

B. C-shaped patch antenna

This antenna is built using a standard FR4 substrate (dielectric constant=4.7) with a thickness of 1.6 mm etched on the ground plane. The antenna consists of a C-shaped radiator connected to a 50 Ohm micro strip feed

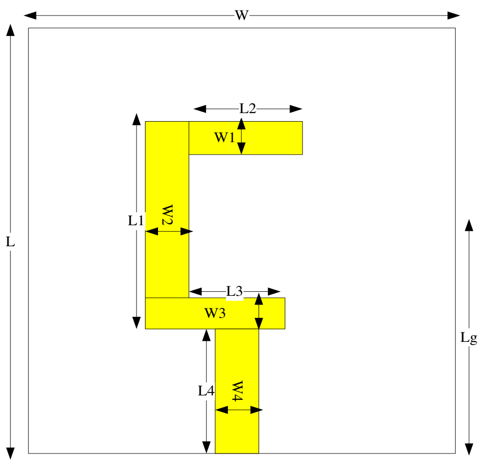
ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

line as shown in Figure-4. The design has been extracted from the rectangular patch antenna presented earlier to compare them in terms of bandwidth improvement, radiation pattern with maximum gain and return loss using the same substrate and dimensions. The optimized dimensions of the C-shaped patch are shown in Table-1.

The antenna resonated at single band with a reflection coefficient below-10 dB. The reduction in the ground plane mades to let the antenna structure compact and so it can be easily integrated with the packaging device.

Table-1. The optimize dimension of the proposed C-shaped patch antenna.

Parameters	Value[mm]	Parameters	Value[mm]
W	**25**	**W3**	**3.7**
L	25	W4	2.8
W1	3.7	L1	18.7
W2	4	L2	7
L3	7	L4	5
Lg	13.3		



Figuer-4. Geometry of the C-shaped patch antenna.

The fabricated antenna is shown in Figure 5.

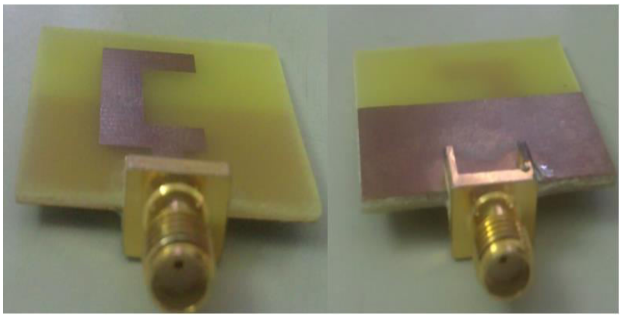


Figure-5. Prototype of the fabricated C-shaped antenna.

RESULTS AND DISCUSSIONS

The simulations were carried out in CST Microwave Studio, which is commercial electromagnetic software. This software uses a Finite Integration Technique (FIT) for simulations. Both patches of the proposed antennas, rectangular and C-shaped, have been designed and simulated for the required bands.

A. Return loss

The return loss magnitude of the rectangular patch antenna is -40.951 dB as seen in Figurer-6 while the return loss value of the C-shaped patch is -43.859 dB as illustrated in Figure-7 and both have resonating frequency of exactly 5.2 GHz. Hence, it can be observed that the C-shaped is shown an improved result compared to rectangular patch in terms of return loss.

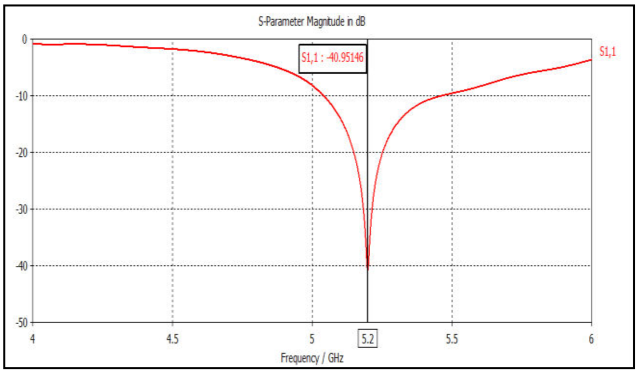


Figure-6. Simulated S_{11} parameter of rectangular patch.

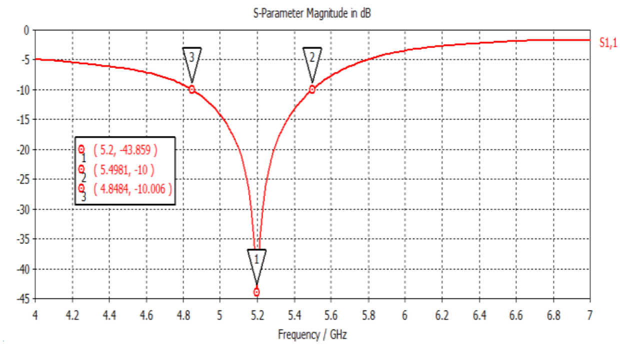


Figure-7. Simulated S_{11} parameter of C-shaped patch.

B. Input impedance

Since the input impedance of the antenna must be identically match in order to achieve maximum energy transfer between the transmission line and the antenna to achieve higher efficiency. In other hand, if there is a mismatch a reflected wave will be travel back towards the energy source which result a reduction in the overall system efficiency. Hence, a consideration has been taken in order to achieve best matching for both rectangular patch and C-shaped patch. It can be seen that from the

ARPN Journal of Engineering and Applied Sciences

Figure-8 and Figure-9 that both designs result with a good matching which is 50 Ohm.

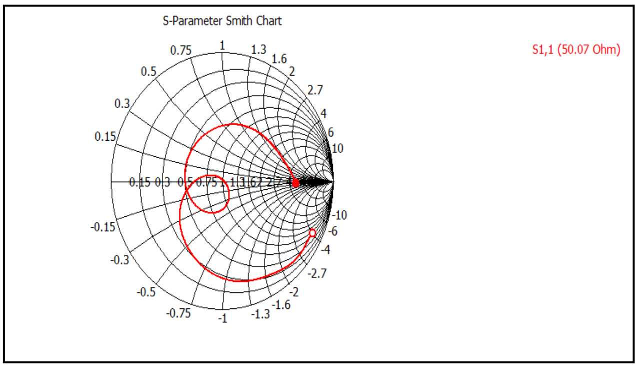


Figure-8. Simulated rectangular patch impedance (smith chart).

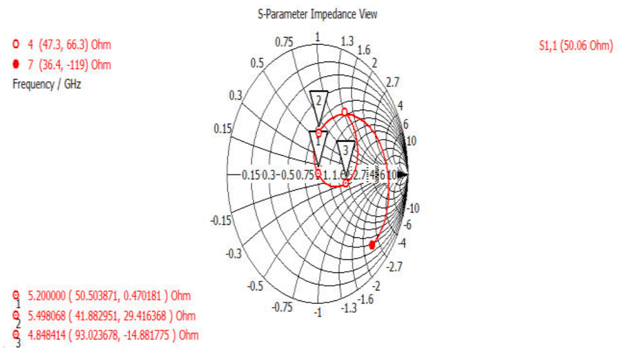


Figure-9. Simulated C-shaped patch impedance (smith chart).

C. Radiation pattern with maximum gain

The radiation pattern with maximum gain of both rectangular and C-shaped antennas has been simulated and compared. It can be seen from Figure-10 and Figure-11 that rectangular patch and C-shape have radiation pattern with maximum gain of 6.58 dBi and 4.830 dBi respectively. It is observed that the rectangular patch has radiation pattern with maximum gain higher than the C-shaped.

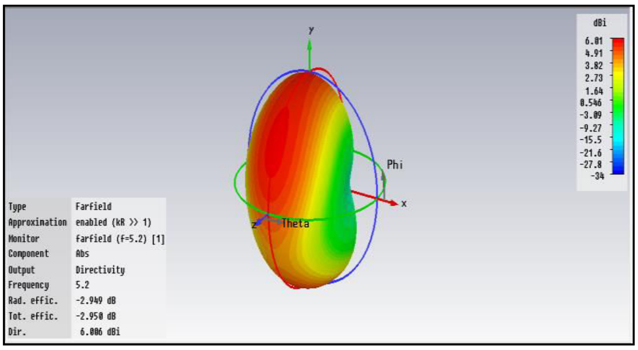


Figure-10. Radiation pattern with maximum gain of the rectangular patch.

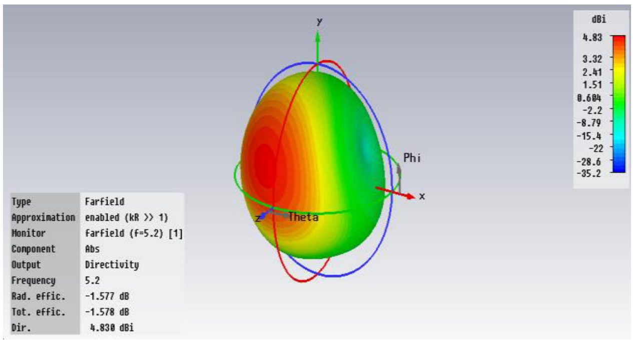


Figure-11. Radiation pattern with maximum gain of the C-shape patch.

D. Bandwidth

The rectangular patch antenna has a start frequency 5.05 GHz at and stop frequency at 5.46 GHz as shown in Figure-6 while the C-shaped patch antenna has a start frequency at 4.8 GHz and stop frequency at 5.5 GHz as shown in Figure-7. By calculating the bandwidth from equation 1 the rectangular patch and C-shaped have the values of 7.9% and 13.5% respectively. It is observed that from the calculation the C-shaped has more improved bandwidth than rectangular patch. The simulation summery of the comparison of the rectangular patch and C-shaped is shown in Table-2.

$$BW = \frac{f_h - f_l}{f_c} \quad \text{Where } f_c = \frac{f_h + f_l}{2} \ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$BW_{Rectangular} = \frac{5.46 - 5.05}{5.2} x100\% = 7.9\%$$

$$BW_{C-shaped} = \frac{5.5 - 4.8}{5.2} x100\% = 13.5\%$$

Table-2. Comparison of the simulation result.

Parameters	**Rectangular patch**	**C-shaped patch**
Return loss	**-40.951**	**-43.859**
Impedance [Ohm]	50	50
Gain [dBi]	6.5	4.830
Bandwidth [%]	7.9	13.5

The performances of both rectangular patch and C-shaped antennas have been measured using Network Analyzer. Return losses have been carried out at the required resonant frequency at 5.2 GHz. Figure-12 and Figure-13 illustrate the comparison of the simulated and measured S_{11} parameter of both antennas at free space have shows that the resonant measured frequency is slight shifted from the simulated and this is something that is expected to occur, a change in the measured result compare to the simulated result due to conductive or copper losses and dielectric losses. In addition, due to improper fabrication or soldering process that accidently changed the size or the shape of the patch antenna in a millimeter difference. Besides that, the size of the width and length of the patch may not be exactly the value used in the simulation software, since the patch is printed on a dry film before fabrication using a normal printer and not so accurate in terms of the exact length or width .The measured result shows that both antennas can operate from 5.38 GHz to 5.93 GHz with a resonant frequency at 5.58GHz for rectangular path and from 4.7 GHz to 5.8 GHz with resonant frequency at 5.3 GHz for C-shape patch.

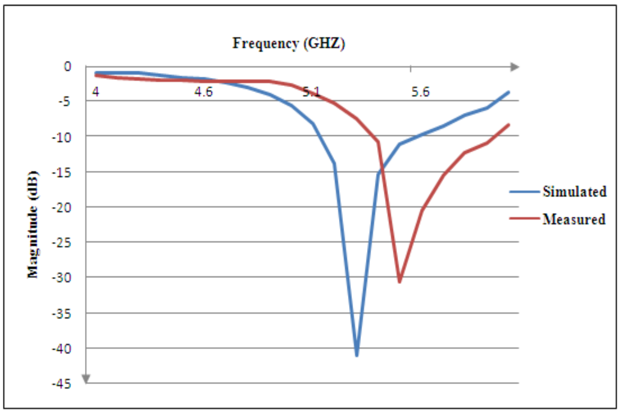


Figure-12. Measured S_{11} parameter of rectangular patch.

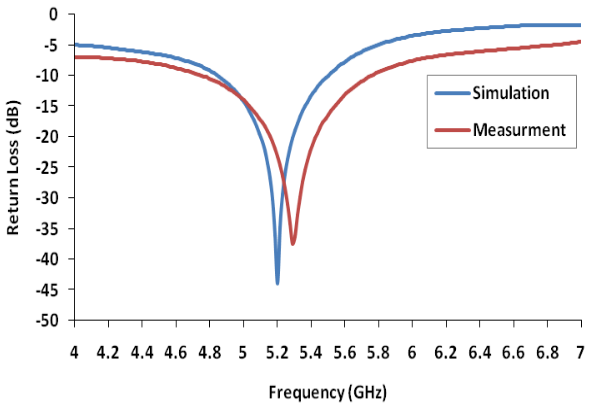


Figure-13. Measured S_{11} parameter of C-shaped patch.

It is noticeable to see that from the measurement of both antennas the bandwidth of C-shaped patch has been improved compare to the measured rectangular patch. Based on formula 1 the bandwidth is 9.86% for rectangular patch and 20.8% for C-shaped antenna which shows a very good improvement.

$$BW_{Rectangular} = \frac{5.93G - 5.38G}{5.58G} x\ 100\% = 9.86\%$$

$$BW_{C-shaped} = \frac{5.8GHz - 4.7GHz}{5.3GHz} x\ 100\% = 20.8\%$$

It is observed from measurements that both antennas show best impedance matching, which indicates that the antenna have a good efficiency as shown in Figure-14 and Figure-15. Table-3 shows the summery of the measurements.

Table-3. Comparison of the measured result.

Parameters	Rectangular patch	C-shaped patch
Return loss	-31	-31
Impedance [Ohm]	50	50
Bandwidth [%]	9.9	20.8

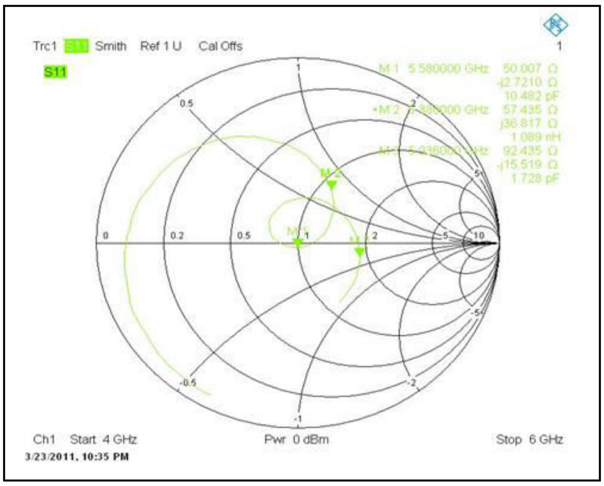


Figure-14. Simulated rectangular patch impedance (Smith Chart).

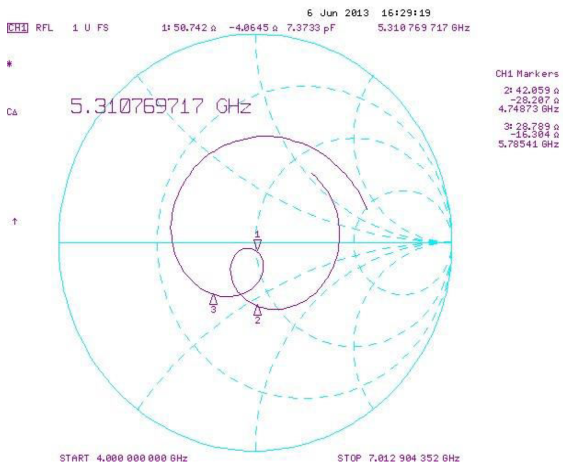


Figure-15. Simulated C-shaped patch impedance (Smith Chart).

CONCLUSIONS

Two types of microstrip antennas were compared. The first type is the design of typical rectangular

ARPN Journal of Engineering and Applied Sciences

microstrip antenna and the second is the design of C-shaped microstrip antenna. A simple microstrip line type feed mechanism was used for both designs. The main concern was to study the comparison of bandwidth improvement, return loss and radiation pattern with maximum gain of both the antennas. It was observed that the C-shaped antenna produced an enhancement bandwidth of more than 13% and a good return loss while rectangular patch antenna produced a better Omni-directional radiation pattern with maximum gain of 6.5dBi.

ACKNOWLEDGEMENT

The authors of this paper wish to acknowledge the funding of this project by FRGS Grant under Vot No. 1418 through Office for Research, Innovation, Commercialization and Consultancy Management (ORICC) at Universiti Tun Hussein Onn Malaysia.

REFERENCES

Alam, M., Islam, M. and Misran, N. 2012. A novel compact split ring slotted electromagnetic bandgap structure for microstrip patch antenna performance enhancement. Pier, 130, pp. 389-409.

Nashaat Elsheakh, D., Iskander, M., Abdallah, E., Elsadek, H. and Elhenawy, H. 2010. Microstrip array antenna with new 2d-electromagnetic band gap structure shapes to reduce harmonics and mutual coupling. Pier C, 12, pp. 203-213.

Ojaroudi, M., Ghobadi, C. and Nourinia, J. 2009. Small Square Monopole Antenna with Inverted T-Shaped Notch in the Ground Plane for UWB Application. IEEE Antennas and Wireless Propagation Letters, 8, pp. 728-731.

Ang, B. and Chung, B. 2007. A wideband e-shaped microstrip patch antenna for 5 - 6 Ghz wireless communications. Pier, 75, pp. 397-407.

Ge, Y., Esselle, K. and Bird, T. 2006. A Compact E-Shaped Patch Antenna with Corrugated Wings. IEEE Trans. Antennas Propagat. 54(8), pp. 2411-2413.

Kin-Lu Wong, and Wen-Hsis Hsu, 2001. A broad-band rectangular patch antenna with a pair of wide slits. IEEE Trans. Antennas Propagat, 49(9), pp. 1345-1347.

Lee, K., Luk, K., Tong, K., Shum, S., Huynh, T. and Lee, R. 1997. Experimental and simulation studies of the coaxially fed U-slot rectangular patch antenna. IEE Proceedings - Microwaves, Antennas and Propagation, 144(5), p. 354.

Rafi, G. and Shafai, L. 2004. Broadband microstrip patch antenna with V-slot. IEE Proceedings - Microwaves, Antennas and Propagation, 151(5), p. 435.

Lotfi Neyestanak, A., Hojjat Kashani, F. and Barkeshli, K. 2007. W-shaped enhanced-bandwidth patch antenna for wireless communication. Wireless Pers Commun, 43(4), pp.1257-1265.

Girase, N., Tiwari, R., Sharma, A. and Singh, H. 2014. Design and Simulation of Slotted Rectangular Microstrip Patch Antenna. International Journal of Computer Applications, 103(17), pp. 19-23.