ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

CIRCULAR-SLOTTED CPW ANTENNA FOR WiMAX/C BAND APPLICATIONS

M. Samsuzzaman[1, 2], M. T. Islam[2] and M. R. I. Faruque[2]
[1]Faculty of Engineering and Built Environment, Universiti Kebangsaan, Malaysia
[2]Institute of Space Science (ANGKASA), Universiti Kebangsaan, Malaysia
E-Mail: sobuzcse@eng.ukm.my

ABSTRACT

In this article, a circular-slot dual band antenna fed by a coplanar waveguide (CPW) for WiMAX/C band applications is presented. The antenna mainly encompasses a ground with a wide circular slot in the centre, a rectangular feeding strip and two pairs of asymmetric planar inverted L (APIL) strips connecting with the slotted ground. By introducing the two pairs of APIL's, two resonant frequencies, 3.70 for WiMAX, and 6.75 GHz for C band applications are agitated. The simulated results show that the proposed antenna has two good impedance bandwidths (VSWR less than 2) of and 1250MHz which make it easily cover the required bandwidths for WiMAX (3.4-3.6GHz) and 4-8 GHz C band applications. Moreover, the obtained radiation patterns demonstrate that the proposed antenna has significantly directional and Omni directional patterns in both E-plane and H-plane.

Keywords: dual band, CPW, L slits, WLAN/C band.

INTRODUCTION

Now the present research activity of the multiple or broad bands operation and miniaturized size for current antenna have become one of a highly competitive topic and are mounting superbly, because of rapid development of modern wireless communication system technique. The planar monopole antennas (Anguera *et al*., 2010; Azim, Islam, Misran, Cheung, and Yamada, 2011) can attain broad bandwidth but have a large size whose configuration do not meet the miniaturization requirements of RF units. However, printed microstrip antenna (MPA) could be a good candidature for their attractive features such as low profile, ease of fabrication, compact size, integrating with active devices and nearly Omni directional radiation characteristics. But narrow bandwidth and low gain are the limiting factor of MPA (Balanis, 2012). Different techniques have been applied to overcome these limitations. Advances in wireless communications have introduced tremendous demands in the antenna technology. It also the paved the way for wide usage of mobile phones in modern society resulting in mounting concerns surrounding its harmful radiation(Faruque, Islam, and Misran, 2011; Mohammad Tariqul Islam, Faruque, and Misran, 2011). Specifically in order to satisfy the WLAN standards of 2.4-2.484 GHz/5.15-5.825 GHz and WiMAX standards of 2.5-2.69 GHz/3.4-3.69 GHz/5.25-5.85 GHz (Pei, Wang, Gao, and Leng, 2011) concurrently many MPA have been extensively studied (Lee, Kim, Park, and Kim, 2009; Pan, Horng, Chen, and Huang, 2007; Shakib, Islam, and Misran, 2010; Tiang, Islam, Misran, and Mandeep, 2011; Yoon *et al*., 2009). A dimension of 61mmx51.5mm antenna has reported (Jan and Wang, 2009) where a pair of parasitic strips introduced to achieve an operating bandwidth of 108.7%. A parasitic U shaped open stub (Lee *et al*., 2009) and a trapezoidal ground (Pan *et al*., 2007) are also used to the design of the antenna for WLAN/WiMAX applications. Another compact multiband antenna (Mobashsher, Islam, and Misran, 2011; Samsuzzaman, Islam, and Mandeep, 2012) has designed length, the feed point position where the authors only varying the slot's construction, width, and length, the CPW gap and feed point position. A CPW-fed dual wideband antenna formed by a triangular monopole and a U- shaped monopole is acquired (Chu and Ye, 2010). A conducting triangular section for dual band operation and a multiband inverted-L monopole with zigzag wire (Chen, Chen, and Cheng, 2003) and a microstrip fed printed double-T monopole antenna (Kuo and Wong, 2003) has mentioned to deliver dual band characteristics to cover the 2.4/5.2 and 5.8 GHz WLAN bands. A dual broadband slot antenna (J.-W. Wu, Hsiao, Lu, and Chang, 2004) is narrated, in which the two wide resonant frequencies were achieved by using a U-shaped strip inset at the centre of the slot antenna of dimensions 75 mm × 75 mm on a substrate of relative permittivity 4.7 and thickness 0.8 mm. The dual-band WLAN dipole antenna (Zhang, Iskander, Langer, and Mathews, 2005) is reported that is fabricated on FR4 substrate with dimensions 12 mm × 45 mm and uses an internal matching circuit to cover the three WLAN bands properly. Anyway, most of them have large dimensions and do not pay consideration on the interference repression, because there are many other existing narrowband services such as c band satellite communications that have engaged some licensed frequency bands, which may result in lower performance of interference suppression. To keep away from the problem several antennas with multi resonated frequency are studied (Nithianandam, 2009; Vyas, Sharma, and Singhal, 2012; C. M. Wu, 2007; Yoon *et al*., 2009) which have good impedance bandwidth and radiation pattern, but these antennas have also either large size or inadequate frequency constraint.

In this article, a dual band resonant antenna for WLAN/C band applications is proposed, which is fed by a coplanar waveguide (CPW). The antenna mainly comprises a ground with a big circular slot in the centre,

ARPN Journal of Engineering and Applied Sciences

rectangular feeding strip as radiating patch, and introducing two pair of asymmetrical planer inverted L-shaped slits connecting the ground. Compared to those designs shown in the literature, the antenna not only better performance of interference suppression but also compact size, large bandwidth and high gain. The simulated results about impedance bandwidth, radiation pattern and gain are discussed in detail in the next section.

ANTENNA DESIGN

The microstrip patch antenna analysis is represented by some models such as the transmission line model, cavity model, full wave model and characteristic mode. The cavity model is more accurate and gives a good physical insight thus very complex compared to the transmission line model that is the simplest of all models and less accurate. The characteristic mode is typically performed on electrically small to intermediate size antennas for simplicity (M. T. Islam, Shakib, and Misran, 2009; Misran, Islam, Shakib, and Yatim, 2008). However, the full wave model is the most accurate and complex of the models and can analyze single elements, arbitrary shaped elements and infinite antenna arrays. The transmission line model is used in this work because of its simplicity to implement and its output good performance in antenna designs in terms of efficiency and return loss and also it is well suited for microstrip patch antenna design. By choosing operating frequency f and a substrate with the required permittivity, and also defining the substrate thickness h, the design starts. Based on the transmission line model, the length L and width W of the patch are calculated as (Balanis, 2012):

$$W = \frac{c}{2f_o}\sqrt{\frac{\varepsilon_r + 1}{2}} \quad (1)$$

$$L = \frac{c}{2f_o\sqrt{\varepsilon_e}} - 2\Delta l \quad (2)$$

Where L is the length of the patch, W is the width of the patch, f_o is target resonance frequency, c is the speed of light in a vacuum and the effective dielectric constant can be calculated by the equation:

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r + 1}{2}\sqrt{\left(1 + \frac{10h}{W}\right)} \quad (3)$$

Where h is the thickness of the substrate and ε_r is the dielectric constant of the substrate. Because of the fringing field around the periphery of the patch, electrically the antenna looks larger than its physical dimensions. Δl takes this effect in account and can be expressed as:

$$\Delta l = 0.412h\frac{(\varepsilon_r + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_e - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (4)$$

Geometrical layout of the proposed antenna is shown in Figure-1. In this design the antenna structure is based on a wide-circular-slotted ground, two pairs of APIL's in the circular slot with the shorter end connecting with the ground, and the CPW feeding strip, as can be observed in Figure-1. The APIL's are applied to achieve the two band performances with sufficient VSWR less than 2. A rectangular is taken as overall design, and then cutting a circular slot in the middle of the rectangular. The antenna is imprinted on a 40 mm x 30 mm fibre glass resin FR4 substrate with dielectric constant of 4.6, thickness of 1.6 mm and a loss tangent of .02, and fed by a 50Ω CPW transmission line two pairs of asymmetrical slots are inserting in to the slotted area. Another rectangular slits are inserting in to the circular slots as CPW feed. The optimal geometrical parameters of the proposed antenna are obtained by using Finite Element Method based simulation software simulator HFSS. The optimal dimensions are determined as follows (unit’s mm): L=40, W=30, R=14, L1=17, W1=4, L2=6.12, L3=12, L4=5, L5=4.67, g=0.5, W2=1.

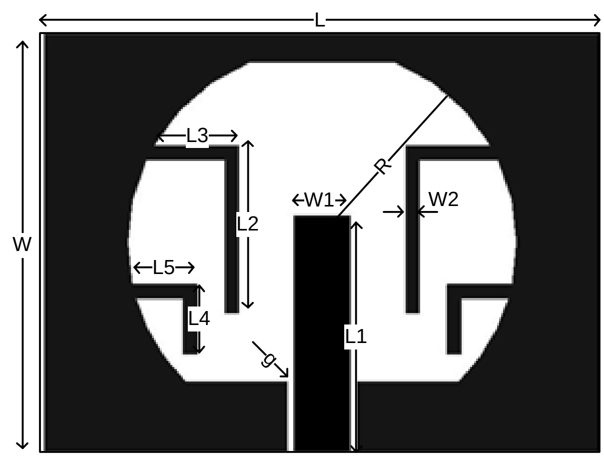

Figure-1. Proposed antenna geometric layout.

RESULTS AND DISCUSSIONS

The voltage standing wave ratio (VSWR) of the proposed antenna is shown in Figure-2. The value of VSWR is less than 2 that is found from the graph apparently. The Gain of the proposed dual frequency slotted circular antenna is shown in Figure-3. The obtained average gains are 2.86 dBi for the lower band and 7.73 dBi for the upper band. Cross-polarization level is higher at H-plane at the lower band. As a result, the gain at the lower band is lower than that at the higher band. Figure-4 shows that the result of radiation efficiency of the proposed antenna. The radiation efficiency is 89.45% in the lower band and 97.97% at the higher band in the proposed antenna. This efficiency is broadly appropriate for WiMAX/C band applications.

VOL. 8, NO. 8, AUGUST 2013 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

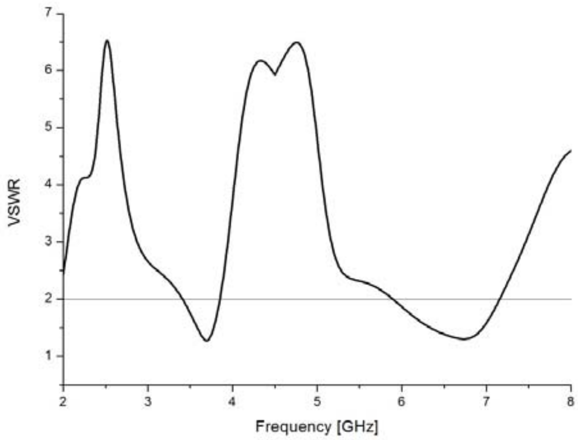

Figure-2. VSWR of the proposed antenna.

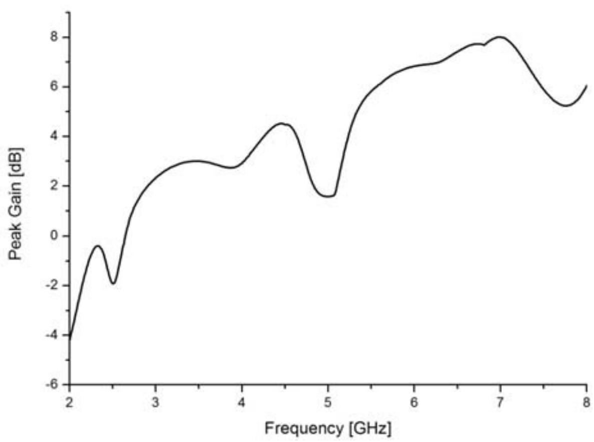

Figure-3. Peak gain of the proposed antenna.

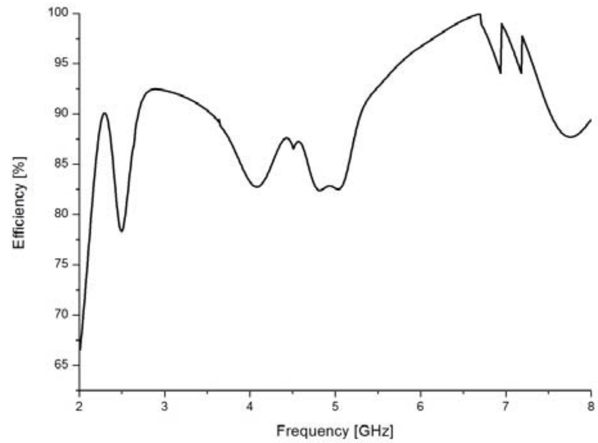

Figure-4. Radiation efficiency of the proposed antenna.

The radiation patterns of the proposed antenna on the E-plane and H-plane at resonant frequencies of 3.70 GHz and 6.75 GHz are shown in Figure-5. Good broadside radiation patterns are observed, and the two frequencies have the same polarization planes. The co-polarization level in the E and H -plane at the both band is relatively low, which is expected to be due to the diffractions from the edges of the small ground plane. This cross-polarization level may be decreased by enlarging the ground plane size. It is shown from the results that significant directional and omni directional radiation patterns are obtained along the E-plane and H-plane respectively. This characteristic is convenient because the propagation environment of wireless communications devices is usually very complicated in practice.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

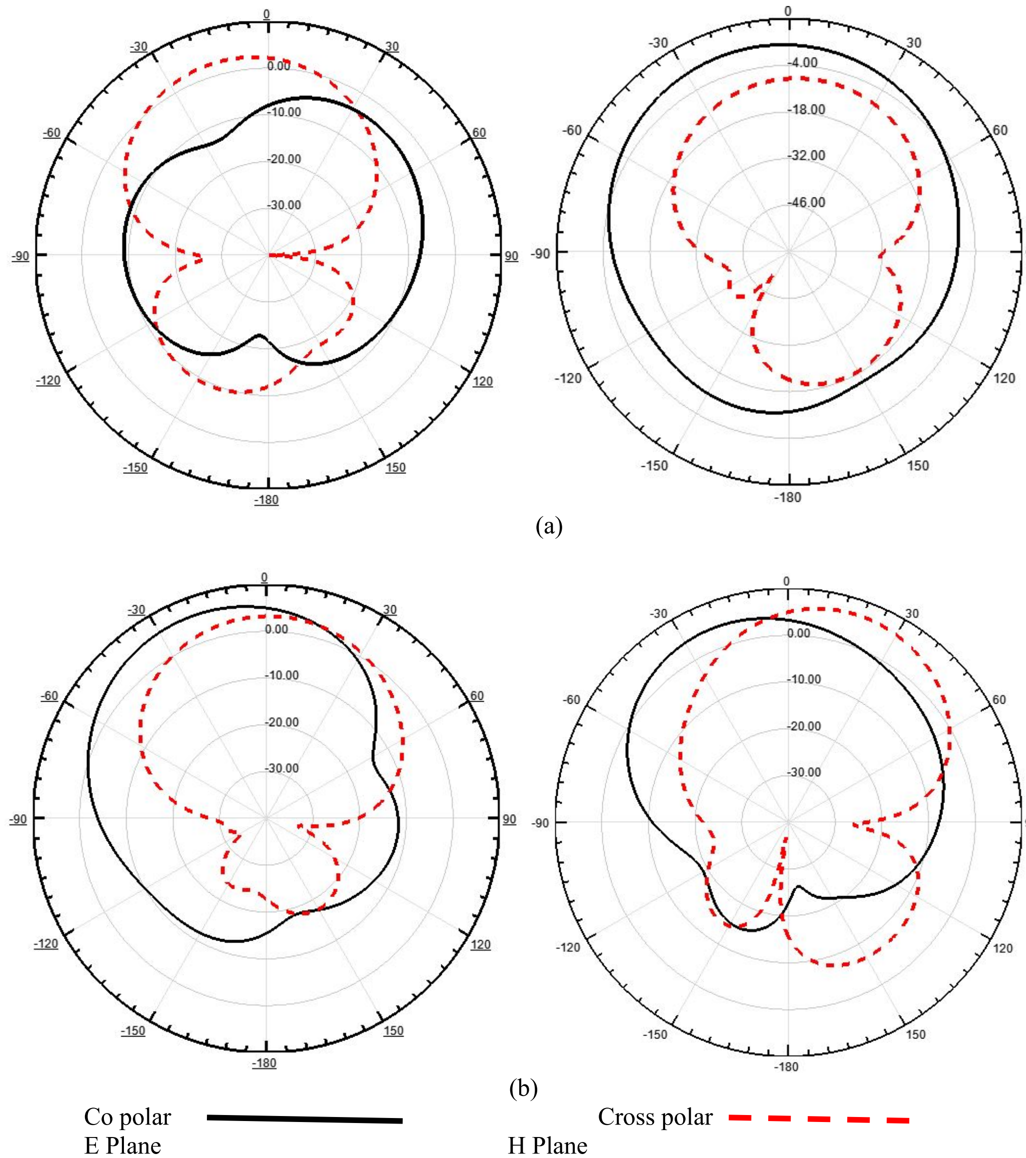

Figure-5. Radiation pattern of the proposed antenna.

CONCLUSIONS

A CPW-fed circular-slot antenna with two asymmetric pairs of planar inverted L strips has been proposed and studied. The obtained two operation bands of the proposed antenna are ranging from 3.35-3.85 GHz and 5.90-7.15 GHz which are wide enough to cover the required bandwidth of the WiMAX/C band applications. The proposed antenna has a gain at 3.70/6.75 GHz is 2.86 dBi, and 7.73 dBi, respectively and achieve less cross polarization in both the principal planes. Finally, the proposed antenna has good performance of interference suppression, excellent resonance character, nice radiation pattern, and compact in size. This designate that the proposed antenna is well suited for WiMAX/C band applications.

REFERENCES

Anguera J., Daniel J. P., Borja C., Mumbru J., Puente C., Leduc T. and Van Roy P. 2010. Metallized foams for antenna design: Application to fractal-shaped Sierpinski-carpet monopole. Progress in Electromagnetics Research. 104: 239-251.

Azim R., Islam M. T., Misran N., Cheung S. W. and Yamada Y. 2011. Planar UWB antenna with multi-slotted ground plane. Microwave and Optical Technology Letters. 53(5): 966-968.

Balanis C. A. 2012. Antenna theory: analysis and design: Wiley-Interscience.

Chen H.-D., Chen J.-S. and Cheng Y.-T. 2003. Modified inverted-L monopole antenna for 2.4/5 GHz dual-band operations. Electronics Letters. 39(22): 1567-1568.

Chu Q.-X. and Ye L.-H. 2010. Design of compact dual-wideband antenna with assembled monopoles. Antennas and Propagation, IEEE Transactions on. 58(12): 4063-4066.

Faruque M. R. I., Islam M. T. and Misran N. 2011. Analysis of electromagnetic absorption in mobile phones using metamaterials. Electromagnetics. 31(3): 215-232.

Islam M. T., Faruque M. R. I. and Misran N. 2011. Electromagnetic (EM) absorption rate reduction of helix antenna with shielding material for mobile phone application. Australian Journal of Basic and Applied Sciences. 5(3): 120-133.

Islam M. T., Shakib M. N. and Misran N. 2009. Multi-slotted microstrip patch antenna for wireless communication. Progress in Electromagnetics Research Letters. 10: 11-18.

Jan J.-Y. and Wang L.-C. 2009. Printed wideband rhombus slot antenna with a pair of parasitic strips for multiband applications. Antennas and Propagation, IEEE Transactions on. 57(4): 1267-1270.

Kuo Y.-L. and Wong K.-L. 2003. Printed double-T monopole antenna for 2.4/5.2 GHz dual-band WLAN operations. Antennas and Propagation, IEEE Transactions on. 51(9): 2187-2192.

Lee J. N., Kim J. H., Park J. K. and Kim J. S. 2009. Design of dual□band antenna with U□shaped open stub for WLAN/UWB applications. Microwave and Optical Technology Letters. 51(2): 284-289.

Misran N., Islam M. T., Shakib M. N. and Yatim B. 2008. Design of broadband multi-Slotted microstrip patch antenna for wireless system. International Conference of Recent Advances in Microwave Theory and Applications, MICROWAVE 2008, 23-25.

Mobashsher A. T., Islam M. T. and Misran N. 2011. Loaded annular ring slot microstrip antenna for wideband and multi-band operation. Microwave Journal. 54(9): 146-158.

Nithianandam J. 2009. A wide-band CPW patch-slot antenna for telemetry applications.

Pan C.-Y., Horng T.-S., Chen W.-S. and Huang C.-H. 2007. Dual wideband printed monopole antenna for WLAN/WiMAX applications. Antennas and Wireless Propagation Letters, IEEE. 6: 149-151.

Pei J., Wang A.-G., Gao S. and Leng W. 2011. Miniaturized triple-band antenna with a defected ground plane for WLAN/WiMAX applications. Antennas and Wireless Propagation Letters, IEEE. 10: 298-301.

Samsuzzaman M., Islam M. T. and Mandeep J. S. 2012. Design of a compact new shaped microstrip patch antenna for satellite application. Advances in Natural and Applied Sciences. 6(6): 898-903.

Shakib M. N., Islam M. T. and Misran, N. 2010. Stacked patch antenna with folded patch feed for ultra-wideband application. IET Microwaves, Antennas and Propagation. 4(10): 1456-1461.

Tiang J. J., Islam M. T., Misran N. and Mandeep J. S. 2011. Circular microstrip slot antenna for dual-frequency RFID application. Progress in Electromagnetics Research. 120: 499-512.

Vyas K., Sharma A. K. and Singhal P. K. 2012. A novel CPW fed multiband circular microstrip patch antenna for wireless applications.

Wu C. M. 2007. Dual-band CPW-fed cross-slot monopole antenna for WLAN operation. Iet Microwaves Antennas and Propagation. doi: DOI 10.1049/iet-map:20050116. 1(2): 542-546.

Wu J.-W., Hsiao H.-M., Lu J.-H. and Chang S.-H. 2004. Dual broadband design of rectangular slot antenna for 2.4 and 5 GHz wireless communication. Electronics Letters. 40(23): 1461-1463.

Yoon C., Lee W. J., Kang S. P., Kang S. Y., Lee H. C. and Park H. D. 2009. A planar CPW□fed slot antenna on thin substrate for dual□band operation of WLAN applications. Microwave and Optical Technology Letters. 51(12): 2799-2802.

Zhang Z., Iskander M. F., Langer J.-C. and Mathews J. 2005. Dual-band WLAN dipole antenna using an internal matching circuit. Antennas and Propagation, IEEE Transactions on. 53(5): 1813-1818.