Pakistan Journal of Science, 71 (4 Suppl.): 2019, Page 103-105
ISSN: 2411-0930

RECTANGULAR ANTENNA WITH VERTICAL SLOTS IMPLEMENTED FOR WLAN APPLICATIONS

Q. Awais[1, *], M.N. Khan[2], T. Zahid[3], K. Mehboob[1], M.H. Malik[4], M. Jamil[5] and M. Farasat[6]

[1]Department of Electrical Engineering, Chenab College of Engineering and Technology, Gujranwala, Pakistan
[2]Department of Electrical Engineering, The University of Lahore, Lahore, Pakistan
[3]Department of Electrical Engineering, Riphah International University, Lahore, Pakistan
[4]Department of computing, Global College of Engineering & Technology, Oman
[5]Department of Electrical and Computer Engineering, Memorial University of Newfoundland, Canada
[6]Department of Electrical and Data Engineering, University of Technology, Sydney,
[*]Corresponding author's E-mail: qasim.awais@yahoo.com

ABSTRACT: In this paper slot lines are introduced in WLAN antenna that has compact size of 97mm x80 to enhance the bandwidth. CPW feed mechanism is implemented which enables the system to be tuned at wide range of frequencies. The size of capacitive slots is optimized to better match 2.45 GHz frequency with Ansoft HFSS 16.0 and FR4 substrate with the thickness of 1.6 mm having loss tangent of 0.002 is chosen due to inherent benefits of low-cost and ease of fabrication. Excellent Impedance matching of 50.06 Ω is achieved at 2.05 GHz-2.74GHz band and current distribution of 6.7 A/m^2 is observed at designated WLAN band.

Keywords: CPW antenna, slot antenna, WLAN, impedance bandwidth

INTRODUCTION

With the modernization of wireless communication number of devices is increasing exponentially. New paradigm of Internet of Things (IoT) is being implemented with the conjunction of 5G and WLAN in which all connected devices will communicate with each other intelligently. Various efficient antenna systems (Alibakhshi Kenari *et al.*, 2015, Liu *et al.*, 2010) are proposed to support these communications. Major requirements of communicating antenna system are small size, high gain and light weight which can be accomplished using coplanar waveguide (CPW) design. Other important features include low cost, reduced complexity and low power handling (Rabbani and Ghafouri-Shiraz, 2014; Pirhadi *et al.*, 2012, Chung and Chaimool, 2012). Wideband/multiband functionality in antenna systems has become fundamental requirement to better use crowded wireless spectrum. Many design topologies have been implemented to achieve these attributes using slit lines defected ground structures (Khan *et al.*, 2018), using array of metal structures (Alibakhshi-Kenari *et al.*, 2015) and tapering patch antennas (Chen *et al.*, 2014). However, the constraint of narrow bandwidth is not completely addressed using these techniques.

MATERIALS AND METHODS

The antenna proposed in this paper address this shortcoming that is compact in size with acceptable bandwidth requirements for WLAN 2.45 GHz band which is universally adopted and accepted frequency band. The idea of continuous CPW ground with vertical slots is implemented to achieve the wide impedance bandwidth. At first Continuous ground structure with CPW feed is designed and then rectangular metal patch is added for 2.45 GHz band. Afterwards, vertical slots have been etched through iterative correction process. Width and length of slots is adjusted to better achieve the distributed current densities which in turn produce efficient radiation pattern at far field with better gain parameters. Design analysis and results are analyzed in second part of this paper and later conclusion is drawn to summarize the findings.

Microstrip antennas are versatile in geometrical shapes and can be easily implemented on inexpensive materials for specific applications. Carefully designed antennas have low profile, lightweight and limited power handling capabilities to provide high data rate for modern communication systems. There are some basic parameters such as substrate thickness that can be used to reduce the size of the antenna with improved efficiency, low losses and higher bandwidth. In literature rectangular, circular and tapered ground structures have been analyzed and similarly, this design investigates continuous ground structure with its effects on antenna performance. Detailed geometrical dimensions are illustrated in Figure 1. Length" L" and width "W" of the substrate is 97 mm and 80 mm respectively. Length of patch "Y" and width of radiating patch "X" is set to be 29 mm and 38 mm. Similarly, the width of feed line "Z" is 3.3 mm and the gap between the feed and ground is 1.3 mm. Length of the feed line is designed to be 34.2 mm.

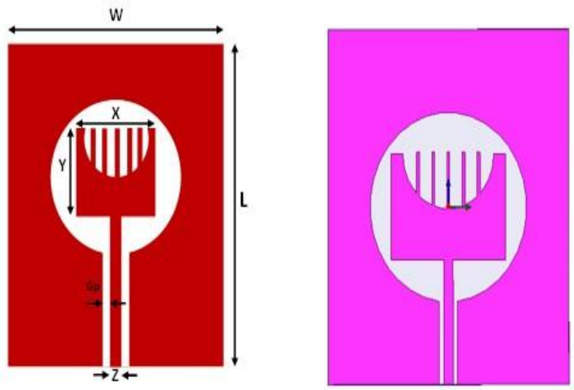


Figure 1: Geometric model of slotted rectangular antenna

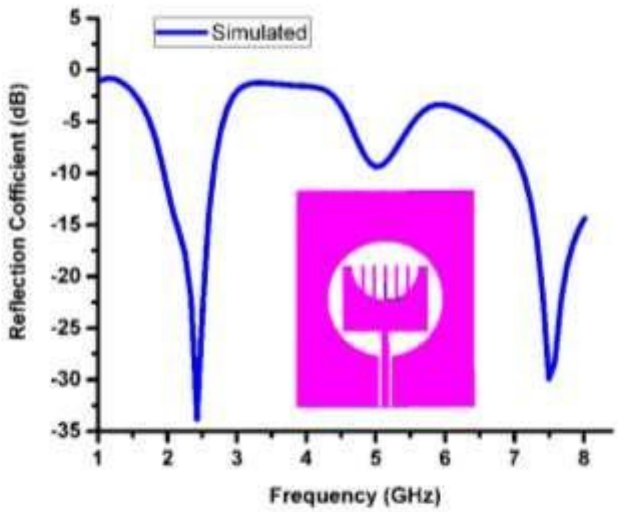


Figure 2: Reflection coefficient plot of slotted rectangular antenna

Five symmetrical slots have been created on the top of the major circular slot in the patch to improve the radiation pattern of the antenna and widen the operational bandwidth. Traditionally, slots have been used in antenna designs to improve the antenna performance as this technique effectively increases the current distribution on the radiator surface.

RESULTS AND DISCUSSION

Simulated reflection coefficient of this novel design with five slots in the main patch is shown in the Figure 2. Reflection coefficient measured at 2.45 GHz is -34.8 dB and wide bandwidth is calculated from 2.05 GHz to 2.74 GHz. This design also finds second resonance band at 7.5 GHz with S_{11} value of -29 dB. Variation of slot width has slightly improved the overall bandwidth but at WLAN band it does not have much effect. Voltage standing wave ratio without slots is calculated to be 1.25 and with the incursion of slots it is improved to 0.62 at 2.45 GHz which is quite improvement due to the even current distribution at upper patch. In the beginning, this design exhibit three resonance bands and when impedance is matched at designated frequency, only two prominent bands are obtained. As per our design requirement, this antenna performs well at the required frequency and reflection coefficient is further improved by adding adjacent slots. Small variation in reflection coefficient curve is visible that means this antenna can be configured to support future 5G frequency band when desired.

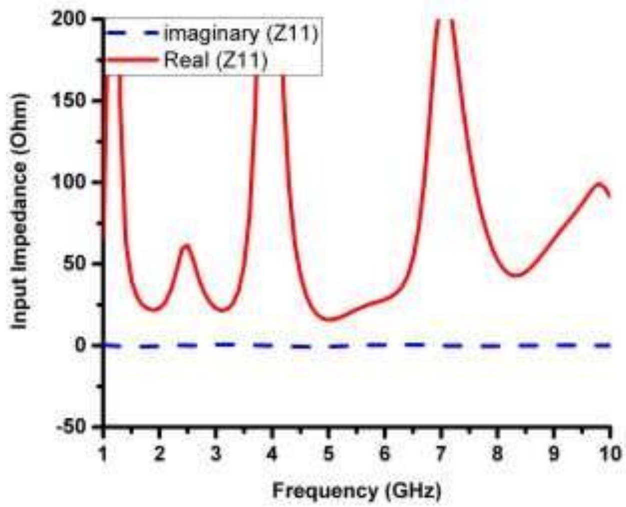


Figure 3: Input impedance of slotted rectangular antenna

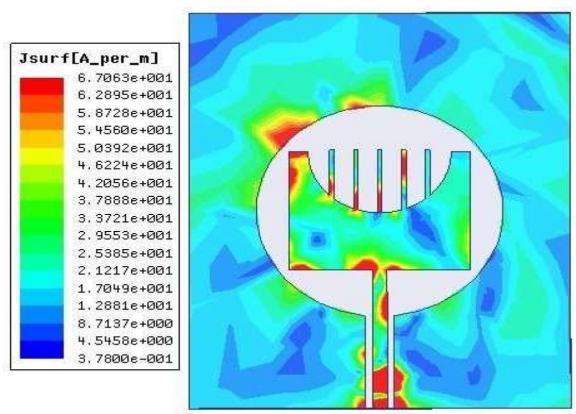
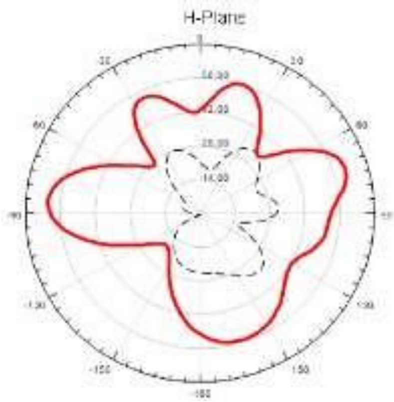


Figure 4: surface current distribution of slotted rectangular antenna (SRA)

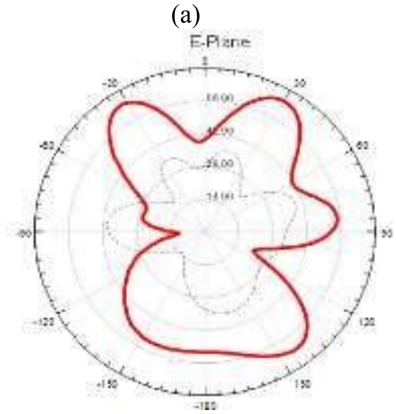
Real and imaginary parts for impedance matching at 2.45 GHz are shown in Figure 3. Imaginary part of impedance is almost constant at zero with very small variations from 0.002Ω to 0.010 Ω while real part is 50.06 Ω. Real manufactured devices some time face issues of impedance mismatching with minor changes due to soldering and in case of metal housing. Therefore, this design is suitable for scenarios where constant power source is available without any metallic surroundings.

Maximum current at the bottom of feed line and at the top of radiating patch is measured. The creation of slots in the main patch is justified as it diverts more current towards the other parts of this antenna. All the slots exhibit high current density due to proper spacing and dimension. Overall satisfactory vector current distribution is calculated on all surfaces except top left and top right corners. Maximum surface current distributions at 2.45 GHz is measured to be 6.7 A/m^2 as depicted in Figure 4.

The radiation pattern of this antenna is flexible in terms of coverage both at E & H planes. Five major angles 300, -300, 900, -1800 and 600 are covered for H-plane and similar kind of pattern at E-plane is observed as illustrated in Figure 5 (a), (b).



(a)



(b)

Figure5: Radiation pattern at H-plane of SRA, (b): Radiation pattern at E-plane of SRA

While comparing radiation patterns of this antenna with literature, it is clearly noted that related designs mostly have 2-dimensional/3-dimensional radiation patterns. In this design, radiation patterns are plotted against radiation efficiency values which implies that overall radiation efficiency is acceptable at implemented frequency and antenna meets the required performance for RF energy harvesting. This antenna with the size of 97 mm X 80 mm produce high gain at the maximum radiation angles. Maximum gain at 2.45 GHz is measured to be 6.85 dB that is well above average for microstrip design with continuous ground structure. By analyzing all the technical details of this design, we can conclude that this design is suitable for RF application where we have space for comparatively compact antenna. The gain of antenna at WLAN band is obtained to be 4.9 dB

Conclusion: A novel CPW antenna (97mm x 80 mm x1.6mm) is proposed to operate at 2.45 GHZ WLAN band with wide impedance bandwidth. By properly choosing the location and size of slots in main radiator dual band characteristics are achieved with tri-directional like radiation pattern at E-plane & H-plane. The gain of antenna is 4.9 dB at 2.45 GHz which is suitable candidate for future 5G and WLAN applications.

REFERENCES

Alibakhshi K., M., M.N. Moghadasi, B.S. Virdee, A. Andújar and J. Anguera (2015). Compact antenna based on a composite right/left handed transmission line. Microwave and Optical Technology Letters, 57(8), 1785-1788.

Chen, H.M., Y.F. Lin, C.H. Chen, C.Y. Pan and Y.S. Cai (2014). Miniature folded patch GPS antenna for vehicle communication devices. IEEE transactions on antennas and propagation, 63(5), 1891-1898.

Chung, K.L. and S. Chaimool (2012). Broadside gain and bandwidth enhancement of microstrip patch antenna using a MNZ metasurface. Microwave and Optical Technology Letters, 54(2), 529-532.

Khan, M.N., S.O. Gilani, M. Jamil, A. Rafay, Q. Awais, B.A. Khawaja, M. Uzair and A.W. Malik (2018). Maximizing throughput of hybrid FSO-RF communication system: An algorithm. IEEE Access, 6, 30039-30048.

Liu, H.W., C.H. Ku and C.F. Yang (2010). Novel CPW-fed planar monopole antenna for WiMAX/WLAN applications. IEEE Antennas and wireless propagation letters, 9, 240-243.

Pirhadi, A., H. Bahrami and A. Mallahzadeh (2012). Electromagnetic Band Gap (EBG) Superstrate Resonator Antenna Design for Monopulse Radiation Pattern. Applied Computational Electromagnetics Society Journal, 27(11).

Rabbani, M.S. and H. Ghafouri-Shiraz (2014). Simple methods for enhancing bandwidth of a rectangular microstrip patch antenna. In 2nd IET Annual Active and Passive RF Devices Seminar (pp. 1-4). IET.