IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol. 8, Issue.10, October 2020 E-ISSN: 2347-2693

Tunable Monopole Circular Microstrip Antenna for tuning WLAN, Radar and Satellite Communication Applications

Biradar Rajendra[1*], S. N. Mulgi[2]

[1,2]Dept. of Applied Electronics, Gulbarga University, Kalaburagi-585106, Karnataka, India

[*]*Corresponding Author: biradarrajendra1864@gmai.com, Tel.: +91-9449140205*

DOI: https://doi.org/10.26438/ijcse/v8i10.4851 | Available online at: www.ijcseonline.org

Received: 13/Oct/2020, Accepted: 21/Oct/2020, Published: 31/Oct/2020

Abstract— This paper presents a design and development of slot and stub loaded tunable monopole circular microstrip antenna for different frequency of microwave communication applications. The antenna proposed is loaded with a U-slot, two I-slots and J- slot over the patch. The dimensions of U-slot, J-slot and upper I-slot are fixed. The one of the I-slot loaded over the patch on opposite side of J–slot is varied to achieve tuning in the WLAN, C and X band frequency ranges. When dimensions of I-slot is changed to 0.722cm, 0.755cm and 0.76 cm and corresponding resonant frequencies are lies at 5.815GHz, 4.825GHz and 4.69GHz at left band where as for right band the resonant frequencies are lies at 7.84GHz, 7.7725GHz and 7.8625GHz respectively. The bandwidth required for WLAN band of 5-22MHz is fulfilled in designed antenna and also for C and X bands. The optimum impedance bandwidth (IBW) of proposed antennas for left and right band is 29.43 % and 42.89 % having peak gain of 2.11 dBi and 2.72 dBi respectively. The radiation patterns are omni directional in nature in both E and H plane.

Keywords— IBW, Notch bands, slots and stubs.

I. INTRODUCTION

In the field of personnel communication system, the wireless communication has brought great break through and it has totally changed the era of wired communication. Thus connecting two or more devices or persons over wide area for the whole globe is possible only using wireless communication. That is wireless local area network WLAN. It can connect to the wider internet and the most modern WLAN IEEE 802.11 become popular for use in the home. In this connection many researchers are involved in designing an antenna for the purpose and it is necessary to design antenna most economically using simpler method such that it should fulfil all the requirements of WLAN for the available bands like 4.9GHz, 5.0GHz and 5.9 GHz with its bandwidth requirement of 5-22MHz. Thus in the proposed antenna, I have designed an antenna using simple conventional method of stub and slot loading over the radiating patch. The antenna is designed by loading fixed U-slot, upper I-slot and J-slot over the radiating patch with varying the dimensions of left I-slot to get tuning of frequencies in the entire WLAN range [1-3]. Further, the antenna can also be tuned for C and X band applications. Thus, the designed antenna covers international telecommunication union (ITU) designated applications of space to earth (7.25-7.75GHz) and earth to space (7.9-8.4GHz). Apart from this, left band covers applications of long range tracking, air borne weather in C band range of (4-8GHz) and right band covers applications like short range tracking, marine radar, and missile guidance, environmental and military communications satellites in X band range of (8-12GHz). The peak gain for left and right band is 2.11dBi and 2.72dBi with the maximum impedance bandwidth of 29.43% and 42.89% respectively. The radiation patterns are omni directional in nature in both E and H plane.

II. DESCRIPTION OF ANTENNA GEOMETRY

The conventional monopole circular microstrip antenna (CMCMSA) is designed using low cost modified glass epoxy of thickness h=1.6mm with relative permittivity ε_r = 4.2. The antenna is fed using microstripline feeding because of its simplicity and it can be simultaneously fabricated along with the antenna element. The radius of this antenna can calculated using equation (1 and 2) [4-5].

$$a = \frac{K}{[1 + (2h/\pi \epsilon_r k)\{ln(\pi k/2h) + 1.7726\}]^{-1/2}} \quad ...(1)$$

Where k = 8.794 / $f \epsilon_r^{1/2}$

$$a_e = a\left\{1 + 2h/\pi \epsilon_r a\left[ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2} \quad ....(2)$$

Figure 1 shows top view geometry of CMCMSA in which W_f and L_f are width and length of microstrip feed line where as W_g and L_g are width and length of ground plane.

Figure 2 shows return loss verses frequency of monopole CMCMSA and it resonates at 1.99 GHz.

Figure 3 shows top view geometry of tunable monopole circular microstrip antenna for WLAN, radar and satellite communications and this antenna is having the same basic design as that of conventional monopole CMSA as shown in Figure 1. The monopole CMSA has been modified into the proposed antenna by loading U; J-slot with stub and I-slots over the patch of fixed dimensions and the dimensions of another I-slot L_7 loaded opposite to J-slot is varied to tune both Left and right bands [6-7]. The design parameters of the proposed antennas are given in Table 1.

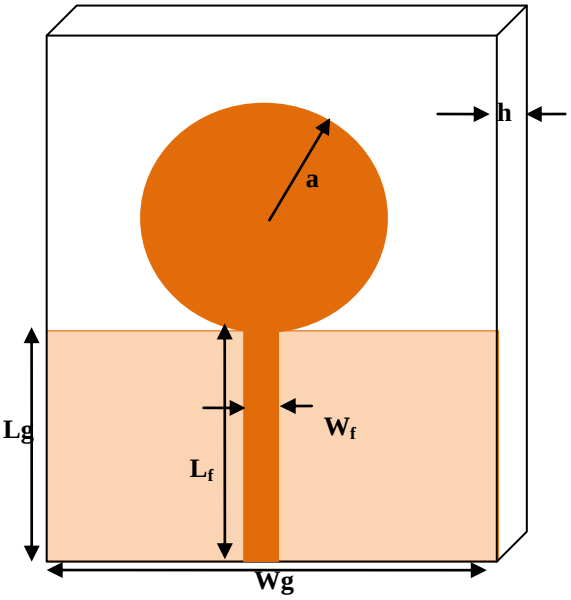

Figure 1. Geometry of CMCMSA

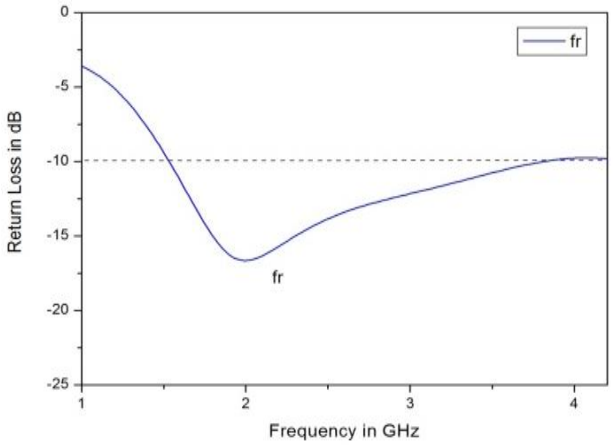

Figure 2. Variation of return loss verses frequency of CMCMSA

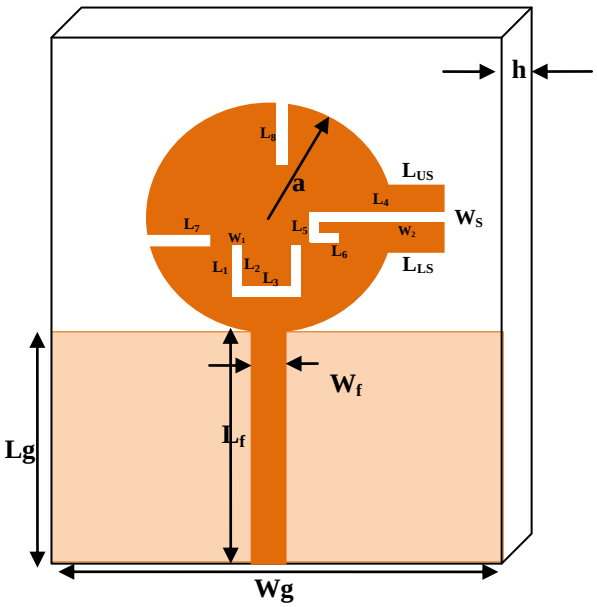

Figure 3. Geometry of proposed antenna

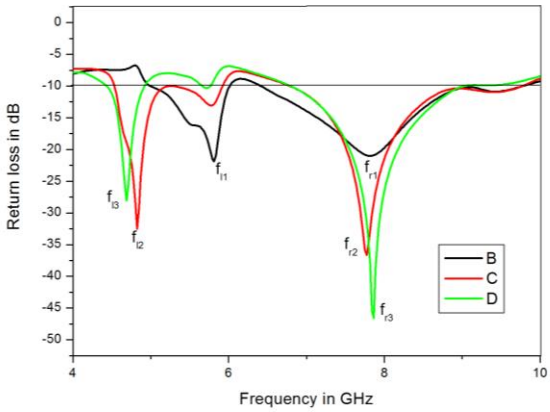

Figure 4. Variation of return loss verses frequency of Antenna

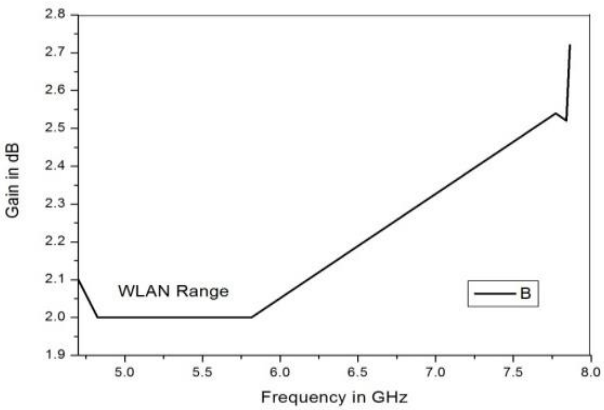

Figure 5.Variation of gain verses frequency of proposed antenna

Table 1. Design parameter of proposed tunable monopole circular microstrip antenna for left and right band.

For constant stub width Ws=0.8cm and lengths of stub L_{US}=0.568cm and L_{LS} =0.457cm with fixed dimensions of U-slot that is L_1=0.8cm, L_2=0.7cm, L_3=0.6cm and W_1=0.1cm and length of J-slot L_4 =1.4 cm, L_5 = 0.3cm, L_6 =0.8cm and L_8 =0.882cm						
Variation of dimensions of I-slot in cm.	Left band resonant frequencies in GHz	Return loss in dB	Impedance bandwidth in %	Right band resonant frequencies in GHz	Return loss in dB	Impedance bandwidth in %
L_7 = 0.722	$f_{l1=}$5.815	21.88	17.533	$f_{r1=}$7.8400	20.96	42.89
L_7 = 0.755	$f_{l2=}$4.825	32.36	29.43	$f_{r2=}$ 7.7725	36.51	39.06
L_7 = 0.760	$f_{l3=}$4.690	28.00	10.21	$f_{r3=}$7.8625	46.59	28.14

III. RESULT AND DISCUSSION

Figure 4 shows the variation of return loss verses frequency of proposed antenna. When the dimensions of L_7 of I-slot is changed to 0.722cm, 0755 and 0.760 then **t**he resonant frequencies of left and right bands are changes from f_{l1} to f_{l3} and f_{r1} to f_{r3} respectively. The resonant frequencies for left band is 5.815GHz, 4.825GHz and 4.69GHz with impedance bandwidth in percentages are 17.53, 29.43 and 10.21 having gain of 2.0dBi,2.0dBi and 2.11dBi and for right band it is 7.84GHz, 7.7725GHz and 7.8625GHz having impedance bandwidth are 42.89,39.06 and 28.14 having peak gains are 2.52dBi, 2.54dBi and 2.72dBi respectively. The left band tunes towards left from f_{l1} to f_{l3} that is from 5.815GHz to 4.69 of total shift towards left is 1.12GHz where as right band tunes from f_{r1} to f_{r3} that is from 7.84GHz to 7.7725GHz of total shift towards left is 67.5MHz and again it is shifting towards right to 9MHz.The useful left band of resonant frequency 4.825GHz having band width of 1.42GHz (4.5024-5.9226GHz) covers complete WLAN bands of 4.9GHz, 5GHz and 5.9GHz with required band width of 5-22MHz is achieved [8-10]. The useful right band of resonant frequency 7.7725GHz having band width of 3.0GHz (6.8112-9.7473GHz) also covers C and X band applications in Radar and satellite communications [11-12]. The optimum impedance band with (IBW) and gain for left band is 29.43% and 2.51dBi where as for right band is 42.89% and 2.72dBi respectively. When the dimensions of L_7 increases, the resonant frequency decreases because its reactance increases [13-14] and the gain of left band in the WLAN range is constant where as the gain for right band is increasing towards end applications of C and X band as shown in Figure 5[15]. The impedance band width is calculated using equation (3).

Impedance bandwidth (%) = $[(f_H - f_L)/fc]\times 100$ ....(3)

Figure 6, 7, 8, and 9 shows typical radiation pattern for the proposed antennas at 7.84GHz, 4.825GHz, 7.7725GHz and 4.69GHz respectively. The radiation patterns are Omni directional in nature in both E and H plane.

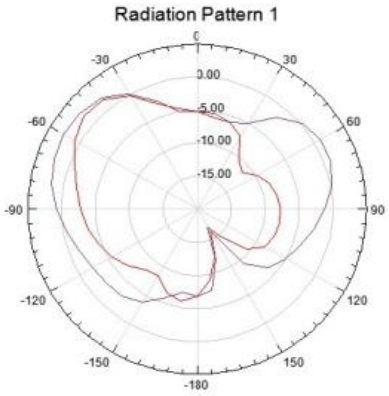

Figure 6. Typical Radiation Pattern of proposed antenna at 7.84 GHz

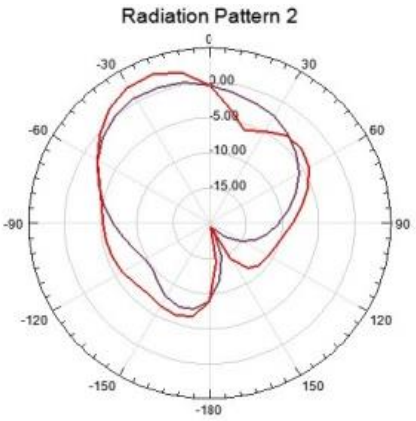

Figure 7. Typical Radiation Pattern of proposed antenna at 4.825 GHz

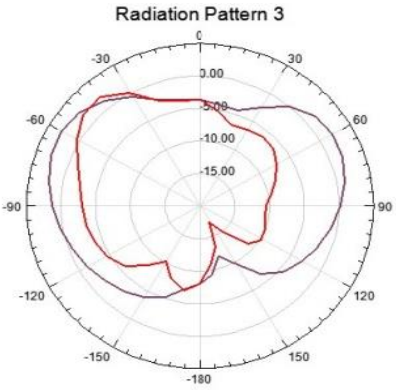

Figure 8. Typical Radiation Pattern of proposed antenna at 7.7725 GHz

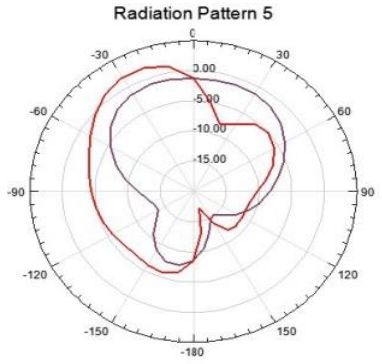

Figure 9. Typical Radiation Pattern of proposed antenna at 4.69 GHz

IV. CONCLUSION

The The proposed antennas are designed and constructed using a simple and economical method of conventional slot and stub loading techniques for the purpose of WLAN, C and X band applications. When the dimensions of I-slot changes to L_7 =0.755cm then it resonates at 4.825GHz for left band of bandwidth 1.42GHz (4.5024-5.9226GHz). This band width covers complete WLAN bands of 4.9GHz, 5.0GHz and 5.9GHz where as the right band resonates at 7.7725GHz of band width 3.0GHz (6.8112-9.7473GHz) and it covers both radar and satellite applications in the C (4-8GHz) and X (8-12GHz) band range .The gain of left band remains constant over entire WLAN band and the gain of right band is increasing over the entire band due to higher frequencies and lower impedance bandwidths. The applications for right band is long range tracking, air borne weather in the C band range and short range tracking, marine radar, and missile guidance, environmental and military communications satellites in the X band range. Thus, the peak gain of left and right bands are 2.51dBi and 2.72dBi with impedance band width of 29.43dBi and 42.89 dBi respectively. The radiation patterns are Omni directional in nature in both E and H plane.

ACKNOWLEDGMENT

The author would like to thank the Department of Applied Electronics, Gulbarga University, Kalaburgi and also to the Principal, Karnatak Arts, Science and Commerce College, Bidar for support and encouragement.

REFERENCES

[1]. Kosuru Murthy, Kodidasu Umakantham and Korlapati Satyanarayana Murthy, "*Reconfigurable Notch band Monopole slot antenna for WLAN/IEEE-802.11n applications*", International Journal of Intelligent Engineering and systems, Vol.**10**, No.**6**, pp.**166-173**, **2017**.

[2]. Y. S. Li and W. X. Li, "*A Circular Slot Antenna with Wide Tunable and Reconfigurable Frequency Rejection Characteristic Using Capacitance Loaded Split-Ring Resonator for UWB Applications*", Wireless Personal Communications, Vol. **78**, No.**1**, pp.**137-149**, March **2014**.

[3]. Pooja J and and Divyanshu Gupta, " Design and Analysis of Half I-U, Half I-F, and Half I-B Microstrip Patch Antenna for Wireless Applications", International Journal of Computer Sciencess and Engineering, Vol. **7**, Issue **4**, pp.**294-300, 2019.**

[4]. Balanis C. A., "Antenna theory, Analysis and design", 2nd Ed, Wiley, New York, **1997**.

[5]. Garg, R. P. Bhartia , I. Bhal and Hipibon, "*Microstrip Antenna Design Hand Book*", Artech Inc., **2001**.

[6]. A. E. Daniel & G. Kumar, "*Tunable dual & triple frequency stub loaded rectangular microstrip antenna (MSA)*", Proc. IEEE antennas propagation symposium, pp. **2140-2143**, **1995**.

[7]. G. Kumar and K. P. Ray, "*Broad Band Microstrip Antennas"*, Artech House, **2003**.

[8]. Yingsong Li, Wenxing Li and QiuboYe, "*A Reconfigurable Triple Notch-band Antenna integrated with defected Microstrip structure band stop filter for Ultra-Wideband cognitive Radio applications*", International Journal of Antenna and Propagation , Vol. **2013**,pp. **1-14**, 12 June **2013**.

[9]. D. Sarkar, K. V. Srivastava and K. Saurav, "*A Compact Microstrip-Fed Triple Band-Notched UWB Monopole Antenna*", IEEE Antennas and Wireless Propag. Lett., Vol.**13**, pp.**396-399**, **2014**.

[10]. Ritu Goyal and Y.K. Jain, "*A revive on Bandwidth Enhancement in Microstrip Antenna*" , International Journal of Computer Sciences and Engineering, Vol. **7**, Issue **4**, pp. **1196-1200**, Apr-**2019**.

[11]. S. Palanivel Rajan and C.Vivek, "*Analysis and Design of Microstrip Patch Antenna for Radar Communication*", Journal of Electrical Engineering and Technology, Vol. **14**, pp**. 923-929**, 21 Jan. **2019**.

[12]. M. Venkata Narayana, Govardhani Immadi,K. Rajkamal and M.S.R.S.Tejeswi, "*Microstrip Patch Antenna for C-band RADAR applications with coaxial fed*", International Journal of Engineering Research and Applications", Vol. **2**, pp. **118-122**, May-Jun. **2012**.

[13]. K. P. Ray, S. Nikhil and A. Nair, "*Compact Tunable and Dual band Circular Microstrip Antenna for GPS Bluetooth Applications*" , International Journal of Microwave and Optical Technology, Vol.**4**, No.**4**, pp.**205-210**, July **2009.**

[14]. Jia-wei Dai, Hong Li Peng, Yao-ping Zhang and Jun Fa Mao, "*A tunable microstrip patch antenna using liquid crystal*", Progress In Electromagnetics Research C , Vol.**71**, pp.**101-109**, **2017**.

[15]. V. Harsha,Ram Keerthi, Dr. Habibullah Khan and Dr. P. Srinivasulu, "*Design of C-band Microstrip Patch Antenna for Radar Applications using IE 3D*", Volume.**5**, Issue. **6**, pp. **49-58**, Mar-Apr. **2013 .**

AUTHORS PROFILE

Mr. Biradar Rajendra pursued Master of Science and Master of Philosphy from Dept of Applied Electronics, Gulbarga University, Kalaburagi, Karnataka in 1988 and 2014 respectively. He is currently pursuing Ph.D and currently working as Associate Professor in Electronics. Karnatak Arts, Science and Commerce College, Bidar, Karnataka since 1990. He has published 10 papers in National and International Journals Approved by UGC. He has organized National level workshops and symposia. His main reseaech work focusses on Tunable properties of Microstrip Antenna of different geometry. He has 30 years of teaching experience.

Dr. S. N. Mulgi pursued Master of Science, Master of Philosphy and Ph.D from Gulbarga University, Kalaburagi, Karnataka in 1986, 1987 and 2003 respectively. He is currently working as Professor, Dept of Applied Electronics, Gulbarga University, Kalaburagi, Karnataka, India since 2010. He has guided 12 Ph.D students and published more than 100 papers in National and International Journals. He has chaired many National and International Confrences, Seminars and Symposia. His area of research is Microwave communications, embeded systems etc. He has 30 years of teaching and Research experience.

