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Multi band and Triple Notch band Tunable Monopole Circular Microstrip Antenna for Wireless Applications

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Abstract— This paper presents a design and development of slot and stub loaded multi band and triple notch band tunable monopole circular microstrip antenna for different microwave communication applications. The antenna is loaded with U-slot, two identical I-slots and J-slot over the radiating patch .When the spacing between two identical I-slots is 0.21 and 0.11cm then the antenna tunes to the four required multi bands with three alternate notch bands. This tunable antenna is the replacement to the broadband antenna. The single antenna can be used to tune different microwave applications over a large range of frequencies. Thus, the antenna produces four useful bands with three alternate notch bands. The four useful bands tunes from 1.675-1.6525GHz, 2.53-2.71GHz, 5.095-5.4775GHz and 79075-7.0975GHz and three alternate notch bands tunes from 2.2375-2.3725GHz, 4.555-4.4875GHz and 5.7475-6.0625GHz respectively. These notch bands resolve the problem of crowding in the frequency spectrum and rejects Wi-Fi, UMTS, LTE, Wi-MAX, WLAN and C band frequencies. The maximum impedance bandwidth of proposed antennas for two spacing between identical I-slots is found to be 37.79 % and 48.33 % having peak gain of 2.14 dBi and 2.39 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

Now-a-days the demand increases for multiband antennas in the wireless communication applications in both industry and academics. Thus, in the literature it is found that, the many researchers designed an antenna for each application separately in the frequency spectrum. However, very less work in the lower side of UWB range where density of channels are maximum. Therefore, it is necessary to design the single antenna which can tune to different frequency of microwave communication where personnel mobile communication system functions and also for radar and satellite applications. However, in this context it is necessary to reject frequency bands where channel density is maximum in the frequency spectrum and having lot of interferences among all the channels and hence it is better to reject and avoid intra and adjacent channel interferences among them by producing multiple notch bands in the designed antenna [1]. In order to obtain required multi band and notch band characteristics, there are numerous methods available in the literature. From past few years it is seen that, the available methods for designing an antenna is to add an electromagnetic perturbation in the surface current flowing in the radiating patch or by adding the slots of different geometry like U-slot, I-slots and J-slot on a radiating patch which gives a required functions. Thus, the proposed antennas are loaded with two identical I-slots, U and J-slots over the patch. For fixed dimensions of one of the I-slot, U-slot and the stub, then by changing spacing between two identical I-slots, the antenna tunes to four useful bands and three notch bands [2]. The four useful bands and three notch bands are tuned from f_{r1} to f_{r2}, f_{n1} to f_{n2}, f_{r3} to f_{r4}, f_{n3} to f_{n4}, f_{r5} to f_{r6}, f_{n5} to f_{n6} and f_{r7} to f_{r8} and finds an applications in different microwave frequency ranges.

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 (1and 2) [3-4].

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

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 multi band and triple notch band of tunable monopole circular microstrip antenna 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 two identical I-slots, U and J-slots over the patch. The U and I-slots have fixed dimensions and by changing the dimensions of other I-slot and small arm of the J-slots to achieve multiband along with notch band functions [5-6]. The design parameters of the two proposed antennas are given in Table 1 and Table 2.

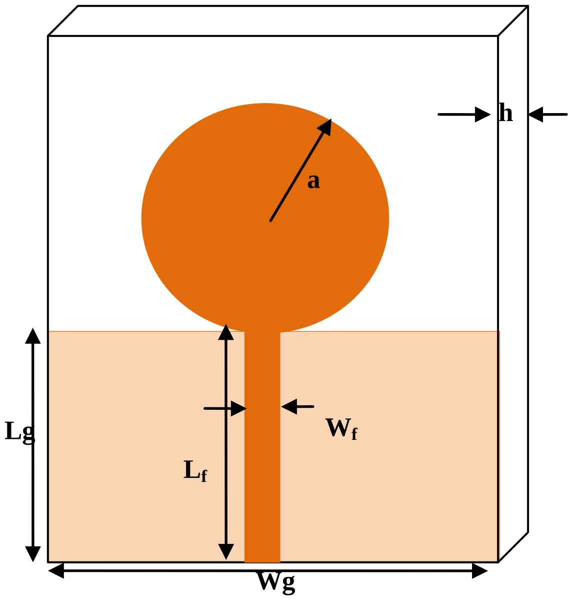

Figure 1. Geometry of CMCMSA

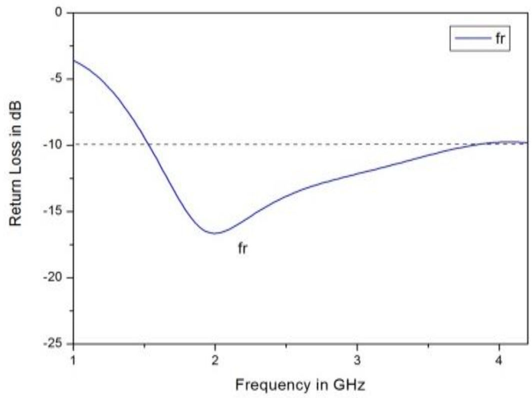

Figure 2. Variation of return loss verses frequency of CMCMSA

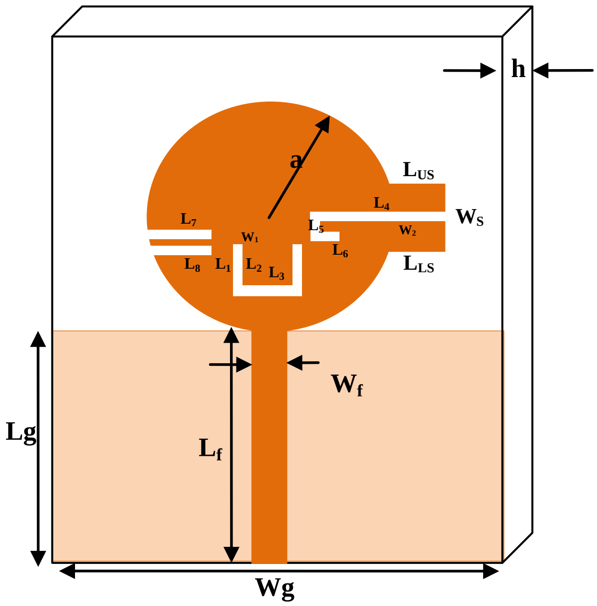

Figure 3. Geometry of proposed antenna

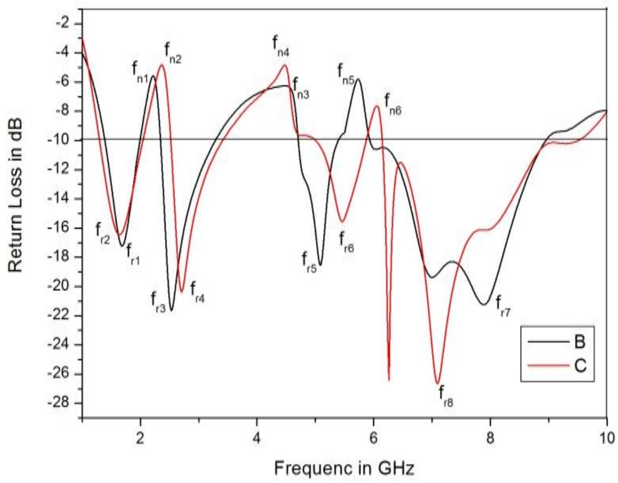

Figure 4. Variation of return loss verses frequency of Antenna

Table 1(a).Design parameter of multi band tunable monopole circular microstrip antenna for wireless Applications

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 , L_7 =0.742 cm and L_8 =0.611 cm												
Spacing between two I-slots in cm.	f_{r1} in GHz	Ret. loss in dB	IBW in %	f_{r3} in GHz	Ret. loss in dB	IBW in %	f_{r5} in GHz	Ret. loss in dB	IBW in %	f_{r7} in GHz	Ret. loss in dB	IBW in %
0.21	1.6750	17.22	36.41	2.53	21.65	37.19	5.095	18.52	13.16	7.9075	21.21	37.79

Table 1(b).Design parameter of triple notch band tunable monopole circular microstrip antenna for wireless Applications

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 , L_7 =0.742 cm and L_8 =0.611 cm									
Spacing between two I-slots in cm.	f_{n1} in GHz	Ret. loss in dB	IBW in %	f_{n3} in GHz	Ret. loss in dB	IBW in %	f_{n5} in GHz	Ret. loss in dB	IBW in %
0.21	2.2375	5.63	15.57	4.555	6.33	31.36	5.7475	5.83	9.85

Table 2(a).Design parameter of multi band tunable monopole circular microstrip antenna for wireless Applications

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 =0.7cm , L_7 =0.722 cm and L_8 =0.611 cm												
Spacing between two I slots in cm.	f_{r2} in GHz	Ret. loss in dB	IBW in %	f_{r4} in GHz	Ret. loss in dB	IBW in %	f_{r6} in GHz	Ret. loss in dB	IBW in %	f_{r8} in GHz	Ret. Loss in dB	IBW in %
0.11	1.6525	16.44	48.37	2.71	20.37	32.46	5.4775	15.50	15.43	7.0975	26.65	48.33

Table 2(b).Design parameter of triple notch band tunable monopole circular microstrip antenna for wireless Applications

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 =0.7cm , L_7 =0.722 cm and L_8 =0.611 cm									
Spacing between two I slots in cm.	f_{n2} in GHz	Ret. loss in dB	IBW in %	f_{n4} in GHz	Ret. loss in dB	IBW in %	f_{n6} in GHz	Ret. loss in dB	IBW in %
0.11	2.3725	4.82	20.19	4.4875	4.84	36.10	6.0625	7.62	4.88

III. RESULT AND DISCUSSION

Figure 4 shows the variation of return loss verses frequency of proposed antenna when spacing between I-slots is 0.21cm when dimensions of J-slot is L_6=0.7 cm**.** **T**he resonant frequencies of first useful band is at f_{r1} =1.675 GHz of bandwidth 610MHz and tunes to f_{r2}, for second useful band resonates at f_{r3} =2.53GHz of bandwidth 941MHz and tunes to f_{r4}, the third useful band resonates at f_{r5}= 5.095GHz of bandwidth 671MHz and tunes to f_{r6} and fourth useful band resonates at f_{r7} =7.9075GHz of bandwidth 2.98GHz and tunes to f_{r8} with three alternate notch bands resonates at f_{n1} =2.2375GHz of bandwidth 348MHz and tunes to f_{n2}, the second notch band resonates at f_{n3}=4.555 GHz of bandwidth 1.42GHz and tunes to f_{n4} and the third notch band resonates at f_{n5} =5.7475GHz of bandwidth 566MHz and tunes to f_{n6} [7]. The impedance bandwidth (IBW) of four useful bands in percentages are 36.41, 37.19, 13.16 and 37.79 and for three notch bands is 15.57, 31.36 and 9.85 and having peak gain of 1.67 dBi, 1.73dBi, 1.8dBi, 2.14 dBi and for notch bands it is 1.15 dBi, 2.82dBi and1.5dBi respectively as shown in Table 1 (a and b).

Similarly when spacing between two I-slots is 0.11cm when dimensions of J-slot is L_6=0.6 cm**.** The resonant frequency of first tuned useful band is at f_{r2}=1.6525GHz of bandwidth 741 MH , the resonant frequency of second tuned useful band is at f_{r4} =2.71GHz of bandwidth 880MHz , the resonant frequency of third tuned useful band is at f_{r6}=5.4775GHz of bandwidth 845MHz and the resonant frequency fourth tuned useful band is at f_{r8} = 7.0975GHz of bandwidth 3.38GHz with three alternate notch bands resonates and tunes to f_{n2}=2.3725GHz of bandwidth 479MHz, f_{n4} = 4.4875GHz of bandwidth 1.62GHz and f_{n6}=6.0625GHz of bandwidth 296MHz. The impedance bandwidth of useful bands in percentages are 48.37, 32.46, 15.43 and 48.33 and for three notch bands are 20.19, 36.10 and 4.88 and having peak gain of 2.0 dBi, 1.42dBi, 2.1dBi, 2.39 dBi and for notch bands it is 0.76 dBi, 2.0dBi and1.41dBi respectively as shown in Table 2(a and b) .

The proposed antenna have an applications of GPS(1575MHz), GSM(1800/1900MHz), LTE, FCC ID(2.63-2.68GHz), WiMAX(2.5GHz), WLAN(4.9 and 5.0GHz), C and X band (Radar and Satellite) and rejects the bands of Wi-Fi, UMTS(2100MHz), LTE(2-2.5GHz), WiMAX(3.5GHz) and WLAN (5.9GHz) and C band (5.3-6.1GHz). The optimum impedance bandwidth of both the dimensions of proposed antenna is of 37.79% and 48.37 % having peak gain of 2.14dBi and 2.39dBi for useful bands [8-9]. The gain is less for notch bands because of misalignment and surrounding environment during real time communications [10-11]. For both the dimensions of an antennas, when spacing between two I-slots changed then the frequency of first band shifts to left, second band shifts to right, third band shifts to right and fourth band shifts to left and the notch bands of frequency shifts to right. The shift in frequency is depending on variation in reactance of loaded slot and stubs as shown in Figure 4. The impedance band width is calculated using equation (3).

Impedance bandwidth (%) = $[(f_H\text{-}f_L)/fc]\times100$ ....(3)

Figure 5, 6 and 7 shows typical radiation pattern for the proposed antennas at 5.095GHz and 5.4775GHz and 7.0975GHz respectively. The radiation patterns are omni directional in nature in both E and H plane [12-16].

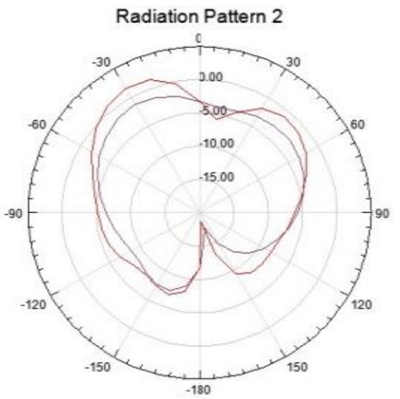

Figure 5. Typical Radiation Pattern of proposed antenna at 5.095 GHz

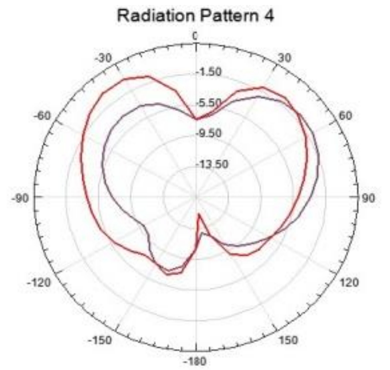

Figure 6. Typical Radiation Pattern of proposed antenna at 5.4775 GHz

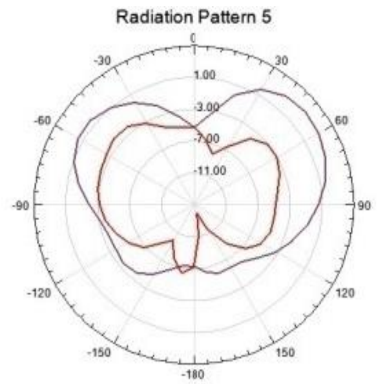

Figure7. Typical Radiation Pattern of proposed antenna at 7.0975 GHz

IV. CONCLUSION

The proposed antennas are designed and constructed for multiband and triple notch band wireless microwave applications using a simple and economical method of conventional slot and stub loading techniques. This kind of single antenna can replace the broadband antennas by tuning to a large range of frequencies. Thus in the proposed antenna, when the dimensions of small arm of J-slot L_6 =0.7 and 0.6cm and spacing between two I-slots is 0.21 and 0.11cm then the antenna is tuned to multiple operating bands and also for notch bands. Among the operating multi bands, the first band, fourth band tunes to left where as second and third band tunes to right and all the three notch bands tunes to right. The applications of four operating bands are found in GPS, GSM, LTE, FCC ID, WiMAX, WLAN, C and X band (radar and satellite) by rejecting Wi-Fi, UMTS, LTE, WiMAX and WLAN and C band (5.3-6.1GHz) by three notch bands which are found in fully crowded frequency spectrum. The band width requirement of the operating bands is fulfilled. The peak gain obtained for operating bands of both dimensions is 2.14 dBi and 2.39 dBi with impedance band width are 37.79 % and 48.33 % respectively. The peak gain and impedance bandwidth for notch bands is less in comparison with operating bands. The radiation patterns are omni directional in nature in both E and H plane.

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REFERENCES

[1]. R.C. Jain , M. M. Kadam, "*A Novel Design of Compact Planner UWB Antenna with Multiple Band Rejection*" , International Journal of Scientific Research in Network Security and Communication. Vol.**5**, No. **2**. May **2017**.

[2]. Anukriti Chauhan, B K Singh, R P S Gangwar and Shakti Singh, "Penta band Slotted Microstrip Patch Antenna for Wireless Applications", International Journal of Computer Sciencess and Enginering", Vol.**2**, Issue **11**, pp.**1-5**, Nov. **2014.**

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

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

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

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

[7]. 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**.

[8]. P. Tilanthe1, P. C. Sharma and T. K. Bandopadhyay, "*A Monopole microstrip antenna with enhanced dual band rejection for UWB applications*" , Progress In Electromagnetics Research B, Vol. **38**, pp.**315-331**, **2012**.

[9]. K. G. Jangid, Ajay Tiwari, Vijay Sharma, V.S. Kulhar, V. K. Sexena and D. Bhatnagar, "*Circular patch antenna with defected ground for UWB communication with WLAN band rejection*", Defence Science Journal, Vol.**66**, No. **2**, pp.**162-167**, March **2016**.

[10]. 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**.

[11]. 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**.

[12]. 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**.

[13]. 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**.

[14]. V. Harsha,Ram Keerthi, Dr. Habibullah Khan and Dr. P. Srinivasulu, "*Design of C-band Microstrip Patch Antenna for Radar Applications using IE3D*" , Vol.**5**, Issue. **6**, pp. **49-58**, Mar-Apr. **2013**.

[15]. 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**.

[16]. 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**.

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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.

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