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Tunable Monopole Circular Microstrip Antenna for Dual frequency Covering L, C and X band Applications

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Abstract— In this paper, we have presented simulated and measured results of tunable monopole circular microstrip antenna for dual frequency which covers L, C, and X band applications. The proposed antenna consists of two identical stubs placed along the patch axis having fixed width W_S =1.0 cm. The slot is placed on left side of feed axis which is having fixed L_1= 1.279 cm, L_2 =1.3 cm and width W_1= 0.1 cm. The upper and lower length of two identical stub is varied from L_{US}=0.483 to 1.83 cm and L_{LS}=0.257 to 0.957 cm to tune an antenna for dual band. The first band varies from 1.8325 GHz to 1.5175 GHz having tuning range of 17.48% and 16.0% and second band varies from 8.5375 GHz to 7.2775 GHz having tuning range of 14.77% and 12.48% when simulated and measured respectively. The maximum impedance bandwidth of 111 % and 30.9 % is achieved for first and second band respectively. The antenna has peak gain of 3.0 dB. The VSWR is less 2 than for all tuned frequencies. The proposed antenna covers applications of L, C and X band. The simulated results are in good agreement with experimental results. The radiation patterns are nearly omni-directional nature both in E and H plane.

Keywords- Identical stubs, slot, CMCMSA and TMCMSADF

I. INTRODUCTION

The microstrip antennas are having many advantages like low cost, low profile, easy to operate and design and construction etc. In spite of their merits, they also have some demerits like low gain, low efficiency, narrow impedance bandwidth etc. However, now a day, there are many challenges for researchers to design an antenna with available geometry like rectangular, circular, triangular, etc. to meet out required response of an antenna. In the literature many designs are available for dual bands operation of an antenna. The tunable antenna for dual bands is found to be rare in the literature. Hence the present demand is to design an integrated antenna capable of operating for more than one band of frequency and should be tunable for different frequencies for optimum use of frequency spectrum. To meet out this requirement in the proposed antenna, a simple circular geometry loaded by stub and slot technique over a radiating patch is used. This method is most simple and less complex to design and fabricate [1]. The proposed antenna is tunable for two bands by just changing the length of identical stub by keeping slot dimensions constant. The first band varies from 1.8325 to 1.5175 GHz with frequency shift of 315 MHz and second band varies from 8.5375 to 7.2775 GHz with frequency shift of 1.26 GHz. The peak gain of antenna is 3.0 dB. The radiation patterns are omni-directional in both E and H plane. These two bands cover applications of L, C and X band.

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 is calculated using the equation (1) [2-4].

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

(1)

where, $K = \dfrac{8.794}{f \epsilon_r^{\frac{1}{2}}}$

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

Figure (1) shows the top view geometry of Conventional Monopole Circular Microstrip Antenna (CMCMSA) in which W_f and L_f are width and length of microstrip feed line respectively.

Figure (2) shows the variation of simulated and an experimental return loss verses frequency of CMCMSA. Further from this figure it is seen that, the antenna resonates at 1.99 GHz and 2.0 GHz when simulated and measured respectively.

Figure (3) shows the top view of geometry of proposed antenna and it is having the same design as that of CMCMSA as shown in figure 1. The radius of the patch and dimensions of microstripline feed in both figures are remains same. The CMCMSA has been modified into new proposed antenna by adding two identical stubs placed along the axis of the patch on either sides with fixed width W_S= 1.0 cm. The dimensions of the slot placed on left side of feed axis is fixed having L_1=1.279 cm, L_2= 1.3 cm and W_1=0.1 cm. The length of stub is varied from L_{LS}=0.257cm to 0.957 cm and L_{US}=0.483 cm to 1.183 cm to tune from 1.8.325 to 1.5175 GHz for first band where as for second band it is varied from 8.8375 GHz to 7.2775 GHz.

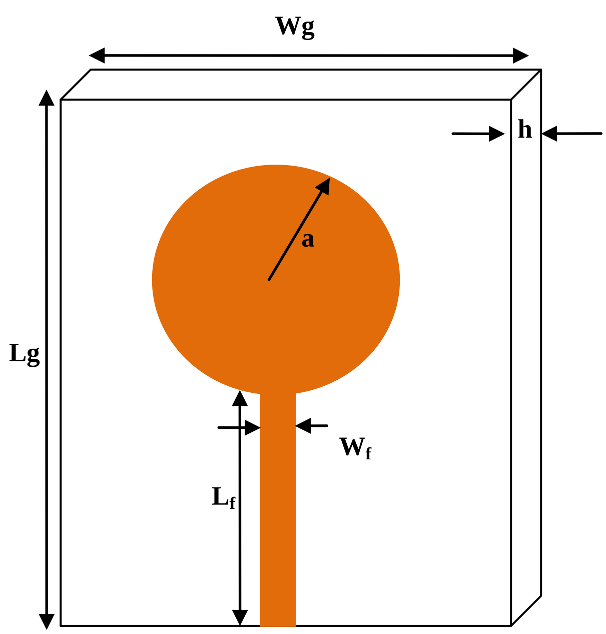

Figure 1. Geometry of CMCMSA

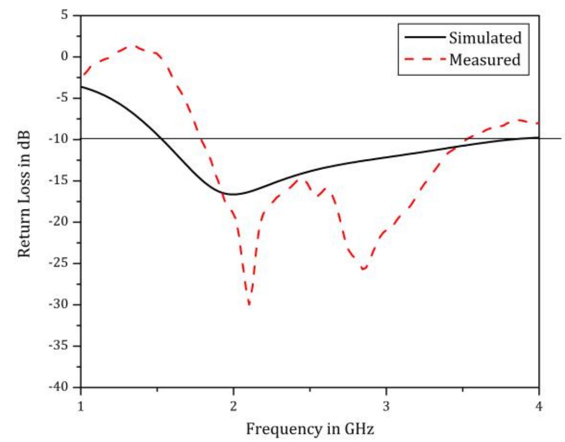

Figure 2. Variation of return loss verses frequency of CMCMSA

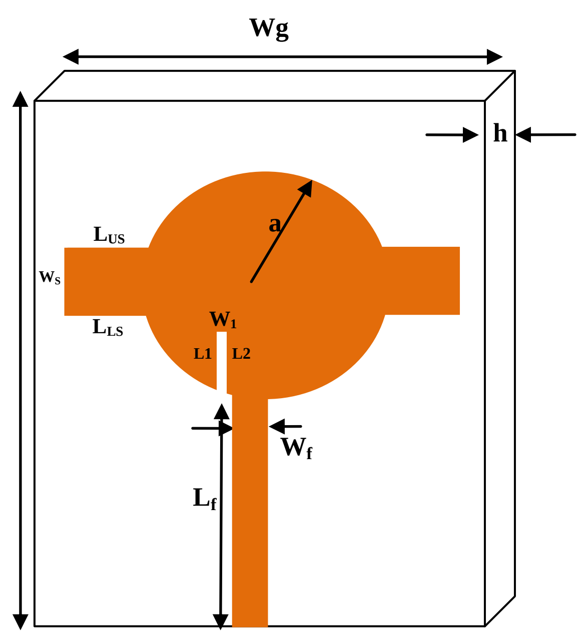

Figure 3. Geometry of proposed TMCMSADF

Table 1: Design parameter **of** tunable monopole circular microstrip antenna for Dual frequency (simulated)

For constant width of left stub Ws=1.0 cm and with fixed dimensions of left slot L_1=1.279cm, L_2=1.3 cm, and W_1=0.1cm				
Variation of length of left stub in cm.	First band Resonant frequencies (f_r) In GHz	Return loss in dB	Second band Resonant frequencies (f_r) in GHz	Return loss in dB
L_{US} =0.483 cm & L_{LS} = 0.257cm	f_{r1}=1.83	26.03	f_{r1}=8.53	27.09
L_{US} =0.683 cm & L_{LS} = 0.457 cm	f_{r2}=1.72	38.15	f_{r2}=7.95	32.47
L_{US} =0.883 cm & L_{LS} = 0.657 cm	f_{r3}=1.60	31.85	f_{r3}=7.70	30.92
L_{US} =1.083 cm & L_{LS} = 0.857 cm	f_{r4}=1.54	24.58	f_{r4}=7.27	15.72
L_{US} =1.183 cm & L_{LS} = 0.957 cm	f_{r5}=1.51	31.26	f_{r5}=7.59	24.19

Table 2: Design parameter **of** tunable monopole circular microstrip antenna for Dual frequency (measured)

For constant width of left stub Ws=1.0 cm and with fixed dimensions of left slot L_1=1.279 cm, L_2=1.3 cm, and W_1=0.1cm				
Variation of length of left stub in cm.	First band Resonant frequencies (f_r) in GHz	Return loss in dB	Second band Resonant frequencies (f_r) in GHz	Return loss in dB
L_{US} =0.483 cm & L_{LS} = 0.257cm	f_{r1}= 1.75	18.53	f_{r1}=8.57	25.04
L_{US} =0.683 cm & L_{LS} = 0.457 cm	f_{r2}=1.62	17.33	f_{r2}=8.17	31.62
L_{US} =0.883 cm & L_{LS} = 0.657 cm	f_{r3}=1.54	25.19	f_{r3}=7.92	27.94
L_{US} =1.083 cm & L_{LS} = 0.857 cm	f_{r4}=1.50	18.10	f_{r4}=7.50	14.31
L_{US} =1.183 cm & L_{LS} = 0.957 cm	f_{r5}=1.47	22.46	f_{r5}=7.81	22.24

III. Results and Discussion

Figure 4 and Figure 5 shows the variation of simulated and measured return loss verses frequency of first band where as Figure 6 and Figure 7 shows variation of simulated and measured return loss verses frequency of second band of proposed antenna. When an antenna is constructed with two identical stubs placed on either side along the patch axis with fixed width W_S=1.0 cm. The dimensions of slot placed on left side of feed axis is fixed having L_1= 1.279 cm and L_2= 1.3 cm with width W_1=0.1 cm. The upper and lower lengths of two identical stub is varied from L_{US} = 0.483 to 1.183 cm and lower length L_{LS} = 0.257 to 0.957 cm to tune 1.8325 to 1.5175 GHz and 8.5375 to 7.2775 GHz when simulated where as it is 1.75 GHz to 1.47 GHz and 8.57 GHz to 7.50 GHz when measured for first and second band respectively . The tuning range of first band is 17.48% and 16.0% when simulated and measured where as it is 14.77% and 12.48% for second band respectively [5-7]. The impedance bandwidth of first band in percentages is 71, 58, 61.8, 111 and 57 where as for second band it is 30.48, 30.9, 23.8, 9.11 and 34.3. The total shift in the frequency for first band is 315 MHz and 280 MHz when simulated and measured respectively as shown in figure 4 and figure 5 where as for second band it is 1.26 GHz and 1.07 GHz when simulated and measured as shown in figure 6 and figure 7 respectively. The optimum impedance bandwidth of first and second band is 111% and 30.9% respectively having peak gain of 3.0 dB [8-11]. The S11 parameters of both bands of proposed antenna are in close agreement with measured results. The table 1 and Table 2 shows design parameter **of** tunable monopole circular microstrip antenna for Dual frequency when simulated and measured respectively. The VSWR is less than 2 for all tunable frequencies and there is good matching of an antenna. All five resonant frequencies of both bands have L, C, and X band applications [12].The impedance bandwidth is calculated using the equation (2).

$$\text{Impedance bandwidth (\%)} = \frac{(f_H - f_L)}{f_C} \times 100 \qquad (2)$$

Figure 8 and 9 shows typical radiation pattern of proposed antenna measured at 1.72 GHz and 7.9525 GHz respectively. The patterns are nearly Omni directional in nature both in E and H plane.

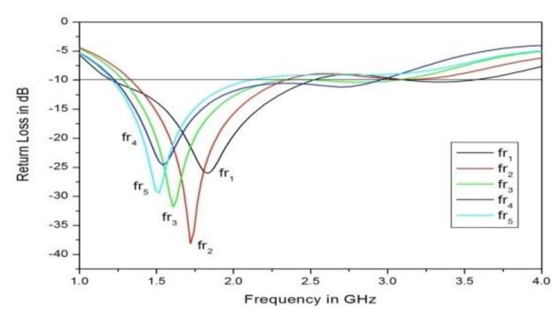

Figure 4. Variation of return loss verses frequency of TMCMSADF (Simulated)

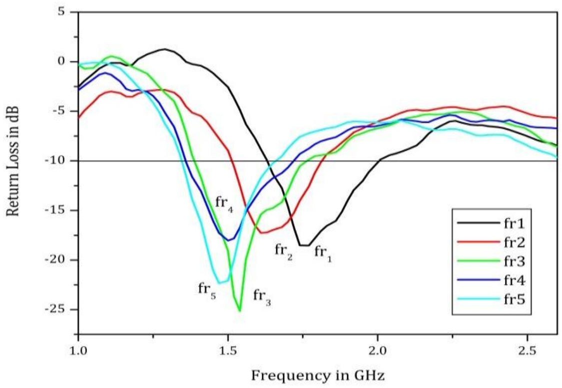

Figure 5. Variation of return loss verses frequency of TMCMSADF (measured)

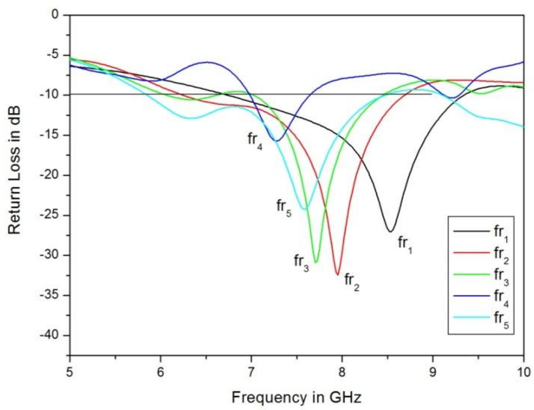

Figure 6. Variation of return loss verses frequency of TMCMSADF (simulated)

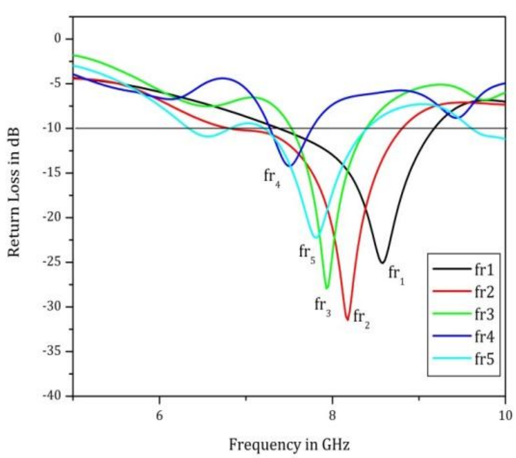

Figure 7. Variation of return loss verses frequency of TMCMSADF (measured)

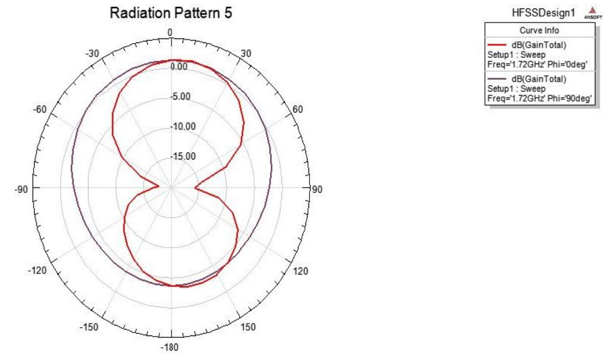

Figure 8: Typical radiation pattern of TMCMSADF measuredat 1.72 GHz

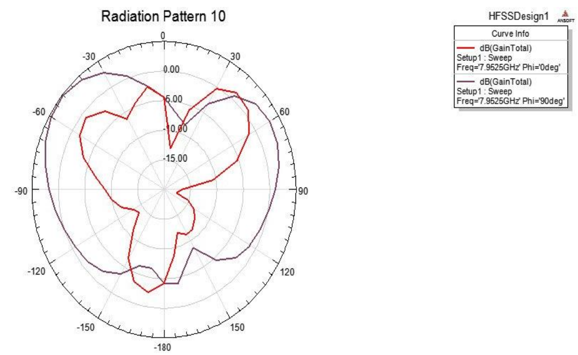

Figure 9: Typical radiation pattern TMCMSADF measured at 7.9525 GHz

IV. CONCLUSION

The proposed antenna is specifically designed for tuning dual band frequencies with the frequency shift of 315 MHz and 1.26 GHz having peak gain of 3.0 dB when simulated where as it is 280 MHz and 1.07 GHz when measured for first and second band respectively.The tuning range for first band is 17.48% and 16.0% where as it is 14.77% and 12.48% for second band when simulated and measured respectively. The impedance bandwidth of first and second band is 111 % and 30.9 %. The S11 parameters for both bands of proposed antenna is in close agreement with experimental values.This is achieved by designing a novel geometry of antenna proposed in this study. This antenna cover many applications at L, C and X band frequencies. Therefore, the new concept of using identical stubs along the patch axis on both sides with a slot on left side of feed axis with the antenna element is very effective in tuning the operating bands of an antenna and finds monopole radiation pattern both in E and H plane. The VSWR for resonating frequencies is less than 2. The simulated and experimental results of return loss verses frequency of above antenna is in good agreement with each other.

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