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Tunable Monopole Circular Microstrip Antenna for Wide FIBW covering Low frequency wireless applications

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Abstract— In this paper, we have presented simulated and measured results of tunable monopole circular microstrip antenna for wide frequency impedance bandwidth which covers low frequency wireless applications. The proposed antenna consists of two identical slots placed on either side of feed axis having fixed dimensions of L_1=0.446 cm, L_2= 0.6 cm and width W_1= 0.4cm. A stub of fixed width is loaded on left side of patch having with Ws=0.9 cm .The upper and lower length of stub is varied from L_{US}=0.62 to 1.22 cm and L_{LS}=0.457 to 1.057 cm to tune an antenna for wide frequency impedance bandwidth from 1.7425 GHz to 1.4725 GHz. This variation also increases the impedance bandwidth from 163 to 200%when simulated where as it varies from 98.6 to 164 % when measured and gives a peak gain of 1.9079 dB. The proposed antenna can cover all low frequency microwave applications like GPS, GSM, DCS, PCS, UMTE, LTE, Wi-Fi, WLAN, Wi-MAX, FCC ID etc., The simulated results are in good agreement with experimental results .The VSWR is less than 2. The radiation patterns are nearly Omni directional nature both in E and H plane.

Keywords— Identical slots, stub, TMCMSAWB and FIBW

I. INTRODUCTION

The microstrip antennas are more popular due to their inherent properties like low cost, easy to operate, easy to fabricate, Omni directional radiation pattern etc. However, there are some disadvantages such as narrow impedance bandwidth, low gain, poor radiation characteristics etc. [1-4]. In spite of limitations of microstrip antennas, in the recent wireless communications, they are of more useful for many applications. The tunable antennas with wide band width are more useful in many modern wireless communication systems in which optimum use of frequency spectrum is possible to use. Hence it is necessary to design tunable antennas for realizing the tunability for wide impedance band width. In this regard, there are numerous methods are proposed in the literature to enhance the impedance bandwidth with tunable property of microstrip antenna, like increasing the thickness of the substrate, decreasing dielectric constant of the substrate, using parasitic patches in single layer and multi layers configuration, employing electromagnetic band gap structures, using backed edge-fed cavity etc. All these are made by adding additional structure so that, the antenna geometry become more complex and bulky. The antennas of wider bandwidth and tunable properties are available in the literature designed separately, but a single antenna possessing both the properties are very rarely found in the literature. This property of an antenna helps in using antenna for the desired band of frequency assigned for a specific application. Therefore, in the proposed study, the antenna is designed using a simple conventional method of slot and stub loading technique on a radiating patch. This technique also helps in widening the impedance bandwidth and shows the property of tuning. The impedance bandwidth increases when we increase the length of the stub where as it decreases inversely with frequency. The impedance bandwidth is increased up to 200% in this study. The single band property of an antenna also avoids interference between the nearby operating bands as in case of the multiband property of an antenna [5-11]. The proposed antenna gives a peak gain of 1.9079 dB in its operating band and shows Omni directional radiation properties in both E and H plane. This antenna can cover all low frequency microwave applications like GPS, GSM, DCS, PCS, UMTE, LTE, Wi-Fi, WLAN, Wi-MAX, FCC ID Etc., The experimental variation of return loss versus frequency of proposed antenna is in good agreement with the simulated results.

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 $\varepsilon_r = 4.2$ .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) [12].

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

where,

$$K = \frac{8.794}{f \in_r^{\frac{1}{2}}} \quad \text{and} \quad a_e = a\left\{1 + \frac{2h}{\pi \in_r a\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]}\right\}^{\frac{1}{2}}$$

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 graph of return loss verses frequency of CMCMSA for both simulated and measured. Further 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 TMCMSAWB .This antenna is having the same basic design as that of CMCMSA as shown in figure 1. The radius of the patch and dimensions of microstripline feed are remains same. The conventional monopole CMSA has been modified into TMCMSAWB by adding two identical slots placed on either side of feed axis with a fixed dimensions and the outward stub placed on left side of the patch. The dimensions of the stub width W_S is fixed where as its length are varied from L_{LS}=0.257cm to 1.057 cm and L_{US}=0.42 cm to 1.22 cm to tune from 1.74 to 1.47 GHz of TMCMSAWB.

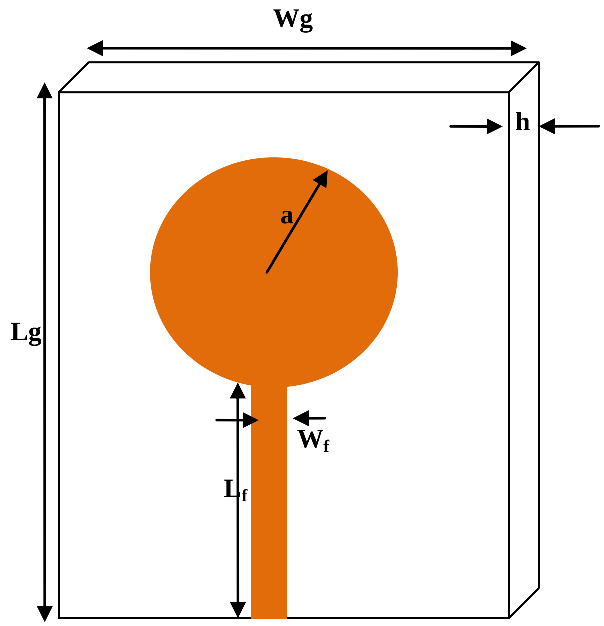

Figure 1. Geometry of CMCMSA

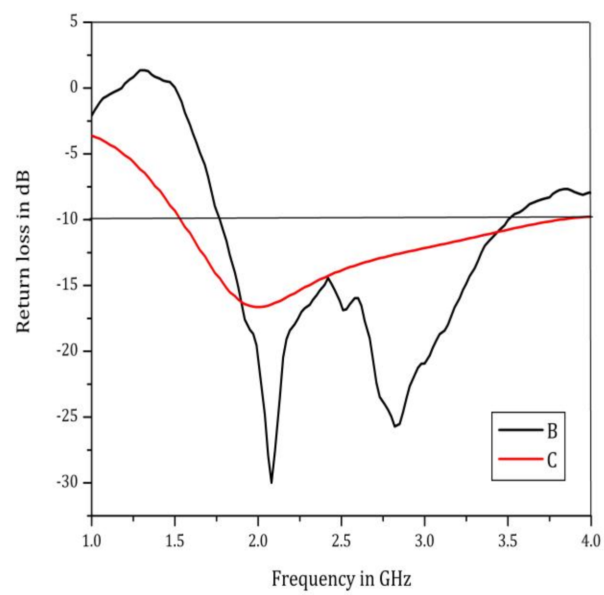

Figure 2. Variation of return loss verses frequency of CMCMSA (simulated and measured)

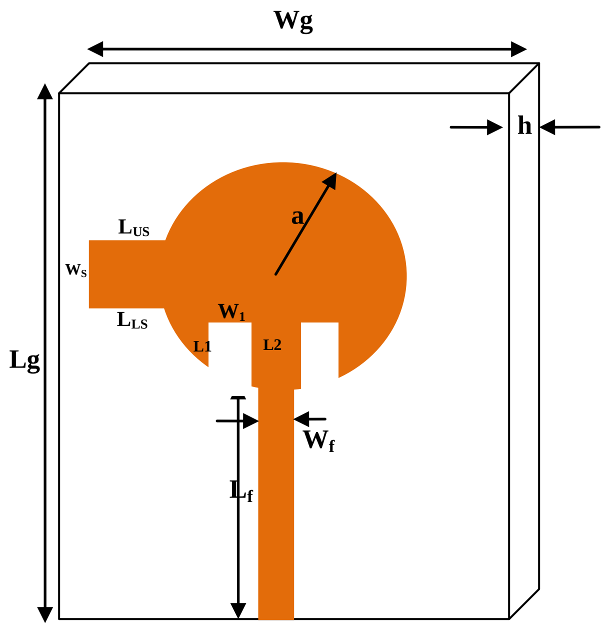

Figure 3. Geometry of proposed TMCMSAWB

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

For constant stub width Ws=0.9cm and with fixed dimensions of two identical slots L_1=0.446 cm, L_2=0.6cm, and W_1=0.4 cm				
Variation of length of stub in cm.	Resonant frequencies in GHz	Return loss in dB	10 dB Bandwidth in GHz	Impedance bandwidth in %
L_{US} =0.42 cm & L_{LS}=0.257cm	$F_{r1=}$1.74	27.89	2.81	161.58
L_{US} =0.62 cm & L_{LS} =0.457 cm	$F_{r2=}$1.72	31.43	2.82	164.19
L_{US} =0.82 cm & L_{LS} =0.657 cm	$F_{r3=}$1.65	26.55	2.81	169.87
L_{US} =1.02 cm & L_{LS} =0.857 cm	$F_{r4=}$1.51	45.8	2.97	197.00
L_{US} =1.22 cm & L_{LS} =1.057 cm	$F_{r5=}$1.47	23.4	2.94	200.00

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

For constant stub width Ws=0.9cm and with fixed dimensions of two identical slots L_1=0.446 cm, L_2=0.6cm, and W_1=0.4 cm				
Variation of length of stub in cm.	Resonant frequencies in GHz	Return loss in dB	10 dB Bandwidth in GHz	Impedance bandwidth in %
L_{US}=0.42 cm & L_{LS} = 0.257cm	$F_{r1=}$1.83	28.06	1.81	96.9
L_{US} =0.62 cm & L_{LS} = 0.457 cm	$F_{r2=}$1.74	25.34	1.71	98.2
L_{US} =0.82 cm & L_{LS} = 0.657 cm	$F_{r3=}$1.65	24.70	2.04	123
L_{US} =1.02 cm & L_{LS} = 0.857 cm	$F_{r4=}$1.55	24.63	2.02	129
L_{US} =1.22 cm & L_{LS} = 1.057 cm	$F_{r5=}$1.46	35.50	2.40	164

III. Results and Discussion

Figure 4 and Figure 5 shows the variation of return loss verses frequency of TMCMSAWB when simulated and measured respectively**.** When an antenna is constructed with two identical slots placed on either side of feed axis with fixed length L_1= 0.4468 cm and L_2= 0.6cm with width W_1=0.4 cm. The width of left stub Ws=0.9 cm can be kept constant and its upper length L_{US} can be varied from 0.42, 0.62, 0.82, 1.02 and 1.22 cm and lower length L_{LS} can be varied from 0.257, 0.457, 0.657, 0.857 and 1.057 cm respectively to tune an antenna from 1.74, 1.72, 1.65, 1.51 and 1.47 GHz of impedance bandwidth in percentages are 161.58, 164.19, 169.87, 197.0 and 200 respectively as shown in Table 1. Table 2 shows measured results in which impedance bandwidths are varies from 98.6 to 164 % and these are in good agreement with simulated values. Figure 6 shows the variation of impedance bandwidth verses frequency in which impedance bandwidth increases when frequency tunes on lower side. The total shift in the frequency from 1.74 to 1.47 GHz is 270 MHz when simulated where as it is 370 MHz when measured having peak gain of 1.9079 dB. All five resonant frequencies have tuned without changing its wideband. In the measured values it is seen that the tuned wide band remains almost constant. The VSWR is less than 2 and shows good matching of antenna. This operating band covers all low frequency wireless communication applications like *GPS (L1 and L2)*, *GSM (1800/1900)*, *Wi-Fi (2.42-2.48 GHz) WLAN*, WiMAX bands (2.3-2.4 GHz, and 3.3-3.4 GHZ, 3.4-3.6 GHz, 3.6-3.8 GHz), DCS-1900, UMTS-2000, LTE-2300/2500, *FCC ID (*2.63 to 2.68GHz) *etc.* The impedance band with is calculated using equation (2).

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

Figure 7 shows typical radiation pattern for TMCMSAWB measured at 1.4725 GHz. The patterns are nearly Omni directional in nature both in E and H plane and linearly polarized in both E and H plane [13-17].

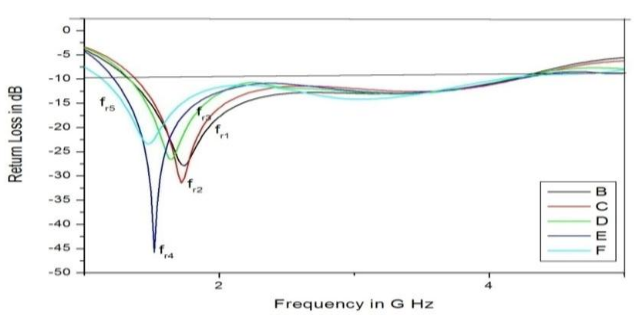

Figure 4. Variation of return loss verses frequency of TMCMSAWB (simulated)

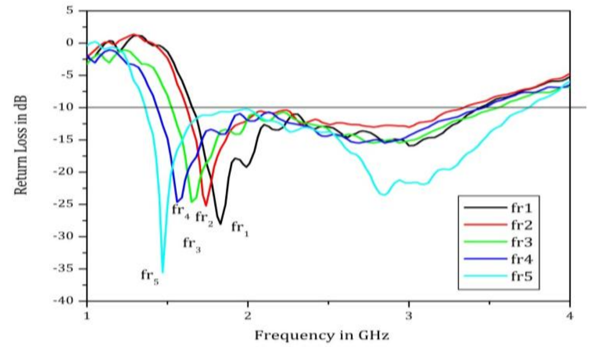

Figure 5. Variation of return loss verses frequency of TMCMSAWB (measured)

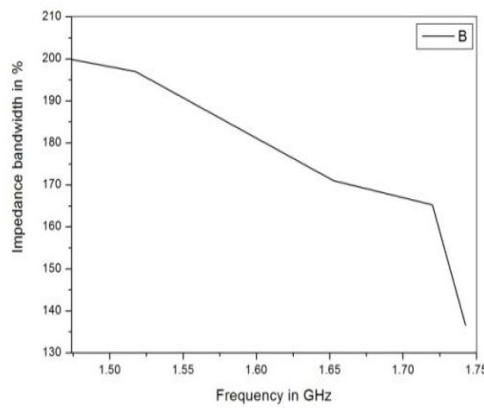

Figure 6. Impedance bandwidth verses frequencyof TMCMSAWB

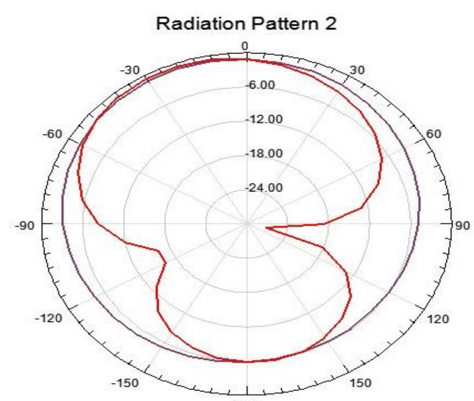

Figure 7: Typical Radiation Pattern TMCMSAWB at 1.4725 GHz

IV. CONCLUSION

The proposed antenna is specifcally designed for tuning single wideband having an impedance bandwidth of 200% and this values is in good agreement with measured values of 164 %. This is is achieved by designing a novel geometry of antenna proposed in this study. This antenna cover many applications operating at lower microwave frequency range. The new concept of using slots and stub along with the antenna element is very effective in tuning the wide operating band of an antenna. The antenna shows maximum impedance bandwidth of 200 % with a peak gain of 1.9079 dB and finds monopole radiation pattern both in E & H plane. The simulated and experimental results of return loss verses frequency of above is in good agreement with each other . The VSWR is less than 2 for all tuned frequencies with proper matching of antenna . The antenna is simple in its design and uses low cost substrate material.With these features the proposed antenna can be used for the applications such as GPS, GSM, PCS, Wi-Fi, DCS, WiMAX, WLAN and FCC ID etc.

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