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TRIPLE BAND OPERATION FOR TUNING 5 GHz FOR WLAN APPLICATION

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ABSTRACT

This paper presents a novel geometry of design and development of stub and slot loaded circular microstrip antenna (CMSA) for triple band operation. The middle operating band in the triple band operation of the antenna can be tuned to cover entire upper band of WLAN range (5.74-5.82 GHz) by changing the width of slots from 0.3 to 0.8 cm without affecting the first and third band. Further, the tuning of middle band does not affect much the gain and radiation pattern of an antenna. This technique helps in rejecting the undesired frequency in the tunable range of an antenna to avoid interferences. The antenna has been designed by using low cost modified glass epoxy substrate material of thickness 1.6 mm and permittivity of 4.2. The antenna gives a peak gain of 2dB in its tunable band and shows nearly omnidirectional radiation pattern.

KEYWORDS: Stub, Slots, WLAN, Triple Band, Tunable CMSA

Tunable microstrip antennas are used for resonating the other nearby frequencies for specific application where instantaneous band must be narrow. For this purpose, there are many methods like stub technique, slot loading technique, shorting posts over or between the patches and ground plane, reactance tuning using varactor or PIN diode etc are used. Among all these methods, the use of geometry of an antenna is complex and difficult to fabricate. Tuning of bands from either side of the resonant frequency is possible (K. L. Wong, 2002; K. P. Ray and Girish Kumar, 2000). However, tuning the mid band in the triple bands keeping remaining bands unaffected using simple stubs and slots is found to be rare in the literature. The stub protrudes out from the periphery of the patch, which increases in the size of the patch, and hence limits its application where narrow tunable antenna is required. But slot is a complementary structure of the stub, cutting slots inside the patch near the feed point gives better tuning operation (K. P. Ray et.al, 2009; Kale Ganesh et.al, 2015). In this paper, two identical slots are used which are placed on either of feed line cut over the patch having length greater than half of the radius of the patch gives larger change in resonance frequency (A. E. Daniel and G. Kumar, 1995). By varying width of the slots from 0.3 to 0.8 cm gives triple band operation in which the frequency resonates from 5.59 to 6.06 GHz for WLAN application. The radiation pattern of all the resonant frequency in the tunable band is found to be nearly omnidirectional in nature. The simulation of this antenna is carried out by using HFSS simulating software.

DESCRIPTION OF THE ANTENNA GEOMETRY

The proposed antenna is designed using low cost modified glass epoxy substrate material of thickness h=0.16cm with relative permittivity $\varepsilon_r = 4.2$. The antenna is fed by using simple microstripline feeding. This feeding has been selected because of its simplicity and it can be simultaneously fabricated along with an antenna element. A semi miniature-A (SMA) connector is used at the tip of microstripline feed for feeding the microwave power. The CMSA is designed for resonant frequency of 3 GHz. Figure 1 shows the top view geometry of stub and slot loaded CMSA. It consists of radiating circular patch of radius a. A quarter wave transformer of length L_t and width W_t which are used between the patch and 50 ohm microstripline feed of length L_f and width W_f to match their impedances. The stub of length L_S and width W_S is connected to the circular patch. The dimension of stub is kept fixed. The dimensions of two identical slots having length L_{SL} and width W_{SL}. The width of both the slots W_{SL} is varied from 0.3 to 0.8 cm simultaneously. The radius a and effective radius a_e of circular patch is calculated as per the equations 1 and 2 respectively. Below the patch surface of a tunable CMSA is ground plane. The two identical slots of fixed length L_{SL} and W_{SL} are placed near feed point one on either side of the patch. Table-1 gives the design parameters of tunable CMSA.

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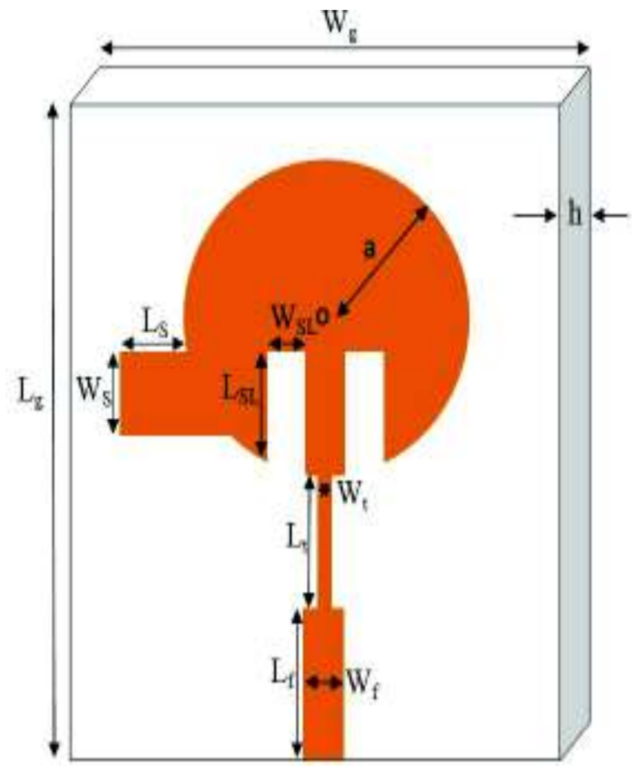

Figure 1: Geometry of tunable CMSA

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

where $k = \frac{8.794}{f \times \in_r{}^{1/2}}$,

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

Table 1: Design parameter of tunable CMSA

For constant stub length Ls=1.0cm and width Ws=0.8cm			
Variation of slot width W_{SL} with fixed slot length L_{SL}=1.1	Resonant frequencies in GHz	Return loss in dB	Impedance bandwidth in %
W_{SL} =0.3	fr_1=5.59	fr_1=25.28	fr_1= 4.83
W_{SL} =0.4	fr_2=5.74	fr_2=22.63	fr_2= 4.44
W_{SL} =0.7	fr_3=5.90	fr_3=13.49	fr_3= 2.74
W_{SL} =0.8	fr_4=6.06	fr_4=14.40	fr_4= 2.22

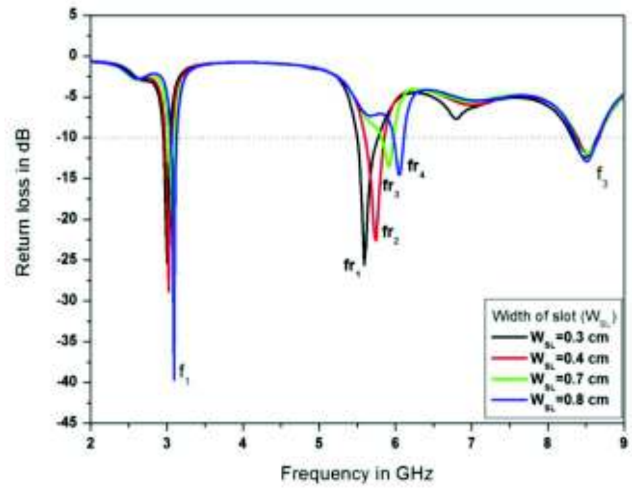

Figure 2: Variation of return loss verses frequency of tunable CMSA from f_{r1} to f_{r4}

RESULTS AND DISCUSSION

Figure 2 shows the variation of return loss verses frequency of tunable CMSA. When antenna is constructed having W_{SL} =0.3 cm, the resonant frequency appears at fr1, this corresponds to an operating bandwidth of 4.83% with a peak gain of 2 dB. The operating bandwidth of an antenna is calculated by using the equation 3. In equation 3, f_H and f_L are the upper and lower cut off frequency of the band respectively when its return loss reaches -10 dB and f_c is the center frequency of the band. When W_{SL} is changed to 0.4, 0.7 and 0.8 cm the operating band f_{r1} is varies towards the higher frequency range and resonant frequency of the operating bands appears at fr_2, fr_3 and fr_4 respectively as shown in Fig. 2. In each case it is found that, the first and last band of the antenna remains almost constant for all values of W_{SL} as shown in Fig. 2. The resonant frequencies f_{r2}, f_{r3} and f_{r4} corresponds to an operating bandwidth of 4.44, 2.74 and 2.2 2% respectively. This also indicates that, when operating band of an antenna moves towards the higher frequency range the operating bandwidth of an antenna decreases. This is due to the effect of stub used along with the circular patch. Hence, by varying the width of the slot from 0.3 to 0.8 cm the resonant frequency of an antenna can be made to vary from 5.59 to 6.06 GHz which covers the WLAN range. Further, from Fig. 2, it is seen that, the antenna also operates for first and third bands which are lies at S and X band frequency range and remains unchanged in spite of variation of middle band. The magnitudes of impedance bandwidlth of first and third bands are 3.0 % and 4.1 % respectively and this antenna may be used for S and X band microwave communication applications (S. Maci et.al, 1995; Girish Kumar and K. P. Ray, 2003; Du Plessis and Cloete, 1993; Lu. J. H, 1999; Nagaraj Kulkarni et.al, 2012; Ali Ejaz et.al., 2013) also.

Impedance bandwidth (%) = $\frac{f_H - f_L}{f_c} x100$ ……. (3)

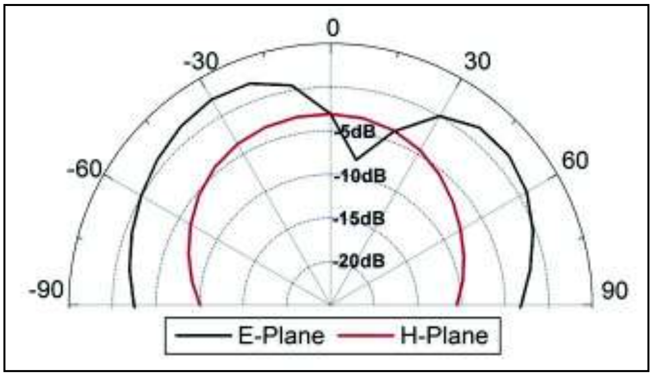

Figure 3: Typical radiation pattern of tunable CMSA found at 5.59 GHz

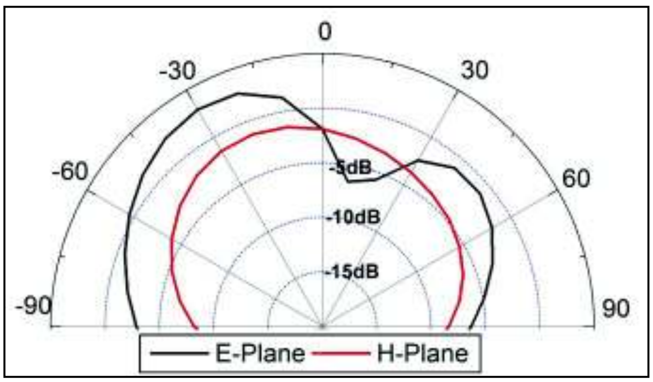

Figure 4: Typical radiation pattern of tunable CMSA found at 5.74 GHz

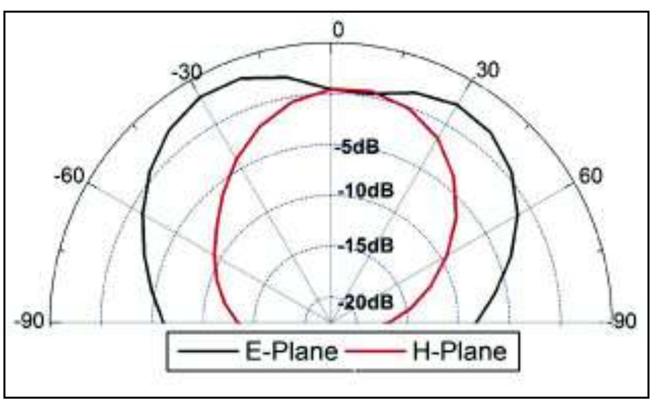

Figure 5: Typical radiation pattern of tunable CMSA found at 5.90 GHz

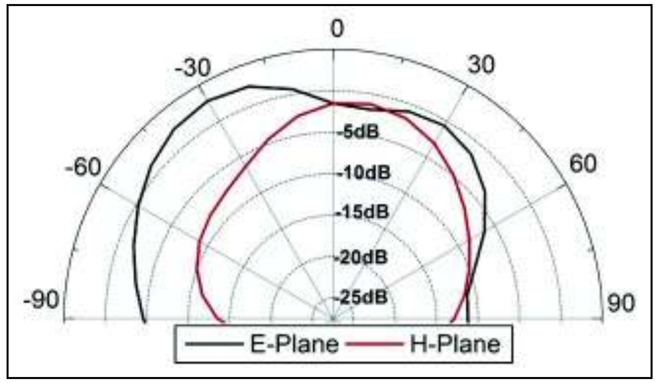

Figure 6: Typical radiation pattern of tunable CMSA found at 6.06 GHz

Figure 3- 6 shows the typical radiation patterns of tunable CMSA found at the resonant frequency of f_{r1} to f_{r4} respectively. All the radiation patterns are nearly omnidirectional in nature both in E and H plane.

CONCLUSION

From the detailed study of tunable CMSA it is concluded that, the triple band tunable CMSA can be realized by using simple stub and slot loading technique along with the circular patch. The tuning of the band can be achieved by varying the width of the slots used in the circular patch without affecting the remaining operating bands. It is found that, the decrease of magnitude of impedance bandwidth of tunable band at higher frequency is depends on the stub connected to the circular patch.The tuning of the middle band is achieved to cover the complete WLAN range from 5.59 to 6.06 GHz. The proposed antenna shows the nearly omnidirectional radiation pattern and gives a peak gain of 2 dB in its tunable bands. The antenna has been realized using low cost modified glass epoxy substrate material and is simple in its geometry. This technique helps in rejecting the undesired frequency in the tunable range of an antenna to avoid interferences.

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