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A Triple Band Notched Reconfigurable Micro strip Fed UWB Applications Antenna

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Abstract---In this paper a compact ultra wide band (UWB) triple band notched reconfigurable micro strip antenna is proposed. The bands 2.6GHZ-3.11GHZ (WIMAX) and 5.0GHZ-5.6GHZ (WIFI) and 7.4-8.6(C BAND) are notched from the antenna operating frequency. The triple band notched antenna is designed by itching two slots having different shapes on the radiating patch. One slot is of T shaped and the other slot is of rectangular shaped. Design specifications for notching the desired bands are provided. The results are simulated using HFSS and compared with the experimental results which suggest that the antenna can be used very efficiently in the UWB range without much interference.

Index terms---Antennas, Reconfigurable Antenna, notch bands, ultra wide band, WI MAX, WLAN, MEMS switch.

I. INTRODUCTION

Ultra wide band (UWB) is a wireless technology for transmission of large amounts digital data over a wide spectrum of frequency bands with very low power and a short distance .The spectrum allocated by FCC (federal communication commission) to UWB communication is 3.1GHZ to 10.6GHZ and this band is used for commercial communication applications [1].In order to operate an antenna efficiently designers have to ensure high impedance bandwidth and less interference due to other narrow band systems. Antenna reconfigurability can be performed in many of the ways depending on changing different antenna parameters like frequency, polarization patterns etc. depending on taking a particular antenna parameter into consideration, antenna reconfiguration can be performed in three different ways. The first method of antenna reconfiguration is frequency reconfiguration in which a multi antenna system is made to operate on a single operating frequency. Frequency reconfiguration is now a day used widely in wireless communication such as cognitive radio systems. The second method is called pattern reconfiguration in which the pattern of the radiation of antenna changes based on the system requirements. The third method of antenna reconfiguration is based on polarization pattern of antenna and is called polarization reconfiguration. In this reconfiguration the antenna polarization is changed and it can be changed from circular polarized to horizontal polarized or vertical polarization. The major problem faced by UWB antennas is the interference created by other narrow band systems like WIMAX, WIFI and C band and many other narrow systems, and it's of greater concern. These interferences can be reduced by using band stop filters for every particular band. But using a band stop filter for every narrow band increases the system complexity and size, hence without changing the antenna design and increasing system complexity, designers have adopted another way of avoiding interference due to these narrow bands by using resonators and slots of different shapes in the radiating patch or in the ground plane [2]-[5].In most of the applications an UWB antenna requires more than one notch band and hence making it compulsory that the band notch elements don't interact mutually. Different band notched UWB topologies have been presented in recent literature [6]-[9].Use of different types of resonators to design reconfigurable UWB antennas have been presented in [10]-[11].In this paper we propose a simple micro strip fed triple band notched monopole antenna. The elliptic monopole UWB antenna is more compact as compared to circular, rectangular antennas as described in [10] and [11].The design of triple band notched reconfigurable antenna is presented in section II. Section III presents the results of antenna simulated and finally section IV presents the conclusion of this paper.

II. ANTENNA DESIGN METHODOLOGY.

A. ANTENNA GEOMETRY.

The desired triple band notched reconfigurable micro strip fed antenna is outlined here in this section below. We start the design with a micro strip fed monopole antenna shown in figure 1. The antenna has overall dimensions of 24×24×0.8 mm^3. It is designed on FR^4 epoxy substrate with a permittivity of $\varepsilon r = 4.4$ and the thickness of substrate is equal to h=0.8mm.

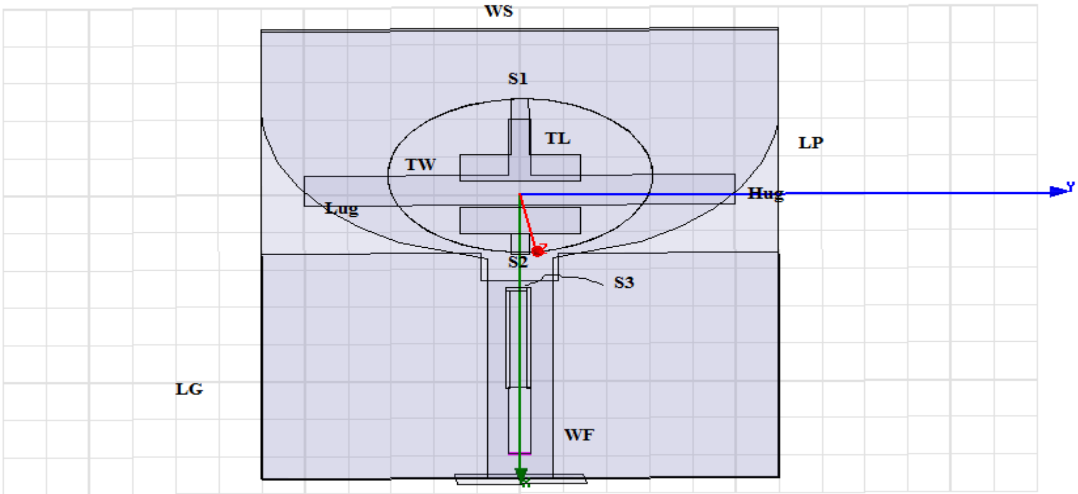

Figure 1. Geometry of triple band notched micro strip fed antenna

The dimension and position of feed point is set in such a way to get the best possible impedance match for antenna to get better results. The dimensions of antenna are given in the table below I.

TABLE I
MEASUREMENTS OF DIFFERENT ANTENNA VARIABLES

VARIABLE	MEASUREMENT(MM)	VARIABLE	MEASUREMENT(MM)
wp	24	Lf	11.8
Lp	12	L_{ug}	20
Wg	24	H_{ug}	1.6
Lg	12	$S1^l$	1.1
L1	10.2	$S1^b$	0.8
L2	10.2	$S2^l$	1.1
Lt	24	$S2^b$	0.8
Wf	3.6	$S3^l$	1
R1	14.3	$S3^b$	0.2
R2	14.3	L^t	5.6
Rm	31.72	B^t	1.9

Where

wf = width of feed line Lf = length of feed line
ug^l =length of upper ground ug^b =breadth of upper ground
$s1^l$ =length of switch s1s1^b=breadth of switch s1
$s2^l$ =length of switch s2s2^b=breadth of switch s2
$s3^l$ =length of switch s3 $s3^b$= breadth of switch s3
L^t = length of t slot B^T= breadth of t slot

B. FREQUENCY BAND NOTCHING.

In order to make the UWB antenna not to respond to certain frequencies we can either make use of resonators or cut slots in the radiating patch or ground of antenna [12]. A total of two notches are drawn in designing this triple notched reconfigurable antenna, one notch in the radiating patch and the other notch in the ground. Three switches are used such that turning them on makes the antenna to respond in to certain resonant frequencies and notch some frequency band. Depending upon which switch is kept on and which switch is kept off the antenna accordingly responds to different resonant frequencies [10, 12].The tables below show the switch alignment used in different stages and the resonant frequency to which the antenna responds in different stages and the frequency bands notched by the designed UWB antenna by making use of different slots.

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TABLE II
SWITCH STATES AND THEIR RESPECTIVE RESONANT FREQUENCY BAND

SWITCH ALIGNMENT	RESONANT BANDWIDTH.
State 1 I – (S1, S2, S3- ON).	6.8 GHZ
state II–(S1, S3 – ON) (S2- OFF)	7.2GHZ
State III – (S1, S2- ON) (S3-OFF)	I Band-4.5 GHZ II Band-6.3 GHZ III Band- 10.3 GHZ

TABLE III
SWITCH STATES AND THEIR RESPECTIVE FREQUENCY BAND NOTCHED.

SWITCH ALIGNMENT	BAND NOTCHED.
State I– (S1, S2, S3- ON).	5.2GHZ
State II – (S1, S3 – ON) (S2- OFF)	5.2GHZ
state III – (S1, S2- ON) (S3-OFF)	I Band-3.1GHZ II Band-5.2GHZ III Band- 8.3GHZ

A total of three MEMS switches have been used in the design of this triple band notched reconfigurable antenna. Depending upon the state of switches (ON/OFF), antenna can be used for different wireless applications [12].

III. SIMULATION RESULTS

The designed reconfigurable antenna is simulated using ANSYS HFSS simulator for a frequency range of 2-12 GHZ. Antenna reconfigurability is expressed in terms of return loss (S11), VSWR and antenna radiation pattern.

(A) VSWR of designed UWB antenna. Figure 2 below shows a graph which is plotted between VSWR and Frequency for basic ultra wide band antenna.

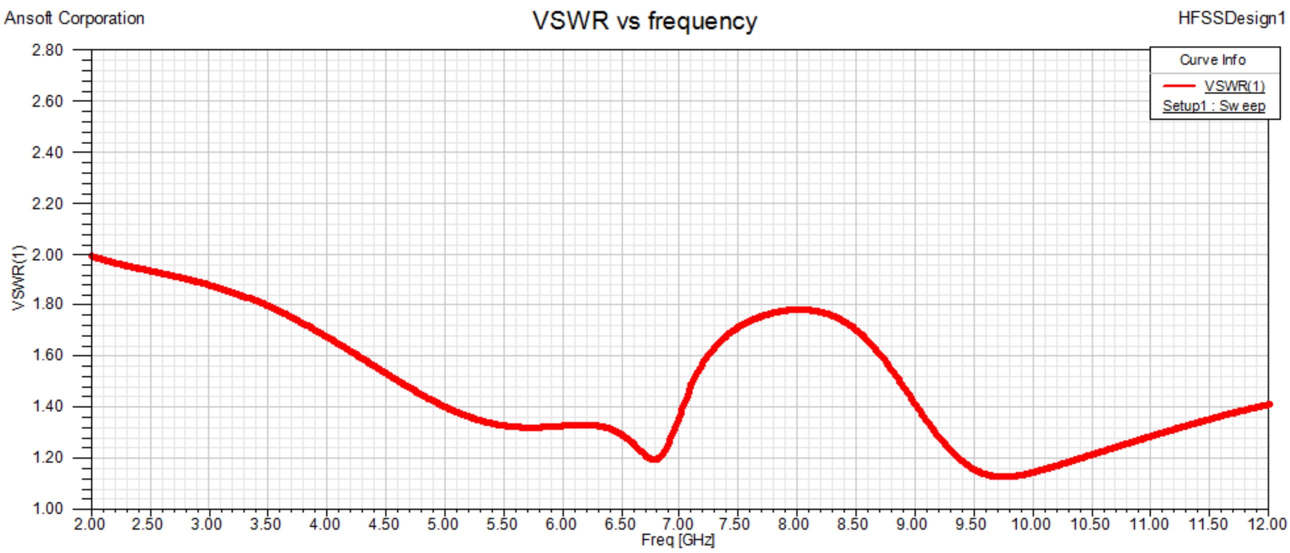

Figure 2: Return loss vs. frequency for basic UWB antenna.

From the simulated results obtained, it's clear that the VSWR of basic ultra wide band antenna is less than 2 for the entire frequency range, hence making the designed UWB antenna to be used very efficiently over whole ultra wide band frequency spectrum.

(B). Return loss (S11) for state I of the triple band notched reconfigurable antenna i.e. when all the three switches used are in the ON state is shown in figure 3 below.

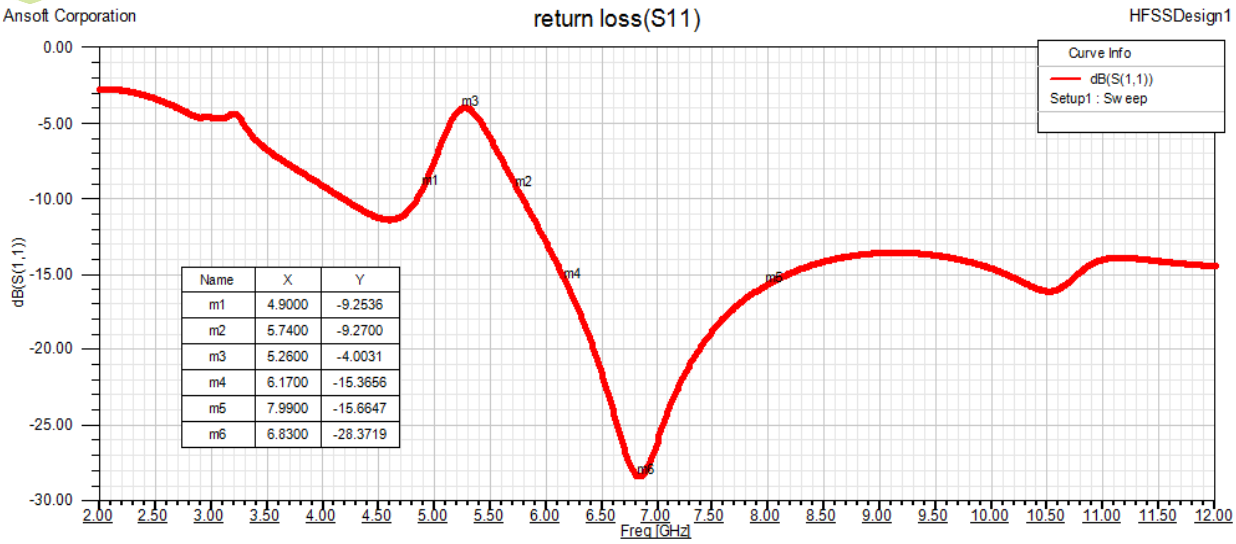

Figure 3: Return loss vs. frequency for state 1.

From the simulated results obtained, it is seen that the return loss of antenna at the resonance frequency of 6.8GHZ is -28.37db and the return loss for the frequency band 5.2 GHZ is -4db as shown in figure 3. From the graph above it is clear that the antenna with this switch configuration can be used efficiently in wireless applications in this frequency band.

(C). Figure 4 below shows the return loss (S11) for the designed reconfigurable antenna for frequency of 2-12GHZ when switch S1and S3 are ON while switch S2 is kept OFF i.e. state 2.

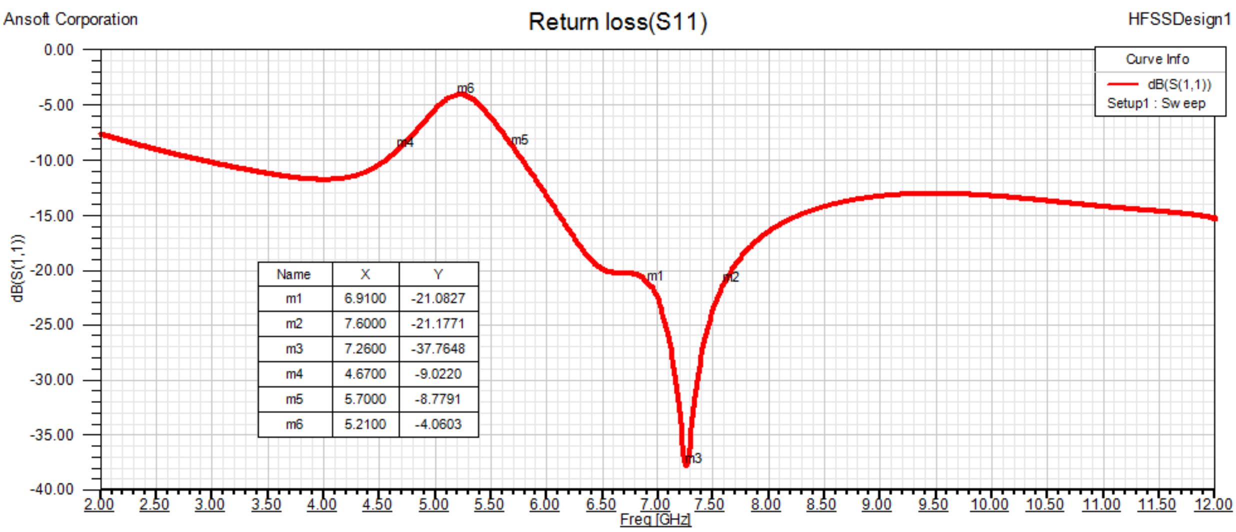

Figure 4. Return loss vs. frequency for state 2.

The results simulated in the switch configuration II as shown in graph above clearly shows that the antenna shows a resonance frequency at 7.2GHZ with a return loss (S11) of -32.7db at this frequency and a return loss of -4db for the frequency of 5.2GHZ. From these results it can be concluded that the antenna in this configuration can be used for WIFI/WIMAX applications efficiently.

(D). Figure 5(A) below shows the return loss (S11) for the designed reconfigurable antenna for frequency of 2-12GHZ when switch S1and S2 are ON while switch S3 is kept OFF i.e. configuration no.3.

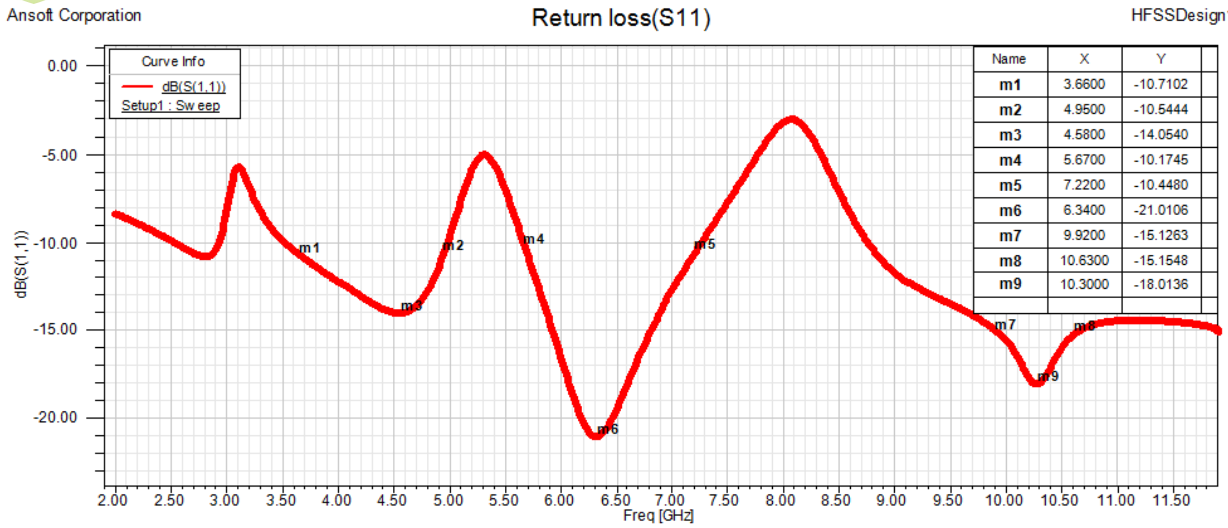

Figure 5(A). Return loss vs. frequency for state 3.

(E) Figure 5(B) below shows the VSWR for the designed reconfigurable antenna for the frequency of 2-12 GHZ when switch S1 and S2 ON while S3 is kept OFF i.e. configuration no.3

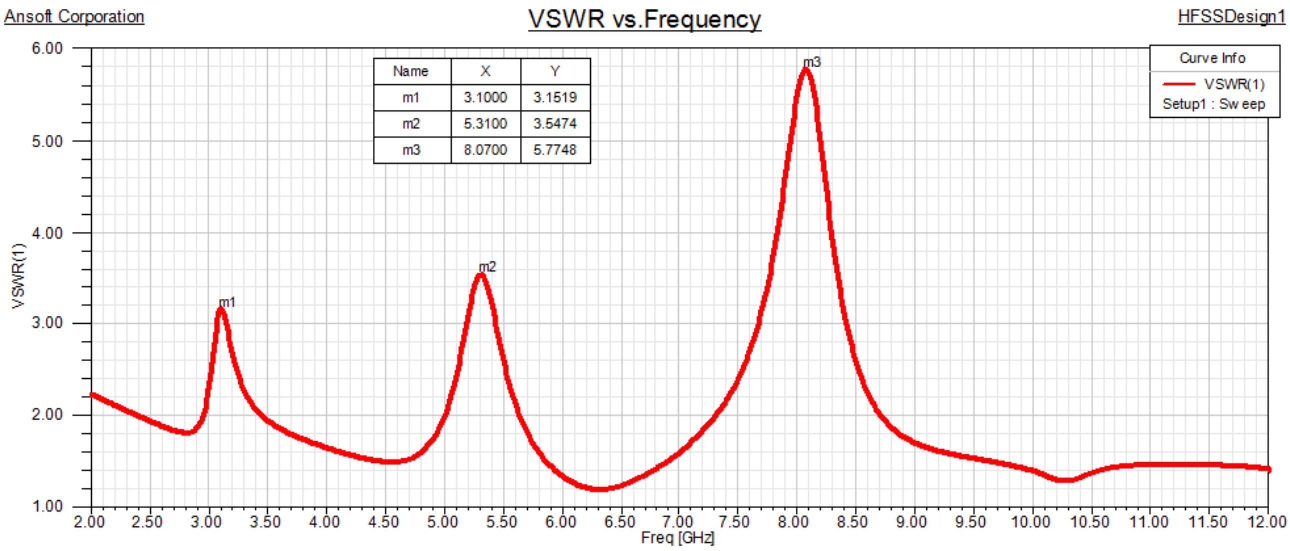

Figure 5(B). VSWR vs. frequency for state 3

(a). From the simulated results for this configuration (return loss vs. frequency graph), it is seen that the antenna obtained a return loss of -14db at a resonant frequency of 4.58GHZ, -21db at a resonant frequency of 6.34GHZ and -18db at resonant frequency of 10.3GHZ. Hence from these results of antenna in this configuration it is clear that the antenna can be used very efficiently at these frequency bands for wireless communication.

(b). From the above graph plotted between (return loss and frequency) and simultaneous (VSWR and frequency), it is clear that return loss for frequency band (2.9-3.4GHZ) is -5.6db with a respective VSWR of 3.15 for this band, (5-5.6GHZ) is -5db and a VSWR of 3.54 for this band notched and (7.4-8.6GHZ) is -3db with a VSWR of 5.8 for this respective band notched. Hence the antenna will not respond to these frequency bands which clearly shows that these frequency bands are notched from the operating frequency of the UWB antenna.

(F). In order to study the designed triple notched band with more accuracy we studied other parameter of deigned antenna called as radiation pattern. The radiation pattern for the designed UWB antenna and other triple notched band antenna at different notch frequencies is given in figures below.

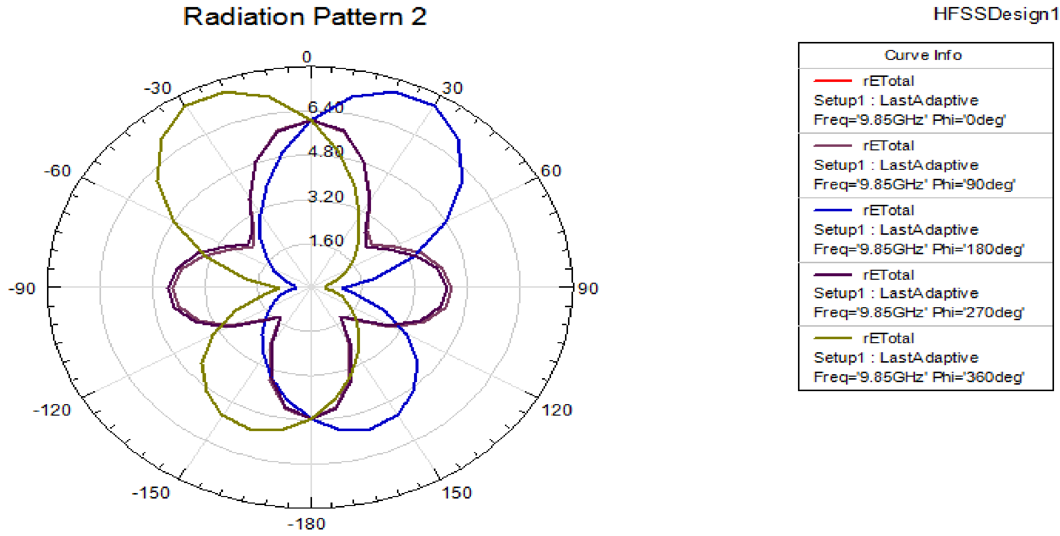

Figure 6.Radiation pattern of designed UWB antenna

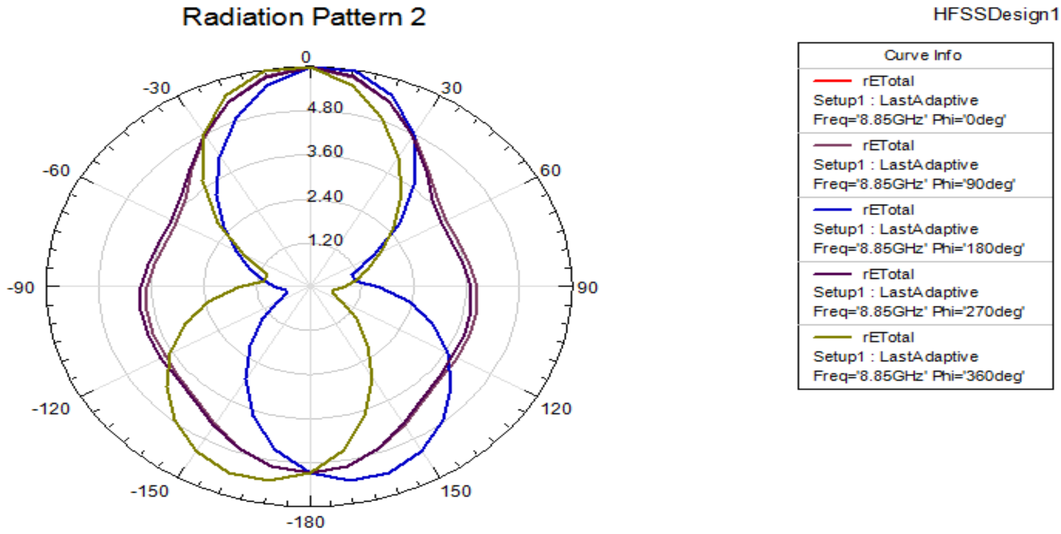

Figure 7. Radiation pattern of triple band notched antenna

G.Other parameter of the antenna called as surface current density was also studied for different frequencies as is shown in figure below.

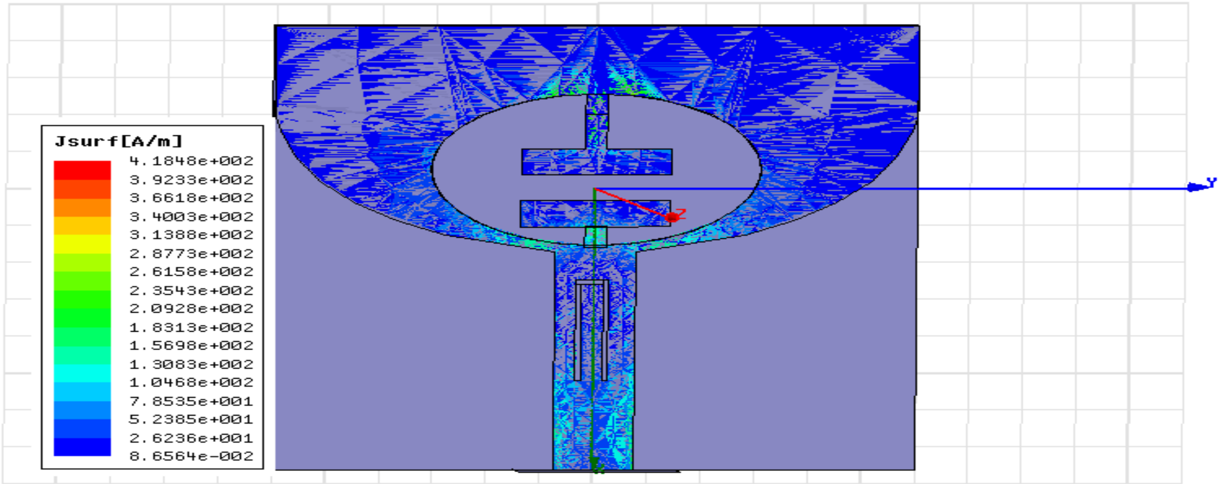

Figure 8.Distribution of surface current vector on the antenna structure for the three notch frequencies (a) 3.1GHZ, (b) 5.2GHZ and (c) 8.3GHZ.

IV. CONCLUSIONS

A triple band notched micro strip fed reconfigurable antenna has been presented and designed by using HFSS. A total of three bands are notched from the operating frequency of the UWB antenna. The notch bands are achieved by slots which are drawn from the radiating patch and the ground. The antenna is made reconfigurable by using a total of three MEMS switches. From the simulation results it is clear that the antenna doesn't respond to interferences created by WIMAX, WLAN and C band, while it can perform very efficiently in many of the wireless applications like some Wi-Fi/cordless telephone and other satellite communication applications. The simulated results also show the antenna has a good omni directional radiation pattern over most of the operating frequency.

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