ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3, Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)

On 21st & 22nd March Organized by

K.L.N. College of Engineering, Madurai, Tamil Nadu, India

Design and Analysis of Novel Integrated Antenna Using Band Pass Defected Micro strip Structure (DMS) Filter

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ABSTRACT –This paper shows the design of multiband antenna that can be reconfigured for five different frequencies without any changes in resonant modes. This reconfigurability is done by band-pass filter that is integrated on the feedline of the antenna. Filter is of T-shaped defected structure with switches which helps in switching the frequency. This structure consists of dual sided tapered antenna which helps in remaining very less distortion. This type of antenna can be used for application like cognitive radios which makes use of free white space available on the spectrum. This novel antenna is simulated using Ansoft High Frequency Structure Simulator (HFSS) fabricated and tested.

INDEX TERMS—Cognitive radio, band-pass filter, defected microstrip structure, frequency reconfigurable, multiband antenna.

I INTRODUCTION

Cognitive radio technology is the system that can sense the free white space that is available on the spectrum of the band and makes use of that free space by altering the frequency of the band and helps in minimizing interference of that wireless system and maximizing the throughput. In this cognitive system antenna acts as both scanning antenna and reconfigurability antenna. This scanning antenna scans for the white space available on the spectrum and tells the reconfigurability antenna to utilise that band and hence this reconfigurability antenna tunes within itself with the help of filter and uses that band [1][2].Main challenges in cognitive radio are design of reconfigurable antenna and its reconfigurability. Before this reconfigurable antenna was designed using photoconductive switches, RF MEMS, PIN diodes and other components for alteration of frequency were used.

Many researches on reconfigurable antenna and its reconfigurability were made and presented as follows. In this paper [3] author used photoconductive silicon switches to control the switching state by eliminating the usage of optical fibre cables. An UWB antenna is also covering 3.1-1GHz acts as scanning antenna or the sensing antenna and a triangular shaped antenna with two separate patches different band of spectrum is seen [4].An Antenna structure designed on a single substrate with different patch structure for sensing and reconfigurable antenna where reconfigurability is achieved by rotational motion using a stepper motor [5].

Defected microstrip structure with T-shaped slot as filter is designed with changes of gap size for changing the frequency of the filter in [6]. A filter consisting of two defected structure having H-shaped and E-shaped designed for dual-stop-band filter with wide tuning range in smaller size antenna [7].Novel class of band-pass filter designed using chebyshev model which is realised with Defected Microstrip structure(DMS) to have the characteristic of passing and rejecting the band[8]. Rational model based filters estimation is done here with two numerical based optimization for improving speed and robustness using both simulation data and measured data [9].In this paper tapered slot antenna is configured in the design to optimize and is used in this design to compose an array with a Wilkinson power divider to develop a UWB antenna [10].Important issue with wideband antenna is electrical length variations with frequencies causing distortion in radiation pattern can be solved by a double exponentially tapered slot antenna (DETSA) on a flexible organic material(LCP), is introduced which have lower loss when measured in planar or even is significantly folded[11].Here in this paper we design a antenna with reconfigurable filter to attain frequency reconfigurability for cognitive radio applications. Filter tuning is done by switches.

II DESIGN

A.DMS Band-Pass Filter Configuration

This design has a reconfigurable filter i.e. band-pass filter consisting of Defected Microstrip structure (DMS) integrated in the antenna which reconfigures frequency of that UWB antenna is studied. Filter is of T-shaped slot with 2.9 mm x 2.8 mm and this filter has two band gaps beside the slot of width 0.25mm each. This gaps in this filter acts as band-pass characteristics acting as a parallel-series resonance.

Antenna structure wholly is printed on the Taconic TLY substrate which has dielectric constant ε_r=2.2 and with height 1.6mm.Switches used in this patch antenna are RF which changes its state as relay and helps in tuning the frequency of the antenna without changing the structure of the patch. Thus the Defected Microstrip Structure (DMS) Filter is shown in below Fig.1

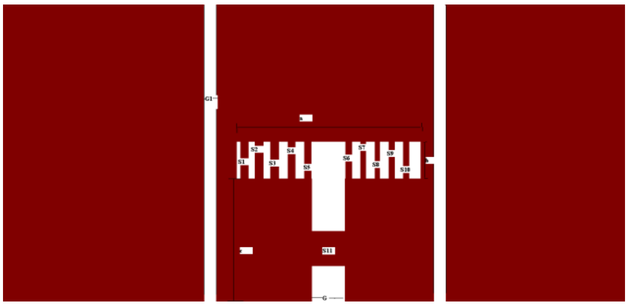


Fig.1: Defected Microstrip Structure (DMS) Filter with a=2.9mm, b=0.8mm, c=2mm, g=0.25mm, g1=0.2mm with S1, S2, S3, S4, S5, S6, S7, S8, S9, S10 and S11 switches.

Thus the reconfigurability in the filter is attained by the integration of 11switches available within the T-Slot. The switches are operated in pairs from the edges of the T-slot. Mainly switches are used to switch between slots which reconfigure frequency and act as band-pass filter. Thus switching the switches changes the length of the slot (e.g. labelled as ‘a’ in Fig.1).This varying length are summarized in modes in below Table.1

This filtantenna design is a reconfigurable band-pass filter integrated into the Vivaldi antenna structure which allows certain band of frequency with certainty to the modes it is subjected to. So that this filtantenna acts as a multiband antenna operated with the single defected structure with A T-shaped slot which is more important in cognitive radio transmission.

TABLE I
COMBINATIONS OF THE SWITCHES

MODE	SWITCHES ON
0	*None*
1	*[S1,10]*
2	*[S1,S10],[S2,S9]*
3	*[S1,S10][S2,S9][S3,S8]*
4	*[S1,S10][S2,S9][S3,S8][S4,S7]*
5	*[S1,S10][S2,S9][S3,S8][S4,S7][S5,S6]*
6	*[S1,S10][S2,S9][S3,S8][S4,S7][S5,S6][S11]*
7	*All*

This DMS filter that is shown in Fig.1 has a corresponding circuit model expressed in terms f lumped elements where gaps beside the T-slot are modelled as inductor Ls and capacitor Cs whereas the T-shaped slot is modelled by Lp and Cp. To determine the values of L and C, we have used equations and given below as,

$$C_{s,p} = \frac{f_c}{200\pi(f_0{}^2 - f_c{}^2} \quad \dots (1)$$

$$L_{s,p} = \frac{1}{4\pi^2 f_0{}^2 C_{s,p}} \quad \dots (2)$$

Where f_0 is the centre frequency and f_c is the cut-off frequency of the designed filter. The change of frequency is the change of values of C and L. Each state of the filter with change in state of the switch has corresponding data and the values of L and C data are summarized in following Table.2

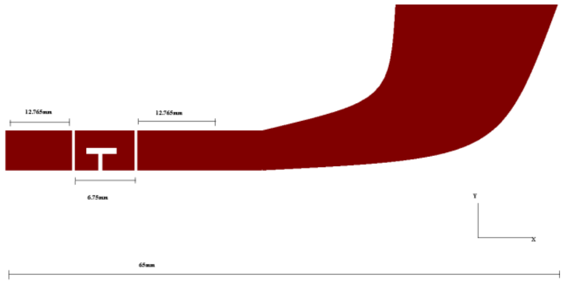
TABLE II
VALUES OF C and L

Cs (pF)	*Ls (nH)*	*Cp (pF)*	*L (nH)*	*Frequency (GHz)*
0.778	61.10	0.09913	1.142	9.4
0.1675	1.254	0.113	0.999	10.23
0.1516	1.239	0.147	0.7691	11.18
0.1326	1.288	0.2393	4.729	12.3077

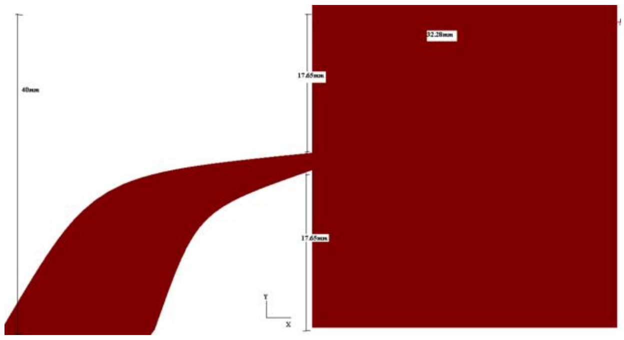
III Dual-Sided Tapered Slot Antenna Configuration

Complete design of the antenna involves a Dual-sided tapered slot antenna (TSA) which has inner and outer contours designed based on exponential functions with DMS filter discussed before. This antenna consists of defected ground plane and a feeding microstrip transmission line. Here the DMS filter is integrated into the feedline of the antenna. This makes the antenna operated on switching basis at different modes of the filter.

This entire design is of 65mm x 40mm dimension. Feedline width of the structure is chosen to attain 50Ω characteristic impedance over the interested frequency range. Integrated filter length is of 6.75mm.TSA contours are curved on basis of exponential function for both inner and outer contours. This structure helps to act as a wideband antenna. The structure of the antenna is shown in below Fig.2.Also the ground structure of this antenna is defected ground with contours is shown in Fig.3. With dimension 40mm x 32.28 mm



(a)



(b)

Fig.2. Simulated structure of antenna (a) Top layer (b) Bottom Layer with dimensions in mm.

IV Simulation and Results

The simulated results of the filter with six modes are discussed here which is been simulated using Ansoft HFSS. It is necessary to notice that this antenna allows only certain band between 7.4GHz-12.6GHz.This antenna works for six modes as said before in Table.1.Tuning can be noticed by changing the status of the switches that are available on T-slot. Modes and the frequency operated is shown in below Table.3.By these modes presented here it is said that this integrated antenna with filter show great effect in frequency agility.

TABLE III
STATES AND FREQUENCY TUNED

SWITCHES ON	**FREQUENCY [GHZ]**
[S1,10]	8.8
[S1,S10],[S2,S9]	9.2
[S1,S10][S2,S9][S3,S8]	9.9
[S1,S10][S2,S9][S3,S8][S4,S7]	10.6
[S1,S10][S2,S9][S3,S8][S4,S7][S5,S6]	11.5
[S1,S10][S2,S9][S3,S8][S4,S7][S5,S6] [S11]	12.3

This proposed design is more important in cognitive radio applications which act as scanning antenna when the filter is OFF Once the antenna scans for the available free space and then function as a communicating antenna by the switches available on the filter. When all switches are in ON state then all the available bands are free and is utilized for cognitive transmission. Below plots corresponds to the five states that are shown in Table.3.

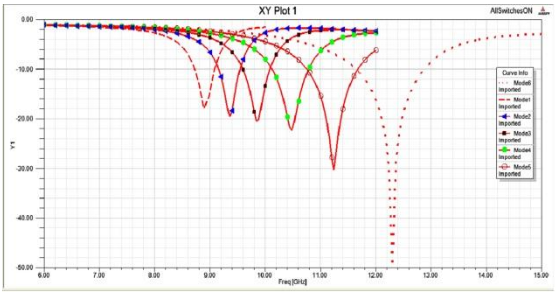


Fig.3.Simulated returnloss of the antenna structure representing 6 states.

When the band-pass filter is activated, then the antenna acts as a UWB antenna and the plot of the mode6 i.e. when filter is ON allows all band of frequency is shown in below Fig.4.

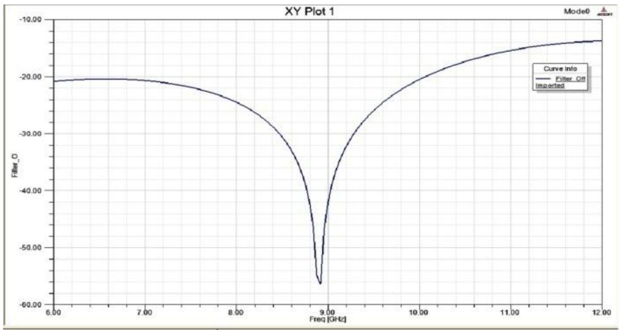


Fig.4.Simulated returnloss of the antenna with filter is ON

When the band-pass filter is deactivated then this antenna is in mode0 i.e. filter is in OFF state and acts as a scanning antenna and the plot of antenna when all switches are in ON state is shown in below Fig.5.

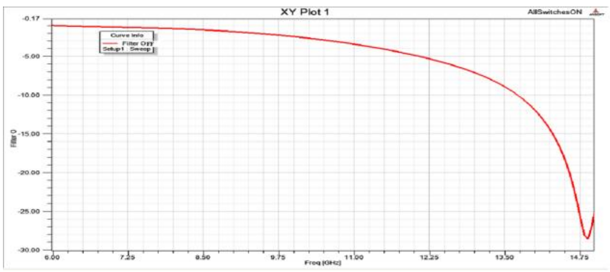


Fig.5.Simulated returnloss of the antenna with filter in OFF state

Normalised radiation pattern of the antenna which is for different modes in the YZ plane is shown in below Fig.6. Almost omni-directional radiation is seen.

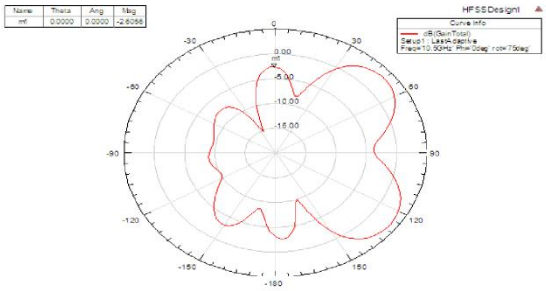


Fig.6. Normalized radiation pattern of the UWB antenna when Filter is in OFF state.

V CONCLUSION

This paper presented about the integrated antenna with reconfigurable antenna which helps in frequency agility that is used for cognitive radio applications. By changing the switches state ON/OFF changes the state of the filter by varying the size of the slot and this helps in tuning antenna frequency. This design helps in minimizing loss and maximizing throughput.

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