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# SMART T-SLOT FILTENNA FOR COGNITIVE RADIO APPLICATION

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**ABSTRACT: This Smart Filtenna can able to sense entire Ultra Wide Band (UWB) spectrum for the availability of spectrum holes and thereby makes use of that spectrum for secondary user transmission. This proposed antenna is capable to sense and make data transmission in the freely available spectrum in the UWB band from 3.1GHz to 10.6 GHz. It can be used for the interference free communication in the UWB spectrum. This proposed Smart Filtenna is a combination of two semi-circular patches. By using this smart filtenna we can able to utilize the entire UWB spectrum effectively.**

KEYWORDS: Cognitive Radio (CR), Defective Microstrip Structure (DMS), Frequency Reconfiguratrion, Smart Filtenna.

## I. INTRODUCTION

The current spectrum allocation policy adopted by communication agencies around the globe mandates for the static licensing of the available spectrum to various technologies and organizations. This non-overlapping partitioning [1] of the spectrum reduces interference and guarantees exclusive spectrum use to licensed users. However, nearly all useful spectrums are now allocated to different entities, without provision for accommodating new wireless technologies. In addition, recent studies have shown that most spectrum frequency bands are heavily underutilized.The increasing demand for higher data rate and connectivity in wireless communication has led to dynamic spectrum access as the licensed and unlicensed spectrum users are very high in number. CR Technology allows users to use this scarily available spectrum in an efficient way by allocating the secondary users with the unused bands of the primary user. In this paper our main objective is to design a novel Smart Filtenna which can able to sense the entire UWB spectrum (3.1 GHz to 10.6 GHz) and it looks for the free available frequency bands. By using these freely available frequency bands it lets the secondary user to make their data transmissions. This Smart Filtenna can be used both in the transmitting and receiving ends of the CR system for both transmission and reception of the user's data in the UWB band. This Smart Filtenna senses the entire UWB spectrum for the presence of the primary user in order to make an interference free communication with the other radio users in the UWB Radio Frequency (RF) spectrum.

## II. SYSTEM ARCHITECTURE

In this CR system we have two types of users (i) Primary user and (ii) Secondary user. The primary user is the one who owns the Radio Frequency (RF) spectrum. The secondary user is one who does not have any static licensed spectrum, On other hand he can make use of the primary user's spectrum whenever the primary user not utilizing his licensed spectrum. By this way we can achieve the efficient utilization of the scarily available spectrum. In order to achieve this functionality we need this Smart Filtenna which can able to sense the entire UWB spectrum [2] and helps the secondary user to make use of the freely available spectrum.

The following figure shows the system

architecture of the smart filtenna system.

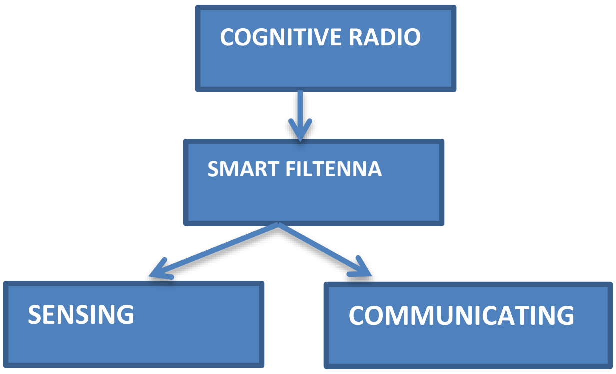



Fig 1.1 Smart Filtenna architecture

## II. ANTENNA DESIGN

***<u>Half- Circular patches radius calculation:</u>***

This proposed Smart Filtenna consists of two semi- circular patches which will acts a radiating area for this design. In this the larger half-circular patch covers the lower frequency range and the smaller semi-circular patch covers the higher frequency range the antenna. The radius of the circular patches from [3] of this antenna can be found using the following mathematical expression,

Radius of the half circular patch,

$$a = \frac{F}{\left\{1+\frac{2h}{F\pi\varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}} \quad (1)$$

$$F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

Where,

- Radius of the half circular Patch
- Effective Dielectric Constant
- Height of the Dielectric Substrate
- Resonating frequency

By using these above mathematical expressions, we found the radius of the two half circular patches which will covers two different frequency ranges in the UWB spectrum.

i) Radius of the smaller half circular patch, a1=6.83 mm.

*ii)* Radius of the larger half circular patch, a2=10.5 mm.

***Microstrip feed line calculation:***

The length of the microstrip line [3] can be calculated using the following mathematical formula,

Length of the feed line, $l_f = \frac{\lambda}{4}$(3)

Where,

- Operating Wavelength
- Length of the Microstrip line

For this antenna design the microstrip line length is calculated using the above equation (3) and it is found to be 17.6 mm. This microstrip line length and width can also be easily calculated using the CST tool's microstrip line calculator. The calculated width and length of the microstrip line is gives as follows,

i) Length of the feed line = 17.6 mm.

ii) Width of the feed line = 3.2 mm.

The following Fig 2.1 shows the microstrip feed line [4]-[8] structure, Fig

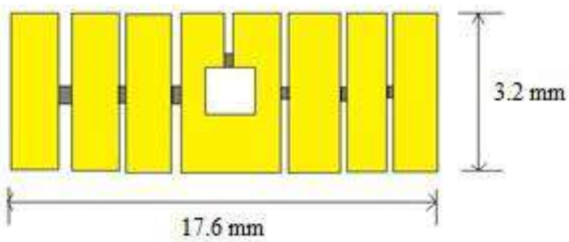



Fig 2.1 Microstrip feed line

## III. ANTENNA GEOMETRY

The schematic of the proposed antenna is shown in Fig.3.1 (front view) and Fig.3.2 (rear view). It consists of a radiating element in the form of two half-circular patches of different radius, fed by a microstrip line. The antenna is based on FR4-epoxy substrate with a dielectric constant of 4.3, thickness of 1.6 mm, and loss tangent of 0.0018.

The following diagram shows the design model of the Smart Filtenna's front view and rear view.

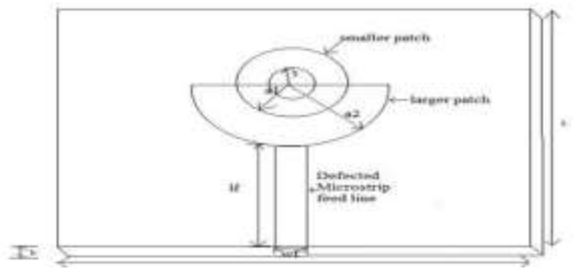
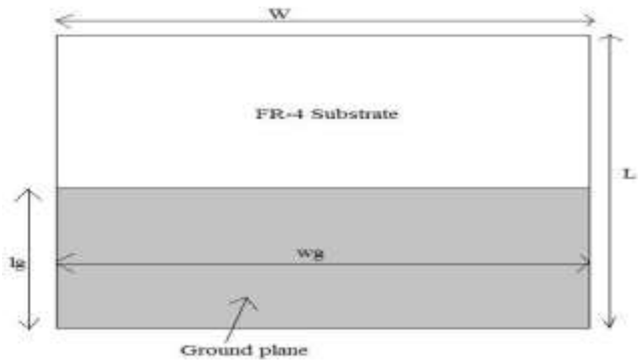



Fig 3.1 Design model of Smart Filtenna's Front view




The following table 3.1 lists the various antenna design parameter which are calculated using the mathematical formula mentioned in Antenna design section.

**Antenna design Parameters**

| PARAMETER | DIMENSION (mm) | DESCRIPTION |
|---|---|---|
| H | 1.6 | Height of the substrate |
| L | 38 | Length of the Substrate |
| W | 44 | Width of the Substrate |
| $l_g$ | 17.6 | Length of the Ground plane |
| $w_g$ | 44 | Width of the Ground plane |
| $l_f$ | 17.6 | Length of the feed line |
| $w_f$ | 3.2 | Width of the feed line |
| a1 | 6.83 | Radius of the Smaller circular patch |
| a2 | 10.5 | Radius of the Larger Circular patch |
| S | 3.5 | Radius of the Circular slot |
| S1, S2, S3, S4, S5, S6 and S7 | L=.2 W=.845 | Switches |

Table 3.1Antenna Design Parameters

By using above parameters the Smart Filtenna was designed using the CST Microwave Studio tool. The following diagram shows the designed Smart Filtenna's front and rear views.

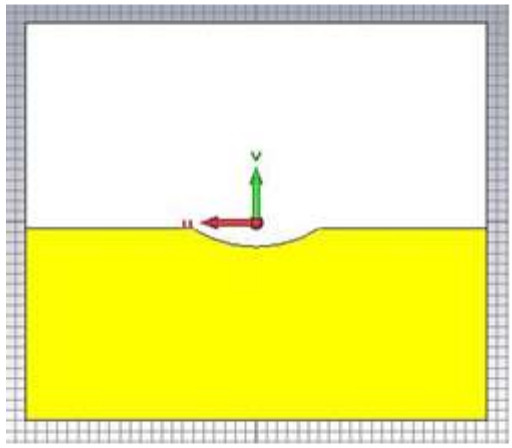



Fig 3.3 Designed Smart Filtenna'sFront view

Where S1, S2, S3, S4, S5, S6 and S7 are the micro stripline connectivity switches [9], which can be enabled and disabled by appropriately providing forward and reverse bias supply. Thus the antenna can be reconfigured thereby it can communicating at different frequency ranges.

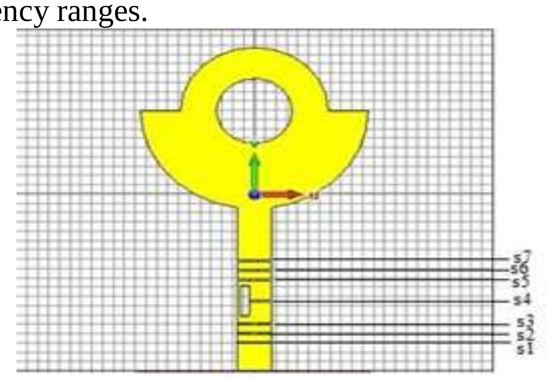



Fig 3.4 Designed Smart Filtenna's Rear view

## IV.SIMULATION RESULTS AND DISCUSSION

Performance of proposed antenna was investigated by using the CST Microwave Studio software. Reflection coefficient (dB) shows it is below -10 dB in frequency range 3.1 GHz to 10.6 GHz, this condition is used to sense spectrum to identify holes (unused) frequency bands. The following diagram Fig 4.1 shows the simulated reflection coefficient response of the designed sensing antenna

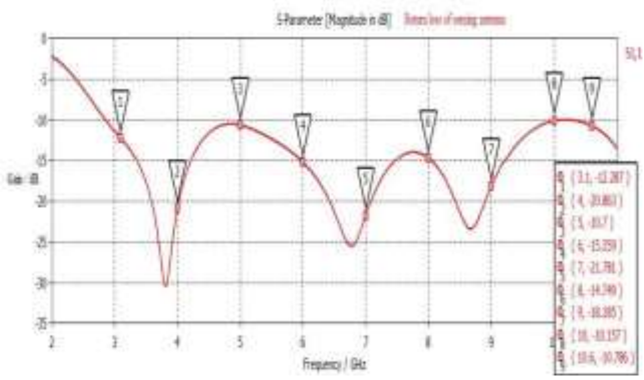
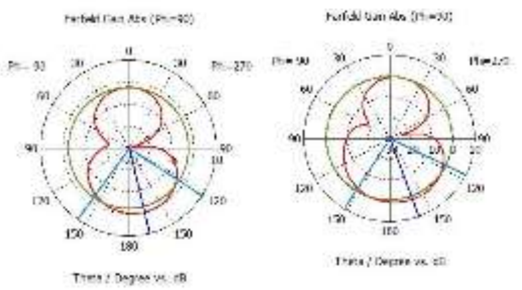
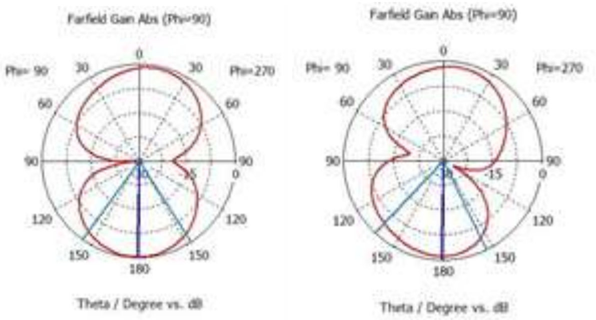



Fig 4.1 Simulated Reflection coefficient response

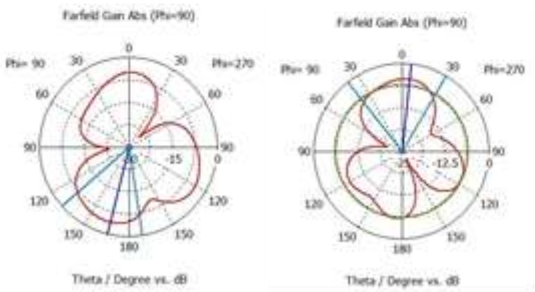
The following diagrams shows the simulated Directivity gain of the antenna at different frequency range in the UWB Spectrum from 3.1 GHz to 10.6 GHz.



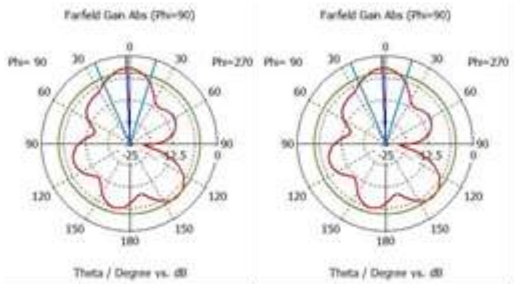
a) 3 GHz b) 4 GHz




c) 5 GHz d) 6 GHz




e) 7 GHz f) 8 GHz




g) 9 GHz h) 10.6 GHz

Fig 4.2 Far-field Directivity gain of an antenna at a) 3 GHz, b) 5 GHz, c) 6 GHz, d) 7 GHz, e) 8GHz, f) 9 GHz, g) 9 GHz and h) 10.6 GHz

From the above results and responses we form the tabular column Table 4.1 which will shows the Simulated Gain and Directivity of a Smart Filtenna at different frequency range of operations in the UWB band when the antenna in the sensing mode

**Gain and Directivity of Smart Filtenna at different frequencies in UWB band**

| FREQUENCY (GHz) | GAIN (dB) | DIRECTIVITY (dBi) |
|---|---|---|
| 3 | 2.463 | 3.145 |
| 4 | 1.565 | 2.168 |
| 5 | 2.468 | 3.045 |
| 6 | 3.489 | 4.184 |
| 7 | 4.581 | 5.555 |
| 8 | 4.058 | 5.370 |
| 9 | 4.012 | 5.615 |
| 10.6 | 3.801 | 5.533 |

Table 4.1 Gain and Directivity at different frequencies in UWB band

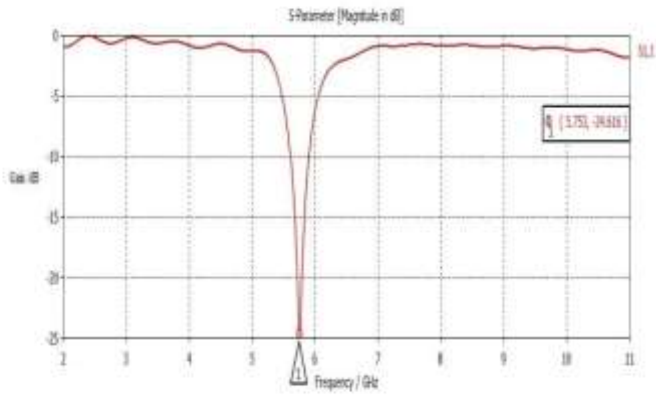



Fig 4.3 S-Parameter when S2, S4 and S7 in OFF state

***Case (2):***

When switches S2, S4 and S6 in OFF state,

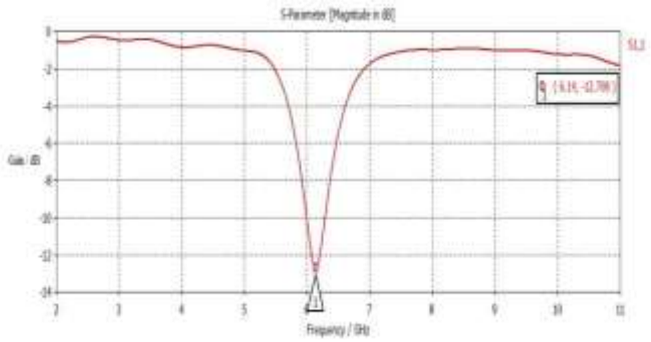


Fig 4.4 S-Parameter when S2, S4 and S6 in OFF state

***Case (3):***

When switches S3, S4 and S5 in OFF state,

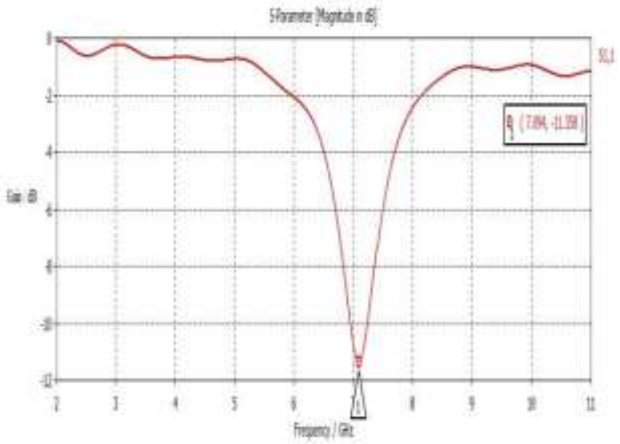


Fig 4.5 S-Parameter when S3, S4 and S5 in OFF state

***Case (4):***

When switches S1, S5 and S7 in OFF state,

Fig 4.6 S-Parameter when S1, S5 and S7 in OFF state

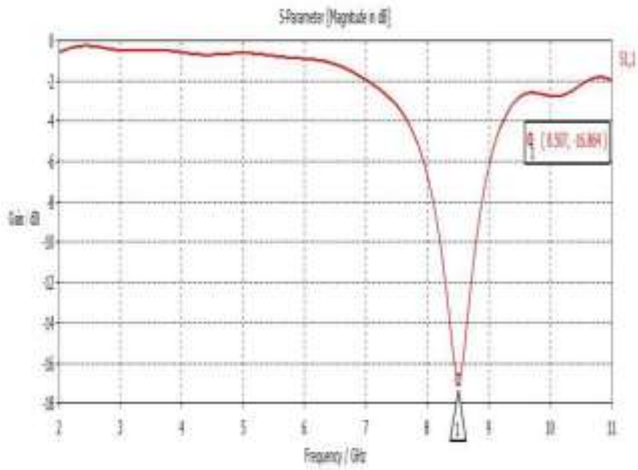


Fig 4.6 S-Parameter when S1, S5 and S7 in OFF state

***Case (5):***

When switches S2,S5 and S7 in OFF state,

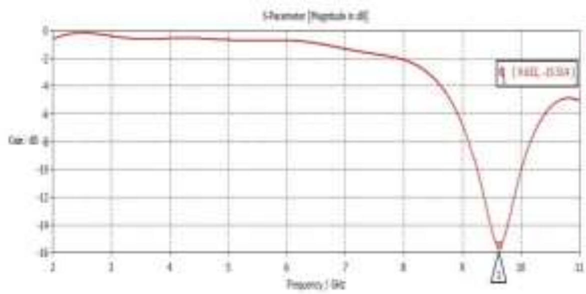


Fig 4.6 S-Parameter when S1, S5 and S7 in OFF state

The following table 4.2 summarizes the Gain and Directivity of the smart filtenna when the antenna in the reconfigured communication mode.

**Gain and Directivity of the reconfigured antenna at the different switching cases**

| Switches in OFF state | Communicating frequency (GHz) | Gain (dB) |
|---|---|---|
| S2,S4,S7 | 5.7 | 0.3101 |
| S2,S4,S6 | 6.14 | 1.567 |
| S3,S4,S5 | 7 | 3.426 |
| S2,S5,S7 | 9.6 | 4.392 |

Table 4.2

## V. CONCLUSION

A Planar Smart Filtenna was studied. And it is found from the results and discussions this Smart Filtenna maintains the reflection coefficient below -10 dB as per our expectation this antenna will operate effectively in the UWB spectrum from 3.1GHz to 10.6 GHz. Thus Smart Filtenna will senses the entire UWB spectrum effectively and let the secondary user to know the presence of freely available spectrum. Therefore with this antenna we can

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