Performance Analysis of Switchable Filtenna with Triple Band Rejection Characteristics for UWB Applications

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Abstract: In this paper, a small switchable filtering antenna (Filtenna) with triple band rejection characteristics is proposed for super UWB applications. The Proposed Filtenna provides Wi-MAX (World-wide Interoperability for Microwave Access), Wireless LAN (Local Area Network) and X-band frequencies band reject characteristics to overcome EMI interference in these bands. Therefore, we analyse the performance of switchable Filtenna with this triple band rejection. Here, the proposed three rejection bands switchable Filtenna is designed by engraving two CSRR (Circular Split Ring Resonators) and a U- shaped resonating structure on a radiation patch. Also, the three RF-MEMS (Radio Frequency Microelectromechanical System) switches is used in the UWB patch antenna to provide the switch-ability. In the proposed Filtenna, two RF-MEMS switches are used in the CSRR and one in the U-shaped resonator. It was observed that small UWB Filtenna provides wide bandwidth with low power consumption.

Keywords–*Circular Split Ring Resonators (CSSR), Filtering antenna (Filtenna), Microelectromechanical System (MEMS), Ultra Wide Band (UWB), Wireless Local Area Network (WLAN), World-wide Interoperability for Microwave Access (WI-MAX).*

I. INTRODUCTION

Today, UWB technology is become very popular in the industry of wireless communication. UWB systems have several advantages like large data rates, low cost, low power consumption and high security application etc. [1]. The sensors used for this purpose usually have limited battery life, capability and size. To overcome these problems, UWB antenna is used for communications among the sensors [2]. But, the UWB antennas is required to design with high bandwidth and compact in size. Various methods have been reported in this literature to mitigate this above problem i.e. Octagonal-shaped patch [3], Stepped connecting structure between tapered patch and slot lines [4], Defected Ground Structure (DGS) [5], Inverted L-strip rectangular patches [6], Circular slot antennas with a trident-shaped feed line [7], Slotted patch antenna [8].

The system employed with external band reject filters are complex and large in size. The parasitic structures or slots of different shapes in the ground plane of the antenna structure is used to solve this problem. The main contribution of this paper is to design a small switchable Filtenna with triple band rejection capability.

The remainder of this paper has been organized as follows. Section II describes antenna geometry and design of Filtenna antenna. The simulation results are discussed in the section III and finally conclusions are drawn in section IV.

II. SWITCHABLE FILTENNA MODEL

In this section, a small switchable Filtenna designed model using with three multiple switch is described in detail. Here, fig. 1 and fig. 2 shows the top and bottom view of the design structure of the switchable Filtenna with MEMS switches respectively. The Filtenna is designed as a pan-shaped patch in which two CSRR and a U-shaped resonator are etched to obtain band rejection characteristics on the FR4 substrate. Also, two rectangular slots is etched out in bottom plane for better impedance matching.

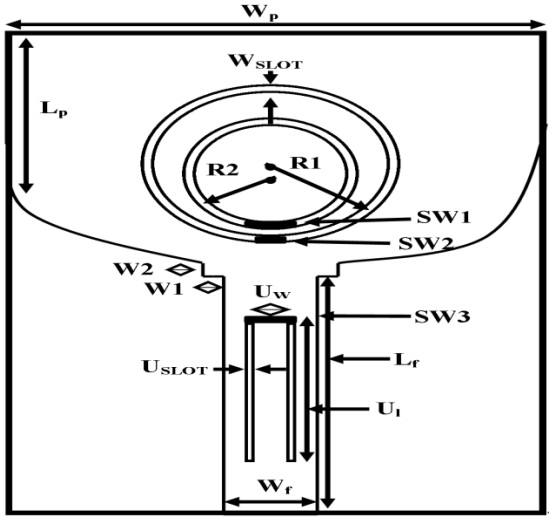


Figure 1: Top view of switchable Filtenna patch with MEMS switches

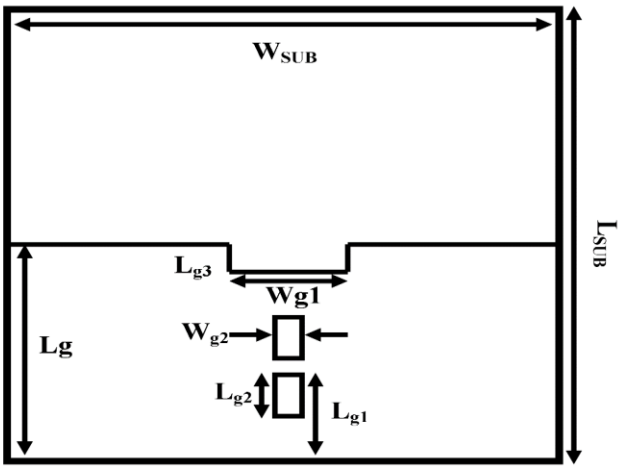


Figure 2: Bottom view of switchable Filtenna ground and substrate

The several parameters which are used in the above figure 1 and 2 are tabulated in Table 1:

Table 1: Design Parameter of proposed switchable Filtenna

Parameter	Dimension (in mm)	Parameter	Dimension (in mm)
W_{sub}	18	Wg1	4
L_{sub}	19	Wg2	0.7
W_f	3	W_{SLOT}	0.3
L_f	9.016	W1	0.9
H	1	W2	1
Lg	9.3	R1	4.3
Lg1	4.15	R2	3.1
Lg2	1.8	U_L	5.4
Lg3	1.2	U_W	1.2
Lp	5.216	U_{SLOT}	0.3

To achieve the desired band rejection capability, three switches are placed between the complementary ring resonating elements and U-shaped resonator on the radiator plane. The proper impedance matching gives the best S_{11} response at the desired frequency. Micro-strip line's impedance can be expressed in equation1 as:

$$Z_c = \frac{120\pi}{\sqrt{\varepsilon_{reff}}\left(\frac{1}{\frac{W_f}{h}+1.393+0.667\ln\left(\frac{W_f}{h}+1.444\right)}\right)} \quad \ldots.1$$

III. RESULT AND DISCUSSION

In the previous section, a small switchable Filtenna structure is designed using with three multiple switch. Now, Ansoft HFSS (high-frequency simulation structure) is used to examine the frequency rejection characteristics of Filtenna by varying the frequency from 1 to 28 GHz. In the figure 1, the absence and presence of a bridge of metal indicates the OFF and ON states of switch respectively. These three switches can be configured in fours ways which are tabulated in Table 2:

Table 2: Switches and their respective frequency tuning

CONFIGURATION NAME	SWITCH CONFIGURATION			FUNCTION
	SW1	SW2	SW3	
I	OFF	OFF	ON	Wide-Band Antenna
II	ON	OFF	ON	Single Band Reject Wideband Filtenna
III	ON	ON	ON	Double Band Reject Wideband Filtenna
IV	ON	ON	OFF	Triple Band Reject Wideband Filtenna

In the above Table 2, when switch 3 is in ON state then no band rejection is observed if both switch 1and switch 2 are OFF as shown in figure 3.

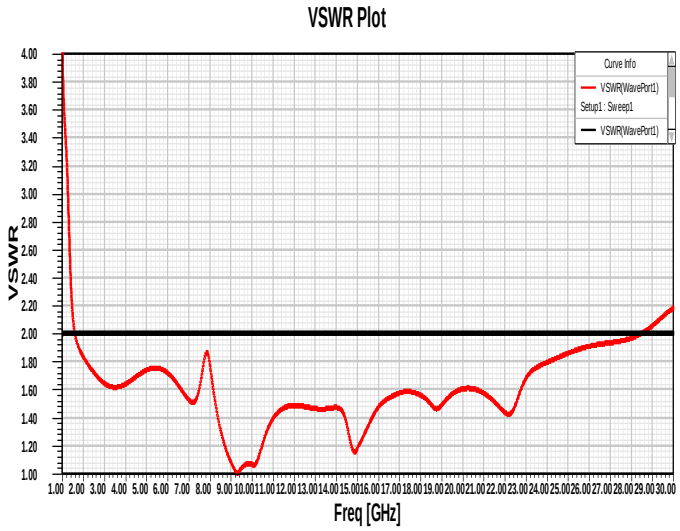


Fig. 3: VSWR v/s Frequency of the switchable patch Filtenna for switch configuration-1

From the above plot of VSWR Vs Frequency, it is seen that Filtenna covers wide bandwidth i.e. 1.6-28.25 GHz for VSWR < 2 dB for the switch configuration I. In further switch 3 ON configuration, if any one of switch 1 or switch 2 is on state then the single frequency is observed as shown in figure 4. But, double frequency rejection is observed if all three switch are in ON state as shown in figure 5.

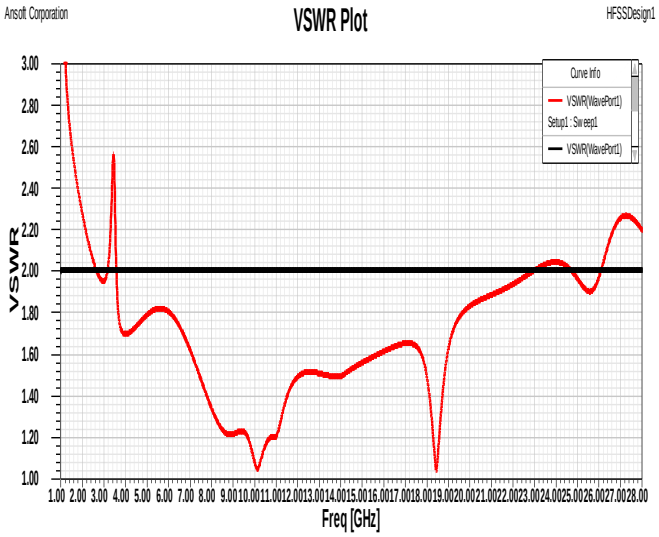


Fig. 4: VSWR v/s Frequency of the switchable patch Filtenna for switch configuration-II

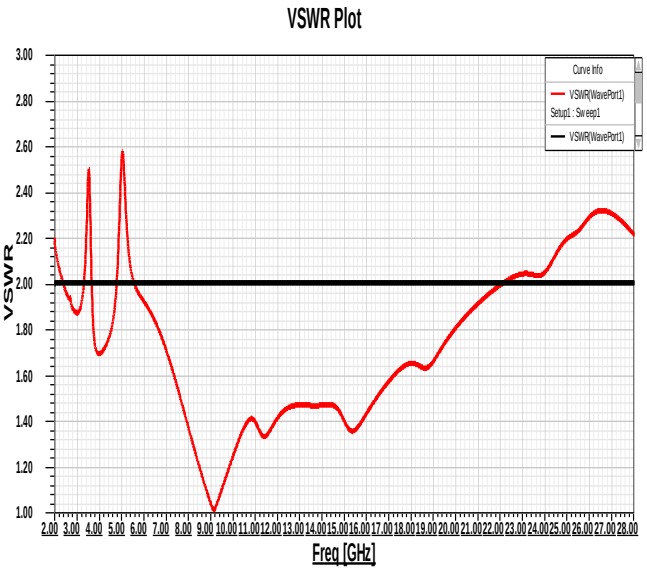


Fig. 5: VSWR v/s Frequency of the switchable patch Filtenna for switch configuration-III

Here, fig. 4 depicts that Filtenna has an impedance bandwidth ranges from 2.7 to 23.14 GHz and VSWR < 2 excluding a reject-band ranges from 3.2 to 3.72 GHz. However, two band rejection is observed in figure 5 at 3.5 GHz and 5.0 GHz for filtering the potential EMI interference from Wi-MAX and Wireless LAN communication system.

In last switch configuration of Filtenna in which switch 1 and 2 are ON state and switch 3 is OFF, three bands is rejected at 3.5 GHz, 5.1 GHz and 8.17 GHz to reject the potential EMI interferences from Wi-MAX ,WLAN and X- frequency bands as show in figure 6 below:

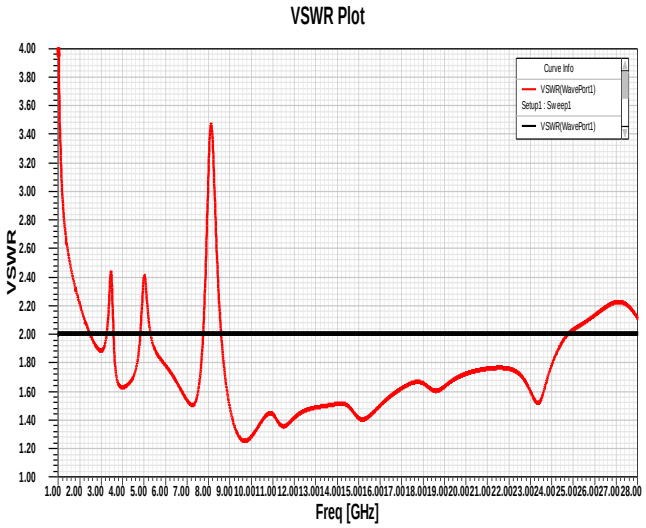
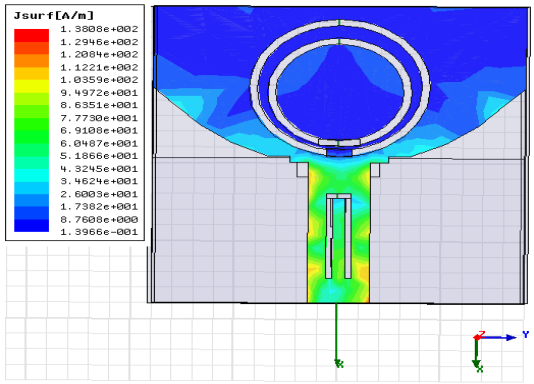
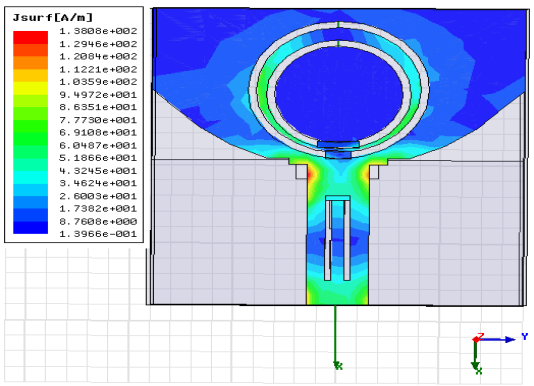


Fig. 6: VSWR v/s Frequency of the switchable patch Filtenna for switch configuration-IV

Furthermore, we also examined the Filtenna surface current distribution after simulation in various switch configurations as shown in Fig 7. Here, Fig 7 (a) and (b) depicts the surface current distribution in switch configuration I. In Figure 7 (c) simulation result shows that the main distribution of current is around inner CSRR at 3.5 GHz. The surface current at 5.1 GHz having mostly concentration around outer CSRR as viewed in Fig 7(d) and at 8.14 GHz the main concentration of surface current distribution is around U resonator.



(a)



(b)

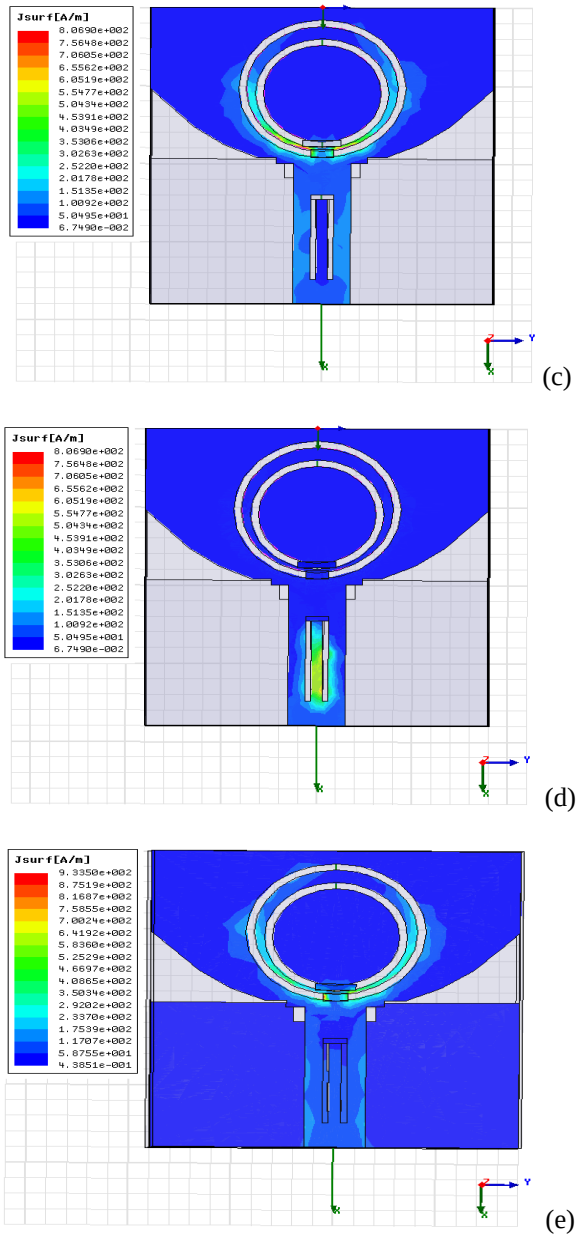


Fig. 7: Current distributions for proposed Filtenna structure in (a) switch configuration I at 3.5 GHz (b) switch configuration I at 8.2 GHz (c) switch configuration II at 3.5 GHz (d) switch configuration III at 5.1 GHz (e) switch configuration IV at 8.14 GHz

This is clearly visible that the main concentration of surface current is on the resonating elements that are responsible for band rejection at that frequency.

IV. CONCLUSION

In this paper, the performance of a small switchable Filtenna structure with triple band-rejection characteristics is analysed. Also, a defected ground structure (DGS) in Filtenna is used to improve antenna's bandwidth. This proposed antenna is having switchable triple band-reject property that is obtained by using two split ring resonators and a U-shaped resonating structure in radiating patch. These resonators provides less interferences at Wi-MAX, WLAN and X-band frequencies. Three ideal switches is used to achieve the switching reconfiguration in proposed antenna. The presented antenna is having VSWR less than 2 except the three unwanted reject-bands. The VSWR and far-field measurements of the antenna is having perfect matching with simulation prediction.

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