# Reconfigurable UWB Filtennas with Dual Bandnotch for Unwanted Bands using Graphene based Switches

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***Abstract*—Presented are the design and results of a reconfigurable UWB filtenna with sharp dual bandnotch at WiMAX 3.5 GHz and WLAN 5.8 GHz bands. The filtenna is formed by placing three loop resonators in an UWB antenna. The resonators are fitted with Graphene based switches which introduce reconfigurability. The filtenna was simulated electromagnetically and with Graphene based switches in switches OFF and switches ON states. Presented results show a passband from 2.81–12.27 GHz in OFF state and ON state results in sharp dual bandnotch within the passband at 3.45 and 5.95 GHz at a return loss of 2–2.5 dB. The gain and efficiency in both states has also been given and is reduced in ON state at the dual bandnotch. The radiation patterns in E- and H-planes are stable.**

***Keywords—reconfigurable; filtennas; graphene; bandnotch.***

## I. Introduction

Since the release of unlicensed 3.1–10.6 GHz frequency band for UWB commercial communications [1], it has become necessary to cull the unwanted, overlapping and interfering wireless services whose power level is higher than the UWB; such as WiMAX 5.15–5.35 GHz and WLAN 5.725–5.825 GHz bands. Thus, notches are realized at these frequencies as an effective solution. To attain this, various methods are used, such as applying SRRs [2], capacitively-loaded loop resonators [3], slots [3] or by using stubs [4] and [5]. However, in the above works, the bandnotch are either not sharp enough or not a good measured rejection value [2]–[3] or the filters have been cascaded with the antenna [4]–[5], rather than being integrated within; thus increasing complexity, cost and size of circuits. This work presents an UWB filtenna, which is developed by incorporating three loop resonators within an UWB antenna. This method does not increase the size and the obtained bandnotch are sharp and measured at good values. Furthermore, this work also shows how Graphene based switches can be used to make the filtenna reconfigurable. Hence, the dual bandnotch can be switched off or on at will.

## II. Design of Proposed Filtennas

The proposed filtenna is illustrated in Fig. 1. The filtenna is designed with a mid-band frequency of 6.85 GHz. It is inductively coupled to the source and is excited via port 1 with a 50 Ω feedline. The designed structure utilizes defected ground structure with a partial ground plane of length 13.1 mm. The filtenna is symmetrical with respect to in the longitudinal direction. A spade shape is chosen for the top metallization. Due to the gradual change in structure of this shape, a broadband impedance bandwidth is easily achieved. This shape also provides a smooth shift from one resonant mode to another. Between the top laying semi-circular patch and the feedline, two rectangular patches of different sizes are laid. These improve impedance matching and also provide good characteristic at the higher frequencies. The 3.5 GHz bandnotch is produced by a circular loop resonator which is laid within the top radiating patch. The 5.8 GHz bandnotch is because of two rectangular loop resonators; each of which is laid on either side of the feedline. Since these resonators would be capacitively coupled, two have been used in order to improve the coupling and obtain better rejection results. A splitting gap exists in all resonators: of 0.8 mm in the circular loop and 0.5 mm in the rectangular loops. All three resonators are $\lambda_g/2$ long; where $\lambda_g$ is the guided wavelength at their respective bandnotch frequency. The switch in the case of the circular loop will be placed within its splitting gap. While the switches in the case of the rectangular loops are placed in the middle of their longest transmission line; thereby dividing each resonator in two mirrored parts. In this way, all three switches can cut or allow the flow of current in the three resonators.

Graphene based switches are realized by modelling the complex surface impedance of Graphene using (1)–(3) from [6]. Modelling of complex surface impedance takes in account the surface resistance and surface reactance of Graphene. Modelling of surface impedance is quicker and uses much less memory and computing resources than traditional bulk modelling. Similar to [6], while $T$ and $\tau$ are fixed to 300 K and 125 ps respectively, The switches are in OFF state when Graphene is unbiased at a chemical potential of $\mu_c$ = 0.0eV and in ON state when Graphene is biased to a chemical potential of $\mu_c$ = 1.0eV. Thus, the reconfigurable states of the switches can be easily obtained. MATLAB was used to model and calculate the varying surface resistance and reactance in the two states and the resultant data exported to the simulation software.

## III. Results

The filtenna is simulated on 0.8 mm thick Rogers RT5880 substrate, of a dielectric permittivity $\varepsilon_r$ = 2.2 and a loss tangent tanδ = 0.0009, using *CST Microwave Studio*. Electromagnetic

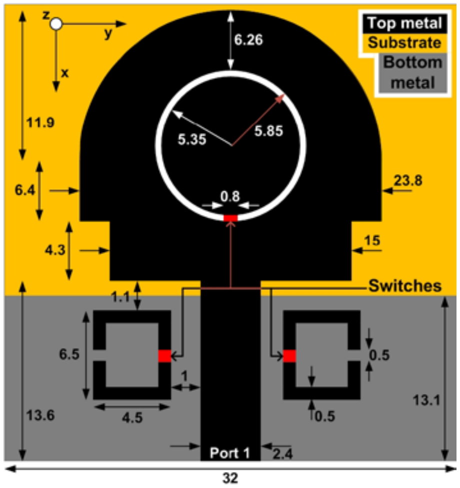


Fig. 1. Geometry of filtenna (dimensions in mm).

simulations in OFF state are done by laying gaps at the switches' places and in ON state by putting perfect electric conducting (PEC) metal patches in these gaps. Simulations for the two states using Graphene based switches (GbS) are carried out by using the exported data from MATLAB. Presented return loss results in Fig. 2 show a good agreement between the PEC electromagnetic and Graphene based switches results. Graphene based switches in OFF state show a full passband in the 2.81–12.27 GHz range. In ON state, results show sharp dual bandnotch at 3.45 GHz and 5.95 GHz at a return loss of 2 dB and 2.5 dB respectively; indicating the desired rejection.

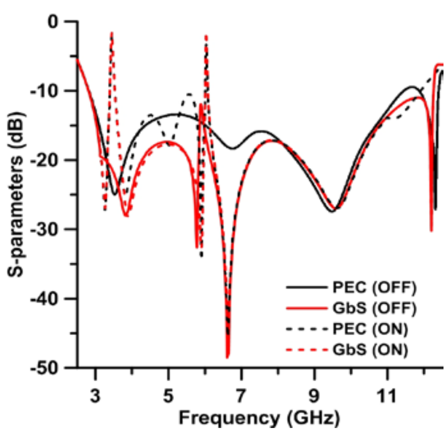


Fig. 2. Return loss of filtenna.

The radiation patterns at various frequencies in the E- and H-planes are shown in Fig. 3. Stable bidirectional patterns in the E-plane and omnidirectional patterns in the H-plane are exhibited. Also, at the 4 GHz passband, there is negligible effect on the patterns regardless of the switching state. But, at the 5.8 GHz bandnotch, both patterns decrease in magnitude when switched from OFF to ON state. The simulated gain and efficiency in both states is given in Fig. 4. The average gain and efficiency in OFF state is 4.33 dBi and 96 %. In OFF state, the gain and efficiency at the dual bandnotch are 3.15 dBi and 5.04 dBi, and 97.5 % and 96.9 %. When in ON state, these fall to 1.53 dBi and -0.85 dBi, and 42.5 % and 24.1 %.

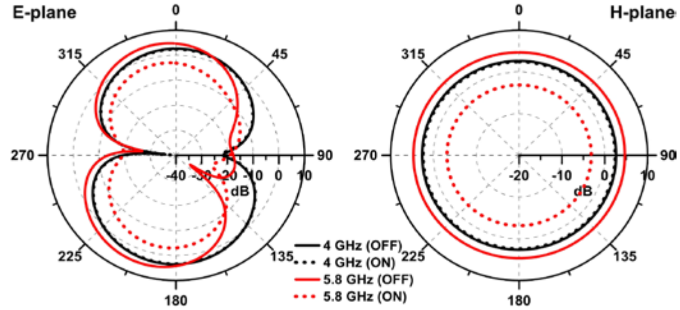


Fig. 3. Radiation patterns of filtenna.

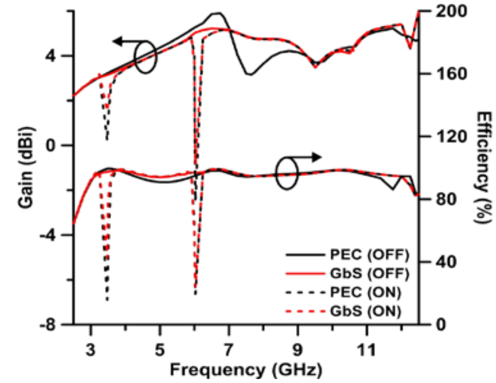


Fig. 4. Gain and efficiency of filtenna.

## IV. Conclusion

A reconfigurable UWB filtenna is proposed. Filtering is achieved by incorporating three looped resonators; which are fitted with Graphene based switches to get reconfigurability. OFF state shows a full passband in the UWB. While in ON state, sharp dual bandnotch exist at the WiMAX and WLAN bands. This trend is evident in the gain and efficiency too. All these reductions show the rejection capability of the filtenna and successful working of the Graphene based switches in both states. This filtenna can be useful for indoor UWB applications with no interferences from WiMAX and WLAN signals.

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