A Reconfigurable Band-Reject MIMO for Cognitive Radio

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***Abstract*—This paper presents a two-port MIMO antenna for cognitive radio applications. The antenna is able to tune its notch frequency based on the integration of a band-reject filter within its feeding line and ground plane. The presented antenna achieves a low envelope correlation coefficient proving its validity for a MIMO and cognitive radio environment.**

***Index Terms*—band-reject, cognitive radio, MIMO,**

I. INTRODUCTION

Cognitive radio is attracting a lot of attention as a solution to improve the spectrum usage efficiency and allow the idle slots of the spectrum to be always utilized [1], [2]. Moreover, MIMO was shown as a good solution to increase channel capacity and combat fading and various propagation effects in a wireless environment. Therefore, future RF front-end should be able to support cognitive radio as well as MIMO implementation in order to achieve an optimal mode of communication [3].

Reconfigurable antennas constitute a potential candidate for cognitive radio RF front-end. The ability of these antennas to change their radiation characteristics on demand represents a major advantage. However, the design of reconfigurable antennas requires an appropriate incorporation of switching elements to be able to perform the corresponding operation without affecting the antenna performance [4].

In this paper, a reconfigurable antenna design suitable for MIMO cognitive radio is presented. The proposed antenna structure makes use of two ports. The antenna is able to change its notch frequency in order to minimize interference with other users. The reconfigurabilty is achieved by incorporating a band-reject filter within the antenna feeding structure. The paper is divided as follows: In section II, the design of the filter is discussed. Section III details the whole antenna structure. The simulated and measured data are presented as well. Conclusions and future work are shown in the last section.

II. FITLER STRUCTURE

The band-reject behavior of the filter presented in this work can be obtained by removing a U-slot from either the feeding line or the ground plane of the structure. The inner length of the U-slot is proportional to the filter notch frequency.

A. *U-slot in the feeding Line*

For this case, the filter consists of a full ground plane of dimensions 30x30 mm^2. The filter feeding line is of width 5 mm and a length of 30 mm. A U-slot of an outer length of L_{out}= 20.425 mm and an inner length of L_{in}=15.475 mm is removed from the feeding line of the filter as shown in Fig. 1(a). The filter response shows that a notch frequency is achieved at f= 3.6 GHz due to the inner length of the U-slot where $L_{in} \approx \lambda_{eff}/4$.

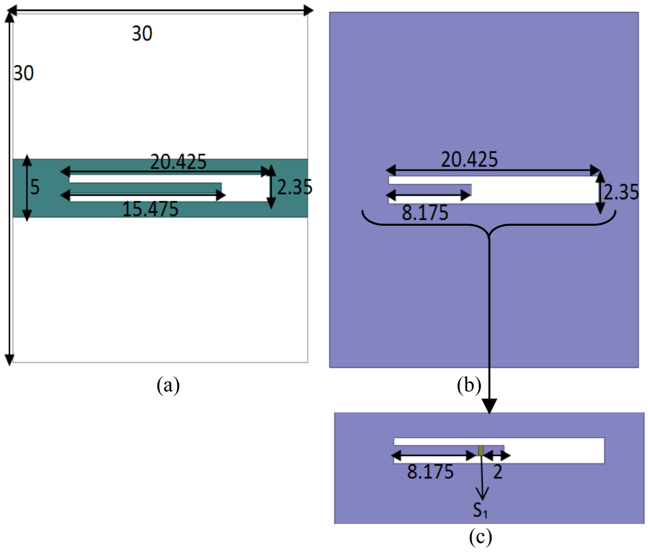

Fig. 1 (a) U-slot in the feeding line of the filter (b) U-slot in the ground plane (c) the incorporation of a pin-diode in the U-slot of the ground plane

B. *U-slot in the ground plane*

For this case, the filter consists of a 5 mm width feeding line and a ground plane that contains the U-slot. The slot has the same outer length as case (a) however the inner length is shorter (L_{in}=8.175 mm) as shown in Fig. 1(b). The filter response shows that a notch frequency is created at a higher frequency (f=6.52 GHz) compared to case (a). This is due to the shorter inner length of the U-slot in the filter ground plane. The inner length of the U-slot corresponds approximately to $\lambda_{eff}/4$ at f=6.52 GHz.

C. Combining the U-slot in the feeding line and the ground plane

If the U-slot in the feeding line and the ground plane are combined together in the same substrate structure, the filter produces a dual notch frequency. These two notch frequencies can be made reconfigurable by changing the inner length of the U-slot in the ground plane or the feeding line.

In this work, the inner length of the U-slot in the ground plane is changed by attaching a switch S_1 as shown in Fig. 1(c). The switch S_1 is modeled as a PIN diode from Infineon. The job of S_1 is to increase the inner length of the U-slot by 2 mm. This has the effect of lowering the notch that is produced by the slot in the ground plane.

The filter response for the two different cases of the switch S_1 is shown in Fig. 2. One should mention that the notch frequency from the U-slot in the ground plane for the case when there is no switch connected is slightly higher than the case when S_1 is connected and in the OFF state. This is due to the lumped RLC effect of the incorporated pin diode switch.

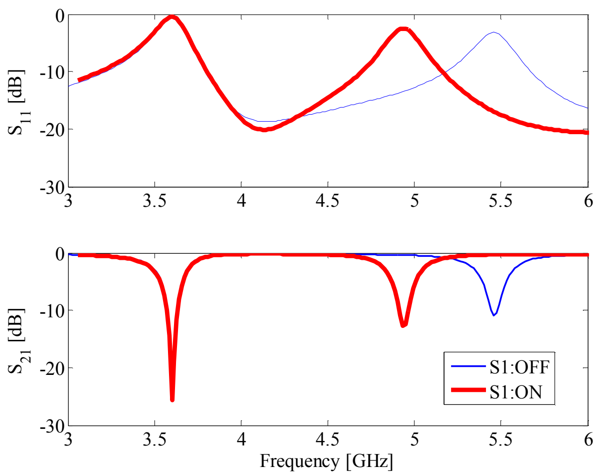

Fig. 2 The filter S-parameter for the two mode of operation of the switch S_1

III. ANTENNA STRUCTURE

The antenna layout presented in this work consists of a two-port MIMO structure. Each port feeds an identical radiating structure as shown in Fig. 3(a). The top layer of each structure is made of a printed monopole of length 20 mm and width 25 mm. In the feeding line and the ground plane of both radiating structures, the filter discussed in the previous section is embedded.

Both structures share the same ground of dimensions 70x30 mm^2 and are separated by a distance of 10 mm in order to ensure a good MIMO behavior. The antenna structure is able to cover a wide bandwidth from 2GHz to 10 GHz. The antenna ground dimensions are summarized Fig. 3(b).

A dual notch frequency is achieved due to the integration of the filter. The upper notch frequency can be changed based on the status of the switches S_1/S_2 that are included in the ground plane of each radiating structure. The top layer of the fabricated antenna is shown in Fig. 3(c) and the integration of the switches in the ground plane is shown in Fig. 3(d). The comparison between the simulated and the measured antenna reflection coefficient for the two cases of the switches is summarized in Fig. 4. A good agreement between both data is achieved.

The maximum measured coupling between the two radiating structures is found to be almost -15 dB as shown in Fig. 5(a). In order to evaluate the performance of the MIMO antenna, the envelope correlation coefficient (ECC) should be calculated based on the S-parameters of the two-port antenna. A low ECC is desirable in order to ensure a good MIMO behavior in a multipath environment. The comparison between the simulated and the measured ECC is summarized in Fig. 5(b).

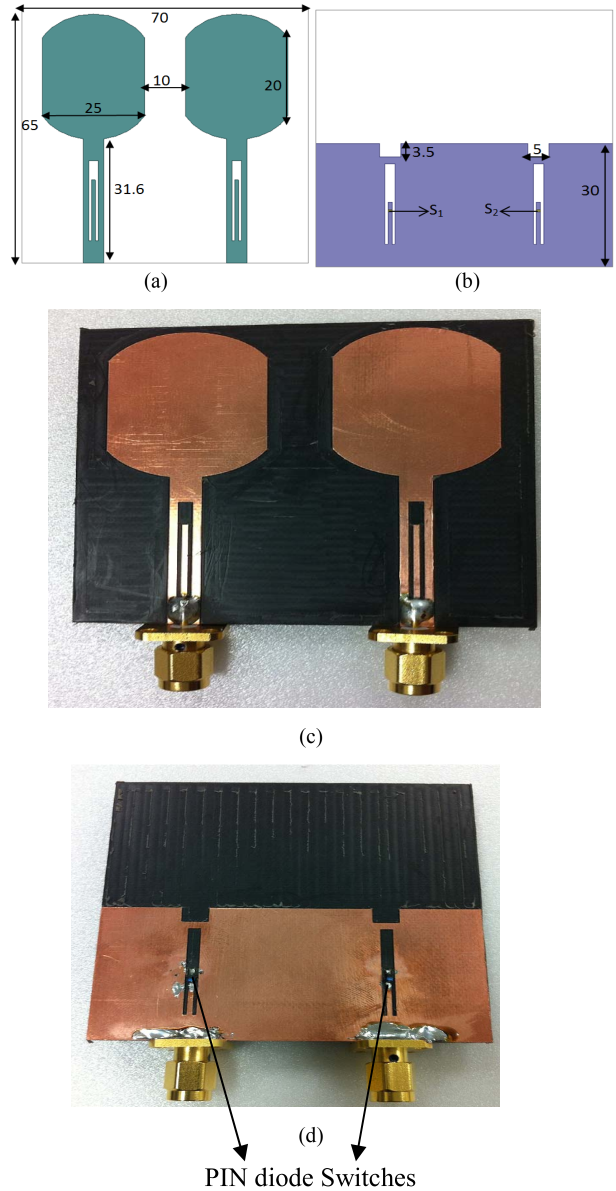

Fig. 3 (a) The antenna top layer (b) the bottom layer (c) the fabricated top layer (d) the integration of the switch in the antenna ground structure

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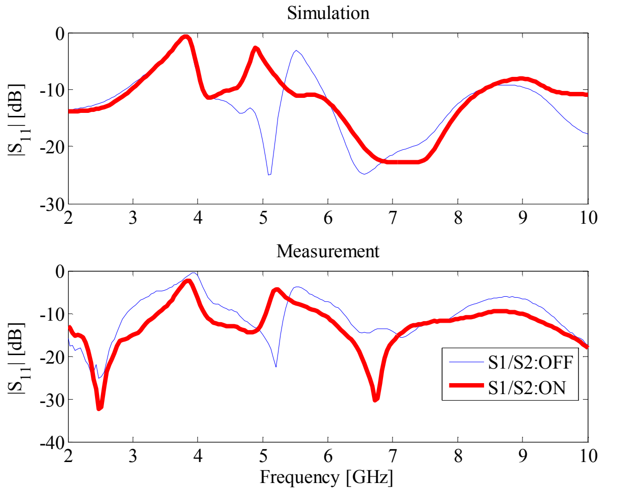

Fig. 4 The simulated/measured reflection coefficient for the MIMO antenna

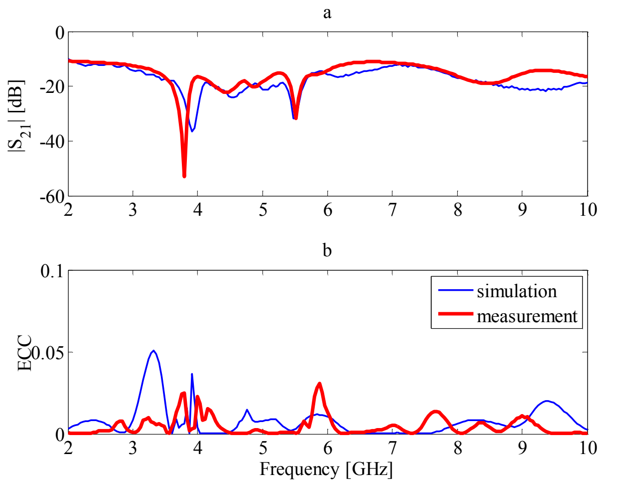

Fig. 5(a) The coupling (b) the envelope correlation coefficient of the antenna

IV. Conclusion

This paper presents a MIMO antenna for a cognitive radio RF front-end. The antenna is able to tune its notch frequency based on the integration of a band-reject filter. The notch frequency of the filter is made reconfigurable by integrating a switch in the inner length of the U-slot that resides in the ground plane. A prototype antenna was fabricated and tested. A good analogy was found between the simulation and measurement. For future work, we are looking to test the behavior of the MIMO antenna in a wireless environment to prove its operation

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