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Multiband Microstrip Antenna for Software Defined Radio/Cognitive Radio based Wireless Communication Systems

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ABSTRACT:| With the stupendous advancements in wireless communications, there is a increasing demand for small, low-cost, easy-to- fabricate , multiband and wideband antennas for use in commercial communications systems. The fact that different wireless standards, such as WLAN and WiMAX, use different operation bands push the need for terminal antennas that are multiband and/or wide band. In this paper, a low-cost multiband micro strip printed-circuit-board (PCB) antenna that employs Koch fractal geometry is designed, simulated and demonstrated . The antenna is fabricated on a 1.6 mm-thick FR4-epoxy substrate with the dimension 4.0 cm*4.5 cm, with micro strip-line feeding and has a partial ground plane. The proposed antenna is simulated using the Finite-Element Method software ANSYS HFSS for three different switching cases and the return loss in dB is measured for each case. It is revealed that the antenna can operate in the bands of several applications including Wi-Fi, WiMAX as well as a portion of the UWB range. This is a prototype antenna designed for Software Defined Radio/Cognitive Radio applications. The radiation patterns are agreeably Omni directional across the antennas desired operational frequency bands.

KEYWORDS: Multiband, Micro strip, PCB, SDR, switching

I.INTRODUCTION

The tremendous advancements in wireless communications, there is an increasing demand for miniature, low-cost, easy-to-fabricate , multiband and wideband antennas for use in wireless communications systems. As a part of an effort to further enhance modern communications systems technology, researchers have been studying different approaches for creating novel and innovative antennas [1]. The approach adopted in this paper combines fractal geometry and reconfigurablity in order to come up with a new antenna design suitable for several wireless applications.

The fact that different wireless standards, such as WLAN and WiMAX, use different frequency bands pushes the need for antennas that are multiband and/or wideband [2, 3] A Koch fractal geometry is introduced in the patch and the U-slot to increase the antenna's electrical length. This will help obtain a resonance at a lower frequency without increasing the overall antenna size. Then, a dynamic switching technique which achieves selective resonance in frequency is used [4]. This technique, known as reconfigurablity, has an important switching property that allows users to access a great number of services of divergent frequency bands with a single wireless device [5].Consequently, the mounting of RF switches across the U-slot would lead to a different set of resonance frequencies for each switching scenario.

Koch curve is an excellent example of self-similar space occupying fractal shape which have been used to develop multiband antennas. The first four iterations of Koch curve are shown in Fig. 1. In [6], it was shown that self-similar fractals affect the electromagnetic property of antennas created on the basis of these geometries, and that Koch fractal antennas are multiband structures.

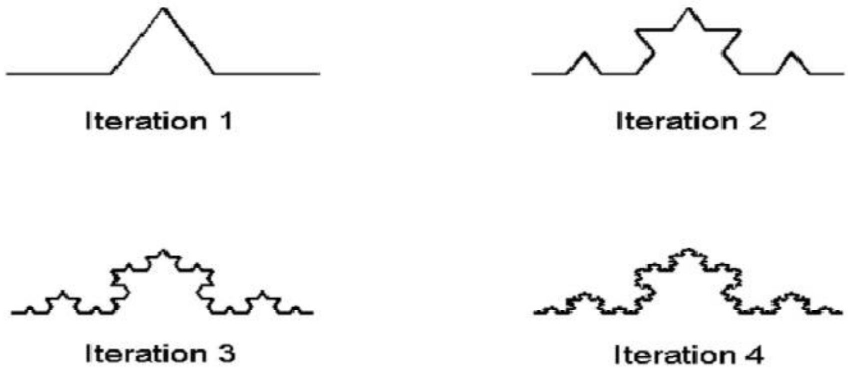

Figure 1: The first four iterations of the standard Kochzz Fractal

Reconfigurablity in antenna systems is a desired feature that has recently received significant attention in developing novel and pioneering multifunctional antenna designs. Compared to conventional antennas, reconfigurable antennas provide the ability to dynamically adjust various antenna parameters. The active tuning of such antenna parameters is typically achieved by manipulating a certain switching behavior. Reconfigurable antennas reduce any adverse effects resulting from inter channel/Co-channel interference and jamming. In addition, they have a remarkable characteristic of achieving diversity in operation, meaning that one or multiple parameters, including operating frequency, radiation pattern, gain and/or polarization, can be reconfigured with a single antenna.

Electronic, mechanical or optical switching may be engaged with reconfigurable antennas [7]. Electronic switching is analyzed using lumped components such as PIN diodes, FET transistors or RF MEMS switches Compared to PIN diodes RF MEMS switches have better performance in terms of isolation, power consumption, insertion loss and linearity [8].

II.ANTENNA GEOMETRY

The geometrical structure and dimensions of the proposed printed circuit board monopole micro strip antenna are described in Figure. 2. The epoxy substrate, which is 1.6mm in thickness, is based on the low-cost Fire Retardant FR4-epoxy material with a dielectric constant of permittivity er = 4.4. The dimensions of the substrate are 4 cm for the width and 4.5 cm for the length. The ground plane is partly filled. The first iteration of Koch fractal geometry is used in the patch and the U-slot is used to increase the antenna's electrical length for operation at lower frequency bands.

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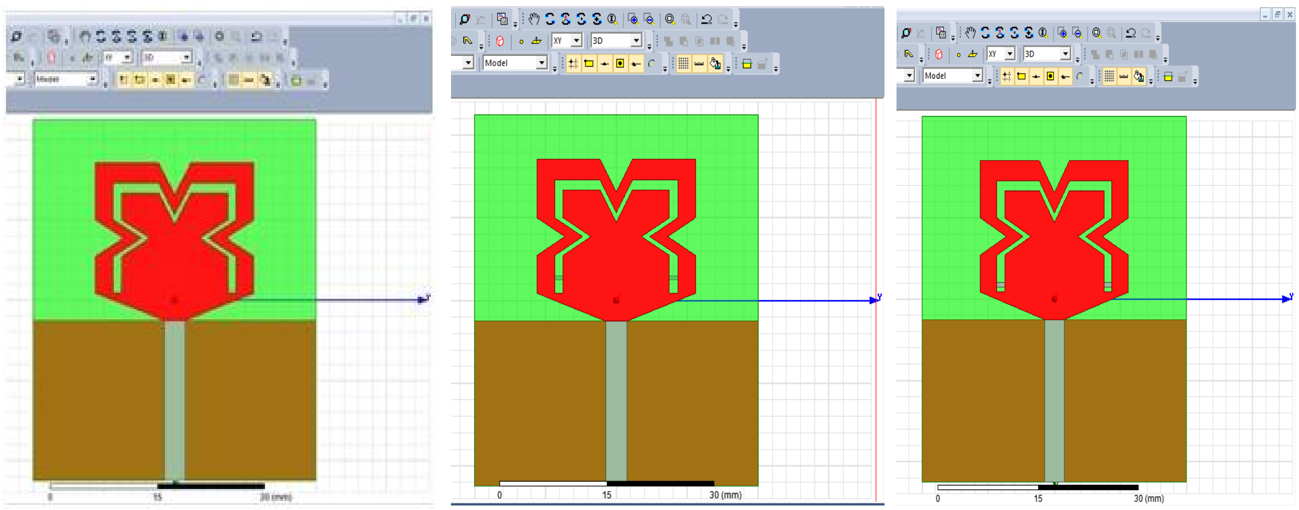
Fig.2a:Geometry of Antenna Fig 2b:Top View Fig 2c:Bottom view

Figure 2: Koch fractal reconfigurable micro strip antenna structure.

Two pairs of RF switches are mounted across the slot, as indicated in Figure 3. A switch in RF systems can be represented either by a resistor to act as a short circuit(ON) or by a capacitor to act as an open circuit(OFF). Therefore, the simplest way to demonstrate an RF switch for use in this design is to construct a 150um^2*150um^2 rectangular strips that has the same dimensions of those presented in [9]. Hence, an OFF state is represented by taking this rectangular strip out of the antenna, and mounting it again in the same location represents its ON state, as depicted in Fig. 3. This method for representing RF MEMS was used in [9]. RF-MEMS are known to possess good performance in terms of isolation and insertion loss. So, representing these by including or omitting copper strips of the same size is considered valid.



Case 1:All switches OFF Case 2: S1,S2' ON Case3: S2,S2' ON

Figure 3: Koch fractal reconfigurable micro strip antenna HFSS model with switches a)All OFF b) S1,S1'ON b) s2,s2'ON

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Although 4 switches are used for the operation, only two switching conditions are selected, as listed in Table 1. These dual switching cases were enough to introduce sought-after frequency bands.

Table 1: Switching state for three cases

Case	S1, S1'	S2, S2'
Case 1	OFF	OFF
Case 2	ON	OFF
Case 3	OFF	ON

III. RESULTS AND DISCUSSION

The design simulated and analysed in this paper is done using ANSYS HFSS [10] Finite-Element Method (FEM) EM simulator.

The selected design was used in a reconfigurable scheme after optimizing the locations of the switches. The simulated return loss plots for three cases are given in the Figures 4-6. The ANSYS HFSS-computed gain patterns in the *X-Z* and *Y -Z* planes, for each case, are shown in Figures 6-8.

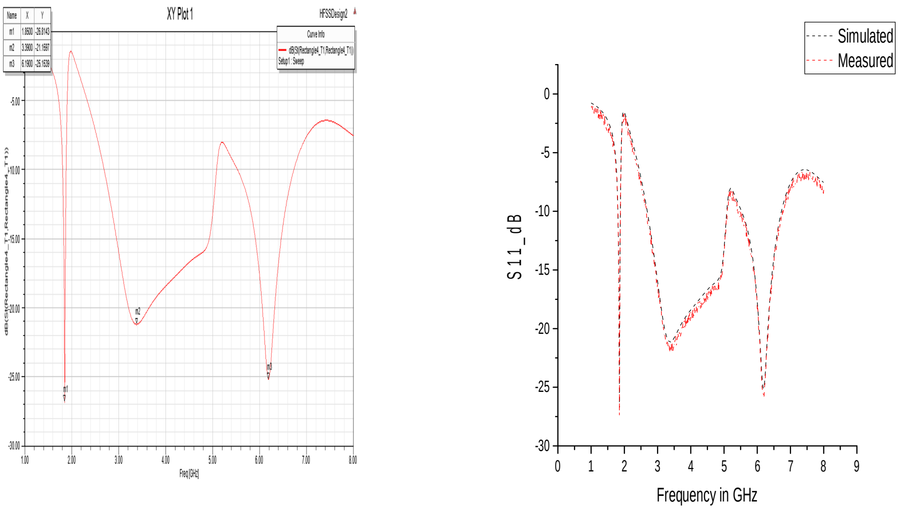

Figure 4: Return loss when all the switches are OFF

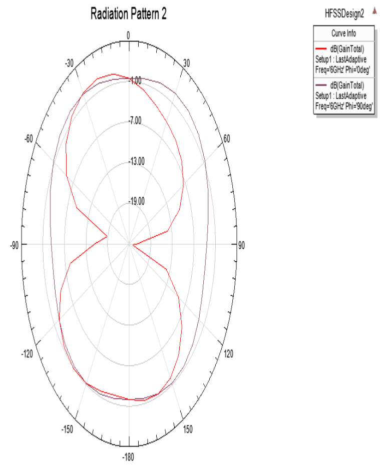

Figure 7:Radiation pattern when all the switches are OFF at 6GHz

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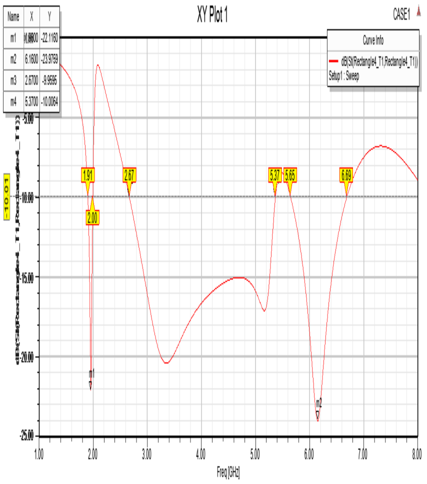
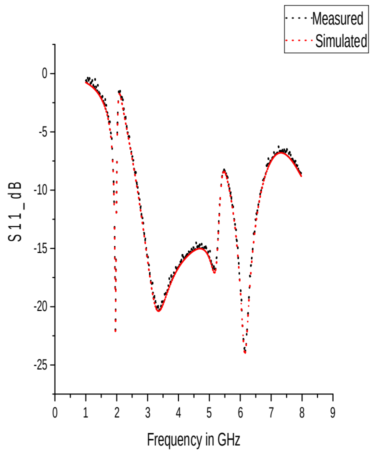




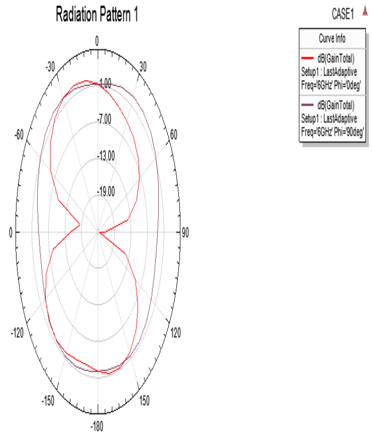
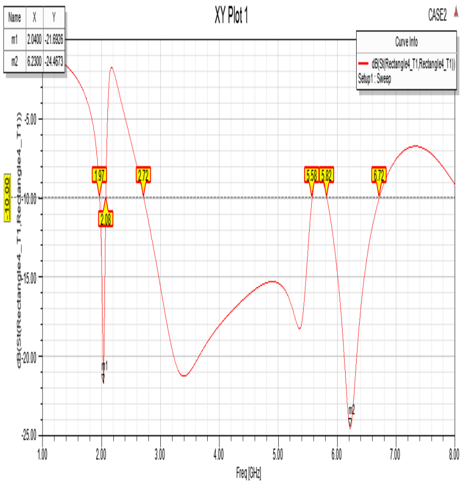
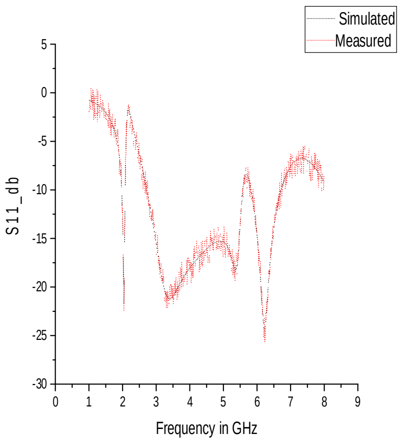


Figure 8: Radiation pattern whenwhen all the switches S1,S1' are ON

Figure 5: Return loss when all the switches S1,S1' are ON





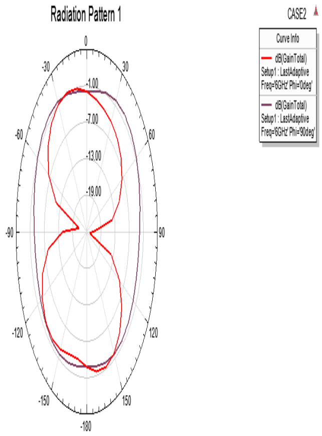


Figure 6: Return loss when all the switches S2,S2' are ON

Figure 9: Radiation pattern when all the switches S2,S2' are ON

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Figure 10: 3D-Polar plot of the radiation characteristics

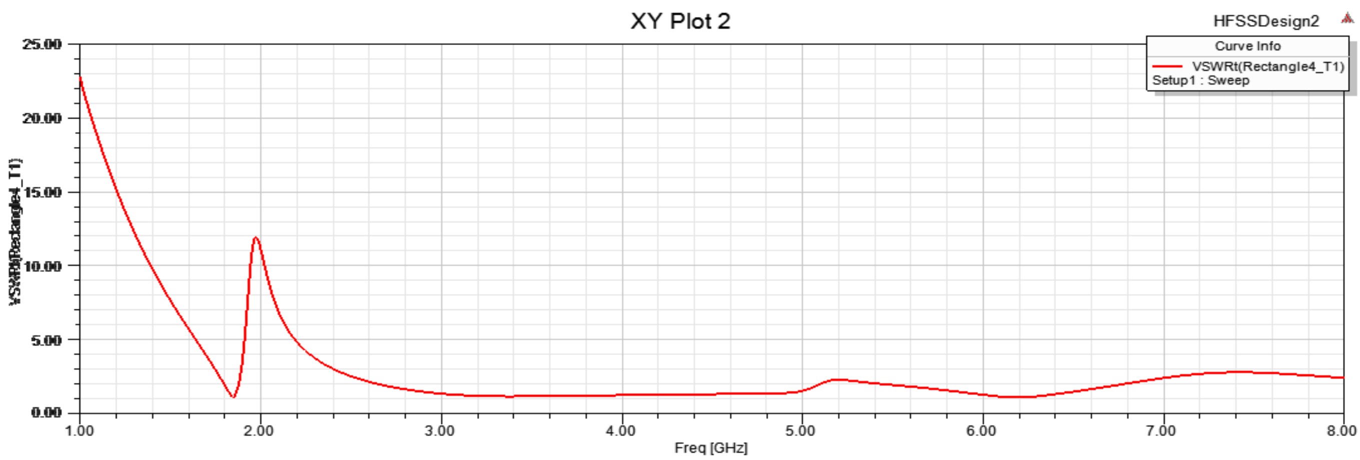

Figure 10: VSWR plot

The impedance matching is also analysed using smith chart and found to be within the desired bounds in the frequency of operation.

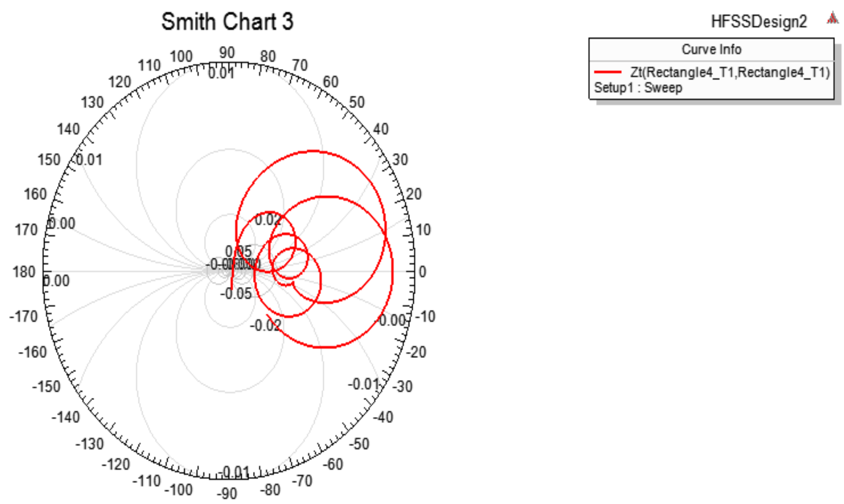

Figure 11: Smith Chart -Terminal Impedance Z_{11}

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The three cases result in omnidirectional patterns with equal radiation in the *X-Z* plane and a figure of 8-shaped pattern corresponding to a 3D pattern shape of a doughnut. This result is expected since the proposed antenna is a printed monopole.

VI.CONCLUSION

An active element integrated micro strip antenna design approach which combines fractal shapes and electronic switching was proposed in this article. The planned design is easy to fabricate, economical and easy integration with MMIC circuits, and multiband/wideband in operation. The antenna is based on a U-slot rectangular patch. Koch fractal geometry was selected to the patch surface and slot sides to increase the resonant electrical length of the antenna without increasing its overall dimension, thus leading to resonance at a desired lower frequency.

Reconfigurability is achieved by integrating RF switches at selected locations across the slot. Three switching scenarios were selected, and these demonstrated a clear frequency selectivity of the antenna, as shown by simulated return loss results. These antennas are a suitable candidate for the cognitive radio and Software defined radio applications.

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