An Ultra-Wide Band Octagonal Antenna With Reconfigurable Narrowband Antenna For Cognitive Radio Applications

Buddi Bhanu Shankar, Dasari Anantha Sai Kumar, Garlapati Venkata Kowndinya, Arjuna Muduli, Deepak Kumar Nayak

Abstract: The idea of this paper is to design a dual port ultra-wide band antenna integrated with reconfigurable narrow band antenna for cognitive radio applications. The narrow band antenna is a microstrip patch antenna attached at the back side of the ultra-wide band octagonal antenna. The ultra-wide band senses over the frequency range of 3.91 – 11.29 GHz. The Narrowband reconfigurable antenna is seen to operate at 6.39GHz, 6.90GHz, 7.81GHz, 8.94 GHz. Isolation between both the ports is kept less than -15 dB over entire operating band. Reconfiguration is done with the help of pin diode. The antenna switched from ultra-wide band to narrow band by switching 'ON' the pin diode.

Keywords: Cognitive radio, ultra-wide band, narrowband, return loss

I. INTRODUCTION

A cognitive radio represents an innovative approach to wireless communications where they can sense, monitor and dynamically reconfigure according to the requirement. This was first introduced by Joseph Mitola in 1999. It can identify unused gaps in spectrum and use them, as they are self-learning and adaptable based on the previous knowledge. The objective of Cognitive Radio (CR) is to reduce the dependency on a single channel spectrum by implementing cognitive radio approach and to utilise available communication channels more efficiently. A cognitive radio network must be able to sense the available spectrum and the gaps in it which is performed by the ultra-wide band antenna. The UWB antenna should have large bandwidth with an omni-directional radiation pattern to make sensing of the complete spectrum swiftly and depending on the requirements narrowband sensing also performed. A CR antenna can be realised in two ways to perform both sensing of spectrum and switching of spectrum: (a)integrating a narrowband (NB) antenna into an ultrawideband (UWB) antenna, and (b) a single UWB antenna performing both operations. The integrated CR antenna provides multi-role actions in single module, and it is suitable for a compatible device where available space is restricted. In this paper, the ultra-wide band is chosen as octagonal patch whose operating frequency is from 3.91 – 11.29 GHz having a partial ground. At the back side of the octagonal antenna, another microstrip antenna that is rectangular in shape is designed which is a reconfigurable narrowband antenna that is used for spectrum selection, meaning it selects the gaps found by the Ultra-wide band antenna.

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The Cognitive Radio is applied on the all the wireless applications such as cellular phones, tv broadcasting, defence applications, TV white spaces, Opportunistic cognitive radio networking, emergency and public safety applications, Vehicular Communications, Operator-controlled/assisted CR networks.

I. DESIGN OF ANTENNA

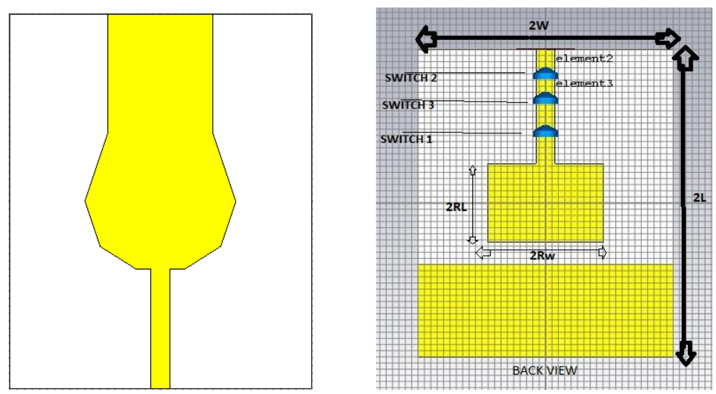


***Fig.1** Front and back side of proposed design*

The above figure shows an Octagonal patch ultra-wide band antenna designed in CST Microwave Studio whose operating frequency is from 3.91 GHz to 11.29 GHz. It is printed on FR-4 substrate of dimensions 40mmX50mm, whose dielectric constant (ε_r) = 4.4 and thickness of the substrate of 1.6mm. The feedline of Octagonal patch is of length 16mm and width 2.6mm. At the back of this antenna there is a partial ground and reconfigurable narrow band antenna (rectangular patch antenna). The dimensions of this rectangular patch are chosen in order to produce sufficient gain as well as have considerable isolation with the octagonal microstrip antenna. The reconfiguration is done by using three PIN diodes which act as variable resistors. The Narrow band antenna operates in different bands, depending on the switching conditions. However, the reconfiguration in simulation is performed by adding resistors for which three slots of 0.2 mm width are cut at different location of the microstrip feed line. These cuts are then joined using lumped elements and sufficient values of the resistance will determine the switching conditions where we get unique gain pattern for each. The parameters of the structure are as follows:

TABLE I. *Design parameters of the CR antenna.*

S.NO	PARAMETERS	VALUE (mm)
1	W_{ef}	3.3
2	W	20
3	R_L	6.422
4	R_W	9.122
5	L	25
6	H_t(thickness of the cupper layer)	0.035
7	Hs(thickness of the substrate)	1.6

The Length and width of feedline of this narrowband antenna is 18.578 mm ,3 mm respectively, which is configured in such a way that it operates on 6.39GHz, 6.90 GHz, 7.81GHz, 8.94 GHz frequencies.

II. RESULTS AND DISCUSSIONS

To simulate and analyse the working of the cognitive radio model designed CST microwave studio suite 2018 is used. Fig. 2 shows the return loss vs frequency plot. From the figure it can be said that the magnitude of S_{11} is less than -10 dB for the UWB sensing antenna from 3.91 to 11.29 GHz. The proposed design has isolation between two ports as less than -15 dB.

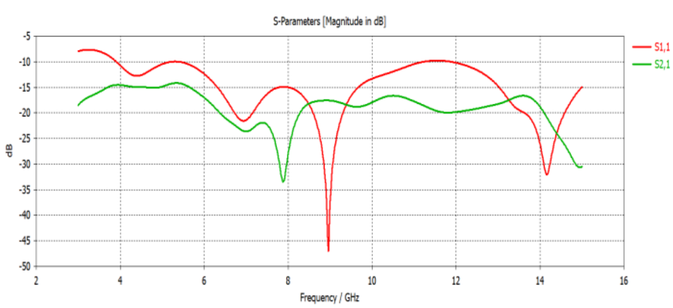


Fig. 2. *Simulated return loss of the UWB antenna and isolation between UWB and NB antenna.*

The rectangular narrowband antenna operates at different frequencies depending upon the switching. Fig. 3 shows the return loss vs frequency plot. From the figure it can be said that the magnitude of S_{22} is less than -10 dB and the operating frequencies include 6.39GHz, 6.90 GHz, 7.81GHz, 8.94 GHz.

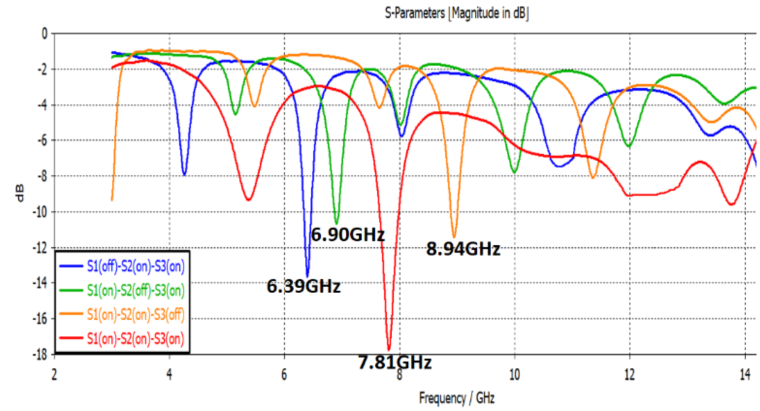
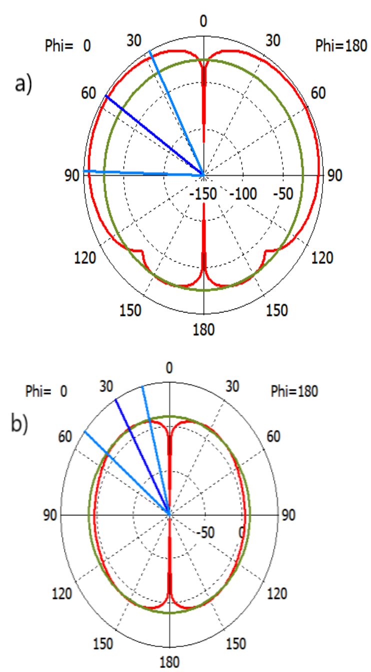


Fig. 3. *Simulated return loss of the reconfigurable antenna at different switching states.*

Port-2 of the NB antenna is matched with 50 Ω load impedance to find the radiation pattern of the sensing antenna at port-1. Similarly, to obtain the radiation patterns of the NB antenna at port-2, port-1 of the sensing antenna is matched with 50 Ω load impedance. The simulated radiation patterns of the CR antenna at various frequencies are depicted in Fig. 4and Fig. 5. The figures show that both the UWB and NB antennas have similar radiation patterns at observed frequencies.



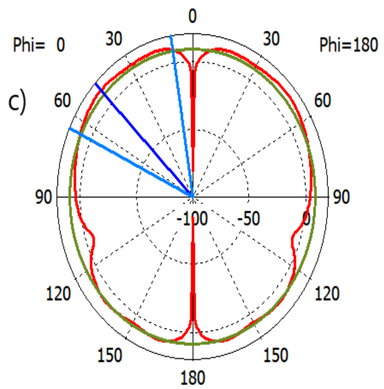


Fig. 4. *Radiation patterns of UWB sensing antenna at (a) 3.00 GHz, (b) 5.98 GHz, and (c) 9.1 GHz.*

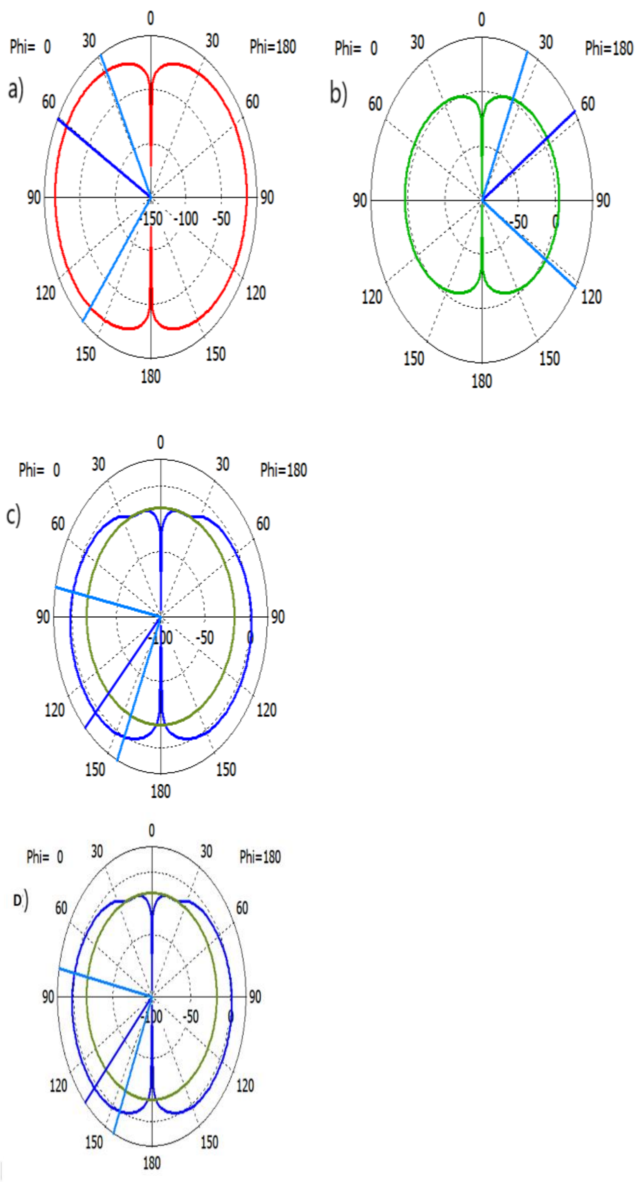


Fig. 5. *Radiation patterns of NB at (a) 6.39 GHz, (b) 6.90 GHz, and (c) 7.81 GHz. (d)8.94GHz*

III. CONCULSIONS

1. In this paper, the integrated ultra-wide band and narrow band antenna was designed and its performance is analysed for cognitive radio applications. The main advantages of the integrated structure are large bandwidth and good isolation between the antennas. The sensing antenna covers the band from 3.91 to 11.29 GHz. The reconfigurable antenna operates at 6.39, 6.90, 7.81, 8.94 GHz frequencies depending upon the switching states of the PIN diodes. Isolation between the antennas is less than -18 dB in the entire operating band.

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