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Research Paper

Antennas for Cognitive Radio Applications

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Abstract: This paper presents two antenna designs suitable for cognitive radio applications in the TV band. Printed micro strip miniaturized monopole antenna and one Planar Inverted F Antenna (PIFA) are proposed. The PIFA antenna consists of a patch above a ground plane with feeding and grounding strips connecting them. These antennas, designed for transmission of cognitive radios in the TV band, operate in the upper part of the UHF band (700-900 MHz) with approximately 2.5 dB gains and Omni directional patterns.

Key Words: Cognitive Radio, Monopole Antenna, PIFA, Omni directional, TV band.

1. Introduction

The development of communication systems and the need for higher data rates have led to the scarcity of the radio frequency (RF) spectrum. This is due to the static frequency allocation which has caused a large portion of the spectrum to be underutilized. With the increasing demand for efficient operation of radio frequency devices with limited resources, such as energy and frequency spectrum, cognitive radio **[1]-[3]** is thought to be a drastic solution. Cognitive radio (CR) is one of the most promising techniques to efficiently utilize the spectrum and intelligently improve communication efficiency. In a CR network, unlicensed users (secondary users) are allowed to access spectrum bands licensed to primary users, while avoiding interference with them. This intelligent radio permits the secondary user to sense the spectrum, locate the free portions or the ones with reduced primary activity, and transmit on the best available channel **[4].**

A crucial step towards efficient spectrum utilization is based on a secondary opportunistic access as proposed by FCC after the digital switchover **[5],** in which CR Secondary Users (SU) could access the unused portions of the TV licensed spectrum, called TV white spaces (TVWS). These unused TV white spaces are an attractive target for cognitive radio applications, since they operate at an easy to use frequency, and have good propagation characteristics, improved communication quality, better building penetration, and lower energy consumption. In cognitive radio networks, two types of antennas are needed: sensing and communicating antennas. The sensing antenna, which is usually an Ultra Wide Band (UWB) antenna, is used to sense the spectrum and find the spectrum holes, and the communicating antenna is used to transmit at the frequencies of these holes. The fact that this CR system can be utilized in portable devices leads to an important challenge especially at the TV band [6]. Indeed, the size of the antenna must be small so that the antenna can be mounted in these portable devices. Hence, a practical solution is to design miniaturized antennas of compact sizes that can be installed in portable devices and can operate on the frequencies of the TV band. Moreover, there is a need to have an Omni directional radiation pattern antenna, so that users can sense and identify the spectrum holes in wireless environment, transmit and receive independently of their direction.

Different techniques have been used to design antennas transmitting and receiving in TVWSs. The UWB antenna designed for cognitive radio in the UHF TV band reported in **[7]** presents a wide bandwidth covering the whole TV band. A pair of slot lines is adopted in order to minimize the antenna size, and this can accomplish good impedance matching at the UHF band. The compact broadband monopole slot antenna described in **[8]** exhibits a wide bandwidth (460 – 1000 MHz) using a feed-in space and a straight gap. In **[9],** a coplanar printed monopole antenna for digital television (DTV) in the UHF band (470-862 MHz) application is designed. The meander loop monopole and step-shaped ground plane are printed on the same side of a substrate with an area of 15 x 170 mm. A compact simple folded dipole antenna for digital television (DTV) signal reception in the TV band is proposed in **[10]**. The proposed antenna can provide the way of the controlling the required bandwidth and impedance matching over the DTV frequency band using narrow rectangular radiating patches and coupling gap. The asymmetric fork-like monopole antenna for digital video broadcasting-terrestrial (DVB-T) signal reception for application in the UHF band is presented in **[11].** It consists of two two-branch strip monopoles on a rectangular ground plane with a concave which results in a wide bandwidth of 461 MHz (451–912 MHz). In **[12]**, a novel grating monopole antenna built through a grating patch and a rectangular ground plane with a concave used for digital video broadcasting-terrestrial application is presented. This antenna exhibits a wideband operating bandwidth which is attained by cutting a notch at the ground pattern opposite to the micro strip line.

In this paper, three antenna designs for transmission of cognitive radios in the TV band are proposed. More precisely, we propose two micro strip miniaturized antennas and one PIFA antenna. A meander structure is used to reduce the size of the antennas for lower band operation. The designed antennas having reduced dimensions operate in the band 700- 900 MHz which is suitable for cognitive radio applications in the TV band. The target behind this band is that it would be highly recommended for mobile broadband access. The geometry, the design guidelines, and the experimental results of the proposed antennas are presented in Section 3. In Section 4, a brief conclusion is given. The characteristics of the designed antenna are investigated via MATLAB and experimentally verified.

2. Design, simulation, and results

2.1. Monopole Antenna

The configuration of this proposed antenna is shown in Figure 1. The design parameters are given in table-1. The size of this antenna is very small compared to antennas operating in the UHF band. This small size allows this antenna to be utilized in portable devices such as mobile phones, tablets and note books. In this antenna, the meander wire is used as a radiating element, and this is done to reduce the size of the antenna. Globally, the meander line is widely employed as a miniaturized radiating element. However, in the literature, the radiation power and the transmission gain are reduced since the direction of the current on the meander line is usually opposite for neighboring wire, therefore the antenna gain will be very low. To overcome this problem in our proposed design, the current in the meander wire follows the same direction, thus the transmission gain is enhanced. The antenna is designed and simulated in MATLAB tool.

The fabricated prototype has undergone the needed measurements. The simulated reflection coefficient plot of the proposed antenna is given in Fig. 3. As stated in **[12],** antennas used for DVB transmission in the TV band can operate on frequencies having the reflection coefficients below -6 dB. This antenna can operate in the band 785-855 MHz, thus it can be suitable for transmission in cognitive radio applications in the TV band. Figure 3 shows the simulated radiation patterns of the monopole antenna. It is observed that the radiation patterns are Omni-directional over its band of operation, with almost equal radiation in the H-plane, and radiation with the shape of digit 8(approximately) in the E-plane.

Table 1: Design parameters of Monopole antenna

▼ Geometry - monopole	
Height	0.088064
Width	0.0037474
GroundPlaneLength	0.18737
GroundPlaneWidth	0.18737
FeedOffset	[0 0]
Tilt	0
TiltAxis	[1 0 0]

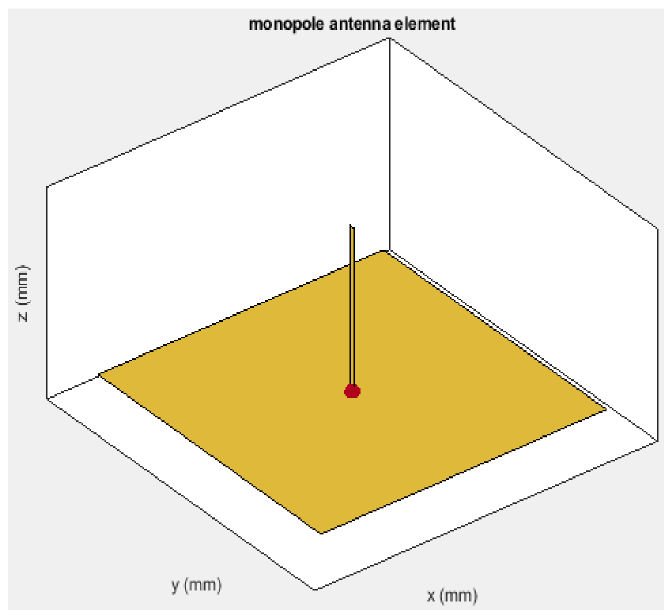

Figure - 1: The shape of Monopole antenna

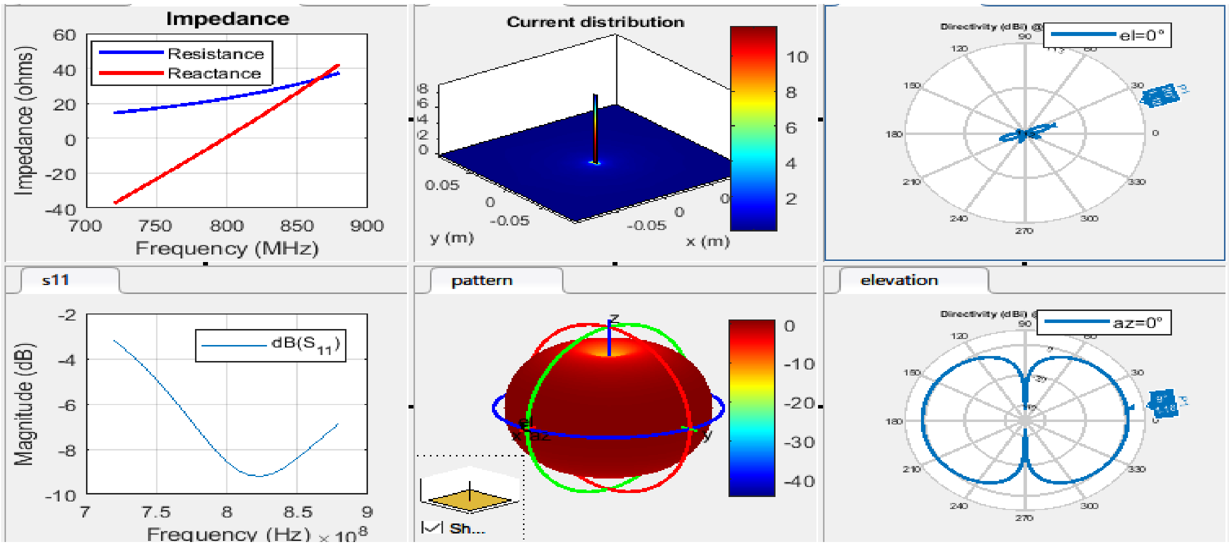

Figure -2: Simulation results of Monopole antenna

2.2. PIFA Antenna

A PIFA antenna is also proposed in this paper, and its configuration is shown in Fig. 3. Design parameters are given in table 2. PIFA antennas are popular for portable wireless devices because of their low profile, small size, built-in structure, and Omni directional patterns, and they are almost used in mobile phone market. In mobile phones, there is a single large ground plane that can be placed at the bottom layer of the phone, and the patch which is of much reduced dimensions can be placed on the opposite layer of the phone. Since the radiation is from the patch away from the ground plane, the energy is directed away from the head giving low values of absorption rates.

Table - 2: Design parameters of PIFA antenna

▼ Geometry - pifa	
Length	0.087502
Width	0.058347
Height	0.029155
GroundPlaneLength	0.105
GroundPlaneWidth	0.105
PatchCenterOffset	[0 0]
ShortPinWidth	0.058347
FeedOffset	[-0.005846 0]
Tilt	0
TiltAxis	[1 0 0]

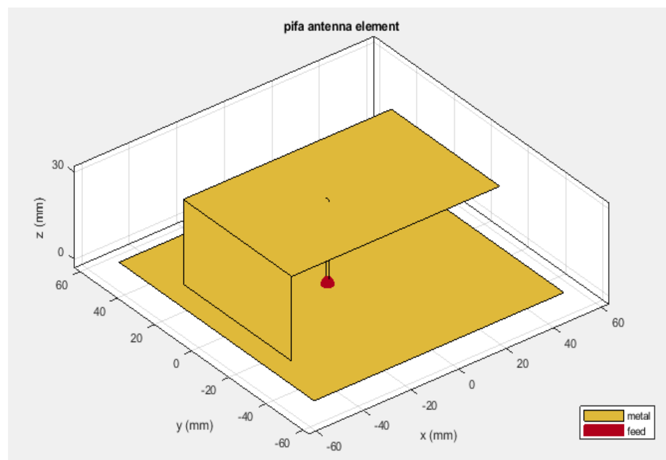

Figure - 3: Shape of PIFA Antenna

The simulated reflection coefficient plot of the proposed PIFA antenna is given in figure 4. The antenna is simulated via MATLAB tool. This antenna can operate in the band 750-850 MHz, and also can be suitable for transmission in cognitive radio applications in the TV band. The main advantages of this PIFA antenna in comparison with the micro strip antennas are the simple structure and the small size of the patch. These properties allow the PIFA antenna to be fabricated inside handsets and portable devices with low manufacturing cost. However, the PIFA antenna is not printed, and this demands a very high accuracy in fabrication. In addition to that, this PIFA's bandwidth is higher than the bandwidth of the micro strip antennas since a thick air substrate is used.

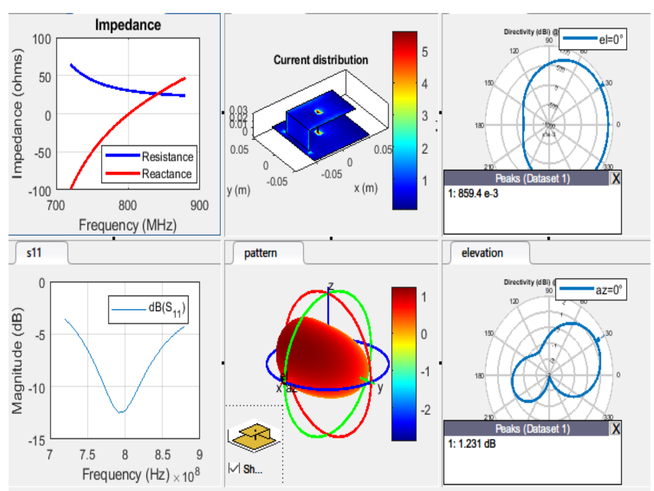

Figure - 4: simulation results PIFA antenna

3. Conclusion

A miniaturized printed monopole antenna and a planar inverted F antenna (PIFA) is suitable for cognitive radio applications in the TV band are proposed in this paper. These antennas are printed with small dimensions and can operate in the frequency band 700 – 900 MHz, with Omni-directional patterns and an acceptable gain of about 2.5 dB .The bandwidth and the size of these antennas make them suitable for portable devices such as notebooks, tablets and mobile phones.

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