A Simple Dual-port Antenna System for Cognitive Radio Applications

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ABSTRACT

This paper presents a simple antenna system design for cognitive radio applications. The system comprises two printed monopoles sharing a common partial ground plane. The first monopole is used for channel sensing over the ultra-wideband (UWB) frequency range. The second one is frequency-reconfigurable and is used to communicate over a selected frequency slot. A prototype of the antenna was fabricated and tested. A good agreement was found between the simulated and measured data.

KEYWORDS: Cognitive radio, printed antenna, UWB.

1. INTRODUCTION

According to the Federal Communications Commission (FCC), a cognitive radio is a radio that can change its transmitter parameters based on interaction with the environment in which it operates [1]. Thus, in a cognitive radio system, there is need for a sensing antenna with the capability to monitor the spectrum, and a communicating antenna that can be reconfigured to communicate over a chosen frequency band.

Recently, there has been some research on the design of antennas for cognitive radio systems. In [2], a frequency reconfigurable antenna that covers either the 3–5 GHz or the 5–8 GHz bands is presented. Therein, the proposed structure also incorporates an UWB antenna, making it suitable for cognitive radio communication. In [3], the authors propose a system that combines a wideband and a narrowband antennas into the same volume. The wideband antenna is a CPW-fed printed hour-glass-shaped monopole that operates from 3 to 11 GHz. The narrowband antenna is a microstrip patch printed on the reverse side of the substrate, and connected to the wideband antenna via a shorting pin and designed to operate from 5.15 to 5.35 GHz.

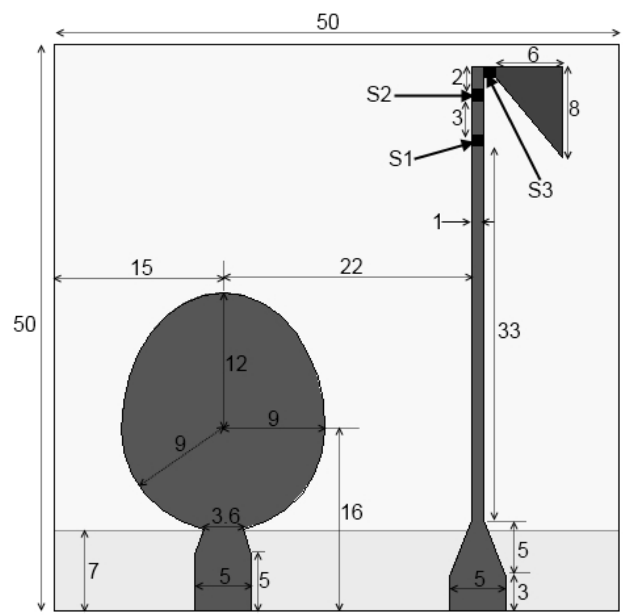


Figure 1. The Antenna System Configuration

2. ANTENNA SYSTEM CONFIGURATION

The presented design is comprised of two microstrip-line-fed monopoles printed on a 1.6mm-thick Taconic TLY substrate with a dielectric constant of 2.2. The two antennas share a common partial ground and are 22.5 mm apart, center to center. The configuration of the antenna system is detailed in Fig. 1.

The sensing antenna is based on an egg-shaped patch, obtained by combining a circle and an ellipse at their centers [4]. The circle has a radius of 9mm, which is also the minor radius of the ellipse. The major radius of the ellipse is 12mm. To match the 50-Ω feed to the input impedance of the patch, a small tapered microstrip section is used. A UWB response of the sensing antenna is guaranteed by the design of the patch, the partial ground plane, and the feed matching section.

The communicating antenna is a combination of 40mm-long 1mm-wide strip line connected to a 50-Ω feed line via a matching section, and a small triangular conducting part. Two 1×1 mm^2 electronic switches are incorporated along the strip line part of the antenna, and a third identical one connects the strip line to the triangular part. By controlling these three switches, the length of the antenna is changed, thus leading to various resonance frequencies in the UWB frequency range.

3. RESULTS AND DISCUSSION

For the presented design, four switching cases are considered. The states of the switches in each case are given in Table 1. HFSS v.11 was used in the design and simulation. A prototype was fabricated and the return loss of the two antennas and their inter-coupling was measured for the four switching cases. Without loss of accuracy, copper tapes were used in the prototype to represent the switches in their activated state.

Table 1. Measured Coupling at the Resonance Frequencies

Case	S1/S2/S3	f_r (GHz)	S_{21} (dB)
1	OFF/OFF/OFF	5.56	-17.9
		9.07	-13.6
2	ON/OFF/OFF	5.05	-23.8
		8.13	-14.4
3	ON/ON/OFF	4.71	-32
		7.56	-16.3
4	ON/ON/ON	4.15	-15.5
		6.69	-11.9

The measured and computed return loss plots of the sensing antenna, for Case 1, are shown in Fig. 2. An impedance bandwidth covering the UWB range is revealed. A similar UWB return loss is obtained in the three other cases. Its radiation pattern, computed at 5 GHz, is shown normalized in Fig. 3 for the H-plane (solid line) and the

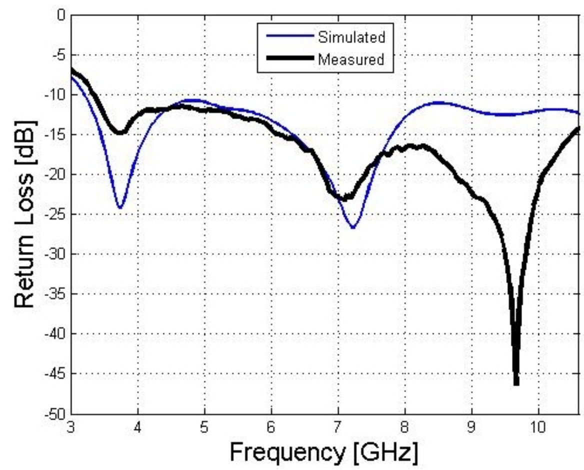


Figure 2. Return Loss of the Sensing Antenna

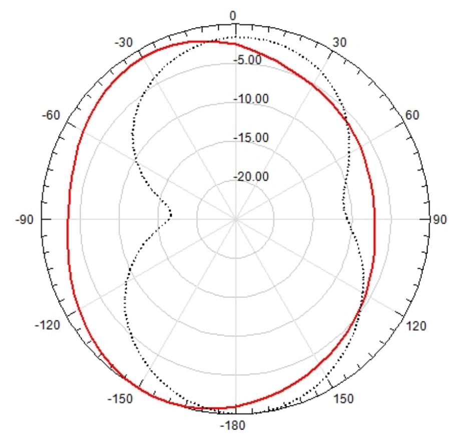
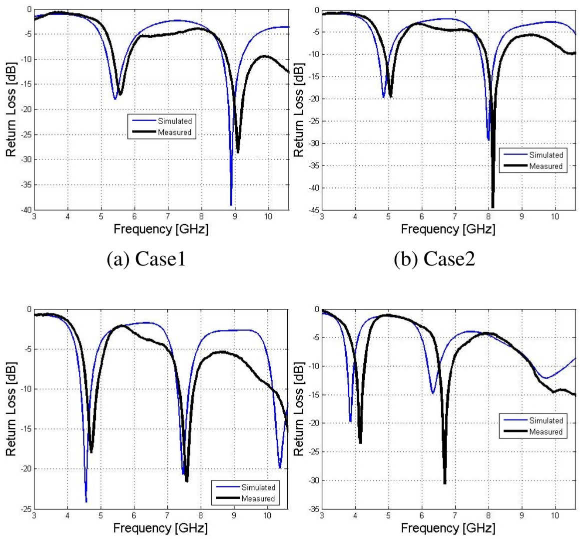


Figure 3. Radiation Pattern of the Sensing Antenna at 5 GHz

E-plane (dashed line). The pattern is omnidirectional, and this is guaranteed by the antenna's structure as a printed monopole over a partial ground plane. Similar results were obtained in the three other cases. At 5 GHz, the peak gain of the sensing antenna is 5.4 dB.

Fig. 4 compares the measured and simulated return loss of the communicating antenna, for the 4 cases. Good agreement is witnessed in all cases. A superimposition of the measured return loss plots is given in Fig. 5, which shows clear frequency reconfigurability and a coverage of most of the UWB range using only three switches.

The coupling between the two antennas, measured at the resonance frequencies of the communicating antenna, is given in Table 1. In all four cases, the coupling is less than -10 dB for all frequencies.



(a) Case1 (b) Case2

(c) Case3 (d) Case4

Figure 4. Return Loss of the Communicating Antenna

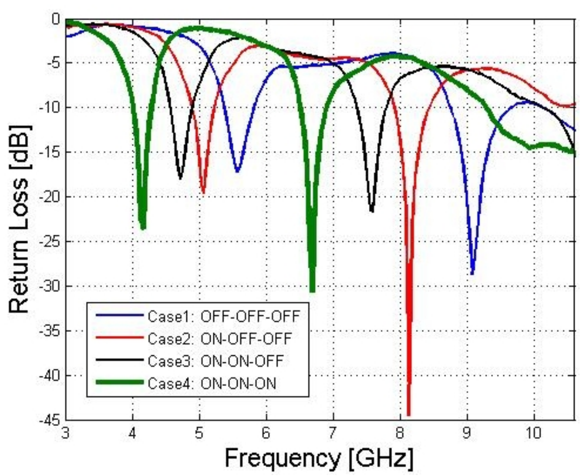
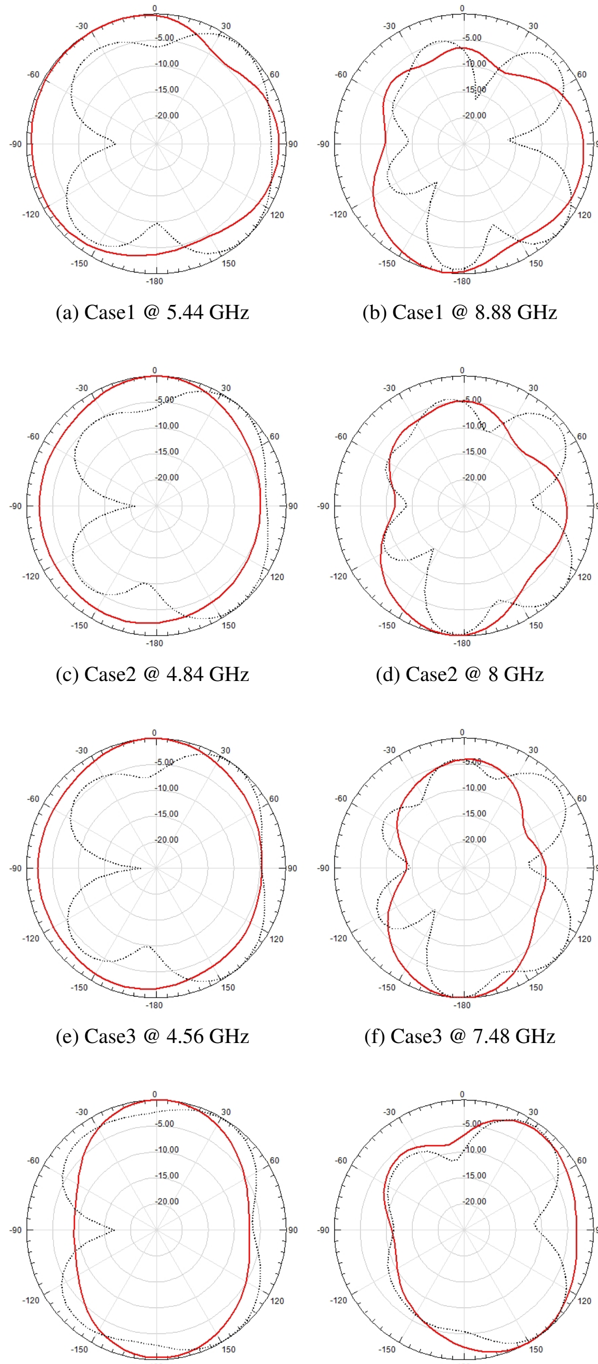


Figure 5. Superimposed Measured Return Loss Plots

Table 2. Computed Peak Gain at the Resonance Frequencies

Case	f_r (GHz)	Peak gain (dB)
1	5.44	5.83
	8.88	4.75
2	4.84	5.69
	8	4.3
3	4.56	4.83
	7.48	4.46
4	3.88	2.84
	6.36	5.79



(a) Case1 @ 5.44 GHz (b) Case1 @ 8.88 GHz

(c) Case2 @ 4.84 GHz (d) Case2 @ 8 GHz

(e) Case3 @ 4.56 GHz (f) Case3 @ 7.48 GHz

(g) Case4 @ 3.88 GHz (h) Case4 @ 6.36 GHz

Figure 6. Radiation Patterns of the Communicating Antenna in the H-plane (solid) and E-plane (dotted)

Similar to the UWB antenna, the communicating antenna possesses omnidirectional patterns. The computed patterns are shown in Fig. 6 at the resonance frequencies for each case. The omnidirectional property degrades with increasing frequency, and as expected, sidelobes appear in the E-plane patterns at high frequencies. The peak gain values are given in Table 2 for the resonance frequencies.

4. CONCLUSION

In this paper, a new antenna design for cognitive radio applications was presented. The design is based on two monopole antennas, one for sensing and the other for communicating, which are printed on a substrate and share a common partial ground. The sensing antenna covers the whole UWB range, whereas the communicating antenna is frequency reconfigurable over this range. A prototype of the system was fabricated and tested. A good agreement was found between the simulated and measured return loss. Acceptable isolation was achieved between the sensing and the communicating antennas.

REFERENCES

[1] FCC, ”Report of the spectrum efficiency working group,” FCC Spectrum Policy Task Torce, Tech. Rep., Nov. 2002.

[2] Y. Tawk, and C.G. Christodoulou, ”A new reconfigurable antenna design for cognitive radio,” *IEEE Antennas and wireless propagation letters*, pp. 1378–1381, Dec. 2009.

[3] E. Ebrahimi, and P.S. Hall, ”A dual port wide-narrowband antenna for cognitive radio,” The third European Conference on Antennas and Propagation, pp. 809–812, Mar. 2009.

[4] M. Al-Husseini, A. Ramadan, Y. Tawk, A. El-Hajj, and K.Y. Kabalan, ”Design and ground plane consideration of a CPW-fed UWB antenna,” The International Conference on Electrical and Electronics Engineering, Bursa, Turkey, 2009.