Investigation on an UWB Antenna combining a Caped-Monopole and a Dielectric Resonator

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Introduction

Ultra-wideband (UWB) technology is not a totally new invention. Although in 2002, it began to attract many researchers and engineers since the Federal Communications Commission's approval. It has been described as 'One of ten technologies that will change your world'. The basic idea of UWB systems is transmitting and receiving signals at very high rates by sending pulses of energy with very short duration in terms of nanoseconds.

The bandwidth of a monopole antenna could be improved if it is surrounded by a dielectric resonator (DR), covering an ultra wide range of frequency [1-4]. Dielectric resonators are characterized by several attractive features including excitation using various feeding techniques, bandwidth enhancement, compact structures and wide range of dielectric constants. Due to these features, dielectric resonators are quite flexible for designs that are characterized by an ultra wide bandwidth and high radiation efficiency. Dielectric constants could have any value up to 100, which facilitates controlling the size and the bandwidth of the designed antenna.

This paper presents a new hybrid antenna consisting of a quarter wavelength monopole that carries a wider metallic disc on its top. This monopole is surrounded by a ring dielectric resonator. The bandwidth achieved by this antenna starts form 3GHz up to 13 GHz, indicating over a 4:1 fractional bandwidth which is 125% impedance bandwidth around the center frequency. Comparing to the previous results in [1-4], the proposed antenna realized a wider impedance bandwidth around the center frequency. The main difference between this antenna and that in [1-4] is that the operational bandwidth covers the whole FCC mask for UWB wireless communications that extends from 3.1-10.6 GHz. CST Microwave Studio is used to design and simulate the antenna [5]. In the following sections, the design of the proposed antenna is described, in addition to the simulated results and discussion.

Antenna Design

Fig. 1 shows the design of the hybrid antenna which was basically studied in [1] and improved by the design guidelines equations provided in [2]. In this configuration a dielectric ring resonator is fed by a quarter wavelength monopole antenna, capped by a metallic disc on its top with a wider diameter. The whole structure is mounted on a ground plane with diameter of 80 mm. The perfect electric conductor upper disc was attached to improve the impedance bandwidth. Through the covered operational bandwidth, the lower resonance is caused by the monopole; the upper resonance is caused by the dielectric resonator (DR), while the middle

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resonances occurred due to combining both the monopole and the DR. The reason for that is that the DR acts as a load on the monopole. In Table 1, the dimensions of the designed antenna are shown based on [2].

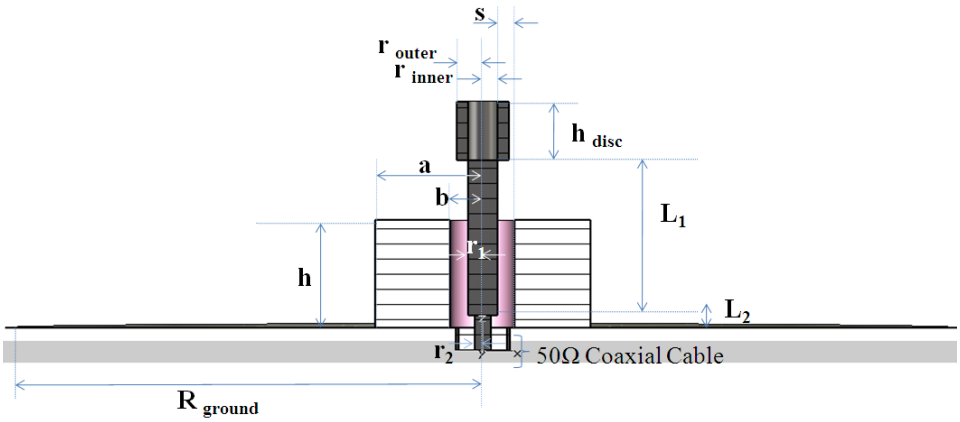

Fig. 1. A Cross sectional view of the Monopole-DR antenna

TABLE 1. Dimensions of Monopole-DR antenna shown in Fig. 1

Parameter	ε_r	R_{ground}	L_1	L_2	h	r_1	r_2	s	a	b	h_{disc}	r_{outer}	r_{inner}
mm	7	40	13	1	9	1.2	0.65	1.5	9	2.7	5	2.2	1.2

Simulation results

In Fig. 2, the return loss characteristics of the designed antenna are obtained using CST Microwave Studio. It shows $S_{11} < -10$ dB starting from 3 GHz and ending at 13 GHz, indicating more than 4:1 impedance bandwidth which is equivalent to 125% bandwidth around the center frequency. However, Fig. 3 shows the S_{11} response of the monopole carrying the upper disc after removing the dielectric ring resonator.

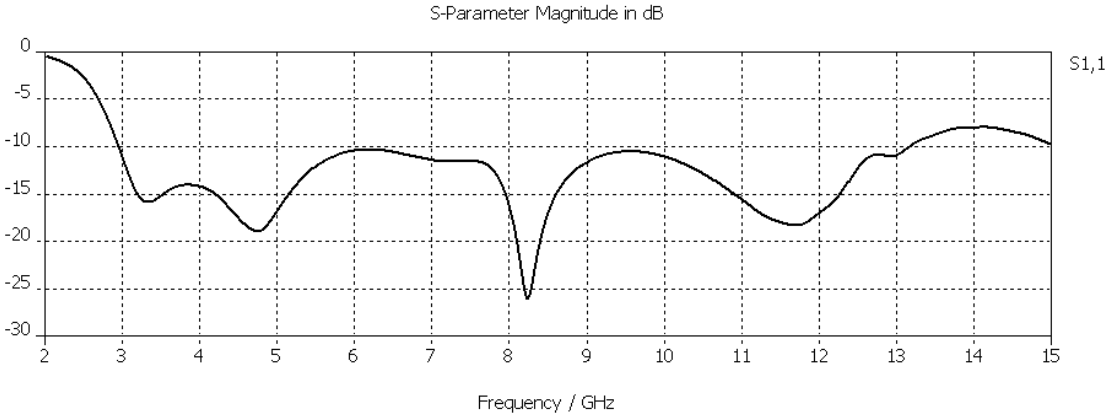

Fig. 2. S_{11} versus frequency of the Monopole-DR antenna

In Fig. 4 the simulated directivity of the proposed antenna is plotted, showing a monopole pattern with maximum directivity of 4.5 dBi at frequency 8 GHz occurring at ±20°.The measured radiation patterns of the antenna are shown in Fig. 5, at different frequencies within the operational bandwidth, 6 and 8 GHz respectively. The monopole-like pattern is achieved in the vertical plane of the designed antenna. The left column shows the co-polarization at Φ=90°, while the right column shows the cross-polarization at the same plane. The main lobe magnitudes are 2.6 dB versus -60.3 dB, and 4.5 dB versus -54.5 dB, which indicates that this antenna is linearly polarized.

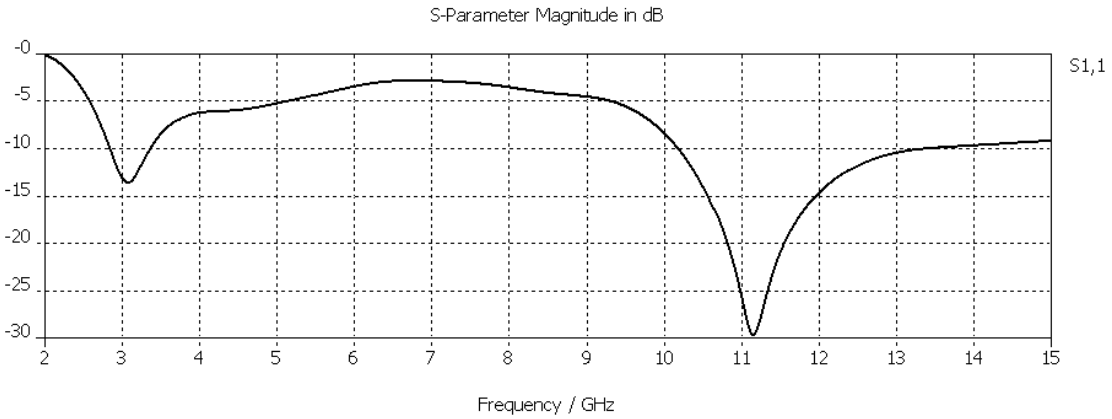

Fig. 3. S_{11} versus frequency of a monopole with an upper disc after removing the DR.

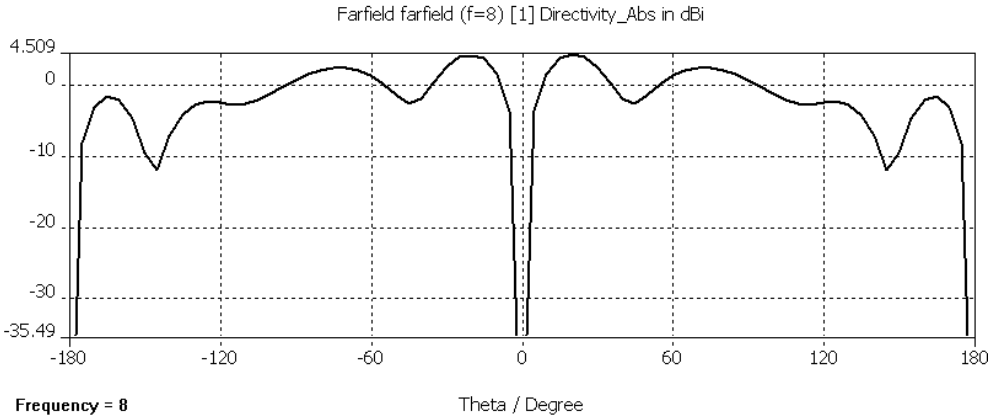

Fig. 4. Simulated directivity plot showing monopole-like radiation at f=8 GHz

Conclusion

In this paper, a hybrid antenna was presented, consisting of a dielectric ring resonator fed by a quarter wavelength monopole with an upper metal disc. This antenna was capable of achieving a bandwidth response starting from 3 GHz up to 13 GHz. Further designs will be studied to reduce the ground plane size keeping the same bandwidth that covers the whole FCC mask for UWB wireless communications. Moreover, more results will be shown later, in addition to the measured results. Such an antenna could be used in medical applications such as imaging for human body tissues

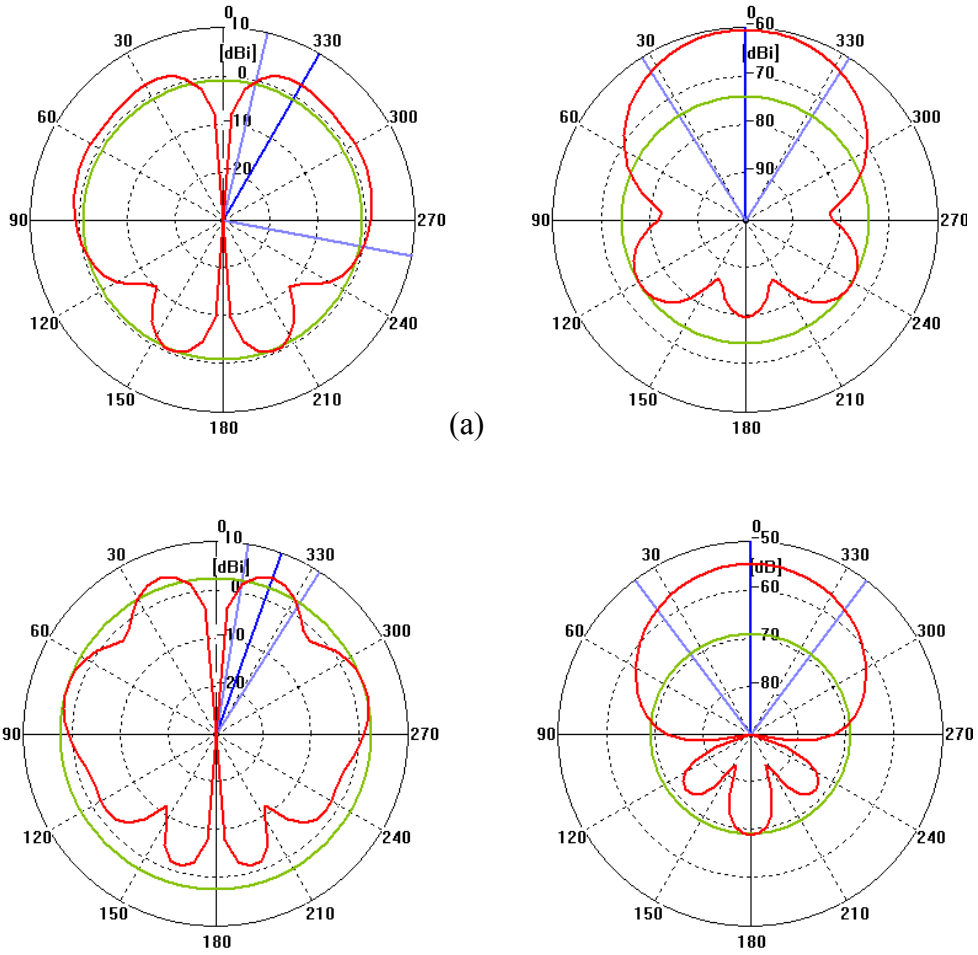

Fig. 5. Simulated radiation patterns of the antenna at different frequencies, E_θ to the left and E_Φ to the right. (a) 6 GHz (b) 8 GHz.

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[5] CST Microwave Studio Version 2008.