Dual-Band Printed Dipole Antenna Loaded with Open Complementary Split Ring Resonators (OCSRRs)

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Abstract

In this paper, a printed dipole antenna loaded with open complementary split ring resonators (OCSRRs) is proposed. The integration of these particles inside the dipole structure provides a dual-band performance. Furthermore, a dipolar-like radiation pattern is obtained at both working frequency bands. A prototype has been designed, manufactured and measured, showing good performance. The working bands of the fabricated prototype are centred at 1.55 GHz and 2.58 GHz. The measured bandwidths are 8.2% and 11.2% at the first and second bands, respectively. The simulated gains are 1.6 dB at the first band and 2.2 dB at the second one.

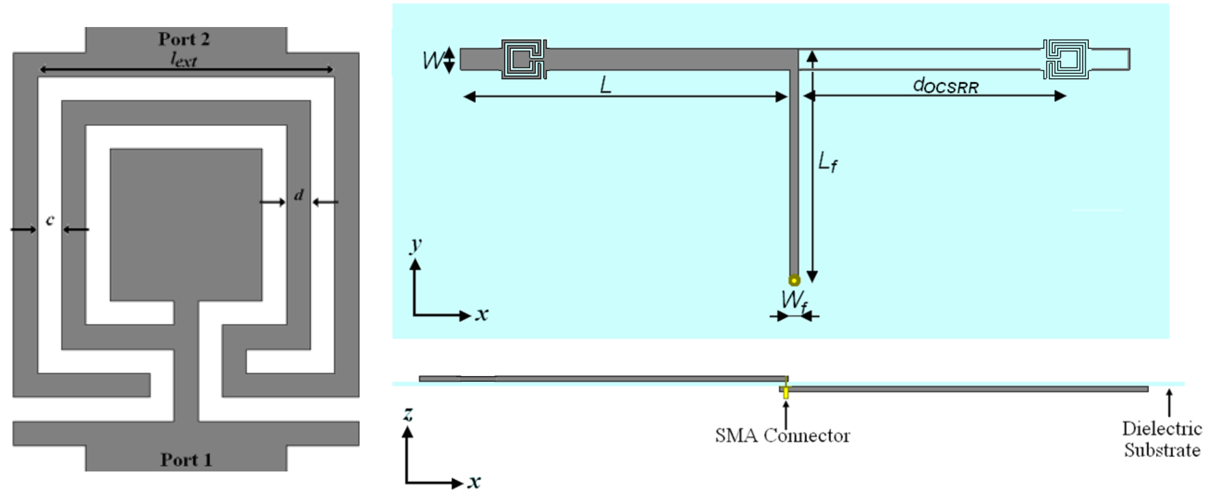
1. Introduction

Printed dipole antennas are a good solution to overcome the increasing demand of antennas for wireless communication systems. The actual trend consists of using dual-band or multi-band antennas in order to use a single radiating element for several frequency bands, while keeping reduced terminal dimensions. In the last years, the use of metamaterials has been effectively proposed for achieving multi-band compact antennas. Several paradigms, such as antennas based on artificial transmission lines or metamaterial-inspired antennas have been proposed [1-5]. One of these approaches is metamaterial-loaded printed antennas [3-5]. The idea of this technique is based on loading a conventional printed antenna with a set of resonant particles. For example, in [3] it is shown that a dual-band antenna is achieved by coupling a set of split ring resonators (SRRs) to a printed dipole. Using this approach the benefits of printed antennas are kept while dual-band antennas are achieved by using a simple design technique. However, in [3] narrow bandwidths are reported for the bands associated with the SRRs loading. Even the use of SRRs with different resonant frequencies leads to bandwidths smaller than 5% [4], which might not be useful for some applications. Recently, it has been demonstrated that novel particles such as the open complementary split ring resonators (OCSRRs) can be used to develop broadband applications [6].

In this paper a dual-band printed dipole loaded with OCSRRs is presented. The topology and small electrical dimensions of these particles allow integrating them inside each half of a printed dipole antenna. The resulting antenna exhibits two frequency bands broader than 8%. Moreover, a dipolar-like radiation pattern is obtained at both working bands. Simulation and experimental results demonstrate the dual-band behaviour of the proposed antenna.

2. Antenna design

The OCSRR is derived by opening the well-known complementary split ring resonator (CSRR). Thus, it can be considered the complementary counterpart of the open split ring resonator (OSRR) [6]. It is important to note that the resonance frequency of the OCSRR is approximately half the resonance frequency of the CSRR (for the same dimensions and substrate), hence it is electrically very small. In this paper, a square geometry is considered (Fig. 1.a). Thus, the parameters of the OCSRRs are the external length (l_{ext}), the width of the gaps (c) and the metallic separation between the gaps (d).



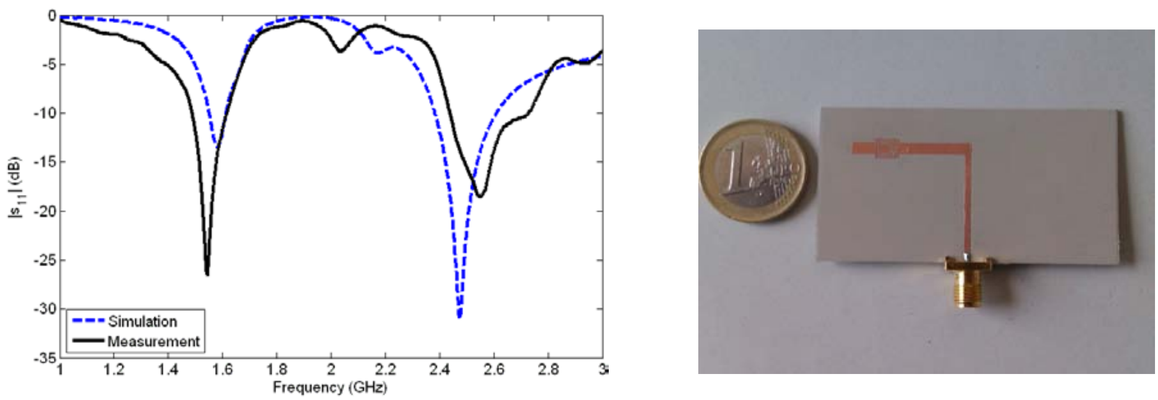
(a) (b)

Fig. 1: Sketch of the proposed antenna. (a) Layout of the OCSRR particle. (b) Top and side views of the antenna.

The proposed antenna (Fig. 1) is based on an antipodal printed dipole. Each half of the dipole is implemented by printing a metallic strip on one side of a dielectric substrate with height h. The parameters of each dipole strip are the length L and the width W. This configuration has been chosen because it avoids the use of a balun to feed the antenna. This is possible because the antipodal printed dipole is fed through a paired strips transmission line with a SMA connector soldered to the end of the line. The dimensions of the feeding line are the length L_f and the width W_f. An OCSRR is connected in series to each dipole strip at a distance d_{OCSRR} from the centre of the antenna. Thus, in this novel design the loading particles are not coupled to the dipole but they are integrated inside each dipole strip thanks to their small electrical dimensions and ports position. This novel layout and the suitability of the OCSRRs for broadband applications allow obtaining two working bands with bandwidth broader than 8%.

3. Simulation and experimental results

A design with L = 24.00 mm, W = 2.50 mm, L_f = 25.00 mm, W_f = 1.15 mm, d_{OCSRR} = 17.00 mm, l_{ext} = 3.80 mm, $c = d$ = 0.30 mm has been simulated by using *CST Microwave Studio*. The considered substrate is *Rogers RO3010* with ε_r = 10.2 and h = 1.27 mm. The simulated reflection coefficient is shown in Fig. 2.a. Two working bands are obtained and the bandwidth of the second resonance (considering $|s_{11}|$ < -10 dB) is over 10%. It is important to note that this is a considerable improvement with respect to previous results in which the bandwidth of this band was below 5% [3-4].



(a) (b)

Fig. 2: (a) Simulated and measured reflection coefficient. (b) Picture of the manufactured prototype.

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Fig. 3 shows the simulated radiation patterns of the proposed antenna at the two working bands. A dipolar-like radiation pattern is obtained at both bands. The simulated gain values are 1.6 dB at the first band and 2.2 dB at the second one.

A prototype of the proposed antenna has been manufactured (Fig. 2.b) and measured. The measured reflection coefficient is shown in Fig. 2.a. Considering $|s_{11}|$ below -10 dB, the first working band is centred at 1.55 GHz with 8.2% bandwidth and the second one is centred at 2.58 GHz with 11.2% bandwidth.

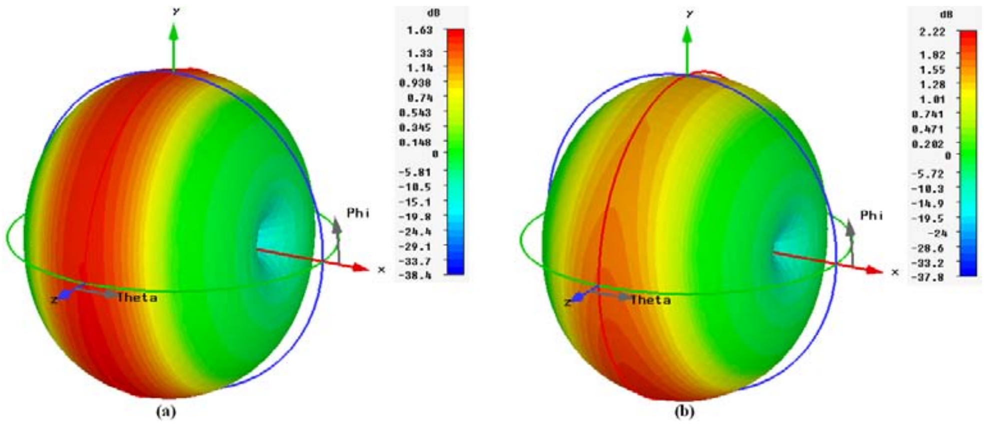

Fig. 3: Simulated radiation patterns of the proposed dipole antenna. (a) 1.55 GHz. (b) 2.58 GHz.

4. Conclusion

In summary, a novel printed dipole antenna loaded with OCSRRs has been presented. It has been demonstrated that the integration of these particles inside the dipole antenna allows obtaining two working bands with bandwidths broader than 8%. Moreover, a dipolar-like radiation pattern is obtained at both bands. A prototype has been manufactured and measured. The experimental results are in good agreement with the simulated ones. These results suggest that the proposed antenna can be useful for multi-band wireless communication terminals.

Acknowledgement

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