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Electrical Loop for 433.92MHz Reader Antenna of RFID Systems

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Abstact

A reader antenna for active RFID technology at 433.92MHz, used for cargo container security, is proposed. The proposed antenna consists of two layer radiating elements excited by a single probe simultaneously. An omnidirectional radiation pattern with ϕ-component of electric field is obtained by an electrical loop with uniform and in-phase current as the radiating source. Measured peak gain is 2.9dBi, and the average gain is 0.92dBi in x-y plane.

Introduction

An omnidirectional radiation antenna pattern is very attractive for many applications in wireless communication [1]. This is the same for RFID (Radio Frequency Identification) systems for cargo container security at 433.92MHz since it is demanded that the reader antenna covers a large area. However, for an instance of this case, θ-component of electric field (vertical polarization) does not guarantee the reader to identify tags such as when the tags are set parallel to the axis of reader antenna. Therefore it can be more advantageous for a reader to identify tags when the reader antenna has a ϕ-component of electric field (horizontal polarization) and the tags are mounted parallel to it.

Although many types of omnidirectional antennas have been widely studied, a loop antenna may be the most promising one as the reader antenna since it can has an omnidirectional radiation pattern with horizontal polarization. Ideally, the radiation pattern of a small loop antenna with 0.1λ diameter is omnidirectional, and increasing the diameter of the loop leads to more nulls along the θ- direction. However, a small loop antenna is very difficult to realize because of its small input resistance and a larger loop antenna does not keep its radiation pattern omnidirectional. For larger loop antennas, more complex feed systems are required since the currents as the radiating source are not uniform and in-phase [2]-[3]. In most cases, large loop antennas operate as a ring patch antenna whose dominant mode is TM_{11}.

In this paper, an electrical loop antenna with uniform and in-phase current is proposed. The proposed antenna has a simple feed system and a compact size of less than 0.43λ. The proposed antenna is designed to operate at 433.92MHz for the RFID reader and its simulated performances are compared with measurements.

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Design and Results

Fig. 1 shows the configuration of the proposed electrical loop antenna. The antenna consists of two radiators and a single ground plane. Two radiators are perpendicular to each other in x-y plane and separated by a gap along z- axis. Both of the two radiators share a single feeding post at the center and they are excited simultaneously. The distance of gap G between them is 15mm, and both radiators have the same size and geometry. The diameter D_1 of the ground plane is 300mm, and diameter D_2 of radiator is 229mm. The other detailed dimensions are shown in Fig. 1.

Simulated and measured return losses are shown in Fig. 2. It is noticed that the proposed antenna works well at 433.92MHz. Resonant frequency of the antenna can be obtained by tuning diameter D_2, gap G, and spacing S. However since changing the gap G between two radiators and the spacing S affects on antenna gain, diameter D_2 is rather tuned for the resonant frequency. The antenna input impedance can be easily matched by the width W. Length L of the single radiator is about a half-wavelength at 433.92MHz, and the current as radiating source is distributed along the length L. Since the feeding post is located at the center of the radiator and the radiator forms symmetrical, there are two resonant modes with half-wavelength, and they are separated by the spacing S. Also the currents are in-phase.

If the antenna has the only one single radiator, the radiation pattern is not perfectly omnidirectional. This is because uniform current can not obtain with only single radiator yet at the half-wavelength resonant mode. By forming another radiator, which is perpendicular to the former one, on the other layer, total current becomes more uniform. Simulated radiation pattern when the antenna has a single or dual radiator is shown in Fig. 3(a). Measured radiation pattern of the proposed antenna with two radiators shown in Fig. 3(b). One can see that the proposed antenna have an omnidirectional radiation pattern with ϕ-component of electric field, in other words, horizontal polarization. The measured peak gain is 2.9dBi and the average gain is 0.92dBi in x-y plane.

Conclusions

A novel electrical loop antenna with uniform and in-phase current is proposed as an RFID reader antenna at 433.92MHz band for cargo container security. Two layered radiators are horizontally perpendicular to each other, and the antenna is optimized for antenna performances such as gain and omni-directional radiation pattern with a compact antenna size. Based on the simulated results, the structure with dual radiator shows better performance than a single radiator in terms of the omni-directional radiation pattern. The antenna performances are verified by a prototype and measurements.

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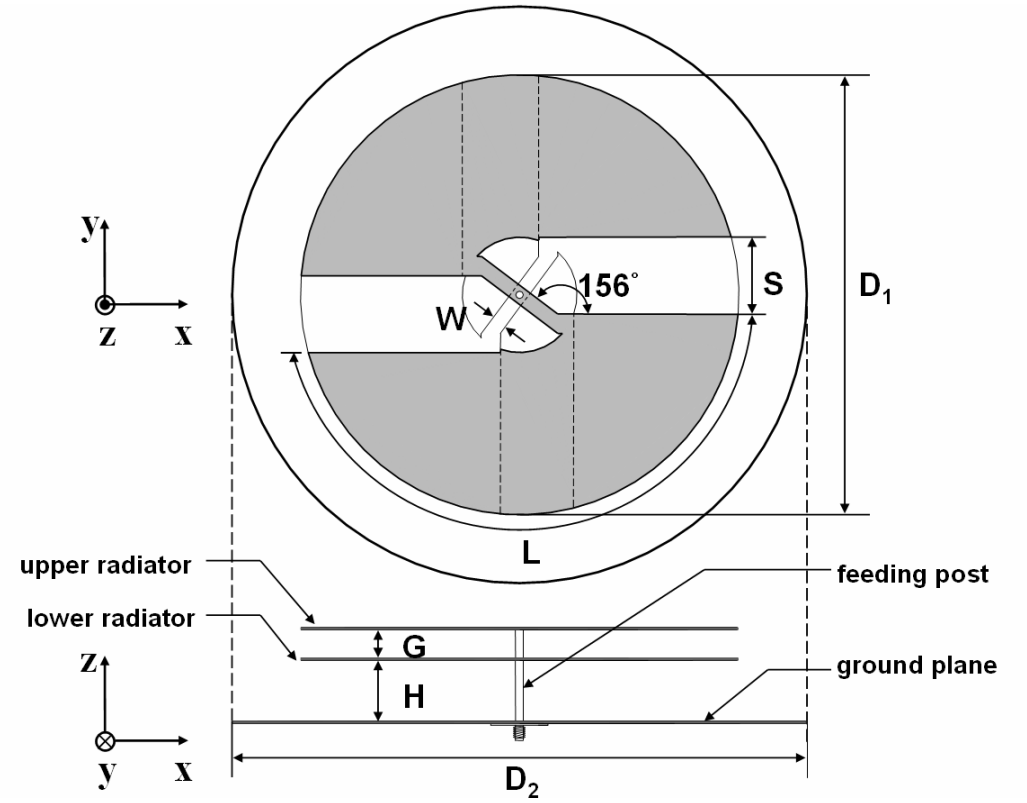


Fig. 1. Geometry of the proposed antenna: (D_1 = 229mm, D_2 = 300mm, S = 30mm, L ≅ 329mm, W = 7.8mm, G = 15mm, H = 32mm)

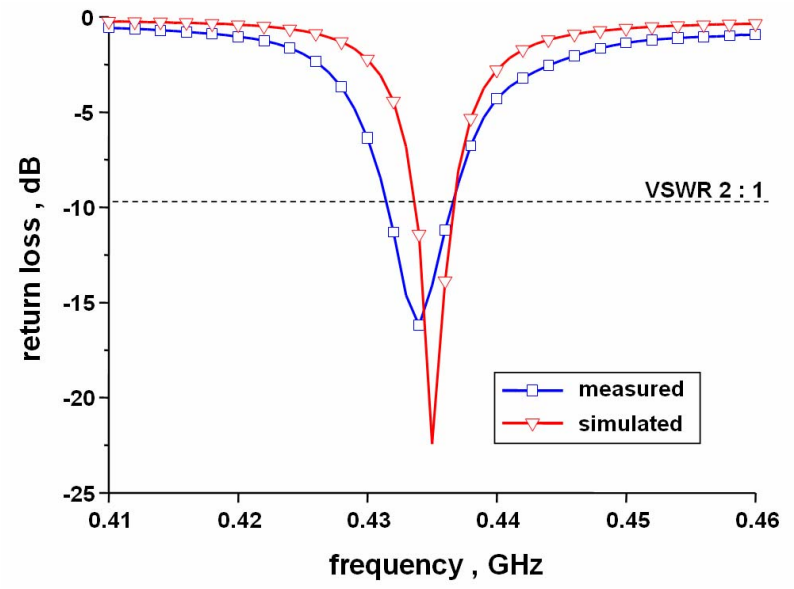
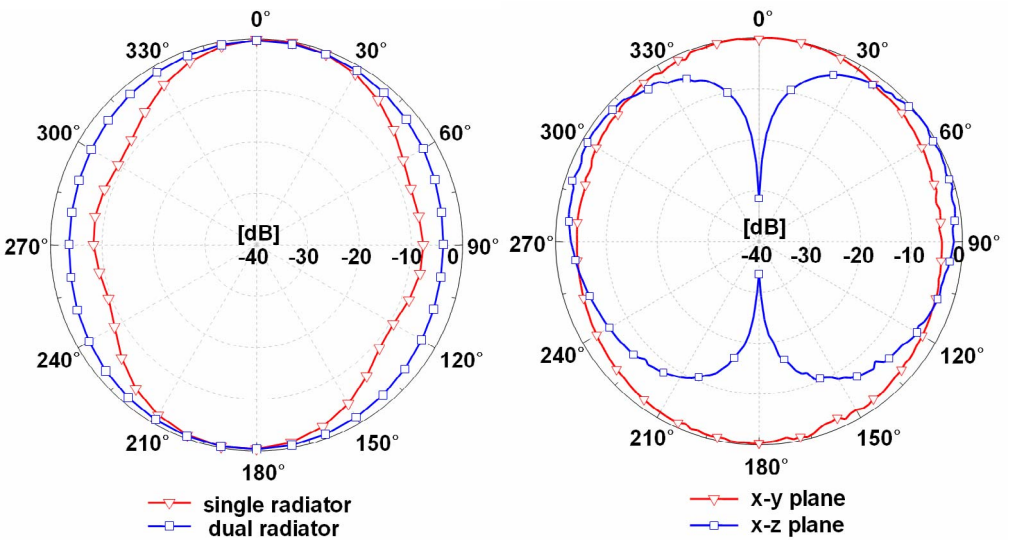


Fig. 2. Simulated and measured return loss of the proposed antenna



(a) (b)

Fig. 3. Radiation patterns at 433.92MHz: (a) simulated pattern of the antenna with a single and dual radiator in x-y plane, (b) measured pattern of the proposed antenna with two radiators in x-y and x-z plane