Compact Miniaturized Antenna for 210 MHz RFID

ABSTRACT

This paper describes the design and simulation of a miniaturized square-ring antenna. The miniaturized antenna, with overall dimensions of approximately one tenth of a wavelength (0.1λ), was designed to operate at around 210 MHz, and was intended for radio-frequency identification (RFID) application. One unique feature of the design is the use of a parasitic element to improve the performance and impedance matching of the antenna. The use of parasitic elements to enhance the gain and bandwidth of patch antennas has been demonstrated and reported in the literature, but such use has never been applied to miniaturized antennas. In this work, we will present simulation results and discuss design parameters and their impact on the antenna performance.

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Introduction

With the rapid growth in mobile communications all over the world, miniaturized antennas have become an area of focused research for many antenna engineers. The need for antenna miniaturization stems from the fact that space available for antenna placement in the mobile platforms is very limited. For low frequency (HF-VHF) radio-frequency identification (RFID) and sensor network applications, miniaturized antennas are important since the antenna size often imposes a significant limitation on the overall size of a portable system. Although many practical designs of miniature antennas have been published in the past several years [1-3], most of these works focus on frequencies around 2.4 and 5.8 GHz and very little work has been devoted to the MHz frequencies. In general, there is a price to pay in antenna performance in reducing the size of the antennas. The impacts on performance include high quality factor Q, low antenna efficiency, complex impedance match, and susceptibility to environmental surroundings [4].

This paper describes the design and simulation of a miniaturized square-ring antenna. The miniaturized antenna, with overall dimensions of approximately one tenth of a wavelength (0.1λ), was designed to operate at around 210 MHz, and was intended for RFID applications. One unique feature of the design is the use of a parasitic element to improve the performance and impedance matching of the antenna. The use of parasitic elements to enhance the gain and bandwidth of patch antennas has been demonstrated and reported in the literature [5], but such use has never been applied to miniaturized antennas. In this work, we will present simulation results and discuss design parameters and their impact on the antenna performance.

Antenna Design

The geometry of the proposed antenna is shown in Fig. 1. The antenna is a square-ring monopole with a tapered ground plane. The antenna has dimensions of 3cm x 2cm and was excited using a 0.06cm x 2.75 cm 50-Ohm microstrip line which was connected to an edge-mounted coaxial connector with the ground plane. Both the line width and gap separation of the square-ring structure are chosen to be 0.1 cm. To achieve compact size, the antenna was fabricated on 25-mil Rogers RT6010.5, a substrate with a relative dielectric constant ε_r = 10.5. To improve impedance matching, a triangular transition is used connecting the antenna and the feed line, as are miter joints to replace the 90 degree bends in the square-ring antenna. Further improvement in impedance matching is achieved using a tapered ground plane as illustrated in Fig.1 (a). In general, the operating frequency is determined by the length of the conducting strip that forms the square-ring antenna. This allows the frequency of operation to be easily tuned by adjusting the position of the open circuit termination of the line. In this study, the antenna performance is optimized at 210 MHz for a single antenna followed by comparing these results with those where a parasitic element of identical geometry is placed directly below the active antenna. Fig.1 (b) shows the metallization of the bottom substrate which contains the parasitic antenna and the ground plane.

Results and Discussion

The design and simulation of the square-ring antenna is performed using Zeland's IE3D, an integrated, full-wave electromagnetics (EM) simulation/ optimization software based on the method of moments (MoM). The antenna shown in Fig.1 (a) is first studied with the miniaturized antenna and the tapered ground plane designed on a finite dielectric substrate of dimensions 2cm x 5.3cm. Preliminary results indicate that the shape, size, and locations of the ground plane as well as the open circuit terminal are very sensitive to impedance match, while the length of the conducting strip has direct impact on the antenna operating frequency. Without using external L-C circuits or tuning stubs, the best return loss is obtained at around -15dB. However, by placing a parasitic antenna element of identical geometry directly underneath the active antenna as shown in Fig.1 (b), a 13dB improvement over the return loss of a single antenna is obtained at the expense of a slight shift in the operating frequency. Fig. 2 shows the simulated S11 results for the two cases. The radiation patterns along the $\varphi=0^o$ and 90^o planes are also calculated with results shown in Fig. 3. Note that the resulting patterns look fairly symmetrical. S11 measurements for several miniaturized square-ring antennas have been conducted. Preliminary test results indicate that the external environment could have a big impact on antenna performance. In addition, the measured resonant frequency observed is lower than the designed frequency. This is probably due to strong fringing fields near the edge of the substrate which is only 0.5 cm from the antenna boundary. Final test results will be presented at the conference.

Conclusion

A miniaturized antenna consisting of a square-ring monopole and a tapered ground plane has been designed and analyzed at around 210 MHz. Simulated results indicate that a 13 dB improvement in impedance matching can be achieved by placing an identical parasitic antenna element directly underneath the active one. The miniaturized antenna, with overall dimensions of approximately one tenth of a wavelength (0.1λ), can be used for RFID or sensor applications.

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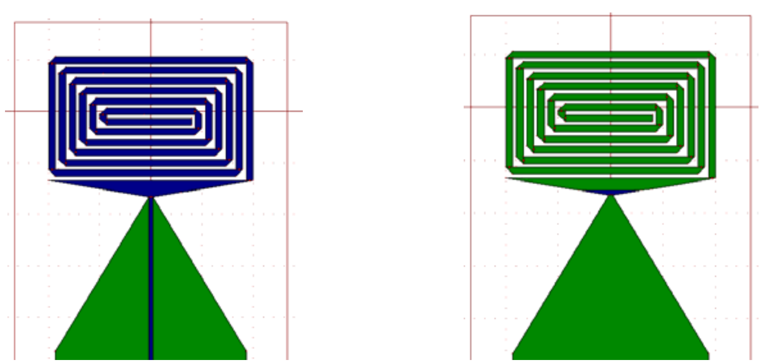

(a) (b)

Figure 1 Schematics of the square-ring antenna: (a) top metallization layer and (b) bottom metallization layer. (Antenna dimensions: 3cm x 2cm; microstrip line: 0.06cm x 2.75cm; base of ground plane: 2.8 cm)

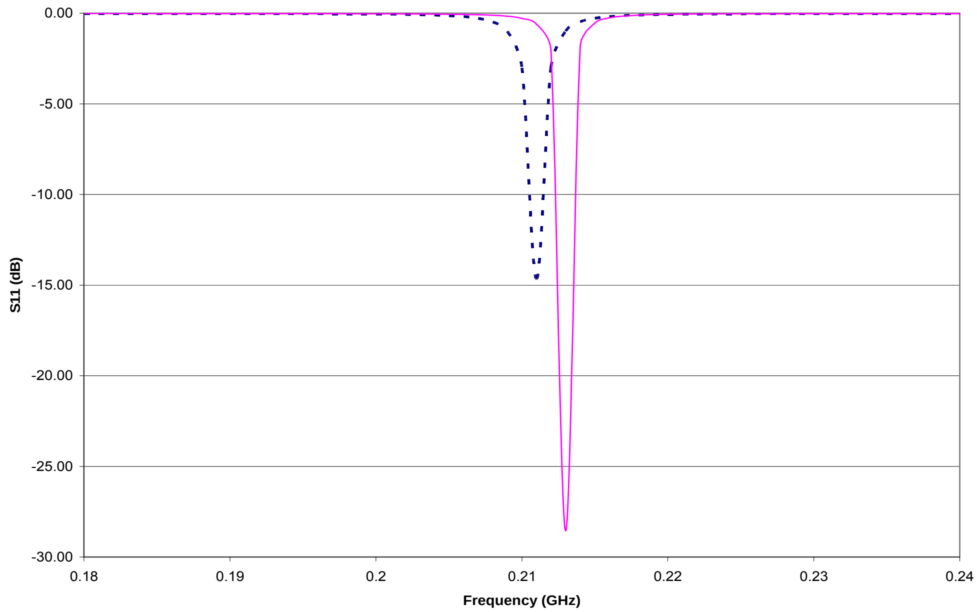

Figure 2 Calculated return loss for the square-ring antenna with (—) and without (- -) parasitic element.

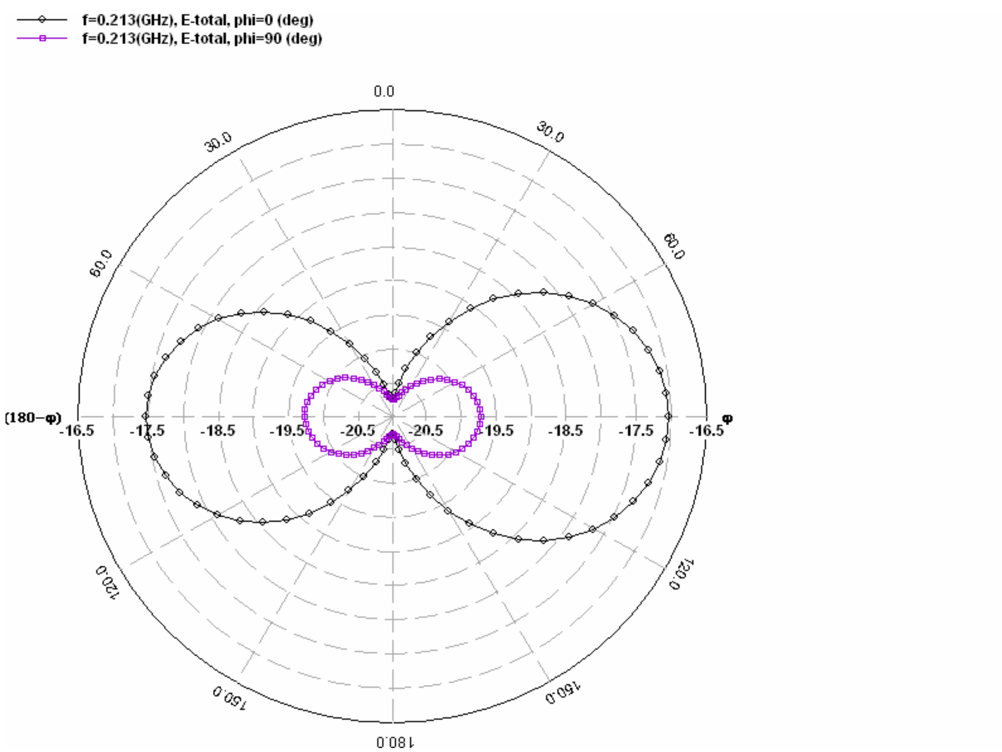

Figure 3 Calculated radiation patterns for the square-ring antenna with parasitic element