High frequency ratio antenna for RFID tags

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ABSTRACT: A novel high frequency ratio of about 180 for dual-frequency Radio Frequency Identification (RFID) antenna with two different operation mechanisms (near field and far field operation) is proposed. The proposed antenna is obtained by printing a rectangular-spiral-shaped and a meander-shaped line, which is placed above on a rectangular microwave substrate as a RFID tag's antenna where its ground plane is at the bottom of substrate. The proposed antenna is fed by a 50 Ω microstrip line printed on the same substrate, and the antenna's two resonant frequencies can be excited with good impedance matching. Closer to omni-directional radiation patterns and the lower cross-polarization levels (at least 25-dB) are also obtained.

INTRODUCTION

RFID systems are tremendous growth due to their wide application field, such as access control, baggage tracking, smart card, pet tracking etc. In these applications, data are contact-free transferred to a local querying system from a remote transponder (tag) including an antenna and a microchip transmitter. A proper antenna to these tags must have low profile, small size and low fabrication cost [1]. It is necessary to achieve more functional antennas for the rapid progress in wireless communications, however, most workers have been done in single frequency [2-5] but none discuss on dual-frequency with different operation mechanisms. In this paper, we propose a promising design of a high frequency ratio RFID antenna (see Fig. 1) for dual-frequency operation with different operational mechanisms. The proposed antenna has the same low-profile and low cost characteristics. The proposed antenna is easily obtained by printing a uniform microstrip line into a rectangular-spiral-shaped portion and a meander-shaped portion. With the proposed design, the antenna's two resonant frequencies can be excited with good impedance matching. The two resonant frequencies also have the same nearly a monopole-like radiation pattern. Prototypes of the proposed antenna have been successfully constructed. Details of the proposed antenna and experimental results of the prototypes are

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presented and discussed.

Antenna Design

The geometry of the proposed high frequency RFID antenna is shown in Fig. 1. It has a dimensions of $L \times W$, and consists of a rectangular-spiral-shaped portion (for near field operation) and a meander-shaped portion (for far field operation) fed with a 50 Ω microstrip feed line. In this study the rectangular-spiral-shaped portion is selected to be a uniform line having width and gap of W and G, respectively. The grounded substrate has a thickness of h and relative permittivity ε_r, on which a ground plane with dimensions of $L_g \times W_g$ is printed in the bottom of microwave substrate. It is used as a circuit board for another design consideration for designer to integrate with their own designs in order to extend the antenna acceptance in different applications or markets to increase the RFID antenna's value.

The rectangular-spiral-shaped portion is centered above the microwave substrate, with a shorting pin and feed position at point B (has the length of L_1 from point A to point B) and C (has the length of L_2 from point A to point C), respectively. The meander-shaped portion is composite with feed network component (including L_3, L_4, L_5, L_6 and L_7) for achieving good impedance matching for the proposed dual-frequency operation and a fixed length antenna arm with uniform width except the end section which has rectangular shape for adjusting resonant band width. The optimal dimension of end section is found in the present study to be about 4×2 mm^2.

EXPERIMENTAL RESULTS AND DISCUSSION

Prototypes of the proposed antenna were constructed and studied. The inexpensive FR4 substrate $\varepsilon_r = 4.4$, $h = 0.4$ mm with a ground-plane size of 19×43 mm^2 were used in the study. Fig. 2 shows the measured return loss of the constructed prototypes of rectangular-spiral-shaped portion operation at f_1 (13.56 MHz), and Fig. 3 presents the measured return loss of meander-shaped portion operation at f_2 (2.45 GHz).The impedance bandwidth (input return loss > 10 dB), 0.75 % for the frequency f_1 and 5.5 % for the frequency f_2 has been obtained. The frequency ratio in this design dual-frequency operation is about 180. The rectangular-spiral-shaped portion and the meander-shaped portion had a total length of 2573 mm and 31 mm, respectively. The corresponding resonant frequency characteristic using in RFID are also listed in Tab. 1 for reference. The radiation patterns characteristics were also studied. Fig.4 show the measured radiation patterns at the centre operating frequencies of f_1 and f_2, respectively. Measurements at other frequencies within the two operating bands were also conducted, and the measured results across each operating band showed similar radiation patterns as those given in Fig. 4 (*x-y* plane shows here only and the rest will be present at symposium). From the measured results, it is seen that, in the *x-y* plane, the radiation patterns are closer to omni-directional radiation patterns and the cross-polarization levels are at least 25-dB lower. Also, the proposed antenna nearly shows a monopole-like radiation pattern.

CONCLUSIONS

A high frequency ratio RFID antenna has been proposed and studied. The two operating frequencies are associated with the rectangular-spiral-shaped portion and the meander-shaped portion, with the length of the proposed being about 0.23λ and 0.5λ, respectively. Owing to the printing of the proposed antenna at an appropriate arrangement, the excited resonant frequency ratio is about 180 with two different operation mechanisms using in RFID antenna. Relatively bandwidths of the two frequencies are about 0.75 % for the lower operating frequency and 5.5 % for the higher operating frequency, it is enough for RFID tag's antenna application.

Acknowledgement

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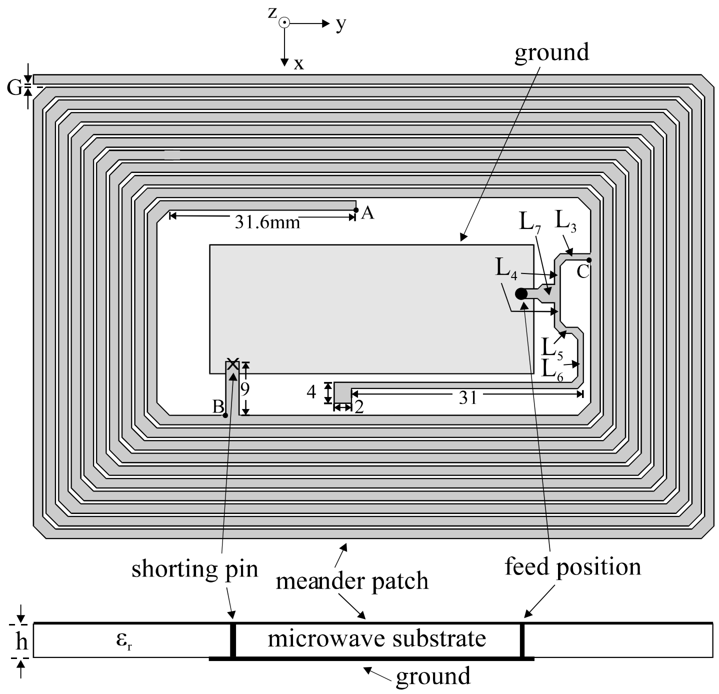

Fig. 1 Geometry of the proposed high frequency ratio antenna for RFID tags; ε_r = 4.4, h = 0.4 mm, L = 80 mm, W = 50 mm, L_g = 48 mm, W_g = 19 mm, W = 0.6 mm, G = 0.2 mm, L_1 = 80 mm, L_2 = 150 mm, L_3 = 5.3 mm (W = 0.4 mm), L_4 = 5.3 mm, L_5 = 3.3 mm (W = 0.4 mm), L_6 = 10 mm, L_7 = 3.7 mm.(W = 0.7 mm, W = 2.1 mm)

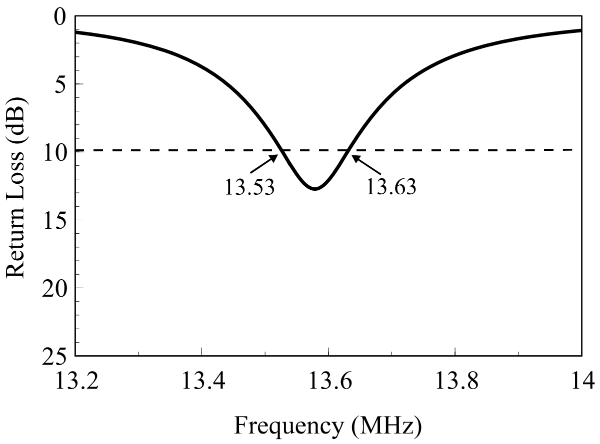

Fig. 2 Measured return loss against frequency at 13.56 MHz.

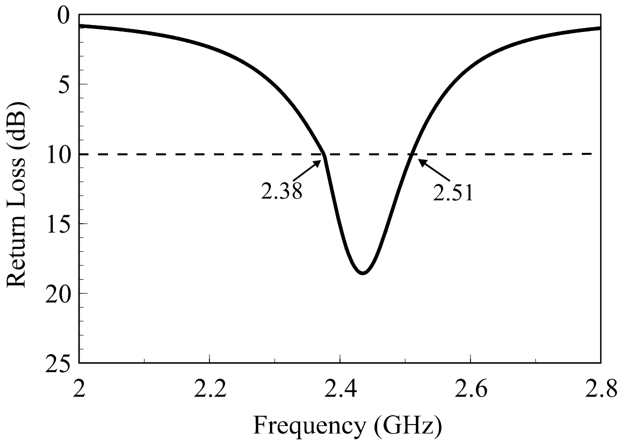

Fig. 3 Measured return loss against frequency at 2.45 GHz.

Tab.1: The corresponding resonant frequency characteristic using in RFID system

Frequency range		operation mechanisms	applications
<135KHz	LF	Inductive Coupling (near field)	Access control, animal tracking etc.
13.56MHz proposed antenna	HF		Smart cart, item level, tracking etc.
433.92MHz	UHF	Backscatter Coupling (far field)	Pallet level, tracking, container tracking, item level tracking etc.
860-930MHz			
2.45GHz Proposed antenna	Microwave		Item level tracking, baggage handing ect.
5.8GHz			

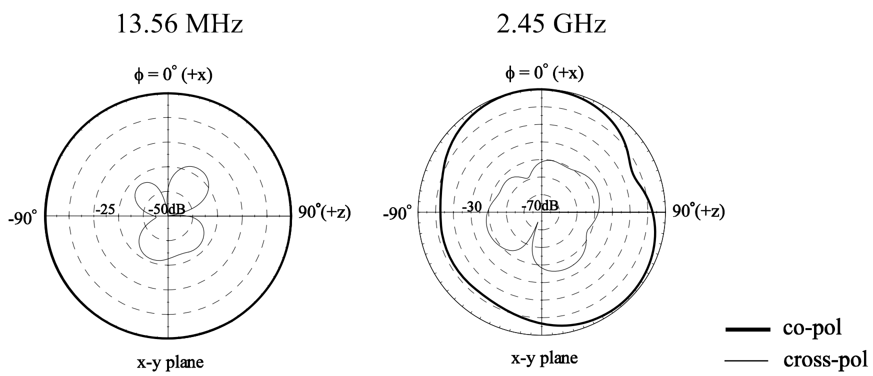

Fig. 4 Measured radiation patterns of the proposed antenna.

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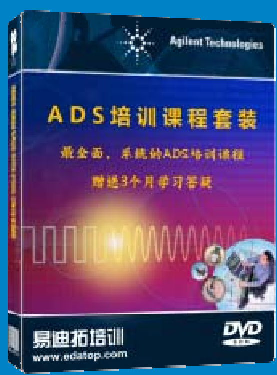

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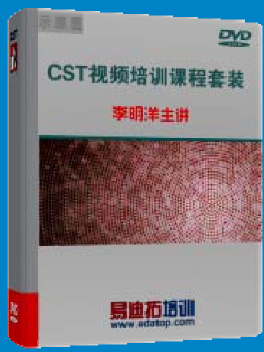

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