Broadband Circularly Polarized Stacked Patch Antenna for Universal UHF RFID Applications

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***Abstract* – A double layer stacked patch antenna with a size of 200 × 200 × 48 mm^3 is proposed in this investigation. To achieve broad CP bandwidth that can cover the universal UHF RFID applications (840–960 MHz), a slot loaded circular patch antenna fed by an L-shaped probe is applied as the lower layer (main patch), while the top layer (parasitic patch) is a simple cross slot loaded circular patch. Besides demonstrating broad 10-dB return loss bandwidth of 16% (823–966 MHz), desirable CP bandwidth (3-dB axial ratio) of 14.2% (833–960 MHz) was also measured. Furthermore, the proposed antenna has also yielded a maximum gain of approximately 8 dBic.**

***Index Terms* — Circular polarization, patch antenna, stacked patch, universal UHF RFID.**

I. Introduction

Presently, one of the methods to develop a CP reader antenna for RFID (Radio Frequency Identification) UHF (Ultrahigh Frequency) is to employ a single probe-fed layer square patch antenna embedded with multiple slits or slots [1], [2]. However, such CP antenna designs have exhibited peak gains of less than 4 dBic, and their 3-dB axial ratio (AR) bandwidth (or CP bandwidth) were usually less than 10 MHz (or 1%). Therefore, such narrow band designs cannot cover the RFID UHF spectrum (902–928 MHz) that is used in most countries, not to mention the universal UHF RFID spectrum (840–960 MHz).

Therefore, a number of broadband CP antennas with top loading design (stacked patch) for UHF RFID applications have been studied recently [3]-[5]. Here, the technique of double shorting four sequential rotating stacked patches was introduced to excite broad CP bandwidth of 11.6%, however, a complicated feeding-network was required in this work [3]. To achieve broader CP bandwidth of more than 13.33%, so that it can cover the entire universal UHF RFID spectrum, antenna designs with meticulously devised single layer feed-structure top loaded by another two layers of corner truncated square patches (main radiating patch and parasitic patch) have been proposed [4], [5]. However, high manufacturing cost can be foreseen as a result of their complicated three-layer stacked structures.

In this paper, two slot loaded CP circular patch antennas are designed. Here, the design of the bottom layer patch antenna with an L-shaped probe is stemmed from the work in [6]. By further stacking another CP patch (top layer) into this bottom layer patch, their respective CP operating band can be integrated and a broad CP bandwidth of 14.2% that can cover the universal RFID UHF spectrum is achieved. Detail design of the proposed antenna will be discussed, and typical measurement results are also presented.

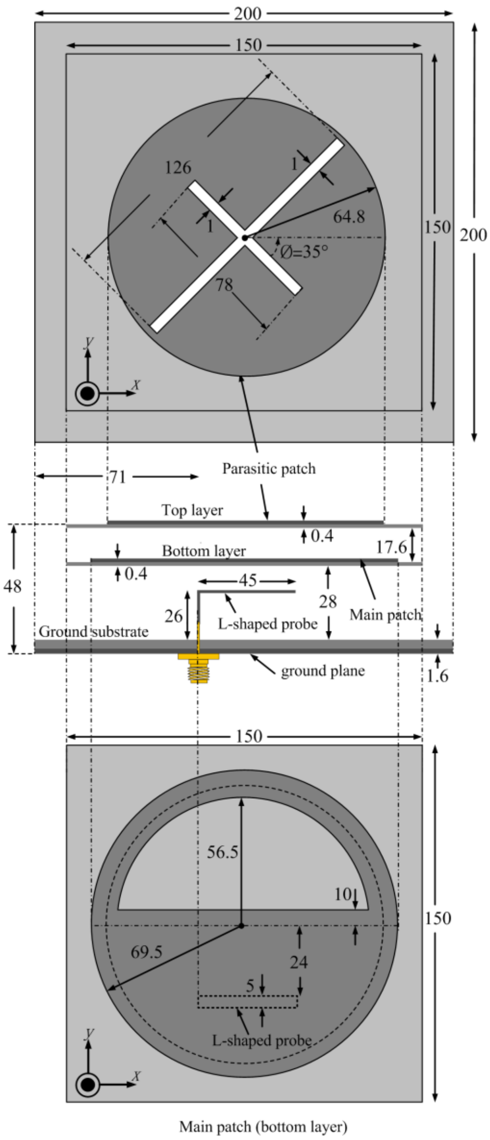
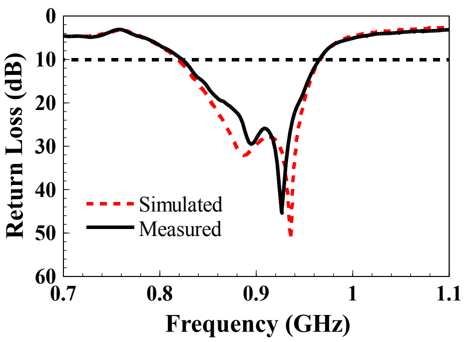


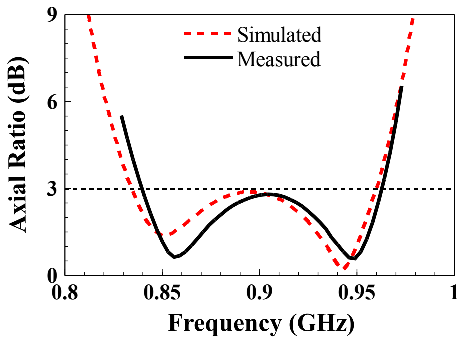
Fig. 1. Geometry of the proposed antenna.

II. Antenna Design

The proposed Antenna as depicted in Fig. 1 was composed of four main elements, namely, the top layer parasitic patch, bottom layer main radiating patch, L-shaped probe, and ground plane. The parasitic patch was a circular patch (with 64.8 mm radius) loaded with a cross slot. The main objective of loading this cross slot is to excite an upper CP frequency at approximately 940 MHz, so that by loading this parasitic patch on top of the main radiating patch, this additionally excited upper CP frequency can be combined with the lower CP frequency (excited by the main patch) to form a wide CP bandwidth. The main patch was located 17.6 mm below the parasitic patch. It was a simple circular patch (radius of 69.5 mm) loaded with a near half-circular slot (radius of 56.5 mm). Both the main and parasitic patches were fabricated on a 0.4 mm thick FR4 substrate of size 150 × 150 mm^2. The L-shaped probe was located 2 mm below the main patch, and it was fabricated by using a 0.2 mm thick copper sheet. It has a width of 5 mm, and was composed of two main sections, namely, the vertical and horizontal section, and they were 26 mm and 45 mm long, respectively. Notably, this L-shaped probe method was applied for achieving good impedance matching. Lastly, the 200 × 200 mm^2 square ground plane was located 28 mm below the main patch, and it was fabricated on a 1.6 mm thick FR4 substrate.



(a)



(b)

Fig. 2. Simulated and measured (a) return loss, (b) axial ratio.

III. Results and Discussion

The simulated and measured return loss and axial ratio of the proposed antenna are presented in Figs. 2(a) and (b), respectively, and the two results validated well with each other. Here, the measured 10-dB impedance bandwidth and 3-dB AR bandwidth were approximately 16% (823–966 MHz) and 14.2% (833–960 MHz), respectively. Therefore, this proposed antenna is able to cover the desired RFID UHF universal band (840-960 MHz).

Table I shows the detail electrical and mechanical performances of the proposed antenna, two reference antennas [4], [5], and three industrial available antennas for universal UHF RFID applications. In this table, the proposed antenna has exhibited broad CP bandwidth of 14.2%, which is much larger than the rest of the reference antennas, except for the one reported in [4] with CP bandwidth of 16.4%. Even though all reference antennas in Table I have higher gain than the proposed antenna, it was no more than 1 dB. This maybe because the proposed antenna has a much smaller planar size (200 × 200 mm^2) than these reference antennas. Nonetheless, the small planar size of this proposed antenna came with a disadvantage of higher antenna's height of 48 mm, as compared with the references.

TABLE I
Comparison between Proposed Antenna and Reference Antennas

Ant	Electrical Specification		Mechanical Specification
	CP Frequency (MHz, %)	Maximum Gain (dBic)	Size (mm^3)
Ref. [4]	818–964, 16.40	8.3	250×250×35.0
Ref. [5]	838–959, 13.50	8.6	250×250×39.5
Motorola AN480	865–956, 10.00	9.0	259×259×33.5
Alien ALR-8696-C	865–960, 10.41	8.5	259×259×33.5
Laird S8658WPR	865–960, 10.41	8.5	259×259×33.5
Proposed	833–960, 14.20	8.0	200×200×48.0

IV. Conclusion

A double-layer stacked patch antenna for universal UHF RFID applications has been successfully implemented and investigated. The proposed antenna has exhibited 10-dB impedance bandwidth and CP bandwidth of 16% and 14.2%, respectively. The results of the proposed antenna were also compared to the references, and the advantages of this proposed antenna include broad CP bandwidth and smaller planar size.

Acknowledgment

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