High Gain Circularly Polarized Substrate Integrated Coaxial Line Fed Antenna Array for RFID Band

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***Abstract*— In this paper, a high gain microstrip patch antenna array for radio frequency identification (RFID) applications is presented. A four-probes-fed microstrip square patch antenna fed by a series power divider is considered as the radiation element of the array. After that, a 2 × 2 antenna array is realized with a second level series power divider feed network implemented with substrate integrated coaxial line (SICL) technology. The series power dividers are used to implement a two levels sequential rotation feed network for generating circular polarization (CP). The SICL based feed network is found to effectively reduce coupling effects between feed network and radiating elements. Measurement results show a S_{11}≤-15 dB bandwidth of 840 – 980 MHz, and gain of 11.8 dBi at the frequency 915 MHz. This antenna array is suitable for outdoor long-distance RFID communication systems.**

I. Introduction

In radio frequency identification (RFID) systems, antennas play significant roles and have gained more and more attention. Many studies are proposed in literature in order to achieve high gain and circularly polarized (CP) RFID reader antennas which can cover the universal ultra-high frequency (UHF) RFID band [1], [2].

Authors in [3] have described an E-shaped patch antenna as an effective method to achieve wideband performance, and our previous work describes its use to realize a wideband array with high gain [4].

Another important aspect in implementing RFID reader antennas is the capability to radiate CP which is shown to provide unique features in propagation. Sequential rotation technique is demonstrated to be an effective method to generate CP, and it is also shown that it can be repeated to construct multiple levels of sequential rotation feed networks, with the advantage of improved performance [5].

In this work, a 2 x 2 CP microstrip patch antenna array antenna is designed to cover the universal RFID band 840-960 MHz. The antenna elements are implemented with a multiple feeding structure through a series power divider that enables CP operation. A second level of sequential rotation feed network applied on the 2 x 2 array is shown to improve return loss, axial ratio (AR) and gain performance.

II. Antenna Design

The proposed antenna is depicted in Fig. 1. A 2 × 2 four-probes-fed patch antenna array configuration is chosen, with a substrate integrated coaxial line (SICL) [6] feed network and an aluminum ground plane. Plastic screws are used to fix the patch elements.

Fig. 1. Fabricated prototype of the four-probes-fed microstrip patch antenna array. (a) Microstrip patch antennas from the top, (b) SICL-based series feed network under the microstrip patch antenna

Each patch antenna is fed through a series power divider, as shown in Fig. 1 (b), which provides 1/4 of normalized power to each antenna probe, and also a progressive 90 deg phase increment to generate right hand circular polarization (RHCP).

The four series power dividers which fed the four antenna elements are then connected to a central series power divider used to reiterate the sequential rotation method application.
SICL technology is used to implement the feed network for reducing coupling effects between feed network and antenna elements [7].

III. Measurement Results

Simulation results obtained with Ansys HFSS electromagnetic simulation software (based on finite element method) are compared with the fabricated prototype measurement results. Return loss is measured with an Agilent NA5320A network analyzer, whereas AR, gain, and radiation patterns are calculated by testing far-field performance in an anechoic chamber.

Fig. 2 shows that the S_{11}≤-15 dB operative bandwidth of the antenna array is 850 – 960 MHz which is almost able to cover the universal UHF RFID bandwidth (the S_{11}≤-10 dB bandwidth fully covers it). Discrepancies between simulation and measurement results are found to be due to little imperfections in the array fabrication.

The gain and AR of the antenna are shown in Fig. 3. As it can be observed, the antenna gain is larger than 10 dBi within the bandwidth of interest, with a peak of 11.8 dBi at the frequency 915 MHz. For what the AR concerns, AR≤3 dB bandwidth is found to be 860-970 MHz.

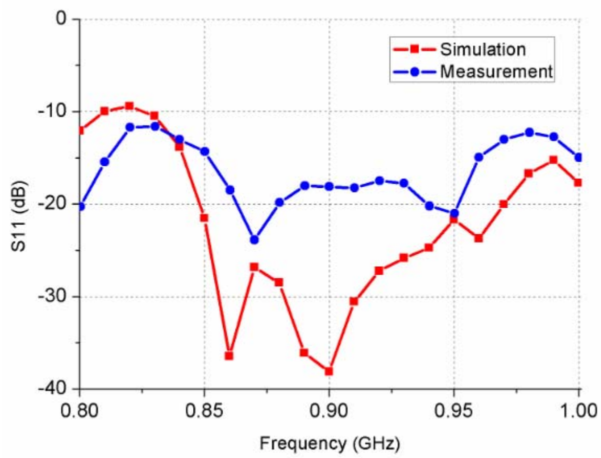

Fig. 2: Simulated and measured S_{11} of the four-probes-fed microstrip patch antenna array prototype

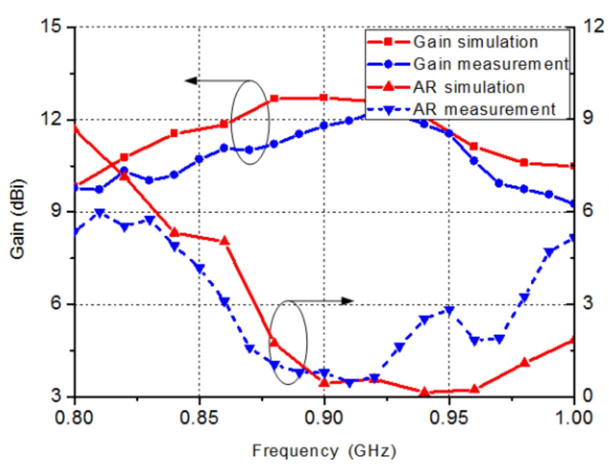

Fig. 3: Simulated and measured broadside gain and AR

The antenna array radiation pattern is shown in Fig. 4. LRCP and RHCP radiation patterns at the frequency 915 MHz are both depicted, showing good agreement with simulation results.

IV. Conclusion

In this paper, four-probes-fed microstrip patch antenna array is designed. The antenna element adopts four-feed square patch structure for enabling CP operations. The feed network is implemented with SICL technology, with a two levels series power divider structure used to easily apply the sequential rotation technique. The antenna array is fabricated, and measurement results on the prototype exhibit a S_{11}≤-15 dB bandwidth and AR≤3 dB bandwidth almost compatible with the universal RFID band 840 – 960 MHz. Furthermore, broadside gain is found to be larger than 10 dBi within the bandwidth of interest, with a peak of 11.8 dBi at the frequency 915 MHz.

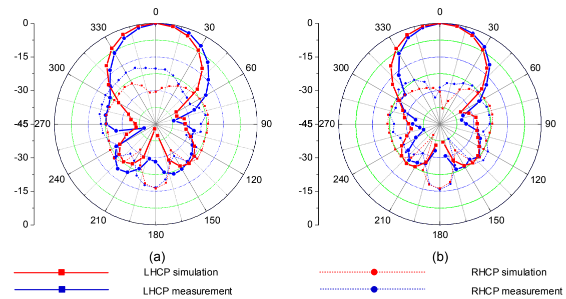

Fig. 4: Simulated and measured LHCP and RHCP radiation patterns at 915 MHz. (a) *xz* plane (b) *yz* plane

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