Design of Low-RCS and Gain Enhancement Microstrip Antenna Based on Miniaturized Polarisation-Dependent AMC

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***Abstract* - In this paper, a novel miniaturized polarisation-dependent artificial magnetic conductor (AMC) is proposed. The proposed AMC element is based on the complementary split-ring resonators (CSRR) structure and via-based methodology. The electric size of one proposed element is as small as 0.09 $\lambda_0 \times$ 0.09 λ_0. It can be used for radar cross section (RCS) reduction of microstrip antenna. For this purpose, chessboard configuration is structured with the orthogonal array of proposed elements. Compared with the reference element, the proposed element achieves 50% size reduction. Meanwhile, the performance of broadband RCS reduction and antenna radiation are well maintained.**

***Index Terms* — Microstrip antenna, miniaturization, polarisation-dependent AMC, RCS reduction.**

1. Introduction

Nowadays, microstrip antennas are widely used in detection and communication systems. As a special scatterer, it exhibits large backward radar cross section (RCS) for low-observable platforms. Unfortunately, antennas by their nature cannot be coated in broadband absorbing materials or hidden within a shielded composite shell while continuing to operate. Meanwhile, in-band RCS reduction of antenna is directly related to the radiation performance. Many methods have been proposed to reduce the RCS of microstrip antenna. For in-band RCS reduction, microstrip resonator (MR) [1] is an excellent candidate. For out-of-band frequencies, the RCS can be reduced by band-pass frequency selective surfaces (FSS) radome [2]. Recently, several methods for broadband RCS reduction are introduced, such as orthogonal array of polarisation-dependent artificial magnetic conductor (AMC) [3], [4] and chessboard configuration of different AMC elements [5].

However, in practice, chessboard-AMC structure is fabricated in a limited size, and sufficient resonant elements are required to lower the sensitivity to the incident waves with different incident angles [6]. Hence, the miniaturization of AMC element is necessary. In this paper, a novel miniaturized polarisation-dependent AMC is proposed to structure the chessboard configuration for broadband RCS reduction and gain enhancement of microstrip antenna.

2. Design Descriptions

The chessboard configuration of proposed miniaturized polarisation-dependent AMC is loaded around the patch as shown in Fig. 1. The loading method is adopted to maintain the radiation characters of patch antenna [4]. The patch antenna is printed on a 3mm-thick square Rogers-TMM substrate, which has a relative permittivity of 9.2. The substrate for the AMC element is F4B-2, which has a relative permittivity of 2.65. The configuration and dimensions of proposed elements (including the reference element) are given in Fig. 2. Where the miniaturization is based on the bended complementary split-ring resonator (CSRR) structure and via-based methodology [7].

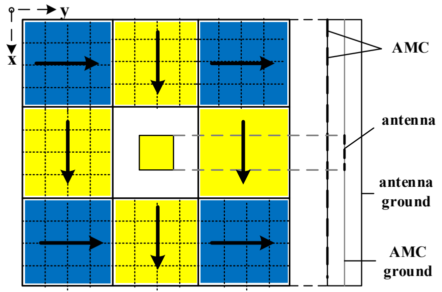


Fig. 1. The brief model of the proposed low-RCS antenna.

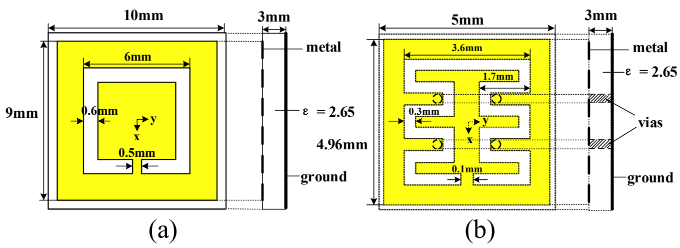


Fig. 2. Configuration and dimensions of AMC element: (a) element in reference [3]; (b) proposed element.

3. Results and Analysis of Simulation

The numerical simulation is carried out to investigate the S-parameters and RCS value of the proposed antenna by CST Microwave 2015. Fig. 3 shows the reflection phase and their differences in frequency of the proposed polarisation-dependent AMC element. We define the element in Fig. 2(b) is in X-orientation, while the Y-orientation is when it rotates 90° along the Z-axis.

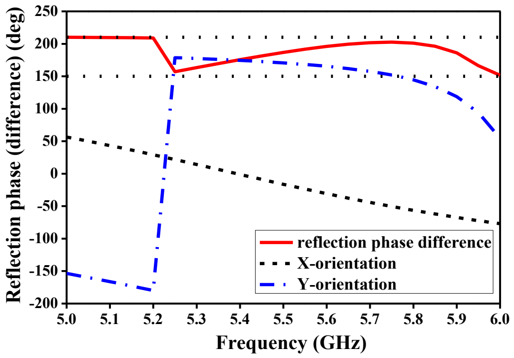
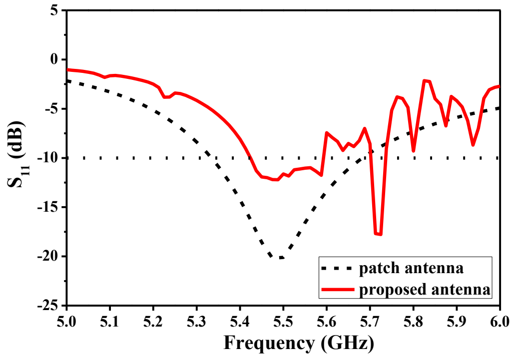
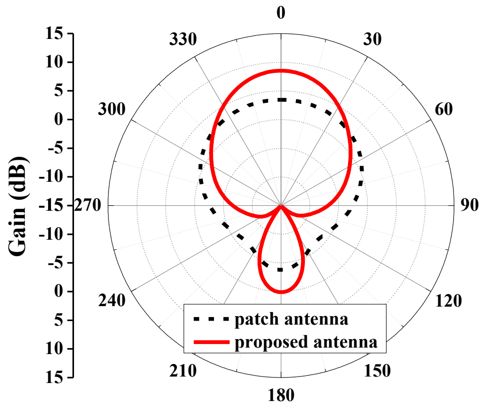


Fig. 3. The reflection phase and difference of the proposed polarisation-dependent AMC element.



(a)



(b)

Fig. 4. The radiation performances of the proposed antenna and reference patch antenna: (a) Reflect coefficient; (b) Radiation pattern at 5.5GHz.

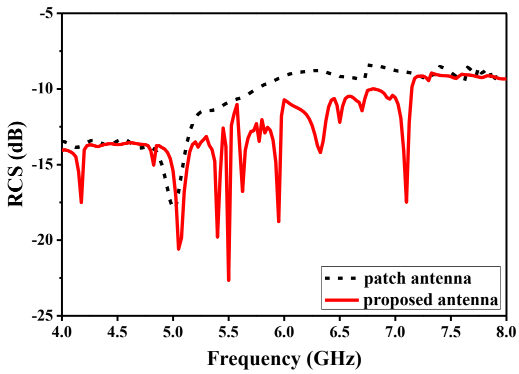


Fig. 5. The scattering performance of the proposed antenna and reference patch antenna.

The validate phase cancellation range is from 5 GHz to 6 GHz. The lateral dimension of the integrated antenna is 60 mm × 60mm. And the working frequency of the integrated antenna is 5.5GHz. The correspondingly radiation and scattering performance of the proposed antennas are presented in Fig. 4 and Fig. 5, which also include the results of traditional patch antenna as comparison. Compared with the reference antenna, the proposed integrated antenna achieves about 10 dB in-band and out-of-band RCS reduction. Furthermore, the maximum gain enhancement reaches about 5 dB at the resonant frequency of antenna, which can be attributed to the compacted high-order mode cavities of the miniaturized polarisation-dependent AMC elements and the fact surface current distribution that proposed structure caused.

4. Conclusion

A novel miniaturized polarisation-dependent AMC element are proposed in this paper. The electric size of one proposed element is as small as $0.09\ \lambda_0 \times 0.09\ \lambda_0$. Compared with the reference CSRR element, it achieves 50% size reduction. And it can be used for RCS reduction and gain enhancement of microstrip antenna.

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