# Decoupling Structure with Complementary Split Ring Resonators in Parallel Array Patch Antennas for MIMO applications

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***Abstract* – This paper presents the new decoupling structure in parallel array patch antennas. The proposed structure consists of periodic arrangement of complementary split ring resonators (CSRRs) and a coupling wall. We will focus on the strategy of high isolation between two patch antennas having the same direction of electric field or radiation mode. The results are given for three different structures, namely, coupling wall, complementary split ring resonators, and their combination.**

***Index Terms* — Decoupling structure, patch antenna, complementary split ring resonator.**

## I. Introduction

Mutual coupling reduction between multiple antennas is important in multiple input multiple output (MIMO) system. Recently, one of the many research trends for high isolation in multiple antennas is to use the metamaterial resonator such as a split ring resonator (SRR) and complementary split ring resonator (CSRR) [1], [2]. In general, the periodic arrangement of SRRs has been used in order to obtain the high isolation between two patch antennas in parallel. In this paper, we proposed the new method to improve the isolation performance of two patch antennas in parallel using the CSRR. The decoupling structure with CSRR in the early research was only composed of the two patch antenna in series [2]. In this sense, using the CSRR as decoupling structure in patch antenna array in parallel may have a noteworthy value providing a novel approach to the decoupling in the antenna application field.

## II. Two patch antennas in parallel

The basic model used to demonstrate the decoupling structure is the typical parallel array antennas which consist of two squared patch antennas fed by a coaxial probe. Fig. 1 shows the geometry and electric field distribution of the basic parallel array antennas. This result was computed by 3D electromagnetic simulator of HFSS of Ansys. The dimension of square patches is 30mm*31.7mm, where two identical coplanar patch antennas operating at 2.63 GHz are placed 60mm ($0.52\lambda_0$) apart from edge to edge. The antenna is constructed on Rogers 4003 substrate with a thickness 0.812 mm ($\varepsilon_r$ = 3.55 and tan $\delta$ = 0.0027). It can be observed that the electric field distributions are highly concentrated on the top edge and bottom edge of patch.

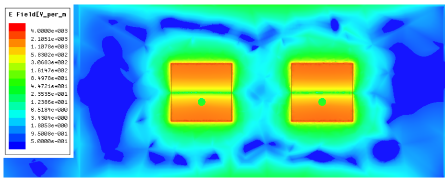

Fig. 1. Electric field distribution of basic parallel array patch antenna.

## III. Decoupling structure

The SRR is formed by two concentric metallic rings strip with a split on opposite side, which behaves as an electrically small LC resonant tank with a high quality factor. This electromagnetic feature can be excited by a time-varying external magnetic field component of normal direction of resonator. Based on the Babinet principle and the duality concept, the CSRR is the negative images of the SRR, and the basic mechanism is the same to both resonators except for excited the axial electric field, so that the CSRR needs the axial electric field. Namely, the SRRs as decoupling structure could not help using in parallel array antennas because there was strong magnetic field distribution in the space between patches as shown in Fig. 1. Fig. 2 shows the geometry of the CSRR used in this study, the following dimensions were selected: $a$ = 9.6 mm, $c$ = 0.5 mm, $d$ = 0.6 mm, and $g$ = 0.3 mm. The resonance frequency of CSRR in Fig. 2 is 2.6 GHz, too. In this paper, a coupling wall was inserted on the CSRR in order to overcome the limitation of CSRR as decoupling element. This wall provides the axial electric field to the CSRR. Fig. 3 shows the geometry of antenna with inserted the proposed decoupling structure.

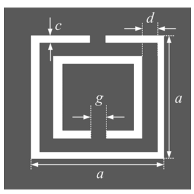


Fig. 2. Geometry of the CSRR (Dark color is copper).

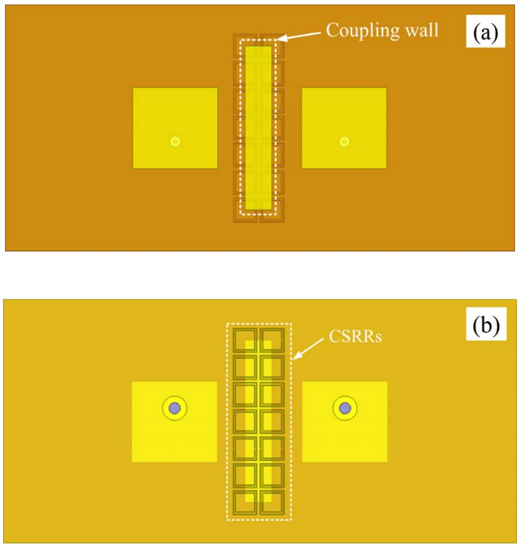


Fig. 3. The geometry of the proposed decoupling structure. (a) Top view. (b) Bottom view.

## IV. SIMULATION RESULTS

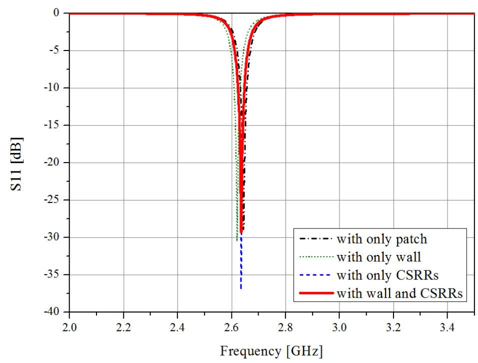


Fig. 4. Return loss result of proposed structure.

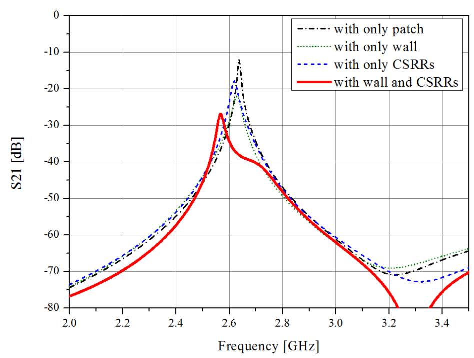


Fig. 5. Isolation result of proposed structure.

Fig. 3 and Fig. 4 show the simulated return loss (S11) and isolation (S21) results of the proposed antenna with decoupling structure for various cases. From the result shown in Fig. 4, it is observed that a good impedance matching of antenna for return loss ≤ -10 dB at 2.63 GHz is almost maintained despite inserting the decoupling structures. In Fig. 5, the isolation value of antenna with combination of coupling wall and CSRRs is below -37dB, which is quite good for high isolation applications. In comparing between S21 curves in Fig. 5, improving the isolation of only finally proposed decoupling structure is observed. Fig. 6 shows the electric field distribution of antenna at side view. These results reveal that decoupling structure with combination of coupling wall and CSRRs generates the null field between two patch antennas.

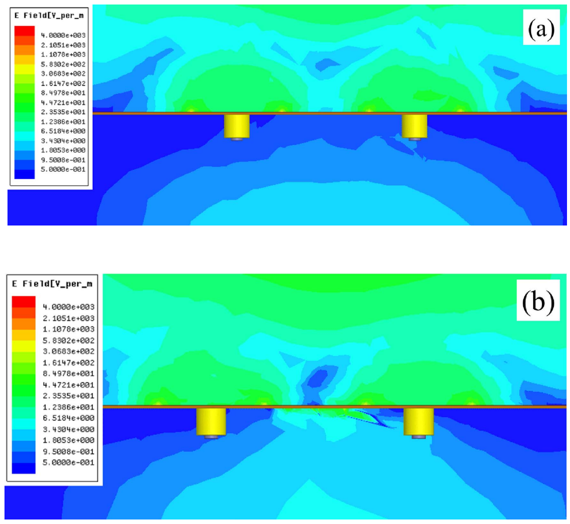


Fig. 6. Electric field distribution of antenna at side view (a) with only patch and (b) with combination of coupling wall and CSRR.

## V. CONCLUSION

In this paper, a decoupling structure for improving the isolation between two parallel array patch antennas has been proposed. The proposed decoupling structure utilized the combination of the CSRRs with coupling wall. The suggested isolation technique might be useful for designing the MIMO antenna to mitigate the mutual coupling between multiple antennas.

## ACKNOWLEDGMENT

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