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Design and simulation of patch antennas with CSRRs units

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Abstract

In this article, a microstrip antennas are designed with complementary split ring resonators (CSRRs) by creating a defective mass (DGS : Defective Ground Structure). The proposed antennas were simulated with the FR_4 substrate. The CSRR units are designed to operate at 3.5 GHz. They are located on the ground plane of the antenna. Moreover, with the change of the position and the number of these units the resonant frequencies as well as the bandwidth are improved. The simulated results show that the proposed antennas enhance the following characteristics: gain, bandwidth and multiple frequency bands.

Keywords: Antennas, microwave range, complementary split ring resonators.

Résumé

Dans cet article, des antennes micro-ruban sont conçus avec des RAFC (résonateurs à anneau fendu complémentaires) en créant une masse défectueuse (DGS). L'antenne proposée a été simulée avec le substrat FR_4. Les unités RAFC sont conçues pour fonctionner à 3.5 GHz. Ils sont gravés sur le plan de masse de l'antenne. De plus, avec le changement de la position et le nombre de ces unités les fréquences de résonance ainsi que la largeur de bande sont améliorées. Les résultats simulés montrent que l'antenne proposée améliore les caractéristiques suivantes : gain, largeur de bande et bandes multiples de fréquences.

Mots-clés : Antennes, micro-ondes, cellules résonateurs complémentaires

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1. Introduction

An antenna is a sensor that converts an electrical signal into electromagnetic waves and radiates into space and vice versa [1]. The micro-strip antenna have several advantages [2] like the low weight, the low profile, the cost and the ease of integration in the MMICs, out of these advantages, these antennas had certain limitations [3], that is, a single operating frequency, a low impedance bandwidth and a low gain [4]. There are a lot of techniques that have been reported to improve the parameters of conventional patch antennas[5], like using different feed techniques [6], frequency selective surfaces (FSS) [7], electromagnetic band gaps (EBG) [8], photonic band break (PBG) [9], metamaterials [7,10].

The antenna with a defect ground structure (DGS) is the most used technique among all the reported techniques to improve the parameters because of its simple structure [11]. Soil defects disturb the current distribution of the ground plane; this disturbance modifies the characteristics of an antenna or a transmission line (or the whole structure) by including certain parameters (slot resistance, slot capacity and slot inductance) to the parameters of the line (line resistance [7], line capacitance and line inductance) [12].

In other words, any defect etched in the ground plane under an antenna patch modifies the effective capacitance and the inductance by adding resistance, capacitance and inductance of the slots [14]. In this paper, we use DGS to design an improved antenna over the conventional one, resonating at 3.5 GHz .Initially, the proposed antenna resonates at 5GHz, and then DGS is used to move the resonance frequency to 4GHz.

2. Microstrip Antenna With CSRR

The patch antenna is designed to work at 5 GHz with the programmed formula figure 1. Then, a unit cell of CSRR is designed to resonate at 3,5GHz figure 2, a CSRR acts as metamaterial or DGS, were introduced into the patch to produce the desired frequencies.

3. Dimensions of the proposed antenna

Table1. Dimensions of the proposed antenna

Height of the substrate, h = 0.63mm.	
The substrate material used is FR4. ε_r = 4.4,	
Wavelength, λ=60mm	
Effective dielectric constant: ε_{eff} 3.45	
Width of patch: W=18.3mm	
Length of patch: L=14.2mm	
Feed length: Fl=13.7mm	
Feed width: Fw=1.2mm	

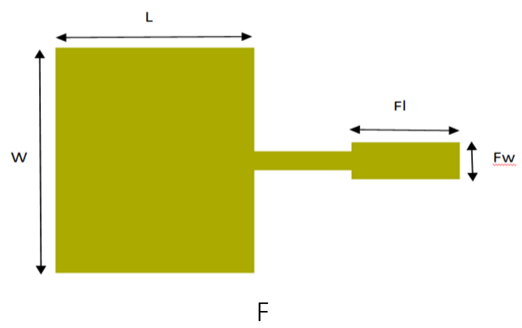

Figure 1. Top View of the designed antenna

4. Configuration of CSRR

The characteristics of CSRRs have been studied by several searchers [8].The orthogonal electric field excites the CSRR that is comparable to an electric dipole which is placed along the axis of the ring. The coupling between CSRR and the patch comes from capacitance coupling [12], through the ring slot and the split of the outer ring produces magnetic coupling. The retrieved results from S-parameters and permittivity of cells are shown in Figure 3and 4.

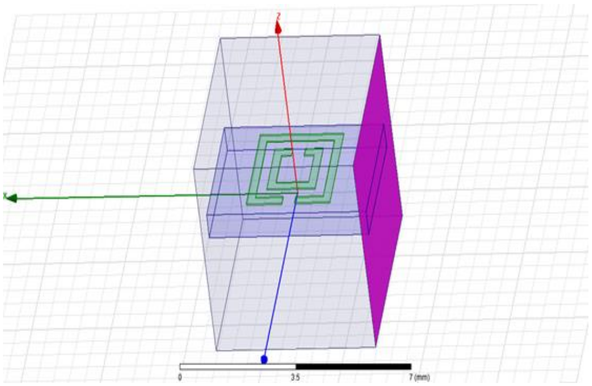

Figure 2. CSRR cell used

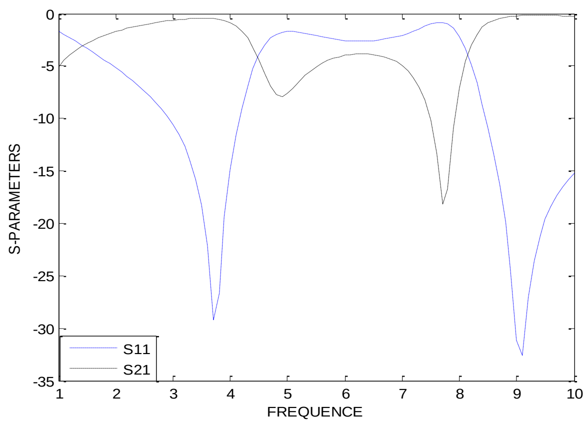

Figure 3. The S parameters of CSRR

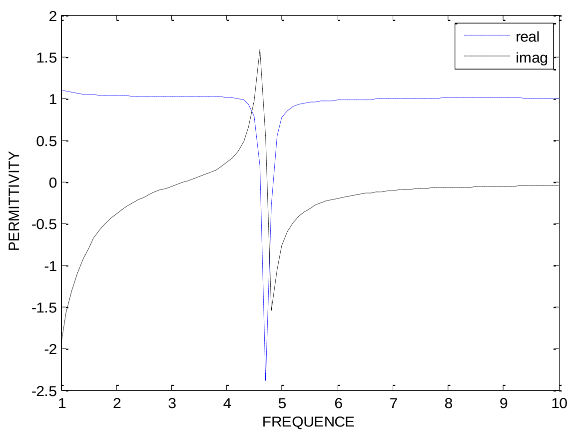

Figure 4. Effective permittivity of CSRR

1. Results

Figure .5 shows the patch antennas with three units CSRRs. We modify the number and the position of CSRR in the antenna ground.

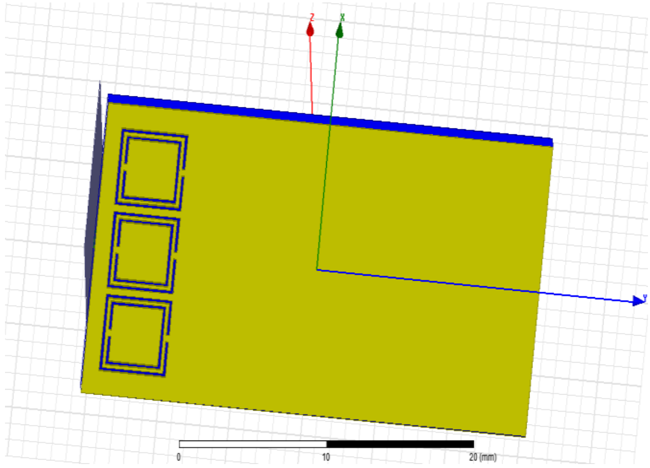

Fig ure 5. CSRR in the antenna ground

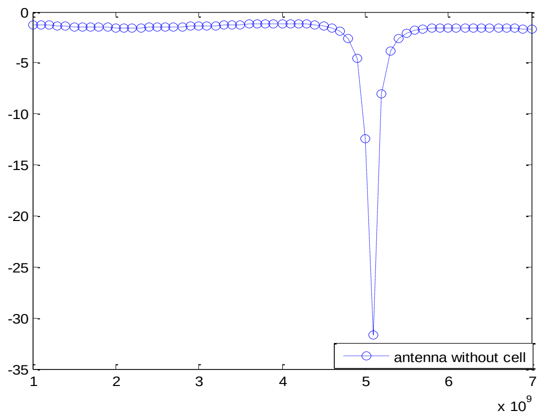

Figure 6. Return loss of the conventional antenna

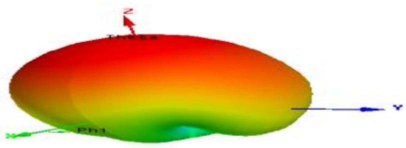

Figure 7. Radiation pattern of conventional antenna

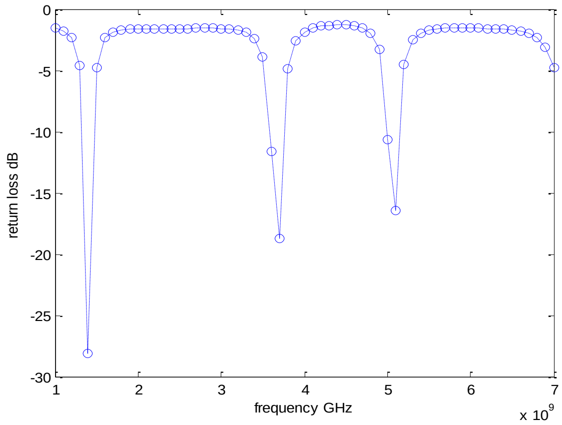

Figure 8. Return loss of the antenna with 1 cell and 0.0mm

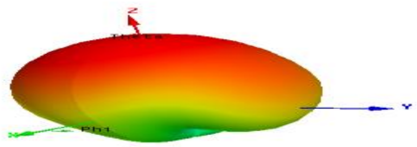

Figure 9. Radiation pattern of the antenna with 1 cell and 0.0mm

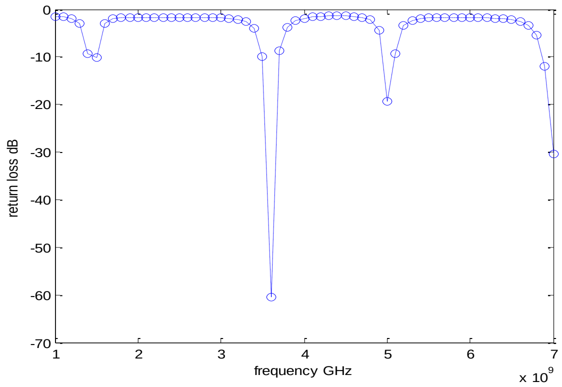

Figure 10. Return loss of the antenna with 1 cell and 1.0mm

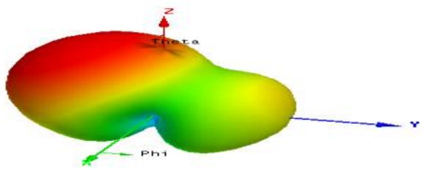

Figure 11. Radiation pattern of the antenna with 1 cell and 1.0mm

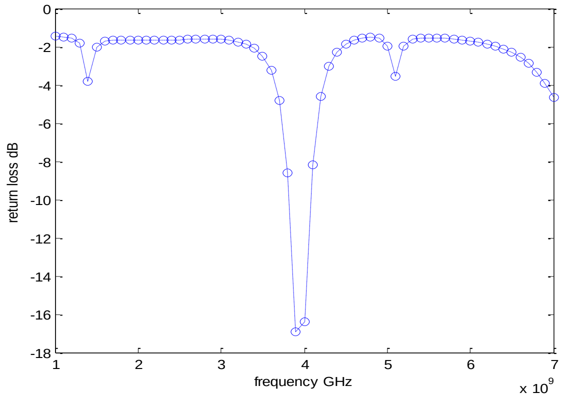

Figure 12. Return loss of the antenna with 1 cell and 5.0mm

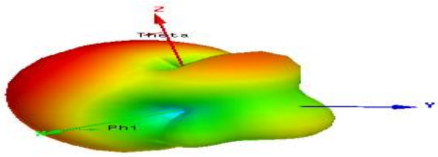

Figure 13. Radiation pattern of the antenna with 1 cell and 5.0mm

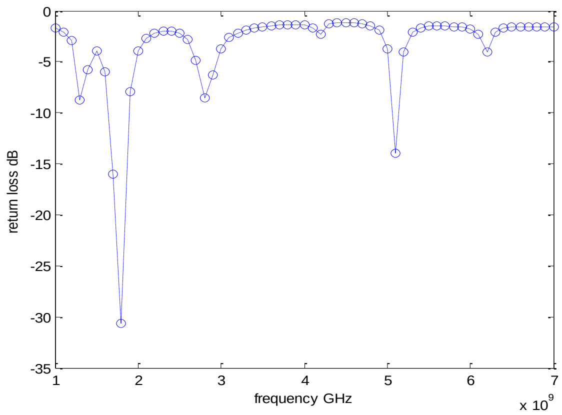

Figure 14. Return loss of the antenna with 3 cells and 0.0mm

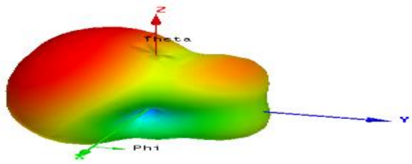

Figure 15. Radiation pattern of the antenna with 3 cells and 0.0mm

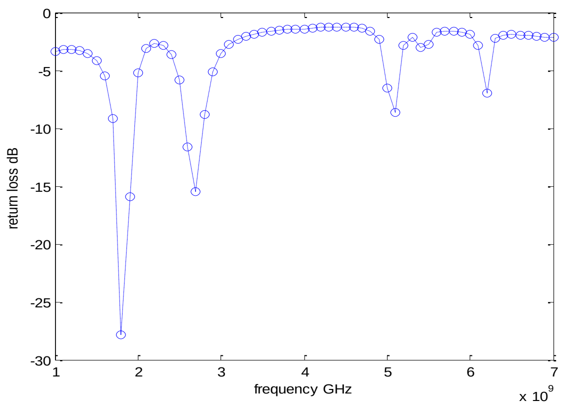

Fig 16. Return loss of the antenna with 3 cells and 1.0mm

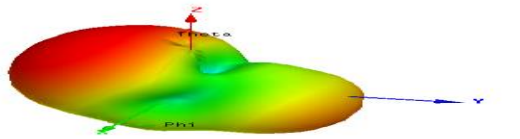

Fig 17. Radiation pattern of the antenna with 3 cells and 1.0mm

We notice that the influence of CSRR is important when it is close to the center for this purpose .Figure.6 demonstrates that the antenna spectrum has numerous frequencies.

Table.2. Results of antennas designed

Type	Antennas	Frequency picks (GHz)	Gain (dB)
A	Without cell	**5.1**	-32
B	1 cell and 0.0mm	1.46 3.8 **5**	-28.63 -19.88 -17.92
C	1 cell and 1mm	1.5 3.5 **4.9**	-10.23 -60.11 -20.08
D	1 cell and 5mm	1.5 3.9 **5**	-4 -17.5 -4
E	3 cells and 0.0mm	1.2 1.8 2.9 **5** 6.1	-8.6 -31.15 -9.90 -15 -5
F	3 cells and 1mm	1.8 2.8 **5** 6.1	-27.91 -15.11 -10 -8

5. Conclusions

In this study, we have designed several antennas by changing the number of CSRR pattern engraved on the ground and changing its positions relatively to the antenna center.

These CSRRs modifier the antenna behavior, such as frequency picks, radiation pattern and the return losses.

The results show that the proposed antennas enhance the gain, the bandwidth and have dual frequency bands.

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