New tri-band AMC cell

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Abstract

This article presents a novel tri-band Artificial Magnetic Conductor (AMC) cell. To obtain the tri-band effect, two dual-band AMC cells are mixed. The first dual band cell is based on the Langley AMC structure [1]. The second one is a new dual-band cell made up of a square patch associated with a Greek cross. The tri-band structure is obtained by replacing in the second one the square patch by the first design. The relative simulated bandwidths are 1.3 %, 1.1 % and 2.7 % at the central resonance frequencies of 1.150, 1.354 and 2.177 GHz respectively.

1. Introduction

Today, antennas are becoming wideband or multiband due to the multiplication of applications in communicating objects. However, in the same time antennas need to be more competitive and more compact. In the case of printed elements, AMC ground planes can provide a higher gain [2-4], a better efficiency or a better isolation from external elements. For example, clothes integrated antennas using AMC ground planes show an important reduction of the energy absorbed by the body [1]. Previous studies have already been performed in the literature about multi-band AMC, however, genetic algorithm was used to design the cells, which limits the physical understanding of the structure [5] and the independent control of each resonance. In this article, three different AMC cells are presented, two dual-band, and one tri-band cell. This last one is obtained by a combination of the two previous dual-band cells. This study has been funded by the French Research National Agency ANR. The aim of this project called METAVEST, consists in the study of antennas using metamaterials for an efficient integration in personal clothes.

2. Dual band AMC

The most popular dual-band AMC cell for clothes integration is the Langley cell (Fig. 1.a) which consists in a square patch surrounded by a square ring. The designed Langley AMC cell phase reflection has 1.2 % and 2.7 % bandwidth with ± 90° phase reflection at 1.154 GHz and 2.194 GHz respectively. The simulations were made using HFSS V.13 electromagnetic simulator considering a perfect substrate without losses, with a dielectric permittivity ε_r of 2.85, a thickness of 2.5 mm, and a perfect conductivity for the metallisation of all the proposed structures. In this cell, the first resonance is due to the square ring and the second one is due to the patch of length Lp. The frequency ratio between the two reflection phase resonances changes with the gap between the patch and the square ring due to the mutual coupling. Here, the obtained ratio is about 1.85 (Fig 2.a). We also present in this paper a new dual-band AMC cell which has the same dimensions than the Langley cell (Fig. 1.b). Each element of this AMC cell made up of a square patch and a Greek cross has its proper frequency resonance in phase reflection (Fig. 2.b).

The square patch Greek cross cell has 1.8 % and 3.3 % of bandwidth at 1.348 GHz and 1.716 GHz respectively (Fig.2.b). The frequency ratio also changes with the coupling between the patch and the cross, as observed previously with the Langley cell. However, a frequency ratio lower than 1.5 can be obtained between the two frequencies, which is not possible with the Langley cell. In this case, the frequency ratio is about 1.3.

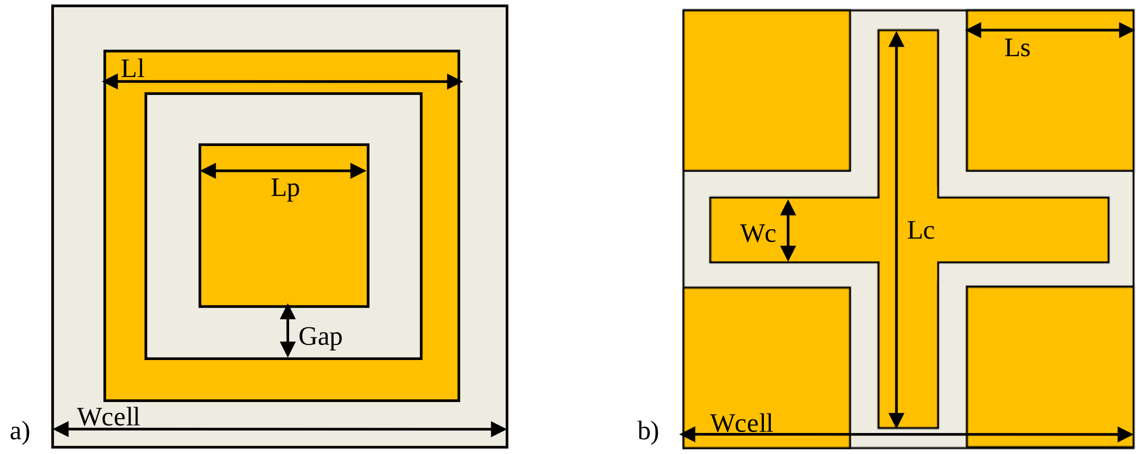


Fig. 1 :Dual band AMC cells, a) Langley AMC cell, cell dimensions : Wcell= 75 mm, Ll =50 mm, Gap = 2 mm, Lp = 40 mm; b) the square patch Greek cross AMC cell, cell dimensions : Wcell = 75 mm, Ls = 25 mm, Lc = 70 mm, Wc = 10 mm.

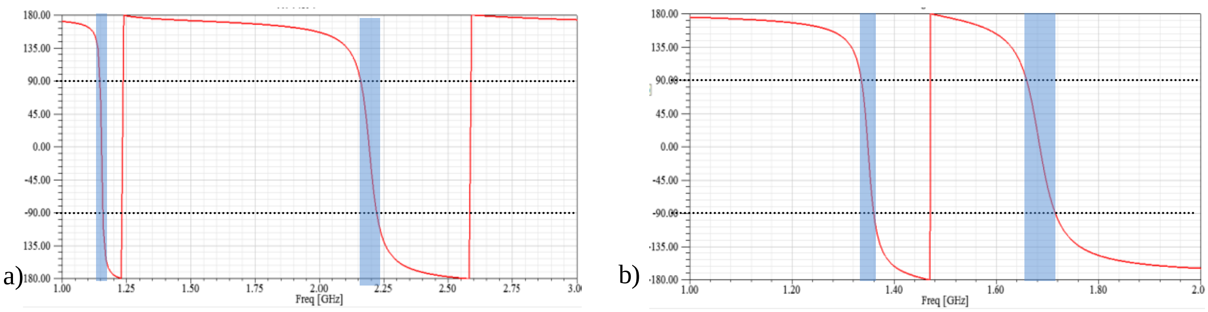
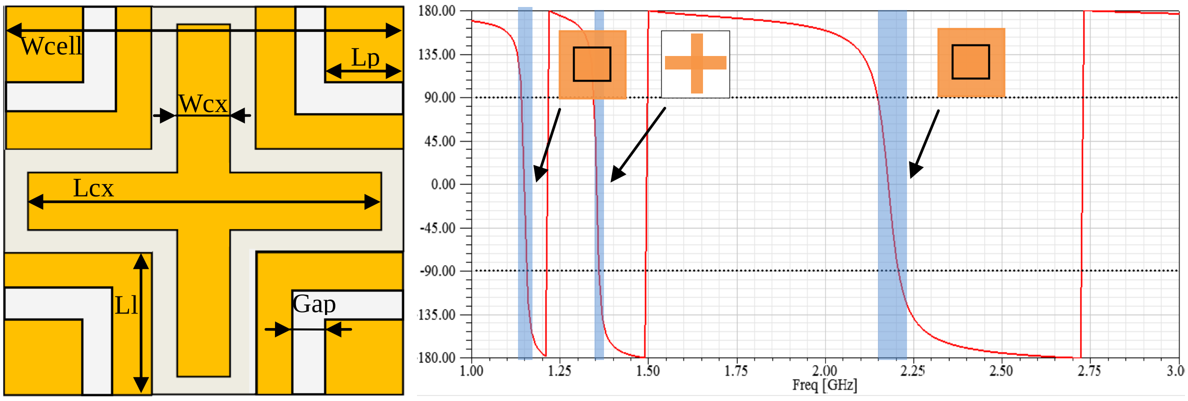


Fig. 2 : Simulated reflection phase ; a) Langley cell, b) Square patch Greek cross cell

3. Tri-band AMC cell

The proposed tri-band AMC cell (Fig. 3.a) uses two dual-band AMC cells. It is based on the square patch Greek cross structure within the patch is replaced by the square patch-ring element presented by Langley (Fig. 1.a). The combination of these two dual-band cells allows producing a tri-band effect. Two of these three bands are attributed to the Langley element and the last one is created by the Greek cross (Fig. 3.b). In this example, the frequency ratio is about 1.85 for the Langley cell frequencies and the cross dimensions were optimized to have a resonance between them. The reflection phase simulation shows a tri-band effect. The obtained bandwidths are respectively 1.3 %, 1.1 % and 2.7 % at 1.150 GHz, 1.354 GHz and 2.177 GHz. The bandwidth obtained for each resonance is close to the one obtained for the separate cells. However a small decrease of the second bandwidth (from 1.8 % to 1.1 %) can be observed due to the coupling between the first two resonances which are very close. Indeed, the frequency ratio between the first and the second resonances is 1.18, which is very low for AMC cells. An interesting property of these structure is that the modification of the cross length directly acts on the second resonance: The reduction of the cross length shifts the second resonance to higher frequencies. The two other frequencies can be controlled simultaneously by the patch and ring dimensions.



a) b)

Fig. 3: a) Tri-band cell, b) Reflection phase simulation; Cell dimensions: Wcell = 75 mm, Wcx = 10 mm, Lcx = 70 mm, Lp =20 mm, Gap = 2 mm, L1 = 25 mm.

4. Conclusion

This paper presents in a first time the design and the simulated results of two dual-band AMC cells based on a Langley cell and a square patch with a Greek cross one. In a second time, the interweaving of these two dual-band cells produces a tri-band reflection phase effect. The bandwidth at the different resonance frequencies is 1.3 %, 1.1 % and 2.7 % at 1.150, 1.354 and 2.177 GHz respectively. With this cell, each resonance can be easily controlled by the specific design dimensions of one element. This property is very interesting to enhance the performance of multiband printed antennas.

References

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