

Design of Triple Band Artificial Magnetic Conductor

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Abstract— This paper presents a design of Artificial Magnetic Conductor (AMC). The AMC operates in three operating frequencies which are 2.3 GHz, 5.8 GHz and 8.36 GHz with the bandwidth of 5.64 %, 1.73% and 3.58 % respectively. The size of AMC unit cells is relatively smaller compare to previous researches that have been done. Parametric results for the reflection phase diagram are also presented.

Keywords-AMC, Triple Band, Reflection Phase

I. INTRODUCTION

Artificial Magnetic Conductor (AMC) is material that mimics the behavior of Perfect Magnetic Conductor (PMC)[1]. PMC is a material that not naturally available and hence artificially material are designed. Unlike Perfect Electric Conductor (PEC) that exhibit opposite reflection phase with original current such as in antenna, PMC provides in phase reflection with the source current [2]. Hence, the antenna potentially improves its performance in terms of gain, bandwidth, efficiency, and so on [3]. AMC also potentially reduces the mutual coupling in antenna [4], such as to improve the design and previous work mentioned in [5]. Similarly with multi band antenna, AMC that able to operate in multi band operation are desirable since it accommodate lesser space rather than placing each single band AMC in a microwave circuit when integrated with antenna[6].

In this paper, multiband AMC is proposed. The proposed AMC operate in three operating frequencies which are at 2.3 GHz, 5.8 GHz and 8.36 GHz that have bandwidth of 5.64 %, 1.73 % and 3.58 % respectively. The size of proposed AMC unit cell is smaller than [7] that operate at 8-10 GHz and [8] that operate at 2.4-2.5 GHz. The triple band AMC without shorting pin, vias are suitable for wireless application especially in improving the performance of various type of antenna [9-10], Microwave Integrated Circuits (MICs) and so on. Low complexity of fabrication and low cost possibly achieved with the design of AMC without using vias [11].

II. AMC DESIGN

The material use for AMC design is inexpensive FR4 substrate with dielectric permittivity, loss tangent, thickness are 4.5, 0.019 and 1.6 mm respectively. The thickness of the copper layer is 0.035 mm. The equations (6)-(7) as in [12] were used to approximate the initial dimensions of conventional AMC. The design is simulated using Computer Simulation Technology (CST) 2010 software. The simulation

for designing AMC is involving simultaneous three simulation steps in order to obtain the reflection phase diagram. First step is simulating the whole structure as vacuum as shown in Fig. 1(a), second step is to simulate the entire structure as Perfect Electric Conductor (PEC) as shown in Fig. 1(b) while the last step is simulation of actual structure as shown in Fig. 1(c). AMC real implementation such as in antenna is in the form of periodic arrays, so the structure of AMC unit cell need to be simulated by considering the effects of periodic duplication. Hence Periodic Boundary Condition (PBC) is used as to observing the effect of the array structure by simulating a single unit cell. So, the computational time is reduced [13]. Fig. 2 shows the AMC dimension with label while Table 1 shows the value of each label of parameter in mm. All the rectangular dimensions are squares that have equal length and width. Yellow colored region is the copper layer; blue shaded colored is the vacuum material while pale brown is the substrate layer.

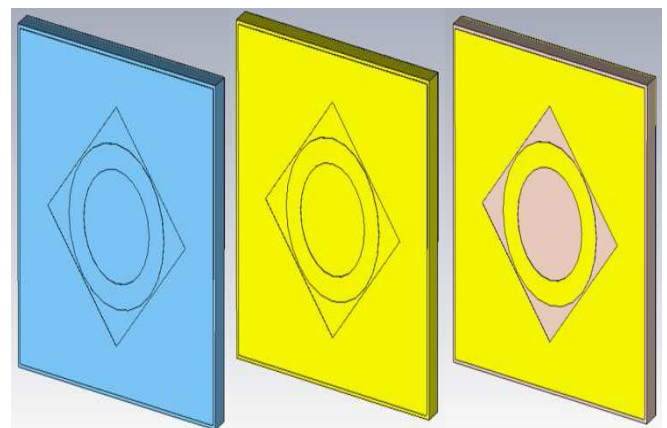


Fig. 1. (a) Simulated entire structure as vacuum, 1 (b) simulated entire structure as PEC while 1(c) simulated of the actual structure respectively for design of AMC.

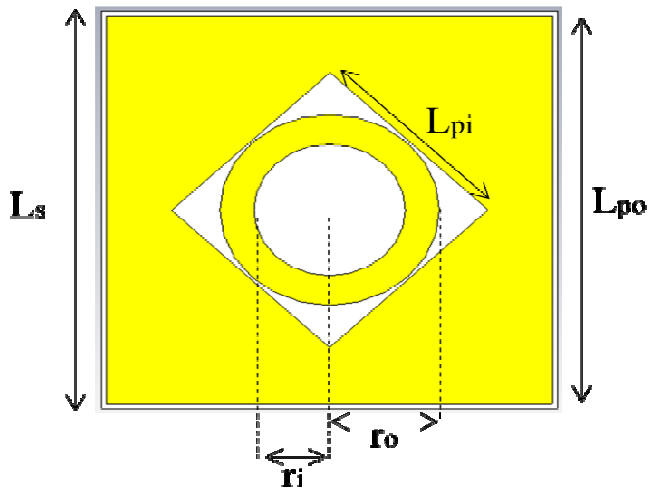


Fig. 2. AMC dimensions.

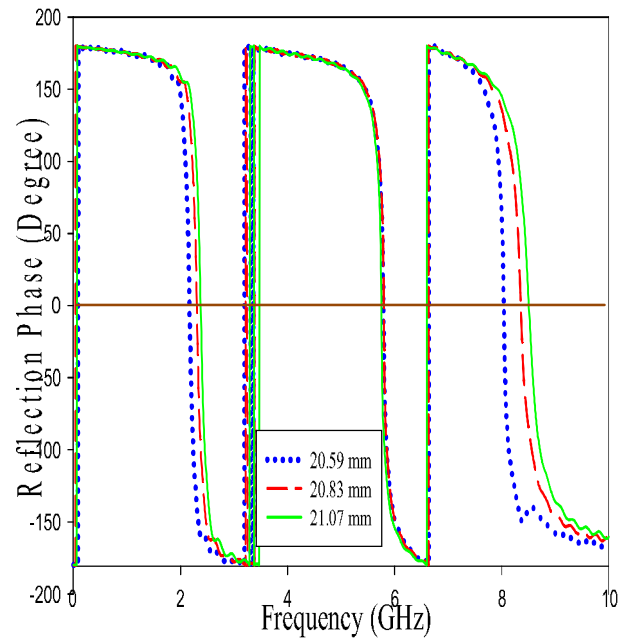
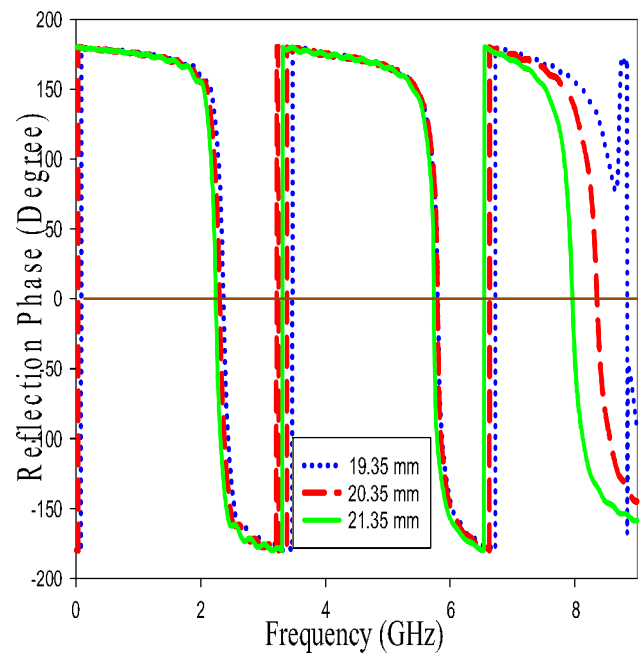
TABLE I. AMC DIMENSION

Parameter	Length (mm)	Parameter	Length (mm)
L_s	20.83	r_o	5.00
L_{po}	20.35	r_i	3.45
L_{pi}	10.20	Gap = $L_s - L_{po}$	0.48

III. RESULT AND DISCUSSION

Fig. 3 to Fig. 8 presents the results of parametric studies done for L_s , L_{po} , L_{pi} , r_o and r_i . Horizontal brown line in all following figures were use to show zero degree points at the reflection phase degree curves. From Fig. 3, it is observed that the substrate dimension of the AMC unit cell have some influence on the reflection phase of the AMC. It can be seen that, variation of L_s affects the first and third reflection phase band curve while second reflection phase band curve relatively unaffected. Reflection phase at 2.3 GHz and 8.36 GHz are shifted to the right when L_s is increased from 20.83 mm to 21.07mm and vice versa. It is also noted that the curve characteristic of third reflection phase band is changing significantly at lower value of L_s .

From Fig. 4, it is observed that L_{po} only significantly affects the third reflection phase band curve, while the first and second reflection phase band curve relatively constant. Third reflection phase band curve is shifted to the left when L_{po} is increased from 20.35 mm to 21.35 mm. It can be seen that curve characteristic changed abruptly for third reflection phase band at smaller value of L_{po} . At value of 19.35 mm for L_{po} , the reflection phase band curve is outside the tuning range for higher reflection phase band curve.

Fig. 3. Variation of reflection phase with respect of L_s Fig. 4. Variation of reflection phase with respect of L_{po}

Parameter L_{pi} affects the entire reflection phase band curve at 2.3 GHz, 5.8 GHz and 8.36 GHz as shown in Fig.5. The first reflection phase band curve is shifted to the right when L_{pi} is decreased from 10.20 mm to 9.20 mm. It is also noted that the first reflection phase band curve slightly shifted to the left when L_{pi} is increased from 10.20 mm to 11.20 mm. The second reflection phase band curve is outside of the tuning range when

L_{pi} is decreased from 10.20 mm to 9.20 mm, while it is shifted to the right when L_{pi} is increased from 10.20 mm to 11.20 mm. The third reflection phase band curve is affected significantly when L_{pi} is either increased or decreased from 10.20 mm.

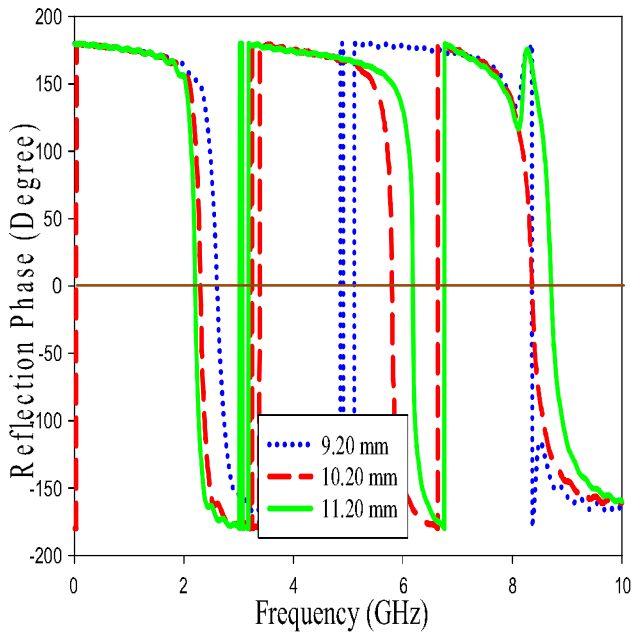


Fig. 5. Variation of return loss with respect of L_{pi}

From Fig. 6, r_o affects all three of the reflection phase band curve at 2.3 GHz, 5.8 GHz and 8.36 GHz. First reflection phase band curve is shifted to the right when r_o is increased from 5 mm to 6 mm while it remains unaffected when r_o is decreased from 5 mm to 4 mm. Second reflection phase band curve is abruptly affected, and it is outside of the tuning range when r_o are either increased or decreased from 5 mm. At the third reflection phase band curve, the curve is slightly shifted to the right when r_o is decreased from 5 mm to 4 mm. Third reflection phase band curve lost is curve characteristics when r_o is increased from 5 mm to 6 mm.

Based on Fig. 7, r_i only affect second reflection phase band curve while the first and third reflection phase band curve are approximately remain unchanged. The bandwidth of AMC at 2.3 GHz and 8.36 GHz relatively constants for variation of r_i . Second reflection phase band curve is shifted to the right when r_i is decreased from 3.45 mm to 2.45 mm, while the curve characteristics is changed when r_i is increased from 3.45 mm to 4.45 mm. Fig. 8 shows the reflection phase diagram of the finalised design. It can be seen that AMC possess triple band characteristics at 2.3 GHz, 5.8 GHz and 8.36 GHz where it exhibit zero degree of reflection phase. Bandwidth of AMC is calculated based on higher frequency and lower frequency that are at -90° and 90° of reflection phase respectively. The bandwidths are 5.64 %, 1.73% and 3.58 % at 2.3 GHz, 5.8 GHz and 8.36 GHz respectively.

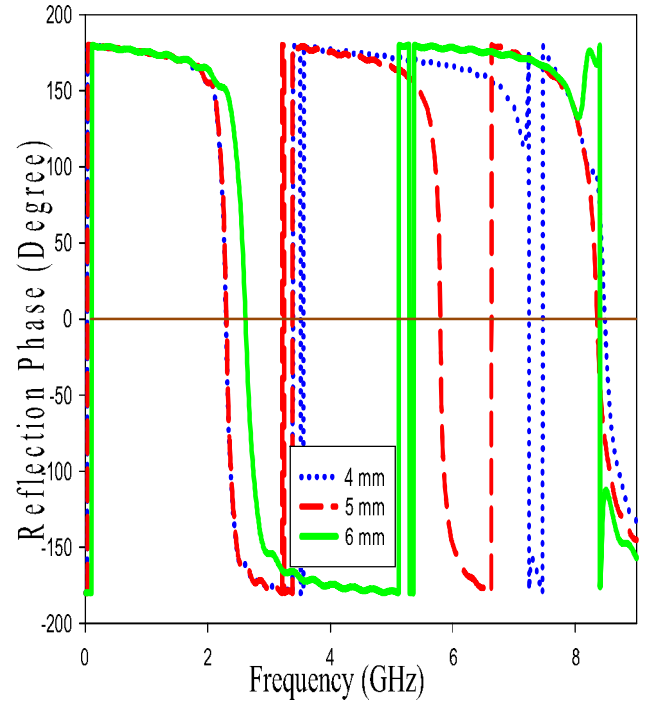


Fig. 6. Variation of return loss with respect of r_o

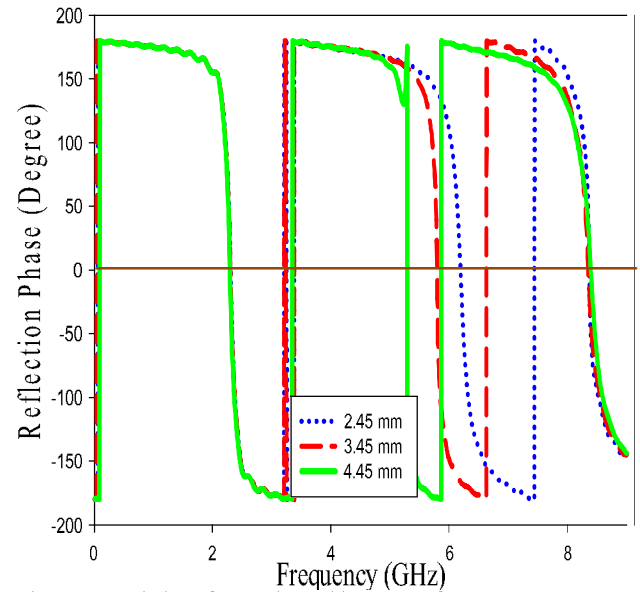


Fig. 7. Variation of return loss with respect of r_i