Four Layer 2-4 Slot Metamaterial Based Cross Polarization Converter

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Abstract. Metamaterial was one of the major tool in the design of polarization conversion. Cross polarization converter was one of the important part of electromagnetic wave manipulation device.The metamaterial for the cross polarization converter was formed by using multi- layer split ring resonator. Also cross polarization converter was more beneficial in the area of communication, imaging, anti interference, etc. This paper was about the design of a four layer 2-4 slot cross polarization converter and its array. Compare the Bandwidth, polarization convertion ratio(PCR), Radar cross section(RCS).

1 Introduction

In the field of modern communication, electromagnetic wave plays an important role. The important parameter of the electromagnetic wave was polarization. For controlling the polarization state of the EM wave, polarization converters, lenses, and phase modulators are widely used. Future communication will be based on multiple polarization devices to exchange in- formation, so controlling polarization is essential. Optical crystals were conventionally used for polarization manipulation which are limited bandwidth, thick volume, and incident angle dependency.A cross polarization converter can be used to convert the polarization direction of the electromagnetic wave. There are different types of cross polarization converters, includ- ing waveguide, coaxial, and microstrip designs. They are typically made from materials such as metal or dielectric materials, and may include reflectors or lenses to help focus the signal. Metamaterials are synthetically created materials intended to offer material qualities not eas- ily accessible on the market. Materials with permittivity values close to zero, materials with negative permittivity or permeability, or materials with simultaneous negative permittivity and permeability can all be realised using MTMs. Epsilon negative refers to a material with solely negative permittivity, whereas - negative describes a substance with only negative per- meability. Negative permittivity and permeability are both characteristics of double-negative materials. A variety of structures have been realised over the past ten years that, when placed regularly, displayed MTM characteristics across a specific frequency range. These structures have attracted a lot of attention and have undergone extensive study and development [3].

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In order to produce fascinating features, they have also been utilised in numerous RF, microwave, and photonics devices. Metamaterials that are not found in nature can be endowed with entirely unexpected properties. The application such as negative refraction, invisibility cloak, and high resolution imaging are possible because of the exotic properties of metamaterials. For controlling electromagnetic wave, metasufrace have been proposed which is a 2-D equivalent metamaterial. Metasurface possses low profiles and low losses compared to 3-D metamaterial,which is quite bulky. Metamaterial based polarization converters have been developed to improves the mechanical stability and optical transparency. Anisotropic or chiral metasurfaces are different types of polarization converter. Even though metamaterial based cross polarization converter is widely used it has a drawback of narrow bandwidth [4].In order to increase the bandwidth, it is typically necessary to modify or stack many layers of complementary structures. We employ a square patch, a bi-layered substrate, and a flawed ground plane [1]. For different frequency ranges, cross polarisation converters in the shapes of ovals, H-shaped patches, double U-shaped patches, split ring resonators, and other shapes are employed [5].Numerous fields, including anti-interference, analytical chemistry, biology, communication, and imaging, use polarisation coverter. Miniaturized polarisation technology. Focused converters have higher conversion efficiencies, wider bandwidths, or several bands.

2 DESIGN OF CROSS POLARIZATION CONVERTER

2.1 FOUR LAYER 2-4 SLOT

Figure 1. show the geometry of the proposed cross polarization converter(CPC). A four layer split ring resonator(SRR) structure with copper(Cu) as the conductor and FR4 epoxy as the dielectric. The period of the optimized unit structure was p = 10mm, the bottom arm width of the bottom SRR was W1 = 0.8 mm, the arm length L1 = 7 mm, a = 0.5 mm, the thickness of the bottom dielectric layer was h1 = 1.5 mm; the arm width of the second SRR was W2 =0.7 mm, the arm length L2 = 4.7 mm, b = 2 mm, the thickness of the middle dielectric layer was h2 = 1.2 mm; the arm width of the third SRR was W3 = 0.4 mm, the arm length L3 =2.4 mm, c = 3.2 mm; the arm width of the top SRR was w4 = 0.1mm, [**?**] the arm length L4 = 0.1, d = 4.3, the thickness of the middle dielectric layer was h4 = 0.9 mm. CST Studio Suite was the simulation tool used to design the CPC.

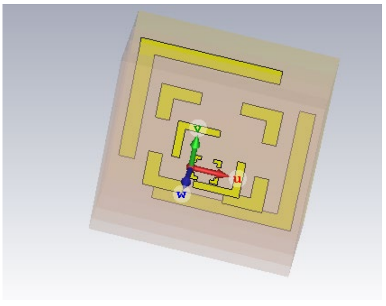

Figure 1. 3-D Schematic diagram and Top View of Polarization Converter

2.2 ARRAY OF FOUR LAYER 2-4 SLOT

This was a 2 by 2 array of a four layer 2-4 slot CPC. The design parameter and the mate- rial assigned was same as that of four layer 2-4 slot. CST Studio Suite was used for the cross-polarization converter spectrum simulation, and the Floquet port, master slave bound- ary condition and adaptive meshing were set in the software.

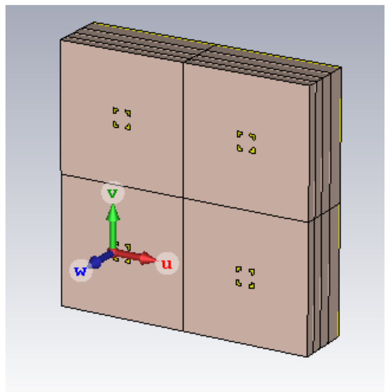

Figure 2. 3-D Schematic diagram and Top View of Polarization Converter

3 RESULT AND DISCUSSION

In this section we were discussing about the result of both the designed CPC and there comparision. Reflection and transmission coefficient curves of co-polarization and cross-polarization, Polarization conversion ratio,Radar cross section were the comparision param- eters.Fig.(3)and fig.(4)shows the reflection and transmission coefficient curve of four layer 2-4 slot CPC and array of four layer 2-4 slot CPC. The transmittance in both directions are negligible, i.e., less than 28 dB in the whole band, and mostly less than 30 dB.

3.1 Bandwidth

From fig.(3) and fig.(4) shows the bandwidth of the two designed CPC. For four layer 2-4 slot CPC has a bandwidth of 3GHz for a frequency range of 7.8GHz to 10.8GHz and for array based CPC has a bandwidth of 3.5GHz for a frequency range of 7.8GHz to 11.3GHz. The array based CPC has wider bandwidth compare to the four layer 2-4 slot CPC.

3.2 POLARIZATION CONVERSION RATIO

The polarization conversion ratio of a cross polarization converter refers to the ratio of the output power of the converted polarization to the input power of the original polarization. The polarization conversion ratio depends on the design and characteristics of the cross polariza- tion converter, including the type of material used, the thickness and shape of the device, and the wavelength of the incoming signal. In general, the higher the polarization conversion ratio, the more efficient the cross polarization converter was at converting the polarization of the input signal.

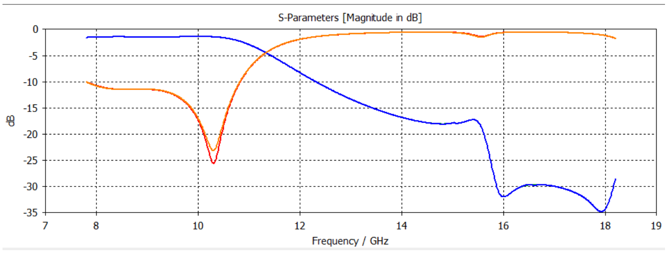

Figure 3. S parameter of four layer 2-4 slot CPC

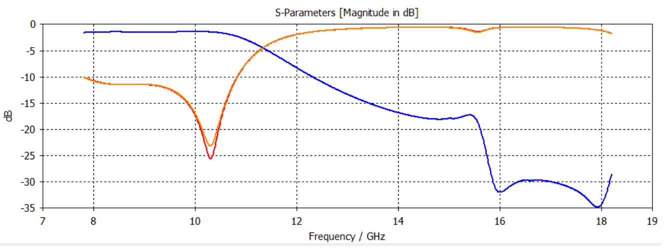

Figure 4. S parameter of Array of four layer 2-4 slot CPC

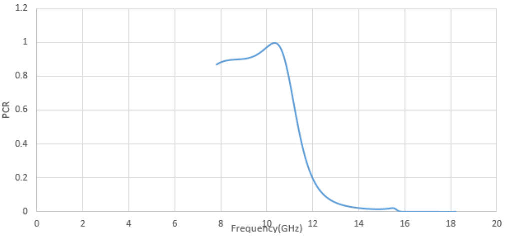

Figure 5. PCR of four layer 2-4 slot CPC

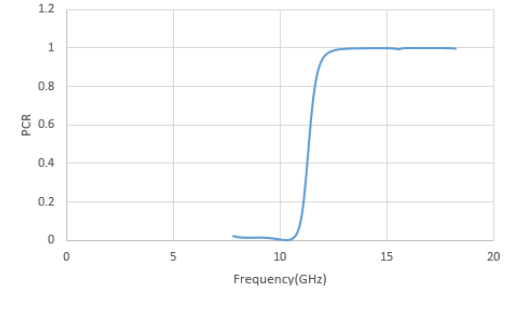

Figure 6. PCR of Array of four layer 2-4 slot CPC

Table 1. Comparison of bandwidth and frequency range for three different designed CPC.

Structure	Frequency range	Bandwidth	PCR	RCS
4 Layer 2-4 slot	7.8GHz-10.8GHz	3GHz	88%	-40.66d
Array of 4th Layer 2-4 slot	7.8GHz-11.3GHz	3.5GHz	99%	-34.6dB

3.3 RADAR CROSS SECTION

The RCS of a cross polarization converter is expected to be relatively low, meaning it was not likely to reflect much of the radar signal. However, the exact RCS value would depend on the specific design and materials used in the cross polarization converter, as well as the frequency and angle of incidence of the radar signal. The RCS of the cross polarization converter can be further reduced by adding absorbing or scattering materials around the device to minimize any reflected signal [16]. The fig.(10), fig.(11), and fig.(12) shows the RCS of the proposed CPC.

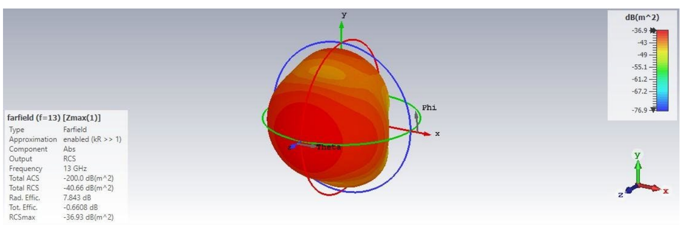

Figure 7. RCS of four layer 2-4 slot CPC

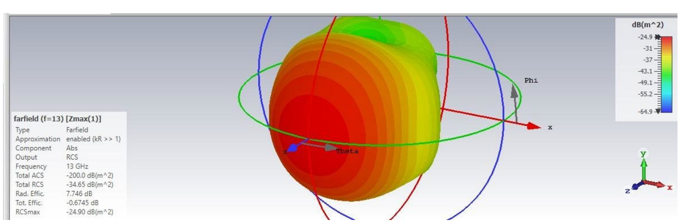

Figure 8. RCS of Array of four layer 2-4 slot CPC

4 Conclusion

In this work, a multilayer SRR-structure CPC and an array of multilayer SRR-structure CPC was simulated by using CST Studio Suite.The aaray based CPC shows better performance compared to the four layer 2-4 slot CPC. The array based CPC showing a polarization conversion ratio greater than 99% in the range of (7.8-18.2).GHz, bandwidth of 3.5GHz and an RCS of -34.65.From these two designed CPC, the array based CPC can act as a better Metamaterial absorber.

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