Design of Circuit Analog Absorber Using Swastika Geometry

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***Abstract*— This paper presents a low profile Frequency Selective Surface (FSS) absorber with low periodicity and good angular stability. The FSS geometry consists of lumped resistor loaded Swastika structure. The absorber has a minimal profile of 0.74 wavelengths at its lower -10 dB cutoff frequency with a fractional bandwidth of 104.45 % (1.75 GHz - 5.59 GHz) covering the S-band completely and portions of the L and C bands. The design has four fold symmetry and is polarization insensitive.**

Keywords —circuit analog absorber, selective surface, low profile, swastika.

INTRODUCTION

Electromagnetic absorbers have traditionally been designed for their applications in improving the electromagnetic compatibility of high precision electronic devices, reducing the radar cross-section of objects in stealth technology, reducing electromagnetic interference, and in radar absorbing materials. The most fundamental absorber is a Salisbury screen [1] consisting of a resistive layer placed a one-fourth wavelength above a conducting plane. The Salisbury screen provides absorption centred only around a particular frequency and has a large thickness. To resolve this issue of narrow absorption bandwidth, the Jaumann absorber can be used [2]. It uses multiple resistive sheets separated by lossless spacers and is backed by a conducting plane. This structure, however, has a thickness that is far from optimal. Due to these factors, their applications in stealth technology and precision instruments where lower thickness and wideband absorption are critical aspects are severely limited.

Recently, Circuit Analog Absorbers (CAA) with a resistive Frequency Selective Surface (FSS) have been investigated for wideband absorption, reduced thickness, and lower periodicity [3]. The typical structure of a CAA consists of a FSS based resonator on top of a dielectric substrate and a ground plane on its back. For wider absorption bandwidth, multiple substrates separated by lossless spacers are also commonly used [4]. The working principle is based on the concept of generating multiple resonances in the frequency span of interest [5].

Another important figure of merit of an absorber is its performance towards the oblique incidence of radiation [6]. Performance at higher angles of incidence depends primarily on the unit cell size or the periodicity of the absorber as a larger unit cell size causes occurrence of grating lobes. Hence, when stable performance at higher incidence angles is required, low periodicity becomes an important design objective. Wideband microwave absorbers operating in the C- and X- bands [7] are more common than those operating in the S-band [8]. This is because of the difficulty possessed in attenuating the large wavelengths of the waves in the S-band by the absorbers.

In this paper, a dual substrate CAA is presented. It utilizes a 8 lumped resistor loaded Swastika as the FSS geometry. The design has been proposed to minimize the thickness, maximize the absorption bandwidth.

DESIGN AND ANALYSIS OF ABSORBER

The structure of the proposed absorber consists of two FR-4 lossy dielectric substrates each with a thickness of 1.59 mm separated by an air gap. The substrates have a relative permittivity s_r = 4.4 and tan δ = 0.02. The FSS geometry on the top substrate and the conducting ground plane beneath the bottom substrate are realized using metallic annealed copper having a conductivity of 5.8×10^7 S/m and a thickness of 0.035 mm.

Fig. 1 shows the FSS geometry consisting of 4 lumped resistor loaded pure Swastika. This design is used as a base design in the paper. To improve the performance of the base design, modifications have been proposed in the form of an four added lumped resistor, widened copper surface and reduced substrate area as shown in Fig. 2(a). The lumped resistors have been placed. Fig. 2(b) shows the side view of the absorber. All the other remaining geometry parameters of the modified design are nearly the same as that of the base design.

STRUCTURE OVERVIEW

Base Design

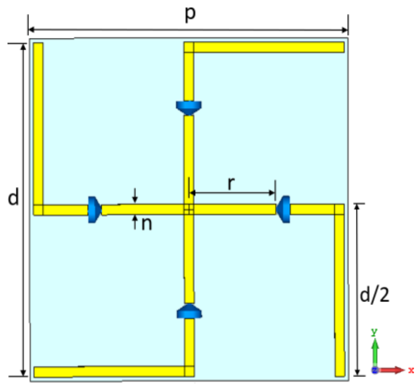


Fig. 1: Front view of the base design with pure swastika. The optimum values of the geometry parameters are p = 16.4 mm, d = 16 mm, r = 4.5 mm, n = 0.5 mm.

Proposed Design

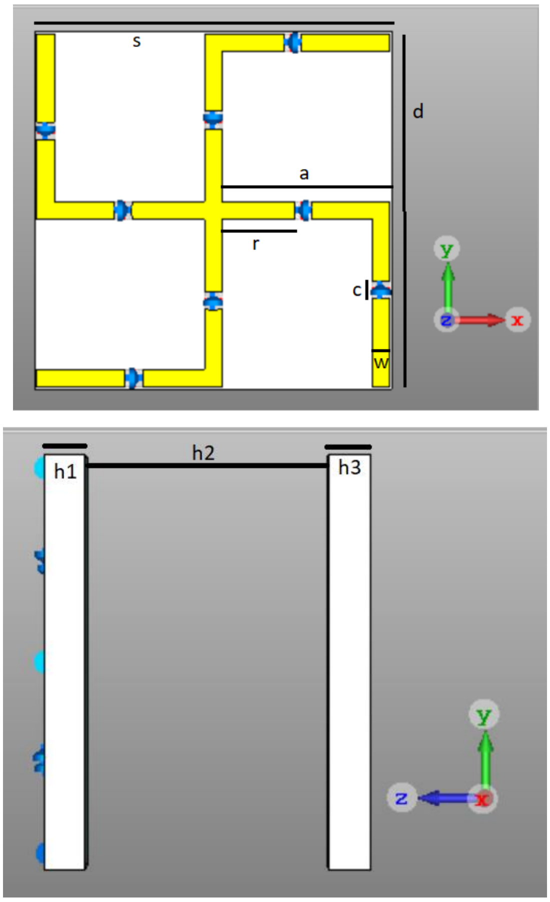


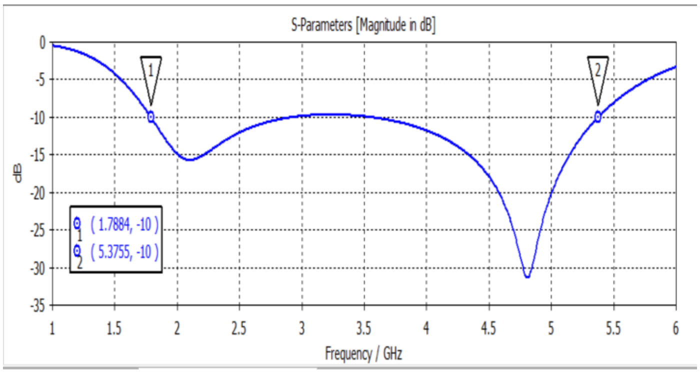
Fig. 2: Front and side view of the proposed absorber(in that order). s = 16.2 mm, w = 0.8 mm, c = 0.8 mm, d = 16 mm, a = 7.6 mm, r = 3.28 mm, h_1 = h_3 = 1.59 mm, h_2 = 9.5 mm.

RESULTS AND DISCUSSION

S – Parameters

Base Design

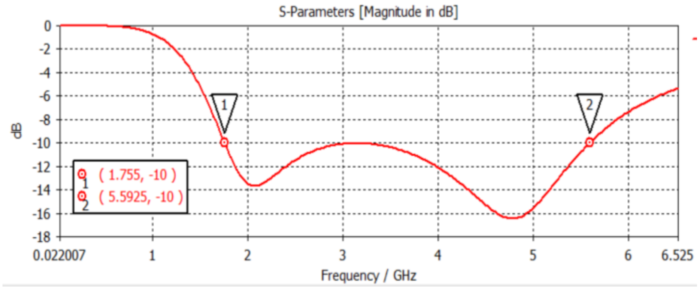
Fractional Bandwidth: 98.59%



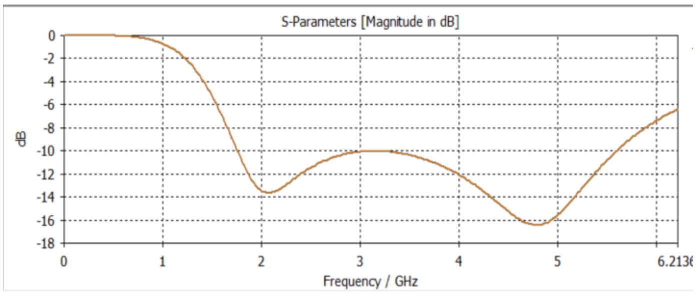
Proposed Design

Fractional Bandwidth: 104.45%

TE:



TM:



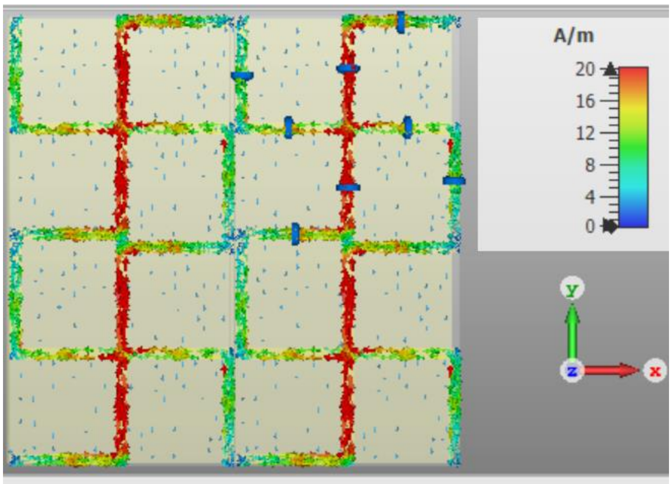
S- parameters for TM and TE are equal due to symmetric design.

These results show that the proposed design has higher bandwidth without than basic design in terms of bandwidth without compromising thickness.

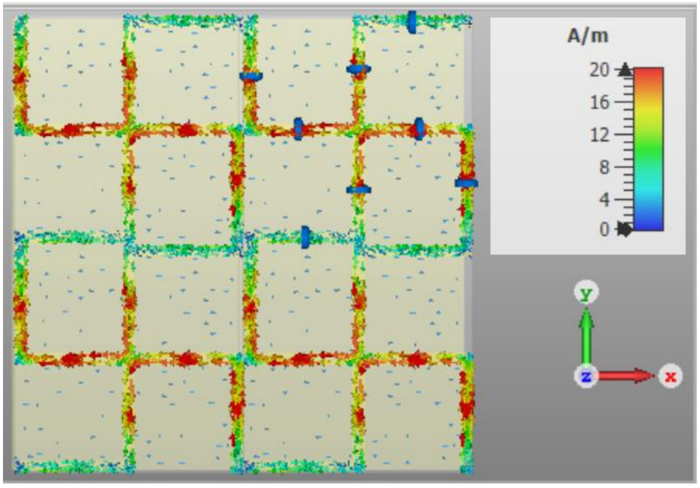
SURFACE CURRENT DISTRIBUTIONS

<u>Resonance at 2.068 GHz</u>

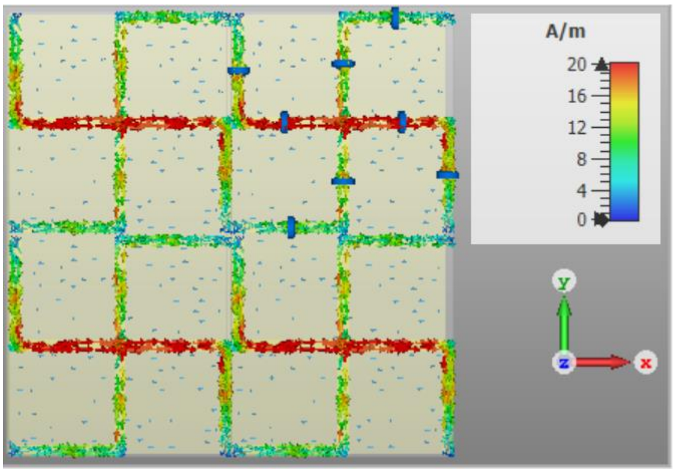
TE:



TM:

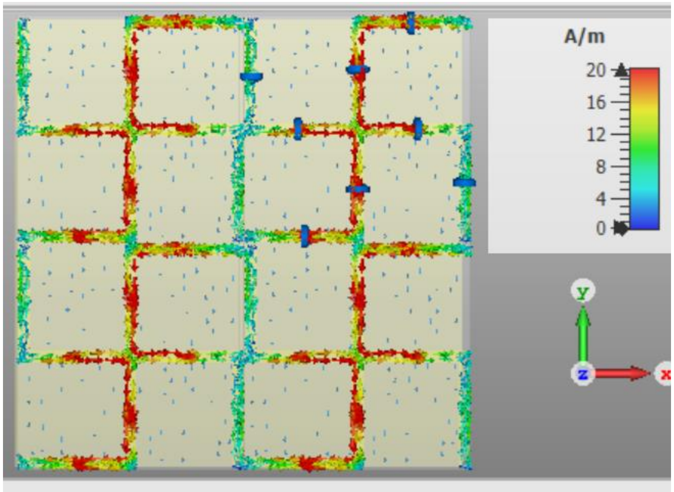


TM:



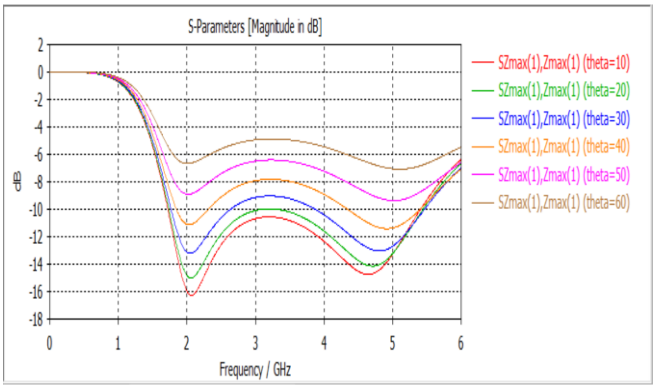
<u>Resonance at 4.784 GHz</u>

TE:



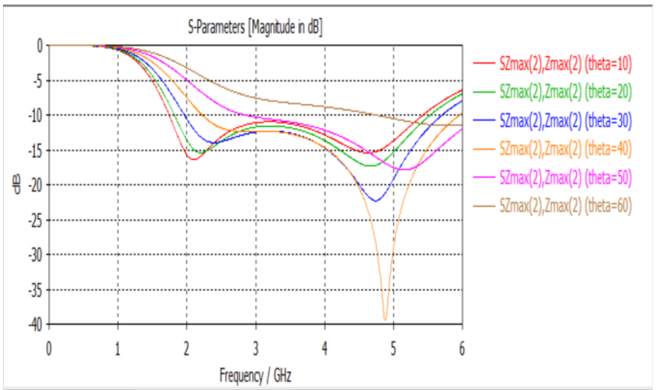
ANGLE OF INCIDENCE

TE



Till 20˚ the absorber meets -10dB requirement.

TM



Till 50˚ S-parameters -10dB requirement is satisfied.

So, average angle of stability is (20+50)/2=35˚.

COMPARISION TABLE

Reference	Thickness(λ_l)	Periodicity(λ_l)	BW	Angle of stability
[4]	0.246	0.502	114.4	45 ˚
[7]	0.077	0.234	70.7	30 ˚
[9]	0.102	0.249	99.2	45 ˚
[10]	0.08	0.208	127.9	30 ˚
[11]	0.097	0.09	88	40 ˚
[12]	0.076	0.097	100.83	40 ˚
This Work	0.074	0.095	104.45	35 ˚

CONCLUSION

This paper presents a novel, low profile FSS absorber composed of two dielectric substrates with an air gap. The absorber has a very low profile of 0.074λl and a continuous -10 dB absorption bandwidth of 104.45% ranging from 1.75 GHz - 5.59 GHz. It has a periodicity of 0.095λl with the angle of incidence averaging at 35˚ - 20 ˚ for TE and 50˚ for TM.

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