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Effect of Increment of Slit on Compactness of Frequency Selective Surfaces

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Abstract- This paper presents an investigation on the effect of change of dimension of slit on compactness of a frequency selective surface. Initially a square shaped patch is selected with a certain periodicity. For the purpose of experiment, a slit is introduced in the patch and the slit dimension is varied in different models keeping the periodicity constant. A compactness of approximately 92% is achieved in the final modification. The various models are simulated using the Ansoft Nexxim software. The simulated results along with the models are given in this paper.

Index Terms— Compactness, Frequency Selective Surface, Method of Moment, Notch frequency, Resonant frequency, Slit, Bandwidth.

1 Introduction

FILTERS are one of the basic components of electrical circuits. The wireless counterpart of filters is considered as frequency selective surfaces in microwave engineering [1]. In recent time, in the wireless communication system frequency selective surfaces are used as filters [2]. Frequency selective surfaces (FSSs) have been widely implemented in many areas of microwaves and optics. In early days it was used as Cassegrain Sub Reflectors in parabolic dish antenna [3]. Now, FSSs are used in airborne radomes, absorbers and electromagnetic shielding application etc [4]. A typical FSS is a two dimensional metallic array printed on a dielectric slab or an array of apertures within a metallic screen [5]. It is a periodic structure which exhibits band pass or band-stop characteristics [6]. The first one, referred to known as patch type FSS, performs similar to a band reject filter, exhibits total reflection at resonating frequency and another type is aperture type FSS which exhibits total transmission at resonating frequency, acts as band pass filter[7]. In recent years, reduced sized hand held communication devices and hence compact sized FSS is preferred. So our aim is to reduce the size and therefore make the FSS more compact. Various accurate numerical techniques were developed for the analysis of FSS such as the method of moments, the finite difference method and the finite element method.Among these method the most accurate is the method of moments [8]. This paper contains the variation of slit size and its effect on compactness of the FSS. The proposed design is simulated using Ansoft (Designer) software which is based on method of moments.

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2 Design of FSS

In this work, initially a square shaped patch is selected whose length of each side is 18 mm and the periodicity assigned to the design is 25 mm. Several variations of the initial model along with the initial one is used for this simulation. At first a small sized slit is introduced in the square patch at middle of one side. Then in subsequent variations the slit dimension is increased by 1mm in each of the models keeping the width of the slit at a constant value of 2 mm. The designs used here are free standing i.e., dielectric used is air.

3 Simulated Result

Different models along with the transmission characteristics are given below. Also, the results are summarized in tabular form at the end of this topic.

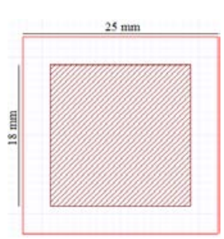

Fig.1.Reference patch

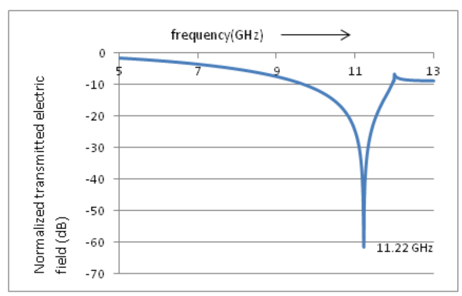

Fig.2.Transmission characteristics

The reference patch is shown in fig.1 and the corresponding transmission characteristics are shown in fig. 2.It has been observed that the percentage bandwidth as obtained from simulation is 19.78%.
In fig. 3 the first modification is shown and its transmission characteristics is shown in fig.4.The dimension of the slit in fig. 3 is 2mm.
Due to introduction of the slit in the reference patch as shown in fig.3 a notch has been observed at 8.90 GHz and the percentage bandwidth of the band around 11GHz increased from 19.78 % in the reference patch to 21.11 % as seen from fig.4.

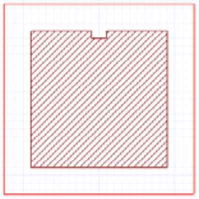

Fig.3.1st modification

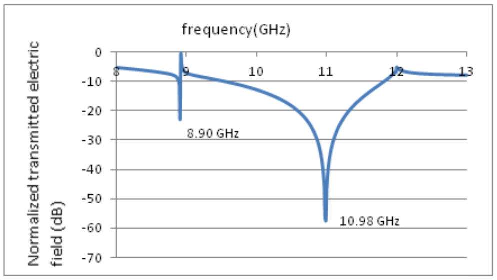

Fig. 4.Transmission characteristics

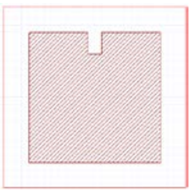

Fig.5.3rd modification

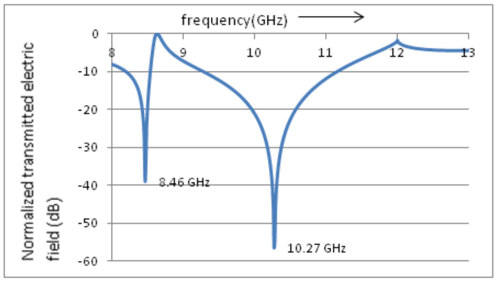

Fig. 6.Transmission characteristics

In fig.5 and fig.6 the 3rd modification and its transmission characteristics are shown respectively. From the above figures it has been seen that, as the slit length is increased to 3 mm keeping the width constant at a value of 2mm, the band around 8.5 GHz becomes prominent with a percentage bandwidth of 4.13% but the percentage bandwidth of the band around 10 GHz decreases to 18.50 % and a left shift in the resonant frequency of this band is observed.

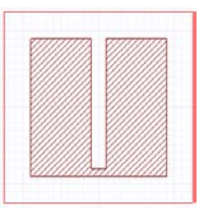

Fig.7.Final modification

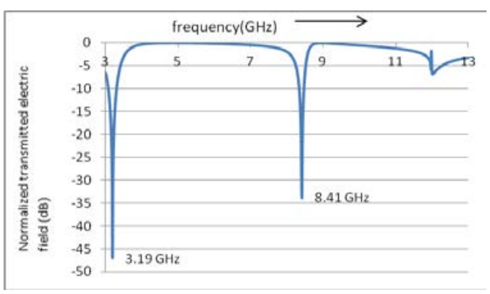

Fig. 8.Transmission characteristics

Fig.7 and fig.8 shows the final modification and its transmission characteristics respectively. The dimension of the slit in fig.7 is increased to 2mmx17mm. In the final modification it can be seen from fig.8 that the percentage bandwidth of the first band decreased to a value of 7.21% from 9.23 % in the 7th modification(max. value obtained for this band) with a left shift in the resonant frequency. The resonating frequency of the second band also shifts left to a value of 8.41 GHz but the percentage bandwidth in this case decreased to 1.54% which implies that the band tends towards a notch frequency.
T he table includes the summarized result of all the modifications.

TABLE 1: SUMMARIZED RESULT:

Slit length (mm)	Lower frequency (GHz)	Resonant frequency (GHz)	Higher frequency (GHz)	Percentage bandwidth (%)	Size reduction (%)
Ref.	9.71	11.22	11.93	19.78	
1	9.51	10.99	11.83	21.11	
2	9.38	10.69	11.61	20.86	
3	8.19	8.47	8.54	4.13	43
	9.27	10.27	11.17	18.50	
4	7.68	8.07	8.21	6.56	48.29
	9.22	9.96	10.67	14.55	
5	7.10	7.51	7.72	8.25	54.27
	9.16	9.71	10.24	11.12	
6	6.58	6.97	7.22	9.18	61.43
	9.16	9.58	9.97	8.45	
7	6.04	6.39	6.63	9.23	67.58
	9.13	9.47	9.77	6.75	
8	5.62	5.94	6.17	9.26	71.97
	9.11	9.39	9.64	5.64	
9	5.21	5.48	5.71	9.2	76.16
	9.08	9.33	9.53	4.8	
10	4.87	5.12	5.32	8.78	79.19
	9.05	9.27	9.45	4.31	
11	4.54	4.76	4.95	8.61	82.03
	9.00	9.20	9.35	3.80	
12	4.25	4.45	4.61	8.08	84.28
	8.95	9.12	9.25	3.28	
13	4.00	4.18	4.34	8.13	86.14
	8.89	9.04	9.16	2.98	
14	3.77	3.94	4.08	7.86	87.69
	8.81	8.94	9.04	2.57	
15	3.51	3.66	3.79	7.65	89.36
	8.67	8.78	8.87	2.27	
16	3.31	3.44	3.57	7.55	90.62
	8.54	8.63	8.70	1.85	
17	3.07	3.19	3.30	7.21	91.97
	8.34	8.41	8.47	1.54	

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4 CONCLUSION

Enhancement of compactness of FSS is the main purpose of this paper. Compactness of a certain design is achieved when a left shift in the resonant frequency compared to the reference patch is obtained. Here in this work it has been observed that the resonant frequency of the reference patch is at 11.22 GHz and the area of the reference patch is 18mmx18mm=324 sq.mm.(say A).After the final modification it appears that the designed FSS with slit resonates at 3.19 GHz. Using the evaluation techniques of compactness it has been found that if a patch similar to the reference patch without any slit or any other modifications is required to resonate at 3.19 GHz then its area should be equal to 63.31mmx63.31mm=4038.19sq.mm.(B).

% size reduction obtained= [(B-A)/B]x100%=91.97%(approx.)

So it can be said that a compact FSS has been achieved by introduction of a slit and its certain modifications in the model.

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