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# Design of Compact-Broadband Frequency Selective Surface (FSS) by Modifying the Dimension of Slot and Periodicity

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***Abstract- This paper deals with the theoretical investigation on a reduced sized Frequency Selective Surface (FSS). The FSS is designed by cutting a unique shaped slot into square patch. It has been shown, how the variation of the dimension of the slot and periodicity results in shifting of resonant frequency . Compared to conventional square patch FSS the designed FSS can provide reduction in resonant frequency resulting in size reduction up to 91.32% with the bandwidth of 39.54% corresponding to resonant frequency of 3.54GHz. Theoretical investigations have been done by Ansoft Designer® software.***

***Keywords- Frequency Selective Surface, Multi frequency, Size Reduction, slot.***

## I.INTRODUCTION

In microwave engineering frequency selective surfaces (FSSs) are the wireless counterpart of electrical filters. A two dimensional array of metallic patches on a dielectric slab, separated by a certain distance from each other constitutes a frequency selective surface (FSS) for electromagnetic waves[2]. In literature two generic geometries are typically discussed. The first geometry, commonly referred to as a patch type FSS, performs similarly to a band-reject filter. The second case, the aperture type FSS, performs similarly to a band-pass filter[1].

If the periodic elements within an FSS possess resonance characteristics, the aperture type FSS will exhibit total transmission at wavelengths near the resonant wavelengths, while the patch type FSS will exhibit total reflection. They are used in various applications, such as band pass radomes for radar; sub reflectors for dual frequency reflector system microwave, optical and infrared filters etc[1]. FSS structures are basically analyzed by three methods - Finite Difference Time Domain (FDTD) , Finite Element Method (FEM) and the Method of Moment (MoM)[3]. Here in our paper we have analyzed the proposed FSS structure theoretically by Ansoft Designer® software which based on MoM.

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## II.DESIGN OF FSS

The reference patch is a two dimensional metallic copper patch of 20mmx20 mm as shown in fig.1 The patches are considered to be present on one side of a thin dielectric slab of glass PTFE having relative permittivity of 2.4 and thickness of 1.6mm . Periodicity is taken 22 mm both in x and y-directions. The dimensions are shown in the fig1.

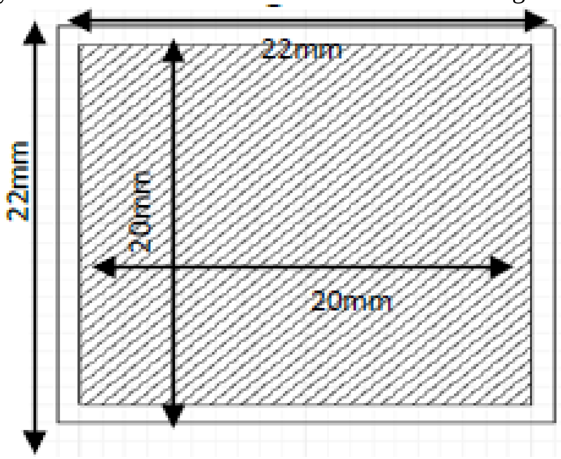


Fig1. FSS with reference patch

The following proposed designs of FSS are obtained by cutting unique shaped slot in the rectangular patch. The height of the middle portion of the unique shaped slot is 10mm. The dimensions of the proposed designed FSS are shown in Fig.2.

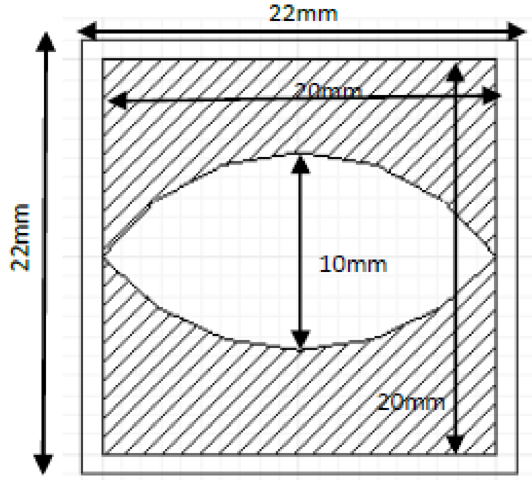


Fig2. FSS with proposed first design

Now we are modifying the slot by increasing the height of the middle portion of the slot by 2mm periodically. The structure of the slot is same but the height is increasing up to 20mm [shown in fig3].

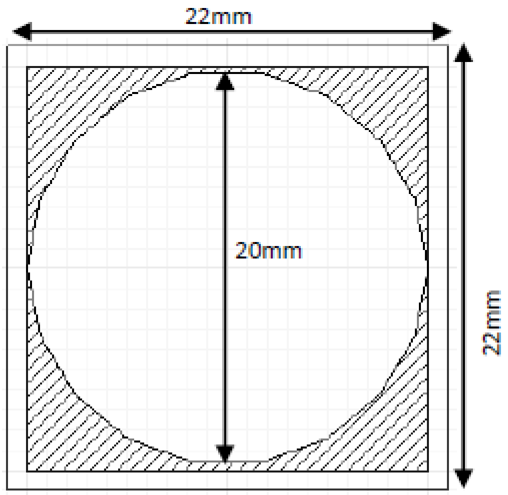


Fig3. Proposed Design FSS with 20mm height

Again we are increasing the periodicity by 2mm in both X&Y directions of the design[fig3.] from 22mm to 36mm for observing the shifting of the resonant frequency with periodicity [shown fig4].

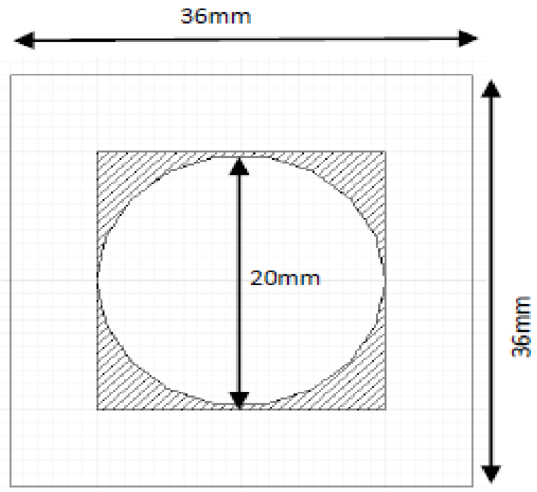


Fig4. Proposed Design FSS with 36mm periodicity in both direction

## III.RESULT

Computed transmission characteristics for reference patch [fig.1] using Ansoft is plotted in Fig.5, which shows that the FSS resonates at 12GHz while considering the first frequency band.

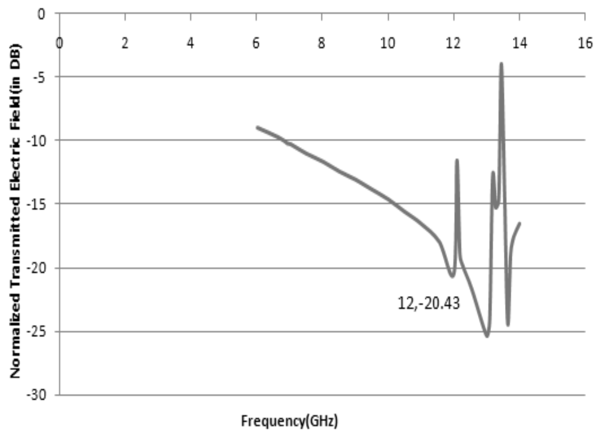


Fig.5 Transmission Characteristics of proposed FSS (corresponding to Fig.1).

Computed transmission characteristics for proposed FSS [fig.2] using Ansoft is plotted in Fig.6, which shows that the FSS resonates at 7.54 GHz while considering the first frequency band. Before designing the FSS with proposed grid, the first resonating frequency is obtained at 12GHz [fig.5]. To obtain the resonating frequency at 7.54 GHz it would require the perimeter of the patch is127.32 mm approximately. So the length of each side of the required patch is 31.8mm (approx). So the size reduction of $[(31.83^2-20^2)/31.83^2]$=60.50% (approx) has been achieved with the help of this proposed design.

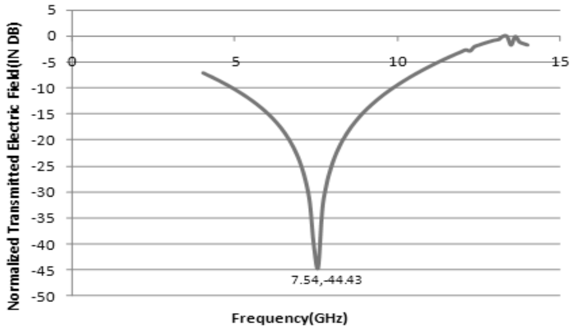


Fig.6 Transmission Characteristics of proposed FSS (corresponding to Fig.2).

In the above mentioned way we calculate the size reduction of Fig3 is 91.32% and the transmission characteristics is shown in fig7.

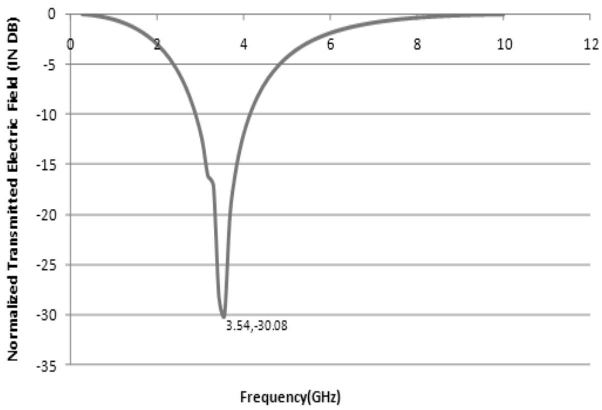


Fig.7 Transmission Characteristics of proposed FSS (corresponding to Fig.3).

Computed transmission characteristics for proposed FSS [fig.4] using Ansoft designer® is plotted in Fig.8, which shows that the FSS resonates at 4.32 GHz.

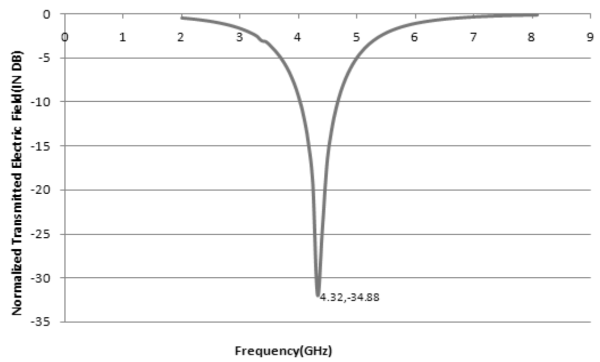


Fig.8 Transmission Characteristics of proposed FSS (corresponding to Fig.4).

Now the results which we are measured theoretically, are manipulated in the tabular form. The table1 is Summarized Results of varying the dimension of slot keeping the same periodicity throughout (22mm in both direction) and the table 2 is Summarized Results of varying the periodicity of the optimum design[fig 3].

Table 1:

| Sl No | Designed FSS | Resonating Frequency in GHz | Transmission Gain (dB | Bandwidth in GHz | Percentage Bandwidth | Size Reduction |
|---|---|---|---|---|---|---|
| 1. | Patch without slot(fig1) | 12 | -20.43 | 6.60 | 54.50 % | ------- |
| 2. | Patch with slot height 10mm | 7.54 | -44.43 | 4.94 | 65.51 % | 60.50% |
| 3. | Patch with slot height 12mm | 6.07 | -62.26 | 3.54 | 58.32 % | 74.36% |
| 4. | Patch with slot height 14mm | 5.44 | -44.30 | 2.91 | 53.50 % | 79.40% |
| 5. | Patch with slot height 16mm | 4.68 | -37.78 | 2.27 | 48.50 % | 84.79% |
| 6. | Patch with slot height 18mm | 4.05 | -36.16 | 1.80 | 44.44 % | 88.45% |
| 7 | Patch with slot height 20mm | 3.54 | -30.08 | 1.40 | 39.54 % | 91.32% |

Table 2:

| Sl No | Designed FSS | Resonating Frequency in GHz | Transmission Gain (dB | Band width in GHz | Percentage Bandwidth |
|---|---|---|---|---|---|
| 1. | Patch with periodicity in both direction 24mm | 4.00 | -39.37 | 1.20 | 30% |
| 2. | Patch with periodicity in both direction 26mm | 4.16 | -38.34 | 1.05 | 24.30% |
| 3. | Patch with periodicity in both direction 28mm | 4.24 | -30.57 | 1.00 | 23.14% |
| 4. | Patch with periodicity in both direction 30mm | 4.32 | -44.35 | 0.76 | 17.60% |
| 5. | Patch with periodicity in both direction 32mm | 4.32 | -31.94 | 0.65 | 15.04% |
| 6. | Patch with periodicity in both direction 34mm | 4.32 | -30.75 | 0.55 | 12.73% |
| 7. | Patch with periodicity in both direction 36mm | 4.32 | -34.88 | 0.50 | 11.58% |

In the similar way size reduction for different designs has been calculated, which shows, there is a changing resonating frequency and it changes with the varying of the height of the slot and also with the periodicity.

The study shows that, the resonating frequency is non-proportionate with the height of the slot but it is proportionate with the periodicity. The size reduction is 91.32% for this particular design and it is the maximum value of size reduction.

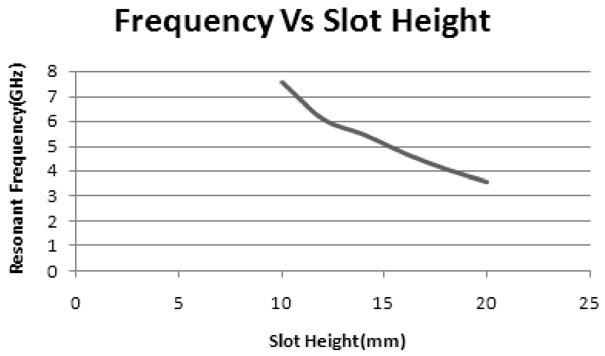


Fig9. Variation of resonating frequencies with the height of the slot

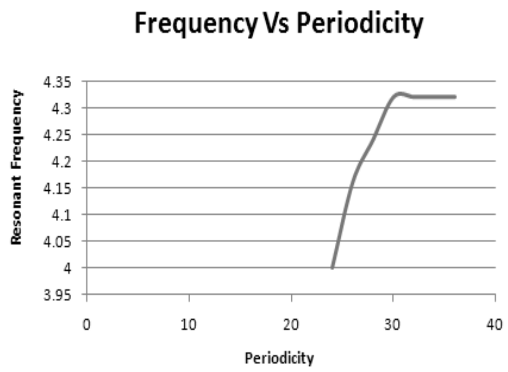


Fig10. Variation of resonating frequencies with the periodicity

## IV.CONCLUSION

All the designs proposed in this paper can be deployed as bandstop filter having less than -10dB transmission gain, in microwave range communication. With the help of the plots and results obtained theoretically, it can be observed that with the increase of the height of the slot the resonant frequency decreases. Minimum 3.54 GHz of resonant frequency is achieved. Here size reduction obtained is 91.32% and the percentage bandwidth is 39.54%. We can obtain percentage bandwidth viz. 65.51%, 58.32%, 53.50%, 48.50%, 44.44% by varying the height of the slot according to the use of the band , which falls in the range of S,C & J band. Again we can also see that the resonant frequency increases with the increase of the periodicity. Finally by varying the periodicity in both directions optimum resonant frequency is obtained.

## V. ACKNOWLEDGEMENT

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