FREQUENCY SHIELDING WITH FSS FOR 5G APPLICATIONS

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Abstract - *Nowadays, mobile phone is essential to everyone's life for day-to-day activities. Almost 2.7 billion of people are using smart phone worldwide. Radiofrequency radiations are used for the communication of mobile phones with base stations. If RF radiation is high, it raises the body temperature. The RF radiation emitted by mobile phones cause health problems such as headaches, brain tumors, dizziness, neurosis, insomnia. The Frequency Selective Surface(FSS) can be placed on the mobile phone flip cover to shield the unwanted EM radiation from mobile phones. The FSS was designed to operate at 28GHz which is used for 5G applications. The proposed FSS consists of a single layer. The top layer of 2.87 mm length Rogersrt5880 substrate consists of a modified square loop along with a square patch to act as a stop band filter at a required frequency. The designed 2D structure for 5G applications shows a stable transmission coefficient and it is insensitive to incidence angles. The simulation studies are done by using Computer Simulation Technology (CST) Microwave Studio software. The result shows a return loss of -39.460dB at 28.013GHz.*

***Key Words*: Mobile phones, EM radiation, Health problems, Frequency Selective Surface, Shielding, 5G applications.**

1. INTRODUCTION

Metamaterials are artificial materials which are used to alter the electromagnetic properties of antennas. Metamaterials such as artificial magnetic conductor (AMC), high impedance surface (HIS), and electromagnetic band gap (EBG) structure and frequency selective surface (FSS) are suitable for shielding applications. The main feature of FSS is the shielding property that reduces the EMI interference.

Frequency Selective Surfaces (FSS) consists of metallic patches which are arranged in a periodic structure. Mostly Frequency Selective Surface are two dimensional structure which act as a filter.FSS will have a regular or arbitrary geometry on a dielectric slab or apertures of regular or arbitrary geometries within a metallic screen. FSS structures are used for its property to reflect or transmit or absorb Electromagnetic waves. The FSS have pass band or stop band spectral behavior, depending upon the array element type (i.e. patch or aperture). Patch type FSS acts as Band Stop Filter and Aperture type FSS behaves as Band Pass Filter. The structure of patch type FSS is called as wire array or conducting array whereas Aperture type FSS is called as Mesh array.

FSS is a plane wave microwave spatial filter. The reflection or transmission of the FSS filter is maximum at resonant frequency. Hence elements are designed in such a manner so that they can resonant near the desired frequency of operation. The factor which affects the performance of the desired FSS are substrate and its parameters such as dielectric constant and thickness , spacing between the unit cell and geometry.These parameters should be considered while designing the Frequency Selective Surface in order to achieve the stable transmission coefficient over various incidence angle.

2.1 PROBLEM STATEMENT

With the advancement in science and technologies, the usage of mobile phones is increasing day-by-day. There is a rising danger as users become addicted to mobile phones and often fail to care about the radiation emitted from these wireless devices.

The effects occurring due to the emission of RF radiation is more from mobile phones when compared to other wireless electronic device. So we are designing a FSS which act as a shielding for 5G applications.

2.2 PROBLEM SCOPE

PRODUCTIVITY- Recent studies have suggested that by using the FSS in flip cover it can reduce the effect of radiation to the brain and ear thereby pushing up productivity.

QUALITY- FSS are capable of allowing users to offer a better service by minimizing the incoming radiation.

MOBILE-The smart phone has become one of the most vital tools. It has become almost essential for many businesses.

3. OBJECTIVES

- To shield the frequency used for 5G applications.
- To provide a good polarization-independent performance.
- To exhibit a stable transmission/reflection performances over a wide range of incident angle.

4. METHODOLOGY

The concept behind this FSS design is wire array or conducting element array. A unit cell consisting of series LC component will become short circuit at the resonant frequency. As a result, it acts as a band stop filter.

4.1 DESIGN SPECIFICATION

SUBSTRATE MATERIAL : Rogers RT5880

SQUARE LOOP MATERIAL : Copper

PHYSICAL PARAMETERS : Thickness=1.57mm, Dielectric constant=2.2, tan ☡=0.0009

OPERATING FREQUENCY : 28GHz

4.2 DESIGN EQUATION

$$L = \frac{C}{4 * fr * \sqrt{(\in r + 1)/2}}$$

Where, L is the length of the rectangular loop

c is the speed of light in vacuum in mm/s
fr is the center frequency in GHz
εr is the dielectric constant of the substrate

5. DESIGN STRUCTURE

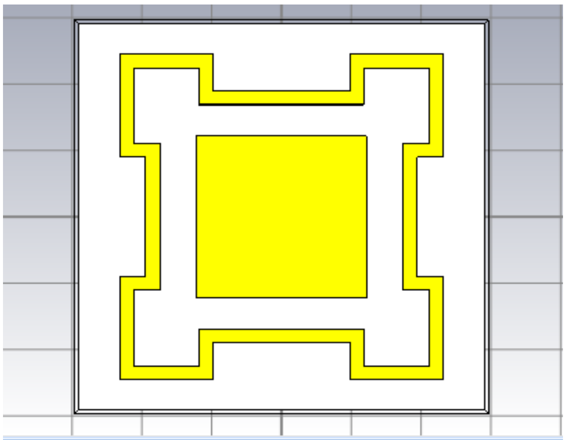

Figure 1 Design structure of FSS

SIMULATED RESULT

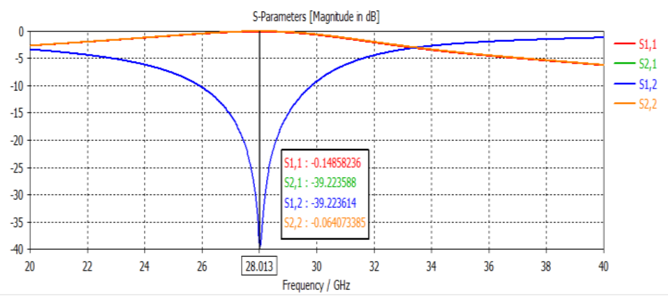

Figure 2 Simulaated CST result for single unit FSS

SIMULATED RESULT FOR VARIOUS ANGLES OF PHI

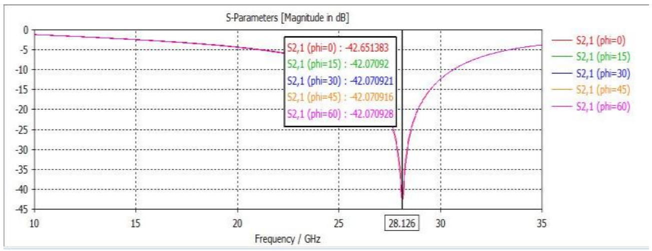

Figure 3 Simulated CST result for various angles of phi

SURFACE CURRENT DISTRIBUTION

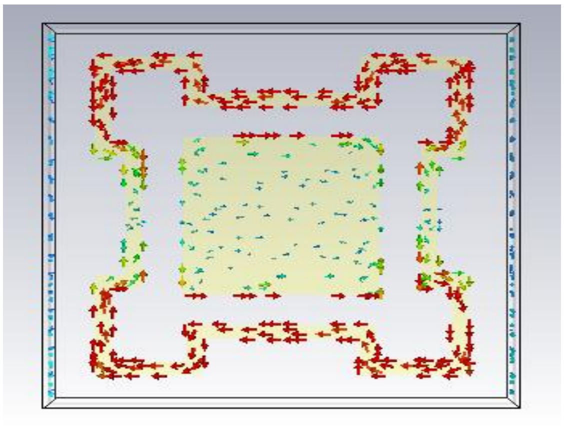

Figure 5 Surface Current Distribution

Figure 5 shows the surface current distribution and the direction of the current in the design structure.Red arrow indicates the large current intensity, green arrow indicates the medium current intensity whereas blue arrow indicates the small current intensity.

The maximum current is distributed on the outer modified loop, while very weak current is distributed in the inner square patch.

Therefore, the outer modified loop acts as a stop band at 28GHz which is used for 5G applications.

6. ANALYSIS OF DESIGN

The length of the modified loop should be equal to guided wavelength(λg). i.e one side of the modified loop will be equal to quarter wavelength(λg/4).

Theoretical guided wavelength =7.22mm

Practical gudided wavelength =8.8 mm

The length of the loop can also b determined by the formula.

The square patch is introduced to achieve stable transmission coefficient.

6.1. FACTORS AFFECTING THE DESIGN OF FSS

6.1.1. RELATIVE PERMITIVITY OF THE SUBSTRATE

The relative permittivity of the dielectric has an influence on the design of FSS since it affects the resonating frequency. This is due to the capacitive effect of the FSS on the dielectric constant. Larger bandwidth can be obtained by reducing the dielectric constant. Hence the relative permittivity of the substrate determines the transmission coefficient.

6.1.2 SUBSTRATE THICKNESS

The thickness of the substrate has an effect on dielectric constant. Each substrate will have a unique relative permittivity. Hence if there is a change in the substrate thickness, there will be a change in the resonating frequency.

6.1.3 INCIDENCE ANGLE

The signal from the environment will travel in a multipath manner. The incident wave which is coming in contact with the structure causes the current distribution. This current can cause disturbances to the resonating frequency. Thus the incidence angle has an effect in the design of FSS to achieve a stable transmission coefficient.

6.1.4 LENGTH OF THE LOOP

Length and the frequency are inversely proportional to each other. If the length of the design is increased then the resonating frequency will get decreased. At the same time, if the length of the structure gets decreased, the resonating frequency will get increased. Thus length of the design has an influence on transmission coefficient

7. PARAMETRIC ANALYSIS

MODIFICATIONS	LENGTH	FREQUENCY	OPTIMISED LENGTH
Length of the modified square loop	9.58mm	31.855 GHz	8.8mm
	6.82 mm	24.35GHz	
Length of the square patch	0.6mm	29.064GHz	1.2 mm
	0.8mm	28.211 GHz	
	1 mm	28.494 GHz	
	1.4mm	27.479 GHz	
Substrate thickness	0.125mm	30.312 GHz	1.57mm
	0.254 mm	29.128 GHz	

Table 1 Inference from parametric analysis

Parametric analyses are done to study the influence of different geometric and physical parameters of the designed structure. Table 1 shows the modifications done to analyze the performance of the unit cell FSS.Here the length of the entire modified square loop is changed to 7.62mm and 6.82 mm. The square patch is changed to 0.6mm, 0.8mm, 1 mm, 1.4mm. The substrate thickness is changed to 0.125mm, 0.254mm. The substrate is changed to Rogers RT5880LZ, RogersRT5870. But the simulated result does not achieve the required transmission coefficient at 28GHz.Thus the FSS structure design depends on the substrate permittivity, substrate thickness, length of the loop and patch, incidence angle and shape.

8. CONCLUSIONS

2D Frequency Selective Surface (FSS) for 5G applications operating at 28GHz has been proposed. The design procedure shows that the optimized modified square loop with a square patch placed on the top layer of Rogers RT5880 substrate which can be integrated on the flip cover of mobile phones. The results show that the single layered FSS has a return loss of -39.22 dB which act as a stop band at 28.013 GHz. The FSS design consists of a unit structure. It can be extended with a periodic array which can be placed on the flip cover of mobile phones. The 2D single layered FSS is introduced to increase its stability over the wide range of incidence angles. As the design method is easy to fabricate, the product will be easy to implement in hardware.

FUTURE WORK

The same structure can be designed for multilayer FSS in which the bandwidth can be made wider which in turn increases the gain of the FSS. By doing so, the size of the structure can further be reduced and compact.

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