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# A NOVEL SHIELD FOR GSM 1800 MHz BAND USING FREQUENCY SELECTIVE SURFACE

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**Abstract**—This paper describes a novel FSS which functions as band stop filter to shield the GSM 1800 MHz downlink band. The FSS is designed to operate with the resonant frequency of 1820 MHz which is the centre frequency for the GSM 1800 MHz downlink band. The novelty is attributed to its unique geometry and the circular apertures endowed with it. The proposed geometry provides shielding effectiveness of 20 dB alongside with 133 MHz bandwidth. The structure holds identical response for both TE and TM Modes of polarization. In addition, the geometry with its circular apertures, a hitherto unexplored feasibility serves the purpose of ventilation and heat dissipation. The simulated results are validated using experimental measurements.

## 1. INTRODUCTION

The rampant developments in mobile technology lead to mushrooming of mobile phones and its infrastructure. In a nut shell we can say that mobile phones have their presence everywhere. Though they are constructive in one side, they have their destructive side too. The radiation from the mobile phones invariably affects and poses serious threat to human beings. In most of the public places these mobile phones turn out to be nuances where the signals cause interference and turn out to be the root cause of all problems. The effective isolation from these interference signals through proper shielding mechanism

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is the need of the hour. Frequency selective surfaces step in as the potential candidate in meeting the aforesaid requirements by functioning as band stop filters.

Frequency Selective Surfaces are exhaustively studied in the literature [1, 2] and implemented for gamut of applications especially in shielding [3–7]. The erstwhile contribution from FSS's designed for shielding GSM signals have their array elements as square [8, 9] and ring geometries [9]. Exploiting these FSS's provides immaculate shielding at the cost of ventilation or heat dissipation due to lack of openings. Contrarily, the presence of apertures in the FSS compromises the design by allowing the electromagnetic waves to protrude, thereby affecting the filter's performance. Addressing this issue along with shielding the desired range of frequencies is the need of the hour.

In this paper, a novel FSS design has been proposed for shielding GSM 1800 MHz downlink band. In addition, the proposed design with its circular apertures materializes the ventilation requirements. The structure is imbibed with the geometry similar in appearance to the dipole but convoluted in the center to achieve high value of $\lambda/p$ ratio where $p$ represents unit cell dimension [10], a figure of merit for FSSs.

## 2. PROPOSED FSS GEOMETRY

The unit cell contour of the proposed FSS is portrayed in Fig. 1. The structure is obtained by rotating the alphabet V one to the other by 90° to get a cross like design (CLD) and is printed on either side of the dielectric substrate. The circular slots penetrating deep into the substrate in each of its notches cater to the ventilation needs. Various parameters of the proposed unit cell geometry are detailed in Table 1.

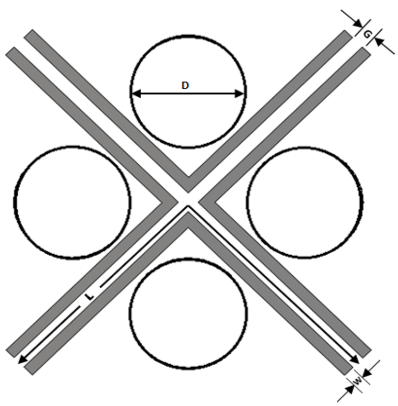


**Figure 1.** Unit cell geometry.

**Table 1.** Unit cell dimensions.

| **Parameter** | **Dimension** |
|---|---|
| Resonant Frequency | 1820 MHz |
| Substrate Details (FR4) | $h = 1.6$ mm, $\varepsilon r = 4.3$ |
| Line Thickness, $H$ (mm) | 0.035 |
| Unit Cell Area (mm$^2$) | $63 \times 63$ |
| Diameter of the Vent, $D$ (mm) | 20 |
| Length of each V element, $L$ (mm) | 75.4 |
| Width of the line, $W$ (mm) | 2 |
| Gap between the elements, $G$ (mm) | 1.2 |

The proposed unit cell is embraced from the simple dipole owing to its simplicity and is convoluted to increase the $\lambda/p$ ratio which is the figure of merit for FSS amounts to 2.61 against the typical value of 1.5 for dipoles [10] ensures that there is less probability for the onset of grating lobes. The simple dipole can address only one type of polarization but this is overcome by the proposed CLD by its symmetrical nature. The double layer FSS is to achieve wider band stop response in the desired range. These merits make the CLD the suitable choice to be used in shielding the GSM signals.

## 3. SIMULATION RESULTS

The Transmission Characteristics ($S_{21}$) of the proposed FSS design is given in Fig. 2. The length of each element is designed to reflect 1820 MHz which is the center frequency for the GSM 1800 MHz downlink band. It is observed from the result that the response of the FSS at −20 dB gives a rejection bandwidth of 133 MHz having lower and upper cutoff frequency points at 1.76 GHz to 1.89 GHz respectively is sufficient enough to shield GSM 1800 MHz downlink band. It is evident from the result that the designed structure with its symmetrical nature gives identical response for both TE and TM modes of polarization. Thus the proposed CLD FSS is found to exhibit polarization independency which is the most desired metric in the design of FSS.

The Transmission Characteristics ($S_{21}$) of the proposed FSS with and without the circular apertures are compared in Fig. 3. The need for ventilation is satisfied by incorporating circular apertures between

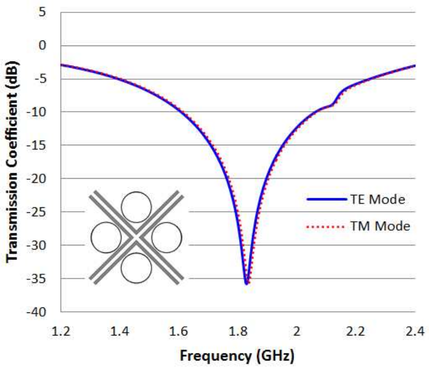


**Figure 2.** TE and TM mode characteristics.

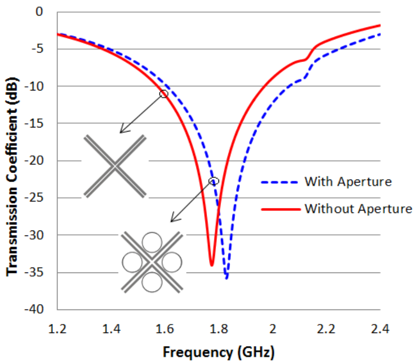


**Figure 3.** Comparison of the transmission characteristics.

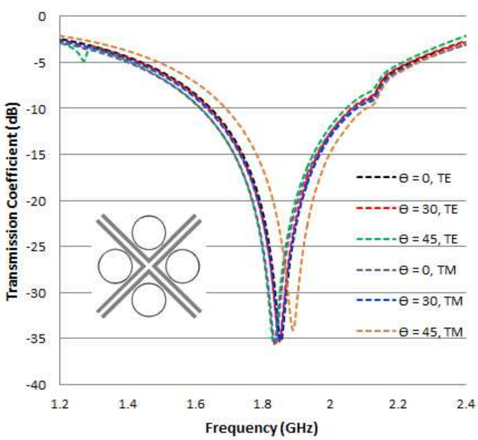


**Figure 4.** Simulated TE and TM mode responses for various incident angles.

the openings of each V's in the unit cell geometry. This addition though causes a slight shift in the resonant frequency, which helps in serving the ventilation needs. The shift in the center frequency can be controlled by adjusting the lengths of the V's.

The stability of the design for various incident angles is simulated for both TE and TM modes of polarization, and their responses are plotted in Fig. 4. From the results it is clear that the proposed design offers stable response irrespective of the angle of incidence as in [11].

## 4. MEASUREMENT SETUP

The proposed FSS design is fabricated on an FR4 substrate and illustrated in Fig. 5. The dimension of the fabricated prototype is $33\,\mathrm{cm} \times 31.2\,\mathrm{cm}$ containing $4 \times 4$ elements. The prototype is housed in an anechoic chamber for measuring the Transmission characteristics. It is a ferrite and foam absorber lined shielded anechoic chamber. This chamber is used for carrying out radiated emission measurements as per CISPR standard for 10 m distance. The fabricated FSS is mounted on a measurement stand in-between the Transmitting and Receiving double ridged horn antennas separated by a distance of approximately 3 m as shown in Fig. 6. Transmit antenna is connected to a tracking generator and Receive antenna is connected to a preamplifier and EMI Receiver. Entire measurement setup is surrounded by microwave foam absorbers. The measured transmission characteristics ($S_{21}$) for both TE and TM modes of polarization are compared with the simulated results in Fig. 7 and Fig. 8 respectively. The measured results show good conformance with those of the simulated results. The small deviation from the simulated result may be attributed to the lossy dielectric used for fabricating the prototype. The $-10\,\mathrm{dB}$ bandwidth of the measured result exactly coincides with the simulated one for both TE and TM modes.

The measured results show shielding effectiveness of more than 30 dB at the resonant frequency making it sufficient enough to attenuate the GSM 1800 MHz downlink band signals.

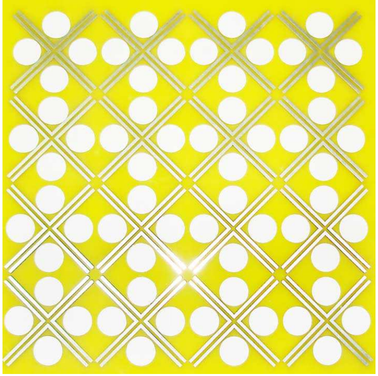

**Figure 5.** Fabricated prototype.

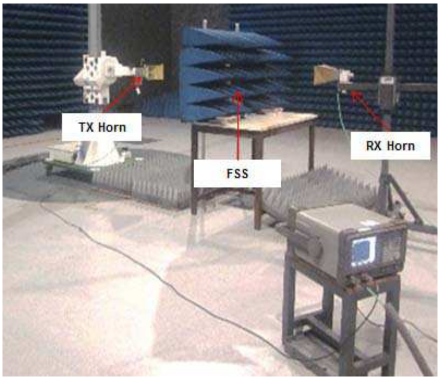


**Figure 6.** Measurement setup.

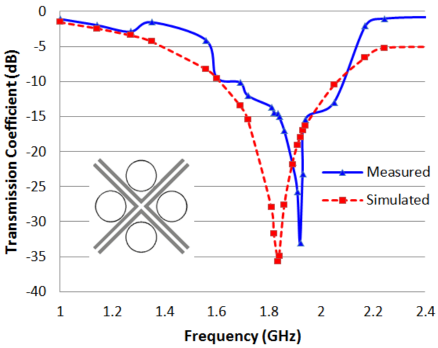


**Figure 7.** Transmission characteristics of TE mode.

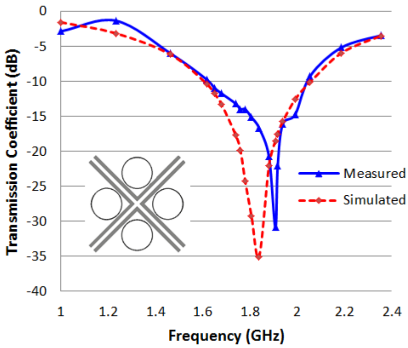


**Figure 8.** Transmission characteristics of TM mode.

## 5. CONCLUSION

A novel frequency selective surface for shielding the GSM 1800 MHz downlink band is proposed and validated using experimental results. The design provides −20 dB bandwidth of 133 MHz and is suitable for angular and polarization independent operation. The apertures in the structure meet the prime requisite of ventilation and heat dissipation. The future scope of this paper will be the extension of this structure for reconfigurable operation.

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