A NOVEL FREQUENCY-SELECTIVE SHIELDING ENCLOSURE (FSSE) FOR MOBILE TERMINALS

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I. Introduction

In the past, frequency selective surfaces (FSS) [1]-[3] have been primarily used for military, especially for the stealth technology. Nowadays, FSS is applied extensively in numerous technologies, such as satellite communication, antennas, and microstrip filters. Uniplanar photonic bandgap (PBG) structures [4], [5] may be adopted as one kind of FSS, and have been applied in photonic crystals [6] for optical technology. In recent years, PBG structures have many applications in lasers, microwave devices, and optical integrated circuits. PBG structures are periodic structures consist of periodic materials, and present an ability to control the propagation of electromagnetic waves with certain resonant frequencies.

In this paper, a new application called frequency-selective shielding enclosure (FSSE) is proposed. The purpose of the FSSE is to shield the electromagnetic interference except for the communicational signal in the Digital Communication Systems (DCS band: 1.71-1.88 GHz). A prototype of the FSSE has been constructed. The simulated and experimental results have been shown and studied. The main parameters of designing the FSSE are also discussed. The special features of the FSSE are employed for shielding the EMI noise. The shielding effectiveness (SE) of the FSSE closes to 0 dB in the passband. In addition, the simulated results are in conformity with the experimental ones. Therefore, the FSSE may be applied for modern mobile terminals.

II. FSSE Design

FSS is a surface constructed by periodic structures, which can be obtained by arranging duplicate elements in one or two-dimension infinite array with the same specific period. This specific period of elements determines the resonant frequency. Here, we propose a single layer FSS consisting of an FR4 substrate and a metal patch which is etched with a PBG structure. This PBG structure is a two dimension finite array which is constructed by small pieces of metals with four branches connecting to each other. Because the period between each element determinates the resonant frequency in the passband, we may calculate the period approximately according to

$$\beta \times \pi = a \tag{1}$$

where β is the phase constant and a is the period. For the bandpass FSS, the period between each element is nearly equal to a half-wavelength of its resonant frequency. The period of the FSS for DCS applications is about 32 mm.

The geometric structure of an FSSE for mobile terminals in the DCS band is shown in Fig. 1. The volume of FSSE is $64(\mathrm{W})\times 128(\mathrm{L})\times 32(\mathrm{H})\ \mathrm{mm}^3$. The FSSE is a six-sided shielding box covered with six FSS's designed for mobile terminals in order to shield the EMI noise except for the communicational signal in the DCS band.

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Ⅲ. Results and Discussions

An FSS for the DCS applications was constructed and studied. The numerical simulation can be obtained by using full-wave simulators. Regarding the numerical simulation in Fig.2, there is an apparent passband occurred at 1.85 GHz. The SE of the FSS closes to 0.43 dB at 1.85 GHz. The measured results are in good agreement with the simulated results. Presented in Fig. 3 is the transmittance of the FSS. The transmittance in the DCS band is over 90 % and reaches to 95 % approximately at 1.85 GHz! The EMI noise is indeed suppressed except for the DCS band.

A prototype of the FSSE for the DCS applications was constructed. In order to test the SE of the FSSE, a dipole antenna is adopted as the transmitting antenna within the center of the FSSE, and another one is placed perpendicularly at the distance of 1 m height as the receiving antenna. Presented in Fig. 4 is the return loss of the dipole antenna within the FSSE. The return loss is about -18.9 dB before shielding (no FSSE) and still lower than -10 dB after shielding (with FSSE). Shown in Fig. 5 is the SE of the FSSE. The SE closes to 1.6 dB at 1.8 GHz and the transmittance in the DCS band reaches to 82.7 %. Shown in Fig. 6 (a) and (b) are the radiation patterns of a dipole antenna within the FSSE. The radiation patterns are slightly affected by the FSSE for the vertical and horizontal polarizations. The maximum antenna gain reaches to 2.1 dB after the FSSE's shielding. The discussion above shows that the influence of the FSSE on the return loss and the radiation patterns is little. The FSSE has a good performance in shielding and suitable for mobile terminals.

Ⅳ. Conclusion

In this study, a novel FSSE has been proposed. The FSSE shows an ability to forbid the propagation of electromagnetic waves except for its resonant frequency. A prototype of the FSSE has been constructed for DCS mobile terminals. The simulated and experimental results display that the EMI noise is indeed shielded by the FSSE. Its SE closes to 1.6 dB at 1.8 GHz and its transmittance reaches to 82.7 %. These features are attractive and significant to the shielding applications. An FSSE with better shielding ability and compact size is worthy of further researching.

V. Acknowledgment

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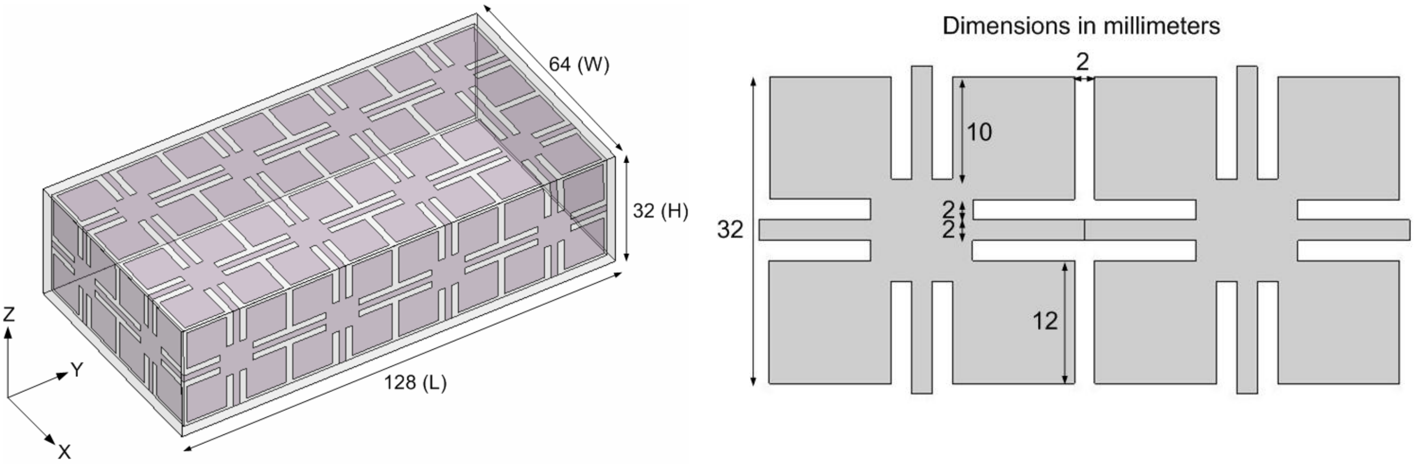


(a) (b)

Fig. 1 Geometry of an FSSE. (a) 3D configuration, (b) an element

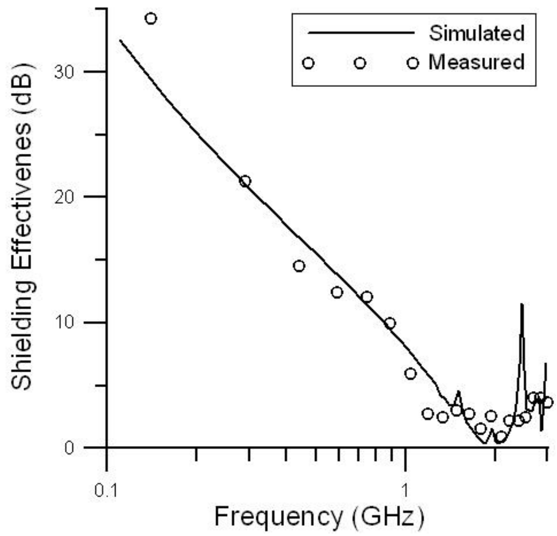


Fig. 2 Shielding effectiveness of an FSS.

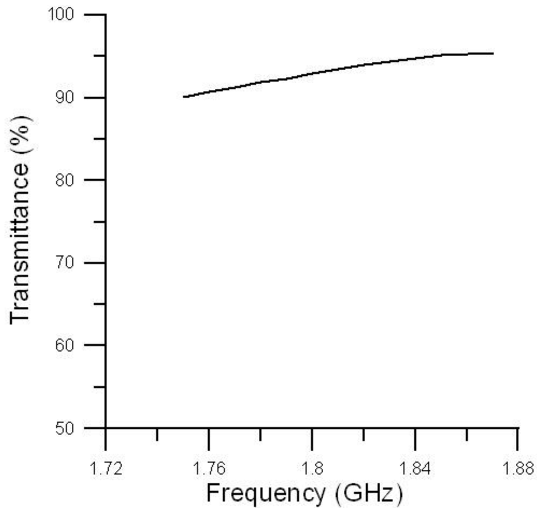


Fig. 3 Transmittance of an FSS in the DCS band.

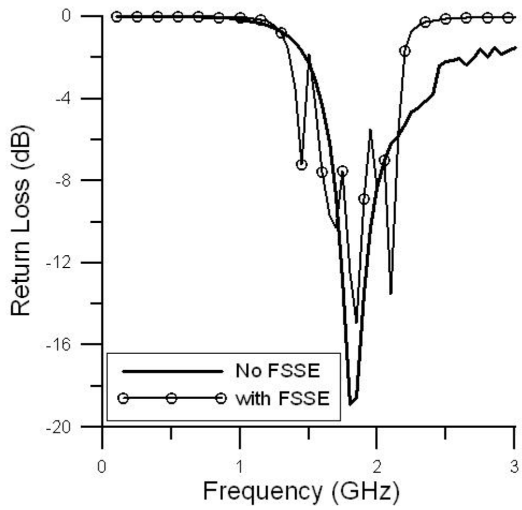


Fig. 4 Return Loss of an dipole antenna within FSSE for DCS mobile terminals.

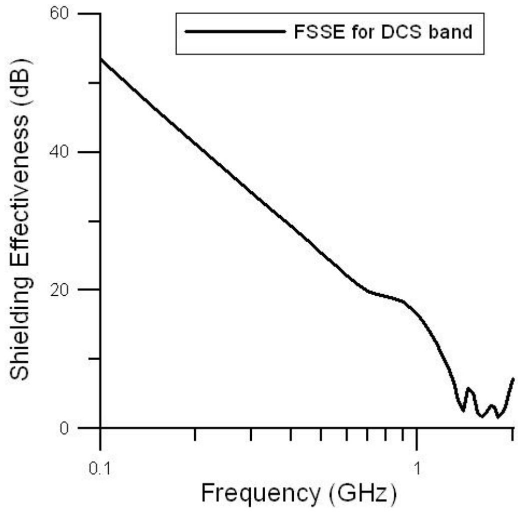
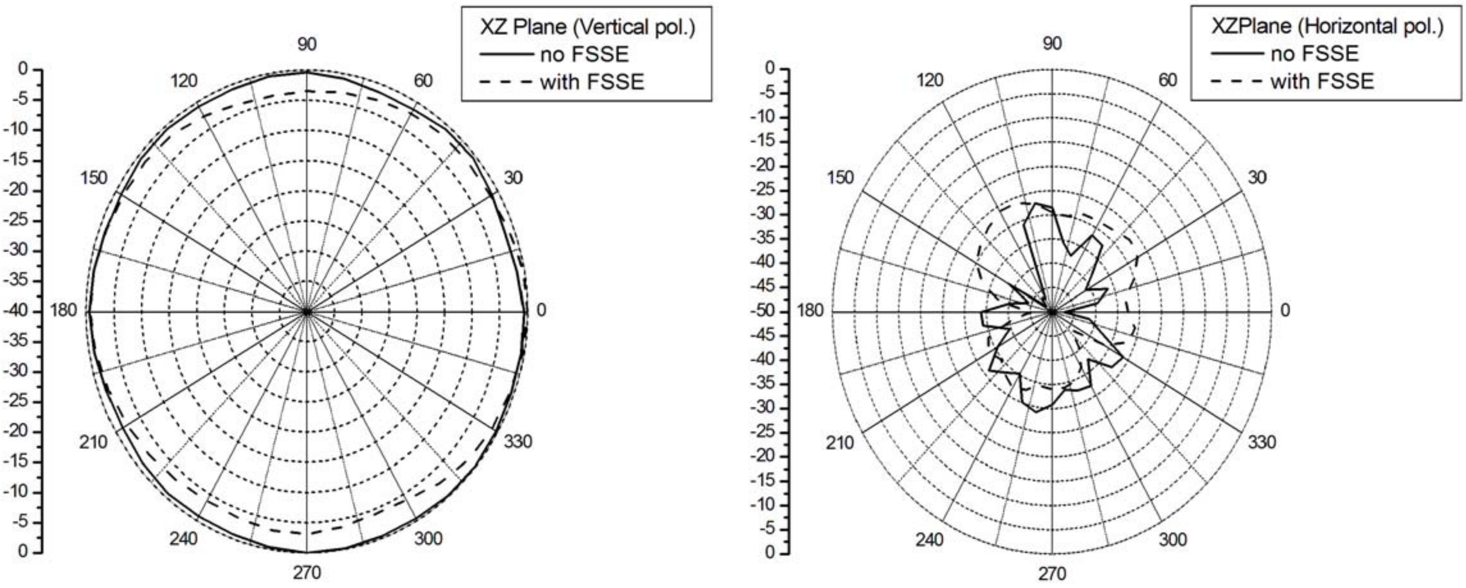
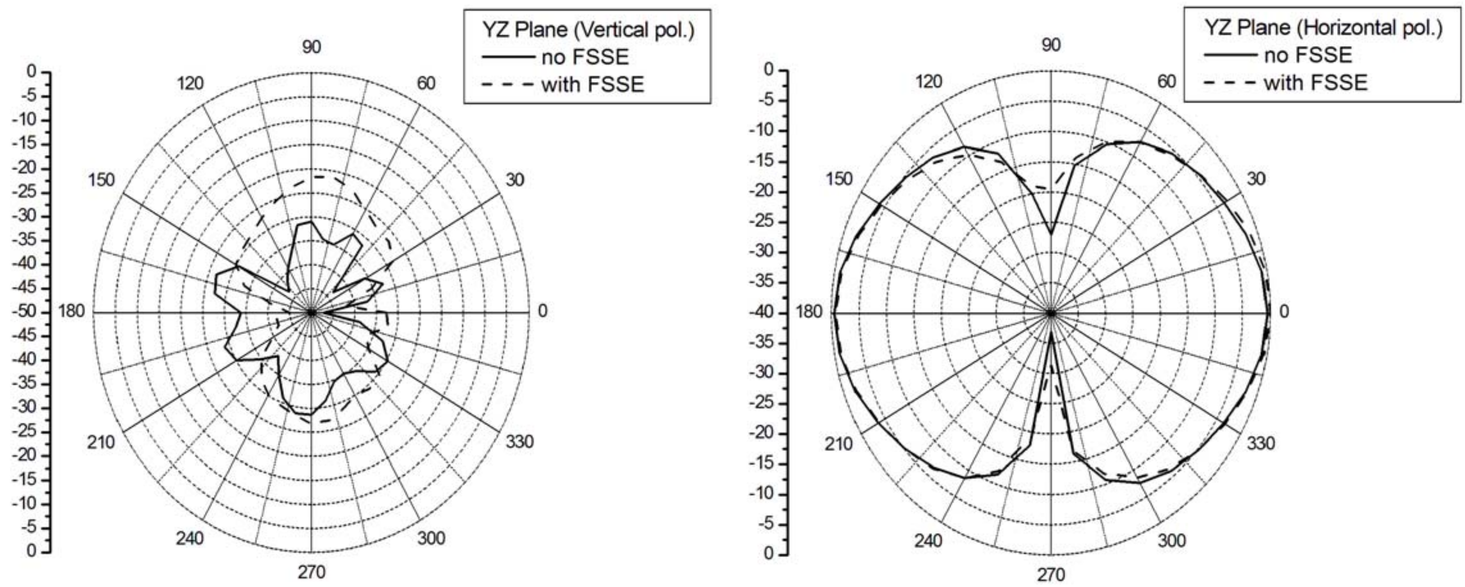


Fig. 5 Shielding effectiveness of an FSSE for DCS mobile terminals.



(a) XZ Plane



(b) YZ Plane

Fig. 6 Antenna patterns of an antenna in the FSSE (as shown in Fig. 1).