Proceedings of ISAP2012, Nagoya, Japan

1A4-5

Multiband Dipole Antenna with Reflector Comprising Additional Reflector Composed of FSS

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1. Introduction

The increase of data rate of mobile communication services has pushed to assign more frequency resources for wireless communication systems. ITU-R has assigned 3.5GHz band to the IMT systems in WRC2007[1], the frequency band is more than 4 times compared to 800MHz band which is the lowest IMT frequency band. In view of base station antenna installation, since the spaces for establishing base station antennas are limited, multi-band antenna configurations are demanded for the base station antennas[2].

Dipole antenna with reflector (it is called 'DAR' hereafter) is commonly used for a base station antenna applied to a sector cell[3]. To form sector radiation pattern with the DAR, the spacing between dipole element and reflector should be less than 0.25 wavelengths. Here we consider multi-band DAR using multi-band resonant dipole element in this paper. When the spacing between the dipole element and the reflector in the multi-band DAR is set to around 0.25 wavelengths at a high frequency band, the spacing at a low frequency becomes too narrow so that the operating bandwidth is degraded. On the other hand, when the spacing is set to 0.25 wavelengths at a low frequency band, the spacing at a high frequency band exceeds 0.25 wavelengths, it causes the distortion in the radiation pattern. The distortion increases as increasing the frequency separation increases.

To solve the problem, this paper proposes multi-band DAR comprising additional reflector composed of FSS (Frequency Selective Surface) designed for high frequency bands. 850MHz and 4GHz dual-band configuration is considered in this paper and band-rejection FSS at 4GHz is used as the FSS reflector[4][5]. The effectiveness in the radiation property is analyzed by FDTD calculation.

2. Proposed Antenna Configuration

Figure 1 shows the proposed antenna configuration. Dipole element is located along the z axis. FSS reflector composed of loop-type FSS elements is placed with the 15mm spacing s_f from the dipole element in the x direction. 9 by 3 FSS elements are placed in the z and y directions to configure the FSS reflector, respectively. The size of the loop-type FSS element is 20mm x 20mm square, the element width is 1mm, and the spacing d between adjacent FSS elements is 22mm as shown in Fig. 2. These FSS works as band-rejection reflector at around 4GHz. Conductive reflector is placed with the 70mm spacing s_r from the dipole element. The size of the conductive reflector is 192mm in the z direction and 64mm in the y direction. This paper investigates the cases in which the 850MHz or 4GHz dipole elements is placed at the position shown in Fig. 1, individually. In this FDTD analysis, analytic space is 115mm x 80mm x 240mm and the unit of mesh is 1mm. *MAGNA/TDM* of ITOCHU Techno-Solutions Corporation[6] is used for this FDTD analysis.

3. Characteristics of FSS

To check the reflection and transmission characteristics of the FSS reflector, one loop-type FSS element with periodic boundary is considered and plane wave is injected to the FSS. The analysis model is shown in Fig. 2. The transmission characteristics are investigated by comparing the case in which the FSS exists with the case in which it doesn't exit. Figure 3 shows the frequency characteristics of transmission loss of the FSS. The transmission loss at 4GHz is -50.6dB while the transmission loss at 850MHz is -0.7 dB when plane wave is injected.

4. Radiation Pattern Using Proposed DAR

Figure 4 shows the radiation pattern comparison of E_θ polarization between the case using a conventional DAR and that using the proposed DAR, which comprises a FSS reflector for the 4GHz when a 4GHz dipole element is placed. As can be seen in Fig. 4, when the FSS reflector is not placed, the radiation patterns in the zx and xy-planes are severely distorted. In this case, the electrical spacing s_r between the dipole element and the conductive reflector at 4GHz is 0.97 wavelengths. On the other hand, when the FSS reflector is placed, that is the proposed configuration, the distortion in the radiation pattern is greatly improved. Generally, FSS is used for filtering plane wave, however it can be confirmed that the FSS is also effective when near field electromagnetic components exist. When comparing the radiation pattern using the FSS reflector with that using conductive reflector instead of the FSS reflector, the radiation pattern in the xy plane using the FSS is almost coincident with that using the conductive plate. Slight beam split is observed in the radiation pattern in the zx plane by using the FSS reflector while it is not observed in the case of the conductive reflector. The reason causing the distortion and the method to remove the distortion will be the future work. Note that the conductive reflector shown in Fig. 1 is not places in this comparison.

Figure 5 shows the radiation patterns in the cases using a conventional DAR and the proposed DAR when a 850MHz dipole element is placed. As we can see in Fig. 5, the FSS reflector does not influence on the radiation pattern of 850MHz. Thus, we can confirm that the proposed DAR that comprises a band-rejection FSS reflector can achieve sector radiation pattern at both low and high frequency bands.

5. Conclusion

This paper proposed a dual-band dipole antenna with reflector adding band-rejection FSS reflector designed for high frequency band in between dipole element and conductive reflector designed for low frequency band. The radiation characteristics are investigated by FDTD analysis. The result showed that the proposed antenna is effective to achieve multi-band sector antenna.

Acknowledgments

The author thanks ITOCHU Techno-Solutions Corporation for their support in providing FDTD analysis simulator *MAGNA/TDM*.

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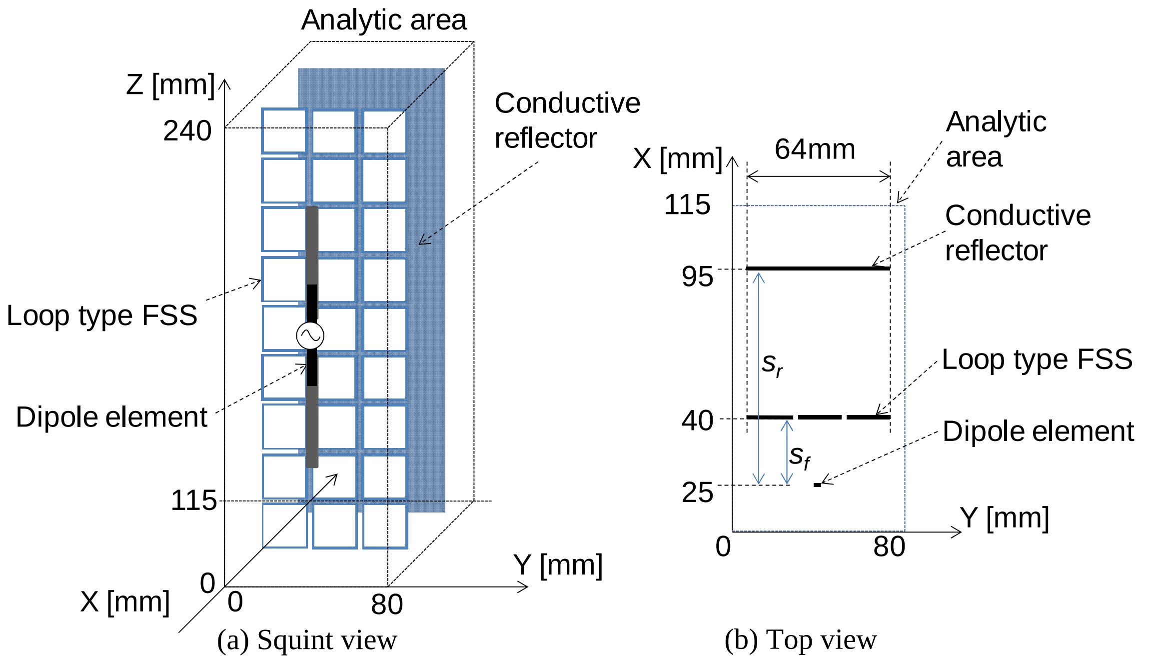
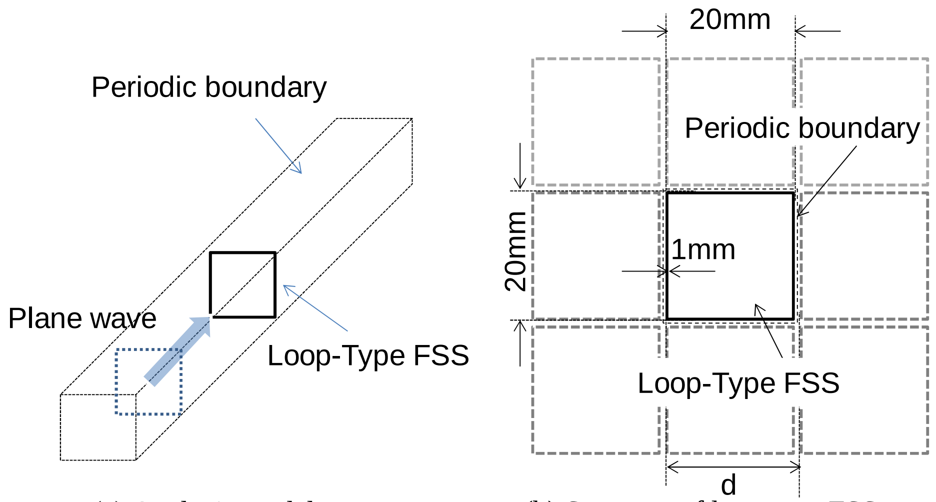


(a) Squint view (b) Top view

Figure 1 Proposed antenna configuration



(a) Analysis model (b) Structure of loop type FSS

Figure 2 Analysis model to investigate transmission characteristics of loop-type FSS

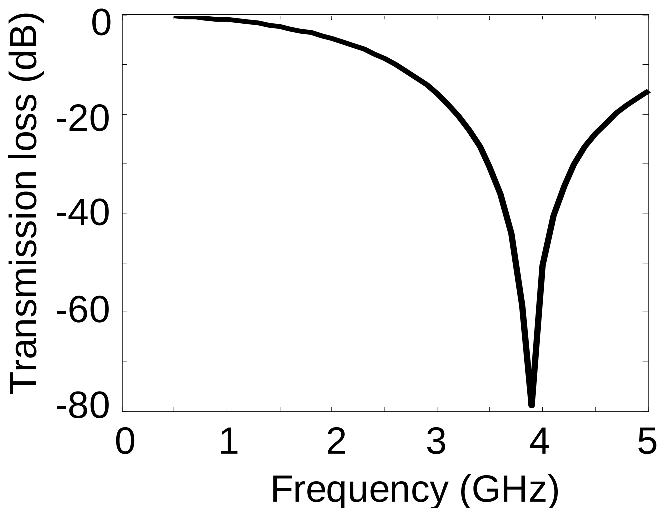
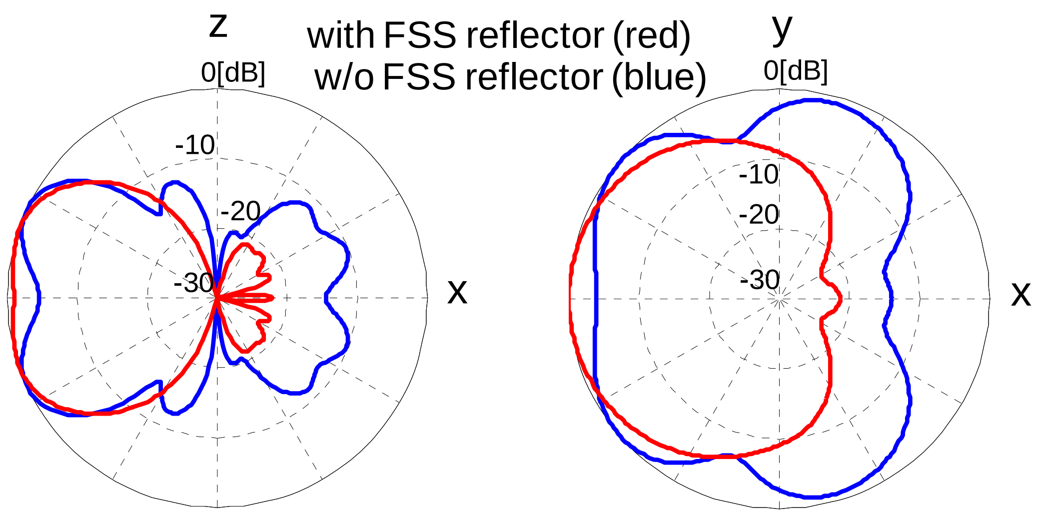
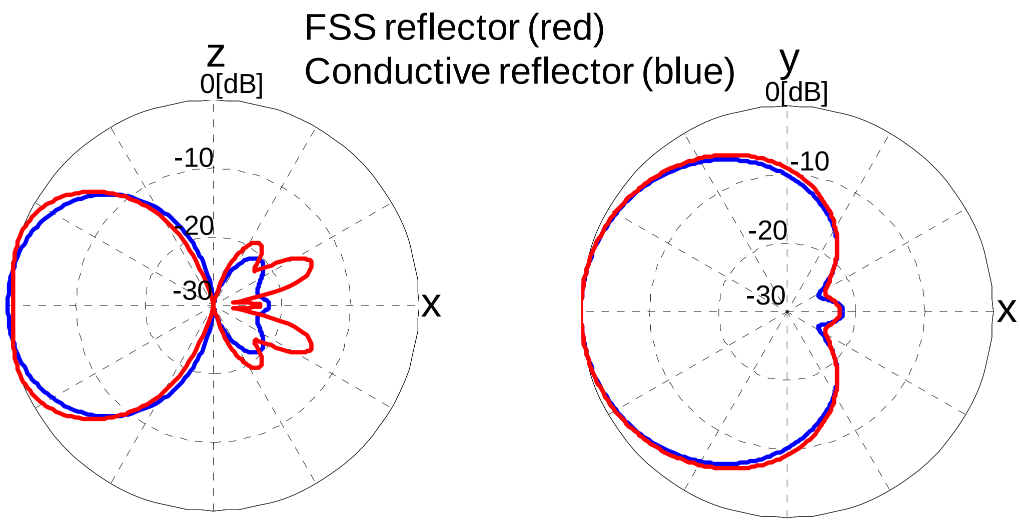


Figure 3 Transmission characteristics of loop-type FSS



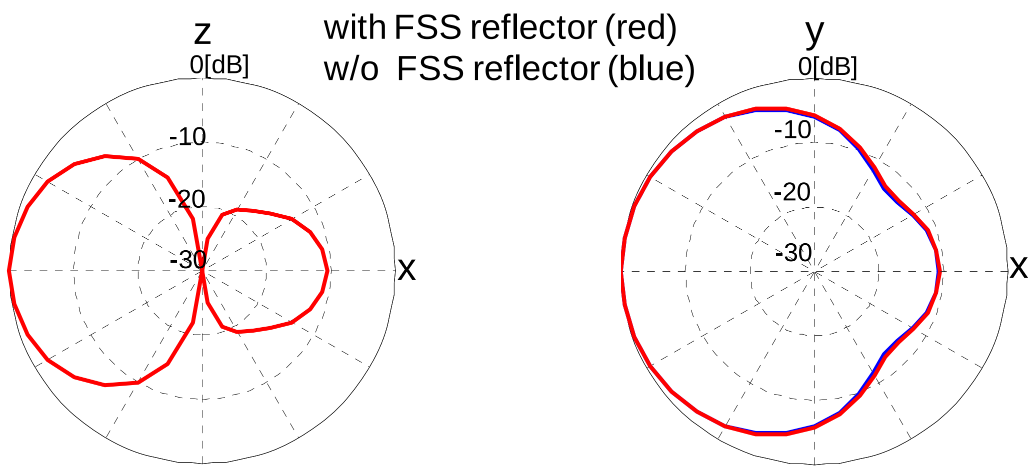
(a) zx plane (b) xy plane

Figure 4 Radiation pattern comparisons between with and without FSS reflector at 4GHz



(a) zx plane (b) xy plane

Figure 5 Radiation pattern comparisons between FSS and conductive reflector at 4GHz



(a) zx plane (b) xy plane

Figure 6 Radiation pattern comparisons between with and without FSS reflector at 850MHz