Antenna radiation pattern arrangement with pipe-formed frequency selective surface

Toyohisa Takano[1)], Suguru Yamagishi[1)], Masayuki Nakano[2)], Ho Yu Lin[2)]
1) SUMITOMO ELECTRIC INDUSTRIES, LTD. 1-1-3 Shimaya, Konohana-ku, Osaka, 554-0024 Japan
2) KDDI R&D Laboratories Inc. 2-1-15 Oohara, fujimino, Saitama 356-8502 Japan

***Abstract* – Some papers regarding frequency selective surface (FSS) for improving antenna performances have been reported, but it is formed into a plane form, and there are few reports about FSS formed into a cylindrical form. In this paper, we carry out simulation and examination about pipe-formed FSS which cross section consists of two semicircles and straight lines. We confirmed that we can arrange an antenna radiation pattern inside pipe-formed FSS by changing the unit cell shape to the circumference direction.**

***Index Terms* — FSS, Cylinder, Radiation pattern.**

1. Introduction

The frequency selective surface (FSS) has structure called the unit cell that locates the metal element periodically in a small gap on the dielectric substrate. FSS has the characteristic to pass or reflect the electromagnetic wave of the specific frequency. Application of FSS includes a wireless LAN block screen, a multi-band antenna with FSS which has a transparent characteristic at the high frequency band and a reflective characteristic at low frequency[1], a multi-band antenna which has several different operational frequency FSS to control the antenna radiation pattern at each operational frequency[2], and a waveguide filter which places FSS inside the waveguide[3][4]. Multiband, wideband, and miniaturization of FSS is also reported [5][6]. However, it is formed into a plane form, and there are few reports about FSS formed into a cylindrical form.

We confirmed that we can arrange the antenna radiation pattern inside a cylindrical FSS by changing the unit cell shape to the circumference direction.

2. Cylindrical FSS Structure and radiation pattern

Figure 1 shows the unit cell structure which constitutes FSS, and Table 1 shows its dimensions. As for the dielectric substrate, its thickness is 0.02mm, its relative dielectric constant is 3.2, its dielectric loss tangent is 0.004, and its copper foil thickness is 0.012mm.

The unit cell has the loop slot that could realize band pass filter properties. Fig.2 shows that the insertion loss property of FSS can be controlled by keeping a cell width of the unit cell (L1), the loop slot width (W) and by changing the loot slot size (L2). We carried out examination about the antenna radiation pattern arrangement of the dipole antenna inside cylindrical FSS using this property of insertion loss.

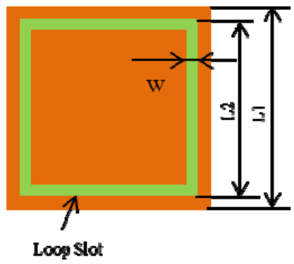

TABLE 1
Unit cell dimension

L1	22.3mm
L2	20.75mm
W	0.9mm

Fig.1 Unit cell structure

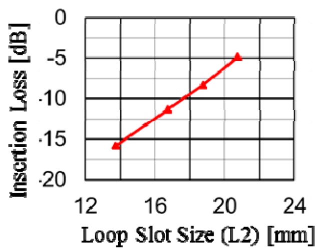

Fig.2 Insertion loss property

Fig.3 shows FSS structure. FSS formed into a cylindrical form. At the unit cell placed in the X-axis direction, loot slot size is largest. The loop slot size gradually becomes small along the clockwise, counter-clockwise direction, and loop slot size is smallest in the opposite direction of the X-axis. The loop slot size is the same in the cylinder axial (Z-axis) direction.

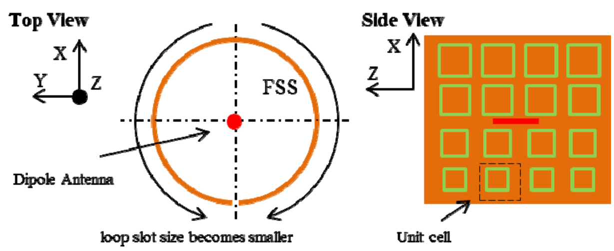

Fig.3 FSS Structure

Fig.4 shows radiation pattern of antenna which was placed at the center of the cylindrical FSS. The horizontal radiation pattern becomes a directional pattern of 100 degrees beam width from an omnidirectional pattern. Vertical radiation pattern beam width changes from 80 degrees to 38 degrees and antenna gain becomes higher from 2.1dBi to 9.5dBi.

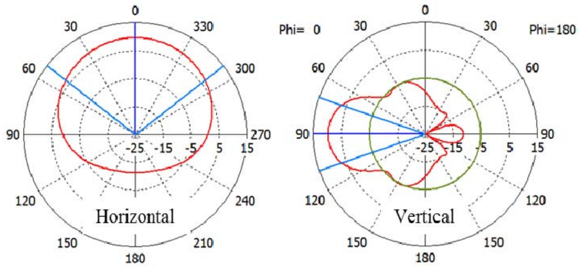

Fig.4 Radiation pattern with FSS

To narrow the horizontal beam width furthermore, we propose a pipe-formed FSS structure (Fig.5). The cross-section of FSS consists of two semicircles and straight lines. Loop slot size is largest at the unit cell placed in the X-axis direction and gradually becomes small along the clockwise, counterclockwise direction.

Fig.6 shows the radiation pattern of an antenna which is placed at the pipe-formed FSS. Horizontal radiation pattern beam width becomes narrow from 100 degrees to 79degrees.

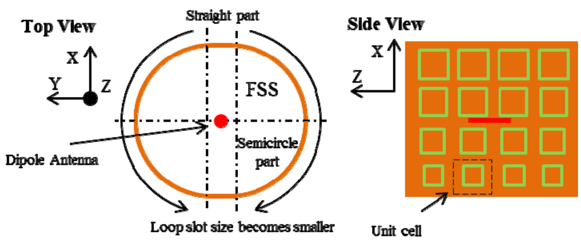

Fig.5 FSS structure (pipe-formed)

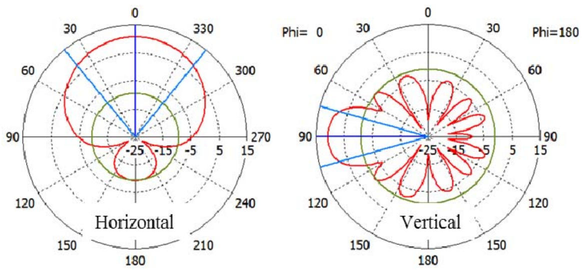

Fig.6 Radiation Pattern with pipe-formed FSS

3. Evaluation of FSS prototype

We manufactured pipe-formed FSS by way of trial. A folded print dipole antenna is placed at the center of FSS (Fig.7). Unlike the dipole antenna described in the previous chapter, the horizontal radiation pattern beam width of this antenna is 185 degrees. By placing pipe-formed FSS, the horizontal beam width is narrowed to 82 degrees as well as when the dipole antenna is placed at the center of pipe-formed FSS. Fig.8 shows the simulated and measured radiation pattern of an antenna placed in FSS prototype.

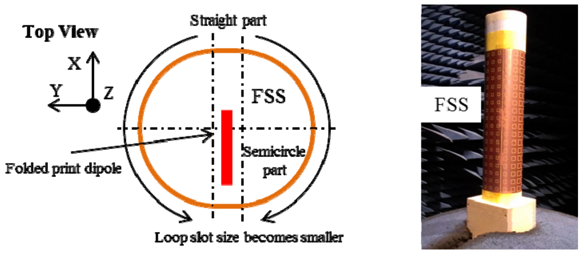

Fig.7 FSS prototype structure

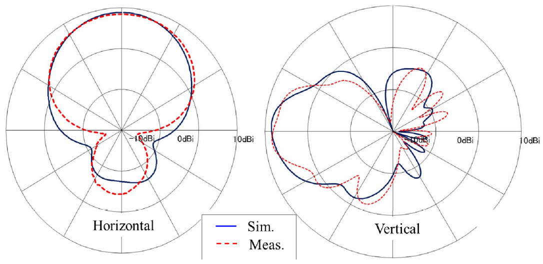

Fig.8 Radiation Pattern with pipe-formed FSS Prototype

4. Conclusion

In this paper, we have carried out simulation and examination about cylindrical FSS. We confirmed that we can arrange the horizontal radiation pattern of antenna placed in the center of cylindrical FSS from an omnidirectional pattern to a directional pattern of 100 degrees beam width by changing the unit cell shape to the circumference direction. Additionally, we propose pipe-formed FSS structure to narrow the horizontal beam width further.

We have manufactured pipe-formed FSS by way of trial and confirmed that horizontal beam width became narrow according to the simulation.

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