A Design of Metamaterial Electromagnetic Scattering Wall

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5G wireless communications use electromagnetic (EM) waves in the 28 GHz band and the EM waves radiated from the high-directivity (gain) antennas are hence scattered in a specular direction by walls. If there are some obstructions between the transmitter and receiver, the wireless communication quality will be deteriorated since the receiver can receive neither direct waves nor reflected waves. In our past research, an EM scattering wall using the metal plates has been designed applying array antenna theory [1]. In ref. [1], the proposed EM scattering wall which reflects the EM waves with a wider angle than that of a perfect electric conductor (PEC) of the same size to improve wireless communication quality.

In this research, we propose the EM scattering wall is designed using a metamaterial (MTM) having the characteristics of an artificial magnetic conductor (AMC).

Figure 1(a) shows the configuration of the EM scattering wall using the MTM. The EM scattering wall is composed of two surfaces with different reflection phases at the reference surface are 0° and 180°. One surface having the AMC characteristics shown Fig 1(b) is composed of the loop surface, dielectric slab (FR4) and the ground planed, and the other is used the metal plate instead of the loop surface.

The scattering pattern $E'(\theta)$ of the EM scattering wall using MTM is derived following Eq. (1). And the scattering pattern is evaluated a diffusion coefficient. The combination of two surface having maximum diffusion coefficient is defined the optimum configuration of the EM scattering wall.

$$E'(\theta) = \sum_{k=1}^{K} g'_k(\theta) D'_k(\theta) \qquad \begin{cases} g'_k(\theta) = \begin{cases} \lambda \sin\left\{\pi \frac{w}{\lambda} \sin(\theta)\right\} / \{\pi w \sin(\theta)\} : \text{[metal plate]} \\ 0.1 \quad : \text{[loop]} \end{cases} \\ D'_k(\theta) = A_k^{\text{feed}} \exp\left\{ j\left(-\frac{2\pi}{\lambda} d_k \sin\theta + \delta_k + \delta_k^{\text{feed}}\right)\right\} \end{cases} \tag{1}$$

Here, $g'_k(\theta)$ and $D'_k(\theta)$ are the element factors of two surface and the array factor, respectively.

Figure 2 shows the optimum configuration of designed EM scattering wall and the scattering pattern. From Fig. 2, it is found that the scattering pattern of the array antenna theory (Eq. (1)) and the result of moment method (MOM) are almost same. It is shown that the EM wave scattering wall can be designed by using the MTM.

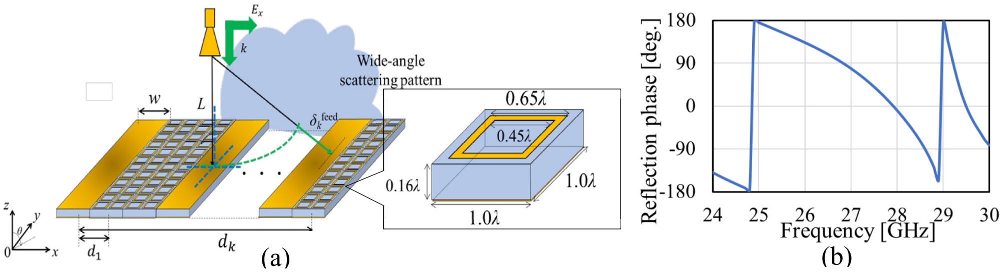

Figure 1. (a) Configuration of EM scattering wall using MTM and (b) AMC characteristics.

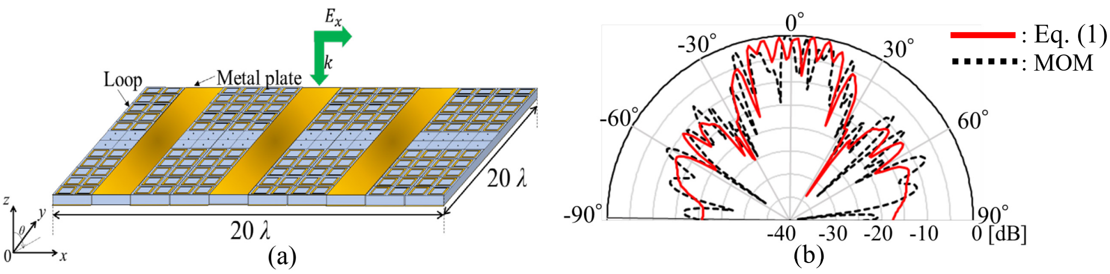

Figure 2. (a) Designed EM scattering wall using MTM and (b) scattering pattern at 28 GHz.

References

[1] Y. Murakami, J. Chakarothai and K. Fujii, "Design of an Electromagnetic Scattering Wall Applying Array Antenna Theory," *Proc. APEMC2020*, Sydney, Australia, May 2020.