§38. Optimization of a Corrugated Millimeter-wave Waveguide and a Miter Bend by FDTD Simulation

Nakamura, H., Kubo, S., Takayama, A., Ito, A.M., Tamura, Y. (Dept. Intelligence and Informatics, Konan Univ.),
Sawada, K. (Dept. Engineering, Shinshu Univ.),
Kashima, N. (Dept. Energy Engi. and Sci., Nagoya Univ.)

Electromagnetic waves to heat plasma in the nuclear fusion devices have been studied both in experiment and in theory. In this paper, we analyze the electromagnetic field in a miter bend (Fig.1) by Finite-Difference Time-Domain (FDTD) simulation to improve the transmission efficiency of electromagnetic wave. The FDTD method was introduced by Yee in 1966[1] to solve numerically Maxwell's equation. The transmission system of the electromagnetic wave is composed mainly of two components, that is (i)cylindrical corrugated-waveguide[2] and (ii)miter bend. Grooves are engaged in both of them, which prevent eddy currents from being generated on the surface of them. The depth, the pitch, and the width of the grooves are designed by the phenomenological theory[3]. Our aim to use the FDTD simulation is to improve the propagation loss of the components. In the present paper, we pick up the miter bend as the target of analysis. The miter bend changes the direction of the electromagnetic wave. We estimate the propagation loss of the millimeter-wave through the miter bend.

Figure 2 illustrates the cross-sectional view in the *xz* plane at $y = 0$ of the three-dimensional FDTD geometry of the miter bend.

The cross-sectional view in the *xy* plane of the cylindrical waveguide is Fig.3. The input electromagnetic wave with TE_{11} mode enters from the top-left size of the waveguide and it is bended by the miter bend. After all, the electromagnetic wave goes out from the lower-right side. The waveguide and the miter bend (which are made of aluminum) are approximated as the perfect electric conductor (PEC). The whole system is surrounded by the simulation box with Mur's first-order absorbing boundary condition[4].

To compare the effect of the groove on the surface of the miter bend, we simulated two types of the miter bends. Moreover, we plotted the intensity of the electric field at the input position in Fig. 3. The averaged electric field is given by the time-averaged electric-field intensity for 5 periods in the steady state for each position in the $k = k_0$ plane, where the *k* axis is defined in Fig.2.

We also estimated the *k* dependence of the averaged electromagnetic energy, which is given by the time average for 5 periods of the electromagnetic energy density.

Thus, we established the FDTD simulation to estimate the electromagnetic wave transport in the miter bend.

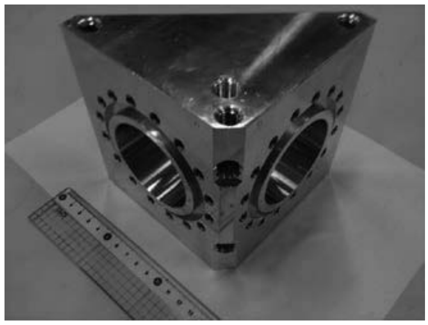

Fig. 1. Photoshop of miter bend. Grooves are engraved in the inside of miter bend. The width, the depth and the pitch of grooves are 1.0 mm, 0.76 mm, and 1.3 mm, respectively.

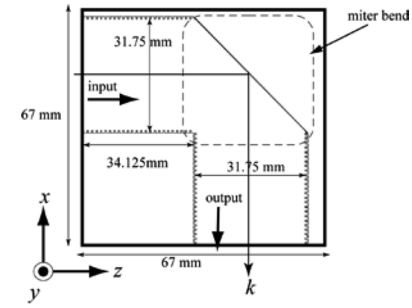

Fig.2. Schematic picture of wave guide system. The direction of electromagnetic traveling-wave is bended by miter bend. The guiding axis *k* is defined in the center of the wave guide along the traveling-wave.

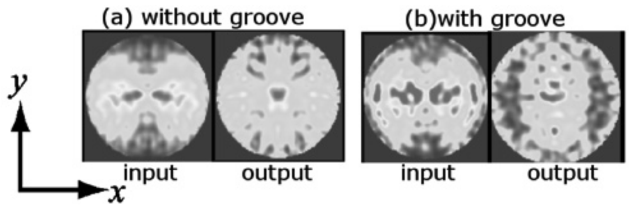

Fig. 3. Simulated distributions in the *xy* plane of the averaged electric-field intensity for two types of miter bends. We plotted the distributions of intensity of the electric field at the input position and the output position for each miter bend without grooves (a) and with grooves (b), respectively.

This work is supported by KAKENHI (24656560).1)

[1] Yee K S 1966 IEEE Trans. Antennas Propagat. 14 302.
[2]Tamura Y, Nakamura H, Okamura T, Kashima N, Fujiwara S and Kubo S 2012 International Conference on Mathematical Modeling in Physical Sciences (IC-MSQUARE 2012) September 3-7, 2012 Budapest, Hungary.
[3] Doane J L 1985 Infrared and millimeter waves 13 123.
[4] Mur G 1981 IEEE Trans. Electromagn. Compat. 23 377.