Numerical Evaluation on Cutoff Frequency of Twisted Waveguide with Rectangular Cross-section

Jing Wang, Masanori Hashiguchi
Keisoku Engineering System Co.,Ltd, 1-9-5 Uchikanda, Chiyoda-ku, Tokyo, 101-0047 Japan

INTRODUCTION: Waveguide is widely adopted for propagation of high frequency signals. Due to misalignment of waveguide system, it is necessary to use bended or twisted waveguide for connection between waveguides. In this study, the cutoff frequency of twisted waveguide with rectangular cross-section is numerically evaluated by RF module, COMSOL Multiphysics 5.4. Propagation of microwave in this type of waveguide is discussed. An application is designed based on the results of simulations.

COMPUTATIONAL METHODS: The electromagnetic waves, frequency domain interface of RF module is selected for this modeling. One hollow twisted waveguide with rectangle cross-section is modeled and the size is listed in table 1. Boundary condition of perfect electric conductor is adopted for simulating perfect conductive walls. Eigen frequency study is used for the first calculation. The inlet and outlet of twisted waveguide, are determined by boundary condition of perfect magnetic conductor, as fig.1 shows. Study of frequency domain is subsequently utilized for the second calculation. Different from the first one, boundary condition of port is applied for inlet and outlet of the twisted waveguide. The TE10 mode is excited on at the inlet and off at the outlet. The solved equation is showing as following

$$\nabla \times \boldsymbol{\mu}_{\boldsymbol{r}}^{-1}(\nabla \times \vec{\boldsymbol{E}}) - \boldsymbol{k}_0^2\left(\boldsymbol{\varepsilon}_{\boldsymbol{r}} - \frac{\boldsymbol{j\sigma}}{\boldsymbol{\omega\varepsilon_0}}\right)\vec{\boldsymbol{E}} = 0$$

Where E ⃗ denotes the electric field, μ_r the relative permeability, σ the electrical conductivity, k_0 the free space wave number, j the imaginary unit. Beside, ε_r and ε_0 are the relative permittivity and the permittivity of free space, respectively.

Variable	Value	Units
Width of cross-section	4	cm
Height of cross-section	2	cm
Length of waveguide	10	cm
Twist angle	range(0,30,90)	degree

Table 1. Size of twisted rectangular waveguide

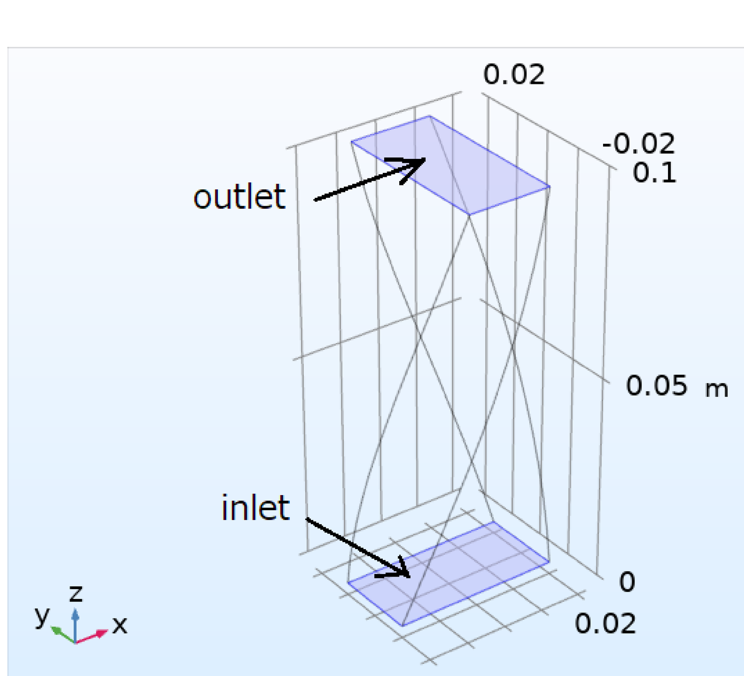

Figure 1. Geometry of the model

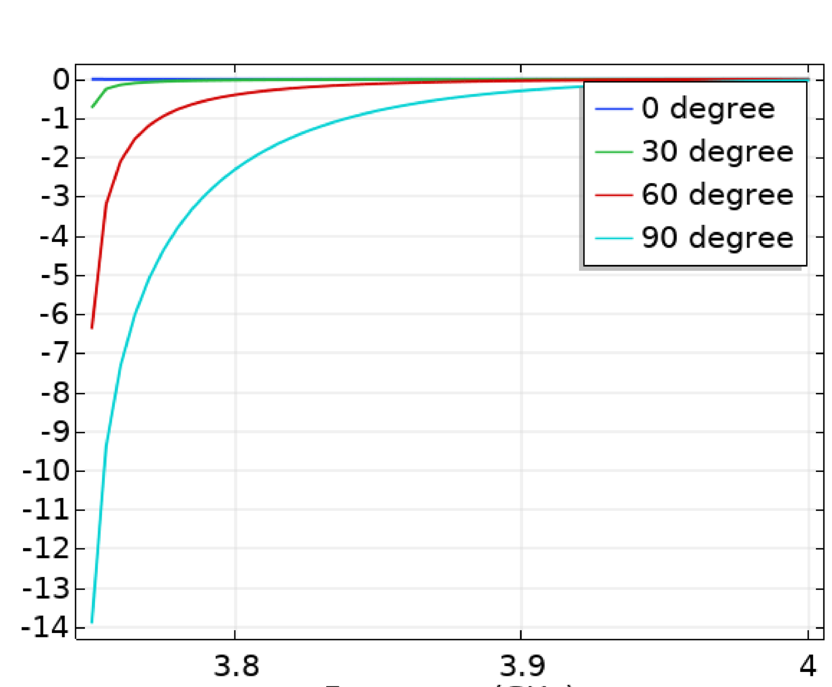

Figure 2. The S-parameters, on a dB scale, as a function of the frequency

RESULTS: The S-parameter of waveguide are shown as functions of the frequency in fig. 2. It is observed that a shift of the cut off frequency occurs in case of twisted waveguide. Figure 3 shows the comparison between simulation result and theoretical result. Results basically agree with each other. The cut off frequency increases with rise in twist angle. However, the discrepancy between them becomes larger and larger. It is probably caused by the observational error on the reading of figure 1 of reference [3]. Figure 4 illustrates the distribution of electric field in twisted rectangular waveguide when twist angle is 90 degree and applied frequency is 7 GHz which is selected so that the TE10 mode is the only propagation mode through the twisted rectangular waveguide. The view is rotated for clear illustration. One application is designed according to above simulations for efficient determination on twisted rectangular waveguide and demonstration dynamic wave propagation, as fig. 5 shows

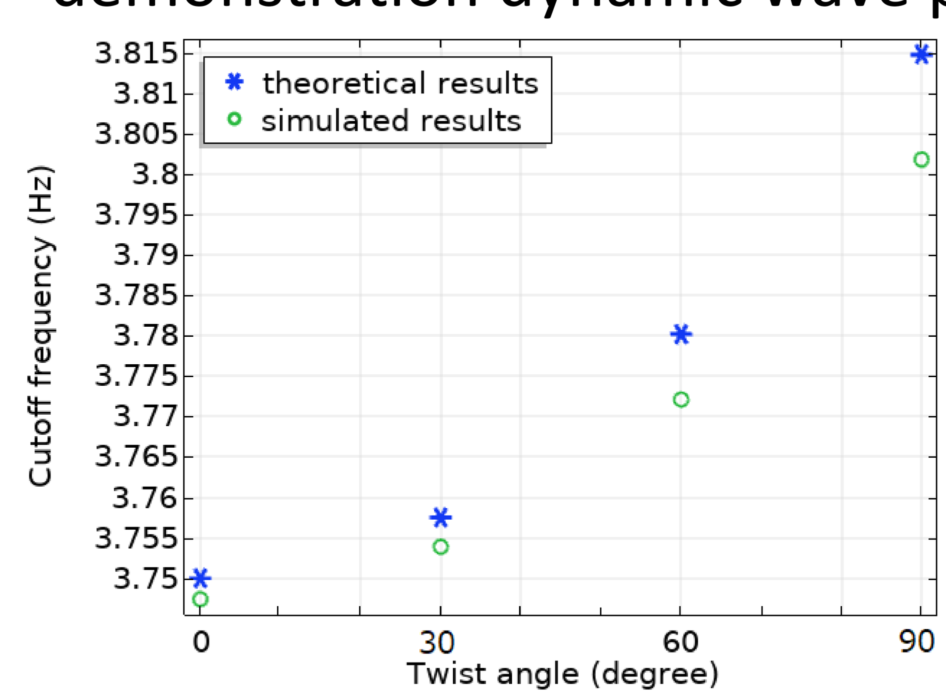

Figure 3. Cutoff frequency versus twist angle

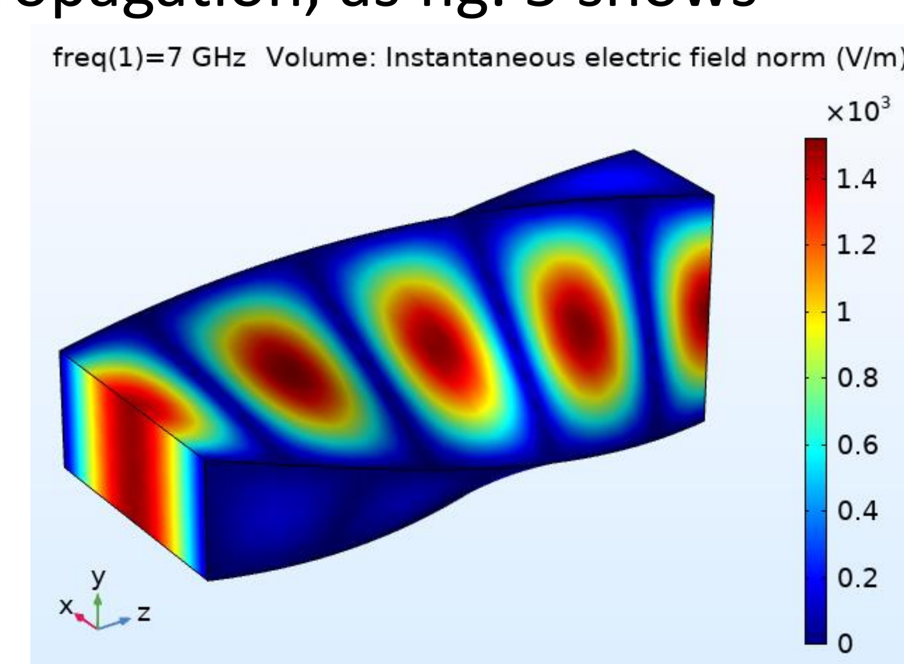

Figure 4. Electric field in twisted waveguide

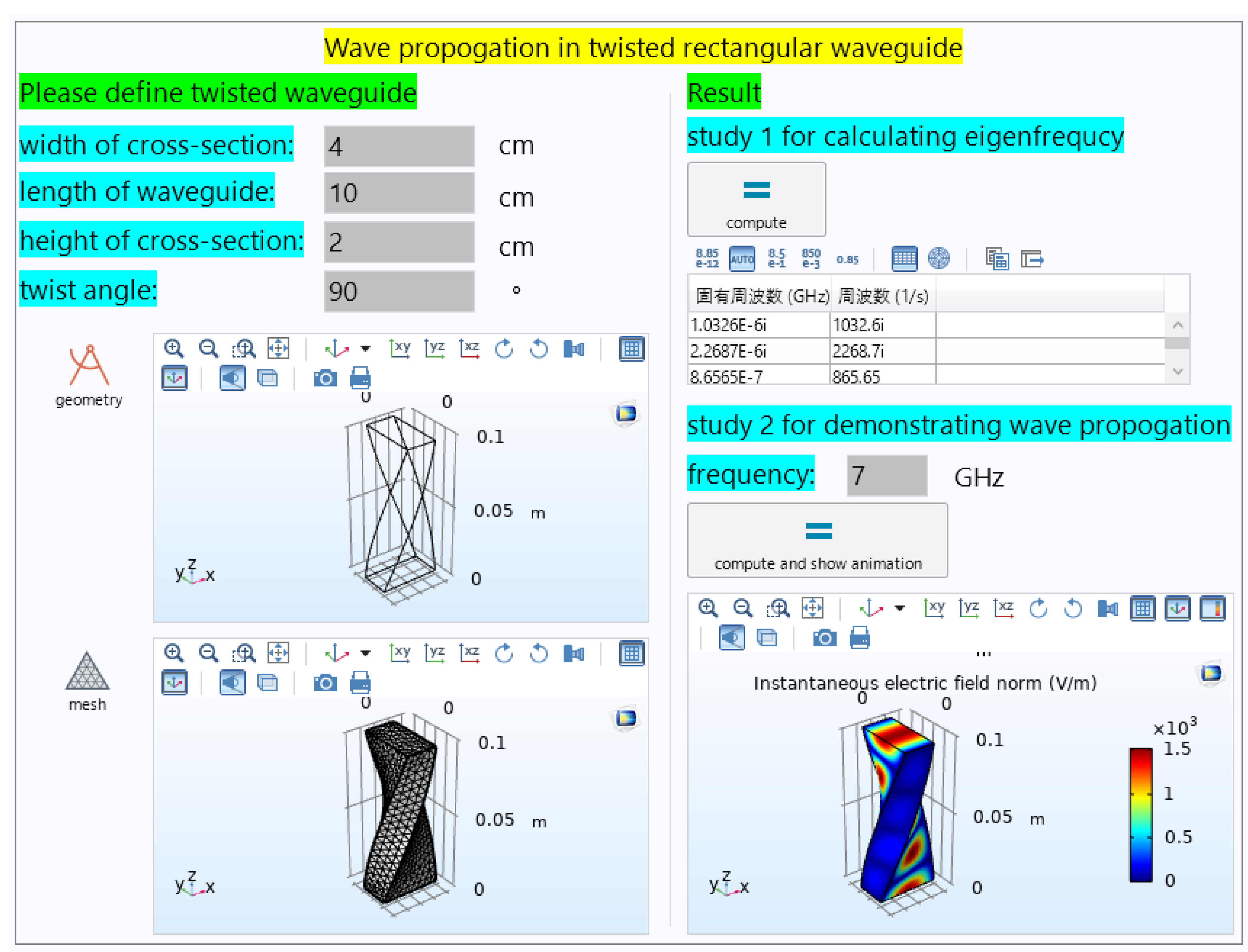

Figure 5. Design of application

CONCLUSIONS: This work investigated the cutoff frequency of twisted waveguide with rectangular cross-section in simulation. Results of simulation agree with theoretical result. Furthermore, propagation of microwave in this type of waveguide is discussed. With the aid of application builder, efficient design of twisted waveguide with rectangular cross-section are achieved.

REFERENCES:

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2. H. Yabe, et al., Dispersion characteristics of twisted rectangular waveguides, IEEE Transactions on microwave theory and techniques, vol. MTT-32, No.1, January 1984.