Problem statement

The geometry of the unit cell, as shown in Figure 1, is currently implemented. The mesh is tetrahedral with a minimum size of 10 cells per wavelength, and the meshing method is surface-based.

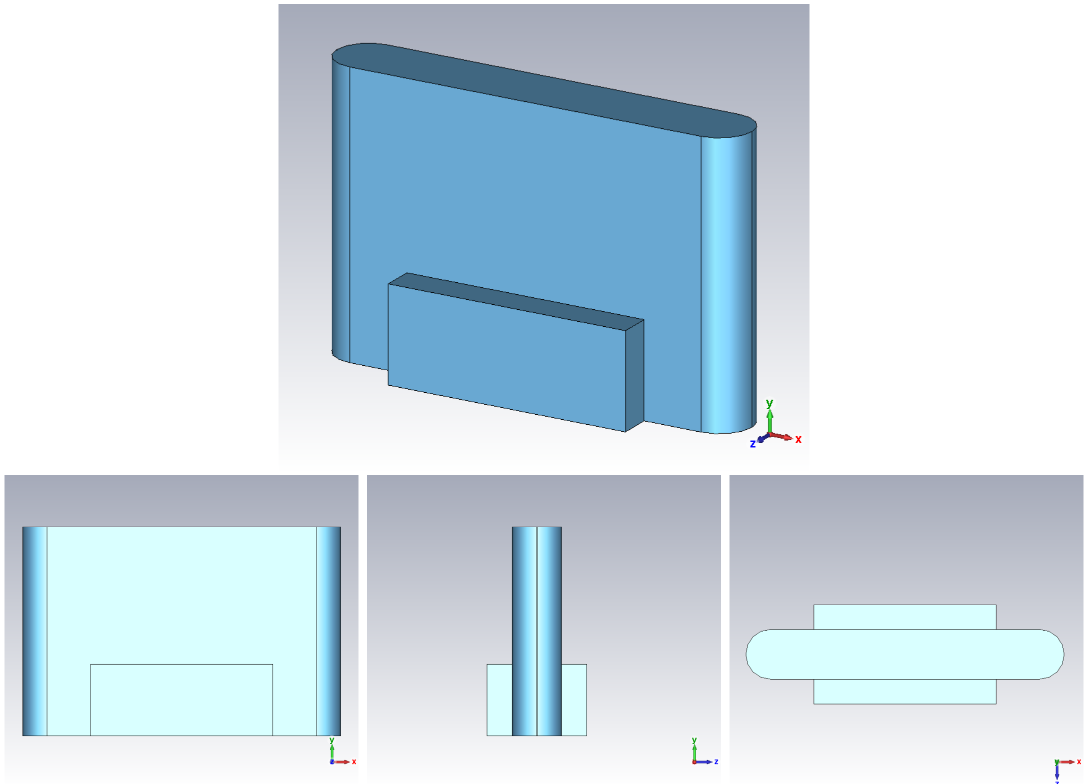

Figure 1: Currently established geometry of a unit cell

The simulation calculates the two lowest eigenmodes and their corresponding frequencies for an unexcited unit cell. These are solved using

$$\nabla \times \left(\frac{1}{\mu} \nabla \times \mathbf{E}(\mathbf{r}, \omega) \right) = \omega^2 \epsilon \mathbf{E}(\mathbf{r}, \omega) \tag{1}$$

where μ is the permeability and ϵ is the permittivity.

Inside the shape is vacuum, so $\epsilon = 1$ and $\mu = 1$. The walls have perfect conductor boundary conditions $\mathbf{n} \times \mathbf{E} = 0$ except the two faces marked in fig. 2, which have periodic boundary conditions with a phase shift p.

The results of the simulation are a map of the phase shift p to the frequency ω for a specific geometry. An example is shown in fig. 3.

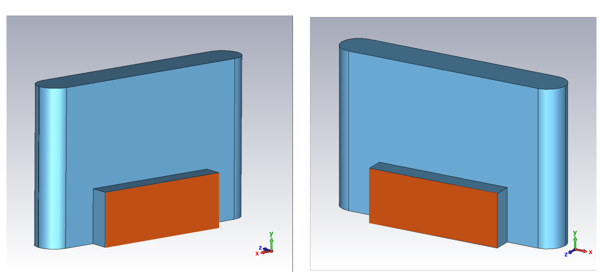

Figure 2: Two marked faces with periodic boundary conditions and a phase shift p.

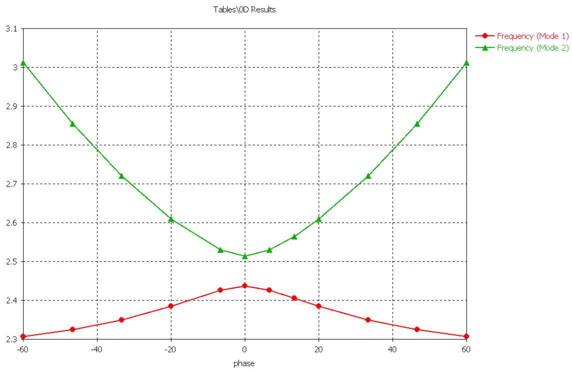

Figure 3: The frequency ω in GHz of two eigenmodes depending on the phase shift p for the unit cell layout shown in fig. 1.

Requirements

1. The equations should be solved for various geometrical parameters and shapes. Therefore, the formulation of the shape and mesh must be adaptable.
2. The simulation will generate machine learning data and must be scalable to handle up to 100,000 datasets efficiently. The available hardware includes 8 CPUs with a total of 104 cores and 180GB of RAM for computation.