

Extra Credit

ECE 3318 Project

Spring 2024

If you decide to do this extra credit part, then please turn it in separately (not attached to the main project), by the project deadline.

Background

The finite difference method should become more accurate as the mesh is made finer, i.e., the value of Δ becomes smaller. This means, equivalently, that we have a larger number N of nodes on the strip. However, having a finer mesh obviously means more nodes and thus a larger spreadsheet, and also a larger computational run time. Therefore, it might be nice to use some numerical analysis to try to predict what our result for the capacitance would converge to if N was allowed to get very large (ideally approaching infinity), even though we do not want to actually solve the problem with this large of a value for N . The approach given below is one way to do this, based on using extrapolation.

Approach

First calculate the capacitance per unit length C_l of the microstrip transmission line for three different values of m , using $m = 2, 4, 8$. (In the main project, you only used $m = 8$.) Make a table showing C_l in [pF/m] for $m = 2, 4, 8$ (corresponding to $N = 5, 9, 17$). From your capacitance values, then make a plot showing C_l (in [pF/m]) vs. the quantity $1/N$. (The plot will have three data points in it.) A sketch of what the plot might look like is shown in Fig. 1 below.

Next, do a curve fitting of the data points and from this extrapolate the curve to estimate what the capacitance would be if we let $N \rightarrow \infty$ (so that $1/N \rightarrow 0$). First try using a linear fit to the two leftmost data points on your plot ($N = 17$ and 9) to do the extrapolation. Then try using a quadratic fit to all three data points. Compare both results, from the linear fit and the quadratic fit, together with the CAD formula given in the project.

Excel should have the capability to do the curve fitting for you, i.e., to generate a curve-fitting equation (polynomial) that fits the data points. Or, you can do the curve fitting yourself if you wish. Using a polynomial to fit data points is discussed in many places; for example, a Wikipedia article can be found at:

https://en.wikipedia.org/wiki/Polynomial_interpolation

The extrapolation process is illustrated in Fig. 1 below (illustrated for fitting to all three data points). Mathematically, if the bottom axis ($1/N$) is called “ x ”, then we are really fitting a polynomial $P(x)$ to the three data points, which can be called $(x_1, x_2, x_3) = (1/N_1, 1/N_2, 1/N_3)$, and then using this polynomial to calculate $P(0)$. The value $P(0)$ corresponds to our predicted value of capacitance if we let $N \rightarrow \infty$. Note that two data points define a straight line, and three data points define a quadratic function. So, if we choose only the two leftmost data points (the two with the largest N values), we are using a straight line to do the interpolation.

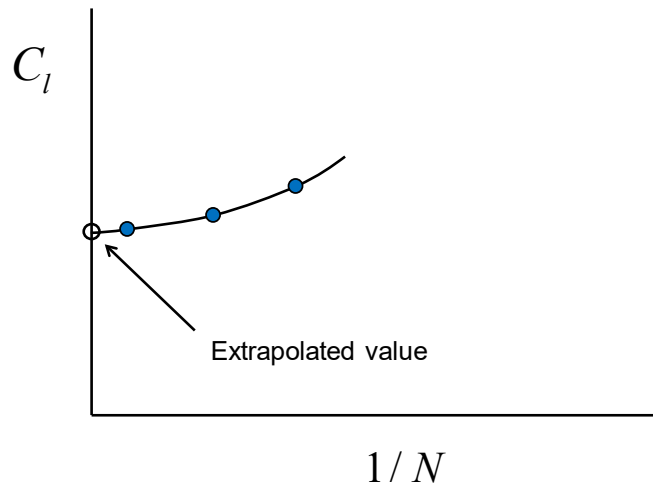


Fig. 1. Illustration of the extrapolation process. The three blue dots are the data points, corresponding to the three different values of N . The white dot is the extrapolated value.