Study Material

Text Book
Elements of Electromagnetics, 6th Ed.
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Oxford University Press

Study Waveguides
Read Chapter 12, pp. 612–646.

Problems

Problem #1
Write a MATLAB program that determines the first 20 modes supported by an air-filled rectangular waveguide and sorts them to be in ascending order, starting with the fundamental mode. The program should output a formatted table that labels each mode as either TE_{mn} or TM_{mn} along with its cutoff frequency. Please write your own code. Do not copy another student’s work. Be sure to use the correct integers in place of \( m \) and \( n \) in the labels. Create five difference tables, one for each of the following five cases:

Table 1: \( a = 0.5 \) cm and \( b = 1.0 \) cm
Table 2: \( a = 1.0 \) cm and \( b = 1.0 \) cm
Table 3: \( a = 1.5 \) cm and \( b = 1.0 \) cm
Table 4: \( a = 2.0 \) cm and \( b = 1.0 \) cm
Table 5: \( a = 2.5 \) cm and \( b = 1.0 \) cm

Problem #2
Use MATLAB to plot the fractional bandwidth (FBW) for single mode operation as a function of \( a/b \) over the range \( 0.2 \leq a/b \leq 2.5 \). Remember the order of the modes changes with dimension of the waveguide and your calculation of FBW must take this into account in order to be correct.

Problem #3
Assuming \( a > b \), what is the ideal choice for the size of \( a \) in order to maximize the FBW? Derive this analytically from the cutoff conditions and compare this to the data in Problem #2.

Problem #4
Use MATLAB to visualize the first four electromagnetic modes in a rectangular waveguide with \( a/b = 2.25 \).

Problem #5
Design a single mode rectangular waveguide (i.e. choose \( a \) and \( b \)) filled with air to operate at 1.5 GHz. Justify your design and specify the range of frequencies over which the waveguide is single mode.

Problem #6
Use MATLAB to plot the phase constant \( \beta \) of the fundamental mode in Problem #5 from 0.5 GHz up to 3.0 GHz.