Problem Set No. 9

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Reading assignment: Section 4.2 A-C, G ; J. A. Kong, *"Electromagnetic Wave Theory,"* EMW Publishing, 2008.

Problem P9.1

What is the lowest frequency of an electromagnetic wave that can be propagating in the TE mode in the earth-ionosphere waveguide? Model the latter as two perfectly conducting parallel plates separated by 80 km.

Problem P9.2

Consider a perfectly conducting parallel-plate waveguide filled with a dielectric medium for $z > 0$ as shown in the figure. The dielectric medium has permittivity ϵ_1. The operating frequency is 30 GHz. The guided wave propagates in the $\hat{z}$ direction.
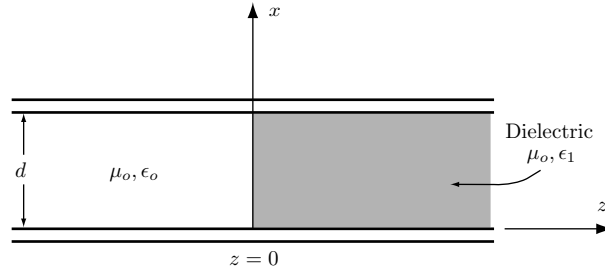

Fig. 1.

(a) Let $d = \sqrt{3}$ cm and consider the empty waveguide with $\epsilon_1 = \epsilon_o$ (in the absence of the dielectric). Which TE_m and TM_m modes can propagate in this waveguide?

(b) Find expressions for the $\overline{E}$ and $\overline{H}$ fields for the TM_2 mode in the absence of the dielectric.

(c) What are the phase and group velocities for the TM_2 mode at this operating frequency in the absence of the dielectric?

(d) Let $\epsilon_1 = 3\epsilon_o$ and $d = \sqrt{3}$ cm. For waves propagating in the $+\hat{z}$ direction, for which values of m will the TM_m modes be totally reflected at the dielectric boundary? Why?

(e) Let $\epsilon_1 = 3\epsilon_o$ and $d = \sqrt{3}$ cm. Calculate k_x and k_z for the TM_m mode. Will the TM_m mode be totally transmitted (no reflection) and why?

Problem P9.3

Practical rectangular-geometry optical waveguides are most easily understood as variants of the simple dielectric slab waveguide. Consider a plane slab of polystyrene ($\epsilon = 2.56\epsilon_o$) with 1 cm thickness whose operation frequency is 30 GHz. How many propogating modes are available using this dielectric waveguide? Determine the operation frequency range within which only the fundamental mode(s) is(are) available.