ASSIGNMENT 1

Review of Transmission Line Basics

(due Thursday Sep. 15, 2022)

1. (50 points) The parallel-plate transmission line shown in the figure has dimensions $b = 4$ mm and $d = 2$ mm. The medium between the plates is characterized by $\mu_r = 1$, $\varepsilon_r = 9.8$, $\sigma = 0$ S/m. Neglect fringing and the field outside the dielectric. Given the TEM-wave electric field

$$\mathbf{E}(z,t) = \hat{\mathbf{y}} 5\cos(2\pi 10^9 t - \beta z), \text{ V/m}$$

find:

(a) β ($\beta > 0$);

(b) the intrinsic impedance η of the medium between the plates;

(c) the magnetic field $\mathbf{H}(z,t)$;

(d) the average transmitted power density $\mathbf{p}_{av}$ (give direction and magnitude);

(e) the displacement current density $\mathbf{J}_D(t) = \partial \mathbf{D} / \partial t$ at $z = 0$;

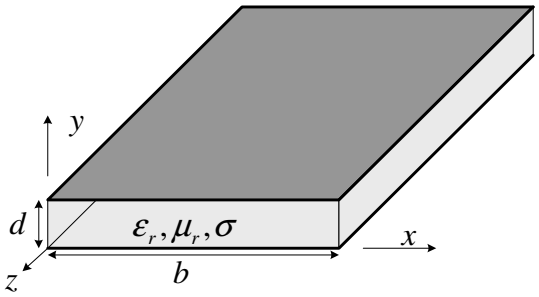
(f) the displacement current $I_D(t)$ crossing the surface $y = 0.5d$, $0 \le x \le b$, $0 \le z \le 0.01$ m, in the y direction;

(g) the voltage of the line $V(z,t)$;

(h) the current of the line $I(z,t)$;

(i) the characteristic impedance Z_0 of the transmission line;

(j) the total power transmitted through the line *P*.



2. (20 points) An antenna has an impedance $Z_A = 50 + j100$ Ω at $f_0 = 300$ MHz. It is connected to the receiver through a loss-free coaxial cable of length $L = 1.25$ m, characteristic impedance $Z_0 = 50$ Ω and a phase constant equal to the free-space wave number: $\beta = k = 2\pi / \lambda_0$. What is the impedance "seen" by the receiver?

3. (30 points) A low-loss optical cable has a loss of 3 dB/km. Assume that the strength of the signal V_0 at a distance $D_0 = 0.001$ km provided by the transmitter is the same regardless of whether the transmission is realized through the optical cable or through a wireless link (in air). Determine the distance *D*, after which the wireless link would provide a stronger signal.

Hints: A nonlinear equation needs to be solved: use the mathematical package of your preference (possible MATLAB function is `fzero`).