COMM.RF.430 Transmission lines and waveguides

Small Exam I, January 31st 2023. Answer to all questions.
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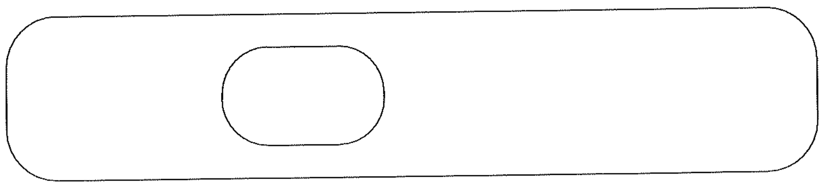
1. Consider a segment of a lossless parallel plate transmission line. Figs. 1–2 give "side–view", the plates are on top and bottom, the TL is fed from its left end and connected to a (matched) load at its right end. The Figs. show how fields vary along the z –axis on the line, the Figs. are of the same case.
   In the Figs. the positive y –axis points upwards and the positive x –axis points away from you.
   (a) Find the relative permittivity of the insulator, assume $\mu_r = 1$.
   (b) Sketch the surface charge density (in reasonable manner). Explain also briefly how it is determined.
   (c) Derive expression for the $\mathbf{H}$–field.
   (d) How would the picture 1 change if ϵ_r and μ_r are doubled.
   Power fed to the TL and other settings stay the same.

   In total 4 p.

2. (a) Use the given data sheet to estimate v_p, C, L, and Z_0 in lossless case.
   (b) Explain what is $\gamma = \alpha + j\beta$ and the terms included. Use the data sheet to find α and results of the (a)-item to find γ (at 400 MHZ).

   In total 4 p.

3. Let us consider the transmission line below that consists of two conductors and dielectric in between (lets assume ideal conductors and ideal dielectric with relative permittivity ϵ_r and relative permeability μ_r).
   Explain options and the related expressions to find L from appropriate field quantities, use of suitable drawings is suggested. You may assume that the field quantities are solved via numerical simulation (e.g. in Comsol). (2 p.)



Constants in free space and some formulas:

- dielectric constant $\epsilon_0 \approx 8.854 * 10^{-12}$ F/m
- permeability $\mu_0 \approx 4\pi * 10^{-7}$ H/m
- speed of light $c \approx 2.997925 * 10^8$ m/s
- intrinsic impedance $\eta_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} \approx 120\pi\ \Omega$
- $e^x \approx 1 + x$ if $|x|$ small
- $\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} = \alpha + j\beta$
- $I(z) = \frac{\gamma}{R + j\omega L} V(z)$
- $\mathbf{u}_x \times \hat{\mathbf{E}} = \frac{\eta}{\mu}\hat{\mathbf{B}}$