Centre for Applied Research in Electronics,
I.I.T. Delhi
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Marks : 5+7+3+10

1. The following expression is often used to calculate the electrical properties of a microstrip transmission line : Zc (in ohms) = $(60 / \sqrt{\varepsilon_{eff}}) \ln((8h/w) + (0.25w/h))$. Here, w and h are the strip width and substrate height respectively. If a microstrip is built using 0.5 mm thick quartz ($\varepsilon_r = 3.8$) , and the strip width is 1 mm , calculate the inductance per unit length of this transmission line. ε_{eff} is the effective dielectric constant (rigorously defined as C_L / C_{L0} , where C_{L0} is the capacitance / length if all dielectrics were replaced by air).

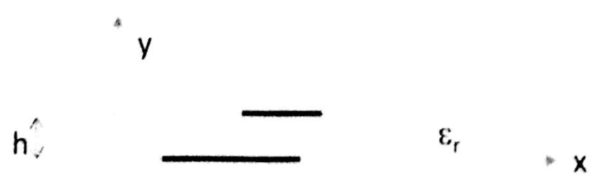
2. A 1pF series capacitor, a lossless 50Ω transmission line of length λ/3 , and another 1 pF series capacitor are cascaded. If port 1 of this 2-port is fed with a 1 A current source at 2 GHz and port 2 is terminated with a 50Ω resistor, what power will be dissipated in the resistor ?

3. What will be the VSWR on a lossless 50Ω transmission line loaded with a 100Ω resistor ?

4. A dielectric sheet of thickness 'h' (the constant cross-section is shown) has metal strips on top and bottom. If the surface charge density on the top surface is called ρ_1 (x) and on the lower surface it is called ρ_2 (x) , the voltages on the top and bottom layers can be related to ρ_1 and ρ_2 in the Fourier domain by :

$$\begin{bmatrix} \tilde{V}(u, y=h) \\ \tilde{V}(u, y=0) \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} \tilde{\rho}_1(u) \\ \tilde{\rho}_2(u) \end{bmatrix}$$

Find the expressions for A , B , C, D, which are of course functions of u. (Don't confuse them with some constants appearing in solutions of Laplace's equation). Zero reference for voltage V(x,y) is y = -∞



[Hint : In Fourier domain (spatial with 'u' being the transform variable for 'x') , it is easily shown that the voltage function has exponential forms in the 3 regions : below the sheet , in the sheet and above the sheet. The unknown constants associated with these exponential functions have to be evaluated by applying some continuity relations at the material interfaces, involving voltage, electric field and surface charge density. Once this is done, the constants show up as functions of the surface charge densities, this in turn leads to the voltages at y = 0 and y = h becoming functions of the surface charge densities. The exact expression for surface charge densities is not important in this problem]