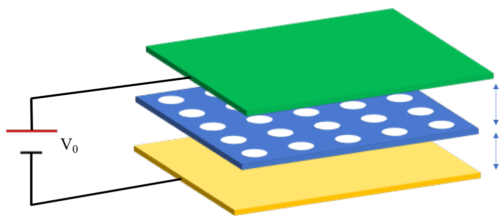
Problem Set 3

Due March 24, 16:00 PM

Problem 1

Investigate the electric field $\vec{\mathbf{E}}$ in the following model.



Parameters	Value	Description
L	2 mm	Length
W	2 mm	Width
narr	5x5	Array of holes
D	10 um	Diameter
d	100 um	Gap

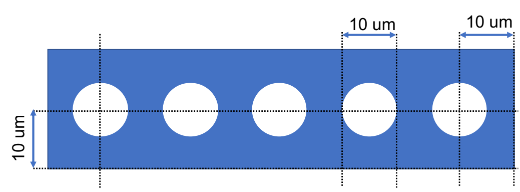


Figure 1: Triode structure (Figure not to scale).

A. How does the distribution of holes affect the fringing of the electric field $\vec{\mathbf{E}}$ in the triode structure?
B. Do you need the 3D geometry to study this? Can you perform similar studies in 1D structure?

Problem 2

Perform the transient-model study for the following structure.

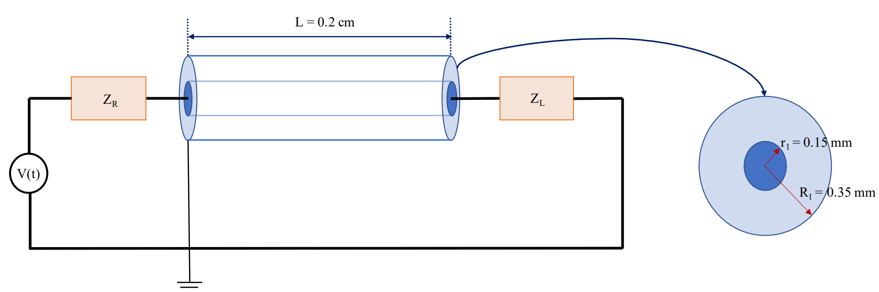


Figure 2: Coaxial cable connected to a time-dependent voltage source $V(t)$ through input and output impedance Z_{R} and Z_{L}, respectively.

Study this structure for different frequencies $f_1 = 1\,\mathrm{GHz}$ and $f_2 = 100\,\mathrm{GHz}$ ($f = 20\,\mathrm{GHz}$ demonstrated in the lecture).

If you short or open the circuit, that is,

- $Z_{\mathrm{R}} = 0$ (short) — Perfect Conductor
- $Z_{\mathrm{L}} = \infty$ (open) — Perfect Magnetic Conductor

then,

A Study the transient response and explain the difference you observe.

B Which one will make a best cavity resonator and why?

C Does the cavity resonance depend on the voltage source?

(a) $V(t) = V(f_1)$ x gaussian pulse
(b) $V(t) = V_0 \sin(2\pi f_1 t + \phi)$
(c) $V(t) = V(f_1)$ x rectangular pulse

Bonus
Now, let's deform the one end (dielectric) of the load as shown in the figure below.

Figure 3: Deformed coaxial cable at the end.

where k is a constant. What will happen if we make curved boundary as perfect metal?

Problem 3

Calculate the transfer function of the following circuit:

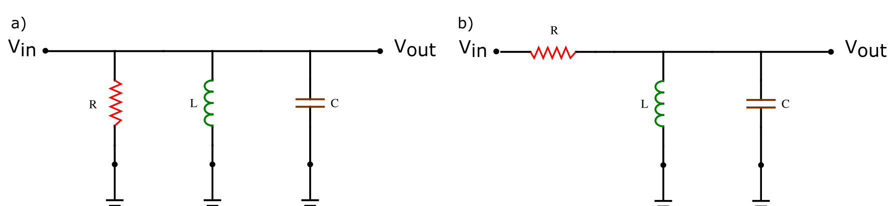


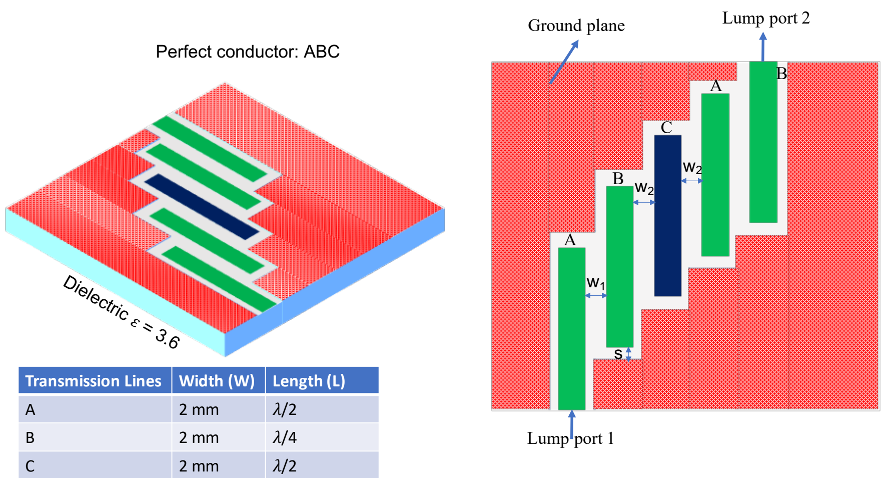
Figure 4: RLC circuit.

where $R = 10\,\mathrm{K}\Omega$, $L = 47\,\mu\mathrm{H}$, and $C = 50\,\mathrm{pF}$.

Now, hook this RLC circuit to the coaxial line. What will happen? Note $Z_{\mathrm{L}} = Z(\omega)$ is the impedance of the RLC circuit. It is enough to solve for the case $Z_{\mathrm{L}} = Z(\omega_0)$, where ω_0 is the resonant frequency of the RLC circuit. What are the quality factors Q of these circuits?

Problem 4

a. Calculate S21 and S11 parameters for the following structure.



Transmission Lines	Width (W)	Length (L)
A	2 mm	$\lambda/2$
B	2 mm	$\lambda/4$
C	2 mm	$\lambda/2$

Figure 5: Transmission line (Figure not to scale).

The gap between the transmission line and the ground plane in both direction is $s = \frac{\lambda}{10}$. The gap between transmission lines A&B is $w_1 = \frac{\lambda}{20}$, for both B&C and A&C is $w_2 = \frac{\lambda}{10}$. Simulate for $\lambda = 35\,\text{mm}$ and frequency $f = 8\,\text{GHz}$. Would you observe a different result if the material for the transmission lines are set to some metal, for eg: Gold?

b. What will be the effect of another ground plane above the transmission lines?

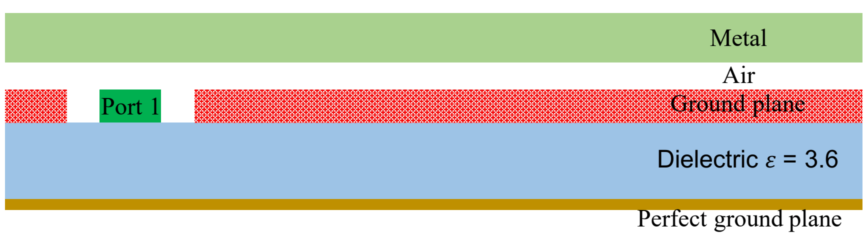


Figure 6: Same structure as above but now, there is a metal layer on top.