Electromagnetic Compatibility
Problem Set 1

1. Derive the transmission line equations from each of the circuits in Fig. 1 in the limit as $\Delta x \to 0$. Observe that the total inductance (capacitance) in each structure is L' Δx (C' Δx). This shows that the structure of the per-unit-length equivalent circuit is not important in obtaining the transmission line equations from it so long as the total per-unit-length inductance and capacitance is contained in the structure and we let $\Delta x \to 0$.

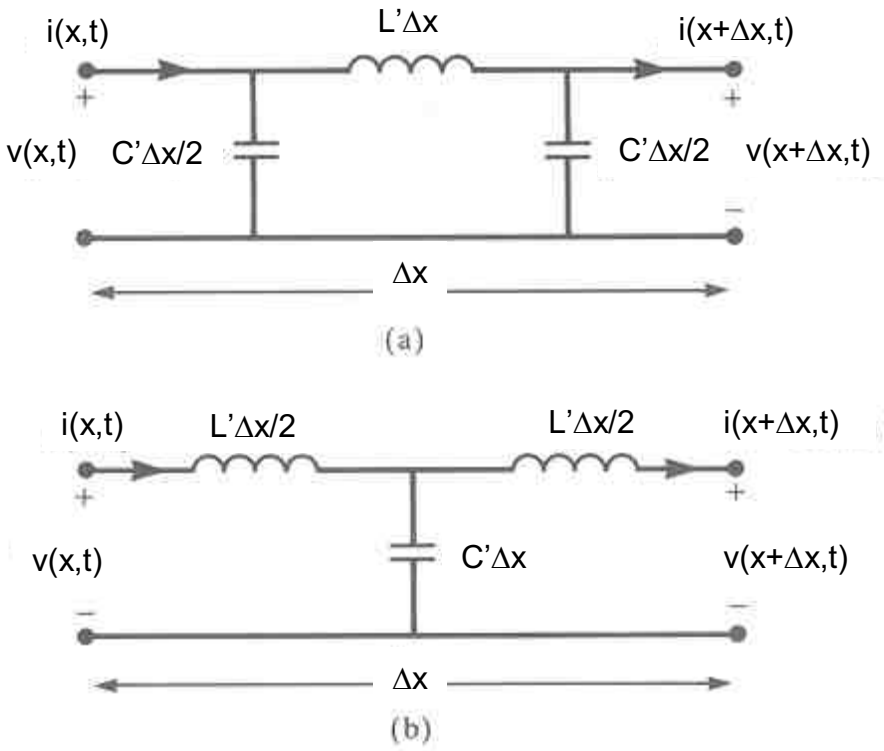


Fig. 1

2. For a particular section of coaxial cable, the following electrical parameters have been measured at a frequency of *f* = 250 kHz: characteristic impedance $Z_c = 93.0 \quad \Omega$, line propagation phase constant $\beta = 96.28 \times 10^{-3} \quad \text{rad/m}$. Assuming a lossless line, compute the per-unit-length parameters *L*', and *C*'.

3. Consider the special case of a lossy, yet distortionless line for which R'/L'=G'/C'. Compute the general complex propagation constant and show that it leads to a distortionless propagation, even though the losses can be large. This is known as the *Heaviside line*.

4. Consider the line of Fig. 2. The line is supposed to be lossless. Apply the expressions derived in the lecture notes and compute in the frequency domain the voltages at the two line ends of the line V(0) and V(L). Discuss the obtained results. Convert the solution into the time domain considering a lossless line.

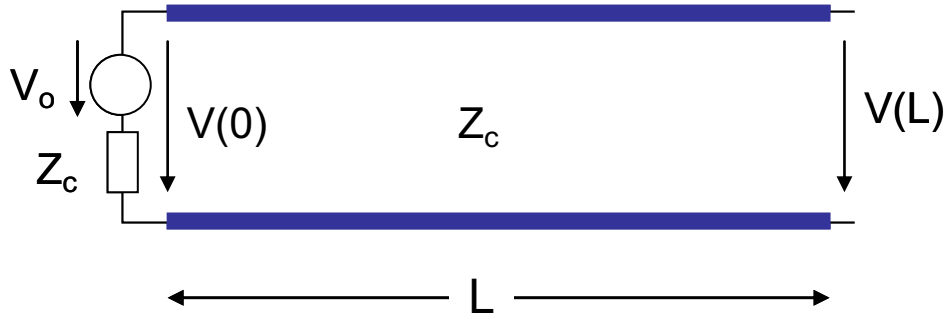


Fig. 2

5. Make reference to Fig. 3 and answer to the following questions (the two lines are supposed to be infinitely-long).
   - Calculate the values of the reflection and transmission coefficients at the junction point P1.
   - What is the amplitude of the total voltage at point P1?
   - What is the amplitude of the transmitted voltage to the line 2?
   - What is the amplitude of the reflected and transmitted current traveling waves associated to the voltage ones?

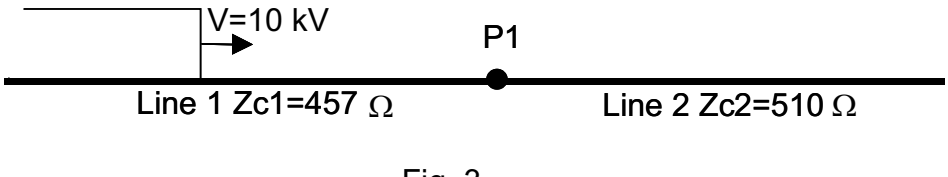
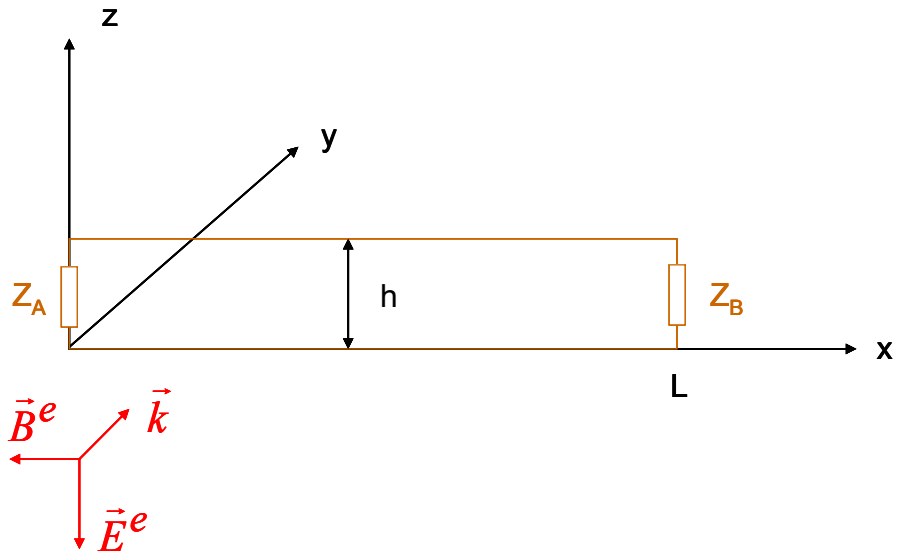
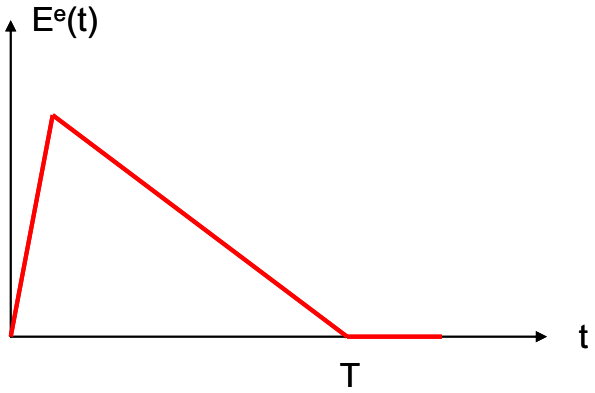


Fig. 3

6. Consider a transmission line formed by a conductor above a perfect ground plane matched at its two extremities (Z_A=Z_B=Z_c). The line is in presence of an exciting plane wave with vertical polarization propagating along the y-axis. We would like to calculate the current along the line



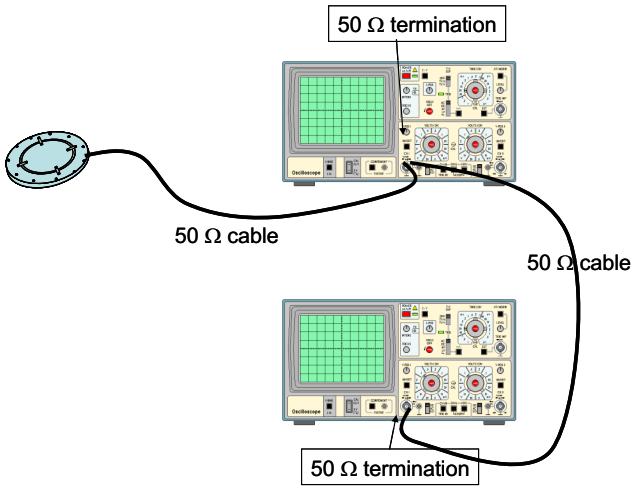
A. We have seen that there are three equivalent models describing the electromagnetic coupling. Nous avons vu qu'il existe trois formulations équivalentes des équations de couplage. Select the most appropriate one for the problem at hand (by justifying your choice) and give the equivalent circuit.
B. Assuming a lossless line, determine analytically the expressionss for the current and voltage along the line $v(x,t)$ and $i(x,t)$.
C. Represent the current $i(0,t)$ for an exciting electric field shown in the next figure, with T<L/c.



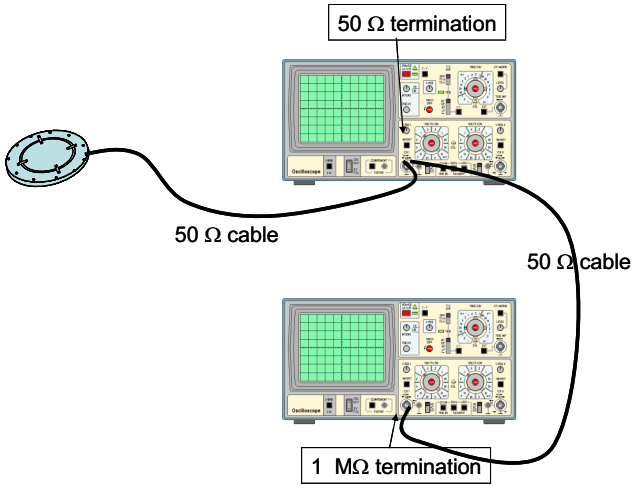
D. What would be the induced current and voltage when the duration of the impulse electric field is much longer than the propagation time along the line ?

7. We would like to measure (digitize) a high-frequency signal coming from a sensor on two different oscilloscopes. The output of the sensor should be on a 50 Ω impedance. Which one of the following arrangements is recommended to avoid multiple-reflections? The two cables at disposal are both electrically long

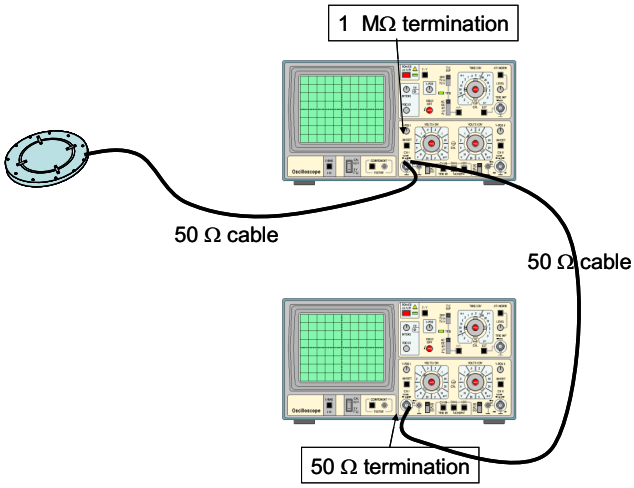
a)


50 Ω termination
50 Ω cable
50 Ω cable
50 Ω termination

b)


50 Ω termination
50 Ω cable
50 Ω cable
1 MΩ termination

c)


1 MΩ termination
50 Ω cable
50 Ω cable
50 Ω termination