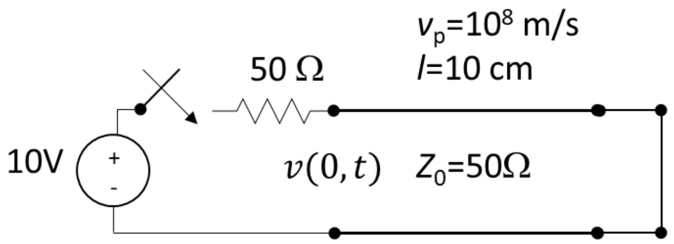
High-speed electronics 2019 – Exercise 4

"Transmission Lines and Gain"

1. For a short-circuited transmission line connected to a constant voltage source (see below), we expect $v(0,t) = 0$ after a long time. However, when we close the line, there should be a voltage wave travelling towards the short. Draw a bounce diagram and explain on how $v(0,t)$ settles to 0V!

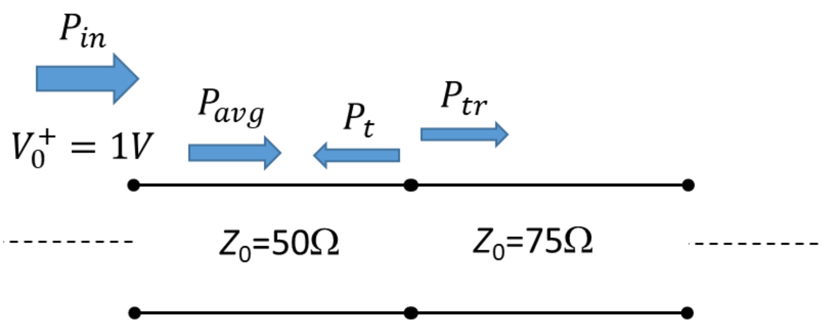


2. A 100Ω transmission line has ϵ_{eff}=1.5 and is used at f=10 GHz.

   a) Find the *shortest* open-circuited stub making the line appear at a capacitance C_{in}=1 pF.
   b) Do the same for an inductance of L_{in}=1 nH instead.

3. A 50 Ω source is injecting power (P_{in}) with a voltage amplitude $V_0^+ = 1V$ towards a 50Ω/75Ω junction.

   a) Calculate the injection and transmission coefficients.
   b) Calculate the amplitude of V_0^- in the 50Ω region and V_0^+ in the 75Ω region.
   c) Calculate the input power P_{in}, the reflected power P_t and the transmitted power P_{tr}. Show that energy is conserved – i.e. $P_{in} - P_t = P_{tr}$ and $P_{avg} = P_{tr}$ despite a larger V_0^+ in the 75Ω region.



4. For the simplified NQS model, derive an expression for f_{max}, assuming that R_D=R_G=R_S=0 (given C_{gs},C_{gd}, g_m and g_d. Assume C_m=0)

5. Parasitic capacitances add typically 0.1-0.5 fF/µm to C_{gs} and C_{gd}. For an InAs MOSFET with L_g=20 nm, t_w=8 nm, t_{ox}=5 nm, ε_{rox}=25,
   a) how large g_m is needed to obtain f_T>1THz?
      (Assuming an optimistic R_D=R_S=0 and g_d=0).
   b) Can this be reached with a (quasi-ballistic) FET?

6. A transistor is operated in saturation with g_m = 2000 µS/µm, g_d = 10 µS/µm, R_i = 30 Ohm, Cgs = 3fF/µm, Cgd =0.3 fF/µm. We neglect parasitic capacitances. Calculate the following at 60 GHz: Consider the width of the transistor to be 10µm for calculations.
   a) The Stern stability factor of the device.
   b) What is the maximum stable gain?
   c) What is the maximum available gain?
   d) Is the device stable at 60 GHz? If not then unilaterize the device and calculate U.