University ☺f P☺rtland
Sch☺☺l ☺f Engineering

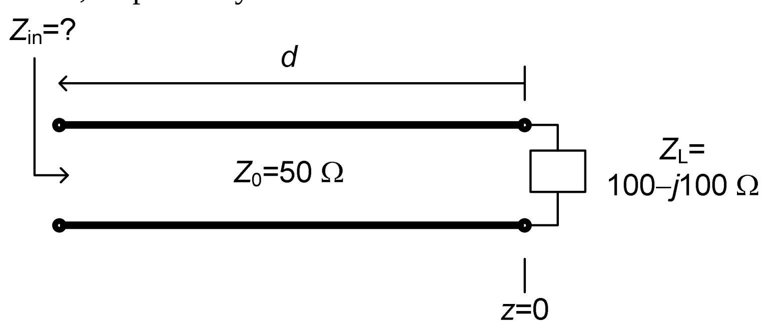
EE 301
Spring 2014
A.Inan

<u>Homework # 4</u>
(Monday, February 25, 2014)
<u>Sinusoidal Steady-State (SSS) Waves on Transmission Lines</u>
(<u>Due Friday, March 7, 2014, 11:25a.m.</u>)

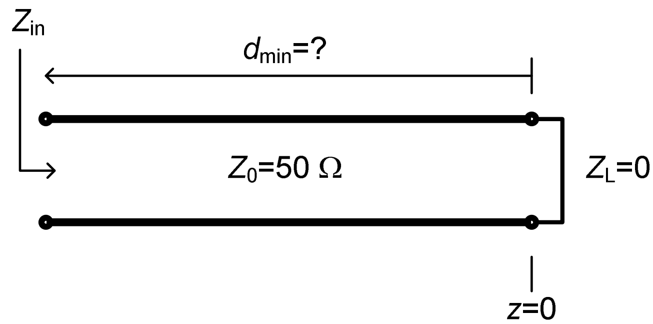
(1) Electrical length of transmission lines. Find the electrical lengths of the following transmission lines:

(a) 100-kilometer long air transmission line at 60 Hz;
(b) 100-meter long coaxial line with a velocity factor of 0.67 at 300 MHz.

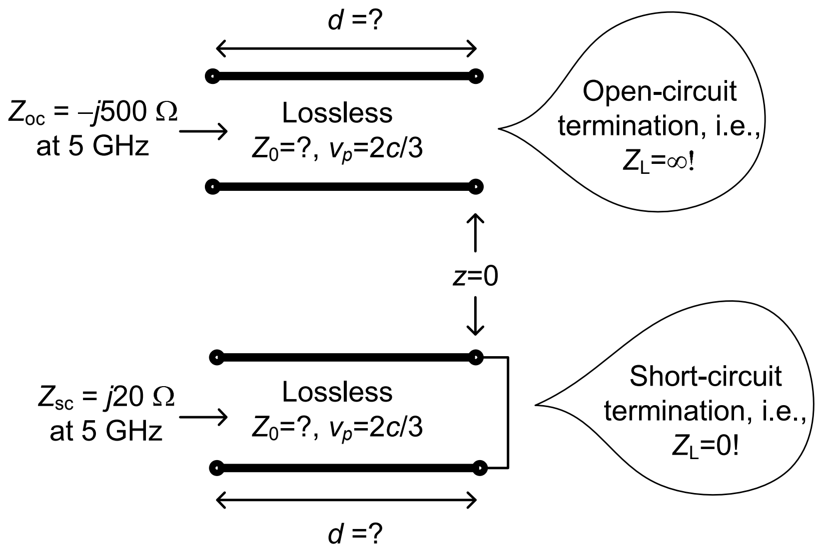
(2) Load reflection coefficient, standing wave ratio, and input impedance. A 50 Ω transmission line is terminated with a capacitive load having a load impedance of $Z_L = 100 - j100\,\Omega$, as shown. (a) Find the load reflection coefficient, i.e., Γ_L. (b) Find the standing wave ratio S on the line. (c) Find the input impedance of the line, Z_{in}, for four different line lengths: $d_1 = 0.125\lambda$, $d_2 = 0.25\lambda$, $d_3 = 0.375\lambda$, and $d_4 = 0.5\lambda$, respectively.



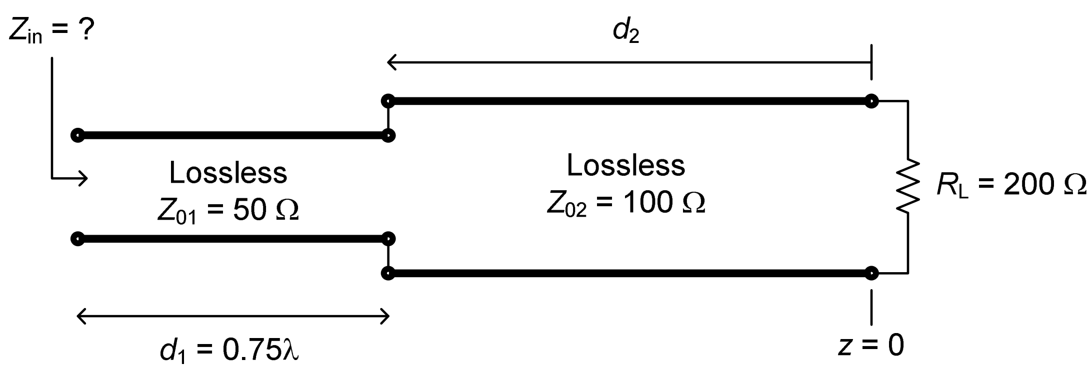
(3) Input impedance of a transmission line. Consider a short-circuited 50 Ω transmission line (a short-circuited stub) as shown. Find the shortest electrical length of the line such that (a) $Z_{in} = j50\,\Omega$; (b) $Z_{in} = -j150\,\Omega$; (c) $Z_{in} = \infty$, and (d) $Z_{in} = 0$.



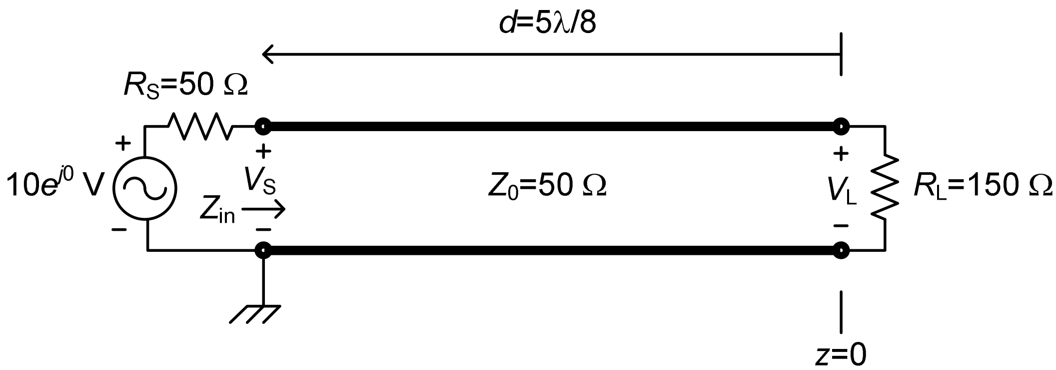
(4) Open- and short-circuit impedance measurements. If the open- and short-circuit terminated input impedances of a lossless transmission line with characteristic impedance Z_0, length d and phase velocity $v_p = 2c/3$ are measured at 5 GHz to be $Z_{oc} = -j500\ \Omega$ and $Z_{sc} = j20\ \Omega$ respectively, calculate Z_0 and the length d of this line. (Note that $c = 3 \times 10^8$ m/s.)



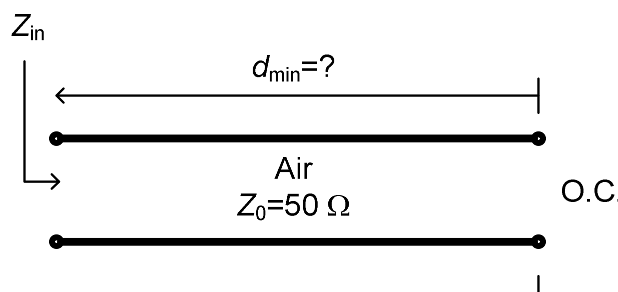
(5) Input impedance. Find the input impedance Z_{in} of the transmission line system shown for (a) d_2=0.25λ; (b) d_2=0.5λ; and (c) d_2=0.125λ.



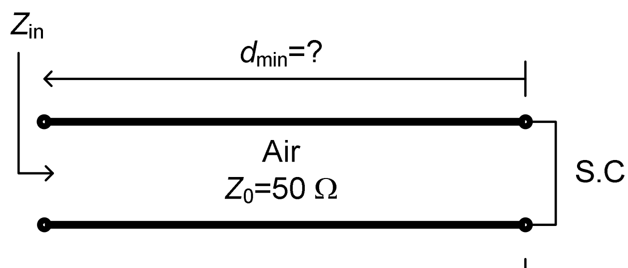
(6) Source- and load-end voltages. For the transmission line shown, assuming sinusoidal steady state, calculate the source-end and load-end voltages V_S and V_L in phasor form.



(7) Designing a capacitor using a stub. Capacitive and inductive circuit elements can be designed using short-circuit or open-circuited stubs. The lengths of these stubs are typically short with respect to the associated wavelength. (a) Design an open-circuited 50 Ω air stub that will provide the impedance of a 4 nF capacitor at 10 GHz. Find the shortest length of the stub. (b) Redesign the capacitor in part (a) using a short-circuited 50 Ω air stub. (c) Which design yields the shortest length and why?



(a) Open-circuited stub.



(b) Short-circuited stub.

(8) Designing an inductor using a stub. (a) Design an open-circuited 50 Ω micro-strip transmission-line stub having an effective relative dielectric constant of $\varepsilon_r \cong 6$ that will provide the impedance of a 5 nH inductor at 5 GHz. Find the shortest length of the stub. (b) Repeat the same design using a short-circuited 50 Ω micro-strip line stub having an effective relative dielectric constant of $\varepsilon_r \cong 6$. (c) Which design resulted in a shorter stub and why?

Please use the following guidelines for your homework solutions:

1) On the first sheet, at the top center, write: Homework #4-Solutions.
2) Provide your full name on the upper right corner of the first sheet.
3) Also write: EE 301/Spring 2014 on the upper left corner of the first sheet.
4) Solve each problem on a separate sheet unless your solution is very short.
5) Box all of your answers.
6) Staple your solutions in the above order before you turn them in.

Please turn in your homework on time.

An Important Reminder Note:

EE 301-Midterm # 2 is scheduled to be given on Friday, April 4, 2014

(It will be in-class closed-book exam. Two formula sheets will be allowed.)