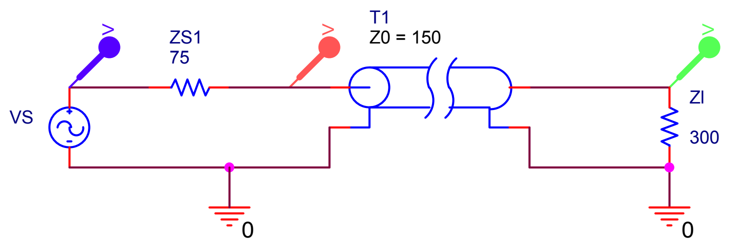
Name ______________ Fields and Waves I ECSE-2100 Fall 2002 Section ___________

Homework 2

Due Thursday 6, February, 2003

1) Input Impedance

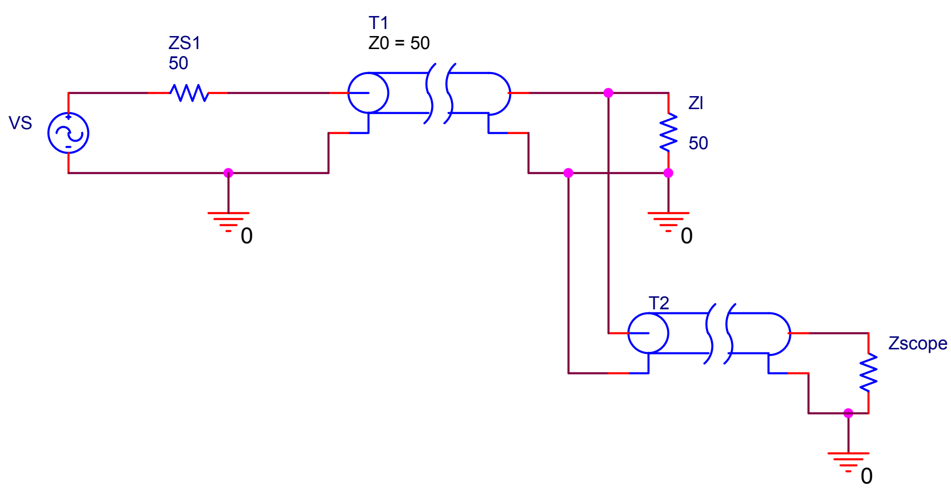


The above poorly designed lossless transmission line circuit has a length of 200 [m] and the velocity of propagation is 3E8 [m/s]. Assuming a 2E6 [Hz] source frequency and a 10 [V] source amplitude, determine the input voltage, V_{in}, and load voltage, V_l. Include a phase term relative to the source phase. The phase of the source is zero. Express your solution in time domain form.

Hint: This problem is identical to the one in lesson 1.5. You need to find Z_{in} and V^+, both of which are complex.

Verify your solution by implementing the circuit in PSpice. Include the plots in your homework.

2) Input Impedance - Oscilloscope



The above lossless circuit is equivalent to the circuits we use to measure load voltages with the equipment in class. T1 is the RG 58 A/U spool and T2 is the short section of coax we connect to the input of channel 1 or 2 on the oscilloscope. This short section is also RG 58 A/U. In taking any measurements, it is very important that the measurement circuit does not interfere with the circuit that is being measured.

Without the measurement circuit connected, how should the load voltage behave as a function of frequency?

Implement the circuit in PSpice and perform an AC sweep, measuring the load voltage as a function of frequency. Include the plot in your homework.

At what frequency does the measurement circuit affect the load voltage?

Approximately, what is the input impedance of the short section of line, T2? Your answer should be symbolic, not quantitative. Make reasonable approximations to simplify your formula.

At what frequency is the input impedance to T2 a short circuit? How does this answer compare with your PSpice plot?

3) Lossy Lines

A lossy transmission line with characteristics, $v_p = 2.6E8$ [m/s], $Z_o \sim 50$ [Ω], and a resistance per unit length of R = 0.09 [Ω/m] at 1.5E9 [Hz]. The conductance may be considered zero.

What are the inductance per unit length, *l*, and the capacitance per unit length, *c*?

Recalculate Z_o, including the imaginary components. Is it reasonable to only use the real part when calculating reflection coefficients or determining the current wave from a known voltage wave?

Determine the wave number, $\gamma = \sqrt{(r + j\omega\, l) * (g + j\omega\, c)}$?

Determine the forward propagating wave in phasor form. The voltage amplitude is 5 [V] at z = 0. (There is not a phase term).

Determine the forward propagating wave in time domain form.

Transmission lines are often used for delivering power. However, lossy lines cause power losses. Symbolically, determine the power loss as a function of position relative to the power input to the line. Express your result in dBs, where

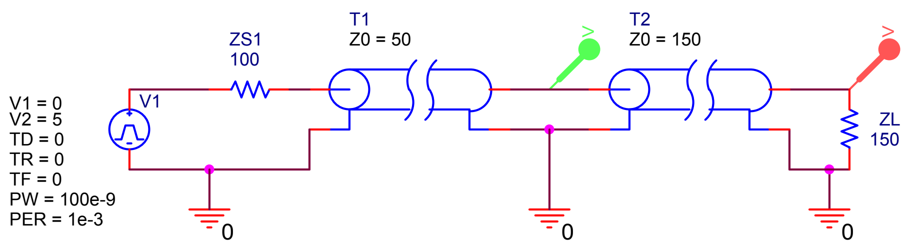
$$dB = 10\log\left(\frac{P(z)}{P_{in}}\right)$$

For this formula z = 0 at the input, so at the location $P(z) = P_{in}$ and the power loss is zero, as expected. (Hint: $P = VI^*/2$ for time average power.)

Where is the 3dB point? (3dB corresponds to a point where half the power is lost. Also, the log will be negative at the half power point, so technically it is –3dB. However, the negative sign is considered implicit when talking about 3dB points.)

Extra Credit: Losses on the transmission line are unavoidable. Dispersion is another affect of the lossy components. It causes pulses to lose their shapes as they propagate down the line. A dispersionless line can be fabricated by making Z_o purely real. To do this, we add conductance to the line. Perhaps by adding some conductive material to the insulator. For the above values or *l*, *c*, and *r*, what conductance per unit length, *g*, makes the characteristic impedance real? Simulate a line with dispersion and a line without dispersion using PSpice (TLOSSY parts). Use a pulsed source and 500 [m] of line. Plot the voltage at the output and compare the results. Eliminating the dispersion came with a price. What effect did adding conductance have on the line?

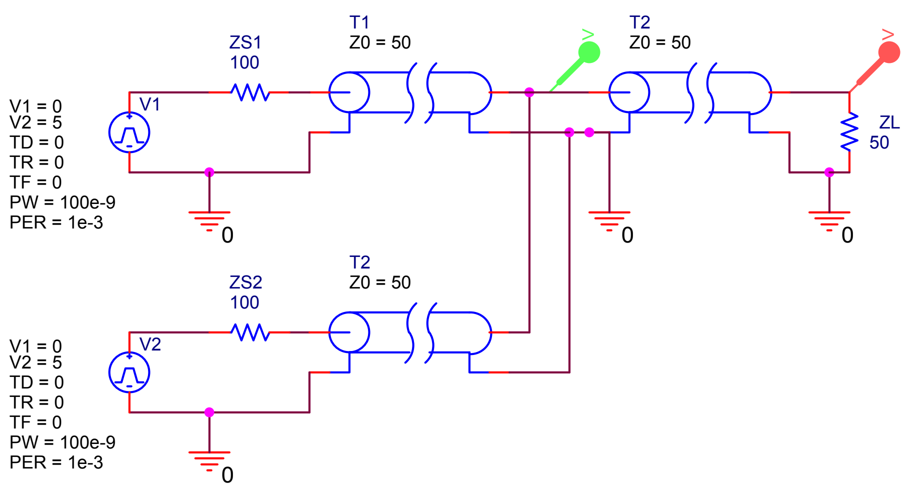
4) Easy Pulse Problem



In the above circuit, both transmission lines are lossless, 100 [m] long, and have a velocity of propagation 2E8 [m/s]. Determine the lattice diagram for both T1 and T2. Plot the voltage at the markers indicated for the time frame, t ∈ [0,4E-6]s. (Do this prior to using PSpice.)

Verify your voltage plots using PSpice.

4) Harder Pulse Problem



In the above circuit, all transmission lines are lossless, 100 [m] long, and have a velocity of propagation 2E8 [m/s]. Determine the lattice diagram for both T1 and T2. Plot the voltage at the markers indicated for the time frame, $t \in [0,4E-6]$s. (Do this prior to using PSpice.) Note, ZL and T2 have different impedance values than problem 4.

Verify your voltage plots using PSpice.