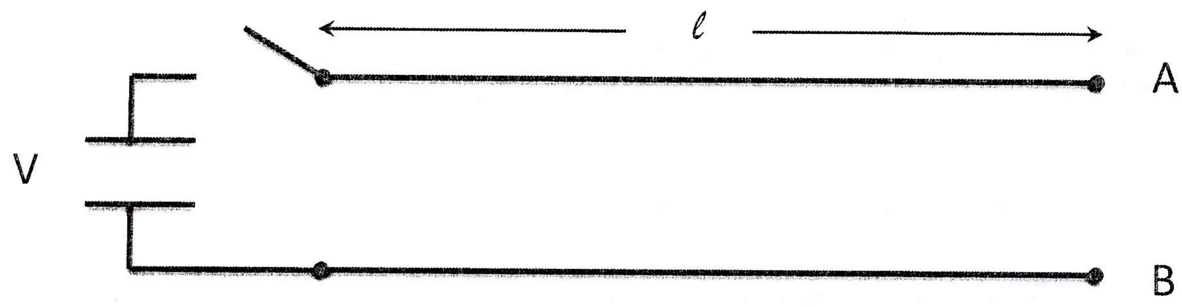
Name:__________________________

Reflection of em signals



1. The above figure illustrates a transmission line of length ℓ and impedance Z which delivers power from a battery of voltage V to a load connected between points A and B.

a) If no load is connected between points A and B (the end is open, and thus provides infinite resistance), what conditions must the current and the voltage satisfy at point A?

The current at point A must be zero, the voltage, however, does not have such a constraint since there can be a voltage change between A and B.

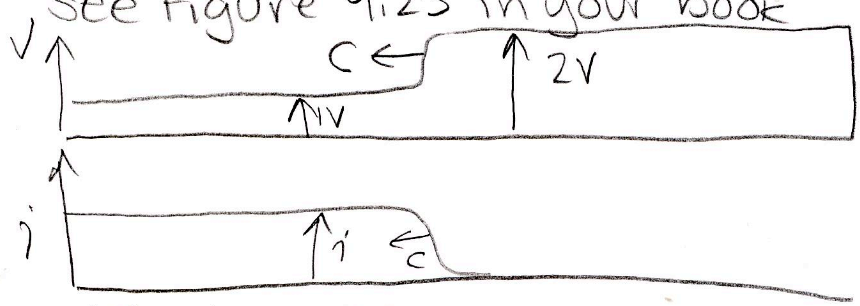
b) In analogy to the "hard" and "soft" boundaries for mechanical waves discussed in Chapter 6, is this a hard or soft boundary for voltage? for current?

Point A is a "hard" boundary for current and a "soft" boundary for voltage.

c) If the voltage from the battery propagates at the speed of light, how long does it take for the voltage to reach point A? $t = \ell / c$

d) Sketch the reflected voltage wave superimposed on the incoming voltage wave. Do the same for the current.

see Figure 9.23 in your book



e) What is the net result of the circuit after it has settled into a steady state (after the voltage wave has had time to get to the load and back to the battery several times)?

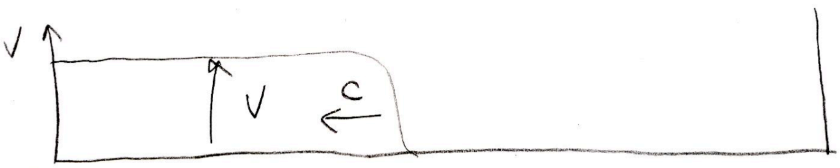
The net result is that the voltage drop between A and B must be equal to the voltage drop between the terminals of the battery. If we assume that the battery has some internal resistance that matches the impedance of the cable, the wave would be absorbed and steady state achieved (as in example 8 of your book). If the battery has zero internal resistance, the battery becomes a "hard boundary" for voltage, and the incoming +V pulse in reflected as a negative 1V pulse, but a battery always maintains a constant potential difference between it's terminals, so the battery outputs 2V for a net voltage of 1V going toward A, after anothe reflection at A, a steady state of 0 current and 1V potential difference is set up.

2. Now suppose a wire (with no resistance) is connected between points A and B.

a) What boundary conditions must the voltage and current satisfy at point A? Is it a "hard" or "soft" boundary for voltage? for current? The voltage at points A and B must be the same, $V_A = V_B$, so it is a hard boundary for voltage and a soft boundary for current.

b) Sketch the incoming voltage superimposed on the reflected voltage. Do the same for the current.

see Figure 9.24 of your book.



c) What is the net result of this circuit after enough time has elapsed that several reflections have been allowed to occur? If the internal resistance of the battery is zero the current again sees a shorted end at the battery. The current then keeps building up!

3. Now suppose you wish to connect a load of resistance R between points A and B.

see http://physics.usask.ca/~hirose/ep225/animation/emreflection/anin-emreflection.ht

a) For which R will you be able to power the load most efficiently? Discuss and justify your answer. The most efficient transfer of power occurs when R=Z because, in that case, there is no reflection,

b) What will happen if the load does not satisfy this condition?

There will be a partial reflection and a partial transmission of the incoming power.