EE Ph.D. Qualifying Exam, January 2006 Question

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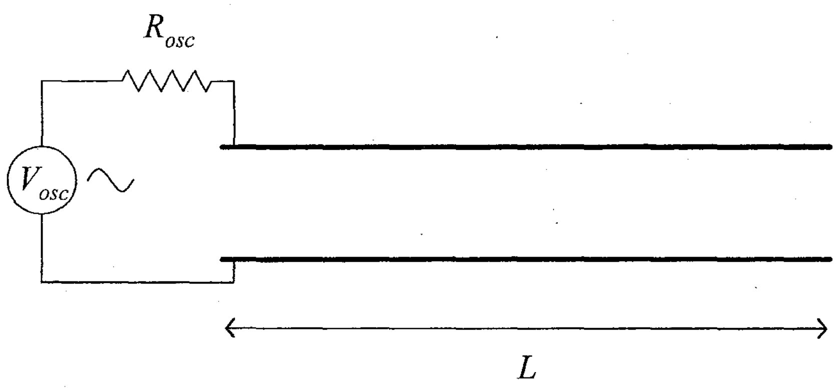
Transmission Line Resonances

Note: if you finish the questions on this sheet, subsequent questions will be asked.

Consider a uniform electrical transmission line of length L. An electrical oscillator produces a sinusoidally oscillating voltage of some fixed amplitude V_{osc} at a frequency f that can be varied. The oscillator is connected through a resistor to the transmission line at a point just inside one end of the transmission line as shown in the figures. The value of this resistor, R_{osc}, is very much greater than the characteristic impedance of the transmission line, Z. We will consider resonant frequencies in this line, i.e., frequencies at which the amplitude of the oscillating voltage on the line can build up to very large values at points or regions on the line.

For this problem, the line can be assumed to have very low loss, and to have a wave propagation velocity of c, the velocity of light in free space.

(a) For the case where the line has an open circuit at both ends,



(i) what is the lowest frequency at which there is a resonance?

(ii) what is the next frequency at which there is a resonance?

(iii) in general, at what frequencies are there resonances?

(b) For the case where the line is short-circuited at one end,

(i) what is the lowest frequency at which there is a resonance?

(ii) what is the next frequency at which there is a resonance?

(iii) in general, at what frequencies are there resonances?

(c) Returning again to case (a) (open circuit at both ends), what is the effect on the resonances of adding a resistor with value $R_{shunt} << Z$ across the line at the middle?