

Problem 2.1 A transmission line of length l connects a load to a sinusoidal voltage source with an oscillation frequency f . Assuming the velocity of wave propagation on the line is c , for which of the following situations is it reasonable to ignore the presence of the transmission line in the solution of the circuit:

- (a) $l = 20 \text{ cm}$, $f = 20 \text{ kHz}$,
- (b) $l = 50 \text{ km}$, $f = 60 \text{ Hz}$,
- (c) $l = 20 \text{ cm}$, $f = 600 \text{ MHz}$,
- (d) $l = 1 \text{ mm}$, $f = 100 \text{ GHz}$.

Solution: A transmission line is negligible when $l/\lambda \leq 0.01$.

- (a) $\frac{l}{\lambda} = \frac{lf}{u_p} = \frac{(20 \times 10^{-2} \text{ m}) \times (20 \times 10^3 \text{ Hz})}{3 \times 10^8 \text{ m/s}} = 1.33 \times 10^{-5} \text{ (negligible).}$
 - (b) $\frac{l}{\lambda} = \frac{lf}{u_p} = \frac{(50 \times 10^3 \text{ m}) \times (60 \times 10^0 \text{ Hz})}{3 \times 10^8 \text{ m/s}} = 0.01 \text{ (borderline).}$
 - (c) $\frac{l}{\lambda} = \frac{lf}{u_p} = \frac{(20 \times 10^{-2} \text{ m}) \times (600 \times 10^6 \text{ Hz})}{3 \times 10^8 \text{ m/s}} = 0.40 \text{ (nonnegligible).}$
 - (d) $\frac{l}{\lambda} = \frac{lf}{u_p} = \frac{(1 \times 10^{-3} \text{ m}) \times (100 \times 10^9 \text{ Hz})}{3 \times 10^8 \text{ m/s}} = 0.33 \text{ (nonnegligible).}$
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