ECE 3065 Homework 4: Link Budgets and Large-Scale Path Loss

1. **Link Budget:** The signal-to-noise ratio of a wireless link is the ratio of received power P_R (in Watts) to noise power P_N (also in Watts). The noise power of a link is a function of Bandwidth B (in Hz) and system noise temperature T_{sys} (in Kelvin):

$$P_N = kBT_{sys}$$

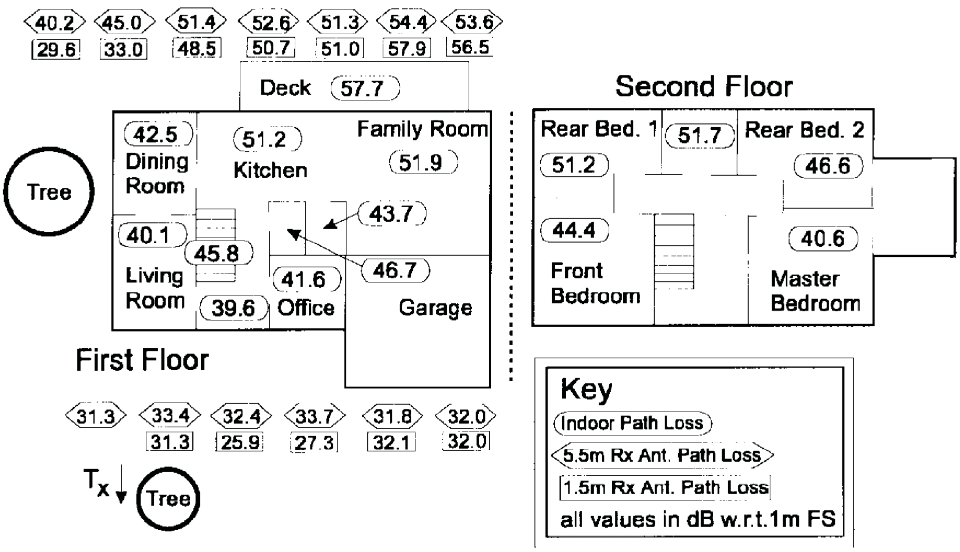
where k is Boltzmann's constant: $k = 1.3807 \times 10^{-23}$ J K^{-1}. The *Shannon Limit* on channel capacity is the highest possible data rate (in bits-per-second) that a given wireless link can support. This capacity is calculated with the following formula:

$$C = B \log_2(1 + \mathrm{SNR})$$

An IEEE 802.11g wireless network operates with 22 MHz of bandwidth at a center frequency of 2.45 GHz. The system noise temperature of a typical WiFi receiver is 190 K. If transmit and receive antennas both have gains of 0 dBi and the transmitter sends 800 mW into the transmit antenna, what is the furthest possible separation distance between transmitter and receiver before it becomes physically impossible to support transmission limits of 100 Mbit/sec in a line-of-sight channel? (**5 points**)

2. **RFID Warehouse:** Warehouses across the world have recently rolled out 915 MHz RFID tags on their palettes, with hopes of extending the technology for product-level tracking. These "wireless barcodes" are adhesive strips of paper with a small antenna (gain of -2 dBi) and a small passive chip that must power itself up by scavenging energy from the incoming 915 MHz radio wave, which is also used for communications. The source of this wave is a *reader* that, for safety reasons, has a transmitted power limit of 1 Watt. A typical reader antenna has a gain of 3 dBi. If the chip requires at least -13 dBm of received power to charge up, what is the maximum separation distance between RFID tag and reader that can be maintained? (5 points)

3. **Path Loss Exponent:** You are hired as a consultant to study signal propagation in and around homes and trees at 5.85 GHz, which is the unlicensed radio band for IEEE 802.11a networks. Your client is interested in delivering wireless internet into homes from 5m-high utility top poles. You collect a great deal of data in and around a sample home, which has been recorded to scale on the last sheet of this homework assignment. Using a ruler to calculate distances, estimate a path loss exponent for this indoor/outdoor data that helps network planners model coverage. Report the standard deviation of your model. (**10 points**)



Scale: 0 1 2 3 4 5m

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