Example 4.11

This example demonstrates how to use Equations (4.94) and (4.95) to predict the mean path loss 30 m from the transmitter, through three floors of Office Building 1 (see Table 4.5). Assume that two concrete block walls are between the transmitter and receiver on the intermediate floors. From Tables 4.5 and 4.7, the mean path loss exponent for same-floor measurements in a building is $n = 3.27$, the mean path loss exponent for three-floor measurements is $n = 5.22$, and the average floor attenuation factor is FAF = 24.4 dB for three floors between the transmitter and receiver. Table 4.3 shows a concrete block wall has about 13 dB of attenuation. Let $d_0 = 1$ m.

Solution

The mean path loss using Equation (4.94) is

$$\begin{aligned}\overline{PL}(30\text{ m})[\text{dB}] &= \overline{PL}(1\text{m})[\text{dB}] + 10 \times 3.27 \times \log(30) + 24.4 + 2 \times 13 \\ &= 130.2\text{ dB}.\end{aligned}$$

The mean path loss using Equation (4.95) is

$$\overline{PL}(30\text{ m})[\text{dB}] = \overline{PL}(1\text{ m})[\text{dB}] + 10 \times 5.22 \times \log(30) + 2 \times 13 = 108.6\text{ dB}.$$

4.12 Signal Penetration into Buildings

The signal strength received inside of a building due to an external transmitter is important for wireless systems that share frequencies with neighboring buildings or with outdoor systems. As with propagation measurements between floors, it is difficult to determine exact models for penetration as only a limited number of experiments have been published, and they are sometimes difficult to compare. However, some generalizations can be made from the literature. In measurements reported to date, signal strength received inside a building increases with height. At the lower floors of a building, the urban clutter induces greater attenuation and reduces the level of penetration. At higher floors, a LOS path may exist, thus causing a stronger incident signal at the exterior wall of the building.

RF penetration has been found to be a function of frequency as well as height within the building. The antenna pattern in the elevation plane also plays an important role in how much signal penetrates a building from the outside. Most measurements have considered outdoor transmitters with antenna heights far less than the maximum height of the building under test. Measurements in Liverpool [Tur87] showed that penetration loss decreases with increasing frequency. Specifically, penetration attenuation values of 16.4 dB, 11.6 dB, and 7.6 dB were measured on the ground floor of a building at frequencies of 441 MHz, 896.5 MHz, and 1400 MHz, respectively. Measurements by Turkmani [Tur92] showed penetration loss of 14.2 dB, 13.4 dB, and 12.8 dB for 900 MHz, 1800 MHz, and 2300 MHz, respectively. Measurements made in front of windows indicated 6 dB less penetration loss on average than did measurements made in parts of the buildings without windows.