Outdoor Channel Modeling at Sub-THz Frequencies for Future Fixed Wireless Access Applications

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The large bandwidths that are available in the mmWave and sub-THz spectrum enable high-throughput wireless communication for applications such as fixed wireless access, and pilot programs have proven the viability of fixed wireless access networks at mmWave frequencies as a cheaper and reliable alternative to fiber optic installations. In this paper, we present outdoor channel measurements at sub-THz frequencies in the D-band, ranging from 110 to 170 GHz, contributing to the design of future fixed wireless access networks.

We measure angular path loss (PL) along different tracks, categorized into Line-of-Sight (LOS) and non-Line-of-Sight (NLOS), using a spectrum analyzer-based channel sounder with an omnidirectional transmit antenna and directional receiving horn antenna, both vertically polarized. For the LOS tracks, we measure directional PL for distances ranging from 1 to 100 m, in steps of 1 m. Every 10 m, a full angular scan is performed with angular steps of 12°, which corresponds to the horn antenna’s half-power beamwidth. For the NLOS tracks, we perform a full angular scan for distances ranging from 9 to 26 m. The angular PL data is combined into omnidirectional PL, and used to calculate angular spread. The measured PL samples are fitted to the floating-intercept (FI) model from (1), with $PL_0$ the reference PL in dB at 1 m, $n$ the PL exponent, and $\chi_\sigma$ the shadow fading term in dB, based on a zero-mean normal distribution with standard deviation $\sigma$.

$$PL_{FI,dB}(d) = PL_0 + 10n\log_{10}(d/1m) + \chi_\sigma$$

Next to LOS and NLOS measurements, we also perform building reflection loss measurements as a function of angle of incidence for different building facade materials, as well as vegetation loss measurements.

![Figure 1. Measured path loss samples and floating-intercept path loss model.](image)

Fitting directional LOS PL to the FI model results in $PL_0 = 80.7$ dB, $n = 1.88$, and $\sigma = 1.45$ dB. For the omnidirectional LOS FI PL model, $PL_0$ decreases to 76.2 dB, due to the power that is received via multipath components, $n = 1.87$ and $\sigma = 1.47$ dB. The angular spread of the LOS measurements is 19.7°. The omnidirectional NLOS FI PL model has a much higher $PL_0$ of 84.4 dB and $n = 2.32$. The angular spread increases to 54.4°. Reflection on a car gives an additional loss up to 4 dB, whereas losses up to 11 dB should be taken into account for reflection on a fiber cement or building brick facade. For a roughcast or stone brick facade, the reflection losses further increase up to 15 or 20 dB. Vegetation loss ranges from 0.1 dB/m for light vegetation up to 10 dB/m for dense vegetation, and should be taken into account when designing future FWA networks.