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

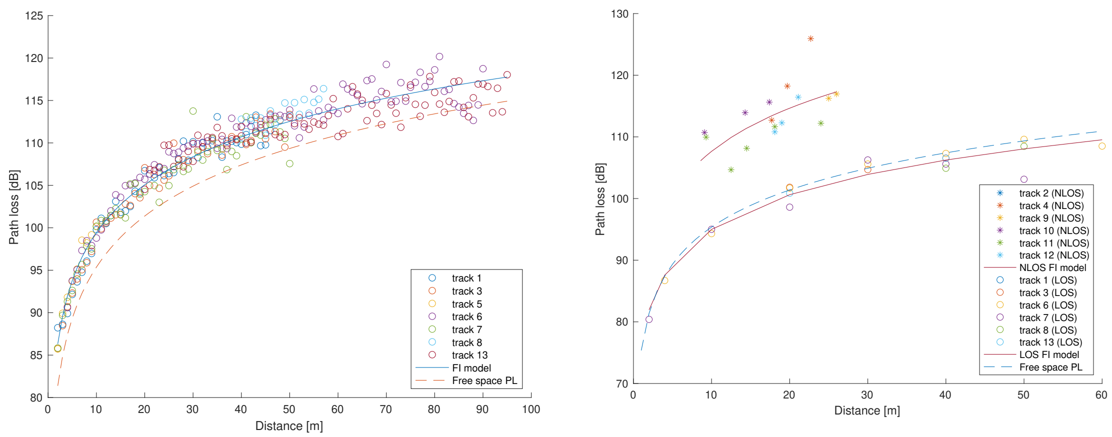
Brecht De Beelde*, Emmeric Tanghe, David Plets, and Wout Joseph
Department of Information Technology, Ghent University/IMEC, 9052 Ghent, Belgium

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 χ_σ the shadow fading term in dB, based on a zero-mean normal distribution with standard deviation σ.

$$\text{PL}_{\text{FI,dB}}(d) = \text{PL}_0 + 10n\log_{10}(d/1\text{m}) + \chi_\sigma \tag{1}$$

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.



(**a**) Directional LOS path loss

(**b**) Omnidirectional LOS and NLOS path loss

Figure 1. Measured path loss samples and floating-intercept path loss model.

Fitting directional LOS PL to the FI model results in PL_0 = 80.7 dB, n = 1.88, and σ = 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 σ = 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.