Path loss and angle of arrival measurements at 27 GHz in urban environments

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Abstract

This paper describes path loss measurements carried out at 27 GHz in London and Brighton.
The primary purpose of the measurement campaign was to provide empirical support for the development of clutter loss models (being undertaken separately) for use in predicting inter-system interference at millimetre wave frequencies,. Particular attention has been paid to characterising the role of reflections in coupling energy on such interference paths.

1 Introduction

The drive to exploit new frequency bands for 5G systems has brought with it the need to characterise short-range propagation in urban areas (e.g. [1]). While much of the focus has been on understanding the behaviour of the wanted path from base station to user, it is also necessary to characterise potential interference paths to terminals of other services.
With the latter objective in mind, a brief series of propagation measurements have been made in London and Brighton in the UK, intended to inform model development within the ITU-R by gathering data on the clutter losses applicable to paths from terminals below the height of urban clutter to points well clear of that clutter.

2 Measurement method

The principal quantity of interest in the present study is the basic path loss associated with urban and outdoor-to-indoor paths at millimetre-wave frequencies. Although information on the wideband channel is not necessary, the use of a channel sounder to make the measurements is a straightforward way to remove multipath fading from the measurements; the information recorded on the power delay profile of the channel may also be valuable in later comparison with ray-tracing models.

A simple channel sounder has been constructed, with a bandwidth of 200 MHz, using the sliding correlator principle, and operates with an IF of 2.3 GHz with up- and down-converter heads for the required frequency (see Figure 1).

The sounder operates in a non-coherent mode, as the local oscillators for the up/down-converters are not locked to the rubidium standards used in the IF part of the system.

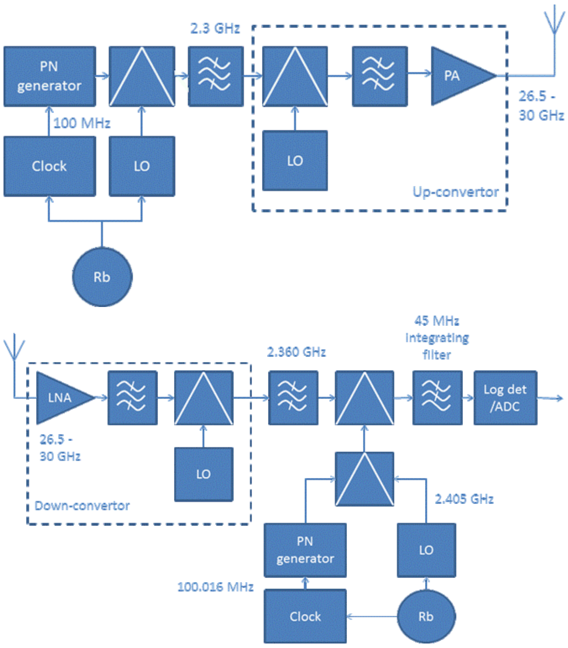

Figure 1: Channel sounder

The transmitter up-converter unit is shown in operation in Figure 2 below. Identical 20 dBi horn antennas are used at each terminal, with a 3dB beamwidth 0f 18.3° in the H-plane. The measurements described here were made using vertical polarisation, and with a transmitter EIRP of 20dBW.


Figure 2: Transmit up-converter

The receiver unit was mounted on a vehicle at 2m above ground, with the down-converter configured to scan in azimuth in 5° increments. Data is logged in the form of a sequence of channel impulse responses captured to a computer as the azimuth scan progresses. The receiver arrangement is illustrated in Figure 3.

Figure 3: Receive down-converter on scanning mount

Measurements were made with the car stationary (an azimuth sweep takes approximately two minutes). Measurement locations were chosen quasi-randomly, based largely on the availability of parking spaces.

3 Data processing

The raw measurement data for each measurement point is in the form of a series of 72 power delay profiles (PDP), sampled at 5° increments of receiver azimuth. While this data could provide information relevant for wideband channel modelling, only the overall received power is relevant to the present study.
For each point, the significant, discrete arrivals in azimuth have been identified (e.g. Figure 4); in general, one arrival will lie on the geometric azimuth of the transmitter, and will correspond to the direct path, often diffracted over rooftops, and sometimes lying below the receiver noise floor. Up to three arrivals due to reflected paths are also tabulated.

4 Results

Measurements were made in three contrasting environments; a relatively open university campus (Figure 5), the dense, but low-rise Victorian centre of Brighton and substantial concrete architecture of the South bank area in London.

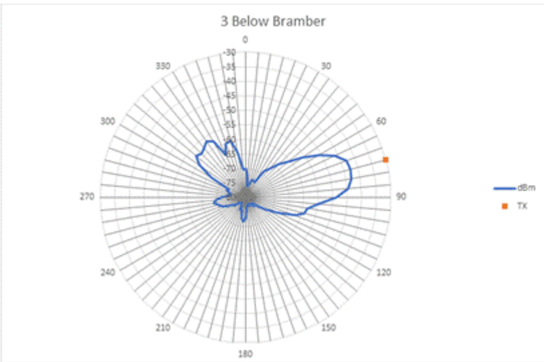

Figure 4: Azimuth plot of received power (Sussex University)
In general, paths that were non-line of sight exhibited very high loss, as would be expected at these frequencies. In a number of cases, however, the overall loss was determined by the presence of specular reflections from building facades, as seen in the azimuth plot above.

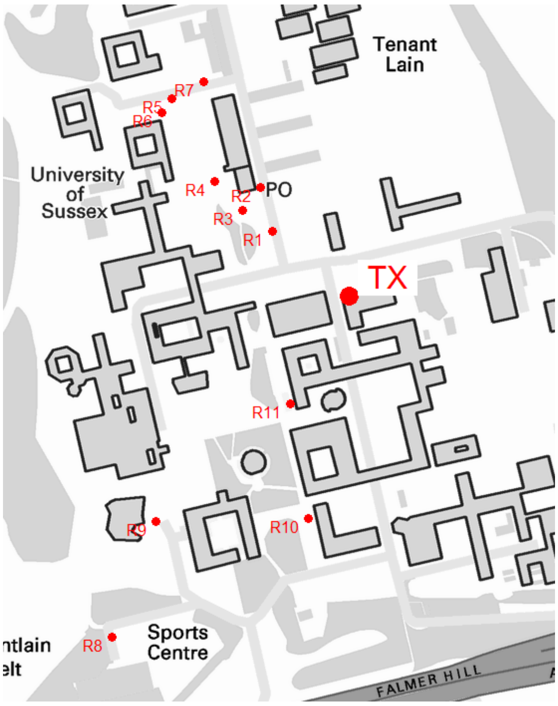

Figure 5: Measurement sites (Sussex University)

The overall set of 37 measurement results have been combined to give a cumulative distribution function for the path loss in excess of the free space value (Figure 6). The limited size of the data set should be borne in mind when examining this figure. This data has been used in the validation of the new ITU-R model in [2].

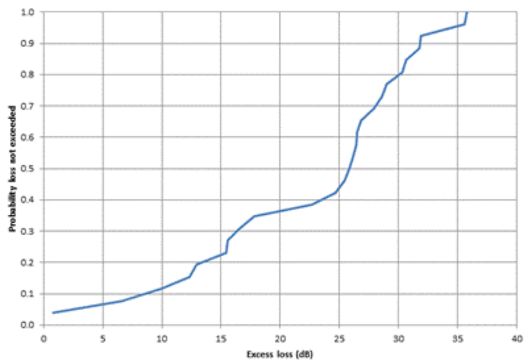

Figure 6: CDF of excess loss (all measurements)

References

[1] Maccartney, G.R., et al "*Millimeter-Wave Omnidirectional Path Loss Data for Small Cell 5G Channel Modelling*", IEEE Access Volume 3, pp.1572-1580, 6 August 2015
[2] ITU-R Recommendation P.2108 "*Prediction of clutter loss*", ITU-R, Geneva, June 2017