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Contents

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1 Scope

The present document establishes channel models to be used for deployment evaluation.

References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

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[1] L.M. Correia, ed., Wireless flexible personalized communications – COST 259: European co-operation in mobile radio research, John Wiley & Sons 2001.

[2] GSM 05.05, 'Digital cellular telecommunications system (Phase 2+); Radio transmission and reception'

3 Definitions, symbols and abbreviations

3.1 Definitions

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3.2 Symbols

For the purposes of the present document, the following symbols apply:

σ_τ R.M.S. delay spread.
Fd Maximum Doppler shift
fs Doppler frequency of the direct path, given by its direction relative to the mobile direction of movement

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

COST European Co-operation in the field of Scientific and Technical research
GSM Global System for Mobile communications
HT Hilly Terrain
RA Rural Area
TU Typical Urban
UMTS Universal Mobile Telecommunications System

4 General

The channel models have been chosen as simplifications, or typical realisations of the COST 259 model [1] that is described in more detail in Annex A.

A large number of paths (20) in each model ensure that the correlation properties in the frequency domain are realistic. Path powers follow the exponential channel shapes in the COST 259 model. The delay spreads for each model are close to expected medians when applying the COST 259 model in reasonably sized macrocells. In the rural model a direct path is present, resulting in Rice-type fading when filtered to wideband channels. The hilly terrain model consists of two clusters, a typical situation in these environments.

With the chosen parameters the models will be quite similar to the GSM channel models [2], after filtering to the GSM bandwidth.

In Section 5, the channel models are specified explicitly. The tap delays have been determined by generating 20 independent identically distributed values from a uniform distribution in the interval $[0, 4 \cdot \sigma_\tau]$, where σ_τ is the rms delay spread. For the Hilly Terrain channel 10 paths have been generated for each cluster and for the Rural Area model there is a total of 10 taps. Relative powers have then been calculated using the channel shapes in Annex A, Table A.3. The channels have been normalised so that the total power in each channel is equal to one.

Channel model descriptions

Radio wave propagation in the mobile environment can be described by multiple paths which arise due to reflection and scattering in the mobile environment. Approximating these paths as a finite number of N distinct paths, the impulse response for the radio channel may be written as:

$$h(\tau) = \sum_i^N a_i \delta(\tau_i)$$

which is the well known tapped-delay line model. Due to scattering of each wave in the vicinity of a moving mobile, each path a_i will be the superposition of a large number of scattered waves with approximately the same delay. This superposition gives rise to time-varying fading of the path amplitudes a_i, a fading which is well described by Rayleigh distributed amplitudes varying according to a classical Doppler spectrum:

$$S(f) \propto 1/(1-(f/f_D)^2)^{0.5}$$

where $f_D = v/\lambda$ is the maximum Doppler shift, a function of the mobile speed v and the wavelength λ. In some cases a strong direct wave or specular reflection exists which gives rise to a non-fading path, then the Doppler spectrum is:

$$S(f) = \delta(f_s)$$

where f_s is the Doppler frequency of the direct path, given by its direction relative to the mobile direction of movement.

The channel models presented here will be described by a number of paths, having average powers $|a_i|^2$ and relative delays τ_i, along with their Doppler spectrum which is either classical or a direct path. The models are named Tux, Rax and HTx, where x is the mobile speed in km/h. Default mobile speeds for the models are according to Table 5.1. The relative position of the taps is for each model listed with a 0.001 µs resolution.

Table 5.1: Default mobile speeds for the channel models.

Channel model	Mobile speed
Tux	3 km/h
	50 km/h
	120 km/h
Rax	120 km/h
	250 km/h
HTx	120 km/h

The models may in certain cases be simplified to a specific application to allow for less complex simulations and testing. The simplification should be done with a specific time resolution ΔT, which should be stated to avoid confusion: e.g. Rax(ΔT=0.1µs). An example of such a simplified model is shown in Annex B.

9.0 Typical Urban channel model (Tux)

Table 5.2: Channel for urban area

Tap number	Relative time (µs)	average relative power (dB)	7oppler spectrum
1	0	-5.7	Class
2	0.217	-7.6	Class
3	0.512	-10.1	Class
4	0.514	-10.2	Class
5	0.517	-10.2	Class
6	0.674	-11.5	Class
7	0.882	-13.4	Class
8	1.230	-16.3	Class
9	1.287	-16.9	Class
10	1.311	-17.1	Class
11	1.349	-17.4	Class
12	1.533	-19.0	Class
13	1.535	-19.0	Class
14	1.622	-19.8	Class
15	1.818	-21.5	Class
16	1.836	-21.6	Class
17	1.884	-22.1	Class
18	1.943	-22.6	Class
19	2.048	-23.5	Class
20	2.140	-24.3	Class

9.0 Rural Area channel model (Rax)

Table 5.3: Channel for rural area

Tap number	Relative time (µs)	average relative power (dB)	7oppler spectrum
1	0	-5.2	Direct path, $f_s = 0.7 \cdot f_D$
2	0.042	-6.4	Class
3	0.101	-8.4	Class
4	0.129	-9.3	Class
5	0.149	-10.0	Class
6	0.245	-13.1	Class
7	0.312	-15.3	Class
8	0.410	-18.5	Class
9	0.469	-20.4	Class
10	0.528	-22.4	Class

9.0 Hilly Terrain channel model (HTx)

Table 5.4: Channel for hilly terrain area

Tap number	Relative time (µs)	average relative power (dB)	8oppler spectrum
1	0	-3.6	Class
2	0.356	-8.9	Class
3	0.441	-10.2	Class
4	0.528	-11.5	Class
5	0.546	-11.8	Class
6	0.609	-12.7	Class
7	0.625	-13.0	Class
8	0.842	-16.2	Class
9	0.916	-17.3	Class
10	0.941	-17.7	Class
11	15.000	-17.6	Class
12	16.172	-22.7	Class
13	16.492	-24.1	Class
14	16.876	-25.8	Class
15	16.882	-25.8	Class
16	16.978	-26.2	Class
17	17.615	-29.0	Class
18	17.827	-29.9	Class
19	17.849	-30.0	Class
20	18.016	-30.7	Class