



millimetre Wave Transmission (mWT); V-band street level interference analysis

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Contents

Intellectual Property Rights	4
Foreword.....	4
Modal verbs terminology.....	4
Executive summary	4
Introduction	4
1 Scope	6
2 References	6
2.1 Normative references	6
2.2 Informative references.....	6
3 Definitions, symbols and abbreviations	7
3.1 Definitions.....	7
3.2 Symbols.....	7
3.3 Abbreviations	7
4 Equipment and propagation characteristics.....	8
4.1 Equipment and RF.....	8
4.2 Capacities and requirements.....	8
4.3 Propagation: oxygen absorption - loss.....	9
5 Link Planning	10
5.1 Model used	10
6 Link calculations - geometrical approach.....	10
6.1 Physical analysis	10
6.1.1 Single link- LoS -Mainbeam.....	10
6.1.2 Interference area	20
6.1.3 Urban Streets' geometry.....	22
6.2 Conclusions on the geometrical approach.....	25
7 Statistical models.....	25
7.1 Introduction	25
7.1.1 Simulation highlights.....	25
7.1.2 Interference criteria.....	26
7.2 Backhaul implemented by FS links only	27
7.2.1 Introduction.....	27
7.2.2 Simulations	27
7.2.3 Conclusions on statistical simulation.....	31
Annex A (informative): Bibliography.....	33
Annex B (informative): Authors & contributors.....	34
History	35

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) millimetre Wave Transmission (mWT).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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Executive summary

The present document is related to the evaluation of interference that is expected to affect Fixed Service (FS) links, operating at street level in Radio Frequency (RF) band 57 - 66 GHz, (so called V-band), which is widely subject to unlicensed or light licensed regimes for part below 64 GHz.

The interference level in such conditions is a function of network density, equipment and antenna characteristics, available Bandwidth (BW).

In particular, the probabilistic analysis made with the SEAMCAT[®] tool, and the equipment and antennas designed according to the ETSI EN 302 217 multipart standard [i.1] and [i.2], show that, provided that a limited number of channels (5 to 10) are available, with limited channel BW (200 to 400 MHz), the operations of very high density networks with link density of up to about 200 links / km², to transmit high transmission capacities (in the order of 1 GHz/s per channel), are achieving acceptable confidence levels of operations (less than 2 % interference probability). Antenna class 2 RPE is proven to be already enough effective.

NOTE: SEAMCAT[®] is the trade name of a product supplied by the European Communications Office (ECO). This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Introduction

The specific characteristics of the V-band, concerning propagation and licensing, implies further analysis for understanding the condition of usage in specified environments.

While the high propagation loss due to oxygen absorption is expected to simplify frequency reuse and interference related impairments, the widespread adoption of licensing regimes, not generally link-by-link based, implies that it is not generally possible to implement an interference control mechanism based on the knowledge of the characteristics of links in a common geographic area.

For same reasons, even in the case a block license is assigned, the licensee can experience difficulties in undertaking this activity, due to the difficulty of knowing if other services, apart from FS, are also using the band in some locations. In any case, the user of the block needs to evaluate, in relation with the block size, how much the block can be used in term of exploitable link density.

The present document is intended to clarify these issues and aims to provide some general considerations and guidance.

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1 Scope

The present document examines the application of radio links in the V-band frequencies, in urban applications, with special regard to interference issues, taking into account equipment characteristics, propagation issues and expected requirements.

Wherever possible, punctual and statistical analyses are performed and applicability of calculation methods is investigated.

The purpose of the present document is to investigate the feasibility of using unlicensed band by analysing interference levels in co-channels and adjacent channels in dense deployment of Point to Point (PP) radio at the street level, taking into considerations

- equipment characteristics,
- capacities and BW requirements,
- standards,
- available channels,
- antennas,
- available standards and propagation:
 - oxygen absorption;
 - loss and modelling.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

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The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

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NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI EN 302 217-3: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 3: Equipment operating in frequency bands where both frequency coordinated or uncoordinated deployment might be applied; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".
 - [i.2] ETSI EN 302 217-4-2 (V1.4.1): "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-2: Antennas; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".
 - [i.3] ECC Report 20: "Methodology to determine the density of Fixed Service".
 - [i.4] Recommendation ITU-R F.699: "Reference radiation patterns for line-of-sight radio-relay system antennas for use in coordination studies and interference assessment in the frequency range from 1 GHz to about 70 GHz".
 - [i.5] Recommendation ITU-R P.676: "Attenuation by atmospheric gases".
 - [i.6] ECC Report 114: "Compatibility studies between multiple gigabit wireless systems in frequency range 57-66 GHz and other services and systems (except its in 63-64 GHz)".
 - [i.7] Recommendation ITU-T G.826: "End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections".
 - [i.8] ETSI EN 302 217-4-1: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-1: System-dependent requirements for antennas".
 - [i.9] SEAMCAT® Spectrum Engineering Advanced Monte Carlo Analysis.
- NOTE: Available at: <http://www.seamcat.org/>.
- [i.10] ITU-R Recommendation P.452: "Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Void.

3.2 Symbols

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

C/I	Carrier-to-interference Ratio
I/N	Interference-To-Noise Ratio
P.Out	Output Power
Rx	Receiver
Tx	Transmitter

3.3 Abbreviations

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

ATPC	Adaptive Transmitter Power Control
BW	BandWidth

C	Carrier
dBi	dB relative to an isotropic radiator
DFS	Dynamic Frequency Selection
FR	Frequency Range
FS	Fixed Service
G	antenna Gain
I	Interferer
LoS	Line of Sight
N	Noise
PP	Point-to-Point
RF	Radio Frequency
RPE	Reference Pattern Envelope
RSL	Received Signal Level
thr	threshold
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying

4 Equipment and propagation characteristics

4.1 Equipment and RF

Link calculation has been executed starting from different equipment characteristics with different modulation schemes.

The following assumptions were made, based on ETSI EN 302 217-3 [i.1] for equipment in the 64 - 66 RF band:

Transmitter (Tx) power = +10 dBm

Quadrature Phase Shift Keying (QPSK), 16 Quadrature Amplitude Modulation (QAM) and 64QAM modulation schemes are considered.

Receiver (Rx) threshold: 4 QPSK: -65,5 dBm

16QAM: -58,5 dBm

64QAM: -52,5 dBm

Carrier-to-interference Ratio (C/I) (1 dB degradation): 4 QPSK = 24 dB

16QAM = 31 dB

64QAM = 38 dB

C/I (3 dB degradation): 4 QPSK = 15 dB

64QAM = 29 dB

Channel size: 200 MHz Channels have been used, obtained by joining 4 consecutive 50 MHz basic channels.

4.2 Capacities and requirements

Modulation schemes adopted in the examples are QPSK, 16QAM and 64QAM, corresponding to capacities in the order of 300 Mbit/s to 1 Gbit/s.

Parameters and Objectives:

- Availability has only been accounted for two values: 99,9 %, 99,99 %.

Values in this range are commonly used when unlicensed spectrum use is considered, and are coherent with the general approach of objectives' apportionment expressed by the ITU-T (e.g. Recommendation ITU-T G.826 [i.7])

for end-to-end paths, where less relaxed objectives are allowed to the edge (terminating) sections in comparison with the transit portions, where much higher requirements are needed to allow for proper end-to-end figures.

Rain rate: Three values for rain rate have been used from low to moderate: 30 mm/h, 42 mm/h, 60 mm/h.

- Antennas:
 - Antennas - RPE have been calculated according to Recommendation ITU-R F.699 [i.4] and ETSI EN 302 217-4-2 [i.2].
 - Antenna gain: Two gain values have been considered: 38 dBi; 32 dBi.

In order to be relatively close to real devices, characteristics in the main lobe have been done in accordance with Recommendation ITU-R F.699 [i.4], while Reference Pattern Envelope (RPE) outside the main lobe has been obtained as a realistic compromise between ITU-R and ETSI, since ETSI does not provide values for mainlobe.

An example of the RPE derivation is shown in figure 4.2.1 (38 dBi, ETSI EN 302 217-4-2 [i.2] FR7 class 3).

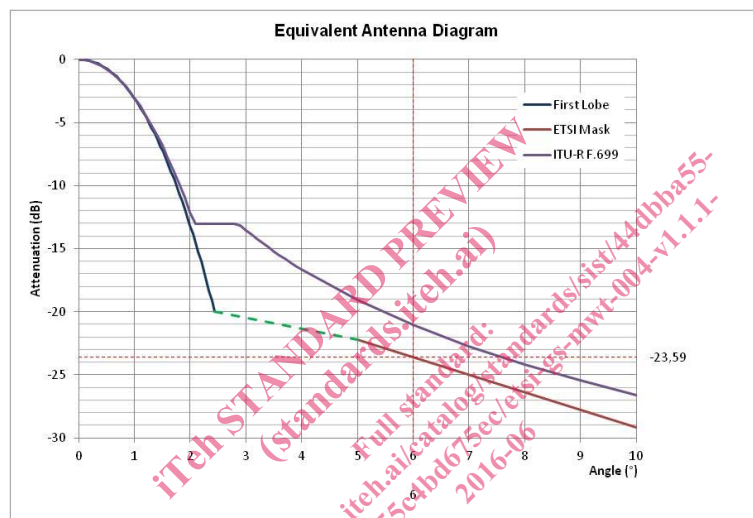


Figure 4.2.1: RPE derivation

4.3 Propagation: oxygen absorption - loss

Effect of gas absorption can be found in Recommendation ITU-R P.676 [i.5].

Figures 4.3.1 and 4.3.2 show current values according to version in force (Recommendation ITU-R P.676-10) [i.5].

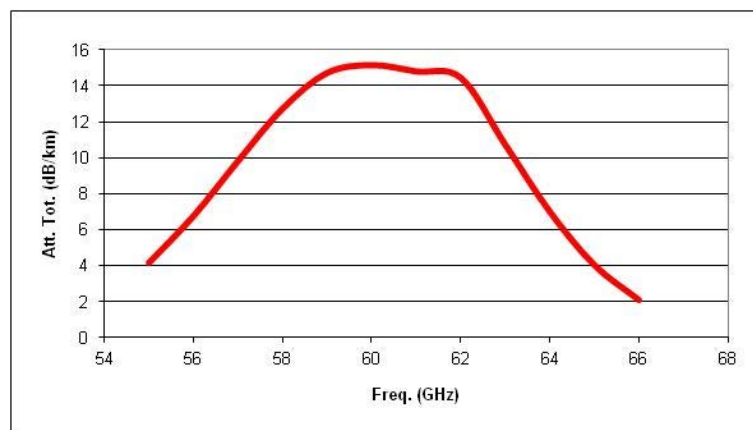


Figure 4.3.1: total attenuation

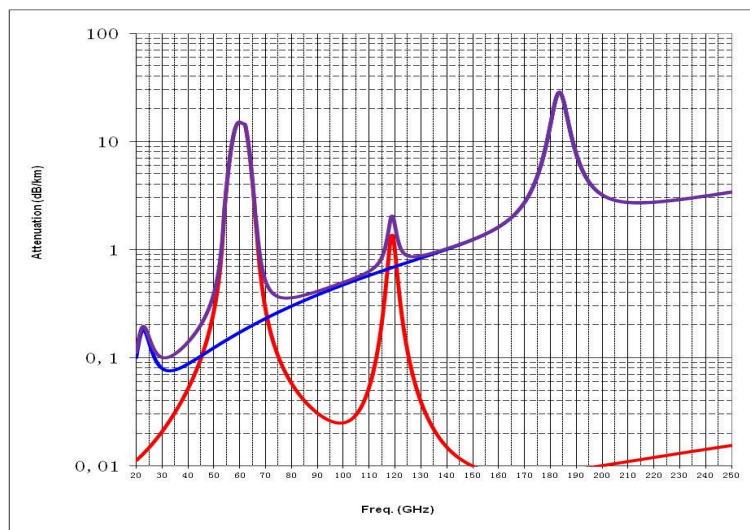


Figure 4.3.2: attenuation

5 Link Planning

5.1 Model used

Initial calculations have been performed based on a single link in Line of Sight (LoS) condition:

- Analysis of expected hop length has been performed.
- Analysis of interference areas in same conditions are reported.

6 Link calculations - geometrical approach

6.1 Physical analysis

6.1.1 Single link- LoS -Mainbeam

Effect of frequency /Effect of rain

The maximum hop length corresponding to 99,9 % of availability have been computed for QPSK, 16QAM, 64QAM with a 32 dBi and 38 dBi antennas, at three rain rates as above.

Three different oxygen attenuations have been used (4,1 / 12,8 / 14,6 dB/km) representing different frequency (58, 61,5 and 65 GHz) of the considered V band.

Related diagrams are shown in figures 6.1.1.1 and 6.1.1.2.

Same results are shown with 99,99 % availability (figures 6.1.1.3 and 6.1.1.4).

