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Technical Specification

Broadband Radio Access Networks (BRAN);
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Radio Conformance Test Specification

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Foreword

This Technical Specification (TS) has been produced by ETSI Project Broadband Radio Access Networks (BRAN).

1 Scope

The present document applies to the HIPERACCESS air interface with the specifications of radio conformance test of layer 1 (Radio conformance tests). HIPERACCESS is confined to only the radio subsystem consisting of the *physical (PHY) layer* and the *DLC layer* - which are both core network independent - and the core network specific *convergence sub-layer*.

In order to ensure if the equipment built by different manufacturers from the PHY-perspective are interoperable and compliant with TS 101 999 [1], standardized conformance test procedures for HA-PHY specifications on the mutual recognition within ETSI, shall be specified. However, for supporting these test procedures some basic functionalities from DLC layer [2] are required.

The scope of the present document is as follows:

- It gives a description of the requirements for the radio conformance test suites.
- It specifies the test procedure and the test condition limit in order to ensure the interoperability between equipment developed by different manufacturers. This is achieved by testing all signal processing structure in the transmitter and the reception sides including scrambling, channel coding, modulation, framing, power control parameters and measurements to support the radio resource management.
- The present document covers basic RF aspects, including the radio frequency channel plans and those other parameters necessary for radio regulatory coexistence purposes.
- Some normative annexes are also included covering the test sheet and the supplier declaration.

2 References

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

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

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

[1] ETSI TS 101 999: "Broadband Radio Access Networks (BRAN); HIPERACCESS; PHY protocol specification".

[2] ETSI TS 102 000: "Broadband Radio Access Networks (BRAN); HIPERACCESS; DLC protocol specification".

[3] ETSI EN 300 019-1-4: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weather protected locations".

[4] ETSI EN 300 385: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for fixed radio links and ancillary equipment".

[5] ETSI EN 301 489-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements".

[6] CENELEC EN 61000-6-1: "Electromagnetic compatibility (EMC); Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments".

[7] CENELEC EN 55022: "Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement".

[8] CENELEC EN 60950: "Safety of information technology equipment".

[9] CEPT/ECC/REC (01)-04: "Recommended guidelines for the accommodation and assignment of Multimedia Wireless Systems (MWS) in the frequency band 40,5 to 43,5 GHz".

[10] CEPT/ERC/REC 01-02: "Preferred channel arrangement for digital fixed service systems operating in the frequency band 31,8 - 33,4 GHz".

[11] CEPT/ERC/REC 13-04: "Preferred frequency bands for fixed wireless access in the frequency range between 3 and 29,5 GHz".

[12] CEPT/ERC/REC T/R 13-02: "Preferred channel arrangements for fixed services in the range 22,0 - 29,5 GHz".

[13] CEPT/ERC/REC 01-03: "Use of parts of the band 27,5-29,5 GHz for Fixed Wireless Access (FWA)".

[14] CEPT/ERC/REC 00-05: "Use of the band 24,5 - 26,5 GHz for fixed wireless access".

[15] ETSI EN 301 215-2: "Fixed Radio Systems; Point-to-Multipoint Antennas; Antennas for point-to-multipoint fixed radio systems in the 11 GHz to 60 GHz band; Part 2: 24 GHz to 30 GHz".

[16] ETSI EN 301 215-3: "Fixed Radio Systems; Point to Multipoint Antennas; Antennas for point-to-multipoint fixed radio systems in the 11 GHz to 60 GHz band; Part 3: Multipoint Multimedia Wireless System in 40,5 GHz to 43,5 GHz".

[17] ETSI EN 301 213-1: "Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 1: Basic parameters".

[18] ITU-T Recommendation G.821: "Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an integrated services digital network".

[19] ITU-T Recommendation G.826: "Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate".

[20] ITU-T Recommendation G.827: "Availability parameters and objectives for path elements of international constant bit-rate digital paths ".

[21] ITU-T Recommendation M.2100 (Series): "Performance limits for bringing-into-service and maintenance of international multi operator PDH paths, and connections".

[22] ETSI EN 301 126-2-3: "Fixed Radio Systems; Conformance testing; Part 2-3: Point-to-Multipoint equipment; Test procedures for TDMA systems".

[23] ETSI EN 301 126-3-2: "Fixed Radio Systems; Conformance testing; Part 3-2: Point-to-Multipoint antennas - Definitions, general requirements and test procedures".

[24] ETSI EN 301 213-3, V1.4.1: "Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 3: Time Division Multiple Access (TDMA) methods".

[25] ETSI TR 100 028-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1".

[26] ETSI TR 100 028-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".

[27] ETSI EN 301 215-4: "Fixed Radio Systems; Point-to-Multipoint Antennas; Antennas for multipoint fixed radio systems in the 11 GHz to 60 GHz band; Part 4: 30 GHz to 40,5 GHz".

[28] ERC/REC 74-01: "Spurious emissions".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Access Point (AP): generalized equipment consisting of an Access Point Controller (APC) and several Access Point Transceivers (APT)

cell: geographical area controlled by an Access Point

control zone: part of the DL frame

DL burst: transmission event consisting of a channel-symbol-sequence (preamble and the data symbols) corresponding to a given PHY mode transporting one or several FEC-blocks in the optional TDMA zone of the DL frame

DL MAC frame: structured data sequence with fixed duration of 1 ms

NOTE: It contains a 32-symbol frame preamble, a variable length control zone, a variable length TDM-zone and an optional variable length TDMA-zone.

DL map: MAC message that defines the starting symbols for both TDM and TDMA access by an AT on the DL

Downlink (DL): direction from AP to AT

downlink channel: channel transmitting data from APT to AT

FEC-block: block resulted from the encoding of traffic (up to a maximum number of 216 (downlink)/220 (uplink) bytes) received from the DLC (1, 2, 3 or 4 MAC PDUs when supporting a fixed PDU size DLC)

Frame Offset (FO): time difference between the DL frame and UL frame, selected by the AP in case of FDD mode

frequency reuse: ratio between the available frequency carriers to the number of frequency carriers used per sector

full-duplex: equipment (e.g. AT) which is capable of transmitting and receiving data at the same time

guard-time: time at the beginning or end of each burst to allow power ramping-up and down

half-duplex: equipment (e.g. AT) which cannot transmit and receive data simultaneously

MAC PDU: data unit exchanged between the DLC and PHY layers, consisting of the MAC PDU header and the MAC PDU payload

Net Filter Discriminator (NFD): ratio between the interfering power and portion of the interfering power falling into the victim Rx filter

PHY mode: combination of a signal constellation (Modulation alphabet) and FEC parameters (i.e. inner, outer, block-length, etc.)

power ramping: operation performed during the guard time period for power transition from OFF-level to ON-level and vice versa

preamble: sequence of channel symbols with a given auto-correlation property assisting modem synchronization and channel estimation

puncturing: operation for increasing the coding rate of a convolutional code by not transmitting (= by deleting) some coded bits

sector: geometrical area resulting from the cell-splitting by the use of a Sector Antenna

shortening: operation for decreasing the length of a systematic block code that allows an adaptation to different information bits/bytes sequence length

supplier: organization requesting the conformance test approval

supplier declaration: procedure by which a supplier gives written assurance that a parameter or function conforms to the EN/ETS

tail-bits: 6 zero bits inserted for trellis termination of a convolutional code in order to force the trellis to go to the zero state

TDM-Zone: part of the DL frame consisting of contiguous TDM-data streams regions corresponding to different PHY modes-regions, starting by the most robust PHY mode

TDMA-Zone: part of the DL frame consisting of optional TDMA data using different PHY modes, where each PHY mode-region is separated with preamble

Tx/Rx switching time: amount of time required to transition from the PHY reception to the PHY transmission or vice versa for H-FDD AT or TDD AP and AT

UL burst: transmission event consisting of a power ramp-up, channel-symbol-sequence (preamble and the data symbols) corresponding to a given PHY mode transporting DLC traffic and control bytes in the UL TDMA frame and power ramp-down

UL burst concatenation: process for concatenation of several UL bursts, where a unique power ramp-up time shall be used at the beginning of the first burst

UL map: MAC message scheduling UL bursts

Uplink (UL): direction from AT to AP

uplink channel: channel transmitting data from AT to APT

3.2 Symbols

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

α	Roll-off factor
β	Primitive element of the Galois Field
B	Channel bandwidth in MHz
B_n	Equivalent Noise bandwidth in MHz
dBi	decibel relative to isotropic radiator
dBm	decibel relative to 1 mW
DS	Duplex spacing ($f_{n'}$ - f_n)
ΔI	Inphase rms error voltage
ΔQ	Quadrature rms error voltage
Δloss	Implementation loss
eqloss	Equalization and synchronization loss
f_c	The carrier frequency
f_r	The reference frequency in MHz
f_n	The centre frequency (MHz) of the radio-frequency slot in the lower half of the band
$f_{n'}$	The centre frequency (MHz) of the radio-frequency slot in the upper half of the band
f_N	The Nyquist frequency: 1/(2 T_s)
h	hour
h(t)	Raised root cosine filter impulse response
H(f)	Raised root cosine filter transfer function
K	Number of information byte per RS codeword
M	Number of bits transmitted per modulated symbol
NF	Noise Figure in dB
N_o	Noise Spectral density in dBm/Hz
R_s	Symbol rate
Rxloss	Receiver branching loss
S_{max}	Transmit Amplitude of the utmost symbol vector
t	Number of error correction capability of a RS code (t=8 here)

T_{samp}	Symbol duration after sampling
T_s	Channel symbol duration
r	Inner code rate (convolutional code rate)
φ	Phase
μs	Micro second

3.3 Abbreviations

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

A/D	Analogue/Digital
AH	Artificial Hop
AP	Access Point
APC	AP Controller
APT	AP Transceiver
ARQ	Automatic Repeat reQuest
AT	Access Termination
ATM	Asynchronous Transfer Mode
ATPC	Automatic Transmit Power Control
ATTC	Automatic Transmit Time Control
AWGN	Additive White Gaussian Noise
BB	Base Band
BER	Bit Error Rate
CAZAC	Constant Amplitude Zero Auto Correlation
CCF	Channel Centre Frequency
C/I	Carrier to Interference power ratio
CW	Continuous Wave
D/A	Digital/Analogue
DDPC	Dynamic Downlink Power Control
DL	DownLink
DLC	Data Link Control
ECC	Error Correction Coding
EIRP	Effective Isotropic Radiated Power
EVM	Error Vector Magnitude
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FO	Frame Offset
FWA	Fixed Wireless Access
HA	HIPERACCESS
HD	Half Duplex
H-FDD	Half-duplex Frequency Division Duplex
IDU	InDoor Unit
MAC	Medium Access Control
MWS	Multimedia Wireless System
NFD	Net Filter Discriminator
ODU	OutDoor Unit
PDU	Protocol Data Unit
PHY	PHYsical (layer)
PSU	Power Supply Unit
QAM	Quadrature Amplitude Modulation with square constellation
RCTS	Radio Conformance Test Specification
RF	Radio Frequency
RS	Reed-Solomon
Rx	Receiver
SP	Symbol Period
STC	Symbol Transmit Clock
TDD	Time Division Duplex
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TPC	Turbo Product Code

Tx	Transmitter
UL	UpLink

4 Overview

The HA PHY- and the DLC Technical Specification, TS 101 999 [1] and TS 102 000 [2] specify the HIPERACCESS (HA) transmission scheme in order to guarantee ***interoperability*** between equipment developed by different manufacturers. This is achieved by describing all signal processing structures and all protocol issues.

The HA-Radio Conformance Test Specification (HA-RCTS) is intended to specify the conformance testing procedures and requirements (for both direction of each transceiver, i.e. AP and AT) of all parameters specified by TS 101 999 [1].

In addition to the main requirements of the HA-RCTS, Supplier Declaration and the Test Report are also detailed. The purpose is to provide a harmonized test report format in order to achieve a uniform and comprehensive presentation of suppliers' declarations and test results.

The general block diagram of the HA transmission system is illustrated in figure 1 and taken from TS 101 999 [1].

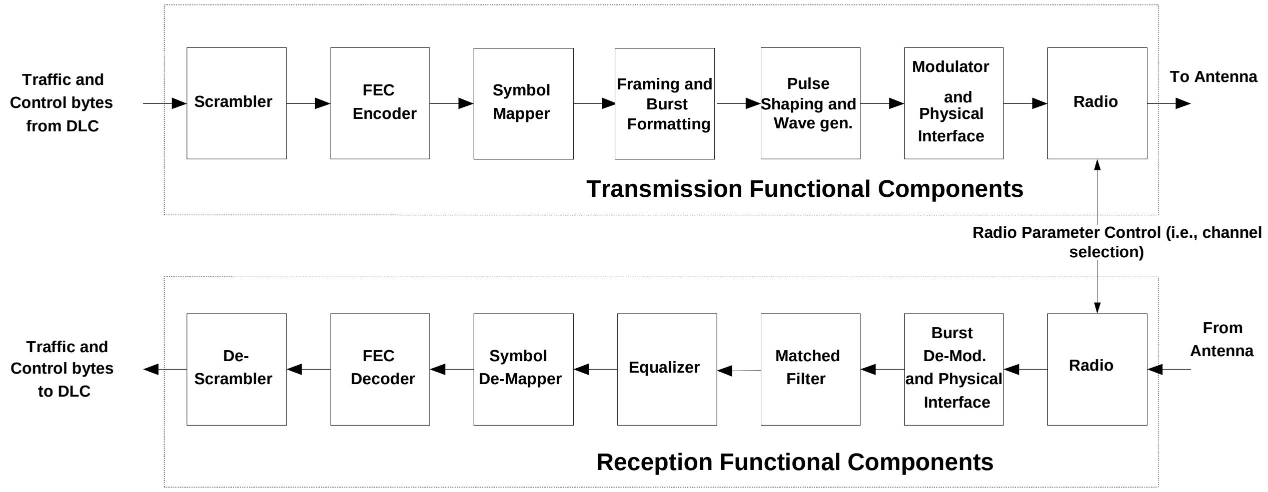

Figure 1: PHY layer conceptual block diagram

The HA-PHY implementation includes transmission and reception functional components. For the downlink, transmission occurs in the AP and reception in the AT. For the uplink, transmission occurs in the AT and reception in the AP. Although very similar in concept, note that the AP equipment in general handles more than one RF channel and more than one user (AT); hence its actual architecture will be different.

The HA transmission operation from the PHY perspective starts with a stream of traffic and control bytes sent from the DLC layer. These data will be randomized using a scrambler. The resulting data after FEC-coding is then mapped into symbols according to the designated modulation density. These modulated symbols and the corresponding preambles are multiplexed to form a frame or a burst (in the downlink case the preamble exists only at the beginning of the frame or at the beginning of each optional TDMA region). The resulting symbols after framing or burst formatting are pulse shaped and wave formed (i.e. root raised cosine filtered) and are forwarded through a physical interface (i.e. D/A) to the radio transmitter.

The HA reception operation from the PHY perspective starts with receiving an analog signal from the radio receiver. The physical interface (i.e. A/D) converts the signal to the digital domain and a demodulator identifies the preamble existence and the reception process may properly initiate. A matched filter is used to extract symbol values and an equalizer structure can be used to further enhance signal quality. Symbols are translated to actual bits by constellation de-mapping. A FEC decoder corrects channel errors and may be used to identify data integrity. Any randomization done by the scrambler in the transmission process is removed and finally the received control and traffic bytes are sent to the higher DLC-layer for continued processing.

Main features of HA PHY-layer are:

- single carrier transmission;
- adaptive coding and modulation;
- dynamic power control;
- support of FDD and TDD.

4.1 General requirements

The general block-diagram with naming of test interfaces is given in figure 2. Such block-diagram is only meant to describe conceptually main system components and interfaces, and does not dictate any implementation.

The following abbreviations have been used:

A: Antenna interface;

D: DLC interface;

P: PHY interface;

STC: Symbol Transmit Clock interface.

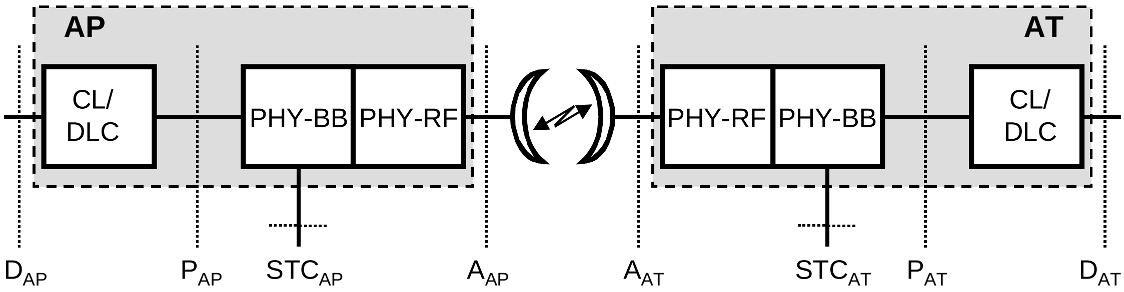

Figure 2: General block-diagram

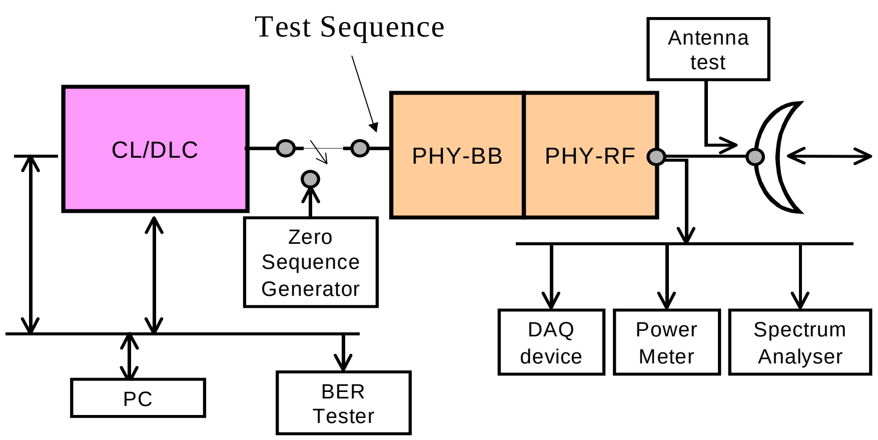

Figure 3: Interconnection of test instruments at test interfaces

Two possibilities for test sequence generation at PHY input are allowed, as reported in figure 3.

- Injection of an externally generated sequence, by means of a test pattern generator instrument.

- Self-generated test sequence by means of DLC.

Even if the supplier is free to choose between above possibilities, for the sake of simplicity all figures in the rest of the document will assume the injection of an externally generated sequence.

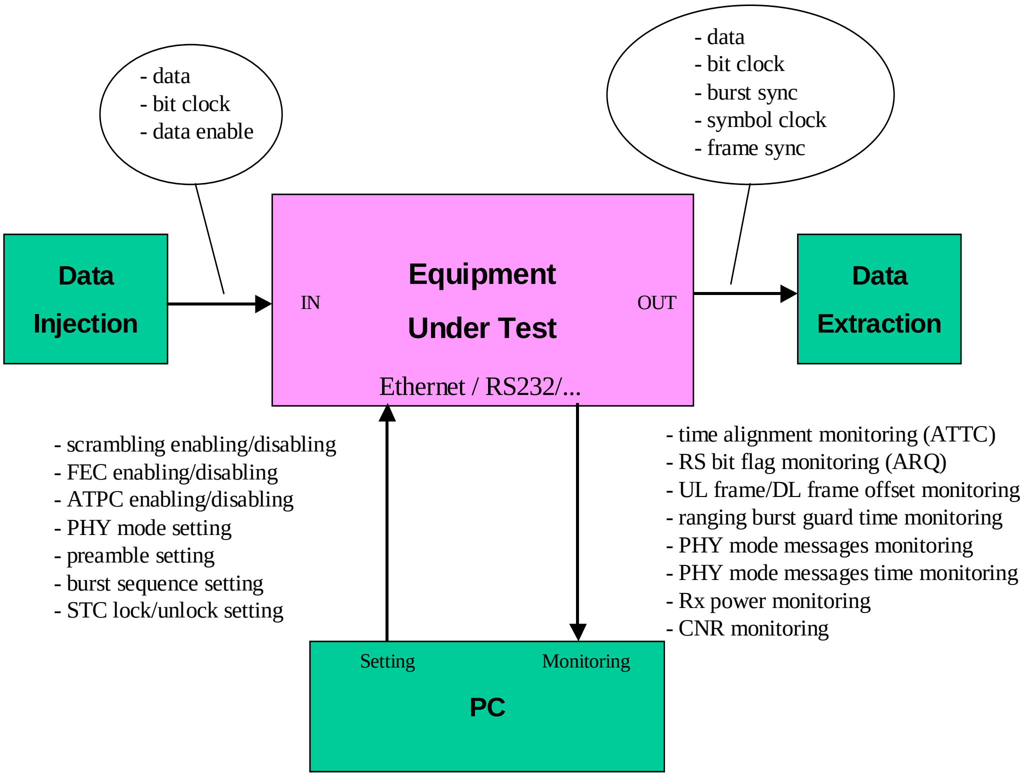

Figure 4: Configuration and measurement test interfaces

4.1.1 Test equipment

The following equipment will be needed for all the test-operations:

- PC for system configuration (parameter setting) and control;
- RF-Adapter;
- Spectrum Analyser;
- Variable RF-Attenuator (Equivalent to free space/rain attenuation);
- Power meter, Power sensor;
- Power Supply Unit (PSU);
- IF-Cable;
- BER Test Equipment;
- (Zero sequence generator);
- RF-Synthesizer;
- Oscilloscope;
- Printer, Plotter.

4.1.2 General test conditions

Most of the tests have to be performed in **normal** environmental conditions:

Temperature: +15°C up to +30°C

Humidity: 45 % up to 75 % (relative).

All technical data should be measured after warm-up. The warm-up time is defined as the time needed for the reference oscillator to achieve the required frequency offset error. Assuming a normal ambient temperature the warm-up time shall be less than or equal to 30 min. Therefore, all measurements have to be done after a **warm-up time of 30 min**.

4.1.3 Test set-up definitions

Reference test temperatures are named as (see clause A.1.2.1):

- (L: Lowest),
- M: Medium;
- H: Highest.

These temperatures depend on environmental classes, which is subject to the supplier declaration.

Reference test frequencies are named as: B: Bottom; M: Middle; T: Top, where Bottom means the channel at lowest carrier frequency, Top means the channel at highest carrier frequency and Middle means the nearest channel to the centre of equipment frequency band, which is subject to the supplier declaration.

PHY modes are named according to the labels in the following tables, where:

- the first letters indicate if the mode is for DownLink (DL) or UpLink (UL);
- the following number is progressive with mode efficiency;
- the final letter (only for UL) indicates the length of the mode (S for Short).

Table 1: DL PHY modes labels

Set	Label	Inner code	Outer code	Modulation	Optional/ Mandatory	Protection goal
Set 1	DL-0	CC1/2	RS (46,30, t=8)	4QAM	Mandatory	DL control zone
	DL-1	CC2/3	RS (232, 216, t=8)	4QAM	Mandatory	4 x MAC PDUs
	DL-2	no	RS (232, 216, t=8)	4QAM	Mandatory	4 x MAC PDUs
	DL-3	CC7/8	RS (232, 216, t=8)	16QAM	Mandatory	4 x MAC PDUs
	DL-5	CC5/6	RS (232, 216, t=8)	64QAM	Optional	4 x MAC PDUs
Set 2	DL-0	CC1/2	RS (46,30, t=8)	4QAM	Mandatory	DL control zone
	DL-1	CC2/3	RS (232, 216, t=8)	4QAM	Optional	4 x MAC PDUs
	DL-2	no	RS (232, 216, t=8)	4QAM	Optional	4 x MAC PDUs
	DL-4	no	RS (232, 216, t=8)	16QAM	Optional	4 x MAC PDUs
	DL-6	no	RS (232, 216, t=8)	64QAM	Optional	4 x MAC PDUs

Table 2: UL PHY modes labels

Set	Label	Inner code	Outer code	Modulation	Optional/ Mandatory	Protection goal
Set 1	UL-1	CC2/3	RS (236, 220, t=8)	4QAM	Mandatory	4 x MAC PDUs
	UL-1S	CC2/3	RS (28,12, t=8)	4QAM	Mandatory	Short signalling PDU
	UL-2	no	RS (236, 220, t=8)	4QAM	Mandatory	4 x MAC PDUs
	UL-2S	no	RS (28,12, t=8)	4QAM	Mandatory	Short signalling PDU
	UL-3	CC7/8	RS (236, 220, t=8)	16QAM	Optional	4 x MAC PDUs
	UL-3S	CC7/8	RS (28,12, t=8)	16QAM	Optional	Short signalling PDU
Set 2	UL-1	CC2/3	RS (236, 220, t=8)	4QAM	Mandatory	4 x MAC PDUs
	UL-1S	CC2/3	RS (28,12, t=8)	4QAM	Mandatory	Short signalling PDU
	UL-2	no	RS (236, 220, t=8)	4QAM	Mandatory	4 x MAC PDUs
	UL-2S	no	RS (28,12, t=8)	4QAM	Mandatory	Short signalling PDU
	UL-4	no	RS (236, 220, t=8)	16QAM	Optional	4 x MAC PDUs
	UL-4S	no	RS (28,12, t=8)	16QAM	Optional	Short signalling PDU

4.2 Required tests

Table 3 lists all the required tests (mandatory and optional) to ensure conformance with TS 101 999 [1].

Table 3: List of tests to be performed to ensure conformance

	Mandatory	Optional
Radio Parameters		
Carrier frequencies	M	
Channel allocation	M	
Symbol transmit clock and tolerance	M	
RF channel and spectrum mask	M	
Transmitter output power and tolerance	M	
Dynamic DL Power Control (DDPC)		O
Tx static power setting		O
Automatic Transmit Power Control (ATPC)	M	
Error vector magnitude	M	
Antenna gain	M	
Time mask for burst transmission	M	
Tx/Rx switching time	M	
Receiver sensitivity	M	
Performance in multi-path channel	M	
Background BER	M	
Receiver dynamic range	M	
Co-channel interference performance	M	
Adjacent channel interference performance	M	
CW spurious interference	M	
Rx-power measurement	M	
CNR measurement	M	
Spurious emissions	M	
Automatic transmit timing control	M	
Load levelling and carrier recovery time	M	
Base band parameters		
Scrambler/De-scrambler	M	
FEC Encoder/Decoder and ARQ	M	
Signal constellation and mapping	M	
Framing and alignments	M	
Burst formatting and alignments	M	
UL-preamble selection	M	
Set of PHY modes	M	
PHY mode adaptation parameters	M	
Performance monitoring and management parameters	M	

4.3 General test platform

The general test platform is depicted in figure 5. The test platform consists mainly of an Artificial Hop (AH), the AP (IDU and ODU), the AT (IDU and ODU) and further test-equipment (see clause 7).

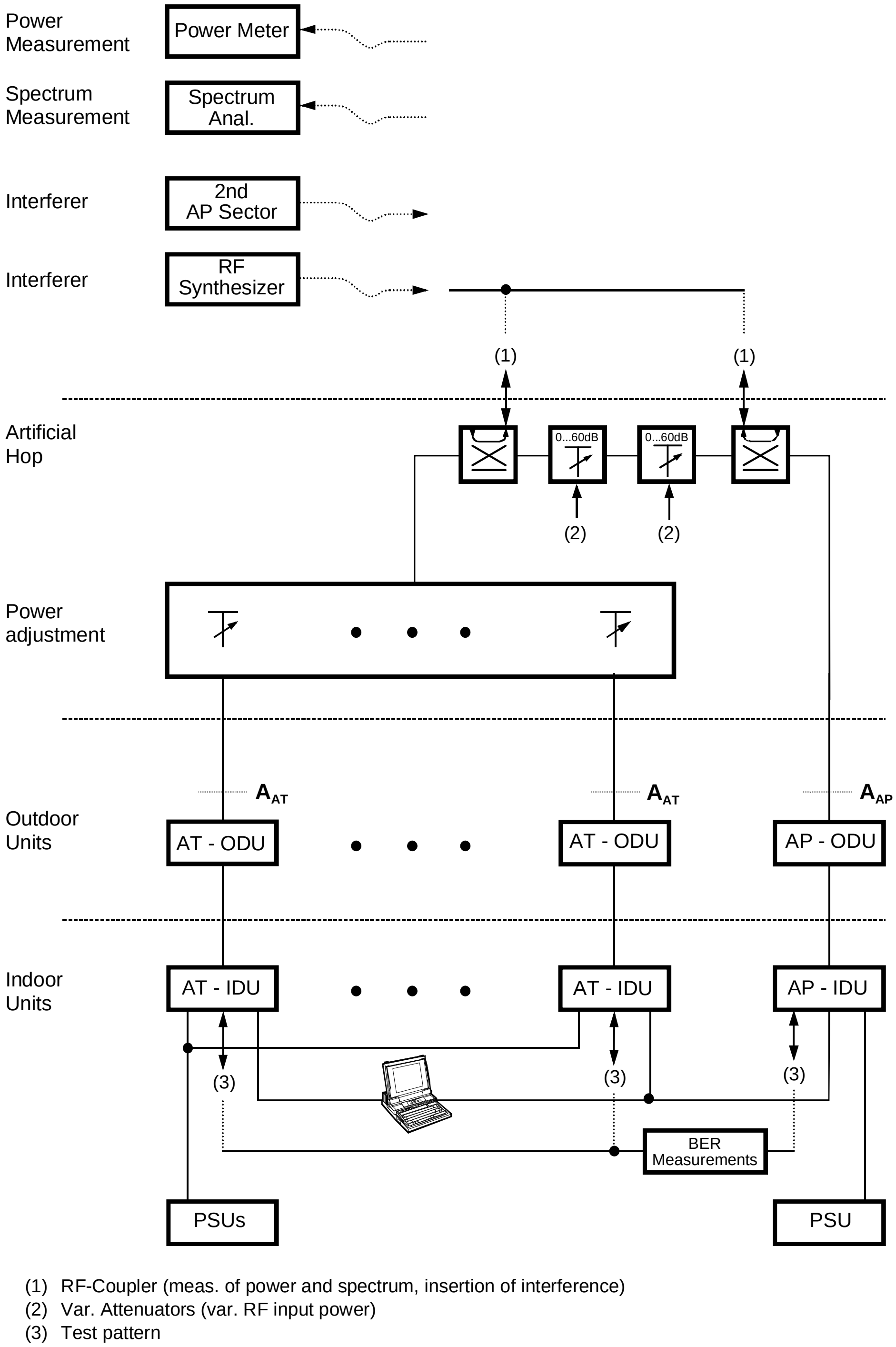

Figure 5: Detailed block-diagram of the test-platform

For major part of the tests it is necessary to perform the disconnection of the antennae from the RF. Therefore, the functional test ports can be connected to an artificial-hop as shown in the detailed block-diagram of the test platform in figure 5. Furthermore, adequate test patterns shall be generated.

5 Environmental profile

The equipment shall meet the environmental conditions set out in ETS 300 019-1-4 [3] which defines weather protected and non-weather protected locations, classes and test severity.

The supplier shall state which class the equipment is designed to withstand.

In table 4 the parameters for the environmental, safety, and electromagnetic conditions are summarized.

Table 4: HA environmental, safety and electromagnetic conditions

Environmental conditions	**Recommendations**
Operation, ODU	ETS 300 019-1-4, class 4.1 [3]
Operation, IDU	ETS 300 019-1-4, class 3.1 [3]
Electromagnetic and safety conditions	**Recommendations**
Electromagnetic compatibility	EN 300 385 [4], EN 301 489-1 [5]
Immunity to electromagnetic interference	EN 61000-6-1 [6]
Immunity to electromagnetic radiation	EN 55022 [7]
Electrical Safety	EN 60950 [8]

5.1 Equipment within weather protected locations (indoor locations)

The equipment intended for operation within temperature controlled locations or partially temperature controlled locations shall meet the requirements of ETS 300 019-1-4 [3], class 3.1.

Optionally, more stringent requirements of ETS 300 019-1-4 [3], classes - e.g. 3.2, 3.3 (Non-temperature controlled locations), 3.4 (Sites with heat trap) and 3.5 (Sheltered locations) - may be applied, according to supplier declaration.

5.2 Equipment for non-weather protected locations (outdoor locations)

Equipment intended for operation within non-weather protected locations shall meet the requirements of ETS 300 019-1-4 [3], class 4.1.

Optionally, more stringent requirements of ETS 300 019-1-4 [3], classes - e.g. 4.1E - may be applied, according to supplier declaration.

NOTE: Class 4.1 applies to many European countries and class 4.1E applies to all European countries.

For systems supplied within a specific radio cabinet which gives full protection against precipitation, wind, etc. the ETS 300 019-1-4 [3], classes 3.3, 3.4 and 3.5 may be applied also for equipment intended for operation in non-weather protected locations.

6 Technical requirements specification

6.1 Requirements for radio parameters

6.1.1 Carrier frequencies

6.1.1.1 Definition

HIPERACCESS is targeted for operation in the frequency bands above 11 GHz identified for Fixed Wireless Access (FWA) service use. A list of available frequency bands is reported in table 5.

Other bands which are not specified in the present document can be used for FWA.

The supplier shall declare the frequency band where the equipment is HA compliant.

Table 5: HA frequency bands

Frequency band	Lower Sub-band (GHz)	Upper Sub-band (GHz)	CEPT/ERC/REC	Ref.
"42 GHz"	40,500 - 41,500	41,500 - 43,500	01-04	[9]
	40,500 - 42,000	42,000 - 43,500	01-04	[9]
"38 GHz"	38,600 - 39,300	39,300 - 40,000		
"32 GHz"	31,800 - 32,600	32,600 - 33,400	01-02	[10]
"31 GHz"	31,000 - 31,300	31,500 - 31,800	01-02	[10]
"31 GHz"	31,000 - 31,075	31,225 - 31,300		
"31 GHz"	29,100 - 29,250	31,075 - 31,225		
"28 GHz"	27,500 - 28,500	28,500 - 29,500	13-04; 13-02; 01-03	[11]; [12]; [13]
	27,500 - 27,925	27,925 - 28,350	13-04; 13-02; 01-03	[11]; [12]; [13]
"26 GHz"	24,500 - 25,500	25,500 - 26,500	13-04; 13-02; 00-05	[11]; [12]; [14]
"26 GHz"	24,250 - 24,450	25,050 - 25,250		

6.1.1.2 Limits

The transmitted RF carrier centre frequency for the APT shall have an absolute accuracy better than ±8 ppm.

The AT shall be locked in frequency to the APT.

The relative accuracy of the AT in locked state shall be ±1 ppm with respect to the APT.

6.1.1.3 Conformance

Conformance tests as defined in clause 7.1.1 shall be carried out.

The values shall be guaranteed at the Bottom (B), Middle (M) and Top (T) frequencies of the equipment band.

The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.2 Channel allocation

6.1.2.1 Definition

The nominal carrier frequencies for HIPERACCESS systems shall be spaced 28 MHz apart. In case of FDD the same spacing is foreseen in both uplink and downlink direction.

For the frequency bands having a recommended channel arrangement, HIPERACCESS will operate in a manner consistent with the centre frequencies identified for 28 MHz channelization.

6.1.2.2 Limits

The channel arrangement (e.g. duplex in case of FDD) and the frequency resolution required for channel allocation for both AP and AT, e.g. nominal carrier frequency resolution in both UL and DL directions for all frequencies shall be in accordance with the ERC/CEPT recommendation given in CEPT/ERC/REC T/R 13-02 [12]. However, for 42 GHz, due to the block allocation the carrier frequency resolution with the current ERC recommendation shall be 1 MHz CEPT/ECC/REC 01-04 [9].For frequency bands which are not specified in the present document, the supplier shall declare the channel selection resolution.

Table 6: Void

6.1.2.3 Conformance

Conformance tests as defined in clause 7.1.2 shall be carried out.

The values shall be guaranteed at the Bottom (B), Middle (M) and Top (T) frequencies of the equipment band.

The values shall be guaranteed at normal conditions (e.g. M temperature).

6.1.3 Symbol transmit clock and tolerance

6.1.3.1 Definition

The M-QAM modulated symbols for all permissible modulations (M = 4, 16, 64) are transmitted with the same symbol clock rate of 22,4 MHz.

6.1.3.2 AP

6.1.3.2.1 Limits

The frequency accuracy of the symbol transmit clock shall be according to table 7. Within a measuring interval of 10 s the deviation to the nominal frequency (22,4 MHz) shall be less than ± 8 ppm.

The peak-to-peak jitter of the transmit symbol clock, referenced to the previous symbol zero crossing of the transmitted waveform, shall be less than 2 % of the nominal symbol clock deviation over a 2-second measurement period.

Table 7: AP and AT symbol transmit clock requirements

Temperature	Symbol Transmit Clock Frequency	
	Tolerance (ppm) (see note 1)	**Jitter (%) (see note 2)**
L	±8	< 2
M	±8	< 2
H	±8	< 2
NOTE 1: Measuring time 10 s NOTE 2: Related to $T_{tx,clock}$ = 1/(22,4 MHz) and referenced to previous symbol zero crossing; measurement time 2 s.		

6.1.3.2.2 Conformance

Conformance is proved if the measured frequency is within the range of 22,399 821 MHz and 22,400 179 MHz and the jitter is within 2 % for all cases listed in table 7.

The values shall be guaranteed at middle (M) frequency of the equipment band.

The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.3.3 AT

6.1.3.3.1 Limits

The phase difference between the AT symbol transmit clock and the AP symbol transmit clock shall be constant (phase locked to APT condition). If there is no constant phase difference (not phase locked) the AT shall not send any signal (see table 8).

Within a measuring interval of 10 s the deviation to the nominal frequency (22,4 MHz) shall be less than ±8 ppm (see table 7).

The peak-to-peak jitter of the transmit symbol clock, referenced to the previous symbol zero crossing of the transmitted waveform, shall be less than 2 % of the nominal symbol clock deviation over a 2-second measurement period (see table 7).

Table 8: AT phase lock and Tx data behaviour

Phase difference between AP symbol transmit clock and AT symbol transmit clock	Tx data present ?
not constant	no
constant (locked)	yes

6.1.3.3.2 Conformance

Conformance is proved if the measured frequency is within the range of 22,399 821 MHz and 22,400 179 MHz and the jitter within 2 % for all cases listed in table 7. In addition the sending data behaviour according to table 8 shall be guaranteed.

The values shall be guaranteed at middle (M) frequency of the equipment band.

The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.4 RF channel and spectrum mask

6.1.4.1 Definition

The transmitted spectrum shall not exceed the limits given by the spectrum masks defined in clause 6.1.4.2.

The test will be performed both with constant power versus time and with switched power on a burst basis.

6.1.4.2 Limits

The APT transmit spectrum shall not exceed the mask defined by table 9 (also depicted in figure 6).

The AT transmit spectrum shall not exceed the mask defined by table 10 (also depicted in figure 7).

Table 9: APT spectrum mask definition

Frequency offset (MHz)	13	14	14,4	14,8	22,4	28	56	70
Relative attenuation (dB)	0	-15	-20	-28	-34	-42	-52	-52

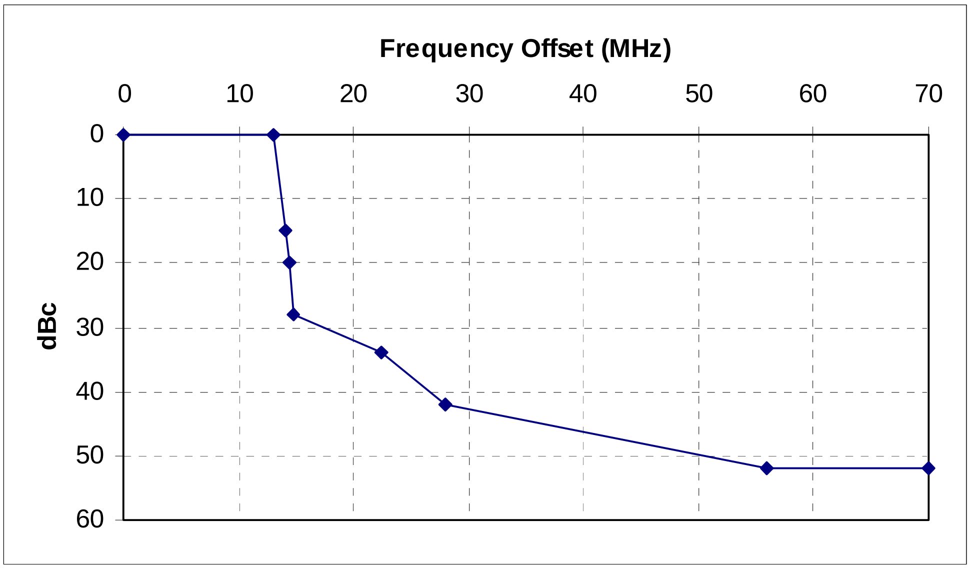

Figure 6: APT spectrum mask

Table 10: AT spectrum mask definition

Frequency offset (MHz)	11,2	13,5	14,5	22,4	28	56	70
Relative attenuation (dB)	0	-7	-17	-32	-37	-52	-52

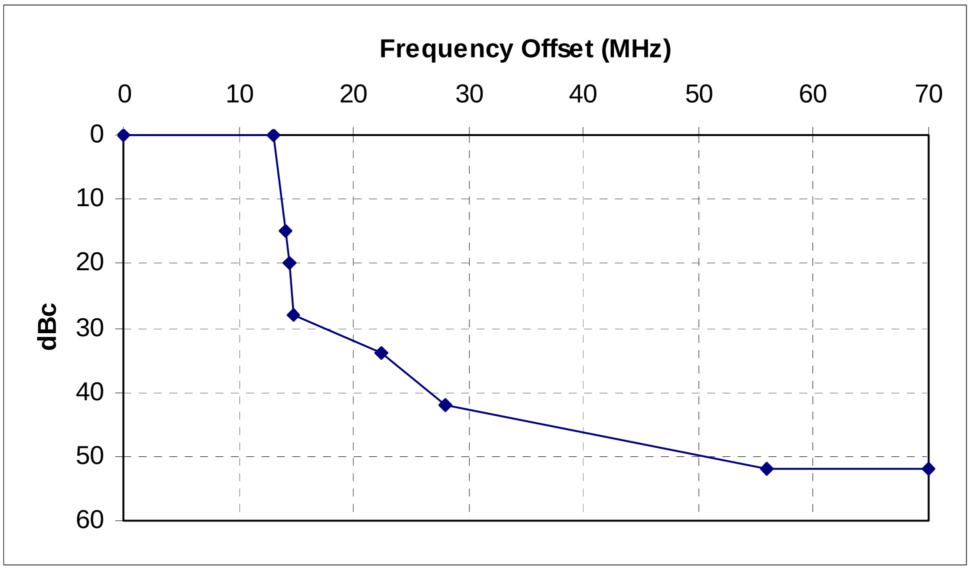

Figure 7: AT spectrum mask

6.1.4.3 Conformance

Conformance tests as defined in clause 7.1.4 shall be carried out.

The values shall be guaranteed at the Bottom (B), Middle (M) and Top (T) frequencies of the equipment band.

The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.5 Transmitter output power and tolerance

6.1.5.1 Definition

The transmitter output power P_{tx} is referred to the RF connection to the antenna (figure 2), for both the APT (interface A_{AP}) and the AT (interface A_{AT}).

6.1.5.2 AP

6.1.5.2.1 Limits

For each set of DL PHY mode the APT shall operate with the maximum output power setting. Tables 11 and 12 summarize the requirements for the two sets of possible DL PHY modes. The naming of PHY modes is according to table 1.

Table 11: AP maximum transmitter output power (DL set-1)

Set-1 (mandatory)		Output Power $P_{tx,AP}$ (dBm)	Tolerance (dB)
DL-1	4QAM	15	±2
DL-2	4QAM	15	±2
DL-3	16QAM	15	±2
DL-5 (optional)	64QAM	15	±2

Table 12: AP maximum transmitter output power (DL set-2)

Set-2 (optional)		Output Power $P_{tx,AP}$ (dBm)	Tolerance (dB)
DL-1	4QAM	15	±2
DL-2	4QAM	15	±2
DL-4	16QAM	15	±2
DL-6 (optional)	64QAM	15	±2

6.1.5.2.2 Conformance

Conformance is proved if the output power $P_{tx,AP}$ is within the range of 13 dBm and 17 dBm for all cases listed in tables 11 and 12.

The values shall be guaranteed at the Bottom (B), Middle (M) and Top (T) frequencies of the equipment band.

The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.5.3 AT

6.1.5.3.1 Limits

For each set of UL PHY mode (set-1 and set-2) the AT shall operate with the maximum output power setting. According to the applied modulation different maximum output powers are required. Table 13 summarizes the requirements for the two sets of possible UL PHY modes. The naming of PHY modes is according to table 2.

Table 13: AT maximum transmitter output power

Set-1		Output Power $P_{tx,AT}$ (dBm)	Tolerance (dB)
UL-1, UL-1S	4QAM	14	±2
UL-2, UL-2S	4QAM	14	±2
UL-3, UL-3S (optional)	16QAM	11	±2
Set-2		**Output Power $P_{tx,AT}$ (dBm)**	**Tolerance (dB)**
UL-1, UL-1S	4QAM	14	±2
UL-2, UL-2S	4QAM	14	±2
UL-4, UL-4S (optional)	16QAM	11	±2
NOTE: 16QAM can be up to 14 dBm, according to supplier declaration			

6.1.5.3.2 Conformance

Conformance is proved if the output power $P_{tx,AT}$ is within the range of 12 dBm and 16dBm in case of 4QAM modulation and within the range of 9 dBm and 13 dBm in case of 16QAM modulation. All cases of table 13 shall be proved.

- The values shall be guaranteed at the Bottom (B), Middle (M) and Top (T) frequencies of the equipment band.
- The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.6 Dynamic Downlink Power Control (DDPC)

6.1.6.1 Definition

DDPC is the dynamic control of the AP transmit power in order to meet possible regularity requirements. The implementation is optional in HA.

6.1.6.2 Limits

The AP shall apply first the most robust PHY mode. If this action is not sufficient then DDPC is applied. To verify the rules in case the DDPC is implemented the following tests shall be performed. The maximum AP Tx output power of 15 dBm shall be selected. Depending on the APT-class the dynamic range for AP Tx output power control is different (table 14). The dynamic ranges belonging to the APT-classes shall be swept in 1 dB steps. The duration of the DL power adjustment of a 1 dB step shall not be less than 50 ms. The duration of the whole dynamic range sweep shall not be less than the figures in table 14.

NOTE: Remark: Within the frame's duration a change of the Tx power is not allowed.

Table 14: DDPC requirements (optional)

DL PHY Mode 1)	APT-class	Dynamic range (sweep in ≤ 1 dB steps) (dBm)	Duration of 1 dB transition step (ms)	Duration of total sweep (s)
Set-1 (mandatory)	class 1	15 to 11	≥ 50	≥ 2,0
		11 to 15	≥ 50	≥ 2,0
	class 2	15 to 8	≥ 50	≥ 3,5
		8 to 15	≥ 50	≥ 3,5
Set-2 (optional)	class 3	15 to 5	≥ 50	≥ 5,0
		5 to 15	≥ 50	≥ 5,0
NOTE 1: The most efficient PHY-mode of set-1 (set-2 if applicable) shall be applied. NOTE 2: Within one DL-frame the AP Tx power shall not change!				

6.1.6.3 Conformance

Conformance is proved if all the requirements in table 14 are met.

- The values shall be guaranteed at middle frequency of the equipment band and normal temperature.

6.1.7 Tx static power setting

6.1.7.1 Definition

Static DL power setting of the APT is optional. It can be implemented in view of a higher flexibility for the HA system, e.g. different cell size.

6.1.7.2 Limits

To verify the rules in case of an implemented static DL power setting the following tests shall be performed. The maximum AP Tx output power of 15 dBm shall be decreased in steps of 2 dB down to the minimum of 5 dBm according to the required power setting range of 0 dB to 10 dB. After each power setting the accuracy of the measured Tx output power shall be within the borders given in table 15.

Table 15: Static DL power setting requirements (optional)

AP Tx Output Power	
setting	**measured**
15 dBm	15 dBm ±2 dB
13 dBm	13 dBm ±2 dB
11 dBm	11 dBm ±2 dB
9 dBm	9 dBm ±2 dB
7 dBm	7 dBm ±2 dB
5 dBm	5 dBm ±2 dB

6.1.7.3 Conformance

Conformance is proved if all requirements in table 15 are met.

The values shall be guaranteed at middle frequency of the equipment band and normal temperature.

6.1.8 Automatic Transmit Power Control (ATPC)

6.1.8.1 Definition

The UL power control functionality, ATPC, is mandatory in HA and is under complete AP control (TS 101 999 [1], clause 5.5.3.5.3).

The Power Control function shall try to minimize the interference. The algorithm (not standardized) shall be implemented in a way forcing each AT to never exceed the minimum Tx power level guaranteeing the achievement of the wanted link performances.

In order to achieve that, the APT shall manage to receive signals coming from every AT with an excess power (with respect to the nominal threshold for BER = 10^{-11}); the gap in dB between actual Rx power and threshold Rx power is called *Rx Power Margin*.

6.1.8.2 Limits

The value of the *Rx Power Margin* shall belong to the range 4dB to 8dB from the nominal threshold for BER = 10^{-11}, in conjunction with the corresponding minimum repetition rate selected, minimum power control performances are fulfilled even considering maximum control loop lag.

For a given implementation, *Rx Power Margin* shall be the same for each PHY mode.

The following rules shall be applied:

- The power control level shall be adjusted in a relative manner.
- The absolute minimum time between ATPC control messages shall never be less than 50 ms, whatever the implementation of the power control algorithm. The actual minimum time can be implementation dependent, and shall belong to the range [50 to 200] ms.
- The size of all power control steps shall belong to the range 1 to 4 dB, with resolution of 0,5 dB.

6.1.8.3 Conformance

Conformance tests as defined in clause 7.1.8 shall be carried out.

The values shall be guaranteed at middle frequency of the equipment band and normal temperature.

6.1.9 Error vector magnitude

6.1.9.1 Definition

The accuracy of the transmitted antenna signal is affected by many implementation impairments like transmit filter accuracy, D/A converter, modulator imbalances, synthesizer phase noise and power amplifier non-linearity. The implementation margin containing all these, say N, impairments is defined by means of the Error Vector Magnitude (EVM):

$$EVM = \sqrt{\frac{\frac{1}{N}\sum_{1}^{N}\left(\Delta I^2 + \Delta Q^2\right)}{S_{\max}^2}} \times 100\%$$

ΔI^2 and ΔQ^2 are the in-phase and quadrature phase error powers, respectively. S_{max}^2 is the transmit power of the utmost symbol vector of the M-QAM modulation.

6.1.9.2 Limits

To avoid excessive measurements, it is assumed that all channels of an AP or AT under test show nearly the same behaviour in respect to EVM. In table 16 all relevant data are compiled for the three possible kinds of modulation 4QAM, 16QAM and 64QAM. In the third column the C/N for an ideal transmitter is listed. Column two shows the Tx implementation margin. The real implementation shall not exceed the excess power given by the implementation margin to keep the C/N constant when going from the ideal to the real transmitter. This statement corresponds with the given EVM figures in the last two columns for "ideal" test receivers with and without equalization. The applied carrier recovery loop bandwidth is specified in percentage of the symbol rate (22,4 MHz). In order to relate on the same average transmit power the peak-to-average ratios for the 16QAM and 64QAM have to be considered.

Remark: To perform the measurements a test receiver with known impairments is necessary.

Table 16: EVM requirements

Modulation	Tx implementation margin	TX-AWGN Threshold C/N (BER=10^{-6})	peak-to-average ratio (M-QAM constellation specific)	EVM	
				without equalization (see note)	with equalization (see note)
4QAM+RS	0,5 dB	10 dB	0 dB	≤ 12 %	≤ 12 %
16QAM+RS	1,0 dB	17 dB	2,55 dB	≤ 6 %	≤ 3 %
64QAM+RS	1,5 dB	23 dB	3,68 dB	n.a.	≤ 1,5 %
NOTE: "Ideal" receiver with a carrier recovery loop bandwidth of 1 % to 5 % of the symbol rate (22,4 MHz).					

6.1.9.3 Conformance

Conformance is proved if the figures of " Tx-AWGN threshold C/N" and "Tx implementation margin" are proved or the demanded EVM figures are proved by an EVM measurement.

The values shall be guaranteed at the Bottom (B), Middle (M) and Top (T) frequencies of the equipment band.

The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.10 Antenna gain

6.1.10.1 Definition

In table 17 the maximum antenna gains for different APT classes are given. The remaining characteristics of the antennas shall be compliant with EN 301 215-2 [15], EN 301 215-3 [16] and EN 301 215-4 (see in Bibliography). The manufacturer shall declare their APT antenna gain characteristics according to EN 301 215-2 [15], EN 301 215-3 [16] and EN 301 215-4 (see Bibliography), where the declared maximum antenna gain shall not exceed the values given in this table.

Each APT class corresponds to a given EIRP value.

The APT classes are frequency band and sector angle-independent.

Table 17: APT classes, maximum antenna gains and maximum EIRP

APT class	Maximum antenna gain (dBi)	Tx maximum output power (dBm)		Maximum EIRP (dBmi)	
1	18	+15		+37	
2	21	+15		+40	
3	24	+15		+43	

In case of the AT, antenna gains vary as a function of used frequency band as reported in table 18. Different nominal (and maximum) EIRP values will be available in each frequency band.

Table 18: AT antenna gains and EIRP

Frequency band (GHz)	Nominal antenna gain (dBi)	Tx maximum output power (dBm)	Nominal EIRP	Maximum EIRP	Radiation pattern
42	37	+14	51,0 dBmi	54,0 dBmi	TS3; EN 301 215-3 [16]
32	35,5	+14	49,5 dBmi	52,5 dBmi	TS3; EN 301 215-4 [27]
28	34,5	+14	48,5 dBmi	51,5 dBmi	TS3; EN 301 215-2 [15]
26	33,5	+14	47,5 dBmi	50,5 dBmi	TS3; EN 301 215-2 [15]

6.1.10.2 Limits

The overall EIRP accuracy is the sum of antenna gain and Tx output power accuracy.

The accuracy of antenna gain shall be better than ± 1dB over temperature and ± 1dB over frequency.

Tx power accuracy is considered in clause 6.1.5. (It shall be better than ± 2dB.)

6.1.10.3 Conformance

Conformance tests as defined in clause 7.1.10 shall be carried out.

EIRP is tested splitting power and antenna directivity contributions. Antenna test is addressed here, while Tx power test is considered in clause 6.1.5.

Test to be performed over temperature and frequency band (L, M, H and B, M, T).

6.1.11 Time mask for burst transmission

6.1.11.1 Definition

The power envelope of transmitted burst shall not exceed the limits given by the time mask defined in figure 8.

The transmit power time mask parameters for each AT, detailed in table 19, are derived under the condition that the number of active ATs per sector shall not exceed 64 to obtain negligible threshold degradation due to Tx off noise.

6.1.11.2 Limits

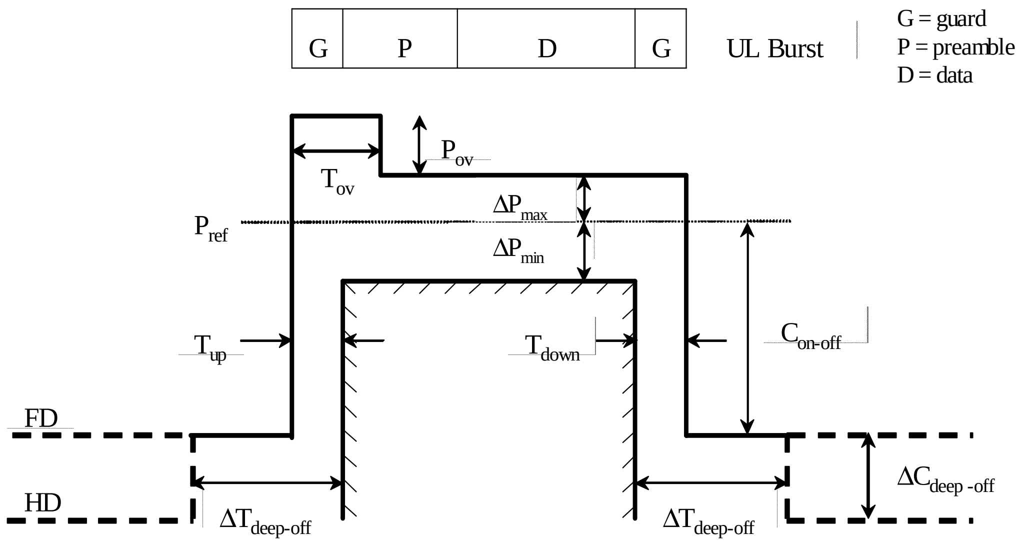

Figure 8: AT average power versus time mask

The mask constraints are the following:

1) Each burst corresponding to the same type of modulation for the data part shall be sampled at:

Symbol rate < Sampling rate < n x Symbol rate, where n is an integer number > 1.

Then, the power of each sample corresponding to the same time position within the bursts shall be averaged over at least 100 bursts. Consecutive bursts during measurement time shall not be overlapped. The time-gap between two consecutive bursts during measurement shall be at least 100 symbols duration for TDD and FDD. For H-FDD, this time gap during measurement shall be at least 600 symbol duration.

2) The *ramp-up time* shall be within 8 symbols.

3) During the *rest of preamble and data part* the power shall be within $[P_{ref} - \Delta P_{min}; P_{ref} + \Delta P_{max}]$.

4) P_{ref} is defined as the average power over the data part of the burst (i.e. excluding the preamble), whereas ΔP_{min} and ΔP_{max} are given in table 20.

5) The *ramp-down time* shall be within 8 symbols.

6) The C_{on-off} *ratio* shall be according to table 21.

7) The parameter $\Delta C_{deep-off}$ (dB) shall be declared by the supplier (see clause A.1.3.2) for H-FDD and TDD ATs.

Table 19: Time mask parameters

Parameter	FDD	H-FDD	TDD
∆Tdeep-off	n. a.	480 symbols	48 symbols
Tup	8 symbols	8 symbols	8 symbols
Tdown	8 symbols	8 symbols	8 symbols
Tov	16 symbols	16 symbols	16 symbols
Pov	4 dB	4 dB	4 dB
Pref	TX output power averaged during data part of the burst		
∆Pmax	2 dB		
∆Pmin	2 dB		
Con-off	See table 21		
∆Cdeep-off	n.a.	To be declared by supplier	

Table 20: Power variations versus mean power due to constellation (with 1 dB margin)

Modulation	$\Delta P_{min\ (dB)}$	$\Delta P_{max\ (dB)}$
4QAM	2	2
16QAM	2	2

Table 21: C_{on-off} minimum requirements for UL TDMA transmission

PHY mode	FDD (64 active ATs) (dB)	H-FDD (8 active ATs) (dB)	TDD (8 active ATs) (dB)
UL-1	38	30	30
UL-2	42	34	34
UL-3	48	40	40

6.1.11.3 Conformance

Conformance tests as defined in clause 7.1.11 shall be carried out.

Test to be performed over temperature and frequency band (L, M, H and B, M, T)

6.1.12 Tx/Rx switching time

6.1.12.1 Definition

Half-duplex ATs (both H-FDD and TDD) are not able to transmit and receive at the same time. A maximum amount of time shall be specified for such ATs to pass from receive mode to transmit mode and vice-versa.

6.1.12.2 Limits

The TDD AT and AP shall have a PHY Tx/Rx or Rx/Tx switching time of 48 symbols (corresponding to about 2 µs).

The H-FDD AT shall have a PHY Tx/Rx or Rx/Tx switching time of 480 symbols (corresponding to about 20 µs).

Table 22: Switching time for H FDD and TDD AT

	FDD	H-FDD	TDD
Rx/Tx or Tx/Rx Switching time	Not applicable	480 symbols 20 µs	48 symbols 2 µs

6.1.12.3 Conformance

Conformance tests as defined in clause 7.1.12 shall be carried out.

Test to be performed over temperature and frequency band (L, M, H and B, M, T).

6.1.13 Receiver sensitivity

6.1.13.1 Definition

The receiver sensitivity corresponding to the given C/N producing a given BER for an equivalent noise bandwidth B_n and a system noise figure NF is defined as:

$$S_{th} = N_0 + NF + 10 \times \log_{10}(B_n) + \frac{C}{N} + \Delta loss + Rxloss$$

where:

- N_0 is the receiver noise floor;
- Δloss includes all implementation losses;
- Rxloss is the receiver branching filter loss.

6.1.13.2 Limits

Tables 23 and 24 show the required input level receiver thresholds at BER=10^{-6} for both AT and APT in case of 4 x MAC PDUs per FEC block (analysis is limited to the fixed size PDU case), as a function of PHY mode and frequency band in AWGN channel.

For frequency bands different from the listed ones, the nearest frequency band requirement applies.

Table 23: AT-Receiver sensitivity for different carrier frequencies at BER=10^{-6}

PHY mode	C/N required AWGN [dB]	P_{rx} @ 26 GHz to 28 GHz [dBm]	P_{rx} @ 32 GHz [dBm]	P_{rx} @ 42 GHz [dBm]
DL-0	5	-88	-87	-86
DL-1	8	-85	-84	-83
DL-2	12	-81	-80	-79
DL-3	18	-75	-74	-73
DL-5	25	-68	-67	-66
DL-4	20	-73	-72	-71
DL-6	27	-66	-65	-64

Table 24: AP-Receiver sensitivity for different carrier frequencies at BER=10^{-6}

PHY mode	C/N required AWGN [dB]	P_{rx} @ 26 GHz to 28 GHz [dBm]	P_{rx} @ 32 GHz [dBm]	P_{rx} @ 42 GHz [dBm]
UL-1S	7	-86	-85	-84
UL-1	8	-85	-84	-83
UL-2	12	-81	-80	-79
UL-3	18	-75	-74	-73
UL-4	20	-73	-72	-71

In case of turbo codes the sensitivity values shall be 2 dB lower than in tables 23 and 24.

6.1.13.3 Conformance

Conformance tests as defined in clause 7.1.13 shall be carried out.

Test to be performed over temperature and frequency band (L, M, H and B, M, T).

6.1.14 Performance in multi-path channel

6.1.14.1 Definition

Two sources of physical impairments are considered modelling the HIPERACCESS propagation channel:

- Rain fading, resulting in frequency *flat fading* effects;
- Multi-path propagation, resulting in frequency *selective fading* effects.

Equipment performances in flat fading conditions are considered in clause 6.1.8 (ATPC).

The multi-path propagation is modelled by a set of *discrete-time* channels, to be considered in testing HIPERACCESS systems. The three different channel models adopted for HA are given in table 25.

Table 25: HA-channel model parameters (normalized parameters)

Channel	Equation	Sampling period (T_{samp})
C_0	C(z) = 1, i.e. AWGN	-
C_1	$C(z) = 0{,}981 - 0{,}194 \times z^{-1}$	T_s
C_2	$C(z) = 0{,}981 - 0{,}194 \times e^{-j\varphi} \times z^{-1}$, $\varphi = \pi/5$	T_s

6.1.14.2 Limits

In presence of multi-path channels C_1 and C_2 the degradation in Rx threshold shall be less than 1 dB with respect to the corresponding values obtained for C_0 (clause 6.1.13, sensitivity).

The measurement shall be performed only for the more efficient PHY modes supported by the equipment (both AT and APT).

6.1.14.3 Conformance

Conformance tests as defined in clause 7.1.14 shall be carried out.

The values shall be guaranteed at middle frequency of the equipment band and normal temperature.

6.1.15 Background BER

6.1.15.1 Definition

The equipment background BER is intended as the minimum BER achievable by the equipment in normal environmental condition, at middle frequency (M) and with C_0 channel (un-faded).

6.1.15.2 Limits

The Equipment Background BER under simulated operating conditions shall be measured with a signal level which is 6 dB above the specified level for BER = 10^{-6} taking into account the actual traffic load conditions.

The test shall be performed at ambient temperature and centre frequency.

The measurement shall be done only for the more efficient PHY mode supported, according to supplier declaration.

For different payload bit rates the measurement time and the maximum number of errors allowed are given in table 26.

Table 26: Maximum number of errors allowed, measuring the Equipment Background BER

	Upper PHY mode	PHY Maximum Net Bit rate [Mbps]	Delta power from threshold @ BER=10^{-6} (dB)	Max number of errors	Record time (h)
AT - receiver (Downlink)	DL-6	≈125	7	40	10 (9,8)
	DL-5	≈104	6	40	12 (11,7)
	DL-4	≈83	6	40	15 (14,6)
	DL-3	≈72	6	40	18 (17,3)
AP - receiver (Uplink)	UL-4	≈83	6	40	15 (14,6)
	UL-3	≈72	6	40	18 (17,3)
	UL-2	≈41	6	40	30 (30,4)

6.1.15.3 Conformance

Conformance tests as defined in clause 7.1.15 shall be carried out.

The values shall be guaranteed at middle frequency of the equipment band and normal temperature.

6.1.16 Receiver dynamic range

6.1.16.1 Definition

The receiver dynamic range is defined as the input power range where receiver BER is never exceeding the threshold value of 10^{-6}, whatever the RF carrier and equipment environmental temperature.

The BER performance is referred to all possible PHY modes specified for HIPERACCESS (in downlink or uplink), control zone PHY mode included.

6.1.16.2 Limits

Different requirements are foreseen for either the AP or the AT.

Receiver dynamic range requirements for HIPERACCESS are reported in table 27.

Table 27: Receiver dynamic range requirements

	26 GHz to 28 GHz		32 GHz		42 GHz	
	Minimum Rx Power [dBm]	Maximum Rx Power [dBm]	Minimum Rx Power [dBm]	Maximum Rx Power [dBm]	Minimum Rx Power [dBm]	Maximum Rx Power [dBm]
AP (Uplink)	-86	-56	-85	-55	-84	-54
AT (Downlink)	-88	-28	-87	-27	-86	-26
NOTE: The lowest level of the dynamic range shall correspond to the least efficient PHY mode sensitivity threshold and the highest level of the dynamic range shall correspond to the most efficient PHY mode sensitivity threshold.						

6.1.16.3 Conformance

Conformance tests as defined in clause 7.1.16 shall be carried out.

The values shall be guaranteed at the Bottom (B), Middle (M) and Top (T) frequencies of the equipment band.

The values shall be guaranteed at normal conditions (e.g. M temperature).

6.1.17 Co-channel interference performance

6.1.17.1 Definition

The co-channel interference is measured as a degradation of non interfered BER threshold due to an interfering modulated signal with the same nominal carrier frequency of the useful signal.

6.1.17.2 Limits

The limits of co-channel interference (external) shall be as in table 28, giving maximum C/I values for 1 dB and 3 dB degradation of the BER = 10^{-6} threshold specified in clause 6.1.13.

All the PHY modes supported by equipment under test shall be used for the test.

In case using turbo codes the C/I values shall be 2 dB lower than in table 28.

Table 28: C/N and C/I for 1 dB and 3 dB threshold degradation at BER = 10^{-6}

PHY mode	C/N @BER=10^{-6}	C/I @1dB C/N degradation	C/I @3dB C/N degradation	Notes
DL-0	5	11	7	
DL-1; UL-1	8	14	10	
DL-2; UL-2	12	18	14	
DL-3; UL-3	18	24	20	
DL-4; UL-4	20	26	22	
DL-5	25	31	27	AT only
DL-6	27	33	29	AT only

6.1.17.3 Conformance

Conformance tests as defined in clause 7.1.17 shall be carried out.

Only middle frequency and normal temperature conditions have to be tested.

6.1.18 Adjacent channel interference performance

6.1.18.1 Definition

The sensitivity of HA system to adjacent channel interference is specified by receiver Net Filter Discrimination (NFD).

One way to test this requirement is to measure the level of the interfering signal positioned at given frequency offset from centre frequency causing a given threshold degradation, and compare it with the level of a co-channel interferer giving the same degradation. The difference between the two level corresponds to the NFD at the offset used.

6.1.18.2 Limits

The NFD masks which shall be guaranteed by an HA system in downlink and uplink are defined by table 29.

Table 29: Downlink and uplink NFD mask

Offset (MHz)	NFD - DL (dB)	NFD - UL (dB)
28	***35,5***	***29***
31,5	39	34,5
35	42	38,5
38,5	45	41
42	46,5	43
49	49	46,5
56	***51***	***50***
59,5	51,5	51
63	52	51,5
70	52	52
77	52	52
84	52	52

The above system requirement translates in the following testing requirements:

- Threshold degradations have to be tested only at 28 MHz offsets, whereas at 56 MHz offset they can be tested on operator request.
- Only 1 dB threshold degradation has to be tested.
- At least the most efficient PHY Mode supported by equipment according to supplier declaration shall be used for the test.

Table 30 reports C/I levels for NFD test (AT and APT Receiver).

Table 30: C/I levels for NFD test

PHY mode	AT receiver C/I Adj. channel 1dB C/N Degradation [dB]	APT receiver C/I Adj. channel 1dB C/N degradation [dB]
DL-0	-24,5	-18
DL-1; UL-1	-21,5	-15
DL-2; UL-2	-17,5	-11
DL-3; UL-3	-11,5	-5
DL-4; UL-4	-9,5	-3
DL-5	-4,5	NA
DL-6	-2,5	NA

6.1.18.3 Conformance

Conformance tests as defined in clause 7.1.18 shall be carried out.

Only middle frequency and normal temperature conditions.

6.1.19 CW spurious interference

6.1.19.1 Definition

This test is designed to identify specific frequencies at which the receiver may have a spurious response, e.g. image frequency, harmonics of the receive filter, etc. The actual test range should be adjusted accordingly.

NOTE: The test is not intended to imply a relaxed specification at all out of band frequencies elsewhere specified in the present document.

6.1.19.2 Limits

The equipment under test shall be in accordance with EN 301 213-1 [17]. In particular, for a receiver operating at the input level specified in clause 6.1.13 (sensitivity) for 10^{-6} BER threshold, the introduction of a CW interferer at a level of +30 dB (provisional) with respect to the wanted signal and at any frequency up to 60 GHz, excluding frequencies either side of the centre frequency of the wanted RF channel by up to 500 % of the co-polar channel spacing, shall not cause a degradation of more than 1 dB of the BER threshold as specified in clause 6.1.13 (sensitivity).

6.1.19.3 Conformance

Conformance tests as defined in clause 7.1.19 shall be carried out.

Only middle frequency and normal temperature conditions.

6.1.20 Rx-power measurement

6.1.20.1 Definition

The Rx power level shall be measured within the dynamic range of the equipment, as described in clause 6.1.16.

6.1.20.2 Limits

The received power in both AT and AP shall be measured with:

- an absolute accuracy of ±3dB;
- a resolution of 0,25 dB.

In order to be compliant with general Power Control algorithm, measurement averaging time shall be not longer than 50 ms.

6.1.20.3 Conformance

Conformance tests as defined in clause 7.1.20 shall be carried out.

The values shall be guaranteed at centre frequency over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.21 CNR measurement

6.1.21.1 Definition

The CNR shall be measured within the dynamic range of the equipment, as described in clause 6.1.16.

6.1.21.2 Limits

The received CNR in both AT and AP shall be measured with:

- an absolute accuracy of ±1 dB;
- a resolution of 0,25 dB.

In order to be compliant with general Power Control algorithm measurement, averaging time shall be not longer than 50 ms.

6.1.21.3 Conformance

Conformance tests as defined in clause 7.1.21 shall be carried out.

The values shall be guaranteed at middle frequency and normal temperature.

6.1.22 Spurious emissions

6.1.22.1 Definition

Spurious emissions encompass any unwanted emission falling in frequency ranges separated from the centre frequency of the emission by more than 250 % of the relevant channel separation. Those emissions include harmonic emissions, parasitic emissions, inter-modulation products, and frequency conversion products.

Transmitter spurious emissions are emissions sent to the antenna port by a transmitter.

Receiver spurious emissions are emissions sent backwards to the antenna port by a receiver.

6.1.22.2 Limits

To avoid excessive measurements, it is assumed that all channels of an AP or AT under test show nearly the same behaviour in respect to spurious emissions. Dependent on the frequency position of the HA channel different spurious emission requirements shall be met ETSI EN 300 019-1-4 [4], ETSI EN 301 489-1 [5]. In addition the requirements for AT are mitigated compared to AP. In case of HA channel positioned below 21,2 GHz the requirements of table 31 shall be met for AP transmitter and receiver spurious emissions, whereas the requirements of table 32 shall be met for AT transmitter and receiver spurious emissions. In case of HA channels positioned above 21,2 GHz the requirements of table 33 apply for AP equipment and the requirements of table 34 apply for AT equipment.

Concerning HA channels above 21,2 GHz a mitigation for *continuous wave* emissions is permissible in the two ranges where a requirement of -40 dBm is valid. In both ranges together up to 10 discrete spurious emissions are permitted to exceed the limit of -40 dBm. However, those discrete emissions shall not exceed -30 dBm.

As a general rule, the resolution bandwidth of the measuring receiver for the spurious emissions should be equal to the reference bandwidth as given in table 31 to table 34.

NOTE: In case where the resolution bandwidth of the receiver is different the note at the end of recommend 4 in ERC/REC 74-01 [28] shall be considered.

Table 31: AP Tx and Rx spurious emissions requirements for CCF below 21,2 GHz

Frequency range		Reference bandwidth	Emission power
No.	**Definition**		
1	30 MHz ≤ f < 1GHz	100 kHz	≤ -50 dBm
2	1 GHz ≤ f < 21,2 GHz	1 MHz	≤ -50 dBm
3	21,2 GHz ≤ f < CCF-70 MHz	1 MHz	≤ -30 dBm
4	CCF+70 MHz ≤ f < 26 GHz (see note 1) CCF+70 MHz ≤ f < 2^{nd} harmonic (see note 2)	1 MHz	≤ -30 dBm
NOTE 1: Upper frequency limit is 26 GHz if 5,2 GHz ≤ CCF < 13 GHz. NOTE 2: Upper frequency limit is the second harmonic of the highest oscillator frequency if 13 GHz ≤ CCF < 150 GHz. NOTE 3: CCF: Channel Centre Frequency.			

Table 32: AT Tx and Rx spurious emissions requirements for CCF below 21,2 GHz

Frequency range		Reference bandwidth	Emission power
No.	**Definition**		
1	30 MHz ≤ f < 1GHz	100 kHz	≤ -40 dBm
2	1 GHz ≤ f < 21,2 GHz	1MHz	≤ -40 dBm
3	21,2 GHz ≤ f < CCF-70 MHz	1 MHz	≤ -30 dBm
4	CCF+70 MHz ≤ f < 26 GHz (see note 1) CCF+70 MHz ≤ f < 2^{nd} harmonic (see note 2)	1 MHz	≤ -30 dBm
NOTE 1: Upper frequency limit is 26 GHz if 5,2 GHz ≤ CCF < 13 GHz. NOTE 2: Upper frequency limit is the second harmonic of the highest oscillator frequency if 13 GHz ≤ CCF < 150 GHz. NOTE 3: CCF: Channel Centre Frequency.			

Table 33: AP Tx and Rx spurious emissions requirements for CCF above 21,2 GHz

Frequency range		Reference bandwidth	Emission power
No.	Definition		
1	30 MHz ≤ f < 1 GHz	100 kHz	≤ -50 dBm
2	1 GHz ≤ f < 21,2 GHz	1 MHz	≤ -50 dBm
3	21,2 GHz ≤ f < CCF-126 MHz (see note 1)	1 MHz	≤ -40 dBm
4	CCF-126 MHz ≤ f < CCF-70 MHz	1 MHz	≤ -30 dBm
5	CCF+70 MHz ≤ f < CCF+126 MHz	1 MHz	≤ -30 dBm
6	CCF+126 MHz ≤ f < 43,5 GHz *)	1 MHz	≤ -40 dBm
7	43,5 GHz ≤ f < 2nd harmonic (see note 2)	1 MHz	≤ -30 dBm
NOTE 1: Up to 10 discrete (continuous wave) spurious emissions are permitted to exceed the limit up to -30 dBm in frequency range no. 3 and no. 6. CCF: Channel Centre Frequency. NOTE 2: Second harmonic of the highest oscillator frequency.			

Table 34: AT Tx and Rx spurious emissions requirements for CCF above 21,2 GHz

Frequency range		Reference bandwidth	Emission power
No.	Definition		
1	30 MHz ≤ f < 1 GHz	100 kHz	≤ -40 dBm
2	1 GHz ≤ f < 21,2 GHz	1 MHz	≤ -40 dBm
3	21,2 GHz ≤ f < CCF-126 MHz (see note 1)	1 MHz	≤ -30 dBm
4	CCF-126 MHz ≤ f < CCF-70 MHz	1 MHz	≤ -30 dBm
5	CCF+70 MHz ≤ f < CCF+126 MHz	1 MHz	≤ -30 dBm
6	CCF+126 MHz ≤ f < 43,5 GHz *)	1 MHz	≤ -40 dBm
7	43,5 GHz ≤ f < 2nd harmonic (see note 2)	1 MHz	≤ -30 dBm
NOTE 1: Up to 10 discrete (continuous wave) spurious emissions are permitted to exceed the limit up to - 30 dBm in frequency range no. 3 and no. 6. CCF: Channel Centre Frequency. NOTE 2: Second harmonic of the highest oscillator frequency.			

6.1.22.3 Conformance

Conformance is proved if the power of all spurious emissions is below the limits listed in tables 31 to 34.

The values shall be guaranteed over the complete temperature range declared by supplier (e.g. L, M, H temperatures).

6.1.23 Automatic transmit timing control

6.1.23.1 Definition

ATTC encompasses the time alignment process due to propagation delay. At the beginning of the ranging process for a particular AT a rough first time alignment is started. After completion of the ranging process the ATTC moves to the time alignment fine-tuning process.

6.1.23.2 Limits

To verify the correct transmit timing control for the first initialization and for the subsequent fine-tuning the following minimum requirements shall be met. For a propagation delay of 100 ns, 40 µs and 79 µs the ranging process shall be started by the AP for a particular AT. The resulting time alignment measured at the AP shall be the propagation delay with an inaccuracy of ±1/4 symbol period (table 35).

The propagation delays are now increased and decreased by 2 symbol periods, respectively. The resulting time alignment measured at the AP shall be the propagation delay with an inaccuracy of ±1/4 symbol period (see table 36). During the transition to the new time alignment a new ranging process is excluded.

Table 35: Accuracy of time alignment starting from ranging

Propagation Delay	Measured Delay at AP
100 ns	100 ns ±¼ SP ≈ 100 ns ±11 ns
40 µs	40 µs ±¼ SP ≈ 40 µs ±11 ns
79,9 µs	79,9 µs ±¼ SP ≈ 79,9 µs ±11 ns
1 SP = 1 Symbol Period = 1/(22,4 MHz) ≈ 44,64 ns	

Table 36: Accuracy for fine tuning time alignment

Propagation Delay	Measured Delay at AP 1)
100 ns - 2 SP ≈ 10 ns	10 ns ±11 ns
100 ns + 2 SP ≈ 190 ns	190 ns ±11 ns
40 µs - 2 SP ≈ 39,91 µs	39,91 µs ±11 ns
40 µs + 2 SP ≈ 40,09 µs	40,09 µs ±11 ns
79,9 µs - 2 SP ≈ 79,81 µs	79,81 µs ±11 ns
79,9 µs + 2 SP ≈ 79,99 µs	79,99 µs ±11 ns
1 SP = 1 Symbol Period = 1/(22,4 MHz) ≈ 44,64 ns	
NOTE: A ranging process during the transition from the old to the new time alignment shall be excluded.	

6.1.23.3 Conformance

Conformance is proved if all the measured delays at AP are within the prescribed ranges shown in tables 35 and 36.

The values shall be guaranteed at middle frequency and normal temperature.

6.1.24 Load levelling and carrier recovery time

6.1.24.1 Definition

If in a sector several carrier frequencies are allocated, then the load from one carrier to another carrier can be shifted, resulting in a higher overall sector capacity.

6.1.24.2 Limits

From the PHY perspective, the time required for either changing from one frequency to another or recovering the same frequency (e.g. after short interruption, where the first initialization is already done), shall be lower than 100 ms. More specifically, all PHY synchronization i.e. frame/carrier/clock recovery and Control zone in DL shall be locked in less than 100 ms.

6.1.24.3 Conformance

Conformance tests as defined in clause 7.1.24 shall be carried out.

The values shall be guaranteed at middle frequency and normal temperature.

6.2 Requirements for base band parameters

All baseband tests shall be done at middle frequency and normal temperature conditions.

6.2.1 Scrambler/De-scrambler

6.2.1.1 Definition

In order to ease receiver synchronization, all transmitted traffic and control zone bytes shall be scrambled with a length 2^{15} - 1 Pseudo Random Binary Sequence bits, in accordance with the polynomial S(x) in TS 101 999 [1], clause 5.3.1:

$$S(x) = x^{15} + x^{14} + 1$$

In order to guarantee the data integrity, the same scrambler shall be used to de-scramble the received data.

6.2.1.2 Limits

All transmitted traffic and control zone bytes shall be scrambled and de-scrambled with the same Pseudo Random Binary Sequence bits with the initial state "100101010000000". All bytes belonging to a given frame are transmitted by using the same initial state for scrambling. The scrambling will affect the whole transmission except the preamble symbols.

The initialization process follows the following procedure:

- For the UL, the initialization shall be done at the beginning of every burst, excluding the UL preamble.
- In case of UL burst concatenation, the initialization shall be done after the first preamble, where the scrambling operation shall exclude all other preambles.
- For the DL the initialization shall be done at the beginning of each frame, excluding the frame-preamble. Additionally, in case of optional TDMA, the initialization shall be done per each TDMA region, excluding the DL TDMA preamble.

6.2.1.3 Conformance

Conformance tests as defined in clause 7.2.1 shall be carried out.

6.2.2 FEC Encoder/Decoder and ARQ

6.2.2.1 Definition

In order to protect the transmitted data from channel impairments, forward error correction coding at the transmission side shall be applied TS 101 999 [1], clause 5.3.2. Two channel coding schemes are adopted in HA. The first one, being mandatory is based on a concatenated Reed-Solomon with convolutional coding. The second optional coding scheme is based on Turbo code that shall be used only for the UL.

The mandatory FEC coding scheme is based on a concatenated coding scheme.

The outer code shall be a shortened Reed-Solomon RS (K + 16, K, t=8) code over GF(256) that can transmit different number of traffic or control zone bytes.

The maximum value of K shall be 216 for the downlink and 220 for the uplink. For test purposes these values correspond to the range 1 MAC PDU to 4 MAC PDU.

The inner code shall be a punctured convolutional code that shall provide from the mother code memory 6 (64 states), rate 1/2, a wide range of higher inner code rates r, e.g. r = 2/3, 5/6 and 7/8. The generator polynomial of the mother convolutional code shall be: $G_1 = 171_{oct}$, $G_2 = 133_{oct}$.

Table 37: The puncturing patterns of the inner convolutional code (X_1 is sent first)

Inner code rate, r	Puncturing patterns	Transmitted sequences (after parallel to serial conversion)
1/2	X: 1 Y: 1	$X_1\ Y_1$
2/3	X: 1 0 Y: 1 1	$X_1Y_1\ Y_2$
5/6	X: 1 0 1 0 1 Y: 1 1 0 1 0	$X_1\ Y_1\ Y_2\ X_3\ Y_4\ X_5$
7/8	X: 1 0 0 0 1 0 1 Y: 1 1 1 1 0 1 0	$X_1\ Y_1\ Y_2\ Y_3\ Y_4\ X_5\ Y_6\ X_7$

In order to guarantee the data integrity, the same inverse operations, i.e. channel decoding at the reception side shall be applied.

Furthermore, the Automatic Retransmission Request (ARQ) functionality is foreseen for HIPERACCESS uplink direction. Therefore, for each decoded FEC-block the RS decoder at APT side shall provide a flag to be activated when in presence of erroneous UL MAC PDU.

6.2.2.2 Limits

By shortening the systematic RS code, the RS codeword length can be adapted to transmit different number of MAC PDU.

For the downlink operation from 1 to 4 x MAC PDUs (each MAC MPDU = 54 bytes) per codeword shall be transmitted, where the RS code will be shortened to transmit one data MAC-PDU of 54 Bytes using RS(70, 54, t = 8) or up to four MAC-PDUs using RS (232, 216, t = 8) code.

For the uplink one or several 4 x MAC PDUs (each MAC MPDU = 54 bytes) per codeword shall be transmitted, where the RS code will be shortened to transmit one data MAC PDU of 55 Bytes using RS(71, 55, t=8) or up to four MAC PDUs using RS(236, 220, t = 8) code.

Additionally the following tests shall be performed:

- For the DL, the FEC corresponding to DL-0 shall be tested.
- For the UL, the FEC corresponding to UL-1S shall be tested.

Depending on the modulation (symbol mapping), the inner code shall support the given punctured inner code.

6.2.2.3 Conformance

Conformance tests as defined in clause 7.2.2 shall be carried out.

Same procedure for TPC.

6.2.3 Signal constellation and mapping

6.2.3.1 Definition

In order to guarantee high spectrally efficient transmission, the digital encoded data, depending on the PHY mode shall be mapped to the required constellation TS 101 999 [1], clause 5.3.3. Three Quadrature Amplitude Modulation (QAM) constellations with Gray mapping are supported: QPSK, 16QAM and 64QAM (see table 38).

Table 38: UL and Downlink constellation

Transmitted direction	Modulation	Optional/mandatory
Downlink	4QAM	Mandatory
Downlink	16QAM	Mandatory
Downlink	64QAM	Optional
Uplink	4QAM	Mandatory
Uplink	16QAM	Optional

In order to guarantee the data integrity, the same inverse operations, i.e. symbol demapping at the reception side shall be applied.

6.2.3.2 Limits

For the downlink a constant RMS Tx power shall be guaranteed. Therefore, all modulation shall be normalized with the value given in table 39. In practical implementations an approximate value of the normalization factor might be used, as long as the device conforms to the general transmitter and receiver performance requirements.

Table 39: Modulation dependent normalization factor K_{MOD}

Modulation	K_{MOD}
4QAM	9
16QAM	4
64QAM	2

6.2.3.3 Conformance

Conformance tests as defined in clause 7.2.3 shall be carried out.

6.2.4 Framing and alignments

6.2.4.1 Definition

AP and AT transmissions are structured in fixed length frames TS 101 999 [1], clause 5.3.4. The frame length is 1 ms. The uplink and downlink frames shall be aligned in time. An appropriate alignment is necessary for proper bandwidth allocation management.

The downlink transmitted data to different ATs are multiplexed in the time domain. As HIPERACCESS employs adaptive PHY modes, a DL frame consists of a few TDM regions (see figure 9). Each TDM region is assigned with a specific PHY mode.

The DL frame consists of a preamble, a control zone and a TDM zone and an optional TDMA zone.

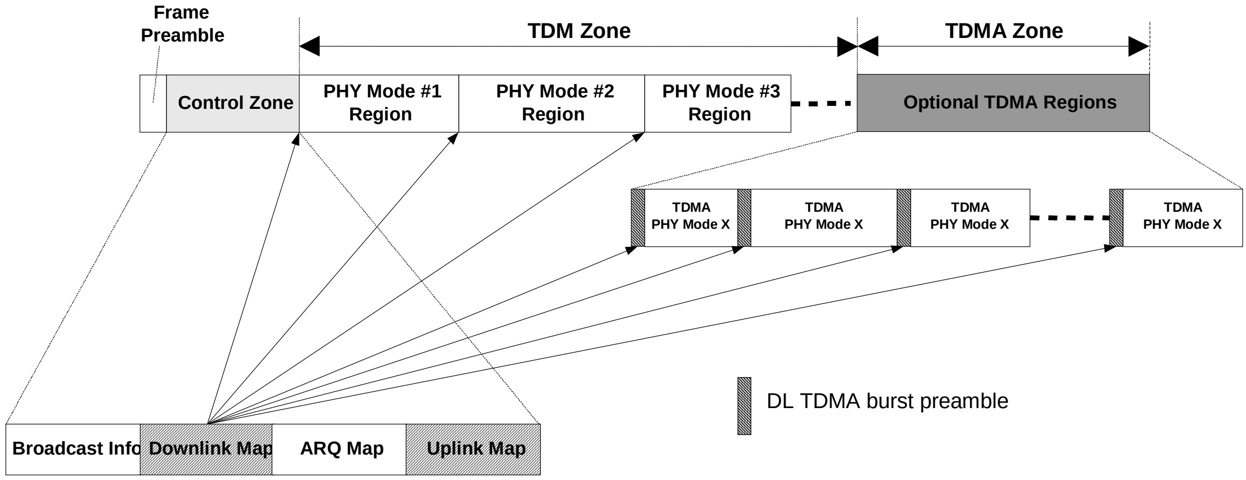

Figure 9: Downlink framing and multiplexing

6.2.4.2 Limits

Each frame shall start with a preamble of length 32 symbols and shall be followed by at least 2 x FEC blocks corresponding to the control zone. For simplifying the demodulation process, TDM regions shall be allocated in a robustness descending order: The most robust PHY mode shall be allocated after the control zone and the least robust PHY mode shall be allocated at the end of the frame.

For the optional TDMA zone, the order of the PHY mode is random.

Furthermore, from the AP point of view the uplink frame shall start with a given Frame Offset (FO) with respect to the downlink frame start. The minimum value of the FO shall be 0,4 ms. The maximum value for this offset FO is 1 ms. The resolution of the frame offset value shall be 1/16 ms (1 400 channel symbols).

6.2.4.3 Conformance

Conformance tests as defined in clause 7.2.4 shall be carried out.

6.2.5 Burst formatting and alignments

6.2.5.1 Definition

The AT transmissions within the UL frames are structured in a bursty manner TS 101 999 [1], clause 5.3.4. The burst has a variable length. Three different types of burst transmissions shall be tested in the uplink channel.

- Long burst (data or signalling): It can be used for data, signalling or dummy bytes transmission.
- Short signalling burst.
- Ranging burst.

Each burst consists of a ramp-up/down symbols (guard time), a preamble (16 or 32 symbols) and one or several FEC blocks.

Two possibilities may exist for each AT for UL burst transmission (see figure 10):

- **AT-without burst concatenation:** Each AT transmits an UL burst, made of a ramp-up time, UL preamble and several FEC-blocks.
- **With burst-concatenation:** Each AT transmits a concatenation of several bursts, where each one carries one FEC block. The Ramp-up time shall be used only at the beginning of the first burst, i.e. the ramp-up time shall be excluded between two consecutive bursts.

The burst concatenation is optional for the APT and mandatory for AT. Burst concatenation will be active on a carrier basis. The APT will broadcast the supported UL burst transmission by a relevant field in the control zone.

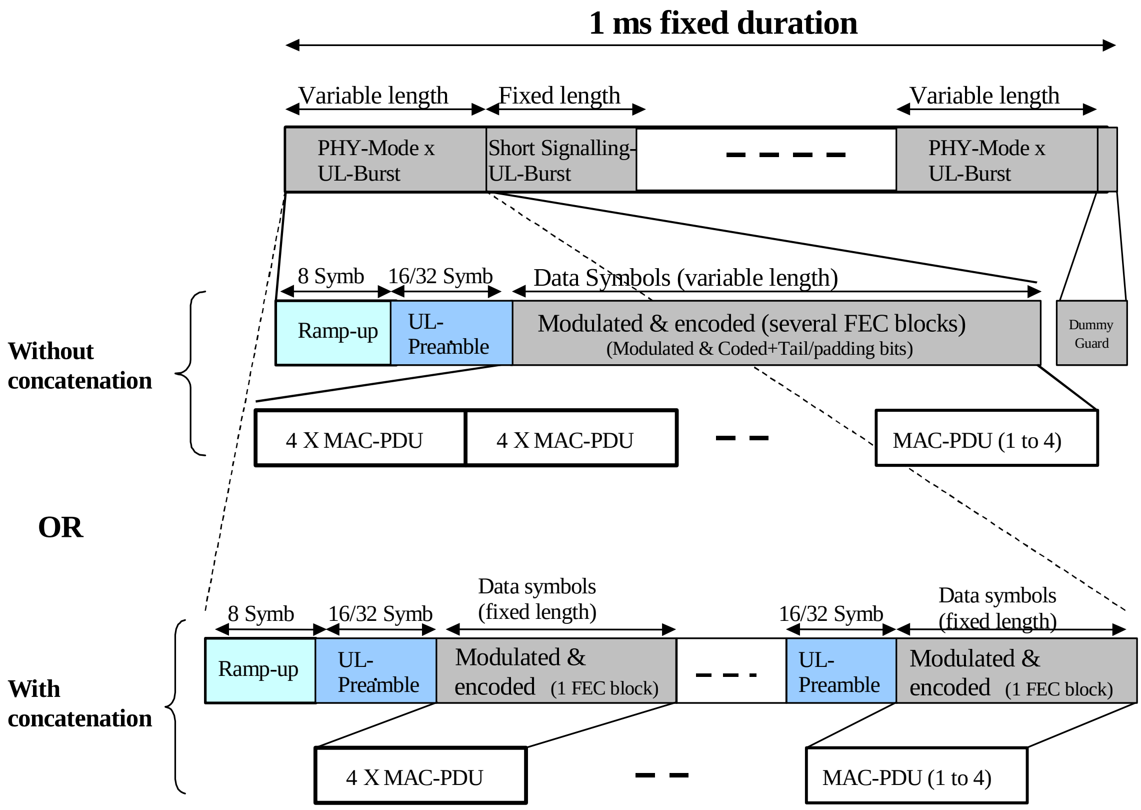

Figure 10: Uplink frame structure

6.2.5.2 Limits

Each data burst shall be able to transmit different FEC blocks.

For ranging burst, the data shall be transmitted at the beginning of the burst. The format of the burst within the window shall comply with the format of a short signalling burst with an extended guard time. The AP measures the delay and through the ATTC messages, the AT corrects its transmission time. The length of the extended guard time shall be between 20 µs and 80 µs.

6.2.5.3 Conformance

Conformance tests as defined in clause 7.2.5 shall be carried out.

6.2.6 UL-preamble selection

6.2.6.1 Definition

The UL TDMA preamble shall have a length of 16 symbols or 32 symbols, which shall be a repetition of CAZAC sequences of length 8 symbols or 16 symbols, respectively, and shall be transmitted using the four corner points of the respective modulation constellation (maximum power) TS 101 999 [1], clauses 5.3.4.3.1 and 5.3.4.4.3.

6.2.6.2 Limits

The AT shall be able to generate both preamble sequences. The AP shall be able to receive at least one of these preamble sequences. The AP shall decide which of these preamble sequences shall be transmitted by the AT. In the case where the AP receives/demodulates both preamble sequences, the selection of these preamble sequences could be done per AT basis.

6.2.6.3 Conformance

Conformance tests as defined in clause 7.2.6 shall be carried out.

6.2.7 Set of PHY modes

6.2.7.1 Definition

Two sets of PHY modes (Set-1 to Set-2) are specified for the downlink and for uplink (see tables 1 and 2). The reason for specifying different sets of PHY modes is to offer a higher flexibility for the HA standard deployment TS 101 999 [1], clause 5.4.2.

6.2.7.2 Limits

The reception of both Sets by the AT is mandatory. However, the reception of Set-1 by the AP is mandatory, but the reception of Set-2 is optional for AP.

Both AT and AP receivers shall be able to receive all mandatory PHY modes.

Each PHY mode shall be able to transmit different numbers of MAC PDUs per FEC codeword. But for the verification of the PHY modes, only the case with 4 x MAC PDUs shall be considered.

The same is valid for the TPC.

6.2.7.3 Conformance

Conformance tests as defined in clause 7.2.7 shall be carried out.

6.2.8 PHY mode adaptation parameters

6.2.8.1 Definition

PHY mode shall be adapted to a given weather (and interference) condition. Dynamic adaptation of PHY mode in conjunction with power control shall be supported in both direction TS 101 999 [1], clause 5.4.4. The choice of a given used PHY mode, i.e. coding and modulation parameters combination will depend on the link quality between the AP and the AT in both directions. If there is a need for changing the used parameters, the dynamic adaptation of PHY mode shall be supported by the PHY layer and shall be switched in a synchronous manner in the transmit and receive side.

6.2.8.2 Limits

For change of UL PHY mode, the following rules shall be applied:

- For the UL, the AP shall grant a minimum amount of traffic of at least 150 channel symbols within a single burst in every time interval 50 ms to 200 ms in order to ensure a continuous measurement of the C/N and receiver power in the AP with a given accuracy.

- The Carrier to Noise ratio (C/N) in the AP shall be measured with an accuracy of ±1 dB over the range 5 dB to 30 dB and with a measurement interval time of 50 ms to 200 ms. The measured C/N shall have a resolution of 0,25 dB.

- Absolute received power measurement shall have an accuracy of ±3 dB and with a measurement interval time of 50 ms to 200 ms. The measured received power shall have a resolution of 0,25 dB.

- Instantaneous transmitted *Tx power margin reserve* in the AT, measured with an accuracy of ±2 dB for the top 12 dB of the dynamic range and with a measurement interval time of 50 ms. The *Tx power margin reserve* shall have a resolution of 0,25 dB. The transmitted *power margin reserve* is the difference between the actual transmitted power and the maximum transmitted power of the AT. If the actual transmitted power shall be also transmitted, e.g. for performance monitoring purposes, it shall have a resolution of 1 dB.

- Each AT shall be able to communicate to the AP its instantaneous Tx power margin reserve within an interval time 50 ms to 200 ms.
- Each AT shall provide to the DLC layer, together with the available Tx power margin reserve, the information about its being ready or not (having enough power margin reserve) to switch to a more efficient PHY mode; such information is called "Power availability for changing to more efficient PHY mode".
- Based on these measured parameters: C/N at AP, Rx Power in AP, and/or the and the instantaneous Tx power margin in the AT, and/or the Power availability for changing to higher PHY mode, the AP can decide for the change of UL PHY mode or performing UL power control.

For change of DL PHY mode, the following rules shall be applied:

- The Carrier to Noise ratio (C/N) in the AT shall be measured with an accuracy of ±1 dB over the range 5 dB to 30 dB and with a measurement interval time of 50 ms. The measured C/N shall have a resolution of 0,25 dB.
- Absolute received power measurement shall have an accuracy of ±3 dB and with a measurement interval time of 50 ms. The measured received power shall have a resolution of 0,25 dB.
- Each AT shall be able to communicate to the AP, its measured C/N and received power within an interval time 50 ms to 200 ms.
- Based on these measured parameters: C/N at AT, Rx Power in AT (and the instantaneous power margin in the AP), the AP can decide for the change of DL PHY mode.

The PHY layer shall also provide some additional means to the DLC layer in order to correctly apply these decisions driven by algorithms, as follows:

- Capability (on the AT) to automatically change the transmission power for every PHY mode change.
- Capability (on the AT) to receive from the DLC layer the values of the automatic power changes for every modulation change foreseen on the Uplink.

6.2.8.3 Conformance

Conformance tests as defined in clause 7.2.8 shall be carried out.

6.2.9 Performance monitoring and management parameters

6.2.9.1 Definition

For network management purposes, the PHY layer shall provide means for performance monitoring and change of PHY parameters.

6.2.9.2 Limits

For performance monitoring purposes the equipment shall be compliant with the following Recommendations:

- Radio link quality monitoring: ITU-T Recommendations G.821 [18], G.826 [19], G.827 [20] and M.2100 Series [21].
- Logical link quality monitoring (in case of ATM): ITU-T Recommendation I.356 (see bibliography).

6.2.9.3 Conformance

Conformance tests as defined in clause 7.2.9 shall be carried out.

7 Test procedures

For some test procedures different test methods are given here. The supplier shall demonstrate, for each requirement given in clause 6, the compliance of the equipment under test by means of at least one of the methods reported.

Furthermore, for some RF conformance tests (e.g. spectrum mask, spurious emission, etc.) some needed measurement parameters (e.g. video bandwidth and others) as given in EN 301 213-3 [24] shall be used.

Two possibilities for test sequence generation at PHY input are allowed, as reported in figure 3:

- injection of an externally generated sequence, by means of a zero sequence generator instrument;
- self-generated test sequence by means of DLC.

In order to perform all Radio Conformance tests specified below, all basic DLC functionalities required shall be guaranteed.

NOTE 1: Some of the following tests require a null sequence. This sequence can also be replaced by the corresponding MAC-PDU-sequence.

NOTE 2: In some tests of the AT a signal generator is foreseen (see e.g. figures 12, 16, 25, etc.) in order to phase lock to the AP carrier. For this purpose, alternatively, an AP can be used.

NOTE 3: In those cases where the symbol transmit clock (22,4 MHz) is not available directly, measurements can be performed alternatively at a corresponding clock. However, the corresponding clock shall be phase locked to the symbol transmit clock.

7.1 Tests for radio parameters

7.1.1 Carrier frequencies

7.1.1.1 Test set-up

Different set-ups are required for AP and AT, as depicted in figures 11 and 12.

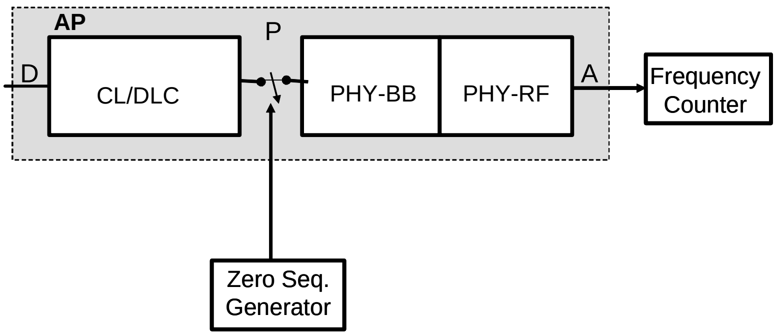

Figure 11: Test set-up for carrier frequency measurement in AP

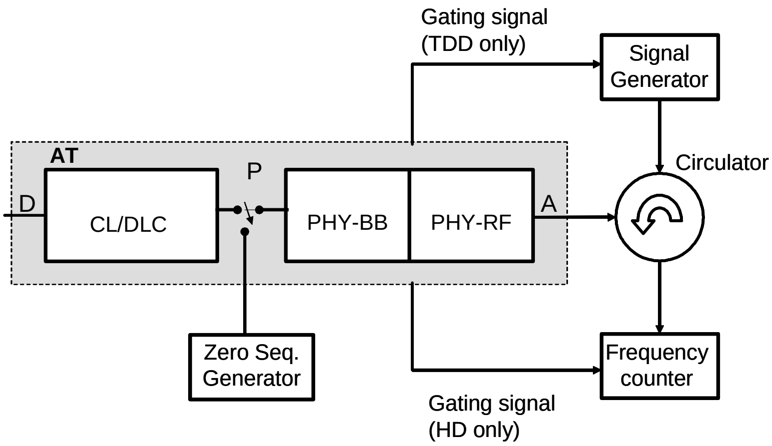

Figure 12: Test set-up for carrier frequency measurement in AT

The AP shall be measured in stand-alone configuration, whereas the AT requires a frequency reference in order to phase lock to the AP carrier; in the latter case the reference is provided by means of a signal generator with injection through a circulator. In case of TDD, the signal generator shall be gated with a suitable enable signal (burst synchronism) provided by the AT, in order to avoid interference between Tx and Rx.

Test instruments: Test pattern generator

Frequency counter

Signal generator and Circulator (for AT only)

Test sequence: Suitable to generate CW signal

7.1.1.2 Test procedure

The transmitter under test shall be put in CW mode (pure sine wave) when in transmit mode.

The signal generator shall provide to the AT a downlink signal using PHY mode DL-3 (16QAM). The DL preamble shall be present with the same timing as normal operation. In the case of a full duplex FDD AT, the AT shall transmit the CW tone continuously. For a TDD or half-duplex FDD AT, the CW tone shall be transmitted with a 50 % duty cycle (i.e. 50 % of frame), synchronized with the DL preamble.

The carrier shall be measured by means of a Frequency Counter with an accurate frequency reference (recommended two orders of magnitude greater than the allowed limit), internal or external.

If adequate measurement stability cannot be achieved by this method, then the supplier shall make available an appropriate method to place the transmitter in a mode that allows the frequency of the carrier to be measured.

7.1.2 Channel allocation

7.1.2.1 Test set-up

Same as in clause 7.1.1.

7.1.2.2 Test procedure

The system (AP or AT) shall be able to shift the carrier frequency by the resolution limit from the nominal value, still providing the same accuracy.

The transmitter under test shall be put in CW mode. The carrier shall be measured by means of a Frequency Counter with an accurate frequency reference (recommended two orders of magnitude greater than the allowed limit), internal or external.

7.1.3 Symbol transmit clock and tolerance

7.1.3.1 Test set-up

Different test configurations are necessary for AP and AT as shown in figures 13 and 14.

The AP shall be measured in stand-alone configuration, whereas the AT requires an AP in order to phase lock to the AP clock.

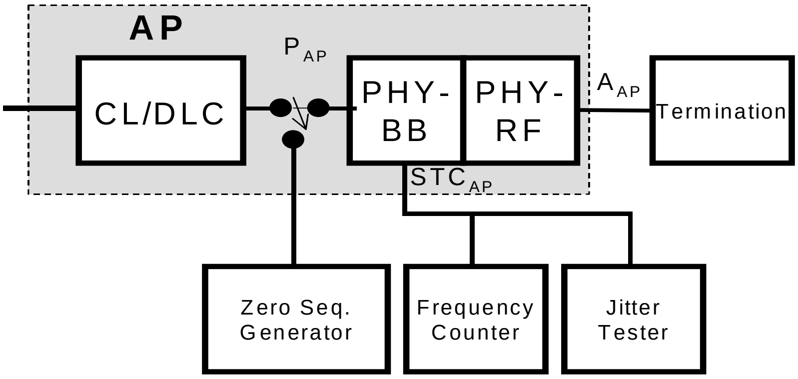

Figure 13: Test configuration for AP symbol transmit clock

Test instruments:	Resistance termination
	Zero sequence Generator
	Frequency counter
	Jitter tester
Test sequence:	Null sequence

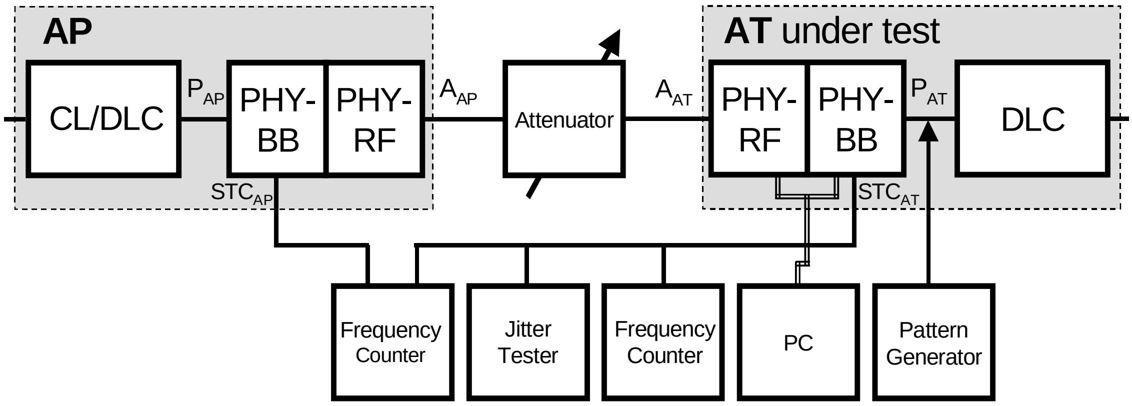

Figure 14: Test configuration for AT symbol transmit clock

Test instruments: Variable attenuator

Jitter tester

Frequency counter

Zero sequencegenerator

PC

Test sequence: Null sequence

7.1.3.2 Test procedure

AP test (figure 13).The test sequence is fed in at interface P_{AP}. The symbol transmit clock frequency and the peak-to-peak jitter shall be measured according to clause 6.1.3.2 at interface STC_{AP}. The requirements are listed in table 7.

AT test (figure 14). The variable attenuator, simulating the RF link attenuation, shall be adjusted to given attenuation (e.g. 30 dB). The AP shall provide the normal DL framing and preamble, and the normal ranging procedure will be completed (including timing advance ranging). The phase difference between the AP symbol transmit clock and the AT symbol transmit clock shall be monitored by the Phase Comparator. The AT symbol transmit clock shall be set to "phase lock condition" by the PC. The AT symbol transmit clock frequency and the peak-to-peak jitter at interface STC_{AT} shall be measured according to clause 6.1.3.3.

The AT symbol transmit clock shall now be set to "phase unlock condition" by the PC. According to table 8 no AT data shall be sent.

7.1.4 RF channel and spectrum mask

7.1.4.1 Test set-up

Different set-ups are required for AP and AT, as depicted in figures 15 and 16.

The AP shall be measured in stand-alone configuration, whereas the AT requires a frequency reference in order to phase lock to the AP carrier; in the latter case the reference is provided by means of a signal generator with injection through a circulator. In case of TDD, the signal generator shall be gated with a suitable enable signal (burst synchronism) provided by the AT, in order to avoid interference between Tx and Rx. The AT may also be tested in a stand-alone mode if the AT vendor chooses to implement a test mode that provides a bursted, modulated PN sequence with a burst duty cycle controlled by the PC interface.

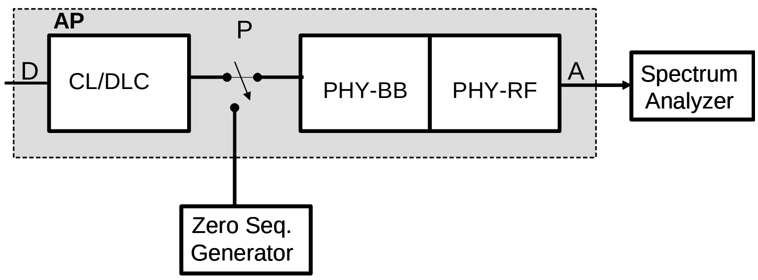

Figure 15: Test set-up for spectrum mask measurement in AP

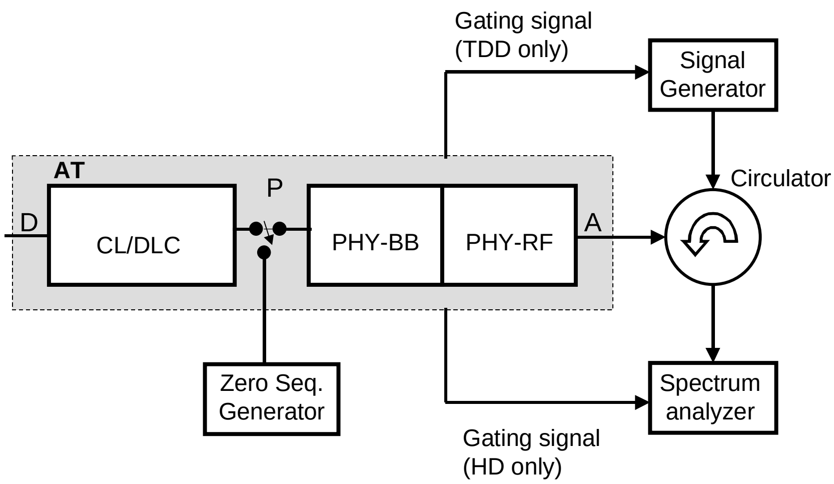

Figure 16: Test set-up for spectrum mask measurement in AT

Test instruments: Zero sequence generator

Spectrum Analyser

Signal generator and Circulator (for AT only)

Test sequence: Null sequence

7.1.4.2 Test procedure

The transmitter under test shall be set on the maximum power.

The AP shall be measured with continuous power Vs time.

The AT shall be measured both with continuous power Vs time and with switched power on a burst basis (periodic sequence of one burst on and the following off, as defined in figure 17 and table 40). In the latter case the test shall consider the short signalling burst as well.

The signal generator shall provide to the AT a downlink signal using PHY mode DL-3 (16QAM).

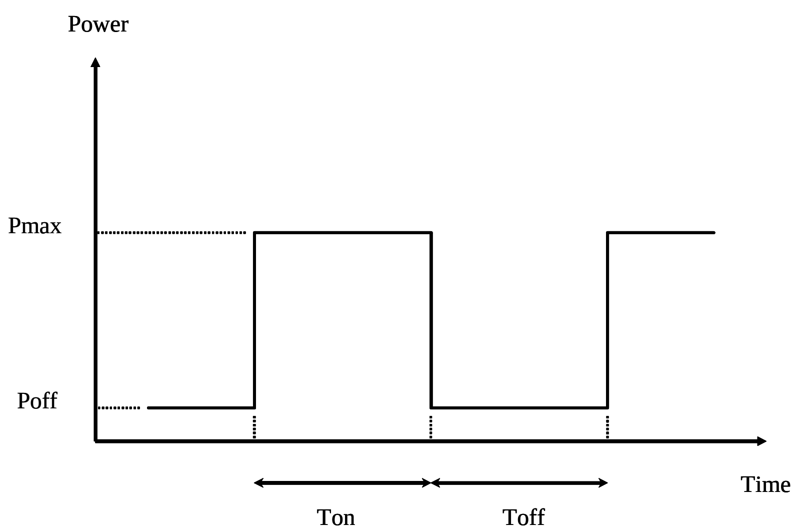

Figure 17: Burst test sequence for spectrum mask measurement in AT

Table 40: Burst test sequence parameters

Parameter	Value
P_{max}	See clause 6.1.5
P_{off}	See clause 6.1.11
T_{on}	5 µs (112 symbols)
T_{off}	5 µs (112 symbols)

The settings of the spectrum analyser are to be in accordance with the indications of table 41 see EN301 126-2-3[22].

Table 41: Spectrum analyser settings for spectrum mask measurement

Parameter	AP	AT
Centre frequency	Actual	Actual
Span	140 MHz	140 MHz
Scan time	Auto	Auto
Resolution bandwidth	100 kHz	300 kHz
Video bandwidth	0,3 kHz	100 kHz

7.1.5 Transmitter output power and tolerance

7.1.5.1 Test set-up

Figure 18 shows the test set-up to measure the maximum output power at AP and AT, respectively.

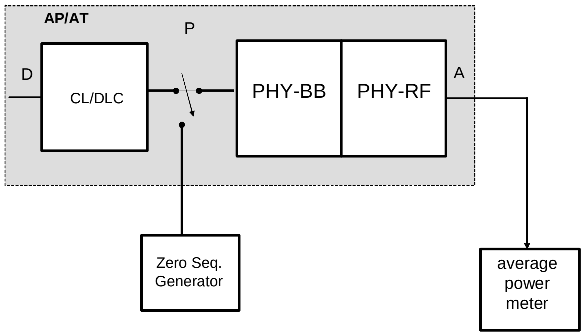

Figure 18: Test configuration for transmitter output power measurements

Test instruments: Zero sequence generator

Average power meter

Test sequence: Null sequence

7.1.5.2 Test procedure

The test sequence is fed in at interface P. The transmitter shall operate in a continuous mode. According to tables 11 and 12 for the different DL PHY modes the maximum output power is measured at the A-interface of AP. The same procedure is performed for the UL PHY modes according to table 13.

NOTE: The scrambler shall be active and the power control shall guarantee the maximum transmit power.

7.1.6 Dynamic Downlink Power Control (DDPC)

7.1.6.1 Test set-up

Figure 19 shows the test set-up to verify the Dynamic Downlink Power Control (DDPC).

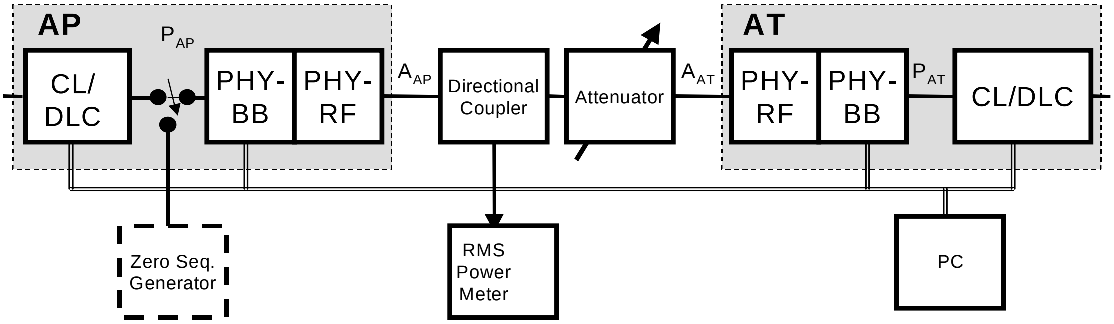

Figure 19: Test configuration for DDPC

Test instruments: Zero sequence generator

RMS power meter

Directional coupler

Variable attenuator

Test sequence: Null sequence

7.1.6.2 Test procedure

DLC functionality required for downlink power control shall be guaranteed.

The test sequence is fed in at interface P_{AP}. The variable attenuator which simulates the RF link attenuation shall be adjusted to 20 dB. After slowly decreasing the attenuation the AP first applies the most efficient PHY mode before the DDPC becomes active. After finding that attenuation the dynamic ranges according to table 14 shall be swept by means of attenuator variation.

Fixed modulation:

- DL-3.
- DL-4 (optional mode).

NOTE: Scrambler shall be active.

7.1.7 Tx static power setting

7.1.7.1 Test set-up

The test set-up to measure the Tx static power setting of the APT is shown in figure 18 and is the same as for the Tx output power. The same test sequence shall be applied.

7.1.7.2 Test procedure

The AP Tx output power for the settings of table 15 in clause 6.1.7.2 are measured.

Fixed modulation:

- DL-3.
- DL-4 (optional mode).

NOTE: Scrambler shall be active.

7.1.8 Automatic Transmit Power Control (ATPC)

7.1.8.1 Test set-up

Figure 20 shows the test set-up to verify the Automatic Transmit Power Control (ATPC).

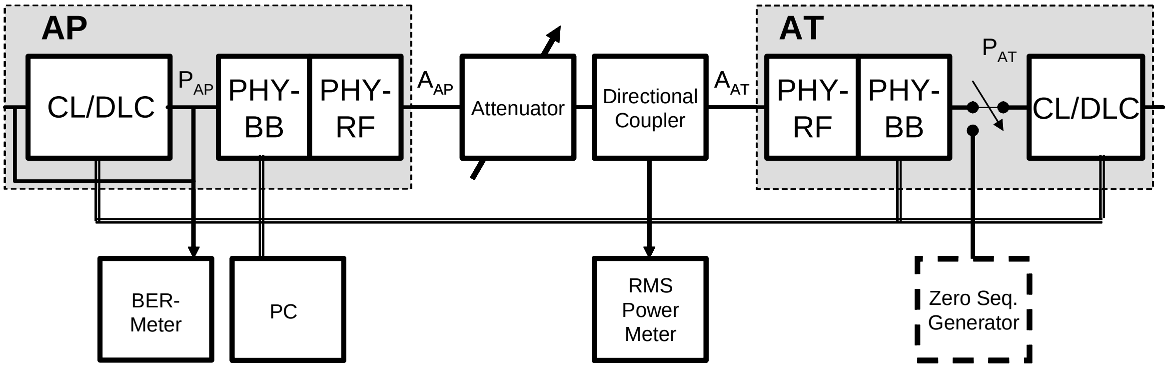

Figure 20: Test configuration for ATPC

Test instruments: BER-Meter

Variable attenuator

Directional coupler

RMS power meter

Zero sequence generator

PC

Test sequence: Null sequence

7.1.8.2 Test procedure

The DLC functionality required for uplink power control (ATPC) shall be guaranteed.

The test sequence is fed in at interface P_{AT}. The verification of correct ATPC is performed in the following three steps:

1) The ATPC is deactivated. The variable attenuator, simulating the RF link attenuation, shall be adjusted in such a way that the BER-Meter at interface P_{AP} indicates 10^{-6}. The nominal Rx power threshold for BER = 10^{-6} can be measured indirectly by the RMS power meter considering the losses of attenuator and directional coupler. The ATPC is now activated. The resulting Rx power shall be in the allowed range of Rx power margin (see clause 6.1.8.2). The transition time, measured by the PC, shall be according to clause 6.1.8.2.

2) The ATPC is deactivated. The variable attenuator shall be adjusted 10 dB below the attenuation necessary to get BER = 10^{-11}. The ATPC is now activated. The resulting Rx power shall be in the allowed range of Rx power margin (see clause 6.1.8.2). The transition time, measured by the PC, shall be according to clause 6.1.8.2.

3) The ATPC is activated. The link attenuation shall be varied ±1 dB resulting in an actual Rx power deviation according to maximally the granularity (see clause 6.1.8.2).

The test shall be performed for the PHY modes DL-2 and UL-2.

NOTE: The scrambler shall be active.

7.1.9 Error vector magnitude

Three test methods are described. These tests require very accurate test equipments. In case of not using accurate "golden receiver" or "golden transmitter" then, the result of this test may not be sufficiently accurate.

7.1.9.1 Method A (Golden Transmitter)

7.1.9.1.1 Test set-up

Figure 21 shows the test configuration to measure the loss of CNR due to transmitter implementation. The used "Golden Transmitter" shall be a transmitter with known impairments and with a significant better performance than the transmitter to be tested.

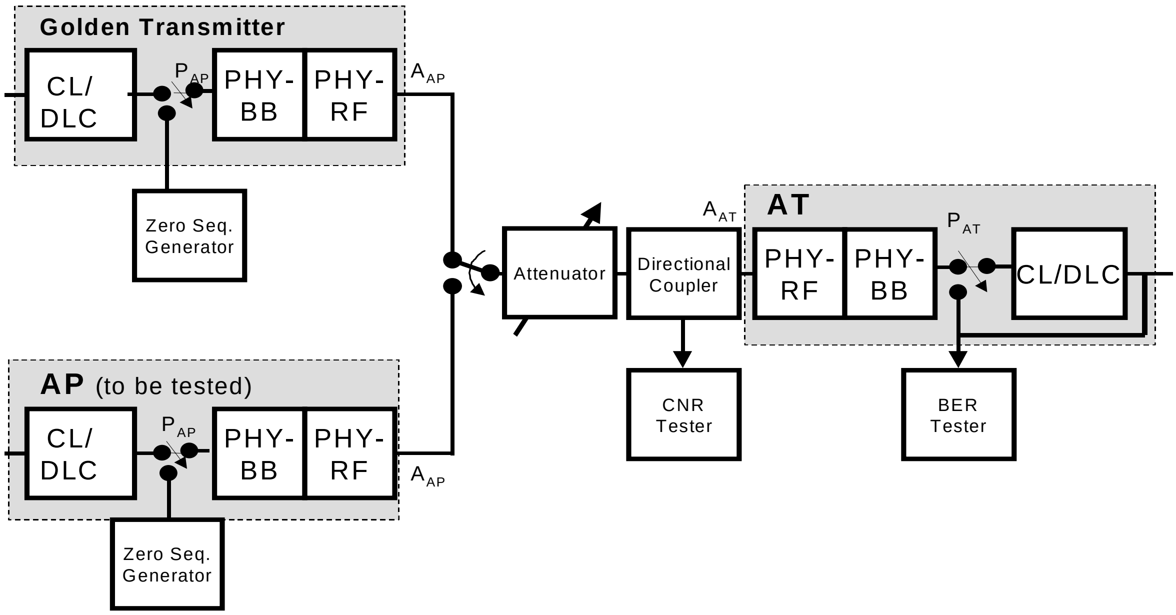

Figure 21: Test configuration for EVM

Test instruments:	Zero sequence generator
	Variable attenuator
	CNR tester
	BER tester
	Directional coupler
Test sequence:	Null sequence

7.1.9.1.2 Test procedure

The test shall be performed in two steps. In the first step the configuration consisting of the "Golden Transmitter" and an AT shall be used. In the second step the configuration consisting of the AP to be tested and the same AT as before shall be used (see figure 21).

Step 1: The test sequence shall be fed in at interface P_{AP}. Now the variable attenuator shall be adjusted in such a manner that the BER tester shows 10^{-6}. The CNR belonging to BER = 10^{-6}, CNR_{GT}, is read.

Step 2: The same procedure shall be performed with the AP to be tested. The corresponding CNR is now CNR_{RT}.

The known implementation impairment of the "Golden Transmitter" shall be TxI_{GT}. The transmitter impairment TxI_{AP} of the AP to be tested is:

$$TxI_{AP} = CNR_{RT} - CNR_{GT} + TxI_{GT}.$$

TxI_{AP} shall be less or equal to the figure in column 2 of table 16.

NOTE: The same method shall be applied for AT EVM testing with DLC support to achieve bursty transmission.

7.1.9.2 Method B (Golden Receiver)

7.1.9.2.1 Test set-up

Figure 22 shows the test configuration to measure the loss of CNR due to transmitter implementation. The used "Golden Receiver" shall be a receiver with known impairments and with a significant better performance than an HA AT.

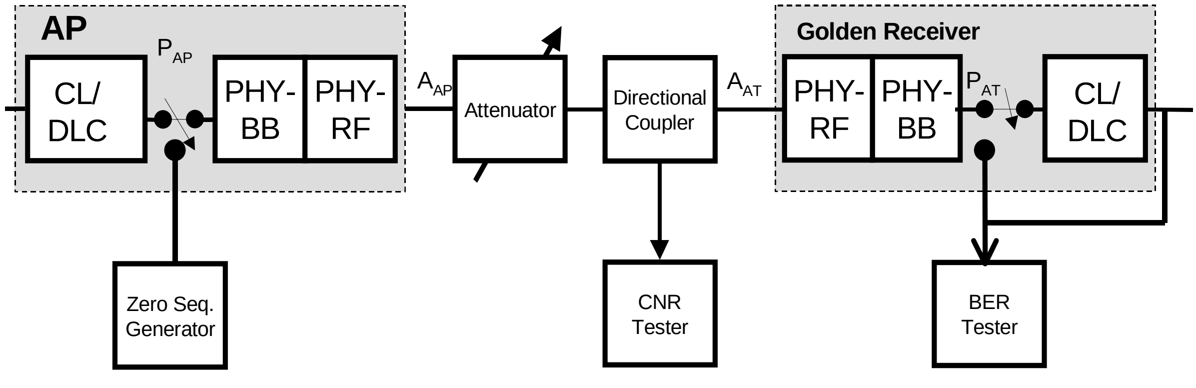

Figure 22: Test configuration for EVM

Test instruments: Zero sequence generator

Variable attenuator

CNR tester

BER tester

Directional coupler

Test sequence: Null sequence

7.1.9.2.2 Test procedure

The test sequence shall be fed in at interface P_{AP}. The variable attenuator shall be adjusted in such a manner that the BER tester shows 10^{-11}. The CNR belonging to BER = 10^{-11}, CNR_{AP}, is read.

The known implementation impairment of the "Golden Receiver" shall be RxI_{GR}. The transmitter impairment TxI_{AP} of the AP to be tested is

$$TxI_{AP} = CNR_{AP} - (CNR_{IDEAL} + RxI_{GR}),$$

where the CNR_{IDEAL} is listed in the third column of table 16. TxI_{AP} shall be less or equal to the figure in column 2 of table 16.

NOTE: The same method shall be applied for AT EVM testing with DLC support to achieve bursty transmission.

7.1.9.3 Method C (Golden Receiver with computer processing)

7.1.9.3.1 Test set-up

Figure 23 shows the test configuration to measure the loss of CNR due to transmitter implementation. The needed "Golden Receiver" shall be a receiver with known impairments and with a significant better performance than an HA AT. In the "Golden Receiver" the incoming RF is downconverted to a suitable intermediate frequency where an analog-to-digital conversion takes place. The data are stored to enable an offline computer simulation for the PHY-BB processing in order to make available the P_{AT} interface.

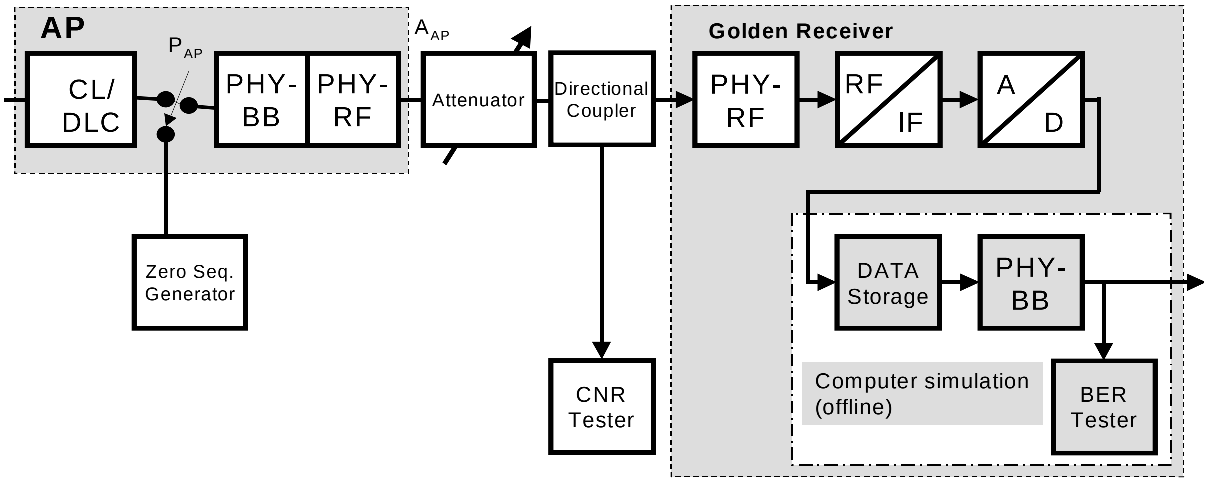

Figure 23: Test configuration for EVM

Test instruments:	Zero sequence generator
	Variable attenuator
	CNR tester
	Directional coupler
Test sequence:	Null sequence

7.1.9.3.2 Test procedure

The test sequence shall be fed in at interface P_{AP}. The variable attenuator shall be adjusted in such a manner that the BER tester shows 10^{-11}. The CNR belonging to BER = 10^{-11}, CNR_{AP}, is read.

The known implementation impairment of the "Golden Receiver" shall be RxI_{GR}. The transmitter impairment TxI_{AP} of the AP to be tested is:

$$TxI_{AP} = CNR_{AP} - (CNR_{IDEAL} + RxI_{GR}),$$

where the CNR_{IDEAL} is listed in the third column of table 16. TxI_{AP} shall be less or equal to the figure in column 2 of table 16.

NOTE: The same method shall be applied for AT EVM testing with DLC support to achieve bursty transmission.

7.1.10 Antenna gain

7.1.10.1 Test set-up

In order to measure antenna gain different set-ups can be employed, according to EN 301 126-3-2 [23].

7.1.10.2 Test procedure

Corresponding to the employed set-up, the test procedure is described in EN 301 126-3-2 [23].

7.1.11 Time mask for burst transmission

7.1.11.1 Method A (Golden Receiver with computer processing)

7.1.11.1.1 Test set-up

The set-up needed for the measurement of the time mask is depicted in figure 24. The needed "Golden Receiver" shall be a receiver with known impairments and with a significant better performance than an HA AT. In the "Golden Receiver" the incoming RF is down-converted to a suitable intermediate frequency where an analog-to-digital conversion takes place. The data are stored to enable an offline computer simulation for the PHY-BB processing in order to perform the Time Mask measurement.

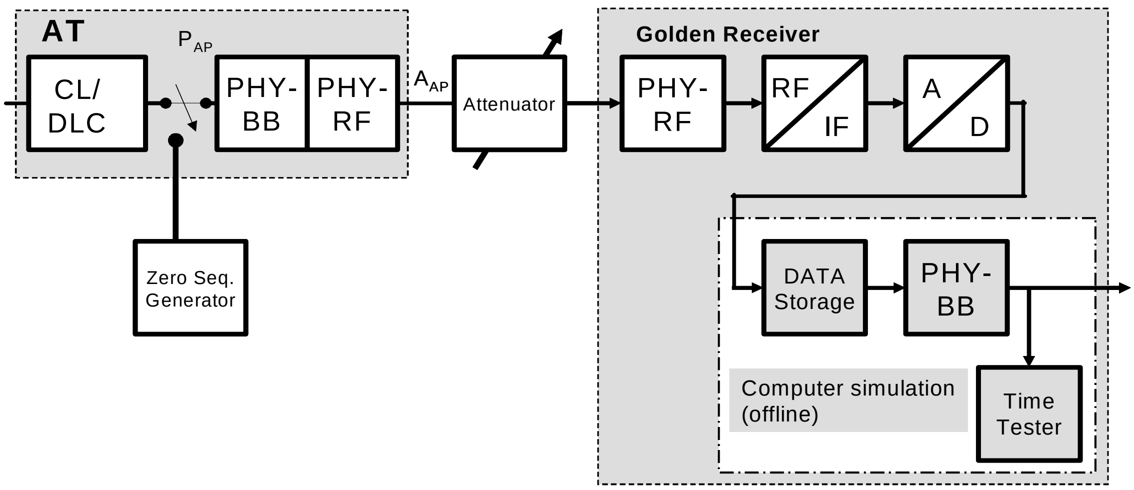

Figure 24: Test set-up for time mask measurement with golden receiver

Test instruments: Zero sequence generator

Attenuator

Golden Receiver

Test sequence: Null sequence

7.1.11.1.2 Test procedure

The DLC shall support the generation of bursty transmission with characteristics as described in figure 17 and table 40.

Set the attenuator so that the AT is working at the centre of its dynamic range.

Power is considered at the sampling instants only, in order to get rid of the variations due to filtering. The variations due to constellation (4QAM or 16QAM) are taken into account.

The Time Mask measurement shall be done by means of software post-processing.

7.1.11.2 Method B (Spectrum Analyzer with zero-span mode)

7.1.11.2.1 Test set-up

In order to phase lock to the AP, the AT requires a frequency reference carrier that is provided by means of a signal generator with injection through a circulator. In case of TDD, the signal generator shall be gated with a suitable enable signal provided by the AT (burst synchronism), in order to avoid interference between Tx and Rx.

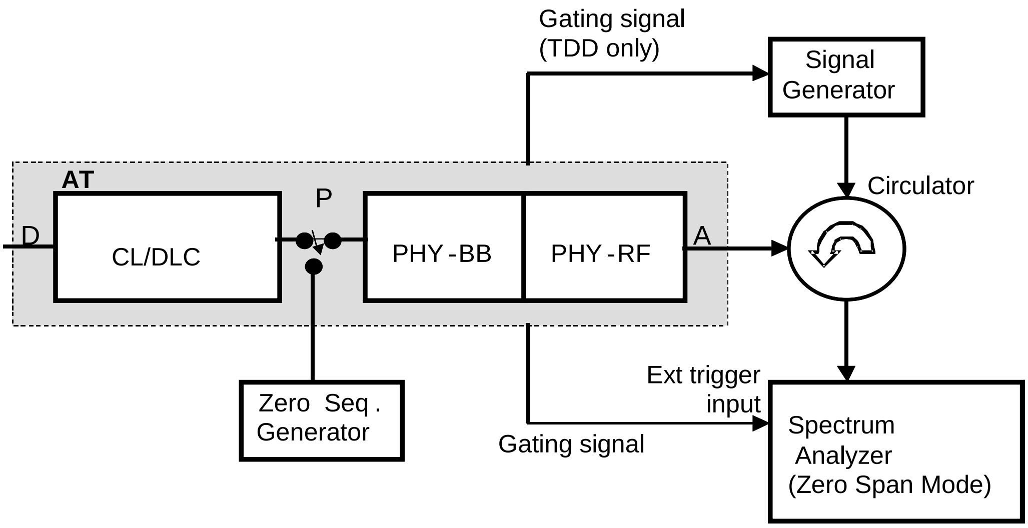

Figure 25: Test set-up for time mask measurement with oscilloscope

Test instruments: Zero sequence generator

Signal generator and Circulator

Oscilloscope

Test sequence: Null sequence

7.1.11.2.2 Test procedure

The DLC shall support the generation of bursty transmission with characteristics as described in figure 17 and table 40.

The signal generator shall provide to the AT a downlink signal using PHY mode DL-3 (16QAM).

The limits, shown in the mask in figure 8 and detailed in table 19, shall be fulfilled.

7.1.12 Tx/Rx switching time

7.1.12.1 Test set-up

Same as in clause 7.1.11, HD case.

7.1.12.2 Test procedure

The supplier shall declare the value of $\Delta C_{deep\text{-}off}$ (see mask in figure 8).

The switching time between Rx and Tx is measured from when the output power is less than $C_{on\text{-}off} + \Delta C_{deep\text{-}off}$ dBc to the start of the burst (centre of the first sample of the preamble part).

The switching time between Tx and Rx is measured from the end of the burst (centre of the last sample of the data part) to when the output power is less than $C_{on\text{-}off} + \Delta C_{deep\text{-}off}$ (dBc).

7.1.13 Receiver sensitivity

7.1.13.1 Test set-up

Figure 26 shows the set-up to measure the receiver sensitivity at AP and AT.

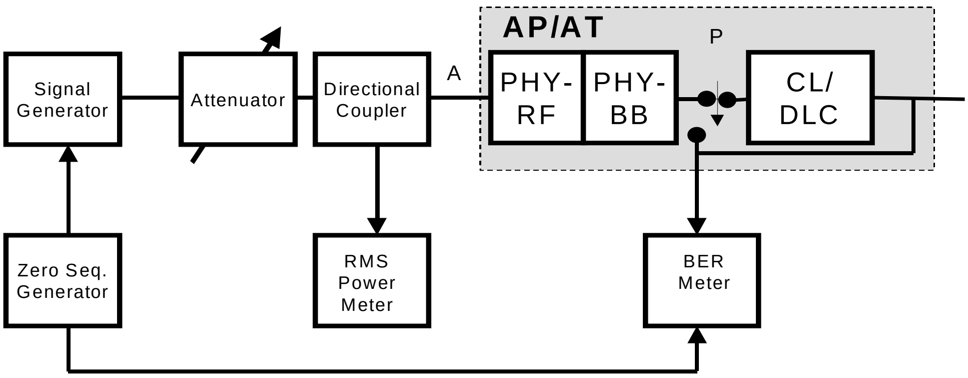

Figure 26: Test set-up for Rx sensitivity measurement

Test instruments: Zero sequence and BER meter

Attenuator, Directional coupler and Power meter

Test sequence: Periodic repetition of 1 ms sequences, constituted by Preamble (16 or 32 symbols, CAZAC) and Data, according to figure 27.

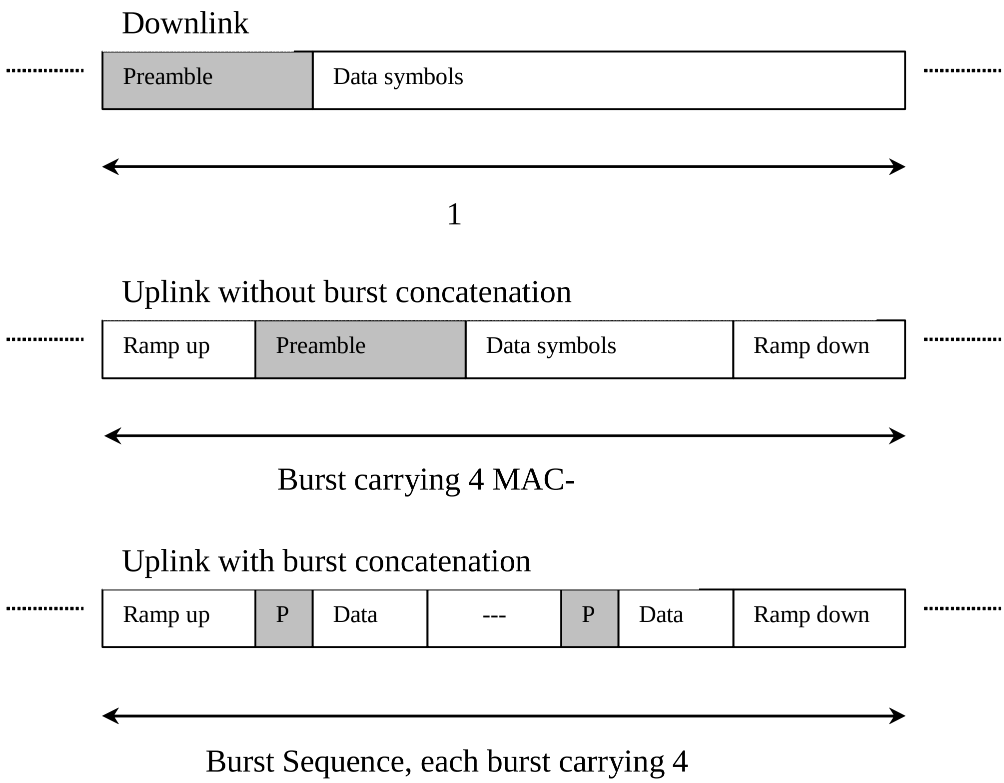

Figure 27: Test sequences for Rx sensitivity measurement

7.1.13.2 Test procedure

Connect the pattern generator to the transmitter (signal generator). The receiver under test shall send output data, clock and enable (burst synchronism) signals from P interface to the BER meter.

Set the transmitter at a power level within the detection range of the power meter and get the values of the detected power P_{ref} and of the attenuation A_{ref} (calibration of the set-up). For the uplink and TDD downlink measurements, the calibration shall take into account the duty cycle of the burst.

Increase the attenuation to the value A_{fin} until the BER reaches the value of 10^{-6}. The sensitivity value is given by:

$$S_{th} = P_{rx} \text{ @ } (BER=10^{-6}) = P_{ref} + A_{ref} - A_{fin}$$

7.1.14 Performance in multi-path channel

7.1.14.1 Test set-up

Figure 28 shows the set-up to measure the multi-path performance at AP and AT.

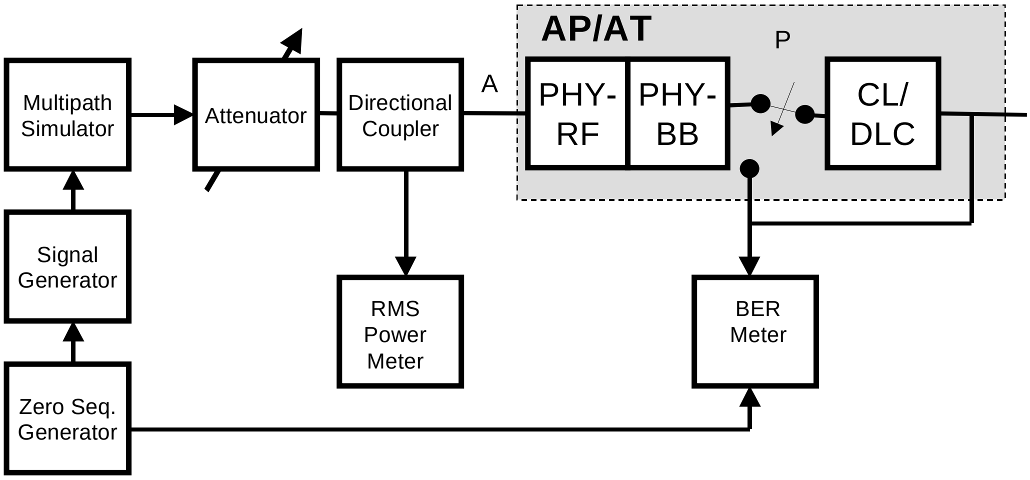

Figure 28: Test set-up for multi-path performance measurement

Test instruments:	Zero sequence generator and BER meter
	Attenuator, Directional coupler and Power meter
	Multi-path channel simulator
Test sequence:	Null sequence

7.1.14.2 Test procedure

Same as in clause 7.1.13, apart from using the multi-path channel simulator.

7.1.15 Background BER

7.1.15.1 Test set-up

Same as in clause 7.1.13.

7.1.15.2 Test procedure

Initially measure the output power of the transmitter (signal generator) at a level within the calibrated range of the power meter. Then increase the attenuator setting to give the RF level specified in clause 6.1.15 and record the BER.

The receiver under test shall send output data, clock and enable (burst synchronism) signals from P interface to the BER meter.

7.1.16 Receiver dynamic range

7.1.16.1 Test set-up

Same as in clause 7.1.13. Use the least efficient PHY mode for the lower limit and the most efficient PHY mode for the upper limit.

7.1.16.2 Test procedure

The lower limit of the dynamic range is given by the sensitivity level on the least efficient PHY mode (measured in clause 7.1.13).

In order to measure the upper limit connect the zero sequence generator to the transmitter input (signal generator) and the BER meter to the receiver output (P interface). The receiver under test shall send output data, clock and enable (burst synchronism) signals from P interface to the BER meter.

Adjust the variable attenuator to provide maximum attenuation. Switch on the transmitter working on the most efficient PHY mode and reduce the attenuation to set the power to the upper limit of the dynamic range.

At a BER of 10^{-6} the received level shall be higher than the upper limit, as reported in clause 6.1.16. The dynamic range is given by the difference between the upper and the lower limits of the received signal.

7.1.17 Co-channel interference performance

7.1.17.1 Test set-up

Figure 29 shows the set-up to measure the co-channel interference at AP and AT.

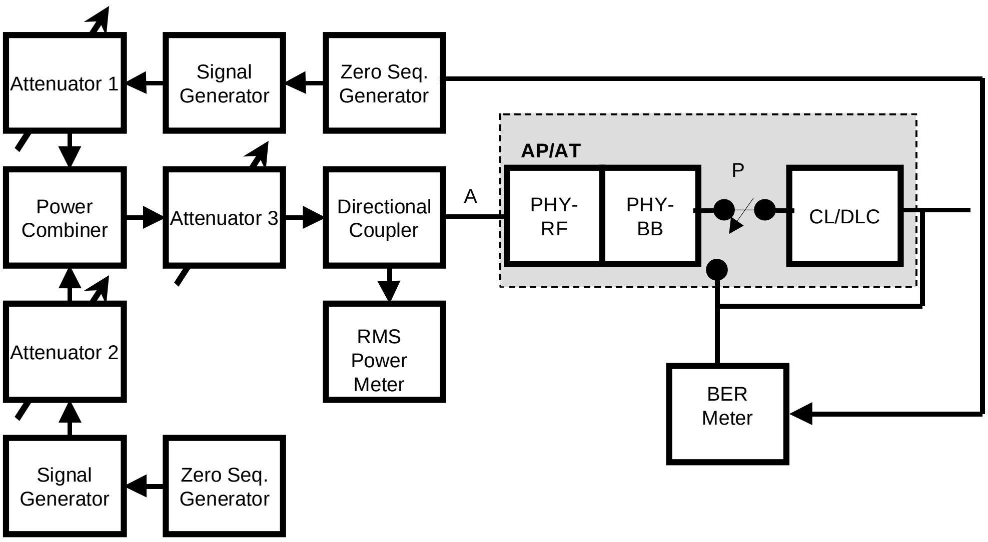

Figure 29: Test set-up for Co-channel interference measurement

Test instruments: Zero sequence generators and BER meter

Signal generators

Attenuators and Power combiner

Directional coupler and Power meter

Test sequence: Same as in clause 7.1.13.1

7.1.17.2 Test procedure

During this test both transmitters (wanted signal on Tx 1 and interferer on Tx 2) shall transmit on the same channel and be modulated with signals having the same characteristics. The function of attenuators 1 and 2 is to maintain the correct Carrier to Interference ratio, attenuator 3 can be used to control the absolute signal levels into the receiver. The receiver under test shall send output data, clock and enable (burst synchronism) signals from P interface to the BER meter.

With both transmitters off, set attenuators 1 and 2 to their maximum values. Switch on Tx 1 and adjust attenuator 1 to set the wanted signal to the level required for a BER of 10^{-6}. Decrease attenuator 1 by 1 dB (or 3 dB) and record its setting. Switch off Tx 1.

Switch on both transmitters and reduce attenuator 2 to achieve a BER of 10^{-6} on the BER meter. Record the setting of attenuator 2 and switch off both transmitters.

Switch on Tx 1 and reduce attenuator 1 to produce a wanted signal level within the calibrated range of the power meter. Record the power level and reduction in attenuation. Calculate $Power_{wanted\ signal}$ = Measured power level minus change in attenuation. Switch off Tx 1, switch on Tx 2 and repeat the procedure to calculate the $Power_{unwanted\ signal}$.

The maximum C/I value for 1 dB (or 3 dB) degradation on 10^{-6} is:

$$C/I = Power_{wanted\ signal}/Power_{unwanted\ signal}$$

The procedure shall be repeated for all the supported PHY modes.

7.1.18 Adjacent channel interference performance

7.1.18.1 Test set-up

Same as in clause 7.1.17.

7.1.18.2 Test procedure

During this test the interferer (or unwanted signal, Tx 2) shall transmit on the first adjacent channel and be modulated with a signal having the same characteristics as the signal modulating the wanted transmitter (Tx 1). The function of attenuators 1 and 2 is to maintain the correct Carrier to Interference Power ratio, attenuator 3 can be used to control the absolute signal levels into the receiver. The receiver under test shall send output data, clock and enable (burst synchronism) signals from P interface to the BER meter.

With both transmitters off, set attenuators 1 and 2 to their maximum values. Switch on Tx 1 and adjust attenuator 1 to set the wanted signal to the level required for a BER of 10^{-6}. Decrease attenuator 1 by 1 dB (or 3 dB) and record its setting. Switch off Tx 1.

Switch on both transmitters and reduce attenuator 2 to achieve a BER of 10^{-6} on the BER meter. Record the setting of attenuator 2 and switch off both transmitters.

Switch on Tx 1 and reduce attenuator 1 to produce a wanted signal level within the calibrated range of the power meter. Record the power level and reduction in attenuation. Calculate $Power_{wanted\ signal}$ = Measured power level minus change in attenuation. Switch off Tx 1, switch on Tx 2 and repeat the procedure to calculate the $Power_{unwanted\ signal}$.

The maximum C/I value for 1 dB (or 3 dB) degradation on 10^{-6} is:

$$C/I = Power_{wanted\ signal}/Power_{unwanted\ signal.}$$

Repeat the test with the interferer on the other first adjacent channel and on both the second adjacent channels upon request.

The procedure shall be done at both the least and the most efficient PHY modes supported by the system.

7.1.19 CW spurious interference

7.1.19.1 Test set-up

Figure 30 shows the set-up to measure CW spurious interference at AP and AT.

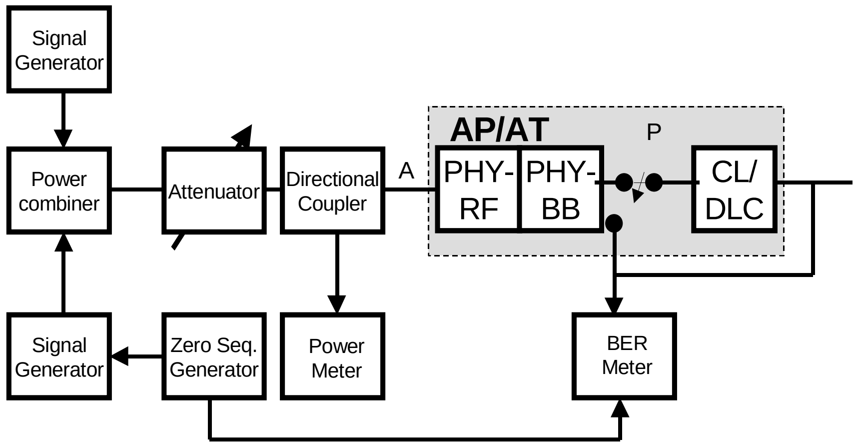

Figure 30: Test set-up for CW spurious interference measurement

Test instruments:	Zero sequence generator and BER meter
	Signal generators
	Attenuator and Power combiner
	Directional coupler and Power meter
Test sequence:	Same as in clause 7.1.13.1

7.1.19.2 Test procedure

During this test the interferer (or unwanted signal, Tx 2) shall be non-modulated (CW) and shall have a power +30 dB above the wanted signal (Tx 1) on a frequency of interest over 500 % of the channel spacing from the centre frequency, up to 60 GHz.

With both transmitters off, set the attenuator to its maximum value. Switch on Tx 1 and adjust the attenuation to set the wanted signal to the level (threshold) required for a BER of 10^{-6}. Switch off Tx 1, set Tx 2 to a power of +30 dBc and on the first frequency of interest, switch on Tx 2.

Switch on Tx 1 and verify that the degradation of the threshold is not more than 1 dB.

Repeat the test on all the frequencies of interest.

7.1.20 Rx-power measurement

7.1.20.1 Test set-up

Same as in clause 7.1.13.

7.1.20.2 Test procedure

Connect the zero sequence generator to the transmitter (signal generator). The receiver under test shall send output data, clock and enable (burst synchronism) signals from P interface to the BER meter.

Set the transmitter at a power level within the detection range of the power meter and get the values of the detected power P_{ref} and of the attenuation A_{ref} (calibration of the set-up).

Set the attenuator at the lower limit of the dynamic range (sensitivity threshold at BER 10^{-6}) and measure the Rx power at the Power meter, taking into account the coupling factor of the directional coupler. Compare the value with the one detected by the AP/AT (monitored by means of a PC). The difference shall be within the limits reported in clause 6.1.20.

Set the attenuator 10 dB less than the lower limit of the dynamic range and repeat the procedure.

Continue to reduce the attenuation by 10 dB up to the higher limit of the dynamic range, every time repeating the procedure.

7.1.21 CNR measurement

7.1.21.1 Test set-up

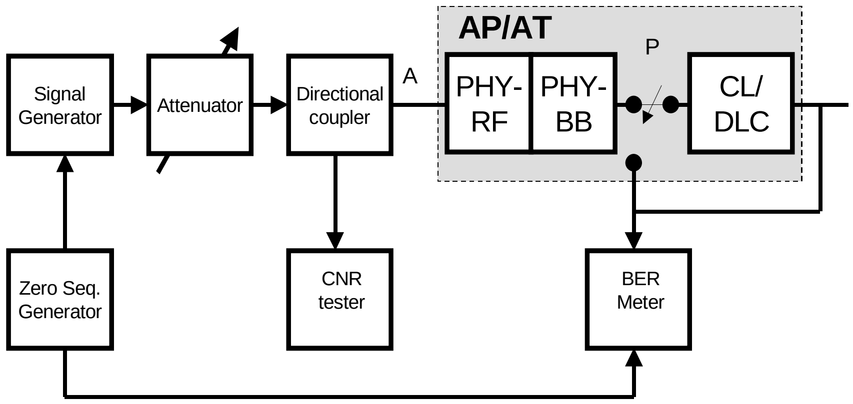

Figure 31: Test set-up for CNR measurement

Test instruments:	Zero sequence generator
	BER meter
	Signal generator
	Attenuator
	Directional coupler
	CNR tester
Test sequence:	Same as in clause 7.1.13.1

7.1.21.2 Test procedure

Connect the zero sequence generator to the transmitter (signal generator). The receiver under test shall send output data, clock and enable (burst synchronism) signals from P interface to the BER meter.

Set the transmitter at a power level within the detection range of the CNR tester and get the values of the detected power P_{ref} and of the attenuation A_{ref} (calibration of the set-up).

Set the attenuator at the lower limit of the dynamic range (sensitivity threshold at BER 10^{-6}) and measure the CNR in the range 5 to 30 dB. Compare the values with the ones detected by the AP/AT (monitored by means of a PC). The difference shall be within the limits reported in clause 6.1.21.

Set the attenuator 10 dB less than the lower limit of the dynamic range and repeat the procedure.

Continue to reduce the attenuation by 10 dB up to the higher limit of the dynamic range, every time repeating the procedure.

7.1.22 Spurious emissions

7.1.22.1 Test set-up

Figure 32 shows the test configuration for spurious emissions measuring.

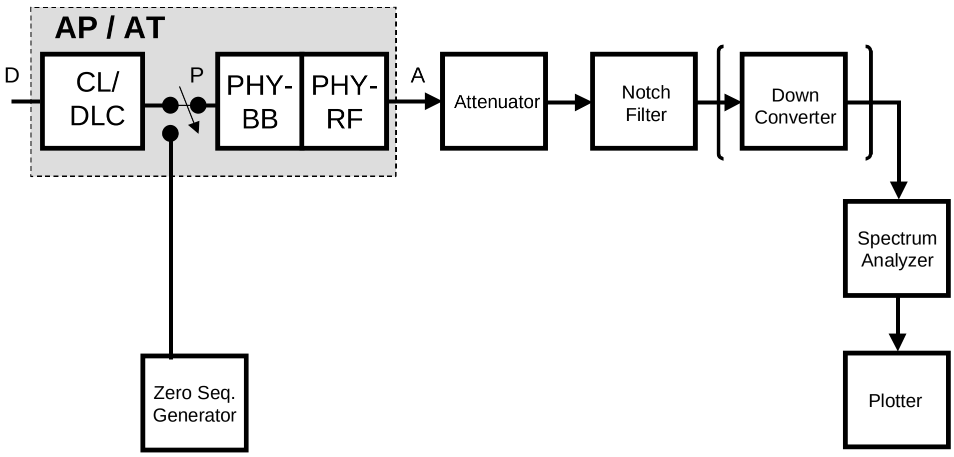

Figure 32: Test configuration for spurious emissions

Test instruments:	Zero sequence generator
	Attenuator
	Notch filter (band-stop in the range CCF - 70 MHz < f < CCF + 70 MHz)
	Down-Converter
	Plotter
	Spectrum analyser
Test sequence:	Null sequence

7.1.22.2 Test procedure

The zero sequence is fed in at interface P. The transmitter shall send with maximum power according to table 11, table 12, and table 13 for AP and AT, respectively. The transmitter output port shall be connected via an attenuator and a suitable notch filter to the spectrum analyser. The notch filter and the attenuator limit the power into the front end of the analyser. In those cases, where the upper frequency limit exceeds the basic operating range of the analyser, a suitable mixer will be required. It is important that the circuit between the transmitter and the input to the mixer or spectrum analyser is well known over the frequency range to be measured according to table 31, table 32, table 33, and table 34. These losses should be compensated at the spectrum analyser in order to ensure that the demanded specification criteria at interface A are met.

The level and frequency of all significant signals are to be measured and plotted throughout the frequency bands quoted in table 31, table 32, table 33, and table 34 for AP and AT, respectively. Spurious emissions close to the limit should be plotted over a restricted range clearly demonstrating that the signal does not exceed the relevant limit.

Since HA is a duplex equipment using a common port for transmitter and receiver in both, AP and AT, Tx and Rx spurious emissions are measured simultaneously.

Fixed modulation:

- DL-3
- DL-4(optional mode)

NOTE: Scrambler shall be active.

7.1.23 Automatic transmit timing control

7.1.23.1 Method A

7.1.23.1.1 Test set-up

The test set-up to verify the correct time alignment of the automatic transmit timing control (ATTC) is shown in figure 33. It consists of an AP and two ATs. To get a basis for the time alignment to be tested AT#1 contains no delay. AT#2 contains a "propagation delay" simulated by means of delayed fed in data.

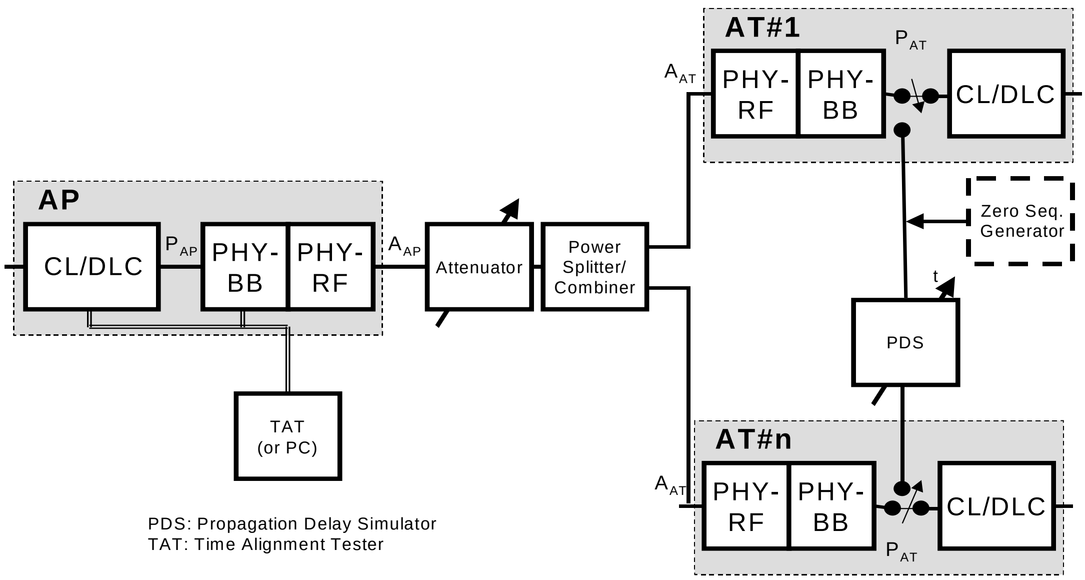

Figure 33: Test configuration for ATTC

Test instruments: Time alignment tester (PC)

Variable attenuator

Zero sequencegenerator

Power splitter/combiner

Variable propagation delay simulator

Test sequence: Null sequence

7.1.23.1.2 Test procedure

The DLC functionality required for ranging shall be guaranteed.

The variable attenuator, simulating the RF link attenuation, shall be adjusted to an attenuation of [40] dB. The test is organized in two parts:

a) The propagation delay simulator shall be adjusted to 100 ns, 40 µs and 79,9 µs as stated in table 35. For each propagation delay the ranging process shall be started. The measured delay at TAT shall be in accordance with table 35.

b) The propagation delay simulator shall be adjusted to the same three delays as before (table 36). The ranging process shall be finished. For these three propagation delays a variation of ±2 symbol periods shall be adjusted. The measured delay at TAT shall be within the ranges given in table 36.

The test shall be performed for PHY-Mode DL-2.

7.1.23.2 Method B

Connect the AT output to an oscilloscope using a directional coupler and microwave power detector. Trigger the oscilloscope on the DL frame start. Set up the AP to provide the AT with a constant starting-symbol allocation, and disable the DLC portion of the ATTC algorithm. Measure the time difference between the AT transmission and the DL frame start using the oscilloscope. Send a set of time-advance messages covering range of 0,1µs to 79,9µs to the AT (either over the RF link, or using the AT PC interface). Verify that the AT transmit time changes the appropriate amount within 1/2 symbol time using the oscilloscope. Using the PC interface to the AP, verify that the measured time-of-arrival by the AP agrees with the oscilloscope measurement to within 1/4 symbol time.

7.1.24 Load levelling and carrier recovery time

7.1.24.1 Test set-up

The test set-up to measure carrier recovery time is shown in figure 34.

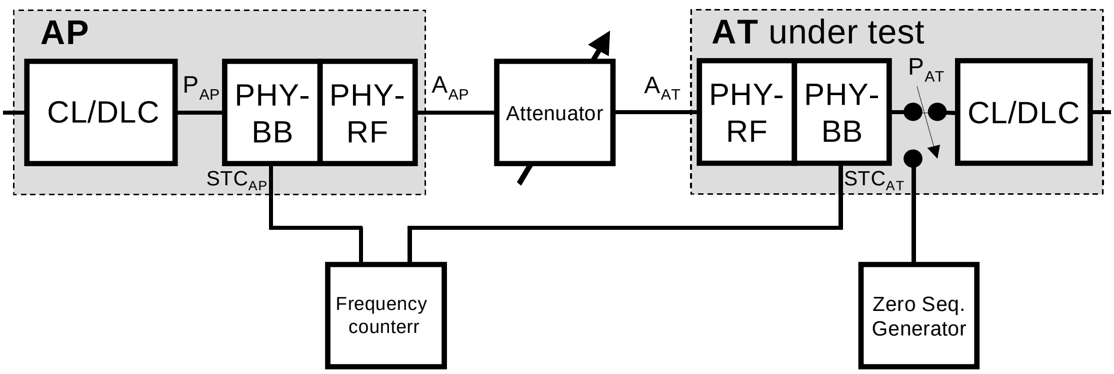

Figure 34: Test configuration for carrier recovery time

Test instruments: Variable attenuator

Frequency counter

Zero sequence generator

Test sequence: Null sequence

7.1.24.2 Test procedure

Set the attenuator so that the AT is locked to the AP in frame, carrier and symbol clock.

Increase the attenuation so to cause the AT to unlock.

Decrease the attenuator so to cause the AT to lock again to the AP. Register the locking time on the frequency counter and check that it is within the limit stated in clause 6.1.24.

7.2 Tests for baseband parameters

7.2.1 Scrambler/De-scrambler

This test is already covered by the background BER test (see clause 7.1.15) and the receiver sensitivity test (see clause 7.1.13).

7.2.2 FEC Encoder/Decoder and ARQ

The FEC Encoder/Decoder test is already covered by the receiver sensitivity test (see clause 7.1.13).

7.2.2.1 Test set-up

The test set-up to verify the ARQ is shown in figure 35.

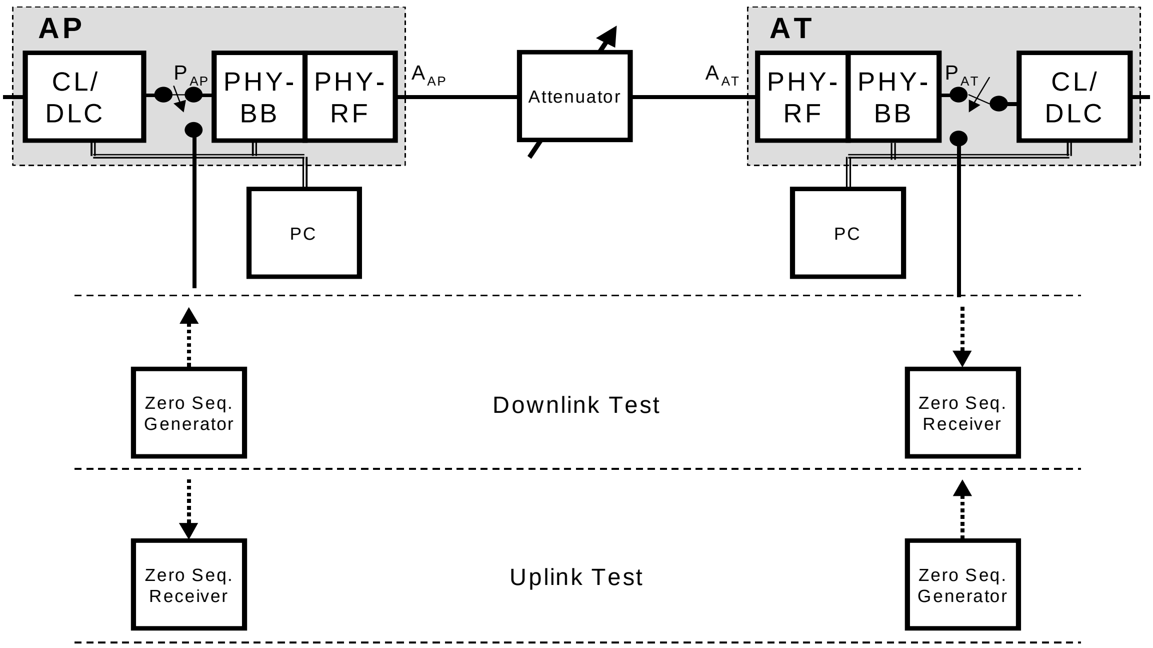

Figure 35: Test configuration for ARQ

Test instruments: Zero sequence generator

Variable attenuator

Test pattern receiver

Test sequence: Null sequence

7.2.2.2 Test procedure

The variable attenuator shall be adjusted to an attenuation of 1 dB more than the attenuation to reach a BER of 10^{-6}. The pattern generator and receiver are located like in the uplink test above. The scrambler/de-scrambler shall be activated. The test shall be performed with PHY mode DL-2. The RS bit flag at APT shall be monitored. In case of erroneous UL MAC PDU the RS flag shall be activated.

7.2.3 Signal constellation and mapping

This test is already covered by the receiver sensitivity test (clause 7.1.13).

7.2.4 Framing and alignments

7.2.4.1 Test set-up

Figure 36 shows the test set-up to verify the correct frame offset of the uplink (AT) frame in relation to the downlink (AP) frame.

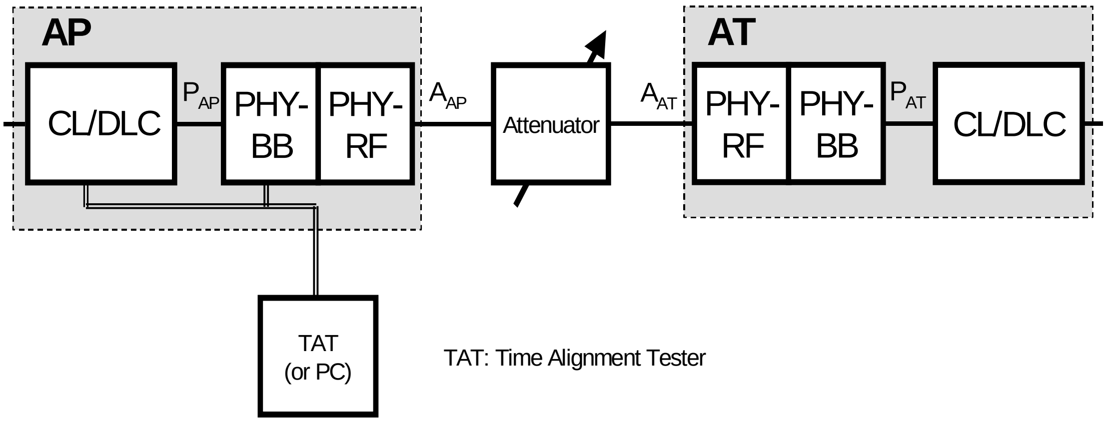

Figure 36: Test configuration for UL frame alignment

Test instruments: Time alignment tester (PC)

Variable attenuator

7.2.4.2 Test procedure

The variable attenuator, simulating the RF link attenuation, shall be adjusted to an attenuation of [40] dB. The time alignment tester (figure 36) measures the time between the start of the downlink frame (AP frame) and the start of the received uplink frame (AT frame). This frame offset time shall be within the range of 400 µs and 1 000 µs with a granularity of 1/16 ms according to 1 400 channel symbols.

Remark concerning testing of framing: The correct framing (preamble, FEC blocks, sequential order of modulations in TDM zone, etc.) is implicitly tested by this test and most other tests.

7.2.5 Burst formatting and alignments

7.2.5.1 Test set-up

Figure 37 shows the test set-up to verify the uplink burst formatting and alignment.

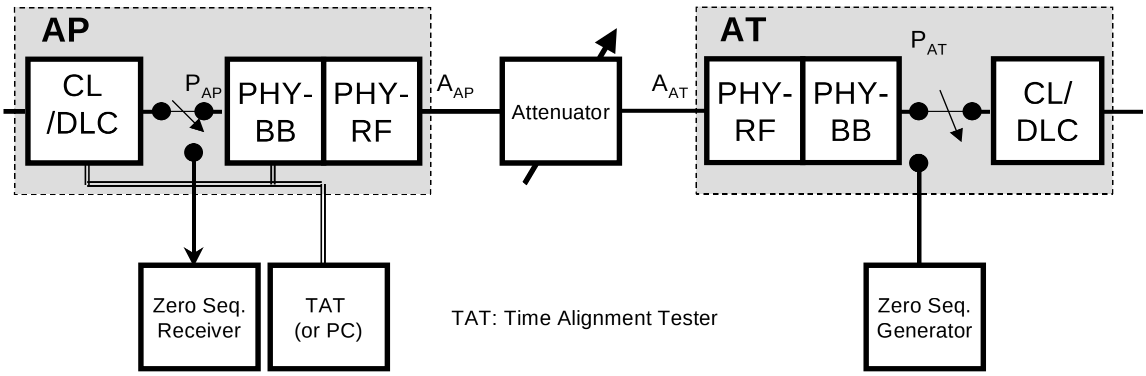

Figure 37: Test configuration for UL burst formatting and alignment

Test instruments:	Time alignment tester (PC)
	Variable attenuator
	Zero sequencegenerator
Test sequence:	Null sequence

7.2.5.2 Test procedure

The variable attenuator, simulating the RF link attenuation, shall be adjusted to an attenuation of [40] dB. The test sequence is fed in at interface P_{AT} and received at interface P_{AP}.

The ranging process to acquire the AT shall be initialized. The time alignment tester is now able to measure the extended guard time for ranging bursts (see clause 6.2.5.2).

The ranging process shall now be terminated and data shall be transmitted uplink.

The AT shall send bursts without burst concatenation. The received and the generated pattern shall be identical.

The AT shall now send bursts in the burst-concatenated mode. The received and the generated pattern shall be identical.

Remark: The correct burst formatting (UL preamble, FEC blocks, etc.) is implicitly tested by other tests.

7.2.6 UL-preamble selection

7.2.6.1 Test set-up

Figure 38 hows the test set-up to verify the UL-preamble selection. In order to test the mandatory ability of the ATs to generate two different UL TDMA preambles the particular AP in figure 38 shall be able to receive both preambles.

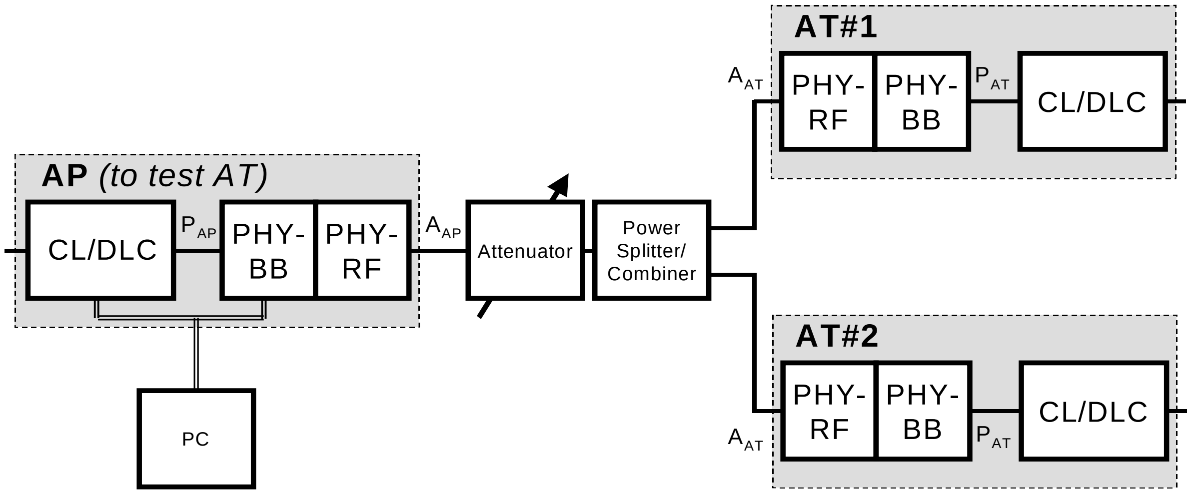

Figure 38: Test configuration for UL-preamble selection

Test instruments: PC

Power splitter/combiner

Variable attenuator

7.2.6.2 Test procedure

The variable attenuator, simulating the RF link attenuation, shall be adjusted to an attenuation of 40dB. By means of the PC the following adjustments and checks shall be carried out:

- AT#1 and AT#2 shall transmit with 16 symbols UL TDMA preamble. The correct interaction shall be checked. (Mandatory for AT);
- AT#1 and AT#2 shall transmit with 32 symbols UL TDMA preamble. The correct interaction shall be checked. (Mandatory for AT);
- AT#1 shall transmit with 16 symbols and AT#2 shall transmit with 32 symbols UL TDMA preamble. The correct interaction shall be checked. (Optional for AT);
- AT#1 shall transmit with 32 symbols and AT#2 shall transmit with 16 symbols UL TDMA preamble. The correct interaction shall be checked. (Optional for AT).

NOTE: The ability to receive both UL TDMA preambles is not mandatory for the AP (see clause 6.2.6.1).

7.2.7 Set of PHY modes

7.2.7.1 Test set-up

The test configuration is shown in figure 39.

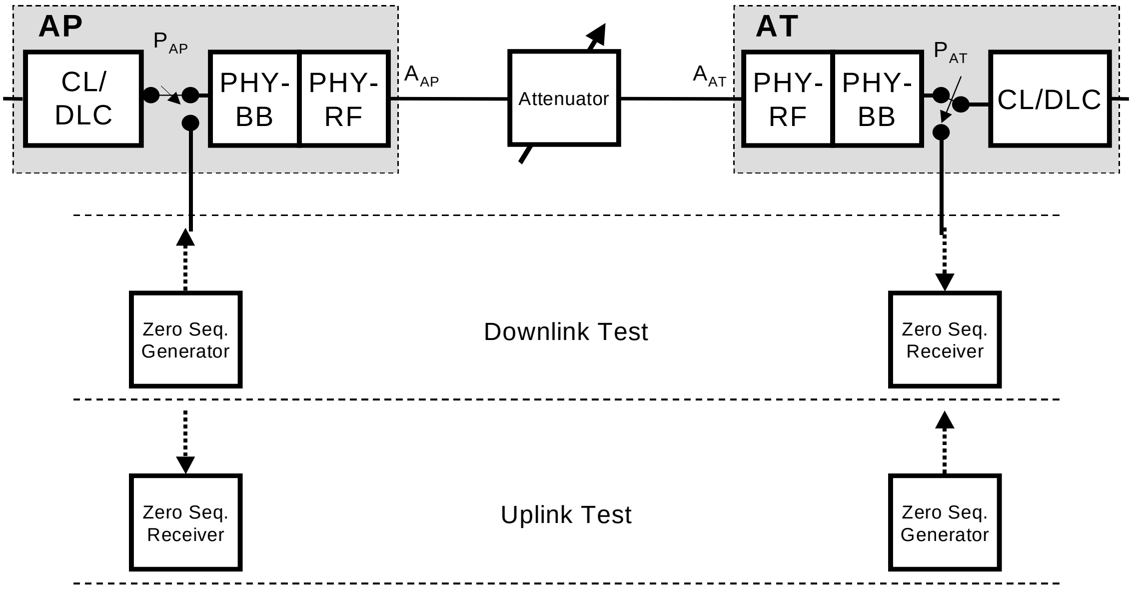

Figure 39: Test configuration for PHY modes

Test sequence: Null sequence

7.2.7.2 Test procedure

The variable attenuator, simulating the RF link attenuation, shall be adjusted to an attenuation 20 dB less than the attenuation to reach a BER of 10^{-6}. The test consists of a downlink and an uplink test (figure 39).

Downlink Test: The zero sequence is fed in at interface P_{AP}. The zero sequence is connected at interface P_{AT}. According to table 1 the downlink PHY modes of Set-1 and Set-2 are activated at AP as stated below. The received data at AT and the generated data shall be identical for each PHY mode.

Set-1, mandatory (table 1)	**Set-2**, mandatory (table 1)
DL-0 (mandatory)	DL-0 (mandatory)
DL-1 (mandatory)	DL-1 (optional)
DL-2 (mandatory)	DL-2 (optional)
DL-3 (mandatory)	DL-4 (optional)
DL-5 (optional)	DL-6 (optional)

Uplink Test: The zero sequence is fed in at interface P_{AT}. The zero sequence is connected at interface P_{AP}. According to table 2 the uplink PHY modes of Set-1 and Set-2 are activated at AP as stated below. The received data at AP and the generated data shall be identical for each PHY mode.

Set-1, mandatory (table 2)	**Set-2**, optional (table 2)
UL-1(mandatory)	UL-1 (mandatory)
UL-1S(mandatory)	UL-1S(mandatory)
UL-2(mandatory)	UL-2(mandatory)

UL-2S(mandatory)	UL-2S(mandatory)
UL-3(optional)	UL-4 (optional)
UL-3S(optional)	UL-4S(optional)

7.2.8 PHY mode adaptation parameters

7.2.8.1 Test of adaptation parameters

7.2.8.1.1 Test set-up

Figure 40 shows the test set-up to verify the PHY mode adaptation parameters.

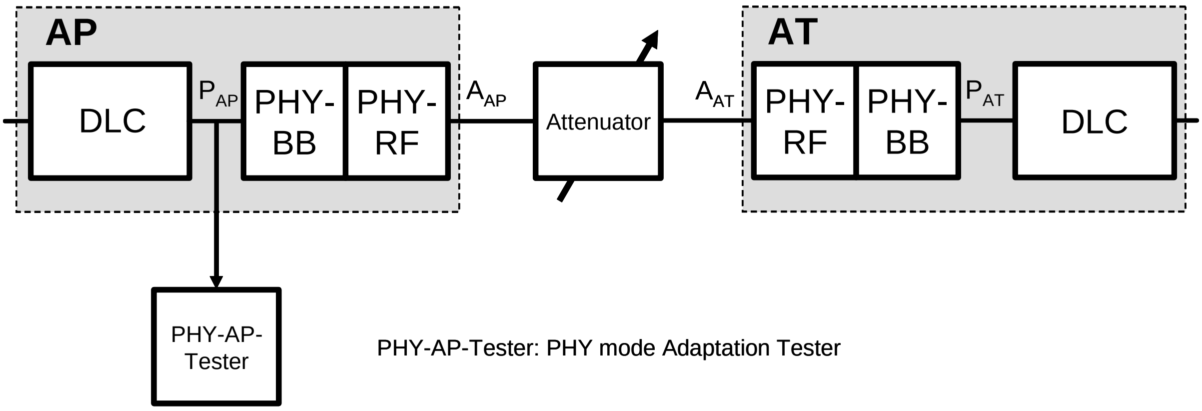

Figure 40: Test configuration PHY mode adaptation parameters

Test instruments: PHY mode adaptation parameter tester (PC)

Variable attenuator

7.2.8.1.2 Test procedure

The variable attenuator, simulating the RF link attenuation, shall be adjusted to an attenuation of 40 dB. By means of the PHY-AP-tester the messages concerning PHY adaptation parameters can be read and the time between these messages can be measured. The parameters listed in clause 6.2.8.2 shall be identified. The time period of the parameters for uplink and downlink mode shall be checked. The time period shall be in accordance with clause 6.2.8.2.

7.2.8.2 Test of PHY mode change

7.2.8.2.1 Test set-up

Figure 40 shows the test set-up to test the correct automatic change of PHY mode due to e.g. weather conditions

Test sequence: Null sequence

7.2.8.2.2 Test procedure

Figure 40 represents a rough simulation of the radio link. By means of the variable attenuator different weather conditions can be adjusted. The AP shall react on different attenuations (weather conditions) with the change of the PHY mode, both in UL and DL.

Downlink test figure 40

The test shall start with an attenuation 3dB below the threshold where the AP changes from the most efficient to the next efficient PHY mode.

The attenuation shall be increased slowly (less than 20 dB/s) up to 3 dB over the threshold where the AP changes to the most robust PHY mode.

The attenuation shall now be decreased slowly (less than 20 dB/s) down to the starting attenuation.

The test is passed if in all conditions the BER does not exceed the required value.

Uplink test

The same test shall now be started with the uplink configuration according to figure 40.

The test is passed if in all conditions the BER does not exceed the required value.

8 Interpretation of the measurement results

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be included in the test report;
- the recorded value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in table 40.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with TR 100 028-1 [25] and shall correspond to an expansion factor (coverage factor°k°=°1,96 or k°=°2 (which provide confidence level of 95 % and 95, 45 %, respectively, in the case where the distributions characterising the actual measurement uncertainties are normal (Gaussian)).

The accumulated measurement uncertainties of the test system for the parameters to be measured shall not exceed these given in table 40 taken from TR 100 028-2, annex B,[26]. This is in order to ensure that the measurements remain within an acceptable quality.

Table 40: Maximum acceptable measurement uncertainties

Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-7}$
RF power	±0,75 dB
Adjacent channel power	±3 dB
Conducted emissions of transmitters	±4 dB
Sensitivity	±3 dB
Conducted emissions of receivers	±4 dB
Radiated emissions of transmitters	±6 dB
Radiated emissions of receivers	±6 dB
Temperature	±5 %
Time	±5 %

Annex A (normative): Supplier's Declaration

A.1 Supplier declaration of conformity

Hereby we,

____

Company name

____

Company address

declare under our sole responsibility that the Fixed Radio Equipment

____

Product name, description

____

Product type/data rate(s)

is in conformity with the appended supplier specification:

Specification: __________________________________

and the following relevant standards:

____

____

____

____

____

____

Place, date

____

Company

____

Authorized signature

A.1.1 Supplier declaration summary

General characteristics	
Environmental conditions	
Electromagnetic and safety conditions	
HA operating frequency band and channelization	
Power supply	
Specific characteristics	
Supported PHY modes	
Burst transmission parameter	
Rx power thresholds for least efficient PHY modes	
Support of dynamic downlink power control	
Support of Tx static power setting	
Use of Turbo code	
Use of burst concatenation	

A.1.2 General characteristics

A.1.2.1 Environmental conditions

In this clause the environmental (climatic only) stresses which the equipment shall withstand shall be declared. The requirements are generally given in ETS 300 019-1-4 [3], which defines weather protected and non-weather protected locations, classes and test severity.

A.1.2.1.1 AP equipment

The AP equipment can be implemented as a single part, located indoor or outdoor, or as a split version with an indoor and an outdoor part.

A.1.2.1.1.1 Non-splitted AP equipment

AP equipment - indoor locations	**Yes**	**No**	**Test Temperature (°C)**		
			L	**M (see note)**	**H**
ETS 300 019-1-4 [3], class 3.1 (Temperature controlled locations)			5	20	35
ETS 300 019-1-4 [3], class 3.2 (Partly temperature controlled locations)			-5	20	45
ETS 300 019-1-4 [3], class 3.3 (Not temperature controlled locations)			-25	20	55
ETS 300 019-1-4 [3], class 3.4 (Sites with heat-trap)			-40	20	70
ETS 300 019-1-4 [3], class 3.5 (Sheltered locations)			-40	20	40
NOTE: The medium test temperature (M) can be in the range +15°C to 30°C.					

AP equipment - outdoor locations	**Yes**	**No**	**Test Temperature (°C)**		
			L	**M *)**	**H**
ETS 300 019-1-4 [3], class 4.1 (Non-weather protected locations)			-33	20	40
ETS 300 019-1-4 [3], class 4.1E (Non-weather prot. locations - extended)			-45	20	45
NOTE: The medium test temperature (M) can be in the range +15°C to 30°C.					

A.1.2.1.1.2 Splitted AP equipment

A.1.2.1.1.2.1 Indoor equipment

AP indoor equipment - (IDU)	**Yes**	**No**	**Test Temperature (°C)**		
			L	**M *)**	**H**
ETS 300 019-1-4 [3], class 3.1 (Temperature controlled locations)			5	20	35
ETS 300 019-1-4 [3], class 3.2 (Partly temperature controlled locations)			-5	20	45
ETS 300 019-1-4 [3], class 3.3 (Not temperature controlled locations)			-25	20	55
ETS 300 019-1-4 [3], class 3.4 (Sites with heat-trap)			-40	20	70
ETS 300 019-1-4 [3], class 3.5 (Sheltered locations)			-40	20	40
NOTE: The medium test temperature (M) can be in the range +15°C to 30°C.					

A.1.2.1.1.2.2 Outdoor equipment

AP outdoor equipment - (ODU)	**Yes**	**No**	**Test Temperature (°C)**		
			L	**M *)**	**H**
ETS 300 019-1-4 [3], class 4.1 (Non-weather protected locations)			-33	20	40
ETS 300 019-1-4 [3], class 4.1E (Non-weather prot. locations - extended)			-45	20	45
NOTE: The medium test temperature (M) can be in the range +15°C to 30°C.					

A.1.2.1.2 AT equipment

AT equipment - outdoor locations	**Yes**	**No**	**Test Temperature (°C)**		
			L	**M *)**	**H**
ETS 300 019-1-4 [3], class 4.1 (Non-weather protected locations)			-33	20	40
ETS 300 019-1-4 [3], class 4.1E (Non-weather prot. locations - extended)			-45	20	45
NOTE: The medium test temperature (M) can be in the range +15°C to 30°C.					

A.1.2.2 Electromagnetic and safety conditions

A.1.2.2.1 Electromagnetic compatibility

		Comments
Relevant standard or recommendation: EN 300 385 [4] EN 301 489-1 [5]		
Tested ? (yes/no)		
Compliant ? (yes/no)		
NOTE: If a test or re-test is scheduled the date may be declared as a comment.		

A.1.2.2.2 Immunity to electromagnetic interference

		Comments
Relevant standard or recommendation: EN 61000-6-1 [6]		
Tested ? (yes/no)		
Compliant ? (yes/no)		
NOTE: If a test or re-test is scheduled the date may be declared as a comment.		

A.1.2.2.3 Immunity to electromagnetic radiation

		Comments
Relevant standard or recommendation: EN 55022 [7]		
Tested ? (yes/no)		
Compliant ? (yes/no)		
NOTE: If a test or re-test is scheduled the date may be declared as a comment.		

A.1.2.2.4 Electrical safety

		Comments
Relevant standard or recommendation: EN 60950 [8]		
Tested ? (yes/no)		
Compliant ? (yes/no)		
NOTE: If a test or re-test is scheduled the date may be declared as a comment.		

A.1.2.3 HA operating frequency band and channelization

Frequency band (see note)			
Lower sub-band (downlink)			
Upper sub-band (uplink)			
Duplex scheme			
NOTE: If a test or re-test is scheduled the date may be declared as a comment.			

Channelization of frequency band		
Channel no.	Centre frequency downlink (GHz)	Centre frequency uplink (GHz)
#1		
#2		
#3		
. . .		

Reference test frequencies in the frequency band (see note)		
	Downlink (GHz)	Uplink (GHz)
Bottom (B)		
Middle (M)		
Top (T)		
NOTE: Reference test frequencies shall be the centre frequency of the lowest channel (Bottom), the centre frequency of the channel in the middle (middle), and the centre frequency of the highest channel (top) of the HA frequency band.		

A.1.2.4 Power supply

Nominal input voltage (V)		
Maximum input voltage (V)		
Minimum input voltage (V)		
Type of voltage (AC or DC)		
Total power dissipation (W)	AP:	AT:

A.1.3 Specific characteristics

A.1.3.1 Supported PHY modes for AP

A.1.3.1.1 Downlink PHY modes

The naming of PHY modes is according to table 1.

Set-1 (mandatory set)	Supported	Not supported
DL-0 (mandatory)		
DL-1 (mandatory)		
DL-2 (mandatory)		
DL-3 (mandatory)		
DL-5 (optional)		

Set-2 (optional set)	Supported	Not supported
DL-0 (mandatory)		
DL-1 (optional)		
DL-2 (optional)		
DL-4 (optional)		
DL-6 (optional)		

A.1.3.1.2 Uplink PHY modes

Set-1 (mandatory set)	Supported ?		AT maximum
	yes	no	Tx power
UL-1 (mandatory)			14 dBm
UL-1S (mandatory)			14 dBm
UL-2 (mandatory)			14 dBm
UL-2S (mandatory)			14 dBm
UL-3 (optional)			To be declared
UL-3S (optional)			To be declared

Set-2 (mandatory set)	Supported ?		AT maximum
	yes	no	Tx power
UL-1 (mandatory)			14 dBm
UL-1S (mandatory)			14 dBm
UL-2 (mandatory)			14 dBm
UL-2S (mandatory)			14 dBm
UL-4 (optional)			To be declared
UL-4S (optional)			To be declared

A.1.3.2 Supported PHY modes for AT

A.1.3.2.1 Downlink PHY modes

The naming of PHY modes is according to table 1.

Set-1 (mandatory set)	Supported	Not supported
DL-0 (mandatory)		
DL-1 (mandatory)		
DL-2 (mandatory)		
DL-3 (mandatory)		
DL-5 (optional)		

Set-2 (optional set)	Supported	Not supported
DL-0 (mandatory)		
DL-1 (optional)		
DL-2 (optional)		
DL-4 (optional)		
DL-6 (optional)		

A.1.3.2.2 Uplink PHY modes

Set-1 (mandatory set)	Supported	Not supported	AT maximum Tx power
UL-1 (mandatory)			14 dBm
UL-1S (mandatory)			14 dBm
UL-2 (mandatory)			14 dBm
UL-2S (mandatory)			14 dBm
UL-3 (optional)			dBm
UL-3S (optional)			dBm

Set-2 (mandatory set)	Supported	Not supported	AT maximum Tx power
UL-1 (mandatory)			14 dBm
UL-1S (mandatory)			14 dBm
UL-2 (mandatory)			14 dBm
UL-2S (mandatory)			14 dBm
UL-4 (optional)			dBm
UL-4S (optional)			dBm

A.1.3.2 Burst transmission parameter

Parameter $\Delta C_{deep\text{-}off}$ (see figure 8) =		dB

A.1.3.3 Rx power thresholds for least efficient PHY modes

The channel numbers shall be in accordance with clause A.1.2.3. For details of threshold see clause 6.1.16.

Channel no.	AP threshold for DL-0 @ BER = 10^{-6}	AT threshold for UL-1S @ BER = 10^{-6}
#1		
#2		
#3		
. . .		

A.1.3.4 Support of Dynamic Downlink Power Control (DDPC)

DDPC supported (yes/no) ?	

A.1.3.5 Support of Tx static power setting

Tx power setting supported (yes/no) ?	

A.1.3.6 Use of Turbo code

Use of Turbo code in UL (yes/no) ?	

A.1.3.7 Use of burst concatenation

Burst concatenation is optional for AP and mandatory for AT.

Use of burst concatenation in AP (yes/no) ?	

Annex B (normative): Test report

Outcome of Conformance Test	Passed	Failed
Radio Parameters		
Carrier frequencies		
Channel allocation		
Symbol transmit clock and tolerance		
RF channel and spectrum mask		
Transmitter output power and tolerance		
Dynamic DL power control (DDPC)		
Tx static power setting		
Automatic transmit power control (ATPC)		
Error vector magnitude		
Antenna gain		
Time mask for burst transmission		
Tx/Rx switching time		
Receiver sensitivity		
Performance in multi-path channel		
Background BER		
Receiver dynamic range		
Co-channel interference performance		
Adjacent channel interference performance		
CW spurious interference		
Rx-power measurement		
CNR measurement		
Spurious emissions		
Automatic transmit timing control		
Load levelling and carrier recovery time		
Base band parameters		
Scrambler/De-scrambler		
FEC Encoder/Decoder and ARQ		
Signal constellation and mapping		
Framing and alignments		
Burst formatting and alignments		
UL-preamble selection		
Set of PHY modes		
PHY mode adaptation parameters		
Performance monitoring and management parameters		

Annex C (informative): Bibliography

ITU-T Recommendation I.356: "B-ISDN ATM layer cell transfer performance".

ETSI EN 301 997-1: "Transmission and Multiplexing (TM); Multipoint equipment; Radio Equipment for use in Multimedia Wireless Systems (MWS) in the frequency band 40,5 GHz to 43,5 GHz; Part 1: General requirements".

ETSI EN 301 390: "Fixed Radio Systems; Point-to-point and Point-to-Multipoint Systems; Spurious emissions and receiver immunity at equipment/antenna port of Digital Fixed Radio Systems".

ERC Report 99: "The analysis of the coexistence of two FWA cells in the 24,5 - 26,5 GHz and 27,5 - 29,5 GHz bands".

ITU-T Recommendation G.783: "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".

ITU-T Recommendation G.825: "The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)".

ITU-T Recommendation G.831: "Management capabilities of transport networks based on the synchronous digital hierarchy (SDH)".

ETSI ETS 300 132-1: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) derived from direct current (dc) sources".

ETSI ETS 300 132-2: "Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc)".

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ITU-R Recommendation P.676-5: "Attenuation by atmospheric gases".

ITU-R Recommendation P.835-3: "Reference standard atmospheres".

ITU-R Recommendation P.452-10: "Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0,7 GHz".

ETSI EN 301 213-2: "Fixed Radio Systems; Point-to-multipoint equipment; Point-to-Multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 2: Frequency Division Multiple Access (FDMA) methods".

List of figures

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History

Document history		
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