ETSI EN 300 674-2-1 V2.1.1 (2016-09)

HARMONISED EUROPEAN STANDARD

**Transport and Traffic Telematics (TTT);
Dedicated Short Range Communication (DSRC)
transmission equipment (500 kbit/s / 250 kbit/s)
operating in the 5 795 MHz to 5 815 MHz frequency band;
Part 2: Harmonised Standard covering the essential
requirements of article 3.2 of the Directive 2014/53/EU;
Sub-part 1: Road Side Units (RSU)**

Reference

REN/ERM-TG37-26

Keywords

data, DSRC, harmonised standard, radio, regulation, RTTT, testing

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Foreword

This Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.6] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.5].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

The present document is part 2, sub-part 1 of a multi-part deliverable covering Transport and Traffic Telematics (TTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5 795 MHz to 5 815 MHz frequency band, as identified below:

Part 1: "General characteristics and test methods for Road Side Units (RSU) and On-Board Units (OBU)";

Part 2: "Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU";

    Sub-part 1: "Road Side Units (RSU)";

    Sub-part 2: "On-Board Units (OBU)".

National transposition dates	
Date of adoption of this EN:	12 September 2016
Date of latest announcement of this EN (doa):	31 December 2016
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 June 2017
Date of withdrawal of any conflicting National Standard (dow):	30 June 2018

Modal verbs terminology

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

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1   Scope

The present document applies to Transport and Traffic Telematics (TTT) systems:

- with a Radio Frequency (RF) output connection and specified antenna or with an integral antenna;

- for data transmission only;

- operating on radio frequencies in the 5,725 GHz to 5,875 GHz Short Range Devices frequency band.

The applicability of the present document covers only the Road Side Units (RSU).

The present document does not necessarily include all the characteristics which may be required by a user, nor does it necessarily represent the optimum performance achievable.

The present document complies with the Commission Implementing Decision 2013/752/EU [1] and CEPT/ERC Recommendation 70-03 [2]. It is a specific standard covering various TTT applications.

The present document applies to the following radio equipment types operating in all or in part of the following service frequency bands given in table 1.

Table 1: Frequency bands and centre frequencies f_{Tx} allocated for DSRC

	Pan European Service Frequencies	National Service Frequencies
Channel 1	5,795 GHz to 5,800 GHz, f_{tX} = 5,7975 GHz	
Channel 2	5,800 GHz to 5,805 GHz, f_{tX} = 5,8025 GHz	
Channel 3		5,805 GHz to 5,810 GHz, f_{tX} = 5,8075 GHz
Channel 4		5,810 GHz to 5,815 GHz, f_{tX} = 5,8125 GHz

The present document contains requirements to demonstrate that radio equipment both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.

2   References

2.1   Normative references

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

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

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

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

[1]   Commission Implementing Decision 2013/752/EU of 11 December 2013 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2005/928/EC.

[2]   CEPT/ERC Recommendation 70-03 (2016): "Relating to the use of Short Range Devices (SRD)".

[3]   CEN EN 12253:2004: "Road transport and traffic telematics - Dedicated short-range communication - Physical layer using microwave at 5,8 GHz".

[4] ETSI TR 100 028 (V1.4.1) (12-2001) (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[5] IEC 60721-3-4:1995 including Amendment 1:1996: "Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 4: Stationary use at non-weatherprotected locations".

[6] IEC 60721-3-5:1997: "Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 5: Ground vehicle installations".

[7] CEN EN 12795:2003: "Road transport and traffic telematics - Dedicated Short Range Communication (DSRC) - DSRC data link layer: medium access and logical link control".

[8] CEN EN 12834:2003: "Road transport and traffic telematics - Dedicated Short Range Communication (DSRC) - DSRC application layer".

[9] ISO 14906 (2011): "Electronic fee collection -- Application interface definition for dedicated short-range communication".

[10] CEPT/ERC Recommendation 74-01E (2011): "Unwanted emissions in the spurious domain".

[11] ETSI TR 102 273-2 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 2: Anechoic chamber".

[12] ETSI TR 102 273-6 (V1.2.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 6: Test fixtures".

[13] CISPR 16-1 (2015): "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus".

2.2 Informative references

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

[i.1] Void.

[i.2] Void.

[i.3] ETSI TR 102 273-4 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 4: Open area test site".

[i.4] Commission Directive 95/54/EC of 31 October 1995 adapting to technical progress Council Directive 72/245/EEC on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles and amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers.

[i.5] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.6]   Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

3   Definitions, symbols and abbreviations

3.1   Definitions

For the purposes of the present document, the terms and definitions given in Directive 2014/53/EU [i.5] and the following apply:

adjacent channel: channel at a distance of 5 MHz relative to the centre frequency, i.e. in the channel at the next upper or lower centre frequency

bit: acronym for "binary digit" which can have one out of two possible values

EXAMPLE: 0/1, or +1/-1, or low/high.

bit rate: in a bit stream, the number of bits occurring per unit time, usually expressed in bits per second

boresight: direction of maximum radiation of a directional antenna

NOTE: If boresight cannot be determined unambiguously, then boresight may be declared by the manufacturer.

carrier frequency: frequency f_{Tx} to which the RSU transmitter is tuned

NOTE: In DSRC, the carrier frequency is in the centre of a channel, see table 2 of the present document.

carrier signal or carrier: harmonic signal whose nominal single frequency f_{Tx} can vary within a range specified by the carrier frequency tolerance and which is capable of being modulated by a second, symbol-carrying signal

channel: continuous part of the radio-frequency spectrum to be used for a specified emission or transmission

NOTE: A radio-frequency channel may be defined by two specified limits, or by its centre frequency and its bandwidth, or any equivalent indication. It is often designated by a sequential number. A radio-frequency channel may be time-shared in order to allow radio communication in both directions by simplex operation. The term "channel" is sometimes used to denote two associated radio-frequency channels, each of which is used for one of two directions of transmission, i.e. in fact a telecommunication circuit.

co-channel: transmission using the same channel (frequency band of 5 MHz width)

cross-polar discrimination (XPD): ratio $P_{\mathrm{LHCP}} / P_{\mathrm{RHCP}}$ of power P_{LHCP} of the left hand circular polarized wave to the power P_{RHCP} of the right hand circular wave when the total power of the transmitted wave is $P_{\mathrm{LHCP}} + P_{\mathrm{RHCP}}$

downlink: transmission in direction from RSU to OBU

ellipticity of polarization: ratio of the polarization main axes of an elliptic polarized radio wave

EXAMPLE: The ellipticity of circular polarized radio waves is one.
The ellipticity of linear polarized waves is infinity.

environmental profile: range of environmental conditions under which equipment within the scope of the present document is required to comply with the provisions of the present document

equivalent isotropically radiated power: signal power fed into an ideal loss-less antenna radiating equally in all directions that generates the same power flux at a reference distance as the one generated by a signal fed into the antenna under consideration in a predefined direction within its far field region

integral antenna: antenna, with or without a connector, designed as an indispensable part of the equipment

OBU sleep mode: optional mode for battery powered OBUs that allows to save battery power

NOTE: In this mode, the OBU can only detect the presence of a DSRC downlink signal to initiate under certain defined conditions a transition to the stand-by mode.

OBU stand-by mode: mode, in which the OBU is capable of receiving DSRC downlink signals, but is never transmitting

operating frequency: nominal frequency at which equipment is operated; also referred to as the operating centre frequency

NOTE: Equipment may be able to operate at more than one operating frequency.

out-of-band emissions: emissions on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process and which cannot be reduced without affecting the corresponding transmission of information, but excluding spurious emissions (see also CEPT/ERC Recommendation 74-01E [10])

polarization: locus of the tip of the electrical field vector in a plane perpendicular to the direction of transmission

EXAMPLE: Horizontal and vertical linear polarization.
Left and right hand circular polarization.

Portable Equipment (PE): generally intended to be self-contained, free standing and portable

NOTE: A PE would normally consist of a single module, but may consist of several interconnected modules. It is powered by one or more internal batteries.

radiated measurements: measurements which involve the measurement of a radiated electromagnetic field

spurious emissions: emission on a frequency, or frequencies, which are outside an exclusion band of ±2,5 times the channel spacing around the selected centre frequency f_{Tx}, and the level of which may be reduced without affecting the corresponding transmission of information

NOTE: Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out-of-band emissions (see also CEPT/ERC Recommendation 74-01E [10]).

uplink: transmission in direction from OBU to RSU

3.2 Symbols

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

A_{CW}	Amplitude of CW signal
A_{mod}	Amplitude of modulated signal
ATN_{AT2}	Attenuation of attenuator AT2
ATN_{BLN}	Attenuation of balun BLN
ATN_{CA1}	Attenuation of calibrated coaxial cable 1
BER	Bit Error Ratio
C_F	Number of frames transmitted
C_E	Number of erroneous frames received
d	Distance between phase centres of transmitting and receiving antenna
$d_{displace}$	Horizontal displacement of TTA and RTA antenna phase centres
d_{F1}	Distance from transmitting antenna to first Fresnel ellipse
d_{F2}	Distance from first Fresnel ellipse to receiving antenna
D_{fb}	Distance between neighbouring ferrite beads
D_i	Directivity relative to an isotropic radiator
$D_{0,TA}$	Largest linear dimension of test antenna
$D_{0,EUT}$	Largest linear dimension of EUT antenna
$EIRP_{max}$	Maximum e.i.r.p. of RSU

$EIRP_{MaxObuTx}$	Maximum e.i.r.p. generated by the OBU in a single side band
$EIRP_{ObuTx}$	e.i.r.p. generated by the OBU within a single side band
$EIRP_{OBU}$	e.i.r.p. generated by the OBU antenna
$EIRP_{TSM}$	e.i.r.p. referred to transmitter spectrum mask
Δf_{RSU}	Frequency error of RSU
Δf_s	Sub-carrier frequency error
f	Frequency
f_c	Centre frequency of receiving device or of MSS2 used for calibration
FER	Frame error ratio
f_{ObuTx}	Actual centre frequency of the lower and upper side band of the OBU uplink channel
f_{MSS1}	Frequency of MSS1
f_{offset}	Offset frequency
f_s	Nominal OBU sub-carrier frequency
f_{Tx}	Nominal RSU carrier frequency
$f_{Tx,actual}$	Actual centre frequency of the downlink carrier
f_u	Nominal centre frequency of unwanted signal
f_{u1}, f_{u2}	Centre frequencies of unwanted signal
G_c	Conversion gain
G_{corr}	Correction gain
$G_{OBU,Rx}$	Gain of OBU receiving antenna
$G_{OBU,Tx}$	Gain of OBU transmitting antenna
G_{RSA}	Gain of receiving substitution antenna
G_{TA}	Gain of test antenna
G_{TSA}	Gain of transmitting substitution antenna
$G_{RSU,Tx}$	Gain of RSU transmitting antenna
k	Expansion factor (coverage factor)
$lg(.)$	Logarithm to the base ten
m	Modulation index
N	Total number of transmitted bits within a single frame
P_{CW}	Power of CW signal
P_{D11a}	Power limit for communication (upper)
P_{D11b}	Power limit for communication (lower)
P_{inc}	Incident signal power as received by an ideal isotropical receiving antenna
$P_{inc,scan}$	Incident signal power obtained from a scanning process
$P_{inc,dBm}$	P_{inc} in dBm
P_{LHCP}	Signal power of left hand circular polarized wave
P_{max}	Maximum signal power
P_{mod}	Power of modulated signal
P_{MMS1}	Output signal power of MSS1
P_{MMS2}	Output signal power of MSS2
P_{ObuRx}	Incident signal power to OBU, referred to an ideal isotropical receiving antenna
P_{pol}	Signal power of wave with corresponding polarization
P_v	Signal power of wave featuring vertical polarization
P_h	Signal power of wave featuring horizontal polarization
P_{PM1}	Signal power measured by the power meter 1
P_{ref}	Reference signal power limit in Watt
$P_{ref,dBm}$	Reference signal power limit in dBm
P_{reTx}	Retransmitted signal power
P_{RSA}	Signal power obtained from receiving substitution antenna
P_{RHCP}	Signal power of right hand circular polarized wave
P_{ssb}	Signal power within single side band

P_{sens}	Declared sensitivity of receiver
$P_{spurious}$	Signal power of spurious signal
P_{tot}	Sum of signal power $P_1 + P_2$, or $P_1 + P_2 + ... + P_5$, whichever applies
$P_{tot,dBm}$	P_{tot} in dBm
P_{TSM}	Transmitter spectrum mask
P_u	Power of unwanted signal at RSU antenna
$P_{u\,max}$	Unwanted signal power limit at RSU antenna
P_w	Signal power of wanted signal
P_0	Reference signal power of 1 mW corresponding to 0 dBm
RBW	Resolution bandwidth
T_{CW}	Duration of CW signal
T_{mod}	Duration of modulated signal
V_{max}, V_{min}	Maximal amplitude of modulated output signal of RSU caused by data bit 1, or 0
α	Tilt angle of test antenna
$\alpha_{displace}$	Displacement angle between TTA and RTA
θ	Angle relative to OBU boresight indicating worst case direction
$\theta°$	Value of θ measured in degree
λ	Wavelength
ρ_{RSA}	Reflection coefficient at antenna connector of the receiving substitution antenna
ρ_{TSA}	Reflection coefficient at antenna connector of the transmitting substitution antenna

3.3   Abbreviations

For the purposes of the present document, the abbreviations given in CEN EN 12253 [3] and the following apply:

AT1	Attenuator 1
AT2	Attenuator 2
BER	Bit Error Ratio
BLN	Balun
BST	Beacon Service Table
CC	Coaxial Circulator
CISPR	Comité International Spécial des Perturbations Radioélectriques
CRC	Cyclic Redundancy Checking
CW	Continuous Wave
DC	Direct Current
doa	date of announcement
dop	date of publication
dow	date of withdrawal
DSRC	Dedicated Short Range Communication
e.i.r.p.	Equivalent Isotropically Radiated Power also called EIRP, eirp, E.I.R.P.
EC	European Community
EFC	Electronic Fee Collection
EFTA	European Free Trade Association
EUT	Equipment Under Test
FCCA	Ferrited Coaxial CAble
FCCA1	Ferrited Coaxial CAble 1
FER	Frame Error Ratio
IEC	International Electrotechnical Commission
LHCP	Left Hand Circular Polarized
LOS	Line-Of-Sight
LP	Linear Polarized
M_{centre}	Centre point between phase centres of TTA and RTA
MSS1	Monochromatic Signal Source 1
MSS2	Monochromatic Signal Source 2
OBU	On Board Unit
PE	Portable Equipment
PM1	Power Meter 1

ppm	parts per million (10^{-6})
RBW	Resolution BandWidth
RD	Receiving Device
REC	RECommendation
RF	Radio Frequency
RRxA	RSU Receiving Antenna
RSA	Receiving Substitution Antenna
RSU	Road Side Unit
RTA	Receiving Test Antenna
RTTT	Road Transport and Traffic Telematics
RTxA	RSU Transmitting Antenna
Rx	Receiver
SMS1	Signal or Message Source 1
SR	Special Report
TA	Test Antenna
TM1	Test Message 1
TS1	Test Signal 1
TS2	Test Signal 2
TSA	Transmitting Substitution Antenna
TSM	Transmitter Spectrum Mask
TTA	Transmitting Test Antenna
TTT	Transport and Traffic Telematics
Tx	Transmitter
VBW	Video BandWidth
VST	Vehicle Service Table
VSWR	Voltage Standing Wave Ratio
XP	Cross Polarized
XPD	Cross-Polar Discrimination

4   Technical requirements specifications

4.1   Mechanical and electrical design

4.1.1   Units

The present document specifies the characteristics of Road Side Units.

Transmitters and receivers may be individual or combination units; some units may be transmitter only, some units may be receiver only and some units may combine transmitter and receiver functionalities.

4.1.2   Controls

Those controls which if maladjusted might increase the interference possibilities to and from the equipment shall only be accessible by partial or complete disassembly of the device and requiring the use of tools.

4.2   General characteristics

4.2.1   RSU classes

There exist three classes of RSUs which are distinguished by the parameter D2 (4) "in band spurious emissions with modulated carrier wave" of CEN EN 12253 [3].

Those classes are called class A, class B and class C, see table 3. The manufacturer shall declare to which class the equipment complies with.

NOTE: The use of class A for new equipment is not recommended.

4.2.2   Carrier frequencies

The present document applies to RSUs operating in some or all of the following channels detailed in table 2.

The centre frequencies f_{Tx} indicated in table 2 are referred to as parameter D1 in CEN EN 12253 [3].

Table 2: Frequency bands and centre frequencies f_{Tx} allocated for DSRC

	Pan European Service Frequencies	National Service Frequencies
Channel 1	5,795 GHz to 5,800 GHz, f_{Tx} = 5,7975 GHz	
Channel 2	5,800 GHz to 5,805 GHz, f_{Tx} = 5,8025 GHz	
Channel 3		5,805 GHz to 5,810 GHz, f_{Tx} = 5,8075 GHz
Channel 4		5,810 GHz to 5,815 GHz, f_{Tx} = 5,8125 GHz

Where equipment can be adjusted to operate at different operating frequencies other than channel 1 and channel 2, a minimum of two operating frequencies shall be chosen for the tests described in the present document such that the lower and higher limits of the manufacturer's declared operating ranges of the equipment are covered.

4.2.3   Modulation

The carrier of frequency f_{Tx}, see table 2, shall be modulated in accordance with parameters D6 and D6a in CEN EN 12253 [3].

4.2.4   Antenna characteristic

All RSU antennas shall be LHCP in accordance with parameters D5 and D5a in CEN EN 12253 [3].

4.3   Environmental conditions

4.3.1   Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the declared operational environmental profile.

Recommended environmental profile parameters are summarized in annex C.

4.3.2   Power supply

All the characteristics and essential requirements applying to RSUs shall be fulfilled within the range of all declared operational conditions of the power supply.

Power supply may be a built in battery, an external battery or a stabilized power supply, etc.

NOTE: If an RSU is supplied by the battery of a vehicle, e.g. car or truck, the automotive Directive 95/54/EC [i.4] applies.

4.4   Conformance requirements

4.4.1   Transmitter parameters

4.4.1.1   General

When the transmitter is properly installed, maintained and used for its intended purpose, it generates radio wave emissions that do not create harmful interference, while unwanted radio wave emissions generated by the transmitter (e.g. in adjacent channels) with a potential negative impact on the goals of radio spectrum policy are limited to such a level that, according to the state of the art, harmful interference is avoided (Directive 2014/53/EU [i.5]).

4.4.1.2   Maximum equivalent isotropically radiated power

The maximum e.i.r.p. is the e.i.r.p. in the direction of maximal radiation of the RSU antenna.

The maximum e.i.r.p. is referred to as parameter D4 in CEN EN 12253 [3].

The transmitter maximum e.i.r.p. shall not exceed the limit of 2 W independent of duty cycle.

4.4.1.3   Transmitter frequency error

The relative frequency error of the equipment is the difference between the frequency at which the transmitter outputs its largest carrier signal level in its unmodulated mode of operation and the corresponding nominal carrier frequency f_{Tx} listed in table 2 in relation to f_{Tx}.

The maximum allowed relative frequency error is referred to as parameter D1a in CEN EN 12253 [3].

The relative frequency error shall not exceed ±5 ppm.

4.4.1.4   Transmitter spectrum mask

The RSU TSM defines the maximum e.i.r.p. allowed to be transmitted by the RSU within specified frequency bands, where distinction is made between different classes providing different values of limits, see clause 4.2.1.

The RSU TSM is referred to as parameter D2 in CEN EN 12253 [3].

The limits for the TSM shall not exceed the values given in table 3. Those limits apply within an equivalent bandwidth as indicated in table 3.

Table 3: RSU TSM upper limits

Position	Frequencies	Unmodulated	Modulated			Equivalent Bandwidth
		All Classes	Class A	Class B	Class C	
Co-channel	$f_{TX} \pm 1,5$ MHz	-27 dBm	-7 dBm	-17 dBm	-27 dBm	500 kHz
Co-channel	$f_{TX} \pm 2,0$ MHz	-27 dBm	-27 dBm	-27 dBm	-27 dBm	500 kHz
Adjacent channels	$f_{TX} \pm 3,0$ MHz $f_{TX} \pm 3,5$ MHz $f_{TX} \pm 6,5$ MHz $f_{TX} \pm 7,0$ MHz	-47 dBm	-30 dBm	-37 dBm	-47 dBm	500 kHz

4.4.1.5   Transmitter unwanted emissions

The e.i.r.p. of any unwanted emissions, i.e. spurious and out-of-band emission, shall not exceed the limits presented in table 4 for units with an operating transmitter (see also clause 4.1.1), i.e. with modulation.

Measurements shall not be performed within an exclusion band of ±2,5 times the DSRC channel spacing of 5 MHz, i.e. ±12,5 MHz around the RSU carrier frequency f_{Tx} under test.

**Table 4: Limits of unwanted emissions as specified in
CEPT/ERC Recommendation 74-01E [10] for transmitters**

Mode	Frequency bands	Limits (e.i.r.p.)	Reference bandwidth	Type of emission
Operating	47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	-54 dBm	100 kHz	**Spurious and out-of-band emissions**
	Other frequencies > 30 MHz and ≤ 1 GHz	-36 dBm	100 kHz	
	Frequencies > 1 GHz and < 26 GHz outside the exclusion band	-30 dBm	1 MHz	

4.4.2   Receiver parameters

4.4.2.1   Receiver spurious emissions

The e.i.r.p. of any spurious emission of receiver only units (see clause 4.1.1) shall not exceed the limits presented in table 5 for "stand-by" mode.

Measurements shall not be performed within an exclusion band of ±2,5 times the DSRC channel spacing of 5 MHz, i.e. ±12,5 MHz around the RSU carrier frequency f_{Tx} under test.

**Table 5: Limits of unwanted emissions as specified in
CEPT/ERC Recommendation 74-01E [10] for receivers**

Mode	Frequency bands	Limits (e.i.r.p.)	Reference bandwidth	Type of emission
Stand-by	Other frequencies > 30 MHz and ≤ 1 GHz	-57 dBm	100 kHz	**Spurious emissions**
	Frequencies > 1 GHz and < 26 GHz outside the exclusion band	-47 dBm	1 MHz	

4.4.2.2   Blocking

The blocking capability is the receiver's capability to receive a wanted modulated signal at the receiver RF input without exceeding a given degradation due to the presence of an unwanted modulated or unmodulated signal at any other frequency outside the DSRC band (table 2) and an exclusion band of ± 2,5 MHz above and below it, in terms of power of the unwanted signal referred to a loss-less isotropic antenna.

When other channels are used than listed in table 2, the blocking range shall start 2,5 MHz above and below the used frequency range.

For the purpose of testing only an unmodulated monochromatic unwanted signal shall be considered.

The frequencies f_u shall be within the frequency range 30 MHz to 26 GHz.

The degradation limit is defined by the maximum allowed BER of $2,0 \times 10^{-2}$ for a wanted DSRC signal 6 dB above the sensitivity limit of the RSU.

    NOTE: CEN EN 12253 [3] requires BER to be 10^{-6} for a proper operation of the DSRC system.

The blocking capability shall be ≥ -30 dBm.

4.4.2.3   Sensitivity

The RSU sensitivity is the minimum received signal power P_{sens} at the antenna connector that allows the RSU to receive DSRC frames with a BER of less than or equal to 10^{-6}.

The manufacturer shall declare the RSU receiver sensitivity class according to table 6.

Table 6: RSU receiver sensitivity classes

RSU receiver sensitivity class	Sensitivity I P_{sens} (dBm)
Class 1	≤ -20
Class 2	≤ -84
Class 3	≤ -94

The receiver sensitivity P_{sens} shall conform to the limit given in table 6 for the declared RSU receiver sensitivity class.

5   Testing for compliance with technical requirements

5.1   Environmental conditions for testing

Tests defined in the present document shall be carried out at representative points within the boundary limits of the declared operational environmental profile.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the declared operational environmental profile) to give confidence of compliance for the affected technical requirements.

A possible manufacturer declaration can be based on the extreme categories I, II, III as defined in clause C.3.

5.2   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 7.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated and shall correspond to an expansion factor (coverage factor) k = 1,96 or k = 2 (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028 [4], in particular in annex D of the ETSI TR 100 028-2 [4].

Table 7 is based on such expansion factors.

Table 7: Absolute measurement uncertainty

Parameter	Uncertainty
RF power (conducted)	±4 dB
RF frequency, relative	±1 × 10^{-7}
Radiated emission of transmitter, valid to 40 GHz	±6 dB
Adjacent channel power	±5 dB
Sensitivity	±5 dB
Two and three signal measurements	±4 dB
Two and three signal measurements using radiated fields	±6 dB
Radiated emission of receiver, valid to 40 GHz	±6 dB
Temperature	±1 K
Relative humidity	±5 %

5.3   Essential radio test suites

5.3.1   Transmitter parameters

5.3.1.1   Maximum equivalent isotropically radiated power

5.3.1.1.1   General

This test shall be performed either with radiated or conducted measurements.

Basic requirements and guidelines for measurements are provided in annex B.

Parameter descriptions and limits are provided in clause 4.4.1.2.

The manufacturer shall declare all RSU transmit centre frequencies f_{Tx} supported by the RSU under test in accordance with clause 4.2.2. In case of conducted measurements the manufacturer shall declare the gain $G_{RSU,Tx}$ of the RSU transmit antenna to be used with the RSU under test.

5.3.1.1.2   Radiated measurements

1)   Set up the measurement arrangement as detailed in clause B.1.7.5.1.

2)   Replace the RD by a power meter PM1.

3)   Set the transmit power of the RSU to its maximum possible operational value.

4)   Set the RSU to the mode, where it transmits only an unmodulated carrier.

5)   Set the RSU transmit centre frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

6)   Measure the power P_{CW} with PM1 and report the value together with the actual carrier frequency f_{Tx}.

7)   Repeat step 6 for the remaining value of the carrier frequency f_{Tx} in accordance with clause 4.2.2.

8)   Replace the RTxA by the LHCP TSA with maximum gain G_{TSA} and reflection coefficient ρ_{TSA} at the antenna connector such that their phase centres and bore sights coincide.

9)   Connect the output of the TSA via the optional balun BLN, if required, of feed through attenuation ATN_{BLN}, and a calibrated FCCA of feed through attenuation ATN_{CA1} to a MSS1.

10)   Set the frequency f_{MSS1} of the MSS1 output signal equal to the initial value of the carrier frequency f_{Tx} supported by the RSU under test in accordance with clause 4.2.2.

11) Adjust the power P_{MSS1} such that PM1 shows the same value P_{CW} as report for this frequency $f_{MSS1} = f_{Tx}$ in step 6 and report P_{MSS1} together with f_{MSS1}.

12) Repeat step 10 and step 11 for the remaining value of the carrier frequency f_{Tx} in accordance with clause 4.2.2.

13) Calculate the maximum equivalent isotropically radiated power for all tested carrier frequencies f_{Tx}:

$$EIRP_{max} = P_{MSS1} \times G_{TSA} \times \left(1 - \left| \rho_{TSA} \right|^2 \right).$$

14) The maximum value of $EIRP_{max}$ from all measurements performed in step 13 is the maximum e.i.r.p. of the RSU. This value shall not exceed the limit reported in clause 4.4.1.2.

5.3.1.1.3   Conducted measurements

1) Connect a power meter PM1 to the connector for the RSU transmit antenna.

2) Set the transmit power of the RSU to its maximum possible operational value.

3) Set the RSU to the mode, where it transmits only an unmodulated carrier.

4) Set the RSU transmit centre frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

5) Measure the power P_{CW} with PM1. Calculate the corresponding maximum equivalent isotropically radiated power $EIRP_{max} = P_{CW} \times G_{RSU,Tx}$.

6) Repeat step 5 for the remaining RSU transmit centre frequency f_{Tx} in accordance with clause 4.2.2.

7) The maximum value of $EIRP_{max}$ from all measurements performed in step 5 and step 6 is the maximum e.i.r.p. of the RSU. This value shall not exceed the limit reported in clause 4.4.1.2.

5.3.1.2   Transmitter Frequency error

5.3.1.2.1   General

This test shall be performed either with radiated or conducted measurements.

Basic requirements and guidelines for measurements are provided in annex B.

Parameter descriptions and limits are provided in clause 4.4.1.3.

The manufacturer shall declare all RSU transmit centre frequencies f_{Tx} supported by the RSU under test and in accordance with table 2.

5.3.1.2.2   Radiated measurements

1) Set up the measurement arrangement as detailed in clause B.1.7.5.1.

2) Set the transmit power of the RSU to its maximum possible operational value.

3) Set the RSU to the mode, where it transmits only an unmodulated carrier.

4) Set the RSU transmit centre frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

5) Measure the actual carrier frequency $f_{Tx,actual}$.

6) Calculate the frequency error:

$$\Delta f_{RSU}/ppm = \frac{|f_{Tx} - f_{Tx,actual}|}{f_{Tx}} \times 10^6.$$

7) The test failed if the frequency error exceeds the maximum allowed limit as stated in clause 4.4.1.3.

8) Repeat step 5 to step 7 for the remaining carrier frequency f_{Tx} in accordance with clause 4.2.2.

5.3.1.2.3 Conducted measurements

1) Connect output of the RSU transmitter to the RD.

2) Set the transmit power of the RSU to its maximum possible operational value.

3) Set the RSU to the mode, where it transmits only an unmodulated carrier.

4) Set the RSU transmit centre frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

5) Measure the actual carrier frequency $f_{Tx,actual}$.

6) Calculate the frequency error:

$$\Delta f_{RSU}/ppm = \frac{|f_{Tx} - f_{Tx,actual}|}{f_{Tx}} \times 10^6.$$

7) The test failed if the frequency error exceeds the maximum allowed limit as stated in clause 4.4.1.3.

8) Repeat step 5 to step 7 for the remaining carrier frequency f_{Tx} in accordance with clause 4.2.2.

5.3.1.3 Transmitter spectrum mask

5.3.1.3.1 General

This test shall be performed either with radiated or conducted measurements.

Basic requirements and guidelines for measurements are provided in annex B.

Parameter descriptions and limits are provided in clause 4.4.1.4.

The manufacturer shall declare all RSU transmit centre frequencies f_{Tx} supported by this RSU and in accordance with table 2 and the class, e.g. A, B or C, of the RSU. In case of conducted measurements the manufacturer shall declare the maximum gain $G_{RSU,Tx}$ of the RSU transmit antenna to be used with the RSU under test.

The centre frequencies $f_c = f_{Tx} + f_{offset}$ and the resolution bandwidth RBW of the RD shall be set for measurements in the sequence as indicated for the offset frequencies f_{offset} in table 8, both valid for unmodulated and modulated emissions of the RSU.

Table 8: Offset frequencies and RBW for testing RSU Tx spectrum mask

#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
f_{offset} (MHz)	-1	+1	-1,5	+1,5	-2	+2	-3	+3	-3,5	+3,5	-4	+4	-6	+6	-6,5	+6,5	-7	+7
RBW	30 kHz		100 kHz								30 kHz				100 kHz			

5.3.1.3.2 Radiated measurements

1) Set up the measurement arrangement as detailed in clause B.1.7.5.1.

2) Set the transmit power of the RSU and its modulation index m to the maximum possible operational value.

3) Set the RSU to the mode, where it transmits only an unmodulated carrier.

4) Set the RSU transmit centre frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

5) Set the RD to the CW mode, also called zero span mode of operation, where the instrument is not sweeping across a frequency band.

6) Select one of the offset frequencies f_{offset} from table 8. If f_{offset} amounts to either ± 1 MHz, ± 4 MHz or ± 6 MHz, proceed with step 7, otherwise proceed with step 12.

7) Set the centre frequency $f_c = f_{Tx} + f_{offset} - RBW/2$ and RBW of the RD according to table 8.

8) Measure the power P_1 and report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

9) Set the centre frequency $f_c = f_{Tx} + f_{offset} + RBW/2$ and RBW of the RD according to table 8.

10) Measure the power P_2 and report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

11) Determine the total signal power P_{tot} by summing up the two signal power values as $P_{tot} = P_1 + P_2$, and compute the power $P_{tot,dBm}$ in dBm as $P_{tot,dBm} = 10 \times \lg(P_{tot}/P_0)$. Report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}. Proceed with step 18.

12) Set the centre frequency f_c of the RD to its initial value $f_c = f_{Tx} + f_{offset} - 2 \times RBW$ and RBW according to table 8. Set the counter $i = 1$.

13) Measure the power P_1 and report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

14) Increase the value of the counter by 1. When the counter equals 6, proceed with step 17, otherwise proceed with step 15.

15) Increase the centre frequency f_c of the RD by RBW and measure the signal power P_i from the RD and record its value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset} in the test report.

16) Repeat step 14 and step 15.

17) Determine the total signal power P_{tot} by summing up five signal power values as $P_{tot} = P_1 + P_2 + P_3 + P_4 + P_5$ and compute the total power $P_{tot,dBm}$ in dBm as $P_{tot,dBm} = 10 \times \lg(P_{tot}/P_0)$. Report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

18) Repeat step 6 to step 17 until the whole sequence of offset frequencies listed in table 8 has been processed.

19) Repeat step 6 to step 18 for the other carrier frequency f_{Tx} in accordance with clause 4.2.2.

20) For a specific combination of carrier frequency f_{Tx} and offset frequency f_{offset} the value of P_{tot} reported shall apply for the subsequent evaluation.

21) Replace the RTxA by a LHCP calibrated TSA of gain G_{TSA} and reflection coefficient ρ_{TSA} at its connector suited for the range of carrier frequencies f_{Tx} in accordance with clause 4.2.2 in such a way that its phase centre coincides with the one of the RTxA. The bore sight of the TSA shall point towards the phase centre of the RTA.

22) Connect the output of the TSA via the optional balun BLN, if required, of feed through attenuation ATN_{BLN}, and the calibrated FCCA1 of feed through attenuation ATN_{CA1} to a MSS1.

23) Tune the frequency of the MSS1's output signal to the frequency $f_c = f_{Tx} + f_{offset}$, where f_{Tx} is one of the values supported by this RSU in accordance with clause 4.2.2 and f_{offset} shall be according to table 8.

24) Adjust the output signal level P_{MSS1} of the MSS1 until the level, measured on the RD, becomes identical to P_{tot} as reported in step 20 at the same combination of carrier frequency f_{Tx} and offset frequency f_{offset}. This output signal level P_{MSS1} from the MSS1 shall be reported together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

25) Repeat step 23 and step 24 for all remaining combinations of carrier frequencies f_{Tx} and offset frequencies f_{offset}.

26) The TSM at this combination of carrier frequency f_{Tx} and offset frequency f_{offset}, expressed as an e.i.r.p. of the RSU shall be calculated by:

$$EIRP_{TSM} = \frac{P_{MSS1} \times G_{TSA} \times \left(1 - \left|\rho_{TSA}\right|^2\right)}{ATN_{CA1} \times ATN_{BLN}},$$

where all the parameters in the above formula are related to the corresponding measurement frequencies. The result shall be reported together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}. It shall not exceed the limit stated in clause 4.4.1.4.

27) Repeat step 4 to step 26 for a mode, where the RSU transmits a modulated carrier using test signal TS1.

5.3.1.3.3 Conducted measurements

1) Connect the RSU transmitter output via a calibrated FCCA to the input of the RD.

2) Set the transmit power of the RSU and its modulation index m to the maximum possible operational value.

3) Set the RSU to the mode, where it transmits only an unmodulated carrier.

4) Set the RSU transmit centre frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

5) Set the RD to its CW mode, also called zero span mode of operation, where the instrument is not sweeping across a frequency band.

6) Select one of the offset frequencies f_{offset} from table 8. If f_{offset} amounts to either ±1 MHz, ±4 MHz or ±6 MHz, proceed with step 7, otherwise proceed with step 12.

7) Set the centre frequency f_c of the RD to $f_c = f_{Tx} + f_{offset} - RBW / 2$ and select RBW according to table 8.

8) Measure the signal power P_1 from the RD taking into account all losses the signal suffers between the output connector of the OBU and the input connector of the RD and report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

9) Set the centre frequency f_c of the RD to $f_c = f_{Tx} + f_{offset} + RBW / 2$ and select RBW according to table 8.

10) Measure the signal power P_2 from the RD taking into account all losses the signal suffers between the output connector of the OBU and the input connector of the RD and report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

11) Determine the total signal power P_{tot} by summing up the two signal power values as $P_{tot} = P_1 + P_2$, and compute the power $P_{tot,dBm}$ in dBm as $P_{tot,dBm} = 10 \times \lg(P_{tot} / P_0)$. Report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}. Proceed with step 18.

12) Set the centre frequency f_c of the RD to its initial value $f_c = f_{Tx} + f_{offset} - 2 \times RBW$, select RBW according to table 8 and set the counter $i = 1$.

13) Measure the signal power P_i from the RD taking into account all losses the signal suffers between the output connector of the OBU and the input connector of the RD and report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

14) Increase the value of the counter by 1. When the counter equals 6, proceed with step 18, otherwise proceed with step 15.

15) Increase the centre frequency f_c of the RD by RBW and measure the signal power P_i from the RD and record its value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset} in the test report.

16) Repeat step 14 and step 15.

17) Determine the total signal power P_{tot} by summing up five signal power values as $P_{tot} = P_1 + P_2 + P_3 + P_4 + P_5$ and compute the total power $P_{tot,dBm}$ in dBm as $P_{tot,dBm} = 10 \times \lg(P_{tot}/P_0)$. Report this value together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

18) Repeat step 6 to step 17 until the whole sequence of offset frequencies listed in table 8 has been processed.

19) Repeat step 6 to step 18 for the other carrier frequency f_{Tx} in accordance with clause 4.2.2.

20) For a specific combination of carrier frequency f_{Tx} and offset frequency f_{offset} the value of P_{tot} reported for different sub-carrier frequencies f_s shall apply for the subsequent evaluation.

21) Compute the signal power P_{TSM} associated with each carrier frequency f_{Tx} and each offset frequency f_{offset} from the corresponding signal power values P_{tot} considering all losses within the signal path between the RD and the connector of the RSU's transmitting antenna. Record all values of P_{TSM} together with the associated carrier frequency f_{Tx} and offset frequency f_{offset}.

22) The TSM for each combination of carrier frequency f_{Tx} and offset frequency f_{offset}, expressed as an e.i.r.p. of the OBU shall be calculated by:

$$EIRP_{TSM} = P_{TSM} \times G_{RSU,Tx} .$$

It shall be understood that all parameter values are taken at the corresponding frequency $f = f_{Tx} + f_{offset}$. The result shall be reported together with the associated carrier frequency f_{Tx} and offset frequency f_{offset} in the test report. None of these values shall exceed the limit stated in clause 4.4.1.4.

23) Repeat step 6 to step 22 for a mode, where the RSU transmits a modulated carrier using test signal TS1.

5.3.1.4   Transmitter unwanted emissions

5.3.1.4.1   General

Basic requirements and guidelines for measurements are provided in annex B.

Parameter descriptions and limits are provided in clause 4.4.1.5.

The test shall be performed with radiated measurements within all frequency bands as referred to as "operating state" in table 4.

The manufacturer shall declare all RSU transmit centre frequencies f_{Tx} supported by the RSU under test in accordance with clause 4.2.2.

The test shall be performed either in an anechoic chamber or in an open area test site. The set up is illustrated in figure B.1 and figure B.3.

Figure 1 shows the turntable in its initial position MT0. MT1, MT2, MT3, MT4, MT5, MT6 and MT7 indicate the other angular positions used.
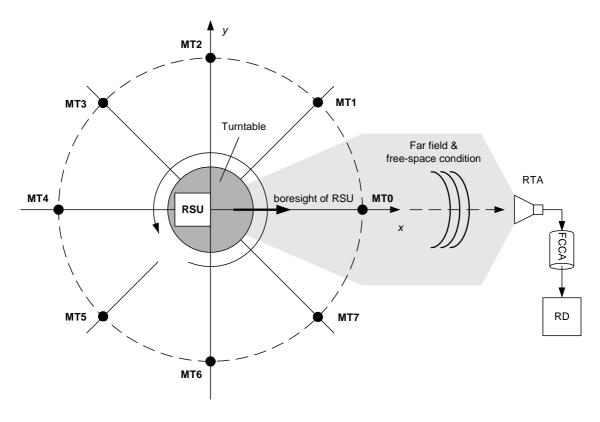

Figure 1: Test set up for RSU unwanted emission measurements (top view)

5.3.1.4.2   Radiated measurements

The following procedure applies for simultaneous spurious and out-of-band emissions radiated by the RSU transmit antenna.

1)   Set up the measurement arrangement as detailed in clause B.1.7.5.1.

2)   Replace the RTxA by a vertical polarized TSA such that their bore sights and phase centres coincide.

3)   The vertical polarized TSA shall be suited for the range of carrier frequencies f_{Tx} in accordance with clause 4.2.2. It shall be connected to a calibrated MSS1 using calibrated FCCA.

4)   The vertical polarized RTA shall be suited for the range of carrier frequencies f_{Tx} in accordance with clause 4.2.2.

5)   Move the turntable to its initial angular position MT0 as shown in figure 1.

6)   Table 4 in clause 4.4.1.5 specifies the maximum spurious and out-of-band emissions for the operating state as function of frequency. Adjust the output power of the MSS1 such that the e.i.r.p. of the TSA is equal to these limits for each measurement frequency and measure the power at the RD with a RBW equal to the reference bandwidth as indicated in table 4. Report the power levels as a function of frequency in Watt measured at the RD for further usage as a limit line.

7)   Replace the TSA by the RTxA such that the volume centre of the RSU transmitter matches the phase centre of the TSA. The RSU transmitter output shall be connected to a terminator matched to its nominal characteristic impedance featuring a VSWR of less than 1,5 in order to avoid radiation. The distance between any part of the RSU transmitter and the ceiling, floor or walls shall be at least 0,5 m.

8)   Set the RSU to the mode, where it transmits test signal TS1.

9)   Set the transmit power of the RSU and its modulation index m to the maximum possible operational value and switch on the RSU transmitter.

10) Select the first frequency band to be tested according to table 4.

11) Set the RSU transmit centre frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

12) Move the turntable to its initial angular position MT0 as shown in figure 1.

13) The resolution bandwidth of the RD used to measure signal power shall be set equal to the reference bandwidth as indicated in table 4. Measure the power spectrum P_{pol}, i.e. $P_{pol} = P_v$ in case of vertical polarized RTA and $P_{pol} = P_h$ in case of horizontal polarized RTA, received by the RD and report the result for further processing in step 18. Repeat step 13 for all other angular positions MT1 to MT7 of the turntable according to figure 1.

14) Repeat step 12 to step 13 for the other carrier frequency f_{Tx} in accordance with clause 4.2.2.

15) Repeat step 11 to step 14 for all frequency bands indicated in clause 4.4.1.5, see there table 4 for the operating state of the RSU and the exclusion band.

16) Rotate the RTA such that it is horizontally polarized, without changing position of its phase centre and bore sight orientation.

17) Repeat step 10 to step 15.

18) Compute the resulting power $P_{spurious} = P_v + P_h$ and compare it with the limit line. If the power $P_{spurious}$ exceeds the limit evaluated in step 6 for any frequency, the test failed.

19) Replace the RSU by the RTxA such that the volume centre of the RSU matches the phase centre of the RTxA, and such that the RTxA points towards the phase centre of the RTA and connect the RSU transmitter output to the RTxA.

20) Repeat step 8 to step 18 without step 12 and with the restriction that in step 13 there is no repetition.

5.3.2   Receiver parameters

5.3.2.1   Receiver unwanted emissions in the spurious domain

5.3.2.1.1   General

The test shall be performed on receiver only units (see clause 4.1.1) with radiated measurements within all frequency bands as referred to as "stand-by mode" in table 5.

Basic requirements and guidelines for measurements are provided in annex B.

Parameter descriptions and limits are provided in clause 4.4.2.1.

The manufacturer shall declare all RSU transmit centre frequencies f_{Tx} supported by the RSU under test and in accordance with table 2.

The test shall be performed either in an anechoic chamber or in an open area test site. The setup is illustrated in figure B.1 and figure B.3.

5.3.2.1.2   Radiated measurements

With reference to figure B.1 and figure B.3, the test procedure for spurious and out-of-band emissions according to clause 5.3.1.4.2 shall apply with the following modifications:

1)   The RSU shall be operated in the receive mode.

2)   If the RSU supports a receive only mode, the applicable limits and resolution band widths are indicated in table 5 for the "stand-by" mode.

3)   If the RSU does not support a receive only mode, but is transmitting a carrier whilst receiving, the applicable limits and resolution band widths are indicated in table 4 for the "operating" mode.

5.3.2.2   Blocking

5.3.2.2.1   General

This test shall be performed with radiated measurements.

Basic requirements and guidelines for measurements are provided in annex B.

Parameter descriptions and limits are provided in clause 4.4.2.2.

The emissions by the unwanted signal within the band $f_{Tx} \pm 2{,}5$ MHz shall be 6 dB below the sensitivity level of the RSU to avoid co-channel interference.

The representative centre frequencies f_u of the unwanted signal as selected by the manufacturer shall be at least 5 MHz separated from f_{Tx}. The selected frequencies f_u for testing shall be stated in the test report.

NOTE: The manufacturer may extend the test in order to determine the actual value of the immunity against other services.

5.3.2.2.2   Radiated measurements

1)   Set up the measurement arrangement as detailed in clause B.1.7.5.2.

2)   Switch off the MSS2 as it is never used in this test. Alternatively, this source shall be replaced by a 50 Ω terminator.

3)   Set the RSU to the mode that it transmits an unmodulated carrier.

4)   Set the RSU output power to its maximum allowed value.

5)   Set the modulation index to any convenient value, if it is adjustable.

6)   Set the RSU carrier frequency f_{Tx} to the initial value supported by this RSU in accordance with clause 4.2.2.

7)   Set the RSU to a mode such that the OBU shall use the lower sub-carrier frequency f_s.

8)   Set the frequency of the MSS1 to the initial value of f_u.

9)   Ensure that MSS1 and the RSU are switched off.

10) Replace the RSU receiver by a power meter PM1.

11) Switch on MSS1 and adjust the power of its output signal such that PM1 measures $P_{PM1} = -30$ dBm.

12) Switch off MSS1.

13) Switch on the RSU transmitter and adjust AT1 such, that the incident signal power received by a loss-less isotropic antenna at the location of the OBU antenna equals -25 dBm in order to ensure reliable reception of messages by the OBU.

14) Set the OBU into a test mode that it transmits test signal TS2.

15) Adjust AT2 such, that the power measured by PM1 equals the sum of the sensitivity P_{sens} of the RSU declared by the manufacturer plus 6 dB.

16) Replace the PM1 by the RSU receiver.

17) Set RSU and OBU to a mode that they are able to process test messages TM1.

18) Switch on MSS1.

19) Measure BER of the RSU receiver according to clause B.4. If the BER is greater than 2.0×10^{-2} the test failed.

20) Set the RSU to a mode such that the OBU shall use the upper sub-carrier frequency f_s.

21) Repeat step 19.

22) Repeat step 9 to step 21 for all remaining values f_u of the frequency of the unwanted signal.

23) Set the RSU to a mode such that the OBU shall use the lower sub-carrier frequency f_s.

24) Repeat step 8 to step 22 for the remaining value of the carrier frequency f_{Tx} in accordance with clause 4.2.2.

5.3.2.3   Sensitivity

5.3.2.3.1   General

This test shall be performed with radiated measurements.

Basic requirements and guidelines for measurements are provided in annex B.

Parameter descriptions and limits are provided in clause 4.4.2.3.

The description below assumes that an OBU is used to receive downlink signals and to generate uplink signals, both of type TM1.

NOTE: The manufacturer may extend the test in order to determine the actual value of the receiver sensitivity.

5.3.2.3.2   Radiated measurements

1) Set up the measurement arrangement as detailed in clause B.1.7.5.2.

2) Switch off MSS1 and MSS2 as these sources are never used in this test. Alternatively, these sources shall be replaced by 50 Ω terminators.

3) Set the RSU carrier frequency f_{Tx} to the initial value supported by the RSU under test in accordance with clause 4.2.2.

4) Set the RSU to the mode that it transmits an unmodulated carrier.

5) Set the RSU output power to its maximum allowed value.

6) Set the modulation index to any convenient value, if it is adjustable.

7) Switch on the RSU transmitter and adjust AT1 such, that the incident signal power received by an loss-less isotropic antenna at the location of the OBU antenna equals -25 dBm in order to ensure reliable reception of messages by the OBU.

8) Set the OBU into a test mode that it transmits test signal TS2.

9) Replace the RSU receiver by a power meter PM1.

10) Adjust AT2 such, that the power measured by PM1 equals the sensitivity limit P_{sens} for the RSU receiver class from table 6 as declared by the manufacturer.

11) Replace the PM1 by the RSU receiver.

12) Set RSU and OBU to a mode that they are able to process test messages TM1.

13) Set the RSU to a mode such that the OBU shall use the lower sub-carrier frequency.

14) Measure BER of the RSU receiver according to clause B.4. If the BER is greater than 10^{-6} the test failed.

15) Repeat step 14 for the upper sub-carrier frequency.

16) Repeat step 4 to step 15 for the remaining value of the carrier frequency f_{Tx} in accordance with clause 4.2.2.

Annex A (normative):
Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.6] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.5].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

**Table A.1: Relationship between the present document and
the essential requirements of Directive 2014/53/EU**

Harmonised Standard ETSI EN 300 674-2-1 The following requirements are relevant to the presumption of conformity under the article 3.2 of Directive 2014/53/EU [i.5]				
Requirement			**Requirement Conditionality**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**
1	Maximum equivalent isotropically radiated power	4.4.1.2	U	
2	Frequency error	4.4.1.3	U	
3	Transmitter spectrum mask	4.4.1.4	U	
4	Transmitter unwanted emissions	4.4.1.5	U	
5	Receiver spurious emissions	4.4.2.1	U	
6	Blocking	4.4.2.2	U	
7	Sensitivity	4.4.2.3	U	

Key to columns:

Requirement:

No   A unique identifier for one row of the table which may be used to identify a requirement.

Description   A textual reference to the requirement.

Clause Number Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

U/C   Indicates whether the requirement shall be unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

Condition   Explains the conditions when the requirement shall or shall not be applicable for a requirement which is classified "conditional".

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (normative):
Basics on testing

B.1 General conditions

B.1.1 Power source

For testing the equipment shall be powered by a test power source, capable of producing test voltages as declared by the manufacturer.

For battery operated equipment the battery shall be removed and an external test power source shall be suitably decoupled. For radiated measurements any external power leads shall be arranged so as not to affect the measurements. If necessary, the external test power source may be replaced with the supplied or recommended internal batteries at the required voltage, or a battery simulator. This shall be stated in the test report. For radiated measurements on portable equipment, fully charged internal batteries shall be used. The batteries used shall be as supplied or recommended by the manufacturer.

During tests the external test power source voltages shall be within a tolerance of ±1 % relative to the voltage at the beginning of each test. The value of this tolerance can be critical for certain measurements. Using a smaller tolerance provides a better uncertainty value for these measurements. If internal batteries are used, at the end of each test the voltage shall be within a tolerance of ±5 % relative to the voltage at the beginning of each test.

The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible. For the purpose of the tests, the voltage of the external test power source shall be measured at the input terminals of the equipment.

B.1.2 Thermal balance

Before measurements are made the equipment shall have reached thermal balance in the test chamber.

The equipment shall be switched off during the temperature stabilizing period.

In the case of equipment containing temperature stabilization circuits designed to operate continuously, the temperature stabilization circuits shall be switched on for a time period as declared by the manufacturer such that thermal balance has been obtained, and the equipment shall then meet the specified requirements.

If the thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour, or such period as may be decided by the test laboratory, shall be allowed. The sequence of measurements shall be chosen and the relative humidity content in the test chamber shall be controlled so that condensation does not occur.

B.1.3 Test signals

The following test signals and test messages are defined.

Table B.1: Test signals and messages

Test signal/message	Description
Test Messages (TM1)	Set of DSRC messages supporting initialization and ECHO command compliant to CEN EN 12795 [7], CEN EN 12834 [8], and ISO 14906 [9].
Test Signal (TS1)	Properly modulated and coded DSRC signal where the data is a continuously repeated maximum length pseudo-random sequence generated by a linear feedback shift register. The period of the pseudo-random sequence shall be 511 bits.
Test Signal (TS2)	Continuous DSRC uplink signal with unmodulated sub-carrier. The sub-carrier frequency shall be settable to f_s = 1,5 MHz and f_s = 2,0 MHz, respectively.

Data coding and bit rates in downlink and uplink shall be according to parameters D7, U7 and D8, D8a, U8, U8a of CEN EN 12253 [3], respectively.

B.1.4   Test sites

B.1.4.1   Shielded anechoic chamber

A typical anechoic chamber is shown in figure B.1. This type of test chamber attempts to simulate free space conditions.
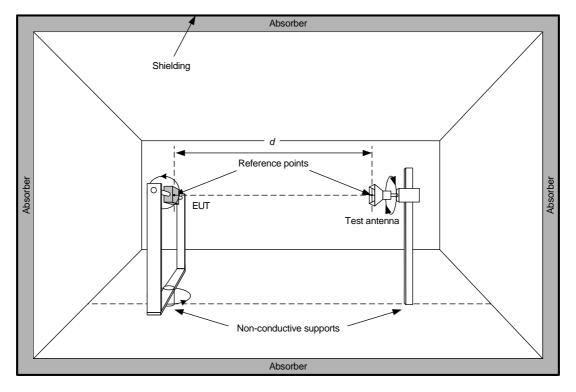

Figure B.1: Typical anechoic chamber

The chamber contains suitable antenna supports on both ends.

The supports carrying the test antenna and EUT shall be made of a non-permeable material featuring a low value of its relative permittivity.

The anechoic chamber shall be shielded. Internal walls, floor and ceiling shall be covered with radio absorbing material. The shielding and return loss for perpendicular wave incidence versus frequency as detailed in figure B.2 shall be met by anechoic chambers used to perform tests.
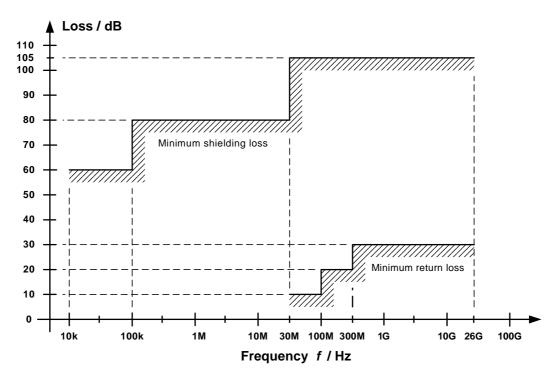
Figure B.2: Minimal shielding and return loss for shielded anechoic chambers

Both absolute and relative measurements can be performed in an anechoic chamber. Where absolute measurements are to be carried out the chamber shall be verified.

The shielded anechoic chamber test site shall be calibrated and validated for the frequency range being applicable.

NOTE: Information on uncertainty contributions, and verification procedures are detailed in clause 5 and clause 6, respectively, of ETSI TR 102 273-2 [11].

B.1.4.2   Open area test site

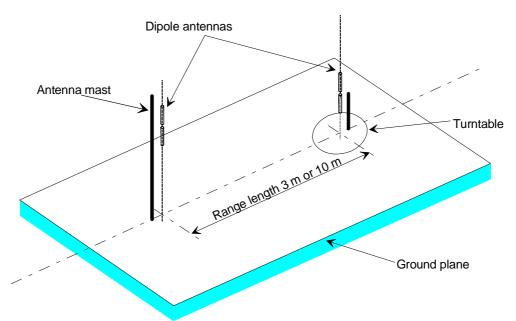A typical open area test site is shown in figure B.3.

Figure B.3: Typical open area test site

The ground plane shall provide adequate size, such as to approximate infinite size. Relevant parts of the ground plane shall be covered by absorbing material.

Test shall be limited to the frequency range between 30 MHz and 1 000 MHz.

Measurements performed in open area test sites follow the same procedures as detailed for radiated measurements performed in shielded anechoic chambers.

The open area test site shall be calibrated and validated for the frequency range being applicable.

NOTE: Information on uncertainty contributions, and verification procedures are detailed in clause 5 and clause 6, respectively, of ETSI TR 102 273-4 [i.3].

B.1.4.3   Test fixture

A test fixture is a device that allows for conducted measurements of an EUT that does not provide antenna connectors itself. The EUT can be either an OBU or a RSU. A test fixture consists of at least one RF connector featuring a characteristic impedance of 50 Ω, subsequently called 50 Ω RF connector, and a device for electromagnetic coupling to the EUT. It incorporates a means for repeatable positioning of the EUT. Figure B.4 illustrates a typical test fixture.
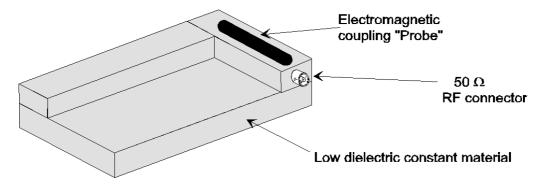

Figure B.4: Typical test fixture

The coupling device usually comprises a small antenna that is placed, physically and electrically, close to the EUT. This coupling device is used for sampling or generating the test fields when the EUT is undergoing testing. Figure B.5 illustrates an EUT mounted on a test fixture.
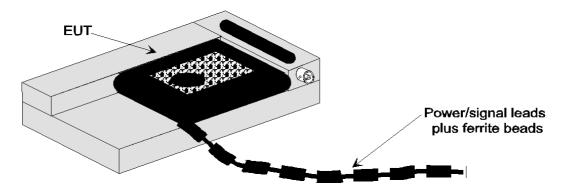

Figure B.5: EUT mounted in a typical test fixture

The entire assembly of test fixture plus EUT is generally compact and it can be regarded as a EUT with antenna connector. Its compactness enables the whole assembly to be accommodated within a test chamber, usually a climatic facility. The circuitry associated with the RF coupling device should contain no active or non-linear components and should present a VSWR of better than 1,5 to a 50 Ω line.

Absolute measurements shall not be made in a test fixture as the antenna of the EUT and the one of the test fixture might be mutually in the near-field range of each other. Hence, only relative measurements shall be performed that have to be related to results taken on a verified free field test site.

The way to relate the results is by a process, referred to as field equalization, in which the relevant parameter, e.g. effective radiated power, receiver sensitivity, etc. is initially measured on a free field test site under normal environmental conditions and then subsequently re-measured using the test fixture under the very same environmental conditions. The difference, e.g. in dB, of the two results is termed the coupling factor of the test fixture and provides the link between all the results of EUT tests carried out in the test fixture and its performance on a verified free field test site. As a general rule, the coupling factor should not be greater than 20 dB.

Emission tests are generally limited to the nominal frequencies, for which the performance of the test fixture has been verified.

Only after it has been verified that the test fixture does not affect performance of the EUT, the EUT can be confidently tested.

The test fixtures shall be calibrated and validated for the frequency range they are used for.

NOTE: Information on uncertainty contributions, and verification procedures are detailed in clause 5 and clause 6, respectively, of ETSI TR 102 273-6 [12].

B.1.5   General requirements for RF cables

All RF cables including their connectors at both ends used within the measurement arrangements and set ups shall be of coaxial type featuring within the frequency range they are used:

- a nominal characteristic impedance of 50 Ω;

- a VSWR of less than 1,2 at either of their ends, preferably better;

- a shielding loss in excess of 60 dB, preferably better.

All RF cables exposed to radiation shall be loaded with ferrite beads spaced with a gap of D_{fb} between each other along the entire length of the cable. Such cables are referred to as FCCA. The gap D_{fb} shall be less than half of the signal's wavelength under test.

All RF cables shall be routed suitably in order to reduce impacts on antenna radiation pattern, antenna gain, antenna impedance.

NOTE: Further details are provided in ETSI TR 102 273-2 [11].

B.1.6   Conducted measurements

B.1.6.1   One antenna connector arrangement

Figure B.6 shows the measurement arrangements that shall be used in case of a single antenna connector at the EUT.
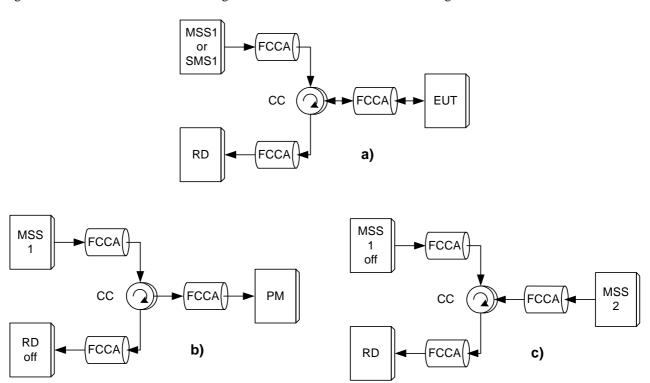
Figure B.6: Measurement arrangement with one antenna connector:
a) for measurement of EUT parameters
b) for adjusting input power to EUT
c) for substitution measurements

B.1.6.2   Two antenna connectors arrangement

Figure B.7 shows the measurement arrangements that shall be used in case of a two antenna connectors at the EUT.
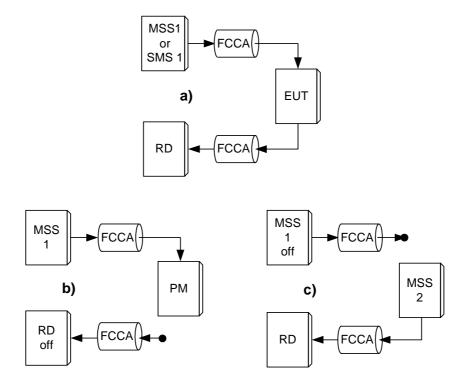

Figure B.7: Measurement arrangement with two antenna connectors:
a) for measurement of EUT parameters
b) for adjusting input power to EUT
c) for substitution measurements

B.1.6.3   Test site requirements

Conducted measurements shall be performed at the antenna connector(s) of the EUT.

B.1.6.4   Site preparation for conducted measurements

B.1.6.4.1   Monochromatic signals

If the measurement arrangement with one antenna connector is used, the measurement set up depicted in figure B.6 applies and the site preparation is as follows:

1)   The calibrated MSS1 shall be connected to the antenna connector of the EUT via the calibrated CC providing three terminals.

2)   The RD shall be connected to the antenna connector of the EUT via the remaining third terminal of the calibrated CC.

If the measurement arrangement with two antenna connectors is used, the measurement set up depicted in figure B.7 applies and the site preparation is as follows:

1)   The calibrated MSS1 shall be connected to the receive antenna connector of the EUT.

2)   The RD shall be connected to the transmit antenna connector of the EUT.

B.1.6.4.2 Modulated signals

If the measurement arrangement with one antenna connector is used, the measurement set up depicted in figure B.6 applies and the site preparation is as follows:

1) The calibrated SMS1 shall be connected to the antenna connector of the EUT via the calibrated CC providing three terminals.

2) The RD, i.e. either an RSU receiver or a measurement receiver, shall be connected to the antenna connector of the EUT via the remaining third terminal of the calibrated CC.

If the measurement arrangement with two antenna connectors is used, the measurement set up depicted in figure B.7 applies and the site preparation is as follows:

1) The calibrated SMS1 shall be connected to the receive antenna connector of the EUT.

2) The RD, i.e. either an RSU receiver or a measurement receiver, shall be connected to the transmit antenna connector of the EUT.

B.1.7 Radiated measurements

B.1.7.1 One antenna arrangement

Figure B.8 shows the measurement arrangements that shall be used in case one test antenna TA for transmitting and receiving signals are selected for testing the EUT.
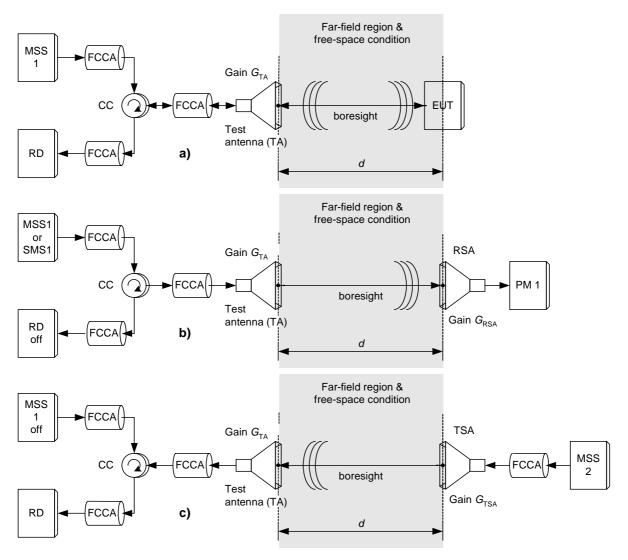
Figure B.8: Measurement arrangement with one test antennas:
a) for measurements of EUT parameters
b) for adjustment of the incident power to the EUT
c) for measurement steps using the substitution antenna

B.1.7.2 Two antennas arrangement

Figure B.9 shows the measurement arrangements that shall be used in case two test antennas, i.e. TTA and RTA, are selected for testing the EUT.
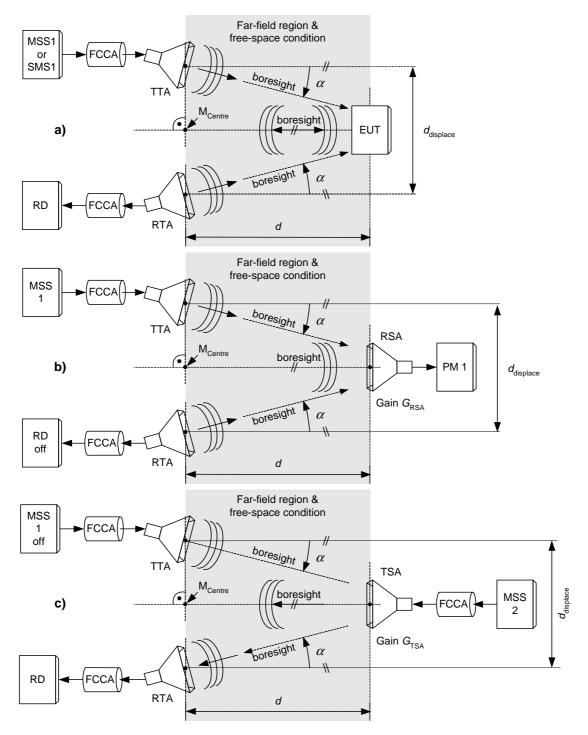

Figure B.9: Measurement arrangement with two test antennas:
a) for measurements of EUT parameters
b) for adjustment of the incident power to the EUT
c) for measurement steps using the substitution antenna

B.1.7.3 Test site requirements

B.1.7.3.1 Measurement distances

Within an open area test site or a shielded anechoic chamber the measurement distance or range length d depicted in figure B.8 and figure B.9 shall be such, that the antennas on both sides of the radio link are mutually in the far field of each other, i.e. d shall be according to the most stringent of the following three equations:

$$d > \frac{2 \times \left(D_{0,\mathrm{TA}} + D_{0,\mathrm{EUT}}\right)^2}{\lambda} \, , \, d > 5 \times \left(D_{0,\mathrm{TA}} + D_{0,\mathrm{EUT}}\right) \text{ and } d > 2 \times \lambda,$$

where $D_{0,\mathrm{TA}}$, $D_{0,\mathrm{EUT}}$ and λ denote the largest dimension of the test antenna, the EUT antenna, and the wavelength, respectively.

This distance d shall be measured between:

- the centre of aperture of the test antenna TA, in case of a horn antenna, or the feeding point in case the TA is of another type; and

- the feeding point of the EUT antenna if the location of the EUT antenna is known, or the volume centre of the EUT if the location of its antennas is unknown.

B.1.7.3.2 Free-space wave propagation

Within an open area test site or a shielded anechoic chamber a radio path between a transmitting and receiving antenna requires a certain amount of clearance around the central or direct ray if the signal expected from free-space propagation is to be received.

The clearance is usually quoted in terms of Fresnel zones. As depicted in figure B.10 the first Fresnel zone encloses all radio paths from the transmitting to the receiving antenna for which the detour path length $d_{\mathrm{F1}} + d_{\mathrm{F2}}$ relative to the length d of the direct radio path does not exceed half of the wavelength λ, i.e. a phase change of 180°, of the radiated signal in air.

$$d_{\mathrm{F1}} + d_{\mathrm{F2}} - d \leq \lambda / 2.$$

Disregarding the non-conductive, dielectric supports of the EUT and the test antenna(s) the clearance around the LOS path between the transmitting and receiving antenna shall be such that at least the first Fresnel zone is free of any obstacles.
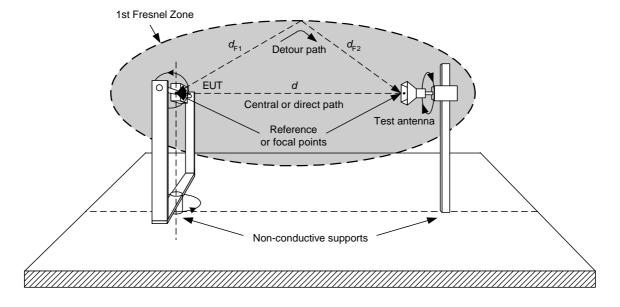

Figure B.10: First Fresnel zone with direct and detour radio path

B.1.7.4   Test and substitution antennas

Test antennas are used to detect the radiation from the EUT or to transmit a signal towards the EUT while substitution antennas together with signal generators are used to replace the EUT and its antenna in substitution measurements.

The test or substitution antenna shall be either LHCP, LP, or XP, whichever is required in the test procedure of the respective EUT parameter. Cross-polarized test or substitution antennas require a XPD > 25 dB within their specified frequency range.

Preferably test or substitution antennas with pronounced directivities shall be used. However, their directivities D_i relative to an isotropic radiator shall be such that the antennas on both sides of the radio link are mutually in the far field region of each other.

If the symmetry of the test or substitution antenna does not match the one of its feeding cable, a symmetry matching circuit (balun) shall be inserted between the antenna output and the input of its feeding RF cable.

The return loss at the terminal of the test or substitution antenna shall exceed 15 dB within its specified frequency range.

When measuring signals in the frequency range up to 1 GHz the test or substitution antenna shall be either:

- a half wavelength dipole, resonant at the operating frequency,

- a shortened dipole, calibrated to the half wavelength dipole, or

- a biconical antenna.

For measurements between 1 GHz and 4 GHz either:

- a half wavelength dipole,

- a biconical antenna, or

- a horn radiator may be used.

When measuring signals in the frequency range above 4 GHz a horn antenna shall be used.

The type of test or substitution antenna actually used in the tests shall be stated in the test report.

B.1.7.5   Site preparation for RSU measurements

B.1.7.5.1   Arrangement for transmit parameters

Figure B.11 details the arrangement used for measurement of the transmitter parameters maximum e.i.r.p., frequency error, TSM, spurious and out-of-band emissions and receiver spurious emissions.
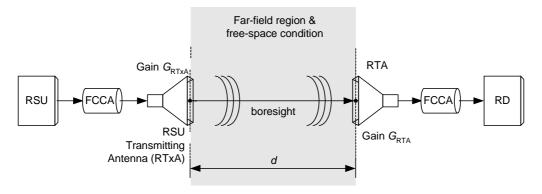

Figure B.11: RSU transmit parameter measurement arrangement

1) The LHCP RTxA shall be mounted on a vertical pole within the "quiet zone" of the shielded anechoic chamber. The distance between any part of the RTxA and the ceiling, floor or walls shall be at least 0,5 m.

2) The RTA shall be suited for the range of carrier frequencies f_{Tx} in accordance with clause 4.2.2. It shall be mounted on a pole at the other end of the shielded anechoic chamber. The distance between any part of the RTA and the ceiling, floor or walls shall be at least 0,5 m. The RTA shall be LHCP if not stated otherwise in the test procedures.

3) The distance d between the RTxA and the RTA shall be such that the two antennas are mutually in the far field of each other, see clause B.1.7.3.1.

4) The phase centres of the RTxA and the RTA shall be at the same height above floor.

5) The bore sight of the RTA shall point towards the phase centre of the RTxA. The bore sight of the RTxA shall point towards the phase centre of the RTA.

6) Connect the RSU transmitter to the RTxA via an FCCA.

7) Connect the RTA to the RD via an FCCA.

B.1.7.5.2   Arrangement for receive parameters

Figure B.12 and figure B.13 detail the arrangements used for measurement of the receiver parameters dynamic range, intermodulation immunity, co-channel rejection, blocking and selectivity. Figure B.12 applies for a RSU with separate antenna connectors for the receive and transmit path.
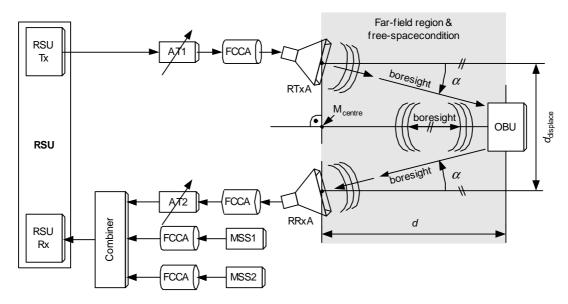

**Figure B.12: RSU receive parameter measurement arrangement
for horizontally separated antennas**

In case the RSU under test provides only a single antenna connector for both, transmit and receive path, a CC shall be used in order to split up the single antenna connector into two antenna connectors, one for the receive path and one for the transmit path; see figure B.13.
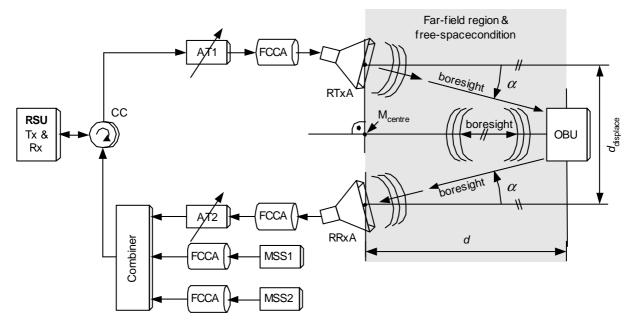
**Figure B.13: RSU receive parameter measurement arrangement with CC
for horizontally separated antennas**

1) The RTxA shall be mounted on a vertical pole within the "quiet zone" of the shielded anechoic chamber. The distance between any part of the RTxA and the ceiling, floor or walls shall be at least 0,5 m.

2) The RRxA shall be mounted on a vertical pole within the "quiet zone" of the shielded anechoic chamber. The distance between any part of the RRxA and the ceiling, floor or walls shall be at least 0,5 m.

3) The phase centre of the RTxA shall be displaced from the phase centre of the RRxA by $d_{displace}$. The position between both phase centres is denoted M_{centre}.

4) The displacement shall either be horizontally or vertically such as to minimize the coupling between these antennas. The distance $d_{displace}$ shall be such that the coupling loss between the two antennas exceeds 30 dB. The actual coupling loss and the distance $d_{displace}$ shall be stated in the test report together with the unique identification of the RTxA and RRxA used.

5) The OBU shall be mounted on a vertical pole at the other end of the shielded anechoic chamber, such that its bore sight points towards M_{centre}.

6) The height of the phase centres above floor of the RTxA, RRxA and the OBU antenna shall be equal.

7) Bore sight of the RTxA shall point towards the phase centre of the OBU antenna.

8) Bore sight of the RRxA shall point towards the phase centre of the OBU antenna.

9) The OBU antenna(s) shall be mutually in the far field of RTxA and RRxA, see clause B.1.7.3.1.

10) Connect the RSU transmitter to the RTxA via an adjustable attenuator AT1 and an FCCA.

11) Connect the RRxA to the RSU receiver via a combiner with four terminals, an isolator, an adjustable attenuator AT2 with attenuation ATN_{AT2} and an FCCA.

12) Connect a MSS1 via a FCCA to one of the remaining terminals of the combiner.

13) Connect a MSS2 via a FCCA to the remaining terminal of the combiner.

B.2 Instruments

B.2.1 Receiving device

The RD shall be either a spectrum analyser or a measurement receiver. The subsequent requirements shall apply for a spectrum analyser:

1) The level of the superposition of all RF signals simultaneously fed to the input of the spectrum analyser shall be within its range of specification applying for its calibrated operational mode of operation.

2) The RD shall be operated only within modes for which the instrument has been calibrated.

3) For any frequency to be measured, the noise floor of the RD shall be at least 10 dB below any power value intended to be measured, e.g. limits for spurious emissions, referred to the location where the limit applies.

4) The DC voltage fed to the input of the spectrum analyser shall be within its range of specification applying for its calibrated operational mode of operation.

5) The frequency error of the spectrum analyser shall be compliant with table 7.

6) The nominal characteristic impedance of the spectrum analyser's input connector shall match the nominal characteristic impedance of the device connected to this input connector. The VSWR shall be less than 2,0. If this cannot be met, an attenuator or an isolator featuring a VSWR less or equal to 2,0 within the frequency range of the measurement shall be attached to the input of the spectrum analyser and the EUT shall be connected to the input of this attenuator or isolator.

7) The Video Bandwidth (VBW) shall always be equal to or larger than the Resolution Bandwidth (RBW) selected. The RBW will also be referred to as the reference or equivalent bandwidth. See as well clause 4.5 of CISPR 16-1 [13].

8) For spurious and out-of-band emission measurements the RBW of the spectrum analyser shall be set to the required RBW specified in the test procedure:

   - The measurements may be performed using an RBW that is less than the required one and multiple measurements shall be carried out across the required RBW within non-overlapping frequency bins whose width equal to the selected RBW. The signal power measured within each of these frequency bins shall be added up to obtain the wanted signal power within the required RBW.

   - If the required RBW is less than the smallest one offered by the spectrum analyser and does not match any of the available ones of the spectrum analyser, the measured signal powers shall be performed with a RBW that is closest to the required RBW. The signal power measured shall be scaled according to the ratio of the required RBW to the RBW used while performing the measurements.

9) Signal power measurements performed using the spectrum analyser's CW mode shall equal to the arithmetic average of the largest and smallest signal level measured during the observation time.

10) The spectrum analyser shall be used only after the instrument has warmed up. The minimum warm up duration is usually specified in the manual of the spectrum analyser. If this is not the case, a warm up time of at least half an hour shall be considered.

11) The spectrum analyser shall be calibrated before usage.

12) If the dynamic range of the spectrum analyser in conjunction with the required setting of the RBW is not sufficient to measure relevant weak signals in the presence of irrelevant strong signal components appropriate measures to suppress the irrelevant strong signal components shall be applied in agreement between manufacturer and test laboratory and shall be described in the test report.

13) The peak detector shall be used.

For the usage of a measurement receiver the above requirements shall apply as well with the exception, where requirements are not applicable, e.g. VBW.

B.2.2   RF power sensor

The subsequent requirements shall apply for RF signal power measurements.

1) RF signal power measurements shall not be performed before warm-up of the RF power sensor and the RF power meter. The warm-up duration is usually specified in the manual of the instrument. If this is not the case the instrument shall be allowed for a warm-up time of at least half an hour.

2) The RF power sensor and RF power meter shall be calibrated and zeroed before usage according to the requirements and the procedure specified in the manual of the instrument.

3) The RF power sensor shall be kept within a small enough temperature range such as to keep the measurement uncertainty of the measurement set up within the range specified in clause 5.2.

4) The VSWR at the input of the RF power sensor shall be less than 1,5 within the frequency range of the measurement under investigation.

5) The level of the superposition of all signals simultaneously fed to the input of the RF power sensor shall be within the dynamic range of the RF power sensor as stated by its manufacturer for its operational mode.

6) The power sensor shall be dedicated for the signal waveform under consideration.

B.2.3   Combiner

All RF combiners used within the measurement arrangements and set ups shall provide coaxial connectors at all ports and feature within the frequency range they are used:

- a nominal characteristic impedance of 50 Ω at each port;

- a VSWR of less than 1,5 at each port;

- an isolation between the input ports of at least 10 dB; and

- an amplitude balance between each of the input ports and the output port of less than 1 dB.

B.3   Power of modulated RSU carrier

Figure B.14 illustrates as an example the basic time-dependent sequence of unmodulated and modulated RSU transmit signals for a case of a modulation index $m = 0,5$, where the transmit signal power P_{mod}, and P_{CW}, respectively, of the modulated, and unmodulated signal parts are equal. The condition of equal power $P_{mod} = P_{CW}$ is not required by the present document.

NOTE: Figure B.14 does not allow extracting valid timing relations between carrier frequency and bit rate.
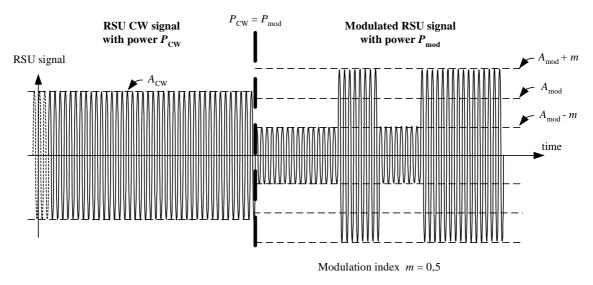
Modulation index $m = 0{,}5$

Figure B.14: RSU transmit signal

An RSU normally allows for a transmit mode "send unmodulated carrier", i.e. continuous transmission of the unmodulated carrier. Thus it is possible to measure the power of the unmodulated signal in figure B.14, $P_{CW} = \frac{1}{2} A_{CW}^2$, by means of a thermal power sensor or a spectrum analyser.

An RSU does normally not allow for continuous transmission of the modulated carrier. In what follows a procedure is described, that allows to estimate the power $P_{mod} = \frac{1}{2} A_{mod}^2 (1 + m^2)$ of the modulated carrier:

1) Set the RSU in a mode that it transmits an unmodulated carrier. Measure P_{CW}.

2) Set the RSU in a mode that it transmits BSTs of maximum possible duration T_{mod} with a repetition period as close as possible to twice of the duration of a BST transmission. The gap between subsequent BST transmissions has duration T_{CW}. The duration T_{mod} and T_{CW} shall be constant within the following test.

3) Measure the average signal power P_{avg} of the signal transmitted according to step 2 with measurement time of at least ten times the repetition period $T_{CW} + T_{mod}$.

4) Measure the duration T_{mod} and T_{CW}.

5) Calculate $P_{mod} = P_{avg} + \frac{T_{CW}}{T_{mod}} \left(P_{avg} - P_{CW} \right)$.

B.4   Bit error ratio measurements

B.4.1   Basics

The required BER for communication is referred to as parameters D9 and U9 in CEN EN 12253 [3].

BER measurements shall be conducted either in a direct or indirect way.

The direct way requires the possibility to generate and receive a continuous bit stream of significant length. The fraction of erroneous bits out of the total number of received bits is the BER. This approach uses standard laboratory equipment for BER measurement and requires a modification of the EUT.

The indirect way is based on generating and receiving frames of limited length where any bit errors in the frame can be detected by means of a CRC. The fraction of erroneous frames out of the total number of frames, which is called the FER, allows to estimate the BER assuming that bit errors are equally distributed. Precautions shall be taken to prevent drops of error-free received frames caused by specific implementation of upper layers.

B.4.2   BER measurement

BER may be measured indirectly, see clause B.4.3.

B.4.3   FER measurement

B.4.3.1   Mathematical expressions

Assuming equally distributed and statistically independent occurrence of erroneous bits the following relations between *FER*, *BER*, and total number *N* of transmitted bit within a single frame apply:

$$FER = 1 - (1 - BER)^N,$$

$$BER = 1 - 10^{\frac{\lg(1-FER)}{N}} = 1 - \sqrt[N]{1 - FER}.$$

The minimum number C_F of frames together with the frame size shall be reported.

> EXAMPLE 1:   With $BER = 10^{-6}$ and frame length $N = 1\ 000$ the equivalent *FER* amounts to approximately $1,0 \times 10^{-3}$. A reasonable number C_F of frames to be transmitted is 10 000, i.e. 10 frames may be lost on average.

> EXAMPLE 2:   For a large value of FER, e.g. 0,999 9 which may result from a BER $= 2,0 \times 10^{-2}$ as used for test, a reasonable number C_F of frames to be transmitted is 100 000, i.e. 10 frames may be error-free on average. The very large number of frames to be transmitted is to be able at all to estimate the BER, as a small variation in erroneous frames may change significantly the corresponding estimated BER.

B.4.3.2   Equipment

FER measurements can be easily conducted using the set of test messages TM1. Thus standard DSRC equipment might be used, if the following software configuration has been implemented:

- initialization with BST and VST is implemented; see CEN EN 12795 [7] and CEN EN 12834 [8];

- the EFC command ECHO is implemented; see ISO 14906 [9].

In case of a bit error performance measurement of the RSU receiver, the following additional configuration requirements apply:

- An ECHO.request transmitted by the RSU and not responded by the OBU shall be treated as "never transmitted", as in this case the ECHO.request was received erroneous.

- An erroneous ECHO.response received shall not result in a retransmission of the related ECHO.request as normally required by the DSRC protocol, but shall just lead to an increment of the frame error counter.

In case of a bit error performance measurement of the OBU receiver, the following additional configuration requirements apply:

- An ECHO.request transmitted by the RSU and not responded by the OBU shall not result in a retransmission of the related ECHO.request as normally required by the DSRC protocol, but shall just lead to an increment of the frame error counter.

- An erroneous ECHO.response received shall not result in a retransmission of the related ECHO.request as normally required by the DSRC protocol, but shall just be ignored, as in this case the ECHO.request was received error free at the OBU.

B.4.3.3   Procedure

1) The RSU shall perform initialization with the OBU by exchanging BST and VST. The signal level at the receiver input relevant for BER measurement shall be set to the level required for the test. The signal level at the other receiver input shall be set at a reasonable high value as declared by the manufacturer such that error free reception is very likely. In the unexpected case of transmission errors, the initialization attempt shall be repeated. During initialization any additional interfering signals as requested by a specific test procedure shall be switched off.

2) The RSU shall transmit a single ECHO command of maximum length. Reception of the corresponding response from the OBU is expected to be error free. In case of errors, repetitions of the ECHO command according to the DSRC protocol shall happen. This finalizes initialization.

In case of a bit error performance measurement of the RSU receiver, the following additional procedural steps shall be processed:

3) Repeat step 2 C_F times, C_F see clause B.4.3.1, and report the total number C_E of erroneous ECHO.response frames received by the RSU. Calculate the actual Frame Error Ratio $FER = C_E / C_F$. Continue with step 5.

In case of a bit error performance measurement of the OBU receiver, the following additional procedural steps shall be processed:

4) Repeat step 2 for C_F times, C_F see clause B.4.3.1, and report the total number C_E of ECHO.response frames not received by the RSU. Calculate the actual Frame Error Ratio $FER = C_E / C_F$.

5) Calculate BER out of FER according to clause B.4.3.1.

Annex C (informative):
Guidance on declaring the environmental profile

C.1   Recommended environmental profile

The requirements of the present document should apply under the environmental profile for intended operation, either normal or extreme environmental conditions, which are recommended to be selected by the manufacturer in accordance with clause C.2 and clause C.3.

C.2   Normal environmental conditions

The normal temperature and humidity conditions for tests should be any convenient combination of temperature and relative humidity within the following ranges:

- temperature: +15 ℃ to +35 ℃;

- relative humidity: 20 % to 75 %.

C.3   Extreme environmental conditions

Extreme environmental conditions are classified in categories according to table C.1.

Table C.1: Extreme environmental conditions

Temperature category	RSU	OBU
Category I (General):	temperature: -20 °C to +55 °C	temperature: -20 °C to +55 °C
Category ll:	IEC 60721-3-4 [5] / 4K2	IEC 60721-3-5 [6] / 5K2
Category III:	IEC 60721-3-4 [5] / 4K3	IEC 60721-3-5 [6] / 5K3
Category IV:	IEC 60721-3-4 [5] / 4K4	IEC 60721-3-5 [6] / 5K4

The extreme environmental conditions for tests should be any convenient selection of environmental parameter values, except temperature, of a single category. For tests at extreme temperature, measurements should be made at both, the upper and lower temperature of the selected category.

Annex D (informative):
Bibliography

- Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations.

- ETSI EN 301 489: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services".

- ETSI EG 203 336: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guide for the selection of technical parameters for the production of Harmonised Standards covering article 3.1(b) and article 3.2 of Directive 2014/53/EU".

- ETSI EN 300 674-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band; Part 1: General characteristics and test methods for Road Side Units (RSU) and On-Board Units (OBU)".

- ETSI EN 300 674-2-2: "Transport and Traffic Telematics (TTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5 795 MHz to 5 815 MHz frequency band; Part 2: Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Sub-part 2: On-Board Units (OBU)".

Annex E (informative):
Change History

Version	Information about changes
2.1.1	First published version covering Directive 2014/53/EU [i.5]. Receiver blocking characteristics and receiver sensitivity have become essential requirements.

History

Document history				
V1.1.1	February 1999	Publication as ETSI EN 300 674		
V1.1.1	February 1999	Publication as ETSI ES 200 674-2		
V1.1.1	August 2004	Publication		
V2.0.2	January 2016	EN Approval Procedure	AP 20160427:	2016-01-28 to 2016-04-27
V2.1.0	July 2016	Vote	V 20160911:	2016-07-13 to 2016-09-12
V2.1.1	September 2016	Publication		