



**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 for access to radio spectrum;  
Sub-part 1: Road Side Units (RSU)**

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**Reference**REN/ERM-TG37-271

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# Foreword

This draft Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.4] 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.3].

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 complies with the Commission Implementing Decision (EU) 2019/1345 [i.1] and CEPT/ERC Recommendation 70-03 [i.2].

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 for access to radio spectrum";**

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

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

<b>Proposed national transposition dates</b>	
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Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
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## Modal verbs terminology

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

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# 1 Scope

The present document specifies technical characteristics and methods of measurements for Transport and Traffic Telematics (TTT) systems intended to be operated as Road Side Units (RSU) with the following characteristics:

- with a Radio Frequency (RF) connection and specified antenna or with an integral antenna;
- used for data transmission only;
- operating in the 5 795 MHz to 5 815 MHz frequency band (see also table 1).

NOTE: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU [i.3] is given in annex A.

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## 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.

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

- [1] EN 12253:2004: "Road transport and traffic telematics - Dedicated short-range communication - Physical layer using microwave at 5,8 GHz", (produced by CEN).
- [2] ISO 14906:2018/AMD 1:2020: "Electronic fee collection -- Application interface definition for dedicated short-range communication -- Amendment 1".
- [3] ETSI TS 103 052 (V1.1.1) (03-2011): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radiated measurement methods and general arrangements for test sites up to 100 GHz".

### 2.2 Informative 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.

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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] Commission Implementing Decision (EU) 2019/1345 of 2 August 2019 amending Decision 2006/771/EC updating harmonised technical conditions in the area of radio spectrum use for short-range devices.
- [i.2] CEPT/ERC Recommendation 70-03 (2020): "Relating to the use of Short Range Devices (SRD)".
- [i.3] 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.4] 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.
- [i.5] ETSI EG 203 336 (V1.2.1) (05-2020): "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".
- [i.6] CEPT/ERC Recommendation 74-01 (2019): "Unwanted emissions in the spurious domain".

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## 3 Definition of terms, symbols and abbreviations

### 3.1 Terms

For the purposes of the present document, the terms given in Directive 2014/53/EU [i.3] 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:** number of bits occurring per unit time, usually expressed in bits per second

**boresight:** direction of maximum radiation of a directional antenna

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

**carrier signal or carrier:** harmonic signal whose nominal single frequency  $f_{Tx}$  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 uplink or downlink channel in a frequency band of 5 MHz width

**cross-polar discrimination (XPD):** ratio  $P_{Rx,LHCP} / P_{Rx,RHCP}$  of power  $P_{Rx,LHCP}$  of the received left hand circular polarized wave to the power  $P_{Rx,RHCP}$  of the received right hand circular wave when the power of the transmitted waves  $P_{Tx,LHCP}$  is equal to  $P_{Tx,RHCP}$

**downlink:** transmission in direction from RSU to OBU

**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 bandwidth:** bandwidth equivalent to the bandwidth of a frequency selective power measurement

**equivalent isotropically radiated power (e.i.r.p.):** 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

**monochromatic signal:** sinusoidal signal with fixed frequency



**operating frequency:** nominal frequency at which equipment is operated

NOTE 1: Also referred to as the operating centre frequency.

NOTE 2: 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, excluding spurious emissions

**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 it may consist of several interconnected modules. It is powered by one or more internal batteries.

**radiated measurements:** measurements where the coupling to the EUT is obtained by radiation

**receive mode:** mode, in which the device receives a backscattered signal from an OBU while the device is transmitting at the same time an unmodulated carrier to the OBU

**Road Side Unit (RSU):** equipment that can communicate with an on board unit

**spurious emissions:** emissions on a frequency, or frequencies, which are outside an exclusion band of  $\pm 2,5$  times the channel spacing around the selected centre frequency  $f_{TX}$ , at a level 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.

**stand-by mode:** mode, in which the device may receive DSRC signals, but is never transmitting

**transmit mode:** mode, in which the device transmits a modulated carrier

**unwanted emissions:** spurious emissions and out-of-band emissions

**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
$ATN_{BLN}$	Attenuation of balun
$BER$	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
$D_i$	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
$\Delta f_{RSU}$	Relative frequency error of RSU
$\Delta P_{drl}$	Dynamic range limit
$f$	Frequency

$FER$	Frame error ratio
$f_{Rx}$	Nominal RSU receiver centre frequency
$f_{Rx\ hi}$	Highest operational RSU receiver centre frequency
$f_{Rx\ lo}$	Lowest operational RSU receiver centre 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
$G_{RSA}$	Gain of receiving substitution antenna
$G_{RTA}$	Gain of receiving test antenna
$G_{RTxA}$	Gain of RSU transmitting antenna
$\lg(.)$	Logarithm to the base ten
$m$	Modulation index
$N$	Total number of transmitted bits within a single frame
$P_{acsl}$	Receiver adjacent channel selectivity
$P_{bl}$	Receiver blocking capability
$P_{cochr}$	Co-channel rejection limit
$P_{CW}$	Power of CW signal
$P_{Rx,LHCP}$	Signal power of the received left hand circular polarized wave
$P_{Tx,LHCP}$	Signal power of the transmitted left hand circular polarized wave
$P_{max}$	Maximum receiver input power value for $BER \leq 10^{-6}$
$P_{min}$	Minimum receiver input power value for $BER \leq 10^{-6}$
$P_{mod}$	Power of modulated signal
$P_{Rx,RHCP}$	Signal power of the received right hand circular polarized wave
$P_{Tx,RHCP}$	Signal power of the transmitted right hand circular polarized wave
$P_{sens}$	Receiver sensitivity limit at the antenna connector of the receiver
$P_u$	Power level of received unwanted signal referred to a linear polarized antenna
$P_w$	Signal power of wanted signal
$RBW$	Resolution bandwidth
$RMS$	Root mean square
$V_{max}$	Amplitude of modulated output signal of RSU caused by data bit 1
$V_{min}$	Amplitude of modulated output signal of RSU caused by data bit 0
$\alpha$	Tilt angle of test antenna
$\lambda$	Wavelength

### 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in EN 12253 [1], clause 4 and the following apply:

AT1	Attenuator 1
AT2	Attenuator 2
BER	Bit Error Ratio
BST	Beacon Service Table
CC	Coaxial Circulator
CRC	Cyclic Redundancy Checking
CW	Continuous Wave
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
EFTA	European Free Trade Association
EUT	Equipment Under Test
FER	Frame Error Ratio

LHCP	Left Hand Circular Polarized
$M_{\text{centre}}$	Centre point between phase centres of TTA and RTA
MSS	Monochromatic Signal Source used to measure the antenna decoupling
MSS1	Monochromatic Signal Source 1 used for generating the unwanted signal
n.a.	not applicable
OBU	On Board Unit
ORxA	On Board Unit Receive Antenna
OTxA	On Board Unit Transmit Antenna
PE	Portable Equipment
PM	Power Meter
ppm	parts per million ( $10^{-6}$ )
RBW	Resolution BandWidth
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
SA	Spectrum Analyser
SR	Special Report
TM1	Test Message 1
TS1	Test Signal 1
TS2	Test Signal 2
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
XPD	Cross-Polar Discrimination

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## 4 Technical requirements specifications

### 4.1 Units

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

The antenna is always considered to be part of the EUT.

### 4.2 General characteristics

#### 4.2.1 RSU classes

For the Transmitter Spectrum Mask (TSM) there are three classes of RSU transmitters which are distinguished by the parameter D2 (point 4) "in band unwanted emissions with modulated carrier wave" of EN 12253 [1], clause 5.2, table 1.

Those TSM classes are called class A, class B and class C. Class A shall not be used.

To distinguish between RSUs built for different communication ranges, RSU receiver sensitivity classes are used. They are called class 1, class 2, class 3 and class 4, and they are specified in table 6.

Receiver sensitivity class 1 is applicable for equipment intended to communicate at a distance shorter than 1 m with a static OBU.

Receiver sensitivity class 2 is applicable for an RSU mounted at medium height, communicating with an OBU moving at medium speed.

Receiver sensitivity class 3 is applicable for an RSU mounted at heights above 5 m, communicating with an OBU at a minimum of 4 m distance along the road moving at medium and high speed.

Receiver sensitivity class 4 is applicable for an RSU mounted at heights above 5 m, communicating with an OBU at a minimum of 8 m distance along the road moving at high speed.

EXAMPLE 1: The receiver sensitivity class 1 is used in OBU programming stations.

EXAMPLE 2: The receiver sensitivity class 2 is used for access systems.

EXAMPLE 3: The receiver sensitivity classes 3 and 4 are used in tolling systems.

## 4.2.2 Carrier frequencies

The present document applies to RSUs operating in some or all of the channels detailed in table 1.

The centre frequencies  $f_{TX}$  indicated in table 1 are referred to as parameter D1 in EN 12253 [1], clause 5.2, table 1.

**Table 1: Frequency bands and centre frequencies  $f_{TX}$  allocated for DSRC**

	<b>Pan European Service Frequencies</b>	<b>National Service Frequencies</b>
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

NOTE: The corresponding receiver centre frequencies  $f_{RX}$  are equivalent to the transmitter carrier frequencies  $f_{TX}$ .

## 4.2.3 Modulation

The carrier of frequency  $f_{TX}$ , see table 1, shall be two level amplitude modulated with a modulation index  $m$  in the range from 0,5 to 0,9 as defined in EN 12253 [1], clause 5.2, table 1 (parameters D6 and D6a). The modulation index is defined in clause B.4 of annex B.

## 4.2.4 Antenna characteristic

All RSU antennas shall be LHCP with a cross-polar discrimination (XPD) larger or equal to 15 dB in boresight and larger or equal to 10 dB for a direction with 3 dB less antenna gain than in boresight, as defined in EN 12253 [1], clause 5.2, table 1 (parameters D5 and D5a).

## 4.3 Testing for compliance with technical requirements

### 4.3.1 Environmental conditions for testing

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use, which, as a minimum, shall be that specified in the test conditions contained in the present document.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions as specified in the present document to give confidence of compliance for the affected technical requirements.

## 4.3.2 Environmental test conditions

### 4.3.2.1 General

All the tests shall be performed in both normal and extreme test conditions unless otherwise specified.

### 4.3.2.2 Normal test conditions

Normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity, within the following ranges:

- temperature: +15 °C to +35 °C
- relative humidity: 20 % to 75 %

### 4.3.2.3 Extreme test conditions

For tests at extreme temperatures, measurements shall be made at the lower and upper temperatures of -20 °C and +55 °C.

Under extreme conditions the relative humidity is not applicable.

## 4.3.3 Power supply

The power supply for testing shall be able to provide the nominal supply voltage range under load as specified in the RSU manual. All characteristics and essential requirements applying to RSUs shall be fulfilled with such a power supply.

## 4.4 Conformance requirements

### 4.4.1 General requirements

For an RSU with a transmitter only, the transmitter requirements in clause 4.4.2 shall be applied.

For an RSU with a receiver only, the receiver requirements in clause 4.4.3 shall be applied.

For a combined RSU with a transmitter and a receiver, the transmitter requirements in clause 4.4.2 and the receiver requirements in clause 4.4.3 shall be applied.

### 4.4.2 Transmitter requirements

#### 4.4.2.1 Maximum equivalent isotropically radiated power

##### 4.4.2.1.1 Definition

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

The maximum e.i.r.p. is defined in EN 12253 [1], clause 5.2, table 1 (parameter D4).

##### 4.4.2.1.2 Limit

For the operation in transmit mode (modulated carrier) and receive mode (unmodulated carrier), the maximum e.i.r.p. shall not exceed the limit of 2 W.

##### 4.4.2.1.3 Conformance

The conformance test for the e.i.r.p. limit is specified in clause 5.2.1.1.

## 4.4.2.2 Transmitter frequency error

### 4.4.2.2.1 Definition

The relative frequency error  $\Delta f_{RSU}$  of the equipment is the difference between the frequency  $f_{Tx,actual}$  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 1 in relation to  $f_{Tx}$ :

$$\Delta f_{RSU} = \frac{f_{Tx,actual} - f_{Tx}}{f_{Tx}} \quad (1)$$

The maximum relative frequency error is defined in EN 12253 [1], clause 5.2, table 1 (parameter D1).

### 4.4.2.2.2 Limit

The absolute value of the relative frequency error,  $|\Delta f_{RSU}|$ , shall not exceed 5 ppm.

### 4.4.2.2.3 Conformance

The conformance test for the transmitter frequency error is specified in clause 5.2.1.2.

## 4.4.2.3 Transmitter spectrum mask

### 4.4.2.3.1 Definition

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

NOTE: This e.i.r.p. depends on the power level of the transmitter output signal and reaches its maximum when the radiated power level of this signal is set to its maximum.

The RSU TSM is defined in EN 12253 [1], clause 5.2, table 1 (parameter D2).

### 4.4.2.3.2 Limits

The limits for the TSM shall not exceed the values given in table 2. Those limits apply within an equivalent bandwidth as indicated in table 2.

Figure 1 to figure 3 show the essential frequency values from table 2 to be used for the conformance test marked with circles.

NOTE: The frequency values given in table 2 are the RSU receiver uplink frequencies and the adjacent channel uplink frequencies. To protect the OBU uplink reception from interference by simultaneous RSU transmissions in the adjacent channel, these e.i.r.p. limits are lower than the out of band emission limits.

**Table 2: RSU TSM e.i.r.p. upper limits**

Position	Frequencies	Unmodulated	Modulated		Equivalent Bandwidth
		All Classes	Class B	Class C	
Co-channel	$f_{Tx} \pm 1,5$ MHz	-27 dBm	-17 dBm	-27 dBm	500 kHz
Co-channel	$f_{Tx} \pm 2,0$ MHz	-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	-37 dBm	-47 dBm	500 kHz

NOTE: Class A is not used.

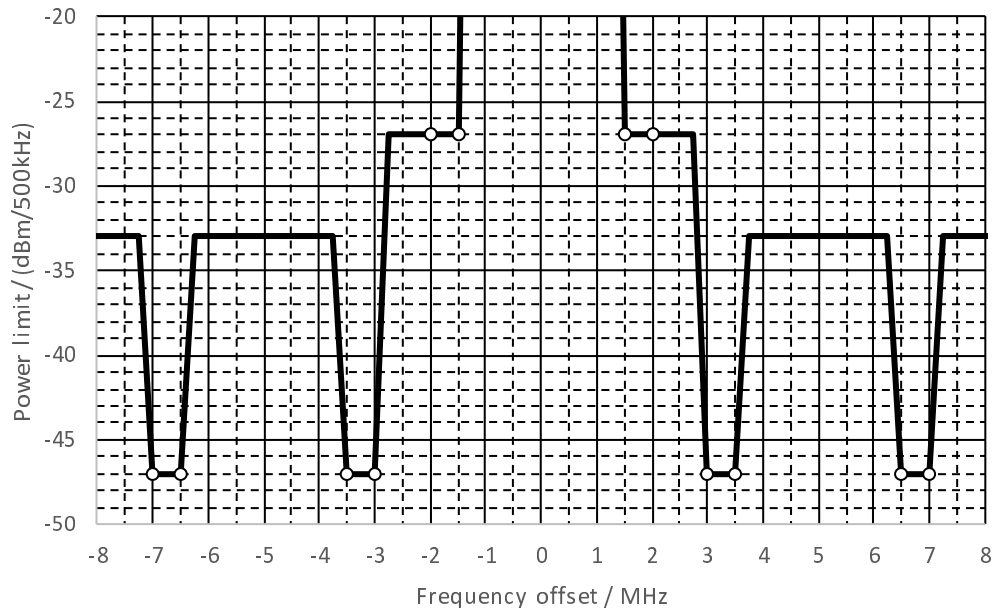


Figure 1: Transmitter spectrum mask for an unmodulated carrier independent of the TSM class

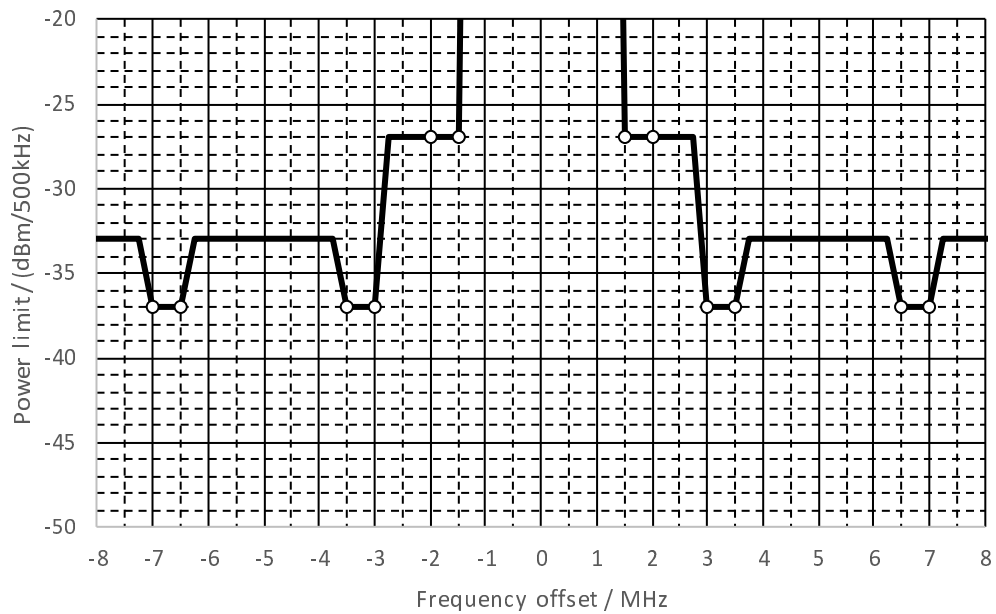
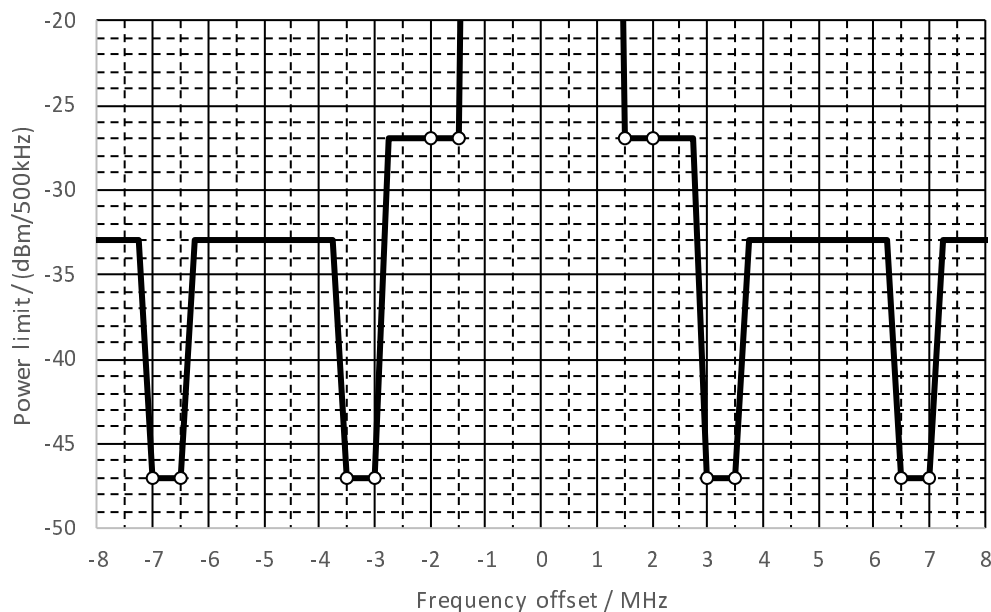


Figure 2: Transmitter spectrum mask for a modulated carrier and TSM class B



**Figure 3: Transmitter spectrum mask for a modulated carrier and TSM class C**

#### 4.4.2.3.3 Conformance

The conformance test for the transmitter spectrum mask is specified in clause 5.2.1.3.

#### 4.4.2.4 Transmitter unwanted emissions

##### 4.4.2.4.1 Definition

Unwanted emissions, i.e. spurious and out-of-band emission, are any signal transmitted by the RSU outside of the frequency band in which the equipment is intended to operate.

The spurious and out-of-band domain starts outside an exclusion band of  $\pm 2,5$  times the DSRC channel spacing of 5 MHz, i.e.  $\pm 12,5$  MHz around the RSU carrier frequency  $f_{Tx}$  under test.

##### 4.4.2.4.2 Limits

The e.i.r.p. of any unwanted emission shall not exceed the limits specified in table 3 for units with an operating transmitter (see also clause 4.1), i.e. the RSU is not in "stand-by" mode and a signal is transmitted (e.g. the RSU is operating in transmit mode or receive mode).

**Table 3: Limits of unwanted emissions for transmitters**

Mode	Frequency bands	Limits	Reference bandwidth	Type of emission
Operating	87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 694 MHz	-54 dBm	100 kHz	Spurious and out-of-band emissions
	Other frequencies $\geq 30$ MHz and $\leq 1$ GHz	-36 dBm	100 kHz	
	Frequencies $> 1$ GHz and $\leq 26$ GHz outside the exclusion band	-30 dBm	1 MHz	

NOTE: These values are taken from CEPT/ERC Recommendation 74-01 [i.6] annex 2, table 6.

#### 4.4.2.4.3 Conformance

The conformance test for the transmitter unwanted emissions is specified in clause 5.2.1.4.



## 4.4.3 Receiver requirements

### 4.4.3.1 Receiver unwanted emissions

#### 4.4.3.1.1 Definition

Unwanted emissions, i.e. spurious and out-of-band emission, are any signal transmitted by the RSU outside of the frequency band in which the equipment is intended to operate.

The spurious and out-of-band domain starts outside an exclusion band of  $\pm 2,5$  times the DSRC channel spacing of 5 MHz, i.e.  $\pm 12,5$  MHz around the RSU carrier frequency  $f_{Tx}$  under test.

#### 4.4.3.1.2 Limits

The e.i.r.p. of any unwanted emission of receiver only units (see clause 4.1) shall not exceed the limits presented in table 4. For units including a transmitter supporting a stand-by mode, the limits in table 4 shall also apply for operation in this stand-by mode.

**Table 4: Limits of unwanted emissions for receivers**

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

NOTE: These values are taken from CEPT/ERC Recommendation 74-01 [i.6], annex 2, table 6.

#### 4.4.3.1.3 Conformance

The conformance test for the receiver unwanted emissions is specified in clause 5.2.2.1.

### 4.4.3.2 Receiver selectivity

#### 4.4.3.2.1 Receiver blocking

##### 4.4.3.2.1.1 Definition

The blocking capability is defined by the power level  $P_{bl}$  of an unwanted unmodulated signal at the receiver input with a frequency  $f_u$  of at least 2,5 MHz above or below the DSRC band at which a wanted modulated signal can be received without exceeding a given degradation.

NOTE: The DSRC band is specified in table 1.

For proper operation, the bandwidth of the receive filter is always less than 1 000 MHz. Therefore, the most critical blocking frequency range is  $\pm 500$  MHz around the receiver centre frequency  $f_{Rx}$ . Therefore, only frequencies  $\pm 500$  MHz around the receiver centre frequency  $f_{Rx}$  shall be tested.

##### 4.4.3.2.1.2 Limits

The blocking capability shall be at least  $P_{bl} = -30$  dBm at the receiver input referred to a linear polarized loss-less isotropic antenna.

The degradation limit is given by the maximum allowed BER of  $2,0 \times 10^{-2}$  for a wanted LHCP DSRC signal power level  $P_w$  of 6 dB above the sensitivity limit  $P_{sens}$  that corresponds to the RSU receiver sensitivity class as specified in table 6 ( $P_w = P_{sens} + 6$  dB).

#### 4.4.3.2.1.3 Conformance

The conformance test for the receiver blocking is specified in clause 5.2.2.2.2.

#### 4.4.3.2.2 Receiver adjacent channel selectivity

##### 4.4.3.2.2.1 Definition

The adjacent channel selectivity is a measure of the capability of the RSU receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted unmodulated signal differing in frequency by an amount equal to the DSRC channel separation of  $\pm 5$  MHz.

The adjacent channel selectivity is the power level of the unwanted signal at the receiver input referred to a linear polarized loss-less isotropic antenna at which the degradation limit is achieved.

##### 4.4.3.2.2.2 Limit

The adjacent channel selectivity shall be at least  $P_{acsl} = -30$  dBm.

The degradation limit is given by the maximum allowed BER of  $2,0 \times 10^{-2}$  at a wanted DSRC signal power level  $P_w$  of 6 dB above the sensitivity limit  $P_{sens}$  that corresponds to the RSU receiver sensitivity class as listed in table 6 ( $P_w = P_{sens} + 6$  dB).

##### 4.4.3.2.2.3 Conformance

The conformance test for the receiver adjacent channel selectivity is specified in clause 5.2.2.2.3.

#### 4.4.3.2.3 Receiver co-channel rejection

##### 4.4.3.2.3.1 Definition

The receiver co-channel rejection is a measure of the capability of the RSU receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted unmodulated signal, using the same sub-carrier frequency as the uplink signal from the OBU.

The receiver co-channel rejection limit  $P_{cocr}$  is defined as the difference of the received signal power levels of the wanted and unwanted signals measured in dB referred to a linear polarized antenna ( $P_{cocr} = P_w - P_u$ ) at which the degradation limit is achieved.

##### 4.4.3.2.3.2 Limits

The degradation limit is defined by the maximum allowed BER of  $2,0 \times 10^{-2}$  for a wanted DSRC signal power level  $P_w$  of 6 dB above the sensitivity limit  $P_{sens}$  that corresponds to the RSU receiver sensitivity class as listed in table 6 ( $P_w = P_{sens} + 6$  dB).

For receiver sensitivity class 2, class 3 and class 4 the receiver co-channel rejection  $P_{cocr}$  at which the degradation limit shall be achieved is specified in table 5.

RSUs with receiver sensitivity class 1 use a near field communication link that is shielded under operation. Due to transmit power restrictions for potential interferers given by frequency regulators, co-channel interference for RSUs with receiver sensitivity class 1 is not applicable.

**Table 5: RSU co-channel rejection (receiver sensitivity class 2, class 3, class 4 only)**

RSU receiver sensitivity class	co-channel rejection limit $P_{\text{cccr}}$ (dB) for $\text{BER} \leq 2 \times 10^{-2}$
Class 2	6
Class 3	6
Class 4	6

#### 4.4.3.2.3.3 Conformance

The conformance test execution for the receiver co-channel rejection is specified in clause 5.2.2.2.4.

### 4.4.3.3 Receiver dynamic range and sensitivity

#### 4.4.3.3.1 Receiver sensitivity

##### 4.4.3.3.1.1 Definition

The RSU sensitivity is the minimum received signal power level  $P_{\text{min}}$  at the Rx antenna connector that allows the RSU to receive DSRC frames with a given maximum BER.

##### 4.4.3.3.1.2 Limits

For a signal power level at the antenna connector of the receiver that is equal to the sensitivity limit  $P_{\text{sens}}$  the BER shall be less than or equal to  $10^{-6}$ . The sensitivity limit  $P_{\text{sens}}$  is specified in table 6 for the RSU receiver sensitivity classes defined in clause 4.2.1.

**Table 6: RSU sensitivity limits for a BER of  $10^{-6}$** 

RSU receiver sensitivity class	Sensitivity limit $P_{\text{sens}}$ (dBm)
Class 1	-50
Class 2	-84
Class 3	-94
Class 4	-104

##### 4.4.3.3.1.3 Conformance

The conformance test execution for the receiver sensitivity is specified in clause 5.2.2.3.

#### 4.4.3.3.2 Receiver dynamic range

##### 4.4.3.3.2.1 Definition

The receiver dynamic range is the ratio between the maximum received signal power level  $P_{\text{max}}$  at the antenna connector and the receiver sensitivity limit  $P_{\text{sens}}$  as specified in clause 4.4.3.3.1.2 that allows the RSU to receive DSRC frames with a given maximum BER.

##### 4.4.3.3.2.2 Limits

For a signal power level at the antenna connector of the receiver, measured in dB, that is equal to  $P_{\text{sens}} + \Delta P_{\text{drl}}$  the BER shall be less than or equal to  $10^{-6}$ . Where the sensitivity limit  $P_{\text{sens}}$  is specified in clause 4.4.3.3.1.2 and the minimum dynamic range  $\Delta P_{\text{drl}}$  is specified in table 7 for the RSU receiver sensitivity classes defined in clause 4.2.1.

**Table 7: RSU dynamic range limits**

RSU receiver sensitivity class	minimum dynamic range $\Delta P_{\text{drl}}$ (dB)
Class 1	10
Class 2	44
Class 3	54
Class 4	54

#### 4.4.3.3.2.3 Conformance

The conformance test execution for the receiver dynamic range is specified in clause 5.2.2.3.

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## 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 operational environmental profile defined by its intended use, which, as a minimum, shall be that specified in the test conditions contained in the present document.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions as specified in the present document to give confidence of compliance for the affected technical requirements.

### 5.2 Radio test suites

#### 5.2.1 Transmitter parameter tests

##### 5.2.1.1 Maximum equivalent isotropically radiated power

This clause specifies the measurement procedure for the determination of the maximum e.i.r.p. of the RSU for all carrier frequencies  $f_{\text{Tx}}$  with and without modulation of the RSU Tx signal.

For outdoor equipment, the maximum e.i.r.p. measurement shall be performed under normal temperature conditions as specified in clause 4.3.2.2 and at the upper and the lower limit of the extreme temperature range as specified in clause 4.3.2.3. Indoor equipment shall be tested under normal temperature conditions only, as specified in clause 4.3.2.2.

General conditions for testing shall be as described in clause B.1 of annex B.

If the EUT has no integral antenna, measurements shall be performed in a test setup where the coupling to the EUT is obtained via cables, using the test setup as specified in clause B.2.2. Clause B.2 of annex B specifies further prerequisites of such conducted measurements.

If the EUT has an integral antenna, measurements shall be performed in a test setup where the coupling to the EUT is obtained by radiation in an anechoic chamber (as detailed in clause B.1.4 of annex B), using the test setup as specified in clause B.3.2. Clause B.3 of annex B specifies the prerequisites, methods, and the test setup to perform such a radiated e.i.r.p. test.

The transmit power level of the RSU shall be set to its maximum possible operational value, and the supply voltage shall be set to the upper limit of the supply voltage range, when performing the e.i.r.p. measurement.

The measurement shall be performed with all RSU transmit centre frequencies  $f_{\text{Tx}}$  supported by the RSU under test in accordance with clause 4.2.2.

All measurements shall be performed with both, an unmodulated RSU carrier signal and a modulated carrier, using test signal TS1 (as detailed in clause B.1.3 of annex B) with a modulation index  $m$  set to the maximum possible operational value. Details of the modulation index are defined in clause B.4 of annex B.

The maximum e.i.r.p. level ( $EIRP_{max}$ ) at the transmit antenna RTxA shall be determined from all measured power levels  $P_{CW}$  of the unmodulated carrier and all measured power levels  $P_{mod}$  of the modulated carrier (see also figure B.10), taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.

The conformance limit for  $EIRP_{max}$  shall be as provided in clause 4.4.2.1.2.

### 5.2.1.2 Transmitter frequency error

This clause specifies the measurement procedure for the determination of the transmitter frequency error of the RSU for all supported carrier frequencies  $f_{Tx}$ .

For outdoor equipment, the transmitter frequency error measurement shall be performed under normal temperature conditions as specified in clause 4.3.2.2 and at the upper and the lower limit of the extreme temperature range as specified in clause 4.3.2.3. Indoor equipment shall be tested under normal temperature conditions only, as specified in clause 4.3.2.2.

General conditions for testing shall be as described in clause B.1 of annex B.

If the EUT has no integral antenna, measurements shall be performed in a test setup where the coupling to the EUT is obtained via cables, using the test setup as specified in clause B.2.2. Clause B.2 of annex B specifies further prerequisites of such conducted measurements.

If the EUT has an integral antenna, measurements shall be performed in a test setup where the coupling to the EUT is obtained by radiation in an anechoic chamber (as detailed in clause B.1.4 of annex B), using the test setup as specified in clause B.3.2. Clause B.3 of annex B specifies the prerequisites, methods, and the test setup to perform such a radiated measurements.

The transmit power level of the RSU shall be set to its maximum possible operational value when performing the measurement.

The transmitter frequency measurement shall be performed with an unmodulated RSU carrier, using the frequency counter capability of the SA for all RSU transmit centre frequencies  $f_{Tx}$  supported by the RSU under test in accordance with clause 4.2.2 and for the supply voltage set to the upper and lower limit of the supply voltage range.

NOTE: See clause B.1.7 of annex B for the required SA capabilities.

The absolute value of the frequency error  $\Delta f_{RSU}$  shall be calculated according to equation (2).

$$|\Delta f_{RSU}| = \frac{|f_{Tx,actual} - f_{Tx}|}{f_{Tx}} \times 10^6 \text{ ppm} \quad (2)$$

Where the measured transmitter frequency is  $f_{Tx,actual}$  and the configured transmitter frequency is  $f_{Tx}$ .

The conformance limit for  $|\Delta f_{RSU}|$  shall be as provided in clause 4.4.2.2.2.

### 5.2.1.3 Transmitter spectrum mask

This clause specifies the measurement procedure for the determination of the transmitter spectrum mask (TSM) of the RSU for all supported carrier frequencies  $f_{Tx}$ .

For outdoor equipment, the measurement shall be performed under normal temperature conditions as specified in clause 4.3.2.2 and at the upper and the lower limit of the extreme temperature range as specified in clause 4.3.2.3. Indoor equipment shall be tested under normal temperature conditions only, as specified in clause 4.3.2.2.

General conditions for testing shall be as described in clause B.1 of annex B.

If the EUT has no integral antenna, measurements shall be performed in a test setup where the coupling to the EUT is obtained via cables, using the test setup as specified in clause B.2.2. Clause B.2 of annex B specifies further prerequisites of such conducted measurements.

If the EUT has an integral antenna, measurements shall be performed in a test setup where the coupling to the EUT is obtained by radiation in an anechoic chamber (as detailed in clause B.1.4 of annex B), using the test setup as specified in clause B.3.2. Clause B.3 of annex B specifies the prerequisites, methods, and the test setup to perform such radiated tests.

The transmit power level of the RSU shall be set to its maximum possible operational value, and the supply voltage shall be set to the nominal value, when performing the measurement.

The measurement shall be performed with all RSU transmit centre frequencies  $f_{Tx}$  supported by the RSU under test in accordance with clause 4.2.2.

All measurements shall be performed with both, an unmodulated RSU carrier signal and a modulated carrier, using test signal TS1 (as detailed in clause B.1.3 of annex B) with a modulation index  $m$  set to the maximum possible operational value. Details of the modulation index are defined in clause B.4 of annex B.

The TSM at the transmit antenna RTxA shall be determined with the channel power measurement capability of the SA, by setting the SA RBW to 100 kHz, the SA channel bandwidth to 500 kHz, and the SA channel centre frequency to the frequencies specified in table 2, taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.

NOTE: See clause B.1.7 of annex B for the required SA capabilities.

The conformance limits for the TSM shall be as provided in clause 4.4.2.3.2.

#### 5.2.1.4 Transmitter unwanted emissions

This clause specifies the measurement procedure for the determination of the RSU transmitter unwanted emissions.

The Tx unwanted emission measurement shall be performed under normal temperature conditions as specified in clause 4.3.2.2.

General conditions for testing shall be as described in clause B.1 of annex B.

The measurement shall be performed in a test setup where the coupling to the EUT is obtained by radiation in an anechoic chamber (as detailed in clause B.1.4 of annex B), using the test setup as shown in figure 4. Clause B.3 of annex B specifies the prerequisites and methods to perform such radiated tests.

The transmit power level of the RSU shall be set to its maximum possible operational value and the supply voltage shall be set to the nominal value when performing the measurement.

All measurements shall be performed with both, an unmodulated RSU carrier signal and a modulated carrier, using test signal TS1 (as detailed in clause B.1.3 of annex B) with a modulation index  $m$  set to the maximum possible operational value. Details of the modulation index are defined in clause B.4 of annex B.

The unwanted emission measurement for all frequency bands listed in table 3 shall be performed with all RSU transmit centre frequencies  $f_{Tx}$  supported by the RSU under test in accordance with clause 4.2.2.

For the measurement, the RBW of the SA shall be set to the same value as the reference bandwidth in table 3 that corresponds to the frequency band under test.

All measurements shall be done for horizontal and vertical RTA polarization.

Set the SA to max hold mode. Move the turntable clockwise at a speed of 5 degree per second for a full turn and record the maximum obtained unwanted emission.

Set the SA in max hold mode. Move the turntable to each angular position from MT0 to MT7. At each of these angular positions record the maximum obtained unwanted emission.

Compare the maximum power level obtained by the max hold function of the SA with the transmitter unwanted emissions limit provided in clause 4.4.2.4.2 that corresponds to the frequency band under test.

The maximum power level for the transmitter unwanted emissions shall not exceed the limit as provided in clause 4.4.2.4.2.

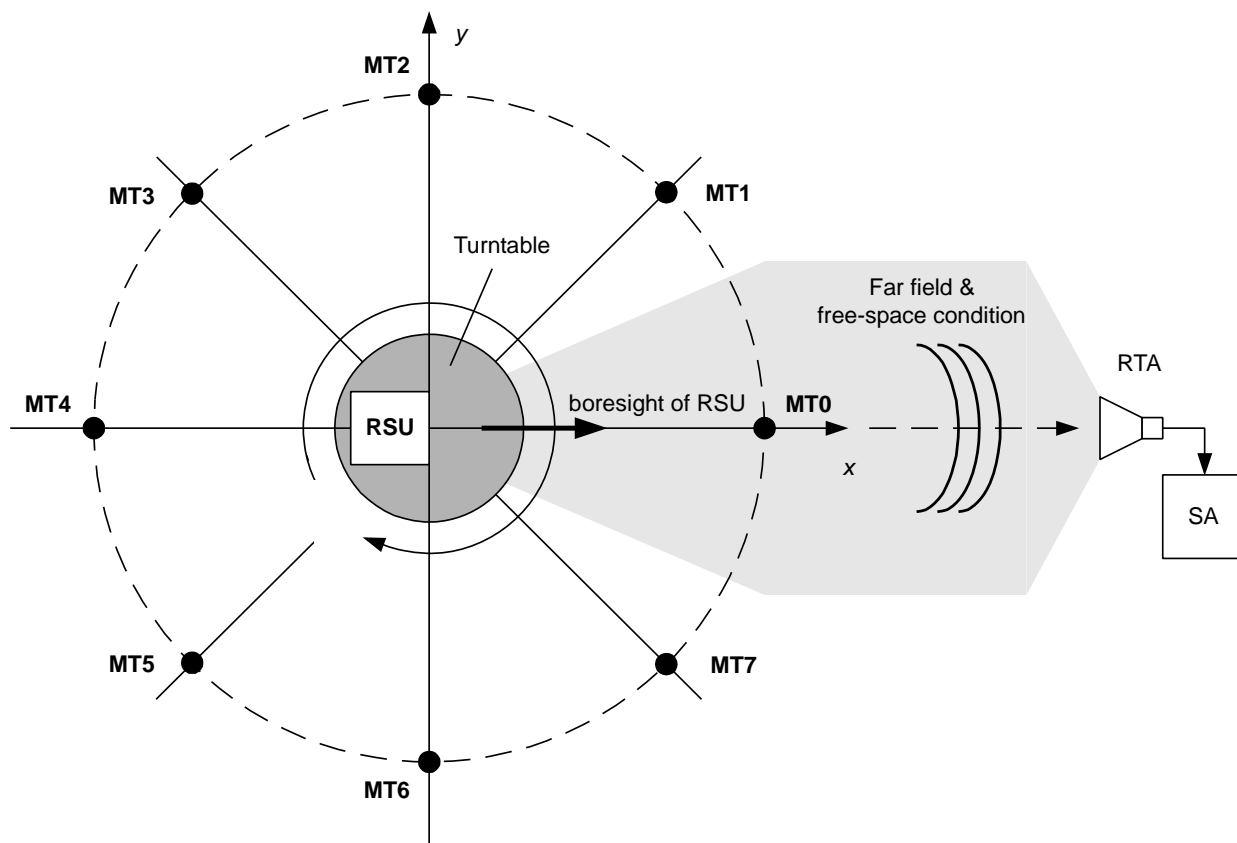


Figure 4: Test set up for RSU unwanted emission measurements (top view)

## 5.2.2 Receiver parameter tests

### 5.2.2.1 Receiver unwanted emissions in the spurious domain

This clause specifies the measurement procedure for the determination of the RSU receiver unwanted emissions for receiver only units (see clause 4.1) and for units with a transmitter in "stand-by mode".

The Rx unwanted emission measurement shall be performed under normal temperature conditions as specified in clause 4.3.2.2.

The supply voltage of the EUT shall be set to the nominal value.

General conditions for testing shall be as described in clause B.1 of annex B.

The unwanted emission measurement for all frequency bands listed in table 4 shall be performed with all RSU receive centre frequencies  $f_{RX}$  supported by the EUT in accordance with clause 4.2.2.

For the measurement, the RBW of the SA shall be set to the same value as the reference bandwidth in table 4 that corresponds to the frequency band under test.

The measurement procedure, the measurement setup and the evaluation of the test results shall be the same as specified for the transmitter unwanted emissions in clause 5.2.1.4.

The conformance limits for the receiver unwanted emissions shall be as provided in clause 4.4.3.1.2.

## 5.2.2.2 Receiver selectivity

### 5.2.2.2.1 General Requirements and prerequisites for testing

This clause specifies the preparation and common requirements for the conformity test of different receiver selectivity parameters.

The receiver selectivity tests shall be performed under normal temperature conditions as specified in clause 4.3.2.2.

The receiver selectivity tests shall be performed in a test setup where the coupling to the EUT is obtained by radiation in an anechoic chamber (as detailed in clause B.1.4 of annex B), using an appropriate test setup as specified in clause B.3.3 of annex B. Clause B.3 of annex B specifies the prerequisites and methods to perform such radiated tests.

General conditions for testing shall be as described in clause B.1 of annex B.

The supply voltage of the EUT shall be set to the nominal value.

The modulation index of the RSU transmission shall be set to the value specified in the RSU handbook for normal operation of the RSU.

The receiver centre frequencies  $f_{RX}$  for the selectivity tests are given by the operating frequency range of the RSU receiver as described in clause 4.2.2. The tests shall be performed for the lowest operational receiver centre frequency  $f_{RX\ lo}$  and for the highest operational receiver centre frequency  $f_{RX\ hi}$ .

All receiver selectivity tests shall be performed with the RSU receiver and the OBU transmitter tuned to the lower subcarrier frequency  $f_s = 1,5$  MHz and with both of them tuned to the upper subcarrier frequency  $f_s = 2,0$  MHz.

For reliable message reception by the OBU, adjust AT2 such, that the average incident signal power level at the OBU receiver (OBU Rx) equals -25 dBm in all tests, taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2. Report the setting of AT2 together with the frequency  $f_{TX}$ .

Adjust for each receiver centre frequency  $f_{RX}$  and for each subcarrier frequency  $f_s$  AT1 such, that the wanted incident uplink signal power level  $P_w$  at the RSU receiver connector equals the RSU receiver sensitivity limit  $P_{sens}$  plus 6 dB ( $P_w = P_{sens} + 6$  dB), taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.  $P_{sens}$  is specified in table 6 corresponding to the receiver sensitivity class. Report the setting of AT1 together with the frequencies  $f_s$  and  $f_{TX}$ .

The unwanted signal generated by the MSS1 to test the RSU receiver selectivity shall be an unmodulated carrier.

### 5.2.2.2.2 Receiver blocking test execution

This clause specifies the test procedure for the determination of the conformity of the RSU receiver blocking capabilities.

General Requirements and prerequisites for the receiver blocking test are specified in clause 5.2.2.2.1.

All frequency combinations of  $f_{RX}$  (receiver centre frequencies) and  $f_u$  (unwanted frequencies) specified in table 8 shall be used for testing the receiver blocking.

The frequencies  $f_u$  and  $f_{RX}$  used for testing shall be recorded in the test report.

For the receiver blocking conformance test, set the output power level of the MSS1 such that the unwanted signal with frequency  $f_u$  at the EUT receiver RF input, referred to a linear polarized loss-less isotropic antenna, results in the blocking capability  $P_u = P_{bl} = -30$  dBm (specified in clause 4.4.3.2.1.2), taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.

Measure the BER of the RSU receiver as specified in clause B.5 of annex B.

The obtained BER shall not exceed the degradation limit specified in clause 4.4.3.2.1.2.



**Table 8: Frequencies of the unwanted signal  $f_u$  for testing the receiver blocking**

#	1	2	3	4	5	6	7	8
$f_{Rx} (= f_{Tx})$	$f_{Rx lo}$	$f_{Rx lo}$	$f_{Rx lo}$	$f_{Rx lo}$	$f_{Rx hi}$	$f_{Rx hi}$	$f_{Rx hi}$	$f_{Rx hi}$
$f_u - f_{Rx}$	-500 MHz	-100 MHz	-50 MHz	-20 MHz	+20 MHz	+50 MHz	+100 MHz	+500 MHz
NOTE:	The definition of $f_{Rx lo}$ and $f_{Rx hi}$ is given in clause 5.2.2.2.1.							

NOTE: The blocking test for 2,5 MHz above and below the used frequency range is equivalent to the adjacent channel selectivity tests for the upper and lower operating channels as specified in clause 5.2.2.2.3. Therefore, these frequencies are omitted in table 8.

#### 5.2.2.2.3 Receiver adjacent channel selectivity test execution

This clause specifies the test procedure for the determination of the conformity of the RSU receiver adjacent channel selectivity.

General Requirements and prerequisites for the receiver adjacent channel selectivity test are specified in clause 5.2.2.2.1.

All frequency combinations of  $f_{Rx}$  (receiver centre frequencies) and  $f_u$  (unwanted frequencies) as specified in table 9 shall be used for testing the receiver adjacent channel selectivity.

The frequencies  $f_u$  and  $f_{Rx}$  for testing shall be recorded in the test report.

For the receiver adjacent channel selectivity conformance test, set the output power level of the MSS1 such that the unwanted signal with frequency  $f_u$  at the EUT receiver RF input, referred to a linear polarized loss-less isotropic antenna, results to the adjacent channel selectivity  $P_u = P_{acsl} = -30$  dBm (specified in clause 4.4.3.2.2.2), taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.

Measure the BER of the RSU receiver as specified in clause B.5 of annex B.

The obtained BER shall not exceed the degradation limit specified in clause 4.4.3.2.2.2.

**Table 9: Frequencies of the unwanted signal for testing the receiver adjacent channel selectivity**

#	1	2	3	4
$f_{Rx} (= f_{Tx})$	$f_{Rx lo}$	$f_{Rx lo}$	$f_{Rx hi}$	$f_{Rx hi}$
$f_u$	$f_{Rx lo} - 5$ MHz	$f_{Rx lo} + 5$ MHz	$f_{Rx hi} - 5$ MHz	$f_{Rx hi} + 5$ MHz
NOTE:	The definition of $f_{Rx lo}$ and $f_{Rx hi}$ is given in clause 5.2.2.2.1.			

#### 5.2.2.2.4 Receiver co-channel rejection test execution

This clause specifies the test procedure for the determination of the conformity of the RSU receiver co-channel rejection.

This test is not applicable for EUTs with receiver sensitivity class 1.

General Requirements and prerequisites for the receiver co-channel rejection test are specified in clause 5.2.2.2.1.

All frequency combinations of  $f_{Rx}$  (receiver centre frequencies) and  $f_u$  (unwanted frequencies) as specified in table 10 shall be used for testing the receiver co-channel rejection.

The frequencies  $f_u$  and  $f_{Rx}$  for testing shall be documented in the test report.

For the receiver co-channel rejection conformance test, set the output power level of the MSS1 such that the unwanted signal with frequency  $f_u$  at the EUT receiver RF input, referred to a linear polarized loss-less isotropic antenna, results in the sensitivity limit  $P_{sens}$  from table 6 plus 6 dB minus the co-channel rejection limit  $P_{cocr}$  from table 5  $P_u = P_{sens} + 6$  dB -  $P_{cocr}$ , taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.

NOTE:  $P_{\text{ccr}}$  is specified in clause 4.4.3.2.3.2 and  $P_{\text{sens}}$  is specified in clause 4.4.3.3.1.2.

Measure the BER of the RSU receiver as specified in clause B.5 of annex B.

The obtained BER shall not exceed the degradation limit specified in clause 4.4.3.2.3.2.

**Table 10: Frequencies of the unwanted signal for testing the receiver co-channel rejection**

#	1	2	3	4
$f_{\text{RX}} (= f_{\text{TX}})$	$f_{\text{RX lo}}$	$f_{\text{RX lo}}$	$f_{\text{RX hi}}$	$f_{\text{RX hi}}$
$f_{\text{u}}$	$f_{\text{RX lo}} + f_{\text{s}}$	$f_{\text{RX lo}} - f_{\text{s}}$	$f_{\text{RX hi}} + f_{\text{s}}$	$f_{\text{RX hi}} - f_{\text{s}}$
NOTE 1: The definition of $f_{\text{RX lo}}$ and $f_{\text{RX hi}}$ is given in clause 5.2.2.2.1.				
NOTE 2: $f_{\text{s}}$ is the subcarrier frequency the RSU receiver is tuned to as given in clause 5.2.2.2.1.				

### 5.2.2.3 Receiver dynamic range and sensitivity test execution

This clause specifies the conformance test execution for the receiver dynamic range and the receiver sensitivity.

The test shall be performed under normal temperature conditions as specified in clause 4.3.2.2.

The test shall be performed in a test setup where the coupling to the EUT is obtained by radiation in an anechoic chamber (as detailed in clause B.1.4 of annex B), using an appropriate test setup as specified in clause B.3.3 of annex B. Clause B.3 of annex B specifies the prerequisites and methods to perform such radiated tests.

General conditions for testing shall be as described in clause B.1 of annex B.

For the dynamic range and sensitivity test set the modulation index of the RSU transmission to the value specified in the RSU handbook for normal operation of the RSU.

The receiver centre frequencies  $f_{\text{RX}}$  for the receiver dynamic range and sensitivity tests are given by the operating frequency range of the RSU receiver as described in clause 4.2.2. The tests shall be performed for the lowest operational receiver centre frequency  $f_{\text{RX lo}}$  and for the highest operational receiver centre frequency  $f_{\text{RX hi}}$ .

All tests shall be performed with the RSU receiver and the OBU transmitter tuned to the lower subcarrier frequency  $f_{\text{s}} = 1,5$  MHz and with both of them tuned to the upper subcarrier frequency  $f_{\text{s}} = 2,0$  MHz.

All tests shall be performed with the supply voltage of the EUT set to the upper limit and to the lower limit of the supply voltage range.

For reliable message reception by the OBU, adjust AT2 such, that the average incident signal power level at the OBU receiver (OBU Rx) equals -25 dBm in all tests, taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2. Report the setting of AT2 together with the frequency  $f_{\text{TX}}$ .

Conformance test of the receiver sensitivity:

- 1) For the receiver sensitivity evaluation adjust AT1 such, that the power level at the EUT Rx antenna connector equals the sensitivity limit  $P_{\text{sens}}$  that corresponds to the RSU receiver sensitivity class as listed in table 6, taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.
- 2) Determine the BER of the RSU receiver as specified in clause B.5 of annex B.
- 3) The obtained BER shall not exceed the degradation limit specified in clause 4.4.3.3.1.2.

Conformance test of the receiver dynamic range:

- 1) For the receiver dynamic range evaluation adjust AT1 such, that the power level at the EUT Rx antenna connector equals the sensitivity limit  $P_{\text{sens}}$  plus the dynamic range limit  $\Delta P_{\text{drl}}$  measured in dB that corresponds to the RSU receiver sensitivity class as listed in table 7 (i.e.  $P_{\text{sens}} + \Delta P_{\text{drl}}$ ), taking into account the overall attenuation determined by the substitution measurement described in clause B.3.1.2.

- 2) Determine the BER of the RSU receiver as specified in clause B.5 of annex B.
- 3) The obtained BER shall not exceed the degradation limit specified in clause 4.4.3.3.2.2.

## Annex A (informative): 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.4] 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.3].

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					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Maximum equivalent isotropically radiated power	3.2	4.4.2.1	C	RSU has a transmitter, see clause 4.1
2	Transmitter frequency error	3.2	4.4.2.2	C	RSU has a transmitter
3	Transmitter spectrum mask	3.2	4.4.2.3	C	RSU has a transmitter
4	Transmitter unwanted emissions	3.2	4.4.2.4	C	RSU has a transmitter
5	Receiver unwanted emissions	3.2	4.4.3.1	C	RSU has a receiver, see clause 4.1
6	Receiver blocking	3.2	4.4.3.2.1	C	RSU has a receiver
7	Receiver adjacent channel selectivity	3.2	4.4.3.2.2	C	RSU has a receiver
8	Receiver sensitivity	3.2	4.4.3.3.1	C	RSU has a receiver
9	Receiver dynamic range	3.2	4.4.3.3.2	C	RSU has a receiver
10	Receiver co-channel rejection	3.2	4.4.3.2.3	C	RSU has a receiver (sensitivity class 2, class 3, and class 4 only)

### 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.

#### Essential requirements of Directive

Identification of article(s) defining the requirement in the Directive.

#### Clause(s) of the present document

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 is unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

**Condition** Explains the conditions when the requirement is or is not 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.

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## Annex B (normative): General condition for testing and test setup

### B.1 General conditions

#### B.1.1 Power source

When not battery operated, the equipment shall be powered by a test power source during all tests. This power source shall be capable of producing test voltages as required for proper operation of the RSU under test.

For battery operated non portable equipment the battery shall be removed when possible, and an external test power source shall be used instead. For radiated measurements, any external power leads shall be arranged in such a way that their influence on the electromagnetic field in the anechoic chamber is so small that the influence on any RF power measurement specified in the present document is less than 1 dB. In case the batteries cannot be removed, internal batteries with the required voltage for proper operation of the RSU and of the recommended type shall be used. Battery type, manufacturer, and battery voltage shall be recorded in the test report.

For radiated measurements on portable equipment, fully charged internal batteries shall be used. The batteries used shall be as required for proper operation of the RSU under test. Battery type, manufacturer, and battery voltage shall be recorded in the test report.

During the tests the external test power source voltages shall not change by more than  $\pm 1$  % relative to the voltage at the beginning of each test.

If internal batteries are used, the battery voltage at the end of each test shall not change by more than  $\pm 5$  % relative to the voltage at the beginning of each test.

NOTE: All RSUs have an internal regulated power supply. Therefore, changes of the supply voltage by not more than  $\pm 5$  % can be tolerated without performance degradation.

The internal impedance of the external test power source shall be low enough so that a voltage change of not more than  $\pm 1$  % relative to the voltage at the beginning of each test can be guaranteed for the whole test duration.

For the purpose of the tests, the voltage of the external test power source shall be measured at the power supply 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.

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

The thermal balance shall be checked by temperature measurements. When the equipment temperature is not changing more than 1 K per minute thermal balance is reached.

To avoid condensation, the relative humidity in the test chamber shall be less than 50 %, and the temperature of the equipment shall be at least 1 K higher than the air temperature in the test chamber.

### B.1.3 Test signals

The following test signals and test messages are defined.

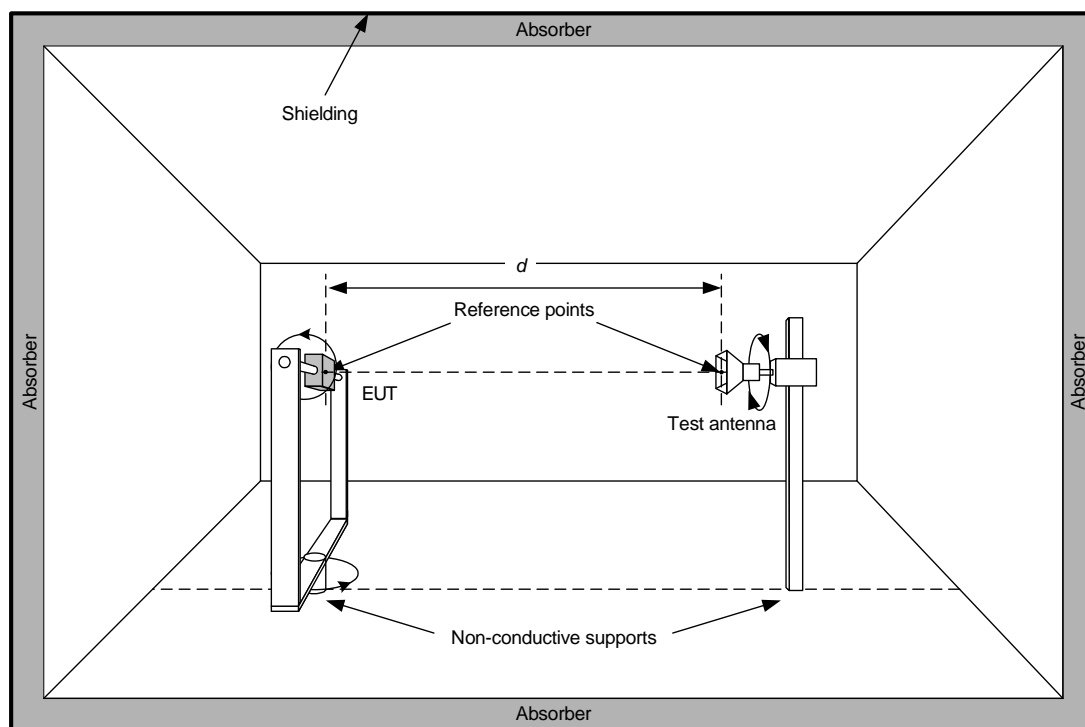
**Table B.1: Test signals and messages**

Test signal/message	Description
Test Messages (TM1)	DSRC communication sequence starting with an initialization phase conform to ISO 14906 [2], clause 6.2 followed by successive ECHO commands conform to ISO 14906 [2], clause 7.2.17.
Test Signal (TS1)	Properly modulated and coded DSRC downlink 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 EN 12253 [1] table 1 and table 2, respectively.

### B.1.4 Shielded anechoic chamber

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

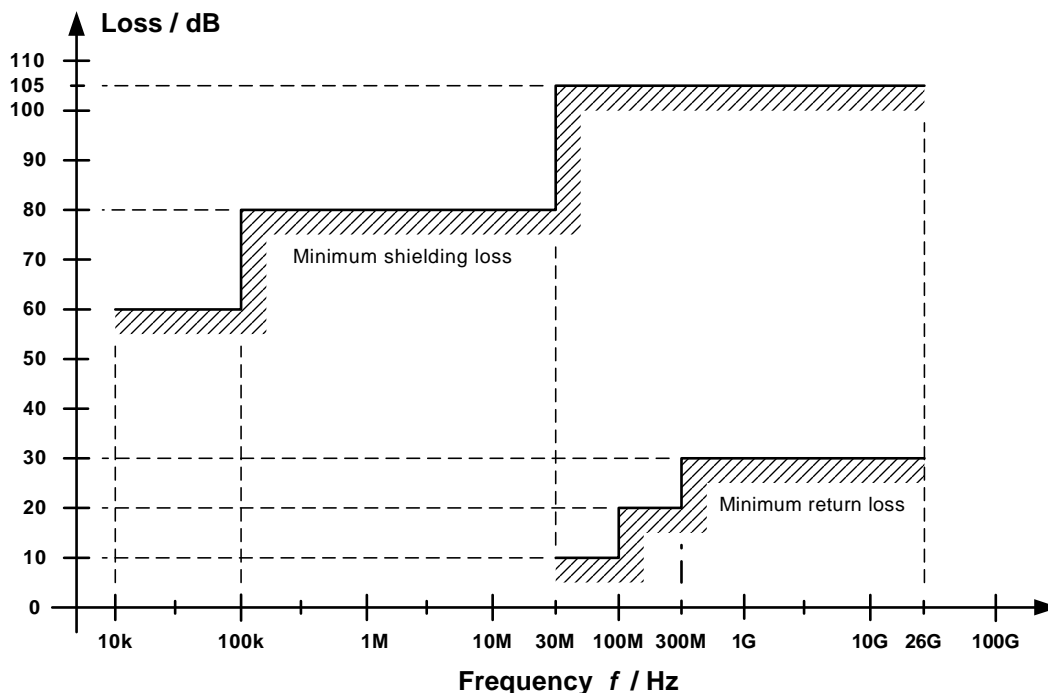


**Figure B.1: Typical anechoic chamber**

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 for the frequency range of the mandatory tests specified in the present document as detailed in figure B.2 shall be met by anechoic chambers used to perform these tests.



**Figure B.2: Minimal shielding (perpendicular to the wall) and return loss for shielded anechoic chambers**

Further details of shielded anechoic chambers are specified in clause 5.2.1.1 of ETSI TS 103 052 [3].

## B.1.5 RF cables

All RF cables including their connectors at both ends used within the measurement arrangements and set ups shall be of coaxial type with the following properties within the frequency range of operation:

- a nominal characteristic impedance of 50  $\Omega$ ;
- a VSWR of less than 1,2 at either of their ends;
- a shielding loss in excess of 60 dB.

All RF cables shall be routed behind RF shielding material, so that they are not directly exposed to any radiation coming from the EUT or a TTA. The requirements for the shielding material are specified in figure B.2.

Further details for RF cables are specified in clause 6.10 of ETSI TS 103 052 [3].

## B.1.6 Splitter

All RF splitters used within the measurement arrangements and set ups shall provide coaxial connectors at all ports with the following properties within the frequency range of operation:

- a nominal characteristic impedance of 50  $\Omega$  at each port;
- a VSWR of less than 1,5 at each port;
- an isolation between the output ports of at least 10 dB.



## B.1.7 Spectrum analyser

The Spectrum Analyser (SA) used for testing shall have following capabilities:

- 1) It shall support an RBW of 100 kHz in the frequency range from 87,5 MHz to 1 000 MHz and an RBW of 1 MHz in the frequency range from 1 GHz to 26 GHz.
- 2) It shall be capable to measure frequencies.
- 3) It shall be capable to perform a channel power measurement with a channel bandwidth of 500 kHz and an RBW of 100 kHz.

The SA settings shall be as follows:

- 1) The RMS detector shall be used.
- 2) The Video Bandwidth (VBW) shall be set to auto mode.
- 3) When not specified differently in the test description, all signal power level measurements shall be performed in averaging mode. The sweep duration shall be set to auto mode, so that the RMS detector can perform a correct root mean square evaluation.

## B.2 Conducted measurements

### B.2.1 Test site requirements

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

### B.2.2 Test arrangement for conducted Tx parameter measurements

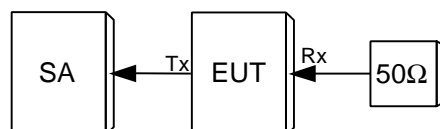
Figure B.3 shows the test setup for conducted Tx parameter measurements for an RSU with separated Rx and Tx antenna connectors.

Figure B.4 shows the test setup for conducted Tx parameter measurements for an RSU with one combined Rx/Tx antenna connector.

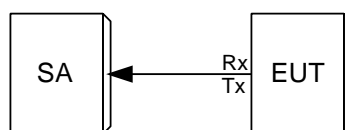
The channel power measurement capabilities of the SA shall be used to measure the transmit power level within a channel bandwidth of 5 MHz.

The frequency measurement capability of the SA shall be used to measure the carrier frequency.

Further requirements on the SA to be used for testing are specified in clause B.1.7.



**Figure B.3: Measurement arrangement for conducted Tx parameter measurements for an EUT with separated Rx and Tx connectors**



**Figure B.4: Measurement arrangement for conducted Tx parameter measurements for an EUT with a combined Rx and Tx connector**

## B.3 Radiated measurements

### B.3.1 Test site requirements

#### B.3.1.1 Measurement distances

Within a shielded anechoic chamber the measurement distance or range length  $d$  depicted in figure B.5 and in the figures in clause B.3.3 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 meet to the most stringent criteria given in equation (B.1) to equation (B.3):

$$d > \frac{2 \times (D_{0,TA} + D_{0,EUT})^2}{\lambda}, \quad (\text{B.1})$$

$$d > 5 \times (D_{0,TA} + D_{0,EUT}) \text{ and} \quad (\text{B.2})$$

$$d > 2 \times \lambda, \quad (\text{B.3})$$

where  $D_{0,TA}$ ,  $D_{0,EUT}$  and  $\lambda$  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 the aperture of the test antenna TA; and
- the centre of the aperture of the EUT antenna if the EUT antenna is known, or the volume centre of the EUT if details about its antennas are unknown.

#### B.3.1.2 Substitution method

An RF measurement setup in an anechoic chamber includes a lot of components such as cables, combiners, amplifiers, antennas and radio propagation paths. All these components together will cause a significant systematic measurement uncertainty, even when the properties of each component are known up to a certain accuracy. This is because the uncertainties of all component properties sum up. On top of this, the mismatch between components having not exactly the same wave impedance will introduce an additional measurement uncertainty not covered by the properties of all single components.

In measurement technology and metrology (science of measurements), the comparison of a measurement value delivered by an EUT with that of a device with known properties and accuracy is called calibration, and the known device is called calibration standard.

By performing a substitution measurement, the systematic measurement uncertainty introduced by the properties of the test setup can be determined with the accuracy given by the measurement device and the calibration standard, independent of the number of components within the whole test setup.

The substitution measurement shall be as follows:

- The test environment for a given measurement is prepared (test setup).
- The EUT is replaced with a device with known properties (the "calibration standard").
- The overall attenuation and related measurement uncertainty caused by the test setup is determined.

**EXAMPLE 1:** To calibrate the receiver chain of the test setup, an antenna with known properties is placed at the same position, with its main lobe pointing in the same direction, as the Tx antenna of the EUT. This substitution antenna is connected to a signal generator with known frequency and output power level. Hence, the output power level at the substitution antenna is known. By measuring the signal power level that is received through the receiver chain from the substitution antenna, the complete loss of the receiver chain can be calculated. This calibration is done for all frequencies intended to be used. In case there are nonlinear components in the test setup e.g. amplifiers, the loss also depends on the power levels. Therefore, in this case the calibration is also done with different transmit power levels.

**EXAMPLE 2:** To calibrate the transmit chain of the test setup, an antenna with known properties is placed at the same position, with its main lobe pointing in the same direction, as the Rx antenna of the EUT (see figure B.9). This substitution antenna is connected to a power measurement device. Hence, the received power level at the substitution antenna can be measured. By measuring the signal power level that is received by the substitution antenna, the complete loss of the transmit chain of the test setup can be calculated. This calibration is done for all frequencies intended to be used. In case there are nonlinear components in the test setup e.g. amplifiers, the loss also depends on the power levels. Therefore, in this case the calibration is also done with different transmit power levels.

For radiated measurements, the substitution antenna shall be as described in clause B.3.1.3.

### B.3.1.3 Test and substitution antennas

Test antennas are used to detect the radiation from the EUT or to transmit a signal towards the EUT as shown in all figures in clause B.3.3 and in figure B.5, while substitution antennas together with signal generators or power meters are used to replace the EUT and its antenna in substitution measurements as shown in figure B.9.

The test or substitution antenna shall be as specified in the test procedure of the respective EUT parameter. Cross-polarized test or substitution antennas shall have an XPD > 25 dB in boresight within their specified frequency range.

Directional test or substitution antennas shall be used. However, the antenna dimensions which are linked to the directivity  $D_i$  relative to an isotropic radiator shall be according to clause B.3.1.1.

If the symmetry of the test antenna or substitution antenna does not match the one of its feeding cables, a symmetry matching circuit (balun) shall be inserted between the antenna output and the input of its feeding RF cable. In the present document this balun is treated as integral part of the antenna. Its attenuation  $ATN_{BLN}$  shall be taken as reduction of the antenna gain into account.

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

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

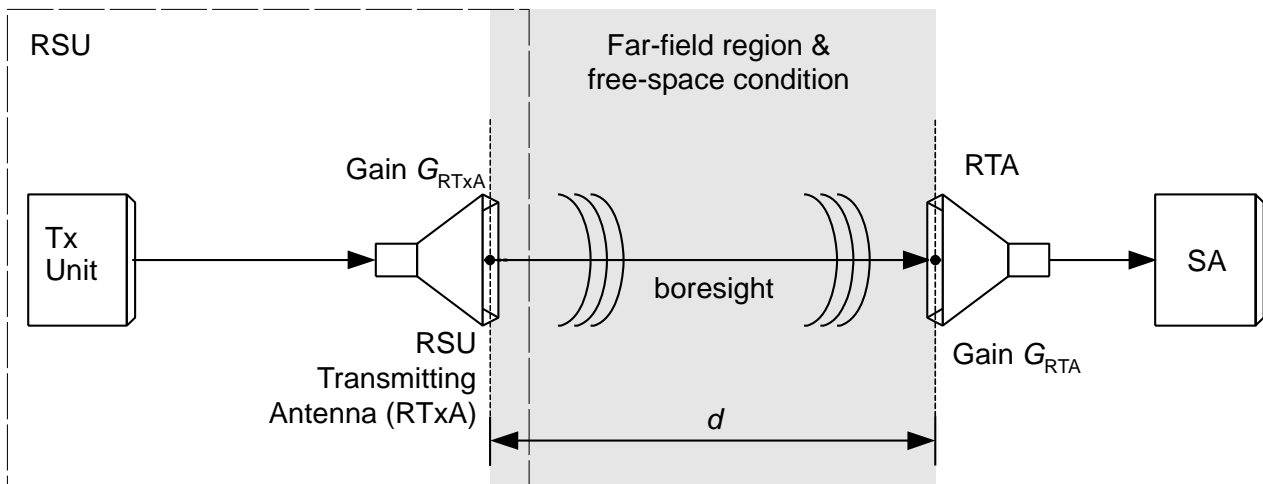
## B.3.2 Test arrangement for the radiated measurement of the transmit parameters

Figure B.5 details the arrangement used for the Tx parameter measurement.

The channel power measurement capabilities of the SA shall be used to measure the transmit power level within a channel bandwidth of 5 MHz.

The frequency measurement capability of the SA shall be used to measure the carrier frequency.

Further requirements on the SA to be used for testing are specified in clause B.1.7.



**Figure B.5: RSU transmit parameter measurement arrangement**

- 1) The LHCP RTxA shall be mounted on a vertical pole at one end of a 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 as specified in clause B.3.1.3 shall be suited for the range of carrier frequencies  $f_{Tx}$  as specified in 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 specified otherwise in the test procedure.
- 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, as specified in clause B.3.1.1.
- 4) The phase centres of the RTxA and the RTA shall be at the same height above floor.
- 5) The boresight of the RTA shall point towards the phase centre of the RTxA. The boresight of the RTxA shall point towards the phase centre of the RTA.
- 6) Connect the RSU transmitter to the RTxA.
- 7) Connect the RTA to the SA.

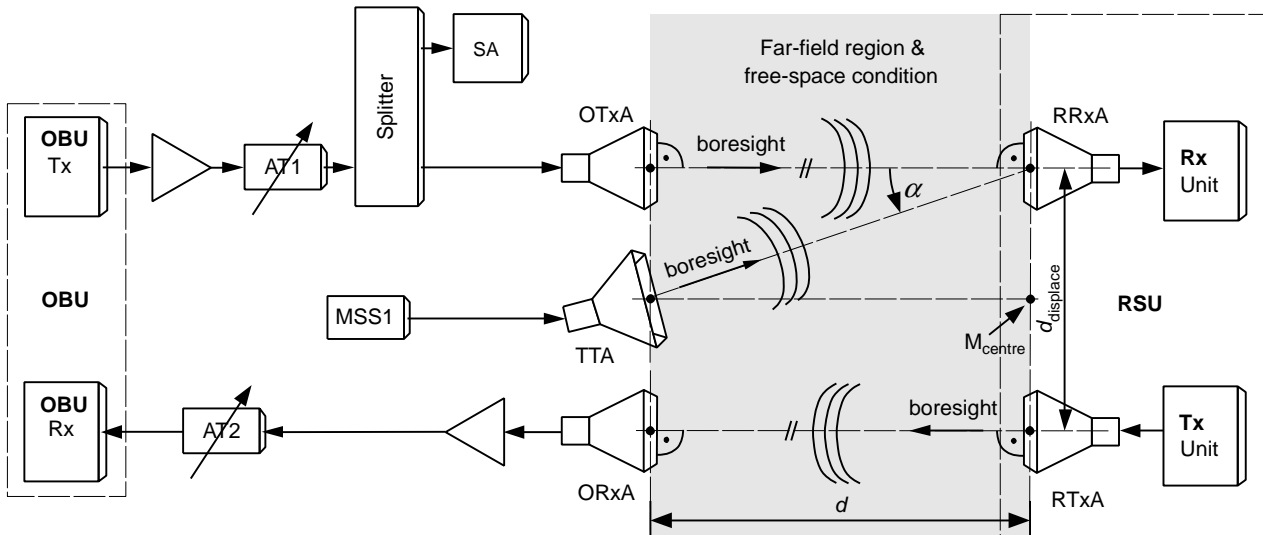
### B.3.3 Arrangement for radiated measurements of the receiver parameters

The antenna configurations of an RSU can be implemented in three ways:

- 1) External antennas with separated Rx and Tx units / connectors (see figure B.6).
- 2) External antennas with a combined Rx and Tx unit / connector (see figure B.7).
- 3) Integral antenna and no external antenna connector (see figure B.8).

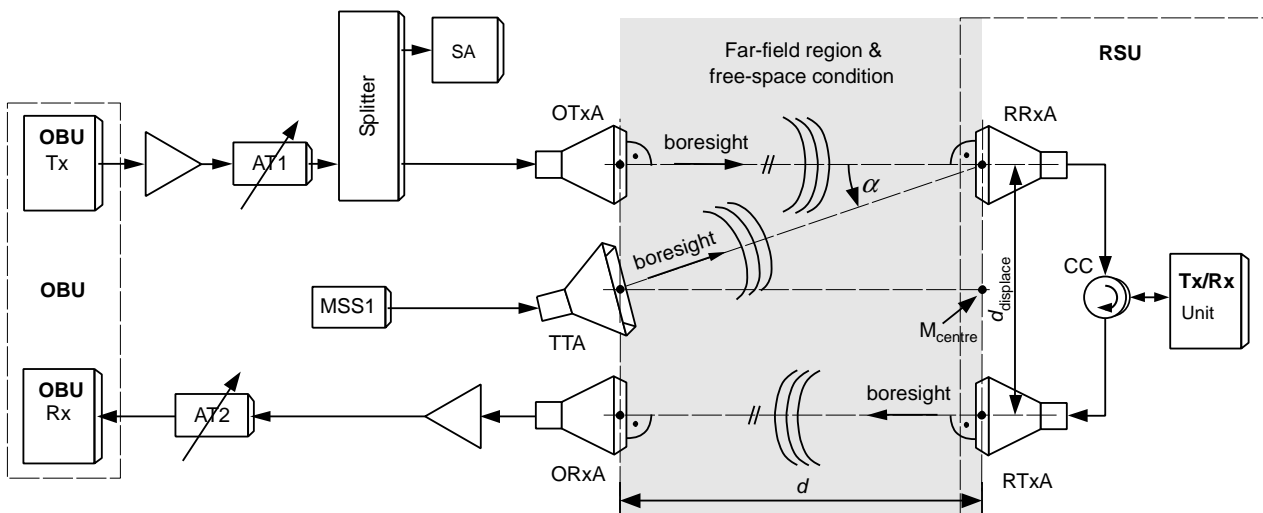
Depending on these three antenna configurations the measurement arrangements shown in figure B.6 to figure B.8 shall be used for measuring the receiver parameters dynamic range, sensitivity, and selectivity.

Figure B.6 applies only for an RSU with separate antenna connectors for the receive and transmit path.



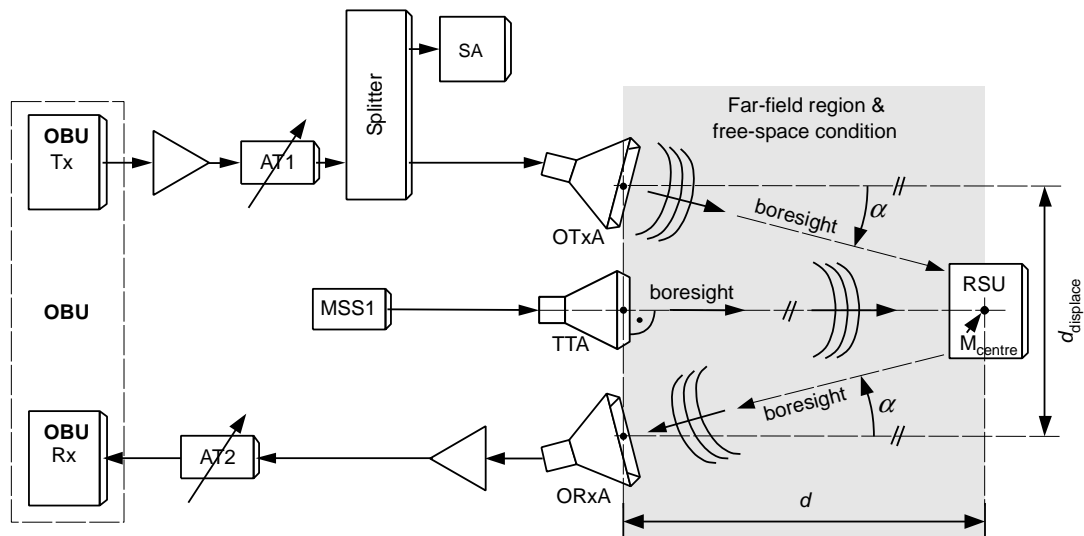
**Figure B.6: RSU receive parameter measurement arrangement for an EUT with separated Rx and Tx units / connectors**

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 as shown in figure B.7.



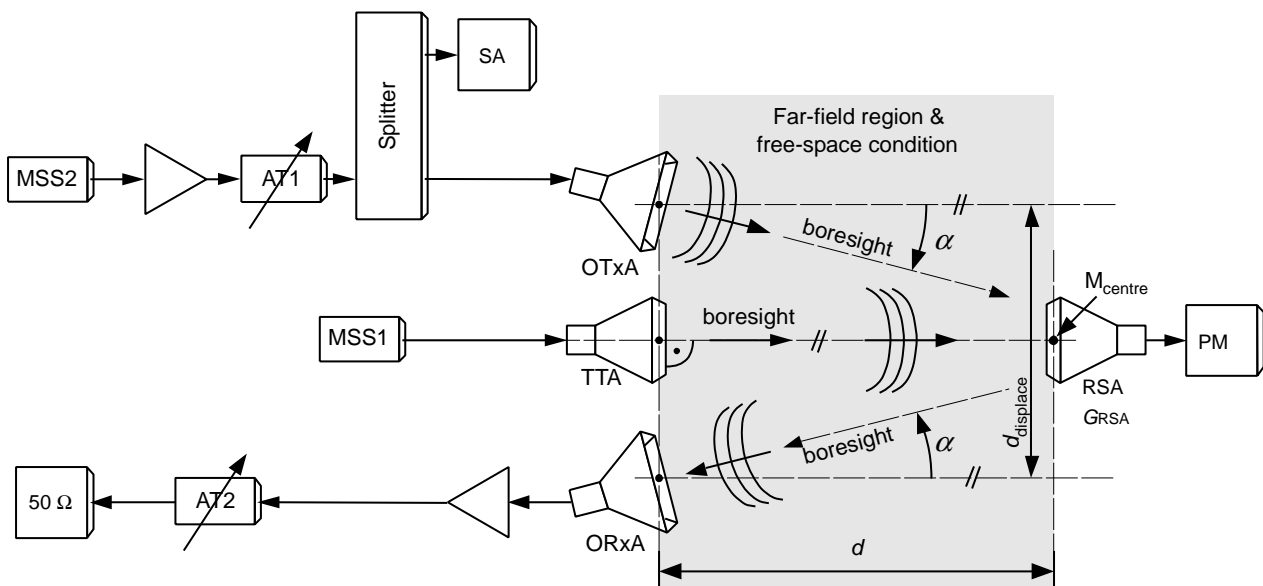
**Figure B.7: RSU receive parameter measurement arrangement with CC for an EUT with a combined Rx and Tx unit / connector**

In case the RSU under test has integral transmit and receive antennas the test setup as shown in figure B.8 shall be used.



**Figure B.8: RSU receive parameter measurement arrangement for RSUs with integral antennas**

Figure B.9 shows the test setup to perform a substitution measurement for determining the relation between the SA measurement result and the power level at the EUT, and the relation between the MSS1 power level and the power level of the unwanted signal at the EUT.



**Figure B.9: Substitution measurement for calibration of the receiver parameter measurements**

Following points specify the applicable measurement arrangement shown in figure B.6 to figure B.9:

- 1) The RTxA shall be mounted on a vertical pole at one end of a 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 at the same end as the RTxA 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  $d_{\text{displace}}$ . The position between both phase centres is denoted  $M_{\text{centre}}$ .

- 4) The displacement distance  $d_{\text{displace}}$  shall be such as to minimize the coupling between RTxA and RRxA:
  - The distance  $d_{\text{displace}}$  shall be such that the coupling loss between RTxA and RRxA exceeds 30 dB for all RSU transmit frequencies used in the test.
  - In addition, the coupling loss between TTA and ORxA shall be at least 10 dB higher than the coupling loss between the OTxA and the RRxA for all MSS1 transmit frequencies used in the test.
  - These coupling losses shall be determined as specified in clause B.3.4.
  - The measured coupling losses and the distance  $d_{\text{displace}}$  shall be recorded 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 boresight points towards  $M_{\text{centre}}$ .
- 6) The height of the phase centres above floor of the RTxA, RRxA and the OBU antenna shall be equal.
- 7) Boresight of the RTxA shall point towards the phase centre of the ORxA.
- 8) Boresight of the RRxA shall point towards the phase centre of the OTxA.
- 9) The OBU antenna(s) shall be mutually in the far field of RTxA and RRxA, as specified in clause B.3.1.1.
- 10) The TTA and the RSA shall be vertically polarized.

### B.3.4 Antenna decoupling loss

To evaluate the decoupling between two antennas, the signal attenuation between the connectors of these antennas is measured. For this measurement an MSS is connected to the Tx antenna to provide a known measurement signal, and a RD is connected to the Rx antenna to measure the received power level.

The following substitution measurement shall be used to determine the decoupling between the antennas:

- 1) Connect the MSS to the connector of the Tx antenna, and the RD to the connector of the Rx antenna.
- 2) Set the MSS frequency to the decoupling measurement frequency.
- 3) Set the MSS power level such that the power level measured at the RD is more than 10 dB above the noise level of the RD and record the measured power level.
- 4) Connect the RD directly to the MSS, measure the output power level of the MSS, and record the measured power level.
- 5) The coupling loss is the difference between the power levels measured in step 4 and step 3.
- 6) Repeat the steps for all relevant and specified decoupling measurement frequencies.

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## B.4 RSU carrier modulation

Figure B.10 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  $P_{\text{mod}}$ , and  $P_{\text{CW}}$ , respectively, of the modulated, and unmodulated signal parts are equal. The condition of equal power  $P_{\text{mod}} = P_{\text{CW}}$  is not required by the present document.

The modulation index is given by  $m = \frac{V_{\text{max}} - V_{\text{min}}}{V_{\text{max}} + V_{\text{min}}}$ .

NOTE: Figure B.10 does not allow extracting valid timing relations between carrier frequency and bit rate.

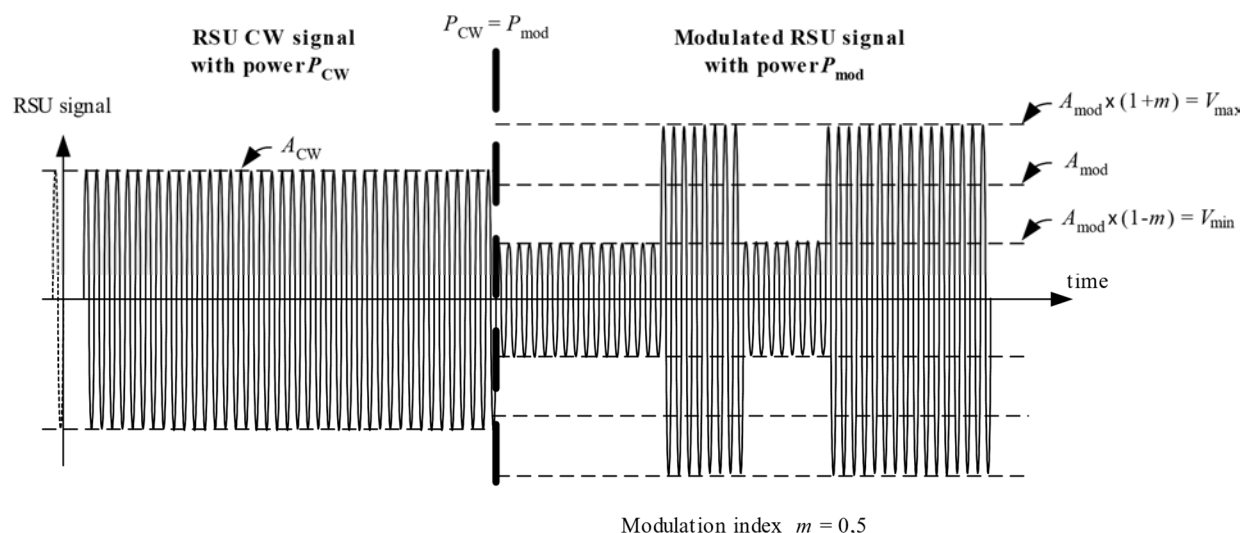


Figure B.10: RSU transmit signal

## B.5 Bit error ratio measurements

### B.5.1 Basics

The required Bit Error Ratio (BER) for communication is defined in EN 12253 [1], clause 5.2, table 1 (parameters D9 and U9).

BER measurements shall be conducted in an indirect way.

This indirect way is based on generating and receiving frames of limited length where a bit error 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 Frame Error Ratio (FER), allows to estimate the BER assuming that bit errors are equally distributed.

### B.5.2 BER measurement

BER shall be measured indirectly based on a FER measurement, as specified in clause B.5.3.

### B.5.3 FER measurement

#### B.5.3.1 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:

$$FER = 1 - (1 - BER)^N, \quad (B.4)$$

$$BER = 1 - 10^{\frac{\lg(1-FER)}{N}} = 1 - \sqrt[N]{1 - FER}. \quad (B.5)$$

The frame count  $C_F$  together with the frame size in bits per frame shall be reported. From this the total number of bits  $N$  can be calculated.

**EXAMPLE 1:** With  $BER = 10^{-6}$  and a frame length  $N = 1\,000$ , the equivalent  $FER$  results 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  $BER = 2,0 \times 10^{-2}$  and a frame length of  $N = 1\ 000$ , a reasonable number  $C_F$  of frames to be transmitted is 100 000, i.e. 10 frames may be error-free on average. Only with the very large number of frames to be transmitted it is possible to estimate the BER, otherwise a small variation in the number of erroneous frames changes the corresponding BER estimation significantly. To overcome this problem the frame length  $N$  should be made shorter.

### B.5.3.2 Equipment

FER measurements shall be conducted using the set of test messages TM1 with the following software configuration:

- DSRC communication sequence starting with an initialization phase conforms to ISO 14906 [2], clause 6.2 followed by successive ECHO commands that conform to ISO 14906 [2], clause 7.2.17.
- An erroneous ECHO.response received does not result in a retransmission of the related ECHO.request as normally required by the DSRC protocol but will lead to an increment of the frame error counter.

### B.5.3.3 Procedure

- 1) The RSU shall perform initialization with the OBU by exchanging BST and VST. The signal level at the RSU receiver input relevant for BER measurement shall be set to the level required for the test. The signal level at the OBU receiver input shall be -25 dBm, such that the extrapolated BER of the received messages is lower than  $10^{-8}$ .

In the unexpected case of transmission errors, the initialization attempt shall be repeated. During initialization any additional interfering signal as requested by a specific test procedure shall be switched off.

NOTE 1: In this setup the bit errors of OBU and RSU receiver sum up. The BER of the OBU receiver adds a systematic measurement uncertainty to the measured RSU BER. Therefore, the BER at the OBU receiver should be at least two magnitudes below the BER of the measured RSU receiver to keep the measurement deviation below 1 %.

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

NOTE 2: See clause B.5.3.1 for a reasonable frame count number  $C_F$ .

- 4) Calculate  $BER$  out of  $FER$  with equation (B.5) in clause B.5.3.1.

## Annex C (informative): Maximum Measurement Uncertainty

The measurements described in the present document are based on the following assumptions:

- the measured value related to the corresponding limit is 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 is included in the test report.

Table C.1 shows the recommended values for the maximum measurement uncertainty figures.

**Table C.1: Maximum measurement uncertainty**

Parameter	Uncertainty
RF power (conducted)	±1,5 dB
RF frequency, relative	±1 × 10 <sup>-7</sup>
Radiated emission of transmitter, valid to 40 GHz	±6 dB
Adjacent channel power	±5 dB
Sensitivity	±3 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 %

## Annex D (informative): Checklist

This annex provides in table D.1 a traceability of the technical parameters for article 3.2 of Directive 2014/53/EU [i.3] defined in ETSI EG 203 336 [i.5] with the technical requirements for conformance defined in clause 4 of the present document. If a technical parameter for article 3.2 of Directive 2014/53/EU [i.3] defined in ETSI EG 203 336 [i.5] has not been included in the present document, an explanation is provided. An explanation is also provided whenever a technical parameter defined in ETSI EG 203 336 [i.5] is covered by an alternative technical requirement.

**Table D.1: Checklist**

Technical Parameters defined in ETSI EG 203 336 [i.5]	Clauses of the present document	Comments
<b>Transmitter Parameters</b>		
Transmit power limits and accuracy	4.4.2.1	
Transmitter Spectrum mask	4.4.2.3	
Transmitter frequency stability	4.4.2.2	
Transmitter Intermodulation attenuation	n.a.	An interfering signal entering the transmitter via its antenna cannot cause any intermodulation, since due to frequency regulations the power level of any interfering signal will always be very low. Moreover, the equipment at one radio site uses directional antennas pointing into directions away from each other and therefore the transmitted signal from one RSU cannot enter the transmitter of another RSU directly via its antenna. Therefore, the probability of an external signal entering the antenna and causing intermodulation during the transmission is very low and therefore no degradation of the radio service is possible.
Transmitter unwanted emissions (OoB and spurious domains)	4.4.2.4	
Transmitter Time domain characteristics (e.g. the duty cycle, turn-on and turn-off, frequency hopping cycle, dynamic changes of modulation scheme and others)	n.a.	Time domain characteristics are not relevant because the transmitter is always switched on, also during receive mode. The transmitter does not use frequency hopping and does not change the modulation type.
Transmitter Transients	n.a.	The transmitter is always switched on.
<b>Receiver Parameters</b>		
Receiver sensitivity	4.4.3.3.1	
Receiver co-channel rejection	4.4.3.2.3	This technical requirement is not applicable for sensitivity class 1 RSUs.
Adjacent band/channel selectivity	4.4.3.2.2	
Receiver blocking	4.4.3.2.1	
Receiver spurious response rejection	4.4.3.2.1, 4.4.3.2.2	This technical requirement is covered by the blocking and selectivity tests.
Receiver radio-frequency intermodulation	n.a.	With constant envelope modulations and superheterodyne receivers, cross modulation is very unlikely to be a cause of receiver degradation.
Receiver unwanted emissions in the spurious domain	4.4.3.1	
Receiver dynamic range	4.4.3.3.1, 4.4.3.3.2	
Reciprocal mixing	4.4.3.2.1, 4.4.3.2.2	The reciprocal mixing effects are implicitly covered in the selectivity requirements (blocking and adjacent channel selectivity).

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## Annex E (informative): Bibliography

- 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 for access to radio spectrum; Sub-part 2: On-Board Units (OBU)".

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## Annex F (informative): Change History

Version	Information about changes
2.1.1	First published version covering Directive 2014/53/EU. Receiver blocking characteristics and receiver sensitivity have become essential requirements.
3.1.1	Editorial amendment based on the latest HS skeleton. New receiver sensitivity classes added. Requirements and test specifications for receiver adjacent channel selectivity, co-channel rejection, and dynamic range added. Technical requirements specifications amended to increase readability and avoid misunderstandings. Testing for compliance with technical requirements simplified to increase readability and avoid misunderstandings. All annexes simplified to increase readability and avoid misunderstandings.

## History

<b>Document history</b>		
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
V2.1.1	September 2016	Publication
V3.0.1	October 2021	EN Approval Procedure AP 20220124: 2021-10-26 to 2022-01-24