Application Report
SWRA670–April 2020

CE Regulations for SRDs Operating in License-Free 2.4 GHz/5 GHz Bands

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ABSTRACT

This application report covers the requirements and procedures for license-free operation of radio equipment in the worldwide 2.4 GHz and 5 GHz bands for regulatory compliance in Europe. The CE regulations for SRD (Short-Range Devices) are covered in detail for both transmitters and receivers in the frequency bands of both 2.4 GHz and 5 GHz. **Note that this application report serves as guidance on CE compliance test limits on the 2.4 GHz and 5 GHz bands. For detailed requirements, refer to ETSI documentation.**

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Trademarks

Bluetooth is a registered trademark of Bluetooth SIG, Inc.
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1 Introduction

Texas Instruments' wireless portfolio consists of wireless Microcontrollers and certified modules, which covers wide range of technologies such as Wi-Fi, *Bluetooth®,* Zigbee, Proprietary, and so forth in 2.4 GHz and 5 GHz frequency bands. In most cases, they are used inside the unlicensed, or license-free, wireless products. Unlicensed means only that the user of these products does not need an individual license from the telecommunication regulatory authorities for the use of the frequency band. Unlicensed does not mean unregulated; the wireless product itself usually will need to meet strict regulations and to be certified by the appropriate regulatory authorities.

International regulations and national laws regulate the use of radio equipment. This document is a summary of the most important aspects of these regulations for license-free operation of radio equipment in the worldwide 2.4 GHz and 5 GHz bands. Although the operation of radio equipment in the 2.4 GHz and 5 GHz bands is license-free, the final product has to be type approved. Please note that the type approval is not required for the Chips (ICs) by themselves, but rather the actual application of an end product requires type approval. The type approval procedure will also be reviewed in this document.

This application note is a summary of the regulations and procedures in the European Union for unlicensed RF products operating in the frequency 2.4 GHz and 5 GHz bands. Such products are often referred to as SRD (Short-Range Devices) products in the EU. EU regulatory agencies place limitations on the operating frequencies, output power, spurious emissions, modulation methods, and transmit duty cycles, among other things. The limitations and requirements in the EU are covered in Section 2 to Section 9.

2 Regulation Overview

The use of radio equipment in most European countries is regulated through the Radio Equipment Directive (RED) 2014/53/EU. The RED 2014/53/EU establishes a regulatory framework for placing radio equipment on the market. It ensures a single market for radio equipment by setting essential requirements for safety and health, electromagnetic compatibility, and the efficient use of the radio spectrum. It also provides the basis for further regulation governing some additional aspects. These include technical features for the protection of privacy, personal data and protection against fraud. Furthermore, additional aspects cover interoperability, access to emergency services, and compliance regarding the combination of radio equipment and software. This directive defines the general requirements for radio operation. The actual standards to comply with are written by standardization bodies like The European Standardization Organizations (ESOs), which contains the European Committee for Standardization (CEN), the European Committee for Electro-technical Standardization (CENELEC) and European Telecommunications Institute (ETSI). The standardization organizations are private bodies, composed of industry experts and other stakeholders, and are fully independent from the Commission.

CEPT (The European Conference of Postal and Telecommunications Administrations) has the responsibility for the allocation of frequency bands, maximum TX power levels, channel spacing or modulation/maximum occupied bandwidth and duty cycle. This is described in the ERC recommendation CEPT/ERC/70-03.

ETSI has developed harmonized European standards in support of the RED (2014/53/EU) for the majority of SRDs and also defines the test methodologies and general transceiver specifications. Different frequency bands and the use of equipment are covered by different standards. In this document the regulations of the 2.4 GHz and 5 GHz bands are reviewed. The 2.4 GHz and 5GHz ISM bands are covered by the following standards:

- EN 300 440 covers non-specific devices in the frequency range of 1 GHz – 40 GHz.
- EN 300 328 V 2.2.2 covers Data transmission equipment operating in the 2.4 GHz band.
- EN 301 893 V 2.1.1 covers the RLAN equipment in the 5 GHz band.
- EN 301 489-1 V 2.2.1 covers EMC for standard radio equipment and services.
- EN 301 489-17 V 3.2.2 covers EMC for Broadband Data Transmission Systems.
- IEC 62368-1 covers Safety for ICT and AV equipment.
- EN 62311 covers Human Exposure Restrictions to Electromagnetic fields.

2.1 CEPT ERC Recommendation 70-03

A summary of the recommendation for the 2.4 GHz and 5 GHz band Short Range Devices (SRD) are provided based on the 7 June 2019 edition of CEPT ERC Recommendation 70-03. The complete document can be downloaded from this site: ERC Recommendation 70-03. Direct links to documents and other useful links from CEPT can also be found at this site: ECO Documentation Database. The CEPT ERC recommendation 70-03 for 2.4 GHz and 5 GHz frequency bands and their application are shown in Table 1.

Table 1. CEPT ERC Recommendation 70-03 for the 2.4 GHz and 5 GHz Frequency Bands

Frequency band		Power EIRP (1)	Spectrum Access and Mitigation Requirements	Modulation/Maximum Occupied Bandwidth	Application / Notes
1i	2400 – 2483.5 MHz	10mW	No requirement	Not specified	Generic use
3b	2400 – 2483.5 MHz	100mW	Adequate spectrum sharing mechanism (for example, LBT and DAA) should be implemented	Not specified	For wideband modulations other than FHSS, the maximum e.i.r.p. density is limited to 10 mW/MHz
6c	2400 – 2483.5 MHz	25mW	No requirement.	Not specified	Radio determination applications including equipment for detecting movement and alert.
11c1	2446 – 2454 MHz	<500mW	No requirement.	Not specified	RFID Application
11c2	2446 – 2454 MHz	>500mW<= 4W	≤ 15% duty cycle FHSS techniques should be used	Not specified	RFID Application. Power levels above 500 mW are restricted to be used inside the boundaries of a building and the duty cycle of all transmissions should in this case be ≤ 15% in any 200 ms period (30 ms on /170 ms off)
12c	2483.5 – 2500 MHz	10mW	LBT+AFA and ≤ 10% duty cycle. The equipment should implement a spectrum access mechanism as described in the Applicable harmonized standard or an equivalent spectrum access mechanism	1 MHz	Medical Implants and associated peripherals applications.
13b1	2483.5 – 2500 MHz	1mW	Adequate spectrum sharing mechanisms (for example, Listen-Before- Talk and Adaptive Frequency Agility) should be implemented by the equipment and ≤ 10% duty cycle	< = 3 MHz	Medical Data acquisition applications. MBANS, indoor only within healthcare facilities.
Ae1	5150 – 5350 MHz	Refer to Table 45	Refer to Section 6.2.7 and Section 6.2.8	Refer to Table 44	For Wireless Access Systems including Radio Local Area Networks (WAS/RLANs).
Ae2	5470 – 5725 MHz	Refer to Table 45	Refer to Section 6.2.7 and Section 6.2.8	Refer to Table 44	For Wireless Access Systems including Radio Local Area Networks (WAS/RLANs).
1j	5725 – 5875 MHz	25mW	No requirement	Not specified	Generic use
2d	5725 – 5875 MHz	400mW	Adequate spectrum sharing mechanism (for example, DFS and DAA) should be implemented	>= 1 MHz and <= 20 MHz	Wireless Industrial Applications (WIA). Registration and /or notification may be required. APC is able to reduce the e.i.r.p to <= 25 mW
5a	5795– 5805 MHz	2W / 8W	No requirement	Not specified	Transport and Traffic Telematics (TTT) applications. Individual license may be required for 8W systems
5b	5805– 5815 MHz	2W / 8W	No requirement	Not specified	Transport and Traffic Telematics (TTT) applications. Individual license may be required

(1) EIRP = effective isotropic radiated power.

The 2.4 GHz and 5 GHz bands are covered by ERC decision, which means that these are harmonized bands in most of Europe. Being a harmonized band means that the Member States should allow the putting into service and use of radio equipment if it complies with the RED when it is properly installed, maintained, and used for its intended purpose.

3 Radio Equipment Directive (RED)

The Radio Equipment Directive 2014/53/EU (RED) was adopted in 2014 and Member States had to transpose it into their national law before 13 June 2016. It revised the Directive on Radio and Telecommunication Terminal Equipment (1999/5/EC) and sets down requirements on safety, health protection and electromagnetic compatibility. It also ensures the efficient use of radio spectrum and provides the basis for further regulation governing some additional aspects (such as access to emergency services, interoperability, safeguards to ensure the protection of privacy and personal data). The Directive applies to radio equipment, such as domestic television and radio sets, mobile phones as well as Wi-Fi, Bluetooth and GPS or other satellite transceivers. The aim is to provide an open market for telecoms products and allow equipment which has been approved for use in one EEA country to be made available in any other. The RED applies throughout the European Union (EU) and the European Economic Area (EEA).The Directive itself can be found in the European Law section of the European Union's website.

3.1 Essential Requirements

The DoC should declare that the essential requirements of the RED are met. The essential requirements for Radio Equipment (RE) can be summarized as follows:

- The RE should protect the health and safety of persons and of domestic animals and the protection of property, including the objectives with respect to safety requirements set out in Directive 2014/35/EU, but with no voltage limit applying.
- The RE should have an adequate level of electromagnetic compatibility as set out in Directive 2014/30/EU.
- The RE should effectively use and support the efficient use of radio spectrum in order to avoid harmful interference.
- The RE should interwork with other RE equipment and accessories to incorporate safeguards that ensure the personal data and privacy of the user, and also support certain features ensuring protection from fraud, and so forth.

Please refer to Article 3 of the Directive 2014/53/EU (RED) for detailed list of Essential requirements.

3.2 Obligations of Manufacturers

Article 10 of the Directive 2014/53/EU (RED) lists the Obligations of manufacturers in order to place the equipment on the EU market. The following is a summary of some of the important aspects of Obligations of manufacturers:

- When placing their radio equipment on the market, manufacturers should ensure that it has been designed and manufactured in accordance with the essential requirements (see Section 3.1) set out in Article 3 of the Directive 2014/53/EU (RED).
- Manufacturers should ensure that radio equipment should be so constructed that it can be operated in at least one Member State without infringing applicable requirements on the use of radio spectrum.
- Manufacturers should draw up the technical documentation referred to in Article 21 of the Directive 2014/53/EU (RED) and carry out the relevant conformity assessment procedure referred to in Article 17 of the Directive 2014/53/EU (RED) or have it carried out.
  - Where compliance of radio equipment with the applicable requirements has been demonstrated by that conformity assessment procedure, manufacturers should draw up an EU declaration of conformity and affix the CE marking.
- Manufacturers should keep the technical documentation and the EU declaration of conformity for 10 years after the radio equipment has been placed on the market.
- Manufacturers should ensure that procedures are in place for series production to remain in conformity with this Directive.
- Manufacturers should ensure that radio equipment which they have placed on the market bears a type, batch or serial number or other element allowing its identification or; where the size or nature of the radio equipment does not allow it, that the required information is provided on the packaging, or in a document accompanying the radio equipment.
- Manufacturers should indicate on the radio equipment their name, registered trade name or registered trade mark and the postal address at which they can be contacted or; where the size or nature of radio

equipment does not allow it, on its packaging, or in a document accompanying the radio equipment.

- Manufacturers should ensure that the radio equipment is accompanied by instructions and safety information in a language which can be easily understood by consumers and other end-users, as determined by the Member State concerned.
- Manufacturers should ensure that each item of radio equipment is accompanied by a copy of the EU declaration of conformity or by a simplified EU declaration of conformity.
  - Where a simplified EU declaration of conformity is provided, it should contain the exact internet address where the full text of the EU declaration of conformity can be obtained.
- In cases of restrictions on putting into service or of requirements for authorization of use, information available on the packaging should allow the identification of the Member States or the geographical area within a Member State where restrictions on putting into service or requirements for authorization of use exist. Such information should be completed in the instructions accompanying the radio equipment.
- Manufacturers who consider or have reason to believe that radio equipment which they have placed on the market is not in conformity with this Directive should immediately take the corrective measures necessary to bring that radio equipment into conformity, to withdraw it or to recall it, if appropriate.

3.3 Conformity of Radio Equipment

The conformity assessment is the process carried out by the manufacturer which demonstrates whether specified requirements relating to a product have been fulfilled.

3.3.1 Presumption of Conformity of Radio Equipment

Radio equipment which is in conformity with harmonized standards or parts thereof (the references of which have been published in the Official Journal of the European Union) should be presumed to be in conformity with the essential requirements set out in Article 3 of the Directive 2014/53/EU (RED) (see Section 3.1) covered by those standards or parts thereof.

3.3.2 Conformity Assessment Procedure

Please refer to Article 17 of the Directive 2014/53/EU (RED) for detailed conformity assessment procedures. The following is a summary of the conformity assessment procedures.

- The manufacturer should perform a conformity assessment of the radio equipment with a view to meeting the essential requirements set out in Article 3 (see Section 3.1). The conformity assessment should take into account all intended operating conditions and, for the essential requirement set out in point (a) of Article 3(1) (see Section 3.1), the assessment should also take into account the reasonably foreseeable conditions. Where the radio equipment is capable of taking different configurations, the conformity assessment should confirm whether the radio equipment meets the essential requirements set out in Article 3 (see Section 3.1) in all possible configurations.
- Manufacturers should demonstrate compliance of radio equipment with the essential requirements set out in Article 3(1) of the Directive 2014/53/EU (RED) using any of the following conformity assessment procedures:
  - A conformity assessment procedure based on internal production control set out in Annex II of the Directive 2014/53/EU (RED);
  - A conformity assessment procedure based on EU-type examination that is followed by the conformity to type based on internal production control set out in Annex III of the Directive 2014/53/EU (RED);
  - A conformity based on full quality assurance set out in Annex IV of the Directive 2014/53/EU (RED), based on full quality assurance by having a quality system approved by a “notified body”. The quality system must contain elements for design, manufacture and final radio equipment inspection and testing. The manufacturer should lodge an application for assessment of his quality system with the notified body of his choice, for the radio equipment concerned and the corresponding technical documentation as set out in Annex V of the Directive 2014/53/EU (RED).

Manufacturers of SRDs in the license-free 2.4 GHz and 5 GHz frequency bands can choose to follow the procedure in Annex III, when the product conforms to harmonized standards. The applicable harmonized standards are EN 300 440 (Non-specific SRDs), EN 300 328 (Wideband transmission systems), EN 301 893 (RLAN equipment in the 5 GHz band), EN 301 489 (EMC), and EN 62368 (safety).

3.3.3 EU Declaration of Conformity

The manufacturer declares compliance by drawing up and signing an EU Declaration of Conformity (DoC) before placing the product on a market, and also by affixing the CE Marking on the product. Both the equipment user and the member state should be notified about the DoC, and the full technical documentation must be kept for 10 years from the date of placing the product on the market, unless the applicable Union harmonization legislation expressly provides for any other duration. Please refer to Article 18 of the Directive 2014/53/EU (RED) for details on EU declaration of Conformity.

3.3.4 Rules and Conditions for Affixing the CE Marking

Please refer to Articles 19 and 20 of the Directive 2014/53/EU (RED) for complete details on CE marking. The rules and conditions for affixing CE marking are as follows:

- The CE marking should be subject to the general principles set out in Article 30 of Regulation (EC) No 765/2008.
- The CE marking should be affixed visibly, legibly and indelibly to the radio equipment or to its data plate, unless that is not possible or not warranted on account of the nature of radio equipment. The CE marking should also be affixed visibly and legibly to the packaging.
- The CE marking should be affixed before the radio equipment is placed on the market.
- The CE marking should be followed by the identification number of the notified body where the conformity assessment procedure set out in Annex IV of the Directive 2014/53/EU (RED) is applied.

3.3.5 Technical Documentation

- The technical documentation should contain all relevant data or details of the means used by the manufacturer to ensure that radio equipment complies with the essential requirements set out in Article 3 (see Section 3.1). It should, at least, contain the elements set out in Annex V of the Directive 2014/53/EU (RED).
- The technical documentation should be drawn up before radio equipment is placed on the market and should be continuously updated.
- The technical documentation and correspondence relating to any EU-type examination procedure should be drawn up in an official language of the Member State in which the notified body is established or in a language acceptable to that body.

3.4 Restrictions on Putting into Service

- If radio equipment is subject to restrictions on putting into service or to requirements for authorization of use, as provided for in Article 10(10) of Directive 2014/53/EU, the packaging of the radio equipment should indicate visibly and legibly:
  - A pictogram, as set out in Annex I of Regulation (EU) 2017/1354; or
  - The words ‘Restrictions or Requirements in’, in a language easily understood by end-users as determined by the Member State concerned, followed by the abbreviations of the Member States, as prescribed in Annex II of Regulation (EU) 2017/1354, where such restrictions or requirements exist.
- If radio equipment is subject to restrictions on putting into service or to requirements for authorization of use, as provided for in Article 10(10) of Directive 2014/53/EU, the instructions accompanying the radio equipment should indicate, in a language easily understood by end-users as determined by the Member State concerned, the list of the Member States and geographical areas within the Member States where such restrictions or requirements exist, as well as the types of restrictions or requirements applicable in each Member State and each geographical area within a Member State.

The example of a pictogram is shown in Figure 1. Please refer to Annex I and Annex II of Regulation (EU) 2017/1354 for complete details about pictogram.

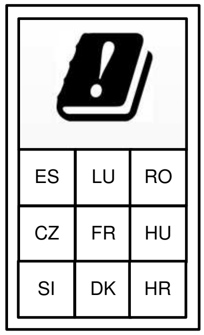


Figure 1. Pictogram Example

4 ETSI EN 300 440

The ETSI EN 300 440 is a Harmonized European standard which describes the performance requirements and conformance test procedures for license exempt Short Range Devices (SRDs) intending to use frequency bands within the range of 1 GHz to 40 GHz. The complete document can be downloaded from the ETSI website. The following is a summary of the most important requirements for Non-Specific SRDs in the 2.4 GHz and 5 GHz bands in EN 300 440. The permitted frequency band limits for 2.4 GHz and 5 GHz bands are shown in Table 2.

Table 2. Limits on Permitted Frequency Bands in 2.4 GHz and 5 GHz Bands - EN 300 440

Mode of operation	Frequency Band	Applications
Transmit and Receive	2400 MHz to 2483.5 MHz	Non-specific short range devices
Transmit and Receive	5725 MHz to 5875 MHz	Non-specific short range devices

4.1 Technical Requirements

The equipment should comply with all applicable technical requirements at all times when operating within the boundary limits of the operational environmental profile declared by the manufacturer. The technical requirements are shown in Table 3.

Table 3. Technical Requirements and Conditions - EN 300 440

Requirement				Requirement Conditionality	
No	Description	Essential Requirements of Directive 2014/53/EU	Clause(s) of the EN300 440	U/C (1)	Condition
1	RF Output Power (e.i.r.p.)	3.2	4.2.2	C	Applies to all devices with transmitters
2	Permitted range of operating frequencies	3.2	4.2.3	C	Applies to all devices with transmitters
3	Unwanted emissions in the spurious domain	3.2	4.2.4	C	Applies to all devices with transmitters
4	Duty Cycle	3.2	4.2.5.4	C	Transmitting devices which do not use LBT, DAA, or RFID transmitters operating in the 2446 to 2454 MHz band transmitting more than 500 mW e.i.r.p. power level
5	Additional requirements for FHSS equipment	3.2	4.2.6	C	Equipment utilizing FHSS modulation
6	Adjacent channel selectivity	3.2	4.3.3	C	Applies to equipment Category 1 receivers
7	Blocking or Desensitization	3.2	4.3.4	C	Applies to category 1, 2, and 3 SRD communication media receivers
8	Spurious radiation	3.2	4.3.5	C	Applies to all receivers, except receivers used in combination with permanently co-located transmitters continuously transmitting
9	Spectrum access techniques	3.2	4.4	C	Equipment which are not using duty cycle restrictions for media access
10	GBSAR antenna pattern	3.2	4.6.4	C	Applies only GBSAR systems
11	Limits for GBSAR	3.2	Annex I	C	Applies only GBSAR systems

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

4.1.1 Environmental Profile

The environmental profile for operation of the equipment should be declared by the manufacturer. The equipment should comply with all applicable technical requirements at all times when operating within the boundary limits of the declared operational environmental profile.

4.2 Transmitter Requirements

Where the transmitter is designed with adjustable carrier power, then all transmitter parameters should be measured using the highest power level. The spurious emissions should be measured at both the highest and the lowest carrier power settings.

If the equipment to be tested is designed with a permanent external 50 Ω RF connector and a dedicated or integral antenna, then full tests should be carried out using this connector. If the RF connector is not 50 Ω, then a calibrated coupler or attenuator should be used to provide the correct termination impedance to facilitate the measurements. The equivalent isotropically radiated power is then calculated from the declared antenna gain.

The following is a summary of the most important requirements for the transmitter in the 2.4 GHz and 5 GHz bands in EN 300 440.

4.2.1 Transmitter Maximum Radiated Power (e.i.r.p.)

The transmitter maximum radiated power (e.i.r.p) limits under normal and extreme test conditions are shown in the Table 4.

Table 4. Limits on TX Maximum Radiated Power (e.i.r.p.)

Entry	Frequency Bands	TX Power	Application
1	2400 MHz to 2483.5 MHz	10 mW e.i.r.p	Non-specific short range devices
5	5725 MHz to 5875 MHz	25 mW e.i.r.p	Non-specific short range devices

4.2.2 Permitted Range of Operating Frequencies

The permitted range of operating frequencies includes all frequencies on which the equipment may operate within an assigned frequency band. The operating frequency range should be declared by the manufacturer. The frequency range of the equipment is determined by the lowest and highest frequencies occupied by the power envelope, where the output power envelope drops below the level of –75 dBm/Hz spectral power density (or –30 dBm if measured in a 30 kHz bandwidth) e.i.r.p. Where differing modes of emission are available, all modes and their associated bandwidths should be stated.

For all equipment the frequency range should lie within the frequency band specified in Table 4.

4.2.3 Unwanted Emissions in the Spurious Domain

Unwanted emissions in the spurious domain (spurious emissions) are those at frequencies beyond the limit of 250% of the occupied bandwidth above and below the center frequency of the emission. The occupied bandwidth is measured as declared by the manufacturer. Out-of-band and spurious emissions are measured as spectral power density under normal operating conditions. The maximum power limits of any unwanted emissions in the spurious domain are shown in Table 5.

Table 5. Limits on Spurious Emissions

Frequency Ranges / State	47-74 MHz 87.5-118 MHz 174-230 MHz 470-862 MHz	Other frequencies below 1000 MHz	Frequencies Above 1000 MHz
Operating	4nW = -54dBm	250nW = -36dBm	1μW = -30dBm
Standby	2nW = -57dBm	2nW = -57dBm	20nW = -47dBm

4.2.4 Duty Cycle

Duty cycle is defined as a ratio expressed as percentage of the cumulative duration of transmissions ON time within a 1-hour observation period. Duty Cycle (DC) should apply to all transmitting equipment except those which utilize Listen Before Talk (LBT) clause 4.4.2, or Detect And Avoid (DAA) clause 4.4.3. The limits for the maximum Duty Cycle within 1-hour observation period is shown in Table 6.

Table 6. Limits on Duty Cycle within 1-Hour Period

Frequency Band	Duty Cycle	Application
2400 MHz to 2483.5 MHz	No Restriction	Generic use
5725 MHz to 5875 MHz	No Restriction	Generic use

4.2.5 Additional Requirements for FHSS Equipment

Equipment employing FHSS (Frequency Hopping Spread Spectrum) should transmit over multiple channels by moving its transmission frequency from channel. The requirements in this section apply only to equipment using FHSS modulation. The limits for FHSS are shown in Table 6.

Table 7. Limits on FHSS Modulation

Parameter	Limits	Notes
No of Channels	> 20 Channels hopping over > 90% of assigned frequency band.	
Dwell Time / Channel	< 1 Sec.	While the equipment is operating (transmitting and/or receiving) each channel of the hopping sequence should be occupied at least once during a period not exceeding four times the product of the dwell time per hop and the number of channels.

4.3 Receiver Requirements

The product family of short range radio devices is divided into three receiver categories (see Table 8) each having a set of relevant receiver requirements and minimum performance criteria. The set of receiver requirements depends on the choice of receiver category by the equipment manufacturer.

4.3.1 Receiver Categories

The product family of short range radio devices is divided into three receiver categories, which are defined in Table 8. The manufacturer should specify the receiver category of their choice.

Table 8. Receiver Categories

Receiver Category	Relevant Receiver Requirements	Risk assessment of receiver performance
1 (1)	Refer to Section 4.3.3, Section 4.3.4 and Section 4.3.5	Highly reliable SRD communication media; for example, serving human life inherent systems (may result in a physical risk to a person.
2 (1), (2)	Refer to Section 4.3.4 and Section 4.3.5	Medium reliability SRD communication media for example, causing inconvenience to persons, which cannot simply be overcome by other means.

Table 8. Receiver Categories (continued)

Receiver Category	Relevant Receiver Requirements	Risk assessment of receiver performance
3	Refer to Section 4.3.4 and Section 4.3.5	Standard reliability SRD communication media and radiodetermination devices. for example, Inconvenience to persons, which can simply be overcome by other means (for example, manual).

(1) Receiver Category 1 or 2 should be used for all equipment using LBT or DAA for interference mitigation.

(2) Receiver category 2 may be required for specific spectrum access techniques are specified in Section 4.4.1.

4.3.2 Receiver Performance Criteria

For the purpose of the receiver performance tests, the receiver should produce an appropriate output under normal conditions as indicated below:

- A SND/ND ratio of 20 dB, measured at the receiver output through a telephone psophometric weighting network as described in Recommendation ITU-T O.41; or
- After demodulation, a data signal with a bit error ratio of 10-2 without correction; or
- After demodulation, a message acceptance ratio of 80%; or
- An appropriate false alarm rate or sensing criteria as declared by the manufacturer.

Unless otherwise specified, the measurements should be performed using normal operation of the equipment with the equipment operating in accordance, utilizing the worst-case configuration with regards to the requirement to be tested. For each of the requirements in the present document, this worst-case configuration should be declared by the manufacturer and documented in the test report to assure that the equipment is performing in accordance with its intended use. Special software or other alternative methods may be used to operate the equipment in this mode.

4.3.3 Adjacent Channel Selectivity

The adjacent channel selectivity is a measure of the capability of the receiver to operate satisfactorily in the presence of an unwanted signal that differs in frequency from the wanted signal by an amount equal to the adjacent channel separation for which the equipment is intended. This requirement applies to channelized Category 1 receivers only. The adjacent channel selectivity limits are shown in Table 9.

Table 9. Limits on Adjacent Channel Selectivity

Parameter	Limit	Performance Criteria
Adjacent Channel Level	> (-30dBm + k), Where, k=(-20*logf-10*logBW) k should be within the limits of -40 < k < 0dB	should meet the performance criteria as specified in Section 4.3.2
f – is the frequeny in GHz BW - is the channel bandwidth in MHz.		

4.3.4 Blocking or Desensitization

Blocking is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequencies other than those of the spurious responses or the occupied bandwidth. This requirement applies to all Categories 1, 2 and 3 receivers. The adjacent channel selectivity limits are shown in the Table 10.

Table 10. Limits on Blocking or Desensitization

<table>
<tr><th>Receiver Category</th><th>Limit</th><th>Performance Criteria</th></tr>
<tr><td>1</td><td>> (-30dBm + k),
Where, k =(−20*logf −10*logBW)
k should be within the limits of -40dB < k < 0dB</td><td rowspan="3">should meet the performance criteria as specified in Section 4.3.2</td></tr>
<tr><td>2</td><td>> (-45dBm + k)</td></tr>
<tr><td>3</td><td>> (-30dBm + k)</td></tr>
<tr><td colspan="3">f – is the frequeny in GHz
BW - is the channel bandwidth in MHz.</td></tr>
</table>

4.3.5 Spurious Radiations - Receiver

Spurious radiations from the receiver are components at any frequency, radiated by the equipment and antenna. The level of spurious radiations should be measured by either:

- Their power level in a specified load (conducted spurious emission) and their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation); or
- Their effective radiated power when radiated by the cabinet and the integral or dedicated antenna, in the case of portable equipment fitted with such an antenna and no permanent RF connector.

The power of any spurious emission should not exceed the limits shown in Table 11.

Table 11. Limits on Spurious Radiations - Receiver

Frequency Range	Spurious Emission Level Limit
25 MHz to 1 GHz	< 2nW (-57dBm)
>1GHz	< 20nW (-47dBm)

4.4 Spectrum Access Techniques

For equipment with radiated power of less than 100 μW e.i.r.p., no access technique is required. There are two mechanisms to access the spectrum:

- Listen Before Talk (LBT), which is used to share spectrum between SRD transceiver equipment with similar power and bandwidth; or
- Detect And Avoid (DAA), which is used to protect radio communication services. This applies to 17.1 GHz to 17.3 GHz GBSAR only.

Receiver Category 2 or better should be used for all equipment using LBT or DAA.

Equipment utilizing LBT or DAA do not have to comply with the duty cycle conditions.

For spread spectrum systems, LBT may be used if the required timing and threshold limits can be met; if not, then a duty cycle requirement applies.

4.4.1 Listen Before Talk

In order to make maximum use of the available channels, intelligent or polite equipment may use a Listen Before Talk (LBT) protocol with a preferred option of Adaptive Frequency Agility (AFA). AFA is defined as the capability of equipment to dynamically change channel within its available frequencies for proper operation.

For LBT equipment, the device should listen on the next intended frequency before transmitting. If it is intended to move to a different channel then this channel can be monitored whilst still transmitting at its first channel. If it is not intended to move to a different channel then it should be treated as a single frequency device waiting for a free channel.

4.4.1.1 LBT Timing Paramters

The minimum Tx off-time is defined as the period where a specific transmitter should remain off after a transmission or a communication dialogue between units or a polling sequence of other units.

The minimum listening time is defined as the minimum time that the equipment listens for a received signal at or above the LBT threshold level (see Section 4.4.1.2) immediately prior to transmission to determine whether the intended channel is available for use.

An acknowledge transmission is defined as a receipt for a received message.

For automatic operated LBT devices (either software controlled or pre-programmed devices), the manufacturer should declare all the channel LBT timings for the equipment under test.

For manual operated or event dependent devices (with or without software controlled functions), the manufacturer should declare whether the transmission, once triggered, follows a pre-programmed time-out-timer, or whether the transmitter remains on until the trigger is released or the device is manually reset.

The equipment with LBT should meet the LBT timing parameter limits shown in Table 12.

Table 12. Limits for LBT Timing Parameters

Parameter	Limits	Notes
Minimum Tx Off-time	>25 mSec	
Minimum Listening time (tL)	> (tF + tPS) mSec	tF = 5 mSec, tPS should be randomly varied between 0 ms and a value of 5 ms or more in equal steps of approximately 0.5 ms as the following: -If the channel is free from traffic at the beginning of the listen time, tL, and remains free throughout the fixed part of the listen time, tF, then the pseudo random part, tPS, is automatically set to zero by the equipment itself. - If the channel is occupied by traffic when the equipment either starts to listen or during the listen period, then the listen time commences from the instant that the intended channel is free. In this situation the total listen time tL should comprise tF and the pseudo random part, tPS.
Maximum Tx ON-time for a Single Transmission	< 2 Sec	
Maximum Tx ON-time for a Transmission dialogue or a polling sequence	< 10 Sec	In the case the time reaches the limit then the minimum Tx off-time limit should apply automatically.

4.4.1.2 Receiver LBT Threshold and Transmitter Max On-Time

The LBT threshold is defined as the received signal level above which the equipment can determine that the channel is not available for use. If the received signal is below the LBT threshold, then the equipment can determine that the channel is available for use.

The maximum LBT threshold limits for the receiver in listen mode are shown in Table 13. The limits for Tx max on-time is shown in Table 12.

Table 13. Limits for LBT Threshold Values Versus Transmit Power

Tx Power	LBT Threshold Limit (1), (2)	Notes
< 100 mW	-80 dBm + C	C = 10*logBW, Where, BW is the bandwidth in MHz.
500 mW	-87 dBm + C	

(1) The limit is independent of the receiver category, see Section 4.3.1.

(2) The limits are based on an antenna gain of +2 dBi maximum. For other antenna gains greater than +2 dBi the limits should be adjusted accordingly.

4.4.2 Detect And Avoid Technique (DAA)

DAA is specified for use with Ground Based Synthetic Aperture Radar (GBSAR) systems only. It provides protection to other radio communication services. As GBSAR is not in the scope of this application note, DAA is not covered. Please refer to the standard ETSI EN 300 440 for details.

5 ETSI EN 300 328

The ETSI EN 300 328 is a Harmonized European standard which applies to Wideband transmission systems operating in the 2.4 GHz band. This standard describes the spectrum access requirements, technical requirements specifications, conformance requirements and test procedures for compliance. The complete document can be downloaded from the ETSI website. The following is a summary of the most important requirements for both the transmitter and the receiver in the EN 300 328 standard. The operating frequency band limits is shown in Table 14.

Table 14. Limits on Frequency Bands

Mode of operation	Frequency Band
Transmit	2400 MHz to 2483.5 MHz
Receive	2400 MHz to 2483.5 MHz

5.1 Technical Requirements

The equipment should comply with all applicable technical requirements at all times when operating within the boundary limits of the operational environmental profile declared by the manufacturer. The technical requirements for different types of equipment are shown in Table 15.

Table 15. Technical Requirements and Conditions

Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive 2014/53/EU	Clause(s) of the EN 300 328	U/C(1)	Condition
1	RF Output Power	3.2	4.3.1.2 or 4.3.2.2	U	
2	Power Spectral Density	3.2	4.3.2.3	C	Only for non-FHSS equipment
3	Duty cycle, Tx-Sequence, Tx-gap	3.2	4.3.1.3 or 4.3.2.4	C	Only for non-Adaptive equipment
4	Accumulated Transmit time, Frequency Occupation and Hopping Sequence	3.2	4.3.1.4	C	Only for FHSS equipment
5	Hopping Frequency Separation	3.2	4.3.1.5	C	Only for FHSS equipment
6	Medium Utilization	3.2	4.3.1.6 or 4.3.2.5	C	Only for non-Adaptive equipment
7	Adaptivity	3.2	4.3.1.7 or 4.3.2.6	C	Only for Adaptive equipment
8	Occupied Channel Bandwidth	3.2	4.3.1.8 or 4.3.2.7	U	
9	Transmitter unwanted emissions in the OOB domain	3.2	4.3.1.9 or 4.3.2.8	U	
10	Transmitter unwanted emissions in the spurious domain	3.2	4.3.1.10 or 4.3.2.9	U	
11	Receiver spurious emissions	3.2	4.3.1.11 or 4.3.2.10	U	
12	Receiver Blocking	3.2	4.3.1.12 or 4.3.2.11	U	
13	Geo-location capability	3.2	4.3.1.13 or 4.3.2.12	C	Only for equipment with geo-location capability

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

5.1.1 Environmental Profile

The environmental profile for operation of the equipment should be declared by the manufacturer. The equipment should comply with all applicable technical requirements at all times when operating within the boundary limits of the declared operational environmental profile.

5.2 Equipment Types

The standard covers the following equipment.

- Wideband Data transmission equipment.
- Adaptive and Non-adaptive equipment
- Receiver categories
- Antenna types

5.2.1 Wideband Data Transmission Equipment Types

There are two categories of the Wideband Data Transmission equipment. They are:

- Frequency Hopping Spread Spectrum (FHSS) equipment.
- Other types of Wideband Data Transmission (Non-FHSS) equipment, (for example, DSSS, OFDM, and so forth).

The equipment categories should be declared by the manufacturer.

5.2.2 Adaptive and Non-Adaptive Equipment

Adaptive equipment can use an automatic mechanism which allows the equipment to adapt to its radio environment by identifying other transmissions on the operating frequency. Adaptive equipment may have more than one adaptive mode implemented. Adaptive equipment is allowed to operate in a non-adaptive mode. Equipment is allowed to switch between any of these modes.

Non-adaptive equipment does not use such an automatic mechanism and hence is subject to certain restrictions with respect to using the medium (for more information, see Table 6) in order to ensure sharing with other equipment.

Unless otherwise specified, the equipment should comply with the corresponding requirements (Table 6) in each of the modes in which it can operate.

The manufacturer should declare whether the equipment is adaptive equipment or non-adaptive equipment. In case of adaptive equipment, the manufacturer should declare all adaptive modes in addition to whether the equipment can also operate in a non-adaptive mode.

5.2.3 Receiver Categories

The receivers are divided into three different categories based on their modes of operation. They are:

- Receiver category 1 – the equipment which operates as Adaptive equipment with a maximum RF output power greater than 10 dBm e.i.r.p.
- Receiver category 2 – the equipment which operates as non-adaptive equipment with a Medium Utilization (MU) factor greater than 1% and less than or equal to 10% (irrespective of the maximum RF output power) or equipment (adaptive or non-adaptive) with a maximum RF output power greater than 0 dBm e.i.r.p. and less than or equal to 10 dBm e.i.r.p.
- Receiver category 3 – non-adaptive equipment with a maximum Medium Utilization (MU) factor of 1% (irrespective of the maximum RF output power) or equipment (adaptive or non-adaptive) with a maximum RF output power of 0 dBm e.i.r.p.

Different receiver requirements and/or corresponding limits apply based on the category of the receiver.

5.2.4 Antenna Types

There are two types of antenna. They are:

- Integral antenna

- Dedicated antenna

The equipment should have either type of the antenna.

5.3 Conformance Requirements

The Conformance requirements are different for different type of equipment. Basically they are classified into two types of categories. They are:

- Frequency Hopping equipment (both Adaptive and Non-adaptive types)
- Wideband Data Transmission equipment (Non – FHSS equipment)

The conformance requirements for both the equipment types are covered in the following sub-sections.

5.3.1 Conformance Requirements for Frequency Hopping Equipment

The Conformance requirements for Frequency Hopping equipment (both Adaptive and Non-adaptive types) are covered in the following sub-sections.

5.3.1.1 RF Output Power

The RF output power is defined as the mean equivalent isotropic radiated power (e.i.r.p.) of the equipment during a transmission burst. The RF output power (e.i.r.p) limits are shown in the Table 16.

Table 16. Limits on RF Output Power

Equipment type	RF Output Power (e.i.r.p)	Notes
FHSS (Frequency Hopping) equipment	< = 20 dBm	
Non-adaptive FHSS (Frequency Hopping) equipment	< = Manufacturer declared value	Where the Manufacturer declare the value of < 20 dBm

5.3.1.2 Duty Cycle

Duty Cycle is defined as the ratio of the total transmitter 'on'-time to an observation period. The observation period is equal to:

- The average dwell time multiplied by 100; or
- The average dwell time multiplied by 2 times the number of hopping frequencies (N); whichever is the greater.

Tx-sequence is defined as a period in time during which a single or multiple transmissions may occur and which is followed by a Tx-gap. These multiple transmissions within a single Tx-sequence may take place on the same hopping frequency or on multiple hopping frequencies. Tx-gap is defined as a period in time during which no transmissions occur on any of the hopping frequencies.

Duty cycle limit applies to non-adaptive FHSS equipment only.

Duty cycle limit doesn't apply for equipment with a declared RF Output power of less than 10 dBm e.i.r.p. or for equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.

The Duty cycle must be declared by the manufacturer and should be in compliance with the limits mentioned in Table 8. The Duty Cycle limits are shown in the Table 17.

Table 17. Limits on Duty Cycle

Equipment type	RF Output Power (e.i.r.p)	Limits
FHSS (Frequency Hopping) equipment (adaptive or non-adaptive)	< 10 dBm	Doesn't Apply
Non-adaptive FHSS (Frequency Hopping) equipment	> = 10 dBm	<= Maximum value declared by the Manufacturer Maximum Tx-sequence time < = 5 ms. Minimum Tx-gap time <= 5 ms

5.3.1.3 Accumulated Transit Time, Frequency Occupation and Hopping Sequence

The Accumulated Transmit Time is defined as the total of the transmitter 'on'-times, during an observation period, on a particular hopping frequency.

The Frequency Occupation is defined as the number of times that each hopping frequency is occupied within a given period. A hopping frequency is considered to be occupied when the equipment selects that frequency from the Hopping Sequence. FHSS equipment may be transmitting, receiving or stay idle during the dwell time spent on that hopping frequency.

The Hopping Sequence of an FHSS equipment is defined as the pattern of the hopping frequencies used by the equipment.

The limits are different for both Adaptive and Non-adaptive equipment. The limits are shown in the Table 18.

Table 18. Limits on Accumulated Transmit Time, Frequency Occupation and Hopping Sequence

Equipment type	Limits		
	Accumulated Time	Frequency Occupation	Hopping Sequence
Non-adaptive FHSS (Frequency Hopping) equipment	< 15 ms within observation period of (15 ms * N) on any hopping frequency. Where, N is the number of hopping frequencies that have to be used.	Each hopping frequency of the Hopping Sequence should be occupied at least once within a period not exceeding four times the product of the dwell time and the number of hopping frequencies in use. The probability that each hopping frequency is occupied should be between ((1 / U) × 25%) and 77%. where U is the number of hopping frequencies in use.	The Hopping Sequence(s) should contain at least N hopping frequencies where N is either 5 or the result of 15 MHz divided by the minimum Hopping Frequency Separation in MHz, whichever is the greater.
Adaptive FHSS (Frequency Hopping) equipment	< 400 ms within any observation period of (400 ms * N) on any hopping frequency. Where, N is the number of hopping frequencies that have to be used.	Each hopping frequency of the Hopping Sequence should be occupied at least once within a period not exceeding four times the product of the dwell time and the number of hopping frequencies in use. The occupation probability for each frequency should be between ((1 / U) × 25%) and 77% where U is the number of hopping frequencies in use.	The Hopping Sequence(s) should contain at least N hopping frequencies at all times, where N is either 15 or the result of 15 MHz divided by the minimum Hopping Frequency Separation in MHz, whichever is the greater. Adaptive FHSS equipment should be capable of operating over a minimum of 70% of the band specified in table 5.

5.3.1.4 Hopping Frequency Separation

The Hopping Frequency Separation is defined as the frequency separation between two adjacent hopping frequencies.

The limit applies to all types of FHSS equipment.

The Hopping Frequency Separation limits are shown in the Table 19.

Table 19. Limits on Hopping Frequency Separation

Equipment type	RF Output Power (e.i.r.p)	Limits
FHSS (Frequency Hopping) equipment (adaptive or non-adaptive)	< 10 dBm	>= 100KHz
Non-adaptive FHSS (Frequency Hopping) equipment		>= OCBW with a Minimum separation of 100KHz
Adaptive FHSS (Frequency Hopping) equipment		>= 100KHz

5.3.1.5 Medium Utilization (MU) Factor

The Medium Utilization (MU) factor is defined as a measure to quantify the amount of resources (Power and Time) used by non-adaptive equipment. The Medium Utilization factor is defined by the formula:

$$MU = (Pout/ 100\ mW) \times DC \tag{1}$$

Where,

MU is Medium Utilization factor in %.

Pout is the RF output power in mW.

DC is the Duty Cycle in %.

The limit doesn't apply to adaptive FHSS equipment unless operating in a non-adaptive mode. The maximum Medium Utilization factor limits are shown in the Table 20.

Table 20. Limits on Medium Utilization Factor

Equipment Type	RF Output Power (e.i.r.p)	Limits
FHSS (Frequency Hopping) equipment (adaptive or non-adaptive)	< 10 dBm	Doesn't Apply
Adaptive FHSS (Frequency Hopping) equipment		Doesn't Apply
Non-adaptive FHSS (Frequency Hopping) equipment		<= 10%

5.3.1.6 Adaptivity (Adaptive FHSS)

The adaptive FHSS equipment is defined as equipment using a mechanism which allows it to adapt to its radio environment by identifying frequencies that are being used by other equipment. The adaptive frequency hopping mechanism is a method that allows FHSS equipment to adapt to its radio environment by identifying channels that are being used and excluding them from the list of available channels. There are two mechanisms in Adaptive FHSS, which are LBT (Listen-Before-Talk) and DAA (Detect And Avoid). Adaptive FHSS equipment should implement either of the mechanisms (LBT or DAA) and it is allowed to switch dynamically in between the two adaptive modes.

Adaptive FHSS equipment is allowed to have Short Control Signaling Transmissions without sensing the frequency for the presence of other signals.

The limit does not apply to non-adaptive FHSS equipment or adaptive equipment operating in a non-adaptive mode. In addition, this requirement does not apply for FHSS equipment with a maximum declared RF Output power level of less than 10 dBm e.i.r.p. or for FHSS equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.

The Adaptive FHSS limits are shown in the Table 21.

Table 21. Limits on FHSS Equipment

Equipment Type	RF Output Power (e.i.r.p)	Limits
FHSS (Frequency Hopping) equipment (adaptive or non-adaptive)	< 10 dBm	Doesn't Apply
Non-adaptive FHSS (Frequency Hopping) equipment		Doesn't Apply
Adaptive FHSS (Frequency Hopping) equipment - LBT		Please refer to Section 5.3.1.6.1
Adaptive FHSS (Frequency Hopping) equipment - DAA		Please refer to Section 5.3.1.6.2

5.3.1.6.1 Adaptive FHSS using LBT

Adaptive FHSS using LBT is a mechanism by which a given hopping frequency is made 'unavailable' because an interfering signal was detected before any transmission on that frequency.

Adaptive FHSS equipment using LBT should comply with the following minimum set of requirements.

1. At the start of every dwell time, before transmission on a hopping frequency, the equipment should perform a Clear Channel Assessment (CCA) check using energy detect. The CCA observation time should not be less than 0.2% of the Channel Occupancy Time with a minimum of 18 μs. If the equipment finds the hopping frequency to be clear, it may transmit immediately.
2. If it is determined that a signal is present with a level above the detection threshold defined in step 5, the hopping frequency should be marked as 'unavailable'. Then the equipment may jump to the next frequency in the hopping scheme (even before the end of the dwell time), but in that case the 'unavailable' channel cannot be considered as being 'occupied' and should be disregarded with respect to the requirement of the minimum number of hopping frequencies. Alternatively, the equipment can remain on the frequency during the remainder of the dwell time. However, if the equipment remains on the frequency with the intention to transmit, it should perform an Extended CCA check in which the (unavailable) channel is observed for a random duration between the value defined for the CCA observation time in step 1 and 5% of the Channel Occupancy Time defined in step 3. If the Extended CCA check has determined the frequency to be no longer occupied, the hopping frequency becomes available again. If the Extended CCA time has determined the channel still to be occupied, it should perform new Extended CCA checks until the channel is no longer occupied.
3. The total time during which an equipment has transmissions on a given hopping frequency without reevaluating the availability of that frequency is defined as the Channel Occupancy Time. The Channel Occupancy Time for a given hopping frequency, which starts immediately after a successful CCA, should be less than 60 ms followed by an Idle Period of at least 5% minimum of the Channel Occupancy Time with a minimum of 100 μs. After the Idle Period has expired, the procedure as in step 1 should be repeated before having new transmissions on this hopping frequency during the same dwell time.
   EXAMPLE: Equipment with a dwell time of 400 ms can have 6 transmission sequences of 60 ms each, separated with an Idle Period of 3 ms. Each transmission sequence was preceded with a successful CCA check of 120 μs.
   For LBT based adaptive FHSS equipment with a dwell time < 60 ms, the maximum Channel Occupancy Time is limited by the dwell time.
4. 'Unavailable' channels may be removed from or may remain in the Hopping Sequence, but in any case:
   - Apart from Short Control Signalling Transmissions, there should be no transmissions on 'unavailable' channels;
   - A minimum of N hopping frequencies should always be maintained.
5. The detection threshold should be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the detection threshold level (TL) should be equal to or less than -70 dBm/MHz at the input to the receiver assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) should not be taken into account. For power levels less than 20 dBm e.i.r.p., the detection threshold level may be relaxed to:

   $$TL = -70\ dBm/MHz + 10 \times \log10\ (100\ mW / Pout) \quad (2)$$

   Pout in mW e.i.r.p.
6. The equipment should comply with the requirements defined in step 1 to step 4 of the present clause in the presence of an unwanted CW signal as defined in Table 22.

Table 22. Limits on FHSS LBT Equipment - Unwanted Signal parameters

Wanted signal mean power from companion device	Unwanted CW signal frequency (MHz)	Unwanted CW signal power (dBm)
sufficient to maintain the link (2)	2395 or 2488.5 (1)	-35 (3)

(1) The highest frequency should be used for testing operating channels within the range 2400 MHz to 2442 MHz, while the lowest frequency should be used for testing operating channels within the range 2442 MHz to 2483.5 MHz.

(2) A typical conducted value which can be used in most cases is -50 dBm/MHz.

(3) The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna.

5.3.1.6.2 Adaptive FHSS Using DAA

Adaptive FHSS using Detect And Avoid (DAA) is a mechanism by which a given hopping frequency is made 'unavailable' because an interfering signal was reported after transmissions on that frequency. This mechanism should operate as intended in the presence of an unwanted signal on frequencies other than those of the operating band.

Adaptive FHSS equipment using DAA should comply with the following minimum set of requirements.

- During normal operation, the equipment should evaluate the presence of a signal for each of its hopping frequencies. If it is determined that a signal is present with a level above the detection threshold defined in step 5, the hopping frequency should be marked as 'unavailable'.
- The hopping frequency should remain unavailable for a minimum time equal to 1 second or 5 times the actual number of hopping frequencies in the current (adapted) channel map used by the equipment, multiplied with the Channel Occupancy Time, whichever is greater. There should be no transmissions during this silent period on this hopping frequency. After this, the hopping frequency may be considered again as an 'available' frequency.
- The total time during which an equipment has transmissions on a given hopping frequency without re-evaluating the availability of that hopping frequency is defined as the Channel Occupancy Time. The Channel Occupancy Time for a given hopping frequency should be less than 40 ms. For equipment using a dwell time > 40 ms that wants to have other transmissions during the same hop (dwell time), an Idle Period (no transmissions) of at least 5% minimum of the Channel Occupancy Period with a minimum of 100 μs should be implemented. After the Idle Period has expired, the equipment may continue its normal operation as explained in step 1.
  Example: An equipment with a dwell time of 400 ms can have 9 transmission sequences of 40 ms each, separated with an Idle Period of 2 ms.
  For FHSS equipment using DAA with a dwell time < 40 ms, the maximum Channel Occupancy Time may be non-contiguous; in other words, spread over a number of Hopping Sequences (equal to 40 ms divided by the dwell time [ms]).
- In case the 'unavailable' channels remain in the Hopping Sequence, apart from the Short Control Signalling Transmissions, there should be no transmissions on these 'unavailable' channels. In case the 'unavailable channels' are removed from the Hopping Sequence, a minimum of N hopping frequencies should always be maintained.
- The detection threshold should be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the detection threshold level (TL) should be equal to or less than -70 dBm/MHz at the input to the receiver, assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) should not be taken into account. For power levels less than 20 dBm e.i.r.p., the detection threshold level may be relaxed to:

$$TL = -70\ \text{dBm/MHz} + 10 \times \log10\ (100\ \text{mW} / \text{Pout}) \qquad (3)$$

  Pout in mW e.i.r.p.

- The equipment should comply with the requirements defined in step 1 to step 4 of the present clause in the presence of an unwanted CW signal as defined in Table 23.

Table 23. Limits on Adaptive FHSS DAA Equipment - Unwanted Signal parameters

Wanted signal mean power from companion device (dBm)	Unwanted CW signal frequency (MHz)	Unwanted CW signal power (dBm)
-30 (2)	2395 or 2488.5 (1)	-35 (3)

(1) The highest frequency should be used for testing operating channels within the range 2400 MHz to 2442 MHz, while the lowest frequency should be used for testing operating channels within the range 2442 MHz to 2483.5 MHz.

(2) The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density in front of the UUT antenna.

5.3.1.6.3 Adaptive FHSSS - Short Control Signaling Transmissions

Short Control Signalling Transmissions are transmissions used by Adaptive FHSS equipment to send management and control signals without sensing the hopping frequency for the presence of other signals. Adaptive equipment may have Short Control Signalling Transmissions.

Short Control Signalling Transmissions should have a maximum limit of TxOn / (TxOn + TxOff), ratio of 10% within any observation period of 50 ms or within an observation period equal to the dwell time, whichever is less.

5.3.1.7 Occupied Channel Bandwidth

The Occupied Channel Bandwidth is defined as the bandwidth that contains 99% of the power of the signal when considering a single hopping frequency.

The limits apply to all types of FHSS equipment. The limits are shown in Table 24.

Table 24. Limits on Occupied Channel Bandwidth

Equipment type	RF Output Power (e.i.r.p)	Limits
FHSS (Frequency Hopping) equipment (adaptive or non-adaptive)		OCBW should be within the Frequency band of 2400 MHz to 2483.5 MHz
Non-adaptive FHSS (Frequency Hopping) equipment	< 10 dBm	OCBW < = 5 MHz

5.3.1.8 Transmitter Unwanted Emissions in the Out-of-Band Domain

Transmitter unwanted emissions in the out-of-band domain are defined as emissions on frequencies immediately outside the allocated band, but excluding unwanted emissions in the spurious domain, when the equipment is in Transmit mode.

The limits apply to all types of FHSS equipment. The limits for unwanted emissions in the out-of-band-domain are shown in Table 25.

Table 25. Limits on Transmitter Unwanted Emissions in Out-Of-Band (OOB) domain

OOB Band (Frequency Range) (1)	Limits (Emission level in e.i.r.p)
From (2400 MHz – BW) to 2400 MHz From 2483.5 MHz to (2483.5 MHz + BW)	< -10 dBm/MHz
From (2400 MHz – 2*BW) to (2400 MHz – BW) From (2483.5 MHz + BW) to (2483.5 MHz + 2*BW)	< -20 dBm/MHz
From <(2400 MHz - 2*BW) to 2400 - 2*BW From >(2483.5 MHz + 2*BW) to (2483.5 MHz + 2*BW)	Refer to spurious domain limits

(1) BW = OCBW in MHz or 1 MHz whichever is greater

5.3.1.9 Transmitter Unwanted Emissions in the Spurious Domain

Transmitter unwanted emissions in the spurious domain are defined as emissions outside the allocated band and outside the out-of-band domain as shown in Table 16, when the equipment is in Transmit mode.

The limits apply to all types of FHSS equipment. The limits for unwanted emissions in the spurious domain are shown in Table 26.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 26. Limits on Transmitter Unwanted Emissions in Spurious domain

Frequency Range (Spurious Domain)	Limits (Maximum power level)	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz
47 MHz to 74 MHz	-54 dBm	100 kHz
74 MHz to 87.5 MHz	36 dBm	100 kHz
87.5 MHz to 118 MHz	-54 dBm	100 kHz
118 MHz to 174 MHz	-36 dBm	100 kHz
174 MHz to 230 MHz	-54 dBm	100 kHz
230 MHz to 470 MHz	-36 dBm	100 kHz
470 MHz to 694 MHz	-54 dBm	100 kHz
694 MHz to 1 GHz	-36 dBm	100 kHz
1 GHz to 12.75 GHz	-30 dBm	1 MHz

5.3.1.10 Receiver Spurious Emissions

Receiver spurious emissions are defined as emissions at any frequency when the equipment is in receive mode.

The limits apply to all types of FHSS equipment. The limits for receive spurious emissions are shown in Table 27.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 27. Limits on Receiver Spurious Emissions

Frequency Range	Limits (Maximum power level)	Bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12.75 GHz	-47 dBm	1 MHz

5.3.1.11 Receiver Blocking

Receiver blocking is defined as a measure of the ability of the equipment to receive a wanted signal on its operating channel without exceeding a given degradation due to the presence of an unwanted input signal (blocking signal) on frequencies other than those of the operating band and spurious responses.

If the receiver supports PER/FER tests, then the minimum performance criterion should be a PER or FER of <= 10% otherwise the minimum performance criterion should be no loss of the wireless transmission function needed for the intended use of the equipment.

The requirements apply to all types of FHSS equipment. There are different requirements for different receiver categories. The limits for different receive categories are shown in Table 28.

Table 28. Limits on Receiver Blocking (All Categories)

Receiver Category	Wanted signal mean power from companion device (dBm) (1),(4)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (4)	Type of blocking signal
1	(-133 dBm + 10 × log10(OCBW)) or -68 dBm whichever is less (2)	2380	>=-34	CW
		2504		
	(-139 dBm + 10 × log10(OCBW)) or -74 dBm whichever is less (3)	2300		
		2330		
		2360		
		2524		
		2584		
		2674		
2	(-139 dBm + 10 × log10(OCBW) + 10 dB) or (-74 dBm + 10 dB) whichever is less (5)	2380	>=-34	CW
		2504		
		2300		
		2584		
3	(-139 dBm + 10 × log10(OCBW) + 20 dB) or (-74 dBm + 20 dB) whichever is less (6)	2380	>=-34	CW
		2504		
		2300		
		2584		

(1) OCBW is in Hz.

(2) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 26 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in this section in the absence of any blocking signal.

(3) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 20 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in in this section in the absence of any blocking signal.

(4) The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned for maximum e.i.r.p. towards the measuring antenna.

(5) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 26 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in this section in the absence of any blocking signal.

(6) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 30 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in this section in the absence of any blocking signal.

5.3.1.12 Geo-Location Capability

Geo-location capability is a feature of the equipment to determine its geographical location with the purpose to configure itself according to the regulatory requirements applicable at the geographical location where it operates.

The geo-location capability may be present in the equipment or in an external device (temporary) associated with the equipment operating at the same geographical location during the initial power up of the equipment. The geographical location may also be available in equipment already installed and operating at the same geographical location.

The requirement only applies to FHSS equipment with geo-location capability. The geographical location determined by the FHSS equipment should not be accessible to the user in a way that would allow the user to alter it.

5.3.2 Conformance Requirements for Wideband Data Transmission Equipment (Non-FHSS)

Wideband Data Transmission equipment different from FHSS equipment typically operates on a fixed frequency. The Conformance requirements for Wideband Data Transmission equipment are covered in the following sub-sections.

5.3.2.1 RF Output Power

The RF output power is defined as the mean equivalent isotropic radiated power (e.i.r.p.) of the equipment during a transmission burst.

The limits apply to types of non-FHSS equipment. The RF output power (e.i.r.p.) limits are shown in the Table 29.

Table 29. Limits on RF Output Power - Non-FHSS Equipment

Equipment type	RF Output Power (e.i.r.p.)	Notes
Non-FHSS equipment	< = 20 dBm	
Non-adaptive Non-FHSS equipment	< = Manufacturer declared value	Where the Manufacturer declare the value of < 20 dBm

5.3.2.2 Power Spectral Density

The Power Spectral Density (PSD) is defined as the mean equivalent isotropically radiated power (e.i.r.p.) spectral density in a 1 MHz bandwidth during a transmission burst.

The limits apply to types of non-FHSS equipment.

The maximum Power Spectral Density for non-FHSS equipment is < = 10 dBm per MHz.

5.3.2.3 Duty Cycle, Tx-sequence and Tx-gap

Duty Cycle is defined as the ratio of the total transmitter 'on'-time to a 1 second observation period. Tx-sequence is defined as a period in time during which a single or multiple transmissions may occur and which is followed by a Tx-gap.

Tx-gap is defined as a period in time during which no transmissions occur.

The limits apply to all non-FHSS equipment.

The limit doesn't apply for equipment with a declared RF Output power of less than 10 dBm e.i.r.p. or for equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.

The Duty cycle must be declared by the manufacturer and should be in compliance with the limits mentioned in Table 28. The Duty Cycle limits are shown in the Table 30.

Table 30. Limits on Duty Cycle, Tx-sequence and Tx-gap - Non-FHSS Equipment

Equipment type	RF Output Power (e.i.r.p.)	Limits
Non- FHSS equipment (adaptive or non-adaptive)	< 10 dBm	Doesn't Apply
Non-FHSS equipment	> = 10 dBm	<= Maximum value declared by the Manufacturer Maximum Tx-sequence time < = 10 ms. Minimum Tx-gap time <= 3.5 ms

5.3.2.4 Medium Utilization Factor

The Medium Utilization (MU) factor is defined as a measure to quantify the amount of resources (Power and Time) used by non-adaptive equipment. The Medium Utilization factor is defined by the formula:

$$MU = (Pout / 100 \text{ mW}) \times DC \quad (4)$$

Where,

MU is Medium Utilization factor in %.
Pout is the RF output power in mW.
DC is the Duty Cycle in %.

The limit doesn't apply to adaptive non-FHSS equipment unless operating in a non-adaptive mode. The maximum Medium Utilization factor limits are shown in the Table 31.

Table 31. Limits on Medium Utilization Factor - Non-FHSS Equipment

Equipment type	RF Output Power (e.i.r.p.)	Limits
Non-FHSS equipment (adaptive or non-adaptive)	< 10 dBm	Doesn't Apply
Adaptive Non-FHSS equipment		Doesn't Apply
Non-adaptive Non-FHSS equipment		<= 10%

5.3.2.5 Adaptivity (Non-FHSS)

The adaptive Non-FHSS equipment is defined as equipment using a mechanism which allows it to adapt to its radio environment by identifying other transmissions present within its Occupied Channel Bandwidth.

There are two mechanisms in Adaptive Non-FHSS, which are LBT (Listen-Before-Talk) and DAA (Detect And Avoid). Adaptive Non-FHSS equipment should implement either of the mechanisms (LBT or DAA) and it is allowed to switch dynamically in between the two adaptive modes.

Adaptive Non-FHSS equipment is allowed to have Short Control Signaling Transmissions without sensing the frequency for the presence of other signals.

The limit doesn't apply to non-adaptive Non-FHSS equipment or adaptive equipment operating in a non-adaptive mode. In addition, this requirement does not apply for Non-FHSS equipment with a maximum declared RF Output power level of less than 10 dBm e.i.r.p. or for Non-FHSS equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.

The Adaptive Non-FHSS limits are shown in the Table 32.

Table 32. Limits on Non-FHSS Equipment

Equipment type	RF Output Power (e.i.r.p)	Limits
Non-FHSS equipment (adaptive or non-adaptive)	< 10 dBm	Doesn't Apply
Non-adaptive Non-FHSS equipment		Doesn't Apply
Adaptive Non-FHSS equipment - LBT		Please refer to Section 5.3.2.5.1
Adaptive Non-FHSS equipment - DAA		Please refer to Section 5.3.2.5.2

5.3.2.5.1 Adaptive Non-FHSS using LBT

Adaptive Non-FHSS using LBT is a mechanism by which Non-FHSS adaptive equipment avoids transmissions in a channel in the presence of an interfering signal in that channel. This mechanism should operate as intended in the presence of an unwanted signal on frequencies other than those of the operating band.

There are two types Adaptive Non-FHSS equipment that uses an LBT mechanism, which are:

- Frame Based Equipment, and
- Load Base Equipment

Adaptive non-FHSS equipment which is capable of operating as either Load Based Equipment or as Frame Based Equipment is allowed to switch dynamically between these types of operation.

5.3.2.5.1.1 Frame Based Equipment

Frame Based Equipment should comply with the following minimum set of requirements.

- Before transmission, the equipment should perform a Clear Channel Assessment (CCA) check using energy detect. The equipment should observe the operating channel for the duration of the CCA observation time, which should be not less than 18 μs. The channel should be considered occupied if the energy level in the channel exceeds the threshold given in step 5 below. If the equipment finds the channel to be clear, it may transmit immediately.
- If the equipment finds the channel occupied, it should not transmit on this channel during the next Frame Period.
  The equipment is allowed to switch to a non-adaptive mode and to continue transmissions on this channel providing it complies with the requirements applicable to non-adaptive equipment.
  Alternatively, the equipment is also allowed to continue Short Control Signalling Transmissions on this channel, providing it complies with the requirements to Signalling Transmissions.
- The total time during which an equipment has transmissions on a given channel without re-evaluating the availability of that channel, is defined as the Channel Occupancy Time. The Channel Occupancy Time should be in the range 1 ms to 10 ms followed by an Idle Period of at least 5% of the Channel Occupancy Time used in the equipment for the current Frame Period.
- An equipment, upon correct reception of a transmission which was intended for this equipment, can skip CCA and immediately (see also next paragraph) proceed with the transmission of management and control frames. A consecutive sequence of such transmissions by the equipment without a new CCA should not exceed the maximum Channel Occupancy Time. For the purpose of multi-cast, the ACK transmissions (associated with the same data packet) of the individual devices are allowed to take place in a sequence.
- The energy detection threshold for the CCA should be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the CCA threshold level (TL) should be equal to or less than -70 dBm/MHz at the input to the receiver assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) should not be taken into account. For power levels less than 20 dBm e.i.r.p. the CCA threshold level may be relaxed to:

  $$TL = -70\ dBm/MHz + 10 \times \log10\ (100\ mW / Pout) \quad (5)$$

  Pout in mW e.i.r.p.

- The equipment should comply with the requirements defined in step 1 to step 4 in the present clause in the presence of an unwanted CW signal as defined in Table 33.

Table 33. Limits on Unwanted Signal Parameters - Frame Based Equipment

Wanted signal mean power from companion device	Unwanted CW signal frequency (MHz)	Unwanted CW signal power (dBm)
sufficient to maintain the link (2)	2395 or 2488.5 (1), (2), and (3)	-35 (3)

(1) The highest frequency should be used for testing operating channels within the range 2400 MHz to 2442 MHz, while the lowest frequency should be used for testing operating channels within the range 2442 MHz to 2483.5 MHz.

(2) A typical conducted value which can be used in most cases is -50 dBm/MHz.

(3) The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna.

5.3.2.5.1.2 Load Based Equipment

Load Based Equipment may implement an LBT based spectrum sharing mechanism based on the Clear Channel Assessment (CCA) mode using energy detect as described in IEEE 802.11™ [i.3], clause 10, clause 11, clause 15, clause 16, clause 18 and clause 19; or in IEEE 802.15.4™ [i.4], clause 5, clause 6 and clause 10, providing the equipment complies with the conformance requirements referred in this section. Load Based Equipment not using any of the mechanisms referenced above should comply with the following minimum set of requirements:

- Before a transmission or a burst of transmissions, the equipment should perform a Clear Channel Assessment (CCA) check using energy detect. The equipment should observe the operating channel for the duration of the CCA observation time which should be not less than 18 µs. The channel should be considered occupied if the energy level in the channel exceeds the threshold given in step 5 below. If the equipment finds the channel to be clear, it may transmit immediately.
- If the equipment finds the channel occupied, it should not transmit on this channel. The equipment should perform an Extended CCA check in which the channel is observed for a random duration in the range between 18 µs and at least 160 µs. If the extended CCA check has determined the channel to be no longer occupied, the equipment may resume transmissions on this channel. If the Extended CCA time has determined the channel still to be occupied, it should perform new Extended CCA checks until the channel is no longer occupied.
  Please note that the Idle Period in between transmissions is considered to be the CCA or the Extended CCA check as there are no transmissions during this period.
  The equipment is allowed to switch to a non-adaptive mode and to continue transmissions on this channel providing it complies with the requirements applicable to non-adaptive equipment.
  Alternatively, the equipment is also allowed to continue Short Control Signalling Transmissions on this channel providing it complies with the requirements given in Signalling Transmissions section.
- The total time that an equipment makes use of an RF channel is defined as the Channel Occupancy Time. This Channel Occupancy Time should be less than 13 ms, after which the device should perform a new CCA as described in step 1 above.
- The equipment, upon correct reception of a transmission which was intended for this equipment can skip CCA and immediately (see also next paragraph) proceed with the transmission of management and control frames. A consecutive sequence of transmissions by the equipment without a new CCA should not exceed the maximum channel occupancy time as defined in step 3 above.
  For the purpose of multi-cast, the ACK transmissions (associated with the same data packet) of the individual devices are allowed to take place in a sequence.
- The energy detection threshold for the CCA should be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the CCA threshold level (TL) should be equal to or less than -70 dBm/MHz at the input to the receiver assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) should not be taken into account. For power levels less than 20 dBm e.i.r.p., the CCA threshold level may be relaxed to:

$$TL = -70 \text{ dBm/MHz} + 10 \times \log10 (100 \text{ mW} / Pout) \quad (6)$$

  Pout in mW e.i.r.p.

- The equipment should comply with the requirements defined in step 1 to step 4 in the present clause in the presence of an unwanted CW signal as defined in Table 34.

Table 34. Limits on Unwanted Signal parameters - Load Based equipment

Wanted signal mean power from companion device	Unwanted CW signal frequency (MHz)	Unwanted CW signal power (dBm)
sufficient to maintain the link (3)	2395 or 2488.5 (1)	-35 (2)

(1) The highest frequency should be used for testing operating channels within the range 2400 MHz to 2442 MHz, while the lowest frequency should be used for testing operating channels within the range 2442 MHz to 2483.5 MHz.

(2) A typical conducted value which can be used in most cases is -50 dBm/MHz.

(3) The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna.

5.3.2.5.2 Adaptive Non-FHSS Using DAA

Adaptive Non-FHSS using DAA (Detect And Avoid) is a mechanism for Non-FHSS equipment by which a given channel is made 'unavailable' because an interfering signal was reported after the transmission in that channel.

Adaptive Non-FHSS equipment using DAA should comply with the following minimum set of requirements.

- During normal operation, the equipment should evaluate the presence of a signal on its current operating channel(s). If it is determined that a signal is present with a level above the detection threshold defined in step 4 that channel should be marked as 'unavailable'.
- The channel(s) should remain unavailable for a minimum time equal to 1 s after which the channel may be considered again as an 'available' channel.
- The total time during which an equipment has transmissions on a given channel without re-evaluating the availability of that channel is defined as the Channel Occupancy Time. The Channel Occupancy Time should be less than 40 ms. Each such transmission sequence should be followed by an Idle Period (no transmissions) of at least 5% of the Channel Occupancy Time, with a minimum of 100 μs. After this, the procedure as in step 1 needs to be repeated.
- The detection threshold should be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the detection threshold level (TL) should be equal to or less than -70 dBm/MHz at the input to the receiver assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) should not be taken into account. For power levels less than 20 dBm e.i.r.p., the detection threshold level may be relaxed to:

$$TL = -70 \text{ dBm/MHz} + 10 \times \log10 (100 \text{ mW} / Pout) \quad (7)$$

Pout in mW e.i.r.p.

- The equipment should comply with the requirements defined in step 1 to step 4 of the present clause in the presence of an unwanted CW signal as defined in Table 35.

Table 35. Limits on Unwanted Signal Parameters - Adaptive Non-FHSS DAA Equipment

Wanted signal mean power from companion device (dBm)	Unwanted CW signal frequency (MHz)	Unwanted CW signal power (dBm)
-30 (2)	2395 or 2488.5 (1)	-35 (3)

(1) The highest frequency should be used for testing operating channels within the range 2400 MHz to 2442 MHz, while the lowest frequency should be used for testing operating channels within the range 2442 MHz to 2483.5 MHz.

(2) The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density in front of the UUT antenna.

5.3.2.5.3 Adaptive Non-FHSS - Short Control Signaling Transmissions

Short Control Signaling Transmissions are transmissions used by Adaptive Non-FHSS equipment to send management and control signals without sensing the operating channel for the presence of other signals. Adaptive equipment may have Short Control Signaling Transmissions.

Short Control Signaling Transmissions should have a maximum limit of TxOn / (TxOn + TxOff) ratio of 10% within any observation period of 50 ms.

5.3.2.6 Occupied Channel Bandwidth

The Occupied Channel Bandwidth is defined as the bandwidth that contains 99% of the power of the signal.

The limits apply to all types of Non-FHSS equipment. The limits are shown in Table 36.

Table 36. Limits on Occupied Channel Bandwidth - Non-FHSS Equipment

Equipment type	RF Output Power (e.i.r.p)	Limits
Non-FHSS equipment (adaptive or non-adaptive)		OCBW should be within the Frequency band of 2400 MHz to 2483.5 MHz
Non-adaptive Non-FHSS equipment	>10 dBm	OCBW < = 20 MHz

5.3.2.7 Transmitter Unwanted Emissions in the Out-of-Band Domain

Transmitter unwanted emissions in the out-of-band domain are defined as emissions on frequencies immediately outside the allocated band, but excluding unwanted emissions in the spurious domain, when the equipment is in Transmit mode.

The limits apply to all types of Non-FHSS equipment. The limits for unwanted emissions in the out-of-band-domain are shown in Table 37.

Table 37. Limits on Transmitter Unwanted Emissions in Out-of-Band (OOB) domain - Non-FHSS

OOB Band (Frequency Range) (1)	Limits (Emission level in e.i.r.p)
From (2400 MHz – BW) to 2400 MHz From 2483.5 MHz to (2483.5 MHz + BW)	< -10 dBm/MHz
From (2400 MHz – 2*BW) to (2400 MHz – BW) From (2483.5 MHz + BW) to (2483.5 MHz + 2*BW)	< -20 dBm/MHz
From <(2400 MHz - 2*BW) to 2400 -2*BW From >(2483.5 MHz + 2*BW) to (2483.5 MHz + 2*BW)	Refer to spurious domain limits

(1) BW = OCBW in MHz or 1 MHz whichever is greater

5.3.2.8 Transmitter Unwanted Emissions in the Spurious Domain

Transmitter unwanted emissions in the spurious domain are defined as emissions outside the allocated band and outside the out-of-band domain as shown in Table 28, when the equipment is in Transmit mode.

The limits apply to all types of Non-FHSS equipment. The limits for unwanted emissions in the spurious domain are shown in Table 38.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 38. Limits on Transmitter Unwanted Emissions in Spurious domain - Non-FHSS

Frequency Range (Spurious Domain)	Limits (Maximum power level)	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz
47 MHz to 74 MHz	-54 dBm	100 kHz
74 MHz to 87.5 MHz	36 dBm	100 kHz
87.5 MHz to 118 MHz	-54 dBm	100 kHz
118 MHz to 174 MHz	-36 dBm	100 kHz
174 MHz to 230 MHz	-54 dBm	100 kHz
230 MHz to 470 MHz	-36 dBm	100 kHz
470 MHz to 694 MHz	-54 dBm	100 kHz
694 MHz to 1 GHz	-36 dBm	100 kHz
1 GHz to 12.75 GHz	-30 dBm	1 MHz

5.3.2.9 Receiver Spurious Emissions

Receiver spurious emissions are defined as emissions at any frequency when the equipment is in receive mode.

The limits apply to all types of Non-FHSS equipment. The limits for receive spurious emissions are shown in Table 39.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 39. Limits on Receiver Spurious Emissions - Non-FHSS Equipment

Frequency Range	Limits (Maximum power level)	Bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12.75 GHz	-47 dBm	1 MHz

5.3.2.10 *Receiving Blocking*

Receiver blocking is defined as a measure of the ability of the equipment to receive a wanted signal on its operating channel without exceeding a given degradation due to the presence of an unwanted input signal (blocking signal) on frequencies other than those of the operating band and spurious responses.

If the receiver supports PER/FER tests, then the minimum performance criterion should be a PER or FER of <= 10%. Otherwise, the minimum performance criterion should be no loss of the wireless transmission function needed for the intended use of the equipment.

The requirements apply to all types of Non-FHSS equipment. There are different requirements for different receiver categories. The limits for different receiver categories are shown in Table 40.

Table 40. Limits on Receiver Blocking (All Categories) - Non-FHSS Equipment

Receiver Category	Wanted signal mean power from companion device (dBm) (1)(4)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (4)	Type of blocking signal
1	(-133 dBm + 10 × log10(OCBW)) or -68 dBm whichever is less (2)	2380	>=-34	CW
		2504		
	(-139 dBm + 10 × log10(OCBW)) or -74 dBm whichever is less (3)	2300		
		2330		
		2360		
		2524		
		2584		
		2674		
2	(-139 dBm + 10 × log10(OCBW) + 10 dB) or (-74 dBm + 10 dB) whichever is less (5)	2380	>=-34	CW
		2504		
		2300		
		2584		
3	(-139 dBm + 10 × log10(OCBW) + 20 dB) or (-74 dBm + 20 dB) whichever is less (6)	2380	>=-34	CW
		2504		
		2300		
		2584		

(1) OCBW is in Hz.

(2) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 26 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in this section in the absence of any blocking signal.

(3) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 20 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in in this section in the absence of any blocking signal.

(4) The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements,

this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned for maximum e.i.r.p. towards the measuring antenna.

(5) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 26 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in this section in the absence of any blocking signal.

(6) In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to Pmin + 30 dB where Pmin is the minimum level of wanted signal required to meet the minimum performance criteria as defined in this section in the absence of any blocking signal.

5.3.2.11 Geo-Location Capability

Geo-location capability is a feature of the equipment to determine its geographical location with the purpose to configure itself according to the regulatory requirements applicable at the geographical location where it operates.

The geo-location capability may be present in the equipment or in an external device (temporary) associated with the equipment operating at the same geographical location during the initial power up of the equipment. The geographical location may also be available in equipment already installed and operating at the same geographical location.

The requirement only applies to Non-FHSS equipment with geo-location capability. The geographical location determined by the Non-FHSS equipment should not be accessible to the user in a way that would allow the user to alter it.

6 ETSI EN 301 893

The ETSI EN 301 893 is a Harmonized European standard which applies to 5 GHz Wireless Access Systems (WAS), including RLAN (Radio Local Area Networks) equipment used in wireless local area networks for high speed data communication. This standard describes the spectrum access requirements, technical requirements specifications, conformance requirements and test procedures for compliance. The complete document can be downloaded from the ETSI website. The following is the summary of the most important requirements for both the transmitter and the receiver in EN 301 893 standard. The operating frequency band limits is shown in Table 41.

Table 41. Limits on Service Frequency Bands - 5 GHz

Mode of operation	Frequency Band
Transmit	5150 MHz to 5350 MHz
Receive	5150 MHz to 5350 MHz
Transmit	5470 MHz to 5725 MHz
Receive	5470 MHz to 5725 MHz

6.1 Technical Requirements

The equipment should comply with all applicable technical requirements at all times when operating within the boundary limits of the operational environmental profile declared by the manufacturer. The technical requirements for different types of equipment are shown in Table 42.

Table 42. Technical Requirements and Conditions

Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive 2014/53/EU	Clause(s) of the EN301 893	U/C (1)	Condition
1	Carrier frequencies	3.2	4.2.1	U	
2	Nominal, and occupied, channel bandwidth	3.2	4.2.2	U	
3	RF Output Power	3.2	4.2.3	U	Only for non-Adaptive equipment
	Transmit Power Control (TPC)	3.2	4.2.3	C	1) Not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz. 2) Not required for devices that operate at a maximum mean e.i.r.p. of 20 dBm when operating in 5250 MHz to 5350 MHz or 27 dBm when operating in 5470 MHz to 5725 MHz.
	Power Density	3.2	4.2.3	U	
4	Transmitter unwanted emissions outside the 5 GHz RLAN bands	3.2	4.2.4.1	U	
5	Transmitter unwanted emissions within the 5 GHz RLAN bands	3.2	4.2.4.2	U	
6	Receiver spurious emissions	3.2	4.2.5	U	

Table 42. Technical Requirements and Conditions (continued)

Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive 2014/53/EU	Clause(s) of the EN301 893	U/C (1)	Condition
7	DFS: Channel Availability Check	3.2	4.2.6.2.2	C	1) Not required for channels whose Nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz. 2) Not required for Slave devices with a maximum transmit power of less than 200 mW e.i.r.p. 3) Not required at initial use of a channel for slave devices with a maximum transmit power of 200 mW e.i.r.p.
8	DFS: Off-Channel CAC – Radar Detection Threshold Level	3.2	4.2.6.2.3	C	1) Where implemented by the manufacturer. 2) Not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz. 3) Not required for slave devices with a maximum transmit power of less than 200 mW e.i.r.p. 4) Not required at initial use of a channel for Slave devices with a maximum transmit power of 200 mW e.i.r.p.
9	DFS: Off-Channel CAC – Detection Probability	3.2	4.2.6.2.3	C	1) Where implemented by the manufacturer. 2) Not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz. 3) Not required for slave devices with a maximum transmit power of less than 200 mW e.i.r.p. 4) Not required at initial use of a channel for Slave devices with a maximum transmit power of 200 mW e.i.r.p.
10	DFS: In service Monitoring	3.2	4.2.6.2.4	C	1) Not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz. 2) Not required for Slave devices with a maximum transmit power of less than 200 mW e.i.r.p.
11	DFS: Channel shutdown	3.2	4.2.6.2.5	C	Not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz.
12	DFS: Non-occupancy period	3.2	4.2.6.2.6	C	1) Not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz. 2) Not required for Slave devices with a maximum transmit power of less than 200 mW e.i.r.p.
13	DFS: Uniform spreading	3.2	4.2.6.2.7	C	1) Not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz. 2) Not required for Slave devices.
14	Adaptivity	3.2	4.2.7	U	
15	Receiver Blocking	3.2	4.2.8	U	

Table 42. Technical Requirements and Conditions (continued)

Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive 2014/53/EU	Clause(s) of the EN301 893	U/C (1)	Condition
16	User Access Restrictions	3.2	4.2.9	U	
17	Geo-location capability	3.2	4.2.10	C	Where implemented by the manufacturer.

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

6.1.1 Environmental Profile

The environmental profile for operation of the equipment should be declared by the manufacturer. The equipment should comply with all applicable technical requirements at all times when operating within the boundary limits of the declared operational environmental profile.

6.2 Conformance Requirements

The Conformance requirements are covered in the following sub-sections.

6.2.1 Nominal Center Frequencies

The Nominal Center Frequency is defined as the center frequency of the Operating Channel.

The Nominal Center Frequencies (Fc) for a Nominal Channel Bandwidth of 20 MHz are defined by the following equation.

$$Fc = 5160 + (g \times 20) \text{ MHz}, \quad (8)$$

where $0 \leq g \leq 9$ or $16 \leq g \leq 27$ and where g should be an integer.

A maximum offset of the Nominal Centre Frequency of ±200 kHz is permitted. Where the manufacturer decides to make use of this frequency offset, the manufacturer should declare the actual center frequencies used by the equipment.

The limits on actual center frequency tolerance are shown in Table 43.

Equipment may have simultaneous transmissions on more than one Operating Channel with a Nominal Channel Bandwidth of 20 MHz.

Table 43. Limits on Center Frequency

Channel Frequency	Limits
Actual Center Frequency (Fc)	< = Fc ± 20 ppm

6.2.2 Nominal Channel Bandwidth and Occupied Channel Bandwidth

The Nominal Channel Bandwidth is defined as the widest band of frequencies, inclusive of guard bands, assigned to a single channel.

The Occupied Channel Bandwidth is defined as the bandwidth containing 99% of the power of the signal.

The limits on Nominal Channel Bandwidth and Occupied Channel Bandwidth are shown in Table 44.

Table 44. Limits on Nominal and Occupied Channel Bandwidth

Parameter	Limits
Nominal Channel Bandwidth for a single operating channel	20 MHz or >5MHz provided if the equipment comply with the Nominal Center Frequencies defined in Section 6.2.1
Occupied Channel Bandwidth for a single operating channel	>= 80% <= 100% of Nominal Channel Bandwidth In case of smart antenna systems (devices with multiple transmit chains) each of the transmit chains should meet the above requirement. During a Channel Occupancy Time (COT), equipment may operate temporarily with an occupied Channel Bandwidth of < 80% of its Nominal Channel Bandwidth with a minimum of 2 MHz

6.2.3 RF Output Power, Transmit Power Control (TPC) and Power Density

The RF output power is defined as the mean equivalent isotropic radiated power (e.i.r.p.) during a transmission burst.

Transmit Power Control (TPC) is defined as a mechanism to be used by the RLAN device to ensure a mitigation factor of at least 3 dB on the aggregate power from a large number of devices. This requires the RLAN device to have a TPC range from which the lowest value is at least 6 dB below the values for mean e.i.r.p. given in table 36 for devices with TPC.

The Power Density is defined as the mean equivalent isotropically radiated power (e.i.r.p.) density during a transmission burst.

The limits below are applicable to the system as a whole and in any possible configuration. This means that the antenna gain of the integral or dedicated antenna has to be taken into account as well as the additional (beamforming) gain in case of smart antenna systems (devices with multiple transmit chains).

In case of multiple (adjacent or non-adjacent) channels within the same sub-band, the total RF Output Power of all channels in that sub-band should not exceed the limits defined in Table 45 and Table 46.

In case of multiple, non-adjacent channels operating in separate sub-bands, the total RF Output Power in each of the sub-bands should not exceed the limits defined in Table 45 and Table 46.

TPC is not required for channels whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz.

The limits on RF output power and the Power Density at the highest power level (PH) of the TPC range and without TPC are shown in Table 45.

Table 45. Limits on RF Output Power and Power Density at the Highest Power Level (P_H)

Frequency Range (MHz)	Mean e.i.r.p. limit for PH (dBm)		Mean e.i.r.p. density limit (dBm/MHz)	
	With TPC	Without TPC	With TPC	Without TPC
5150 to 5350	< 23	< 20 / 23 (1)	< 10	< 7 / 10 (2)
5470 to 5725	< 30 (3)	< 27 (3)	< 17 (3)	< 14 (3)

(1) The applicable limit is 20 dBm, except for transmissions whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz, in which case the applicable limit is 23 dBm.

(2) The applicable limit is 7 dBm/MHz, except for transmissions whose nominal bandwidth falls completely within the band 5150 MHz to 5250 MHz, in which case the applicable limit is 10 dBm/MHz.

(3) Slave devices without a Radar Interference Detection function should comply with the limits for the frequency range 5250 MHz to 5350 MHz.

For devices using TPC, the limits on RF output power at the lowest power level (P_L) of the TPC range are shown in Table 46.

Table 46. Limits on RF Output Power at the Lowest Power Level (P_L) of TPC

Frequency Range (MHz)	Mean e.i.r.p. limit for P_L (dBm)
5250 to 5350	< 17
5470 to 5725	< 24 (1)

(1) Slave devices without a Radar Interference Detection function should comply with the limits for the frequency range 5250 MHz to 5350 MHz.

(2) The above limits don't apply to the devices without TPC.

6.2.4 Transmitter Unwanted Emissions - Outside the 5 GHz RLAN Bands

Transmitter unwanted emissions outside the 5 GHz RLAN bands are defined as the radio frequency emissions outside the 5 GHz RLAN bands (5150 MHz to 5350 MHz and 5470 MHz to 5725 MHz), when the equipment is the transmit mode.

The limits for transmitter unwanted emissions outside the 5 GHz RLAN bands are shown in Table 47.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 47. Limits on Transmitter Unwanted Emissions - Outside the 5 GHz RLAN Bands

Frequency Range (Spurious Domain)	Limits (Maximum power level)	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz
47 MHz to 74 MHz	-54 dBm	100 kHz
74 MHz to 87.5 MHz	36 dBm	100 kHz
87.5 MHz to 118 MHz	-54 dBm	100 kHz
118 MHz to 174 MHz	-36 dBm	100 kHz
174 MHz to 230 MHz	-54 dBm	100 kHz
230 MHz to 470 MHz	-36 dBm	100 kHz
470 MHz to 862 MHz	-54 dBm	100 kHz
862 MHz to 1 GHz	-36 dBm	100 kHz
1 GHz to 5.15 GHz	-30 dBm	1 MHz
5.35 GHz to 5.47 GHz	-30 dBm	1 MHz
5.725 GHz to 26 GHz	-30 dBm	1 MHz

6.2.5 Transmitter Unwanted Emissions - Within 5 GHz RLAN Bands

Transmitter unwanted emissions within the 5 GHz RLAN bands are defined as the radio frequency emissions within the 5 GHz RLAN bands (5150 MHz to 5350 MHz and 5470 MHz to 5725 MHz), when the equipment is in transmit mode.

The limits for transmitter unwanted emissions within the 5 GHz RLAN bands are shown in Table 48.

In case of smart antenna systems (devices with multiple transmit chains), each of the transmit chains should meet the spectral mask limits provided in Table 48. The spectral mask limits are also shown in Figure 2.

For transmitter unwanted emissions within the 5 GHz RLAN bands, simultaneous transmissions in adjacent channels may be considered as one signal with an actual Nominal Channel Bandwidth of "n" times the individual Nominal Channel Bandwidth, where "n" is the number of adjacent channels used simultaneously.

For simultaneous transmissions in multiple non-adjacent channels, the overall transmit spectral power mask is constructed in the following manner. First, a mask as provided in Table 48 is applied to each of the channels. Then, for each frequency point, the greatest value from the spectral masks of all the channels assessed should be taken as the overall spectral mask requirement at that frequency.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 48. Limits on Transmitter Unwanted Emissions - Within the 5 GHz RLAN Bands

Frequency relative to the Center of the Channel	Limits		
	Relative spur level to the Maximum Power Density in 1MHz Bandwidth, dBc/MHz	Absolute Spur level of the Power Density in 1MHz Bandwidth, dBm/MHz	Requirement
From < ((-10.8)*N) to (-10.8)*N	<= -47	<= -30	should not exceed either Relative level or an Absolute level, whichever is greater.
From ((-10.8)*N) to (-9*N)	<= -42	<= -30	
From (-9*N) to (-1.5*N)	<= -40	<= -30	
At -1*N	<= -28	<= -30	
At -0.55*N	<= -20	<= -30	
At -0.50*N	0		
From (-0.5*N) to (0*N)	0		
At 0*N	0 (Reference Level)		
From (0*N) to (0.5*N)	0		
At +0.50*N	0		
At +0.55*N	<= -20	<= -30	
At +1*N	<= -28	<= -30	
From (1.5*N) to (9*N)	<= -40	<= -30	
From (9*N) to ((10.8)*N)	<= -42	<= -30	
From > ((10.8)* N) to (10.8)* N	<= -47	<= -30	
N = Nominal Channel Bandwidth in MHz			

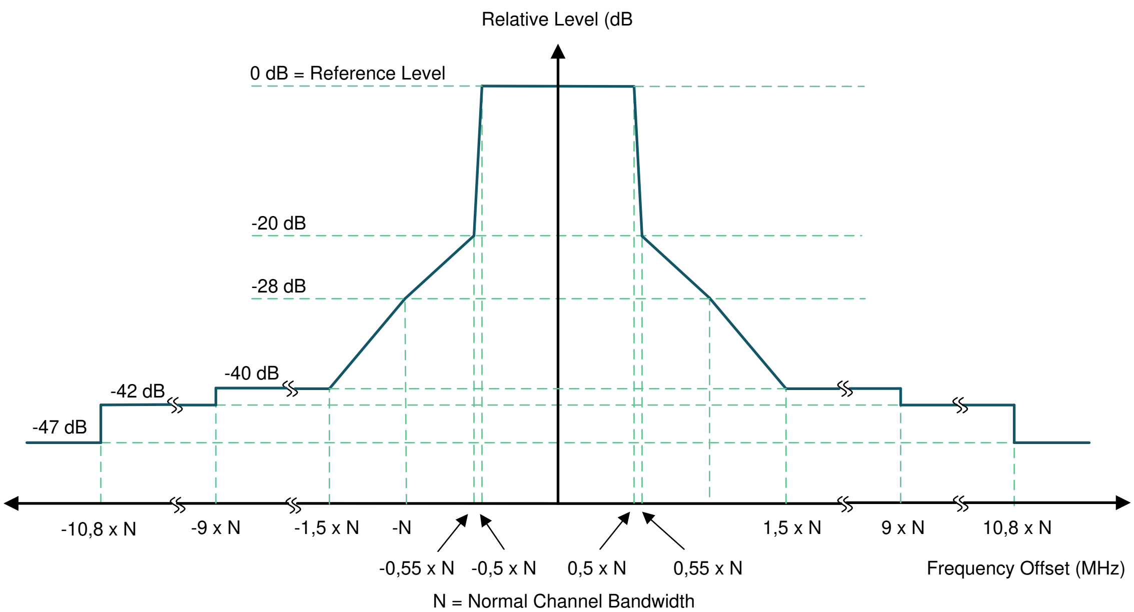


Figure 2. Transmit Spectral Power Mask

6.2.6 Receiver Spurious Emissions

Receiver spurious emissions are defined as emissions at any frequency when the equipment is in receive mode.

The limits for receiver spurious emissions are shown in Table 49.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 49. Limits on Receiver Spurious Emissions

Frequency Range	Limits (Maximum power level)	Bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12.75 GHz	-47 dBm	1 MHz

6.2.7 Dynamic Frequency Selection (DFS)

An RLAN should employ a Dynamic Frequency Selection (DFS) function to:

- Detect interference from radar systems (radar detection) and to avoid co-channel operation with these systems;
- Provide on aggregate a near-uniform loading of the spectrum (Uniform Spreading).

Within the context of the operation of the DFS function, an RLAN device should operate as either a master or a slave. RLAN devices operating as a slave should only operate in a network controlled by an RLAN device operating as a master. A device which is capable of operating as either a master or a slave should comply with the requirements applicable to the mode in which it operates.

Some RLAN devices are capable of communicating in ad-hoc manner without being attached to a network. RLAN devices operating in ad-hoc manner on channels whose nominal bandwidth falls partly or completely within the frequency ranges 5250 MHz to 5350 MHz or 5470 MHz to 5725 MHz should employ DFS and should be tested against the requirements applicable to a master.

Slave devices used in fixed outdoor point to point or fixed outdoor point to multipoint applications should behave as slave with radar detection independent of their output power.

Refer to ETSI EN 301 893 for a detailed operational behavior and individual requirements for both master and slave devices.

The DFS requirements and their applicability are shown in Table 50.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 50. DFS Requirements and their Applicability

Requirement	DFS Operational mode		
	Master	Slave without radar detection (see Table 52, (2))	Slave with radar detection (see Table 52, (2))
Radar Interference detection Function	Required (3)	Not required	Required
Channel Availability Check	Required	Not required	Required (2)
Off-Channel CAC (see [(1)])	Required	Not required	Required (2)

Table 50. DFS Requirements and their Applicability (continued)

Requirement	DFS Operational mode		
	Master	Slave without radar detection (see Table 52, (2))	Slave with radar detection (see Table 52, (2))
In-Service Monitoring	Required	Not required	Required
Channel Shutdown	Required	Required	Required
Non-Occupancy Period	Required	Not required	Required
Uniform Spreading	Required (4)	Not required	Not required

(1) Where implemented by the manufacturer.

(2) A slave with radar detection is not required to perform a CAC or Off-Channel CAC at initial use of the channel but only after the slave has detected a radar signal on the Operating Channel by In-Service Monitoring and the Non-Occupancy Period resulting from this detection has elapsed.

(3) Radar detection should be used when operating on channels whose nominal bandwidth falls partly or completely within the frequency ranges 5250 MHz to 5350 MHz or 5470 MHz to 5725 MHz.

(4) Uniform Spreading is required across the frequency ranges 5150 MHz to 5350 MHz and 5470 MHz to 5725 MHz. Uniform Spreading is not applicable for equipment that only operates in the band 5150 MHz to 5250 MHz.

The limits for the DFS requirements are shown in Table 51.

Table 51. Limits on DFS Requirements

Parameter	Limits
Channel Availability Check Time	> 60 Seconds (1)
Minimum Off-Channel CAC Time	> 6 Minutes (2)
Maximum Off-Channel CAC Time	< 4 Hours (2)
Channel Move Time	< 10 Seconds
Channel Closing Transmission Time	< 1 Second
Non-Occupancy Period	> 30 Minutes

(1) For channels whose nominal bandwidth falls completely or partly within the band 5600 MHz to 5650 MHz, the Channel Availability Check Time should be 10 minutes.

(2) For channels whose nominal bandwidth falls completely or partly within the band 5600 MHz to 5650 MHz, the Off-Channel CAC Time should be within the range 1 hour to 24 hours.

The limits for the Radar Detection Threshold levels are shown in Table 52.

Table 52. Limits on Radar Detection Threshold Levels

e.i.r.p. Spectral Density (dBm/MHz)	Limits (1)(2)
10	-62 dBm

(1) This is the level at the input of the receiver of an RLAN device with a maximum e.i.r.p. density of 10 dBm/MHz and assuming a 0 dBi receive antenna. For devices employing different e.i.r.p. spectral density and/or a different receive antenna gain G (dBi) the Radar Detection Threshold Level at the receiver input follows the following relationship:
DFS Detection Threshold (dBm) = -62 + 10 - e.i.r.p. Spectral Density (dBm/MHz) + G (dBi);
however the Radar Detection Threshold Level should not be less than -64 dBm assuming a 0 dBi receive antenna gain.

(2) Slave devices with a maximum e.i.r.p. of less than 23 dBm do not have to implement radar detection unless these devices are used in fixed outdoor point to point or fixed outdoor point to multipoint applications.

The parameters of the reference DFS test signal are shown in Table 53.

Table 53. Parameters of the Reference DFS Test Signal

Pulse width W (μs)	Pulse repetition frequency PRF (PPS)	Pulses per burst (PPB)
1	700	18

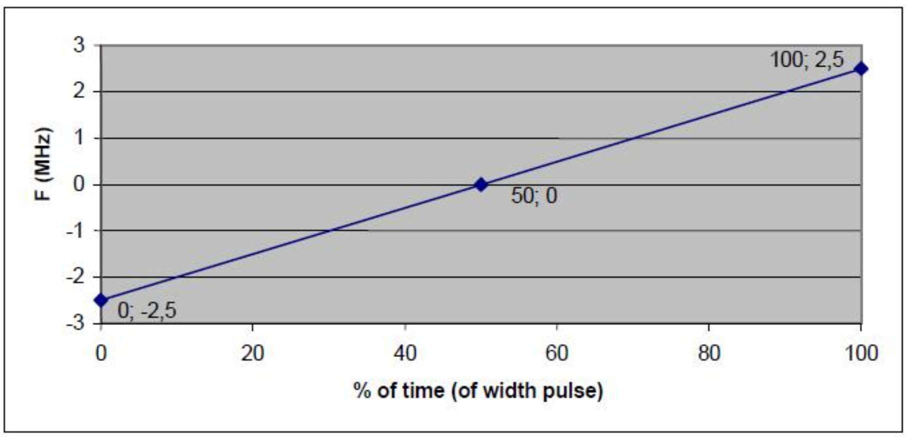
The parameters for Radar test signals are shown in Table 54.

Table 54. Parameters of Radar Test Signals

Radar test signal # (see (1) to (3))	Pulse width W (µs)		Pulse repetition frequency PRF (PPS)		Number of different PRFs	Pulses per burst for each PRF (PPB) (5)
	Min	Max	Min	Max		
1	0.5	5	200	1000	1	10 (6)
2	0.5	15	200	1600	1	15 (6)
3	0.5	15	2300	4000	1	25
4	25	30	2000	4000	1	20
5	0.5	2	300	400	2 / 3	10 (6)
6	0.5	2	400	1200	2 / 3	15 (6)

(1) Radar test signals #1 to #4 are constant PRF based signals. These radar test signals are intended to simulate also radars using a packet based Staggered PRF. For more information, see Annex-D of ETSI EN 301 893 for signal details.

(2) Radar test signal #4 is a modulated radar test signal. The modulation to be used is a chirp modulation with a ±2.5 MHz frequency deviation which is described below.



(3) Radar test signals #5 and #6 are single pulse based Staggered PRF radar test signals using 2 or 3 different PRF values. For radar test signal #5, the difference between the PRF values chosen should be between 20 PPS and 50 PPS. For radar test signal #6, the difference between the PRF values chosen should be between 80 PPS and 400 PPS.

(4) Apart for the Off-Channel CAC testing, the radar test signals above should only contain a single burst of pulses. For the Off-Channel CAC testing, repetitive bursts should be used for the total duration of the test.

(5) The total number of pulses in a burst is equal to the number of pulses for a single PRF multiplied by the number of different PRFs used.

(6) For the CAC and Off-Channel CAC requirements, the minimum number of pulses (for each PRF) for any of the radar test signals to be detected in the band 5600 MHz to 5650 MHz should be 18.

The Detection Probability levels are shown in Table 55.

Table 55. Detection Probability Levels

Parameter	Detection Probability (Pd)(1)	
	Channels whose nominal bandwidth falls partly or completely within the 5600 MHz to 5650 MHz band	Other channels
CAC, Off-Channel CAC	99.99%	60%
In-Service Monitoring	60%	60%

(1) Pd gives the probability of detection per simulated radar burst and represents a minimum level of detection performance under defined conditions. Therefore Pd does not represent the overall detection probability for any particular radar under real life conditions.

6.2.8 Adaptivity (Channel Access Mechanism)

Adaptivity (Channel Access Mechanism) is defined as an automatic mechanism by which a device limits its transmissions and gains access to an Operating Channel. It is not intended to be used as an alternative to DFS to detect radar transmissions, but to detect transmissions from other RLAN devices operating in the band.

There are two types Adaptive equipment, which are:

- Frame Based Equipment, and
- Load Base Equipment

6.2.8.1 Frame Based Equipment (FBE)

Frame Based Equipment is equipment where the transmit/receive structure has a periodic timing with a periodicity equal to the Fixed Frame Period. A single Observation Slot should have duration of not less than 9 μs.

Frame Based Equipment should implement a Listen Before Talk (LBT) based Channel Access Mechanism to detect the presence of other RLAN transmissions on an Operating Channel.

Frame Based Equipment is further classified into two types based on their operation. A device that initiates a sequence of one or more transmissions is denoted as the Initiating Device. Otherwise, the device is denoted as Responding Device. Frame Based Equipment may be an Initiating Device, a Responding Device, or both.

Frame Based Equipment being capable of simultaneous transmissions in adjacent or non-adjacent Operating Channels may use any combination/grouping of 20 MHz Operating Channels out of the list of channels (Nominal Centre Frequencies) provided in Section 6.2.1, if it satisfies the channel access requirements (Channel Access Mechanism) for an Initiating Device as described in Section 6.2.8.1.1 on each such 20 MHz Operating Channel.

The example of timing for Frame based equipment is shown in Figure 3.

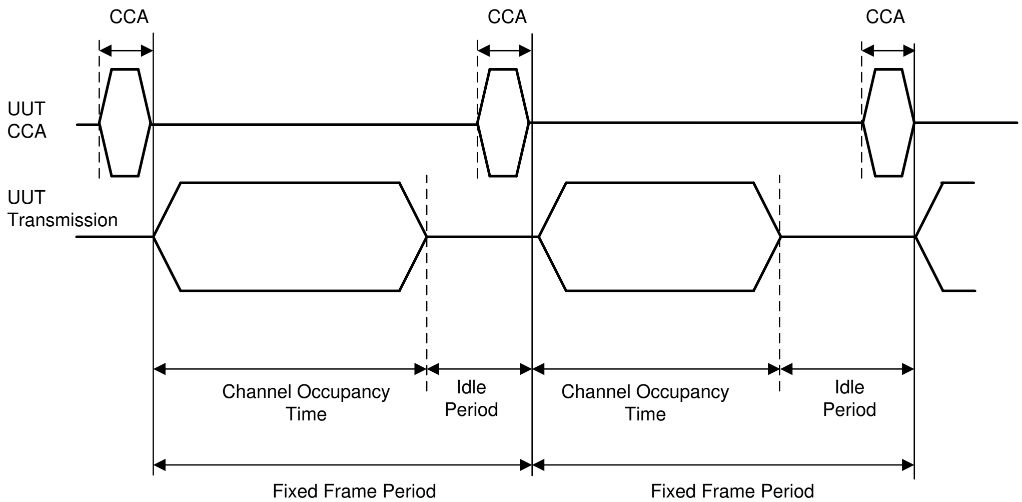


Figure 3. Example of timing for Frame Based Equipment

6.2.8.1.1 Initiating Device Channel Access Mechanism

The Initiating Device (Frame Based Equipment) should implement a Channel Access Mechanism that complies with the following requirements:

- The Fixed Frame Periods supported by the equipment should be declared by the manufacturer. This should be within the range of 1 ms to 10 ms. Transmissions can start only at the beginning of a Fixed Frame Period. An equipment may change its Fixed Frame Period but it should not do more than once every 200 ms.
- Immediately before starting transmissions on an Operating Channel at the start of a Fixed Frame

Period, the Initiating Device should perform a Clear Channel Assessment (CCA) check during a single Observation Slot. The Operating Channel should be considered occupied if the energy level in the channel exceeds the ED Threshold Level (TL) given in point 6) below. If the Initiating Device finds the Operating Channel(s) to be clear, it may transmit immediately. See Figure 1.
If the Initiating Device finds an Operating Channel occupied, then there should be no transmissions on that channel during the next Fixed Frame Period. The Frame Based Equipment is allowed to continue Short Control Signalling Transmissions on this channel providing it complies with the requirements given in Section 6.2.8.3.
For equipment having simultaneous transmissions on multiple (adjacent or non-adjacent) Operating Channels, the equipment is allowed to continue transmissions on other Operating Channels providing the CCA check did not detect any signals on those channels.
The total time during which Frame Based Equipment can have transmissions on a given channel without re-evaluating the availability of that channel, is defined as the Channel Occupancy Time (COT). The equipment can have multiple transmissions within a Channel Occupancy Time without performing an additional CCA on this Operating Channel providing the gap between such transmissions does not exceed 16 μs.
If the gap exceeds 16 μs, the equipment may continue transmissions provided that an additional CCA detects no RLAN transmissions with a level above the threshold defined in point 6. The additional CCA should be performed within the gap and within the observation slot immediately before transmission. All gaps are counted as part of the Channel Occupancy Time.

- An Initiating Device is allowed to grant an authorization to one or more associated Responding Devices to transmit on the current Operating Channel within the current Channel Occupancy Time. A Responding Device that receives such a grant should follow the procedure described in Section 6.2.8.1.2.
- The Channel Occupancy Time should not be greater than 95% of the Fixed Frame Period defined in point 1 and should be followed by an Idle Period until the start of the next Fixed Frame Period such that the Idle Period is at least 5% of the Channel Occupancy Time, with a minimum of 100 μs.
- The equipment, upon correct reception of a packet which was intended for this equipment, can skip CCA and immediately proceed with the transmission of management and control frames (for example, ACK and Block ACK frames). A consecutive sequence of such transmissions by the equipment, without it performing a new CCA, should not exceed the Maximum Channel Occupancy Time as defined in point 4 above.
  For the purpose of multi-cast, the ACK transmissions (associated with the same data packet) of the individual devices are allowed to take place in a sequence.
- The ED Threshold Level (TL), at the input of the receiver, should be proportional to the maximum transmit power (PH) according to the formula which assumes a 0 dBi receive antenna and PH to be specified in dBm e.i.r.p. The levels are shown in Table 56.

Table 56. Limits on ED Threshol Level - FBE

Maximum Tx Power (e.i.r.p.), dBm (P_H)	ED Threshold Level (TL) (1)	Notes
For $P_H \leq 13$ dBm	-75 dBm/MHz	Assumes a 0 dBi receive antenna gain
For 13 dBm < P_H < 23 dBm	-85 dBm/MHz + (23 dBm - PH)	
For $P_H \geq 23$ dBm	-85 dBm/MHz	

(1) Equipment should consider a channel to be occupied as long as other RLAN transmissions are detected at a level greater than the TL.

6.2.8.1.2 Responding Device Channel Access Mechanism

A Responding Device that receives a grant from a Initiating Device to transmit on the current Operating Channel within the current Fixed Frame Period should follow the procedure described in following steps 1 to 3:

1. A Responding Device that received a transmission grant from an associated Initiating Device may proceed with transmissions on the current Operating Channel:
   a. The Responding Device may proceed with such transmissions without performing a Clear Channel Assessment (CCA) if these transmissions are initiated at most 16 μs after the last transmission by

the Initiating Device that issued the grant.

b. The Responding Device that does not proceed with such transmissions within 16 μs after the last transmission from the Initiating Device that issued the grant, should perform a Clear Channel Assessment (CCA) on the Operating Channel during a single observation slot within a 25 μs period ending immediately before the granted transmission time. If energy was detected with a level above the ED Threshold Level (TL) defined in Table 47, the Responding Device should proceed with step 3. Otherwise, the Responding Device should proceed with step 2.

2. The Responding Device may perform transmissions on the current Operating Channel for the remaining Channel Occupancy Time of the current Fixed Frame Period. The Responding Device may have multiple transmissions on this Operating Channel provided that the gap in between such transmissions does not exceed 16 μs. When the transmissions by the Responding Device are completed the Responding Device should proceed with step 3.
3. The transmission grant for the Responding Device is withdrawn.

6.2.8.2 Load Based Equipment (LBE)

Load based Equipment should implement a Listen Before Talk (LBT) based Channel Access Mechanism to detect the presence of other RLAN transmissions on an Operating Channel.

6.2.8.2.1 Device Types - Load Based Equipment

Load based Equipment is further classified into different types of devices based on their operation with regard to Adaptivity. A device that initiates a sequence of one or more transmissions is denoted as the Initiating Device. Otherwise, the device is denoted as Responding Device. Load Based Equipment may be an Initiating Device, a Responding Device, or both. Each transmission belongs to a single Channel Occupancy Time (COT). A Channel Occupancy Time (COT) consists of one or more transmissions of an Initiating Device and zero or more transmissions of one or more Responding Devices.

An equipment that controls (non-DFS related) operating parameters of one or more other equipment is denoted as a Supervising Device. Otherwise, the equipment is denoted as a Supervised Device. The roles of a Supervising Device and Supervised Device has only to be seen in relation to Adaptivity and are different from the roles of a Master device and a Slave Device in the context of DFS as defined in Section 6.2.7. Examples of Supervising Devices are an RLAN Access Point or a mobile phone operating as an RLAN hotspot.

6.2.8.2.2 Multi-Channel Operation - Load Based Equipment

Load Based Equipment being capable of simultaneous transmissions in adjacent or non-adjacent Operating Channels (see Section 6.2.1) should implement either option 1 or option 2 below:

Option 1: Load Based Equipment may use any combination/grouping of 20 MHz Operating Channels out of the list of channels (Nominal Centre Frequencies) provided in Section 6.2.1, if it satisfies the channel access requirements (Channel Access Mechanism) for an Initiating Device as described in Section 6.2.8.2.5 on each such 20 MHz Operating Channel.

Option 2: The bonded 40 MHz, 80 MHz or 160 MHz channels (see also clause 4.2.1.3 for the channel number) are defined and shown in Figure 4. Load Based Equipment that uses a combination/grouping of 20 MHz Operating Channels that is a subset of bonded 40 MHz, 80 MHz or 160 MHz channels, may transmit on any of the 20 MHz Operating Channels, if:

- The equipment satisfies the channel access requirements (Channel Access Mechanism) for an Initiating Device as defined in Section 6.2.8.2.5 on one of the 20 MHz Operating Channels (Primary Operating Channel), and
- The equipment performs a Clear Channel Assessment (CCA) of at least 25 μs immediately before the intended transmissions on each of the other Operating Channels on which transmissions are intended, and no energy was detected with a level above the ED Threshold Level (TL) defined in Section 6.2.8.2.4.

The choice of the Primary Operating Channel should follow one of the following procedures:

- The Primary Operating Channel is chosen uniformly randomly whenever the contention window (CW), corresponding to a completed transmission on the current Primary Operating Channel is set to its minimum value (CWmin). For this procedure, a contention window (CW) is maintained for each Priority Class (see Section 6.2.8.2.3). within each 20 MHz Operating Channel within the bonded channel.

- The Primary Operating Channel is arbitrarily determined and not changed more than once per second.

The bonded 40 MHz, 80 MHz or 160 MHz channel that the combination/grouping of 20 MHz operating channels is a subset of should not be changed more than once per second.

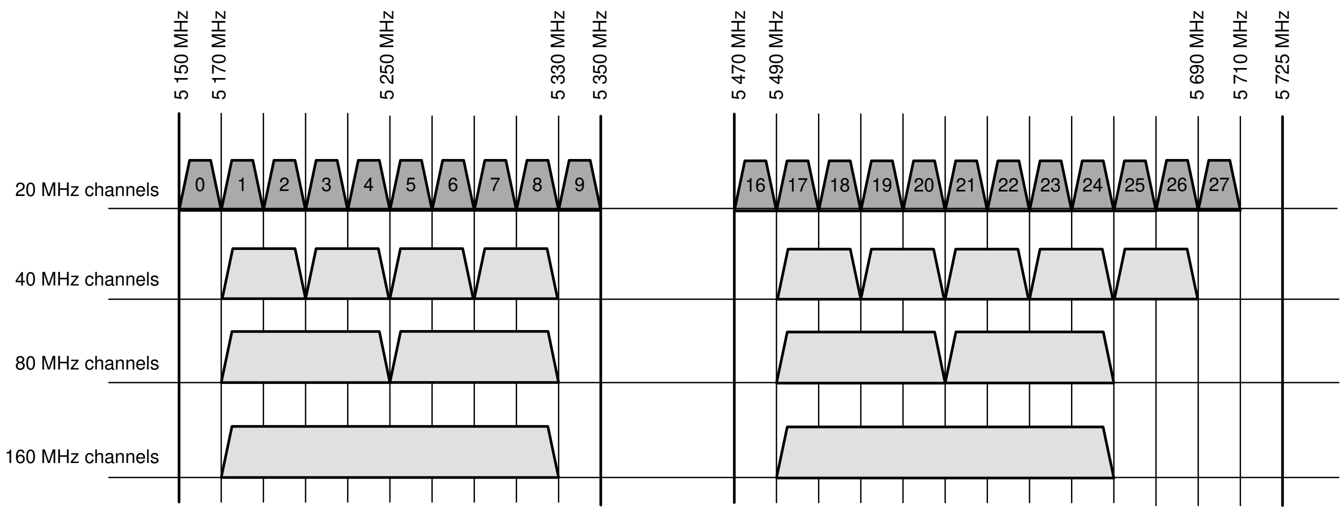


Figure 4. Channel Bonding for option 2

6.2.8.2.3 Priority Classes - Load Based Equipment

There are four different sets of Channel Access parameters for Supervising Devices and Supervised Devices respectively, resulting in different Priority Classes and different maximum Channel Occupancy Times. These parameters are used by the Channel Access Mechanism for the Initiating Device described in section 6.2.8.2.5Section 6.2.8.2.5 to gain access to an Operating Channel. The parameters for Supervising Devices are shown in Table 57 and the parameters for Supervised devices are shown in Table 58.

If a Channel Occupancy consists of more than one transmission the transmissions may be separated by gaps. The Channel Occupancy Time is the total duration of all transmissions and all gaps of 25 µs duration or less within a Channel Occupancy and should not exceed the maximum Channel Occupancy Time in Table 57 and Table 58. The duration from the start of the first transmission within a Channel Occupancy until the end of the last transmission in that same Channel Occupancy should not exceed 20 ms.

The Initiating Device may have data to be transmitted in different Priority Classes and therefore the Channel Access Mechanism is allowed to operate different Channel Access Engines as described in Section 6.2.8.2.4 simultaneously (one for each implemented Priority Class).

Table 57. Priority Class Dependent Channel Access Parameters for Supervising Devices

Class #	p0(3)	CWmin(3)	CWmax(3)	Maximum Channel Occupancy Time (COT), mSec
4	1	3	7	2
3	1	7	15	4
2	3	15	63	6 (1)(2)
1	7	15	1023	6 (1)

(1) The maximum Channel Occupancy Time (COT) of 6 ms may be increased to 8 ms by inserting one or more pauses. The minimum duration of a pause should be 100 µs. The maximum duration (Channel Occupancy) before including any such pause should be 6 ms. Pause duration is not included in the channel occupancy time.

(2) The maximum Channel Occupancy Time (COT) of 6 ms may be increased to 10 ms by extending CW to CW × 2 + 1 when selecting the random number q for any backoff(s) that precede the Channel Occupancy that may exceed 6 ms or which follow the Channel Occupancy that exceeded 6 ms. The choice between preceding or following a Channel Occupancy should remain unchanged during the operation time of the device.

(3) The values for p0, CWmin, CWmax are minimum values. Greater values are allowed.

Table 58. Priority Class Dependent Channel Access Parameters for Supervised Devices

Class #	p0(2)	CWmin(2)	CWmax(2)	Maximum Channel Occupancy Time (COT), mSec
4	2	3	7	2
3	2	7	15	4
2	3	15	1023	6 (1)
1	7	15	1023	6 (1)

(1) The maximum Channel Occupancy Time (COT) of 6 ms may be increased to 8 ms by inserting one or more pauses. The minimum duration of a pause should be 100 µs. The maximum duration (Channel Occupancy) before including any such pause should be 6 ms. Pause duration is not included in the channel occupancy time.

(2) The values for p0, CWmin, CWmax are minimum values. Greater values are allowed.

6.2.8.2.4 ED Threshold Level - Load Based Equipment

Equipment should consider a channel to be occupied as long as other RLAN transmissions are detected at a level greater than the ED Threshold Level (TL). The ED Threshold Level (TL) is integrated over the total Nominal Channel Bandwidth of all Operating Channels used by the equipment. The ED Threshold level (TL) depends on the type of equipment:

Option 1: For equipment that for its operation in the 5 GHz bands is conforming to IEEE 802.11™-2016, clause 17, clause 19 or clause 21, or any combination of these clauses, the ED Threshold Level (TL) is independent of the equipment's maximum transmit power (PH). Assuming a 0 dBi receive antenna the ED Threshold Level (TL) should be:

$$TL = -75 \text{ dBm/MHz} \quad (9)$$

Option 2: For equipment conforming to one or more of the clauses listed in Option 1, and to at least one other operating mode, and for equipment conforming to none of the clauses listed in Option 1, the ED Threshold Level (TL) should be proportional to the maximum transmit power (PH) according to the formula which assumes a 0 dBi receive antenna and PH to be specified in dBm e.i.r.p. The levels are shown in Table 59.

Table 59. Limits on ED Threshold Level - LBE

Maximum Tx Power (e.i.r.p.), dBm (P_H)	ED Threshold Level (TL)(1)	Notes
For PH ≤ 13 dBm	-75 dBm/MHz	Assumes a 0 dBi receive antenna gain.
For 13 dBm < PH < 23 dBm	-85 dBm/MHz + (23 dBm - PH)	
For PH ≥ 23 dBm	-85 dBm/MHz	

(1) Equipment should consider a channel to be occupied as long as other RLAN transmissions are detected at a level greater than the TL.

6.2.8.2.5 Initiating Device Channel Access Mechanism - Load Based Equipment

Before a transmission or a burst of transmissions on an Operating Channel, the Initiating Device should operate at least one Channel Access Engine that executes the procedure described in the following steps 1 to step 8. This Channel Access Engine makes use of the parameters defined in Table 57 or Table 58 in Section 6.2.8.2.3.

A single Observation Slot should have a duration of not less than 9 μs.

An Initiating Device should operate at least one and no more than four different Channel Access Engines each with a different Priority Class as defined in Section 6.2.8.2.3:

1. The Channel Access Engine should set CW to CWmin.
2. The Channel Access Engine should select a random number q from a uniform distribution over the range 0 to CW. (3) in Table 57 defines an alternative range for q when the previous or next Channel Occupancy Time is greater than the maximum Channel Occupancy Time specified in Table 57.
3. The Channel Access Engine should initiate a Prioritization Period as described in the following steps a) to c):
   a. The Channel Access Engine should set p according to the Priority Class associated with this Channel Access Engine. See Section 6.2.8.2.3.
   b. The Channel Access Engine should wait for a period of 16 μs.
   c. The Channel Access Engine should perform a Clear Channel Assessment (CCA) on the Operating Channel during a single Observation Slot:
      i. The Operating Channel should be considered occupied if other transmissions within this channel are detected with a level above the ED threshold defined in Section 6.2.8.2.4. In this case, the Channel Access Engine should initiate a new Prioritization Period starting with step 3a) after the energy within the channel has dropped below the ED threshold defined in Section 6.2.8.2.4.
      ii. In case no energy within the Operating Channel is detected with a level above the ED threshold defined in Section 6.2.8.2.4, p may be decremented by not more than 1. If p is equal to 0, the Channel Access Engine should proceed with step 4, otherwise the Channel Access Engine should proceed with step 3c).
4. The Channel Access Engine should perform a Backoff Procedure as described in step 4a) to step 4d):
   a. This step verifies if the Channel Access Engine satisfies the Post Backoff condition. If q < 0 and the Channel Access Engine is ready for a transmission, the Channel Access Engine should set CW equal to CWmin and should select a random number q from a uniform distribution over the range 0 to CW before proceeding with step 4b). (3) in Table 57 defines an alternative range for when the previous or next Channel Occupancy Time is greater than the maximum Channel Occupancy Time specified in Table 57.
   b. If q < 1 the Channel Access Engine should proceed with step 4d). Otherwise, the Channel Access Engine may decrement the value q by not more than 1 and the Channel Access Engine should proceed with step 4c).
   c. The Channel Access Engine should perform a Clear Channel Assessment (CCA) on the Operating Channel during a single Observation Slot:
      i. The Operating Channel should be considered occupied if energy was detected with a level above the ED threshold defined in Section 6.2.8.2.4. In this case, the Channel Access Engine should continue with step 3.
      ii. If no energy was detected with a level above the ED threshold defined in Section 6.2.8.2.4, the Channel Access Engine should continue with step 4 b).
   d. If the Channel Access Engine is ready for a transmission the Channel Access Engine should continue with step 5. Otherwise, the Channel Access Engine should decrement the value q by 1 and the Channel Access Engine should proceed with step 4c). It should be understood that q can become negative and keep decrementing as long as the Channel Access Engine is not ready for a transmission.
5. If only one Channel Access Engine of the Initiating Device is in this stage, the Channel Access Engine should proceed with step 6. If the Initiating Device has a multitude of Channel Access Engines in this stage, the Channel Access Engine with highest Priority Class in this multitude should proceed with

step 6 and all other Channel Access Engines in the current stage should proceed with step 8.

a. One Channel Access Engine of the Initiating Device is in this stage: This is equivalent to the equipment having no internal collision
b. Initiating Device has a multitude of Channel Access Engines in this stage: This is equivalent to the equipment having one or more internal collisions

6. The Channel Access Engine may start transmissions belonging to the corresponding or higher Priority Classes, on one or more Operating Channels. If the initiating device transmits in more than one Operating Channels, it should comply with the requirements contained in Section 6.2.8.2.2:
   a. The Channel Access Engine can have multiple transmissions without performing an additional CCA on this Operating Channel providing the gap in between such transmissions does not exceed 16 μs. Otherwise, if this gap exceeds 16 μs and does not exceed 25 μs, the Initiating Device may continue transmissions provided that no energy was detected with a level above the ED threshold defined in Section 6.2.8.2.4 for a duration of one Observation Slot.
   b. The Channel Access Engine may grant an authorization to transmit on the current Operating Channel to one or more Responding Devices. If the Initiating Device issues such a transmission grant to a Responding Device, the Responding Device should operate according to the procedure described in Section 6.2.8.2.6.
   c. The Initiating Device may have simultaneous transmissions of Priority Classes lower than the Priority Class of the Channel Access Engine, provided that the corresponding transmission duration (Channel Occupancy Time) is not extended beyond the time that is needed for the transmission(s) corresponding to the Priority Class of the Channel Access Engine.
7. When the Channel Occupancy has completed, and it has been confirmed that at least one transmission that started at the beginning of the Channel Occupancy was successful, the Initiating Device proceeds with step 1 otherwise the Initiating Device proceeds with step 8.
8. The Initiating Device may retransmit. If the Initiating Device does not retransmit the Channel Access Engine should discard all data packets associated with the unsuccessful Channel Occupancy and the Channel Access Engine should proceed with step 1. Otherwise, the Channel Access Engine should adjust CW to $((CW + 1) \times m) - 1$ with $m \geq 2$. If the adjusted value of CW is greater than CWmax the Channel Access Engine may set CW equal to CWmax. The Channel Access Engine should proceed with step 2.

According to Section 6.2.8.2.3 where four different Priority Classes are defined, an Initiating Device should operate only one Channel Access Engine for each Priority Class implemented.

CW may take values that are greater than the values of CW in step 1 to step 8.

6.2.8.2.6 Responding Device Channel Access Mechanism - Load Based Equipment

A Responding Device that receives a grant as per the step 6b) in Section 6.2.8.2.5 should follow the procedure described in the following steps 1 to 3:

1. A Responding Device that received a transmission grant from an associated Initiating Device may proceed with transmissions on the current Operating Channel.
   a. The Responding Device may proceed with such transmissions without performing a Clear Channel Assessment (CCA) if these transmissions are initiated at most 16 μs after the last transmission by the Initiating Device that issued the grant.
   b. The Responding Device that does not proceed with such transmissions within 16 μs after the last transmission from the Initiating Device that issued the grant, should perform a Clear Channel Assessment (CCA) on the Operating Channel during a single observation slot within a 25 μs period ending immediately before the granted transmission time. If energy was detected with a level above the ED Threshold defined in Section 6.2.8.2.4, the Responding Device should proceed with step 3. Otherwise, the Responding Device should proceed with step 2.
2. The Responding Device may perform transmissions on the current Operating Channel for the remaining Channel Occupancy Time. The Responding Device may have multiple transmissions on this Operating Channel provided that the gap in between such transmissions does not exceed 16 μs. When the transmissions by the Responding Device are completed the Responding Device should proceed with step 3.
3. The transmission grant for the Responding Device is withdrawn.

6.2.8.3 Short Control Signalling Transmissions (FBE and LBE)

Short Control Signalling Transmissions are transmissions used by Adaptive equipment to send management and control signals without sensing the channel for the presence of other signals.

Frame Based equipment (FBE) and Load Based Equipment (LBE) are allowed to have Short Control Signalling Transmissions on the Operating Channel providing these transmissions comply with the following requirements.

Short Control Signalling Transmissions should meet the following limits.

- Within an observation period of 50 ms, the number of Short Control Signalling Transmissions by the equipment should be equal to or less than 50; and
- The total duration of the equipment's Short Control Signalling Transmissions should be less than 2 500 μs within said observation period.

6.2.9 Receiver Blocking

Receiver blocking is defined as a measure of the ability of the equipment to receive a wanted signal on its operating channel without exceeding a given degradation due to the presence of an unwanted input signal (blocking signal) on frequencies other than those of the operating frequency bands provided in Table 32.

The minimum performance criterion should be a PER of less than or equal to 10%. The manufacturer may declare alternative performance criteria as long as that is appropriate for the intended use of the equipment.

The limits for receiver blocking levels are shown in Table 60.

Table 60. Limits on Receiver Blocking

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (2)		Type of blocking signal
		Master or Slave signal with radar detection (see Table 52, (2))	Slave without radar detection (see Table 52, (2))	
Pmin + 6 dB(1)	5100	>=-53	>=-59	CW
Pmin + 6 dB(1)	4900	>=-47	>=-53	CW
	5000			
	5975			

(1) Pmin is the minimum level of the wanted signal (in dBm) required to meet the minimum performance criteria as defined above in the absence of any blocking signal.

(2) The levels specified are levels in front of the UUT antenna. In case of conducted measurements, the same levels should be used at the antenna connector irrespective of antenna gain.

6.2.10 User Access Restrictions

User Access Restrictions are defined as constraints implemented in the RLAN device to restrict access of the user to any hardware and/or software settings of the equipment, including software replacement(s), which may impact (directly or indirectly) the compliance of the equipment with the requirements in the section 6 ETSI EN 301 893 of this document.

The requirement is that the equipment should be so constructed that settings (hardware and/or software) related to DFS should not be accessible to the user if changing those settings result in the equipment no longer being compliant with the DFS requirements in Section 6.2.7 of this document.

The above requirement includes the prevention of indirect access to any setting that impacts DFS. The following is a non-exhaustive list of examples of such indirect access.

Example 1: The equipment should not allow the user to change the country of operation and/or the operating frequency band if that results in the equipment no longer being compliant with the DFS requirements.

Example 2: The equipment should not accept software and/or firmware which results in the equipment no longer being compliant with the DFS requirements, for example,:

- Software and/or firmware provided by the manufacturer but intended for other regulatory regimes;
- Modified software and/or firmware where the software and/or firmware is available as open source code;
- Previous versions of the software and/or firmware (downgrade).

6.2.11 Geo-Location Capability

Geo-location capability is a feature of the RLAN device to determine its location at installation, at reinstallation and at each power up of the equipment, with the purpose to configure itself according to the regulatory requirements applicable at the location where it operates.

The geo-location capability may be present in the equipment or in an external device (temporary) associated with the equipment operating at the same geographical location during the initial power up of the equipment. The geographical location may also be available in equipment already installed and operating at the same geographical location.

The requirement is that the geographical location determined by the equipment should not be accessible to the user.

If the equipment cannot determine the geographic location, it should operate in a mode compliant with the requirements applicable in any of the geographic locations where the equipment is intended to operate. The manufacturer should declare whether the equipment complies with the above requirement or not.

7 ETSI EN 301 489

The ETSI EN 301 489 is a Harmonized European Standard for Electro Magnetic Compatibility (EMC) for Radio equipment and services. It is a multi-part EMC standard, in which each part covers specific product related radio equipment requirements. The ETSI EN 301 489-1 covers the common technical requirements for EMC emission and immunity and the ETSI EN 301 489-17 covers specific conditions for Broadband Data Transmission Systems. The examples of Broadband Data Transmission Systems, which are covered by the ETSI EN 301 489-17 standard is shown in Table 61. The complete documents can be downloaded from ETSI website ETSI EN301 489-1 V2.2.1 and ETSI EN 301 489-17 V3.2.2.

Table 61. Examples of Broadband Data Systems

Equipment Type	Frequency Band	Equipment Compliant with the Standard
Data transmission systems operating in the 2.4 GHz ISM band and using wideband modulation techniques.	2400 MHz to 2483.5 MHz	ETSI EN 300 328
5 GHz RLAN Systems	5150 MHz to 5350 MHz 5470 MHz to 5725 MHz	ETSI EN 301 893
Broadband data transmitting systems	5725 MHz to 5875 MHz	ETSI EN 302 502
Broadband data transmitting/BWA Terminal Stations	2300 MHz to 2400 MHz 2500 MHz to 2690 MHz 3400 MHz to 3800 MHz	ETSI EN 302 544-2 or ETSI EN 302 623, ETSI EN 301 908-19 or ETSI EN 301 908-21
Multi-Gigabit Wireless Systems (MGWS)	57 GHz to 66 GHz	ETSI EN 302 567

7.1 Technical Requirements

The ETSI EN 301 489-17 standard together with the ETSI EN 301 489-1 standard specifies the applicable EMC tests and the technical requirements for Broadband Data Transmission equipment. The equipment should comply with all the technical requirements which are applicable at all times when operating within the boundary limits of the operational environmental category declared by the manufacturer. The technical requirements and their conditionality are shown in Table 62.

Table 62. Technical Requirements and Conditions

Requirement				Requirement Conditionality	
No	**Description**	**Essential requirements of Directive 2014/53/EU**	**Clause(s) of the EN301 489-17**	**U/C (1)**	**Condition**
1	Emissions: Enclosure of ancillary equipment measured on a standalone basis	3.1b	7.1	U	
2	Emissions: DC power input/output ports	3.1b	7.1	C	Only where equipment has DC power input and/or output ports with a cable length greater than 3 m or from a vehicle power supply
3	Emissions: AC mains power input/output ports	3.1b	7.1	C	Only where equipment has AC mains power input and/or output ports
4	Emissions: Harmonic current emission (AC mains input port)	3.1b	7.1	C	Only where equipment has AC mains power input ports
5	Emissions: Voltage fluctuations and flicker (AC mains input ports)	3.1b	7.1	C	Only where equipment has AC mains power input ports
6	Emissions: Wired network ports	3.1b	7.1	C	Only where equipment has wired network ports

Table 62. Technical Requirements and Conditions (continued)

Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive 2014/53/EU	Clause(s) of the EN301 489-17	U/C (1)	Condition
7	Immunity: Radio frequency electromagnetic field (80 MHz to 6 000 MHz)	3.1b	7.2	U	
8	Immunity: Electrostatic discharge	3.1b	7.2	U	
9	Immunity: Fast transients common mode	3.1b	7.2	C	Only where equipment has AC mains power input ports or DC power ports or wired network ports with cables longer than 3 m
10	Immunity: Radio frequency common mode	3.1b	7.2	C	Only where equipment has AC mains power input ports or DC power ports or wired network ports with cables longer than 3 m
11	Immunity: Transients and surges in the vehicular environment	3.1b	7.2	C	Only where equipment is fitted to a vehicle power supply
12	Immunity: Voltage dips and interruptions	3.1b	7.2	C	Only where equipment has AC mains power input ports
13	Immunity: Surges, line to line and line to ground	3.1b	7.2	C	Only where equipment has AC mains power input ports and/or wired network ports

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

7.2 Environment Classification

The environment in which the equipment is intended to be used has been classified into the following four categories:

- CENELEC EN 61000-6-3 and CENELEC EN 61000-6-1 for the residential, commercial and light industrial environment; or
- CENELEC EN 61000-6-2 and CENELEC EN 61000-6-4 for the industrial environment; or
- ETSI TR 101 651 for the telecommunication center environment; or
- ISO 7637-2 for the vehicular environment.

The applicable environment for the operation of the equipment should be declared by the manufacturer and it should be in accordance with the equipment documentation. The equipment should comply with all the technical requirements which are applicable at all times when operating within the boundary limits of the declared operational environmental category.

7.3 Test Conditions

The test configuration and mode of operation should represent the intended use and should be recorded in the test report.

Standalone receivers and transmitters should be tested separately. Transceivers should be tested so that operation in each direction is confirmed.

The wanted signals and/or controls required to establish a communication link and should be representative of the EUTs intended use. A suitable companion device should be used to set up a communication link. The transmitter should be operated at maximum rated power.

The level of the wanted signal at the input of the receiver should be not greater than 30 dB above the Pmin (Minimum sensitivity level) for the EUTs.

Refer to the standards ETSI EN 301 489-1 and ETSI EN 301 489-17 for detailed test conditions.

7.4 RF Exclusion Bands

RF Exclusion band is defined as the frequency band which is not subject to test or assessment. The following rules apply for Exclusion bands.

- Whenever an exclusion band is applied, the specific frequency range(s) excluded from assessment should be detailed in the technical documentation.
- Exclusion bands should not be applied when measuring transmitters in standby mode.
- The frequencies on which the transmitter part of the EUT is intended to operate should be excluded from radiated emission measurements when performed in transmit mode of operation.
- The exclusion band for immunity testing of equipment operating in the 2.4 GHz band should be:
  - Lower limit of exclusion band = lowest allocated band edge frequency -120 MHz, such as 2280 MHz;
  - Upper limit of exclusion band = highest allocated band edge frequency +120 MHz, such as 2603.5MHz
- The exclusion band for immunity testing of equipment operating in the 5 GHz Wi-Fi band should be:
  - Lower limit of exclusion band = lowest allocated band edge frequency -270 MHz, such as 4880 MHz;
  - Upper limit of exclusion band = highest allocated band edge frequency +270 MHz, such as 5995MHz
- The exclusion band for immunity testing of equipment operating in the 5.8 GHz band should be:
  - Lower limit of exclusion band = lowest allocated band edge frequency -270 MHz, such as 5445 MHz;
  - As the immunity requirements have an upper frequency range of 6 GHz and any upper edge exclusion band would be greater than this for the 5.8 GHz band. The above frequency should also be regarded as the upper end of the test range.
- For channelized transmitter equipment the exclusion band should extend 250% of the channel width either side of the transmitter center frequency.
- For non-channelized transmitter equipment the exclusion band should extend 250% of the occupied bandwidth either side of the transmitter center frequency.
- There should be no frequency exclusion band applied to emission measurements of the receiver part of transceivers or the stand alone receiver under test, and/or associated ancillary equipment.
- For channelized receiver equipment the exclusion band should be calculated using the following formulae:
  For the lower edge for the exclusion band:

  $$\text{EXband(lower)} = \text{Band}_{Rx}\text{(lower)} - \text{nChW}_{Rx} \quad (10)$$

  and for the upper edge of the exclusion band:

  $$\text{EXband(upper)} = \text{Band}_{Rx}\text{(upper)} + \text{nChW}_{Rx} \quad (11)$$

  Where,
  n = number of channel widths required for exclusion band.
  For equipment that supports multiple channel widths, the Channel Width used is the widest supported by the EUT.
- For non-channelized receiver equipment the exclusion band should be calculated using the following formulae:
  For the lower edge for the exclusion band:

  $$\text{EXband(lower)} = \text{Band}_{Rx}\text{(lower)} - \text{nBW}_{Rx} \quad (12)$$

  and for the upper edge of the exclusion band:

$$EXband(upper) = Band_{Rx}(upper) + nBW_{Rx} \quad (13)$$

Where,
n = number of channel widths required for exclusion band.
Bandwidth of Receiver is the occupied bandwidth of the corresponding transmitter signal.

7.5 Performance Assessment

The manufacturer should supply at the time of submission of the equipment for test, the information required in ETSI EN 301 489-1, Annex C and the following which should be recorded in the test report:

- The operating frequency range(s) of the equipment and, where applicable, band(s) of operation;
- The type of the equipment, for example: stand-alone or plug-in radio device;
- The host equipment to be combined with the radio equipment for testing;
- The minimum performance level under the application of EMC stress (see Section 7.6.1);
- The normal test modulation, the format, the type of error correction and any control signals for example, ACKnowledgement (ACK)/Not ACKnowledgement (NACK) or Automatic Retransmission reQuest (ARQ).

7.5.1 Equipment Classification

For the purpose of the EMC performance assessment, the radio equipment and/or associated ancillary equipment under test should be classified into one of the following three classes:

- Equipment for fixed use (for example, base station equipment); or
- Equipment for vehicular use (for example, mobile equipment); or
- Equipment for portable use (portable equipment)

Hand portable equipment, or combinations of equipment, declared as capable of being powered for intended use by the main battery of a vehicle should additionally be considered as vehicular mobile equipment.

Hand portable or mobile equipment, or combinations of equipment, declared as capable of being powered for intended use by ac mains should additionally be considered as fixed station equipment.

7.6 Performance Criteria

The performance criteria are used to take a decision on whether a radio equipment passes or fails immunity tests. The performance criteria are:

- Performance criteria A for immunity tests with phenomena of a continuous nature;
- Performance criteria B for immunity tests with phenomena of a transient nature;
- Performance criteria C for immunity tests with power interruptions exceeding a certain time.

The equipment should meet the minimum performance criteria as specified in the following Table 63 and Table 64.

Table 63. Performance Criteria

Criteria	During test	After test (or as a result of the application of the test)
A	should operate as intended.(1) should be no loss of function. should be no unintentional transmissions.	should operate as intended. should be no degradation of performance. should be no loss of function. should be no loss of critical stored data.
B	May be loss of function.	Functions should be self-recoverable. should operate as intended after recovering. should be no loss of critical stored data.

Table 63. Performance Criteria (continued)

Criteria	During test	After test (or as a result of the application of the test)
C	May be loss of function.	Functions should be recoverable by the operator. should operate as intended after recovering. should be no loss of critical stored data.

(1) Operate as intended during the test allows a level of degradation in accordance with Minimum performance level in Section 7.6.1

Table 64. Performance Criteria Based on Phenomena of Equipment

Phenomenon	Performance Criteria
CT (Continuous phenomenon applied to Transmitters)	Criteria A should apply (see Table 63) Tests should be repeated with the EUT in standby mode (if applicable) to ensure that unintentional transmission does not occur. In systems using acknowledgement signals, it is recognized that an ACKnowledgement (ACK) or Not ACKnowledgement (NACK) transmission may occur, and steps should be taken to ensure that any transmission resulting from the application of the test is correctly interpreted.
CR (Continuous phenomenon applied to Receivers)	Criteria A should apply (see Table 63) Where the EUT is a transceiver, under no circumstances, should the transmitter operate unintentionally during the test. In systems using acknowledgement signals, it is recognized that an ACK or NACK transmission may occur, and steps should be taken to ensure that any transmission resulting from the application of the test is correctly interpreted.
TT (Transient phenomenon applied to Transmitters)	Criteria B should apply, except for voltage dips of 100 ms and voltage interruptions of 5000 ms duration, for which performance criteria C should apply (see Table 63) Tests should be repeated with the EUT in standby mode (if applicable) to ensure that unintentional transmission does not occur. In systems using acknowledgement signals, it is recognized that an ACKnowledgement (ACK) or Not ACKnowledgement (NACK) transmission may occur, and steps should be taken to ensure that any transmission resulting from the application of the test is correctly interpreted.
TR (Transient phenomenon applied to Receivers)	Criteria B should apply, except for voltage dips of 100 ms and voltage interruptions of 5000 ms duration, for which performance criteria C should apply (see Table 63) Where the EUT is a transceiver, under no circumstances, should the transmitter operate unintentionally during the test. In systems using acknowledgement signals, it is recognized that an ACK or NACK transmission may occur, and steps should be taken to ensure that any transmission resulting from the application of the test is correctly interpreted.

7.6.1 Minimum Performance Level

For equipment that supports a PER or FER, the minimum performance level should be a PER or FER less than or equal to 10%. For equipment that does not support a PER or a FER, the minimum performance level should be no loss of the wireless transmission function needed for the intended use of the equipment.

7.7 Emission Requirements

The EMC Emission requirements for the relevant ports of radio and ancillary equipment and their applicability are shown in Table 65. The applicability of the EMC tests depends upon the type of radio and/or associated ancillary equipment under test.

Table 65. Emission Requirements

Phenomenon	Port	Applicability			Reference Clause / Section in the present document
		Fixed use (for example, base station equipment)	Vehicular use (for example, mobile equipment)	Portable use (portable equipment)	
Radiated emission	Enclosure of Ancillary Equipment	Applicable	Applicable	Applicable	ETSI EN 301 489-1, clause 8.2 or Section 7.7.1
Conducted emission	DC power input/output port	Applicable	Applicable	Not Applicable	ETSI EN 301 489-1, clause 8.3 or Section 7.7.2
Conducted emission	AC mains input/output port	Applicable	Not Applicable	Not Applicable	ETSI EN 301 489-1, clause 8.4 or Section 7.7.3
Harmonic current emissions	AC mains input port	Applicable	Not Applicable	Not Applicable	ETSI EN 301 489-1, clause 8.5 or Section 7.7.4
voltage fluctuations and flicker	AC mains input port	Applicable	Not Applicable	Not Applicable	ETSI EN 301 489-1, clause 8.6 or Section 7.7.5
Conducted emission	Wired network port	Applicable	Not Applicable	Not Applicable	ETSI EN 301 489-1, clause 8.7 or Section 7.7.6

7.7.1 Radiated Emissions - Enclosure Port

This test is only applicable to ancillary equipment not incorporated in the radio equipment and assessed separately from its associated radio equipment. This test should be performed on a representative configuration of the ancillary equipment. The test method should be in accordance with CENELEC EN 55032, annex A.2.

The ancillary equipment should meet the class B limits given in CENELEC EN 55032, annex A, tables A.4 and A.5. Alternatively, for ancillary equipment intended to be used exclusively in an industrial environment or telecommunication centers, the class A limits given in CENELEC EN 55032, annex A, tables A.2 and A.3 may be used.

7.7.2 Conducted Emissions - DC Power Input/Output Ports

The purpose of this test is intended to assess the level of internally generated electrical noise present on the DC power input/output ports. This test is applicable for radio equipment and ancillary equipment for fixed use that may be connected to a local DC power network or to local battery with connecting cables longer than 3 meters.

If the DC power cable of the radio and/or the ancillary equipment is less than or equal to 3 m in length, and intended for direct connection to a dedicated AC/DC power supply, then the measurement should be performed on the AC power input port of that power supply as specified in Section 7.7.3. If the DC power cable is longer than 3 m, then the measurement should additionally be performed on the DC power port of the radio and/or ancillary equipment.

If the DC power cable between the mobile radio and/or ancillary equipment and the dedicated DC/DC power converter is less than or equal to 3 m in length, then the measurement can be limited to the DC power input port of that power converter only. If this DC power cable is longer than 3 m, then the measurement should additionally be performed on the DC power port of the mobile radio and/or ancillary equipment.

This test should be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

The equipment should meet the limits shown in Table 66.

Table 66. Limits for Conducted Emissions - DC Power Input/Output Port

Frequency range	Limit (quasi-peak), (dBµV)	Limit (average), (dBµV)
0.15 MHz to 0.5 MHz	< 79	< 66
0.5 MHz to 30 MHz	< 73	< 60

(1) If the average limit is met when using a quasi-peak detector, the equipment should be deemed to meet both limits and measurement with the average detector is unnecessary.

7.7.3 Conducted Emissions - AC Mains Power Input/Output Ports

The purpose of this test is intended to assess the level of internally generated electrical noise present on the AC power input/output ports. This test is applicable for radio equipment and ancillary equipment for fixed use powered by the AC mains.

This test should be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment. The equipment should meet the limits shown in Table 67.

Table 67. Limits for Conducted Emissions - AC Power Input/Output Port

AC Power port usage	Limits
Used for Power Supply only	The equipment should meet the class B limits given in CENELEC EN 55032, annex A, table A.10. Alternatively, for equipment intended to be used in an industrial environment or a telecommunication center, the class A limits given in CENELEC EN 55032, annex A, table A.9 can be used.
Used for PLC Communications up to 30MHz	The EUT should comply with the requirements of CENELEC EN 50561-1, clause 6.
Used for PLC Communications above 30MHz	The EUT should comply with the requirements of CENELEC EN 50561-3, clause 6.

(1) If the average limit is met when using a quasi-peak detector, the equipment should be deemed to meet both limits and measurement with the average detector is unnecessary.

7.7.4 Harmonic Current Emissions - AC Mains Power Input Port

The equipment should meet the limits shown in Table 68.

Table 68. Limits for Harmonic Current Emissions - AC Mains Power Input Port

Equipment Current Drain	Limits
Input Current Drain < = 16 A / Phase	The classification from CENELEC EN 61000-3-2 , clause 5, should apply together with the limits from CENELEC EN 61000-3-2, clause 7, and the evaluation requirements of CENELEC EN 61000-3-2, clause 6.
Input Current Drain > 16 A / Phase	The limits from CENELEC EN 61000-3-12, clause 5 should apply together with the evaluation requirements of CENELEC EN 61000-3-12, clause 7.

7.7.5 Voltage Fluctuations and Flicker - AC Mains Power Input Port

The equipment should meet the limits shown in Table 69.

Table 69. Limits for Voltage Fluctuations and Flicker - AC Mains Power Input port

Equipment Current Drain	Limits
Input Current Drain < = 16 A / Phase, if no conditional connection is needed	The limits from CENELEC EN 61000-3-3, clause 5 should apply together with the evaluation requirements of CENELEC EN 61000-3-3, clause 6.

Table 69. Limits for Voltage Fluctuations and Flicker - AC Mains Power Input port (continued)

Equipment Current Drain	Limits
Input Current Drain < = 16 A / Phase, if a conditional connection is needed	The limits from CENELEC EN 61000-3-11, clause 5 should apply together with the evaluation requirements of CENELEC EN 61000-3-11, clause 6.
Input Current Drain > = 16 A and < = 75 A / Phase needed	

7.7.6 Conducted Emissions - Wired Network Ports

The purpose of this test is intended to assess the level of unwanted emissions present at the wired network ports. This test is applicable for radio equipment and ancillary equipment for fixed use which have wired network ports.

This test should be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

The equipment should meet the limits shown in Table 70.

Table 70. Limits for Conducted Emissions - Wired Network Ports

Ports	Limits
Wired Network Ports	The equipment should meet the class B limits given in CENELEC EN 55032, annex A, table A.12. Alternatively, for equipment intended to be used in an industrial environment or a telecommunication center, the class A limits given in CENELEC EN 55032, annex A, table A.11 can be used.

7.8 Immunity Requirements

The EMC Immunity requirements for the relevant ports of radio and ancillary equipment and their applicability are shown in Table 71. The applicability of the EMC tests depends upon the type of radio and/or associated ancillary equipment under test.

Table 71. Immunity Requirements

Phenomenon	Port	Applicability			Reference Clause / Section in the present document
		Fixed use (for example, base station equipment)	Vehicular use (for example, mobile equipment)	Portable use (portable equipment)	
RF electromagnetic field (80 MHz to 6000 MHz)	Enclosure Port	Applicable	Applicable	Applicable	ETSI EN 301 489-1, clause 9.2 or Section 7.8.1
Electrostatic Discharge	Enclosure	Applicable	Not Applicable	Applicable	ETSI EN 301 489-1, clause 9.3 or Section 7.8.2
Fast transients common mode	Signal, Wired network and Control ports, DC and AC power ports	Applicable	Not Applicable	Not Applicable	ETSI EN 301 489-1, clause 9.4 or Section 7.8.3
RF common mode 0.15 MHz to 80 MHz	Signal, Wired network and Control ports, DC and AC power ports	Applicable	Applicable	Not Applicable	ETSI EN 301 489-1, clause 9.5 or Section 7.8.4
Transients and Surges	DC power input ports	Not Applicable	Applicable	Not Applicable	ETSI EN 301 489-1, clause 9.6 or Section 7.8.5

Table 71. Immunity Requirements (continued)

Phenomenon	Port	Applicability			Reference Clause / Section in the present document
		Fixed use (for example, base station equipment)	Vehicular use (for example, mobile equipment)	Portable use (portable equipment)	
Voltage dips and Interruptions	AC mains power input ports	Applicable	Not Applicable	Not Applicable	ETSI EN 301 489-1, clause 9.7 or Section 7.8.6
Surges, Line to Line and Line to Ground	AC mains power input ports, wired network ports	Applicable	Not Applicable	Not Applicable	ETSI EN 301 489-1, clause 9.8 or Section 7.8.7

7.8.1 RF Electromagnetic Field (80 MHz to 6000 MHz) - Enclosure Port

The purpose of this test is intended to assess the ability of the EUT to operate as intended in the presence of a radio frequency electromagnetic field disturbance. This test is applicable to radio equipment and associated ancillary equipment. This test should be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment. The test method should be in accordance with CENELEC EN 61000-4-3, clauses 6, 7 and 8.

The EUT should meet the performance criteria for continuous phenomena (see Section 7.6), when it is tested with the following requirements:

- The test level should be 3 V/m (measured unmodulated). The test signal should be amplitude modulated to a depth of 80% by a sinusoidal audio signal of 1000 Hz. If the wanted signal is modulated at 1000 Hz, then an audio signal of 400 Hz should be used;
- The test should be performed over the frequency range 80 MHz to 6000 MHz with the exception of the exclusion band for transmitters, receivers and duplex transceivers (see Section 7.4), as appropriate;
- For receivers and transmitters the stepped frequency increments should be 1% frequency increment of the momentary used frequency;
- The dwell time of the test phenomena at each frequency should not be less than the time necessary for the EUT to be exercised and to be able to respond;
  Dwell time is product dependent.
- The frequencies selected and used during the test should be recorded in the test report.

7.8.2 Electrostatic Discharge - Enclosure

The purpose of this test is intended to assess the ability of the EUT to operate as intended in the event of an electrostatic discharge. This test is applicable for radio equipment and associated ancillary equipment.

This test should be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment. The test method should be in accordance with CENELEC EN 61000-4-2, clauses 6, 7 and 8.

The EUT should meet the performance criteria for transient phenomena (see Section 7.6), when it is tested with the ESD levels shown in Table 72.

Table 72. ESD Levels - Enclosure

ESD Discharge Type	ESD Level	Notes
Contact Discharge	± 4 KV	Electrostatic discharges should be applied to all exposed surfaces of the EUT except where the user documentation specifically indicates a requirement for appropriate protective measures (as specified in CENELEC EN 61000-4-2, clauses 8.3.2 and 8.3.3).
Air Discharge	± 8 KV	

7.8.3 Fast Transients - Common Mode

The purpose of this test is intended to assess the ability of the EUT to operate as intended in the event of fast transients present on one of the input/output ports. This test should be performed on the AC mains power port (if any) of radio equipment and associated ancillary equipment. This test should be additionally performed on signal ports, wired network ports, control ports, and DC power ports, of radio equipment and associated ancillary equipment, if the cables may be longer than 3 m.

Where this test is not carried out on any port because it is not intended to be used with cables longer than 3 m, a list of the ports, which were not tested for this reason, should be included in the test report.

The test method should be in accordance with CENELEC EN 61000-4-4, clauses 7 and 8.

The EUT should meet the performance criteria for transient phenomena (see Section 7.6), when it is tested with the requirements shown in Table 73.

Table 73. Limits for Fast Transients - Common Mode

Port Type	Test Signal Level
Signal ports, Wired network ports (excluding xDSL), and Control ports	0.5 kV open circuit voltage at a repetition rate of 5 kHz as given in CENELEC EN 61000-4-4, clause 5.
xDSL wired network ports	0.5 kV open circuit voltage at a repetition rate of 100 kHz as given in CENELEC EN 61000-4-4, clause 5.
DC power input ports	0.5 kV open circuit voltage at a repetition rate of 5 kHz as given in CENELEC EN 61000-4-4, clause 5.
AC power input ports	1 kV open circuit voltage at a repetition rate of 5 kHz as given in CENELEC EN 61000-4-4, clause 5.

7.8.4 RF - Common Mode

The purpose of this test is intended to assess the ability of the EUT to operate as intended in the presence of a radio frequency disturbance on the input/output ports. This test should be performed on the AC mains power port (if any) of radio equipment and associated ancillary equipment. This test should be additionally performed on signal ports, wired network ports, control ports, and DC power ports, of radio equipment and associated ancillary equipment, if the cables may be longer than 3 m.

Where this test is not carried out on any port because it is not intended to be used with cables longer than 3 m, a list of the ports, which were not tested for this reason, should be included in the test report.

The test method should be in accordance with CENELEC EN 61000-4-6, clauses 6 and 8.

The EUT should meet the performance criteria for continuous phenomena (see Section 7.6), when it is tested with the following requirements:

- The test level should be severity level 2 as given in CENELEC EN 61000-4-6, clause 5 corresponding to 3 V rms unmodulated. The test signal should then be amplitude modulated to a depth of 80% by a sinusoidal audio signal of 1000 Hz. If the wanted signal is modulated at 1000 Hz, then the test signal of 400 Hz should be used;
- The test should be performed over the frequency range 150 kHz to 80 MHz with the exception of an exclusion band for transmitters, and for receivers and duplex transceivers, (see Section 7.4);
- For receivers and transmitters the stepped frequency increments should be 1% frequency increment of the momentary frequency in the frequency range 150 kHz to 80 MHz;
- The injection method to be used should be selected according to the basic standard CENELEC EN 61000-4-6, clause 7;
- Responses on receivers or receiver parts of transceivers occurring at discrete frequencies which are narrow band responses (spurious responses), are disregarded from the test;
- The dwell time of the test phenomena at each frequency should not be less than the time necessary for the EUT to be exercised and to be able to respond;
- The frequencies of the immunity test signal selected and used during the test should be recorded in the test report.

7.8.5 Transients and Surges in the Vehicular Environment

The purpose of this test is intended to assess the ability of the EUT to operate as intended in the event of transients and surges present on their DC power input ports in a vehicular environment. These tests should be performed on nominal 12 V and 24 V DC supply voltage input ports of mobile radio and ancillary equipment, which are also intended for mobile use in vehicles. These tests should be performed on a representative configuration of the mobile radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

The test method should be in accordance with ISO 7637-2 [20], clause 4 for 12 V DC and 24 V DC powered equipment. The test method should be in accordance with ISO 7637-2 [20], clause 4, applying pulses 1, 2a, 2b, 3a, 3b, and 4, using immunity test level III. For the purpose of EMC testing it is sufficient to apply pulses 1, 2a, 2b and 4, 10 times each, and apply the test pulses 3a and 3b for 20 minutes each.

The EUT should meet the performance criteria limits shown in Table 74.

Table 74. Limits for Transients and Surges in the Vehicular Environment

Pulse Types Applied	Performance Criteria
pulse 3a and 3b	Continuous phenomena should apply (see section 7.6).
pulse 1, 2a, 2b, and 4	Transient phenomena should apply (see section 7.6), with the exception that a communication link need not to be maintained during the EMC exposure and may have to be re-established.

7.8.6 Voltage Dips and Interruptions

The purpose of this test is intended to assess the ability of the EUT to operate as intended in the event of voltage dips and interruptions present on the AC mains power input ports. This test should be performed on the AC mains power port (if any) of radio equipment and associated ancillary equipment.

This test should be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

The test method should be in accordance with CENELEC EN 61000-4-11, clauses 8 or for equipment requiring a mains current of greater than 16 A CENELEC EN 61000-4-34, clause 8 should be used.

The equipment should meet the performance criteria limits shown in Table 75.

Table 75. Limits for Voltage Dips and Interruptions

Type of Voltage applied	Test Levels	Performance Criteria
Voltage Dips	• Voltage dip: 0% residual voltage for 0.5 cycle; • Voltage dip: 0% residual voltage for 1 cycle; • Voltage dip: 70% residual voltage for 25 cycles (at 50 Hz)	Transient phenomena should apply (see Section 7.6).
Voltage Interruptions	Voltage interruption: 0% residual voltage for 250 cycles (at 50 Hz).	• In the case where the equipment is fitted with or connected to a battery back-up, the performance criteria for transient phenomena should apply (see Section 7.6). • In the case where the equipment is powered solely from the AC mains supply (without the use of a parallel battery back-up) volatile user data may have been lost and if applicable the communication link need not to be maintained and lost functions should be recoverable by user or operator. • No unintentional responses should occur at the end of the test. • In the event of loss of function(s) or in the event of loss of user stored data, this fact should be recorded in the test report.

7.8.7 Surges

The purpose of this test is intended to assess the ability of the EUT to operate as intended in the event of surges present on the AC mains power input ports and wired network ports. This test should be performed on the AC mains power port (if any) of radio equipment and associated ancillary equipment. This test should be additionally performed on wired network ports, if any.

This test should be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

The test method should be in accordance with CENELEC EN 61000-4-5, clauses 7 and 8.

The equipment should meet the transient performance criteria, when it is tested as per the test level limits shown in Table 76.

Table 76. Limits for Surges

Type of Port and Connection	Test Signal Level
Wired Network port – connected to Outdoor Cables (For Symmetrically Operated)	The test signal level should be 1 kV (applied Line to Ground) as given in CENELEC EN 61000-4-5, clause 5 with a 10/700 uSec pulse as defined in CENELEC EN 61000-4-5, clause 6.2. The total output impedance of the surge generator should be in accordance with the basic standard CENELEC EN 61000-4-5, clauses 6.1 and 6.2.
Wired Network port – connected to Outdoor Cables (For Non-Symmetrically Operated)	The test signal level should be 1 kV (applied Line to Ground or Shield to Ground) and 0.5 kV (applied Line to Line) as given in CENELEC EN 61000-4-5, clause 5 with a 1.2/50 uSec pulse as defined in CENELEC EN 61000-4-5, clause 6.1. The total output impedance of the surge generator should be in accordance with the basic standard CENELEC EN 61000-4-5, clauses 6.1 and 6.2.
Wired Network port – connected to Indoor Cables (Longer than 30 meters)	The test signal level should be 0.5 kV (applied Line to Ground or Shield to Ground) as given in CENELEC EN 61000-4-5, clause 5 with a 1.2/50 uSec pulse as defined in CENELEC EN 61000-4-5, clause 6.1. The total output impedance of the surge generator should be in accordance with the basic standard CENELEC EN 61000-4-5, clauses 6.3.
Mains ports	The test signal level should be 2 kV applied Line to Ground and 1 kV Line to Line as given in CENELEC EN 61000-4-5, clause 6.3 with a 1.2/50 uSec pulse as defined in CENELEC EN 61000-4-5, clause 6.2. In telecom centers, the test signal level should be 1 kV applied Line to Ground and 0.5 kV Line to Line as given in CENELEC EN 61000-4-5, clause 6.3 with a 1.2/50 uSec pulse as defined in CENELEC EN 61000-4-5 , clause 6.2. The total output impedance of the surge generator should be in accordance with the basic standard CENELEC EN 61000-4-5, clauses 6.3.

(1) No test should be required where normal functioning cannot be achieved, because of the impact of the CDN (Coupling/Decoupling Network) on the EUT.

8 IEC 62368-1

The IEC 62638-1 is a Hazard-based product-safety standard for Audio/Video (AV), Information and Communication Technology equipment (ICT) in both the EU and North America. This is a new standard, which is set to supersede the outgoing IEC 60950-1 for ICT equipment and IEC 60065 for AV equipment.

The European and American bodies have harmonized the date December 20, 2020, from which the IEC 60950-1 and IEC 60065 standards will be withdrawn and IEC 62368-1 will take effect. This helps the manufactures to transition from the outgoing standards IEC 60950-1 and IEC 60065 to the new standard IEC 62368-1.

In EU, on the harmonized date December 20, 2020, the presumptions of conformity with directives that reference the outgoing standards IEC 60950-1 and IEC 60065 will also cease, when it withdraws the outgoing standard and transition to the new standard IEC 62368-1. The existing products that comply with IEC 60950-1 or IEC 60065 will need to be re-investigated against the new standard IEC 62368-1 in order to obtain a Re-certification.

In North America, the harmonized date December 20, 2020 is the UL Effective Date. UL will proceed with a transition, whereby new submissions for certification will be investigated against IEC 62368-1, but existing products certified to the legacy standards will not be subjected to an Industry File Review (IFR).

8.1 *Safety Requirements*

The IEC 62638-1 standard is applicable to the safety of electrical and electronic equipment within the field of audio, video, information and communication technology, and business and office machines with a rated voltage not exceeding 600 V and intended for domestic or professional use. The application of this Standard is intended to reduce the risk of injury and damage under normal conditions or abnormal conditions due to the hazards such as Electrical shock, Fire, Burn, Mechanical, Radiation, Chemical and others. The requirements of this Standard are intended to provide protection to persons as well as to the surrounding of the equipment. The safety requirements are very elaborate. Some of the main category requirements are shown in Table 77. There are many sub-requirements under each category. Please refer to IEC 62638-1 standard for a detailed requirements and compliance criteria.

Table 77. Safety Requirements - Main Categories

Category Requirements	Clause(s) of the IEC 62368-1	Compliance Criteria
General	4	Refer to IEC 62638-1
Electrically Caused Injury	5	Refer to IEC 62638-1
Electrically Caused Fire	6	Refer to IEC 62638-1
Injury Caused by Hazardous Substances	7	Refer to IEC 62638-1
Mechanically Caused Injury	8	Refer to IEC 62638-1
Thermal Burn Injury	9	Refer to IEC 62638-1
Radiation	10	Refer to IEC 62638-1

9 EN 62311

The EN 62311 applies to electronic and electrical equipment for which no dedicated product standard or product family standard regarding human exposure to electromagnetic fields applies. It covers equipment with intentional or non-intentional radiators as well as a combination thereof. This standard provides assessment methods and criteria to evaluate equipment against limits on exposure of people related to electric, magnetic and electromagnetic fields. The frequency range covered is from 0 Hz to 300 GHz.

9.1 *Requirements and Limits of EN 62311*

The equipment should meet the Reference Level limits and Basic Restrictions limits in accordance with Council Recommendation 99/519/EC on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (Official Journal L199 of July 30, 1999).

The Reference Level limits as per Annex-III of Council Recommendation 99/519/EC are shown in Table 78. If the quantities of measured values are greater than the reference levels, it does not necessarily follow that the basic restrictions have been exceeded. In this case, an assessment should be made as to whether exposure levels are below the basic restrictions.

Table 78. Reference levels for Electric, Magnetic and Electromagnetic fields

Frequency Range	E-field strength (V/m)	H-field strength (A/m)	B-field (µT)	Equivalent plane wave power density Seq (W/m2)
0-1 Hz	—	3.2×10^4	4×10^4	—
1-8 Hz	10000	$3.2 \times 10^4 / f^2$	$4 \times 10^4 / f^2$	—
8-25 Hz	10000	4000/f	5000/f	—
0.025-0.8 kHz	250/f	4/f	5/f	—
0.8-3 kHz	250/f	5	6.25	—
3-150 kHz	87	5	6.25	—
0.15-1 MHz	87	0.73/f	0.92/f	—
1-10 MHz	$87/ f^{1/2}$	0.73/f	0.92/f	—
10-400 MHz	28	0.073	0.092	2
400-2000 MHz	$1375 \times f^{1/2}$	$0.0037 \times f^{1/2}$	$0.0046 \times f^{1/2}$	f/200
2-300 GHz	61	0.16	0.20	10

(1) “f” as indicated in the frequency range column.

(2) For frequencies between 100 kHz and 10 GHz, Seq, E2, H2, and B2 are to be averaged over any six-minute period.

(3) For frequencies exceeding 10 GHz, Seq, E2, H2, and B2 are to be averaged over any $68/ f^{1.05}$-minute period (f in GHz).

(4) No E-field value is provided for frequencies < 1 Hz, which are effectively static electric fields. For most people the annoying perception of surface electric charges will not occur at field strengths less than 25 kV/m. Spark discharges causing stress or annoyance should be avoided.

The Basic Restriction limits as per Annex-II of Council Recommendation 99/519/EC are shown in Table 79. The assessment should be made as to whether exposure levels are below the basic restrictions or not, when the quantities of measured values are greater than the reference levels shown in Table 78 only.

Table 79. Basic Restrictions Limits for Electric, Magnetic, and Electromagnetic fields

Frequency Range	Magnetic flux density (mT)	Current density (mA/ m2) (rms)	Whole body average SAR (W/kg)	Localized SAR (head and trunk) (W/kg)	Localized SAR (limbs) (W/kg)	Power density, S (W/ m2)
0 Hz	40	—	—	—	—	—
> 0 - 1 Hz	—	8	—	—	—	—
1 - 4 Hz	—	8/f	—	—	—	—

Table 79. Basic Restrictions Limits for Electric, Magnetic, and Electromagnetic fields (continued)

Frequency Range	Magnetic flux density (mT)	Current density (mA/ m2) (rms)	Whole body average SAR (W/kg)	Localized SAR (head and trunk) (W/kg)	Localized SAR (limbs) (W/kg)	Power density, S (W/ m2)
4 - 1000 Hz	—	2	—	—	—	—
1000 Hz – 100 KHz	—	f/500	—	—	—	—
100 kHz – 10 MHz	—	f/500	0.08	2	4	—
10 MHz – 10 GHz	—	—	0.08	2	4	—
10 - 300 GHz	—	—	—	—	—	10

(1) “f” is the frequency in Hz.

(2) The basic restriction on the current density is intended to protect against acute exposure effects on central nervous system tissues in the head and trunk of the body and includes a safety factor. The basic restrictions for ELF fields are based on established adverse effects on the central nervous system. Such acute effects are essentially instantaneous and there is no scientific justification to modify the basic restrictions for exposure of short duration. However, since the basic restriction refers to adverse effects on the central nervous system, this basic restriction may permit higher current densities in body tissues other than the central nervous system under the same exposure conditions.

(3) Because of electrical inhomogeneity of the body, current densities should be averaged over a cross section of 1 cm2 perpendicular to the current direction.

(4) For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by √2 (=1,414). For pulses of duration tp the equivalent frequency to apply in the basic restrictions should be calculated as f = 1/(2tp).

(5) For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.

(6) All SAR values are to be averaged over any six-minute period.

(7) Localized SAR averaging mass is any 10g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure. These 10g of tissue are intended to be a mass of contiguous tissue with nearly homogeneous electrical properties. In specifying a contiguous mass of tissue, it is recognized that this concept can be used in computational dosimetry but may present difficulties for direct physical measurements. A simple geometry such as cubic tissue mass can be used provided that the calculated dosimetric quantities have conservative values relative to the exposure guidelines.

(8) For pulses of duration tp the equivalent frequency to apply in the basic restrictions should be calculated as f = 1/(2tp). Additionally, for pulsed exposures, in the frequency range 0.3 to 10 GHz and for localized exposure of the head, in order to limit and avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SA should not exceed 2mJ kg–1 averaged over 10 g of tissue.

10 References

1. ETSI EN 300 440 V2.2.1 (2018-07)
2. ETSI EN 300 328 V2.2.2 (2019-07)
3. ETSI EN 301 893 V2.1.1 (2017-05)
4. ETSI EN301 489-1 V2.2.1 (2019-03)
5. ETSI EN 301 489-17 V3.2.2 (2019-12)
6. ETSI EN 300 761-2 V1.1.1 (2001-06)
7. ETSI EN 300 683 V1.2.1 (1999-07)
8. IEC 62368-1
9. ERC Recommendation 70-03
10. ECO Documentation Database
11. RED (Radio Equipment Directive)
12. CENELEC EN 55032
13. CENELEC EN 50561-1
14. CENELEC EN 50561-3
15. CENELEC EN 61000-6
16. ETSI TR 101 651
17. ISO 7637-2
18. IEC 61000-3
19. CENELEC EN 61000-4
20. ISO 7637-2
21. EN 62311
22. Council Recommendation 1999/519/EC
23. Regulation (EC) No 765/2008
24. Regulation (EU) 2017/1354