ETSI TS 102 792 V1.2.1 (2015-06)

Intelligent Transport Systems (ITS);
Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and
Intelligent Transport Systems (ITS)
operating in the 5 GHz frequency range

Reference
RTS/ITS-00438

Keywords
DSRC, ITS, radio, RTTT

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Sous-Préfecture de Grasse (06) N° 7803/88

Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

Modal verbs terminology

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Introduction

The band 5 795 MHz to 5 815 MHz has been harmonized for the use by Transport and Traffic Telematics (TTT), also called CEN DSRC, by the EC decision 2013/752/EU [i.12] and the ECC recommendation ECC/REC/70-03 [i.13], which is primarily used for road charging systems in Europe and elsewhere.

By issuing the Directive 2004/52/EC [i.14] of the European Parliament and of the Council and Commission Decision 2009/750/EC [i.15] the European Union has pointed to TTT to be used for road charging systems in Europe.

By issuing ECC/DEC/(08)01 [i.2] and ECC/REC/(08)01 [i.3] ECC has allocated the band 5 855 MHz to 5 925 MHz to be used for Intelligent Transport Systems (ITS). In addition, the band 5875 MHZ to 5905 MHz has been harmonized for the use in the EU by the EC decision 2008/671/EC [i.2]. These documents recommend ITS systems to be designed and to be operated in a way to avoid harmful interference to TTT.

The present document specifies necessary measures to avoid such harmful interference.

1 Scope

Radio transmissions in the ITS-G5A/B/D frequency bands (see ETSI EN 302 571 [i.5]) interfere with CEN DSRC using the TTT band (see EC Decision 2013/752/EC [i.12]) when equipment from both systems are close to each other.

This was shown in ECC Report 101 [i.1], ECC Report 228 [i.8], ETSI TR 102 960 [i.7] and ETSI TR 102 654 [i.6].

The present document specifies requirements to ensure coexistence between ITS stations using the frequency bands ITS-G5A/B/D and CEN DSRC using the TTT band. It is intended to be used as a basis for product development and for development of suitable testing procedures to prove conformance to regulations.

2 References

2.1 Normative references

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

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

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

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

[1] ETSI EN 302 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[2] ETSI TS 102 894-2 (V1.2.1) (2014-09): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary".

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

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

[5] ETSI ES 200 674-1 (V2.4.1): "Intelligent Transport Systems (ITS); Road Transport and Traffic Telematics (RTTT); Dedicated Short Range Communications (DSRC); Part 1: Technical characteristics and test methods for High Data Rate (HDR) data transmission equipment operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band".

2.2 Informative references

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

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

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

[i.1] ECC Report 101: "Compatibility studies in the band 5855- 5925 MHz between Intelligent Transport Systems (ITS) and other systems".

[i.2] ECC/DEC/(08)01: "ECC Decision of 14 March 2008 on the harmonised use of the 5875-5925 MHz frequency band for Intelligent Transport Systems (ITS) (2008/671/EC)".

[i.3] ECC/REC/(08)01: "Use of the band 5855-5875 MHz for intelligent transport systems (ITS)".

[i.4] ETSI EN 300 674 (parts 1, 2-1 and 2-2): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band".

[i.5] ETSI EN 302 571: "Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.6] ETSI TR 102 654: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Co-location and Co-existence Considerations regarding Dedicated Short Range Communication (DSRC) transmission equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range and other potential sources of interference".

[i.7] ETSI TR 102 960: "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (RTTT DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range; Evaluation of mitigation methods and techniques".

[i.8] ECC Report 228: "Compatibility studies between intelligent transport systems (ITS) in the band 5855- 5925 MHz and other systems in adjacent bands".

[i.9] ETSI EN 302 637-3: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

[i.10] ETSI TS 101 539-1: " Intelligent Transport Systems (ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification".

[i.11] ETSI TS 101 539-3: "Intelligent Transport Systems (ITS); V2X Applications; Part 3: Longitudinal Collision Risk Warning (LCRW) application requirements specification".

[i.12] EC Decision 2013/752/EC: "COMMISSION IMPLEMENTING DECISION of 11 December 2013 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2005/928/EC"; Band No. 62.

[i.13] ECC Recommendation ECC/REC/70-03:'Relating to the Use of Short Range Devices (SRD)', Tromsø 1997, amended February 2014.

[i.14] Directive 2004/52/EC: "Directive of the European Parliament and of the Council of 29 April 2004 on the interoperability of electronic road toll systems in the Community".

[i.15] 2009/750/EC: "Commission Decision of 6 October 2009 on the definition of the European Electronic Toll Service and its technical elements".

[i.16] EC Decision 2008/671/EC;"COMMISSION DECISION of 5 August 2008 on the harmonised use of radio spectrum in the 5 875-5 905 MHz frequency band for safety-related applications of Intelligent Transport Systems (ITS)".

[i.17] ETSI EN 302 636-4-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality".

3 Definitions, symbols and abbreviations

3.1 Definition

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

CEN DSRC: dedicated short range communication as specified in CEN EN 12253 [3], CEN EN 12795 [4] and ETSI EN 300 674 [i.4]

coexistence mode: operational mode of an ITS station that avoids harmful interference to CEN DSRC installations

default ITS radio parameters: ITS transmit power level of 23 dBm EIRP and unwanted ITS emissions in the frequency range from 5 795 MHz to 5 815 MHz not exceeding -33 dBm/MHz EIRP

default protected zone radius: protected zone radius for ITS stations with default ITS radio parameters, it is either stored in the protected zone database, or it can be received in a CAM from a roadside ITS station

ITS station: station transmitting in the frequency bands ITS-G5A, ITS-G5B or ITS-G5D

NOTE 1: This definition is more restrictive than in other related documents.

NOTE 2: ITS-G5A, ITS-G5B and ITS-G5D are defined in ETSI EN 302 571 [i.5].

mitigation mechanism: set of rules that an ITS station applies to operate in coexistence mode

protected zone: circular area defined by its centre and radius where mitigation mechanisms are be applied

official protected zone database: database published by an international consortium of toll operators, which contains the positions and protected zone radii of tolling installations

vehicle station type: station types with value range from 3 to 11

NOTE: See ETSI TS 102 894-2 [2].

3.2 Symbols

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

d	distance
d_0	reference distance for path loss model (1 m)
L_{ant}	antenna loss due to polarization or windscreen
N	number of interfering ITS stations
N_{ITS}	number of ITS stations within the protected zone radius
n	path loss coefficient
PL	free space path loss
PL_0	free space path loss in 1 m distance
P_{Rx}	receive power level
P_{Tx}	transmit power level
P_{TXmax}	maximum transmit power level
σ	fading loss for path loss model
T_{off}	Minimum time between two transmissions
$T_{off(C)}$	Minimum time between two transmissions in coexistence mode C
$T_{off(D)}$	Minimum time between two transmissions in coexistence mode D
T_{on}	Maximum length of a transmission

3.3 Abbreviations

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

CEN	Comité Européen de Normalisation
CVIS	Cooperative Vehicle-Infrastructure Systems

NOTE: CVIS was a European project.

C-ITS	Cooperative Intelligent Transport Systems
DEC	Decision
DENM	Decentralised Environmental Notification Message
DSRC	Dedicated Short Range Communication
ECC	Electronic Communications Committee
EIRP	Equivalent Isotropic Radiated Power
EN	European Norm

ERM Radio spectrum Matters
ETSI European Telecommunication Standard Institute
HDR High Data Rate

NOTE: DSRC communication conforming to ETSI ES 200 674-1 [5].

IEEE Institute of Electrical and Electronics Engineers
IPR Intellectual Property Rights
ISO International Standardization Organization
ITS Intelligent Transport System
ITS-S ITS station
ITU International Telecommunication Union
MAC Medium Access Control
OBU On Board Unit
PHY PHYsical (OSI layer)
REC Recommendation
RSU RoadSide Unit
RTTT Road Transport and Traffic Telematics
RX Receive
TS Technical Specification
TTT Transport and Traffic Telematics

NOTE: TTT is a more recent denomination for RTTT.

TX Transmit

4 General overview

4.1 Introduction

Cooperative ITS (C-ITS) uses wireless communication between ITS stations in the frequency bands ITS-G5A/B/D according to ECC/DEC/(08)01 [i.2], ECC/REC/(08)01 [i.3] and ETSI EN 302 571 [i.5].

ITS stations can be:

- fixed, mounted at a fixed geographical position, often close to a road or street (roadside ITS stations);
- mobile, mounted in vehicles (vehicle ITS stations); or
- personal, integrated in smart phones or other personal equipment.

Deployment of C-ITS is expected to start in 2015 with a gradually increasing penetration. Considering this, almost every road vehicle is expected to be equipped with ITS-G5 technology and fixed stations are expected to be installed in great numbers. Deployment of personal ITS stations is also expected.

C-ITS is considered essential to support different European policies intended to reduce road accidents.

CEN DSRC stations operate in the band 5 795 MHz to 5 815 MHz according to ETSI EN 300 674 [i.4]. Fixed installations with one or many road side units (RSUs) are mainly located at road charging points. On board units (OBU), which are only active in close vicinity of the fixed stations, are installed in a significant fraction of the vehicle population in Europe and other regions.

CEN DSRC communication is very local in nature. The area where communication takes place is often referred to as the tolling zone. The tolling zone can be approximated by a box with 10 m length measured from the RSU position opposite the driving direction and a width that includes all lanes of one direction (see figure 4.1). The height of this box is from ground up to 3 m. Even though the CEN DSRC communication zone is limited, interference from radio sources even outside this area may harm CEN DSRC communication when the field strength limits specified in clause 4.2 are exceeded.

Because of the small frequency separation between the bands 5 795 MHz to 5 815 MHz and 5 855 MHz to 5 925 MHz and the fact that both systems operate in the road traffic environment, there is a significant potential for interference. In ECC Report 101 [i.1], ECC Report 228 [i.8], ETSI TR 102 654 [i.6] and ETSI TR 102 960 [i.7] it has been concluded that:

- CEN DSRC transmissions do not cause any significant interference to ITS stations.
- Some mitigation techniques that are specified in the present document degrade the performance of ITS stations.
- The transmit signal from ITS stations can cause blocking at the receiver in a CEN DSRC RSU.
- Unwanted emissions from ITS stations can cause interference at the receiver in a CEN DSRC RSU.
- The transmit signal from ITS stations can cause interference at the receiver in a CEN DSRC OBU in vehicles.

Therefore, technical solutions are required to minimize interference to tolling CEN DSRC RSU and OBU and to minimize the performance degradation of ITS.

For ITS stations, this can be achieved either by always complying with some transmit restrictions (coexistence mode, see clause 5.4) or by receiving and processing information on the position of CEN DSRC tolling stations and complying to transmit restrictions in the immediate vicinity of the CEN DSRC tolling station (protected zone, see clause 5.2). The goal is to restrict the unwanted emissions of an ITS station within the vicinity of a CEN DSRC tolling zone.

CEN DSRC stations may enhance their adjacent channel rejection (blocking) capabilities such that the interference from the ITS stations is reduced.

NOTE: The mitigation mechanisms specified in the current document may help reducing interference to road tolling systems based on high data rate (HDR) DSRC used in Italy (specified in ETSI ES 200 674-1 [5]), which shares the same frequency range as CEN DSRC. At the time of publication of the present document no studies were available that could prove that these mechanisms are also capable to avoid harmful interference to HDR DSRC tolling.

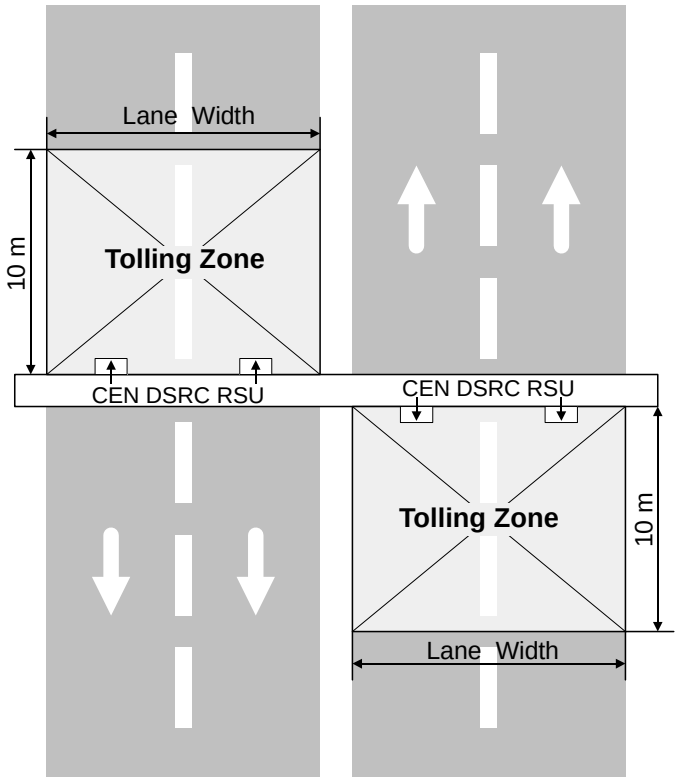

Figure 4.1: Example of tolling zone geometry

4.2 Field strength thresholds for coexistence

A continuous interfering signal within the frequency band from 5 855 MHz to 5 925 MHz (ITS-G5A/B/D band) does not cause harmful interference to the CEN DSRC downlink from the RSU to the OBU, when the electric field strength of this signal within the tolling zone does not exceed 0,11 V/m (-51,6 dBm).

A continuous linear polarized interfering signal within the frequency band from 5 855 MHz to 5 925 MHz (ITS-G5A/B/D band) does not cause harmful interference to the CEN DSRC uplink from the OBU to the RSU, when the electric field strength of this signal at the CEN DSRC RSU antenna does not exceed 0,21 V/m (-46 dBm).

A continuous linear polarized interfering signal within the frequency band from 5 795 MHz to 5 815 MHz (CEN DSRC band) does not cause harmful interference to the CEN DSRC uplink from the OBU to the RSU, when the power density of this signal at the CEN DSRC RSU antenna does not exceed -129 dBm/MHz.

The strictest requirement of these three is taken as a basis for the interference mitigation mechanisms in clause 5.

For non-continuous signals, all these field strength limits can be exceeded for a time span of up to 7 ms under the conditions described in clause 5.4.

NOTE: Values are derived from ECC Report 228 [i.8], ETSI TR 102 654 [i.6] and ETSI TR 102 960 [i.7].

4.3 ITS output power thresholds for coexistence

Taking the field strength thresholds for coexistence at the CEN DSRC OBU antenna and RSU antenna from clause 4.2 into account, the TX power thresholds for ITS transmitters can be calculated for typical use cases. These calculation results are summarized in this clause and requirements based on them are given in clause 5.4.

Mobile ITS stations transmitting a continuous signal with less than or equal to +10 dBm linear polarized EIRP, and having unwanted emissions with an EIRP density of less than or equal to -65 dBm/MHz into the 5 795 MHz to 5 815 MHz frequency band, do not interfere with a receiving CEN DSRC RSU in tolling zones.

When the ITS-G5 antenna is mounted not higher than 2 m above ground (e.g. in a passenger car), this upper unwanted EIRP emission limit in the 5 795 MHz to 5 815 MHz frequency band is -60 dBm/MHz (see ECC Report 228 [i.8]).

When the antenna is mounted inside the vehicle cabin (e.g. personal devices) or closer than 1,5 m to the CEN DSRC OBU, an ITS station fulfilling these requirements may still interfere with a CEN DSRC OBU in the same vehicle (see also clause 5.4, clause B.1, and clause 5.6.1).

4.4 Duty cycle limits

CEN DSRC is based on a packet communication. Typical frames have a duration of 0,5 ms to 2,5 ms. Inter frame time is implementation specific but often in the range 5 ms to 10 ms. The time of a payment transaction may vary between 25 ms and 1 s.

C-ITS is also based on packet communication. Typical frames have a duration T_{on} of less than 1 ms at a data rate of 6 Mbit/s, while frames of maximum allowed size have a duration of 2 ms.

Early C-ITS deployment is expected to use a typical inter frame time T_{off} of more than 100 ms (see ETSI EN 302 637-2 [1]). Later implementations for additional services may require significantly shorter times.

Even if the field strength limits in clause 4.2 and clause 4.3 are exceeded, duty cycle limitations can decrease the risk of interference to negligible levels. These limitations are defined in terms of T_{on} and T_{off} times of an ITS station.

This is further detailed in clause 5.

4.5 Procedures

An ITS station may switch between two modes, normal mode and coexistence mode, where in normal mode:

- transmit duty cycle is not limited;
- output power level is limited to the values specified in ETSI EN 302 571 [i.5] clause 6.3;

- unwanted emissions in the band 5 795 MHz to 5 815 MHz are limited to -30 dBm/MHz.

while in coexistence mode:

- transmit duty cycle is limited; and / or
- output power level and unwanted TX emissions are reduced.

When an ITS station is close to a CEN DSRC tolling station, so that the thresholds in clause 4.2 are exceeded, it shall operate in coexistence mode. Details are found in clause 5.

5 Interference mitigation mechanisms

5.1 Introduction and basic requirements

Each tolling CEN DSRC area shall be associated with a circular protected zone, surrounding the station, designed to protect it from harmful interference from ITS stations.

An ITS station in the protected zone shall operate in coexistence mode (detailed in clause 5.4).

For mobile and personal ITS-S the centre position of a protected zone shall be either determined by radio detection of the tolling signal (detailed in in clause 5.2.5) or by a search among all stored protected zone centre positions (detailed in clause 5.5.1). These positions were either received by CAM messages (detailed in clause 5.2.5 and clause 5.2.2.3) or are stored in a database (detailed in clause 5.2.4).

When the ITS station is using a tolling zone radio detector as described in clause 5.2.5 to determine the centre position of a protected zone, the information about the protected zone centre position shall be indicated in the CAM message as detailed in clause 5.2.5. The CAM generation rate when operating in coexistence mode shall be as specified in ETSI EN 302 637-2 [1] (no additional CAMs).

The protected zone radius is determined by the ITS station output power level and its unwanted emissions (detailed in clause 5.2.3). For the default ITS radio parameters (see clause 3.1) the default protected zone radius is included in the protected zone database and optionally in the data field ProtectedCommunicationZone of a CAM in the data element protectedZoneRadius. When another ITS output power level, or a protected zone radio detection as described in clause 5.2.5 is used, the protected zone radius shall be determined according to table 5.1.

When no longer inside the protected zone the ITS station may revert to normal mode (detailed in clause 5.3).

5.2 Protected zone

5.2.1 Protected zone definition

The protected zone is defined by a centre position and a radius. Protected zones can be either permanently defined by their centre positon for e.g. fixed CEN DSRC tolling installations, or the centre positions are only temporary valid, e.g. for tolling enforcement vehicles.

5.2.2 Protected zone centre position

5.2.2.1 Protected zone centre position overview

Mobile and personal ITS stations operating in normal mode shall be able to receive and interpret information about protected zones transmitted in the data field CenDsrcTollingZone and in the data field ProtectedCommunicationZone as described in ETSI EN 302 637-2 [1] and ETSI TS 102 894-2 [2], clauses A.105 and A.121.

A mobile or personal ITS station shall store the last received protected zone centre position as specified in clause 5.2.2.2 and clause 5.2.2.3. Received protected zone centre positions are either stored in a temporary variable or protected zone centre position list, depending on their origin given by the station type and role (see clause 5.2.2.2 and clause 5.2.2.3).

The temporary position and all positions stored in the list may be removed from storage when the ITS station is switched off, e.g. when the vehicle containing the ITS-S is parked.

From all available protected zone centre position the one closest to the ITS-S shall be used to determine the coexistence mode (see clause 5.5).

5.2.2.2 Temporary protected zone centre positions

Only one temporary position shall be considered by each mobile ITS-S at the same time. The stored temporary protected zone position shall be updated by either

- the result of the detection of a protected zone centre position (see clause 5.2.5), or
- the reception of one protected zone centre position in the data field ProtectedCommunicationZone of a CAM from an ITS station with a station type roadSideUnit (15), when the data element protectedZoneType is 1,

under the condition that the protected zone position is closer to the ITS-S than the previously stored temporary position.

protectedZoneType 1 is used for temporary toll stations and tolling enforcement vehicles.

Protected zone centre positions in the data field CenDsrcTollingZone of a CAM with a vehicle station type, shall be taken into account on reception as temporary protected zone centre position for ITS-S using a protected zone detection as specified in clause 5.2.5. Other ITS-S may also use these positions as temporary protected zone centre positions.

5.2.2.3 Protected zone centre position list

A protected zone centre position list shall be implemented when no update mechanism (see clause 5.2.4) for the protected zone database solution is realized. Otherwise, the protected zone centre position list is optional.

When a protected zone centre position list is used in an ITS station, following requirements apply:

- Positions in the data field ProtectedCommunicationZone of a CAM from an ITS station with station type roadSideUnit (15) shall be stored in the protected zone centre position list when the data element protectedZoneType is set to 0.
- At least 16 protected zone centre positions shall be stored in addition to the fixed protected zone database (specified in clause 5.2.4). All stored positions in the protected zone centre position list can be replaced by the new received positions (no partial update is required).

5.2.3 Protected zone radius

For ITS stations with default ITS radio parameters the default protected zone radius is stored in the protected zone database or it can be transmitted in a CAM from a roadside ITS station.

When a protected zone centre position list is used in an ITS station, and a CAM from a ITS station with a station type roadSideUnit (15) and a protectedZoneType set to 0 is received, following requirements concerning the protected zone radius apply:

- When the data element protectedZoneRadius is present in the data field ProtectedCommunicationZone of the CAM as specified in ETSI TS 102 894-2 [2] and when it is in the range from 0 m to 255 m, the value of this data element shall be stored in the protected zone centre position list together with the protected zone centre positions.
- When the data element protectedZoneRadius is not present, 55 m shall be stored in the protected zone centre position list.
- For protectedZoneRadius values above 255 m a value of 255 m shall be stored in the protected zone centre position list.

When a CAM from a roadside ITS station with a station type roadSideUnit (15) and a protectedZoneType set to 1 is received, following requirements concerning the protected zone radius apply:

- When the data element protectedZoneRadius is present in the data field ProtectedCommunicationZone of the CAM as specified in ETSI TS 102 894-2 [2] and when it is in the range from 0 m to 255 m, the value of this data element shall be stored temporary together with the temporary protected zone position.
- When the data element protectedZoneRadius is not present, 55 m shall be stored temporary together with the temporary protected zone position.

- For protectedZoneRadius values above 255 m a value of 255 m shall be stored temporary together with the temporary protected zone position.

For ITS stations not conform to the default ITS radio parameters, the protected zone radius shall be determined by use of table 5.1. When a database entry or a protected zone radius information from a CAM is available, then the offset to 55 m shall be determined and added to the radius belonging to the TX output power level and unwanted emissions in table 5.1 (see example 2 and example 3).

For a given protected zone radius the requirements for both output power level and unwanted emissions apply. If one of the requirements is not fulfilled, the greater radius shall be used.

NOTE 1: The protected zone radius can be set to more than 55 m to describe a large toll station by only one protected zone position. Such a road toll station uses several RSUs installed across a wide road to cover many lanes. The offset to 55 m is given as the distance between the two outer placed RSUs divided by 2, and the protected zone centre is right in between them (see example 1).

EXAMPLE 1 A typical motorway lane has a width of 3,3 m. For a motorway with four lanes the protected zone centre position can be set in between lane two and three. The protectedZoneRadius value results then to the next integer above 3 × 3,3 / 2 + 55, which is 60.

Table 5.1: Protected zone radius as a function of output power level and unwanted emissions

Protected zone radius (metres)	TX output power level in the frequency range 5 855 MHz to 5 925 MHz (dBm EIRP)	Unwanted emissions in the frequency range 5 795 MHz to 5 815 MHz (dBm/MHz EIRP)
20	≤ 10	≤ -45
25	≤ 14	≤ -40
35	≤ 18	≤ -37
45	≤ 21	≤ -35
55	≤ 23	≤ -33
80	≤ 26	≤ -30
100	≤ 28	≤ -30
120	≤ 30	≤ -30
170	≤ 33	≤ -30

NOTE 2: Unwanted emissions of an ITS station are specific to a certain implementation and often dependent on the ITS output power level.

NOTE 3: The protected zone radius is based on main beam to main beam interference measurement results and the path loss model from ETSI TR 102 960 [i.7].

EXAMPLE 2: If the ITS output power level is 10 dBm, the unwanted emissions are -40 dBm/MHz, and the database entry for the protected zone radius is 60 metres (see example 1), the protected zone radius will be 25 metres plus (60 – 55) metres. This results to 30 metres protected zone radius.

EXAMPLE 3: If the ITS output power level is 30 dBm, the unwanted emissions are -45 dBm/MHz, and the toll station was detected by a radio detector (no database and no CAM reception), the protected zone radius will be 120 metres (only table 5.1 is used).

5.2.4 Protected zone database

When implemented in an ITS station, the protected zone database stores all protected zone centre positions and default protected zone radii for ITS stations which are conform to the default ITS radio parameters.

This database shall include all entries of the official protected zone database published by an international consortium of toll operators, which contains the positions and default protected zone radii of tolling installations.

The official database is expected to be updated over time (e.g. to delete closed down toll installations). New developed ITS stations shall use the updated database version when released.

When a protected zone centre position list as specified in clause 5.2.2.3 is used in an ITS station, a protected zone database update in the field is not required. If the protected zone database of an ITS station is more than two years older than the official protected zone data base, a protected zone centre position list shall be used (see clause 5.2.2.3).

5.2.5 Short range protected zone radio detection

When a protected zone database solution is not used in a mobile or a personal ITS station, and it is not permanently operating in coexistence mode A or B (see clause 5.4), it shall detect the transmissions of a CEN DSRC or HDR DSRC tolling station by continuously monitoring the 5 795 MHz to 5 815 MHz band for either:

- downlink CEN DSRC frame headers as defined in EN 12253 [3] with a detection power range from -50 dBm to -43 dBm, or
- HDR DSRC wakeup trigger signals as defined in ETSI ES 200 674-1 [5], clause 6.8.6 with a detection power range from -50 dBm to -40 dBm.

The position of the detected CEN DSRC or HDR DSRC tolling station can be accurately represented by the position of the ITS station at the time of reception of at least 16 bits of a downlink frame header or a wakeup signal, because the communication range of CEN DSRC or HDR DSRC is very limited.

When an ITS station has identified a tolling station by short range radio detection, the ITS station shall transmit its own position at the time of detection in at least the next 10 CAM messages as described in ETSI EN 302 637-2 [1], using the data elements protectedZoneLatitude and protectedZoneLongitude of the data field CenDsrcTollingZone (see ETSI TS 102 894 2 [2], clause A.105).

When the ITS station is operating in normal mode it shall store its current position immediately after the detection of a CEN DSRC or HDR DSRC tolling station and use that position as the basis for the procedure in clause 5.5.

5.3 Normal mode

ECC/DEC(08)01 [i.2], ECC/REC(08)01 [i.3], and ETSI EN 302 571 [i.5] regulate output power level and unwanted emissions for ITS stations (see table 5.2). Operation limited only by these requirements is referred to as normal mode.

Table 5.2: Normal mode

ITS-G5 output power level in the frequency range 5 855 MHz to 5 925 MHz (dBm EIRP)	ITS-G5 unwanted emissions in the frequency range 5 795 MHz to 5 815 MHz (dBm/MHz EIRP)
≤ 33	≤ -30

NOTE: Some ITS-G5A/B/D channels have other limits for the output power level, see ETSI EN 302 571 [i.5], clause 6.3.

5.4 Coexistence mode

In coexistence mode additional restrictions apply. These restrictions apply to output power level, unwanted emissions and transmit timing. The restrictions are designed to decrease the interference from ITS stations to a level which implies no harmful performance degradation of CEN DSRC based toll stations.

An ITS station may be designed to operate in coexistence mode all the time.

Four different coexistence modes, designated A, B, C, and D are defined (see table 5.3). An ITS station shall choose one of these modes when applicable.

Table 5.3: Coexistence modes

Coexistence mode	ITS output power level in the frequency range 5 855 MHz to 5 925 MHz (dBm EIRP)	ITS unwanted emissions in the frequency range 5 795 MHz to 5 815 MHz (dBm/MHz EIRP)	T_{on} time	T_{off} time
A	≤ 10	≤ -65	no limit	no limit
B	≤ 10	≤ -45	≤ 1 ms	≥ 50 ms
C	≤ 33	≤ -30	≤ 1 ms	equation 5.1
D	≤ 33	≤ -30	1 ms to 7 ms	equation 5.2

DENM (ETSI EN 302 637-3 [i.9]) with priority level 0 (pre-crash situation) or priority level 1 (driver assistance or automatic action) may be transmitted disregarding the limits for the T_{off} time, the ITS output power level, and the unwanted emissions. The priority level is defined by the related DENM use case (e.g. as specified in ETSI TS 101 539-1 [i.10] or ETSI TS 101 539-3 [i.11]).

Only in case the ITS antenna is mounted at least 1,5 m away from the intended CEN DSRC OBU mounting position, or the field strength at this position does not exceed the threshold specified in clause 4.2 when the ITS station is transmitting with 10 dBm, coexistence mode A may be used (see also clause B.1 and clause 5.6.1 for more details).

Coexistence mode C is intended for data packets having a transmission duration of up to 1 ms.

Coexistence mode D is intended for larger data packets having a transmission duration of up to 7 ms.

In coexistence modes C and D, all ITS stations transmitting at transmit power levels up to the default level of 23 dBm shall continuously keep track of the number N_{ITS} of other ITS stations using the channel that have positions closer to the protected zone centre position than the distance given by the default protected zone radius. For ITS stations transmitting above the default transmit power level, the number N_{ITS} shall be evaluated by use of the protected zone radius associated with the transmit power level of the ITS stations (see table 5.1). N_{ITS} shall be calculated per channel used by the ITS station and the maximum shall be used to determine the T_{off} time limit. If it is not possible (e.g. by the used protocol – GeoNetworking provides the position information within the header (ETSI EN 302 636-4-1[i.17]); the position is also provided within a CAM) to evaluate the number N_{ITS} with an accuracy of at least ± 10 % of N_{ITS} ± 1 ITS-S, only coexistence modes A or B shall be used.

EXAMPLE: When the output power level of the ITS station is 23 dBm and the unwanted emissions are -45 dBm/MHz (conform to the default ITS radio parameters), the protected zone radius is given by the protected zone database entry, the protected zone centre position list, or the default value of 55 metres (see table 5.1) and N is the number of other ITS stations within 55 metres of the protected zone centre position.

The T_{off} time limit shall be calculated according to equation 5.1 for coexistence mode C and according to equation 5.2 for coexistence mode D. When the resulting value of $T_{off(C)}$ is less than 50 ms, $T_{off(C)}$ shall be set to 50 ms. The T_{off} time limit is the minimum time between two consecutive transmissions on any ITS channel. The assumed number of interfering ITS stations N is N_{ITS} / 2 to account for the asymmetric antenna characteristic of the CEN DSRC OBU and RSU.

$$T_{off(C)} \geq (45 \times N) \text{ ms} \quad (5.1)$$

$$T_{off(D)} \geq T_{off(C)} + 15{,}4 \times N \times (T_{on} - 1 \text{ ms}) \quad (5.2)$$

NOTE: Figure A.1 and table A.1 in clause A.1 show T_{off} results for a typical parameter range.

5.5 Procedures

5.5.1 Mobile and personal ITS stations

Mobile and personal ITS stations shall apply the following procedure:

1) All ITS stations shall determine the distance d to the closest protected zone centre position. The closest position shall be obtained from:

   - the temporary stored protected zone centre position (clause 5.2.2.2),
   - a lookup in the protected zone centre position list (clause 5.2.2.3), and
   - a lookup in the protected zone database (clause 5.2.4), or
   - the result of the protected zone detector as described in clause 5.2.5.

   After reception of a CAM according to ETSI EN 302 637-2 [1] with a station type roadSideUnit (15), the data fields ProtectedCommunicationZone (see ETSI TS 102 894-2 [2], clauses A.105 and A.121) shall be evaluated. This might update the protected zone centre position list (see clause 5.2.2.3), or might refresh the temporary stored protected zone centre position (see clause 5.2.2.2).

For ITS stations that use the short range protected zone radio detector as described in clause 5.2.5 this operation shall also be deployed for CAM messages with a vehicle station type, by evaluating the corresponding CenDsrcTollingZone data field.

If the determined distance *d* is less than 250 metres proceed with step 2), otherwise wait for up to one second and proceed with step 1).

2) All ITS stations shall determine their own protected zone radius as described in clause 5.2.3 and monitor their own position to determine if it they are inside the protected zone.
If an ITS station is inside the protected zone it shall proceed with step 3), otherwise it shall wait for up to the maximum of 100 ms and *d*/250 seconds and proceed with step 1). Where *d* is the distance value to the nearest protected zone centre position measured in metres.

3) If the ITS station is inside the protected zone it shall:

   - adjust its output power level and/or unwanted emissions so that it is no longer inside the protected zone and continue to monitor its position relative to the closest protected zone centre position; or

   - apply a coexistence mode according to table 5.3 and continue to monitor its position relative to the protected zone centre position.

   When the ITS station moves outside its maximum protected zone radius given from table 5.1 by its maximum TX power level and its and maximum unwanted emissions, it may switch to normal mode (see clause 5.3) and proceed with step 1).

5.5.2 Fixed ITS stations

Fixed ITS stations which are installed at CEN DSRC tolling stations can operate in normal mode at all times provided that the ITS station transmissions are synchronized with the transmissions of the CEN DSRC tolling station at which it is installed in such a way that the ITS station is never transmitting during CEN DSRC downlink or uplink windows.

Otherwise, a fixed ITS station shall be configured at installation time to transmit in a coexistence mode if its position is inside the protected zone of the nearest CEN DSRC tolling station. The protected zone centre position shall be the position of the nearest CEN DSRC RSU and the protected zone radius shall be according to table 5.1.

5.6 Additional requirements

5.6.1 Personal equipment

Personal equipment may have an arbitrary position which is closer to the CEN DSRC OBU than to the CEN DSRC RSU.

In a personal ITS station, or where the ITS station antenna is mounted closer than 1,5 m to the CEN DSRC OBU, when the ITS station is in the protected zone the ITS-G5A/B/D signal shall be muted or coexistence modes B, C or D shall be used.

Annex A (informative): Calculations and examples

A.1 Idle time T_{off} as function of the number of interferers

Several investigations of the interference impact of non-continuous ITS-G5A/B/D signals to tolling systems have been performed per measurements and computer simulations (see ETSI TR 102 960 [i.7]). Most important are the results for several independent ITS stations that transmit frames with up to 7 ms length. For these interference signals a lower bound for the idle time T_{off} was be found that is specified in equation 5.1 and equation 5.2 as function of the upper bound of the transmission length T_{on} and the number of other interfering ITS stations N within the protected zone. The results are depicted in figure A.1 and listed in table A.1. When applying this interference mitigation method, the relative number of broken CEN DSRC tolling transactions caused by interference is limited to 10^{-4}.

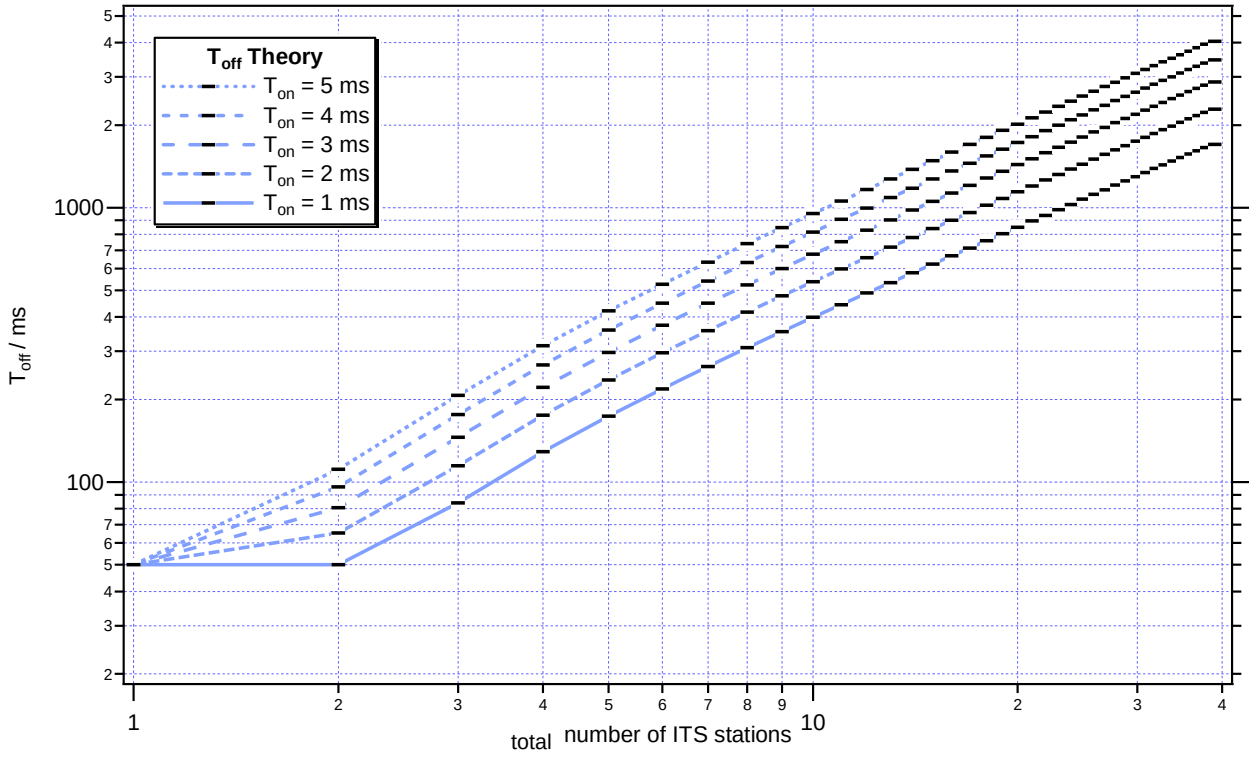

Figure A.1: Lower bound of the idle time T_{off} to limit the relative number of broken CEN DSRC tolling transactions to 10^{-4} according to equation 5.1 and equation 5.2 (see also ETSI TR 102 960 [i.7])

Table A.1: Lower bound of T_{off} according to equation 5.1 and equation 5.2 to limit the relative number of broken CEN DSRC tolling transactions to 10^{-4} (see ETSI TR 102 960 [i.7])

Minimum T_{off} / ms	Maximum T_{on} / ms				
N	**1**	**2**	**3**	**4**	**5**
0	50	50	50	50	50
1	50	65,4	80,8	96,2	111,6
2	84	114,8	145,6	176,4	207,2
3	129	175,2	221,4	267,6	313,8
5	219	296	373	450	527
7	309	416,8	524,6	632,4	740,2
9	399	537,6	676,2	814,8	953,4
11	489	658,4	827,8	997,2	1 166,6
13	579	779,2	979,4	1 179,6	1 379,8
15	669	900	1 131	1 362	1 593
17	759	1 020,8	1 282,6	1 544,4	1 806,2
19	849	1 141,6	1 434,2	1 726,8	2 019,4
21	939	1 262,4	1 585,8	1 909,2	2 232,6
23	1 029	1 383,2	1 737,4	2 091,6	2 445,8
25	1 119	1 504	1 889	2 274	2 659
27	1 209	1 624,8	2 040,6	2 456,4	2 872,2
29	1 299	1 745,6	2 192,2	2 638,8	3 085,4
31	1 389	1 866,4	2 343,8	2 821,2	3 298,6
33	1 479	1 987,2	2 495,4	3 003,6	3 511,8
35	1 569	2 108	2 647	3 186	3 725
37	1 659	2 228,8	2 798,6	3 368,4	3 938,2
39	1 749	2 349,6	2 950,2	3 550,8	4 151,4

A.2 Implementation example of a mobile ITS station with power level adjustment

Coexistence can be achieved by adjusting the output power level and the unwanted emissions of an ITS station transmitter according to table 5.1 in such a way that it is no longer inside the protected zone. This transmit power reduction can be implemented stepwise. Table A.2 and figure A.2 show how such an implementation could look like.

Table A.2: Example of stepwise power level adjustment

Distance *d* from protected zone centre	TX power (EIRP)	Unwanted emissions (EIRP)
> 170 m	≤ 33 dBm	≤ -30 dBm/MHz
70 m < *d* < 170 m	≤ 25 dBm	≤ -31 dBm/MHz
< 70 m	≤ 10 dBm	≤ -65 dBm/MHz

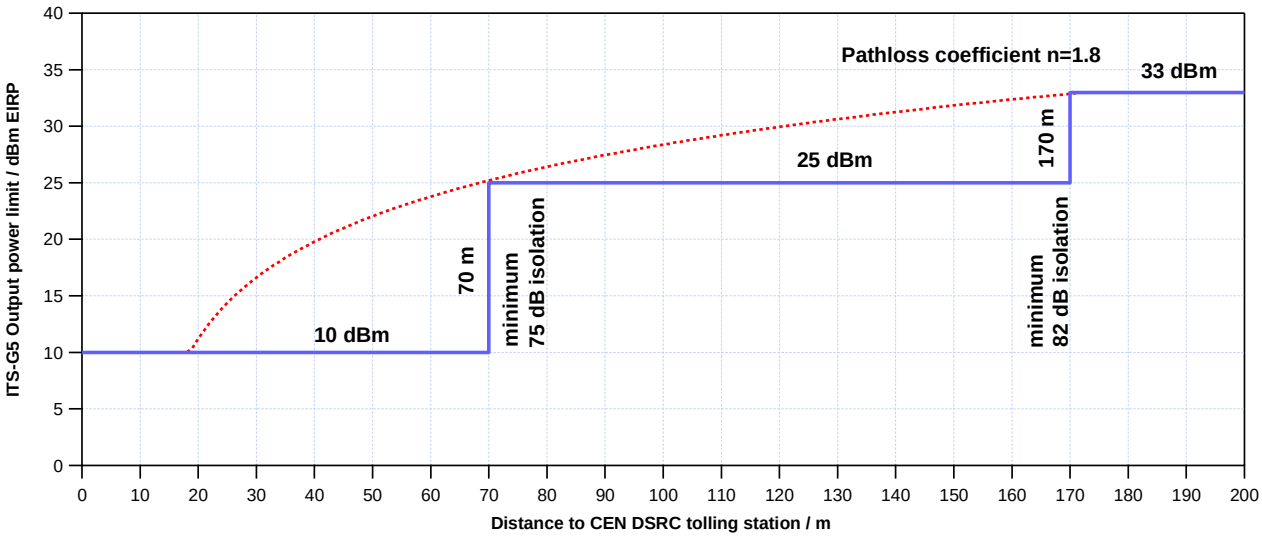

Figure A.2: Power level steps for a simple implementation of the power level adjustment method

Annex B (informative): Recommendations

B.1 Mobile ITS station antenna mounting

When installing an ITS station in a vehicle, its antenna should be mounted in such a way that the field strength at the recommended CEN DSRC OBU mounting position does not exceed 0,11 V/m (-51,6 dBm) for an ITS output power level of $\leq$ 10 dBm.

ITS stations with a fixed transmit antenna position that is more than 1,5 m away from the CEN DSRC OBU and that transmit with a power level of up to 10 dBm do not generate any interference to the CEN DSRC tolling system when the unwanted emission limits are met (see clause 5.4). Smaller distances to the CEN DSRC OBU are possible without interference, if the field strength threshold at the CEN DSRC OBU specified in clause 4.2 is not exceeded.

Annex C (informative): Bibliography

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History

Document history		
V1.1.1	October 2012	Publication
V1.2.1	June 2015	Publication