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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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.

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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.

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

[i.1] 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.

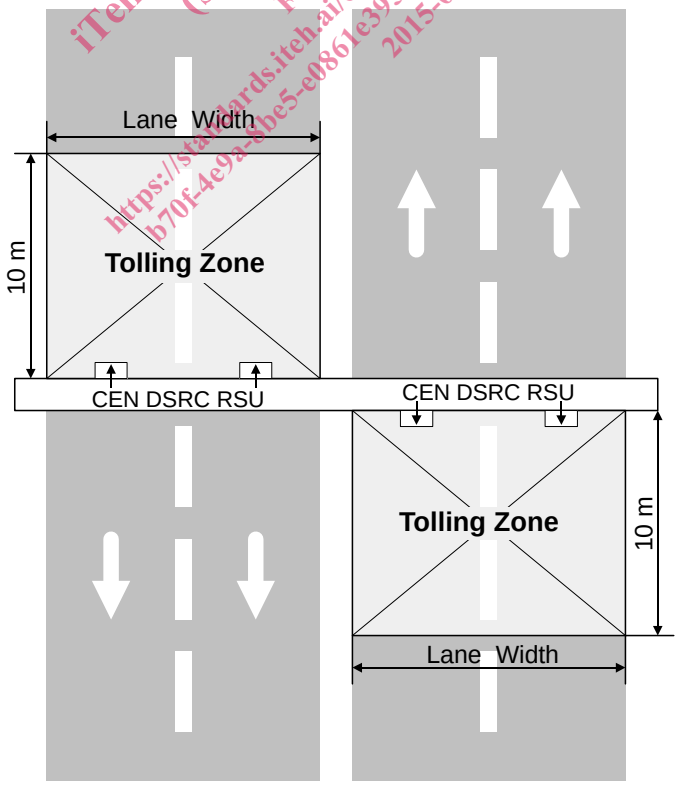

Figure 4.1: Example of tolling zone geometry

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;