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ITS-G5 Access layer in the 5 GHz frequency band;
Release 2

Reference

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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

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Modal verbs terminology

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

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Introduction

The present document outlines the two lowest OSI layers - physical layer and data link layer - for the Cooperative ITS (C-ITS) direct ITS-S to ITS-S wireless AdHoc Networking communication protocol stack used in the 5,9 GHz frequency band as allocated in Europe in compliance with Commission Decision 2008/671/EC [i.1], ECC/DEC/(08)01 [i.2] and ECC/REC/(08)01 [i.3] and specified in the COMMISSION IMPLEMENTING DECISION (EU) 2020/1426 of 7 October 2020 [i.1]. The two lowest layers together form the access layer. The technology specified in the present document is part of the so called ITS-G5 stack.

In the ITS-G5 access layer, the data link layer is divided into two sublayers: Medium Access Control (MAC) and Logical Link Control (LLC). The physical layer and the medium access control layer are specified in IEEE 802.11™-2020 [1] and corresponding extension IEEE 802.11bd™-2022 [2]. The logical link control is based on the IEEE/ISO/IEC 8802-2-1998 [3].

ITS-G5 realizes AdHoc peer-to-peer mode communication functionality as defined in IEEE 802.11™-2020 [1] and corresponding extension IEEE 802.11bd™-2022 [2]. Operating profiles requiring synchronization and authentication as specified in IEEE 802.11™-2020 [1] or any other version of 802.11™ are not supported. To manage congestion, ITS-G5 provides Decentralized Congestion Control (DCC) mechanisms as specified in clause 4.6. How to ensure coexistence with other systems is handled in clause 4.7.

1 Scope

The present document defines the access layer for ITS-G5 consisting of the physical layer and the data link layer, as part of the ITS station architecture.

2 References

2.1 Normative references

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

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

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

[1] IEEE 802.11™-2020: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks-Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[2] IEEE 802.11bd™-2022: "IEEE Standard for Information technology- Tele- communications and information exchange between systems Local and metropolitan area networks- Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Next Generation V2X". .

[3] IEEE/ISO/IEC 8802-2-1998: "Information technology -- Telecommunications and information exchange between systems -- Local and metropolitan area networks -- Specific requirements -- Part 2: Logical Link Control".

[4] IEEE 802™-2014: "IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture".

[5] ETSI EN 302 571: "Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[6] ETSI TS 102 792: "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".

2.2 Informative references

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

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

[i.1] Commission Implementing Decision (EU) 2020/1426 of 7 October 2020 on the harmonised use of radio spectrum in the 5 875-5 935 MHz frequency band for safety-related applications of intelligent transport systems (ITS) and repealing Decision 2008/671/EC.

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

[i.3] ECC/REC/(08)01: "ECC Recommendation (08)01 on the use of the band 5855-5875 MHz for Intelligent Transport Systems (ITS)".

[i.4] ETSI TS 103 695: "Intelligent Transport Systems (ITS); Access layer specification in the 5 GHz frequency band; Multi-Channel Operation (MCO) for Cooperative ITS (C-ITS); Release 2".

[i.5] ETSI TS 102 687: "Intelligent Transport Systems (ITS); Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

basic service set: smallest building block of an IEEE 802.11™ network

channel: instance of a Wireless Medium (WM) use for the purpose of passing physical layer (PHY) Protocol Data Units (PDUs) between two or more ITS-S's

NOTE: Unless otherwise stated the channel refers to a 10 MHz bandwidth.

Channel Busy Ratio (CBR): ratio between the time a receiver perceives a radio channel as busy and the total time, expressed as a percentage

coexistence: situation in which one radio system operates in an environment where another radio system having potentially different characteristics may be using the same or different channels, and radio systems are able to operate with some tolerable impact to each other

data rate: number of user data bits which can be transmitted in a stream per unit of time (EG/Mbs)

duty cycle: ratio between the transmitter T_{on} time and the total time, expressed as a percentage

ethertype: identifier to the network protocol above the data link layer

ITS-G5 access layer: access layer technology to be used in frequency bands dedicated for European Intelligent Transport Systems (ITS)

spectrum band: specific range of frequencies in the electromagnetic frequency spectrum assigned to specific applications

3.2 Symbols

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

aCWmax	Maximum value of Contention Window
aCWmin	Minimum value of Contention Window
AIFS	Arbitration InterFrame Space
AIFSN	Arbitration InterFrame Space Number
aSIFSTime	Short InterFrame Space defined by the physical layer
aSlotTime	A slot time defined by the physical layer

CW	Contention Window
CW_{max}	Maximum value of Contention Window
CW_{min}	Minimum value of Contention Window
CBR_{CH}	Channel busy ratio for a specific channel used by the MAC
Cth	congestion threshold
G_{max}^{+}	control parameter
G_{max}^{-}	control parameter
$GCBR$	Channel busy ratio provided by upper layers derived from all ITS-Ss active in the AdHoc network
$GCBR_{CH}$	Channel busy ratio for a specific channel provided by upper layers derived from all ITS-Ss active in the AdHoc network
$LCBR$	Channel busy ratio measured by the ITS-S
$LCBR_{CH}$	Channel busy ratio for a specific channel measured by the ITS-S
T_{Lbusy}	period of time the channel is busy for a given ITS-S
T_{LCBR}	period of time for a given ITS-S
T_{on}	duration of a transmission
T_{on_pp}	duration of the previous transmission
T_{off}	minimum time between two transmissions
Nss	Number of spatial streams
δ	$T_{on} /(T_{on} + T_{off})$
α	control parameter α
β	control parameter β
δ_{max}	maximum value of δ
δ_{min}	minimum value of δ
δ_{offset}	offset value of δ
t	current system time
t_{go}	time when gate keeper opens
t_{pg}	time when the gate keeper closes

3.3 Abbreviations

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

BPSK	Binary Phase Shift Keying
BSS	Basic Service Set
CAM	Coopearative Awareness Message
CBR	Channel Busy Ratio
CEN	European Committee for Standardization
CH	Channel
C-ITS	Cooperative Intelligent Transport Systems
DC	Duty Cycle
DCC	Decentralized Congestion Control
DCM	Dual Sub-Carier Modulation
DSRC	Dedicated Short-Range Communication
DUT	Device Under Test
ECC	Electronic Communication Committee
EN	European Norm
EPD	EtherType Protocol Discrimination
FiFo	First in First out
GCBR	Global CBR
HalfBT	Half Bathtub
HDR	High Data Rate
ID	IDentifier
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transport Systems
ITS-S	Intelligent Transport Systems Station
LCBR	Local CBR
LLC	Logical Link Control
LOS	Line-Of-Sight
LPD	Low Probability of Detection

LTF	Long Training Field
MAC	Medium Access Control
MCO	Multi Channel Operation
MCS	Modulation and Coding Scheme
MIB	Management Information Base
MIMO	Multiple-Input and Multiple-Output
NGV	Next Generation V2X
NLOS	Non Line-Of-Sight
NUM_SS	Number of Spetial Streams
N&T	Networking & Transport
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open Systems Interconnection
PDU	Protocol Data Unit
PER	Packet Error Rate
PHY	Physical layer
PSDU	PLCP Service Data Unit
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RLAN	Radio Local Area Network
RSSI	Received Signal Strength Indicator
SNAP	SubNetwork Access Protocol
SPATEM	Signal Phase And Timing Extended Message
TDL	Tapped Delay Line
TH	Thress Hold
TS	Technical Specification
TX	Transmitter
VNC	Vehicular Networking Conference

4 Access layer requirements

4.1 Introduction

The access layer bundles the data link layer and the physical layer and is situated at the bottom of the protocol stack, (see Figure 1) for the ITS protocol stack is part of the ITS-S reference architecture. The data link layer includes the Logical Link Control (LLC) entity and the Medium Access Control (MAC) entity.

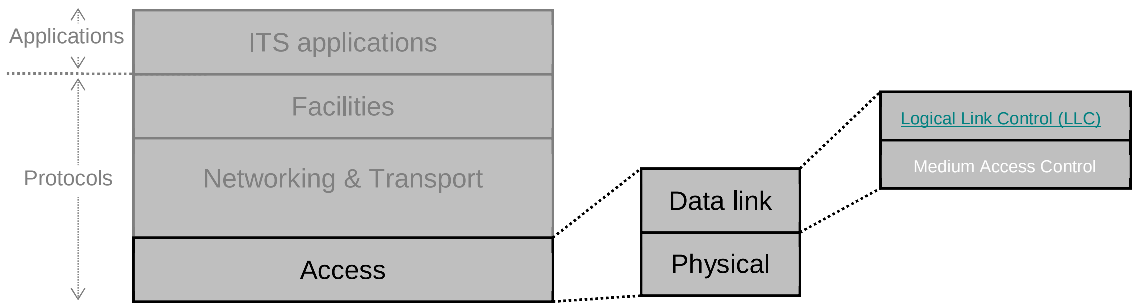


Figure 1: Access layer in the ITS-S reference architecture

For ITS-G5, the access layer is based on IEEE 802.11™-2020 [1], IEEE802.11bd™-2022 [2], IEEE/ISO/IEC 8802-2-1998 [3] and IEEE 802 ™-2014 [4] specifications.

The Management Information Base (MIB) parameter `dot11OCBActivated` as specified in IEEE 802.11™-2020 [1] shall be set to true, with the result that the system communicates outside the context of a Basic Service Set (BSS), by which neither authentication/association specified procedures nor security specified mechanisms are used. Further, no access point functionality is present. It also disables the requirement that ITS-Ss should share a common clock and scanning of available frequency channels for joining a BSS. The effect of operating outside the context of the BSS, implies that additional functionality is required to manage the congestion in a channel (see clause 4.6).

As the C-ITS operates in a spectrum band where also other systems may be active possible mitigation measures are identified in clause 4.7.

An ITS-S may support C-ITS data dissemination via multiple radio channels operating in different spectrum bands.

4.2 Access layer architecture

An overview of the functionalities is depicted in Figure 1.

An ITS-G5 Access layer shall be based on the IEEE 802.11™-2020 [1] with the band-specific operating requirements in Annex E.2.4 [1], and optionally includes NGV operations as specified in the amendment IEEE 802.11bd™-2022 [2].

An Access layer shall be implemented according at least one of the profiles as defined in Table 1.

Table 1: Access layer profiles

Profile number	MAC-PHY specification	Comment
Profile 1	IEEE 802.11™-2020 [1]	Profile for ITS low-data rate type of messages.
Profile 2	IEEE 802.11™-2020 [1] amended by IEEE 802.11bd™[2]	Profile for ITS low-data rate type of messages, with enhanced performance.

When Access layer Profile 2 with NGV format is supported, channel bonding as defined in the IEEE 802.11bd™-2022 [2] amendment that supports 20 MHz channel access with a 10 MHz primary and 10 MHz secondary channels can be implemented as an option.

An example of how the Management and Data interface could look like is given in Annex B.

4.3 Physical layer

4.3.1 Introduction

The ITS-G5 physical layer can operate with different Modulation and Coding Schemes (MCSs) and comply to specific Transmitter and Receiver performance requirements. Some of these MCSs including the transmitter and receiver performance requirements are mandatory as specified in clause 4.3.

4.3.2 Mandatory MCSs

The MCSs BPSK, QPSK, and 16-QAM with coding rate 1/2 and one spatial stream ($Nss = 1$) shall be supported. 10 MHz bandwidth shall be supported in profile 1 and in profile 2. If channel bonding is supported in profile 2 then those MCSs are mandatory for a bandwidth of 20 MHz.

4.3.3 Transmitter requirements

For the operation in 10 MHz mode the transmitter requirements shall be as specified in ETSI EN 302 571 [5], clause 4.2.1, clause 4.2.2, clause 4.2.3, clause 4.2.4 and clause 4.2.5.

For operation with profile 2 with NGV format in 20 MHz channel bonding mode the transmitter requirements as given in ETSI EN 302 571 [5], clause 4.2.5.2 shall be as given in Table 2.

Table 2: Out-of-band emission limits for channels with 20 MHz bandwidth

Frequency offset to carrier frequency (MHz)	Emission limits e.i.r.p. (dBm)	Measurement bandwidth
±10,0	-16	100 kHz
±11,0	-22	100 kHz
±20,0	-30	100 kHz
±30,0	-40	100 kHz
±40,0	-40	100 kHz

The maximum RF power for operation with profile 2 with NGV format in 20 MHz channel bonding mode shall not exceed 30 dBm e.i.r.p.

For operation with profile 2 with NGV format in 20 MHz channel bonding mode all other transmitter requirements shall be as specified in ETSI EN 302 571 [5], clause 4.2.1, clause 4.2.2, clause 4.2.3, clause 4.2.4 and clause 4.2.5.1.

4.3.4 Receiver requirements

The packet Error Ratio (PER) shall be 10 % or less when the PSDU length is 1 000 octets, and the rate-dependent input level is as shown in Table 3 for static receiver sensitivity and as shown in Table 4 for dynamic receiver sensitivity. The minimum input levels are measured at the antenna connector (noise factor of 10 dB and 5 dB implementation margins are assumed).

The limits for static receiver sensitivity shall be as specified in Table 3.

Table 3: Static receiver sensitivity

Modulation	Coding rate	Minimum sensitivity for 10 MHz channel spacing (dBm)	Minimum sensitivity for 20 MHz channel spacing (dBm)
BPSK-DCM	1/2	-94	-85
BPSK	1/2	-91	-85
BPSK	3/4	-90	-84
QPSK	1/2	-88	-82
QPSK	3/4	-86	-80
16-QAM	1/2	-83	-77
16-QAM	3/4	-79	-73
64-QAM	2/3	-75	-69
64-QAM	3/4	-74	-68
64-QAM	5/6	-73	-67
256-QAM	3/4	-68	-62
256-QAM	5/6	N/A	-60

NOTE: The receiver sensitivity for 10 MHz channels is 6 dB less than the corresponding values in the IEEE 802.11bd™ -2022 [2] for 10 MHz channels. For 20 MHz channels, the values are 3 dB less than the corresponding in IEEE 802.11bd™ -2022 [2].

The limits for dynamic receiver sensitivity shall be as specified in Table 4. The test procedure for the dynamic receiver sensitivity is given in clause 5.2.

Table 4: Dynamic receiver sensitivity

Modulation	Coding rate	Minimum sensitivity for 10 MHz channel spacing (dBm)
QPSK	1/2	-85

The limits for receiver adjacent channel rejection and alternate adjacent channel rejection shall be as specified in Table 5.

Table 5: Limits for receiver adjacent channel rejection and alternate adjacent channel rejection

Modulation	Coding rate	Bandwidth (MHz)	Adjacent channel rejection (dB)	Alternate adjacent channel rejection (dB)
BPSK-DCM	1/2	10	31	45
BPSK-DCM	1/2	20	28	42
BPSK	1/2	10 or 20	28	42
BPSK	3/4	10 or 20	27	41
QPSK	1/2	10 or 20	25	39
QPSK	3/4	10 or 20	23	37
16-QAM	1/2	10 or 20	20	34
16-QAM	3/4	10 or 20	16	30
64-QAM	2/3	10 or 20	12	26
64-QAM	3/4	10 or 20	11	25
64-QAM	5/6	10 or 20	10	24
256-QAM	3/4	10 or 20	5	19
256-QAM	5/6	20	3	17

Table 3, Table 4 and Table 5 are applicable to Profile 1 and Profile 2 with format NGV and NON_NGV_10. 20 MHz channels with format NON_NGV_10 are not applicable.

4.3.5 Physical Layer parameters

The timing parameters as specified in table 32-6, table 32-8, and table 32-20 of IEEE 802.11bd™-2022 [2] shall be used.

NOTE 1: These timing parameters are the same as those found in IEEE 802.11™-2020 [1].

A physical layer instance shall be implemented according at least one of the profiles as defined in Table 6.

NOTE 2: For Profile 1 there is only one mode and therefore no further parameters are considered.

Table 6 provides physical Layer parameters for Profile 2.

Table 6: Physical Layer parameters for Profile 2 per message

Profile number	Parameter	Parameter value(s) to be supported	Comment
Profile 2	FORMAT	NGV, NON_NGV_10	Selected by upper layers Default value: NGV
	NUM_SS	1	Single stream (no spatial multiplexing, no MIMO)
	LTF_REP	0	
	NGV_LTF_TYPE	NGV-LTF-1x, NGV-LTF-2x, NGV-LTF-2x-Repeat	Value depends on MCS: • BPSK-DCM: NGV-LTF-2x-Repeat • BPSK, QPSK, 16QAM: NGV-LTF-2x • 64QAM, 256QAM: NGV-LTF-1x
	MIDAMBLE_PERIODICITY	4, 8, 16	Selected by upper layers Default value: 8
	N_PPDU_REP	0, 1, 2, 3	Selected by upper layers Default value: 0

The parameters and parameter values are defined in IEEE 802.11bd™-2022 [2].

4.4 MAC

The MAC layer shall operate in conformance to IEEE 802.11™-2020 [1] or IEEE 802.11bd™-2022 [2].

For all packets, the MAC sublayer functionality shall be enabled by setting the MIB parameter `dot11OCBActivated` to true in IEEE 802.11™-2020 [1] or in IEEE 802.11bd™-2022 [2].

4.5 Logical link control

For packets encoded as per IEEE 802.11™-2020 [1] or IEEE 802.11bd™-2022 [2] with FORMAT having value different than 'NGV' (i.e. 'NON_NGV_10'), the LLC functionality shall be according to IEEE/ISO/IEC 8802-2-1998 [3] with the mode of operation set to Type 1 (unacknowledged connectionless mode) and the SubNetwork Access Protocol (SNAP) shall be according to IEEE 802 ™-2014 [4].

For packets encoded as per IEEE 802.11bd™-2022 [2] with FORMAT having value 'NGV', EtherType Protocol Discrimination (EPD) as defined in IEEE 802 ™-2014 [4] shall be used.

4.6 Decentralized Congestion Control (DCC)

4.6.1 Introduction

In AdHoc networks such as in C-ITS sensor networks, the communicating stations themselves are responsible for a graceful degradation of the message dissemination and related data transmission. Decentralized Congestion Control (DCC) in each C-ITS-S can provide such graceful degradation.

To allow some applications to be temporarily shut down, while others could possibly continue without disruption at the higher layers, decisions could be made based on detected congestion levels at lower layers to manage the message dissemination. The access layer has the responsibility to provide the level of congestion to higher layers.

When the required access layer resources are exceeded in a AdHoc Network, the Medium Access Control (MAC) limits the data transmission depending on the allowed congestion level to protect the system operation of the AdHoc Network. DCC functionality as part of the MAC should schedule transmissions to avoid interference between communicating stations. All MAC schemes applied in an AdHoc setting, such as the high-speed C-ITS system, should include an interoperable DCC functionality. DCC is an ITS specific functional extension of the MAC functionality as specified in IEEE™ RLAN specifications. The base DCC functionality resides at the access layer in the ITS-S and estimates the congestion locally. This DCC access layer functionality can be extended with DCC functionalities at higher layers for improvement of the estimation. One of such possibilities is to share the local congestion levels to other ITS-Ss and identify global congestion levels at higher layers as shown in clause 4.6.2.

4.6.2 Channel Busy Ratio

For the realization of DCC algorithms, the Local Channel Busy Ratio (LCBR), measured in each implemented channel by each C-ITS-S is used for determining the transmission behaviour. The LCBR is an estimate of how much a channel is used based on listening to signals received from surrounding radio transmitters. The LCBR shall be provided to higher layers.

LCBR is defined in Equation 1.

$$LCBR \equiv \frac{T_{Lbusy}}{T_{LCBR}} \qquad (1)$$

Where T_{Lbusy} is the total time duration during which the channel is busy, aggregated over a time period of T_{LCBR}. T_{LCBR} is equal to 100 milliseconds.

The LCBR for a specific channel CH is denoted by $LCBR_{CH}$.

If profile 1 is supported, then the channel busy status shall be determined at least every millisecond over a time period of T_{LCBR} to determine T_{Lbusy}. If a received ITS-G5 signal exceeds -85 dBm, the channel shall be detected as being busy.

If profile 2 is supported, then the RadioEnvironmentMeasurementPeriod shall be set to T_{LCBR} and the channel busy percentage value from the IEEE 802.11bd™-2022 [2] amendment shall be used as $LCBR_{CH}$ value for a specific channel *CH*.

NOTE 1: The channel busy percentage value is given in the unit percent, the $LCBR_{CH}$ is a ratio without unit - a unit conversion is necessary.

When global congestion mechanisms are used, a Global CBR for a given channel ($GCBR_{CH}$) can be provided by upper layers to improve the congestion control behaviour. Higher layers should provide the GCBR to the Access Layer.

NOTE 2: The $GCBR_{CH}$ may depend on all $LCBR_{CH}$'s perceived by all C-ITS's in the area, as specified in higher layer specifications in which the GCBR is defined.

If $GCBR_{CH}$ is not available, then the CBR for a given radio channel (CBR_{CH}) is defined in Equation 2:

$$CBR_{CH} \equiv LCBR_{CH} \quad (2)$$

Otherwise, if *Global* CBR_{CH} is available, then the CBR_{CH} is defined in Equation 3:

$$CBR_{CH} \equiv GCBR_{CH} \quad (3)$$

The *Duty Cycle (DC)* is defined as the ratio between the transmitter "on" time (T_{on}) and a specified total time, expressed as a percentage. Given T_{on} (the duration of a transmission by the equipment) and T_{off} (the time interval between two consecutive transmissions by the equipment), the following limits apply:

$$0 < T_{on} \leq 4 \text{ ms} \quad (4)$$

$$\textit{DC over one second for each channel:} \leq 3\ \% \quad (5)$$

If CBR_{CH} is $< C_{TH}$, **then** $T_{off} \geq 25$ ms (6)

If CBR_{CH} is $\geq C_{TH}$, **then**

$T_{off} \geq 25$ ms, **and** $T_{off\,Limit} = \min\left\{1\,000 \text{ ms},\ T_{on} \times \left(4\,000 \times \frac{CBR_{CH} - C_{TH}}{CBR_{CH}} - 1\right)\right\}$ (7)

where T_{on} and $T_{off\,Limit}$ are time parameters, CBR_{CH} is a ratio. All timing values are related to transmission time on the air. The coefficient values 4 000 and C_{TH} are chosen to avoid radio channel overload based on the traffic scenarios as identified in Annex A. For operation in the channel from 5 895 MHz to 5 905 MHz, the C_{TH} shall be 0,62. For operation outside 5 895 MHz to 5 905 MHz, the C_{TH} shall be 0,62 unless there is an interface to higher layers that provides other C_{TH} values.

EXAMPLE: Different C_{TH} values could result from MCO settings (ETSI TS 103 695 [i.4].

T_{off} shall be equal to or greater than $T_{off\,Limit}$, as calculated according to Equation 7, where T_{on} is the duration of the transmission. A negative value of $T_{off\,Limit}$ indicates that no DCC limitation needs to be applied, which is the case when the CBR_{CH} value is less than or equal to the congestion threshold C_{TH}.

An ITS-S shall be able to limit its individual data transmissions for each radio channel independently of other channels in order not to exceed its transmit ratio given by T_{on} and T_{off}. In addition, the transmit power level may optionally be used to control its own contribution to the aggregated channel utilization.

The $T_{off\,Limit}$ defined in this clause is calculated under the assumption that there is a fixed sensitivity threshold for the CBR estimation for all stations in the system. Figure 2 shows the $T_{off\,Limit}$ for typical message durations T_{on} for the ITS Release 1 operation in the 5 895 MHz to 5 905 MHz channel.

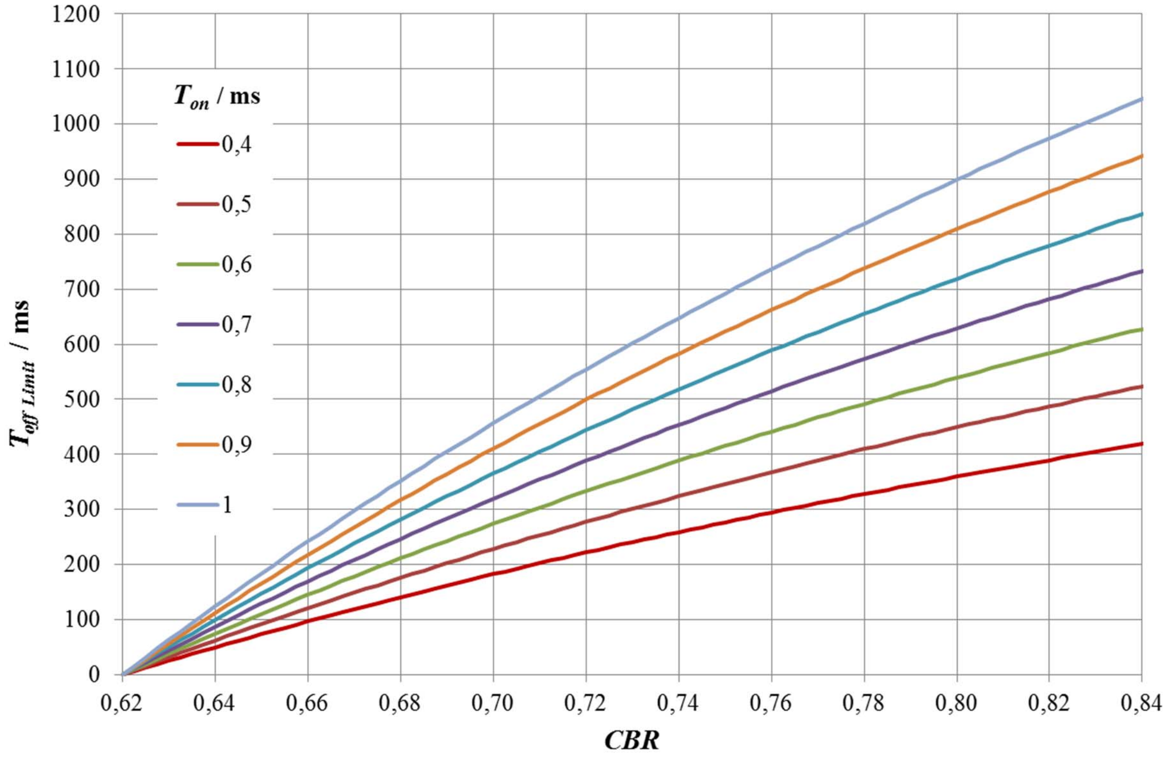


Figure 2: $T_{off\ Limit}$ representation for the ITS Release 1 the 5 895 MHz to 5 905 MHz channel

NOTE 2: The present document specifies the requirements in terms of limits for which DCC algorithms have to comply to, but it does not specify any DCC Algorithm itself. DCC algorithms should be tested for their coexistence with existing DCC algorithms. Such DCC algorithms are defined elsewhere. Examples are identified in the ETSI TS 102 687 [i.5].

4.7 CEN DSRC and HDR DSRC protection

The ITS station shall be conformant to ETSI TS 102 792 [6].

5 ITS-G5 radio tests

5.1 Radio tests defined in ETSI EN 302 571

ITS-G5 radio tests shall be done according to ETSI EN 302 571 [5], clause 5.3.2, clause 5.3.3, clause 5.3.4, 5.3.7 and clause 5.3.8 with the following modifications:

a) for receiver sensitivity, the limits shall be as specified in Table 3;

b) for receiver selectivity, the limits shall be as specified in Table 5;

c) for operation with profile 2 with NGV format in 20 MHz channel bonding mode the limits for the out-of-band emissions shall be as specified in Table 2;

d) for operation with profile 2 with NGV format in 20 MHz channel bonding mode the limits for RF power shall be as given in clause 4.3.3.

5.2 Additional radio tests

5.2.1 Dynamic receiver sensitivity

The dynamic sensitivity limit shall be as specified in Table 4.

The testing of dynamic receiver sensitivity shall be performed with the channel models outlined in Table A.2 and the test procedure shall be as follows:

Step 1:

- Connect the DUT receiver to the output of the test system.

Step 2:

- Activate a test transmission from the test system at the carrier frequency of the DUT, at a level adjusted to reference sensitivity +5 dB at the receiver input.

Step 3:

- Reduce the power level until the packet error rate PER is 10^{-1}.

Step 4:

- Compare the power level value to the limit specified in Table 2.

The transmitter shall use a frame size of 1 000 octets. The PER is calculated from the number of sent packets Pkt_{Tx} and the number of correctly received packets Pkt_{Rx} as shown in Equation (8). At least 1 000 frames shall be used for evaluating the PER.

$$PER = \frac{Pkt_{Tx} - Pkt_{Rx}}{Pkt_{Tx}} \times 100\,\% \qquad (8)$$

Annex A (normative): Channel models for testing dynamic sensitivity values.

The present annex outlines channel models representing different vehicular specific ITS-S scenarios with accompanied specific channel conditions. The type of channel model selected for capturing more dynamic behaviour such as fading and multipath is a Tapped Delay Line (TDL) model. The TDL models provided herein shall be used when testing the dynamic receiver selectivity outlined in clause 4.3.4. Five different vehicular specific ITS-S scenarios have been selected, where three are under Line-Of-Sight (LOS) conditions and two are under Non-LOS (NLOS) conditions, see Table A.1.

Table A.1: Description of scenarios

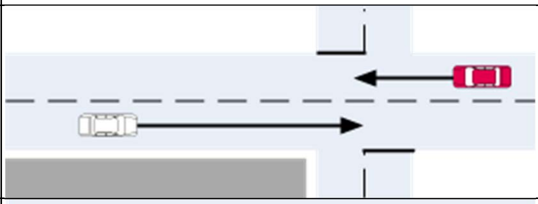
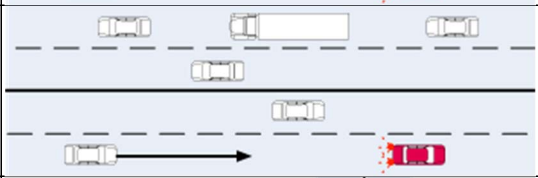
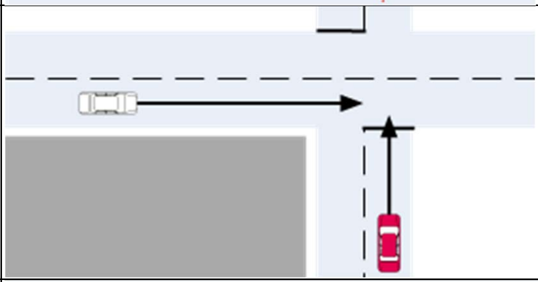
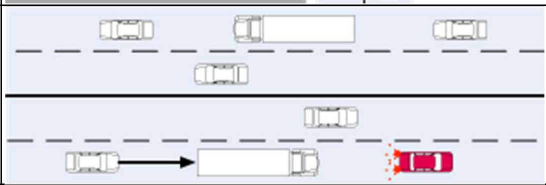
Scenario	Picture	Description
Urban approaching LOS		Two vehicles approaching each other in an urban setting with buildings.
Rural LOS		This setting reflects an open environment where other vehicles, buildings and fences are absent.
Highway LOS		Two vehicles communicating in a multilane scenario where other vehicles as well as road infrastructure such as traffic signs are present.
Urban crossing NLOS		Two vehicles approaching an intersection where the LOS component is blocked by a building.
Highway NLOS		Highway scenario where the LOS component is blocked by other vehicles.

Table A.2 provides the parameter settings for the TDL for the different scenarios in Table A.1.

Table A.2: Channel model parameters for the different scenarios

		Power (dB)	Delay (ns)	Doppler (Hz)	Profile
Urban approaching LOS	**Tap 1**	0	0	0	Static
	Tap 2	-8	117	236	HalfBT
	Tap 3	-10	183	-157	HalfBT
	Tap 4	-15	333	492	HalfBT
Rural LOS	**Tap 1**	0	0	0	Static
	Tap 2	-14	83	492	HalfBT
	Tap 3	-17	183	-295	HalfBT
Highway LOS	**Tap 1**	0	0	0	Static
	Tap 2	-10	100	689	HalfBT
	Tap 3	-15	167	-492	HalfBT
	Tap 4	-20	500	886	HalfBT
Urban crossing NLOS	**Tap 1**	0	0	0	Static
	Tap 2	-3	267	295	HalfBT
	Tap 3	-4	400	-98	HalfBT
	Tap 4	-10	533	591	HalfBT
Highway NLOS	**Tap 1**	0	0	0	Static
	Tap 2	-2	200	689	HalfBT
	Tap 3	-5	433	-492	HalfBT
	Tap 4	-7	700	886	HalfBT

Annex B (informative): Data and management service

B.1 Introduction

The present annex outlines the service exposed to the Networking & Transport layer. The interface is an internal interface and can be implemented in various ways. Depending on the Release, examples may differ. For Release 1 already 2 different ways are described. One in the DCC specification and one in the Networking and Transport independent specification. An example which can be used in various Releases for the Data interface and for the Management interface is provided in clauses B.2 and B.3 below.

B.2 Access layer data service

The access layer provides connectionless transfer of Protocol Data Units (PDUs) across the ITS-G5 radio interface. The service is specified by two primitives AL_DATA.request and AL_DATA.indicate, which extend the primitives of LLC based on the IEEE/ISO/IEC 8802-2-1998 TM [3] and are specific for proper operation of vehicular ad hoc communication.

Transmission-specific parameters, such as priority, transmit power and Modulation and Coding Scheme (MCS) enable setting TX parameters on a per-packet basis. Channel number and transceiver ID support multi-transceiver and multi-channel operation over ITS-G5 radio, whereas the transceiver ID specifies the ITS-G5 device if multiple devices are attached to one N&T layer protocol and logically appear as a single network interface.

The parameters of the AL-DATA.request are as follows:

```
AL_DATA.request (
    Source MAC address,
    Destination MAC address,
    Priority,
    Transmit power,
    MCS, -- Modulation and coding scheme
    Bandwidth, -- Transmission bandwidth
    Channel number,
    Transceiver ID, -- If several ITS-G5 devices are attached to one N&T layer protocol
                         -- and appear as a single network interface
    Tranceiver Mode, (optional)
    Datastream ID, (optional)
    Length,
    Data
)
```

The *Source MAC address* determines the Source Address in the IEEE 802.11TM header.
The *Destination MAC address* determines the Destination Address in the IEEE 802.11TM header.
The *Priority* determines the access category as defined in in IEEE 802.11TM.
The *Transmit power* determines the transmit power of the packet transmission.
The *MCS* parameter determines the modulation and coding scheme to be used.
The *Bandwidth* parameter determines the transmission bandwidth to be used.
The *Channel number* determines the radio channel to be used.
The *Transceiver ID* specifies the ITS G5 device if multiple devices are attached to one N&T layer protocol and logical appear as a single network interface.
The OPTIONAL *Tranceiver Mode* specifies the operation mode to be used, if the Transceiver supports also non-AdHoc mode IEEE 802.11TM operation. When absent, use AdHoc mode IEEE 802.11TM & LPD.
The OPTIONAL *Datastream ID* determines a unique identifier of related packets (e.g. all CAMs or SPATEMs will set this parameter to a unique and consistent value. This parameter may be used in Queueing algorithms to flush old frames that are replaced by new content. If absent unrelated transmission is assumed.
The *Length* parameter indicates the length of the Data.
The *Data* parameter represents the payload of the Access Layer packet to be sent.

The parameters of the AL-DATA.indication are as follows:

```
AL_DATA.indication (
    Source MAC address,
    Destination MAC address,
    CBR, -- Current local CBR
    Channel number,
    RSSI,
    Receiver ID,
    Receiver Mode, (optional)
    Length,
    Data
)
```

The *Source MAC address* is the Source Address from the IEEE 802.11™ header.
The *Destination MAC address* is the Destination Address from the IEEE 802.11™ header.
The *CBR* is the current local CBR.
The *Channel number* is the radio channel of this packet.
The *RSSI* is the Received signal strength.
The *Receiver ID* provides the ITS G5 device if multiple devices are attached to one N&T layer protocol and logical appear as a single network interface.
The OPTIONAL *Receiver Mode* is the receiver's operation mode of this packet. When absent AdHoc mode IEEE 802.11™ is assumed.
The *Length* parameter is the length of the Data parameter.
The *Data* parameter is the payload of the received Access Layer packet.

B.3 Access layer management service

The interface description below described is an example how an interface to the management plane (including MCO support) could be designed.

Table B.1: Example interface between access layer and management plane

I-Parameter Name	Access from access layer	Format	Description
Channel_Number_enumeration_1_channel	R/W	1 octet, Range: 1 to 100	This is a selector for the interface values. A write to this parameter selects for which radio channel the values are returned when reading a parameter and for which radio channel a parameter is written. A read from this parameter reports the current radio channel number the next read or write will use (see note).
CBR_local_ratio_1_percent	W	1 octet, Range: 0 to 100	*Local* $CBR_{CH.}$
TX_recent_duration_8_us	W	1 octets, granularity is 1 OFDM symbol duration – 8 µs	Duration of the recently transmitted message (airtime) T_{on} on the selected radio channel.
TX_TimeStamp_time_8_us	W	4 octets, granularity is 1 OFDM symbol duration – 8 µs	Time when the last message was forwarded to the radio channel.
TX_IdleTime_duration_1_ms	R/W	2 octets, in ms	Idle time T_{off} for the selected radio channel.
TX_PowerLimit_PowerLevel_1_dBm	R/W	1 octet, Bit 0 to Bit 4: values 0 to 31 unit 1 dBm Bit 5 to Bit 7: Reserved	Upper E.I.R.P. limit E.I.R.P. limit ≥ 31 dBm is represented by the value 31.
TX_FreeFiFoCells_enumeration_1_cell	W	1 octet, Range: 1 to 256	The number of empty FiFo cells available for storage of new to be transmitted data bytes before any are overwritten.
NOTE: Channel number represents a specific part of spectrum set by its boundary parameters in spectrum regulation. The channel numbering is Release and implementation specific.			

Annex C (informative): Bibliography

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History

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