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Intelligent transport systems — Lower layer protocols for usage in the European digital tachograph

Systèmes de transport intelligents - Protocoles de couche basse pour utilisation dans le cadre du chrono tachygraphe numérique européen

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Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is designed to encompass communication requirements in support of the Smart Digital Tachograph (SDT) as identified by Regulation 2016/799 of the European Union[23].

This document specifies SDT Communications (SDTC). SDTC is the application of CEN Dedicated Short Range Communication (DSRC) for SDT. See the following:

— EN 12253, *Road transport and traffic telematics — Dedicated short-range communication — Physical layer using microwave at 5,8 GHz*[1]

— EN 12795, *Road transport and traffic telematics — Dedicated Short Range Communication (DSRC) — DSRC data link layer: medium access and logical link control*[2]

— EN 12834, *Road transport and traffic telematics — Dedicated Short Range Communication (DSRC) — DSRC application layer*[3]

— EN 13372, *Road transport and traffic telematics — Dedicated short-range communication — Profiles for RTTT applications*[4]

Complementing the standardized specifications and descriptions, several private documents describe this dedicated short range semi-passive communication technology in an informative manner, providing additional detailed explanations and implementation hints. See for example:

— DSRC tutorial published by ESF GmbH in July 2003 (publicly available)[24];

— GSS industry specification published in August 2003[25] (no longer available from the authors; essential content is now available in ISO 15509);

It is to be noted that the abovementioned private documents provide information that can be essential to easily achieving interoperability with existing DSRC equipment and optimum performance.

EN 12253[1] deals with the physical layer of the DSRC protocol stack presented in Figure 1; i.e. it comprises requirements for Open Systems Interconnection (OSI) Layer 1 at 5,8 GHz for DSRC.

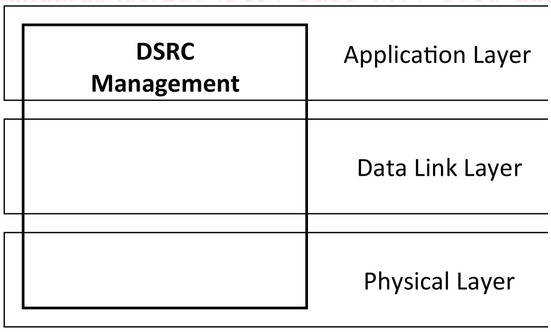

Figure 1 — DSRC protocol stack

EN 12253[1] does not include associated measurement procedures for verification of the requirements. Test methods for conformity are provided in ETSI EN 300674-1[12], ETSI EN 300674-2-1[13] and ETSI EN 300674-2-2[14].

EN 12253[1] caters for on-board units based on transponder technologies. Furthermore, it allows for mixed time, frequency and space division multiple access approaches.

EN 12253[1] is conceived for the 10 MHz part (i.e. 5,795 GHz to 5,805 GHz) of the ISM band at 5,8 GHz which is recommended by ECC/DEC(01)01[10]. An additional sub-band (5,805 GHz - 5,815 GHz) may be allocated on a national basis. National restrictions on the usage of these frequency bands can apply according to CEPT/ERC REC 70-03[11].

EN 12795[2] gives the architecture and services offered by the DSRC data link layer.

EN 12834[3] and the almost identical ISO 15628 give the architecture and services offered by the DSRC application layer.

EN 13372[4] deals with the interlayer management of the DSRC protocol stack.

Figure 2 illustrates the global data flow between the elements of the SDTC stack, (physical layer, data link layer and application layer) and the SDT application.

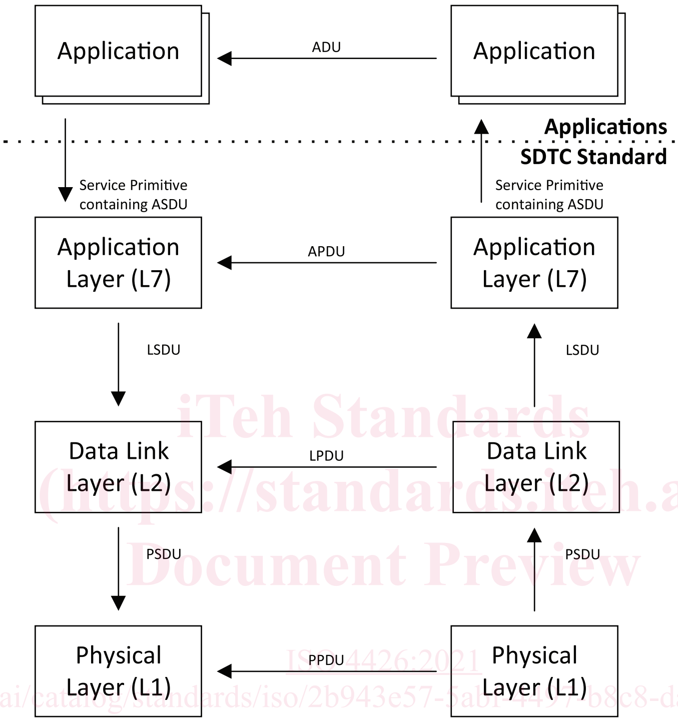

Figure 2 — Architecture and data flow of the SDTC stack

Intelligent transport systems — Lower layer protocols for usage in the European digital tachograph

1 Scope

This document specifies communication requirements in support of the Smart Digital Tachograph (SDT) as identified by Regulation 2016/799 of the European Union[23].

The specification covers:

— the physical layer at 5,8 GHz for SDT communications (SDTC);

— the data link layer (DLL) of SDTC;

— the application layer of SDTC;

— SDTC profiles which provide coherent sets of communication tools for applications based on SDTC.

This document provides further information beneficial for the design and development of SDTC equipment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15628, *Intelligent transport systems — Dedicated short range communication (DSRC) — DSRC application layer*

ISO/IEC 13239, *Information technology — Telecommunications and information exchange between systems — High-level data link control (HDLC) procedures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
adjacent channel
neighbouring SDTC channel for use by two or more emissions

Note 1 to entry: It is possible that a SDTC channel has either one of two adjacent channels.

3.2
antenna bore sight direction
direction of maximum antenna gain

3.3
application
set of processes including related functions and structured data that uses the services offered by the SDTC communication stack

3.4
beacon service table
BST
data structure transmitted by the fixed equipment indicating available services

3.5
bit error ratio
averaged number of erroneous bits relative to the total number of transmitted bits

3.6
co-channel
refers to the use of the same SDTC channel by two or more emissions

3.7
communication initialization
procedure used to establish communication between an RSU and a newly arrived OBU

Note 1 to entry: Terms prefixed with D present downlink parameters; downlink parameters apply to transmission of data from RSU to OBU.

3.8
D1 — carrier frequencies
number and values of the downlink carrier frequencies, which are equal to the frequencies of the CW, transmitted by the RSU and used by transponder OBUs for uplink communication

Note 1 to entry: Each carrier frequency is the centre frequency of a downlink channel.

3.9
D1a — tolerance of carrier frequencies
maximum deviation of the carrier frequency resulting from any cause

Note 1 to entry: It is expressed in parts per million (ppm)

EXAMPLE ±1 ppm of a 5,8 GHz carrier allows for the carrier frequency to be in the range of 5,8 GHz ± 5,8 kHz.

3.10
D2 — RSU transmitter spectrum mask
maximum allowed power within a defined frequency band emitted by the RSU transmitter

3.11
D3 — OBU minimum frequency range
minimum range of frequencies that has to be received by the OBU receiver

3.12
D4 — maximum E.I.R.P.
maximum allowed value of E.I.R.P.

3.13
D4a — angular E.I.R.P. mask
E.I.R.P. as a function of the angle Θ, where Θ indicates the angle relative to a vector perpendicular to the road surface, pointing downwards

3.14
D5 — polarization
locus of the tip of the vector of the electrical field strength in a plane perpendicular to the transmission vector

EXAMPLE Horizontal and vertical linear polarization and left- and right-hand circular polarization.

3.15
D5a — cross-polarization
ellipticity of polarization
antenna designed to transmit left-hand circular waves, which can transmit some right-hand circular waves in addition

Note 1 to entry: Cross-polar discrimination (XPD) is defined as the ratio between left- and right-hand circular power, $P_{\mathrm{LHC}}/P_{\mathrm{RHC}}$, when the total power transmitted is $P_{\mathrm{LHC}} + P_{\mathrm{RHC}}$. XPD is related to the ellipticity of polarization.

3.16
D6 — modulation
keying of the carrier wave by coded data

EXAMPLE Amplitude shift keying (ASK), phase shift keying (PSK), frequency shift keying (FSK) and linear amplitude modulation (AM).

3.17
D6a — modulation index
ratio of the variation of the modulation parameter (frequency, amplitude, phase) caused by the modulation signal (data signal)

EXAMPLE Given the minimum and maximum values V_{max} and V_{min} of the envelope amplitude V of the modulated signal, the amplitude modulation index m is defined as:

$$m = \frac{V_{\mathrm{max}} - V_{\mathrm{min}}}{V_{\mathrm{max}} + V_{\mathrm{min}}}.$$

3.18
D7 — data coding
downlink base band signal presentation, i.e. a mapping of logical bits to physical signals

EXAMPLE Bi-phase schemes (Manchester, FM0, FM1, differential Manchester), NRZ and NRZI. NRZI: No transition at beginning of "1" bit, transition at beginning of "0" bit, no transition within bit.

3.19
D8 — bit rate
number of bits per second, independent of the data coding

3.20
D8a — tolerance of bit clock
maximum downlink deviation of the bit clock resulting from any cause, expressed in ppm

EXAMPLE 100 ppm of 500 kbit/s allows for the bit clock to be in the range of 500 kHz ± 50 Hz.

3.21
D9 — bit error ratio for communication
maximum allowed bit error ratio valid within the dynamic range of the receiver as defined by D11a and D11b

3.22
D10 — wake-up trigger for OBU
signal which:

a) indicates to the OBU that it is within a communication zone, i.e. that it can now communicate with an RSU;

b) switches the OBU main circuitry from sleep mode to the active mode

Note 1 to entry: This is a feature to allow the OBU to save battery power. It is not mandatory for an OBU to use a wake-up process.

3.23
D10a — maximum start time
maximum time between the reception of the wake-up trigger and the time when the OBU has switched to the active mode

3.24
D11 — communication zone
spatial region within which the incident power of the OBU has a dynamic range as defined by D11a and D11b

3.25
D11a — power limit for communication (upper)
upper level of incident power referred to a lossless isotropic antenna (0 dB) in front of the OBU

Note 1 to entry: This is the level below which, subject to D11b, communication is guaranteed with a specified bit error ratio. Communication can take place above this limit, but is not guaranteed. Together with D11b it also specifies the minimum dynamic range of the OBU receiver. Power values are measured without any additional losses due to rain or misalignment.

3.26
D11b — power limit for communication (lower)
lower level of incident power referred to a lossless isotropic antenna (0 dB) in front of the OBU

Note 1 to entry: This is the level above which, subject to D11a, communication is guaranteed with a specified bit error ratio. Communication can take place below this limit, but is not guaranteed. Together with D11a it also specifies the minimum dynamic range of the OBU receiver. Power values are measured without any additional losses due to rain or misalignment

3.27
D12 — cut-off power level of OBU
incident power that is lower than the specified cut-off power level that does not result in communication

3.28
D13 — preamble
specific downlink layer 1-bit pattern

Note 1 to entry: Preamble is the bit pattern transmitted immediately before a frame.

3.29
D13a — preamble length
length of the downlink preamble measured in number of bits

3.30
D13b — preamble wave form
signal shape of the preamble

3.31
D13c — trailing bits
sequence of bits transmitted after the end flag of the data link layer

3.32
downlink
communication channel on which the fixed equipment transmits its information

3.33
downlink communication
communication from the RSU to the OBU

3.34
equivalent isotropically radiated power
E.I.R.P.
signal power fed into an ideal lossless antenna radiating equally in all directions that generates the same power flux at a reference distance as the one generated by a signal fed into the antenna under consideration in a predefined direction within its far field region

3.35
fixed equipment
fixed communication facility with one or more downlink channels and, optionally, one or more uplink channels

Note 1 to entry: Normally the fixed equipment is installed at a fixed location, but it may be installed on a mobile platform.

3.36
interlayer management
assembly of communication parameters of all protocol layers such that a consistent communication protocol is provided

3.37
link identifier
LID
unique address used for addressing the mobile equipment

3.38
mobile equipment
mobile communication facility capable of receiving information from the fixed equipment on the downlink and, optionally, also capable of transmitting information to the fixed equipment on the uplink

Note 1 to entry: The mobile equipment normally corresponds to the vehicle’s communication unit.

3.39
on-board unit
OBU
physical assembly that is located and operated in or on the vehicle to transmit and/or receive SDTC signals

Note 1 to entry: An OBU may be in a form that is removable from the vehicle, or mountable in or on any part of the vehicle structure, or bonded to a part of the vehicle, or an integral part of a vehicle component, such as a windscreen, bumper or licence plate. In this document, parameters that refer to an OBU relate to the form that the OBU takes as it is supplied to the vehicle manufacturer or constructor.

Note 2 to entry: An OBU is an alternative descriptor to Mobile Equipment.

3.40
roadside unit
RSU
SDTC equipment usually residing by the side of the road or overhead the road

Note 1 to entry: An RSU is an alternative descriptor to Fixed Equipment.

3.41
SDTC channel
frequency band for SDTC indicated by reference to the downlink centre frequency of one of up to four frequency bands with 5 MHz width each

3.42
SDTC profile
consistent and standardized set of cross layer parameters controlling the behaviour of the SDTC

3.43
service access point
SAP
interface point between data link layer and application layer, that has a unique link identifier and that allows layers to communicate

3.44
smart digital tachograph communication
SDTC
CEN DSRC applied for the Smart Digital Tachograph (SDT)

Note 1 to entry: This is as identified by Regulation 2016/799 of the European Union[23].

3.45
termination
procedure used to terminate communication between an RSU and an OBU

3.46
U1 — sub-carrier frequencies
number and values of the uplink sub-carrier frequencies, i.e. the frequency separation from the centre of the uplink side band to the centre of the corresponding downlink band

3.47
U1a — tolerance of sub-carrier frequencies
maximum deviation of the sub-carrier frequency resulting from any cause

EXAMPLE 1 % of 1,5 MHz sub-carrier allows for the sub-carrier frequency to be in the range of 1,5 MHz ± 15 kHz.

Note 1 to entry: Normally this is expressed in percentage (%) or in parts per million (ppm) of the sub-carrier frequency.

Note 2 to entry: Terms prefixed with U present uplink parameters; uplink parameters apply to transmission of data from OBU to RSU.

3.48
U1b — use of side bands
specification of the use of the uplink side bands

Note 1 to entry: Data can be modulated on the upper side band only, or the lower side band only, or on both side bands. In principle, different data can be modulated on the two side bands.

3.49
U2 — OBU transmitter spectrum mask
maximum allowed power emitted by the OBU transmitter within a defined frequency band

3.50
U4 — maximum single side band E.I.R.P. (bore sight)
maximum E.I.R.P. transmitted by the OBU within a single side band, measured at the maximum incident power defined by D11a

Note 1 to entry: For a non-isotropic OBU antenna the single side band E.I.R.P varies with the direction of the incident power and the direction in which the emitted power is measured.

3.51
U4a — maximum single side band E.I.R.P. (bore sight)
measurement when the incident power is in bore sight and the emitted power is measured in bore sight

3.52
U4b — maximum single side band E.I.R.P. (35°)
measurement when the incident power is in bore sight and the emitted power is measured at any angle not less than 35° away from bore sight

3.53
U5
uplink parameter indicating the uplink polarization

3.54
U5 — cross-polarization
uplink parameter indicating the cross-polarization

3.55
U6 — sub-carrier modulation
keying of the sub-carrier wave by coded data

EXAMPLE Amplitude shift keying (ASK), phase shift keying (PSK), and frequency shift keying (FSK).

Note 1 to entry: U6b is not used.

3.56
U6b — duty cycle
ratio of the length of high or low pulses to the duration of a complete cycle

Note 1 to entry: In NRZI a sequence of zero bits results in a pulse of alternating high- and low-level sections. A low-level section and the adjacent high-level section constitute a cycle of the pulse. The nominal duration of such a single section is equal to the bit duration. The cycle duration is twice the bit duration. The duty cycle is the ratio of the duration of the high-level section to the cycle duration.

3.57
U6c — modulation on carrier
keying of the carrier wave by the modulated sub-carrier

3.58
U7 — data coding
uplink base band signal presentation, i.e. a mapping of logical bits to physical signals

3.59
U8 — bit rate
number of bits per second, independent of the data coding

3.60
U8a — tolerance of symbol clock
maximum uplink deviation of the bit clock resulting from any cause, expressed in ppm

3.61
U9 — bit error ratio for communication
maximum allowed bit error ratio valid within the dynamic range of the receiver

3.62
U11 — communication zone
spatial region within which the OBU is situated such that its transmissions are received by the RSU with a bit error ratio of less than a specified value

3.63
U12 — conversion gain
difference between OBU E.I.R.P. within one side band and the carrier incident power on OBU

3.64
U13 — preamble
specific uplink layer 1-bit pattern

3.65
U13a — preamble length
length of the uplink preamble

Note 1 to entry: Preamble length is measured either in multiples of symbols or in seconds.

3.66
U13b — trailing bits
sequence of bits transmitted after the end flag of the data link layer

3.67
uplink
communication channel on which mobile equipment transmits its information

3.68
uplink communication
communication from the OBU to the RSU

3.69
vehicle service table
VST
data structure transmitted by the OBU to indicate available services

3.70
window
period of time during which the physical medium is allocated either to the fixed equipment or to the mobile equipment

4 Abbreviated terms and symbols

2-PSK	binary phase shift keying
ACK	acknowledge
ACn	acknowledged command with sequence bit n
ADU	application data unit
AM	amplitude modulation
APDU	application protocol data unit
ASDU	application service data unit
ASK	amplitude shift keying
C/R	command/response
CEN	European Committee for Standardization
CEPT	European Conference of Postal and Telecommunications Administrations
CW	continuous wave
DLL	data link layer
DSRC	dedicated short-range communication
EC	European Commission

