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Intelligent transport systems — Localized communications — Optical camera communication

Systèmes intelligents de transport — Communications localisées — Communication par caméra optique

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

Localized communications are an essential component of hybrid communications in Intelligent Transport Systems (ITS). Various access technologies are suited for localized communications. An increasing interest of ITS stakeholders for Cooperative ITS (C-ITS), Urban ITS (U-ITS), and Advanced Driver Assistance Systems (ADAS) is on the access technology in OCC (Optical Camera Communication) specified by IEEE.

OCC is capable of:

a) interoperating with cameras and LEDs devices, and

b) receiving messages from LED sources, and transmitting messages from back light and front light of vehicles to other vehicles.

The purpose of OCC is broadcast dissemination of ITS information from:

— light sources (traffic light, street light, traffic sign), and

— vehicles

to other vehicles (one-to-many); see Figure 1.

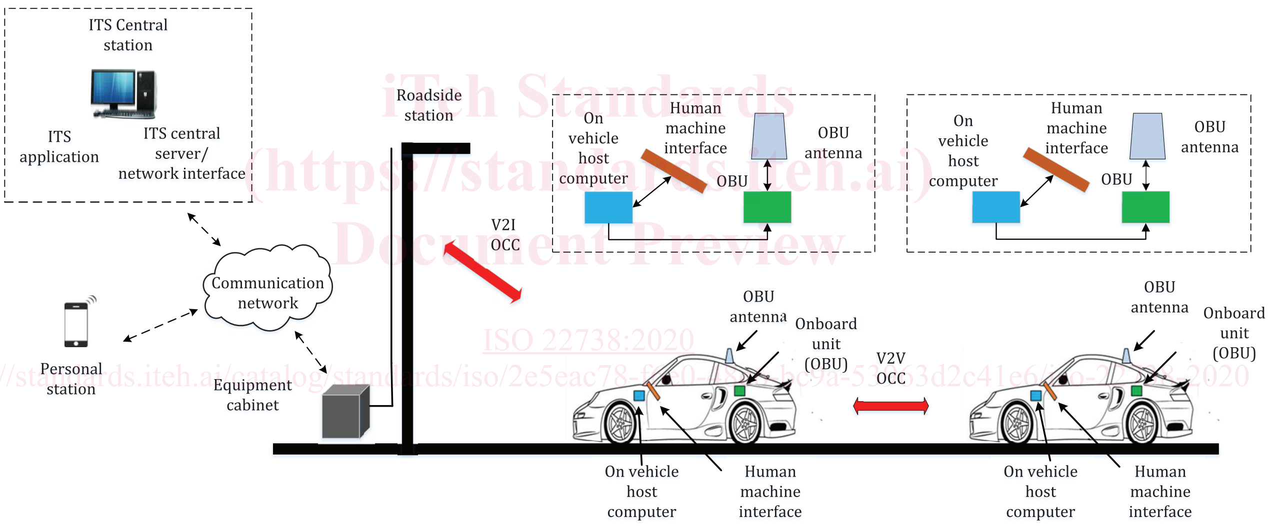

Figure 1 — OCC based ITS Communication

OCC is considered for usage in:

1) roadside ITS station units (ITS-SUs), and

2) vehicle ITS-SUs.

OCC is intended to provide information to vehicles, see Figure 2.

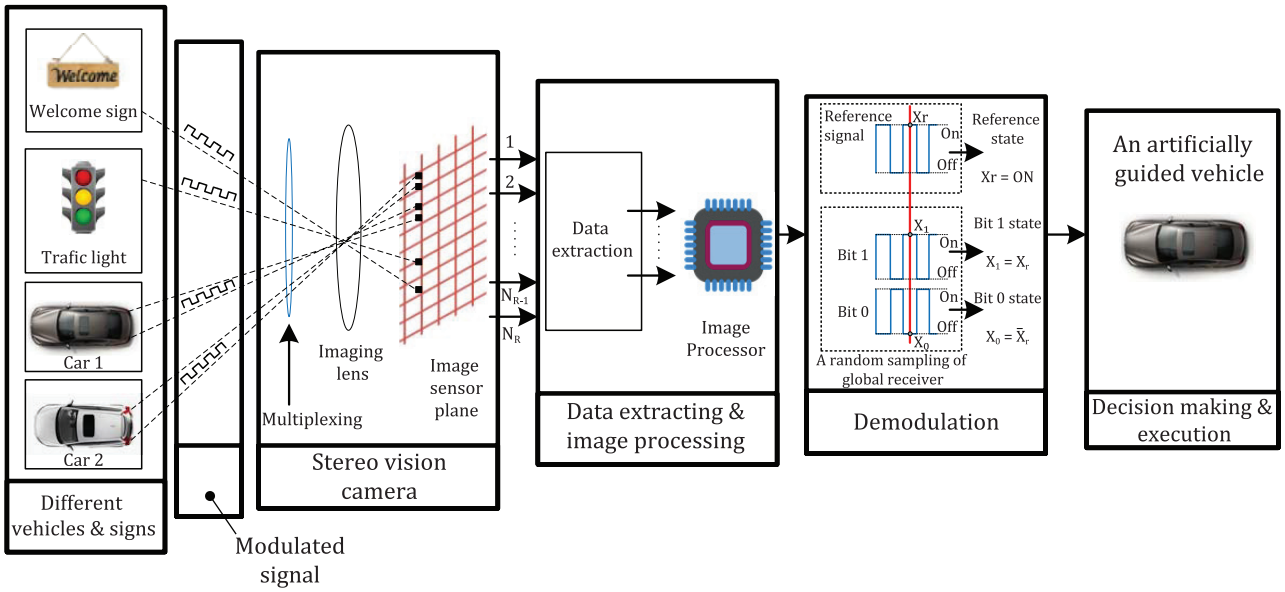

Figure 2 — Vehicle-centric data flow in OCC

OCC uses LEDs as transmitters and cameras as receivers with visible light or near IR (NIR). Characteristics of OCC are:

— visibility (visible light band);

— no regulation in optical frequency;

— harmlessness to human health (infrared and visible light band);

— non-interference with CIs based on radio waves; and

— licence-free operation.

See also Reference [6].

Figure 3 shows the basic operation of OCC. OCC supports ITS applications for vehicular scenarios such as those already proposed by universities and companies[7], [8], [9].

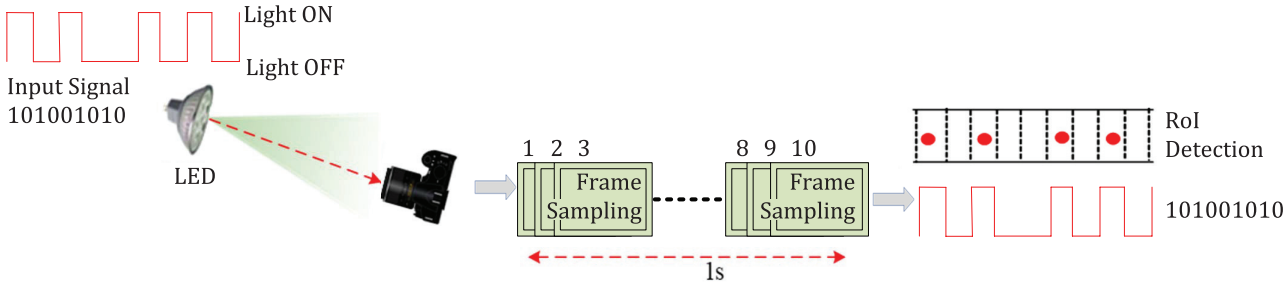

Figure 3 — Basic OCC operation

Intelligent transport systems — Localized communications — Optical camera communication

1 Scope

This document specifies OCC (Optical Camera Communication) as an access technology for localized communications applicable in ITS stations conforming with ISO 21217.

OCC access technology is specified for the implementation context of ISO 21218. This document provides specifications of a communication interface (CI) named "ITS-OCC".

This document specifies the additions to and deviations from IEEE 802.15.7:2018 which are required in order to make ITS-OCC CIs compatible with:

— the ITS station and communication architecture specified in ISO 21217, and

— the hybrid communications support specified in ISO 21218.

This document specifies:

— an OCC profile of IEEE 802.15.7:2018 for usage in C-ITS;

— details of CAL (ISO 21218); and

— details of MAE (ISO 21218, ISO 24102-3).

NOTE Considering safety-related services involving communications between a vehicle and a roadside station being performed on the basis of OCC, it is noted that, due to shadowing, communications can be interrupted or blocked for a significantly long time.

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 17419, *Intelligent transport systems — Cooperative systems — Globally unique identification*

ISO 21217, *Intelligent Transport System — Communications access for land mobiles (CALM) — Architecture*

ISO 21218, *Intelligent transport systems — Hybrid communications — Access technology support*

ISO/IEC 8825-2, *Information technology — ASN.1 encoding rules: Specification of Packed Encoding Rules (PER) — Part 2:*

IEEE 802.15.7:2018, *IEEE standard for Optical Wireless Communication (OWC)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21217, ISO 21218, and IEEE 802.15.7:2018 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/

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO 21217, ISO 21218, and IEEE 802.15.7:2018, and the following apply.

ATS	abstract test suite
DC	direct current
DME	device management entity
DS8-PSK	dimmable spatial 8-phase shift keying
EIRP	equivalent isotropic radiation power
FSK	frequency shift keying
HS-PSK	hybrid spatial phase shift keying
ICS	implementation conformance statement
ITS-OCC	name of the OCC communication interface
LED	light-emitting diode
LLC	logical link control
MAC	medium access control sub-layer
M-FSK	M-ary FSK
NIR	near-infrared radiation
OCC	optical camera communications
OOK	on-off keying
OWC	optical wireless communications
PAN	personal area network
PHY	physical layer
PIB	PAN information base
S2-PSK	spatial 2-phase shift keying
SAP	service access point
SSCS	service-specific convergence layer
SUT	system under test
TSS&TP	test suite structure and test purposes

UFSOOK	undersampled frequency shift OOK
VPPM	variable pulse-position modulation
VPWM	variable pulse-width modulation

5 IEEE 802.15.7

5.1 General requirements

An ITS-OCC CI implementation shall be conformant with the specifications presented in IEEE 802.15.7, with restrictions and amendments as specified in this document.

NOTE IEEE 802.15.7 represents the basis for developing products with guaranteed functionalities. It also provides a minimum benchmark for future developments. IEEE 802.15.7 is intended to support a variety of expected applications, relating to OWC Personal Area Networks. This document only supports a subset of the whole functionality of IEEE 802.15.7.

Information on the frequency band and frequency allocation for rolling shutter OCC are presented in Annex E.

Information on the dimming method is provided in Annex F.

5.2 OCC PHY and MAC architecture

IEEE 802.15.7 defines a PHY and MAC layer for short-range optical wireless communications using visible light in optically transparent media. It considers mobility of the visible link, compatibility with visible-light infrastructures, impairments due to noise and interference from sources like ambient light, and a MAC layer that accommodates visible links. Furthermore, IEEE 802.15.7 adheres to applicable eye safety regulations.

Figure 4 presents the OCC PHY and MAC architecture as specified in IEEE 802.15.7. This architecture maps to the ITSS access layer of the station architecture presented in Figure 5 and Figure 6.

NOTE According to IEEE 802.15.7:2018 Annex B, an LLC sub-layer is part of the "upper layers". Figure 4 does not reflect this fact.

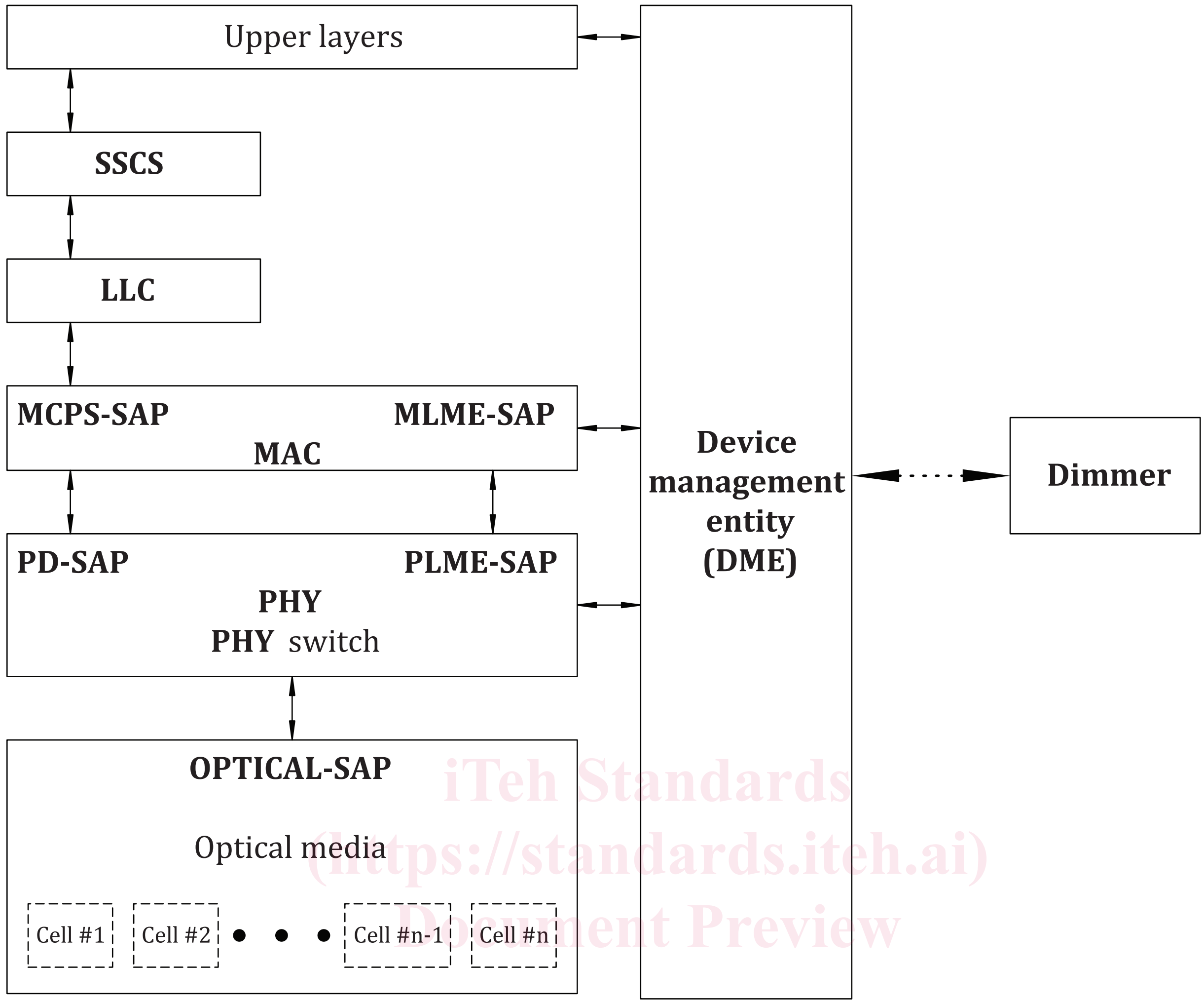

Figure 4 — OCC PHY and MAC architecture in IEEE 802.15.7

5.3 PHY mode

An ITS-OCC CI implementation conformant with this specification shall support PHY mode IV specified in IEEE 802.15.7.

NOTE 1 PHY IV is intended for use with discrete light sources.

NOTE 2 For PHY IV, over-the-air PHY and MAC frame configuration is forbidden.

NOTE 3 PHY IV distinguishes 5 sub-modes by different modulation schemes, i.e. UFSOOK, Twinkle VPPM, S2-PSK, HS-PSK, Offset-VPWM, see also 5.4.

5.4 Modulation schemes

An ITS-OCC implementation shall be conformant with the specification of:

— Spatial 2 Phase Shift Keying (S2-PSK) modulation scheme specified in IEEE 802.15.7;

— Hybrid Spatial Phase Shift Keying (HS-PSK) modulation scheme specified in IEEE 802.15.7.

NOTE The choice between S2-PSK and HS-PSK is given by implementation, i.e. read from the PIB. Thus, there is a potential interoperability problem, as the modulation scheme is not reported in a frame header.

5.5 MAC frame format

This document does not specify normative requirements on the MAC frame format.

NOTE 1 According to IEEE 802.15.7, for PHY IV, the frame control field, the sequence number field, the destination OWPAN identifier field, the MAC source address field, the MAC destination address field, and the auxiliary security header field are not present.

NOTE 2 According to IEEE 802.15.7, in PHY IV, the frame payload field is not used except in the Twinkle VPPM and Offset-VPWM PHY modes. The Twinkle VPPM and Offset-VPWM PHY modes use only the frame payload. The frame payload field has a variable length and contains information specific to individual frame types. If the security is enabled, then the frame payload is protected as defined by the security suite selected for that frame.

NOTE 3 According to IEEE 802.15.7, in PHY IV, the FCS field is not used except in the UFSOOK, Offset-VPWM PHY, and Twinkle VPPM PHY modes.

5.6 Dimming

An ITS-OCC CI implementation conformant with this document shall support dimming specified in IEEE 802.15.7. Dimming requests from upper layers to the PHY shall be indicated using the PHY PIB attribute specified in IEEE 802.15.7. The PHY shall support dimming using one of the techniques specified in either dimming during idle time or dimming during data transmission time when the PHY PIB attribute *phyDim* specified in IEEE 802.15.7 is set.

5.7 Mitigation of flickering

An ITS-OCC CI implementation conformant with this document shall support the mitigation of flickering in intra-frames and inter-frames as specified in Table 1.

Table 1 — Flickering mitigation

Operational mode	Data transmission (Intra-frame flicker)	Idle or RX periods (Inter-frame flicker)
S2-PSK	DC-balanced waveforms, ½-rate line code	Out-of-band idle pattern
HS-PSK	VPPM waveforms	

6 ITS station

6.1 ITS station and communication architecture

The ITS station architecture specified in ISO 21217 is presented in Figure 5. The ITS-OCC CI is allocated in the ITS-S access layer of the ITS station architecture.