

---

---

**Intelligent transport systems —  
Continuous air interface, long and  
medium range (CALM) — Infra-red  
systems**

*Systèmes intelligents de transport — Interface d'air continue, gamme  
longue et moyenne (CALM) — Systèmes à infrarouges*

**iTeh STANDARD PREVIEW  
(standards.iteh.ai)**

[ISO 21214:2006](https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006)

[https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-  
0ff81efa9053/iso-21214-2006](https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006)



**PDF disclaimer**

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

ISO 21214:2006

<https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006>

© ISO 2006

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.org](mailto:copyright@iso.org)  
Web [www.iso.org](http://www.iso.org)

Published in Switzerland

## Dedication

Exceptionally this International Standard is dedicated to the late Dipl. Ing. Helmut Strasser in grateful recognition of his leadership as the editor and project leader of ISO 21214, and for his commitment and services over more than a decade to meet the challenges of international standardization in the rapidly changing arena of ITS technology.

## iTeh STANDARD PREVIEW (standards.iteh.ai)

ISO 21214:2006

<https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006>

## Contents

Page

|   |      |
|---|------|
| Dedication .....  | iii  |
| Foreword .....  | vii  |
| Introduction .....  | viii |
| 1 Scope .....   | 1    |
| 2 Conformance .....   | 2    |
| 3 Normative references .....  | 2    |
| 4 Terms and definitions .....   | 2    |
| 4.1 General .....   | 2    |
| 4.2 Optical parameters .....  | 4    |
| 5 Symbols and abbreviated terms .....   | 8    |
| 6 Requirements: transmitter and receiver parameters .....                     | 10   |
| 6.1 Transmitter wavelengths and bandwidths .....                              | 10   |
| 6.2 Radiated power .....  | 10   |
| 6.2.1 Radiated power limits .....   | 10   |
| 6.2.2 Transmitter classes .....   | 11   |
| 6.3 Receiver wavelengths and bandwidths .....                                 | 11   |
| 6.4 Receiver class .....  | 12   |
| 7 Modulation and coding .....   | 13   |
| 7.1 Generic modulation parameters .....                                       | 13   |
| 7.1.1 Wake-up signal .....  | 13   |
| 7.1.2 Transmitter generic modulation parameters .....                         | 13   |
| 7.1.3 Receiver generic modulation parameters .....                            | 13   |
| 7.2 Communications profiles .....   | 13   |
| 7.3 Profile 0 (base profile) and profile 1 (default profile) modulation ..... | 14   |
| 7.4 Profiles 2 to 6 .....   | 15   |
| 8 Directivity and communication zones .....                                   | 16   |
| 8.1 Directivity parameters .....  | 16   |
| 8.2 Communication zones .....   | 17   |
| 8.2.1 Basic beam .....  | 17   |
| 8.2.2 Communication zone construction .....                                   | 17   |
| 8.2.3 Communication zone shortcuts .....                                      | 18   |
| 9 Frames and windows .....  | 20   |
| 9.1 General structure .....   | 20   |
| 9.2 Frame .....   | 20   |
| 9.2.1 Frame structure .....   | 20   |
| 9.2.2 Frame synchronisation signal ( <i>F-Sync</i> ) .....                    | 21   |
| 9.3 Windows .....   | 21   |
| 9.3.1 Window structure and types .....  | 21   |
| 9.3.2 Window synchronisation ( <i>W-Sync</i> ) .....                          | 22   |
| 9.3.3 Management window .....   | 22   |
| 9.3.4 Private window .....  | 24   |
| 9.3.5 Broadcast window .....  | 25   |
| 9.3.6 Multicast window .....  | 26   |
| 9.3.7 Spare window .....  | 27   |
| 9.3.8 Compatibility window .....  | 27   |
| 9.3.9 Wake-up window .....  | 27   |
| 9.4 Command alert (CA) .....  | 27   |

|         |  |    |
|---------|--|----|
| 9.5     | Summary.....   | 29 |
| 10      | MAC commands.....  | 31 |
| 10.1    | General.....   | 31 |
| 10.2    | MAC commands related to the frame and window organisation..... | 31 |
| 10.2.1  | frame organisation table ( <i>MC-FOT</i> ).....                | 31 |
| 10.2.2  | When generated.....  | 32 |
| 10.2.3  | Effect on receipt.....   | 32 |
| 10.2.4  | frame organisation table update ( <i>MC-FOT U</i> ).....       | 33 |
| 10.2.5  | frame organisation table steady ( <i>MC-FOT S</i> ).....       | 34 |
| 10.2.6  | Broadcast ( <i>MC-BRC</i> ).....                               | 34 |
| 10.2.7  | Re-establish session ( <i>MC-REST</i> ).....                   | 35 |
| 10.2.8  | Session re-establishment confirmed ( <i>MC-RESC</i> ).....     | 35 |
| 10.2.9  | Session re-establishment denied ( <i>MC-RESD</i> ).....        | 36 |
| 10.2.10 | Kill all ( <i>MC-KIA</i> ).....                                | 36 |
| 10.2.11 | Kill slave ( <i>MC-KIS</i> ).....                              | 37 |
| 10.2.12 | De-register ( <i>MC-DREG</i> ).....                            | 37 |
| 10.2.13 | Suspend all ( <i>MC-SUA</i> ).....                             | 38 |
| 10.2.14 | Suspend slave ( <i>MC-SUS</i> ).....                           | 39 |
| 10.2.15 | Free airtime ( <i>MC-FAT</i> ).....                            | 39 |
| 10.3    | MAC commands related to flow control.....                      | 40 |
| 10.3.1  | Command not supported ( <i>MC-CNS</i> ).....                   | 40 |
| 10.3.2  | Token ( <i>MC-TKN</i> ).....                                   | 40 |
| 10.3.3  | Block start ( <i>MC-BLS</i> ).....                             | 41 |
| 10.3.4  | Control channel block start ( <i>MC-CCBS</i> ).....            | 41 |
| 10.3.5  | IEEE-frame block start ( <i>MC-FBS</i> ).....                  | 42 |
| 10.3.6  | Start of MAC control block ( <i>MC-SMC</i> ).....              | 42 |
| 10.3.7  | Packet start ( <i>MC-PAS</i> ).....                            | 43 |
| 10.3.8  | Packet end ( <i>MC-PAE</i> ).....                              | 43 |
| 10.3.9  | Block end ( <i>MC-BLE</i> ).....                               | 44 |
| 10.3.10 | Transmission acknowledged ( <i>MC-TAck</i> ).....              | 44 |
| 10.3.11 | Transmission acknowledged & ( <i>MC-TAck&amp;</i> ).....       | 45 |
| 10.3.12 | Transmission not acknowledged ( <i>MC-TNack</i> ).....         | 45 |
| 10.3.13 | Transmission not acknowledged & ( <i>MC-TNack&amp;</i> ).....  | 46 |
| 10.3.14 | Retransmission request ( <i>MC-RTQ</i> ).....                  | 46 |
| 10.3.15 | Block acknowledge ( <i>MC-BAck</i> ).....                      | 47 |
| 10.4    | MAC commands related to the registration process.....          | 47 |
| 10.4.1  | Registration enable ( <i>MC-REN</i> ).....                     | 47 |
| 10.4.2  | Registration request ( <i>MC-RRQ</i> ).....                    | 48 |
| 10.4.3  | Identifier request ( <i>MC-IDQ</i> ).....                      | 49 |
| 10.4.4  | Identifier response ( <i>MC-IDP</i> ).....                     | 49 |
| 10.4.5  | Registration confirmation ( <i>MC-REC</i> ).....               | 50 |
| 10.5    | MAC commands related to the physical layer parameters.....     | 50 |
| 10.5.1  | Profiles request ( <i>MC-PRQ</i> ).....                        | 50 |
| 10.5.2  | Profiles response ( <i>MC-PRP</i> ).....                       | 51 |
| 10.5.3  | Request new profile ( <i>MC-RNP</i> ).....                     | 52 |
| 10.5.4  | Set profile ( <i>MC-SPR</i> ).....                             | 52 |
| 10.5.5  | Set profile confirmation ( <i>MC-SPC</i> ).....                | 53 |
| 10.5.6  | Set multicast profile ( <i>MC-SMP</i> ).....                   | 53 |
| 10.6    | MAC commands related to test and services.....                 | 54 |
| 10.6.1  | Status request 1 ( <i>MC-SRQ1</i> ).....                       | 54 |
| 10.6.2  | Status request 2 ( <i>MC-SRQ2</i> ).....                       | 55 |
| 10.6.3  | Status request 3 ( <i>MC-SRQ3</i> ).....                       | 56 |
| 10.6.4  | Status request 4 ( <i>MC-SRQ4</i> ).....                       | 56 |
| 10.6.5  | Status response 1 ( <i>MC-SR1</i> ).....                       | 57 |
| 10.6.6  | Status response 2 ( <i>MC-SR2</i> ).....                       | 58 |
| 10.6.7  | Status response 3 ( <i>MC-SR3</i> ).....                       | 59 |
| 10.6.8  | Status response 4 ( <i>MC-SR4</i> ).....                       | 60 |
| 10.6.9  | Echo alert ( <i>MC-EA</i> ).....                               | 61 |
| 10.6.10 | Echo request ( <i>MC-ERQ</i> ).....                            | 62 |

|              |   |     |
|--------------|---|-----|
| 10.6.11      | Echo ( <i>MC-ECH</i> ).....   | 62  |
| 10.7         | MAC command set overview .....  | 63  |
| 11           | Registration procedure.....   | 66  |
| 11.1         | General .....   | 66  |
| 11.2         | Normal registration procedure .....   | 66  |
| 11.3         | Sequence of the registration procedure without collision .....                    | 67  |
| 11.4         | Sequence of the registration procedure with collision .....                       | 67  |
| 11.4.1       | Both signals appear with equal signal strength .....                              | 67  |
| 11.4.2       | Both signals appear with different signal strength .....                          | 68  |
| 11.4.3       | Identical <i>TempIDs</i> .....  | 68  |
| 11.5         | Handover and re-registration.....   | 68  |
| 11.5.1       | Cancel <i>TempID</i> .....  | 69  |
| 11.5.2       | Advise adjacent masters .....   | 69  |
| 11.6         | Registration process timers.....  | 69  |
| 12           | Window management .....   | 70  |
| 12.1         | General .....   | 70  |
| 12.2         | Window allocation by frame organisation tables .....                              | 70  |
| 12.3         | Spare windows .....   | 70  |
| 12.4         | Windows for isochronous services .....  | 71  |
| 13           | Infra-red management entity.....  | 72  |
| 13.1         | General .....   | 72  |
| 13.2         | MAC command not supported.....  | 72  |
| 13.3         | Communication profiles.....   | 72  |
| 13.4         | Equipment status .....  | 72  |
| 13.5         | Testing.....  | 72  |
| 13.6         | Registration .....  | 72  |
| 13.7         | Session management .....  | 73  |
| 13.8         | Communication .....   | 73  |
| 13.8.1       | Organisation of IR communication .....  | 73  |
| 13.8.2       | Unique block number reference .....   | 74  |
| 13.9         | Window management .....   | 74  |
| 13.10        | MAC tunnel .....  | 74  |
| 14           | Adaptation.....   | 75  |
| 14.1         | Architecture .....  | 75  |
| 14.2         | <i>IR-CAL</i> .....   | 75  |
| 14.2.1       | Communication SAP .....   | 75  |
| 14.2.2       | Communication types.....  | 76  |
| 14.2.3       | WLAN functionality .....  | 77  |
| 14.2.4       | MAC addresses .....   | 79  |
| 14.2.5       | Fragmentation and defragmentation .....   | 80  |
| 14.3         | <i>IR-MAE</i> .....   | 80  |
| 15           | Adoption of other standards and internationally adopted practices.....            | 81  |
| 16           | Marking and labelling .....   | 82  |
| 17           | Declaration of patents and Intellectual Property .....                            | 83  |
| Annex A      | (normative) Coding and error correction of profiles 0 and 1 and of commands ..... | 86  |
| Annex B      | (normative) Coding and modulation of profiles 2 to 6 .....                        | 88  |
| Annex C      | (informative) Link power budget .....   | 95  |
| Annex D      | (informative) Link directivity considerations .....                               | 101 |
| Annex E      | (informative) Compatibility of CALM and non-CALM infra-red systems .....          | 103 |
| Bibliography | .....   | 106 |

iTech STANDARD PREVIEW  
(standards.iteh.ai)

ISO 21214:2006  
https://standards.iteh.ai/catalog/standards/sist/3ccd1f0b-8c4d-4705-a3cc-0f81ca9053/iso-21214-2006

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21214 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

## iTeh STANDARD PREVIEW (standards.iteh.ai)

[ISO 21214:2006](https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006)

<https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006>

## Introduction

This International Standard is part of a family of International Standards for CALM (continuous air interface, long and medium range) which determine a common architecture, network protocols and air-interface definitions for wireless communications using cellular second generation, cellular third generation, 5 GHz, millimetre, and infra-red communications. Other air interfaces may be added at a later date. These air interfaces are designed to provide parameters and protocols for broadcast, point/point, vehicle/vehicle, and vehicle/point communications in the ITS sector.

This International Standard determines the air interface using infra-red systems operating in the wavelength range at 850 nm.

The fast movement of information across the longer distances using wireless technology is functionally very different from the requirements definition for dedicated short range communication (DSRC). High volumes of data are required for purposes such as traffic information and management, video downloads to vehicles for tourist information and entertainment and navigation system updates, etc.

In order to support such services, transmitters need to be able to operate over long or medium range, and to be able to hand over a session from one transmitter to another.

These International Standards are designed to enable quasi-continuous communications, or communications of protracted duration, between vehicles and service providers, or between vehicles. As such they are complementary to dedicated short range (single point, technologies standardised in various regions of the world.

The CALM concept supports multiple bearer types (such as cellular, microwave, infra-red), where an option is proposed to offer user selection of preferred media, and to enable resumption of session interruptions (whether to change bearer media, service provider, or because of signal interruption or interference).

Some applications will have the requirement that communication sessions set up in a first communication zone may be continued in following communication zones; therefore “handover mechanisms” are included. Handover mechanisms need to be defined at two levels:

- Firstly, handover mechanisms within the same technology and service provider. These handover mechanisms are defined within the frequency-specific CALM International Standards.
- Secondly, handover mechanisms at the application level, for use where either the technology or the service provider changes. These handover mechanisms will be defined within the CALM architecture International Standard (ISO 21217), within the CALM networking protocols International Standard (ISO 21210) and within the CALM lower layer SAP International Standard (ISO 21218).

Applications include the update of roadside telemetry and messaging, internet, image and video transfer, infotainment, traffic management, monitoring and enforcement in mobile situations, route guidance, car-to-car safety messaging, maintenance management, and “yellow page” services. For medium- and long-range high-speed roadside/vehicle transactions such as on-board web access, broadcast and subscription services, entertainment, yellow page and booking transactions, etc., the functional characteristics of such systems require contact over significantly longer distance than is feasible or desirable for DSRC, and often for significantly longer connection periods – in some circumstances, continuous communication.



# Intelligent transport systems — Continuous air interface, long and medium range (CALM) — Infra-red systems

## 1 Scope

This International Standard determines the air interface using infra-red systems at 820 nm to 1 010 nm.

It provides protocols and parameters for medium-range, medium- to high-speed wireless communications in the ITS sector using infra-red systems.

Such links are required for quasi-continuous, prolonged or short communications

- between vehicles and the roadside,
- between vehicles, and
- between mobile equipment and fixed infrastructure points,

over medium and long ranges.

Vehicles may be moving or stationary.

Wherever practicable, this International Standard has been developed by reference to suitable extant International Standards, adopted by selection. Required regional variations are provided.

Due account is given to, and use made of, any relevant parts of appropriate communications systems, such as global positioning systems (GPS), digital audio broadcasting (DAB), digital video broadcasting (DVB), radio local area networks (RLANs), digital data broadcasting (DDB), TETRA, FM subcarrier, mobile broadband systems (MBS, W-ATM), internet protocols, and dedicated short range communication (DSRC).

The International Standard:

- supports data rates of 1 Mbit/s up to 128 Mbit/s (it may support higher data rates);
- supports vehicle speeds up to a minimum of 200 km/h (closing speeds could be double this value);
- defines or references environmental parameters relevant to link operation;
- supports communication distances up to 100 m (it may support longer communication distances of 300 m to 1 000 m);
- supports latencies and communication delays in the order of milliseconds;
- is compliant to regional/national regulatory parameters;
- may support other regional/national parameters as applicable.

Application-specific requirements are outside the scope of this International Standard. These requirements will be defined in the CALM management and upper layer standards and in application standards.

Application-specific upper layers are not included in this International Standard, but will be driven by application standards (which may not be technology specific).

## 2 Conformance

Systems claiming conformance with this International Standard shall meet the specifications herein.

## 3 Normative references

The following referenced documents are indispensable for the application 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/IEC 8802-11, *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*

IEC 60050-845, *International Electrotechnical Vocabulary. Lighting*

IEC 60825-1, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide*

## 4 Terms and definitions

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

### 4.1 General

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

#### 4.1.1

##### **broadcast window**

##### **BcW**

window used to broadcast information to slaves, even to those which have not yet performed the “registration process”

ISO 21214:2006

http://standards.iteh.ai/catalog/standards/siv/0ca1160-604d-4793-920c-0ff81efa9053/iso-21214-2006

0ff81efa9053/iso-21214-2006

#### 4.1.2

##### **chip**

smallest information unit communicated over the link

NOTE Depending on the chosen coding, one information bit may be represented by one or more consecutive chips.

#### 4.1.3

##### **communication profile**

specific set of data rate, modulation and flow control

#### 4.1.4

##### **communication zone**

spatial zone in which two CALM-IR units are able to communicate with acceptable performance

#### 4.1.5

##### **compatibility window**

##### **CmpW**

enables non-CALM-IR systems that follow certain rules to co-exist with a CALM-IR system without harmful interference

#### 4.1.6

##### **default data rate**

data rate used in the “default communications profile”

**4.1.7****default communications profile**

communications profile used unless another communications profile is successfully negotiated

**4.1.8****flush byte**

8 bit sequence used to denote the end of the main body of the information to be transmitted using the *HHH(1,13)* coding procedure

**4.1.9****forward direction**

communication flow from master to slave

EXAMPLES forward link, forward window

**4.1.10****frame length indicator*****Flen***

indicator is used to calculate the frame length from the last "slot index"

**4.1.11****frame organisation table*****FOT***

table which carries all organisation data of the TDMA frame

**4.1.12****free airtime indicator*****FATI***

indicator which signals that "free airtime" follows the current frame

**NOTE**

This airtime may be used by units not being a slave of the current master to establish "secondary mastership".

**4.1.13****guard time** **$T_G$** 

time period preceding a "command alert" (*CA*) in certain cases in order to allow the automatic gain control of the receivers to resettle

**4.1.14*****HHH(1,13)* code**

special run length limited code with  $d = 1$  and  $k = 13$  used in the CALM-IR communications profiles 2 to 6

**4.1.15****management window**

first window in a CALM-IR frame, which carries all organisation information for the current frame

**4.1.16****master identifier*****MID***

code which uniquely identifies a CALM-IR master

**4.1.17****multicast window*****McW***

window used for communication from master to multiple slaves, forward direction only

**4.1.18****private window**

window which carries the information exchange between a master and a specific slave

4.1.19

**registration phase**

phase during which a master identifies devices newly entering its communication zone

4.1.20

**slave**

device that is under the control of another device

4.1.21

**spare window**

**SpW**

window, not allocated to a slave, which reserves airtime for any slaves registering during the current frame in order to enable the master to instantly allocate them a private window without the need for frame reorganisation

4.1.22

**slot index**

index used to count time slots

4.1.23

**TDMA frame**

time (division multiple access) structure based on a train of consecutive time slots (at least one)

4.1.24

**time slot**

subunit of a TDMA frame

4.1.25

**temporary identifier**

**TempID**

identifier used for addressing the slave device while it resides in the communication environment of the master

NOTE Each time the slave registers in a communication zone, a new *TempID* is created.

4.1.26

**wake-up window**

**WuW**

special case of a broadcast window which is used to “wake-up” sleeping units entering the communication zone of an active master

4.1.27

**window**

smallest addressable time span of a CALM-IR frame which may consist of one or multiple time slots

**4.2 Optical parameters**

4.2.1

**radiant power**

**radiant flux**

$\Phi_e$

power emitted, transmitted or received in the form of radiation

NOTE 1 The unit is the watt (W).

NOTE 2 Adapted from IEC 60050 (845-01-24).

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

ISO 21214:2006  
<https://standards.iteh.ai/catalog/standards/sist/3ecd110b-8c4d-4705-a3ce-0ff81ef9053/iso-21214-2006>

#### 4.2.2 radiant intensity

$I_e$

quotient of the radiant flux  $d\Phi_e$  leaving the source and propagated in the element of solid angle  $d\Omega$  containing the given direction, by the element of solid angle

$$I_e = \frac{d\Phi_e}{d\Omega}$$

NOTE 1 Unit: W/sr (watts per steradian).

NOTE 2 Adapted from IEC 60050 (845-01-30).

#### 4.2.3 irradiance

$E_e$

quotient of the radiant flux  $d\Phi_e$  incident on an element of a surface containing a given point divided by the area  $dA$  of that element

NOTE 1 Unit: W/m<sup>2</sup>.

NOTE 2 Equivalent definition. Integral, taken over the hemisphere visible from the given point, of the expression  $L_e \cdot \cos\theta \cdot d\Omega$ , where  $L_e$  is the radiance at the given point in the various directions of the incident elementary beams of solid angle  $d\Omega$ , and  $\theta$  is the angle between any of these beams and the normal to the surface at the given point.

$$E_e = \frac{d\Phi_e}{dA} = \int_{2\pi\text{sr}} L_e \cdot \cos\theta \cdot d\Omega$$

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

NOTE 3 Adapted from IEC 60050 (845-01-37).

[ISO 21214:2006](https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006)

#### 4.2.4 radiant exitance

$M_e$

quotient of the radiant flux  $d\Phi_e$  leaving an element of a surface containing a given point divided by the area  $dA$  of that element

NOTE 1 Unit: W/m<sup>2</sup>.

NOTE 2 Equivalent definition. Integral, taken over the hemisphere visible from the given point, of the expression, where  $L_e \cdot \cos\theta \cdot d\Omega$  is the radiance at the given point in the various directions of the emitted elementary beams of solid angle  $d\Omega$ , and  $\theta$  is the angle between any of these beams and the normal to the surface at the given point.

$$M_e = \frac{d\Phi_e}{dA} = \int_{2\pi\text{sr}} L_e \cdot \cos\theta \cdot d\Omega$$

NOTE 3 Adapted from IEC 60050 (845-01-47).

#### 4.2.5 radiance

$L_e$

quantity (in a given direction, at a given point of a real or imaginary surface) ( $L_e$ ;  $L$ ) defined by the formula

$$L_e = \frac{d\Phi_e}{dA \cdot \cos\theta \cdot d\Omega}$$

where

$d\Phi_e$  is the radiant flux transmitted by an elementary beam passing through the given point and propagating in the solid angle  $d\Omega$  containing the given direction;

$dA$  is the area of a section of that beam containing the given point;

$\theta$  is the angle between the normal to that section and the direction of the beam.

NOTE 1 Unit: W/sr.m<sup>2</sup>.

NOTE 2 Adapted from IEC 60050 (845-01-34).

**4.2.6  
radiant intensity**

$I_e$   
quotient of the radiant flux  $d\Phi_e$  leaving the source and propagated in the element of solid angle  $d\Omega$  containing the given direction divided by the element of solid angle

NOTE Adapted from IEC 60050 (845-01-30).

**4.2.7  
steradian  
sr**

dimensionless SI unit of solid angle

NOTE 1 The steradian is the solid angle of a cone which, having its vertex in the centre of a sphere, cuts off on the surface of the sphere an area equal to that of a square with sides of length equal to the radius of the sphere. [ISO 31-1:1992, 1-2.a]

NOTE 2 Usually the abbreviation "sr" is appended, although mathematically this is incorrect.  
<https://standards.iteh.ai/catalog/standards/sist/3eccd10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006>

**EXAMPLE**

The unity solid angle, in terms of geometry, is the angle subtended at the centre of a sphere by an area on its surface numerically equal to the square of the radius (see Figure 1). Other than the figure might suggest, the shape of the area does not matter at all. Any shape on the surface of the sphere that holds the same area will define a solid angle of the same size.

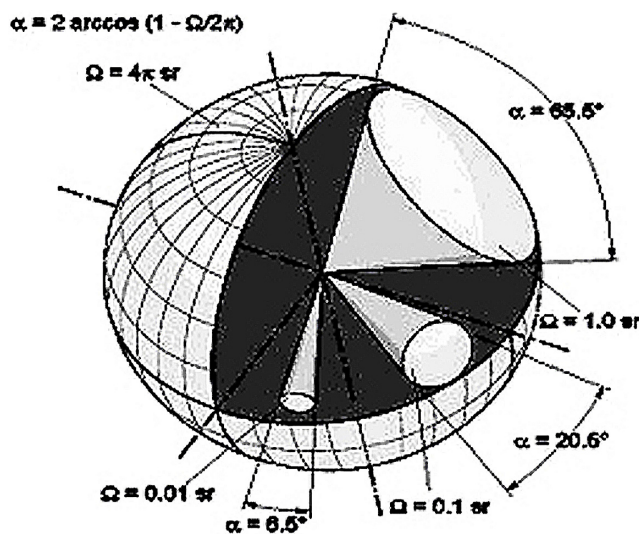


Figure 1 — Solid angle

**Relation between distance  $r$ , irradiance  $E_e$  and intensity  $I_e$** 

Using a single radiation point source, we get the following relation:

$$E_e = \frac{d\Phi_e}{dA} = \frac{I_e \cdot d\Omega}{dA} = \frac{I_e}{r^2}; \left[ \frac{W}{m^2} \right]$$

NOTE 3 Adapted from IEC 60050 (845-01-20).

**4.2.8****luminous flux**

$\Phi_v$

quantity derived from radiant flux  $\Phi_e$  by evaluating the radiation according to its action upon the CIE standard photometric observer, for photopic vision

$$\Phi_v = K_m \int_0^{\infty} \frac{d\Phi_e(\lambda)}{d\lambda} \cdot V(\lambda) \cdot d\lambda$$

where

$$\frac{d\Phi_e(\lambda)}{d\lambda}$$

is the spectral distribution of the radiant flux and  $V(\lambda)$  is the spectral luminous efficiency

NOTE 1 For the values  $K_m$  (photopic vision) and  $K'_m$  (scotopic vision), see IEC 60050 (845-01-56).

NOTE 2 Adapted from IEC 60050 (845-01-25), [SO 21214:2006](https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006)

<https://standards.iteh.ai/catalog/standards/sist/3ecdf10b-8c4d-4705-a3ce-0ff81efa9053/iso-21214-2006>

**4.2.9****luminous efficacy of radiation**

$K$

quotient of the luminous flux  $\Phi_v$  divided by the corresponding radiant flux  $\Phi_e$

$$K = \frac{\Phi_v}{\Phi_e}$$

NOTE 1 When applied to monochromatic radiation, the maximum value of  $K(\lambda)$  is denoted by the symbol  $K_m$ :

$K_m = 683 \text{ lm}\cdot\text{W}^{-1}$  for  $\nu_m = 540 \times 10^{12} \text{ Hz}$  ( $\lambda_m \approx 555 \text{ nm}$ ) for photopic vision.

$K'_m = 1700 \text{ lm}\cdot\text{W}^{-1}$  for  $\lambda'_m \approx 507 \text{ nm}$  for scotopic vision.

For other wavelengths,  $K(\lambda) = K'_m V(\lambda)$  and  $K(\lambda) = K'_m V(\lambda)$ .

NOTE 2 Adapted from IEC 60050 (845-01-55).