BS ISO/IEC 4005-3:2023

BSI Standards Publication

Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN)

Part 3: Physical and data link protocols for control communication

Documents
Document Sharing Hub

Full document details: BS ISO/IEC 4005-3:2023

National foreword

This British Standard is the UK implementation of ISO/IEC 4005-3:2023.

The UK participation in its preparation was entrusted to Technical Committee IST/6, Data communications.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 539 13066 9

ICS 35.100.10; 35.100.20; 49.020

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2023.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS ISO/IEC 4005-3:2023

INTERNATIONAL STANDARD

ISO/IEC 4005-3

First edition
2023-03

Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) —

Part 3: Physical and data link protocols for control communication

Télécommunications et échange d'information entre systèmes — Réseau de zone de drones (Unmanned aircraft area network - UAAN) —

Partie 3: Protocoles de liaison de données et physiques pour la communication de contrôle

Reference number
ISO/IEC 4005-3:2023(E)

Documents
Document Sharing Hub

© ISO/IEC 2023

Full document details: BS ISO/IEC 4005-3:2023

COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

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

Published in Switzerland

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO/IEC 4005-3:2023

Contents

Page

Foreword ... **v**
Introduction ... **vi**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms and definitions ... **1**
4 Abbreviated terms ... **1**
5 Physical layer ... **2**
5.1 Channel and frame structure for data channel ... 2
5.1.1 Number of data channels and bandwidth ... 2
5.1.2 Frame structure ... 2
5.1.3 Slot transmit time mask ... 3
5.1.4 Subchannels ... 3
5.1.5 Initial work resources (IWR) and channel ... 4
5.1.6 Dedicated slots and dedicated subchannels ... 5
5.2 Channel and frame structure for tone channel ... 5
5.2.1 Frame structure and bandwidth ... 5
5.2.2 Slot transmit power ... 6
5.2.3 Slot block structure ... 6
5.2.4 Subslot transmission time mask ... 8
5.2.5 Subslot signal waveform ... 8
5.3 Encoding procedure ... 9
5.4 Physical layer procedure ... 9
5.4.1 Synchronization ... 9
5.4.2 Subchannel power ... 9
5.4.3 Measurements ... 9
5.4.4 Coexistence operation ... 9
6 Data link layer ... **10**
6.1 General ... 10
6.2 Channel mapping and measurements ... 12
6.2.1 General ... 12
6.2.2 Mapping of communication resources and subslot sets ... 12
6.2.3 Interference power calculation ... 13
6.2.4 Subchannel map ... 14
6.3 Subchannel negotiation for allocation ... 14
6.3.1 General ... 14
6.3.2 Subchannel negotiation using shared channel ... 19
6.3.3 Subchannel negotiation using dedicated slot ... 21
6.3.4 Subchannel negotiation using IWR ... 23
6.4 Resource allocation competition and generated link confirmation ... 26
6.4.1 General ... 26
6.4.2 Subchannel resource allocation competition ... 27
6.4.3 Generated link confirmation ... 29
6.4.4 Broadcasting control channel information being allocated or occupied ... 31
6.5 Subchannel occupation and collision management ... 32
6.5.1 General ... 32
6.5.2 Subchannel occupation and return ... 32
6.5.3 Collision tone transmission and collision management ... 32
6.5.4 Power control in occupation stage ... 34
6.6 Reallocation ... 35
6.6.1 General ... 35
6.6.2 Reallocation decision ... 35
6.6.3 Subchannel reallocation procedure ... 38

AVA Documents
Document Sharing Hub

© ISO/IEC 2023 – All rights reserved

Full document details: BS ISO/IEC 4005-3:2023

6.7 Data exchange ... 39
6.7.1 General ... 39
6.7.2 Data packet format ... 39
6.8 Synchronization ... 43
6.9 Data link layer security ... 43
6.10 Interface with upper layers ... 45
6.10.1 General ... 45
6.10.2 Initialization interface ... 45
6.10.3 Dynamic interface ... 51
6.11 Interface with other communication layer ... 55
6.11.1 General ... 55
6.11.2 Interface with SC ... 55
6.11.3 Interface with VC ... 56
Bibliography ... 59

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

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 document 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 or www.iec.ch/members_experts/refdocs).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see https://patents.iec.ch).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

A list of all parts in the ISO/IEC 4005 series can be found on the ISO and IEC websites.

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 and www.iec.ch/national-committees.

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

Introduction

Unmanned aircrafts (UAs) operating at low altitudes will provide a variety of commercial services in the near future. UAs that provide these services are distributed in the airspace. In low uncontrolled airspace, many people operate their own UAs without the assignment of communication channels from a central control centre.

This document describes control communication, which is a wireless distributed communication. Control communication allows control pairs of UA and controller distributed over the airspace to communicate with each other without serious interference. The channel used for control communication has a multi-channel structure, which enables UAs and controllers to independently use the communication link occupied by each other. A wireless distributed communication described by this document is intended to be used in licensed frequency bands.

The ISO/IEC 4005 series consists of the following four parts:

ISO/IEC 4005-1: To support various services for UAs, it describes a wireless distributed communication model and the requirements that this model shall satisfy.

ISO/IEC 4005-2: It describes communication in which all units involved in UA operation can broadcast or exchange information by sharing communication resources with each other.

ISO/IEC 4005-3 (this document): It describes the control communication for the controller to control the UA.

ISO/IEC 4005-4: It describes video communication for UAs to send video to a controller.

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of patents.

ISO and IEC take no position concerning the evidence, validity and scope of these patent rights.

The holders of these patent rights have assured ISO and IEC that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statements of the holders of these patent rights are registered with ISO and IEC. Information may be obtained from the patent database available at www.iso.org/patents.

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

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) —

Part 3: Physical and data link protocols for control communication

1 Scope

This document specifies communication protocols for the physical and data link layer for control communication, which is wireless distributed communication network for units related with unmanned aircrafts (UAs) in level II.

This document describes control communication, which is one-to-one communication between a UA and a controller.

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/IEC 4005-1, *Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) — Part 1: Communication model and requirements*

ISO/IEC 4005-2:2023, *Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) — Part 2: Physical and data link protocols for shared communication*

ISO/IEC 4005-4, *Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) — Part 4: Physical and data link protocols for video communication*

ISO 21384-4, *Unmanned aircraft systems — Part 4: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in ISO/IEC 4005-1, ISO/IEC 4005-2, ISO 21384-4 and the following apply.

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

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

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

3.1
subchannel map
2-bit string indicating whether subchannels are available

Note 1 to entry: In wireless distributed communication, the subchannel map of each unit is generally different.

4 Abbreviated terms

CC Control Communication

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

CRC	Cyclic Redundancy Check
CSCH	Control Subchannel
DLL	Data Link Layer
DS	Dedicated Slot
FN	Frame Number
IWR	Initial Work Resource
LFSR	Linear Feedback Shift Register
PB	Parsing Block
PKH	Packet Header
PN	Pseudo Noise
SA	Source Address
SC	Shared Communication
TSB	Tone Slot Block
TX	Transmission
UTC	Coordinated Universal Time
VC	Video Communication
VSCH	Video Subchannel

5 Physical layer

5.1 Channel and frame structure for data channel

5.1.1 Number of data channels and bandwidth

The number of data channels is *N* as shown in Figure 1. *N* is greater than or equal to one. The bandwidth of one data channel is 1,25 MHz. The *N* is determined in the upper layer.

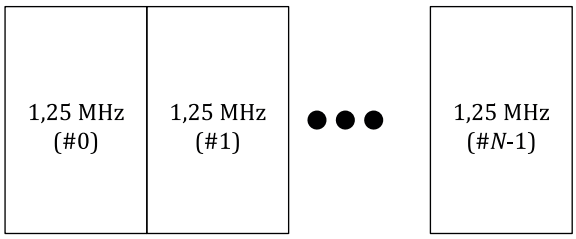
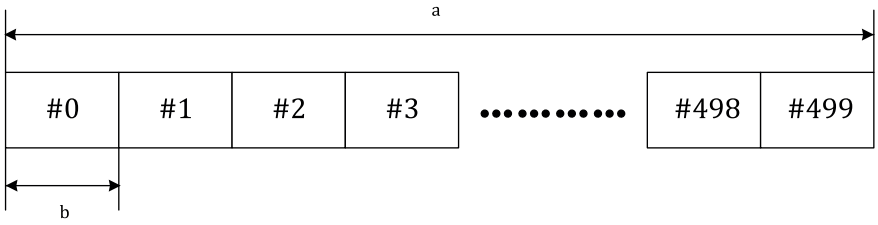


Figure 1 — Data channels in frequency region

5.1.2 Frame structure

The frame length of the data channel is 1 sec and consists of 500 slots and one slot time T_s is 2 ms as shown in Figure 2. *FN* is a frame number that varies from 0 to 59 and has the same value as the second of the current time.

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023



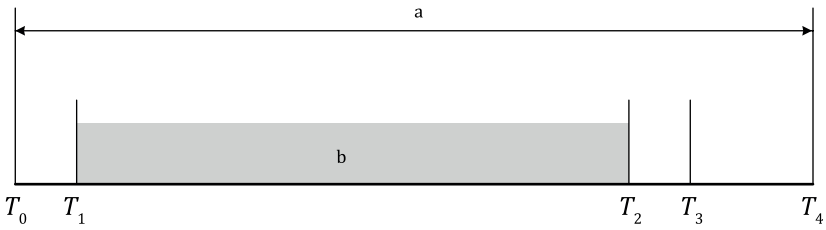
a 1 frame, T_f = 1 sec = 500 T_s.

b 1 slot, T_s = 2 ms.

Figure 2 — Frame structure of the control channel

5.1.3 Slot transmit time mask

The transmission time mask of a slot is shown in Figure 3.



a 2 ms.

b Modulated signal.

Figure 3 — The transmission time mask of a slot

T_1, T_2, T_3, T_4 are symbol offsets from T_0 and symbol time is 1/672000 sec. Each value is as follows: T_1 is 2, T_2 is 1297, T_3 is 1299, T_4 is 1344.

T_0 is 0 µs as the start time of the slot and the power amplifier is gated on and unmodulated fine signals begin to be transmitted. T_1 is an offset at which modulation signal transmission starts. T_2 is an offset at which the transmission of the modulated signal ends. T_3 is an offset at which the power amplifier is gated off, and transmission of unmodulated fine signals is stopped. The transmit power of T_0 to T_1, T_2 to T_3 shall be at least 50 dB less than the modulation signal transmit power.

5.1.4 Subchannels

5.1.4.1 General

One data channel consists of 20 subchannels as shown in Figure 4. Subchannel y of control channel x is composed of the following slot set.

$$CCH_{x,y} = S_{x,z}, S_{x,z+20}, S_{x,z+40}, \ldots, S_{x,z+480}$$

$$z = \begin{cases} y, & evenframe \\ y+2-\lfloor (y \bmod 4)/2 \rfloor \times 4, & oddframe \end{cases} \quad (1)$$

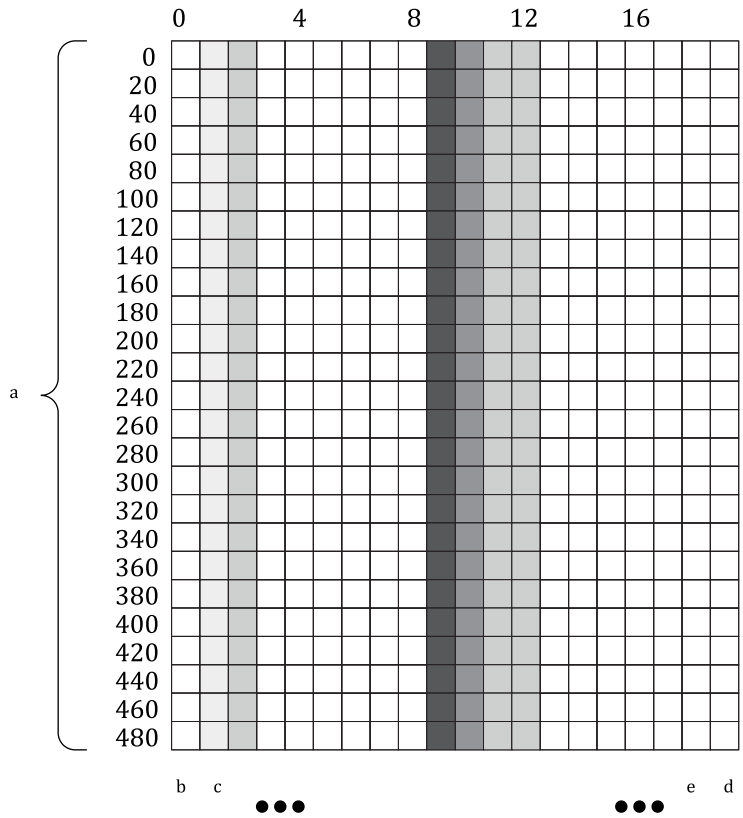
where

y is subchannel number, y=0, 1, …, 19;

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

$S_{x,z}$ is slot z of control channel x.



a CCH_x
b $CCH_{x,0}$
c $CCH_{x,1}$
d $CCH_{x,18}$
e $CCH_{x,19}$

Figure 4 — Subchannel structure of control communication in even frame

A subchannel consists of 25 slots, the i-th slot resource of the subchannel y of the channel x is indicated by $SR_{x,y,i}$ and the subchannel y of frequency channel x is indicated by $CCH_{x,y}$. Therefore, $CCH_{x,y}$ *is* as follows.

$$CCH_{x,y} = SR_{x,y,0}, SR_{x,y,1}, \ldots, SR_{x,y,24} \tag{2}$$

where $SR_{x,y,i}$ is i-th slot resource of subchannel y of channel x, i=0, ..., 24.

5.1.4.2 Up and down link decision of slot resources

For $SR_{x,y,i}$, 5 slots satisfying (i *mod* 5) =(FN *mod* 5) are downlink and remain 20 slots are uplink, where *mod* means modulo operation.

5.1.5 Initial work resources (IWR) and channel

The upper layer can set the initial work resource (IWR) as follows, and the use of the IWR is determined by the upper layer.

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

Four subchannels of frequency channel N_IWR, $CCH_{N_IWR,16}$, $CCH_{N_IWR,17}$, $CCH_{N_IWR,18}$, $CCH_{N_IWR,19}$ are designated as initial work channels. They are newly named $IWRCH_0$, $IWRCH_1$, $IWRCH_2$, $IWRCH_3$ respectively. These four initial work channels are not used for control, but are initially used to allocate control subchannels (CSCHs) between the UA and the controller, where N_IWR is received from the upper layer with UPtoDL.InfoIWRSlot.

The 25 slots of $IWRCH_y$ are divided into five IWRs in order.

$$IR_{y,i} = ISR_{x,5i}, ISR_{x,5i+1}, ISR_{x,5i+2}, ISR_{x,5i+3}, ISR_{x,5i+4} \quad (3)$$

where

y	is an *IWRCH* number and has the value from 0 to 3;
$ISR_{x,y,i}$	is i-th slot resource of $IWRCH_y$.

5.1.6 Dedicated slots and dedicated subchannels

The upper layer can pre-determine one or more subchannels as dedicated subchannels. In this case, the tone subslot sets mapped with the dedicated subchannel is not used as a competition tone and can be used for other purposes. Slots in the dedicated subchannel are used as dedicated slots (DSs). One or several dedicated slots can be assigned to UAs and controllers in advance. UAs and controllers use the dedicated slots without competition.

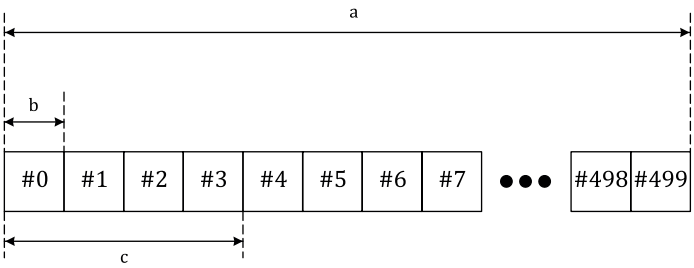
It is recommended to set the dedicated subchannel in frequency channel N_IWR.

Dedicated subchannel information and dedicated slot information are received from an upper layer through UPtoDL.InfoDedicatedChannel and UPtoDL.InfoDedicatedSlot.

5.2 Channel and frame structure for tone channel

5.2.1 Frame structure and bandwidth

The tone channel of the control communication indicates a competitive tone channel. The frame length of tone channel is 1 sec and the number of slots per frame is 500. Four tone slots constitute one tone slock block (TSB). Thus, there are 125 TSBs in one second frame as shown in Figure 5.



a 1 frame, T_f = 1 second = 500 T_s.

b 1 slot, T_s = 2 ms.

c 1 slot block, T_{sb} = 8 ms.

Figure 5 — Frame structure of tone channel in control communication

The bandwidth of the tone channel is 250 kHz. *FN* is a frame number that varies from 0 to 59 and has the same value as the second of the current time.

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

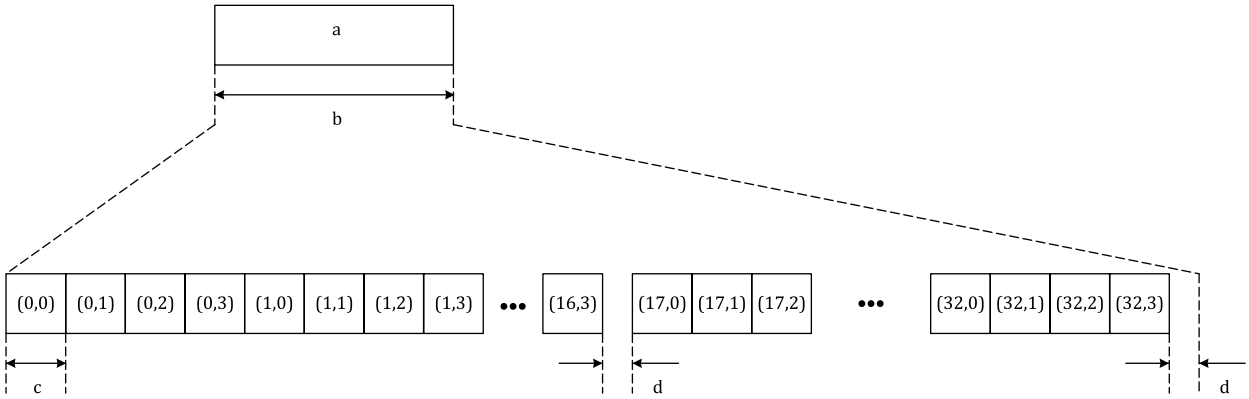
5.2.2 Slot transmit power

The maximum slot transmission power of the tone channel, PmaxTCH, is received as UPtoDL. InfoPowerParamCCH from the upper layer. The transmission power of the tone subslot signal is determined by adding the PTX_CCHTCH_differ value to the transmission power of the mapped CSCH.

5.2.3 Slot block structure

There are three types of slot blots. TSBtype0, TSBtype1, TSBtype2 are these. The type of each slot blot of the TCH is received from the upper layer as UPtoDL.InfoTSBTypeMap.

There are 132 subslots in one slot block of TSBtype0. The length T_{ss} of the subslot is 60 µs. The 132 subslots are divided into four parts, as shown in Figure 6, according to each slot numbers.



a Type 0.

b 1 slot block, T_{sb} = 8 ms.

c T_{ss} = 60 µs.

d 40 µs.

Figure 6 — Type 0 TSB structure

In case of TSBtype0, n-th slot block is composed as follows.

— (0, 4n), (0, (4n + 1)), (0, (4n + 2)), (0, (4n + 3)), (1, 4n), (1, (4n + 1)), (1, (4n + 2)), (1, (4n + 3)),… , (32, 4n), (32, (4n + 1)), (32, (4n + 2)), (32, (4n + 3))

where (x, y) is the x-th subslot of the y-th subslot set. The 132 subslots are divided into four subslot sets.

— $\{S_{4n}\}$ = {(0, 4n), (1, 4n), …, (32, 4n)}

— $\{S_{4n+1}\}$ = {(0, (4n + 1)), (1, (4n + 1)), …, (32, (4n + 1))}

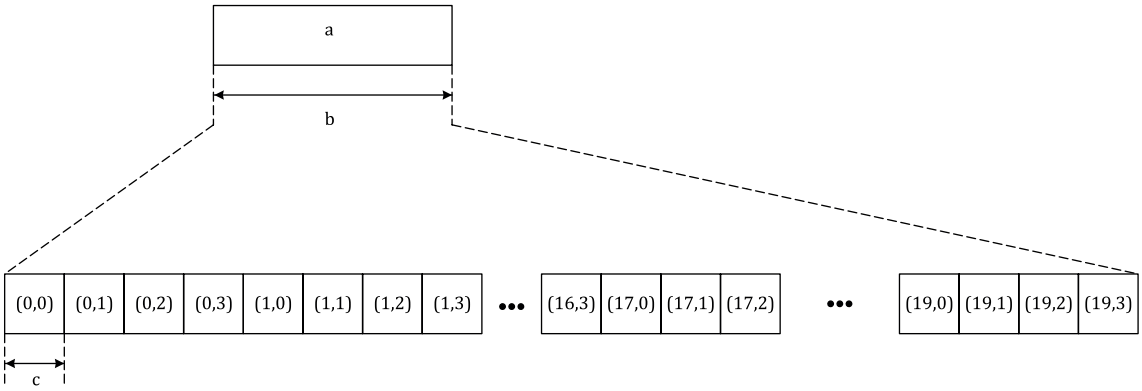
— $\{S_{4n+2}\}$ = {(0, (4n + 2)), (1, (4n + 2)), …, (32, (4n + 2))}

— $\{S_{4n+3}\}$ = {(0, (4n + 3)), (1, (4n + 3)), …, (32, (4n + 3))}

where $\{S_x\}$ is the x-th subslot set.

There are a total of 80 subslots in TSBtype1. The length T_{ss} of the subslot is 100 µs. The 80 subslots are divided into four parts, as shown in Figure 7, according to each slot number.

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023



a Type1.

b 1 slot block, T_{sb} = 8 ms.

c T_{ss} = 100 µs.

Figure 7 — Type 1 TSB structure

The n-th slot block that belongs to TSBtype1 is composed of the following subslot combinations.

— (0, 4n), (0, (4n + 1)), (0, (4n + 2)), (0, (4n + 3)), (1, 4n), (1, (4n + 1)), (1, (4n + 2)), (1, (4n + 3)),... , (19, 4n), (19, (4n + 1)), (19, (4n + 2)), (19, (4n + 3))

The 80 subslots make up four subslot sets.

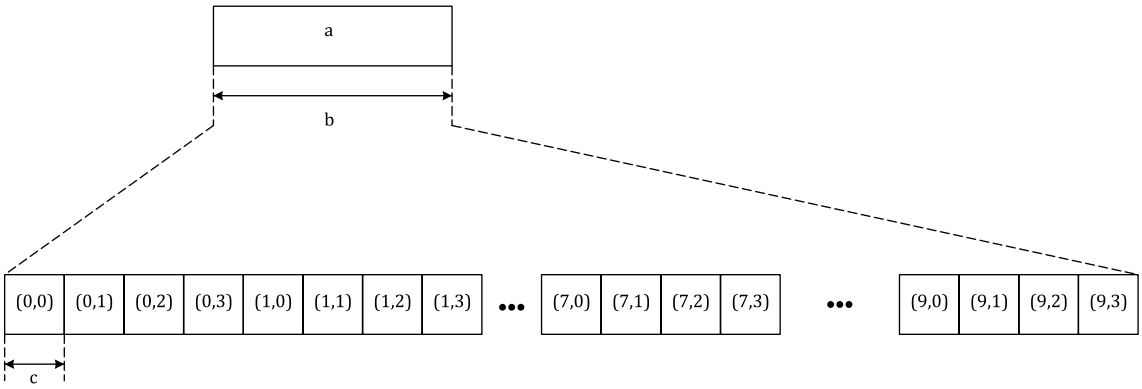
— $\{S_{4n}\}$ = {(0, 4n), (1, 4n), ..., (19, 4n)}

— $\{S_{4n+1}\}$ = {(0, (4n + 1)), (1, (4n + 1)), ..., (19, (4n + 1))}

— $\{S_{4n+2}\}$ = {(0, (4n + 2)), (1, (4n + 2)), ..., (19, (4n + 2))}

— $\{S_{4n+3}\}$ = {(0, (4n + 3)), (1, (4n + 3)), ..., (19, (4n + 3))}

There are a total of 40 subslots in TSBtype2. The length T_{ss} of the subslot is 200 µs. The 40 subslots are divided into four parts, as shown in Figure 8, according to each slot numbers.



a Type2.

b 1 slot block, T_{sb} = 8 ms.

c T_{ss} = 200 µs.

Figure 8 — Type 2 TSB structure

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

The n-th slot block that belongs to TSBtype2 is composed of the following subslot combinations.

— (0, 4n), (0, (4n + 1)), (0, (4n + 2)), (0, (4n + 3)), (1, 4n), (1, (4n + 1)), (1, (4n + 2)), (1, (4n + 3)),... , (9, 4n), (9, (4n + 1)), (9, (4n + 2)), (9, (4n + 3))

The 40 subslots make up four subslot sets.

— $\{S_{4n}\}$ = {(0, 4n), (1, 4n), ..., (9, 4n)}

— $\{S_{4n+1}\}$ = {(0, (4n + 1)), (1, (4n + 1)), ..., (9, (4n + 1))}

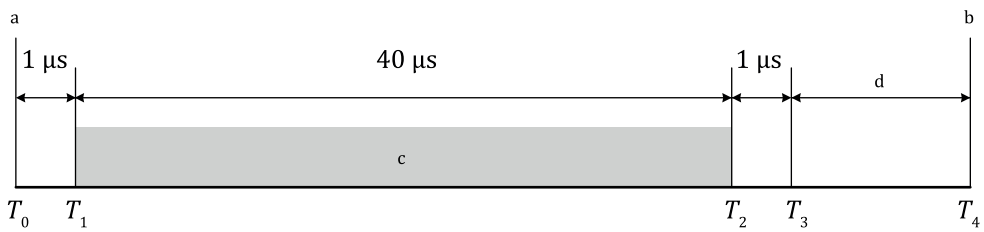
— $\{S_{4n+2}\}$ = {(0, (4n + 2)), (1, (4n + 2)), ..., (9, (4n + 2))}

— $\{S_{4n+3}\}$ = {(0, (4n + 3)), (1, (4n + 3)), ..., (9, (4n + 3))}

Regardless of the type of TSB, there are a total of 500 subslot sets in one frame.

5.2.4 Subslot transmission time mask

Subslot transmission time mask is shown in Figure 9.



Key

T_0	0 µs
T_1, T_2, T_3, T_4	time offsets from T_0
a	Subslot start.
b	Subslot end.
c	Tone signal.
d	Guard time.

Figure 9 — Subslot transmission time mask

T_1, T_2, T_3, and T_4 are time offsets from T_0. T_1 is 1 µs, T_2 is 41 µs, and T_3 is 42 µs.

In TSBtype0, T_4 is 60 µs, guard time is 18 µs.

In TSBtype1, T_4 is 100 µs, guard time is 58 µs.

In TSBtype2, T_4 is 200 µs, guard time is 158 µs.

T_0 is the time when the power amplifier is gated on, and unmodulated fine signals begin to be transmitted. T_1 is the time at which transmission of the modulated signal begins. T_2 is the time at which transmission of the modulated signal is terminated. T_3 is the time when the power amplifier is gated off and the transmission of unmodulated fine signals is stopped. The transmission power of the time region from T_0 to T_1 and the transmission power of the time region from T_2 to T_3 shall be 50dB or more less than the modulated signal transmission power.

5.2.5 Subslot signal waveform

The subslot signal waveform is the same as that of shared communication. See ISO/IEC 4005-2:2023, 5.1.2.3.

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

The modulation scheme of subslot signal is on-off keying. The subslot signal is started at T_1 and transmitted during the 40 µs interval. The waveform of the subslot transmission signal uses a raised cosine function. The subslot signal is generated by the following formula.

$$g(t;\alpha)=\frac{\cos(\pi\alpha(t-2T))}{1-(2\alpha(t-2T)/T)^2}\sin c\left(\frac{(t-2T)}{T}\right),\qquad 0\le t\le 4T \tag{4}$$

where

α is 0,75 as a roll-off factor;

T is 10 µs as a raised cosine period.

5.3 Encoding procedure

The encoding procedure is identical with that of shared communication. See ISO/IEC 4005-2:2023, 5.2.

The final encoded signal is located between T_1 and T_2 in Figure 3, i.e. in the modulated signal part.

5.4 Physical layer procedure

5.4.1 Synchronization

All messages shall be transmitted based on UTC absolute time. All times are measured on UTC.

The synchronization mode of the unit includes 'A sync', 'B sync' and 'C sync'.

— A sync is synchronization obtained from UTC.

— B sync is secondary synchronization acquired from the synchronization signal of the A sync unit.

— C sync is sync status within 20 sec after sudden loss of sync in A or B sync mode.

A sync unit shall know the date, hour, minute, second, slot number.

The time error of A sync shall be within ±0,4 µs. The time error of B sync shall be within ±4 µs. The time error of C sync shall be within ±5 µs.

The frequency error of A sync shall be within ±0,1 ppm. The frequency error of the B sync shall be within ±0,2 ppm. The frequency error of the C sync shall be within ±0,3 ppm.

5.4.2 Subchannel power

The maximum power of the CSCH, PmaxCCH, is received as UPtoDL.InfoPowerParamCCH from the upper layer. The maximum transmission power and minimum transmission power of each CSCH are received from the upper layer as UPtoDL.InfoPowerParamCCHsub. The power control of each CSCH is described in the resource allocation procedure.

5.4.3 Measurements

The physical layer shall have the ability to measure the following parameters. The received signal power of a tone subslot, the received signal power of a data slot, and propagation delay time of the received data signal shall be measured. The receiving power determination point shall be the receiving antenna connector.

5.4.4 Coexistence operation

If the hardware of shared communication described in ISO/IEC 4005-2 and the hardware of control communication described in this document and the hardware of video communication described in

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

ISO/IEC 4005-4 are completely physically isolated and do not affect each other at all, it shall be allowed that they do not perform coexistence operations, which is implementation dependent. In general, the three communications affect each other, and in this case, the following coexistence operations shall be performed.

The TX operation of a shared slot includes the TX of the corresponding shared slot and the TX operation in the mapped tone subslot set. The TX operation of a control communication includes TX of the mapped tone subslot set and CSCH TX. The TX operation of video communication includes TX of a mapped tone subslot set and VSCH TX.

When a UA periodically broadcasts its information to a shared slot of a shared channel, a shared slot and a tone subslot set mapped to the shared slot generally require 1 slot and 4 slots, respectively, for TX operation. If the TX operation of the shared slot used for mandatory periodic broadcasting and the TX operation of the control channel overlap, the TX operation of the shared slot shall be performed.

A CSCH and a VSCH shall be allocated so that they do not overlap in time.

The TX time of the tone subslot set mapped with mandatory periodically broadcasted shared slot, the TX time of the tone subslot set mapped with the CSCH, and the TX time of the tone subslot set mapped with the VSCH shall not overlap each other. If the control TSB type is TSBtype0, the control tone subslot set and the shared tone subslot set can be located in the same TSB. In this case, the two tone subslot set numbers shall be different. If the control TSB type is not TSBtype0, the control tone subslot set and the shared tone subslot set cannot be located in the same TSB.

The TX operation time of the tone subslot set mapped with a CSCH can overlap the TX time of a VSCH, and in this case, the corresponding video slot cannot be transmitted. The TX operation time of the tone subslot set mapped with a VSCH can overlap with the slot TX time of a CSCH, and in this case, the corresponding control slot cannot be transmitted.

The coexistence operation of the tone subslot set mapped with an IWR is the same with coexistence operation of the tone subslot set mapped with the CSCH.

6 Data link layer

6.1 General

The data link layer allocates subchannels consisting of 25 slots to controllers and UAs. The controller can use this subchannel to control the UA. The typical application service of control communication is that the controller controls the UA, but it is possible to provide other services through the occupied control link. This is determined at the upper layer.

The procedure of using the subchannel is shown in Figure 10 and as follows:

— negotiation of subchannel number to be allocated;

— competition for allocation and generated link confirmation;

— occupation and management of subchannels;

— subchannel return or reallocation.

Firstly, the UA and the controller each create a map of the available subchannels. The controller selects one of the subchannels available together and the controller transfers the selected subchannel number to the other unit. This process can be performed by the CC DLL as well as SC DLL.

After that, the UA and the controller attempt to allocate subchannel at the same time. Subchannel can be allocated only when the UA and the controller succeed in allocation at the same time. Therefore, it is necessary to confirm whether a link is formed.

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

If the subchannel allocation is successful, the UA and the controller simultaneously perform slot clearing to occupy the subchannel. While occupying a subchannel, the UA and the controller constantly check for collisions of subchannel resources. They also calculate the amount of interference from neighboring channels.

If collision of subchannel resources or interference with neighbouring channels exceeding the threshold is detected, the UA and the controller reallocate the subchannel. To do this, the UA and the controller decide which subchannels to reallocate and perform allocation competition on that subchannel.

The UA and the controller return the subchannel when they can no longer maintain or need to maintain them.

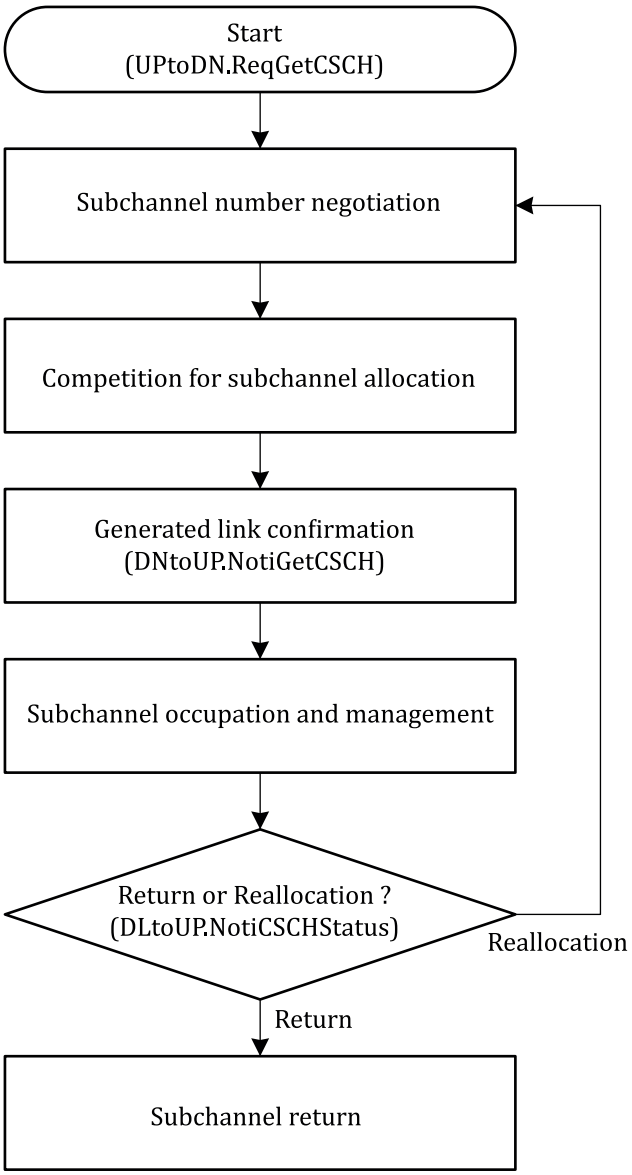


Figure 10 — Subchannel use procedure

NOTE Detecting resource collision satisfies the data link design requirement described in ISO 21384-2[1] that the design of the data link mitigates co-channel interference with other users of the spectrum.

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023

6.2 Channel mapping and measurements

6.2.1 General

Allocating subchannel resources is performed by a tone channel. One subslot set in a tone channel and one subchannel have a mapping relationship. When one tone subslot set is allocated, the subchannel mapped thereto is allocated.

In order for a UA and a controller to allocate a subchannel, the UA and the controller shall find subchannels that can be allocated at the same time. To this end, the UA and the controller determine allocable subchannels by calculating the interference power for each subchannel.

6.2.2 Mapping of communication resources and subslot sets

The competition for allocating a subchannel or an IWR is performed in the subslot set mapped thereto. Subslot sets are mapped to subchannels or IWRs.

If the upper layer does not specify IWRs, the tone subslot set 0 to the tone subslot set 19 are left empty. When the IWRs are specified, the tone subslot sets are mapped as follows.

The tone subslot sets $\{S_0\}$, $\{S_1\}$, $\{S_2\}$, and $\{S_3\}$ are mapped to $IR_{0,0}$, $IR_{1,0}$, $IR_{2,0}$, and $IR_{3,0}$ respectively.

The tone subslot sets $\{S_4\}$, $\{S_5\}$, $\{S_6\}$, and $\{S_7\}$ are mapped to $IR_{0,1}$, $IR_{1,1}$, $IR_{2,1}$, and $IR_{3,1}$ respectively.

The tone subslot sets $\{S_8\}$, $\{S_9\}$, $\{S_{10}\}$, and $\{S_{11}\}$ are mapped to $IR_{0,2}$, $IR_{1,2}$, $IR_{2,2}$, and $IR_{3,2}$ respectively.

The tone subslot sets $\{S_{12}\}$, $\{S_{13}\}$, $\{S_{14}\}$, and $\{S_{15}\}$ are mapped to $IR_{0,3}$, $IR_{1,3}$, $IR_{2,3}$, and $IR_{3,3}$ respectively.

The tone subslot sets $\{S_{16}\}$, $\{S_{17}\}$, $\{S_{18}\}$, and $\{S_{19}\}$ are mapped to $IR_{0,4}$, $IR_{1,4}$, $IR_{2,4}$, and $IR_{3,4}$ respectively.

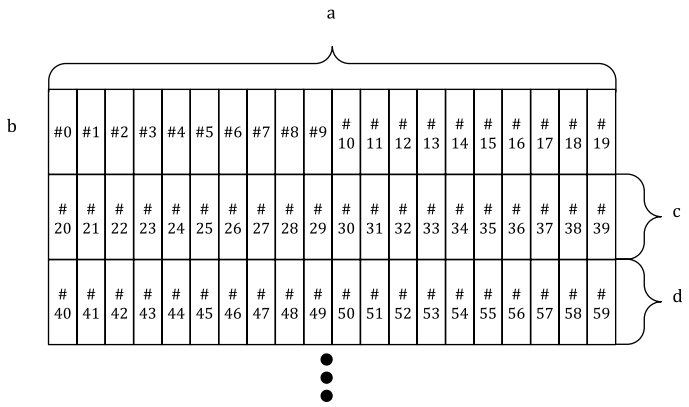
The tone subslot set $\{S_{m+20+n}\}$ is mapped to the subchannel $CCH_{x,y}$, where m is $20x+((y+8)\ mod\ 20)$ and n is as follows.

$$n = \begin{cases} 0, & evenframe \\ 20-(x \bmod 2)\times 40, & odd\ frame \end{cases} \tag{5}$$

Thereafter, $\{S_{m+20+n}\}$ mapped to $CCH_{x,y}$ is expressed as $\{S_{x,y}\}$.

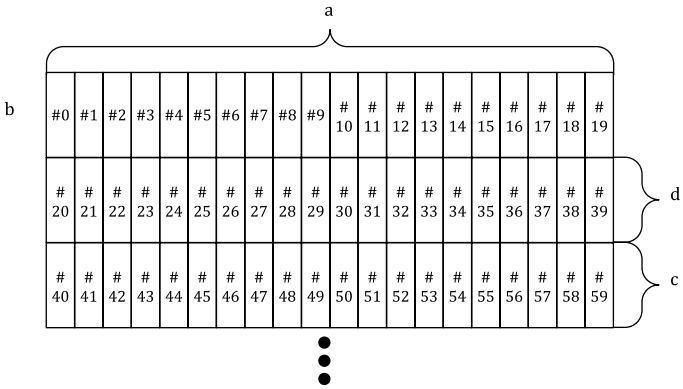
As mentioned above, the four subchannels of frequency channel N_IWR, $CCH_{\text{N_IWR},16}$, $CCH_{\text{N_IWR},17}$, $CCH_{\text{N_IWR},18}$, $CCH_{\text{N_IWR},19}$ are newly renamed as $IWRCH_0$, $IWRCH_1$, $IWRCH_2$, $IWRCH_3$. Therefore, the tone subslot sets mapped with these four subchannels are not used. The upper layer can designate these tone subslot sets as information tone subslot sets. The slot block type of the tone subslot sets from $\{S_0\}$ to $\{S_{19}\}$ is TSBtype2.

This mapping is shown in Figure 11.



a) Even frame

© ISO/IEC 2023 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023



b) Odd frame

a $IR_{0,0}$, $IR_{1,0}$, $IR_{2,0}$, $IR_{3,0}$, $IR_{0,1}$, $IR_{1,1}$, …, $IR_{2,4}$, $IR_{3,4}$

b Tone subslot set.

c $CCH_{0,12}$, $CCH_{0,13}$, … $CCH_{0,11}$

d $CCH_{1,12}$, $CCH_{1,13}$, … $CCH_{1,11}$

Figure 11 — Mapping of control subchannel (CSCH) and tone subslot sets

6.2.3 Interference power calculation

In order to allocate the CSCH, the unit shall calculate the interference power in the allocable subchannels. The interference constants for calculating the interference power are N, IC_1, IC_2, …, IC_{N-1} and received as UPtoDL.InfoICConstant from the upper layer. Where N is the number of CCH channels. The unit of interference constants is dB. The estimated interference power of the subchannel is expressed as $PImCCH_{xy}$.

The interference of the subchannel CCH_{xy} experienced by the controller is calculated as follows.

$$P\mathrm{Im}c\,CCH_{x,y} = \sum_{i=0,i\neq x}^{N-1}(PmdCCH_{i,y} - IC_{|x-i|}) \tag{6}$$

where $PImdCCH_{i,y}$ is the reception power of the tone transmitted by the UA in the tone subslot set mapped with $CCH_{i,y}$ and the unit of this is dBm. The unit of ($PImdCCH_{i,y}$-$IC_{|x-i|}$) is also dBm.

The interference of the subchannel CCH_{xy} experienced by the UA is calculated as follows.

$$P\mathrm{Im}dCCH_{x,y} = \sum_{i=0,i\neq x}^{N-1}(PmcCCH_{i,y} - IC_{|x-i|}) \tag{7}$$

where $PImcCCH_{i,y}$ is the reception power of the tone transmitted by the controller in the tone subslot set mapped with $CCH_{i,y}$.

IWRs exist in four subchannels of frequency channel N_IWR, $CCH_{N_IWR,16}$, $CCH_{N_IWR,17}$, $CCH_{N_IWR,18}$ and $CCH_{N_IWR,19}$. Therefore, the interference power of the IWR is equal to the interference power of $CCH_{N_IWR,16}$, $CCH_{N_IWR,17}$, $CCH_{N_IWR,18}$ and $CCH_{N_IWR,19}$. $PImcIR_{i,y}$ is the interference power of the IWR in controller and $PImdIR_{i,y}$ is the interference power of the IWR in UA.

$$\begin{aligned} PImcIR_{i,y} &= PImcCCH_{N_IWR,16+y} \\ PImdIR_{i,y} &= PImdCCH_{N_IWR,16+y} \end{aligned} \tag{8}$$

© ISO/IEC 2023 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO/IEC 4005-3:2023