IEC 63448

Edition 1.0 2025-11

# INTERNATIONAL STANDARD

**Low and ultra-low latency communication and control systems**

ICS 33.160.60

ISBN 978-2-8327-0816-3

IEC 63448:2025-11(en)

**THIS PUBLICATION IS COPYRIGHT PROTECTED**
**Copyright © 2025 IEC, Geneva, Switzerland**

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 IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

**About the IEC**
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search - webstore.iec.ch/advsearchform**
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - webstore.iec.ch/justpublished**
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**IEC Customer Service Centre - webstore.iec.ch/csc**
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

**IEC Products & Services Portal - products.iec.ch**
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - www.electropedia.org**
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**Warning! Make sure that you obtained this publication from an authorized distributor.**

# CONTENTS

FOREWORD ..... 4
INTRODUCTION ..... 6
1 Scope ..... 7
2 Normative references ..... 7
3 Terms and definitions ..... 7
3.1 Terms and definitions ..... 7
3.2 Abbreviated terms ..... 9
4 General ..... 10
5 System-level design aspects of ULCCS technology ..... 12
5.1 Examples of PHY layers for ULCCS ..... 12
5.2 MAC layer aspects ..... 12
5.3 Management aspects ..... 13
6 Medium access control (MAC) layer ..... 13
6.1 General MAC framework ..... 13
6.2 Frame formats ..... 14
6.2.1 General ..... 14
6.2.2 Signaling frame ..... 14
6.2.3 Downlink frame ..... 15
6.2.4 Uplink frame ..... 15
6.2.5 Retransmission frame ..... 15
6.2.6 Slot structure ..... 15
6.3 Message types ..... 15
6.4 Message structure ..... 15
6.5 MAC functions ..... 18
6.5.1 General ..... 18
6.5.2 Schedule generation ..... 18
6.5.3 Data transmissions ..... 21
6.5.4 Retransmission handling ..... 22
6.5.5 Frequency hopping ..... 25
6.6 MAC parameters ..... 25
6.7 Logical channels ..... 26
7 System management ..... 28
7.1 Time synchronization ..... 28
7.1.1 General ..... 28
7.1.2 Multi-hop time synchronization based on synchronous flooding ..... 28
7.1.3 Multi-hop time synchronization based on timestamping ..... 29
7.1.4 Single-hop time synchronization based on IEEE 802.11-2012 ..... 30
7.2 Multi-hop operation ..... 30
7.2.1 General ..... 30
7.2.2 Topology generation by the network layer ..... 31
7.2.3 Topology generation by the MAC layer ..... 32
7.3 Parallel operation of multiple domains ..... 33
7.3.1 General ..... 33
7.3.2 Synchronous operation of multiple domains ..... 33
7.3.3 Asynchronous operation of multiple domains ..... 34
7.4 Parallel operation over multiple radios ..... 35

7.5 Security ..... 35
Annex A (informative) Use-cases and reference scenarios ..... 37
A.1 Use-case 1: Multi-sensory wireless teleoperation ..... 37
A.2 Use-case 2: Multi-user VR environment ..... 37
A.3 ULCCS operation over Bluetooth® 5.0 PHY layers ..... 38
Bibliography ..... 40

Figure 1 – System model for multimedia-centric communication and control in local environments ..... 10
Figure 2 – Logical view of the protocol layer model for ULCCS technology ..... 11
Figure 3 – Packet format of ULCCS technology over uncoded Bluetooth® 5.0 PHY layer ..... 12
Figure 4 – MAC layer operation of ULCCS technology and its different phases ..... 13
Figure 5 – Reference example for ULCCS operation ..... 13
Figure 6 – Illustration of the signaling frame ..... 14
Figure 7 – RFR message structure ..... 17
Figure 8 – ASG message structure ..... 17
Figure 9 – DLS message structure for distributed scheduling ..... 18
Figure 10 – DLS message structure for centralized scheduling ..... 18
Figure 11 – Exchange of signaling messages for schedule generation ..... 19
Figure 12 – Structure of retransmitted DLS message for distributed scheduling ..... 21
Figure 13 – Data message structure ..... 21
Figure 14 – Schedule duplication technique ..... 22
Figure 15 – Schedule extrapolation technique ..... 22
Figure 16 – G-NACK message structure ..... 23
Figure 17 – Reference example for illustrating schedule extrapolation ..... 23
Figure 18 – Illustration of schedule extrapolation (Scenario A) ..... 24
Figure 19 – Illustration of schedule extrapolation (Scenario B) ..... 24
Figure 20 – Illustration of the logical channels for ULCCS ..... 26
Figure 21 – Illustration of schedule translation functionality ..... 27
Figure 22 – Illustration of time synchronization via synchronous flooding ..... 28
Figure 23 – Illustration of time synchronization via synchronous flooding ..... 29
Figure 24 – W-DREQ message structure ..... 29
Figure 25 – W-DRES message structure ..... 30
Figure 26 – RC message structure ..... 30
Figure 27 – Illustration of topology generation by network layer ..... 31
Figure 28 – RC-ACK message structure ..... 31
Figure 29 – Illustration of advertising and scanning procedures ..... 32
Figure 30 – Illustration of topology generation via managed flooding ..... 33
Figure 31 – Illustration of synchronous operation of multiple domains ..... 33
Figure 32 – Illustration of the two-tier schedule ..... 34
Figure 33 – Illustration of asynchronous operation of multiple domains ..... 34
Figure 34 – Illustration of multi-radio operation ..... 35

Figure 35 – ASG-MR message structure ..... 35
Figure 36 – Illustration of data message with signature ..... 36
Figure A.1 – Wireless teleoperation use-case for ULCCS ..... 37
Figure A.2 – Multi-user VR use-case for ULCCS (enterprise scenario) ..... 38
Figure A.3 – Multi-user VR use-case for ULCCS (edge rendering scenario) ..... 38
Figure A.4 – Multi-hop topology for illustration of ULCCS operation over LE 2M PHY ..... 39

Table 1 – Message types for ULCCS operation ..... 16
Table 2 – MAC layer parameters for ULCCS ..... 25
Table 3 – Logical channel mapping for ULCCS over DECT-2020 NR PHY ..... 27
Table A.1 – Key parameters for illustration of ULCCS operation of LE 2M PHY ..... 39

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

# Low and ultra-low latency communication and control system

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 63448 has been prepared by IEC technical committee TC 100: Audio, video and multimedia systems and equipment. It is an International Standard.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|---|---|
| 100/4293/CDV | 100/4364/RVC |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,
– withdrawn, or
– revised.

# INTRODUCTION

The focus of this document is low and ultra-low latency communication and control system (ULCCS) technology to address the challenges of communication and control for multimedia-centric applications in local environments. State-of-the-art wireless systems targeting multimedia delivery do not adequately fulfil the stringent performance requirements of emerging control-centric applications. Hence, there is a need to develop a new protocol which can satisfy the stringent requirements of such applications.

## 1 Scope

This document specifies the low and ultra-low latency communication and control system (ULCCS) technology to address the communication and control challenges of multimedia-centric applications. It describes the medium access control (MAC) layer specifications:

– MAC frame design for control-centric scheduling.
– Message types and packet formats for MAC layer operation.
– System management aspects at the MAC layer for multiple control domains and multi-hop operation.

## 2 Normative references

There are no normative references in this document.