IEC 63203-801-2

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INTERNATIONAL STANDARD

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**Wearable electronic devices and technologies –
Part 801-2: Smart body area network (SmartBAN) – Low complexity medium access control (MAC) for SmartBAN**

**Technologies et dispositifs électroniques prêts-à-porter –
Partie 801-2: Smart body area network (SmartBAN) – Contrôle d'accès au support (MAC) à faible complexité pour SmartBAN**

IEC 63203-801-2:2022-11(en-fr)

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WEARABLE ELECTRONIC DEVICES AND TECHNOLOGIES –

Part 801-2: Smart body area network (SmartBAN) – Low complexity medium access control (MAC) for SmartBAN

FOREWORD

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

Draft	Report on voting
124/198/FDIS	124/206/RVD

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/standardsdev/publications.

A list of all parts in the IEC 63203 series, published under the general title *Wearable electronic devices and technologies*, can be found on the IEC website.

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- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

TC 124 is developing International Standards (IS) for body area network (BAN) to define the wireless connectivity between the hub coordinator and the sensing nodes. The IEC 63203-801 series consists of the following sub-parts, under the general part title "Smart body area network (SmartBAN)":

IEC 63203-801-1: Enhanced ultra-low power physical layer

IEC 63203-801-2: Low complexity medium access control (MAC) for SmartBAN

The present document describes the medium access control (MAC) specifications including channel structure, MAC frame formats and MAC functions.

This document originates from the corresponding technical specification (ETSI TS 103 325) standardized in the European Telecommunication Standard Institute (ETSI) and captures the results the work of IEC TC 124 Working Group 4 on devices and systems. The current document reflects contributions and discussions by IEC TC 124 experts, mirror committees, liaison members and Joint Advisory Group (JAG) between IEC SyC. AAL, IEC TC 100 and IEC TC 124. This document contains material gathered from reports and group output from the IEC TC 124 meetings in May 2018 (Manchester), October 2018 (Busan), May 2019 (San Francisco), September 2019 (Shanghai), November 2020 (online) as well as information obtained during various web meetings.

Experts from the following national committees, liaison organizations have contributed: BE, CN, DE, FI, FR, GB, IN, JP, KR, MY, NL, US and ETSI TC SmartBAN.

This document is also positioned as a result of the activities of the JAG. At the IEC General Meeting in Busan in 2018, three committees related to wearable systems and technologies, SyC. AAL, IEC TC 100 and IEC TC 124 had a joint workshop and agreed to collaborate to develop relevant standards and to share roles. This collaboration agreement was advanced to a Joint Advisory Group (JAG) and the JAG was established managed by SyC. AAL in 2019.

The target audience for this document includes the following stakeholders who have an interest in the systems and services using wearable devices:

- consumer electronics (CE) and information communications technology (ICT) device manufacturers;
- system integrators who want to utilize wearable device and technologies;
- service operators who are interested in the AAL systems and services;
- stakeholders who want to understand the technologies and requirements for wireless connectivity between wearable sensor nodes and hub coordinators.

WEARABLE ELECTRONIC DEVICES AND TECHNOLOGIES –

Part 801-2: Smart body area network (SmartBAN) – Low complexity medium access control (MAC) for SmartBAN

1 Scope

This part of IEC 63203-801 specifies low complexity medium access control (MAC) for SmartBAN.

As the use of wearables and connected body sensor devices grows rapidly in the Internet of Things (IoT), wireless body area networks (BANs) facilitate the sharing of data in smart environments such as smart homes, smart life, etc. In specific areas of digital healthcare, wireless connectivity between the edge computing device or hub coordinator and the sensing nodes requires a standardized communication interface and protocols.

The present document describes the following medium access control (MAC) specifications:

– channel structure;
– MAC frame formats;
– MAC functions.

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.

IEC 63203-801-1:2022, *Wearable electronic devices and technologies – Part 801-1: Smart body area network (SmartBAN) – Enhanced ultra-low power physical layer*

3 Terms and definitions

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

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
beacon
frame transmitted by a hub to facilitate network management, such as the coordination of medium access and power management of the nodes in the SmartBAN, and to facilitate clock synchronizationwith the hub

3.2
beacon period
duration during which a beacon is transmitted

3.3
downlink
communication link for transfer of management and data traffic from a hub to a node

3.4
hub
entity that possesses a node's functionality and coordinates the medium access and power management of the nodes in the SmartBAN

3.5
inactive period
period in time following an active transmission sequence during which the equipment does not transmit or receive

3.6
node
any entity conforming to the SmartBAN medium access control and physical interface to the wireless medium

3.7
priority channel access
highest priority access during multi-use channel access

3.8
re-use channel access
priority access during multi-use channel access which enables re-use of scheduled but non-utilised slots

3.9
scheduled access
one or more scheduled recurring time intervals that a node and a hub obtain using scheduled access to initiate frame transactions

Note 1 to entry: A scheduled allocation is an uplink allocation or a downlink allocation suitable for servicing high or low duty cycle periodic or quasi-periodic traffic on a committed schedule.

3.10
uplink
communication link for transfer of management and data traffic from a node to a hub

4 Abbreviated terms

ACK	Acknowledgement
BAN	Body area network
C-Ass	Connection assignment
C-Beacon	Control channel beacon
C-Frame	Control frame
CRC	Cyclic redundancy check
C-Req	Connection request
D/SR	Downlink/slot reassignment
D-Beacon	Data channel beacon
D-Frame	Data frame
D-Req	Disconnection request
D-Res	Disconnection response

EUI-48™	Extended Unique Identifier-48 bits
FCS	Frame check sequence
FEC	Forward error correction
IFS	Inter-frame spacing
IM	Information module
ISM	Industrial, scientific and medical
IU	Information unit
MAC	Medium access control
NACK	Negative acknowledgement
NID	Node ID
PHY	Physical layer
REP	Repetition coding
Rx	Receive
S-Ras	Slot reassignment
Tx	Transmit
UL	Uplink

5 General MAC framework

5.1 Different device types

Clause 5 provides the basic MAC framework for the nodes and hubs.

Two different device types can participate in SmartBAN:

1) sensor device (node); and
2) coordinator device (hub).

A hub is a device that acts as a SmartBAN coordinator. A node is any device that acts as an information source or an information sink. One hub and at least one node constitute a SmartBAN.

A SmartBAN shall be organized into a star topology illustrated in Figure 1. It shall consist of at least one node communicating directly with the hub.

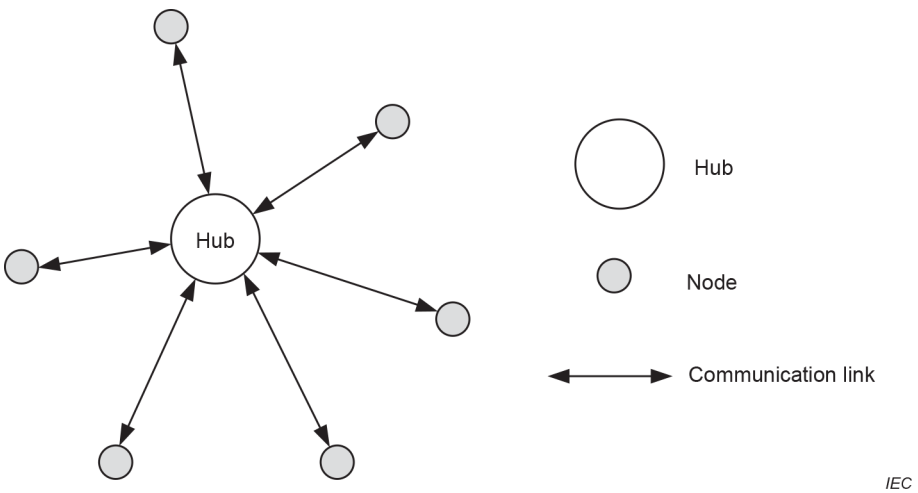

Figure 1 – SmartBAN topology

The hub and nodes shall communicate using communication media known as channels. A SmartBAN shall use two different channel entities to enable communication between the hub and nodes. The channel entities are assigned the following names:

– Data Channel

– Control Channel

Each SmartBAN shall utilise one Control Channel and one Data Channel at any one time.

5.2 Frequency spectrum

The frequency of operation shall fall between 2 401 MHz and 2 481 MHz. The channels shall be arranged in blocks of 2 MHz with centre frequencies as follows:

$$f_{\mathrm{c}} = 2\,402 + 2 \times n \text{ MHz, where } n = 0 \text{ to } 39.$$

The channels are categorised into Data and Control Channels with:

- 3 Control Channels, where control frames (in the form of C-Beacon) from the hub are transmitted;
- 37 Data Channels, where data, control, and management frames are transmitted.

The list of channels can be found in IEC 63203-801-1.

5.3 Channel format

5.3.1 Control channel format

Only hub devices shall transmit on Control Channels shown in Figure 2. A hub shall select one Control Channel from the list of Control Channels in IEC 63203-801-1:2022, Table 1 and transmit one control beacon frame (C-Beacon) on the chosen Control Channel every T_{C} s. The format of the C-Beacon is set out in 6.2.1.

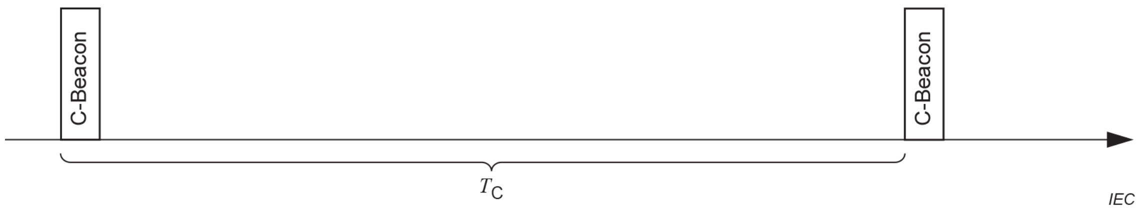

Figure 2 – Structure of Control Channel

5.3.2 Data channel format

5.3.2.1 Data channel description

Both hub and node devices may transmit on the Data Channels. A hub shall select one Data Channel from the list of Data Channels in IEC 63203-801-1:2022, Table 1, on which both hub and node devices in the associated SmartBAN may transmit. Data Channel format is illustrated in Figure 3. For any SmartBAN, the Data Channel is partitioned into time intervals of T_{D} s, known as the Inter-beacon Interval. The boundaries of each Inter-beacon Interval shall be marked by the transmission of a Data Channel Beacon (D-Beacon). A hub shall transmit a D-Beacon at the beginning of each Inter-beacon Interval.

Each Inter-beacon Interval shall be partitioned into L_D distinct time epochs known as slots. The duration of each time slot is T_S. The duration of each Inter-beacon Interval shall be (L_D × T_S) s. Any device transmitting in a time slot shall ensure that the transmission takes place within the duration of that time slot.

Each Inter-beacon Interval shall consist of four distinct periods:

1) Beacon Period, consisting of one single time slot, where the D-Beacon frame shall be transmitted by the hub. No nodes shall transmit in this period;
2) Scheduled Period, consisting of N_S time slots, where scheduled transmissions and acknowledgements occur;
3) Control and Management Period, consisting of N_{CM} time slots, where unscheduled access, and management and control signaling occur;
4) Inactive Period, where no transmission occurs.

The time slots shall be identified by a 10-bit sequence denoting the position of the time slot in an Inter-beacon Interval. The Beacon Period, consisting of 1 time slot shall have the sequence number 0000000000. Subsequent time slots shall have sequence numbers incremented by the number of time slots following the Beacon Period.

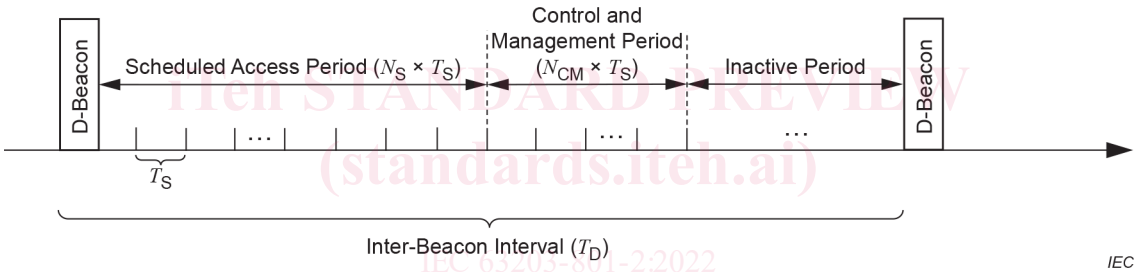

Figure 3 – Access periods in Data Channel

The Scheduled Access Period shall begin on the slot boundary immediately following the Beacon. The Scheduled Access Period may be of zero length, in which case the Control and Management Period shall begin immediately following the Beacon Period. The Control and Management Period shall begin on the slot boundary immediately following the Scheduled Access Period. The Inactive Period shall begin on the slot boundary immediately following the Control and Management Period.

Three types of channel access mechanisms can be used in the access periods:

– Scheduled Channel Access, in the Scheduled Access Period;
– Slotted Aloha Channel Access, in the Control and Management Period;
– Multi-use Channel Access, in both Scheduled Access and Control and Management Period.

The hub and nodes shall always support Scheduled Channel Access and Slotted Aloha Channel Access, and may support Multi-use Channel Access. Multi-use Channel Access may only be used when every node in the SmartBAN supports it. Each channel access mechanism shall adhere to its respective slot structure as described in 5.3.2.2.

5.3.2.2 Scheduled access slot structure

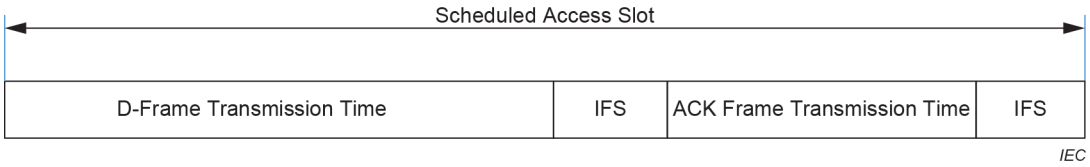

Figure 4 – Scheduled access slot structure

The Scheduled Access time slots shall follow the structure as illustrated in Figure 4. Any Scheduled Access time slots allocated by the hub shall be in the Scheduled Access Period.

The Scheduled Access slot shall consist of at most two transmission periods:

1) D-Frame Transmission: the device allocated to the time slot shall transmit;
2) ACK Frame Transmission: if the ACK policy of the received frame defined in 6.1.2.2.3 is '0' and the transmission is successful, the receiving device shall transmit an Acknowledgement Frame. If the ACK policy is '1' and the transmission is not successful, the receiving device shall transmit a NACK Frame. The ACK Frame Transmission period shall commence one IFS after the end of the Data Transmission period and end at least one IFS before the end of the time slot.

5.3.2.3 Control and management slot structure

Figure 5 – Control and management slot structure

The Control and Management time slots shall follow the structure as illustrated in Figure 5.

The Control and Management slot shall consist of two transmission periods:

1) Data/Management Frame Transmission: any device wishing to transmit either data or management frames may transmit;
2) ACK Frame Transmission: if the ACK policy of the received frame defined in 6.1.2.2.3 is '0' and the transmission is successful, the receiving device shall transmit an Acknowledgement Frame. If the ACK policy is '1' and the transmission is not successful, the receiving device shall transmit a NACK Frame. The ACK Frame Transmission period shall commence one IFS after the end of the Data Transmission period and end at least one IFS before the end of the time slot.

5.3.2.4 Multi-use access slot structure

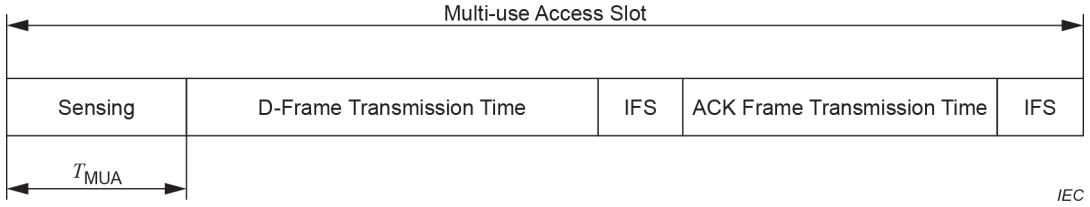

Figure 6 – Multi-use access slot structure

The Multi-use Access time slots should follow the structure as illustrated in Figure 6. The support of the Multi-use Access time slot is optional. The Multi-use Access time slots should be used when Multi-use Access is in operation.

The Multi-use Access slot should consist of one sensing period, and at most two transmission periods:

– Sensing: the sensing period, T_{MUA}, should depend on the traffic type. The values of T_{MUA} are defined in Table 1, where T_{sch} is the minimum sensing period as defined in Clause 8. Any device wishing to transmit should sense the channel for a period of T_{MUA}. If the channel is busy, the device should wait for the next available Multi-use Access time before another attempt is made. If the channel is found to be idle, the device may commence data transmission.
– D-Frame Transmission: any device that has sensed the channel for the sensing period above may transmit if the channel is found to be idle.
– Acknowledgement period: the receiving device may transmit an Acknowledgement frame if the transmission is successful, depending on the acknowledgement policy.

Table 1 – Values of T_{MUA}

Type of user	Type of traffic	Access period	T_{MUA}
Any user	Very high priority traffic (User priority 3)	Scheduled Access	0
Slot owner	Any traffic	Scheduled Access	T_{sch}
Non-slot owner	Any traffic	Scheduled Access	2 × T_{sch}
Any user	Very high priority traffic (User priority 3)	Control & Management Access	0
Any user	Any traffic	Control & Management Access	T_{sch}

5.4 User priorities

Four user priority levels shall be defined in the operation of a SmartBAN. The user priorities are defined in Table 2. The user priority shall determine the contention probability of the node in Slotted Aloha Channel Access. The range of contention probabilities for different user priority levels is listed in Table 3.

Table 2 – List of user priorities

User priority	Data type
0	Low priority
1	Mid priority
2	High priority
3	Very high priority

Table 3 – Contention probabilities for different user priorities

User priority	Contention probability	
	CP_{max}	CP_{min}
0	1/8	1/16
1	1/4	1/16
2	1/2	1/8
3	1	1/2