IEC 63203-801-1

Edition 1.0 2022-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Technologies et dispositifs électroniques prêts-à-porter –
Partie 801-1: Smart body area network (SmartBAN) – Couche physique améliorée à ultra-faible puissance**

IEC 63203-801-1:2022-11(en-fr)

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CONTENTS

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WEARABLE ELECTRONIC DEVICES AND TECHNOLOGIES –

Part 801-1: Smart body area network (SmartBAN) – Enhanced ultra-low power physical layer

FOREWORD

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IEC 63203-801-1 has been prepared by IEC technical committee 124: Wearable electronic devices and technologies. It is an International Standard.

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

Draft	Report on voting
124/197/FDIS	124/205/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- withdrawn,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.

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 physical layer (PHY) specifications including packet formats, modulation and forward error correction.

This document originates from the corresponding technical specification (ETSI TS 103 326) standardized in the European Telecommunication Standard Institute (ETSI) and captures the results of 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 made into a Joint Advisory Group (JAG) and the JAG was established and 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 801-1: Smart body area network (SmartBAN) –
Enhanced ultra-low power physical layer**

1 Scope

This part of IEC 63203-801 specifies the ultra-low power physical layer (PHY) of 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 physical layer (PHY) specifications:

– packet formats;
– modulation;
– forward error correction.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

4 Abbreviated terms

ACK	Acknowledgement
BAN	Body area network
BCH	Bose-Chaudhuri-Hocquenghem
BT	Bandwidth-time
CCA	Clear channel assessment
CE	Consumer electronics
CRC	Cyclic redundancy check
ED	Energy detection
FEC	Forward error correction
GFSK	Gaussian frequency shift keying
ICT	Information communications technology

IFS	Inter-frame spacing
IoT	Internet of Things
ISM	Industrial, scientific and medical
MAC	Medium access control
MPDU	MAC protocol data unit
PHY	Physical layer
PLCP	Physical layer convergence protocol
PPDU	PHY protocol data unit
PSDU	Physical layer service data unit
Sync.	Synchronization

5 General PHY framework – 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:

$$f_c = 2\,402 \text{ MHz} + 2 \times n \text{ MHz, for } n = 0 \text{ to } 39$$

where

n is the channel number.

Table 1 shows the mapping of the channel number to the Data Channel number and the Control Channel number.

Table 1 – Mapping of channel number to Data and Control Channel numbers

Channel number	Centre frequency (MHz)	Channel type	Data Channel number	Control Channel number
0	2 402	Control		0
1	2 404	Data	0	
…		Data		
11	2 424	Data	10	
12	2 426	Control		1
13	2 428	Data	11	
…		Data		
38	2 478	Data	36	
39	2 480	Control		2

6 Packet formats

6.1 PPDU structure

Figure 1 shows the PPDU structure. The PPDU consists of Preamble, Synchronization (Sync.), PLCP Header, PSDU and Frame Parity.

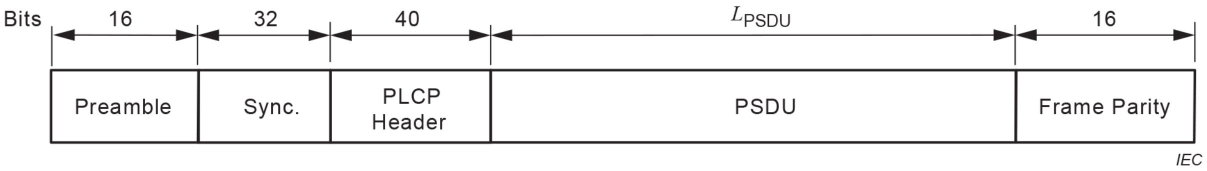

Figure 1 – PPDU structure

6.2 Preamble

PPDUs have a 16-bit preamble used for frequency synchronization, timing synchronization, and automatic gain control.

The preamble for all PPDUs shall be 1010101010101010.

6.3 Sync.

The Sync. field indicates the synchronization pattern that shall be 10000111101100101000011110110010.

6.4 PLCP header

6.4.1 PLCP header structure

The PLCP header is structured as illustrated in Figure 2. The PLCP header consists of Packet Length, PHY Scheme, Reserved, BCH Parity Bits, and the Header Parity fields.

The PLCP header may be scrambled by the procedure described in 7.4.

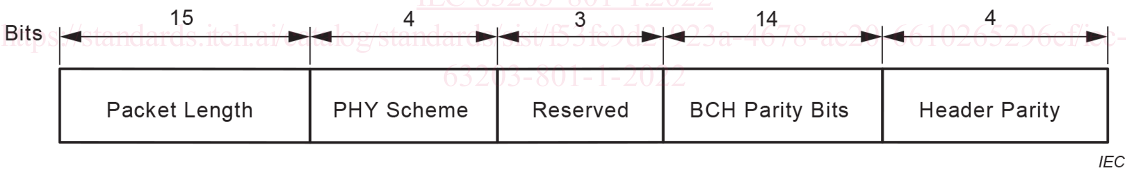

Figure 2 – PLCP header structure

6.4.2 Packet Length

The Packet Length field indicates the length of the PSDU.

6.4.3 PHY Scheme

The PHY Scheme field describes the forward error correction (FEC) type and the repetition type the PPDU employs. The mapping of the field bits is as described in Table 2.

6.4.4 BCH Parity Bits

The BCH Parity Bits field is generated using a BCH (36,22, t = 2) code defined in 7.3.3 to protect the Packet Length, PHY Scheme, and Reserved fields.

6.4.5 Header Parity

The Header Parity field is generated by the CRC polynomial $1 + x + x^4$ on the Packet Length, PHY Scheme, Reserved, and BCH Parity Bits fields.

Table 2 – PHY scheme field bit mapping

Field value b0 b1	FEC type		Field value b2 b3	Repetition type
00	None		00	None
01	BCH (127,113,2)		01	2
10	Reserved		10	4
11	Reserved		11	Reserved

6.5 PSDU

The physical layer service data unit (PSDU) is either an encoded or uncoded MAC protocol data unit (MPDU) as defined in IEC 63203-801-2:2022, 6.1. The MPDU may be encoded using a BCH (127,113, t = 2) code. The encoding procedure shall be described in 7.3. The PSDU shall be scrambled using the procedure described in 7.4.

6.6 Frame parity

The Frame Parity field shall contain a 16-bit CRC sequence of the PSDU generated using the generator polynomial $x^{16} + x^{12} + x^5 + 1$.

7 Modulation and error control

7.1 PPDU formation

The PPDU is formed from the following process described in Figure 3. The dashed boxes represent optional support.

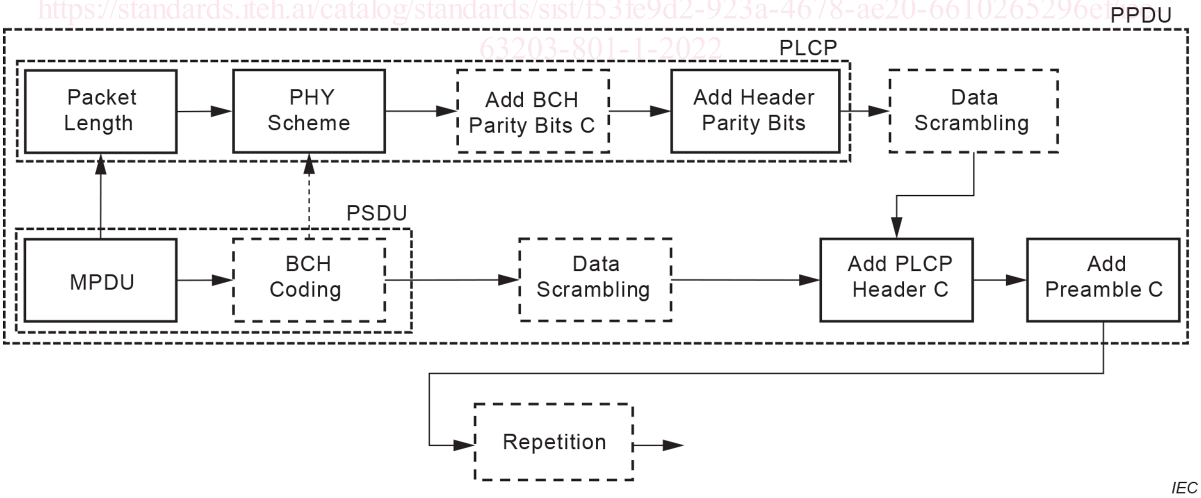

Figure 3 – Transmitter physical layer chain

7.2 Modulation

The modulation is Gaussian frequency shift keying (GFSK) with a bandwidth-time (BT) product that shall be 0,5, and a modulation index h that shall be 0,5.

A symbol rate, T_{sym}, of 1 MSymbols/s shall be supported in both control and data channels. Table 3 shows the possible information rate according to the combination of symbol rate, code rate and number of repetitions.

Table 3 – PHY throughput

Channel (data/control)	Information flow	Symbol rate (MSymbols/s)	Code rate	Repetition	Information rate (Mbps)
Data/control	Downlink/uplink	1,0	1	1	1,0
Data/control	Downlink/uplink	1,0	1	2	0,5
Data/control	Downlink/uplink	1,0	1	4	0,25
Data/control	Downlink/uplink	1,0	113/127	1	0,89
Data/control	Downlink/uplink	1,0	113/127	2	0,44
Data/control	Downlink/uplink	1,0	113/127	4	0,22

7.3 Repetition and FEC

7.3.1 Repetition

The hubs and nodes may implement repetition coding to reduce errors if required. Should repetition coding be implemented, this should be indicated in the PHY Scheme field in 6.4.3. Two repetition schemes should be supported, 2-repetition, repeating the entire PPDU two times, and 4-repetition, repeating the entire PPDU four times.

When repetition is employed, the original PPDU along with its repeated versions should be treated as one single PPDU.

An example of 2-repetition and 4-repetition is shown in Figure 4.

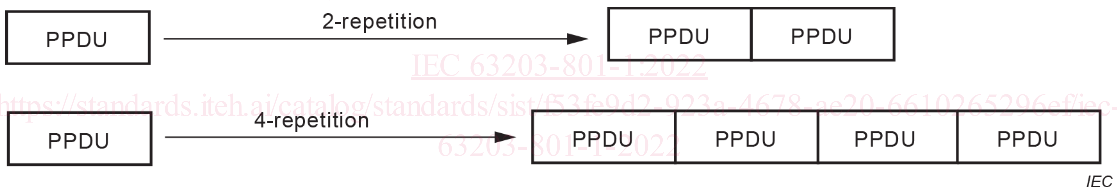

Figure 4 – Example of 2-repetition and 4-repetition

7.3.2 BCH (127,113, *t* = 2) encoding

For error correction control of the MPDU, a systematic BCH (127,113, t = 2) code may be employed. t indicates the maximum number of bits that can be corrected. The generator polynomial of the BCH (127,113, t = 2) code is

$$g(x) = x^{14} + x^9 + x^8 + x^6 + x^5 + x^4 + x^2 + x + 1 \quad (1)$$

The encoding process is as follows:

1) Calculate the number of padding bits, N_{padding}. The number of padding bits depends on the length of the MPDU, L_{MPDU}, and can be calculated as

$$N_{\text{padding}} = \left\lceil \frac{L_{\text{MPDU}}}{k} \right\rceil \times k - L_{\text{MPDU}} \quad (2)$$

where k = 113