

IEEE Standard for Flexible Optical Service Unit (OSUFlex) of Optical Transport Network (OTN) in Power Systems

IEEE Communications Society

Developed by the
Power Line Communications Committee

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IEEE Standard for Flexible Optical Service Unit (OSUFlex) of Optical Transport Network (OTN) in Power Systems

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Power Line Communications Committee
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Approved 15 February 2023

IEEE SA Standards Board

Abstract: A communication layer, Flexible Optical Service Unit (OSUFlex), to provide small service channels in optical transport networks is specified in this standard. The main features of the OSUFlex communication layer are providing massive OSUFlex connections to directly carry power services (e.g., E1 or IEEE Std C37.94™) into an optical transport network, enabling the flexible bandwidth (e.g., $n \times 2$ Mb/s) and hitless bandwidth adjustment for each OSUFlex connection, direct mapping of services into OSUFlex with the capabilities of high-bandwidth efficiency, low latency, low latency jitter, and high-precision clock synchronization for power system applications.

Keywords: flexible bandwidth, IEEE 2893™, IEEE C37.94™, low latency, low latency jitter, optical service unit, optical transport network, OSU, OTN, power systems communication

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Introduction

This introduction is not part of IEEE Std 2893-2023, IEEE Standard for Flexible Optical Service Unit (OSUFlex) of Optical Transport Network (OTN) in Power Systems.

Synchronous digital hierarchy (SDH) equipment is nearing its end of life. OTN, as the replacement technology of SDH, is being widely used in the industry due to its powerful capabilities such as large bandwidth, long distance, low latency, and high security. Currently, OTN is also gradually applying to various specific networks for vertical industry applications. For a power communication system, it requires the standardization of OTN with the specific adaptation for power services that can efficiently support the transport of massive power services (e.g., E1 or IEEE Std C37.94) and satisfy the requirements of high-bandwidth efficiency, low latency, low latency jitter, and high-precision clock synchronization.

Contents

1. Overview	14
1.1 Scope	14
1.2 Purpose	14
1.3 Word usage	14
2. Normative references.....	15
3. Definitions, acronyms, and abbreviations	16
3.1 Definitions	16
3.2 Acronyms and abbreviations	17
4. Power communication network performance	19
4.1 Control class service.....	19
4.2 Data services.....	20
4.3 Voice service	20
4.4 Video service	21
5. Power communication OTN OSU network, device, and function.....	21
5.1 Power communication OTN OSU network	21
5.2 Device system structure and main functions of OTN OSU devices	25
5.3 OTN OSU function.....	28
6. OSU frame structure.....	30
6.1 OSU frame structure overview	30
6.2 General overhead.....	30
6.3 Mapping overhead	36
7. Interface adaptation, mapping, and multiplexing requirements.....	42
7.1 Mapping and multiplexing structure of ODUk and OSU	42
7.2 Mapping and multiplexing paths of client signals	43
8. Interface service performance	43
8.1 OTN performance.....	43
8.2 Ethernet performance.....	44
8.3 E1 and SDH performance	44
9. OTN OSU protection.....	45
9.1 Device-level protection requirements.....	45
9.2 OTN OSU protection.....	45
9.3 Client-side protection requirements.....	46
10. OTN OSU device physical feature requirements	47
10.1 Power supply and power consumption	47
10.2 Ambient temperature and humidity	47
10.3 Electromagnetic characteristics	47
10.4 Anti-seismic capability	47
10.5 Surge protection capability	48
10.6 Environmental noise	48
Annex A (informative) OSU (00) frame format.....	49
A.1 General.....	49

A.2 OSU (00) overhead	49
A.3 OSU (00) Frame Type	57
Annex B (informative) OSU goes through OSU (00) networking scenario	62
B.1 Penetration scene	62
B.2 Requirements for through networking nodes	62
B.3 Penetration limitations	62

IEEE Standard for Flexible Optical Service Unit (OSUFlex) of Optical Transport Network (OTN) in Power Systems

1. Overview

1.1 Scope

This standard specifies a communication layer, Flexible Optical Service Unit (OSUFlex), to provide small service channels in optical transport networks. The main features of the OSUFlex communication layer are providing massive OSUflex connections to directly carry power services (e.g., E1 or IEEE Std C37.94) into the optical transport network, enabling the flexible bandwidth (e.g., $n \times 2$ Mbit/s) and hitless bandwidth adjustment for each OSUflex connection, directly mapping of service into OSUflex with the capabilities of high bandwidth efficiency, low latency, low latency jitter, and high-precision clock synchronization for power system applications.

1.2 Purpose

The standard supports mass transport of mission-critical services (teleprotection, remote terminal units, supervisory control, data acquisition, etc.) that are used in electrical power (smart) grids. The standard meets the communication requirements of electrical power system applications in terms of bandwidth, efficiency, low latency, low latency jitter, and high-precision clock synchronization.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{6,7}

⁶ The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁷ The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ETSI EN 62368, Safety aspects for DC power transfer through communication cables and ports.⁸

ETSI EN 300019, Environmental Engineering (EE), Environmental conditions and environmental tests for telecommunications equipment.

ETSI EN300132, Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment.

ETSI EN 300 386, Telecommunication network equipment—ElectroMagnetic Compatibility (EMC) requirements—Harmonised Standard covering the essential requirements of the Directive.

GB/T 3482-2008, Lightning test method for electronic equipments.⁹

GB/T 19286-2015, Electromagnetic compatibility requirement and measurement methods for telecommunication network equipment.

IEC 61000-6-2, Electromagnetic compatibility (EMC)—Part 6-2: Generic standards—Immunity standard for industrial environments.¹⁰

IEC 61000-6-4, Electromagnetic compatibility (EMC)—Part 6-4: Generic standards—Emission standard for industrial environments.

IEEE Std 802.3™-2022, IEEE Standard for Ethernet.^{11, 12}

IEEE Std 1588™-2019, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

⁸ETSI publications are available from the European Telecommunications Standards Institute (<http://www.etsi.org/>).

⁹GB/T standards are available from the American National Standards Institute (<http://www.ansi.org/>) or from <https://www.chinesestandard.net/>.

¹⁰IEC publications are available from the International Electrotechnical Commission (<http://www.iec.ch>) and the American National Standards Institute (<http://www.ansi.org/>).

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ITU-T G.703, Physical/electrical characteristics of hierarchical digital interfaces.¹³

ITU-T G.709, Interface for the Optical Transport Network (OTN).

ITU-T G.798, Characteristics of optical transport network hierarchy equipment functional blocks.

ITU-T G.806, Transmission systems and media, digital systems and networks.

ITU-T G.825, The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH).

ITU-T G.826, End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections.

ITU-T G.828, Error performance parameters and objectives for international, constant bit-rate synchronous digital paths.

ITU-T G.873.1, Optical transport network: Linear protection.

ITU-T G.8201, Error performance parameters and objectives for multi-operator international paths within optical transport networks.

ITU-T G.8251, The control of jitter and wander within the optical transport network (OTN).

ITU-T M.3100, Generic Network Information Model.

YD/T 1821-2018, The environmental condition requirements and testing methods of telecommunication station rooms.¹⁴

YD 5083-2005, Specification for Seismic Test of Telecommunications Equipment.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.¹⁵

optical service tributary unit (OSTU): An optical service tributary unit consists of multiple payload blocks (PBs) actually occupied by OSU frames in a transmission period. That is, an OSTU consists of multiple 192-byte PBs. Figure 1 shows the OSTU structure. Each OSU corresponds to one OSTU. An OSTU contains a maximum of C PBs. C is the maximum number of PBs allocated to OSU frames in each transmission period.

¹³ITU-T publications are available from the International Telecommunications Union (<http://www.itu.int/>).

¹⁴YD/T standards are available from YD/T 1821-2018.

¹⁵*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

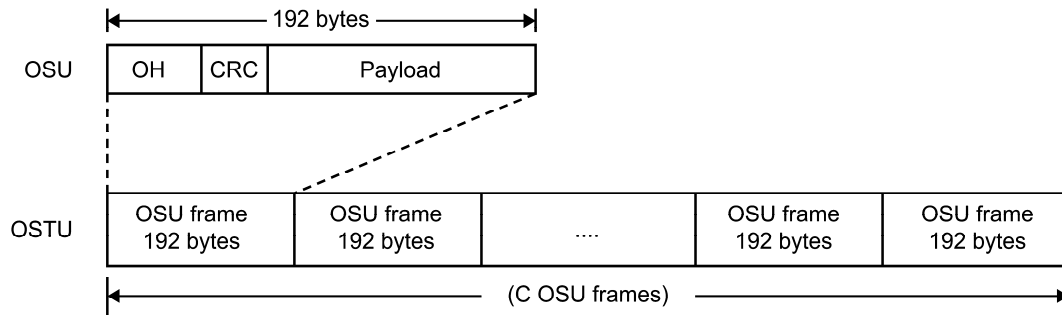


Figure 1—OSTU structure

optical service unit (OSU): A network frame structure to support sub 1 G rate services. Its carrying container frame length is 192 bytes, and the frame structure includes overhead area and payload area.

OPUk transport period: The time for OPUk to continuously transmit P payload blocks. The P value corresponding to OPUk at different rates is different. The P value is determined by OPUk payload rate and osu reference rate.

OSU reference rate: OSU reference rate can be configured in different application scenarios.

NOTE—In this document, the OSU reference rate is recommended to be set as 2.6 Mbit/s.

payload block: Payload block is the continuous 192 bytes area in optical channel payload unit (OPU) frame payload area.

tributary port number (TPN): Used to identify the connection of end-to-end OSU path in each segment layer. In the service layer directly carrying each OSU segment, TPN identification is unique.

3.2 Acronyms and abbreviations

AIS	alarm indication signal
BBE	background block error
BBER	background block error ratio
BEI	backward error indication
BER	bit error rate
BIP	Bit Interleaved Parity
CBR	constant bit rate
CFI	customer fault indication
CRC	Cyclic Redundancy Check
EoS	Ethernet over SDH
ES	errored second

FE	fast Ethernet
FEC	forward error correction
GMP	Generic Mapping Procedure
LOF	loss of frame
LOS	loss of signal
LSB	least significant bit
MSB	most significant bit
MTU	maximum transmission unit
OAM	operations, administration, and maintenance
OCh	optical channel with full functionality
OCI	open connection indication
ODU	optical channel data unit
ODUk	optical channel data unit-k
ODTUjk	optical channel data tributary unit j into k
ODTUG	optical channel data tributary unit group
ODUk-Xv	X virtually concatenated ODUk
OH	overhead
OPU	optical channel payload unit
OPUk	optical channel payload unit-k
OPUk-Xv	X virtually concatenated OPUk
OSC	optical supervisory channel
OSU	optical service unit
OTN	optical transport network
OTS	optical transmission section
OTU	optical channel transport unit
OTUk	completely standardized optical channel transport unit-k
OTUkV	functionally standardized optical channel transport Unit-k
PB	payload block

PLn	payload length
PQMS	power quality monitoring system
PT	payload type
PTN	Packet Transport Network
RES	reserved for future international standardization
SDH	synchronous digital hierarchy
SES	severely errored second
SESR	severely errored second ration
SOH	segment overhead
TTT	Timing Transparent Transcoding
UAS	unavailable second
UNI	User-to-Network Interface

4. Power communication network performance

The service carried by an Electric Power Communication Network can be divided into control class, data class, voice class, and video class, where control class refers to the real-time control of the operation state of the electric power network, including relay protection service and other services.

4.1 Control class service

4.1.1 Interface technical requirement

4.1.1.1 Relay protection service

The relay protection service is as follows:

- General use of 2 Mb/s E1 interface, digital signal nominal bit rate $2 \text{ Mb} \pm 50 \text{ PPM}$.
- The E1 interface shall adopt HDB3 code type, the code rate is $2048 \text{ Kbit/s} \pm 50 \text{ PPM}$, the impedance is 75Ω .
- E1 interface should be able to accommodate line attenuation of $0 \sim 6 \text{ dB}$.
- The data format of E1 interface shall be compatible with frame format and non-frame format; the non-frame format should support non-frame 1B4B and non-frame 1B2B.