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Recommendation

ITU-T L.109.1 (11/2022)

SERIES L: Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant

Optical fibre cables – Cable structure and characteristics

Type II optical/electrical hybrid cables for access points and other terminal equipment

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.109.1

Type II optical/electrical hybrid cables for access points and other terminal equipment

Summary

Recommendation ITU-T L.109.1 explains the type II optical/electrical hybrid cable (OEHC) in which a copper pair is used for power delivery (not for telecommunications) and an optical fibre can support data transmission up to and beyond 1 Gbit/s. The current application scenarios for remote powering and data transmission of access points and other equipment require a type of hybrid cable that has a small footprint, is lightweight, and is convenient for installation.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.109.1	2022-11-13	15	11.1002/1000/15122

Keywords

Access point/terminals, type II optical/electrical hybrid cables.

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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Recommendation ITU-T L.109.1

Type II optical/electrical hybrid cables for access points and other terminal equipment

1 Scope

This Recommendation explains the requirements for type II optical/electrical hybrid cables (OEHC) for access points (APs) and other terminal equipment that can support data transmission up to and beyond 1 Gbit/s that require remote powering. As classified in [ITU-T L.109], a copper pair in the type II OEHC is not used for telecommunication but for power delivery.

This Recommendation:

– explains the cables that may be installed outdoors, indoors and indoors/outdoors;

– describes the characteristics of type II OEHC;

– provides suggestions for cable construction with optical fibres that comply with [ITU-T G.652], [ITU-T G.657] and [IEC 60793-2-10];

– suggests acceptance criteria and requirements in test methods for type II OEHC; and

– suggests installation requirements for type II OEHC.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.650.1] Recommendation ITU-T G.650.1 (2020), *Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable*.

[ITU-T G.650.2] Recommendation ITU-T G.650.2 (2015), *Definitions and test methods for statistical and non-linear related attributes of single-mode fibre and cable*.

[ITU-T G.650.3] Recommendation ITU-T G.650.3 (2017), *Test methods for installed single-mode optical fibre cable links*.

[ITU-T G.652] Recommendation ITU-T G.652 (2016), *Characteristics of a single-mode optical fibre cable*.

[ITU-T G.657] Recommendation ITU-T G.657 (2016), *Characteristics of a bending loss insensitive single-mode optical fibre and cable*.

[ITU-T L.100] Recommendation ITU-T L.100/L.10 (2021), *Optical fibre cables for duct and tunnel application*.

[ITU-T L.102] Recommendation ITU-T L.102/L.26 (2015), *Optical fibre cables for aerial application*.

[ITU-T L.103] Recommendation ITU-T L.103 (2016), *Optical fibre cables for indoor applications*.

[ITU-T L.109] Recommendation ITU-T L.109 (2018), *Construction of optical/metallic hybrid cables*.

[IEC 60227-1] IEC 60227-1:2007, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements*.

[IEC 60228] IEC 60228:2004, *Conductors of insulated cables*.

[IEC 60502-1] IEC 60502-1:2021, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)*.

[IEC 60793-2-10] IEC 60793-2-10:2019, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*.

[IEC 60794-1-1] IEC 60794-1-1 (2015), *Optical fibre cables – Part 1-1: Generic specification – General*.

[IEC 60794-1-21] IEC 60794-1-21:2015, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*.

[IEC 60794-2] IEC 60794-2:2017, *Optical fibre cables – Part 2: Indoor cables – Sectional specification*.

[IEC 60794-2-20] IEC 60794-2-20:2013, *Optical fibre cables – Part 2-20: Indoor cables – Family specification for multi-fibre optical cables*.

[IEC 60794-3] IEC 60794-3:2022, *Optical fibre cables – Part 3: Outdoor cables – Sectional specification*.

[IEC 60794-3-11] IEC 60794-3-11:2010, *Optical fibre cables – Part 3-11: Outdoor cables – Product specification for duct, directly buried, and lashed aerial single-mode optical fibre telecommunication cables*.

[IEC 60794-6] IEC 60794-6:2020, *Optical fibre cables – Part 6: Indoor-outdoor cables – Sectional specification for indoor-outdoor cables*.

[IEC 60794-6-10] IEC 60794-6-10:2020, *Optical fibre cables – Part 6-10: Indoor-outdoor cables – Family specification for universal indoor-outdoor cables*.

[IEC 60811-202] IEC 60811-202:2012/AMD1:2017, *Amendment 1 – Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*.

[IEC 60811-203] IEC 60811-203:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*.

[IEC 60811-607] IEC 60811-607:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 607: Physical tests – Test for the assessment of carbon black dispersion in polyethylene and polypropylene*.

[IEC 61156-1] IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification.*

[IEC 61156-1-4] IEC 61156-1-4:2018, *Multicore and symmetrical pair/quad cables for digital communications – Part 1-4: Assessment of conductor heating in bundled cables due to the deployment of remote powering*.

[IEC 61196-1-10x] IEC 61196-1-10x-series, *Coaxial communication cables – Parts 1-100 to 1-109: Electrical test methods series*.

[IEC 62807-1] IEC 62807-1:2017, *Hybrid telecommunication cables – Part 1: Generic specification*.

3 Definitions

For the purposes of this Recommendation, the definitions given in [ITU-T G.650.1], [ITU-T G.650.2], [ITU-T G.650.3], [ITU-T L.102], [ITU-T L.100], and [IEC 60794-1-1] apply.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AP Access Point

DAS Distributed Antenna Systems

DC Direct Current

GFRP Glass Fibre Reinforced Polymer

IDF Intermediate Distribution Frame

LAN Local Area Network

LSZH Low-smoke zero-halogen

MDF Main Distribution Frame

OD Outer Diameter

OEHC Optical/Electrical Hybrid Cable

OLT Optical Line Terminal

ONT Optical Network Terminal

ONU Optical Network Unit

PE Polyethylene

PO-LAN Passive Optical LAN

PVC Polyvinyl Chloride

RU Radio Unit

SFP Small Form-factor Pluggable

UV Ultraviolet

WAP Wireless Access Points

5 Conventions

None.

6 Type II optical/electrical hybrid cable application scenario

Deployment of OEHC can maximize the utilization of existing infrastructure to optimize the cost of deployment and maintenance. OEHC is classified into one of three types depending on the purpose of the optical and copper pair [ITU-T L.109]. It is mainly used in the drop-and-access section of the network, from the optical electrical hybrid power supply unit to various optical network terminals (ONTs), edge switches, and other application terminals, including wireless access points (WAPs), 5G small cells, digital billboards, public address systems, cameras, monitors, antennas, and smart manufacturing instruments. Figure 6-1 shows one typical application scenario for an OEHC.

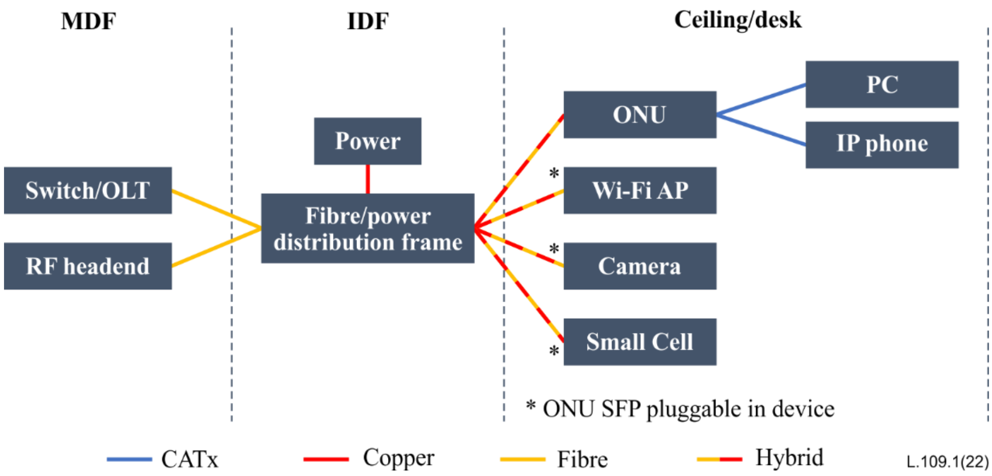

Figure 6-1 – Power and data delivery networking based on OEHC

In large venues, arenas, and/or stadiums, optical/electrical hybrid cables for access points and other terminal equipment are often used to supply power and data to multiple ONTs or edge switches in passive optical local area network (LAN), indoor distributed antenna systems (DAS) terminals, or outdoor small cells. In these use cases, several of these devices may be housed in an aggregation box which can effectively be served with a multi-fibre, multipair cable. Figure 6-2 shows another application scenario for OEHC on the fibre and power to the antenna.

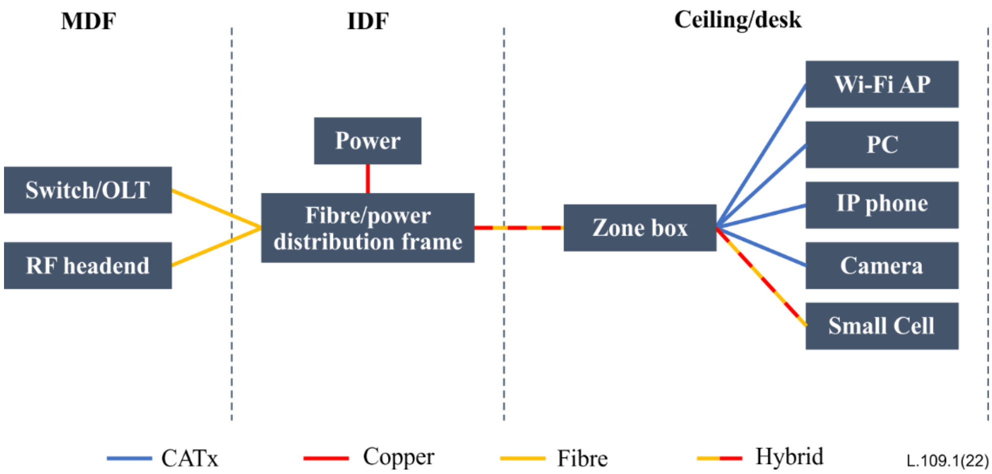

Figure 6-2 – OEHC application on the fibre and power to the zone and the small cell scenario

The OEHC containing the optical fibre for data transmission and copper wire for electrical power delivery to the multiple radio units (RU) distributed within a typical distance of less than 2000 m from the centralised power delivery station is shown in the Figure 6-3. The cable can be designed for multiple deployment scenarios to connect multiple termination points in series by containing multiple fibres and copper pairs in one cable. Centralised power delivery and power backup system are used to eliminate the power outage of active terminal devices (such as 5G RU).

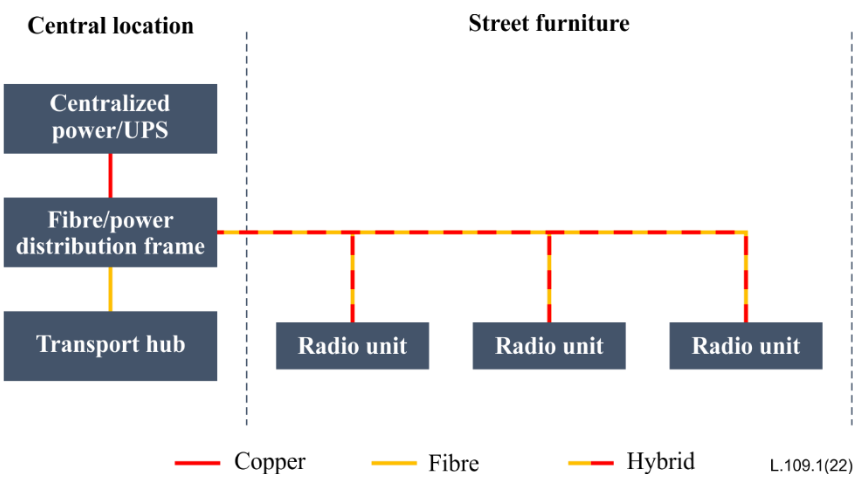

Figure 6-3 – Centralised fibre connectivity and power delivery network based on multi fibre OEHC

The typical distance of these cabled links varies in accordance with the application requirements and can be as long as several hundred metres. This Recommendation considers an optical fibre that supports a bit rate of up to 1 Gbit/s and beyond.

7 OEHC construction

7.1 General

The cable may be composed of one or more optical fibre cores and two or more current carrying electrical conductors under a common outer sheath. The conductor part is used as a remote power supply, with the power supply generally being ≤ 100 W, but higher electrical power can also be considered depending on the application scenarios.

The design of the cable is related to the application area, so the construction type can be divided into outdoor, indoor and indoor/outdoor types. The technical specifications of the optical cables described in [IEC 60794-2], [IEC 60794-3] and [IEC 60794-6] should be used, depending on the circumstances and technical requirements.

The make-up of the cable, particularly the number of fibres, the method of protecting the fibre, and the location of the strength members and metallic wires, should be clearly specified. Designs other than those described in clauses 7.4 to 7.15 may be used, provided that they comply with the aims of this Recommendation.

In this Recommendation, the copper component of the cable is used exclusively for remote power delivery and not for data signal transmission.

7.1.1 Fire safety

Requirements for fire safety in different applications may differ depending on the country. Optical/metallic hybrid cables should meet the fire safety regulations in each country or be in accordance with each telecommunication carrier's requirements. [b-IEC TR 62222] should be considered if there are no fire safety specifications provided.

7.1.2 Electrical power feeding wires

Requirements for electrical performance in different applications may differ by country. Cable type designations and performance requirements should meet the electrical regulations in each country or be in accordance with the requirements of each telecommunication carrier.

The conductor characteristics of the copper wire should comply with [IEC 60228], unless there is a different agreement between a manufacturer and a user. The insulation characteristics of the copper wire should be in accordance with the [IEC 60502-1] or [IEC 60227-1] standard requirements, unless there is a different agreement between a manufacturer and a user.

7.2 Optical fibre element

The following optical fibres or optical fibre elements can be used:

– Single-mode optical fibres described in [ITU-T G.652], [ITU-T G.657], or multimode optical fibres described in [IEC 60793-2-10], should be used, depending on the circumstances and technical requirements.

7.3 Optical fibre coating and requirements

If a secondary coating or buffer is required, it should consist of one or more layers of polymeric material. The coating should be easily removable for fibre splicing. For tight/semi-tight buffers, the buffer and the fibre primary coating should be removable in one operation over a length depending on the customer's requirements. The nominal overall diameter of the tight/semi-tight secondary coating is typically 800/900 μm.

7.4 Conductor requirements

The conductor characteristics of the copper wire and conductors should comply with [IEC 60228], unless there is a different agreement between the manufacturer and user. The insulation characteristic of the copper wire should comply with the [IEC 60502-1] or [IEC 60227-1] standard requirements, unless there is a different agreement between the manufacturer and the user.

The cross-section of the metallic wire should be chosen by taking into account transmission voltage, transmission distance and power consumption. Under extreme operating conditions, for example, when many cables are installed together in the same duct, the heat generated by the electrical conductors should not exceed the maximum allowed temperature specified for the cable element materials. The test recommendations for the temperature rise test of the cable should refer to [IEC 61156-1-4].

The size of the conductor may refer to some commercial products. For example, conductor sizes between 0.404 mm and 1.290 mm can be found in [b-AWG].

Conductors and insulation materials for power-feeding wires should be specified in detail.

A power-feeding wire unit contains power-feeding wire(s) and is fabricated cylindrically with or without suitable material.

The positive and negative poles of the conductor should be distinguished by the colour of the sheath or the colour bar.

7.5 Strength member

The cable should be designed with strength member(s) suitable to meet the installation and service conditions such that the fibre is not subjected to strain levels in excess of those agreed upon between the manufacturer and the user. The strength member(s) may be either metallic or non-metallic. When the metallic strength members are used, care should be taken to avoid hydrogen generation effects and lightning hazards.

For indoor cables, it is recommended to use the conductor itself as the strength member. Non-metallic strength members can be added for particular installation environments.

For an indoor-outdoor duct cable, it is recommended that non-metal strength members be used as the stronger part of cables, such as aramid yarns, fibreglass yarns, or glass fibre reinforced polymer (GFRP).

For an outdoor duct cable, strength members mainly serve to limit tensile strain, but may also serve to limit compressive strain as in temperature changes. The strength members may be located within the core or in the sheath layers, or both.

For outdoor aerial applications, it is recommended that the overhead suspension steel wires be used as an additional component for the 'figure-of-eight' cable type. Alternatively, the cable may be supported by attaching it to a supporting strand. Knowledge of the span, sag, wind and ice loads, as well as the permitted ground clearances is necessary when designing cables for use in aerial applications.

Depending on particular conditions such as short distances or very light cables, the copper pair(s) present in the cable can be used as a reinforcement and/or pulling element.

7.6 Yarn (optional)

Yarns may be used to provide enough tensile strength to meet the cable tensile requirements. Water blocking yarn may also be used. Yarns should be water-resistant and non-oil absorbing.

7.7 Tape (optional)

The cable core may be protected by a tape or tapes, applied longitudinally or helically. The tape may provide thermal insulation, binding and/or provide dielectric properties. The material may be polyester, polyester non-woven tape, water-blocking tape or other suitable materials.

7.8 Ripcord (optional)

A ripcord can be used. It should be non-hygroscopic, non-oil absorbing, and have enough strength to strip the cable sheath

7.9 Inner sheath

If required, an inner sheath over the cable core and beneath the outer sheath with an optional armouring layer and shielding layer can be used. In indoor and indoor-outdoor applications, the material of the inner sheath can be fire retardant in order to meet local regulation requirements. It can be made of polyvinyl chloride (PVC), low-smoke zero-halogen (LSZH) flame-retardant polyolefin, or other materials. The minimum thickness of the conductor sheath must meet the requirements for insulation and the wall thickness of the optical fibre.

The conductor jacket should have markings that identify the positive and negative poles, such as the colour, colour bar, and the corrugated cable.

7.10 Screen or shield (optional)

When electromagnetic compatibility or lightning proofing is required, a screen can be added over the cable core. In passive optical local area network (PO-LAN) applications, the screen is able to reduce the current level induced by lightning, and minimize the electromagnetic noise induced by the current. The screen may consist of a single or double metal tape layers (or foil), single or double metal braid layers or a combined structure of metal braid and metal tape (or foil). A drain wire in contact with the metal shield layers can be used. A metallic sheath or continuous metal armouring layer can also act as the screen of the cable core.

7.11 Moisture barrier (optional)

Filling a cable with water-blocking material or wrapping the cable core with layers of water-swellable material are two means of protecting fibres from water ingress. A water-blocking element (tapes or yarns, water swelling powder or a combination of materials) may be used. Any materials used should not be harmful to personnel. The materials in the cable should be compatible with each other and, in particular, should not adversely affect the fibre characteristics. These materials should not hinder splicing or connection operations. It is recommended to use a moisture barrier for outdoor and indoor-outdoor applications.

7.12 Armouring (optional)

In applications where better mechanical performance is required for hybrid cable; an armouring layer can be added over the cable core. Armouring material can be either metallic or non-metallic.

7.13 Outer sheath

The cable core should be covered with a sheath or sheaths suitable for the environmental and mechanical conditions associated with the storage, installation and operation. The sheath may be of a composite construction and may include strength members.

Sheath considerations for optical fibre cables are generally the same as for metallic conductor cables. Consideration should also be given to the amount of hydrogen generated from a metallic moisture barrier. The minimum acceptable thickness of the sheath should be stated, together with any maximum and minimum allowable overall cable diameter.

The selection of the sheath material is one of the important issues to be considered in order, for example, to ensure stability under the environmental conditions of installation, such as resistant to degradation due to ultraviolet (UV) radiation and biotic hazards, and to satisfy fire safety requirements. The outer sheath material of duct cables should optimize the friction forces between the cable sheath and the duct. Polyethylene (PE), polyvinyl chloride (PVC), outdoor low-smoke zero-halogen (LSZH) and thermoplastic polyurethane are typically used as cable sheath materials for outdoor cables. Fire-retardant sheath materials may vary for indoor or indoor-outdoor cables for fire safety reasons depending on the local regulations.

The electrical tracking resistance of sheath materials may be an issue for type II cables.

For passive optical LAN (PO-LAN) and other outdoor applications, the outer sheath of the hybrid cable should be able to resist ultraviolet rays and heat shock. The cable should have a seamless sheath made of UV-stabilized weather-resistant polyethylene, containing 2.0 % minimum well dispersed carbon black in accordance with [IEC 60811-607], unless otherwise agreed between the customer and the supplier.

The sheath thickness (tested in accordance with [IEC 60811-202]) and the overall cable diameter (tested in accordance with [IEC 60811-203]) and its variations should consider the installation conditions and it shall be determined by the relevant specification or by agreement between the customer and the supplier.

7.14 Sheath marking

It is recommended to provide a visual identification of optical-electrical hybrid cables: this can be done by visibly marking the outer sheath. For identifying cables, embossing, sintering, imprinting, hot foil or ink-jet or laser printing can be used by agreement between the user and supplier. Hybrid cable and cable units containing optical fibres and power-feeding units should be clearly coded in order to indicate that dangerous current flows through them and distinguish one type of unit from another. Colour coding and marking identification may be considered, however guidance differs in each country / region. Additional guidance on cable sheath marking can be found in [b-IEC TR 63194] and [b-ITU-T L.1203].

7.15 Cable structure

Several recommended cable structures are shown in Figures 7-1 and 7-2 as examples. Other cables can also be used as long as they meet the actual requirements in the access scenarios.

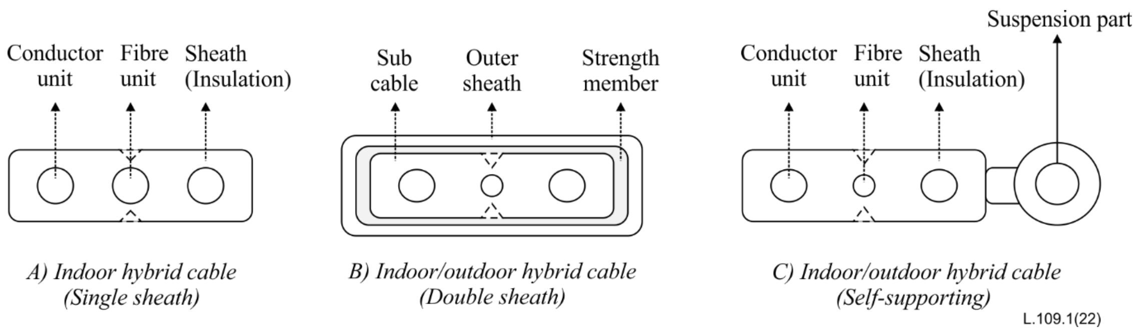

Figure 7-1 – Rectangular cable designs

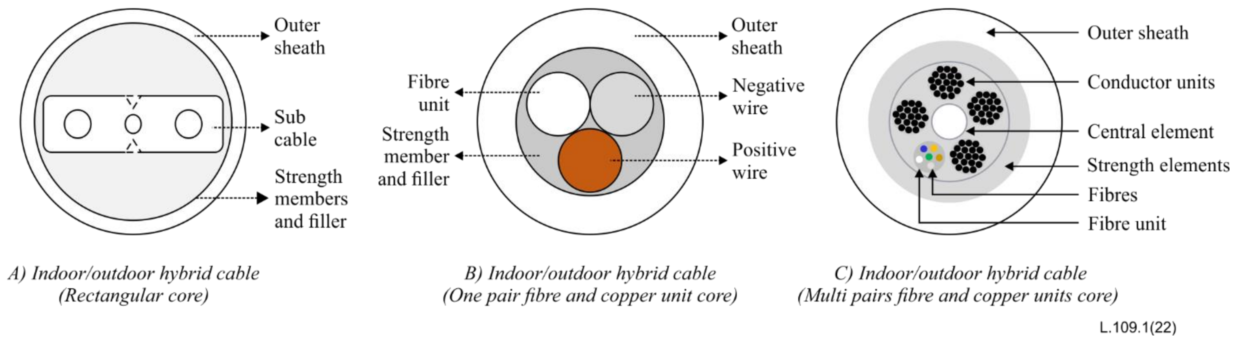

Figure 7-2 – Round cable designs

8 Rated values and characteristics

8.1 Minimum bending radius for installation

The standard installation tensile rating for cables is specified in Table 8-1.

Table 8-1 – Minimum bend

Standard minimum bend diameter	
Unloaded condition (Installed):	20 × Cable outer diameter (OD)
Loaded condition (During installation):	40 × Cable OD

8.2 Temperature range

The normal temperature ranges for cables covered by this Recommendation are listed in Table 8-2.

Table 8-2 – Operating temperature

	Vertical riser		**Horizontal**	
	°C		**°C**	
<u>Indoor</u> Operation Storage and shipping Installation	 −20 to +70 −40 to +70 −10 to 60		 0 to +70 −40 to +70 0 to 60	
<u>Outdoor and indoor/outdoor</u> Operation Storage and shipping Installation	 −40 to +70 −40 to +70 −10 to 60		 −40 to +70 −40 to +70 0 to 60	

8.3 Rated voltages

OEHC should adequately provide voltage for remote powering of distributed antenna systems, optical networks, small cells and more.

The cross-section of the metallic wire should be designed in accordance with the transmission voltage, transmission distance and the power consumption. Under extreme operating conditions, the heat generated by the conductors should not make the cable temperature exceed the maximum allowed temperature of the cable element materials as specified in the detailed specifications under References.

Specifications of conductors and insulation materials of the power feeding wires should also be specified in detail.

9 Performance requirements and test methods

9.1 Optical requirements

The cable element (optical fibre) performance requirements and supported applications for indoor, outdoor and indoor/outdoor are as specified in [IEC 60794-2], [IEC 60794-3], and [IEC 60794-6] respectively.

9.2 Electrical requirements

Electrical characteristics of hybrid cable should include the voltage test, insulation resistance, conductor resistance of power-feeding wires and electrical characteristics of symmetrical metallic pairs listed in clause 7.1.2. Test methods of the voltage test, insulation resistance and conductor resistance of power-feeding wires should comply with [IEC 60502-1] or [IEC 60227-1]. Test methods for electrical characteristics of symmetrical pairs should comply with [IEC 61156-1]. Assessment of conductor heating in bundled cables due to the deployment of remote powering should comply with [IEC 61156-1-4]. Test methods for the electrical characteristics of coaxial units should comply with documents in the series [IEC 61196-1-10x].

9.2.1 Resistance of conductors

Test method: [IEC 60227-1]

Requirement: Direct current (DC) resistance at 20°C $\leq 0.017241\Omega*m^2/m$

9.2.2 Voltage test on the completed cable

Test method: [IEC 60227-1]

Voltage and duration: 2000V for 5 minutes

Requirement: No breakdown

9.2.3 Voltage test on cores

Test method: [IEC 60227-1]

Voltage and duration: 2000V for 5 minutes

Requirement: No breakdown

9.2.4 Insulation resistance at 80°C

Test method: [IEC 60227-1]

Requirement: Insulation resistance at 80°C $\geq$ 0.0094 MΩ.km

9.2.5 Temperature rise test

Test method:

1) [IEC 61156-1-4] Multicore and symmetrical pair/quad cables for digital communications – Part 1-4: Assessment of conductor heating in bundled cables due to the deployment of remote powering.

2) DC current 2 A, ambient 70℃, maximum, under sealed duct conditions.

Requirement: 1. Temperature rise cannot exceed 10℃.

2. No visible damage is found on the sheath surface.

9.3 Mechanical requirements

Unless there is a different agreement between the manufacturer and the user, an OEHC should have the mechanical characteristics specified in [ITU-T L.103] and [IEC 62807-1], depending on the installation environment.

9.3.1 Tensile performance

Test method: Method E1, [IEC 60794-1-21]

The allowable tensile force should meet the specific requirements of the application and the cable construction type.

The recommended tensile force value should be based on the cable construction, however other force requirements can also be determined based on the application requirements.

The tensile performance test methods and requirements are given in Table 9-1.

Table 9-1 – Tensile performance test methods and requirements

	Indoor	**Outdoor**	**Indoor/outdoor**
Method	[IEC 60794-1-21-E1A]	[IEC 60794-1-21-E1A]	[IEC 60794-1-21-E1A]
Requirement	[IEC 60794-2-20] Section 4.3.1	[IEC 60794-3-11] Section 7.5.5	[IEC 60794-6-10] Section 6.2.2

9.3.2 Crush performance

Test method: Method E3, [IEC 60794-1-21]

The allowable crush force should meet the specific requirements of the application and the cable construction type.

The crush performance test methods and requirements are given in Table 9-2.

Table 9-2 – Crush performance test methods and requirements

	Indoor	**Outdoor**	**Indoor/outdoor**
Method	[IEC 60794-1-21-E3]	[IEC 60794-1-21-E3]	[IEC 60794-1-21-E3]
Requirement	[IEC 60794-2-20] Section 4.3.2	[IEC 60794-3-11] Section 7.5.4	[IEC 60794-6-10] Section 6.2.4

9.3.3 Bend

Test method: Method E11A, [IEC 60794-1-21]

The allowable bend should meet the specific requirements of the application and the cable construction type.

The bend performance test methods and requirements are given in Table 9-3.

Table 9-3 – Bend performance test methods and requirements

	Indoor	**Outdoor**	**Indoor/outdoor**
Method	[IEC 60794-1-21-E11A]	[IEC 60794-1-21-E11A]	[IEC 60794-1-21-E11A]
Requirement	[IEC 60794-2-20] Section 4.3.4	[IEC 60794-3-11] Section 7.5.2	[IEC 60794-6-10] Section 6.2.8

9.3.4 Repeated bending

Test method: Method E6, [IEC 60794-1-21]

The allowable repeated bending should meet the specific requirements of the application and the cable construction type.

The repeated bending performance test methods and requirements are given in Table 9-4.

Table 9-4 – Repeated bending performance test methods and requirements

	Indoor	**Outdoor**	**Indoor/outdoor**
Method	[IEC 60794-1-21-E6]	[IEC 60794-1-21-E6]	[IEC 60794-1-21-E6]
Requirement	[IEC 60794-2-20] Section 4.3.5	[IEC 60794-3-11] Section 7.5.7	[IEC 60794-6-10] Section 6.2.6

9.3.5 Bending at low temperature

Test method: Method E11A, [IEC 60794-1-21]

The allowable bending at low temperatures should meet the specific requirements of the application and the cable construction type.

The bending performance at low temperature test methods requirements are given in Table 9-5.

Table 9-5 – Bending performance at low temperature test methods and requirements

	Indoor	**Outdoor**	**Indoor/outdoor**
Method	[IEC 60794-1-21-E11A]	[IEC 60794-1-21-E11A]	[IEC 60794-1-21-E11A]
Requirement	[IEC 60794-2-20] Section 4.3.7	[IEC 60794-3-11] Section 7.5.2	[IEC 60794-6-10] Section 6.2.8

Appendix I

Chinese experience

(This appendix does not form an integral part of this Recommendation.)

I.1 Introduction

In the PO-LAN optical access network, hybrid cables containing both optical fibres and copper cables are developing rapidly. The hybrid cable is used to transmit optical data signals and power supply to active devices.

Power over hybrid cable technology is fast becoming a vital component in campus optical systems. The system consists of the power supply unit, optical/electrical hybrid cable, optical/electrical hybrid adapter, and the optical/electrical hybrid connector. These can transmit optical signals and electrical power at the same time and are cost-effective and easy to install.

I.2 Cable structure

The optical/electrical hybrid cable has been successfully installed and operated in a campus optical access network in the People's Republic of China (PRC).

Figures I.1 and I.2 show the structure of an optical/electrical hybrid cable.

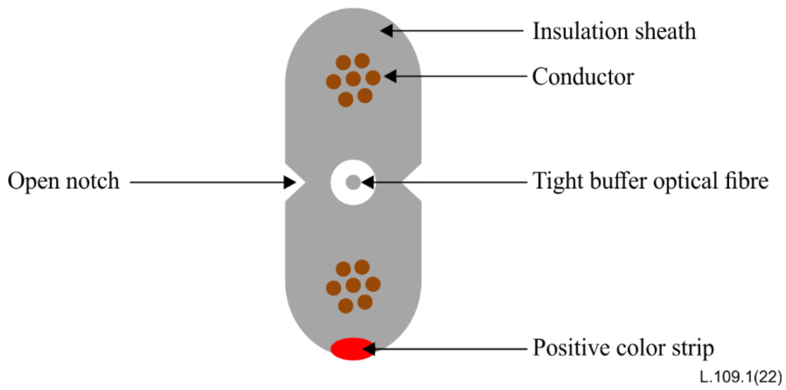

Figure I.1 – Indoor optical/electrical hybrid cable

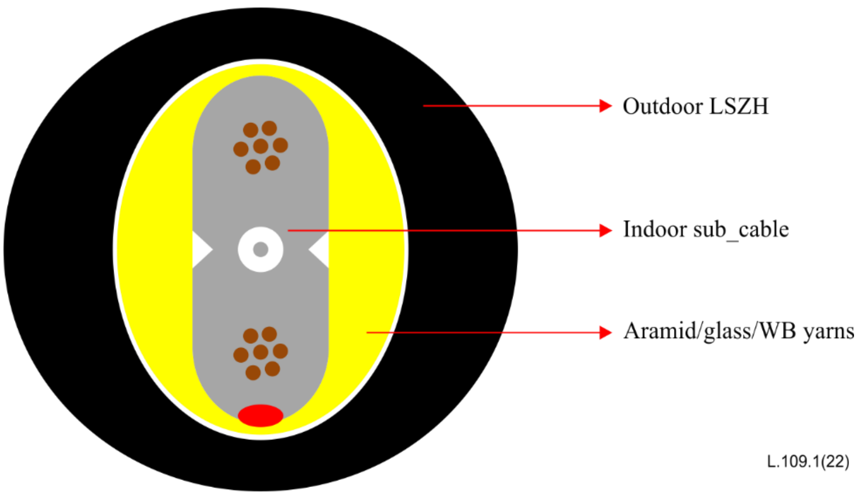

Figure I.2 – Indoor/outdoor optical/electrical hybrid cable

This type of hybrid cable is used for single-fibre bidirectional data signal transmission. The conductors of the copper cable are two flexible wires without the jacket and are used to supply the electrical power.

The cable can be terminated with an optical/electrical hybrid connector that carries optical signals and electrical power alongside each other. This solution improves the operational simplicity because the optical and electrical connections can be made and unmade in a single action.

The transmission distance of this kind of optical/electrical hybrid cable assembly ranges from 100 m (71.3 W) to 800 m (15 W).

Table I.1 gives the recommended sizes of an optical/electrical hybrid cable (OEHC) construction.

Table I.1 – Recommended sizes of an OEHC construction

Type of cable	Dimensions (mm)	Shape
Indoor drop	≤ 3×6	rectangular
Indoor/outdoor duct	≤ 5×8	rectangular
Indoor/outdoor duct	≤ 8	round
Indoor/outdoor overhead	≤ 3×10	Shape examples are shown in Figure 7-1 and Figure 7-2.

I.3 Application network

One end of an optical/electrical hybrid cable assembly is connected to the power supply unit through the hybrid connector, and the other end is connected to an optical port that supports the hybrid connector to transmit and supply optical data to the optical network unit (ONU). Figure I.3 shows the power supply networking for the hybrid cable ONU.

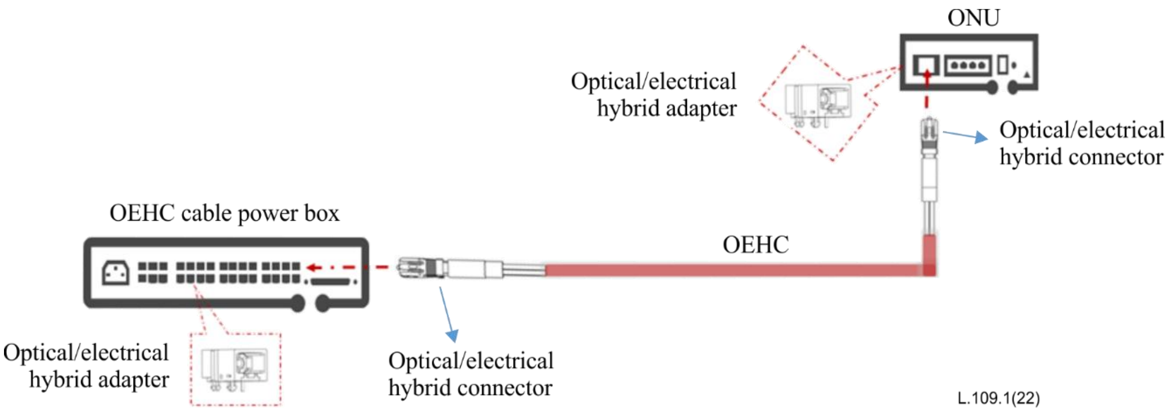

Figure I.3 – Power supply networking for the hybrid cable ONU

The optical/electrical hybrid cable assembly can also connect the optical port of the hybrid connector to the hybrid small form-factor pluggable (SFP) ONU to carry the access point (AP) and the camera. If the AP and the camera do not have optical ports, they can be connected using separate optical and electrical connectors.

Bibliography

[b-ITU-T L.1203] Recommendation ITU-T L.1203 (2016), *Colour and marking identification of up to 400 VDC power distribution for information and communication technology systems*.

[b-AWG] ASTM B258-18 (2018), *Standard Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors*, ASTM international. https://www.astm.org/b0258-18.html

[b-IEC TR 62222] IEC TR 62222:2021, *Fire performance of communication cables installed in buildings*. https://standards.iteh.ai/catalog/standards/iec/ebf8353d-6275-4aa8-9c83-7d053acf65b5/iec-tr-62222-2021

[b-IEC TR 63194] IEC TR 63194:2019, *Guidance on colour coding of optical fibre cables*. https://standards.iteh.ai/catalog/standards/iec/604faf3f-23a5-44ab-a4d7-f38d073ac438/iec-tr-63194-2019

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