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ITU-T

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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Construction of optical/metallic hybrid cables

ITU-T Recommendation L.60

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Construction of optical/metallic hybrid cables

Summary

An optical/metallic hybrid cable is a cable which contains both optical fibres and metallic wires for telecommunication and/or power feeding. Firstly, this Recommendation describes cable construction and secondly keynotes to the use of this type of cable are provided. Technical requirements may differ according to the installation environment. Environmental issues and test methods for cable characteristics are described in other L-series Recommendations.

Source

ITU-T Recommendation L.60 was approved on 6 September 2004 by ITU-T Study Group 6 (2001-2004) under the ITU-T Recommendation A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Construction of optical/metallic hybrid cables

1 Scope

This Recommendation refers to cables containing both optical fibres and metallic wires and:

– Deals with construction of optical/metallic hybrid cables. The optical fibre dimensional and transmission characteristics, together with their test methods, should comply with ITU-T Recs G.652, G.653, G.654, G.655, G.656 and IEC 60793-2-10. Dimensional and transmission characteristics of metallic wires for telecommunication, together with their test methods, should comply with ITU-T Rec. L.1 and other L-series Recommendations;

– Deals with keynotes for the use of optical/metallic hybrid cables;

– Recommends that an optical/metallic hybrid cable should be provided with cable-end sealing and protection during cable delivery and storage, as is usual for metallic and/or optical cables. If splicing components have been factory installed they should be adequately protected;

– Recommends that pulling devices can be fitted to the end of the cable if required.

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.

2.1 Normative references

– ITU-T Recommendation G.650.1 (2004), *Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable*.

– ITU-T Recommendation G.650.2 (2002), *Definitions and test methods for statistical and non-linear related attributes of single-mode fibre and cable*.

– ITU-T Recommendation G.652 (2003), *Characteristics of a single-mode optical fibre and cable*.

– ITU-T Recommendation G.653 (2003), *Characteristics of a dispersion-shifted single-mode optical fibre and cable*.

– ITU-T Recommendation G.654 (2004), *Characteristics of a cut-off shifted single-mode optical fibre and cable*.

– ITU-T Recommendation G.655 (2003), *Characteristics of a non-zero dipersion-shifted single-mode optical fibre and cable*.

– ITU-T Recommendation G.656 (2004), *Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport*.

– ITU-T Recommendation L.1 (1988), *Construction, installation and protection of telecommunication cables in public networks*.

– ITU-T Recommendation L.10 (2002), *Optical fibre cables for duct and tunnel application*.

– ITU-T Recommendation L.26 (2002), *Optical fibre cables for aerial application*.

– ITU-T Recommendation L.43 (2002), *Optical fibre cables for buried application*.

– ITU-T Recommendation L.59 (2004), *Optical fibre cables for indoor application*.

– IEC 60227 (2003), *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*.

– IEC 60228 (2004), *Conductors of insulated cables*.

– IEC 60793-2-10 (2004), *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*.

– IEC 61156-2-1 (2003), *Multicore and symmetrical pair/quad cables for digital communications – Part 2-1: Horizontal floor wiring – Blank detail specification*.

2.2 Informative reference

ITU-T Handbook (1994), *Construction, Installation, Jointing and Protection of Optical Fibre Cables*.

3 Terms and definitions

For the purpose of this Recommendation, the definitions given in ITU-T Recs G.650.1, and G.650.2 apply.

4 Abbreviations

This Recommendation uses the following abbreviations:

FRP Fibre Reinforced Plastic

FTTC Fibre-To-The-Curb

FTTH Fibre-To-The-Home

PE PolyEthylene

PVC PolyVinylChloride

5 Optical/metallic hybrid cable construction

This Recommendation deals with three types of optical/metallic hybrid cables as shown in Table 1.

Table 1/L.60 – Contents of each cable type

Cable type	Optical fibres	Metallic wires for telecommunication	Metallic wires for power feeding
Type-I	Contained	Contained	No
Type-II	Contained	No	Contained
Type-III	Contained	Contained	Contained

Type-I can be used for optical transmission and electric transmission carrying analog and/or digital signals. Type-II can be used for optical transmission and power feeding. Type-III can be used for optical transmission, electric transmission carrying analog and/or digital signals and power feeding.

There are two major methods to contain those media in a cable. One method is to strand each medium fabricated cylindrically (with or without other materials) around a central member. The other is to insert media into slots of a slotted core as described in 5.2.4.

5.1 Characteristics of each media

5.1.1 Optical fibre

Optical fibres described in ITU-T Recs G.652, G.653, G.654, G.655, G.656 and IEC 60793-2-10 should be used, depending upon circumstances and technical requirements.

5.1.2 Symmetrical metallic pair

The electrical characteristics of a symmetrical pair or pairs should meet with those agreed upon between a manufacturer and a user. The following items should be agreed upon:

- maximum conductor direct current resistance;
- maximum conductor direct current resistance unbalance of the pair;
- mutual capacitance;
- capacitance unbalance;
- attenuation (insertion loss);
- near-end crosstalk (NEXT);
- power sum of near-end crosstalk (PSNEXT);
- far-end crosstalk (FEXT);
- equal level of far-end crosstalk (ELFEXT);
- insulation resistance;
- other parameters which will be agreed upon between a manufacturer and a user.

The mechanical and the environmental characteristics should comply with IEC 61156-2-1 unless there is a different agreement between a manufacturer and a user.

5.1.3 Power feeding wires

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 characteristic of the copper wire should be in accordance with IEC 60227 criterion requirements, unless there is a different agreement between a manufacturer and a user.

5.2 Cable element

The make-up of the cable core, in particular the number of fibres, their method of protection and identification, the location of strength members and metallic wires or pairs, if required, should be clearly defined.

5.2.1 Loose tube

A loose tube construction is frequently used for protecting and gathering optical fibres and/or ribbon fibres. Filling material may be contained in the tube.

5.2.2 Symmetrical pair unit

A symmetrical pair unit contains stranded copper pairs. It is fabricated cylindrically with or without additional suitable material. Its diameter is similar to that of a loose tube.

5.2.3 Power feeding wire unit

A power feeding wire unit contains power-feeding wire(s) and is fabricated cylindrically with or without suitable material in order to have a diameter similar to that of a loose tube.

5.2.4 Slotted core

In order to avoid direct pressure on optical fibres from the outside of the cable, optical fibres and/or ribbon fibres may be located into slots. Usually, slots are provided in a helical or SZ configuration stranded around a cylindrical rod. The slotted core usually contains a strength member (metallic or non-metallic). The strength member shall adhere tightly to the slotted core in order to obtain temperature stability and avoid separation when a pulling force is applied during installation.

5.2.5 Strength member

The cable should be designed with strength members suitable to meet installation and service conditions so that the fibres are not subjected to strain levels in excess of those agreed upon between a manufacturer and a user. The strength member(s) may be either metallic or non-metallic.

5.2.6 Water blocking material

Filling a cable with water-blocking material, or wrapping the cable core with layers of water swellable material, are two means of protecting the fibres from water ingress. A water-blocking element (tapes, filling compound, water swelling powder or 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 shall not hinder splicing and/or connection operations.

5.2.7 Sheath

The cable core shall be covered with a sheath or sheaths suitable for environmental and mechanical conditions associated with 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.

Selection of sheath material is one of the important issues to be considered in order, for example, to satisfy fire safety requirements. Polyethylene is widely used as cable sheath material but may not be suitable for indoor cables for fire safety reasons.

5.3 Mechanical characteristics

Unless there is a different agreement between a manufacturer and a user, an optical/metallic hybrid cable should have mechanical characteristics which are described in ITU-T Recs L.10, L.26, L.43 or L.59 depending upon the installation environment.

5.4 Environmental conditions

Unless there is a different agreement between a manufacturer and a user, an optical/metallic hybrid cable should meet environmental conditions which are described in ITU-T Recs L.10, L.26, L.43 or L.59 depending upon the installation environment.

6 Test methods

Unless there is a different agreement between a manufacturer and a user, an optical/metallic hybrid cable should be tested with the test methods which are described in ITU-T Recs L.10, L.26, L.43 or L.59 depending upon the installation environment.

Appendix I

Chinese experience

Introduction

Optical fibre cables used in the access network must be suitable for network topologies such as FTTH and FTTC. Optical/Metallic hybrid cable applies not only to the optical signals, but also to the digital signals to be transmitted and to the power needed to feed active equipment. This contribution presents three types of optical fibre/stranded copper hybrid cables used in different access network application environments. Each type has been successfully installed in the access network in China.

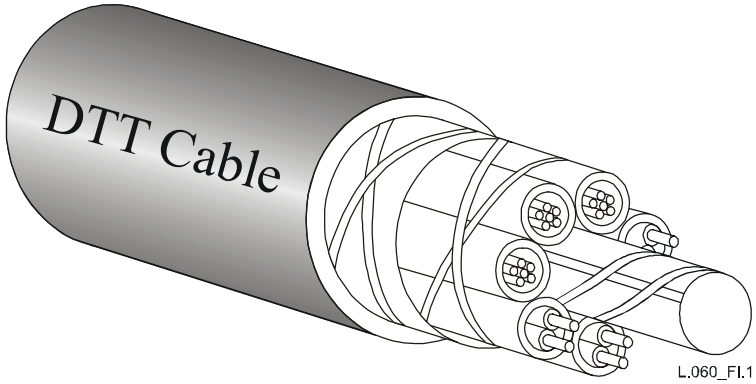

Figure I.1/L.60 – The 3-dimensional sketch map of the optical fibre/copper hybrid cable

The cable types are:

– Optical fibre/symmetrical pair hybrid cable for optical/data signal transmission.

– Optical fibre/stranded copper wire hybrid cable for optical signal transmission and power feeding to active equipment.

– Optical fibre/symmetrical pair/stranded copper wire hybrid cable for optical/data signal transmission and power feeding to active equipment.

The transmission distance of the optical fibre/stranded copper hybrid cables mentioned above should meet customer needs; normally the distance covered is from 100 m to 300 m.

I.1 Cable design

The three types of hybrid cables this Recommendation presents are mentioned below:

a) **Optical fibre/symmetrical pair hybrid cable**

This type of hybrid cable is designed for optical/data signal transmission. The structure is shown in Figure I.2. It contains up to 3 units of fibre loose tubes (or the filling unit) and 4 units of symmetrical pairs. The number of the optical fibres is from 2 cores to 24 cores, according to customer requirements. The number of loose tubes is from 1 to 3, the rest is filled with the filling unit. The central strength unit is made from FRP. The outer insulation layer is made by polyester strip. The water blocking material is the water blocking yarn. The sheath material could include the PE, fire retardant PE (low-smoke zero halogen thermoplastic material), PVC and the termite protection material. The types of the optical fibre in the hybrid cable may be the multimode fibre or the single-mode fibre. The optical fibres comply with the ITU-T Recs G.651 and G.652 requirements. The symmetrical pair has a 100 ohm resistance; the mechanical and environmental characteristics meet those described in IEC 61156-2-1; the electrical characteristics are shown in

Tables I.1 to I.7. Symmetrical pair identification is shown in Table I.8. Loose tube identification is shown in Table I.9.

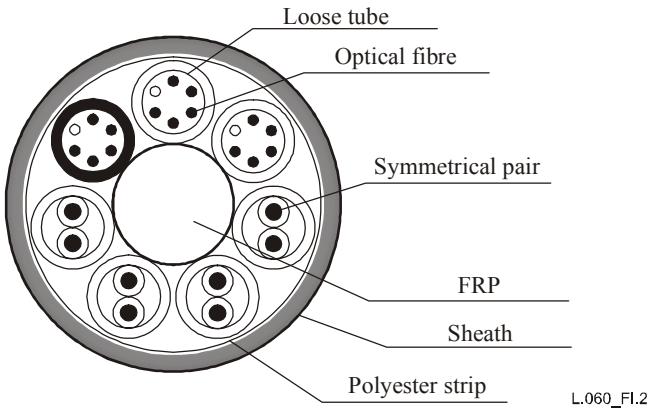

Figure I.2/L.60 – Construction of an optical fibre/symmetrical pair hybrid cable

Table I.1/L.60 – Electrical characteristic of 100 ohm symmetrical pair (20° C)

Item		Unit	Normative diameter of the conductor	
			Φ0.5 mm	**Φ0.6 mm**
Conductor direct current resistance, Maximum		ohm/100 m	9.5	6.58
Conductor direct current resistance unbalance of the pair, Maximum		%	2.5	
Working capacitance, Maximum	5, 5e	nF/100 m	5.6	

Table I.2/L.60 – Attenuation of 100 ohm symmetrical pair (20° C)

Symmetrical pair type	Conductor diameter (mm)	Frequency *f* (MHz)	Attenuation (dB/100 m)
5, 5e	0.5	1~100	$1.967\times\sqrt{f}+0.023\times f+\frac{0.050}{\sqrt{f}}$
5, 5e	0.6	1~100	$1.695\times\sqrt{f}+0.020\times f+\frac{0.040}{\sqrt{f}}$

Table I.3/L.60 – Near-end crosstalk (NEXT) of 100 ohm symmetrical pair

Symmetrical pair type	Frequency *f* (MHz)	NEXT (dB/100 m)
5	1~100	$62.3 - 15 \times \lg f$
5e	1~100	$65.3 - 15 \times \lg f$

Table I.4/L.60 – Power sum of near-end crosstalk (PSNEXT) of 100 ohm symmetrical pair

Symmetrical pair type	Symmetrical pair unit	Frequency *f* (MHz)	PSNEXT (dB/100 m)
5	Over 4	1~100	$62.3 - 15 \times \lg f$
5e	4	1~100	$62.3 - 15 \times \lg f$

Table I.5/L.60 – Characteristic impedance of 100 Ω symmetrical pair

Frequency (MHz)	Characteristic impedance (ohm)	
	5	**5e**
$f \geq 1$	100 ± 15	100 ± 15

Table I.6/L.60 – Minimum return loss (RL) of 100 ohm symmetrical pair

Type	Frequency *f* (MHz)				
	$1 \leq f \leq 10$	$10 < f \leq 16$	$16 < f \leq 20$	$20 < f \leq 100$	$100 < f \leq 250$
5	$17 + 3 \times \lg f$	20	20	$20 - 7 \times \lg(f/20)$	–
5e	$20 + 5 \times \lg f$	25	25	$25 - 7 \times \lg(f/20)$	–

Table I.7/L.60 – Minimum structure return loss (SRL) of 100 ohm symmetrical pair

Type	Frequency *f* (MHz)				
	$1 \leq f \leq 10$	$10 < f \leq 16$	$16 < f \leq 20$	$20 < f \leq 100$	$100 < f \leq 250$
5	23	23	23	$23 - 10 \times \lg(f/20)$	–
5e	28	28	28	$28 - 10 \times \lg(f/20)$	–

Table I.8/L.60 – Pair identification

Pair 1	Blue/white
Pair 2	Orange/white
Pair 3	Green/white
Pair 4	Brown/white

Table I.9/L.60 – Loose tube identification

Tube 1	Red
Tube 2	Green
Tube 3	Natural
Tube 4	Natural

b) **Optical fibre/stranded copper wire hybrid cable for feeding power active equipment**

This type of hybrid cable is designed for optical signal transmission and power feeding to active equipment. The structure is shown in Figure I.3. It contains up to 4 units of fibre loose tube (or filling unit) and 2 units of copper wire for power feeding (direct current). The number of optical fibres is from 2 cores to 24 cores according to customer requirements. The number of loose tubes is

from 1 to 4, the rest is filled with the filling unit. The central strength unit is made by the FRP. The outer insulation layer is adapted with polyester strip. Water blocking material is water-blocking yarn. The sheath material could include PE, fire retardant PE (low-smoke zero halogen thermoplastic material), PVC and termite protection material. The types of optical fibre in the hybrid cable may be multimode or single mode. The optical fibres comply with the ITU-T Recs G.651 and G.652 requirements. The power carried by the copper wire is 50 W. Copper wire conductor characteristics meet IEC 60228 criterion requirements. Copper wire insulation characteristics comply with IEC 60227 criterion requirements. The electrical characteristic of the copper wire conductor is shown in Table I.10. Loose tube identification is shown in Table I.9. Stranded copper wire identification is shown in Table I.11.

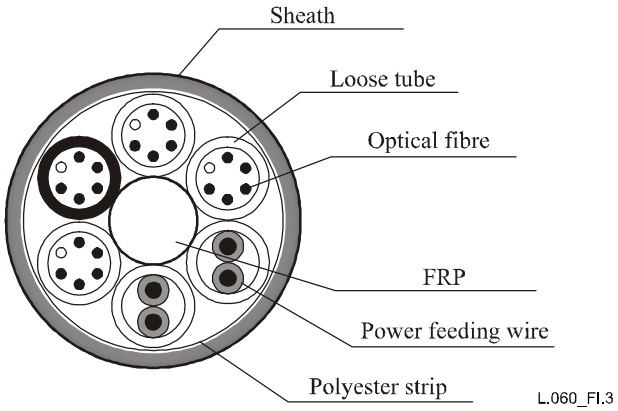

Figure I.3/L.60 – Cross-section of optical fibre/stranded copper wire hybrid cable

Table I.10/L.60 – Electrical characteristics of direct current feeding power conductor

Normative area mm^2	Resistance, Maximum (ohm 20° C)	
	Round copper conductor	
	Metal plating	No metal plating
0.5	36.7	36.0

Table I.11/L.60 – Stranded copper wire identification

Wire 1	Red
Wire 2	Yellow/green

c) **Optical fibre/symmetrical pair/stranded copper wire hybrid cable**

Optical fibre/symmetrical pair/stranded copper wire hybrid cable is designed for optical/data signal transmission and power feeding to active equipment. The structure is shown in Figure I.4 and contains 2 units of fibre loose tube (or filling unit), 4 units of symmetrical pair and 1 unit of copper wire for power feeding (direct current). The number of the optical fibres is from 2 cores to 12 cores according to customer requirements. The number of loose tubes is from 1 to 4, the rest is filled with filling unit. The central strength unit is FRP. The outer insulation layer is polyester strip. The water blocking material is water-blocking yarn. The sheath material could include PE, fire retardant PE (low-smoke zero halogen thermoplastic material), PVC and termite protection material. The types of optical fibre in the hybrid cable may be multimode or single mode. The optical fibres comply with the ITU-T Recs G.651 and G.652 requirements. The symmetrical pair has 100 ohm resistance; the mechanical and environmental characteristics comply with IEC 61156-2-1. Electrical characteristics are shown in Tables I.1 to I.7. The power carried by the copper wire is 50 W. Copper

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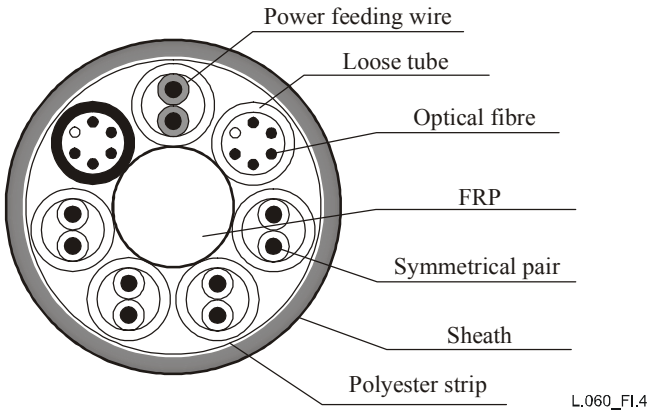

Figure I.4/L.60 – Cross-section of optical fibre/symmetrical pair/stranded copper wire hybrid cable

Conclusion

Testing to IEC 61156-2-1, IEC 60794 and IEC 60227 criteria has proven that the optical fibre/stranded copper hybrid cable mentioned above in this Recommendation not only meets the design purpose, but also that it performs well in the access network.

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