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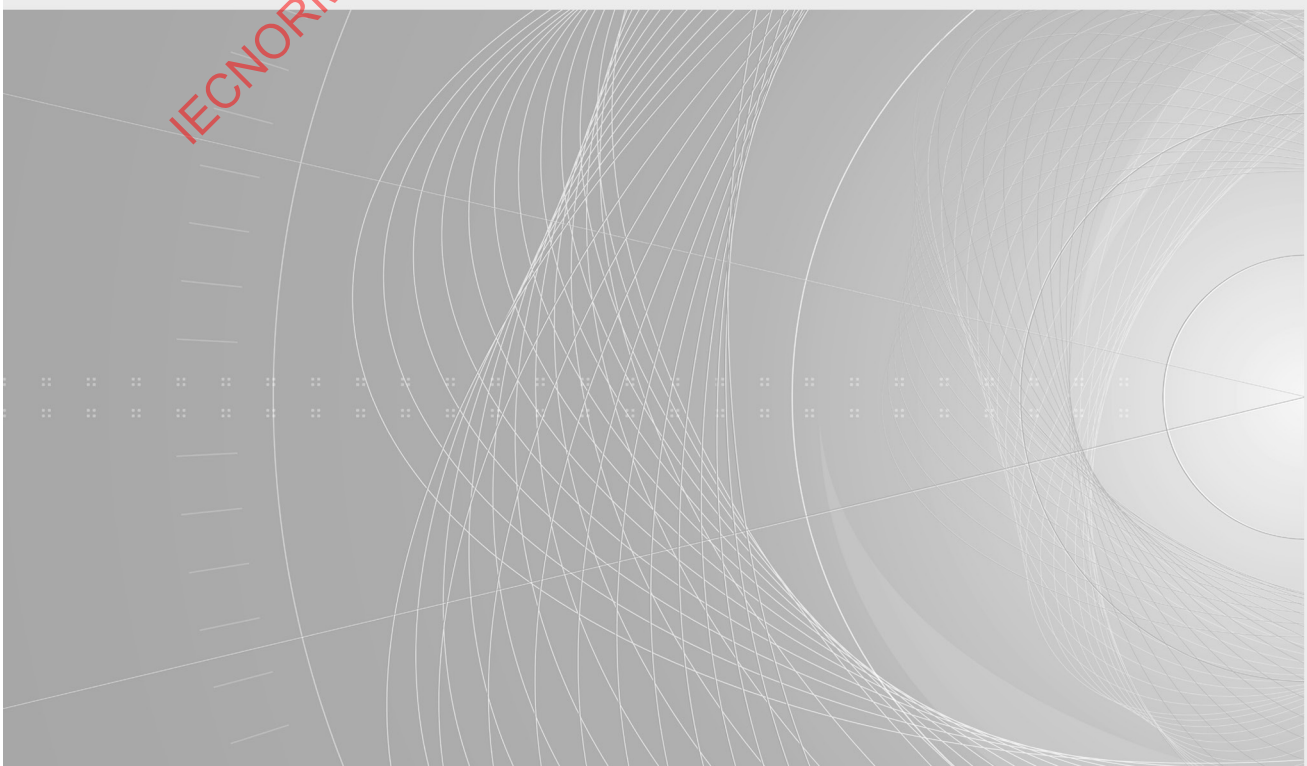
INTERNATIONAL STANDARD

Twinax cables for digital communications – Part 1: Generic specification



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TWINAX CABLES FOR DIGITAL COMMUNICATIONS –

Part 1: Generic specification

FOREWORD

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IEC 62783-1 has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This second edition cancels and replaces the first edition published in 2019. This edition constitutes a technical revision.

This edition includes the following significant technical changes compared with the previous edition:

– 4.1: single pair twinax cable is permitted;
– 5.2.1: addition of length requirement for electrical tests;
– 5.3.1, 5.3.2: addition of test equipment, fixtures and length requirements of cable under test for transmission tests;
– 5.3.3.2: introduction of characteristic impedance in time domain;
– 5.4.11: addition of vibration test of the cable;

– 5.5.8, 5.5.9 and 5.5.12: addition of environmental tests: damp heat steady state, salt mist, halogen-free compounds;
– 5.5.11: updating the test method of flame propagation characteristics of bunched cables.

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

Draft	Report on voting
46C/1257/FDIS	46C/1261/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/publications.

A list of all parts in the IEC 62783 series, published under the general title *Twinax cables for digital communications*, 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

This document specifies the generic characteristics of twinax cables for the transmission of digital signals, which use single or multiple twinax cable element(s).

Twinax cables are intended for use in high-performance information technology systems and data interface interconnection systems. These cables are generally used in short-reach data communication links, which reach about 0,3 m to 10 m. Information technology interconnection standards that use twinax cables include Ethernet, Fibre channel, SAS, SATA, SFP, PCIE and others.

IEC 62783 (all parts) includes separate family specifications, which provide the requirements for each specific twinax cable used in information technology interconnection systems.

TWINAX CABLES FOR DIGITAL COMMUNICATIONS –

Part 1: Generic specification

1 Scope

This part of IEC 62783 specifies definitions, requirements and test methods of twinax cables used in digital communication systems: computer rooms, data centres, servers, etc. These cables are intended to be used indoors.

This document details the requirements and transmission characteristics for single twinax elements as well as multiple twinax elements within the same sheath, i.e. “twinax cable”.

This document is applicable to twinax cables and also twinax cable assemblies.

This document is supplemented with family specifications that give additional requirements based on the specific application, for example, the minimum and maximum specified frequency of the cables.

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 60028, *International standard of resistance for copper*

IEC 60050-726, *International Electrotechnical Vocabulary (IEV) − Part 726: Transmission lines and waveguides*

IEC 60068 (all parts), *Environmental testing*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60189-1, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods*

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for diffusion flame*

IEC 60332-3-24, *Tests on electric and optical fibre cables under fire conditions – Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category C*

IEC 60332-3-25, *Tests on electric and optical fibre cables under fire conditions – Part 3-25: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category D*

IEC 60684-2, *Flexible insulating sleeving – Part 2: Methods of test*

IEC 60754-1, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content*

IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*

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

IEC 60811-201, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*

IEC 60811-202, *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, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

IEC 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

IEC 60811-406, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 406: Miscellaneous tests – Resistance to stress cracking of polyethylene and polypropylene compounds*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-502, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 502: Mechanical tests – Shrinkage test for insulations*

IEC 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 504: Mechanical tests – Bending tests at low temperature for insulation and sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 60811-510, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 510: Mechanical tests – Methods specific to polyethylene and polypropylene compounds – Wrapping test after thermal ageing in air*

IEC 61034 (all parts), *Measurement of smoke density of cables burning under defined conditions*

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

IEC TR 61156-1-2, *Multicore and symmetrical pair/quad cables for digital communications – Part 1-2: Electrical transmission characteristics and test methods of symmetrical pair/quad cables*

IEC 61196-1-105, *Coaxial communication cables – Part 1-105: Electrical test methods – Test for withstand voltage of cable dielectric*

IEC 62012-1:2002, *Multicore and symmetrical pair/quad cables for digital communications to be used in harsh environments – Part 1: Generic specification*

IEC 62153-4-3, *Metallic communication cable test methods – Part 4-3: Electromagnetic compatibility (EMC) – Surface transfer impedance – Triaxial method*

IEC 62153-4-5, *Metallic communication cable test methods – Part 4-5: Electromagnetic compatibility (EMC) – Screening or coupling attenuation – Absorbing clamp method*

IEC 62153-4-9, *Metallic communication cable test methods – Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method*

IEC 62783-1-1, *Twinax cables for digital communications – Part 1-1: Time domain test methods for twinax cables for digital communications − General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61156-1, IEC 62783-1-1, IEC 60050-726 and the following apply.

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

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

3.1
twinax element
pair consisting of two insulated conductors that are laid parallel, side-by-side and designated wire "a" and wire "b", enclosed in a metal foil shield with or without drain wire(s) or enclosed in a wire braid with or without a metal foil

3.2
twinax cable
cable composed of one or multiple twinax elements

3.3
twinax cable assembly
twinax cable terminated on both ends with one or more connectors

4 Materials and cable construction

4.1 General remarks

The choice of materials and cable construction shall be suitable for the intended application and installation of the cable.

Any special requirements of EMC (electromagnetic compatibility), or fire performance (burning properties, smoke generation, evolution of acid gas, etc.), or both, should be considered.

If not specified otherwise, the nominal twinax cable characteristic impedance is 100 Ω. Normal twinax cable configurations range from 1 to 16 elements, with a conductor size range from 0,1 mm to 0,5 mm (38 AWG to 24 AWG), or other sizes as specified in the family specification.

4.2 Cable construction

4.2.1 General

The cable construction shall be in accordance with the details and dimensions given in the relevant family specification.

4.2.2 Conductor

The conductor shall consist of annealed copper, uniform in quality and free from defects. The properties of the copper shall be in accordance with IEC 60028.

The conductor may be either solid or stranded and shall be circular in cross-section.

The conductor should be silver-coated, but tin-coated, bare copper, plated copper or copper alloy are also permitted.

4.2.3 Insulation

4.2.3.1 General requirements

Conductor insulation is composed of one or more suitable dielectric materials. The suitable materials are polyolefin or fluoropolymer. The insulation may be solid, cellular or composite (e.g. foam skin).

The two conductors may be extruded in parallel within a single insulation.

An intermediate sheath or bedding may be extruded around the two insulated conductors.

Multi-layer insulation is permitted to achieve the performance requirements.

The insulation shall be continuous, having a uniform thickness. The minimum thickness of the insulation shall be measured in accordance with the method specified in IEC 60189-1.

The insulation shall be applied to fit closely to the conductor.

When required, the insulated conductors shall be coloured for identification. Colours shall reasonably correspond with the standard colours shown in IEC 60304.

4.2.3.2 Colour code

The colour code for insulation is given in the relevant cable specification.

4.2.4 Cable element

4.2.4.1 General remarks

The cable element is the twinax element specified in 3.1.

The two insulated conductors may be covered by one or multi-layer non-hygroscopic tapes.

The cable element shall have screen(s) and shall correspond with the requirements in 4.2.4.2.

Intermediate sheath underneath the screen is permitted.

4.2.4.2 Screening of cable element

Screening material of cable element may be metallic tape, or metallic laminated to a plastic tape, or braid. Other non-metallic appropriate material with screening performance is permitted.

Screening material(s) may be single-layer or multi-layer, and combination of different screening materials is allowed.

Screening tape(s) may be wrapping or longitudinal lapping.

Non-hygroscopic tape without screening performance may be used.

Drain wire(s) if present shall be placed in continuous electrical contact with the metal foil.

Coatings or other methods of protection should be considered in order to prevent galvanic interaction when putting dissimilar metals in contact with each other.

A protective wrapping may be applied over the screen.

Some typical screening of cable elements can be:

a) single-layer or multi-layer conductive screening tape, with or without drain wire;
b) single-layer or multi-layer conductive screening tape and non-hygroscopic tape without screening performance, and drain wire(s) are allowed to be placed inside the screen;
c) single-layer or multi-layer conductive screening tape and one or multi-layer metallic braid, with or without drain wire(s);
d) non-metallic conductive material applied as a tape or extruded optionally in combination with other permitted screening elements.

4.2.5 Cable make-up

The cable assembly consisting of 1 to 16 element(s) may be laid up in concentric layers or in sub-bundle construction. The cable core may be protected by wrappings of a non-hygroscopic tape and fillers can be used to maintain a circular formation.

4.2.6 Screening of the cable core

When required, the cable core may be screened by a conductive metal foil laminated or not to a plastic tape, or a copper braid (tin coated or plain), or both.

Coatings or other methods of protection should be considered in order to prevent galvanic interaction when putting dissimilar metals in contact with each other.

A protective wrapping may be applied under or over the screen, or both.

4.2.7 Sheath

The sheath shall be of polymetric material and shall be continuous, having a uniform thickness. Examples of sheath materials are:

– PVC;
– polyolefin;
– fluoropolymer;
– flame retardant polyethylene (FRPE);
– low-smoke halogen-free thermoplastic material.

The mechanical strength and elasticity of the sheath shall remain constant during normal use.

The sheath shall be applied to fit closely to the core of the cable. In the case of screened cables, the sheath shall not adhere to the screen except when it is intentionally bonded to it.

The colour of the sheath may be specified in the relevant family specification or agreed between customer and supplier.

4.2.8 Identification

4.2.8.1 Cable marking

The cable shall be marked as specified in the family specification. The marking may include the following information:

a) cable type;
b) name of the manufacturer;
c) date of manufacture;
d) batch number.

One of the following marking methods can be used:

1) coloured threads or tapes;
2) printed tape;
3) printing on the core wrappings;
4) marking on the sheath.

Additional markings may be provided on the sheath as indicated in the family specification or detail specification.

4.2.8.2 Labelling

The cable shall be labelled as specified in the family specification. The labelling may include the following information:

a) type of cable;
b) manufacturer's name or logo;
c) date of manufacture;
d) length of cable in metres.

4.2.9 Finished cable

Finished cables shall be protected for storage and shipment as specified in the family specification.

5 Requirements and test methods

5.1 General requirements

If not specified otherwise in the family specification, all tests shall be carried out under the conditions specified in IEC 60068 (all parts).

Under static conditions, the cables should operate in the temperature range from −25 °C to +70 °C unless otherwise stated in the family specification. The temperature dependence of the cables is also specified.

5.2 Electrical characteristics and tests

5.2.1 General

The tests according to 5.2 shall be carried out on a cable length of not less than 100 m, unless otherwise specified in the family specification.

5.2.2 Conductor resistance

The conductor resistance of each conductor shall be as specified in the family specification and measured in accordance with IEC 60189-1.

5.2.3 Resistance unbalance

The resistance unbalance shall be as specified in the family specification and calculated in accordance with IEC 61156-1.

5.2.4 Dielectric strength

This measurement shall be carried out before the measurement of insulation resistance described in 5.2.5.

Dielectric strength shall be as specified in the family specification and measured in accordance with IEC 61196-1-105.

A voltage shall be applied first between all wires "a" connected together and all wires "b" connected together, then between all wires "a" plus all wires "b" connected together and all screen(s), then between all individual screens connected together and the overall screen (if it exists).

Unless otherwise specified in the family specification, the voltage shall be 1,0 kV DC for 1 min or, alternatively, 2,5 kV DC for 2 s.

An AC voltage may be used. The voltage shall be 0,7 kV AC for 1 min or, alternatively, 1,7 kV AC for 2 s.

5.2.5 Insulation resistance

Insulation resistance shall be as specified in the family specification and measured in accordance with IEC 60189-1.

A voltage shall be applied between each wire and all other wires plus screen(s) connected to the earth; the minimum application time is 1 min.

The test voltage shall be between 100 V DC and 500 V DC or as specified in the family specification.

5.2.6 Surface transfer impedance

Surface transfer impedance shall be as specified in the family specification and measured in accordance with IEC 62153-4-3.

All of the screens shall be connected together at the ends of the test specimen.

5.2.7 Coupling attenuation

Coupling attenuation should be as specified in the family specification and shall be measured in accordance with IEC 62153-4-5 or IEC 62153-4-9, the latter being the referee test method to resolve doubts or disputes.

All of the screens shall be connected together at the ends of the test specimen.

The coupling attenuation of all pairs within the specimen shall be measured .

5.3 Transmission characteristics and tests

5.3.1 General

The transmission parameters are specified in the balanced mode in the frequency domain and time domain; the measurements in 5.3 are specified at 20 °C.

The frequency domain parameters are specified from MHz to GHz; minimum and maximum frequency shall be as specified in the family specification.

a) One of the appropriate items of test equipment can be:
   1) multi-port vector network analyser (VNA) having the capability of virtual baluns and performing a full 4-port calibration as a minimum requirement, at the same time having time domain analysis function by using Inverse Discrete Fourier Transformation (IDFT);
   2) multi-port VNA having the capability of virtual baluns and performing a full 4-port calibration as a minimum requirement, and a TDR equipment with balanced ports;
   3) TDR equipment with balanced ports and having frequency analysis function with DFT.
b) Test leads are usually coaxial cables with a 50 Ω characteristic impedance. The electrical length of the test leads shall be equal and shall not be longer than 1 m.
c) Test fixtures to connect the cable under test to test equipment by test leads if needed.

The description of IDFT can be found in IEC 62153-1-1.

When no fixtures are used, a 4-port calibration shall be done at test leads ends.

When fixtures are used, errors introduced by the fixtures shall be eliminated by using appropriate calibration techniques, for example, Through-Reflect-Line (TRL) calibration or de-embedding technologies.

5.3.2 Length

The length of the cable under test should be shorter when the maximum frequency increases. It is recommended that the length of the cable under test be:

a) 1 m to 2 m when the diameter of the conductor is between 0,102 mm (38 AWG) and 0,160 mm (34 AWG);
b) 3 m when the diameter of the conductor is between 0,254 mm (30 AWG) and 0,203 mm (32 AWG);
c) 5 m when the diameter of the conductor is between 0,511 mm (24 AWG) and 0,320 mm (28 AWG).

The length should be 10 m if the equipment and fixtures (if present) are sensitive enough to meet the transmission performance requirements.

5.3.3 Characteristic impedance

5.3.3.1 General

The differential mode characteristic impedance of twinax cables shall be specified in the family specification.

The common mode characteristic impedance should be considered.

The differential mode characteristic impedance should be 100 Ω ± 5 Ω. Other values of differential mode characteristic impedance are permitted, but should be agreed between customer and supplier.

5.3.3.2 Measurement

The differential mode characteristic impedance of twinax cable is preferred to be measured in time domain for it's short-reach applications, rise time and time range shall be specified in the family specification or detail specification.

The frequency domain characteristic impedance measurement may be used if it meets the twinax cable application requirements. The method of measuring the frequency domain characteristic impedance is described in IEC TR 61156-1-2.

NOTE The method of measuring the time domain characteristic impedance is under consideration.

5.3.4 Return loss

5.3.4.1 General

Differential mode return loss or common mode return loss should be as specified in the family specification or detail specification.

5.3.4.2 Measurement

Return loss shall be measured in accordance with IEC TR 61156-1-2.

5.3.5 Attenuation

5.3.5.1 General

The attenuation shall be as specified in the family specification or detail specification.

5.3.5.2 Measurement

Attenuation shall be measured in accordance with IEC TR 61156-1-2.

Attenuation is specified at 20 °C. The measurements are made at ambient temperature and shall be corrected to 20 °C according to Formula (1):

$$\alpha_{20} = \alpha_T/(1 + 0{,}002(T - 20)) \quad (1)$$

where

α_T is the measured attenuation at cable length in dB;

T is the ambient temperature in degrees Celsius;

α_{20} is the attenuation in dB at cable length, corrected to 20 °C.

NOTE 1 0,2 %/°C is applicable to resistive losses in the temperature range 10 °C to 60 °C. The coefficients can be determined for other temperatures according to the method provided in IEC 61156-1.

NOTE 2 This temperature correction is only valid when dielectric losses are negligible compared to resistive losses, otherwise correction is overestimated.

Measured values are corrected to a standard length of 10 m, or as specified in the family specification or detail specification, using a linear variation with length.

5.3.6 Propagation delay, inter-pair skew, and intra-pair skew

5.3.6.1 General

Propagation delay, inter-pair skew, and intra-pair skew shall be as specified in the family specification or detail specification.

NOTE For single element twinax cable, inter-pair skew is not applicable.

5.3.6.2 Measurement

Propagation delay may be measured by using the frequency domain technology, or using the time domain technology, the latter being preferred. When using the frequency domain technology, the measurement is made according to IEC TR 61156-1-2; the measurement in time domain using differential mode TDR is under consideration.

The inter-pair skew between pairs is given by Formula (2):

$$t_{\mathrm{p}} = t_{\mathrm{p}i} - t_{\mathrm{p}j} \tag{2}$$

where

t_{p} is the inter-pair propagation delay skew between pair i and pair j (in ns/m);

$t_{\mathrm{p}i}$ is the propagation delay of the pair i (in ns/m);

$t_{\mathrm{p}j}$ is the propagation delay of the pair j (in ns/m);

i, j = 1…16 are the pair numbers within the cable.

Intra-pair skew is calculated from the propagation delay between wire "a" and wire "b" within a pair; it is given by Formula (3):

$$t_i = t_{\mathrm{a}} - t_{\mathrm{b}} \tag{3}$$

where

t_i is the intra-pair skew of the pair i (in ps/m);

t_{a} is the propagation delay of the wire "a" within the pair i (in ps/m);

t_{b} is the propagation delay of the wire "b" within the pair i (in ps/m).

The unit of intra-pair is usually ps/m, but other units, for example, ps/10m are also permitted.

5.3.7 Near-end crosstalk (NEXT)

5.3.7.1 General

Near-end crosstalk (NEXT) should be as specified in the family specification or detail specification.

NOTE For single element twinax cable, NEXT is not applicable.

5.3.7.2 Measurement

Near-end crosstalk (NEXT) shall be measured in accordance with IEC TR 61156-1-2.

5.3.8 Differential mode to common mode conversion (Scd21)

5.3.8.1 General

Scd21 shall be as specified in the family specification or detail specification.

Alternatively, common mode to differential mode conversion (Sdc21) is also permitted.

5.3.8.2 Measurement

Scd21 shall be measured in accordance with IEC TR 61156-1-2.

5.3.9 Equal level transverse conversion transfer loss (Scd21-Sdd21)

5.3.9.1 General

Equal level transverse conversion transfer loss shall be as specified in the family specification or detail specification.

Alternatively, equal level longitudinal conversion transfer loss (Sdc21-Scc21) is also permitted when common mode to differential mode conversion (Sdc21) is considered.

5.3.9.2 Measurement

Equal level transverse conversion transfer loss is a calculation of the difference between the differential mode to common mode conversion specified in 5.3.8 and the attenuation specified in 5.3.5.

The length of cable under test in 5.3.8 should be the same as the attenuation measurement length in 5.3.5.

5.4 Mechanical and dimensional requirements and test methods

5.4.1 General

Mechanical and dimensional requirements shall be as specified in the family specification or detail specification.

5.4.2 Measurement of dimensions

The measurement of insulation thickness and sheath thickness shall be in accordance with IEC 60811-201 and IEC 60811-202, respectively; the measurement of overall dimensions shall be in accordance with IEC 60811-203.

5.4.3 Elongation at break of the conductor

The method of measuring the elongation at break of the conductor is specified in IEC 60189-1.

5.4.4 Tensile strength of the insulation

The method of measuring the tensile strength of the insulation is specified in IEC 60811-501.