PROFINET Cabling and Interconnection Technology

Guideline for PROFINET

Version 4.11 – Date October 2019
Order No.: 2.252

File name: PN-Cabling-Guide_2252_V411_Oct19

Prepared by PI Working Group PG1 “Passive Network Components” in Committee B “Technologies”.

In this specification the following key words (in **bold** text) will be used:

may: indicates flexibility of choice with no implied preference.

should: indicates flexibility of choice with a strongly preferred implementation.

shall: indicates a mandatory requirement. Designers **shall** implement such mandatory requirements to ensure interoperability and to claim conformance with this specification.

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Content

Revision Log

Version		Date	Changes/History
1.8	TC2WG6	12-Dec-2002	First draft in PI review
1.96	TC2WG6	31-Aug-2006	Second draft; structure changed, new content
1.99	TC2WG6	05-Oct-2006	WG
2.00	TC2WG6	12-Mar-2007	PI Review finished / Change Requests included
2.01	TC2WG6	03-Mar-2011	First WG Draft (2 and 4 pair Cabling)
2.02	TC2WG6	14-Apr-11	WG
2.03	TC2WG6	14-Apr-11	WG Draft
2.04	TC2WG6	27-Apr-11	Type A,B cable (outer diameter: 9 mm)
2.05	TC2WG6		Editorial revision
2.06	TC2WG6	23-Mai-11	Version for WG meeting 2011-05-26
2.1	TC2WG6	26-Mai-11	WG Draft
2.9	TC2WG6	14-Jun-11	PI Review
3.00	TC2WG6		PI Review finished / Change Requests included
3.01	CB/PG1	15-Nov-11	Final for publishing
3.02	CB/PG1	20-Nov-13	Cabinet cord set specification; M 12 x-coded contact arrangement
3.1	CB/PG1	06-Mar-14	Push Pull Signal, LC Fibre Optic
4.00	CB/PG1	02-Feb-17	M12 L-coded +cable, M8 D-coded, Push Pull LC
4.10	CB/PG1	May 2018	Colour Coding of M12 L and PushPull R cable for robotics applications added
4.11	CB/PG1	01-Oct-19	R Cable specification added

1 Management Summary – Purpose and Scope of the Document

Horizontal communication between automation and field equipment, as well as vertical communication between corporate management level and production, is guaranteed with PROFINET.

This guideline describes the passive infrastructure of PROFINET Networks specified in the IEC 61918 and IEC 61784-5-3 inside and between the automation islands.

In industrial applications networks with 2 pair and 4 pair cabling are required. This document describes techniques and components for 2 and 4 pair cabling. In addition the migration between 2 pair and 4 pair cabling is described.

To fulfil industrial requirements, the industrial installation has to work in industrial environments. This PROFINET guideline describes connectors and cables. The wiring of PROFINET networks has to be realised under system aspects. Compatibility of PROFINET components is necessary to enable easy planning and installation.

This Guideline describes the specification for:

- Connectors, cables, cordsets and other passive network components (e.g. Bulkheads) for PROFINET Data (Optical Fibre and balanced cabling for PROFINET communication)
- Connectors, cables and other passive network components (e.g. T-pieces) for PROFINET 24 Volt power supply
- Connectors and other passive network components (e.g. T-pieces) for PROFINET 400 Volt Power distribution bus
- Device Integration of PROFINET connectors
- Test procedure for the End-to-End link

This Guideline describes the test specification for:

- Connectors, cables, cordsets and other passive network components (e.g. bulkhead) for PROFINET (optical fibre and balanced PROFINET communication)

This PROFINET guideline is intended to be used by:

Manufacturers of PROFINET cables, connectors, devices and manufacturers of test equipment for PROFINET cabling.

2 List of Affected Patents / Certification

Attention is drawn to the possibility that some of the elements of this guideline may be the subject of patent rights as listed below.
The PROFIBUS Nutzerorganisation e.V. (PNO) shall not be held responsible for identifying any or all such patent rights.
Relevant patents are only those which have an impact on mating compatibility.

Affected Patents:
The patent WO 9942877 from company Reichle & De-Massari AG concerns the mating face of the SCRJ FO connector.
PROFIBUS&PROFINET International does not guarantee the completeness of the affectted patents.

For all other connectors the CBPG1 no information is available concerning patents on the mating face.

Passive components are not certified by PI, but the vendor shall give a declaration of conformity to this Guideline.

3 Related Documents and References

Related Documents and References

DIN EN 61076-2-109:2014, Connectors for electronic equipment - Product requirements - Part 2-109: Circular connectors - Detail specification for connectors M12 x 1 with screw-locking, for data transmissions with frequencies up to 500 MHz

EN 50377-6-1:2003, Connector sets and interconnect components to be used in optical fibre communication systems, Product specifications, Part 6-1: Type SC-RJ terminated on IEC

IEC 60050-series: International Electrotechnical Vocabulary

IEC 60060–1: High-voltage test techniques. Part 1: General definitions and test requirements

IEC 60079-11: Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"

IEC 60079-14: Explosive atmospheres – Part 14: Electrical installations design, selection and erection

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

IEC 60332-1-series: Tests on electrical and optical fibre cables under fire conditions

IEC 60364-1: Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, definitions

IEC 60364-4-41: Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock

IEC 60364-4-42: Low-voltage electrical installations - Part 4-42: Protection for safety - Protection against thermal effects

IEC 60364-4-44: Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances

IEC 60364-5-54: Electrical installations of buildings - Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.

IEC 60512-6-3-series:: Connectors for electronic equipment - Tests and measurements - Part 6-3: Dynamic stress tests - Test 6c: Shock

IEC 60512-6-4: Connectors for electronic equipment - Tests and measurements - Part 6-4: Dynamic stress tests - Test 6d: Vibration: sinusoidal

IEC 60603-7-series: Connectors for electronic equipment - Detail specification for 8-way, shielded, free and fixed connectors, for data transmissions

IEC 60603-7: Connectors for electronic equipment - Part 7: Detail specification for 8-way, unshielded, free and fixed connectors

IEC 60664-1: Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests

IEC 60793-2-series:, Optical fibres - Part 2, specification of A1a and A1b multimode fibre

IEC 60793-2-50: Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single–mode fibres

IEC 60794-1-series: Optical fibre cables –: Generic specification – General

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

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 60811-508: 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 60227-2: Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V Part 2: Test methods

IEC 60228: Conductors of insulated cables

IEC 60874-14series: Connectors for optical fibres and cables – all parts 14-x: Detail specification for fibre optic connector type SC

IEC 60950-1: Information technology equipment -Safety- Part 1: General requirements

IEC 60950-1-am1: Amendment 1 - Information technology equipment - Safety - Part 1: General requirements

IEC 60950-21: Information technology equipment -Safety- Part 21: Remote power feeding.

IEC 61000-4 series: Electromagnetic compatibility: EMC, Testing and measurement techniques Parts 4-x ISO 23570-3: Industrial automation systems and integration — Distributed installation

IEC 61000-6-2: Electromagnetic compatibility: EMC) -Part 6-2: Generic Standards -Immunity for industrial environments

IEC 61000-6-4 am1: Electromagnetic compatibility: EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

IEC 61010-1: Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements

IEC 61076-2-101: Connectors for electronic equipment - Product requirements - Part 2-101: Circular connectors - Detail specification for M12 connectors with screw-locking

IEC 61076-2-107: Connectors for electronic equipment – Product requirements – Part 2 107: Detail specification for circular hybrid connectors M12 with electrical and fibre-optical contacts with screw-locking

IEC 61076-3-106: Connectors for electronic equipment - Product requirements - Part 3-106: Rectangular connectors - Detail specification for protective housings for use with 8-way shielded and unshielded connectors for industrial environments incorporating the IEC

IEC 61076-3-117: Connectors for electronic equipment – Product requirements – Part 3 117: Rectangular connectors – Detail specification for protective housings for use with 8-way shielded and unshielded connectors for industrial environments incorporating IEC 60603-7 series interface – Variant 14 related to IEC 61076-3-106 – Push-pull coupling

IEC 61131-2: Programmable controllers - Part 2: Equipment requirements and tests

IEC 61156-2: Multicore and symmetrical pair/quad cables for digital communications - Part 2: Symmetrical pair/quad cables with transmission characteristics up to 100 MHz - Horizontal floor wiring - Sectional specification

IEC 61156-3: Multicore and symmetrical pair/quad cables for digital communications – Part 3: Work area wiring; Sectional specification

IEC 61156-6: Multicore and symmetrical pair/quad cables for digital communications - Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz - Work area wiring - Sectional specific

IEC 61158-2: Digital data communications for measurement and control - Fieldbus for use in

IEC 61300-series Fibre optic interconnecting devices and passive components - Basic test and measurement procedures

IEC 61326-1: Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements

IEC 61326-3-1-series: Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions: functional safety - General industrial applications

IEC 61753-series: Fibre optic interconnecting devices and passive components performance standard

IEC 61754-24: Fibre optic connector interfaces, - Part 24: Type SC-RJ connector family

IEC 61754-24-11: Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 24-11: Type SC-RJ connectors with protective housings based on IEC

IEC 61784-1: Industrial communication networks - Profiles - Part 1: Fieldbus profiles industrial control systems physical layer.

IEC 61784-2: Industrial communication networks - Profiles - Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC

IEC 61784-3: Industrial communication networks - Profiles - Part 3: Functional safety fieldbuses - General rules and profile definitions

IEC 61784-5-3: Industrial communication networks - Profiles - Part 5-3: Installation of fieldbuses - Installation profiles for CPF 3

IEC 61918: Industrial communication networks - Installation of communication networks in industrial premises

IEC 61935-1: Specification for the testing of balanced and coaxial information technology cabling – Part 1: Installed balanced cabling as specified in ISO/IEC 11801 and related Standards

IEC 61935-2: Specification for the testing of balanced and coaxial information technology cabling - Part 2: Cords as specified in ISO/IEC 11801 and related standards

IEC 61984: Connectors - Safety requirements and tests

IEC61156-5: Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Sectional specification

IEC61754-20: Fibre optic connector interfaces – Part 20: Type LC connector family

IEC61754-24-11: Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 24-11: Type SC-RJ connectors with protective housings based on IEC 61076-3-117

ISO 23570-3: Industrial automation systems and integration — Distributed installation in industrial applications — Part 3: Power distribution bus

ISO/IEC 11801-series::20 Information technology –Generic cabling for customer premises

ISO/IEC 14763-2: Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation.

ISO/IEC 24702: Information technology - Generic cabling- Industrial premises

ISO/IEC 24702-AMD 1: Amendment 1 -Information technology - Generic cabling- Industrial premises

ISO/IEC 8802.3: Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 3: Carrier sense multiple access with collision detection: CSMA/CD access method and physical layer specifications

IEC61076-3-101: Connectors with assessed quality, for use in d.c., low-frequency analogue and in digital high-speed data applications - Part 3: Rectangular connectors

IEC 61076-2-111: Connectors for electronic equipment - Product requirements - Part 2-111: Circular connectors - Detail specification for power connectors with M12 screw-l

IEC 61076-2-114: Circular connectors – Detail specification for data and power connectors with M8 screw-locking

IEC/PAS 61076-3-119: Connectors for electronic equipment - Product requirements - Part 3-119: Rectangular connectors - Detail specification for unshielded, free and fixed 10 way connectors with push-pull coupling for industrial environments with frequencies up to 100 MHz

IEC 61076-3-123: Rectangular connector. Detail specification for hybrid connectors for industrial environments, for power supply and fibre optic data transmission, with push-pull locking

PAS IEC 61076-3-series: Rectangular connectors. Detail specification for power connectors for industrial environments with Push-Pull locking

DIS ISO/IEC 14764-3:2017: Information Technology - Implementation and Operation of Customer Premises Cabling – Part 4: Measurement of End-To-End-Link.

IEC 61918: Industrial communication networks – Installation of communication networks in industrial premises

IEC 61784-5-3: Industrial communication networks – Profiles – Part 5-3: Installation of fieldbuses – Installation profiles for CPF 3

IEC 60352-4 Solderless connections - Part 4: Solderless non-accessible insulation displacement connections - General requirements, test methods and practical guidance

IEC 60999-1: Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm2 up to 35 mm2 (included)

4 Definitions and Abbreviations

For definitions and abbreviations see IEC 61918 and IEC 61784-5-3

5 Balanced cabling with 2 or 4 pair-cabling

The decision for 2 or 4 pair cabling is depending on the application.

Decision criteria can be as followed:

	2 pair-cabling	**4 pair-cabling**
Cable design	2 pair-cabling shall be realised as one star-quad or as 2 twisted pair design	4 pair-cabling shall be realised as two star-quad or as 4 twisted pair design
Vendor declaration	Yes	Yes
Devices in the network	PROFINET devices	PROFINET devices and also other IT devices
Max. Channel length	100 m	100 m
Component approach without network calculation applicable	Yes	Yes
Field of application	Specialized and optimized for defined PROFINET automation tasks	Universal use of a PROFINET network for PROFINET and other Ethernet applications, as already described in the planning guide.

Table 5.-1: Decision criteria for 2 or 4 pair cabling

In a PROFINET End-to-End link the transition from a 4 pair balanced cabling into a 2 pair balanced cabling is allowed. Table 9.2.1-3 shows the required contact arrangement.

6 Characterisation of the Environmental Conditions in Production and Field Areas

The environmental conditions and the PROFINET installation classes are defined in IEC 61784-5-3. The following text of this clause is only an informative abstract.

Standard market components for data cabling (cables, plugs, switches etc.) were generally developed for operation in office-type environments. The office environment is covered by existing standards and is not taken into consideration here.
The special environmental conditions in production and field areas call for specially enhanced and rugged components.
Because the same high demands do not exist in all areas in the industrial sector, differentiation has to be made between "inside" and "outside" protected areas from a technical point of view:

- **"Inside"** refers to the environment found in control stations, electronic rooms or inside switch cabinets.
- **"Outside"** refers to higher demands with regard to temperature, dust, moisture, vibration etc. as found when used directly at the field level.

"Inside" and "Outside" do not describe different places in the machine. The only difference is the housing of the electronic equipment.

Table 6.-1 provides a comparison of the general environmental conditions for the passive PROFINET connection system (cable and plug connection) in the two areas.

	Inside enclosure	Outside enclosure
Mechanical		
Shock/bump [a)] Peak acceleration	IEC 60512-6-3, test 6c 20 g / 11 ms 3 per axis in both directions	IEC 60512-6-3, test 6c 50 g / 11 ms 3 per axis in both directions
Vibration 10-500 Hz	IEC 60512-6-4, test 6d 0.35 mm or 5g	IEC 60512-6-4, test 6d 0.35 mm or 5g
Ingress		
IP Protection class	IP20	IP65 and IP67
Climatic		
Ambient temperature	0° C to +70° C b)	-20° C to +70° C b)
Electromagnetic		
Transfer Impedance	See components selection	

a) Bump: the repetitive nature of the shock experienced by the channel shall be taken into account.
b) An additional heating by POE has to be considered by the user.

Table 6.-1: General Environmental Requirements of passive PROFINET Connection Systems (informative chart from IEC 61784-5-3: Edition 4)

7 Connectors and cables for PROFINET

The PROFINET philosophy is to unify the connectors for a safe and easy installation. In order to realise this, only the listed connectors shall be used for PROFINET networks.

The use of these cables and connectors represent a matched system with interoperability.

The connectors can be part of:

- Switch cabinet
- Device
- Cabling between devices
- Connections within a channel
- Controller
- Industrial Outlet
- Network Component
- Sensor, Actuator
- Drive, Motor
- Coupling
- …

The PROFINET Data cabling is referred to as:

- **PROFINET Data connectors and cabling**

  The listed connectors are the specified PROFINET solutions. Other connectors shall not be used for PROFINET applications.

  Vendors only can declare for the listed connectors that fulfil the PROFINET specification a PROFINET vendor conformity declaration.

The integration of the 24 Volt power supply is referred as:

- **PROFINET 24 Volt connectors and cabling**
- **PROFINET Hybrid connector and cabling**

The integration of the signals is referred as:

- **PROFINET Signal connector and cabling**

The listed connector is a preferred PROFINET solution conforming to AIDA requirements.

The integration of the 400 Volt power supply is referred as:

- **PROFINET 400 Volt connector and cabling**

  PROFINET refers to the Power distribution bus standardised in ISO 23570-3. Other connectors can be used for special applications.

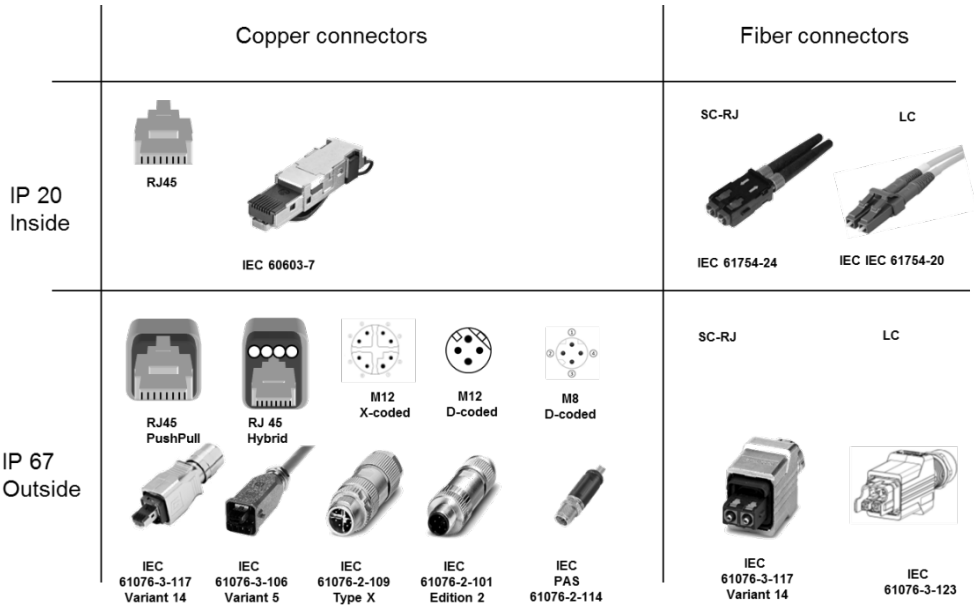


Table 7-1: PROFINET Data Connector overview

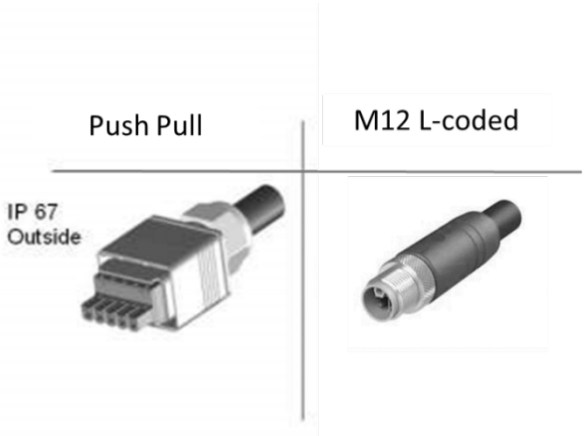


Table 7-2: PROFINET 24 Volt Connector overview

Figure 7-3: PROFINET 400 Volt Connector example

Figure 7-4: PROFINET Signal Connector example

8 Procedure for a PROFINET Conformity Certificate

The conformity testing is only relevant for the PROFINET data connectors and cabling.

Connectors and cables shall fulfil the requirements and standards described in this guideline. To ensure the compatibility of cables and connectors under the PROFINET system, the cables and connectors shall be tested.

The Conformity certificate guarantees that the components have been tested as specified. All tests refer to the inside and outside requirements specified in this guideline.

The product vendors shall issue a conformity certificate through the following procedure.

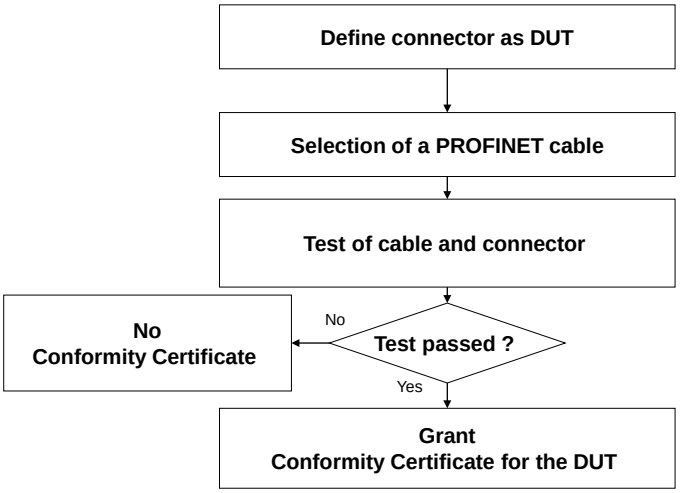


Figure 8-1: Procedure for connectors

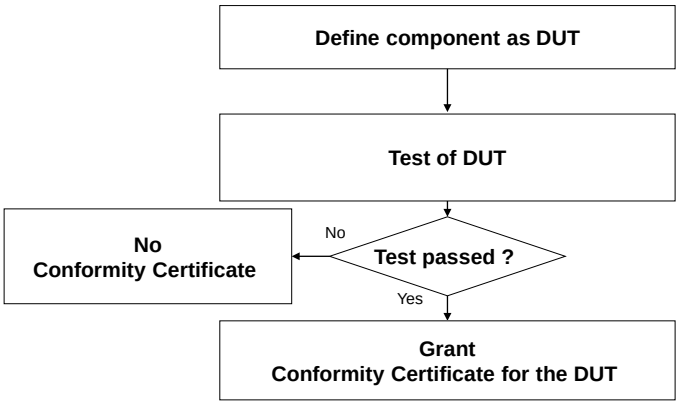


Figure 8-1: Procedure for PROFINET Components, except connectors

The vendor who issues the conformity certificate takes responsibility for the:

- listed cables and connectors or harnessed cables
- performing the test as specified in this guideline
- granting of the conformity certificate

The declaration can be issued unilaterally or bilaterally (e.g. from the cable and/or the connector vendor or the harness maker). Conformity testing is a requirement of PROFINET labelling of the products described in this guideline.

Conformity testing is required for the following components:

- Connectors for PROFINET Data Cabling
- Cables for PROFINET Data Cabling
- Cord sets for PROFINET Data Cabling
- Connectors for PROFINET 24 Volt Cabling
- Cables for PROFINET 24 Volt Cabling
- Cord sets for PROFINET 24 Volt Cabling

The procedure for the declaration is a separate PI document.

The conformity declaration for the listed components is mandatory for PROFINET.

9 Connectors for PROFINET Data Cabling

9.1 Connectors for Inside Environment (Balanced Cabling)

9.1.1 Introduction

For the PROFINET Inside Environment the following connector shall be used:

RJ45 Connector, mating compatible to IEC 60603-7

Application	**Data Cabling** Inside switching cabinet environment	
Cabling type	**2 pair** [2]	**4 pair** [3]
Connector type	RJ45 plug compatible [1]) IEC 60603-7 Edition 3.0 at least IEC 60603-7-3	RJ45 plug compatible [1] IEC 60603-7 Edition 3.0 at least IEC 60603-7-3
Mandatory Number of Contacts Data Power	 4 ---	 8 ---
Rated Voltage [5] Data	57 VDC	
Current (min.) Data	600 mA per contact @ 70°C	
Outer Cable Diameter	5,5 mm to 8,0 mm	5,5 mm to 9,0 mm
Wire Cross Section Data	AWG 22	AWG 22 to 24
Wire Diameter Data	1,4 to1,6 mm	1,0 to 1,6 mm
Wire Construction	Solid / Stranded 4)	
Category	ISO/IEC 11801 Edition 2.0 Amendment 2	
	Category 5	at least Category 5
Shielding	mandatory	
Cable Strain Relief	IEC 61984	
Mating Cycles	Min. 50 (IEC 61984) [6]	
Protection Class Pollution Degree Shock Vibration Operating Temperature Range	see Table 6-1 "Inside enclosure"	

1)RJ-45 pinning compatibility applies only to the pins themselves. For full plug-in compatibility, the shape of the casing of industrial connectors shall also be taken into account. The specified RJ 45 receptacle (Jack) for“Outside” applications has to be mating compatible with the RJ 45 Plug, in accordance with IEC 60 603-7.
2) 2pair or 1 quad
3) 4pair or 2 quad
4) If cables other than AWG 22/7 are used, the conformance to the IDC of the connector is mandatory.
5) As defined by IEC 61984,clause 3.22
6) Mating and Unmating under load (e.g. PoE) not permitted

Table 9.1.1-1: Plug Connector Specifications

9.1.2 Connector for Type C Cables and for Cabinet cord sets

Connectors, which are optimised for the use of type C cable are permitted. These connectors can be matched to the cable in the following parameters:

Outer Cable Diameter, Wire Cross Section, Wire Diameter

All other requirements in Table 10-1: Plug Connector Specifications are not altered. The restricted use of these connectors shall be mentioned in the vendor declaration.

For type C cables the component approach is not supported.

Also connectors, which are harnessed in cabinet cords, can be matched in these parameters. There is no vendor declaration for connectors harnessed in the cabinet cord set.

9.1.2.1 Contact arrangement 2pairs

The contact arrangement of the connectors and the colour coding of the cable is specified as follows:

Signal	Function	Wire Colours	Contact Assignment RJ-45
TD +	Transmit Data +	Yellow	1
TD -	Transmit Data -	Orange	2
RD +	Receive Data +	White	3
RD -	Receive Data -	Blue	6

Table 9.1.2-1: Contact and Wire Assignment 2pairs

The selected contact assignment of the RJ45 is compatible with the Ethernet standard, i.e. compatible with ISO/IEC 8802-3. Four contacts are mandatory for PROFINET, a RJ 45 with eight contacts is also covered by this specification.

Only devices which are designed for use within a protected environment (e.g. Environment Inside) shall be designed with an unprotected RJ45 connector.

9.1.2.2 Contact arrangement 4pairs

The contact arrangement of the connectors and the colour coding of the cable is specified as follows:

Function 2 pair	Wire Colours	Function 4 pair	Wire Colours T568B	Contact Assignment RJ-45
TD +	Yellow	TD/RD 1	White/Green	3
TD -	Orange		Green	6
RD +	White	TD/RD 2	White/Orange	1
RD -	Blue		Orange	2
		TD/RD 3	White/Blue	5
			Blue	4
		TD/RD 4	White/Brown	7
			Brown	8

Function 2 pair	Wire Colours	Function 4 pair	Wire Colours T568A	Contact Assignment RJ-45
TD +	Yellow	TD/RD 1	White/Orange	3
TD -	Orange		Orange	6
RD +	White	TD/RD 2	White/Green	1
RD -	Blue		Green	2
		TD/RD 3	White/Blue	5
			Blue	4
		TD/RD 4	White/Brown	7
			Brown	8

Table 9.1.2-2: Contact and Wire Assignment 4pairs

The selected contact assignment of the RJ45 is compatible with the Ethernet standard, i.e. compatible with ISO/IEC 8802-3 and TIA 568 C0 T Figure T568Bor Figure T568A.

Only devices which are designed for use within a protected environment (e.g. Environment Inside) shall be designed with an unprotected RJ45 connector.

9.1.3 RJ 45 Connector

Selection of RJ45 plug connector products shall comply with the criteria for industrial machinery and equipment. The use of plug connectors with altered technical specifications (for example dielectric strength or connecting system) in comparison with those for office use is stipulated.

Figure 9.1.3-1: Examples of RJ45 Plugs in IP20 with Industrial Performance

9.1.3.1 Qualification Test for Copper Connectors (RJ45 IP20 Connectors)

The Qualification Test shall be performed in accordance with the following standards:

IEC 60603-7 mechanical structure of RJ45

IEC 60603-7-1 introduction of shielding to RJ45

IEC 60603-7-3
Connectors for electronic equipment - Part 7-3: Detail specification for 8-way, shielded, free and fixed connectors, for data transmissions with frequencies up to 100 MHz

IEC 60512-1-100, *Connectors for electronic equipment – Tests and measurements – Part 1-100: General – Applicable publications*

IEC 60352-4 Solderless connections - Part 4: Solderless non-accessible insulation displacement connections - General requirements, test methods and practical guidance

Additional test parameters are described in the IEC 61784-5-3**.**

The plug for Inside Environment shall be pluggable to the jack in the protective housing specified in 9.3.2 to ensure reverse compatibility. An unprotected plug, which does not fulfil industrial requirements, can be used exceptionally as part of diagnosis or commissioning.

9.2 Internal Device Connectivity for PROFINET Process devices

Process devices with a PROFINET connection are used in a variety of applications. The interface must meet the transfer-related requirements for PROFINET. These include the properties defined by PROFINET for a connection terminal.

In addition to the PROFINET requirements, there are the requirements for the specific application in the process automation environment. If the requirements (e.g. Atex) are stricter than the PROFINET requirements, they should take priority. These application-specific requirements are not defined in the PROFINET guidelines.

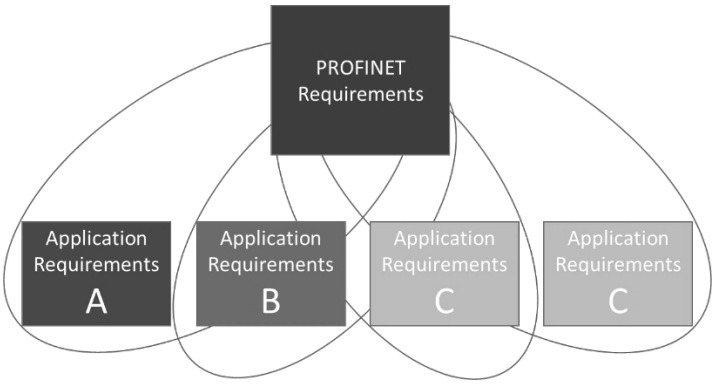


Figure 9.2-1: Diagram of interaction between PROFINET requirements and application requirements.

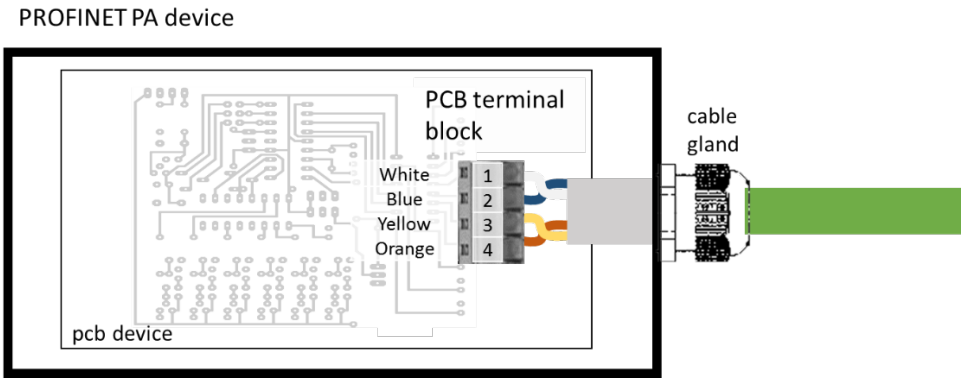
9.2.1 Applications

The fixed connection is used for device connectivity inside field devices in process automation. The PROFINET connection in PA devices consists of the terminal used in the device in combination with the areas of the device designed for the cable connection, plus the shield connection and a suitable strain relief mechanism (e.g. cable gland). The terminal is described as a PROFINET-compliant component and PROFINET compliance is guaranteed by means of a manufacturer declaration. Guidelines are defined for the device connection.
Only the combination of a PROFINET-compliant terminal and a shield connection designed in accordance with the guidelines guarantees a PROFINET-compliant connection for which the manufacturer of the device takes responsibility.

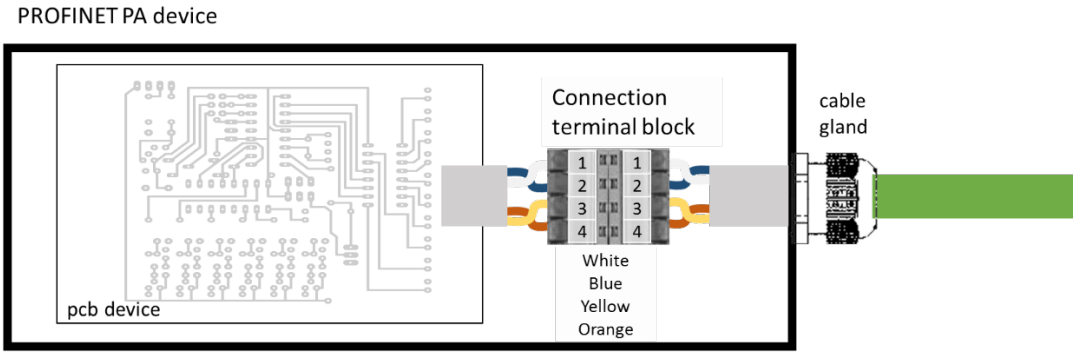
9.2.2 Connection terminal variations

There are two variants of the PROFINET connection terminal:

- PCB terminal block inside the device with direct connection to the PROFINET cable (example 2 pair).



- Connection terminal block inside a device for connection of internal and external PROFINET cables (example 2 pair).



9.2.2.1 PROFINET requirements for the connection terminals

The contact arrangement of the termination and the colour coding of the cable is specified as follows:

Function 2 pair	**Wire Colours**	**Function 4 pair**	**Wire Colours** T568A	**Wire Colours** T568B	**Terminal Block 2pair/4pair**
TD +	Yellow	TD/RD 1	White/Orange	White/Green	**3**
TD -	Orange		Orange	Green	**4**
RD +	White	TD/RD 2	White/Green	White/Orange	**1**
RD -	Blue		Green	Orange	**2**
		TD/RD 3	White/Blue	White/Blue	7
			Blue	Blue	8
		TD/RD 4	White/Brown	White/Brown	5
			Brown	Brown	6

Table 9.2.1-3: Contact and Wire Arrangement 2/4 pair

Shielding / EMC and mechanical design (properties of PROFINET-compliant device connection)

Requirement	Comment:
The position and execution of the shield connection is defined in the device design. The electric parameters of the shield connection must comply with ISO/IEC 11801-1.	The device manufacturer is responsible for a clean shield connection. It defines "Met by Design"
The device must be fitted with a strain relief appropriate to the application.	The strain relief must be designed such that the requirements of the shield connection are complied with
The shield connection must be tailored to the balanced PROFINET 2/4 pair cable specified.	

Table 9.2.2-1: Shielding / EMC

Ethernet transfer (property of PROFINET-compliant terminal)

Requirement	Comment:
Component requirement as per Category 5 in accordance with ISO IEC 11801-series (Connecting hardware)	The electrical approval of the transfer parameters is in analogy as a "mated pair". (Plug-in connector)
PROFINET cable with 2/4 pair is implemented in line with PROFINET Cabling and Interconnection Technology Guideline Balanced 2/4 pair Cables (Type A,B,C).	Additional contacts for further I/Os and power supply are not defined
Identification of contact points with known PROFINET cable colour assignment	See PROFINET Cabling and Interconnection Technology Guideline Chapter: Balanced 2/4 pair Cables (Type A,B,C)
A transfer of POE plus in accordance with IEEE 802.3at-2009 is required.	Additional heating as a result of POE plus me considered by the user
Voltage proof Conditions: IEC 60512, Test 4a, Method A. Standard atmospheric conditions. 1 000 V rms, contact-to-contact. 1 500 V rms, contact to shield.	The contact-to-contact test must be evidenced by the terminal manufacturer If applicable, the contact to shield test must be evidenced by the device manufacturer.
The requirements of IEC 60664-1 (insulation coordination) must be taken into consideration	

Table 9.2.2-2: Ethernet transfer

Mechanical, electrical and climatic requirements (property of PROFINET-compliant terminal)

Requirement	Comment:
Shock and vibration Requirements for contact point in accordance with IEC 60512-6-3, Test 6c / 50 g / 11 ms / 3 per axis in both directions Vibration: IEC 60512-6-4, test 6d 0.35 mm or 5g	Referenced from PROFINET Interconnection Guideline Table 6. 1: General Environmental Requirements of passive PROFINET Connection Systems (informative chart from IEC 61784-5-3
Temperature range -20° C to +70° C	

Requirement	Comment:
The contact point must be designed in accordance with IEC 60999-1.	

Table 9.2.2-3: Ethernet transfer Mechanical, electrical and climatic requirements

9.3 Connectors for Outside Environment (Balanced cabling)

9.3.1 Introduction

For the PROFINET Outside Environment one of the following connectors shall be used:

a) Connector variant 14, as defined in IEC 61076-3-117 with RJ45 Connector as defined in IEC 60603-7
b) Connector variant 5, as defined in IEC 61076-3-106 with RJ45 Connector as defined in IEC 60603-7
c) M12-D connector, as defined in IEC 61076-2-101
d) M12- X connector as defined in IEC 61076-2-109
e) M8- D connector, as defined in IEC 61076-2-114

One of these variants a, b,c,d,e shall be the connector at the PROFINET device for Outside Enivronment and the AO (IEC 61918).

Application		**Data Cabling** Outside switching cabinet environment		**Hybrid cabling** Outside switching cabinet environment
Mode		**2 pair**	**4 pair**	
Type		RJ45 plug compatible [1] or M8/M12-D coded	RJ45 plug compatible [1] or M12- X-coded	RJ45 plug compatible [1]
Mandatory Number of Contacts Data Power		4	8	4 4
Rated Voltage	Data Power	57 VDC [2] ---		57 VDC [2] 24 VDC (20,4 ... 28,8 V)
Current (min.)	Data Power	600 mA per contact @ 70°C ---		600 mA 16 A
Outer Cable Diameter		5,5 mm to 8,0 mm	5,5 mm to 9,0 mm	6,0 mm to 12,0 mm
Wire Cross Section	Data Power	AWG 22	AWG 22 to AWG 24	AWG 22 1,5 mm² to 2,5 mm²
Wire Diameter	Data	1,4 to 1,6 mm	1,0 to 1,6 mm	1,4 to 1,6 mm
Wire Construction		Solid / Stranded		
Transmission Performance		ISO/IEC 11801 Edition 2.0 Amendment 2, Class D at least Category 5		
Category (min.)		ISO/IEC 11801 Edition 2.0 Connector Category 5		
Shielding		Yes		
Cable Strain Relief		IEC 61984		
Mating Cycles		min. 50		
Protection Class Pollution Degree Shock Vibration Operating Temperature Range		see Table 6-1 "Outside enclosure"		

1) RJ-45 pinning compatibility applies only to the pins themselves. For full plug-in compatibility, the shape of the casing of industrial connectors shall also be taken into account. The specified RJ 45 receptacle (Jack) for "Outside" applications has to be mating compatible with the RJ 45 Plug, in accordance with IEC 60 603-7.
2) As defined by IEC 61984,clause 3.22

Table 9.2.1-1: Plug Connector Specifications

9.3.1.1 Contact arrangement 2 pair

The contact arrangement of the connectors and the colour coding of the cable is specified as follows:

Function	Wire Colours	Contact Assignment	
		RJ 45	M12/M8-2 pair
TD +	Yellow	1	1
TD -	Orange	2	3
RD +	White	3	2
RD -	Blue	6	4

Table 9.2.1-2: Contact and Wire Assignment 2 pair

The selected contact assignment of the RJ45 is compatible with the Ethernet standard, i.e. compatible with ISO/IEC 8802-3. Four contacts are mandatory for PROFINET, a RJ 45 with eight contacts is also covered by this specification.

Only devices which are designed for use within a protected environment (e.g. Environment Inside) shall be designed with an unprotected RJ45 connector.

9.3.1.2 Contact arrangement 4 pair

The contact arrangement of the connectors and the colour coding of the cable is specified as follows:

Function	Wire Colours T568A	Wire Colours T568B	Contact Assignment RJ-45	Contact Assignment M12-4 pair
TD/RD 1	White/Orange	White/Green	3	3
	Orange	Green	6	4
TD/RD 2	White/Green	White/Orange	1	1
	Green	Orange	2	2
TD/RD 3	White/Blue	White/Blue	5	7
	Blue	Blue	4	8
TD/RD 4	White/Brown	White/Brown	7	5
	Brown	Brown	8	6

Table 9.2.1-3: Contact and Wire Arrangement 4pairs

The selected contact assignment of the RJ45 is compatible with the Ethernet standard, i.e. compatible with ISO/IEC 8802-3 and TIA 568 C0 T Figure T568B or Figure T568A .

Only devices which are designed for use within a protected environment (e.g. Environment Inside) shall be equipped with an unprotected RJ45 connector.

The selected contact assignment of the RJ45 is compatible with the Ethernet standard, i.e. compatible with ISO/IEC 8802-3.

For IP65/67 field devices either a RJ45 or a M12-based solution is possible, depending on the application.

The contact arrangement for the transition of a M12 2 pairs to a M12 4 pairs is specified as follows:

M12 2-pair			M12 4-pair		
TX+	1	yellow	Pair 2	White-Orange	1
TX-	3	orange		Orange	2
RX+	2	white	Pair 3	White-Green	3
RX-	4	blue		Green	4
			Pair 1	White Blue	7
				Blue	8
			Pair 4	White Brown	5
				Brown	6

Table 9.2.1-3: Contact arrangement M12 2 pair to M12 4 pair

9.3.2 RJ45 PushPull Connector

Standardised RJ45-compatible IP67-plug connectors shall be used and the protective housing is described in the following standard:

IEC 61076-3-117

Figure 9.2.2-1: Examples of IP67 PushPull Connector

9.3.2.1 Qualification Test for Copper Connectors (RJ 45 Based IP 67 Connectors)

The Qualification Test shall be performed in accordance with the following standards:

IEC 61076-3-117

IEC 60603-7 mechanical structure of RJ45

IEC 60603-7-1 introduction of shielding to RJ45

IEC 60603-7-3
Connectors for electronic equipment - Part 7-3: Detail specification for 8-way, shielded, free and fixed connectors, for data transmissions with frequencies up to 100 MHz

IEC 60512-1-100, *Connectors for electronic equipment – Tests and measurements – Part 1-100: General – Applicable publications*

IEC 60352-4 Solderless connections - Part 4: Solderless non-accessible insulation displacement connections - General requirements, test methods and practical guidance

9.3.3 M12 Connector

Standardised M12 connectors (IP65/67 or higher) shall be used and are described in the following standards:

D-coded: IEC 61076-2-101
X-coded: IEC 61076-2-109

Devices deploying M12 connectors for PROFINET data shall be fitted with one or both of these connector types.

9.3.3.1 M12 Connector D coded for 2 pair cabling

Figure 9.3.3.1-1: Examples of M12 Connector D coded

A 4-pin plug connector with D coding for Industrial Ethernet shall be applicable for all connection and 2 pair transmission wires. Devices shall be fitted with the appropriate sockets.

For contact and wire assignment, see Figure 9.3.3-2.

Figure 9.3.3.1-2: M12 D-coded contact assignment and coding

D coding shall be used. The dimensions of the plug connector shall comply with the above-mentioned standards.

9.3.3.2 Qualification Test for M12 Connector D coded

The Qualification Test shall be performed in accordance with the following standards:

IEC 61076-2-101 (M12 D-coded)

IEC 61076-2-101/A1

IEC 60512-29-100 (100 MHz)

IEC 60512-1-100, Connectors for electronic equipment – Tests and measurements – Part 1-100: General – Applicable publications

IEC 60352-4 (Solderless connections - Part 4: Solderless non-accessible insulation displacement connections - General requirements, test methods and practical guidance

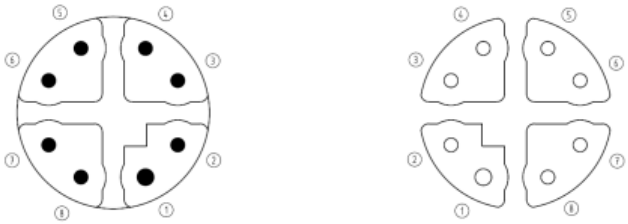
Additional test parameters are described in IEC 61784-5-3 Profile 3/3

Installation Guideline Table 7-1: Plug Connector Specifications for Outside Applications (Data Cabling).

9.3.3.3 M12 Connector X-coded for 2 pair and 4pair cabling

Figure 9.3.3.3-1: Examples of M12 Connectors X-coded

A 8-pin plug connector with X-coding for Industrial Ethernet shall be applicable for all connection and transmission wires. Devices shall be fitted with the appropriate socket connectors.



male female

Figure 9.3.3.3-2: M12 X-coded contact assignment and coding

For contact and wire assignment see Figure 9.3.3-4.

9.3.3.4 Qualification Test for M12 Connector X-coded

The Qualification Test shall be performed in accordance with the following standards:
IEC 61076-2-109 X-coded

Additional test parameters are described in IEC 61784-5-3 Profile 3/3

Installation Guideline Table 7-1: Plug Connector Specifications for Outside Applications (Data Cabling).

9.3.4 M8 Connector D coded

Standardised M8 connectors (IP65/67 or higher) shall be used and are described in the following standards:

D-coded: IEC PAS 61076-2-114
Devices deploying M8 connectors for PROFINET data shall be fitted with this connector type.

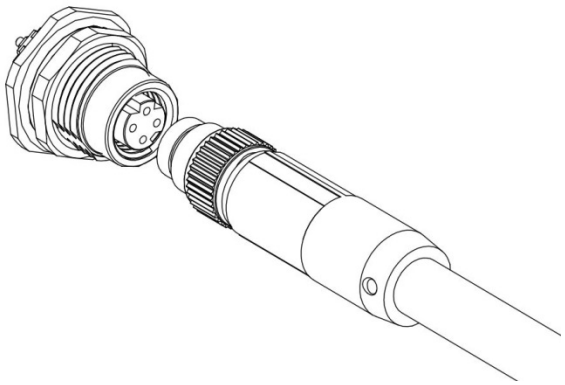
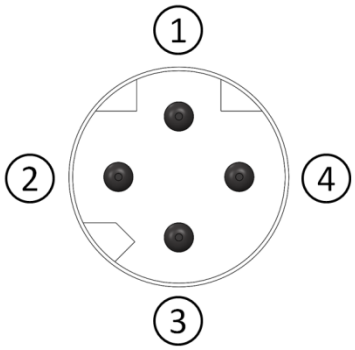


Figure 9.3.4-1: Example of M8 Connector D coded

A 4-pin plug connector with “D“ coding for Industrial Ethernet shall be applicable for all connection and 2 pair transmission wires. Devices shall be fitted with the appropriate sockets.

For contact and wire assignment see Figure 9.3.4 2.

Male connector



Female connector

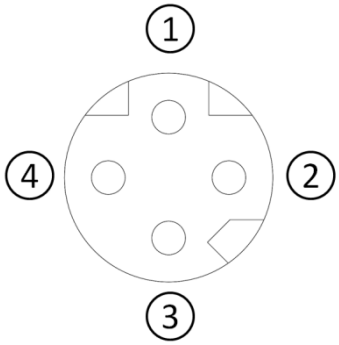


Figure 9.3.4-2: M8 D-coded contact assignment and coding

The dimensions of the plug and socket connector shall comply with the above-mentioned standards.

9.3.4.1 Qualification Test for M8 Connector D coded

The Qualification Test shall be performed in accordance with the following standards:

IEC PAS 61076-2-114 (M8 D-coded)

IEC 60512-29-100 (100 MHz)

IEC 60512-1-100, Connectors for electronic equipment – Tests and measurements – Part 1-100: General – Applicable publications

IEC 60352-4 (1994-09) Solderless connections - Part 4: Solderless non-accessible insulation displacement connections - General requirements, test methods and practical guidance

Additional test parameters are described in IEC 61784-5-3 Profile 3/3

Installation Guideline Table 7-1: Plug Connector Specifications for Outside Applications (Data Cabling).

9.3.5 Connectors for Hybrid Cabling

Standardised RJ45-compatible IP67 plug connectors shall be used and are described in the following standard:
IEC 61076-3-106 – RJ 45 - Industrial RJ45 Variant 05

Figure 9.3.5-1: Example of a Hybrid Plug Connector

The hybrid plug connector is to be used where decentralized field devices are to be connected via combined plug connector for data and power supply. A complete contact-protected plug connector enables the use of the same plug connectors at both ends because no pin-socket change is necessary.

9.3.5.1 Qualification Test for Hybrid Connectors (RJ 45 Based IP 67 Connectors)

The Qualification Test shall be performed in accordance with the following standards:

IEC 61076-3-106

Additional test parameters are described in the Draft IEC 61784-5-x Profile 3/3
Installation Guideline Table 7-1: Plug Connector Specifications for Outside Applications (Data Cabling and Hybrid Cabling).

9.4 Connectors for Inside Environment (optical fibre)

9.4.1 Introduction

The connection of optical fibre cables and device shall be made with SC-RJ or LC connector system:

- a SC-RJ connector system (POF, PCF) inside and outside environment.
- a LC connector system (Multimode, Singlemode) only inside environment

The connection of optical fibre cables with each other shall be made with SC-RJ or LC connector system.

- a SC-RJ connector system (POF, PCF, Multimode, Singlemode) inside and outside environment.
- a LC connector system (Multimode, Singlemode) only inside environment

Socket type connections must be used for appliance and information-system connections. Connecting cables (unit connection cable, equipment cable, patch cords) must be fitted accordingly with plugs at both ends.

Mechanical and optical characteristics	**Requirement**	**Component or test standard**
Physical dimensions		
	Mating dimensions and gauge	ISO/IEC 61754-24
Cable termination compatibility		
Nominal cladding diameter	POF 1000 µm PCF 230 µm Glass 125 µm	IEC 60793-2 A4a A3c A1a, A1b and B1
Nominal secondary coating diameter	POF n.a. PCF 0,5 mm Multimode 1,4 mm Singlemode 1,4 mm	
subcable diameter	POF/PCF 2,2 mm Multimode 2,9 mm Singlemode 2,9 mm	
Outer cable diameter	No requirements	
Mechanical endurance (durability) cycles	min. 50	IEC 61300-2-2
Mated pair transmission performance		
Maximum insertion loss	POF/PCF 1,5 dB Multimode 0,75 dB Singlemode 0,75 dB	IEC 61300-3-34
Minimum return loss	POF/PCF n.a. Multimode 20 dB Singlemode 35 dB	IEC 61300-3-6
Ambient conditions:		
Pollution degree Shock Vibration Operating temperature range	see Table 6-1 "Inside enclosure"	

Table 9.3.1-1 – Mechanical and optical characteristics of optical fibre connecting hardware for "inside" environment

9.4.2 SC-RJ Connector

9.4.2.1 Specification of SC-RJ Connector

The SC-RJ Connector is the main connector for PROFINET POF and PCF fibre connections. The connector is described in EN 50377-6-1, ISO/IEC 61754-24.

PROFINET requirements are shown in Table 9.3.1-1.

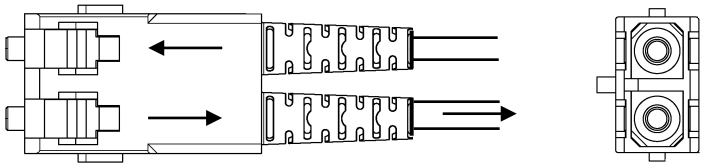


Figure 9.3.2-1: SC-RJ Connector

9.4.2.2 Qualification test of SC-RJ Connector

The connector under test shall be terminated onto PROFINET optical fibre cable as specified in clause 9.2. of this guideline.

A full set of tests as specified in ISO/IEC 61753-series shall be carried out for all fibre types for which PROFINET compliance is claimed. The test load of each test shall meet ISO/IEC 61753 or PROFINET requirements of Table 9.3.1-1 whichever is severe.

All test methods shall be in accordance with the IEC 61300 series of standards.

9.4.3 LC Connector

9.4.3.1 Specification of LC Connector

The LC Connector is the main connector for PROFINET multi and single mode glass fibre connections. The connector is described in IEC 61754-20.

PROFINET requirements are shown in Table 9.3.1-1.

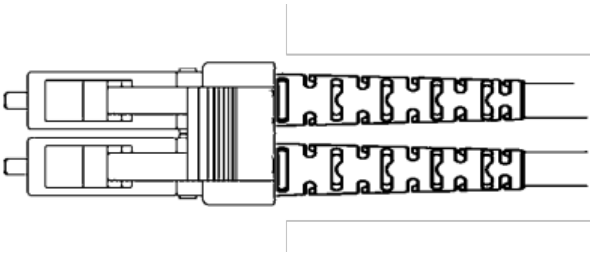


Figure 9.3.3-1: LC Connector

9.4.3.2 Qualification test of LC Connector

The connector under test shall be terminated onto PROFINET optical fibre cable as specified in clause 9.2. of this guideline.

A full set of tests as specified in ISO/IEC 61753-series shall be carried out for all fibre types for which PROFINET compliance is claimed. The test load of each test shall meet ISO/IEC 61753 or PROFINET requirements of Table 9.3.1-1 whichever is severe.

All test methods shall be in accordance with the IEC 61300 series of standards.

9.4.4 Additional Fibre connectors for existing installations

Optical fibre connector types BFOC/2.5 (IEC 60874-10) and SC-Duplex (IEC 60874-14) may be used as an additional alternative to connect existing installations. Both connector types are not recommended for new designs. The connectors used shall also meet IEC 61753 and PROFINET requirements in table 9.3.1-1.

9.5 Connectors for Outside Environment (optical fibre)

9.5.1 Introduction

The connection of optical fibre cables and device or optical fibre cables with each other shall be made with the SC-RJ Push Pull OF connector system or with M12 OF connector system.
Socket type connections must be used for appliance and information-system connections. Connecting cables (unit connection cable, equipment cable, patch cords) must be fitted accordingly with plugs at both ends.

Mechanical and optical characteristics	**Requirement**	**Component or test standard**
Physical dimensions		
Mating dimensions and gauging	SC-RJ Push Pull OF connector M12 OF connector	ISO/IEC 61754-24-2
Cable termination compatibility		
Nominal cladding diameter	 POF 1000 µm PCF 230 µm Glass 125 µm	IEC 60793-2 A4a A3c A1a, A1b and B1
Nominal secondary coating diameter	POF n.a. PCF 0,5 mm Multimode 1,4 mm Singlemode 1,4 mm	
subcable diameter	POF/PCF 2,2 mm Multimode 2,9 mm Singlemode 2,9 mm	
Outer cable diameter	Max. 9,5 mm	
Mechanical endurance (durability) cycles	 ≥50	IEC 61300-2-2
Mated pair transmission performance		
Maximum insertion loss	POF/PCF 1,5 dB Multimode 0,75 dB Singlemode 0,75 dB	IEC 61300-3-34
Minimum return loss	POF/PCF n.a. Multimode 20 dB Singlemode 35 dB	IEC 61300-3-6
Ambient conditions:		
Pollution degree Shock Vibration Operating temperature range	see Table 6-1 "Outside enclosure"	

Table 9.4.1-1 – Mechanical and optical characteristics of optical fibre connecting hardware for "outside" environment

9.5.2 SC-RJ Push Pull connector

9.5.2.1 Specification of SC-RJ Push Pull Connector

The SC-RJ connector with push pull housing is the main connector in harsh environments for PROFINET optical fibre connections and offers a universal system in conjunction with the IP20 environment. The connector is described ISO/IEC 61754-24-2.
The SC-RJ Push Pull OF connector is shown in Figure 9.4.2-1; dimensions are for orientation only.
PROFINET requirements are shown in Table 9.4.1-1.

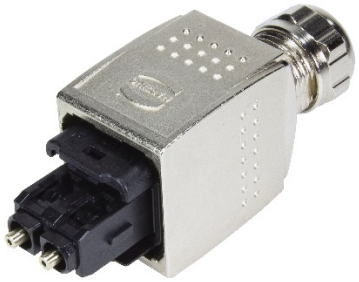


Figure 9.4.2-1: Example of SC-RJ Push Pull Connector

9.5.2.2 Qualification test of SC-RJ Push Pull connector

The connector under test shall be terminated onto PROFINET optical fibre cable as specified in clause 9.2. of this guideline.

A full set of tests as specified in the ISO/IEC 61753-series shall be carried out for all fibre types for which PROFINET compliance is claimed. The test load of each test shall meet either ISO/IEC 61753 or the PROFINET requirements in Table 9.4.1-1 whichever is more severe.

All test methods shall be in accordance with the IEC 61300 series of standards.

9.5.3 LC Push Pull connector

9.5.3.1 Specification of LC Push Pull Connector

The LC connector with push pull housing is an additional connector in harsh environments for PROFINET optical fibre connections and offers a universal system in conjunction with the IP20 environment. The connector is described in IEC 61076-3-123.
The LC Push Pull OF connector is shown in Figure 9.5.3-1; dimensions are for orientation only.
PROFINET requirements are shown in Table 9.4.1-1.

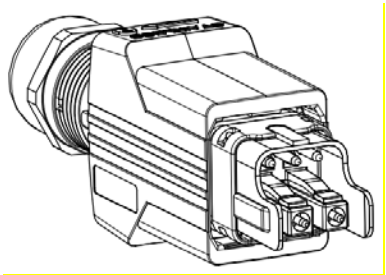


Figure 9.5.3-1: Example of LC Push Pull Connector

9.5.3.2 Qualification test of LC Push Pull connector

The connector under test shall be terminated onto PROFINET optical fibre cable as specified in clause 9.2. of this guideline.

A full set of tests as specified in the IEC 61076-3-123 shall be carried out for all fibre types for which PROFINET compliance is claimed. The test load of each test shall meet either IEC 61076-3-123 or the PROFINET requirements in Table 9.4.1-1 whichever is more severe.

All test methods shall be in accordance with the IEC 61300 series of standards.

10 Device Integration of PROFINET Data Connectors

10.1 Device Integration Balanced Cabling:

Typical PROFINET devices have more than one port, because a switch is integrated, bus devices with one port are allowed.

One port:
The device is equipped with a shielded cable jack. In any case, the connection between the shield of the connector and an equipotential has to be provided.
(For example, a separate shield connection can be designed on the device for equipotential bonding.)

Multiple ports:
As one port, and in addition, a EMC proof connection between the shielding of the ports is mandatory.

Only shielded device sockets shall be used. The socket shall meet or exceed the Category 5 ISO/IEC 11801 requirements. The devices have to comply with the Inside / Outside Environment conditions according to IEC 61784-5-3.

10.1.1 Connectors for Inside Environment

• RJ 45 Connector:

Only RJ 45 in accordance to IEC 60603-7-x shall be used. (Shielded + minimum category 5 ISO/IEC 11801)

10.1.2 Connectors for Outside Environment

• RJ45 Push Pull connector:

Only RJ 45 in accordance to IEC 60603-7-x shall be used. (Shielded + minimum category 5 ISO/IEC 11801)
The data required for mating compatibility is specified in IEC 61076-3-107. The compliance to this standard is ensured by the device manufacturer.

Design rules for the connector integration:

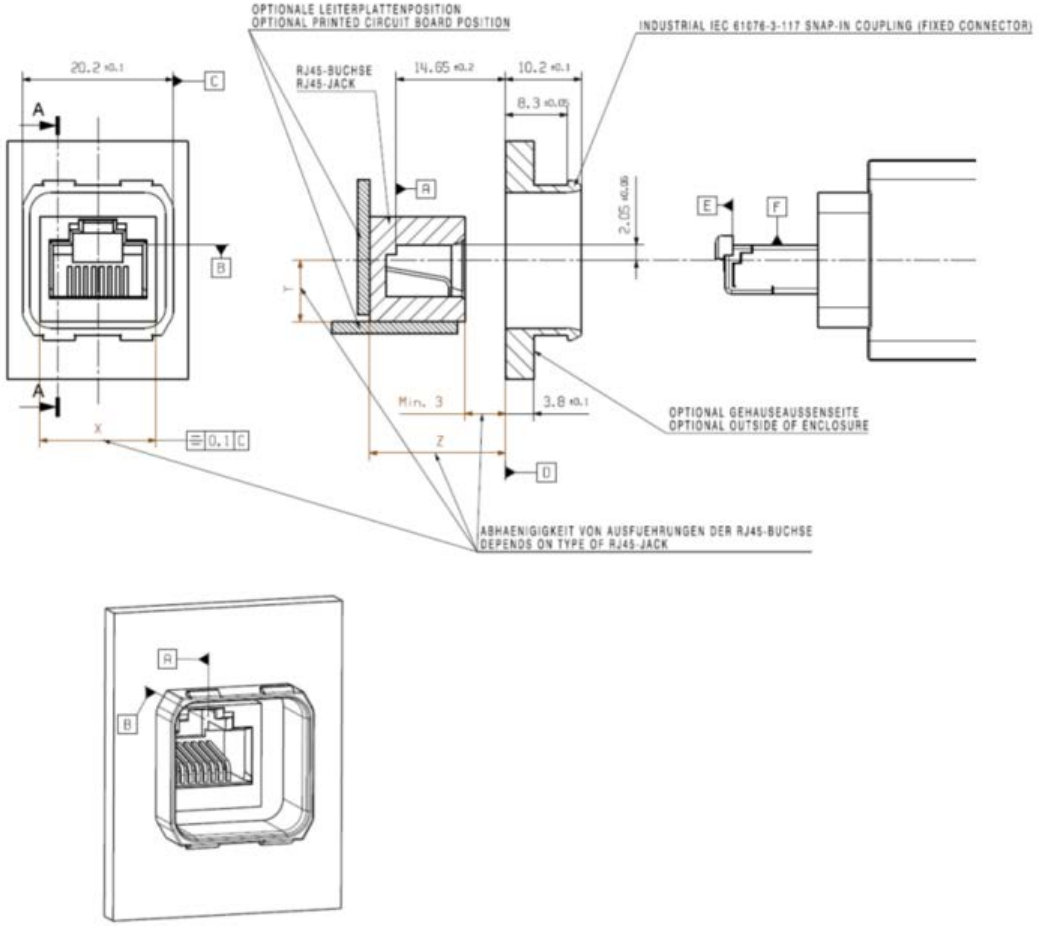


Figure 10.1.2-1: Design Rules for Push Pull RJ45 connector

- **M12 D-coded connector:**

Only a connector in accordance with IEC 61076-2-101 shall be used.

- **M12 X-coded connector:**

Only a connector in accordance with IEC 61076-2-109 shall be used.

- **M12 L-coded connector:**

Only a connector in accordance with IEC 61076-2-111 shall be used.

- **M8 D-coded connector:**

Only a connector in accordance with IEC PAS 61076-2-114 shall be used.

- **PushPull Power connector:**

Only a connector in accordance with IEC-PAS 61076-3-1xx shall be used.

10.2 Device Integration Optical Cabling:

10.2.1 Connectors for inside environment

• **SC- RJ connector:** Only a SCRJ connector or a transceiver with mating face in accordance with IEC 61754-24 shall be used.

• **LC connector:** Only a LC connector or a transceiver with mating face in accordance with IEC 61754-20 shall be used.

• **FC connector:** Only a LC connector or a transceiver with mating face in accordance with IEC 61754-20 shall be used.

10.2.2 Connectors for outside environment

• **SC- RJ Push Pull connector:** Only a SCRJ connector or a transceiver with mating face in accordance with IEC 61754-24 shall be used. The data required for mating compatibility to the Push Pull housing is specified in IEC 61076-3-107. The compliance to this standard is ensured by the device manufacturer.

Design rules for connector integration:

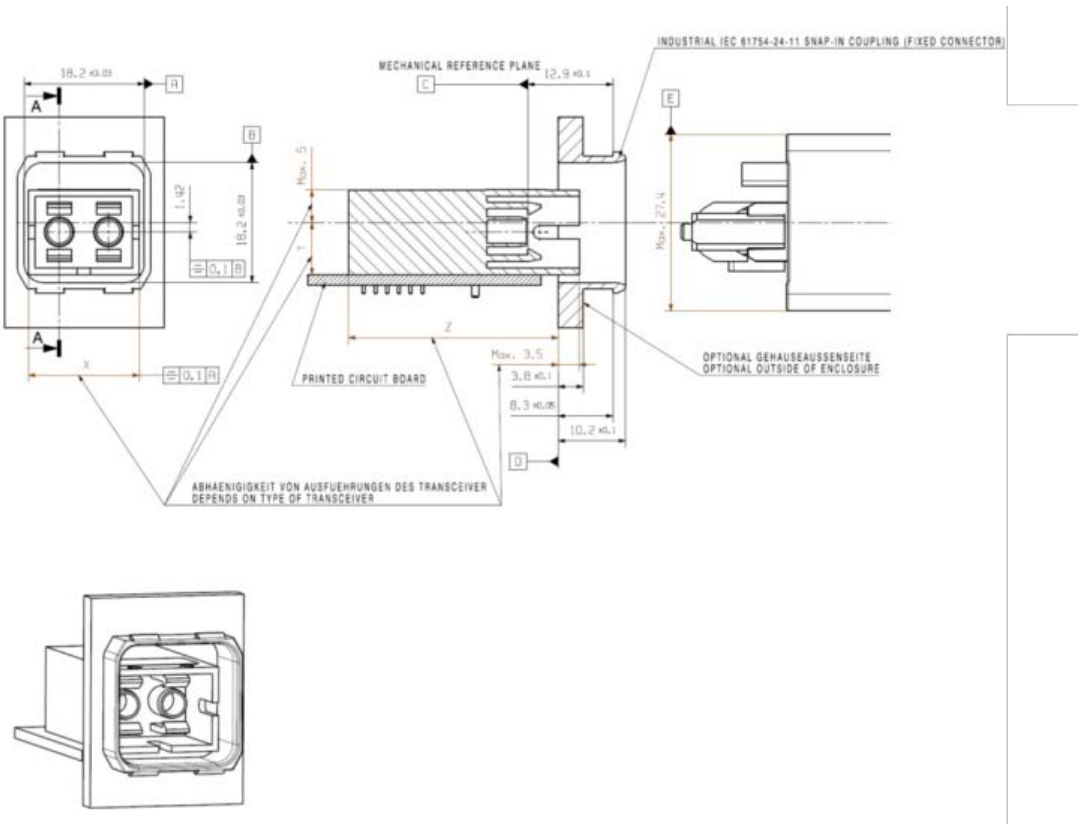


Figure 10.2.2-1: Design for SC- RJ Push Pull Connector

- **SC- RJ connector:** Only a LC connector or a transceiver with mating face in accordance with IEC IEC 61754-20 shall be used.

- **LC Push Pull connector:** Only a LC Push Pull connector or a transceiver with mating face in accordance with IEC 61076-3-123 shall be used. The compliance to this standard is ensured by the device manufacturer.

11 Cables for PROFINET Data Cabling

11.1 Balanced Cables

PROFINET cables used are minimum based electrically on category 5 balanced LAN cables according to ISO/IEC 11801 Edition 2.0.Class D.

In industrial applications networks with 2 pair and 4 pair cabling are required.

- The 2 pair cabling shall be realised as one star-quad or as 2 twisted pair design.
- The 4 pair cabling shall be realised as two star-quad or as 4 twisted pair design.

In special applications (e.g. the use of trailing cables and frequently moved machine parts), cables are permitted whose design and mechanical parameters can deviate from the specifications of type A and type B cable (see Table 10.1.1, while retaining most of the electrical parameters (impedance levels etc.)). These cables are type C cables. Highly flexible copper cables generally have the finest stranded conductors and, for example, a highly resistant polyurethane outer sheath.
Especially for use in robots Type R is created. Due to torsion stress in the application special design is necessary. Additionally we have defined requirements for a mechanical test.

Various outer sheath materials are permitted in order to meet the various demands with regard to flame retardancy, resistance of industrial environments and exterior/underground laying (natural and synthetic oil, grease, coolants/lubricants, chemicals, high and low temperatures, UV radiation).
The cable and used materials shall comply to national, European and international regulations.

Industrial-type plug connectors type RJ45, protection type IP67, or a tried and tested industrial round plug connector M12, minimum category 5, are to be used as plug connectors.
All balanced cables used shall comply with the parameters as described in 10.1-1.

11.1.1 Balanced 2 pair Cables (Type A, B ,R ,C)

2 pair Cable Type	**Application Type A**	**Application Type B**	**Application Type R**	**Application Type C**
Design	2 pair Data Cable	2 pair Data Cable	2 pair Data Cable	2 pair Data Cable
Cable Installation Type	Stationary, no movement after installation	Flexible, occasional movement or vibration	Cable for robot applications	Special applications
System Concept:				
Cable Marking (at least)	“PROFINET Type A”	“PROFINET Type B”	“PROFINET Type R”	“PROFINET Type C”

Conductor Diameter or Cross Section	AWG 22/1 ≥0,610mm	AWG 22/7 ≥0,318mm²	AWG 22/.. ≥0,318mm²	AWG 22/.. ≥0,318mm²
Outer Cable Diameter	5,5 - 8,0 mm		5,5 - 8,0 mm	Application specific
Wire Diameter	1,4 ±0,2 mm		1,4 ±0,2 mm	Application specific
Colour (Outer Sheath)	Green RAL6018		Green RAL6018 (preferred)	Green RAL6018 (preferred)
Wire identification (colours) star quad 2 pair	white, yellow, blue, orange Pair 1: white (RXD+), blue (RXD-); Pair 2: yellow(TXD+), orange(TXT-)			
Number of Wires	4			
Cable Design	2 pairs or 1 star quad			
Shielding Design Type	Aluminium Foil + Copper Braiding		Suitable for robot applications metal tape with 100 % coverage screen of copper wires: optical coverage minimum 85 % for braid and minimum 90% for spiralized (preferred braided screen)	Application specific
Which Plug for which Cable Type	RJ45 (IP 20 or IP 65/67) / M12, M8			
Transmission Performance Requirements:				
Relevant Standard	ISO/IEC 11801 Edition 2.0, IEC 61156-1, IEC 61156-5 (minimum Category 5)		ISO/IEC 11801 Edition 2.0, IEC 61156-1, IEC 61156-6 (minimum Category 5)*	ISO/IEC 11801 Edition 2.0, IEC 61156-1, IEC 61156-6 (minimum Category 5)*
Delay Skew:	<=20ns/100m			
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz; Segregation class d acc. EN 50174-2			
Ambient Conditions:				
Tensile performance of the cable	50 N			
Crush test of the cable	3000 N	3000 N	Application	Application
Pollution Degree Shock Vibration Operating Temperature Range	see Table 6-1 "Outside enclosure"	see Table 6-1 "Outside enclosure"	see Table 6-1 "Outside enclosure" and additional requirements for robot applications	see Table 6-1 "Outside enclosure"
	* Restriction of the component approach is possible according to the specification of the cable manufacturer (reduction of the E2E link length shall be defined by the vendor in the cable specification).			

Note: AWG dimensions are given for information only; normative dimensions of conductor sizes are given in metric size, i.e. in mm for the diameter of solid conductors and mm² for the cross section of stranded conductors.

Table 11.1-1: Balanced 2 pair Cable Specification

The wire assignment of the star-quad cable is indicated by the following colour coding:

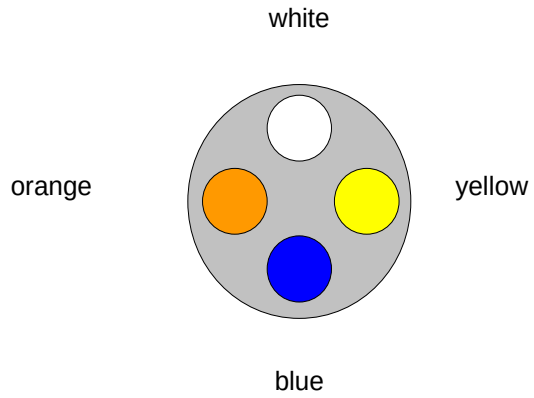


Figure 11.1-1: Wire Assignment of Star-Quad Cables

The following parameters shall preferably adhere to:

- Sheathing materials suitable for the intended application
- Flame retardancy in accordance with IEC 60332-1
- Materials for special applications materials free of substances destructive to lacquer-coatings (e.g. silicone)

11.1.2 Balanced 2 pair Hybrid Cables (Type B,C)

Hybrid cables contain wires for signals transmission and power supply.

- Cu/Cu design (4 wire data transmission / 4 wire for power transmission).

2 pair Cable Type	Application Type B	Application Type C
Design	2 pair Hybrid Cable	2 pair Hybrid Cable
Cable Installation Type	Flexible, occasional movement or vibration	Special Applications (e.g. highly flexible, permanent movement, vibration or torsion)
System Concept:		
Number of Wires Data Power	 4 4	 4 4
Conductor Cross Section Data Power	 AWG 22/7, ≥0,318mm² 1,5 mm²	 AWG 22/.., ≥0,318mm² 1,5 mm²

Cable Marking (at least)	“PROFINET Hybrid Type B”		“PROFINET Hybrid Type C”
Outer Cable Diameter	8,0 ... 12,0 mm		
Wire Diameter Data Power	1,4 ± 0,2 mm 2,4+/-0,2mm		Application Specific
Colour (Outer Sheath)	Green RAL6018		Application Specific
Wire Identification (Colours) Star Quad 2 Pair Power	White, Yellow, Blue, Orange Pair 1: White, Blue Pair 2: Yellow, Orange Black with numbers 1,2,3,4		
Cable Design	2 pairs or 1 star quad + 4 power wires		
Screening Design Type	Aluminium Foil + Copper Braiding (Data Wires)		Application specific
Which Plug for which Cable Type	RJ45 (hybrid)		
Transmission Performance Requirements (Data Wires):			
Relevant Standard	ISO/IEC 11801 Edition 2.0, IEC 61156-1, IEC 61156-5 (minimum Category 5)		
Delay Skew:	<=20ns/100m		
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz Segregation class d acc. EN 50174-2		
Ambient Conditions:			
Tensile performance of the cable	50 N		Application specific
Crush test of the cable	3000 N	3000 N	Application
Pollution Degree Shock Vibration Operating Temperature Range	See Table 6-1 "Outside enclosure"		
Maximal Current in each Power-Wire:	For T<=55°C: 16A For T>55°C the current is not specified but may be indicated in the relevant detailed specification of the cable manufacturer (derating diagram)		

Note: AWG dimensions are given for information only; normative dimensions of conductor sizes are given in metric size, i.e. in mm for the diameter of solid conductors and mm² for the cross section of stranded conductors.

Table 11.2-1: 2 pair Hybrid Cable Specification

Note:

The possible channel length of the hybrid cable depends on the power consumption of the connected devices.

11.1.3 Balanced 4 pair Cables (Type A,B,C)

4 pair Cable Type	Application Type A	Application Type B	Application Type C
Design	4 pair Data Cable	4 pair Data Cable	4 pair Data Cable
Cable Installation Type	Stationary, no movement after installation	Flexible, occasional movement or vibration	Special Applications (e.g. highly flexible, permanent movement, vibration or torsion)
System Concept:			
Cable Marking (at least)	"PROFINET Type A 4 pair CATx"	"PROFINET Type B 4 pair CATx"	"PROFINET Type C 4 pair CATx"
Minimum Conductor Diameter or Cross Section	AWG 23/1 ≥0,546mm	AWG23/7 ≥0,254mm²	≤AWG 24/.. ≥0,485mm for solid conductors ≥0,201mm² for stranded conductors
Outer Cable Diameter	5,5 ...9,0 mm		Application specific
Wire Diameter	1,0 mm to 1,6 mm		Application specific
Colour (Outer Sheath)	Green RAL6018		Application
Wire Identification (colours) 4 pair	White/(Orange), Orange White/(Green), Green White/(Blue), Blue White/(Brown), Brown Ring or stripe marking on the white wire is optional		
Number of Wires	8		
Cable Design	4 pairs		

Shielding Design Type	Aluminium Foil + Copper Braiding		Application
Which Plug for which Cable Type	RJ45 (IP 20 or IP 65/67) / M12 4pair		
Transmission Performance Requirements:			
Relevant Standard	ISO/IEC 11801 Edition 2.0, IEC 61156-1, IEC 61156-5 (min. Category 5)		ISO/IEC 11801 Edition 2.0, IEC 61156-1, IEC 61156-6 (min. Category 5)
Delay Skew:	<=20ns/100m between Pair Orange) and Pair Green		
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz segregation class d EN 50174-2		
Ambient Conditions:			
Tensile performance of the cable	50 N		
Crush test of the cable	2000 N	2000N	Application
Pollution Degree Shock Vibration Operating Temperature Range	see Table 6-1 "Outside enclosure"		

Note: AWG dimensions are given for information only; normative dimensions of conductor sizes are given in metric size, i.e. in mm for the diameter of solid conductors and mm² for the cross section of stranded conductors.

Table 11.3-1: Balanced 4 pair Cable Specification

The following parameters shall preferably adhered to:

- Sheathing materials suitable for the intended application
- Flame retardancy in accordance with IEC 60332-1
- Materials for special applications materials free of substances destructive to lacquer-coatings (e.g. silicone)

11.1.3.1 Qualification test for PROFINET copper-cables

The Qualification Test shall be performed in accordance with the following standards:

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

IEC 61156-5 Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000MHz - horizontal floor wiring - Sectional specification

IEC 61156-6 Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000MHz-Work area wiring - Sectional specification

ISO/IEC 11801 : Information technology - Generic cabling for customer premises

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

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 60811-100 Electric and optical fibre cables - Test methods for non-metallic materials - Part 100: General

IEC 60811-203 Part 203: General tests - Measurement of overall dimensions

IEC 60811-401 Part 401: Miscellaneous tests - Thermal ageing methods - Ageing in an air oven

IEC 60811-501 Part 501: Mechanical tests - Tests for determining the mechanical properties of insulating and sheathing compounds

IEC 60811-508 Part 508: Mechanical tests - Pressure test at high temperature for insulation and sheaths

IEC 60811-509 Part 509: Mechanical tests - Test for resistance of insulations and sheaths to cracking (heat shock test)

EN 50289-1-6 Communication cables - Specifications for test methods - Part 1-6: Electrical test methods - Electromagnetic performance

EN 50289-3-16 Part 3-16: Mechanical test methods - Cable tensile performance

EN 50396: Non electrical test methods for low voltage energy cables

Test requirement for 2 pair PROFINET copper-cables are defined in the following table:

Cable Type to be tested	**Test-Title**	**Severity or condition of test**	**Measurement to be performed**	**Requirements**
Type A and B	IEC 11801 cat 5 component	Category 5	IEC 61156-5	Electrical requirement category 5
Hybrid Type B	IEC 11801 cat 5 component	Category 5	IEC 61156-5	Electrical requirement category 5
Type C, R	IEC 11801 cat 5 component	Category 5	IEC 61156-6	Electrical requirement category 5
Hybrid Type C	IEC 11801 cat 5 component	Category 5	IEC 61156-6	Electrical requirement category 5
Type C, R	Conductor resistance	AWG 22/…	IEC 60189-1	<= 62 Ω/km
Type A	Conductor resistance	AWG 22/1	IEC 60189-1	<= 62 Ω/km
Type B	Conductor resistance	AWG 22/7	IEC 60189-1	<= 60 Ω/km
Type A and B	Elongation at break of the insulation		IEC 60811-501	IEC 61156-5
Type A and B	Elongation at break of the sheath		IEC 60811-501	IEC 61156-5
Type A and B	Elongation at break of the sheath after ageing		IEC 60811-401	IEC 61156-5
Type A and B	Tensile strength of the sheath		IEC 60811-501	IEC 61156-5
Type A and B	Tensile strength of the sheath after ageing		IEC 60811-401	IEC 61156-5
Type A and B	Crush test of the cable		IEC 61156-1	3000 N

Type A and B	Flame retardancy		IEC 60332–1-2	Has to pass the test
Type A and B	Sheath pressure test at high temperature		IEC 60811-508	Max. 50 %
Type A and B	Heat shock test		IEC 60811-509	No cracks
Type A, B, R	Wire diameter	1.40+/- 0.20 mm	IEC 60811-203	>=1.20 <=1,60 mm
Type A, B, R	Outer cable diameter	5,5 mm – 8,0 mm	IEC 60811-203	>=5,5 mm, <=8,0mm
Hybrid Type B	Conductor resistance Datawire	AWG 22/7	IEC 60189-1	<= 60 Ω/km
Hybrid Type B	Flame retardancy		IEC 60332–1-2	Has to pass the test
Hybrid Type B	Sheath pressure test at high temperature		IEC 60811-508	Max. 50 %
Hybrid Type B	Heat shock test		IEC 60811-509	No cracks
Hybrid Type C	Conductor resistance Datawire	AWG 22	IEC 60189-1	<= 62 Ω/km
Hybrid Type B and C	Conductor resistance Powerwire	>=1,5 mm²	IEC 60189-1	<= 14 Ω/km
Hybrid Type B and C	Core diameter Datawire	1.4 +/- 0.2 mm	IEC 60811-203	>= 1.20, <=1,6 mm
Hybrid Type B and C	Outer cable diameter	8.0 mm – 12,0 mm	IEC 60811-203	>=8,0 mm, <=12,0mm
Type A, B and Hybrid Type B	Tensile performance of the cable	50 N	EN 50 289-3-16	IEC 61156-5
Type A, B and Hybrid Type B	Colour outer Jacket	green	Visual inspection	RAL 6018
All	Colour Datawire	White, yellow, blue, orange	Visual inspection	IEC 61784-5-x and this PROFINET Guideline
All	Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz	EN50289-1-6	≥ 80 dB at 30 MHz to 100 MHz
All	Operating temperature	-20°C...+70°C		All cable material have to be designed for -20°C...+70°C
All	Differential delay / Delay skew		IEC 61156-5	<=20ns/100m
Type R	DC resistance screen	R_{DC}≤14mOhm/m (measured cable length 30m)	IEC 60189-1	≤ 14 mOhm/m after mechanical test according trailing chain/torsion/bending test and after 10A DC (30s)
Type R	Trailing chain test (horizontal)	bending radius: max. 15xD acceleration: min. 10 m/s² speed: min. 180 m/min chain length: min. 5 m		After 5 million cycles: Pass test of IEC 61156-6 (min. Category 5) and no crack of jacket

		cycles: min 5 million		
Type R	Torsion test (vertical)	Torsion stress: ± 180°/m Cycles: min 5 million Weight: 300 g	acc. to DIN EN 50289-3-10	After 5 million cycles: Pass test of IEC 61156-6 (min. Category 5) and no crack of jacket
Type R	Reverse bending test	Bending radius: max. 7xD Weight: 300 g, cycles: min. 1 million	EN 50396 paragraph 6.4	After 1 million cycles: Pass test of IEC 61156-6 (min. Category 5) and no crack of jacket

Table 11.1.3-1: Test requirement 2 pair Balanced Cables

Test requirement for 4 pair PROFINET copper-cables are defined in the following table:

Cable Type to be tested	Test-Title	Severity or condition of test	Measurement to be performed	Requirements
Type A and B	IEC 11801 cat 5 component	Category 5	IEC 61156-5	Electrical requirement category 5
Type C, R	IEC 11801 cat 5 component	Category 5	IEC 61156-6	Electrical requirement category 5
Type A	Conductor resistance	AWG 23/1	IEC 60189-1	<= 85 Ω/km
Type B	Conductor resistance	AWG 23/7	IEC 60189-1	<= 85 Ω/km
Type C, R	Conductor resistance	AWG 24	IEC 60189-1	<= 95 Ω/km
Type A and B	Elongation at break of the insulation		IEC 60811-501	IEC 61156-5
Type A and B	Elongation at break of the sheath		IEC 60811-501	IEC 61156-5
Type A and B	Elongation at break of the sheath after ageing		IEC 60811-401	IEC 61156-5
Type A and B	Tensile strength of the sheath		IEC 60811-501	IEC 61156-5
Type A and B	Tensile strength of the sheath after ageing		IEC 60811-401	IEC 61156-5
Type A and B	Crush test of the cable		IEC 61156-1	2000N
Type A and B	Flame retardancy		IEC 60332–1-2	Has to pass the test
Type A and B	Sheath pressure test at high temperature		IEC 60811-508	Max. 50 %
Type A and B	Heat shock test		IEC 60811-509	No cracks
Type A and B	Core diameter	1,0 … 1,6 mm	IEC 60811-203	>=1,0 mm, <=1,6 mm
Type A and B	Outer cable diameter	5,5 … 9,0 mm	IEC 60811-203	>=5,5 mm, >=9,0 mm

Type A and B	Tensile performance of the cable	50N	EN 50 289-3-16	IEC 61156-5
Type A and B	Colour outer Jacket	green	Visual inspection	RAL 6018
All	Colour Datawire	White/(Orange) - Orange, White/(Green) - Green, White/(Blue) – Blue, White/(Brown)- Brown Ring or Stripe marking on the white wire is optional	Visual inspection	IEC 61784-5-x and this PROFINET Guideline
All	Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz	EN50289-1-6	≥ 80 dB at 30 MHz to 100 MHz
All	Operating temperature	-20°C ...+70°C		All cable material have to be designed for -20°C...+70°C
All	Differential delay / Delay skew between Pair 1 (orange) and Pair 2 (green)		IEC 61156-5	<=20ns/100m
Type R	Trailing chain test (horizontal)	bending radius: max. 15xD acceleration: ≥10 m/s² speed: min. 180 m/min chain length: ≥5 m cycles: ≥5 million		After 5 million cycles: Pass test of IEC 61156-6 (min. Category 5)
Type R	Torsion test	Torsion stress: ± 180/m Cycles: ≥5 million		After 5 million cycles: Pass test of IEC 61156-6 (min. Category 5)
Type R	Reverse bending test	Bending radius: max. 7xD Weight: 300 g	EN 50396 paragraph 6.4	After 1 million cycles: Pass test of IEC 61156-6 (min. Category 5)

Table 11.1.3-2: Test requirement 4 pair Balanced Cables

11.2 Optical fibre cables (POF, PCF, multimode, singlemode)

11.2.1 Introduction

PROFINET provides optical fibre cables with four types of optical fibre:

- Plastic optical fibre (POF)
- Plastic clad silica optical fibre (PCF)
- All-silica multimode fibre
- All-silica singlemode fibre

The cable design depends on application requirements and classified into two groups:

- Type B optical fibre cable
  for stationary or flexible use
- Type C optical fibre cable
  for special applications e.g. with permanent movement or vibration or torsion

All cable constructions (Type B and C) include two fibre elements.

11.2.2 POF and PCF cables

11.2.2.1 Specification of POF and PCF cables

Plastic optical fibre (POF) and Polymer clad fibre (PCF) cables shall comply with the requirements listed in Table 9.2.2.1-1. For more information see technical specification “Physical Layer Medium Dependent Sublayer on 650 nm Fibre Optics”, PI order no. 2.432.

Cable type	**Plastic optical fibre and polymer clad fibre cables**	
Design	data cable	data cable
Cable installation type	stationary, flexible, depending on cable construction	highly flexible, permanent movement or vibration or torsion (special applications)
System concept:		
Cable marking (at least)	PROFINET Type B + fibre type i.e.: PROFINET Type B 2P980/1000 PROFINET Type B 2K200/230	PROFINET Type C + fibre type i.e.: PROFINET Type C 2P980/1000 PROFINET Type C 2K200/230

Outer cable diameter (cables for use with IP20 connections)	no requirements	no requirements
Outer cable diameter (cables for use with PROFINET IP65/67 connectors)	max. 9,5 mm	max. 9,5 mm
Diameter secondary coating	POF: n.a. PCF: 0,5 mm	POF: n.a. PCF: 0,5 mm
Diameter subcable	2,2 mm	2,2 mm
Colour (outer sheath)	green RAL6018	depending on the application)*1
Colours (subcable)	orange + black orange with arrow (pointing direction of data stream)	orange + black orange with arrow (pointing direction of data stream)
Number of fibres	2	2
Ambient conditions:		
Minimum tensile strength (cable, long term)	POF: 100 N PCF: 400 N	depending on the application)*1
Bending radius static long term	> 15 times cable diameter	depending on the application)*1
Pollution degree Shock Vibration Operating temperature range	see Table 6-1 "Outside enclosure"	depending on the application)*1
Transmission performance requirements:		
Relevant standard Type (according to IEC 60793-2)	IEC 60793-2 POF: A4a PCF: A3c	
Core/cladding diameter	POF: 980/ 1000 µm PCF: 200/230 µm	
Nominal wavelength	650 nm	
Bandwidth MHz referred to 100 m @650 nm; launch NA = 0,5	POF: >=35 MHz PCF: >=70 MHz	
Maximum attenuation @650 nm; FWHM < 4 nm	POF: 160 dB/km PCF: 10 dB/km	POF: depending on the application)*1 PCF: 10 dB/km
Numerical aperture	POF: 0,50 +/-0,05 PCF: 0,37 +/-0,04	
)*1 for type C cables refer to manufacturers data sheet		

Table 11.2.2.1-1: Requirements for plastic and polymer clad optical fibre cables

11.2.2.2 Qualification test for POF and PCF cables

The PROFINET qualification Test for Plastic optical fibre (POF) and Polymer clad fibre (PCF) cables shall be performed in accordance with Table 9.2.2.1-1

Cable type	**POF and PCF cables**		
Characteristics	**Test Standard**	**Requirements**	
Cable installation type		stationary, flexible, depending on cable construction (type B cable)	highly flexible, permanent movement or vibration or torsion (special applications) (type C cable)
Outer cable diameter (cables for use with PROFINET IP65/67 connectors)	IEC 60811-1-1	max. 9,5 mm	max. 9,5 mm
Diameter secondary coating PCF	IEC 60811-1-1	0,50 +/- 0,05 mm	0,50 +/- 0,05 mm
Diameter subcable POF	IEC 60811-1-1	2,2 +/- 0,1 mm	2,2 +/- 0,1 mm
Diameter subcable PCF	IEC 60811-1-1	2,2 +/- 0,1 mm	2,2 +/- 0,1 mm

Minimum tensile strength POF	IEC 60794-1-2, Methode E1	100 N; 45 m length; max. 1 dB Δ A (@ 650 nm)	depending on the application
Minimum tensile strength PCF	IEC 60794-1-2, Methode E1	400 N; 100 m length; max. 1 dB Δ A (@ 650 nm)	depending on the application
Bending radius	IEC 60794-1-2, Methode E11A	Bending radius 15 times cable diameter, 5 turns, 1 cycle, max. 1,0 dB (@ 650 nm)	depending on the application
Operating temperature range PCF	IEC 60794-1-2, Methode F1	2 cycles -20°C / +70°C; t_1=24h; max. 1,5 dB / 100 m (@ 650 nm)	depending on the application
Operating temperature range POF	IEC 60794-1-2, Methode F1	2 cycles -20°C / +70°C; t_1=24h; max. 2,5 dB/50 m (@ 650 nm)	depending on the application
Bandwidth MHz referred to 100 m @650 nm; launch NA = 0,5	IEC 60793-1-41	POF: >=35 MHz; PCF: >=70 MHz	POF: >=35 MHz; PCF: >=70 MHz
Maximum attenuation @650 nm; FWHM < 4 nm	IEC 60793-1-40	POF: max. 160 dB/km; PCF: max. 10 dB/km	POF: max. 180 dB/km; PCF: max. 10 dB/km
Numerical aperture	IEC 60793-1-20	POF: 0,50 +/-0,05; PCF: 0,37 +/-0,04	POF: 0,50 +/-0,05; PCF: 0,37 +/-0,04

Table 11.2.2.2-1: Test requirements for plastic and polymer clad optical fibre cables

11.2.3 All-silica multimode optical fibre cables

11.2.3.1 Specification of all-silica multimode optical fibre cables

All-silica multimode optical fibre cables shall comply with the requirements listed in Table 9.2.3.1-1.

Cable type	**All-silica multimode optical fibre cables**	
Design	data cable	data cable
Cable installation type	stationary, flexible, depending on cable construction (type B cable)	highly flexible, permanent movement or vibration or torsion (special applications) (type C cable)
System concept:		
Cable marking (at least)	PROFINET Type B + fibre type i.e.: PROFINET Type B 2G50/125 PROFINET Type B 2G62,5/125	PROFINET Type C + fibre type i.e.: PROFINET Type C 2G50/125 PROFINET Type C 2G62,5/125
Maximum length for PROFINET	2000 m	2000 m
Outer cable diameter (cables for use with IP20 connections)	No requirements	No requirements
Outer cable diameter (cables for use with PROFINET IP65/67 connectors)	max. 9,5 mm	max. 9,5 mm
Diameter secondary coating	1,4 mm	1,4 mm
Diameter subcable	2,9 mm	2,9 mm
Colour (outer sheath)	green RAL6018	depending on the application)*3
Colours (subcable)	orange + black orange with arrow (pointing direction of data stream)	orange + black orange with arrow (pointing direction of data stream)
Number of fibres	2	2
Ambient conditions:		
Minimum tensile strength	600 N	depending on the application)*3
Bending radius (static long term)	> 15 times cable diameter)*2	depending on the application)*3
Pollution degree Shock Vibration Operating temperature range	see Table 6-1 "Outside enclosure"	depending on the application)*3
Transmission performance requirements:		
Relevant standard	IEC 60793-2	
Type according to IEC 60793-2	A1a , A1b	
Core/cladding diameter	50/125 µm 62,5/125 µm	
Nominal wavelength	1300 nm	
Bandwidth MHz referred to 1 km	>=500 MHz)*1	
Maximum attenuation	1,5 dB/km)*1	
)*1 measured in accordance with IEC 60793-1-40 and IEC 60793-1-41		
)*2 Deviating bending radius are possible according to manufacturer's specifications.		
)*3 for type C cables refer to manufacturers data sheet		

Table 11.2.3.1-1: Requirements for all-silica multimode optical fibre cables

11.2.3.2 Qualification test of all-silica multimode optical fibre cables

The PROFINET qualification test of all-silica multimode optical fibre cables shall be performed in accordance with Table 10.2.3.2-1.

Cable type	**All-silica multimode optical fibre cables**		
Characteristics	**Test Standard**	**Requirements**	
Cable installation type		stationary, flexible, depending on cable construction (type B cable)	highly flexible, permanent movement or vibration or torsion (special applications) (type C cable)
Outer cable diameter (cables for use with PROFINET IP65/67 connectors)	IEC 60811-1-1	max. 9,5 mm	depending on the application
Diameter secondary coating	IEC 60811-1-1	1,4 +/- 0,1 mm	1,4 +/- 0,1 mm
Diameter subcable	IEC 60811-1-1	2,9 +/- 0,1 mm	2,9 +/- 0,1 mm
Minimum tensile strength	IEC 60794-1-2, Methode E1	600 N; 100 m length; max. 1,0 dB Δ A (@ 1300 nm)	depending on the application
Bending radius	IEC 60794-1-2, Methode E11A	Bending radius 10 times cable diameter, 5 turns, 1 cycle, max. 0,1 dB (@ 1300 nm)	depending on the application
Operating temperature range	IEC 60794-1-2, Methode F1	2 cycles -20°C / +70°C; t_1=24h; max. 1,0 dB/km (@ 1300 nm)	2 cycles -20°C / +70°C; t_1=24h; max. 1,0 dB/km (@ 1300 nm)
Bandwidth MHz referred to 1 km @1300 nm	IEC 60793-1-41	>=500 MHz	>=500 MHz
Maximum attenuation @1300 nm	IEC 60793-1-40	max. 1,5 dB/km	max. 1,5 dB/km

Table 11.2.3.2-1: Test requirements for all-silica multimode optical fibre cables

11.2.4 All-silica singlemode optical fibre cables

11.2.4.1 Specification of all-silica singlemode optical fibre cables

All-silica singlemode optical fibre cables shall comply with the requirements listed in Table 10.2.4.1-1.

Cable type	**All-silica singlemode optical fibre cables**	
Design	data cable	data cable
Cable installation type	stationary, flexible depending on cable construction (type B cable)	highly flexible, permanent movement or vibration or torsion (special applications) (type C cable)
System concept:		
Cable marking (at least)	PROFINET Type B + fibre type i.e.: PROFINET Type B 2E9/125	PROFINET Type C + fibre type i.e.: PROFINET Type C 2E9/125
Outer cable diameter	max. 9,5 mm	depending on the application)*3
Diameter secondary coating	1,4 mm	1,4 mm
Diameter subcable	2,9 mm	2,9 mm
Colour (outer sheath)	green RAL6018	depending on the application)*3
Colours (subcable)	orange + black orange with arrow (pointing direction of data stream)	orange + black orange with arrow (pointing direction of data stream)
Number of fibres	2	2
Ambient conditions:		
Minimum tensile strength (cable, long term)	600 N	depending on the application)*3
Bending radius (Static long term)	> 15 times cable diameter	depending on the application)*3
Pollution degree Shock Vibration Operating temperature range	see Table 6-1 "Outside enclosure"	depending on the application)*3
Transmission performance requirements:		
Relevant standard Type (according to IEC 60793-2)	IEC 60793-2 B1	
Cladding diameter	125 µm ±2 µm	
Nominal wavelength	1300nm	
Maximum attenuation (at 1310 nm)	0,5 dB/km)*2	
Cut-off wavelength	< 1260 nm)*1	
)*1 according IEC 60793-1-44)*2 according IEC60793-1-40)*3 for type C cables refer to manufacturers data sheet		

Table 11.2.4.1-1: Requirements for all-silica singlemode optical fibre cables

11.2.4.2 Qualification test of all-silica singlemode optical fibre cables

The PROFINET qualification test of all-silica singlemode optical fibre cables shall be performed in accordance with Table 10.2.4.1-1.

Cable type	**All-silica singlemode optical fibre cables**		
Characteristics	**Test Standard**	**Requirements**	
Cable installation type		stationary, flexible, depending on cable construction (type B cable)	highly flexible, permanent movement or vibration or torsion (special applications) (type C cable)
Outer cable diameter (cables for use with PROFINET IP65/67 connectors)	IEC 60811-1-1	max. 9,5 mm	depending on the application
Diameter secondary coating	IEC 60811-1-1	1,4 +/- 0,1 mm	1,4 +/- 0,1 mm
Diameter subcable	IEC 60811-1-1	2,9 +/- 0,1 mm	2,9 +/- 0,1 mm
Minimum tensile strength	IEC 60794-1-2, Methode E1	600 N; 100 m length; max. 1,0 dB Δ A (@ 1300 nm)	depending on the application
Bending radius	IEC 60794-1-2, Methode E11A	Bending radius 10 times cable diameter, 5 turns, 1 cycle, max. 0,1 dB (@ 1300 nm)	depending on the application
Operating temperature range	IEC 60794-1-2, Methode F1	2 cycles -20°C / +70°C; t_1=24h; max. 1,0 dB/km (@ 1300 nm)	depending on the application
Maximum attenuation @1300 nm	IEC 60793-1-40	1,0 dB/km	1,0 dB/km
Cut-off wavelength	IEC 60793-1-44	< 1260 nm	< 1260 nm

Table 11.2.4.1-1: Requirements for all-silica singlemode optical fibre cables

12 Cord Sets for PROFINET Data Cabling

12.1 Cord Sets for Balanced Cabling

PROFINET cord sets fulfil the PROFINET component specification and can be used concerning the PROFINET component model. The conformity of the PROFINET cord set to this specification shall be declared by the vendor.

PROFINET cabling is based on the End-to-End link. The End-to-End link extends the IEC 11801 channel about the plug connectors, which are mated to the PROFINET device (TE/PMD).The End-to-End link is specified in IEC 61918.

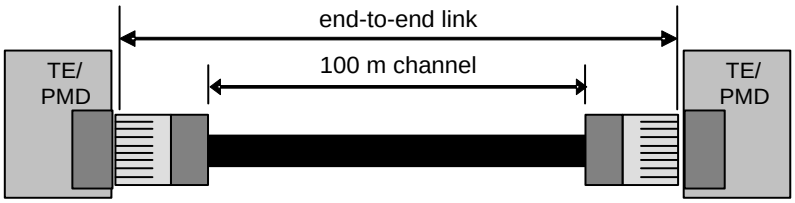


Figure 12.1-1: End-to-End link

The conformity shall be declared for the PROFINET cord set.
PROFINET cord set used shall comply with the following parameters:

Type	PROFINET cord set
Number of wires	4,8
Cable Type	A,B
Connector type	PROFINET connector for type A,B cable
Cord set marking (additional to cable marking)	*"PROFINET cord set"*

12.1.1 Cord Sets for Balanced Type A/B Cabling

Cords shall meet return loss (*RL*) and Next requirements specified in IEC 11801.

Insertion loss (*IL*) of cord sets shall not exceed the value stated for the given length:

IL=IL cab* L / 100 + 2 * IL con

IL cab= 22,0 dB / 100m @ 100 MHz, IL con = 0,4 dB

(Informative values of IL cab at 100 MHz for PROFINET cord sets from IEC 11801)

12.1.2 Cord Sets for Balanced Type C Cabling

Cords shall meet return loss (*RL*) and Next requirements specified in IEC 11801.

Insertion loss (*IL*) of cord sets shall not exceed the value stated for the given length:

IL=*IL* cab* L / 100 + 2 * IL con

IL cab= 33,0 dB / 100m @ 100 MHz , *IL* con = 0,4 dB

(Informative values of *IL* cab @ 100 MHz for PROFINET cord sets from IEC 11801)

12.2 Cabinet cord sets for balanced cabling

PROFINET Cabinet cord sets are cord sets for cabinet applications. PROFINET Cabinet cord sets fulfil the PROFINET component specification and can be used concerning the PROFINET component model. The conformity of the PROFINET cabinet cord set to this specification shall be declared by the vendor.

End-to-End link build up with PROFINET cabinet cord sets meet the requirement described in the following Figure 12.2-1:

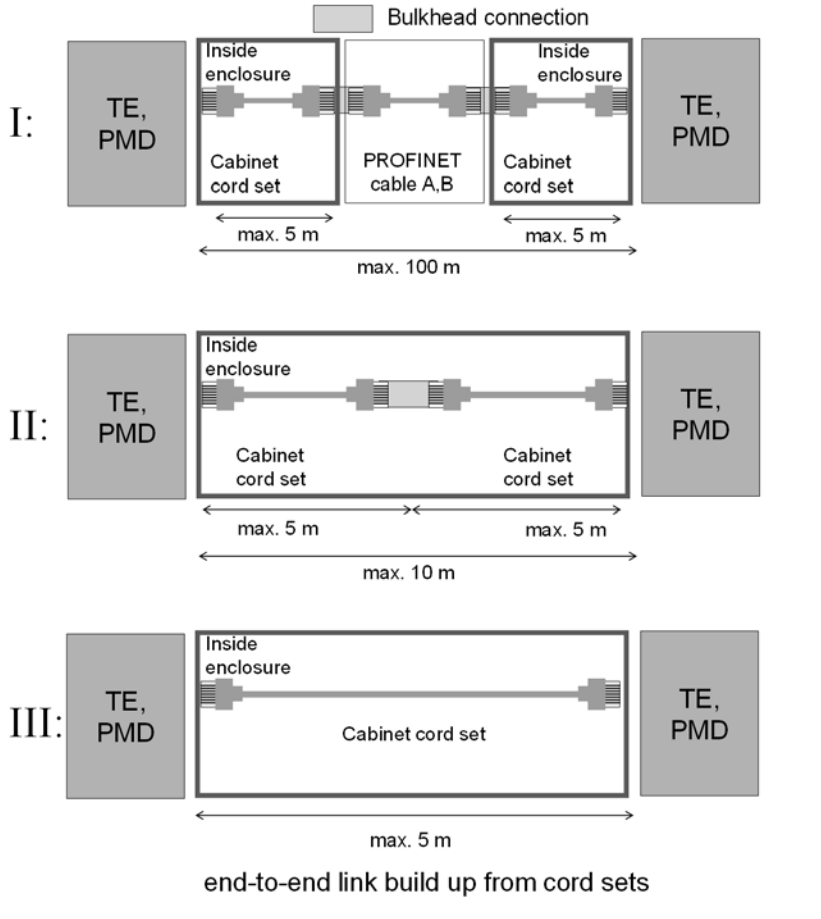


Figure 12.2-1: Assembled End-to-End Link

Connecting hardware performance is influenced by the properties of the plug termination and, therefore cords should be tested to determine the quality of the assembly.

This clause specifies the minimum requirements for cords. The test methods and mechanical stresses are specified in IEC 61935-2. All requirements of this clause have to be met after first exposing the device under test to mechanical stress. Cords shall meet the electrical and mechanical requirements of IEC 61935-2.

The cabinet cord sets shall meet a tightened flexures test in accordance to IEC 61935-2 7.3. The cabinet cord shall fulfil after the specified flexures at least the category 5 patch cord test according to ISO/IEC 11801 Edition 2.0.

PROFINET cabinet cord sets shall be labelled as PROFINET cabinet cord sets.

Cable used to build up a cabinet cord are based electrically on at least category 5 balanced LAN cables according to ISO/IEC 11801 Edition 2.0.Class D.

Connectors used to build up a cabinet cord shall be based on the mating face as defined in clause 9.1. or 9.2..

12.2.1 Qualification test for PROFINET cabinet cord sets

The conformity shall be declared for the PROFINET cabinet cord set.

PROFINET Cabinet cord set used shall comply with the following parameters:

Type	**PROFINET Cabinet cord set**
Comment	only harnessed cord sets are defined
Application	Inside enclosure
Number of wires	4,8
Channel performance	≥Class D (IEC 11801)
Cable performance	at least CAT 5 IEC 61156-6
Cable colour (outer sheath)	RAL 6018
Cabinet cord set marking 2 pair	*“PROFINET cabinet cord 2 pair ”*
Cabinet cord set marking 4 pair	*“PROFINET cabinet cord 4 pair”*
PROFINET Component	X
Ambient temperature	. -20°C... 70°C
Wire diameter	2 pair: AWG 22 - 24 4 pair: AWG22 - 26
Type of wire	stranded

Segregation class D (EN 50174-2)	Yes*[1,2]
Crush test of the cable	1000N
Flexures test in accordance to IEC 61935-2 7.3	F = 10 N; Number of flexures = 750
Bending Radius	8*diameter (repeated movement) 4* diameter (single movement)
Different Delay Skew (20ns/100m)	2 pairs (or/gn)
PoE/ PoE Plus	Yes

*[1]Cable Coupling Attenuation 80dB
(Measurement of the coupling attenuation according to EN 50289-1-6)

*[2] Connector Coupling 45 dB (Measurement of the coupling attenuation according to IEC 62153-4-12)

12.2.2 : PROFINET Cabinet cord set specification

The following parameters shall preferably adhered to:

- Sheathing materials suitable for the intended application
- Materials for special applications materials free of substances destructive to lacquer-coatings (e.g. silicone)

Additional test parameters are described in the Draft IEC 61784-5-3 and in Table 8-1: Plug Connector Specifications for Inside Applications (Data Cabling).

The cable used to build up a cabinet cord shall comply with the following standards:

Test-Title	**Severity or condition of test**	**Measurement to be performed**	**Requirements**
IEC 11801 cat 5 component	Category 5	IEC 61156-6	Electrical requirement category 5
Conductor resistance	AWG 26 stranded	IEC 60189-1	<= 145 Ω/km
Elongation at break of the insulation		IEC 60811-501	IEC 61156-6
Elongation at break of		IEC 60811-501	IEC 61156-6

the sheath			
Elongation at break of the sheath after ageing		IEC 60811-401	IEC 61156-6
Tensile strength of the sheath		IEC 60811-501	IEC 61156-6
Tensile strength of the sheath after ageing		IEC 60811-401	IEC 61156-6
Crush test of the cable		IEC 61156-1	1000N
Flame retardancy		IEC 60332–1-2	Has to pass the test
Sheath pressure test at high temperature		IEC 60811-508	Max. 50 %
Heat shock test		IEC 60811-509	No cracks
Tensile performance of the cable	50N	EN 50289-3-16	IEC 61156-6
Colour outer Jacket	green	Visual inspection	RAL 6018
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz	EN50289-1-6	≥ 80 dB at 30 MHz to 100 MHz
Operating temperature	-20°C ...+70°C		All cable material have to designed for -20°C...+70°C
Differential delay / Delay skew between Pair 1 (orange) and Pair 2 (green)		IEC 61156-6	<=20ns/100m

The connectors used to build up a cabinet cord shall be in accordance to the specification of the inside connector in chapter 11.1.

The Qualification Test for the cabinet cord sets shall meet return loss (RL) and Next requirements specified in IEC 11801 for balanced cords (at least category 5).

The connectors used to build up a cabinet cord shall be in accordance to the specification of the inside connector in chapter 11.1.

The Qualification Test for the cabinet cord sets shall meet return loss (RL) and Next requirements specified in IEC 11801 for balanced cords (at least category 5).

12.3 Cabinet cord sets for optical cabling

PROFINET Cabinet cord sets are cord sets for cabinet applications. PROFINET Cabinet cord sets fulfil the PROFINET component specification and can be used concerning the PROFINET component model. The conformity of the PROFINET cabinet cord set to this specification shall be declared by the vendor.

Connecting hardware performance is influenced by the properties of the plug termination and, therefore cords should be tested to determine the quality of the assembly.

PROFINET cabinet cord sets shall be labelled as PROFINET cabinet cord sets.

Connectors used to build up a cabinet cord shall be based on the mating face as defined in clause 10.1, 10.2. or 10.3.

12.3.1.1 Qualification test for PROFINET cabinet cord sets for optical cabling

The conformity shall be declared for the PROFINET cabinet cord set.

PROFINET FO Cabinet cord set used shall comply with the following parameters:

	PROFINET FO cabinet cord set
Comment	only harnessed cord sets are defined
Application	Inside enclosure
Cable colour (outer sheath)	*RAL 6018*
Cabinet cord set marking 2 pair	PROFINET FO Cabinet Cord Set
PROFINET Component	X
Cable diameter, nominal	2.8 mm (+/- 0.1)
Diameter seondary coating	0,9 / 1,4 mm
Cable type	Duplex-Cable
Connector	SCRJ (IEC 61754-24-11) SC-Duplex (IEC 60874-14-x) LC (IEC 61754-20)
Cable performance SM	OS 2
Cable performance MM	OM 2
Insertion Loss SM, max.	0.4 dB
Insertion Loss MM, max.	0.7 dB
Temperature (Trasport & storage)	- 25 bis +70 °C
Temperature (Installation)	-10°C... 70°C
Temperature (in operation)	- 20 bis +70 °C
Crush	500N / 1 Minute
Impact	20 (Wp=0,74J, r=25mm)
Tensile performance	200 N / 5 Minutes,
Bending Radius	r=30 mm (6 Windungen, 3 Zyklen)
Repeated bending	5000 Zyklen bei r=60 mm
Torsion	10 (±360°, Länge = 1000 mm, F =20 N)
Kink	5 × the cable diameter
Sheath pull-off force for optical fibre cable for use in patch cords	fulfilled
Sheath shrinkage for optical fibre cable for use in patchcords	fulfilled

Buffered fibre movement under compression in optical fibre cables for use in patchcords	fulfilled
Test for vertical flame spread Test for vertical flame propagation	fulfilled
Measurement of smoke density of cables burning	fulfilled
max. length	20m

The cable used to build up a cabinet cord shall comply with the following standards:

Table 12.3-1: PROFINET Cabinet cord set specification

The following parameters shall preferably adhered to:

- Sheathing materials suitable for the intended application
- Flame retardance in accordance with IEC 60332-1
- Materials for special applications materials free of substances destructive to lacquer-coatings (e.g. silicone)

Additional test parameters are described in the Draft IEC 61784-5-3 and in Table 8-1: Plug Connector Specifications for Inside Applications (Data Cabling).

The cable used to build up a cabinet cord shall comply with the following standards:

Test-Title	**Measurement to be preformed by**
Cable performance SM	11801 © ISO/IEC:2002
Cable performance MM	11801 © ISO/IEC:2002
Insertion Loss SM	IEC 61300-3-4, method B
Insertion Loss MM	IEC 61300-3-4, method C
Temperature (Trasport & storage)	IEC 60794-2-50 Method F12
Temperature (in operation)	IEC 60794-2-50 Method F12
Crush	lEC 60794-1-2 E3
Impact	lEC 60794-1-2 E4
Tensile performance	lEC 60794-1-2 E1
Bending Radius	IEC 60794-1-2-E11A.
Repeated bending	lEC 60794-1-2 E6
Torsion	lEC 60794-1-2 E7
Kink	IEC 60794-1-2-E10.
Sheath pull-off force	IEC 60794-2-50 Method E21
Sheath shrinkage	IEC 60794-2-50 Method F11

Buffered fibre movement under compression	IEC 60794-2-50 Method E22
Test for vertical flame spread Test for vertical flame propagation	IEC 60332-3-24 Cat. C IEC 60332-1-2 Annex A
Measurement of smoke density of cables burning	IEC 61034-2

The connectors used to build up a cabinet cord shall be in accordance to the specification of the inside connector in chapter 11.1.

12.4 End-to-End Link assemblies for balanced cabling

PROFINET End-to-End Link assemblies are assemblies to connect active PROFINET devices. PROFINET End-to-End Link assemblies fulfil the PROFINET End-to-End link specification.

Figure12.4-1 shows an End-to-End link without interconnections of 100 m length with connectors installed directly at both ends of the cable.

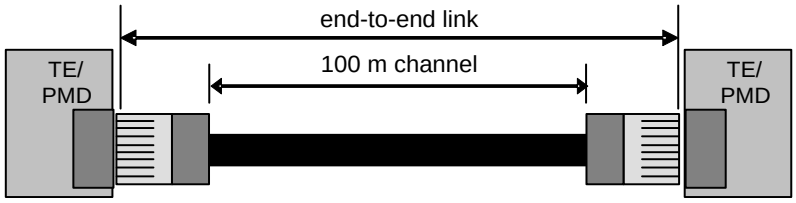


Figure 12.4-1– End-to-End link without interconnections

Figure 12.4-1 shows an assembled End-to-End link of 100 m length, containing an intermediate plug connection established with a bulkhead.

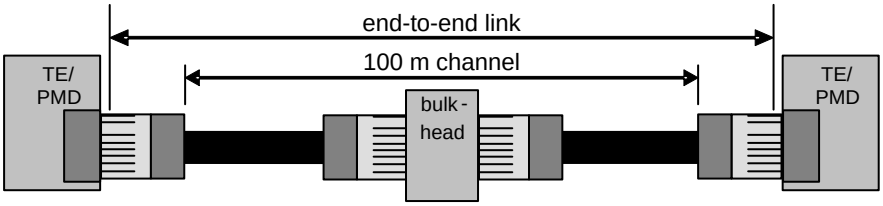


Figure 12.4-2– Assembled End-to-End link

1. **Max. NEXT requirements Class D according ISO/IEC TR 11801-9902**

$$(1{,}05)\cdot\left(1{,}9108\cdot\sqrt{f}+0{,}0222\cdot f+\frac{0{,}2}{\sqrt{f}}\right)+\left(6\cdot 0{,}04\cdot\sqrt{f}\right)$$

Formula 0**-1– Formula for NEXT limits for an End-to-End link**

12.4.1 Procedures for measurement of the End-to-End link

The traditional definition of the channels excludes the contribution of the end connections (connections to the application or the field tester) to the overall NEXT. In order to allow for two alternative but functional equivalent test method values for the End-to-End Link need to be defined in order to support the different test scenario.

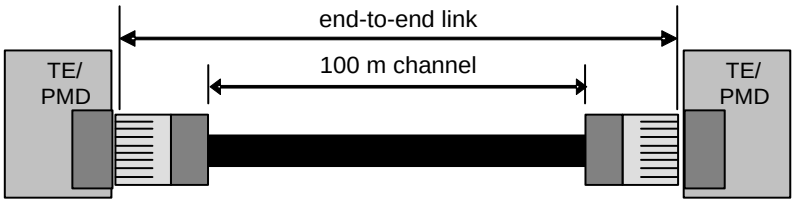


Table 12.4.1-1 – Definition of the reference plain

The procedures of the End-to-End measurement are specified in ISO/IEC 14763-4.

12.5 Bulkheads for Balanced Cabling

Bulkheads are placed between different environmental conditions, different connector mating faces or different installation requirements.

PROFINET bulkheads are implemented in different versions:

1. Adapter
    a. Adapter IP 67 for the Push Pull connector, M12 connector, Hybrid connector on both side of the adapter
    b. Adapter IP 20 for RJ 45 connector on both side of the adapter
2. Cable Adapter for the Push Pull connector, M12 connector, Hybrid connector or RJ 45 connector directly terminated to the PROFINET cable
3. Panel feed-through for the Push Pull connector, M12 connector or Hybrid connector on one side and the RJ 45 connector on the other side

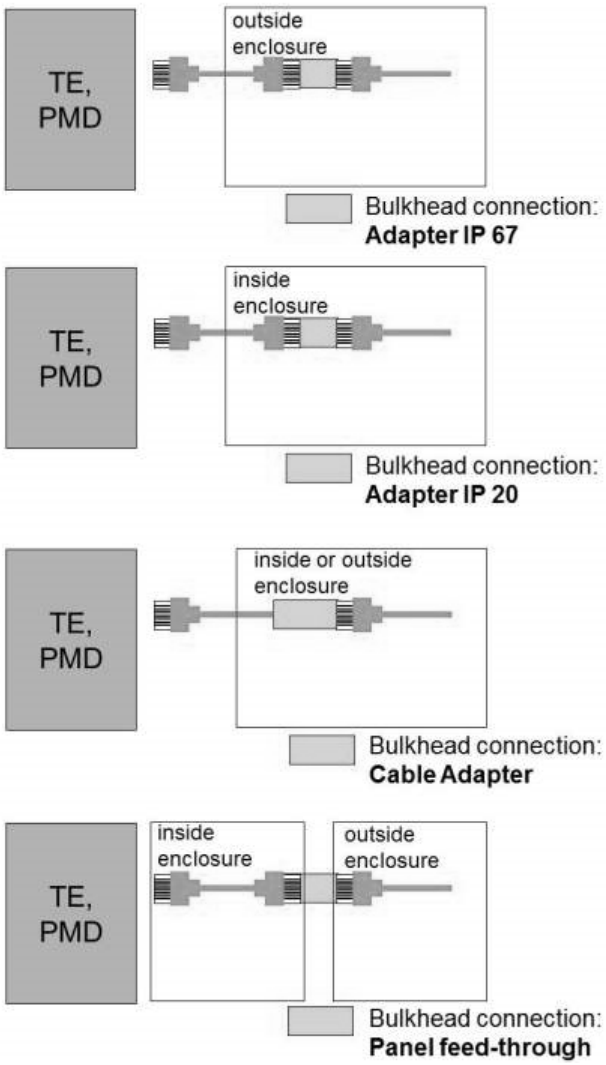


Table 12.5.-1 – Definition of the different Bulkhead connections

12.5.1 The PROFINET bulkhead

The PROFINET bulkhead is counted as 1 connector pair within the PROFINET component model. In an End-to-End link a maximum of 4 PROFINET bulkheads is allowed.

The characteristics of this bulkhead correspond to the connector characteristics in Clause 10.2.4 of IEC 11801 “Connecting hardware for balanced cabling”.

Figure 11.5.1 -1: Example of a PROFINET bulkhead

12.5.1.1 Qualification test for Bulkheads

The Qualification Test of Bulkheads shall be performed in accordance with the following standards:

ISO/IEC 11801-series: Generic cabling

13 24 Volt Cabling

The PROFINET 24 Volt Cabling is intended to be used either with an integrated functional earth (FE) or without a functional earth. There are dedicated connectors and cable designs.

PROFINET recommends the termination to the functional earth (FE) by an external termination point on the device. In this case the 4 way power cabling without functional earth (FE) should be used.

All PROFINET devices shall be equipped with an external functional earth (FE) termination point.

For further information see guideline Order Number 8.101 (Recommendations for functional grounding and bonding).

The PROFINET 24 Volt power supply of PROFINET devices is divided in two different power classes:

1. The supply is in star topology (current is limited to the demand of one device)
2. The supply is in line topology (higher current)

Power Class:	1	2
Application:	24 Volt Power Supply in star topology	24 Volt Power Supply in line or star topology
Operating current:	**max. 4 A**	**max. 16 A** (including power class 1)
Operating voltage	24 Volt	24 Volt
Number of circuits:	1 (optional 2)	1 (optional 2)
Functional earth (FE):	optional	optional

Table 13-1: Power Classes for the 24 Volt installation

13.1 Connectors for 24 Volt Cabling

The connectors described in this guideline are the approved PROFINET connectors for the 24 Volt Power Supply of all PROFINET devices in “Outside” Applications.

The connectors shall comply to one of the Power Classes of Table 13-1: Power Classes for the 24 Volt installation.

The connectors shall comply to Table 13-2: Connector solutions for the 24 Volt installations. Only for special applications other connectors can be used without influencing the certification of the devices.

Type:	**M12 L-coded**	
Style:	**4**	**4+FE**
Colour (insulation body):	**black**	**grey**
Power Class	2	2
Specification according to:	IEC 61076-2-111 L-coded	IEC 61076-2-111 L-coded
Protection level (Tabelle 5-1 Outside Environment):	IP 65/67	IP 65/67
Number of contacts:	4	5
Rated current @ 40°C (IEC 60 512):	16 A	16 A
Wire gauge min:	0,75 mm²	0,75 mm²
Wire gauge max:	2,5 mm²	2,5 mm²
Rated voltage (Pollution grade 2 3):	24 Volt	24 Volt
mating cycles:	100	100
Cable gauge max.:	12,5 mm	12,5 mm
Functional earth:	1)	Pin 5
PROFINET Contact Arrangement L1:	Pin 1	Pin 1
PROFINET Contact Arrangement L2:	Pin 4	Pin 4
PROFINET Contact Arrangement N1:	Pin 3	Pin 3
PROFINET Contact Arrangement N2:	Pin 2	Pin 2
Protection Class	see Table 6-1 "Outside enclosure"	see Table 6-1 "Outside enclosure"
Pollution Degree		
Shock		
Vibration		
Operating Temperature Range		

1) Contact chamber of the device plug closed at the bottom and mating compatible to 4+FE

Type:	**Push Pull Power**
Style:	**4+FE**
Power Class	2
Specification according to:	IEC PAS 61076-3-1xx
Protection level (Tabelle 5-1 Outside Environment):	IP 65/67
Number of contacts:	5
Rated current @ 40°C (IEC 60 512):	16 A
Wire gauge min:	0,75 mm²
Wire gauge max:	2,5 mm²
Rated voltage (Pollution grade 2 3):	24 Volt
mating cycles:	100
Cable gauge max.:	12,5 mm
Functional earth:	Pin 5
PROFINET Contact Arrangement L1:	Pin 1
PROFINET Contact Arrangement L2:	Pin 3
PROFINET Contact Arrangement N1:	Pin 2
PROFINET Contact Arrangement N2:	Pin 4
Protection Class	see Table 6-1 "Outside enclosure"
Pollution Degree	
Shock	
Vibration	
Operating Temperature Range	

Table 13-2: Connector solutions for 24 Volt installations

The characteristics of the installed cable are also to be considered in the selection of the connector (e.g. derating).

13.1.1 Colour Coding for 24 Volt connectors

All PROFINET connectors for field termination shall be equipped with an additional colour coding in the termination area according to Table 13 1-1: Colour Coding for 24 Volt connectors. The colour coding is matched to the PROFINET 24 power cables specified in Section 13.2: Cables for 24 Volt Cabling.

Potential	Contact Number Push Pull AIDA	Additional Push Pull Colour Coding	Contact Number M12-L coded	Additional M12 L-Colour Coding
L1	Pin 1	Brown	Pin 1	Brown
N1	Pin 2	Blue	Pin 3	Blue
L2	Pin 3	Black	Pin 4	Black
N2	Pin 4	White	Pin 2	White
FE	Pin FE	no colour	Pin FE	no colour

Table 13-1-1: Colour Coding for 24 Volt connectors

13.1.2 24 Volt Push Pull connector

Push pull connectors (IP65/67 or higher) can be used for 24 Volt Power supply up to 16 Amp and two circuits. A 5-pin plug connector shall be applicable for all wires. Devices shall be fitted with the appropriate sockets. For line topologies is a junction possible inside the device or with an external T-junction. The design of the plug- and socket-connector is complete contact-protected. This enables the use of the same plug connectors at both ends because no pin-socket change is necessary.

Figure 13.1.1-1: Picture of the Push Pull Plug 24 Volt Connector

T-connector

Push Pull T-Connectors are designed to realise a lined Topology outside of the device to archive hot swapping of devices. T-connectors shall have the capability for the specified connector and cabling solution. The rated current is the sum of all ports.

13.1.2.1 Qualification Test for 24 Volt Push Pull connector

The Qualification Test shall be performed in accordance with the following standards:

IEC-PAS 61076-3-1xx - Push-Pull-Power

Additional test parameters are described in Installation Guideline Table
Table 13 2: Connector solutions for the 24 Volt installation.

13.1.3 M12 Power circular L-coded connector

Figure 13.1.2-1: Picture of M12 L-Coded 24 Volt Connector

The M12 L-coded connectors described below are suitable for the supply of 24 Volt Power to a device.

Devices for line topology shall be equipped with a female connector and a male connector. The voltage carrying mating face (power source) of a device shall be female. System cable in general are harnessed with a female and a male connector.

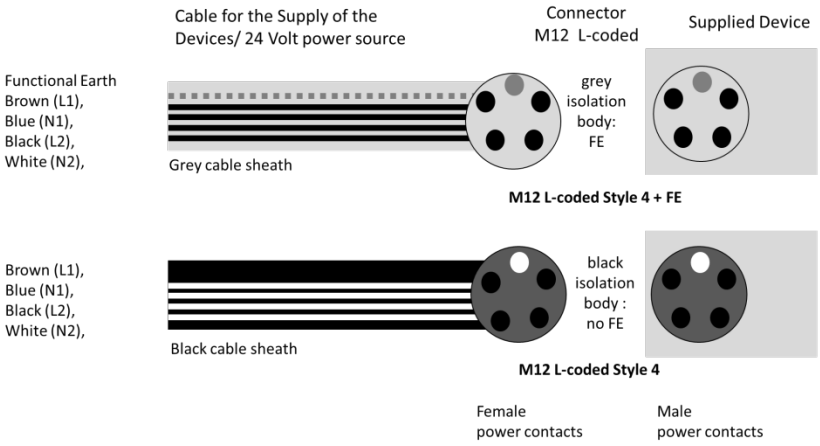


Figure 13.1.2-2: M12 L-coding contact position 5 way (4 + FE) front view

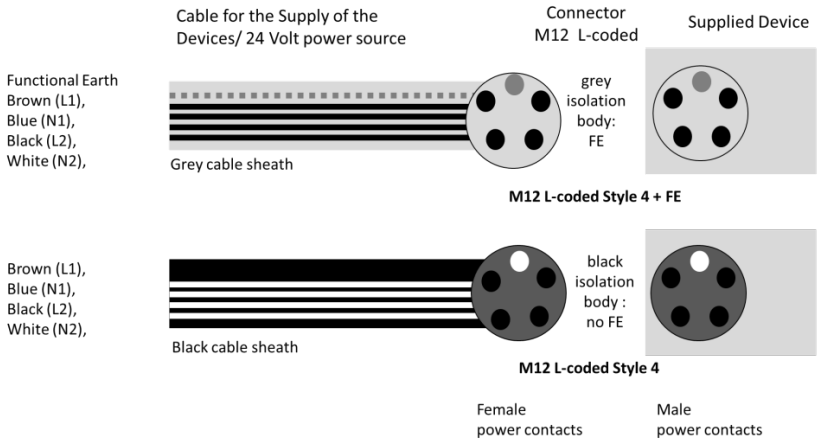
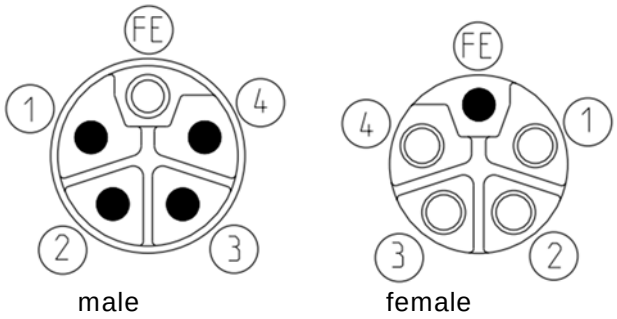


Figure 13.1.2-3: M12 L-coding cable termination for power source devices

The following two styles of the M 12 L-coded connectors shall be used for PROFINET 24 Volt Power:

M12 L-coded Style 4 + FE:

Reference to dimensions and drawings for the M12 Power L-coded connector see IEC 61076-2-111 section 4.3.4. “L-coding”.



male female

Figure 13.1.2-4: M12 L-coding contact position 4+FE front view

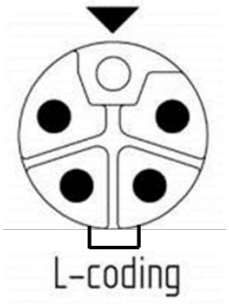
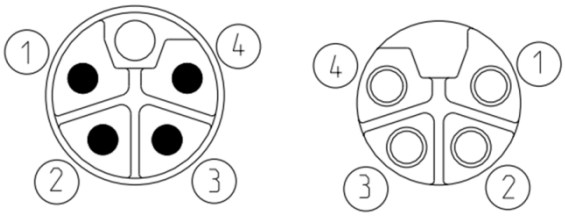


Figure 13.1.2-5: M12 L-coding orientation of coding; position of coding to cable outlet direction (see IEC 61076-2-111)

M12 L-coded Style 4:

Reference to dimensions and drawings for the M12 Power L-coded connector see IEC 61076-2-111 section 4.3.4. “L-coding”.



male female

Figure 13.1.2-6: M12 L-coding contact position 4 way front view

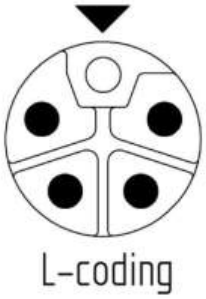


Figure 13.1.2-7: M12 L-coding orientation of coding; position of coding to cable outlet direction

T-connector

M12-L coded T-Connectors are designed to realise a line topology outside of the device.
T-connectors shall have the same capabilities for the specified connector and cabling solution as defined by this specification.

13.1.3.1 Qualification Test for M12 Connector L-coded

The Qualification Test shall be performed in accordance with the following standards:

61076-2-111 section 4.3.4. “L-coding”

Additional test parameters are described in Installation Guideline Table Table 13-2: Connector solutions for the 24 Volt installation

13.2 Cables for 24 Volt Cabling

Various outer sheath materials are permitted in order to meet the various demands with regard to flame retardancy, resistance of industrial environments and exterior/underground laying (natural and synthetic oil, grease, coolants/lubricants, chemicals, high and low temperatures, UV radiation).

The cable and used materials shall comply to national, European and international regulations.

Profinet 24V DC Power Cable Types	**PROFINET 24V Power Cable 0,75 mm²**	**PROFINET 24V Power Cable 1,5 mm²**	**PROFINET 24V Power Cable 2,5 mm²**
Cable Installation Type	Fixed and flexible installation, occasional movement or vibration, Corresponding to Application Type A and B (table 11.1-1)		
Design	4 x 0,75 mm² or 5 x 0,75 mm²	4 x 1,5 mm² or 5 x 1,5 mm²	4 x 2,5 mm² or 5 x 2,5 mm²
Which Plug for which Cable Type	Push Pull Power, M12 L-coded [1), 2)]		
Number of Wires	4 or 5		
Rated Voltage	300 V		
Current-carrying capacity per conductor at 40°C ambient temperature [3)]	8 A	16 A	
nominal conductor cross section	0,75 mm²	1,5 mm²	2,5 mm²
Wire Construction	flexible conductor		
Wire Identification	5 wires with colours: Brown (L1), Blue (N1), Black (L2), White (N2), Optional: 1 wire Pink (Functional Earth) [4)]		
Colour (Outer Sheath)	Black (without Functional Earth) or Grey (with Functional Earth)		
Cable Marking (at least)	"PROFINET 24V Power 4x0,75" (without Functional Earth) or "PROFINET 24V Power 4x0,75 + FE " (with Functional Earth)	"PROFINET 24V Power 4x1,5" (without Functional Earth) or "PROFINET 24V Power 4x1,5 + FE " (with Functional Earth)	"PROFINET 24V Power 4x2,5" (without Functional Earth) or "PROFINET 24V Power 4x2,5 + FE " (with Functional Earth)
Operating Temperature Range	see Table 6-1 "Outside enclosure"		

1) M12 L-coded pinning compatibility applies only to the pins themselves. For full plug-in compatibility, the shape of the casing of industrial connectors shall also be taken into account. The specified M12 L-coded receptacle (Jack) for "Outside" applications has to be mating compatible with the M12 L-coded Plug, 16A, derating in accordance with IEC 61984.
2) also applicable for 7/8" and M12 a-coded connectors
3) Derating in accordance with IEC 60204-1 und IEC 60364-5-52
4) The functional earth should in future comply with DIN EN 60445 VDE 0197 (2018-02) with a pink core (standard cables for PROFINET get a pink FE core). The connectors will be marked with a FE imprint in the future. Existing 24 Volt cables (grey functional earth), according to guideline 4.0, are still PROFINET compliant.

Table 13.2-1: 24V Power Supply Cable Specification

13.2.1.1 Qualification test for PROFINET 24 Volt cables

Test requirement for PROFINET 24 Volt cables are defined in the following table:

Cable Type to be tested	**Test-Title**	**Severity or condition of test**	**Measurement to be performed**	**Requirements**
all	Conductor class	Min. class 5	IEC 60228	class 5 or class 6 of IEC 60228
24V Power Cable 0,75 mm²	Conductor resistance	0,75 mm²	IEC 60227-2 clause 2.1	<= 27 Ω/km
24V Power Cable 1,5 mm²	Conductor resistance	1,5 mm²	IEC 60227-2 clause 2.1	<= 14 Ω/km
24V Power Cable 2,5 mm²	Conductor resistance	2,5 mm²	IEC 60227-2 clause 2.1	<= 8 Ω/km

All	Flame retardancy		IEC 60332–1-2	Has to pass the test
All	Outer cable diameter	6,0 mm – 12,5 mm	IEC 60811-203	>=6,0 mm, <=12,5 mm
All	Wall thickness sheath	min. 0,8 mm	IEC 60811-203	>= 0,8 mm
24V Power Cable with 4 wires	Colour outer Jacket	PROFINET Guideline	Visual inspection	black
24V Power Cable with 5 wires	Colour outer Jacket	PROFINET Guideline	Visual inspection	grey
All	Colour wire	PROFINET Guideline	Visual inspection	brown, blue, black, white, (pink opt. grey)
24V Power Cables with 4 wires	Cable Marking	PROFINET Guideline	Visual inspection	“PROFINET 24V Power 4x0,75”/ “PROFINET 24V Power 4x1,5”/ “PROFINET 24V Power 4x2,5”
24V Power Cables with 5 wires	Cable Marking	PROFINET Guideline	Visual inspection	“PROFINET 24V Power 4x0,75 + FE”/ “PROFINET 24V Power 4x1,5 + FE”/ “PROFINET 24V Power 4x2,5 + FE”
All	Operating temperature	-20°C... 90°C		All cable material have to be designed for -20°C up to 90°C
All	Voltage test on completed cable	test voltage 1500 V	see IEC 60227-2	IEC 60227-1 table 3
All	Trailing chain test	bending test in trailing chain	bending radius: 12xD acceleration: 3 m/s² speed: 3 m/s cycles. 2 mio	no conductor break or breakdown
All	Elongation at break of the insulation		IEC 60811-501	IEC 61156-5
All	Elongation at break of the sheath		IEC 60811-501	IEC 61156-5
All	Elongation at break of the sheat after ageing		IEC 60811-401	IEC 61156-5
All	Tensile strength of the sheat		IEC 60811-501	IEC 61156-5
All	Tensile strength of the sheat after ageing		IEC 60811-401	IEC 61156-5
All	Sheath pressure test at high temperature		IEC 60811-508	Max. 50 %
All	Heat shock test		IEC 60811-509	No cracks

Table 13.2.1.1-1: Test requirement 24V Power Cable

13.3 Cord sets for 24 Volt Cabling

PROFINET cord sets for 24 Volt cabling is a combination of a PROFINET connector and a PROFINET 24 Volt cable

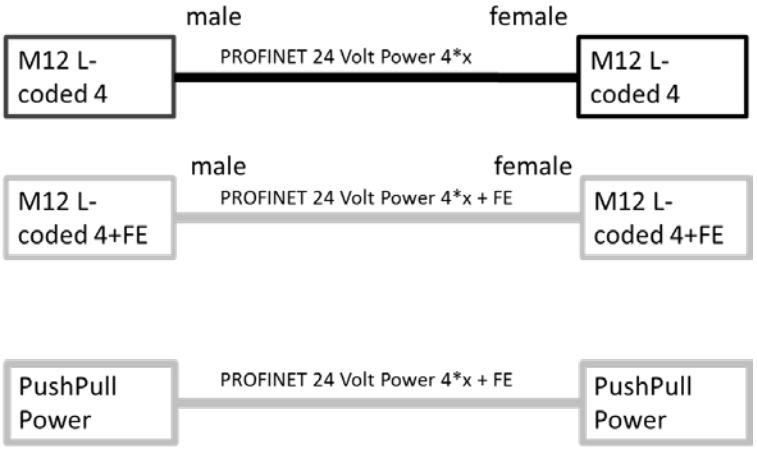


Table 13.3-1: PROFINET 24 Volt Power cord sets

The conformity of the PROFINET cord set to this specification shall be declared by the vendor.

13.3.1.1 Qualification test for PROFINET 24 Volt cord sets

The Qualification Test shall be performed in accordance to the cable and connector specification.

14 Connector for PROFINET Signal Cabling

14.1 Push Pull Signal connector

For Signal applications the standardised shielded 10 pole Push Pull Variant 14 free and fixed connector should be used. If the Push Pull interface is used for Data applications in the same device, the standardised shielded 10 pole Push Pull Variant 14 free and fixed connector shall be used for Signal applications. The shielded 10 pole Push Pull Variant 14 free and fixed connector is described in the standard: IEC/PAS 61076-3-119: Connectors for electronic equipment - Product requirements - Part 3-119: Rectangular connectors - Detail specification for unshielded, free and fixed 10 way connectors with push-pull coupling for industrial environments with frequencies up to 100 MHz.

Figure 14.1-1: Example of a Push Pull Signal Connector

The Signal Connector is to be used where decentralized field devices are to be connected via one combined connection with user specific pin assignment.

The single contacts of the connector shall be used in accordance to the table below:

Push Pull Signal connector:	
Rated Current:	max. 3 A per contact
Rated voltage	24 Volt
Number of contacts	10
locking mechanism	Push Pull
Conductor cross-section:	0,08 - 0,75 mm²
Outer cable diameter:	5 -10 mm

Figure 14.1-2: Basic parameters for shielded 10 pole Push Pull free and fixed connector.

14.1.1 Qualification Test for PROFINET Signal Cabling

The qualification test shall be performed for outside enclosures in accordance with the following standard:

IEC PAS 61076-3-119

15 Application specific Cabling and Interconnection Technology

15.1 Connector Definition according to AIDA Standard

The following connectors fulfil the requirements of German car manufacturers (AIDA: Automation Initiative of German Domestic Automobile Manufacturers):

PROFINET connectors

	PROFINET Data connectors		PROFNINET Signal connectors
	RJ45	SC-RJ	Signal
IP 67 Outside			
	PushPull Data IEC 61076-3-117	PushPull Fiber IEC 61754-24-11	PushPull Signal IEC 61076-3-119

PROFINET 24 V Power Supply connector

IP 67 Outside	 PushPull Power

PROFINET 400 V Power Bus connector

IP 67 Outside	

Figure 15.1-1: Matrix of AIDA connectors

16 Connectors for 400 Volt Power Cabling

The qualification test shall be performed in accordance with the appropriate standard for the connector.

For the ISO 23570 power bus conector the Qualification Test shall be performed in accordance with the following standard:

ISO 23570-3

Design specification for power bus connectors of the ISO 23570-3.

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