

PROFINET Cabling and Interconnection Technology

Guideline

for PROFINET

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- 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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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

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 (CDV) and IEC 61784-5-3 (CDV) inside and between the automation islands.

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 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

This Guideline describes the test specification for:

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

This PROFINET guideline is intended to be used by:

manufacturers of PROFINET cables, connectors and devices.

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.

No patents concerning the mating compatibility:

Connectors for PROFINET data:

- M12 D-coded (IEC 01076-5-101)
- M12 Optical Fibre connector (IEC 61076-3-101)
- RJ 45 IP 67 Push Pull connector (IEC PAS 61076-3-117 Variant 14)
- RJ 45 IP 67 Hybrid connector (IEC 61076-3-106 Variant 5)

Connectors for power supply:

- 24 Volt Push Pull connector
- 7/8 inch connector
- M12 A-coded
- 400 Volt connector (ISO 23570-3)

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 this list.

Passive components are not certified by PI.

3 Related Documents and References

The following documents are indispensable for the use of this document.

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- IEC 60050-131 International Electrotechnical Vocabulary – *Part 131: Electric and magnetic circuits.*
- IEC 60050-191 International Electrotechnical Vocabulary – *Part 191: Dependability and quality of service*
- IEC 60050-195 International Electrotechnical Vocabulary – *Part 195: Earthing and protection against electric shock*
- IEC 60050-826 International Electrotechnical Vocabulary – *Part 826: Electrical installations of buildings*
- IEC 61158-2: *Digital data communications for measurement and control - Fieldbus for use in industrial control systems. Physical layer.*
- IEC 61784, Digital data communications for measurement and control — Fieldbus for use in industrial control systems — *Part 1 (Ed.2.0): Profile sets for continuous and discrete manufacturing relative to fieldbus use in industrial control systems*
- IEC 61784, Digital data communications for measurement and control — Fieldbus for use in industrial control systems — *Part 2 (Ed.4.0): Additional profiles for ISO/IEC 8802-3 based communication networks in real-time applications*
- IEC 61784, Digital data communications for measurement and control — Fieldbus for use in industrial control systems — *Part 3 (Ed.1.0): Profiles for functional safety communications in industrial networks*
- IEC 61784, Digital data communications for measurement and control — Fieldbus for use in industrial control systems — *Part 4 (Ed.1.0): Profiles for secure communications in industrial networks*
- IEC 61784, Digital data communications for measurement and control — Fieldbus for use in industrial control systems — *Part 5-x (Ed.1.0): Installation profiles for communication networks in industrial control systems*
- ISO/IEC 8802-3 (2002): *Standard for 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*
- ISO/IEC 11801 (2002-09): *Information technology –Generic cabling for customer premises*
- IEC 61918_(CDV): *Digital data communication for measurement and control – Installation of communication networks in industrial control system*
- IEC 60950-1 (2001-10): *Information technology equipment -Safety- Part 1: General requirements as a guideline.*
- IEC 60950-21(2004-04): *Information technology equipment -Safety- Part 21: Remote power feeding.*
- IEC 60364-1 (2001-08): *Electrical installations of buildings - Part 1: Fundamental principles, assessment of general characteristics, definitions*
- IEC 60364-4-41 (2001-08): *Electrical installations of buildings - Part 4-41: Protection for safety - Protection against electric shock.*
- IEC 60364-4-42 (2001-08): *Electrical installations of buildings - Part 4-42: Protection for safety - Protection against thermal effects.*
- IEC 60364-4-44 (2003-12): *Electrical installations of buildings - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances*
- IEC 60364-5-54 (2002-06): *Electrical installations of buildings - Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.*
- IEC 61326 (2002-2): *Electrical equipment for measurement, control and laboratory use, control and laboratory use – EMC requirements.*
- IEC 61326-1 (1998-04; July 2004 it was 65A/418/CDV): *Electrical equipment for measurement, control and laboratory use, control and laboratory use – EMC requirements. Part 1: EMC requirements.*
- IEC 61326-3 (early 2004 it was 65A/412/CD): *Electrical equipment for measurement, control and laboratory use, control and laboratory use – EMC requirements – Part 3: Immunity*

requirements for equipment performing or intended to perform safety related functions (functional safety) in industrial applications.

IEC 61010-1 (2001-02) Ed.2.0: *Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements*

ISO/IEC 24702:2006. *"Generic cabling – Industrial Premises"*

ISO/IEC 14763-1 (1999): *Information technology – Implementation and operation of customer premises cabling – Part 1: Administration*

ISO/IEC 14763-2 (2000-07): *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation.*

ISO/IEC 9314-3 (1990): *Information processing systems – Optical fibre Distributed Data Interface (FDDI) - Part 3: Physical Layer Medium Dependent (PMD)*

ISO/IEC 9314-3: *Information processing systems - Optical fibre Distributed Data Interface (FDDI) - Part 3: Physical Layer Medium Dependent (PMD), Optical fibre channels for multimode optical fibres*

ISO/IEC 9314-4 (1999): *Information technology – Optical fibre distributed data interface (FDDI) – Part 4: Singlemode optical fibre physical layer medium dependent (SMF-PMD)*

ISO/IEC 9314-4: *Optical fibre channels for multimode optical fibres*

IEC 61918_WD-v3-3ep_2006-04-12_april-reference-for-profiles - 15 -

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

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

IEC 60332-1: *Tests on electric and optical fibre cables under fire conditions*

IEC 60512-4: *Electromechanical components for electronic equipment; basic testing procedures and measuring methods. Part 4: Dynamic stress tests*

IEC 60603-7: *Connectors for frequencies below 3 MHz for use with printed boards - Part 7: Detail specification for connectors*

IEC 60793 series: *Optical fibres*

IEC 60794 series: *Optical fibre cables*

IEC 60874-10 (1992): *Connectors for optical fibres and cables - Part 10: Sectional specification for optical fibre connector - Type BFOC/2,5*

IEC 60874-14 (1993): *Connectors for optical fibres and cables – Part 14: Sectional specification for fibre optic connector - Type SC*

IEC 61000-6-2 (1999): *Electromagnetic compatibility (EMC) -Part 6-2: Generic Standards - Immunity for industrial environments*

IEC 61000-6-4 (1997): *Electromagnetic compatibility (EMC) - Part 6: Generic Standards - Section 4: Emission standard for industrial environments*

IEC 61076-2-101: *Connectors for electronic equipment - Part 2-101: Circular connectors - Detail specification for circular connectors M8 with screw- or snap-locking, M12 with screw locking for low voltage applications*

IEC 61076-3-106: *Connectors for electronic equipment - Part 3-106: 8 way shielded and unshielded connectors for frequencies up to 600 MHz for industrial environments*

incorporating the 60603-7 series interface

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

IEC 61156-2 Edition 2.0: *Multicore and symmetrical pair/quad cables for digital communications – Part 2: Horizontal floor wiring – Sectional specification*

IEC 61156-5 Edition 2.0: *Symmetrical pair/quad cables with transmission characteristics up to 600MHz communications – Part 2: Horizontal floor wiring – Sectional specification*

IEC 61156-3 Edition 2.0: *Multicore and symmetrical pair/quad cables for digital communications – Part 3: Work area wiring; Sectional specification*

IEC 61984 (2001-06): *Connectors - Safety requirements and tests*

IEC 60079-11 (1999): *Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety "i"*

IEC 60079-14 (1996): *Electrical apparatus for explosive gas atmospheres –Part 14: Electrical installations in hazardous areas (other than mines)*

IEC 60811-1-1(2001): *Part 1-1: Methods for general application - Measurement of thickness and overall dimensions - Tests for determining the mechanical properties*

IEC 60811-1-2 (1985): *Part 1: Methods for general application - Section Two: Thermal ageing methods*

IEC 60811-3-1(1985): *Part 3: Methods specific to PVC compounds - Section One: Pressure test at high temperature - Tests for resistance to cracking*

IEC 60189-1 (1986) *Low-frequency cables and wires with PVC insulation and PVC sheath. Part 1: General test and measuring methods*

IEC 60332 – 1(1993): *Tests on electric cables under fire conditions - Part 1: Test on a single vertical insulated wire or cable*

IEC 61000-4: *Electromagnetic compatibility (EMC): Testing*

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

IEC PAS 61076-3-117:

Rectangular connectors: Protective housings for use with 8-way shielded and unshielded connectors for frequencies up to 600 MHz for industrial environments incorporating the 60603-7 - Variant 14 related to IEC 61076-3-106 - push pull coupling

IEC 61754-24 (Draft): *Fibre optic connector interfaces, - Part 24: Type SC-RJ connector family*

IEC 61754-24-2 Ed 1.0 (Draft): *Fibre optic connector interfaces, - Part 24-2: Detail specification for SC-RJ connectors with protective housings related to IEC/PAS 61076-3-117*

EN 50377-6-1: *Connector sets and interconnect components to be used in optical fibre communication systems, Product specifications, Part 6-1: Type SC-RJ terminated on IEC 60793-2 category A1a and A1b multimode fibre;*

61753-series, *Fibre optic interconnecting devices and passive components performance standard*

61300-series, *Fibre optic interconnecting devices and passive components*

4 Definitions and Abbreviations

For definitions and abbreviations see IEC 61918 (CDV) and IEC 61784-5-3 (CDV).

5 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 (CDV). 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 5.-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 60512-4, test 6c 20 g / 11 ms 3 per axis in both directions	IEC 60512-4, test 6c 20 g / 11 ms 3 per axis in both directions
Vibration 10-500 Hz	IEC 60512-4, test 6d 0.35 mm or 5g	IEC 60512-4, test 6d 0.35 mm or 5g
Ingress		
IP Protection class	IP20	IP65 and IP67
Particulate ingress (dia min)	12.5mm	50 µm
Immersion	None	Intermittent liquid jet ≤12.5 l/min ≥ 6.5 mm jet > 2.5 m distance and immersion (≤1 m for ≤30 minutes)
Climatic		
Ambient temperature	0° C to +60° C	-20° C to +70° C
Electromagnetic		
Transfer Impedance	See components selection	
^{a)} Bump: the repetitive nature of the shock experienced by the channel shall be taken into account.		

Table 5.-1: General Environmental Requirements of passive PROFINET Connection Systems (informative Chart from IEC 61784-5-3 (CDV))

6 Connectors and cables for PROFINET

The PROFINET philosophy is to reduce the number of different connectors and 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**

Only devices with the listed connectors fulfil the PROFINET specification and can be certified in a PROFINET test lab.

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

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

The listed different connectors are the preferred PROFINET solutions. Other connectors can be used for special applications.

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.








	CU	FO
IP 20 Inside	RJ 45  IEC 60603-7	SC-RJ  draft ISO/IEC 61754-24
IP 67 Outside	RJ 45  Variant 14 Pas 61076-3-117	SC-RJ  Related to Variant 14 Pas 61076-3-117 and draft ISO/IEC 61754-24
	Variant 5  IEC 61076-3-106	
	M12 D-coded  IEC 61076-2-101	M12  IEC 61076-2-101/A1

Table 6-1: PROFINET Data Connector overview

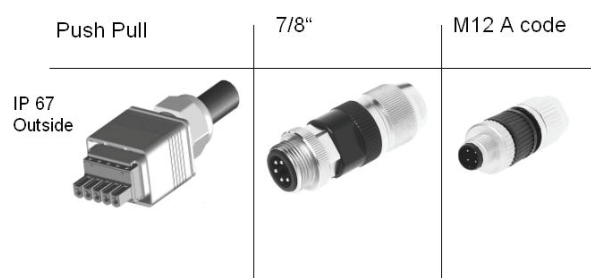


Table 6-2: PROFINET 24 Volt Connector overview



Figure 6-3: PROFINET 400 Volt Connector example

7 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. If the requirements are not covered by these environmental conditions, the vendor of the product has to be asked.

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

Procedure for a Conformity Certificate

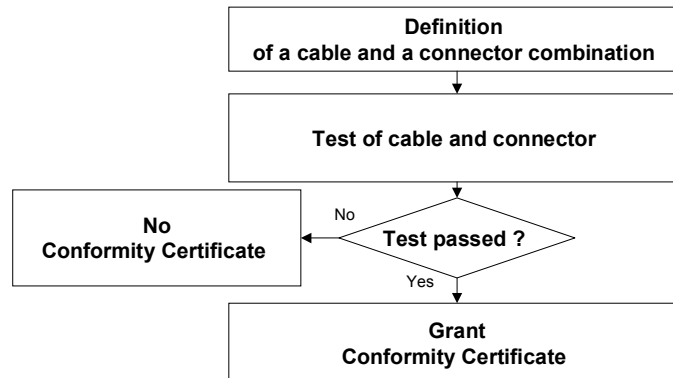


Figure: 7-1: Procedure for a Conformity Certificate

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. The procedure for the declaration is a separate PI document.

The conformity declaration for the listed components is mandatory for PROFINET installation based on IEC 61784-5-3.

8 Connectors for PROFINET Data Cabling

8.1 Connectors for Inside Environment (Balanced Cabling)

8.1.1 Introduction

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

- a) RJ45 Connector, mating compatible to IEC 60603-7

Application		Data Cabling Inside switching cabinet environment
Type		RJ45 plug compatible) ^{*1}
Mandatory Number of Contacts		
Data Power		4 ---
Rated Voltage	Data Power	48 VDC (44 ... 57 V) ---
Current (min.)	Data Power	350 mA ---
Outer Cable Diameter		5,5 mm to 8,0 mm
Wire Cross Section	Data Power	AWG22 ---
Wire Diameter	Data Power	1,4 to 1,6 mm ---
Wire Construction		Solid / Stranded
Category		ISO/IEC 11801 Edition 2.0 Connector min. Category 5
Shielding		mandatory
Cable Strain Relief		IEC 61984
Mating Cycles		min. 50 (IEC 61984)
Protection Class Pollution Degree Shock Vibration Operating Temperature Range		see Table 5-1 "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.		

Table 8-1: Plug Connector Specifications

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 8-2: Contact and Wire Assignment

The selected contact assignment of the RJ45 is compatible with the Ethernet standard, i.e. compatible with ISO/IEC 802-3. 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 RJ45 connectors.

8.1.2 The 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.

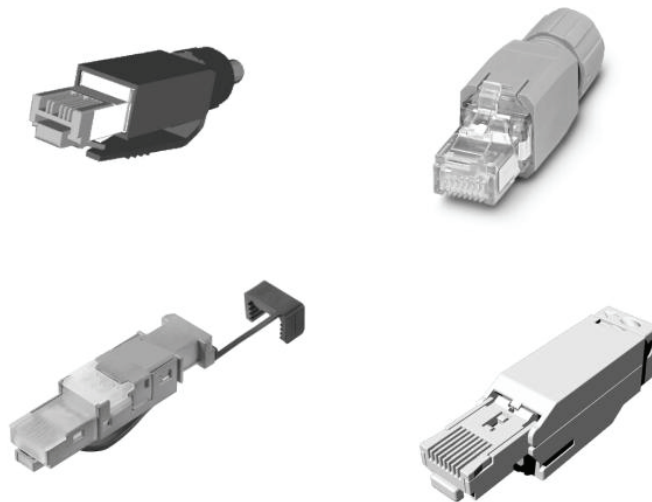


Figure 8.1.2-1: Examples of RJ45 Plugs in IP20 with Industrial Performance

8.1.2.1 Qualification Test for Copper Connectors (RJ45 IP20 Connectors)

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

IEC 60603-7(1996) mechanical structure of RJ45

IEC 60603-7-1(2002) introduction of shielding to RJ45

IEC 60603-7-3 (2007)

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

The plug for Inside Environment shall be pluggable to the jack in the protective housing specified in 8.2.2 to ensure reverse compatibility. An unprotected plug, which does not fulfil industrial requirements can be used exceptionally as part of diagnosis or commissioning.

8.2 Connectors for Outside Environment (Balanced cabling)

8.2.1 Introduction

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

- a) Connector variant 14, as defined in IEC PAS 61076-3-117 (further development of IEC 61076-3-106, variant 4) 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 Connector "D" coded, as defined in IEC 61076-2-101-A1

One of these variants a, b,c shall be the connector at the AO, replacing the TO of IEC 24702. These connectors shall be used at all PROFINET devices conformance class.

Application		Data Cabling Outside switching cabinet environment	Hybrid cabling Outside switching cabinet environment
Type		RJ45 plug compatible) ^{*1} or M12	RJ45 plug compatible) ^{*1}
Mandatory Number of Contacts			
	Data	4	4
	Power	---	4
Rated Voltage	Data	48 VDC (44 ... 57 V)	48 VDC (44 ... 57 V)
	Power	---	24 VDC (20,4 ... 28,8 V)
Current (min.)	Data	350 mA	350 mA
	Power	---	16 A
Outer Cable Diameter		5,5 mm to 8,0 mm	6,0 mm to 12,0 mm
Wire Cross Section	Data	AWG 22	AWG 22
	Power	---	1,5 mm² to 2,5 mm²
Wire Diameter	Data	1,4 to 1,6 mm	1,4 to 1,6 mm
Wire Construction		Solid / Stranded	
Transmission Performance		ISO/IEC 11801 Edition 2.0 Class D	
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 5-1 "Outside enclosure"	

^{*)} 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.

Table 8-3: Plug Connector Specifications

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	M12
TD +	Transmit Data +	Yellow	1	1
TD -	Transmit Data -	Orange	2	3
RD +	Receive Data +	White	3	2
RD -	Receive Data -	Blue	6	4

Table 8-4: Contact and Wire Assignment

The selected contact assignment of the RJ45 is compatible with the Ethernet standard, i.e. compatible with ISO/IEC 802-3. Four contacts are mandatory for PROFINET, a RJ 45 with eight contacts is also covered by this specification.

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

8.2.2 RJ45 IP67 Connector

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

IEC PAS 61076-3-117

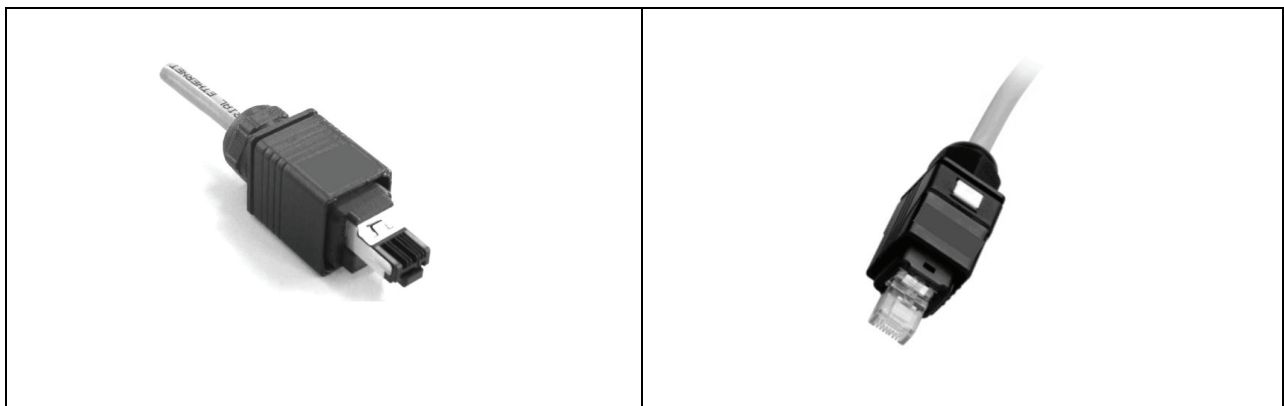


Figure 8.2.2-1: Examples of IP67 RJ45 Plug Connector

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

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

IEC PAS 61076-3-117

Additional test parameters are described in the IEC 61784-5-3 (Draft).

Installation Guideline Table 8-3: Plug Connector Specifications for Outside Applications (Data Cabling and Hybrid Cabling).

8.2.3 M12 Connectors

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

IEC 61076-2-101/A1

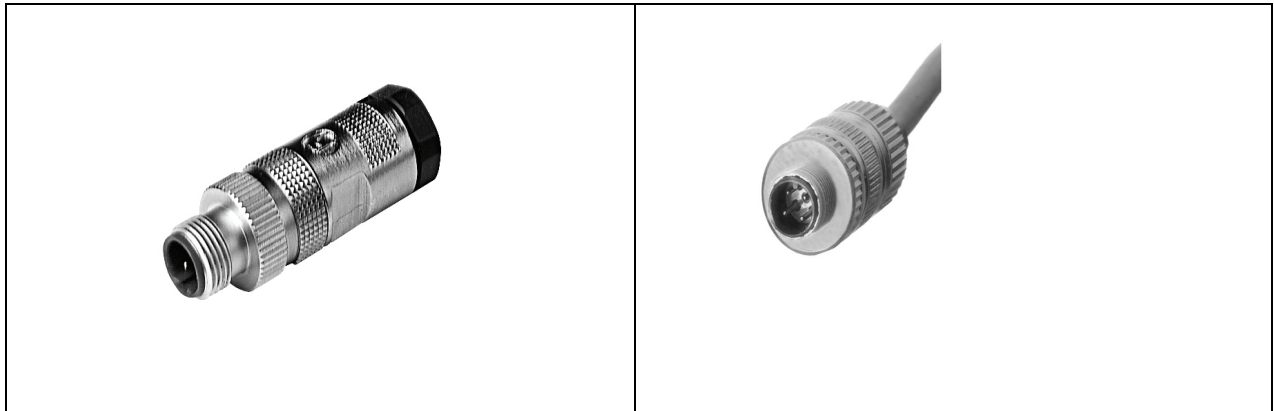


Figure 8.2.3-1: Examples of M12 Plug Connector with “D”-Coding

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

For contact and wire assignment see Figure 8.2.3-2.

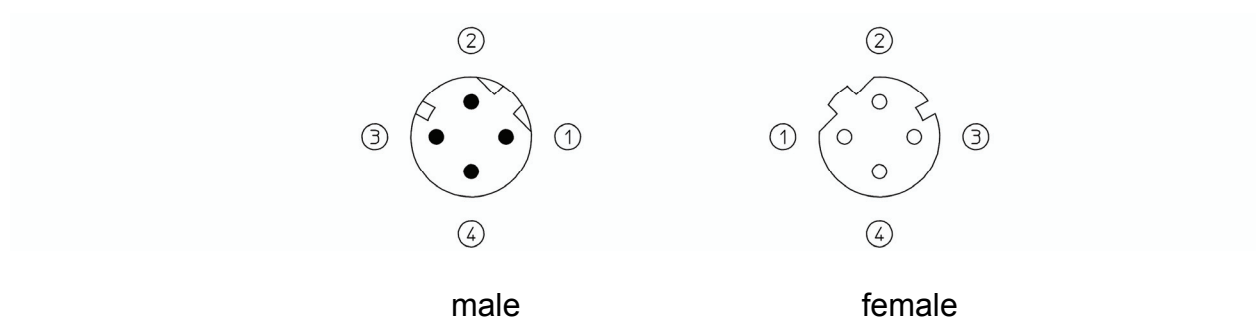


Figure 8.2.3-2: M12 Contact assignment and coding

“D” coding shall be used and contact chamber 5 of an appliance socket shall be closed.

This makes it virtually impossible to plug the M12 PROFINET connector incorrectly into previously installed field buses.

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

8.2.3.1 Qualification Test for Copper Connectors (M12 Connector)

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

IEC 61076-2-101/A1

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).

8.2.4 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**

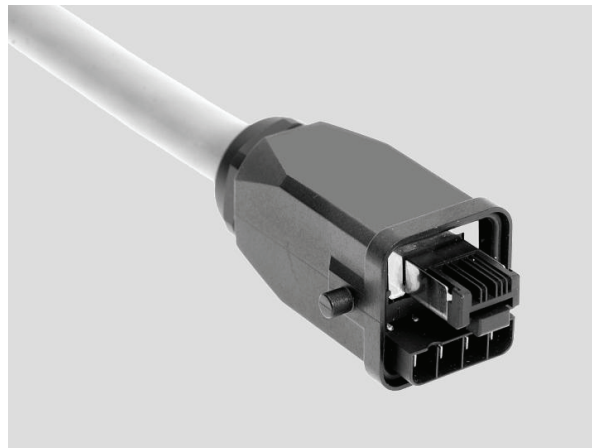


Figure 8.2.4-1: Picture of a Hybrid Plug Connector

The hybrid plug connector is to be used where decentralized field devices are to be connected via one 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.

8.2.4.1 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).

8.3 Connectors for inside environment (optical fibre)

8.3.1 Introduction

The connection of optical fibre cables and device or optical fibre cables with each other shall be made with a SC-RJ 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 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 5-1 "Inside enclosure"	

Table 8.3.1-1 – Mechanical and optical characteristics of optical fibre connecting hardware for “inside” environment

8.3.2 SC-RJ Connector

8.3.2.1 Specification of SC-RJ Connector

The SC-RJ Connector is the main connector for PROFINET fibre connections. The connector is prescribed in EN 50377-6-1, ISO/IEC 61754-24(draft). PROFINET requirements are shown in Table 8.3.1-1.

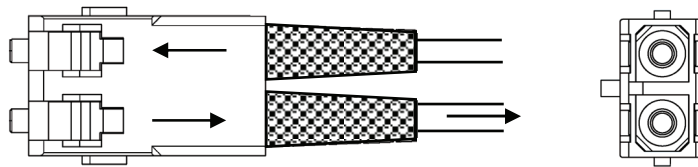


Figure 8.3.2-1: SC-RJ Connector

8.3.2.2 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 8.3.1-1 which ever is severe.

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

8.3.3 Additional Fibre connectors for existing installations

Optical fibre connector types BFOC/2.5 (IEC 60874-10) and SC-Duplex (in 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, Category C and PROFINET requirements in table 8.3.1-1

8.4 Connectors for outside environment (optical fibre)

8.4.1 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 (draft) In preparation
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 5-1 "Outside enclosure"	

Table 8.4.1-1 – Mechanical and optical characteristics of optical fibre connecting hardware for “outside” environment

8.4.2 SC-RJ Push Pull OF connector

8.4.2.1 Specification of Push Pull OF 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 prescribed ISO/IEC 61754-24-2 (draft).

The SC-RJ Push Pull OF connector is shown in Figure 8.4.2-1; dimensions are for orientation only.

PROFINET requirements are shown in Table 8.4.1-1.

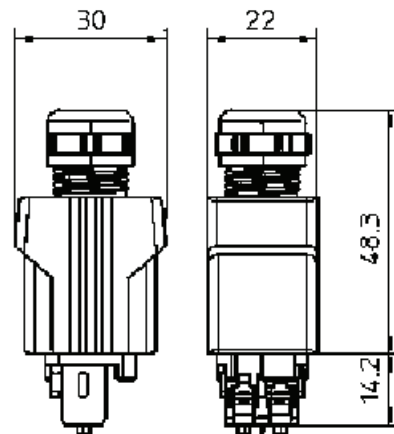


Figure 8.4.2-1: SC-RJ Connector with push Pull housing

8.4.2.2 Qualification test of Push Pull OF 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 8.4.1-1 which ever is more severe.

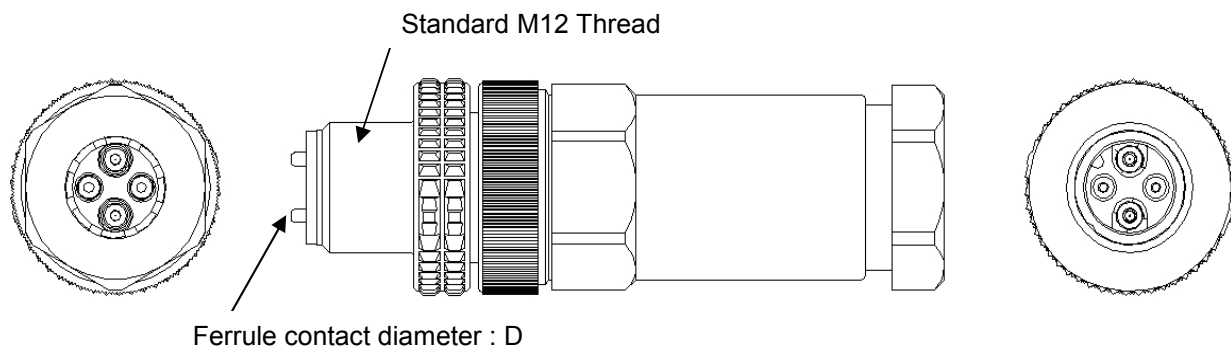
All test methods shall be in accordance with the IEC 61300 series of standards.

8.4.3 M12 OF connector

8.4.3.1 Specification of M12 OF connector

The M12 OF connector is a compact miniature OF connector based on the proven M12 design (standard in preparation). It is applicable for plastic, plastic clad silica, multimode and singlemode optical fibre.

PROFINET requirements are shown in Table 8.4.1-1.



Contact type	SM	MM	POF	PCF
D : ferrule contact diameter	1.25 mm	1.25 mm	1.59 mm	1.59 mm

Figure 8.4.3-1: M12 OF Connector

8.4.3.2 Qualification test of M12 OF 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 8.4.1-1 which ever is more severe.

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

9 Cables for PROFINET Data Cabling

9.1 Balanced Cables

9.1.1 Balanced Cables (Type A,B,C)

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

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 9.1-1), 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.

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

Industrial-type plug connectors type RJ45, protection type IP67, or a tried and tested industrial round plug connector M12, category 5, are to be used as plug connectors.

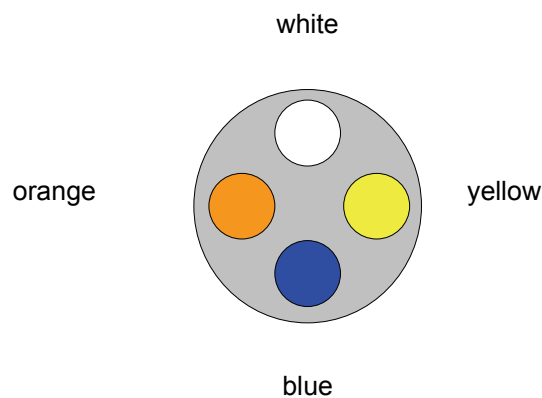
All balanced cables used shall comply with the following parameters:

Cable Type	Application Type A	Application Type B	Application Type C
Design	Data Cable	Data Cable	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	PROFINET Type B	PROFINET Type C
Core Cross Section	AWG 22/1	AWG 22/7	AWG 22/..
Outer Cable Diameter	5,5 - 8,0 mm		Application
Core Diameter	1,5 +/- 0,1 mm		Application
Colour (Outer Sheath)	Green RAL6018		Application
Core Identification (colours) star quad 2 pair	white, yellow, blue, orange Pair 1: white (RXD+), blue (RXD-) Pair 2: yellow(TXD+), orange(TXT-)		
Number of Cores	4		
Cable Design	2 pairs or 1 star quad		

Shielding Design Type	Aluminum Foil + Copper Braiding		Application
Which Plug for which Cable Type	RJ45 (IP 20 or IP 65/67) / M12		
Transmission Performance Requirements:			
Relevant Standard	ISO/IEC 11801 Edition 2.0, IEC 61156 (minimum Category 5)		
Delay Skew:	<=20ns/100m		
Transfer Impedance	<=50 mΩ/m at 10 MHz		
Ambient Conditions:			
Minimum Tensile strength	50 N		
Maximum Lateral forces	3000 N IEC 61156-1 3.4.6	3000 N IEC 61156-1 3.4.6	Application
Pollution Degree Shock Vibration Operating Temperature Range	see Table 5-1 "Outside enclosure"		

Table 9.1-1: Balanced Cable Specification

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

**Figure 9.1-1: Wire Assignment of Star-Quad Cables**

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)

9.1.2 Balanced Hybrid Cables (Type B,C)

Hybrid cables contain wires for signals and voltage supply.

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

Cable Type	Application Type B	Application Type C
Design	Hybrid Cable	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	4	4
Power	4	4
Core Cross Section		
Data	AWG 22/7	AWG 22/..
Power	1,5 mm ²	1,5 mm ²
Cable Marking (at least)	PROFINET Hybrid Type B	PROFINET Hybrid Type C
Outer Cable Diameter	8,0 ... 12,0 mm	
Core Diameter		Application Specific
Data	1,5 +/- 0,1 mm	
Power	2,4+/-0,2mm	
Colour (Outer Sheath)	Green RAL6018	Application Specific
Core Identification (Colours)		
Star Quad	White, Yellow, Blue, Orange	
2 Pair	Pair 1: White, Blue	
	Pair 2: Yellow, Orange	
Power	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)	
Which Plug for which Cable Type	RJ45 (hybrid)	
Transmission Performance Requirements (Data Wires):		
Relevant Standard	ISO/IEC 11801 Edition 2.0, IEC 61156 (minimum Category 5)	
Delay Skew:	<=20ns/100m	
Transfer Impedance	<=50 mΩ/m bei 10 MHz	
Ambient Conditions:		

Minimum Tensile strength	50 N		Application Specific
Maximum Lateral forces	3000 N IEC 61156-1 3.4.6	3000 N IEC 61156-1 3.4.6	Application
Pollution Degree Shock Vibration Operating Temperature Range	See Table 5-1 "Outside enclosure"		
Maximal Current in each Power-Wire:	For $T \leq 55^{\circ}\text{C}$: 16A For $T > 55^{\circ}\text{C}$ the current is not specified but may be indicated in the relevant detailed specification of the cable manufacturer (derating diagram)		

Table 9.2-1: Hybrid Wire Cable SpecificationNote:

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

9.1.2.1 Qualification test for PROFINET copper-cables

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

IEC 61156-5 (2002) Symmetrical pair/quad cables with transmission characteristics up to 600MHz - Horizontal floor wiring - Sectional Specification

IEC 61156-6 (2002) Symmetrical pair/quad cables with transmission characteristics up to 600MHz- Work area wiring - Sectional Specification

ISO/IEC 11801 (2002): Generic cabling

IEC 60189-1 (1986) Low-frequency cables and wires with PVC insulation and PVC sheath. Part 1: General test and measuring methods

IEC 60332 – 1(1993): Tests on electric cables under fire conditions - Part 1: Test on a single vertical insulated wire or cable

IEC 60811-1-1(2001): Part 1-1: Methods for general application - Measurement of thickness and overall dimensions - Tests for determining the mechanical properties

IEC 60811-1-2 (1985): Part 1: Methods for general application - Section Two: Thermal ageing methods

IEC 60811-3-1(1985): Part 3: Methods specific to PVC compounds - Section One: Pressure test at high temperature - Tests for resistance to cracking

Test requirement 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	IEC 11801 cat 5	Category 5	IEC 61156-5	Electrical

Type B	component			requirement category 5
Type C	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 A and C	Conductor resistance	AWG 22	IEC 60189-1	$\leq 62 \Omega/\text{km}$
Type B	Conductor resistance	AWG 22/7	IEC 60189-1	$\leq 60 \Omega/\text{km}$
Type A and B	Screening attenuation	For Grade 1	IEC 61156-5 : 3.3.8	$\geq 60 \text{ dB}$
Type A and B	Elongation at break of the insulation		IEC 60811-1-1	IEC 61156-5
Type A and B	Elongation at break of the sheath		IEC 60811-1-1	IEC 61156-5
Type A and B	Elongation at break of the sheath after ageing		IEC 60811-1-2	IEC 61156-5
Type A and B	Tensile strength of the sheath		IEC 60811-1-1	IEC 61156-5
Type A and B	Tensile strength of the sheath after ageing		IEC 60811-1-2	IEC 61156-5
Type A and B	Maximum Lateral Forces		IEC 61156-1 3.4.6	3000 N
Type A and B	Flame retardant		IEC 60332 - 1	Has to pass the test
Type A and B	Sheath pressure test at high temperature		IEC 60811-3-1	Max. 50 %
Type A and B	Heat shock test		IEC 60811-3-1	No cracks
Type A, B	Core diameter	1,5 +/- 0,1 mm	IEC 60811-1-1	$\geq 1,4 \text{ mm}$, $\leq 1,6 \text{ mm}$
Type A, B	Outer cable diameter	5,5 mm – 8,0 mm	IEC 60811-1-1	$\geq 5,5 \text{ mm}$, $\leq 8,0 \text{ mm}$
Hybrid Type B	Conductor resistance Datawire	AWG 22/7	IEC 60189-1	$\leq 60 \Omega/\text{km}$
Hybrid Type B	Flame retardant		IEC 60332 - 1	Has to pass the test
Hybrid Type B	Sheath pressure test at high temperature		IEC 60811-3-1	Max. 50 %
Hybrid Type B	Heat shock test		IEC 60811-3-1	No cracks
Hybrid Type B	Screening attenuation	For Grade 1	IEC 61156-5 : 3.3.8	$\geq 60 \text{ dB}$
Hybrid Type C	Conductor resistance Datawire	AWG 22	IEC 60189-1	$\leq 62 \Omega/\text{km}$

Hybrid Type B and C	Conductor resistance Powerwire	$\geq 1,5 \text{ mm}^2$	IEC 60189-1	$\leq 14 \text{ } \Omega/\text{km}$
Hybrid Type B and C	Core diameter Datawire	$1,5 \pm 0,1 \text{ mm}$	IEC 60811-1-1	$\geq 1,4 \text{ mm}$, $\leq 1,6 \text{ mm}$
Hybrid Type B and C	Outer cable diameter	$8,0 \text{ mm} - 12,0 \text{ mm}$	IEC 60811-1-1	$\geq 8,0 \text{ mm}$, $\leq 12,0 \text{ mm}$
Type A, B and Hybrid Type B	Minimum tensile strengths	50 N	EN 50 289-3-16 (2002)	IEC 61 156-5
All	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	Transfer impedance	$\leq 50 \text{ m}\Omega/\text{m}$ at 10 MHz	IEC 61156-5 : 3.2.7	$\leq 50 \text{ m}\Omega/\text{m}$ at 10 MHz
All	Operating temperature	$-20^\circ\text{C} \dots +70^\circ\text{C}$		All cable material have to designed for $-20^\circ\text{C} \dots +70^\circ\text{C}$
All	Differential delay / Delay skew		IEC 61156-5	$\leq 20 \text{ ns}/100 \text{ m}$

Table 9.2.1-1: Test requirement Balanced Cables

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

9.2.1 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.

9.2.2 POF and PCF cables

9.2.2.1 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 5-1 "Outside enclosure"	depending on the application) ¹
Transmission performance requirements:		
Relevant standard	IEC 60793-2	
Type (according to 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 9.2.2.1-1: Requirements for plastic and polymer clad optical fibre cables

9.2.2.2 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 _i =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 _i =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 9.2.2.1-1: Test requirements for plastic and polymer clad optical fibre cables

9.2.3 All-silica multimode optical fibre cables

9.2.3.1 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
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 5-1 "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 9.2.3.1-1: Requirements for all-silica multimode optical fibre cables

9.2.3.2 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 9.2.3.2-1.

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 _i =24h; max. 1,0 dB/km (@ 1300 nm)	2 cycles -20°C / +70°C; t _i =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 9.2.3.2-1: Test requirements for all-silica multimode optical fibre cables

9.2.4 All-silica singlemode optical fibre cables

9.2.4.1 Specification of all-silica singlemode optical fibre cables

All-silica singlemode optical fibre cables shall comply with the requirements listed in Table 9.2.4.1-1.

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	see Table 5-1 "Outside enclosure"	depending on the application) ^{*3}
Shock		
Vibration		
Operating temperature range		
Transmission performance requirements:		
Relevant standard	IEC 60793-2	
Type (according to 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 9.2.4.1-1: Requirements for all-silica singlemode optical fibre cables

9.2.4.2 Qualifikation 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 9.2.4.1-1.

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 _i =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 9.2.4.1-1: Requirements for all-silica singlemode optical fibre cables

10 Cord Sets for PROFINET Data Cabling

10.1 Cord Sets for Balanced Cabling

Cord Sets are harnessed cables. PROFINET cords that meet the requirement are described in the following Figure 10.1-2.

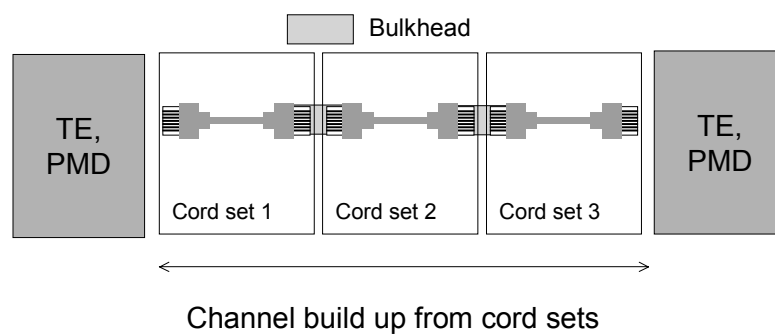


Figure 10.1-2: Channel definition

Cross-Over:

A cross-over changes the signal over from transmitter to receiver and is realised inside the device and not in the cabling.

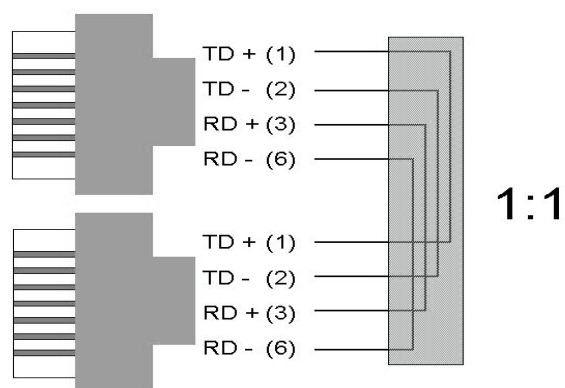


Figure 10.1-1: Cable Connection

PROFINET cord sets consist of a PROFINET conform cable harnessed with a PROFINET conform connector. Only connectors and cables specified in this Guideline shall be used. In addition to the component test it is necessary to fulfil the requirements for cord sets.

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.

Referring the specification in IEC 11801, values of this cord sets are comparable to patch cords. In 11801 these cables are not those specified for the horizontal link. Longer cord sets are possible but shall not be labelled as PROFINET cord sets, also the components are all PROFINET conform.

Frequency MHz	NEXT				
	dB				
	Length				
	2 m	5 m	10 m	>10 m	
1	65,00	65,00	65,00	65,00	
16	50,30	49,50	48,70	48,70	
100	35,00	34,70	34,50	34,50	

Table 10.1-2: Values of NEXT at key frequencies for PROFINET cord sets

10.1.1 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:

$$IL = IL_{cab} * L / 100 + 2 * IL_{con}$$

$$IL_{cab} = 22,0 \text{ dB} / 100\text{m} @ 100 \text{ MHz}, \quad IL_{con} = 0,4 \text{ dB}$$

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

10.1.2 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:

$$IL = IL_{cab} * L / 100 + 2 * IL_{con}$$

$$IL_{cab} = 33,0 \text{ dB} / 100\text{m} @ 100 \text{ MHz} , \quad IL_{con} = 0,4 \text{ dB}$$

(Informative values of IL_{cab} @ 100 MHz for PROFINET cord sets from IEC 11801)

10.2 Bulkheads for Balanced Cabling

Explanation of bulkheads and of the different implementations:

1. Adapter IP 67: Push Pull connector, M12 connector, Hybrid connector
2. Adapter IP 20 : RJ 45 connector
3. Panel feed-through: Push Pull connector, M12 connector, Hybrid / RJ 45 connector

The PROFINET bulkhead is counted as 2 connector pairs within the background of PROFINET scheme of components. A maximum of two bulkheads can be integrated into one channel.

The test specification relevant to PROFINET bulkheads is described in Clause 10.2.4.3 of IEC 11801 "Connecting hardware for use in distributors and consolidation points". The connecting hardware described in IEC 11801 is considered to be like a 5m patch cable.

Due to the system reserves of PROFINET cable, a length reduction is in most cases not mandatory.

Alternatively a special bulkhead can be installed, that corresponds to a connector and which is counted as one connector pair within the PROFINET scheme of components. An increase in the number of sockets is therefore made possible. The characteristics of this bulkhead correspond to the connector characteristics in Clause 10.2.4 of IEC 11801 "Connecting hardware for balanced cabling".



Figure 10.2 -1 : Bulkhead Adapter M12/RJ45**10.2.1.1 Qualification test for Bulkheads**

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

ISO/IEC 11801 (2002): Generic cabling

IEC 61935/2 (2004)

11 Connectors for 24 Volt Power Supply Cabling

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
Rated Current:	max. 4 A	max. 16 A (including power class 1)
Rated voltage	24 Volt	24 Volt
Number of circuits:	1 (optional 2)	1 (optional 2)
Functional earth (FE):	optional	mandatory
Connector:		
Screw lock family:	M12	7/8 inch
Push Pull Family:		Push Pull
Cable:		
Number of conductors:	4 (optional 5)	5
Conductor cross-section:	0,34..0,75 mm ²	1,5..2,5 mm ²
Rated voltage:	24 Volt	24 Volt
Outer diameter:	4,0..6,0 mm	6,0..10,0 mm

Table 11-1: Power Classes for the 24 Volt installation

The described connectors are the preferred PROFINET connectors for the 24 Volt Power Supply of all PROFINET devices in "Outside" Applications. If a listed connector is used, the connector shall comply to Table 11-1: Power Classes for the 24 Volt installation and Table 11-2: Preferred Connector solutions for the 24 Volt installation.

Other connectors can be used for special applications without influencing the certification of the devices.

Name:	7/8 inch	Push Pull	M12
Power Class	2	2	1
Specification according to:	ANSI /B93.55M-1981	Standard in Preparation	IEC 61076-2-101 A codet
Protection level (Tabelle 5-1 Outside Environment):	IP 65/67	IP 65/67	IP 65/67
Temperature range (Tabelle 5-1 Outside Environment):	-20° - +70°C	-20° - +70°C	-20° - +70°C
Number of contacts:	5	5	4 optional 5
Rated current @ 40°C (IEC 60 512):	16 A	16 A	4 A
Wire gauge min:	1,5 mm ²	1,5 mm ²	0,34 mm ²
Wire gauge max:	2,5 mm ²	2,5 mm ²	0,75 mm ²
Rated voltage (Pollution grade 3):	>24 Volt	>24 Volt	>24 Volt
Contact resistance:	< 5 mOhm	< 5 mOhm	< 5 mOhm
Mating cycles:	100	100	100
Cable gauge max.:(x)	10,0 mm	10,0 mm	8,0 mm
Housing available in metal:(x)	no	yes	yes
Housing available in plastic: (x)	yes	yes	yes
Coding and labeling: (x)	yes	yes	yes
Functional earth:	Pin 3	Pin 5	
PROFINET Contact Arrangement L1:	Pin 4	Pin 1	Pin 1
PROFINET Contact Arrangement L2:	Pin 5 optional	Pin 3	Pin 4 optional
PROFINET Contact Arrangement N1:	Pin 2	Pin 2	Pin 3
PROFINET Contact Arrangement N2:	Pin 1 optional	Pin 4	Pin 2 optional
(x) depends on connector manufacturer / mandatory for PROFINET			Pin 4 and 2 of the M12 connector are reserved for N2/L2

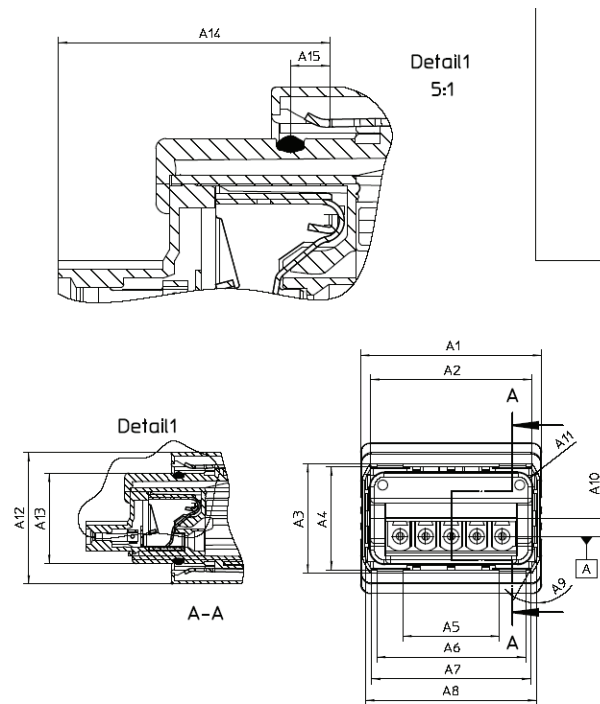
Table 11-2: Preferred Connector solutions for the 24 Volt installation

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

11.1 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 tee. 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.

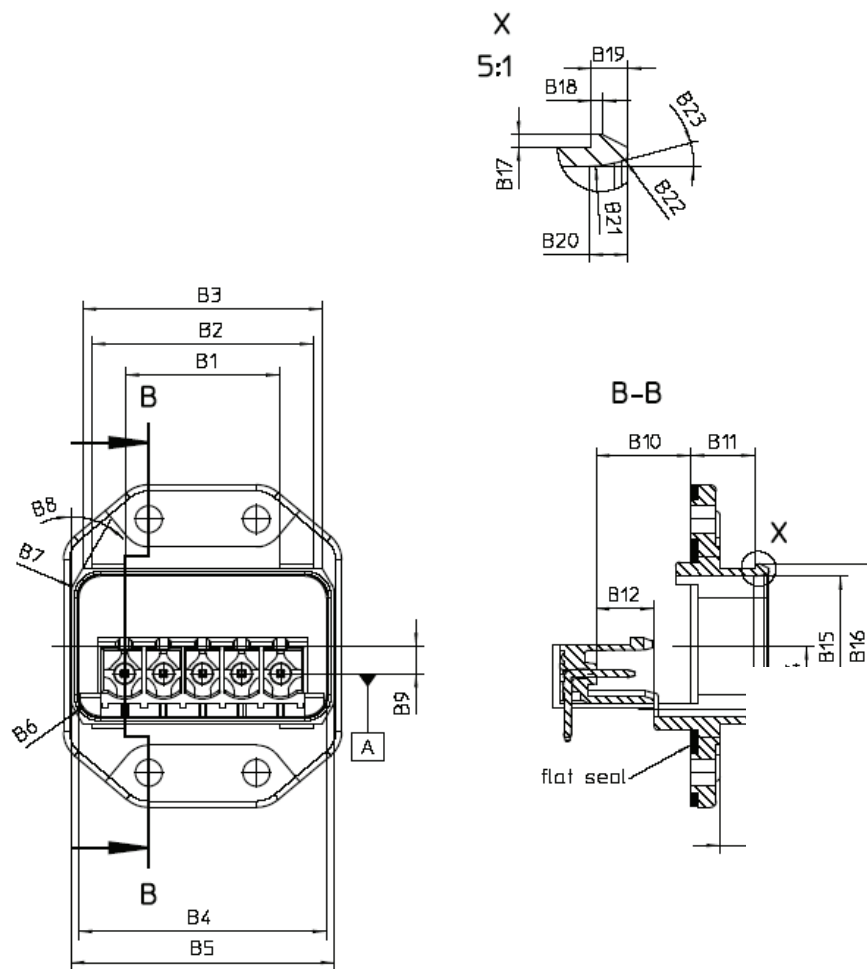
The standard for the connector is under preparation. Today there is no reference standard, so the relevant dimensions are added to this guideline.



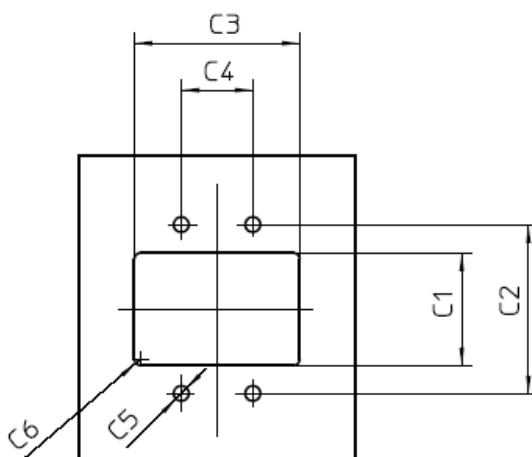
Dimensions free connector

Letter	Nominal mm	Minimum mm	Maximum mm
A1	36	-	-
A2	32,06	31,89	32,09
A3	21,8	21,7	21,9
A4	20,5	20,45	20,55
A5	19,2	19,05	19,35
A6	29,6	29,45	29,75
A7	31,6	31,45	31,75
A8	34	33,9	34,1
A9	30°	29°	31°
A10	3,6	3,55	3,65
A11	R 3,1	R 3,07	R 3,13
A12	26,2	-	-
A13	18,06	17,89	18,09
A14	21,6	21,55	21,65
A15	3,1	-	-

Figure 11.1-1:Dimensions of the Push Pull Plug 24 Volt Connector, free connector

**Dimensions fixed adaptor**

Letter	Nominal mm	Minimum mm	Maximum mm
B1	20	19,9	20,1
B2	28,8	28,7	28,9
B3	31,2	31,05	31,35
B4	32,2	32,17	32,23
B5	34,2	34,1	34,3
B6	R 2,8	R 2,77	R 2,83
B7	R 2	R 1,93	R 2,07
B8	30°	29°	31°
B9	3,6	3,55	3,65
B10	12,35	12,25	12,45
B11	8,3	8,25	8,35
B12	7,5	7,4	7,6
B13	4,5	4,4	4,6
B14	8,15	8,1	8,2
B15	18,2	18,17	18,23
B16	21,5	21,45	21,55
B17	0,65	-	-
B18	0,6	0,55	0,65
B19	1,9	1,85	1,95
B20	2	1,9	2,1
B21	R 5	R 4,9	R 5,1
B22	R 0,4	-	-
B23	15°	14°	16°

Figure 11.1-2:Dimensions of the Push Pull Plug 24 Volt Connector, fixed adaptor**Dimensions for mounting fixed adaptor**

Letter	Nominal mm	Minimum mm	Maximum mm
C1	22,8	22,7	22,9
C2	33	29,9	33,1
C3	33,2	33,1	33,3
C4	14	13,9	14,1
C5	M 3	-	-
C6	R 1,25	-	-

Figure 11.1-3:Dimensions of the Push Pull Plug 24 Volt Connector, cut out

Derating: IEC60512 Test 5d

Allocation : devise side = male side of the connector
cable side = female side of the connector

**Figure 11.1-4:Picture of the Push Pull Plug 24 Volt Connector**

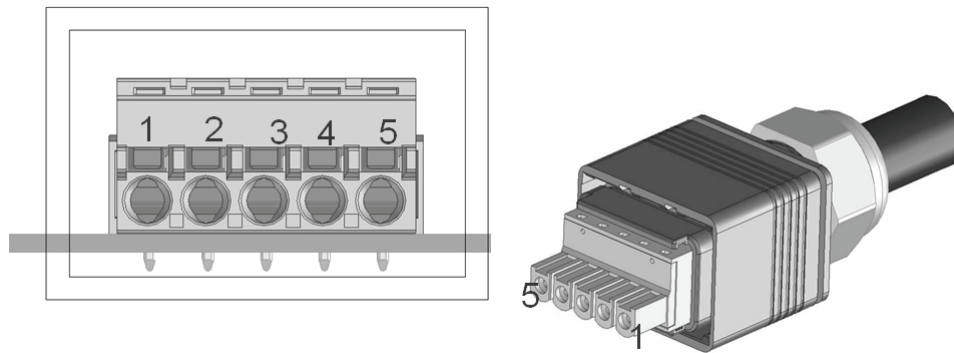


Figure 11.1-5: Contact arrangement and pinning of the Push Pull Plug 24 Volt Connector

In order to avoid a mismatch between the versions for 24 Volt and 400 Volt, the connectors are coded with profiles and have different colours of the contact insert, for the convenience of the user. The plug and the socket are coded in opposite directions as shown in Table 11.1-1. Above each contact is a location for a coding profile.

Application	Color	Binary Number	Contact Plug					Contact Socket				
			1	2	3	4	5	1	2	3	4	5
24 VDC	Black	9	No	Yes	No	No	Yes	Yes	No	Yes	Yes	No

Legend: No = no coding profile in place

Yes = coding profile in place

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 and is described in Table 11-1

11.2 Circular connector

11.2.1 M12 connector



Figure 11.3.1-1: Picture of the M12 24 Volt Connector

The M12 connectors (A-coding) described below are suitable for the supply of power to a device. The input voltage U_A may only be provided from the safety extra-low voltage (SELV). These complement the M12 data connectors (D-coding) for Ethernet signalling described in this guideline.

Derating: according to IEC60512

Note Pin 5: A 5-pole M12 socket should be used on the socket side. Pin 5 is assigned according to the application.

A 4-pole lay-out is available on the pin side, should no application specific function be implemented.

Allocation – Pin /Socket: Current sink = Pin, Power source = Socket

Drawing:

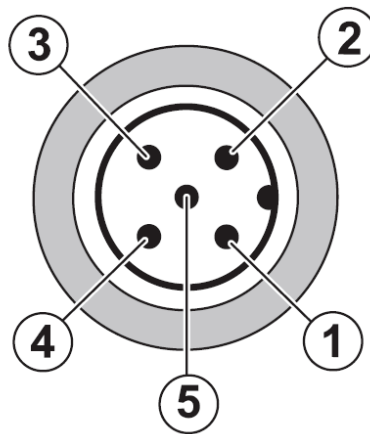


Figure 11.3.1-2: M12 connector pin-out for voltage supply

T-connector

M12 Connectors are typically designed to realise a star Topology.

11.2.2 7/8 inch connector



Figure 11.3.2-1: Picture of the 7/8 inch 24 Volt Connector

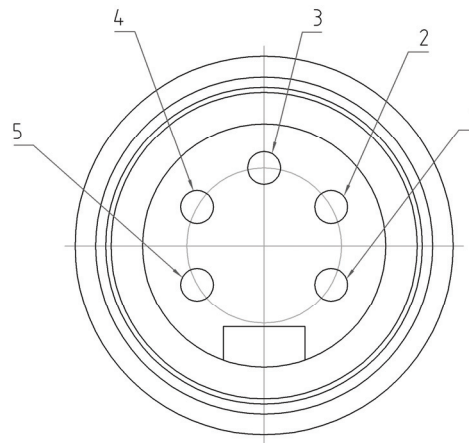


Figure 11.3.2-2: 7/8 inch connector pin-out for voltage supply

Allocation – Pin /Socket:

Current sink = Pin, Power source = Socket

T-connector

7/8" T-Connectors are designed to realise a lined Topology outside of the device to achieve 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 and is described in Table 11-1.

12 Connectors for 400 Volt Power Supply Cabling

For automation applications it is often necessary to equip devices with connectors capable of providing power to the device with 400 Volt power supply..

The 400 Volt Power supply should comply to international standards (e.g. ISO 23570-3). In respect to special applications other connectors can be used without influence to the certification of devices.

Part 3 of ISO 23570 covers the interconnection of three-phase auxiliary motors with their power source.

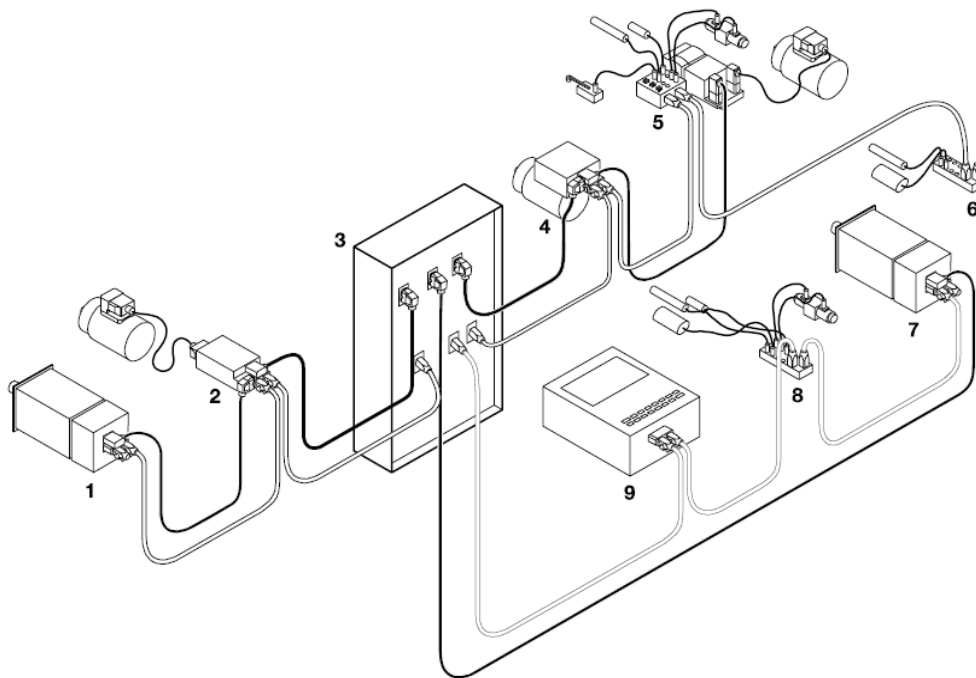


Figure 12-1: System landscape as described in the ISO 23570.

In the Figure 12.1 the landscape according to ISO 23570 is shown. The bold cable indicates the power cable.

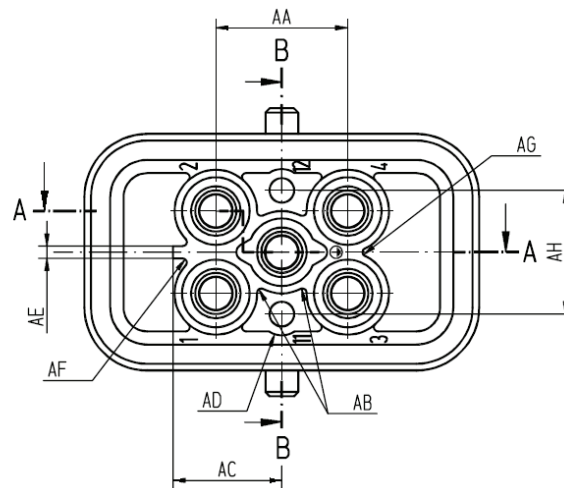


Figure A.1 — Male power bus cable connector

Figure 12-2: Power Bus connector

Table 1 — Contact assignment for power bus connectors

Contact	Assignment
1	Phase 1 power
2	Phase 2 power
3	Phase 3 power
4	Neutral
11	Brake
12	Brake
PE	Protective Earth

Figure 12-2: Contact assignment

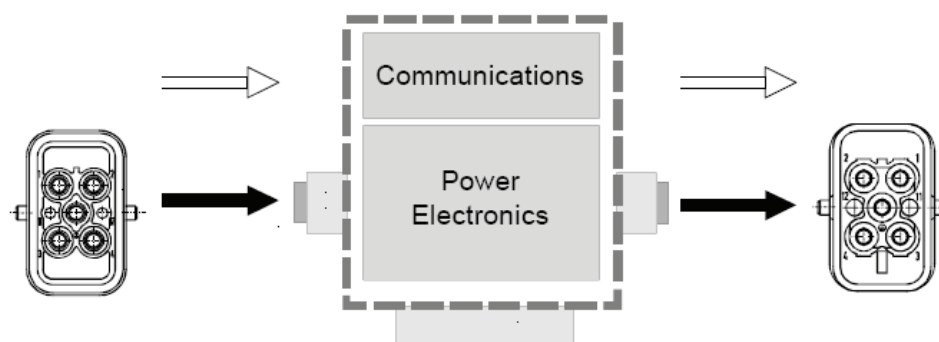


Figure 12-3: Power bus

Each power supply output shall be equipped with a female connector. The connection of the devices to the power supply shall be equipped with male connectors. The supply side of the device shall be equipped with the female connector. This second connector is optional for devices. This arrangement is specific for ISO 23570-3, other concepts may have other arrangements.

12.1.1.1 Test Specification

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

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

ISO 23570-3

The connectors are specified in the Annex A (normative):
Design specification for power bus connectors of the ISO 23570-3.

13 Application specific Cabling and Interconnection Technology

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

PROFINET connectors:

IP 67
Outside

RJ 45



Variante 14
Pas 61076-3-117

SC-RJ



Variante 14
Pas 61076-3-117

PROFINET 24 Power Supply connector:

IP 67
Outside



PROFINET 400 Volt Power Bus connector:



Table 13-1: Matrix of connectors

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