IEC 61784-5-3

Edition 4.0 2018-08

INTERNATIONAL STANDARD

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

IEC 61784-5-3:2018-08(en)

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INDUSTRIAL COMMUNICATION NETWORKS – PROFILES –

Part 5-3: Installation of fieldbuses – Installation profiles for CPF 3

FOREWORD

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International Standard IEC 61784-5-3 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This fourth edition cancels and replaces the third edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) an addition of 4-pair cabling (see C.4.4.1.2.1and C.5.3.2);
b) an addition of the connector M12 X-Coding (see C.4.4.2.2);
c) an addition of the definition of End-to-end links (see C.4.4.3.1);

d) a revision of Table C.17 (see C.5.2.1);

e) a formula for the NEXT limits of End-to-end links (see C.6.3.2.1.2).

This standard is to be used in conjunction with IEC 61918:2018

The text of this international standard is based on the following documents:

FDIS	Report on voting
65C/924/FDIS	65C/925/RVD

Full information on the voting for the approval of this international standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 61784-5 series, under the general title *Industrial communication networks – Profiles – Installation of fieldbuses*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This International Standard is one of a series produced to facilitate the use of communication networks in industrial control systems.

IEC 61918:2018 provides the common requirements for the installation of communication networks in industrial control systems. This installation profile standard provides the installation profiles of the communication profiles (CP) of a specific communication profile family (CPF) by stating which requirements of IEC 61918 fully apply and, where necessary, by supplementing, modifying, or replacing the other requirements (see Figure 1).

For general background on fieldbuses, their profiles, and relationship between the installation profiles specified in this document, see IEC 61158-1.

Each CP installation profile is specified in a separate annex of this document. Each annex is structured exactly as the reference standard IEC 61918 for the benefit of the persons representing the roles in the fieldbus installation process as defined in IEC 61918 (planner, installer, verification personnel, validation personnel, maintenance personnel, administration personnel). By reading the installation profile in conjunction with IEC 61918, these persons immediately know which requirements are common for the installation of all CPs and which are modified or replaced. The conventions used to draft this document are defined in Clause 5.

The provision of the installation profiles in one standard for each CPF (for example IEC 61784-5-3 for CPF 3), allows readers to work with standards of a convenient size.

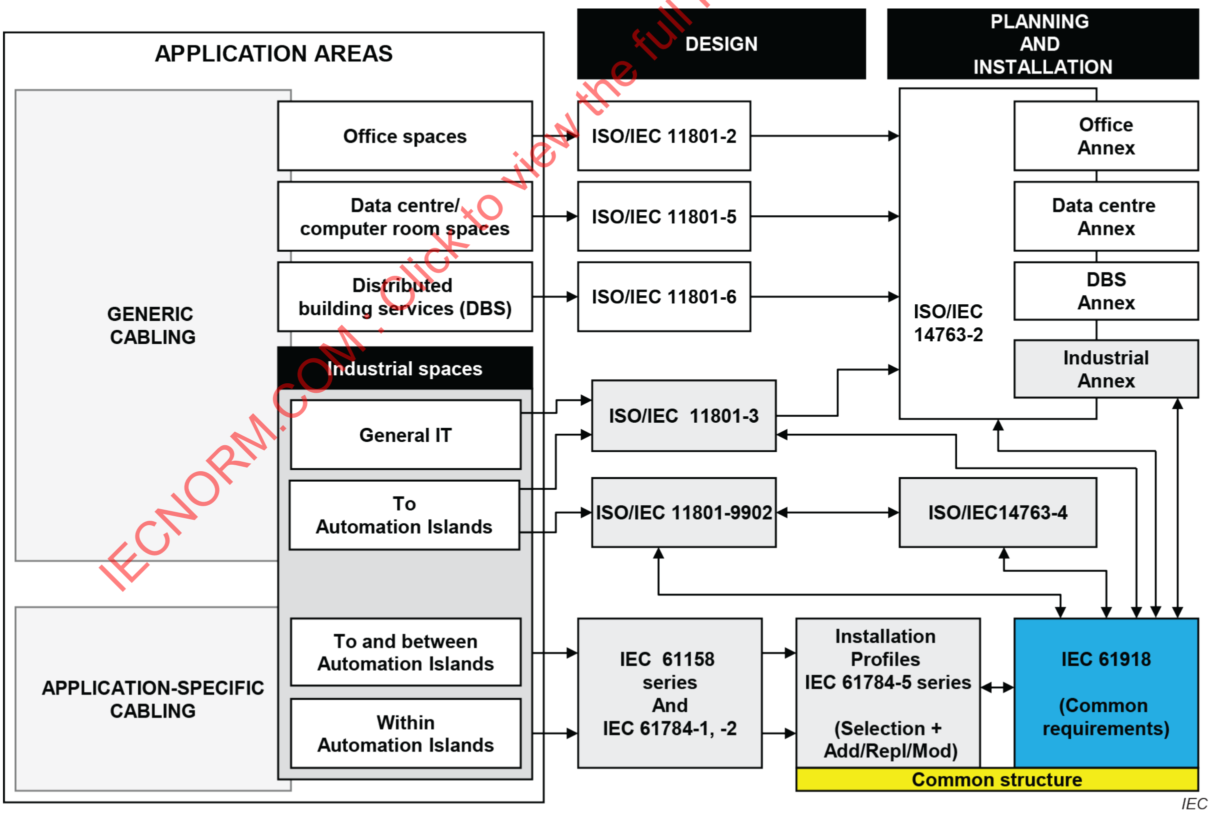

Figure 1 – Standards relationships

INDUSTRIAL COMMUNICATION NETWORKS – PROFILES –

Part 5-3: Installation of fieldbuses – Installation profiles for CPF 3

1 Scope

This part of IEC 61784-5 specifies the installation profiles for CPF 3 (PROFIBUS/PROFINET)[1].

The installation profiles are specified in the annexes. These annexes are read in conjunction with IEC 61918:2018.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61918:2018, *Industrial communication networks – Installation of communication networks in industrial premises*

The normative references of IEC 61918:2018, Clause 2, apply.

NOTE For profile specific normative references, see Clause(s) A.2, B.2 and C.2.

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms, definitions and abbreviated terms of IEC 61918:2018, Clause 3, apply.

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

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

NOTE For profile specific terms, definitions and abbreviated terms see Clause(s) A.3, B.3 and C.3.

4 CPF 3: Overview of installation profiles

CPF 3 consists of six communication profiles as specified in IEC 61784-1 and IEC 61784-2.

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1 PROFIBUS and PROFINET are trade names of the non-profit organization PROFIBUS Nutzerorganisation e.V. (PNO). This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the trade names holder or any of its products. Compliance to this profile does not require use of the trade names. Use of the trade names PROFIBUS and PROFINET requires permission of the trade name holder.

The installation requirements for CP 3/1 (PROFIBUS with physical layer according to RS 485, RS 485-IS, and fibre) are specified in Annex A.

The installation requirements for CP 3/2 (PROFIBUS with physical layer according to MBP, MBP-IS, MBP-LP) are specified in Annex B.

The installation requirements for CP 3/3, CP 3/4, CP 3/5, and CP 3/6 (PROFINET) are specified in Annex C.

5 Installation profile conventions

The numbering of the clauses and subclauses in the annexes of this document corresponds to the numbering of IEC 61918 main clauses and subclauses.

The annex clauses and subclauses of this document supplement, modify, or replace the respective clauses and subclauses in IEC 61918.

Where there is no corresponding subclause of IEC 61918 in the normative annexes in this document, the subclause of IEC 61918 applies without modification.

The annex heading letter represents the installation profile assigned in Clause 4. The annex (sub)clause numbering following the annex letter shall represent the corresponding (sub)clause numbering of IEC 61918.

EXAMPLE "Subclause B.4.4" in IEC 61784-5-3 means that CP 3/2 specifies the subclause 4.4 of IEC 61918.

All main clauses of IEC 61918 are cited and apply in full unless otherwise stated in each normative installation profile annex.

If all subclauses of a (sub)clause are omitted, then the corresponding IEC 61918 (sub)clause applies.

If in a (sub)clause it is written "Not applicable.", then the corresponding IEC 61918 (sub)clause does not apply.

If in a (sub)clause it is written "*Addition:*", then the corresponding IEC 61918 (sub)clause applies with the additions written in the profile.

If in a (sub)clause it is written "*Replacement:*", then the text provided in the profile replaces the text of the corresponding IEC 61918 (sub)clause.

NOTE A replacement can also comprise additions.

If in a (sub)clause it is written "*Modification:*", then the corresponding IEC 61918 (sub)clause applies with the modifications written in the profile.

If all (sub)clauses of a (sub)clause are omitted but in this (sub)clause it is written "*(Sub)clause x has addition*" (or "*replacement*", or "*modification*") or "(Sub)clause is not applicable.", then (sub)clause x becomes valid as declared and all the other corresponding IEC 61918 (sub)clauses apply.

6 Conformance to installation profiles

Each installation profile within this document includes part of IEC 61918:2018. It may also include defined additional specifications.

A statement of compliance to an installation profile of this document shall be stated[2] as either

Compliance to IEC 61784-5-3:201x[3] for CP 3/m <name> or

Compliance to IEC 61784-5-3 (Ed.4.0) for CP 3/m <name>

where the name within the angle brackets < > is optional and the angle brackets are not to be included. The m within CP 3/m shall be replaced by the profile number 1 to 6.

NOTE The name may be the name of the profile, for example PROFIBUS or PROFINET.

If the name is a trade name then the permission of the trade name holder shall be required.

Product standards shall not include any conformity assessment aspects (including quality management provisions), neither normative nor informative, other than provisions for product testing (evaluation and examination).

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2 In accordance with ISO/IEC Directives.

3 The date should not be used when the edition number is used.

Annex A
(normative)

CP 3/1 (PROFIBUS) specific installation profile

A.1 Installation profile scope

Addition:

This annex specifies the installation profile for Communication Profile CP 3/1 (PROFIBUS with a physical layer according to RS 485, RS 485-IS, and fibre). The CP 3/1 is specified in IEC 61784-1.

A.2 Normative references

Addition:

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

IEC 60079-11:2011, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60512-6-3, *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 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

ANSI TIA/EIA-485-A, *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

A.3 Installation profile terms, definitions, and abbreviated terms

A.3.1 Terms and definitions

Addition:

A.3.1.87
hazard
potential source of harm

Note 1 to entry: The term includes danger to persons arising within a short time scale (for example fire and explosion) and also those that have a long term effect on a person's health (for example release of a toxic substance).

[SOURCE: IEC 61508-4:2010, 3.1.2, modified – the note to entry has been added]

A.3.1.88
intrinsic safety "i"
type of protection based on the restriction of electrical energy within apparatus and of interconnecting wiring exposed to the potentially explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects

Note 1 to entry: No single device or wiring is intrinsically safe by itself (except for battery-operated self-contained apparatus such as portable pagers, transceivers, gas detectors, which are specifically designed as intrinsically safe self-contained devices) but is intrinsically safe only when employed as part of a properly designed intrinsically safe system.

[SOURCE: IEC 60079-11:2011, 3.1.1, modified – the note to entry has been added]

A.3.2 Abbreviated terms

Addition:

MAU	Medium attachment unit
PELV	Protective extra low voltage
PNO	PROFIBUS Nutzer Organisation (a non-profit user organisation)
RS 485	MAU according to ANSI TIA/EIA-485-A
RS 485-IS	MAU according to ANSI TIA/EIA-485-A and applicable to IS
SELV	Safety extra low voltage
TN-S	Coded type of system earthing according to IEC 60364-1, 312.2

A.3.3 Conventions for installation profiles

Not applicable.

A.4 Installation planning

A.4.1 General

Subclause 4.1.2 has addition:

Generic cabling in accordance with ISO/IEC 11801-3 is not suitable for the cabling of CP 3/1 networks.

CP 3/1 networks only can be connected to the generic cabling via a converter/adapter as specified in IEC 61918:2018, 4.1.2.

A.4.2 Planning requirements

A.4.2.1 Safety

Subclause 4.2.1.3 has addition:

Each and every device on CP 3/1 networks (standard and safety) should provide a test certificate issued by PROFIBUS International (more information available by <www.profibus.com>) based on IEC 61158 or at least provide a corresponding manufacturers declaration stating compliance with CP 3/1 specification.

Each and every safety device shall comply with IEC 61508 series and other related standards if applicable.

The 24 V power supplies in use shall be one-error proof and provide SELV/PELV only. National regulations shall be considered.

EXAMPLE In the United States of America, the power supplies provide a current limitation of 8 A according to UL508C.

No spurs or branch lines are permitted in a CP 3/1 network for safety applications.

Effective cable shielding especially after bending the cable or after changing connectors shall be ensured. In case of doubt, a more flexible and robust cable type should be used.

Sub-D connectors shall have multi contact features at the connector housing in order to provide an optimal contact between the cable shield, the cable connector and its counterpart at the CP 3/1 device. Care shall be taken to achieve a good (low impedance) contact between the cable shield and connector housing.

For connections of CP 3/1 devices with M12 interface only M12 connectors that guarantee a good (low impedance) contact between cable shield and connector housing are permitted. Cable shield shall not be connected to the connector pin 5.

A cabinet of protection class IP54 (dust, shower water) shall be used for safety devices such as drives with integrated safety that are offering a lower protection class such as IP20. Cabinets with a lower protection class may only be used if safety devices explicitly permit other environments according to the manufacturer's information (for example heat problems).

A.4.2.2 Security

A.4.2.3 Environmental considerations and EMC

A.4.2.3.1 Description methodology

Modification:

The MICE description methodology shown in IEC 61918:2018 is both a rather comprehensive and complex approach but nevertheless does not describe all possible environments. Where an environment exists that cannot be mapped in to the MICE tables, the user shall determine suitability of the components for the targeted environment through agreements with the component providers or additional mitigation techniques.

To make fieldbus installation work more easily for CP 3/1 fieldbus networks the MICE table is condensed into the two basic environments inside and outside data cabinets.

CP 3/1 products should at least meet the MICE parameters of Table A.1.

Table A.1 – Excerpt of MICE definition

	Inside enclosure	Outside enclosure
Mechanical		
Shock/bump Peak acceleration	IEC 60512-6-3 20 g / 11 ms 3 per axis in both directions	IEC 60512-6-3 20 g / 11 ms 3 per axis in both directions
Vibration 10 Hz – 500 Hz	IEC 60512-6-4 0,35 mm or 5g	IEC 60512-6-4 0,35 mm or 5 g
Ingress		
IP protection class	IP20	IP65 / IP67
Particulate ingress (diameter min)	12,5 mm	50 µm
Immersion	None	intermittent liquid jet ≤ 12,5 l/min ≥ 6,5 mm jet > 2, m distance and immersion (≤1 m for ≤30 min)
Climatic and chemical		
Ambient temperature	0 °C to +70 °C	–20 °C to +70 °C
Electromagnetic		
Transfer impedance	See components selection	
Additional parameters out of the MICE definition in IEC 61918:2018, Annex B, may be observed depending on the application. The different products offered for these environments typically meet the requirements of the respective IEC standards. Additional products are offered for special applications (e.g. drag chain, festoon, robots, etc) and the recommendations for cable routing should be followed. The repetitive nature of the shock experienced by the channel shall be taken into account.		

A.4.2.3.2 Use of the described environment to produce a bill of material

Addition:

Manufacturers mark their products designed for CP 3/1 networks in a specific way. Only these marked products shall be used and be mentioned on the bill of material.

The planner shall take into account the mating interface of devices to be connected to the fieldbus network.

A.4.2.4 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.3 Network capabilities

A.4.3.1 Network topology

A.4.3.1.1 Common description

A.4.3.1.2 Basic physical topologies for passive networks

Modification:

For CP 3/1 passive networks, only the bus topology is permitted.

A.4.3.1.3 Basic physical topologies for active networks

A.4.3.1.4 Combination of basic topologies

A.4.3.1.5 Specific requirements for CPs

Addition:

For CP 3/1 networks with a data transmission rate of 12 Mbit/s spurs shall not be used.

For CP 3/1 networks with a data transmission rate of 1,5 Mbit/s spurs should not be used.

Bus repeaters of different manufacturers should not be mixed due to their different optimization strategies. The number of repeaters permitted in a link between any two devices is up to manufacturer's specification.

A.4.3.1.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.3.2 Network characteristics

A.4.3.2.1 General

A.4.3.2.2 Network characteristics for balanced cabling not based on Ethernet

Replacement:

Table A.2 provides values based on the template given in IEC 61918:2018, Table 1.

Table A.2 – Basic network characteristics for balanced cabling not based on Ethernet (ISO/IEC 8802-3)

Characteristic	**CP 3/1 (PROFIBUS)**	
Basic transmission technology	**RS 485**	**RS 485-IS**
Length / transmission speed	**Segment length** m	
9,6 kbit/s – 93,75 kbit/s	1 200	1 200
187,5 kbit/s	1 000	1 000
500 kbit/s	400	400
1,5 Mbit/s	200	200
3 – 6 – 12 Mbit/s	100	Not applicable
Maximum capacity	**Maximum no.**	
Devices / segment	32	32
Number of devices / network [a]	125	125
[a] Limited by addressing scheme.		

A.4.3.2.3 Network characteristics for balanced cabling based on Ethernet

Not applicable.

A.4.3.2.4 Network characteristics for optical fibre cabling.

Replacement:

Table A.3 provides values based on the template given in IEC 61918:2018, Table 3.

Table A.3 – Network characteristics for optical fibre cabling

CP 3/1		
Optical fibre type	**Description**	
Single mode silica	Minimum length (m)	0
	Maximum length (m)	15 000
	Maximum channel Insertion loss/optical power budget (dB)	5
	Connecting hardware	See A.4.4.2.5
Multimode silica	Modal bandwidth (MHz × km) at λ (nm)	600 at 850
	Minimum length (m)	0
	Maximum length (m)	3 000
	Maximum channel insertion loss/optical power budget (dB)	6
	Connecting hardware	See A.4.4.2.5
POF	Modal bandwidth (MHz × km) at λ (nm)	1,0 at 660
	Minimum length (m)	0
	Maximum length (m)	100
	Maximum channel insertion loss/optical power budget (dB)	6
	Connecting hardware	See A.4.4.2.5
Hard clad silica	Modal bandwidth (MHz × km) at λ (nm)	17 at 660
	Minimum length (m)	0
	Maximum length (m)	500
	Maximum channel insertion loss/optical power budget (dB)	3
	Connecting hardware	See A.4.4.2.5

A.4.3.2.5 Specific network characteristics

Not applicable.

A.4.3.2.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4 Selection and use of cabling components

A.4.4.1 Cable selection

A.4.4.1.1 Common description

Addition:

Generic cabling in accordance with ISO/IEC 11801-3 is not suitable for the cabling of CP 3/1 networks.

CP 3/1 networks only can be connected to the generic cabling via a converter/adapter as specified in IEC 61918:2018, 4.1.2.

A.4.4.1.2 Copper cables

A.4.4.1.2.1 Balanced cables for non-Ethernet-based CPs

Not applicable.

A.4.4.1.2.2 Copper cables for non-Ethernet-based CPs

Addition:

Unshielded cables shall not be used with CP 3/1 networks.

Replacement:

Table A.4 provides values based on the template given in IEC 61918:2018, Table 4.

Table A.4 – Information relevant to copper cable: fixed cables

Characteristic	CP 3/1 (PROFIBUS RS 485)	CP 3/1 (PROFIBUS RS 485-IS) [a]
Nominal impedance of cable (tolerance)	135 Ω to 165 Ω; f = 3 MHz to 20 MHz	
Balanced or unbalanced	Balanced	
DCR of conductors	< 55 Ω/km	
DCR of shield	Not defined	
Number of conductors	2	
Shielding	Mandatory	
Colour code for conductor	A = green; B = red	
Jacket colour requirements	Violet	Light blue [b]
Jacket material	Application dependent	
Resistance to harsh environment (e.g. UV, oil resist, LS0H)	Cable types for different applications available	
Agency ratings	Cable types with different ratings available	
Conductor cross-sectional area	≥ 0,34 mm^2	≥ 0,34 mm^2 [c]
Capacitance	< 30 pF/m	
L/R ratio (μH / Ω)	Not specified	≤ 15
The L/R ratio shall be applied for the lowest ambient temperature of the bus cable.		
[a] Cable shall be in accordance with IEC 60079-14.		
[b] If a colour is used for identification.		
[c] If a fine stranded conductor is used: 0,1 mm is the minimum value required for the diameter of a single wire.		

A.4.4.1.3 Cables for wireless installation

A.4.4.1.4 Optical fibre cables

Replacement:

Table A.5 provides values based on the template given in IEC 61918:2018, Table 6.

Table A.5 – Information relevant to optical fibre cables

Characteristics for CP 3/1	9..10/125 µm single mode silica	50/125 µm multimode silica	62,5/125 µm multimode silica	980/1 000 µm step index POF	200/230 µm step index hard clad silica
Standard	IEC 60793-2	IEC 60793-2	IEC 60793-2	IEC 60793-2	IEC 60793-2
Attenuation per km (660 nm)	–	–	–	≤ 230 dB	≤ 10 dB
Attenuation per km (850 nm)	–	≤ 2,7 dB	≤ 3,5 dB	–	–
Attenuation per km (1 320 nm)	≤ 1,0 dB	–	–	–	–
Number of optical fibres	2	2	2	2	2
Connector type (e.g. duplex or simplex)	BFOC/2,5	BFOC/2,5	BFOC/2,5	BFOC/2,5 others	BFOC/2,5 others
Jacket colour requirements	None	None	None	None	None
Jacket material	Several	Several	Several	Several	Several
Resistance to harsh environment (e.g. UV, oil resist, LS0H)	Yes	Yes	Yes	Yes	Yes
Breakout	Yes	Yes	Yes	Yes	Yes

A.4.4.1.5 Special purpose balanced and optical fibre cables

A.4.4.1.6 Specific cable requirements for CPs

Addition:

The data communication part of hybrid cables complies with IEC 61918:2018, 4.4.1.2.2. In addition hybrid cables shall provide 4 × 1,5 mm² copper wires for power supply.

A.4.4.1.7 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.2 Connecting hardware selection

A.4.4.2.1 Common description

Modification:

Applies with consideration of A.4.2.3.1.

A.4.4.2.2 Connecting hardware for balanced cabling CPs based on Ethernet

Not applicable.

A.4.4.2.3 Connecting hardware for copper cabling CPs not based on Ethernet

Replacement:

Table A.6 provides values based on the template given in IEC 61918:2018, Table 8.

Table A.6 – Connectors for copper cabling CPs not based on Ethernet

	IEC 60807-2 or IEC 60807-3	IEC 60947-5-2 or IEC 61076-2-101			IEC 6116 9-8	ANSI/(NFPA) T3.5.29 R1-2007		Others		
	Sub-D	**M12-5 with A-coding**	**M12-5 with B-coding**	**M12-n with X-coding**	**Coaxial (BNC)**	**M 18**	**7/8-16 UN-2B THD**	**Open style**	**Termin al block**	**Others**
CP 3/1	9 pin	No	Yes	No	No	No	No	No	Yes	Hybrid style
NOTE For M12-5 connectors, there are many applications using these connectors that are not compatible and when mixed can cause damage to the applications.										

A.4.4.2.4 Connecting hardware for wireless installation

A.4.4.2.5 Connecting hardware for optical fibre cabling

Replacement:

Table A.7 provides values based on the template given in IEC 61918:2018, Table 9.

Table A.7 – Optical fibre connecting hardware

	IEC 61754-2	IEC 61754-4	IEC 61754-24	IEC 61754-20	IEC 61754-22	Others
	BFOC/2,5	**SC**	**SC-RJ**	**LC**	**F-SMA**	
CP 3/1	Yes	No	No	No	No	Others for POF and hard clad silica
NOTE The IEC 61754 series defines the optical fibre connector mechanical interfaces; performance specifications for optical fibre connectors terminated to specific fibre types are standardised in the IEC 61753 series.						

Replacement:

Table A.8 provides values based on the template given in IEC 61918:2018, Table 10.

Table A.8 – Relationship between FOC and fibre types (CP 3/1)

FOC	Fibre type					
	9..10/125 µm single mode silica	**50/125 µm multimode silica**	**62,5/125 µm multimode silica**	**980/1 000 µm step index POF**	**200/230 µm step index hard clad silica**	**Others**
BFOC/2,5	Yes	Yes	Yes	Recommended	Recommended	No
SC	No	No	No	Yes	Yes	No
SC-RJ	No	No	No	Yes	Yes	No
LC	No	No	No	Yes	Yes	No
F-SMA	No	No	No	Yes	Yes	No
NOTE The IEC 61754 series defines the optical fibre connector mechanical interfaces; performance specifications for optical fibre connectors terminated to specific fibre types are standardised in the IEC 60874 series.						

A.4.4.2.6 Specific requirements for CPs

Not applicable.

A.4.4.2.7 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.3 Connections within a channel/permanent link

A.4.4.3.1 Common description

A.4.4.3.2 Balanced cabling connections and splices for CPs based on Ethernet

Subclause A.4.4.3.2.3 has replacement:

For CP 3/1 networks with RS 485-IS splices are not allowed.

A.4.4.3.3 Copper cabling connections and splices for CPs not based on Ethernet

Subclause 4.4.3.3.1 has addition:

Refer to the manufacturer's data sheet regarding number of allowed connections.

A.4.4.3.4 Optical fibre cabling connections and splices for CPs based on Ethernet

Not applicable.

A.4.4.3.5 Optical fibre cabling connections and splices for CPs not based on Ethernet

Addition:

The maximum channel attenuation is given in Table A.17.

A.4.4.3.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.4 Terminators

A.4.4.4.1 Common description

Addition:

For CP 3/1 networks terminators shall be used. Each end of a network segment shall be terminated.

A.4.4.4.2 Specific requirements for CPs

Addition:

For CP 3/1 networks with RS 485 interface, the terminators shall be in accordance with 22.1.2.4 of IEC 61158-2:2014.

For CP 3/1 networks with RS 485-IS the terminators shall be in accordance with 22.2.2.4 of IEC 61158-2:2014. If the terminators are built-in within a device, then power supply with current limitation via built-in resistors shall be provided (see A.5.3.4).

A.4.4.4.3 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.5 Device location and connection

A.4.4.5.1 Common description

Addition:

If devices according to CP 3/1 with RS 485-IS are intended to be used in hazardous locations, then the national regulation shall be observed when installing such devices.

A.4.4.5.2 Specific requirements for CPs

Refer to the manufacturer's data sheet regarding device location and connection.

A.4.4.5.3 Specific requirements for wireless installation

Not applicable.

A.4.4.5.4 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.6 Coding and labelling

A.4.4.6.1 Common description

Addition:

For CP 3/1 networks with RS 485-IS the colour coding of the bus cable for intrinsically safe circuits shall be light blue.

A.4.4.6.2 Additional requirements for CPs

A.4.4.6.3 Specific requirements for CPs

Not applicable.

A.4.4.6.4 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

Not applicable.

A.4.4.7 Earthing and bonding of equipment and devices and shielded cabling

A.4.4.7.1 Common description

A.4.4.7.1.1 Basic requirements

Addition:

Compliance to IEC 60364-4-41 shall be ensured. Requirements of local or national regulations for the erection of electrical or communication shall be observed in addition.

The configuration of the LV power distribution system shall comply with IEC 60364-1:2005, 312.2.1, TN-S systems, which means separated conductors for neutral (N) and protective earth (PE). Equipotential properties of earth and protection earth are required. Requirements of local or national regulations for the erection of electrical or communication networks shall be observed in addition.

Where the power distribution system does not comply with the TN-S system and AC current can be measured on the fieldbus cable shielding the fieldbus network should be built with OF-cables (see IEC 61918:2018, Annex E for details).

A properly installed AC power system ensures that no currents flow through shields and/or equipotential bonding conductors connected to the CBN.

Currents higher than approximately 0,1 A indicate problems in the electrical installation (that means more than one connection between N and PE anywhere in the power distribution system).

Indications of an unsuitable AC power supply are as follows:

- Currents on the PE conductor.
- Currents through cable shields.
- Currents through water pipes and heating pipes.
- Progressive corrosion at earthing terminals, on lightning conductors, and water pipes.

NOTE Sporadic events such as switching, short circuits, or atmospheric discharge (lightning strike) can cause current peaks in the system many times higher than the average value.

A.4.4.7.1.2 Planner tasks

A.4.4.7.1.3 Methods for controlling potential differences in the earth system

A.4.4.7.1.4 Selection of the earthing and bonding system

A.4.4.7.2 Bonding and earthing of enclosures and pathways

A.4.4.7.2.1 Equalization and earthing conductor sizing and length

A.4.4.7.2.2 Bonding straps and sizing

A.4.4.7.2.3 Surface preparation and methods

A.4.4.7.2.4 Bonding and earthing

A.4.4.7.3 Earthing methods

A.4.4.7.3.1 Equipotential

Addition:

With CP 3/1 networks an equipotential mesh earthing system shall be used.

A.4.4.7.3.2 Star

Replacement:

The star earthing system shall not be used for CP 3/1 networks.

A.4.4.7.3.3 Earthing of equipment (devices)

A.4.4.7.3.4 Copper bus bars

A.4.4.7.4 Shield earthing

A.4.4.7.4.1 Non-earthing or parallel RC

Not applicable.

A.4.4.7.4.2 Direct

Addition:

Shielding of bus cables shall always be connected to earth at both ends of the cables. Single point shield termination shall be avoided.

Where equipotential bonding is not guaranteed or cannot be achieved (for example by installing an equipotential bonding conductor in parallel to the distributed communication cables) optical fibre cabling should be used.

A.4.4.7.4.3 Derivatives of direct and parallel RC

A.4.4.7.5 Specific requirements for CPs

Addition:

For CP 3/1 networks with RS 485-IS the following applies:

For the operation of an installation with fieldbus systems, the earthing concept and thereby also the shielding of the electrical cables is a very important issue. When finalizing the earthing concept, the following aspects should be taken into consideration:

- Ensuring electromagnetic compatibility (EMC).
- Explosion protection.
- Human safety.

Conventional field units (for example with a 4 mA to 20 mA interface) which are connected via two-wire cables with isolating repeaters in the control room process DC signals or low-frequency AC signals. The influence of wire-conducted noise signals with higher frequencies can be suppressed by means of appropriate input filters having a low cut-off frequency. Thus, in contrast to fieldbus systems, for such devices a predominantly electrostatically acting cable shield (earthed on one side) is sufficient.

In fieldbus systems however, the usable frequency for the transmission of the signals is considerably higher – and the requirements placed on the earthing concept of the system accordingly tougher, i.e. earthing as described before (using predominantly electrostatically cables) is not sufficient. Where AC signals are being processed, the components and also the interconnection of elements, like cables, shall be protected against the influence of electromagnetic fields. The protective measures should create a complete encapsulation around the sensitive components. The larger the processed signal frequencies in the systems, the greater the requirement placed on the completeness of this gapless protective encapsulation. Thus, the shielding and earthing concept has to satisfy these requirements in order to constitute the basis for the EMC tests performed by the device manufacturers.

In order to meet the described requirements, shields of cables shall be connected with the terminal locations in the devices intended for this purpose. When connecting the shields, a low-impedance connection should be ensured – considering the high noise frequencies. This applies not only for the connection of the cable shields, but also for the earthing connection of the device. Extended wires usually do not meet these requirements.

For the shielding and earthing measures to have their optimum effect, the devices and shields shall be earthed more than once. According to 12.2.2.3 in IEC 60079-14:—, this method, which is optimal for electromagnetic compatibility and human safety, can be utilised without restriction in the area of the entire installation.

If the installation is made and maintained that it can be ensured with a high degree of certainty that a potential equalization exists between each end of the circuit (that means between the hazardous area and safe area) then cable screens and conducting screens at both ends of the cable and the screens at intermediate points should be connected to earth.

In the process, in the hazardous area according to 6.3 in IEC 60079-14:—, an equipotential bonding system is an absolute requirement anyway. The measures detailed there (inclusion of protective conductors, protective tubes, metallic cable shields, cable reinforcements and metallic components) can be supplemented using the following measures:

- Laying of the bus cables on metallic cable trays.
- Incorporation of the cable tray into the equipotential bonding system.
- Interconnections of the cable trays among each other and to metallic components – these interconnections should consider safety aspects, be of sufficient current-loading capacity and be designed for high-frequency capability and low impedance.

Figure A.1 shows the recommended combination of shielding and earthing for CP 3/1 networks with RS 485-IS.

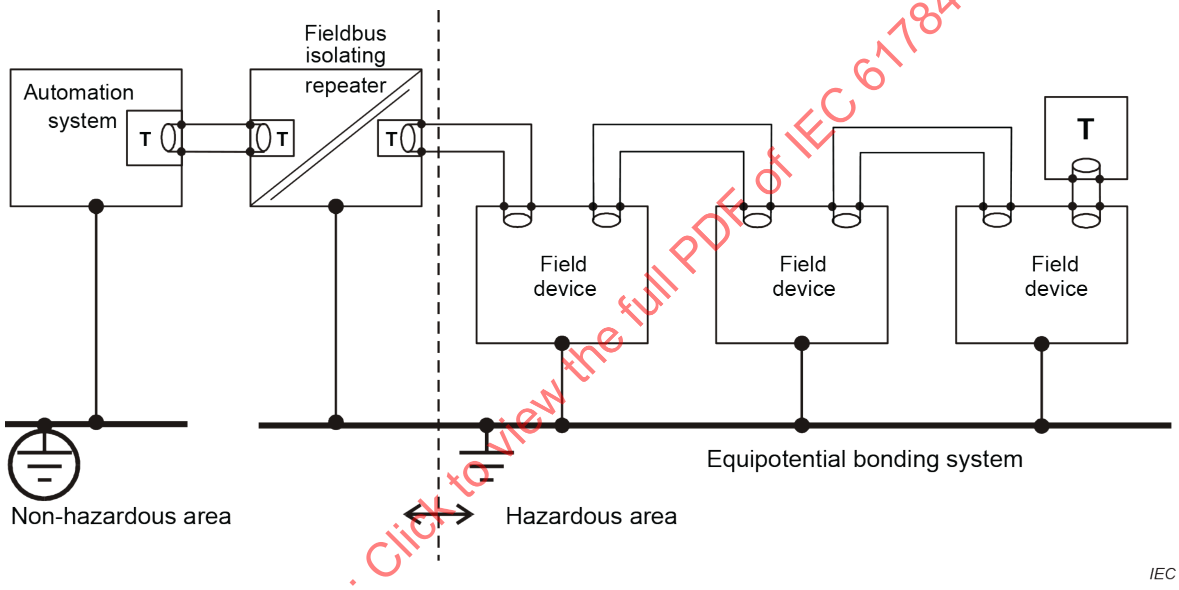


Figure A.1 – Recommended combination of shielding and earthing for CP 3/1 networks with RS 485-IS

At least, equipotential islands should be created by taking these measures. It shall be ensured that low-frequency transient currents (50/60 Hz and harmonics) on the shielding, such as for example those which can develop due to potential differences between "equipotential islands", do not damage the cable and cannot induce sparks in the hazardous area. Damage and sparks can be prevented for example by means of a potential equalization cable having a broad cross-section and laid parallel to the bus cable.

In order to prevent impermissible energy potentials from being carried into the hazardous area, the cable shield shall be connected "safely" to the equipotential bonding system at all points of transition between the safe and hazardous areas. Here, "safely" means that the individual conductors of the cable shield be twisted, be protected from splaying by means of an end covering sleeve and be connected to an appropriate screw terminal.

The connection of the cable shields within the hazardous area is not relevant to safety. It can be realized using conventional shield terminals (clamp straps).

A.4.4.7.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.8 Storage and transportation of cables

A.4.4.8.1 Common description

A.4.4.8.2 Specific requirements for CPs

Not applicable.

A.4.4.8.3 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.9 Routing of cables

A.4.4.9.1 Common description

A.4.4.9.2 Cable routing of assemblies

A.4.4.9.3 Detailed requirements for cable routing inside enclosures

A.4.4.9.4 Cable routing inside buildings

Addition:

For CP 3/1 networks with RS 485-IS the cables for intrinsically safe circuits shall be kept separate from powerlines due to the possible coupling of energy to these cables. IEC 60079-14 and national regulations shall apply.

A.4.4.9.5 Cable routing outside and between buildings

Addition:

Balanced cables routed between buildings shall be installed on metal cable racks. Mesh openings shall be avoided in order to improve EMC capabilities.

Direct buried cables shall be routed in a plastic pipe at least 60 cm below the surface. A cable warning tape shall be placed above it approximately 20 cm below the surface. The equipotential bonding between the buildings (for example galvanized earth strap) shall be routed approximately 20 cm above the fieldbus cable. The earth strap is also used as protection against the effects of a lightning strike. The minimum cross section for the equipotential bonding according to IEC 60364-5-54 for steel is 50 mm^2.

However optical fibre cabling should preferably be used between buildings.

A.4.4.9.6 Installing redundant communication cables

A.4.4.10 Separation of circuits

Addition:

For CP 3/1 networks the distances as given in EN 50174 apply. For CP 3/1 networks with RS 485-IS the IEC 60079-14 shall apply in addition.

A.4.4.11 Mechanical protection of cabling components

A.4.4.11.1 Common description

A.4.4.11.2 Specific requirements for CPs

Not applicable.

A.4.4.11.3 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.4.12 Installation in special areas

A.4.4.12.1 Common description

A.4.4.12.2 Specific requirements for CPs

Not applicable.

A.4.4.12.3 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.4.5 Cabling planning documentation

A.4.5.1 Common description

A.4.5.2 Cabling planning documentation for CPs

A.4.5.3 Network certification documentation

A.4.5.4 Cabling planning documentation for generic cabling in accordance with ISO/IEC 11801-3

A.4.6 Verification of cabling planning specification

A.5 Installation implementation

A.5.1 General requirements

A.5.1.1 Common description

A.5.1.2 Installation of CPs

Addition:

For CP 3/1 networks with RS 485-IS the IEC 60079-14 shall apply in addition.

A.5.1.3 Installation of generic cabling in industrial premises

A.5.2 Cable installation

A.5.2.1 General requirements for all cabling types

Subclause A.5.2.1.2 has replacement:

Table A.9 provides values based on the template given in IEC 61918:2018, Table 18.

Table A.9 – Parameters for balanced cables

Characteristic		Value
Mechanical force	Minimum bending radius, single bending (mm)	30 to 75 [a]
	Bending radius, multiple bending (mm)	60 to 150 [a]
	Pull forces (N)	80 to 150 [a]
	Permanent tensile forces (N)	80 to 100 [a]
	Maximum lateral forces (N/cm)	[a]
	Temperature range during installation (°C)	−20 to +60 [a]
[a] Depending on cable type; see manufacturer's data sheet.		

Table A.10 provides values based on the template given in IEC 61918:2018, Table 19.

Table A.10 – Parameters for silica optical fibre cables

Characteristic		Value
Mechanical force	Minimum bending radius, single bending (mm)	50 to 200 [a]
	Bending radius, multiple bending (mm)	50 to 200 [a]
	Pull forces (N)	500 to 800 [a]
	Permanent tensile forces (N)	500 to 800 [a]
	Maximum lateral forces (N/cm)	300 to 500
	Temperature range during installation (°C)	–5 to +50 [a]
[a] Depending on cable type; see manufacturer's data sheet.		

Replacement:

Table A.11 provides values based on the template given in IEC 61918:2018, Table 20.

Table A.11 – Parameters for POF optical fibre cables

Characteristic		CP 3/1 (PROFIBUS)
Mechanical force	Minimum bending radius, single bending (mm)	30 to 100 [a]
	Bending radius, multiple bending (mm)	50 to 150 [a]
	Pull forces (N)	50 to 100 [a]
	Permanent tensile forces (N)	Not allowed
	Maximum lateral forces (N/cm)	35 to 100
	Temperature range during installation (°C)	0 to 50 [a]
[a] Depending on cable type; see manufacturer's data sheet.		

Table A.12 provides values based on the template given in IEC 61918:2018, Table 21.

Table A.12 – Parameters for hard clad silica optical fibre cables

Characteristic		CP 3/1 (PROFIBUS)
Mechanical force	Minimum bending radius, single bending (mm)	75 to 200 [a]
	Bending radius, multiple bending (mm)	75 to 200 [a]
	Pull forces (N)	100 to 800 [a]
	Permanent tensile forces (N)	≤ 100 [a]
	Maximum lateral forces (N/cm)	≤ 75 to 300
	Temperature range during installation (°C)	–5 to +50 [a]

[a] Depending on cable type; see manufacturer's data sheet.

A.5.2.2 Installation and routing

A.5.2.2.1 Common description

Modification:

Applies with respect to the condensed MICE table according to A.4.2.3.1 of this document.

A.5.2.2.2 Separation of circuits

A.5.2.3 Specific requirements for CPs

Not applicable.

A.5.2.4 Specific requirements for wireless installation

Not applicable.

A.5.2.5 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.5.3 Connector installation

A.5.3.1 Common description

Addition:

Because no mechanical coding exists between intrinsically safe and non-intrinsically safe circuits, the manufacturer shall label his components appropriately in order to prevent connection mistakes.

All left open connections (for example male connectors open wire ends) shall be protected against unattended connections to other circuits or earth by using appropriate insulation caps or similar protection techniques.

A.5.3.2 Shielded connectors

A.5.3.3 Unshielded connectors

Not applicable.

A.5.3.4 Specific requirements for CPs

Addition:

A.5.3.4.1 Sub-D connectors

CP 3/1 networks use the 9-pin Sub-D connector inside control cabinets (IP20). Unless using pre-made cable assemblies, the connector shall be fitted to the CP 3/1 cable.

The CP 3/1 cables are normally daisy-chained through the connector. This allows CP 3/1 device connection without using T-junctions (which introduce spur lines). For this reason, CP 3/1 connectors normally have two cable entries, each with a set of terminals. Each set of terminals is normally labelled "A" and "B" or given a colour reference, for example "green" and "red". These two terminals connect to the two data wires in the CP 3/1 cable. The colour scheme shall be used consistently within a segment; that means the cores shall not be swapped over. The CP 3/1 guideline Interconnection Technology specifies the following assignment:

- A: green
- B: red

CP 3/1 cables approved by the connector manufacturer for use with the respective connector shall be used. This applies particularly to the use of insulation displacement technology.

Sub-D-connectors shall be used to ensure a conducting of the shield with the connector by some grooves. Pin assignment shall be as shown in Figure A.2, Table A.13, and Table A.14.

The pin numbering of a 9 pin Sub-D connector shall be as shown in Figure A.2.

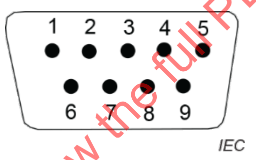


Figure A.2 – Sub-D connector pin numberings (front view)

Table A.13 shows the pin assignment of a 9 pin Sub-D connector when used within CP 3/1 networks and RS 485.

Table A.13 – Use of 9 pin Sub-D connector pins (RS 485)

Pin	Signal	Description		Specification
		Cable	Device	
1	(Shield)	Shield or potential equalization		Not recommended
2	M24		Earth of 24 V power supply	Optional [b]
3	RxD/TxD-P	Receive/transmit data; line B (red)		Mandatory
4	CNTR-P		Control of repeater direction	Optional [b]
5	DGND		Data ground (reference voltage to VP)	Mandatory
6	VP [a]		Power supply +5 V (e.g. for bus termination)	Mandatory
7	P24		+24 V power supply	Optional [b]
8	RxD/TxD-N	Receive/transmit data; line A (green)		Mandatory
9	CNTR-N		Control of repeater direction	Optional [b]

[a] Minimum current capability is 10 mA.

[b] These signals are expected to be provided by the device if converters from RS 485 to fibre optic transmission are supported.

Table A.14 shows pin assignment of a 9 pin Sub-D connector when used within CP 3/1 networks and RS 485-IS.

Table A.14 – Use of 9 pin Sub-D connector pins (RS 485-IS)

Pin	Signal	Description		Specification
		Cable	Device	
1	(Shield)	Shield or potential equalization		Not recommended
2	NC		Not connected	–
3	RxD/TxD-P	Receive/transmit data; line B (red)		Mandatory
4	NC		Not connected	–
5	ISM		Intrinsically safe bus termination minus	Mandatory
6	ISP		Intrinsically safe bus termination plus	Mandatory
7	NC		Not connected	–
8	RxD/TxD-N	Receive/transmit data; line A (green)		Mandatory
9	NC		Not connected	–
Use of the signals ISM and ISP only with an external termination. Without the termination resistor circuit switched on a voltage of 3,3 V ± 5% shall be provided (ISP – ISM).				

A.5.3.4.2 M12-5 B-coding connectors

The 5-pin M12 connector is used for CP 3/1 networks where extreme industrial environments exist.

Only shielded connectors are permitted. The connectors feature a mechanical key (B-coding).

Pin assignment is as shown in Figure A.3, Figure A.4, Table A.15, and Table A.16.

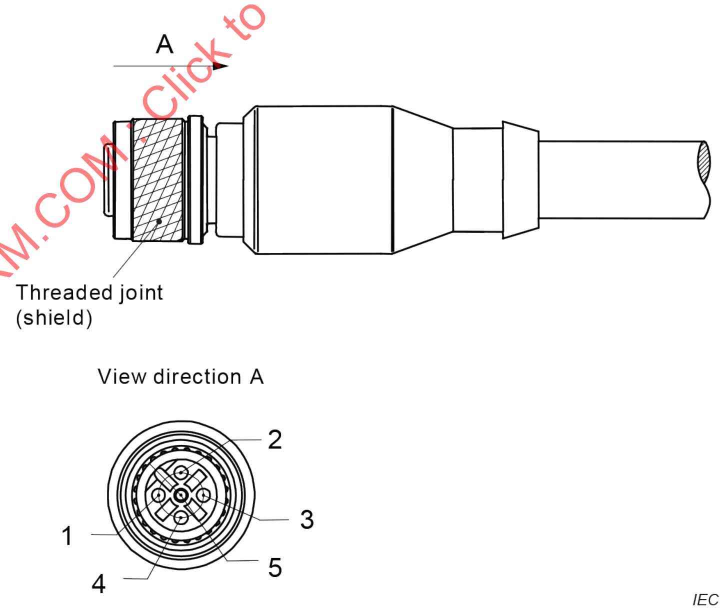


Figure A.3 – 5-pin M12 female socket

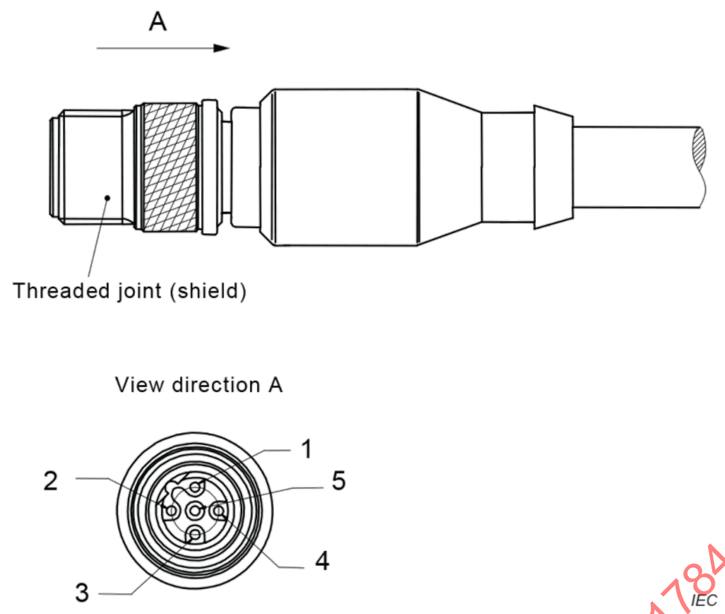


Figure A.4 – 5-pin M12 male plug for CP 3/1

Table A.15 shows pin assignment of an M12 connector when used within CP 3/1 networks and RS 485.

Table A.15 – Use of M12 connector pins (RS 485)

Pin	Signal	Description	
		Cable	**Device**
1	VP		Power supply +5 V (e.g. for bus termination)
2	RxD/TxD-N	Receive/transmit data; line A (green)	
3	DGND		Data ground (reference voltage to VP)
4	RxD/TxD-P	Receive/transmit data; line B (red)	
5	(Shield)	Connection to shield not recommended	
Screwed (gland)	Shield	Shielding	Housing/shield

Table A.16 shows pin assignment of an M12 connector when used within CP 3/1 networks and RS 485-IS.

Table A.16 – Use of M12 connector pins (RS 485-IS)

Pin	Signal	Description	
		Cable	Device
1	ISP		Intrinsically safe bus termination plus [a]
2	RxD/TxD-N	Receive/transmit data; line A (green)	
3	ISM		Intrinsically safe bus termination minus [a]
4	RxD/TxD-P	Receive/transmit data; line B (red)	
5	(Shield)	Connection to shield not recommended	
Screwed (gland)	Shield	Shielding	Housing/shield

[a] With external termination only. Without the termination resistor circuit switched on a voltage of 3,3 V ± 5% shall be provided (ISP – ISM).

A.5.3.5 Specific requirements for wireless installation

Not applicable.

A.5.3.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3:—

A.5.4 Terminator installation

A.5.4.1 Common description

A.5.4.2 Specific requirements for CPs

Addition:

Both ends of a network shall be terminated with a terminator according to IEC 61158-2:2014.

Different devices include a terminator and the option to activate the terminator or not. Care shall be taken that only terminators at the segment ends are activated.

A.5.5 Device installation

A.5.5.1 Common description

A.5.5.2 Specific requirements for CPs

Not applicable.

A.5.6 Coding and labelling

A.5.6.1 Common description

A.5.6.2 Specific requirements for CPs

Not applicable.

A.5.7 Earthing and bonding of equipment and device and shielded cabling

A.5.7.1 Common description

A.5.7.2 Bonding and earthing of enclosures and pathways

A.5.7.2.1 Equalization and earthing conductor sizing and length

A.5.7.2.2 Bonding straps and sizing

A.5.7.2.3 Surface preparation and methods

A.5.7.3 Earthing methods

A.5.7.3.1 Equipotential

Addition:

Cable shields shall be connected to earth at both ends of the cable.

A.5.7.3.2 Star

Addition:

A star/multi-star earthed bonding system should not be used for CP 3/1 networks.

A.5.7.3.3 Earthing of equipment (devices)

A.5.7.3.3.1 Non-earthed or parallel RC termination

Not applicable.

A.5.7.3.3.2 Direct

A.5.7.3.3.3 Installing copper bus bars

A.5.7.4 Shield earthing methods

A.5.7.4.1 General

A.5.7.4.2 Parallel RC

Not applicable.

A.5.7.4.3 Direct

A.5.7.4.4 Derivatives of direct and parallel RC

Not applicable.

A.5.7.5 Specific requirements for CPs

Not applicable.

A.5.7.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.5.8 As-implemented cabling documentation

A.6 Installation verification and installation acceptance test

A.6.1 General

Addition:

Verification of CP 3/1 networks is possible and valid only with network devices connected to the fieldbus, as these devices and proper termination of network segments explicitly impact the electrical characteristic of the whole fieldbus network.

Therefore simple commissioning of the network is essential for network verification.

The commissioning process is divided into eight steps.

- Step 1: Visual inspection.
- Step 2: Acceptance measurements.
- Step 3: System configuration.
- Step 4: Verify the address setting of CP 3/1 devices.
- Step 5: Commission masters and slaves.
- Step 6: Test signal inputs.
- Step 7: Test signal outputs.
- Step 8: Create acceptance checklist.

A.6.2 Installation verification

A.6.2.1 General

A.6.2.2 Verification according to cabling planning documentation

A.6.2.3 Verification of earthing and bonding

A.6.2.3.1 General

A.6.2.3.2 Specific requirements for earthing and bonding

A.6.2.4 Verification of shield earthing

Addition:

Verify that shielding always is connected to earth at both ends of the cables. Single point shield termination shall be avoided.

Verify that shield currents are less than 0,1 A. Currents higher than approximately 0,1 A indicate problems in the electrical installation (that means the power distribution system does not comply with the TN-S rules).

A.6.2.5 Verification of cabling system

A.6.2.6 Cable selection verification

A.6.2.6.1 Common description

A.6.2.6.2 Specific requirements for CPs

Addition:

Verify that all cables are marked by the manufacturer for use within CP 3/1 networks.

Otherwise check with the planner whether the cable parameters meet the transmission requirements of the CP.

A.6.2.6.3 Specific requirements for wireless installation

Not applicable.

A.6.2.7 Connector verification

A.6.2.7.1 Common description

A.6.2.7.2 Specific requirements for CPs

Addition:

Verify that all connectors are classified by the manufacturer for use within CP 3/1 networks (see declarations in the data sheets as provided from the manufacturer and/or marks on the connector).

A.6.2.7.3 Specific requirements for wireless installation

Not applicable.

A.6.2.8 Connection verification

A.6.2.8.1 Common description

A.6.2.8.2 Number of connections and connectors

A.6.2.8.3 Wire mapping

A.6.2.9 Terminator verification

A.6.2.9.1 Common description

A.6.2.9.2 Specific requirements for CPs

Not applicable.

A.6.2.10 Coding and labelling verification

A.6.2.10.1 Common description

A.6.2.10.2 Specific coding and labelling verification requirements

A.6.2.11 Verification report

A.6.3 Installation acceptance test

A.6.3.1 General

A.6.3.2 Acceptance test of Ethernet-based cabling

Not applicable.

A.6.3.3 Acceptance test of non-Ethernet-based cabling

A.6.3.3.1 Copper cabling for non-Ethernet-based CPs

A.6.3.3.1.1 Common description

A.6.3.3.1.2 Specific requirements for copper cabling for non-Ethernet-based CPs

Addition:

Based on Annex N of IEC 61918:2018, the following information details the validation measurements.

a) Determining the loop resistance

Loop resistance is determined by measuring the resistance of the two wires of the CP 3/1 cable. The resistance of the wires depends on the cable construction and also is temperature dependent. Cable resistance is normally specified in Ω per km at a given temperature.

A typical value for CP 3/1 with RS 485 cable type A has a loop resistance of 110 Ω/km at 20 °C. This value is used for the calculation of x in the following measurement and resolution examples. However, this value can deviate for special cable types, for example highly flexible cables. Cable resistance typically increases with temperature by 0,39 % per degree Celsius. The cable resistance values from the cable manufacturer's data sheets shall be used for real verifications.

b) Testing the CP 3/1 cable and the bus connectors

The following 4 test circuits are necessary to perform the measurements. The pin and signal descriptions refer to Table A.13 to Table A.16

1) Test circuit A:

Figure A.5 shows a short circuit between data line B (pin 3) and the shielding at the remote connector. Resistance meter between data line B (pin 3) and the shielding at the local connector. Measurement of the loop resistance of data line B and shield.

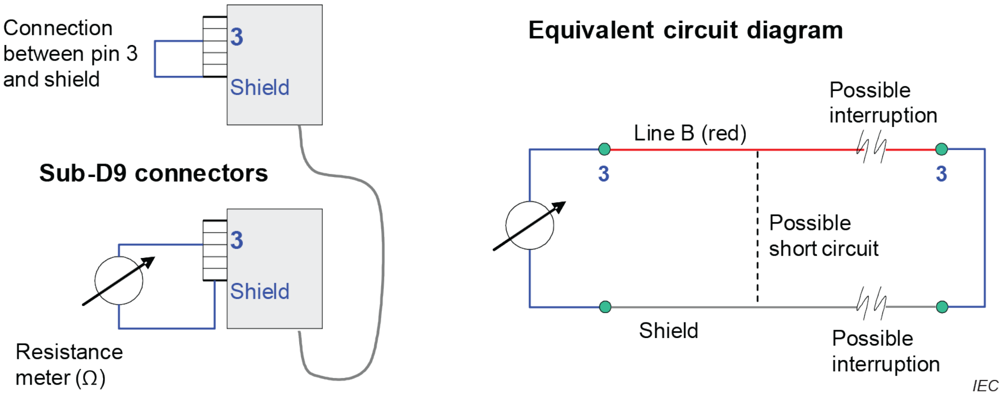


Figure A.5 – Test circuit A – Resistance measurement of data line B and shield

2) Test circuit B:

Figure A.6 shows a short circuit between data line A (pin 8) and the shielding at the remote connector. Resistance meter between data line A (pin 8) and the shielding at the local connector. Measurement of the loop resistance of data line A and shield.

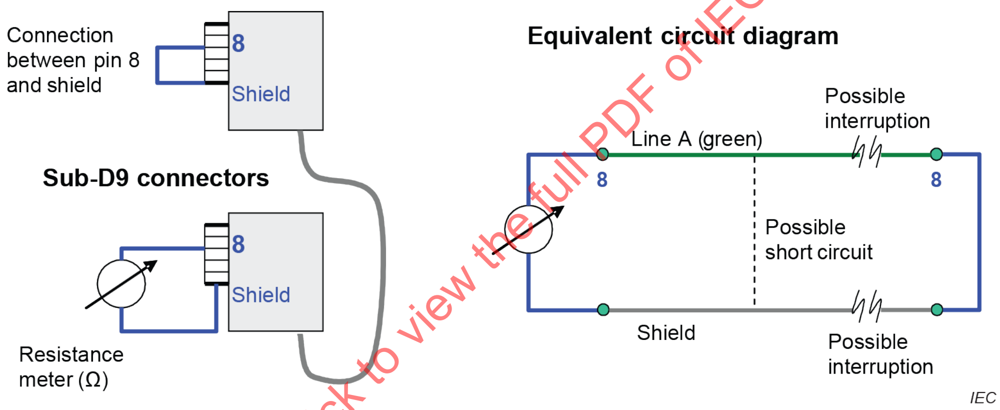


Figure A.6 – Test circuit B – Resistance measurement of data line A and shield

3) Test circuit C:

Figure A.7 shows a short circuit between data line B (pin 3) and the shielding at the remote connector. Resistance meter between data line A (pin 8) and the shielding at the local connector. Measurement of possible short circuits or possible cross wiring of the data lines.

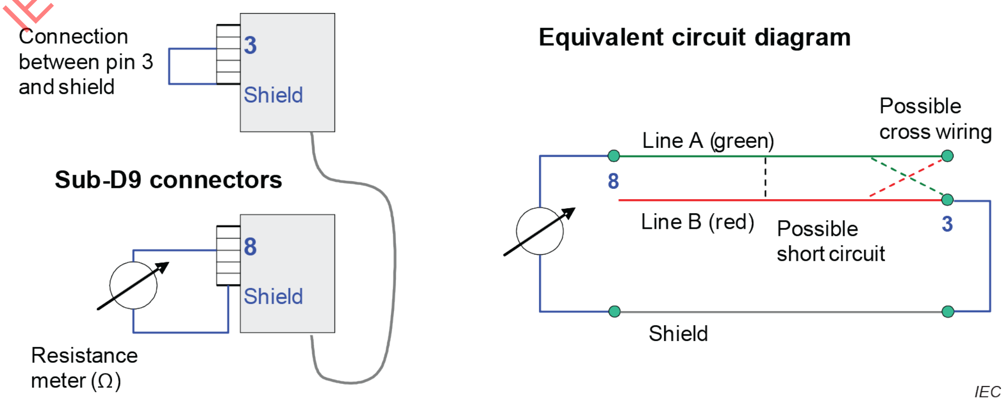


Figure A.7 – Test circuit C – Resistance measurement of data line A, data line B, and shield

4) Test circuit D:

Figure A.8 shows no connection between data line B (pin 3) and data line A (pin 8) at the remote connector. Resistance meter between data line B (pin 3) and data line A (pin 8) at the local connector. Measurement of several possible termination resistor networks.

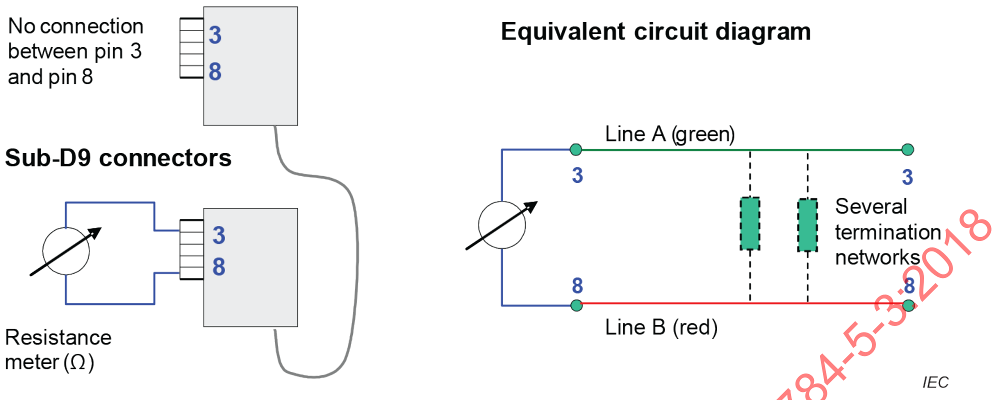


Figure A.8 – Test circuit D – Resistance measurement between data line A and B

If the installation does not have a 9-pin Sub-D plug connector at the beginning and the end of the segment, measurements can be performed directly on the cable, see Figure A.9.

Figure A.9 – Resistance measurement without 9-pin Sub-D plug

The following three measurements can be performed using the test circuits A to D.

c) Measurement 1

The diagram in Figure A.10 shows the relationship between the cable length and the loop resistance of the lines (forward and reverse) of cable type A for CP 3/1 (RS 485). To determine the resistance of a line A or B, the resistance value from the diagram for the respective cable length shall be divided by two. The value for the shielding resistance is best determined by a measurement of a known cable length.

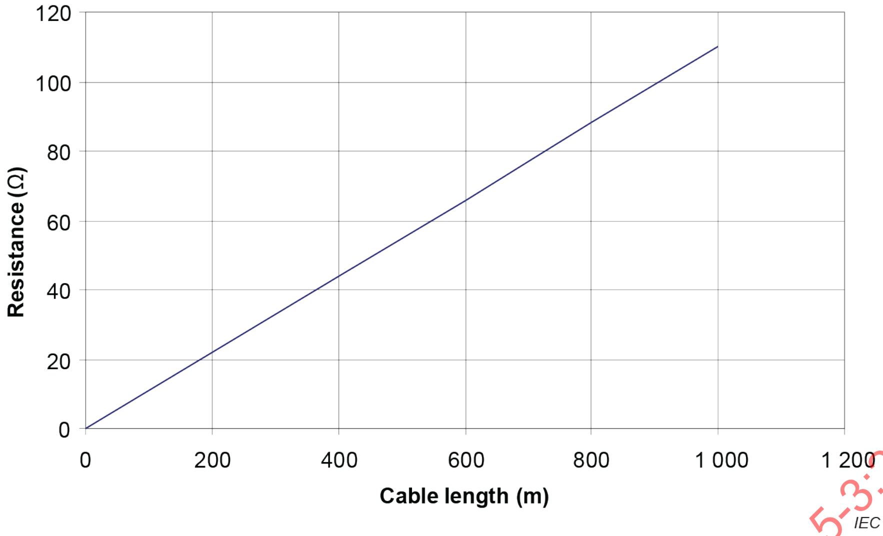


Figure A.10 – Loop core resistance (cable type A)

Figure A.11 shows a measurement action and reasoning plan to be followed for measurement 1. The value × represents the forward and reverse resistance for the respective test circuit. Thus, the resistance of a data line (forward) and the resistance of the shielding (reverse) for the cable in use shall be added. The resistances depend on the cable length.

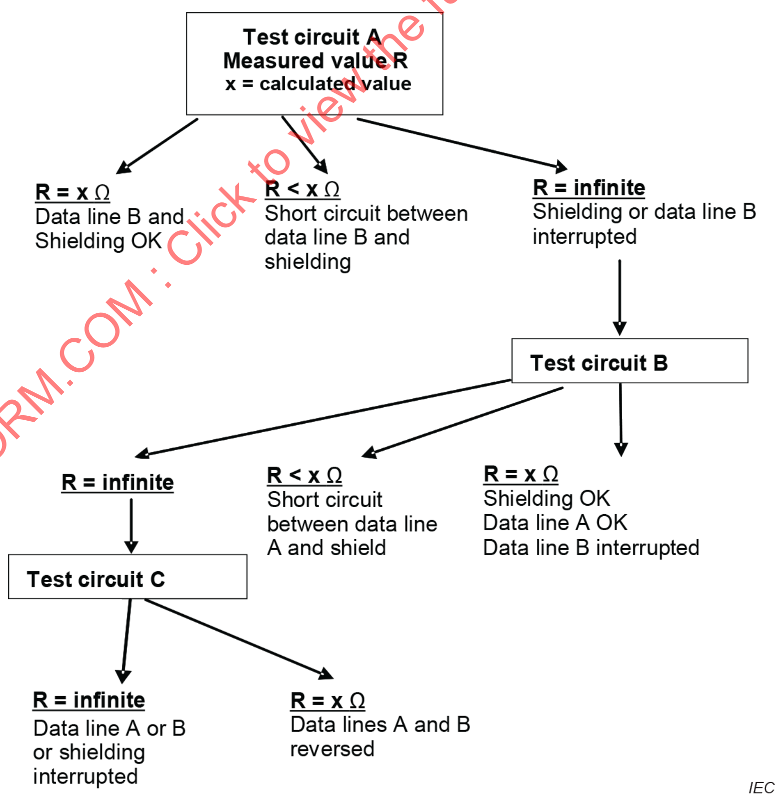


Figure A.11 – Action and resolution tree for measurement 1 (RS 485 and RS 485-IS)

d) Measurement 2

Figure A.12 is showing a measurement action and reasoning plan to be followed for measurement 2. In this case measurement starts with test circuit B followed by test circuit A. The reasoning is inverted in respect to the data lines A and B.

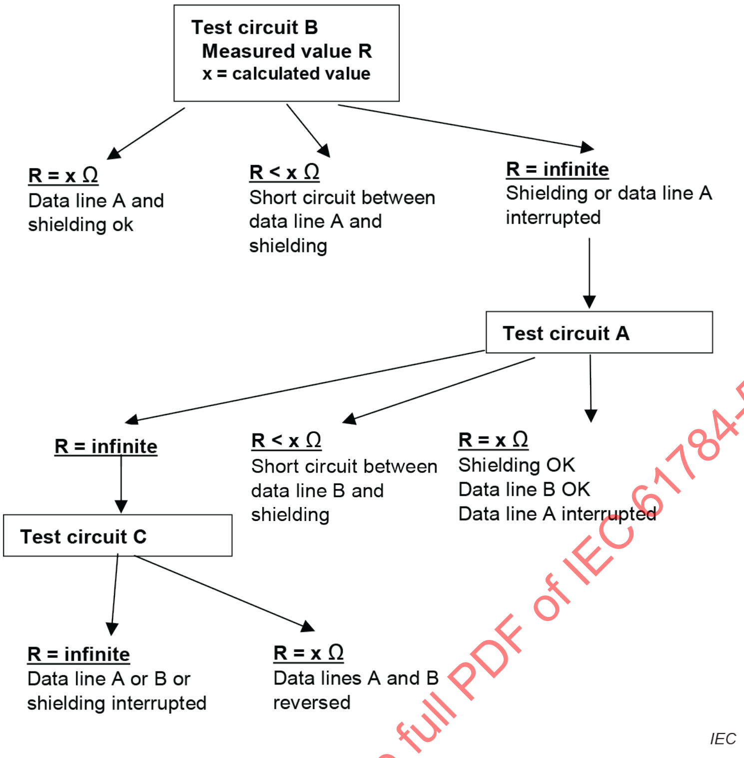


Figure A.12 – Action and resolution tree for measurement 2 (RS 485 and RS 485-IS)

e) Measurement 3

This test reveals whether additional terminators are switched on within the CP 3/1 cable segment. Figure A.13 is showing the corresponding measurement action and reasoning plan.

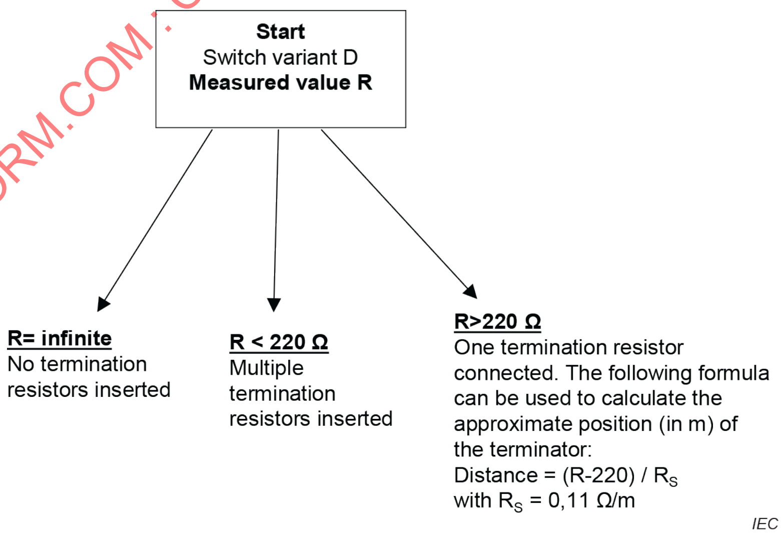


Figure A.13 – Action and resolution tree for measurement 3 (RS 485 and RS 485-IS)

Only one network termination resistor at the end of a segment is permitted to be switched on.

The values for the termination resistor of 220 Ω (with RS 485-IS = 200 Ω) may vary from 215 Ω to 225 Ω (with RS 485-IS = 196 Ω to 204 Ω) due to specified tolerances of ±2 %.

f) Measurements for CP 3/1 networks (RS 485) with 5-pin M12 plug connectors

The measurement for 5-pin M12 plug connectors is similar to the measurements for 9-pin Sub-D plug connectors. It verifies the correct connections (pins 2 and 4) according to Table A.15 or Table A.16.

A.6.3.3.2 Optical fibre cabling for non-Ethernet-based CPs

A.6.3.3.2.1 Common description

A.6.3.3.2.2 Specific requirements for non-Ethernet-based CPs

Addition:

Table A.17 provides information on the maximum attenuation for various PROFIBUS fibre types.

Table A.17 – Maximum fibre channel attenuation for CP 3/1 (PROFIBUS)

	Singlemode fibre optic	Multimode fibre optic	Hard clad silica fibre	Plastic optical fibre	
				Standard	Increased
Typical wavelength	1 320 nm	850 nm	660 nm	660 nm	660 nm
Maximum fibre channel attenuation	5 dB	6 dB	3 dB	6 dB	11 dB

A.6.3.3.3 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

A.6.3.4 Specific requirements for wireless installation

Not applicable.

A.6.3.5 Acceptance test report

A.7 Installation administration

Subclause 7.8 is not applicable.

A.8 Installation maintenance and installation troubleshooting

Subclause 8.4 has addition:

In cases of fieldbus network trouble the checklist according to Annex G of IEC 61918:2018 and the procedures in A.6.3.3.1.2 shall be observed.

Additional troubleshooting means can be bus monitoring tools and/or specific diagnostic repeaters. These activities however are application dependent and therefore out of the scope of this document. Related information for further troubleshooting is available on the CPF 3 User Organisation web-site at <www.profibus.com>.

Annex B
(normative)

CP 3/2 (PROFIBUS) specific installation profile

B.1 Installation profile scope

This annex specifies the installation profile for Communication Profile CP 3/2 (PROFIBUS with physical layer MBP, MBP-IS, and MBP-LP). The CP 3/2 is specified in IEC 61784-1.

B.2 Normative references

Addition:

IEC 60079-0:2011, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-11:2011, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-27:2008, *Explosive atmospheres – Part 27: Fieldbus intrinsically safe concept (FISCO)*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

EN 50020, *Electrical apparatus for potentially explosive atmospheres – Intrinsic safety "i"*

ANSI TIA/EIA-485-A, *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

B.3 Installation profile terms, definitions, and abbreviated terms

B.3.1 Terms and definitions

Addition:

B.3.1.87
bus powering
type of power supply whereby field devices obtain their required auxiliary power via the fieldbus communication lines

B.3.1.88
common mode rejection ratio
CMRR
measure for the deviation from an ideal electrical symmetry of a device symmetrically built to its environment

B.3.1.89
fault disconnect electronic
FDE
equipment used to limit the current consumed by a field device during a malfunction

Note 1 to entry: This unit can be a part of the field device, or it can be connected in front of it.

B.3.1.90
FISCO model
possible implementation of an intrinsically safe fieldbus for use in potentially explosive areas

B.3.1.91
human machine interface
component of a process control system in use for data acquisition from an automated process and its appropriate representation as well as for manipulation of this process

B.3.1.92
intrinsically safe circuit
electric circuit in which sparks or thermal effects cannot occur under specified test conditions (for example EN 50020) neither during normal operation (that means opening and closing of the circuit) nor during a malfunction (that means short circuit or earthing error) which could cause ignition in a potentially explosive area

Note 1 to entry: Opening or short circuiting of intrinsically safe electric circuits only cause low-energy, non-ignitable sparks.

B.3.1.93
Manchester encoding
binary encoding method enabling receivers of serial communications to unambiguously determine the start, end, or middle of each bit without reference to an external clock (synchronous)

B.3.1.94
medium attachement unit
MAU
part of a fieldbus node providing the connection to the fieldbus cable

Note 1 to entry: Within IEC 61158-2:2014 this unit primarily consists of a sending amplifier (that means current modulator), receiving filter, receiving comparator and impedance converter for bus power extraction.

Note 2 to entry: This note applies to the French language only.

B.3.2 Abbreviated terms

Addition:

CMRR	Common mode rejection ratio
EEx ia IIC	Marking of intrinsically safe components according to IEC 60079-0
EEx ib IIC/IIB	Marking of intrinsically safe components according to IEC 60079-0
FDE	Fault disconnect electronic
FISCO	Fieldbus intrinsically safe concept model (IEC 60079-27)
MAU	Medium attachement unit
MBP	Manchester coded and bus powered (IEC 61784-1)
MBP-IS	Manchester coded and bus powered for intrinsic safety (IEC 61784-1)
RS 485	MAU according to ANSI TIA/EIA-485-A
TN-S	Coded type of system earthing according to IEC 60364-1, 312.2

B.3.3 Conventions for installation profiles

Not applicable.

B.4 Installation planning

B.4.1 General

Subclause B.4.1.1 has modification:

CP 3/2 networks are typically not connected directly to the generic cabling but to a CP 3/1 network that is connected to generic cabling via a converter/adapter as mentioned in IEC 61918:2018, 4.1.2.

Interconnection among CP 3/1 and CP 3/2 networks can be accomplished by using a converter/adapter offering a fieldbus interface

1) for CP 3/1 fieldbus networks and a fieldbus interface,
2) for CP 3/2 fieldbus networks.

Addition:

CP 3/2 is specified in IEC 61784-1. CP 3/2 is not usable for a direct physical connection to the AO because it's a non-Ethernet-based fieldbus. CP 3/1 networks only can be connected to the generic cabling via converter/adapter as mentioned in IEC 61918:2018, 4.1.2.

CP 3/2 is a subsystem of the Ethernet-based automation island; see potentially explosive area within Figure B.1.

One of the primary characteristics of CP 3/2 fieldbus networks is that it is easy to be integrated into systems using devices with different physical layers, as RS 485 or fibre optic according to IEC 61784-1 CP 3/1. This means that the entire CP 3/1 infrastructure (for example gateways to other networks, engineering consoles, and display and operator control components) can be utilized.

CP 3/2 networks are linked to the components close to the process by either an integrated CP 3/2 network interface with a physical layer according to IEC 61158-2:2014, Clause 11, or via a CP 3/2 to CP 3/1 signal coupler. This adapts the interface of the components close to the process to the transmission technology used by the CP 3/1 field devices. The combination of signal coupler, power supply and fieldbus terminator is called a segment coupler.

NOTE Fieldbus terminator can possibly be switched off.

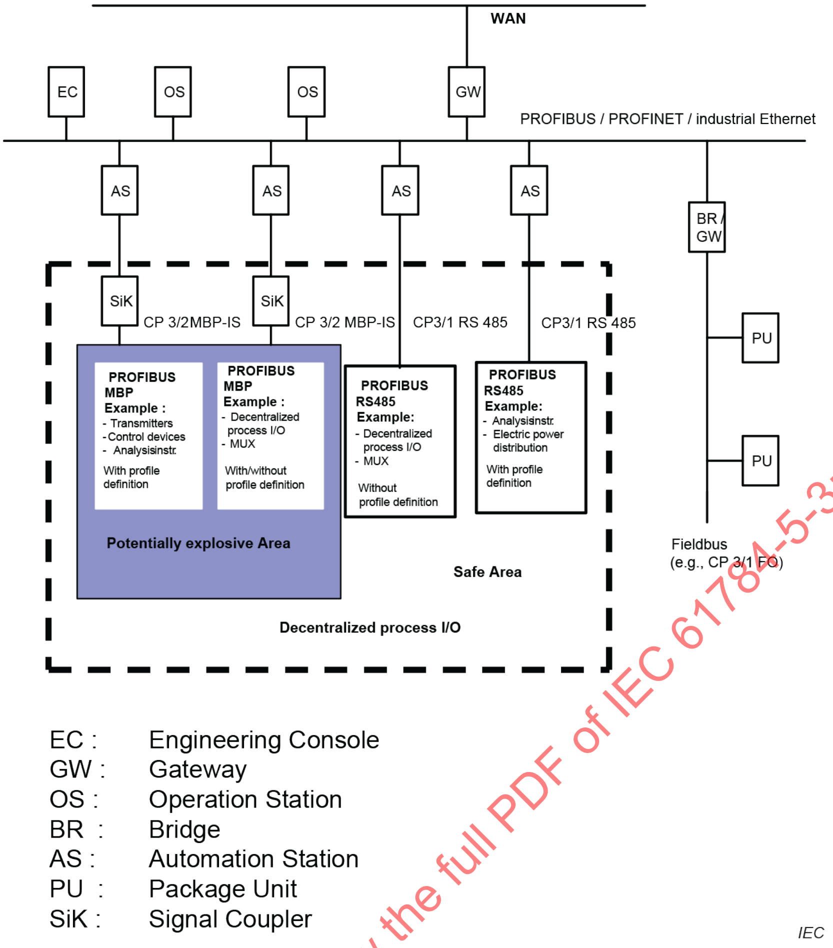


Figure B.1 – Connection of CP 3/1 networks

B.4.2 Planning requirements

B.4.2.1 Safety

B.4.2.1.1 General

Addition:

Three parties share responsibility for a fieldbus installation. The testing authority, which tested and certified the individual components of the system, is responsible for ensuring that the design of the devices meets the applicable standards.

The manufacturer of the individual devices is responsible for ensuring that each individual unit manufactured corresponds to the documentation, which was available to the certifying authority, and that final inspection and quality assurance are performed correctly.

The user also bears a significant share of the total responsibility; the user installs the fieldbus system or gives the order to install it, and then puts it into operation. The user is responsible for ensuring that installation regulations (for example IEC 60079-14) are complied with. The special requirements and notes, concerning installation, operation and maintenance shall be met.

NOTE This can be included in the test certifications or in the instruction manuals.

In addition, maintenance work and system modifications shall be carried out in accordance with the applicable standards and regulations.

When the fieldbus intrinsically safe concept (FISCO) model is applied to a fieldbus installation the system is characterised by a small set of well-known parameters. This permits the user to connect devices of different manufacturers to one intrinsically safe fieldbus system without having to obtain special system certification.

In addition to functional considerations concerning the combination of different fieldbus devices and components, safety and reliable protection against explosion shall also be considered. Since both of these points are often linked together, a systematic analysis is required.

Extensive studies have shown that, under the parameter ranges examined, the probability of ignition is not increased by connection of cables with distributed inductivities and capacitances and line terminations on a power supply. The length of the main fieldbus cable (trunk cable) can thus be selected almost without regard to safety restrictions. This does not mean that environmental conditions resulting from the functional structures can be disregarded. They shall indeed be considered.

The maximum number of fieldbus stations that can be connected (including the CP 3/1 to CP 3/2 coupler and, if present, handheld terminal) depends on two factors:

a) the bus power supply characteristics (that means U/I characteristics), and

b) the basic current requested by every station.

If one field device consumes more than a basic current of 10 mA (for example 20 mA), this reduces the number of devices which can be connected.

The minimum current to be delivered by the power supply shall be calculated. This can be easily derived by adding the basic currents for the field devices (plus those of the handheld terminal and the coupler, if present) and the threshold current for the fault disconnection electronic (FDE) and for the modulation.

Optimization of the system (that means longest possible line lengths and increased number of devices which can be connected) depends on selecting the correct power supply and the appropriate type of cable.

In individual situations, the planner or user for a specific fieldbus configuration shall calculate valid parameters and limit values. Subclause B.4.4.1.1 specifies a suggested procedure to make this analysis easier.

The last step is concerned exclusively with safety.

Field devices, coupler for the fieldbus master and line terminations shall be checked for conformance to safety regulations.

Permissible maximum input values for field devices, couplers and line terminations shall be checked to determine whether they are equal to or greater than the maximum output safety values of the bus power supply.

B.4.2.1.2 Electrical safety

B.4.2.1.3 Functional safety

B.4.2.1.4 Intrinsic safety

Addition:

B.4.2.1.4.1 Planning intrinsic safety systems

CP 3/2 networks can be used outside hazardous areas and in potentially explosive areas with the intrinsic safety type of protection (MBP-IS). Planning of the non-intrinsically safe and intrinsically safe systems follows the same open concept. Field devices can be connected together to create different topologies and be completely powered by the fieldbus. The devices can be manipulated and connected or disconnected during running operation within potentially explosive areas. Devices with higher power requirements can also be powered by separate local power sources that mean local powering.

NOTE 1 Bus powering can or be used in parallel or not.

The "i" intrinsically safe type of protection is advantageous for electrical apparatus and electric circuits which require low current due to their design.

This offers a number of advantages:

- Measurements or calibrations are possible in potentially explosive areas while a device is energized.
- Development and manufacturing of intrinsically safe devices is economical.

  NOTE 2 Added expense over the standard model of a device is low in comparison to the cost of other types of protection.
- Intrinsic safety is the only type of protection which also includes the cables outside the devices in the explosion protection.

The limited electrical power, which intrinsically safe electric circuits can transmit, and the relatively complex rules and general conditions which apply to the connection of active and passive devices, creates certain restrictions. The characteristics of connection lines shall also be considered here. Given today's technology, it is easy to evaluate intrinsically safe systems that usually consist of only one active and one passive device. However, an intrinsically safe fieldbus is harder to evaluate since a large number of devices are connected together.

B.4.2.1.4.2 Architecture

Figure B.2 shows a typical fieldbus architecture. The field devices with low power consumption (for example pressure or temperature transmitters) are powered by a two-wire fieldbus. Signal transmission is also performed over the fieldbus. The sensors/actuators are located in the field area while the plant-floor monitoring unit or components and the signal coupler connecting them to the fieldbus are located in the control room or are to be explosion protected. Intrinsic safety shall be ensured by suitable construction of all devices connected to the fieldbus even when they are not installed in the field.

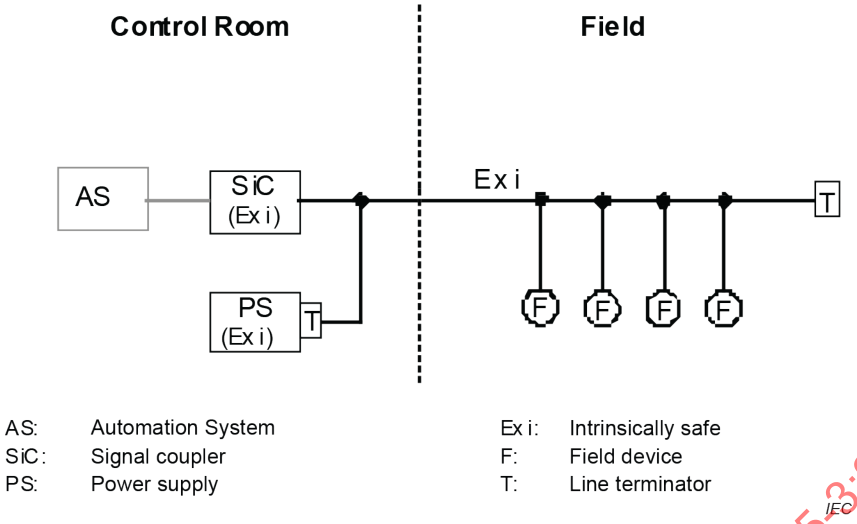


Figure B.2 – Typical fieldbus architecture

Type 1 and type 3 of IEC 61158-2:2014 state that a maximum of 32 field devices can be connected to the fieldbus. However, under certain conditions, this number may have to be reduced. Some applications use field devices (for example transmitters) that cannot be operated on the power available from the fieldbus. Another source of power can be used here. The intrinsically safe fieldbus then transfers the data while separate electric circuits supply the auxiliary power to the transmitters (see Figure B.3).

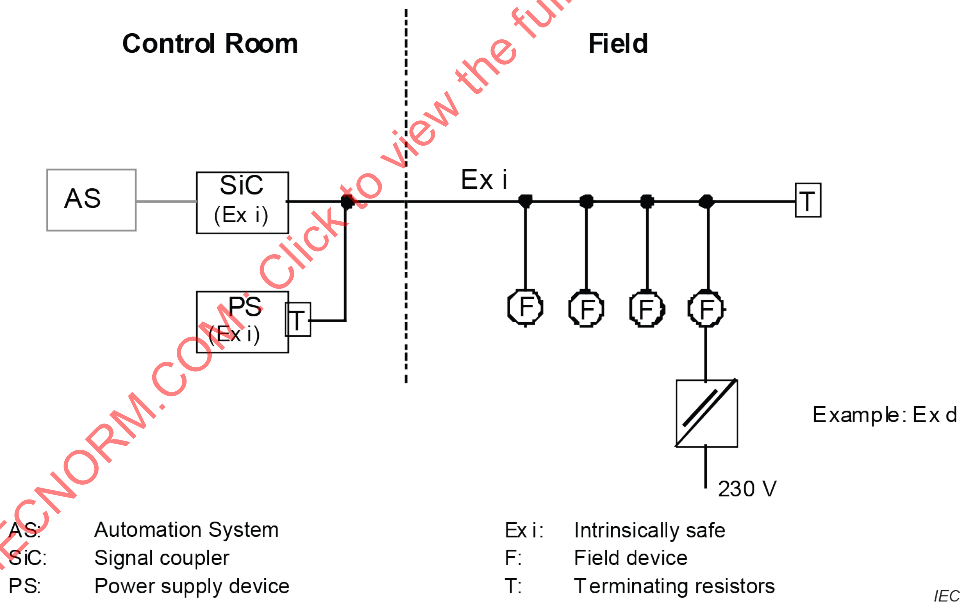


Figure B.3 – Fieldbus with stations supplied by auxiliary power sources

B.4.2.1.4.3 FISCO model

The FISCO model, specified in IEC 60079-27, provides the capability of implementing an "i" fieldbus for use in potentially explosive areas. The main characteristic of this model is that only one active device (typically the bus power supply) is connected to the fieldbus. The other devices are passive with regard to their ability to supply power to the line. In case of malfunctions which shall always be kept in mind (fault conditions), there is only one device that can supply power on the fieldbus line. This maximizes the number of devices, which can be connected. Since only the bus power supply can provide power on the line, only this one device needs to be equipped with a current and voltage limiter safety circuit. Table B.1 and Table B.2 show the limits of the parameter areas for use of the FISCO model for EEx ib

IIC/IIB or EEx ia IIC. These areas are based on the results of previous studies and reasonable extrapolations. Within certain limits, the characteristics of the bus cables do not affect intrinsic safety.

NOTE It is interesting to note that the limit values usually given for maximum permissible external inductance L_a and capacitance C_a are not listed for the supply current circuit of the bus power supply. If these values had been included, it would create the impression that L_a and C_a are presenting the intrinsically safe circuit as unprotected inductance and capacitance, which is not the case for the FISCO model.

In addition, the following requirements apply.

- Intrinsic safety category 'ib' or 'ia' shall be in accordance with EN 50020.
- Only one active source in the sense of intrinsic safety. No power is supplied when a station is sending.
- Each station consumes a basic current (direct current), which remains constant after the transient recovery time.
- The stations (that means transmitter, handheld terminal, bus master and repeater) act as a passive current sink.
- The effective inner inductivities and capacities of the stations can be disregarded in relation to intrinsic safety.
- Different types of lines can be used.
- The main fieldbus line shall be connected to earth at both ends.
- The power supply is connected to one end of the fieldbus line.

Table B.1 – Valid parameter range of the FISCO model for use as EEx ib IIC / IIB

Power supply characteristics **(Output characteristic curve approaching square form)**	**Values**
U_Z (Maximum output voltage) I_k = Short-circuit current in accordance with PTB report W-39 Examples: at U_s = 15 V (group IIC) at U_s = 15 V (group IIB)	14 V to 24 V up to 128 mA up to 280 mA
Cable characteristics	**Values per km**
R' (loop resistance) = L' C' C' (if bus circuit is floating) C' (if the shield is connected to a port of the power supply)	15 Ω to 150 Ω 0,4 mH to 1 mH 80 nF to 200 nF (including an existing shield) C'_{core}/core + 0,5 C'_{core}/shield C'_{core}/core + C'_{core}/shield
Cable length	**Values**
Total length Drop cables (each):	≤ 5 000 m ≤ 30 m
Line terminations	**Values**
RC elements with: R C The resistor shall be infallible in the sense of EN 50020.	 90 Ω to 100 Ω 0 µF to 2,2 µF
A line termination is permitted at each end of the main fieldbus line.	

Table B.2 – Valid parameter range of the FISCO model for use as EEx ia IIC

Power supply characteristics (Trapezoidal output characteristic curve)	**Values**
U_s U_o I_k Short-circuit current in accordance with PTB report W-39 Example: at U_s = 15 V (group IIC)	14 V to 20 V (highest safe value) ≥ 2 × U_s up to 215 mA
Cable characteristics	**Values per km**
R' (loop resistance) L' C' C' (if fieldbus electric circuit is floating) C' (if the shield is connected to one pin of the power supply)	15 Ω to 150 Ω 0,4 mH to 1 mH 80 nF to 200 nF (incl. an existing shield) C'_{core}/core + 0,5 C'_{core}/shield C'_{core}/core + C'_{core}/shield
Cable length	**Values**
Total length Drop cables (each)	≤ 1 000 m ≤ 30 m
Line terminations:	**Values**
RC elements with: R C The resistor shall be infallible in the sense of EN 50020.	 90 Ω to 100 Ω 0 µF to 2,2 µF
A line termination is permitted at each end of the main fieldbus line.	

B.4.2.1.4.4 Fieldbus model

Figure B.4 shows an example of a fieldbus model.

The power supply for powering the fieldbus and the fieldbus master for the coupling to components close to the process are usually located in the control room (that means a non-potentially explosive area). The power supply contains circuits for reliable limitation of current and voltage on the fieldbus.

CP 3/2 shall use a bit-synchronous transmission protocol and a direct-current-free signal, see IEC 61784-1:2010, 7.3.1.

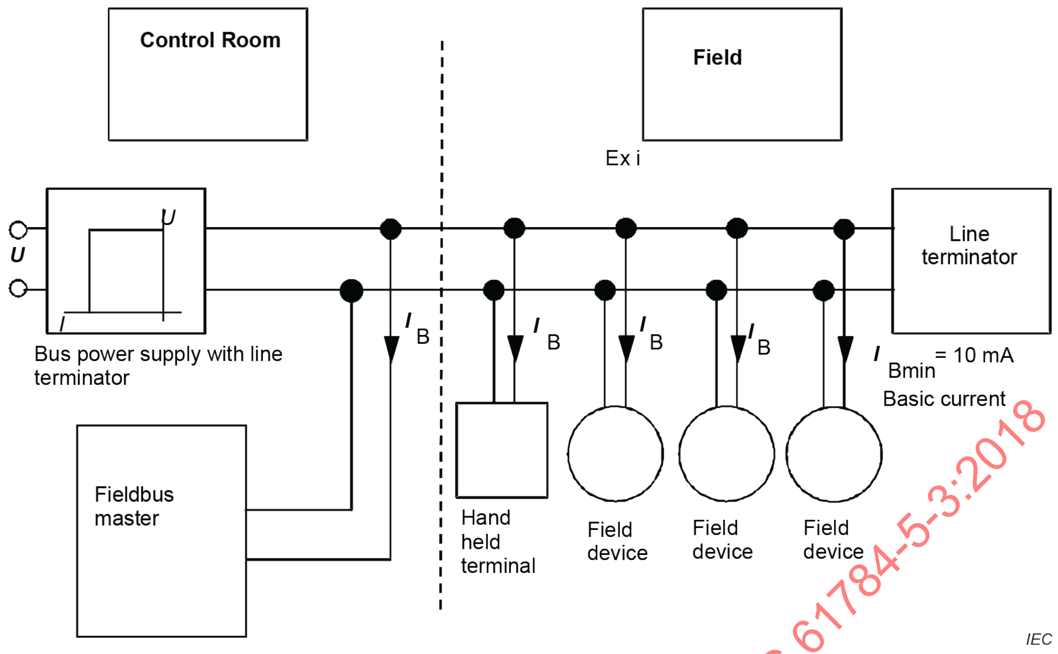


Figure B.4 – Fieldbus model

It is assumed for the modulation that each fieldbus station consumes a basic current of at least 10 mA and is usually used to power the device. The sending devices generate the communication signals by modulating ±9 mA to the basic current (see Figure B.5).

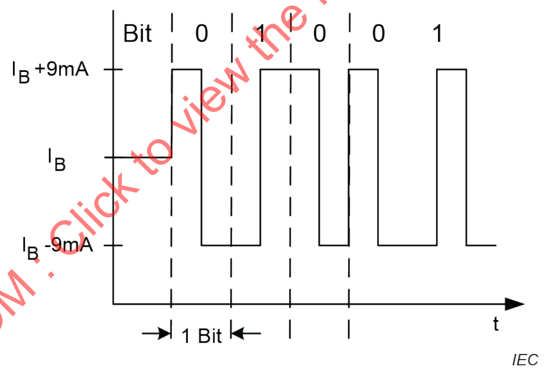


Figure B.5 – Current modulation (Manchester II code)

The primary characteristics of the data transmission in accordance with Type 1 and Type 3 of IEC 61158-2:2014 are listed below.

- Digital, bit-synchronous data transmission.
- Data transmission speed of 31,25 kbit/s.
- Manchester encoding.
- Preamble with adapted coding.
- Fault-proof start and end delimiter.
- Sending level of 0,75 V to 1 V.
- Signal transmission over twisted-pair cables (shielded/unshielded).
- Remote powering via signal cable possible.
- Intrinsically safe operation possible.
- Bus and tree topology.

- Up to 32 stations per line segment.
- Can be expanded with up to 4 repeaters.

B.4.2.1.5 Safety of optical fibre communication systems (OFCS)

Not applicable.

B.4.2.2 Security

B.4.2.3 Environmental considerations and EMC

B.4.2.3.1 Description methodology

Modification:

See A.4.2.3.1.

B.4.2.3.2 Use of the described environment to produce a bill of material

Modification:

See A.4.2.3.2.

B.4.2.4 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.3 Network capabilities

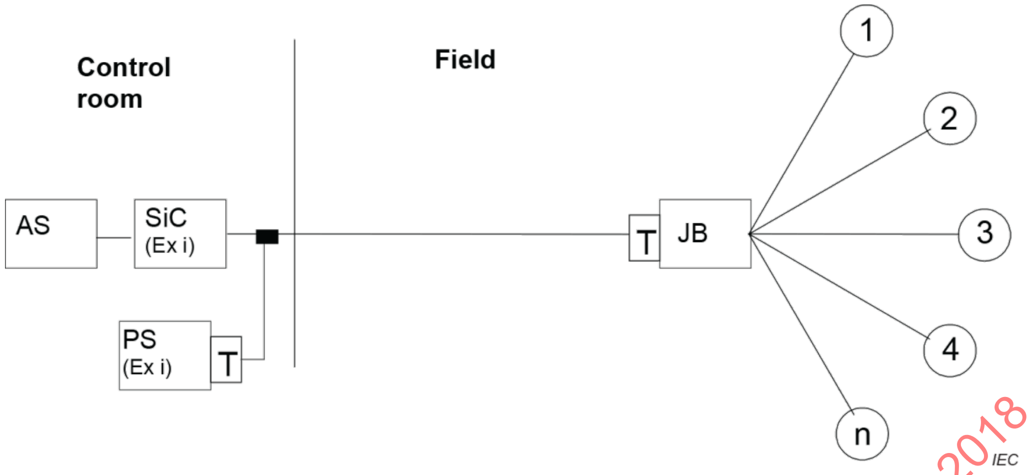
B.4.3.1 Network topology

B.4.3.1.1 Common description

B.4.3.1.2 Basic physical topologies for passive networks

Addition:

The tree topology (see Figure B.6) can be compared to classic field installation topology. The multi-wire trunk cable is replaced by the two-wire fieldbus trunk cable. The junction box retains its role as a central connection unit where all field devices are connected in parallel.

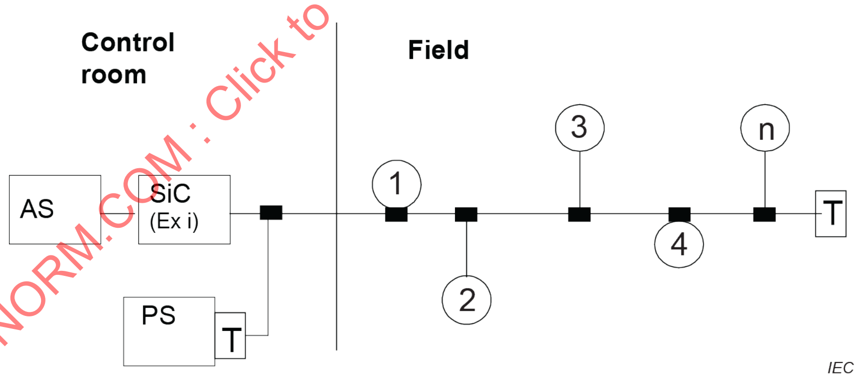


Key

AS Automation system
SiC Signal coupler
PS Power supply
T Line terminator
JB Junction box
(1)...(n) Field devices

Figure B.6 – Tree topology

The bus topology (see Figure B.7) offers connection points (taps or passive couplers) along the fieldbus cable. The cable can be looped through the individual field devices. Field devices may also be connected to the trunk cable via spurs. The combination of tree topology and bus topology (see Figure B.8) permits the optimization of the fieldbus length and the adaptation to existing system structures. The restricting factor for fieldbus design is the attenuation of the communication signal between the fieldbus stations and the signal distortions caused by the concentration of fieldbus stations along the fieldbus cable. For more details, see IEC 61158-2:2014.

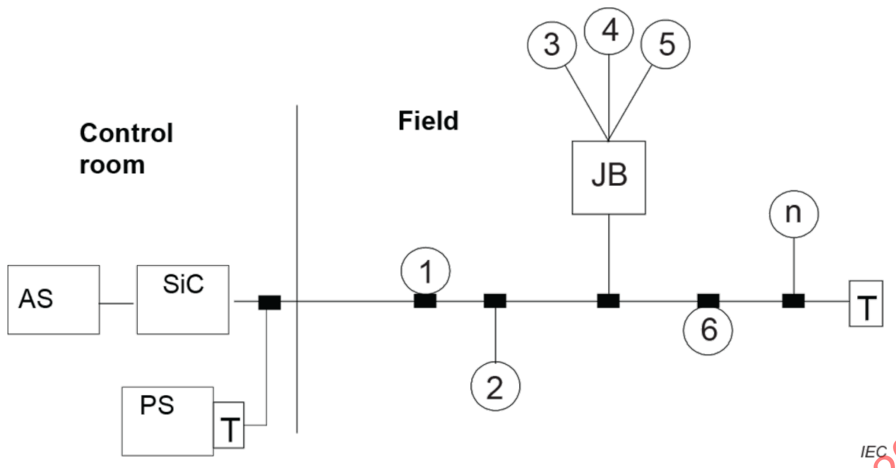


Key

AS Automation system
SiC Signal coupler
PS Power supply
T Line terminator
JB Junction box
(1)...(n) Field devices

Figure B.7 – Bus topology

Tree topology, bus topology or a combination of both can be used as the fieldbus structure for the CP 3/2 shown in Figure B.8.

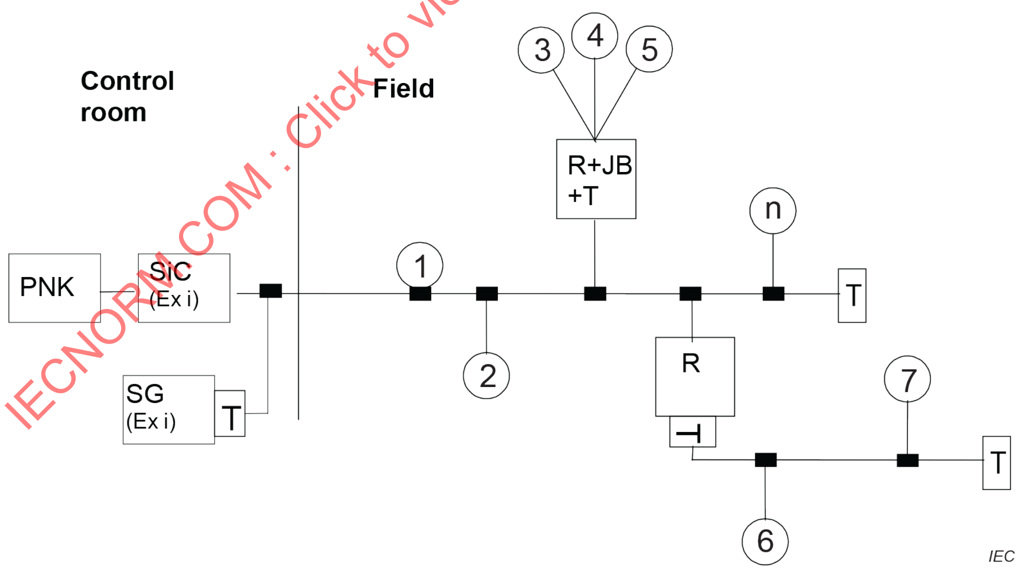


Key

AS	Automation system
SiC	Signal coupler
PS	Power supply
T	Line terminator
JB	Junction box
(1)...(n)	Field devices

Figure B.8 – Combination of the tree topology and the bus topology

It shall be taken into account that the limitation of the spur length for intrinsically safe installations according to FISCO (≤ 30 m, see Table B.10 and Table B.7) is based on a pure tree or bus topology. If a combination as shown in Figure B.8 is used in a hazardous area then the limit shall be applied to each connection between a field device and the trunk cable (via the junction box). As an example, if the cable length between the trunk and the junction box is 20 m, then the cable length between the junction box and any device connected to it shall not exceed 10 m. This rule shall also apply to the topology shown in Figure B.9.



Key

AS	Automation system
SiC	Signal coupler
PS	Power supply
T	Line terminator
JB	Junction box
R	Repeater
(1)...(n)	Field devices

Figure B.9 – Fieldbus extension

The number of field devices that can be used on the fieldbus depends on the supply voltage, the current consumption of the field devices and the extension of the fieldbus (see B.4.3.2.1).

NOTE To improve availability and dependability, redundant fieldbus segments can be installed. However, this makes connection of simple fieldbus stations (for example transmitters, actuators, initiators, valves, and so on) more complicated (for example double lines, double powering, intrinsic safety, and so on).

B.4.3.1.3 Basic physical topologies for active networks

Not applicable.

B.4.3.1.4 Combination of basic topologies

Not applicable.

B.4.3.1.5 Specific requirements for CPs

Addition:

See topology aspects in B.4.3.1.2.

B.4.3.1.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.3.2 Network characteristics

B.4.3.2.1 General

Addition:

Due to the load in the signal frequency range and due to the reflections and distortions related to this, the number of stations, which can be connected to one fieldbus segment, shall be limited to 32. Another restriction that is usually quite important concerns powering via the signal conductors.

For intrinsically safe networks, both the maximum supply voltage and the maximum supply current are specified within narrow limits. Even for non-intrinsically safe networks, the power of the power device is limited. In addition, a large portion of the available power is lost because of voltage drops on the transmission line. An optimally designed fieldbus network requires the precise calculation of the partial voltage drops between the power supply and the individual field devices. The supply voltage on the remote-powered field devices shall be at least 9 V.

NOTE 1 In most cases, it is sufficient to calculate the required current, select a power supply from Table B.3, and take the minimum line length from Table B.4 for the core cross section chosen.

To the extent related to the power balance, the characteristics of a power supply are completely described by the specification of the supply voltage and of the maximum current, regardless of whether an intrinsically safe or non-intrinsically safe power supply is involved. It can be built up as an ideal voltage source followed by a current limitation. Table B.3 lists the characteristics of power supplies. Other combinations are possible, if they do not violate the limits.

Table B.3 – Power supply (operational values)

Type	Area of use	Supply voltage	Supply current	Maximum power
I	EEx ia/ib IIC	13,5 V	110 mA	2,52 W
II	EEx ib IIC	13,5 V	110 mA	2,52 W
III	EEx ib IIB	13,5 V	250 mA	5,32 W
IV	Not intrinsically safe	24 V	500 mA	12 W

Table B.4 – Line lengths which can be achieved

Power supply		Type I	Type II	Type III	Type IV	Type IV	Type IV
Supply voltage	V	13,5	13,5	13,5	24	24	24
Σ current demand	mA	≤ 110	≤ 110	≤ 250	≤ 110	≤ 250	≤ 500
Maximum loop resistance	Ω	≤ 40	≤ 40	≤ 18	≤ 130	≤ 60	≤ 30
Σ Line length for core cross section q=0,5 mm^2	m	≤ 500	≤ 500	≤ 250	≤ 1 700	≤ 850	≤ 400
Σ Line length for core cross section q=0,8 mm^2	m	≤ 900	≤ 900	≤ 400	≤ 1 900	≤ 1 300	≤ 650
Σ Line length for core cross section q=1,5 mm^2	m	≤ 1 000	≤ 1 500	≤ 500	≤ 1 900	≤ 1 900	≤ 1 900
Σ Line length for core cross section q=2,5 mm^2	m	≤ 1 000	≤ 1 900	≤ 1 200	≤ 1 900	≤ 1 900	≤ 1 900

The required current (= Σ current demand) is calculated by the sum of the basic device currents of the field devices, the current of the handheld terminal, the current of the coupler for the bus master, the sum of currents of any repeaters used and the limiting current of the FDE. The latter can be calculated for every device connected to the fieldbus as the difference between the maximum current when a fault occurs and the operating current. The device with the highest threshold current is the determining factor.

The number of field devices that can be connected to a segment is determined by the device with the largest fault current (see B.4.4.5.2) and by the sum of the rated operating currents of all devices.

NOTE 2 It is up to the user to take into account the fault current (≤ 9 mA) or not. Leaving out of consideration can be accepted if a short circuit will not lead to a dangerous situation or to economically unwanted consequences (with an expected probability).

B.4.3.2.2 Network characteristics for balanced cabling not based on Ethernet

Replacement:

Every fieldbus installation shall comply with certain rules (that means the network configuration rules). The rules in 12.3.3 of IEC 61158-2:2014 specify the limit values for attenuation, reflection and distortions in rule 8 and the maximum signal delay in rule 4 that are permitted in the network. Table B.5 summarizes these values.

Table B.5 – Limit values for distortion, reflection and signal delay

Attribute	Value
Attenuation between any two fieldbus interfaces (at 31,25 kHz)	10,5 dB
Attenuation distortion $a(f = 39\ \text{kHz}) - a(f = 7{,}8\ \text{kHz})$, ascending monotonically with f	6 dB
Mismatching distortion at any point (7,8 kHz to 39 kHz)	0,2
Maximum propagation delay between any two devices	640 µs

In a non-hazardous area all topologies of B.4.3.1.2 and all cables are permitted within the framework of these limit values. For intrinsic safe installations according to FISCO the limits and restrictions listed in Table B.10 shall be obeyed.

Since individual calculation of the above four parameters for all possible connections between two fieldbus interfaces to obtain the optimal layout is very time-consuming, rules have been specified for a basic topology which, although below the optimum, will ensure that the above limit values will not be exceeded.

A tree topology was selected as the basic model of a network. This network consists of a main cable (that means trunk), a number of stub cables (that means spurs), connection elements (that means splices), and two line terminators. The maximum cable length is the sum of the lengths of the main cable and all spurs.

IEC 61158-2:2014 requires not exceeding the values listed in Table B.6, Table B.7, and Table B.8.

Although different cable types can be mixed in one network segment, this should be avoided. Determining the maximum cable lengths for such mixed structures is more time-consuming and less accurate than using structures consisting of only one type of cable.

Table B.6 – Recommended maximum cable lengths including spurs

Type of cable	Maximum cable length
A	1 900 m
B	1 200 m
C	400 m
D	200 m

Table B.7 – Recommended length of the spurs

Number of stub cables	Length of one stub cable (Intrinsically safe)	Length of one stub cable (Not intrinsically safe)
25 to 32	–	–
19 to 24	30 m	30 m
15 to 18	30 m [a]	60 m
13 to 14	30 m [a]	90 m
1 to 12	30 m [a]	120 m
Spurs ≤ 1 m shall be considered as splices.		
[a] Preliminary values in accordance with FISCO.		

Table B.8 – Maximum length of the splices

Maximum cable length	Maximum length of the splices
≥ 400 m	8 m
< 400 m	2 %

The network can be enlarged with repeaters. The above limit values then apply to each individual network segment, and only the maximum signal delay shall be calculated for the total network.

Compliance with these requirements ensures accurate signal transmission. If systems with remote-powered fieldbus interfaces are involved, a preparation of a power balance is required in accordance with B.4.4.5.2.

B.4.3.2.3 Network characteristics for balanced cabling based on Ethernet

Not applicable.

B.4.3.2.4 Network characteristics for optical fibre cable

Not applicable.

B.4.3.2.5 Specific network characteristics

Addition:

See aspects of network characteristics in B.4.3.1.

B.4.3.2.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

Not applicable.

B.4.4 Selection and use of cabling components

B.4.4.1 Cable selection

B.4.4.1.1 Common description

Addition:

Generic cabling in accordance with ISO/IEC 11801-3 is not suitable for the cabling of CP 3/2 networks.

CP 3/2 networks only can be connected to the generic cabling via converter/adapter as specified in IEC 61918:2018, 4.1.2.

B.4.4.1.2 Copper cables

B.4.4.1.2.1 Balanced cables for Ethernet-based CPs

Not applicable.

B.4.4.1.2.2 Copper cables for non-Ethernet-based CPs

Replacement:

CP 3/2 MBP according IEC 61784-1 requires that a two-wire cable shall be used as the transmission medium for the fieldbus. Although the electrical data are not specified, these data influence the performance that can be achieved by the fieldbus (that means distances which can be covered, number of stations, electromagnetic compatibility). Subclause 13.8.2 in IEC 61158-2:2014 is required for fieldbus tests and IEC 61158-2:2014, Annex B (informative) is recommended. Table B.9 distinguishes between four types of cables for a temperature of 25 °C.

Table B.9 – Information relevant to copper cable: fixed cables

Characteristic	Type A (Reference)	Type B	Type C	Type D
Cable description	Twisted pair, shielded	One or more twisted pairs, total shielding	Several twisted pairs, not shielded	Several non-twisted pairs, not shielded
Nominal conductor cross sectional area	0,8 mm² (AWG 18) (Ø 1,024 mm)	0,32 mm² (AWG 22) (Ø 0,644 mm)	0,13 mm² (AWG 26) (Ø 0,511 mm)	1,25 mm² (AWG 16) (Ø 1,291 mm)
Maximum DC resistance (loop)	44 Ω/km	112 Ω/km	264 Ω/km	40 Ω/km
Characteristic impedance at 31,25 kHz	100 Ω ± 20 %	100 Ω ± 30 %	[a]	[a]
Maximum attenuation at 39 kHz	3 dB/km	5 dB/km	8 dB/km	8 dB/km
Maximum capacitive unbalance	2 nF/km	2 nF/km	[a]	[a]
Group delay distortion (7,9 kHz to 39 kHz)	1,7 µs/km	[a]	[a]	[a]
Surface covered by shield	90 %	[a]	–	–
Extent of network including spur cables	1 900 m	1 200 m	400 m	200 m
[a] Not specified.				

The reference cable (that means type A) shall be used for the conformance tests.

When new systems are installed, cables that meet the minimum requirements of types A and B shall be used. When multi-pair cables (that means type B) are used, several fieldbuses (31,25 kbit/s) can be operated in one cable.

Installation of other electric circuits in the same cable should be avoided. Type C and D cables should only be used for so called retrofit applications (that means use of already installed cables) for substantially reduced networks. In such cases the interference susceptibility of the transmission frequently does not meet the requirements.

Cables installed in hazardous area shall meet the requirements of the related standards. Installations based on FISCO are not subject to safety restrictions when the limit values listed in Table B.10 are complied with. Although operation outside these limit values is not prohibited in general, each case shall be judged on an individual basis.

Table B.10 – Safety limit values for the fieldbus cable

Indicator	EEx ia	EEx ib IIC / IIB
Loop resistance (direct current)	15 Ω/km to 150 Ω/km	15 Ω/km to 150 Ω/km
Inductivity per unit length	0,4 mH/km to 1 mH/km	0,4 mH/km to 1 mH/km
Capacitance per unit length	80 nF/km to 200 nF/km [a]	80 nF/km to 200 nF/km [a]
Stub line length	≤ 30 m [b]	≤ 30 m [b]
Line length	≤ 1 km	≤ 5 km
For operational reasons the line length of EEx ib IIC / IIB shall be limited to 1,9 km.		
[a] See Table B.1 and Table B.2 for definition. [b] Preliminary values in accordance with the FISCO model, for tree- and bus topologies.		

When multi-pair cables are used in potentially explosive areas, the special installation requirements stated in IEC 60079-14 shall apply.

B.4.4.1.3 Cables for wireless installation

B.4.4.1.4 Optical fibre cables

Not applicable.

B.4.4.1.5 Special purpose balanced and optical fibre cables

Not applicable.

B.4.4.1.6 Specific requirements for CPs

Not applicable.

B.4.4.1.7 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.4.2 Connecting hardware selection

B.4.4.2.1 Common description

Modification:

Subclause B.4.2.3.1 applies.

B.4.4.2.2 Connecting hardware for balanced cabling CPs based on Ethernet

Not applicable.

B.4.4.2.3 Connecting hardware for copper cabling CPs not based on Ethernet

Replacement:

Table B.11 provides values based on the template given in IEC 61918:2018, Table 8.

Table B.11 – Connectors for copper cabling CPs not based on Ethernet

	IEC 60807-2 or IEC 60807-3	IEC 60947-5-2 or IEC 61076-2-101			EN 122120	ANSI/(NFPA) T3.5.29 R1-2007		Others		
	Sub-D	**M12-5 with A-coding**	**M12-5 with B-coding**	**M12-n with X-coding**	**Coaxial (BNC)**	**M 18**	**7/8-16 UN-2B THD**	**Open style**	**Terminal block**	**Others**
CP 3/2	9 pin	No	No	M12-4 with A-coding	No	No	No	No	No	No

NOTE For M12-5 connectors, there are many applications using these connectors that are not compatible and when mixed can cause damage to the applications.

B.4.4.2.4 Connecting hardware for wireless installation

B.4.4.2.5 Connecting hardware for optical fibre cabling

Not applicable.

B.4.4.2.6 Specific requirements for CPs

Not applicable.

B.4.4.2.7 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.4.3 Connections within a channel/permanent link

B.4.4.3.1 Common description

B.4.4.3.2 Balanced cabling connections and splices for CPs based on Ethernet

Not applicable.

B.4.4.3.3 Copper cabling connections and splices for CPs not based on Ethernet

Subclause 4.4.3.3.1 has addition:

Refer to the manufacturer's data sheet regarding number of allowed connections.

B.4.4.3.4 Optical fibre cabling connections and splices for CPs based on Ethernet

Not applicable.

B.4.4.3.5 Optical fibre cabling connections and splices for CPs not based on Ethernet

Not applicable.

B.4.4.3.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.4.4 Terminators

B.4.4.4.1 Common description

B.4.4.4.2 Specific requirements for CPs

Addition:

For CP 3/2 networks terminators shall be used.

Line termination shall consist of a series circuit of one capacitor and one resistor on both ends of the main fieldbus line.

Allowed values:

R = 100 Ω ± 2 %

C = 1 µF ± 20 %

When considering safety of the line terminations, remember that although a single resistor can be designed as infallible in the sense of EN 50020, a capacitor cannot. If a capacitor fault results in a short circuit, the resistor is located directly parallel with the fieldbus. This shall be considered when providing for prevention of thermal ignition.

B.4.4.4.3 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.4.5 Device location and connection

B.4.4.5.1 Common description

Addition:

If devices according to CP 3/2 with MBP-IS are intended to be used in hazardous locations then the national regulation shall be observed when installing such devices.

When selecting the individual components, make sure that all components meet the requirements of the FISCO model regarding safe implementation. Only components that are identified as an intrinsically safe electrical apparatus or as an associated electrical apparatus in accordance with IEC 60079-11 are allowed to be installed in intrinsically safe fieldbus segments. To comply with 12.2.5.1 of IEC 60079-14:— the permitted values of the input parameters U_I, I_I, and P_I of an intrinsically safe apparatus (for example a field device) shall not be less than the certified maximum values of the output parameters U_0, I_0 and P_0 of the associated power device. Additional restrictions applicable to the individual components (for example limitation of the supply power of ≤ 1,2 W) have to be taken into account as well.

Table B.12 lists possible combinations of devices from different system categories.

Table B.12 – Mixing devices from different categories

Explosion protection of the bus-segment	Explosion protection of the power device	Explosion protection of the field device					
			EEx ia			EEx ib	
		IIC	IIB	IIC/IIB	IIC	IIB	IIC/IIB
EEx ia IIC	[EEx ia] IIC	Yes	No	Yes	No	No	No
EEx ia IIB	[EEx ia] IIB	Yes	Yes	Yes	No	No	No
	[EEx ia] IIC	Yes	Yes	Yes	No	No	No
EEx ib IIC	[EEx ib] IIC	Yes	No	Yes	Yes	No	Yes
	[EEx ia] IIC	Yes	No	Yes	Yes	No	Yes
EEx ib IIB	[EEx ib] IIB	(Yes) [a]	Yes	Yes	(Yes) [a]	Yes	Yes
	[EEx ib] IIC	Yes	Yes	Yes	Yes	Yes	Yes
	[EEx ia] IIB	(Yes) [a]	Yes	Yes	(Yes) [a]	Yes	Yes
	[EEx ia] IIC	Yes	Yes	Yes	Yes	Yes	Yes

[a] These combinations are possible in theory but in practice they are irrelevant, because the field devices may be certified for group IIC and for group IIB as well (see column IIC/IIB). By any combination it shall be assured that the absolute maximum ratings for the input of the field device fit to the output characteristics of the power device:

UI ≥ UO,

II ≥ IO, and

PI ≥ PO.

In general, several devices from different manufacturers may be connected via one fieldbus.

Connection of bus-powered devices and local-powered devices on an intrinsically safe fieldbus is only permitted if the local-powered devices are provided with suitable isolation in accordance with IEC 60079-11.

Although connection of a fieldbus station (that means field device, handheld terminal, and coupler for the bus master) with its poles reversed does not affect the functionality of the other devices connected to the fieldbus, an incorrectly installed bus station which is not equipped with automatic polarity detection will not be supplied with power or be able to send and receive. Stations with automatic polarity detection operate correctly with any allocation of the input terminals to the wires.

B.4.4.5.2 Specific requirements for CPs

Addition:

To ensure compatibility with the 21.11.2 of IEC 61158-2:2014, the electrical characteristics shown in Table B.13 shall be applied for all fieldbus interfaces.

Table B.13 gives only an overview of the primary requirements. Details are given in CP 3/2 of IEC 61784-1.

If the device is sensitive to reverse wiring (that means the device will become inoperable if the terminals are reversed), then, the input terminals of a communication device shall be clearly marked with "+" and "-". This is not mandatory for devices equipped with automatic polarity identification.

It is essential to avoid unbalanced capacitance between the two fieldbus terminals and earth that means the CMRR requirements have to be met. This is particularly important when the connection from the connection room to the electronics is made via feed-through capacitors with high tolerances. For more details on CMRR, see 21.4.4 of IEC 61158-2:2014.

Other EMC requirements of industrial process and laboratory control equipment shall be adhered to in order to ensure electromagnetic compatibility.

Table B.13 – Electrical characteristics of fieldbus interfaces

Characteristics	Specification	Subclause in IEC 61158-2:2014
Signal coding	Manchester II	9.2
Start delimiter	1, N+, N-, 1, 0, N-, N+, 0 [a]	9.4
End delimiter	1, N+, N-, N+, N-,1, 0, 1 [a]	9.5
Preamble	1, 0, 1, 0, 1, 0, 1, 0	9.6
Data transmission rate	31,25 kbit/s ± 0,2 %	11.1
Output level (peak – peak)	0,75 V to 1 V	11.3
Maximum difference between pos. and neg. transmit amplitude	± 50 mV	11.3
Maximum transmit signal distortion (oversvoltage, ringing an drop)	± 10 %	11.3
Transmitter noise	1 mV (RMS) [b]	11.3
Output impedance	≥ 3 kΩ [c]	11.3
Operating voltage	9 V to 32 V [d]	11.3
Common Mode Rejection Ratio (CMRR)	≥ 50 dB [e]	11.3
Leakage current [f]	50 µA	

[a] N+ and N- are non-data symbols in accordance with IEC 61158-2:2014.

[b] In frequency range of 1 kHz to 100 kHz.

[c] In frequency range of 7,8 kHz to 39 kHz.

[d] Operational voltage range. Can be limited to 9 V to 17,5 V or to 9 V to 24 V for intrinsically safe devices. For details see IEC 61158-2:2014.

[e] Corresponds to an unbalanced capacitance of 250 pF at 39 kHz.

[f] Only for intrinsic safety.

A further important requirement aims to the system fault tolerance. It shall be avoided that a defective device impairs the operation of the other devices in the system. Appropriate means or methods (for example FDE) shall prevent unwanted excessive current consumption in case of fault. The increase of DC current compared with the rated current is called "fault current". Additionally appropriate means (for example jabber inhibit) shall prevent the device from unwanted excessive signal transmission.

The requirements can be summarised as follows.

- In case of a single fault the current consumption of a device may exceed the rated current by not more than 9 mA (fault current ≤ 9 mA). Faults of components close to the fieldbus interface shall not be regarded.
- In case of a single fault the input impedance of a device shall not fall short of 1 kΩ within the signal frequency range. Faults of components close to the fieldbus interface shall not be regarded.
- The device shall contain a self-interrupt capability (jabber inhibit) according to IEC 61158-2:2014, 12.6.

The fault current (≤ 9 mA) shall be described in the data sheet as well as the normal operation current.

Communication devices, which are used in potentially explosive areas, shall comply with standards for intrinsically safe apparatus. The device documentation shall contain a statement specifying that the devices conform to the FISCO model. Other specifications which should also be given include permissible operating voltage, maximum operating current, maximum leakage current, maximum current consumed during a malfunction (that means limiting current of a fault current limiter which may be installed or FDE), and maximum permissible power of the corresponding power supply. Since the permissible operating voltage can be specified based on the maximum permissible power of the related power supply, one and the same communication device can either be operated with a FISCO power supply (output voltage up to 17,5 V and permissible output power up to 1,8 W) or with a linear barrier (output voltage up to 24 V and permissible output power up to 1,2 W).

If the devices are powered locally, the device documentation shall contain a note on galvanic isolation from the fieldbus interface. Table B.14 provides an overview of recommended specifications for the data sheets of the primary devices.

Table B.14 – Recommended data sheet specifications for CP 3/2 devices

Recommended data sheet specifications	Non intrinsically safe devices	Intrinsically safe devices
Fieldbus interface in accordance with IEC 61158-2:2014	Yes	Yes
Type of explosion protection in accordance with IEC 60079-11 [a]	No	Yes
Communication device in accordance with the FISCO model	No	Yes
Permissible operating voltage	Yes	No
Permissible output voltage of the power supply	No	Yes
Permissible output current of the power supply	No	Yes
Maximum permissible output power of power supply	No	Yes
Maximum operating current	Yes	Yes
Maximum fault current	Yes	Yes
Permissible ambient temperature	Yes	Yes
Isolation class	Yes	Yes
Housing protection rating	Yes	Yes

[a] Other supplementary explosion protection types if necessary. Fieldbus electric circuit is always intrinsically safe.

B.4.4.5.3 Specific requirements for wireless installation

Not applicable.

B.4.4.5.4 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.4.6 Coding and labelling

B.4.4.6.1 Common description

Addition:

For CP 3/2 with MBP-IS the colour coding of the bus cable for intrinsically safe circuits shall be light blue.

B.4.4.6.2 Additional requirements for CPs

B.4.4.6.3 Specific requirements for CPs

Addition:

The wires of all fieldbus cables shall be clearly marked (for example by colour or with rings). Cables with intrinsically safe electric circuits shall be identified in accordance with related standards (for example with light blue jackets).

B.4.4.6.4 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.4.4.7 Earthing and bonding of equipment and devices and shielded cabling

B.4.4.7.1 Common description

B.4.4.7.1.1 Basic requirements

Addition:

An equipotential common bonding network (CBN) system is provided with installing the AC power system according to IEC 60364-1:2005, 312.2.1, TN-S system.

A properly installed AC power system ensures that no currents flow through shields and/or equipotential bonding conductors connected to the CBN.

Currents higher than approximately 0,1 A indicate problems in the electrical installation (that means more than one connection between N and PE anywhere in the power distribution system).

Indications of an unsuitable AC power supply are as follows.

- Currents on the PE conductor.
- Currents through cable shields.
- Currents through water pipes and heating pipes.
- Progressive corrosion at earthing terminals, on lightning conductors, and water pipes.

Addition:

NOTE 1 Sporadic events such as switching, short circuits, or atmospheric discharge (lightning strike) can cause current peaks in the system many times higher than the average value.

For CP 3/2 with MBP-IS the following applies.

For the operation of an installation with fieldbus systems, the earthing concept and thereby also the shielding of the electrical cables is a very important issue. When finalizing the earthing concept, the following aspects should be taken into consideration.

- Ensuring electromagnetic compatibility (EMC).
- Explosion protection.
- Human safety.

Earthing means a permanent connection to the equipotential bonding system via a sufficiently low-impedance connection with adequate current loading capacity in order to keep overvoltages out of connected devices and away from persons.

NOTE 2 Conventional field units (for example with a 4 mA to 20 mA interface) which are connected via two-wire cables with isolating repeaters in the control room process DC signals or low-frequency AC signals. The influence of wire-conducted noise signals with higher frequencies can be suppressed by means of appropriate input filters having a low cut-off frequency. Thus, for such devices, a predominantly electrostatically acting cable shield (earthed on one side) is sufficient. For this reason, the earthing of the cable shield on one side developed to become the traditional earthing concept in process technology.

In fieldbus systems, the usable frequency for the transmission of the signals is considerably higher than in conventional field units and the requirements placed on the earthing concept of the system accordingly tougher. Where AC signals are being processed, the components and also the interconnection of elements, like cables, shall be protected against the influence of electromagnetic fields.

The protective measures should create a complete encapsulation around the sensitive components. The larger the processed signal frequencies in the systems, the greater the requirement placed on the completeness of this gapless protective encapsulation. A shielding and earthing concept which satisfies these requirements constitutes the basis for the EMC tests performed by the device manufacturers.

Shields of cables shall be connected with the terminal locations in the devices intended for intrinsic safety applications. When connecting the shields, a low-impedance connection shall be provided – considering the high noise frequencies. This applies not only for the connection of the cable shields, but also for the earthing connection of the device. Extended wires usually do not meet these requirements.

For the shielding and earthing measures to have their optimum effect, the devices and shields shall be earthed more than once (see Figure B.10). According to 12.2.2.3 in IEC 60079-14:—, this method, which is optimal for electromagnetic compatibility and human safety, can be utilised without restriction in the area of the entire installation.

NOTE 3 If the installation is made and maintained in such a way that it can be ensured with a high degree of certainty that a potential equalization exists between each end of the circuit (that means between the hazardous area and safe area) then – if desired – cable screens and conducting screens at both ends of the cable and the screens at intermediate points, can be connected to earth, if necessary.

In the hazardous area according to 6.3 in IEC 60079-14:—, an equipotential bonding system is an absolute requirement anyway. The measures detailed there (inclusion of protective conductors, protective tubes, metallic cable shields, cable reinforcements and metallic components) may optionally be supplemented using the following measures.

- Laying of the bus cables on metallic cable trays.
- Incorporation of the cable tray into the equipotential bonding system.
- Interconnections of the cable trays among each other and to metallic components – these interconnections should be safe, be of sufficient current-loading capacity and be of a high-frequency-technology and low-impedance design.

Figure B.10 shows the recommended combination of shielding and earthing.

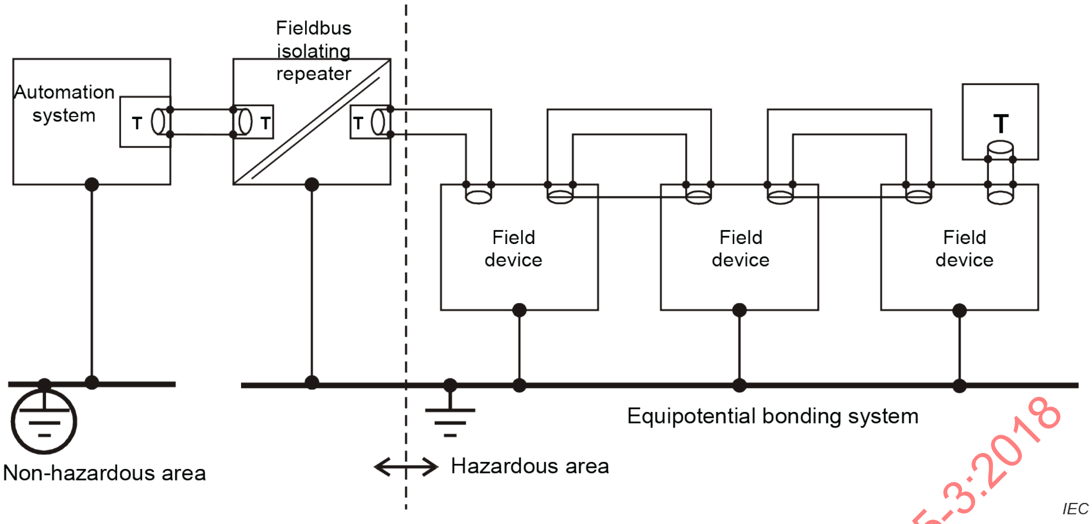


Figure B.10 – Recommended combination of shielding and earthing

By taking these measures, it is possible to at least create equipotential islands (areas free of potential differences). Low-frequency transient currents (50/60 Hz and harmonics) on the shielding, such as for example those which can develop due to potential differences between equipotential islands, have practically no noise impact on account of the high common mode rejection ratio of the overall system and the high-pass effect of the reception filter in the case of AC-interconnected systems. It shall nevertheless be ensured that these transient currents do not damage the cable and cannot induce ignitable sparks in the hazardous area. This can be achieved for example by means of a potential equalization cable having a broad cross-section and laid parallel to the bus cable.

In order to prevent impermissible energy potentials from being carried into the hazardous area, the cable shield shall be connected "safely" to the equipotential bonding system at all points of transition between the safe and hazardous areas. Here, safely means that the individual conductors of the cable shield shall be twisted, shall be protected from splaying by means of an end covering sleeve, and shall be connected to an appropriate screw terminal.

The connection of the cable shields within the hazardous area is not relevant to safety. It can be realized using conventional shield terminals (clamp straps).

B.4.4.7.1.2 Planner tasks

B.4.4.7.1.3 Methods for controlling potential differences in the earth system

B.4.4.7.1.4 Selection of earthing and bonding systems

B.4.4.7.2 Bonding and earthing of enclosures and pathways

B.4.4.7.2.1 Equalization and earthing conductor sizing and length

B.4.4.7.2.2 Bonding straps and sizing

B.4.4.7.2.3 Surface preparation and methods

B.4.4.7.2.4 Bonding and earthing

B.4.4.7.3 Earthing methods

B.4.4.7.3.1 Equipotential

Addition:

Transmission systems using signal frequencies > 10 kHz shall also be protected against (dynamic) electromagnetic fields. Therefore the cable shield and the (metallic) housings of the field devices and of any auxiliary equipment (for example connectors) shall make up a common shielding system, avoiding unnecessary gaps. The importance of this requirement increases with the signal frequencies processed in the system. With regard to the fieldbus, this means that ideally the cable shields are connected to the field devices' housings (or other protective coverings), which are frequently made of metal. The connections between the cable shield and the metallic housings as well as the connections between the shields of different cable segments shall be low-impedance (for high frequencies). Extended wires usually do not meet this requirement.

NOTE 1 As long as unshielded devices are connected to a shielded cable, further methods can be applied to reduce the impact of noise (for example galvanic isolation or filtering). Housings of field devices or power supplies can be connected to earth due to operational or safety reasons. This results in a shielding system, which is connected to earth at several points (see Figure B.11). Taking into account EMC aspects as well as safety against electrical shocks this is the preferable method and can be used without any restriction in systems with an optimum of potential equalization.

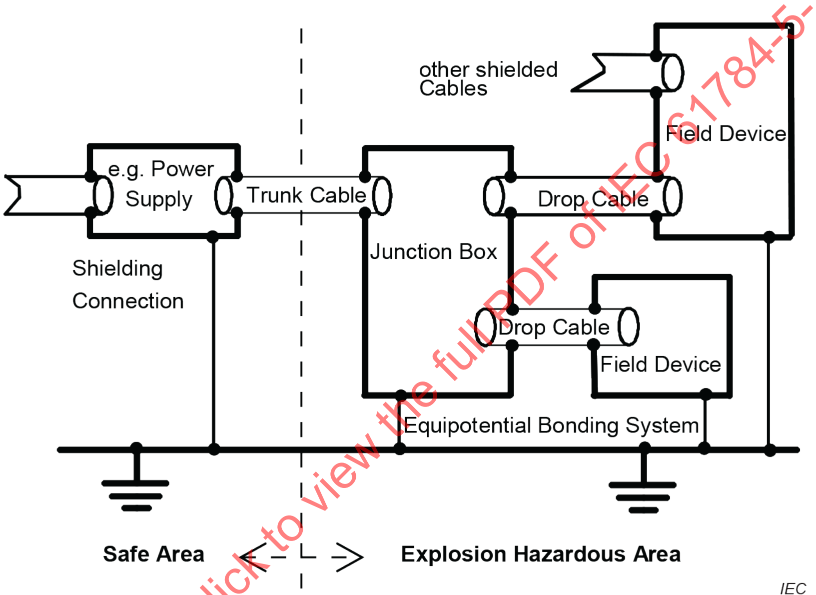


Figure B.11 – Ideal combination of shielding and earthing

In this context, according to 6.3 of IEC 60079-14:—, a potential equalization is principally required for installations in hazardous areas.

NOTE 2 The rules concerning the equipotential bonding system (inclusion of protective conductors, metal conduits, metal cable sheaths, steel wire armouring and metallic parts of structures) can be supplemented by

- placing the cables on metal racks,
- integrating the metal cable racks into the potential equalization system, and
- interconnecting the metal cable racks by permanent, current carrying and low-impedance bonds.

Following these instructions, it is possible to create at least equipotential islands. Low-frequency ground current (50/60 Hz, including harmonics), flowing between the islands, will not impact the signal quality because of the high common mode rejection ratio and the filter characteristics of the receiver circuit. However, damage of the cable shield by exceeding its current carrying capability shall be avoided.

If a sufficient potential equalization between the hazardous area (equipotential island with one or more field devices) and the safe area (for example the control room) cannot be guaranteed, the cable shield shall be directly connected to the equipotential bonding system (earth) only in the hazardous area. In the safe area the shield shall be connected to earth through a capacitor. The impedance of the connection should be minimized for high frequencies. Extended wires usually do not meet this requirement.

Figure B.12 shows a possible solution. However, the need for an electric envelope as complete as possible cannot be entirely fulfilled. The shown connection between both earthing systems through a capacitor may also be placed at another position between power supply and the hazardous area (or between different hazardous areas), but it has always to be in a safe area.

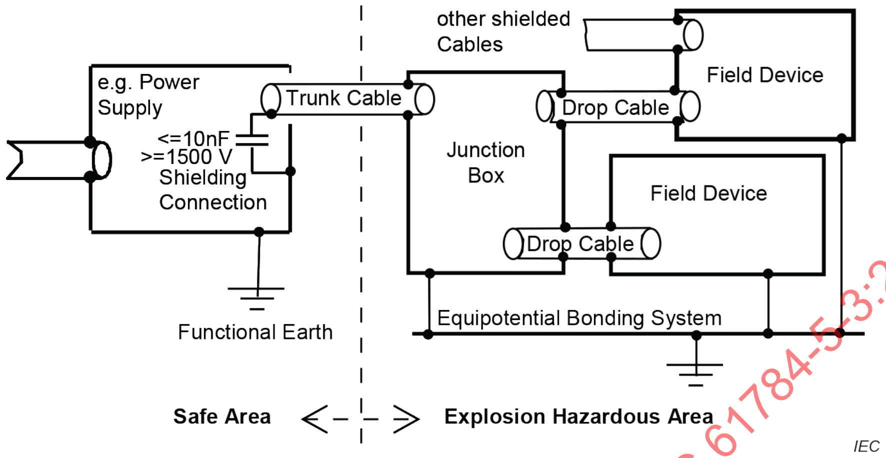


Figure B.12 – Capacitive earthing

The capacitor shall meet the following requirements.

- Solid dielectric (for example ceramic).
- C ≤ 10 nF.
- Isolation voltage ≥ 1,5 kV.

If the described system of equipotential islands cannot be realized then the traditional concept may be used and the screen shall be electrically connected to earth at one point only, normally at the non-hazardous area, far away from the field device. In this case all EMC tests according to IEC 61000-4-2 assume a direct connection between the cable shield and earth close to the device under test (for example a field device).

NOTE 3 Therefore in case of single earthing the EMC can be reduced compared with the test environment.

If a network does not cover or cross a hazardous area single earthing should not be used. If there is danger of exceeding current carrying capability of the shield multiple earthing through small capacitors (for example 10 nF) is acceptable, but the impedance of the connection should be minimized for high frequencies, as already mentioned.

B.4.4.7.3.2 Star

B.4.4.7.3.3 Earthing of equipment (devices)

B.4.4.7.3.4 Copper bus bars

B.4.4.7.4 Shield earthing

B.4.4.7.4.1 Non-earthed or parallel RC termination

Not applicable.

B.4.4.7.4.2 Direct

Addition:

Shielding always shall be connected to earth at both ends of the cables. Single point shield termination shall be avoided.

The IEC 61158-2:2014 requires that all devices with fieldbus connections shall be operated without direct connection to earth. For intrinsically safe devices according to 5.7 of IEC 60079-11:2011 it is required that the isolation voltage (that means effective value) between the intrinsically safe electric circuit and grounded / earthed parts shall be twice as high as the voltage of the intrinsically safe electric circuit, but at least 500 V.

NOTE For some devices, it is possible to meet these requirements by setting up the entire field device isolated from the environment. An example of such a device is a temperature transmitter with its sensor contained in non-conducting material, as shown in Figure B.13.

IEC 61158-2:2014 requires that the unbalanced capacitance measured between the two fieldbus terminals and earth shall not exceed 250 pF.

If a part of the field device cannot be operated unearthed, galvanic isolation shall be provided between this part and the fieldbus. It depends on the device developer where this isolation will be provided. The isolation between the medium attachment unit and Manchester encoder/decoder shown in Figure B.13 is particularly useful since the unbalanced capacitance can be kept very low when isolation is performed near the fieldbus cable.

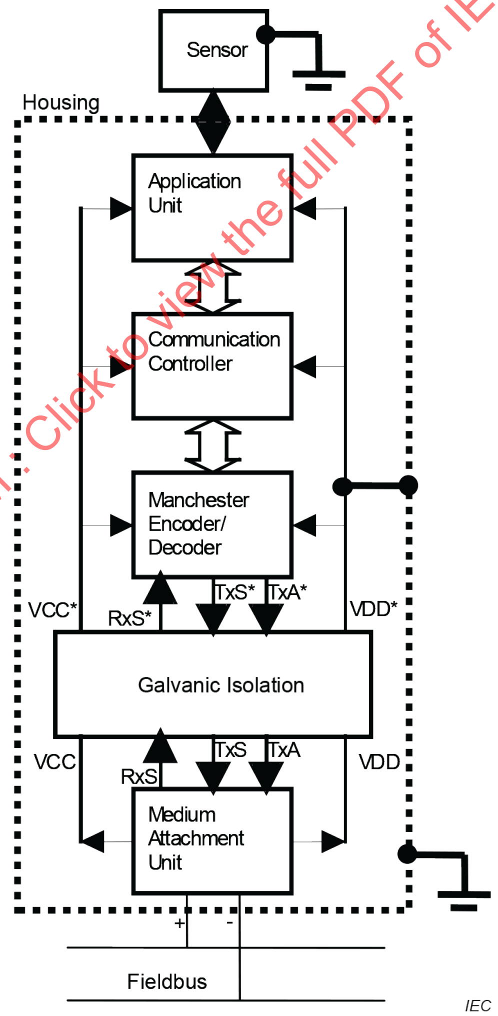


Figure B.13 – Galvanic isolated field device

When a bus-powered field device is involved, the galvanic isolation shall cover both the signals (that means capacitive, inductive or optical transmission) and the power supply of the field device (that means DC/DC converters).

Locally powered devices do not require DC/DC converters. In case of locally powered devices only the medium attachment unit is powered by the fieldbus while the other parts of the field device are powered by a second power circuit. If this electric circuit is intrinsically safe, the above requirements (that means isolation voltage of 500 V) apply to signal isolation. If the supply circuit is not intrinsically safe, isolation voltage shall be at least 1500 V. In addition, the requirements of Table 2 of IEC 60079-11:2011 (that means clearances, creepage, distances and separations between conducting parts) shall be met.

If the intrinsically safe electric circuit is connected capacitively to earth (for example by a capacitive EMC suppresser filter), the guidelines of the individual certification authority applicable to safety isolation by capacitors shall be adhered to.

B.4.4.7.4.3 Derivatives of direct and parallel RC

B.4.4.7.5 Specific requirements for CPs

Not applicable.

B.4.4.7.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3:____

B.4.4.8 Storage and transportation of cables

B.4.4.9 Routing of cables

B.4.4.9.1 Common description

B.4.4.9.2 Cable routing of assemblies

B.4.4.9.3 Detailed requirements for cable routing inside enclosures

B.4.4.9.4 Cable routing inside buildings

Addition:

For CP 3/2 with MBP-IS interface the cables for intrinsically safe circuits shall be kept separate from powerlines due to the possible coupling of energy to this cables. IEC 60079-14 and national regulations shall apply.

B.4.4.9.5 Cable routing outside and between buildings

Addition:

For CP 3/2 networks copper cables routed between buildings shall be installed on cable racks with good conductivity. Mesh openings shall be small.

Direct buried CP 3/2 cables shall be routed in a plastic pipe approximately 60 cm below the surface. A cable warning tape shall be placed above it approximately 20 cm below the surface. The equipotential bonding between the buildings (for example galvanized earth strap) shall be routed approximately 20 cm above the CP 3/2 cable. The earth strap is also used as protection against the effects of a lightning strike. The minimum cross section for the equipotential bonding according to IEC 60364-5-54 for steel shall be 50 mm^2.

B.4.4.9.6 Installing redundant communication cables

B.4.4.10 Separation of circuits

Addition:

For CP 3/2 with MBP-IS interface the IEC 60079-14 applies.

B.4.4.11 Mechanical protection of cabling components

B.4.4.12 Installation in special areas

B.4.5 Cabling planning documentation

B.4.6 Verification of cabling planning specification

B.5 Installation implementation

B.5.1 General requirements

B.5.1.1 Common description

B.5.1.2 Installation of CPs

Addition:

For CP 3/2 with MBP-IS interface the IEC 60079-14 applies.

B.5.1.3 Installation of generic cabling in industrial premises

B.5.2 Cable installation

B.5.2.1 General requirements for all cabling types

Subclause B.5.2.1.2 has replacement:

Table B.15 provides values based on the template given in IEC 61918:2018, Table 18.

Table B.15 – Parameters for balanced cables

Characteristic		Value
Mechanical force	Minimum bending radius, single bending (mm)	30 to 75 [a]
	Bending radius, multiple bending (mm)	60 to 150 [a]
	Pull forces (N)	80 to 150 [a]
	Permanent tensile forces (N)	80 to 100 [a]
	Maximum lateral forces (N/cm)	[a]
	Temperature range during installation (°C)	–20 to +60 [a]

[a] Depending on cable type; see the manufacturer's data sheet.

Subclause B.5.2.1.11 is not applicable.

B.5.2.2 Installation and routing

B.5.2.2.1 Common description

Modification:

Applies with respect to the condensed MICE table according to B.4.2.3.1

B.5.2.2.2 Separation of circuits

B.5.2.3 Specific requirements for CPs

Not applicable.

B.5.2.4 Specific requirements for wireless installation

Not applicable.

B.5.2.5 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

B.5.3 Connector installation

B.5.3.1 Common description

Addition:

Subclause A.5.3.1 applies.

B.5.3.2 Shielded connectors

B.5.3.3 Unshielded connectors

Not applicable.

B.5.3.4 Specific requirements for CPs

Addition:

The M12-4 "A"-coded circular connector and the female connector shall be IP65 or higher. Only shielded connectors are permitted. The connectors feature a mechanical key (A-coding).

Pin assignment is as shown in Table B.16 and Figure B.14.

Table B.16 – Contact assignments for the external connector for harsh industrial environments

Contact No.	Function
1	Data + with the option of power +
2	Not connected
3	Data – with the option of power –
4	Not connected
Thread	Shield

The shield shall be concentric around the thread. The shield potential shall be transmitted via the thread. For new devices pin 4 shall not be used and pin 4 shall not be connected in newly installed cables. Existing Type 3 devices with connected pin 4 still conform to IEC 61158-2:2014. Existing pre-harnessed Type 3 cables with connected pin 4 still conform to IEC 61158-2:2014.

The centred hole of the female plug shall not be fitted because of the increased air and creepage distances in potentially explosive atmospheres.

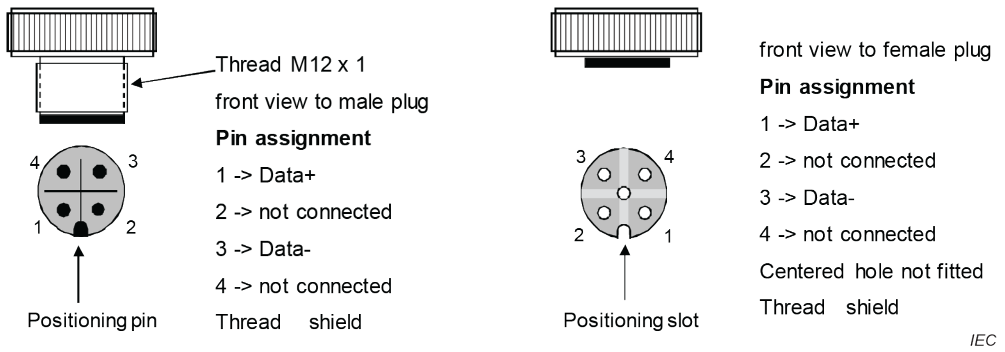


Figure B.14 – Pin assignment of the male and female connectors IEC 60947-5-2 (A-coding)

B.5.3.5 Specific requirements for wireless installation

Not applicable.

B.5.3.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3:

B.5.4 Terminator installation

B.5.4.1 Common description

B.5.4.2 Specific requirements for CPs

Addition:

Subclause A.5.4.2 applies.

B.5.5 Device installation

B.5.5.1 Common description

B.5.5.2 Specific requirements for CPs

Not applicable.

B.5.6 Coding and labelling

B.5.7 Earthing and bonding of equipment and device and shielded cabling

B.5.8 As-implemented cabling documentation

B.6 Installation verification and installation acceptance test

B.6.1 General

Addition:

Subclause A.6.1 applies.

B.6.2 Installation verification

B.6.2.1 General

B.6.2.2 Verification according to cabling planning documentation

B.6.2.3 Verification of earthing and bonding

B.6.2.4 Verification of shield earthing

Addition:

Verify that shielding always is connected to earth at both ends of the cables. Single point shield termination shall be avoided.

Verify that shield currents are less than 0,1 A. Currents higher than approximately 0,1 A indicate problems in the electrical installation (that means the power distribution system does not comply with the TN-S rules).

B.6.2.5 Verification of cabling system

B.6.2.6 Cable selection verification

B.6.2.6.1 Common description

B.6.2.6.2 Specific requirements for CPs

Addition:

Verify that all cables are marked by the manufacturer for use within CP 3/2 networks, if not then check with the planner.

B.6.2.6.3 Specific requirements for wireless installation

B.6.2.7 Connector verification

B.6.2.8 Connection verification

B.6.2.8.1 Common description

Not applicable.

B.6.2.8.2 Number of connections and connectors

B.6.2.8.3 Wire mapping

B.6.2.9 Terminator verification

B.6.2.10 Coding and labelling verification

B.6.2.11 Verification report

B.6.3 Installation acceptance test

B.6.3.1 General

B.6.3.2 Acceptance test of Ethernet-based cabling

Not applicable.

B.6.3.3 Acceptance testing of non-Ethernet-based cabling

B.6.3.3.1 Copper cabling for non-Ethernet-based CPs

B.6.3.3.2 Optical fibre cabling for non-Ethernet-based CPs

Not applicable.

B.6.3.4 Specific requirements for wireless installation

Not applicable.

B.6.3.5 Acceptance test report

B.7 Installation administration

Subclause B.7.8 is not applicable.

B.8 Installation maintenance and installation troubleshooting

Subclause B.8.4 is not applicable.

Annex C
(normative)

CP 3/3, CP 3/4, CP 3/5, CP 3/6 (PROFINET) specific installation profile

C.1 Installation profile scope

This annex specifies the installation profile for Communication Profiles CP 3/3, CP 3/4, CP 3/5, and CP 3/6 (PROFINET). The CP 3/3 is specified in IEC 61784-1 and CP 3/4, CP 3/5, and CP 3/6 are specified in IEC 61784-2.

C.2 Normative references

Addition:

IEC 60793-2-50:2008, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single–mode fibres*

IEC 61076-2-107:2009, *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 61156-5:2009, *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*

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 61076-3-117*

IEEE 802.3ah-2004, *IEEE Standard for Information technology-- Local and metropolitan area networks – Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks*

C.3 Installation profile terms, definitions, and abbreviated terms

C.3.1 Terms and definitions

C.3.2 Abbreviated terms

Addition:

AO	Automation outlet
MMF	Multimode fibre
POF	Plastic optical fibre
RAL	Deutsches Institut für Gütesicherung und Kennzeichnung e. V.
SMF	Single mode fibre
TO	Telecommunication outlet

C.3.3 Conventions for installation profiles

Not applicable.

C.4 Installation planning

C.4.1 General

C.4.1.1 Objective

C.4.1.2 Cabling in industrial premises

C.4.1.3 The planning process

C.4.1.4 Specific requirements for CPs

Not applicable.

C.4.1.5 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

C.4.2 Planning requirements

C.4.2.1 Safety

C.4.2.2 Security

C.4.2.3 Environmental considerations and EMC

C.4.2.3.1 Description methodology

Modification:

Subclause A.4.2.3.1 applies for CP 3/3, CP 3/4 CP 3/5 and CP 3/6 respectively.

C.4.2.3.2 Use of the described environment to produce a bill of material

Addition:

Manufacturers mark their products allowable for CP 3/3, CP 3/4, CP 3/5 and CP 3/6 fieldbus networks. Only these products shall be used and be mentioned on the bill of material.

The planner shall take into account the mating interface of devices to be connected to the fieldbus network.

C.4.2.4 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

C.4.3 Network capabilities

C.4.3.1 Network topology

C.4.3.1.1 Common description

C.4.3.1.2 Basic physical topologies for passive networks

Not applicable.

C.4.3.1.3 Basic physical topologies for active networks

C.4.3.1.4 Combination of basic topologies

Not applicable.

C.4.3.1.5 Specific requirements for CPs

Not applicable.

C.4.3.1.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

C.4.3.2 Network characteristics

C.4.3.2.1 General

Addition

Table C.1 gives information for selecting suitable media for the network.

Table C.1 – General transmission media selection information

	Balanced cables:	**Fibre optical cables (POF/PCF):**	**Fibre optical cables (glass):**
Channel lengths:	+ ≤ 100 m	+ POF: ≤ 50 m PCF: ≤ 100 m	++ MM:≤ 2 000 m SM:≤ 14 000 m
EMC immunity:	+	++	++
Equipotential bond influence:	- Correlations	+ Independent	+ Independent
Field assembly:	++	++	-
Mating cycles:	+	+	+
Network availability:	++	++	++
Security aspects:	+	++	++
Cost:	++	++	-
Mechanical stress:	++	++	-
Inter building channels:	-- Lightning protection necessary	- Short distance	++
Lightning protection:	-- Necessary with inter building channels	++ Not necessary	++ Not necessary

The following meaning applies to the symbols "+" and "-":

++ well suitable;

\+ suitable;

– not suitable;

-- should be avoided.

C.4.3.2.2 Network characteristics for balanced cabling not based on Ethernet

Not applicable.

C.4.3.2.3 Network characteristics for balanced cabling based on Ethernet

Replacement:

Table C.2 provides values based on the template given in IEC 61918:2018, Table 2.

Table C.2 – Network characteristics for balanced cabling based on Ethernet (ISO/IEC 8802-3)

Characteristic	CP 3/3, CP 3/4, CP 3/5 and CP 3/6
Supported data rates (Mbit/s)	100
Supported channel length (m) [b]	100
Number of connections in the channel (maximum) [a b]	4
Patch cord length (m) [a]	100 (AWG22) (Ø 0,644 mm)
Channel class per ISO/IEC 61156 (minimum) [b]	D
Cable category per ISO/IEC 61156 (minimum) [c]	5
Connecting HW category per ISO/IEC 11801-3 (minimum)	5
Cable types	type A type B type C

NOTE See manufacturer's specification for restrictions in link length for cable types B and C.

[a] See C.4.4.3.2.

[b] For the purpose of this table, the channel definitions of ISO/IEC 11801-3 are applicable.

[c] For additional information see IEC 61156 series.

C.4.3.2.4 Network characteristics for optical fibre cabling

Replacement:

Table C.3 provides values based on the template given in IEC 61918:2018, Table 3.

Table C.3 – Network characteristics for optical fibre cabling

CP 3/3, CP 3/4, CP 3/5 and CP 3/6		
Optical fibre type	**Description**	
Single mode silica	Minimum length (m)	0
	Maximum length[a] (m)	14 000
	Maximum channel insertion loss/optical power budget (dB)	n.a. (see IEEE 802.3ah; 10 km specified)
	Connecting hardware	See C.4.4.2.5
Multimode silica	Modal bandwidth (MHz × km) at λ (nm)	600 at 1 300
	Minimum length (m)	0
	Maximum length[a] (m)	2 000
	Maximum channel insertion loss/optical power budget (dB)	4,5
	Connecting hardware	See C.4.4.2.5
POF	Modal bandwidth (MHz × km) at λ (nm)	35 at 660
	Minimum length (m)	0
	Maximum length[a] (m)	50

CP 3/3, CP 3/4, CP 3/5 and CP 3/6		
Optical fibre type	Description	
	Maximum channel insertion loss/optical power budget (dB)	11,5
	Connecting hardware	See C.4.4.2.5
Hard clad silica	Modal bandwidth (MHz × km) at λ (nm)	70 at 650
	Minimum length (m)	0
	Maximum length[a] (m)	100
	Maximum channel insertion loss/optical power budget (dB)	4
	Connecting hardware	See C.4.4.2.5
[a] This value is reduced by connections, splices and bends in accordance with Formula (1) in 4.4.3.4.1 of IEC 61918:2018.		

C.4.3.2.5 Specific network characteristics

C.4.3.2.6 Specific requirements for generic cabling in accordance with ISO/IEC 11801-3

C.4.4 Selection and use of cabling components

C.4.4.1 Cable selection

C.4.4.1.1 Common description

C.4.4.1.2 Copper cables

C.4.4.1.2.1 Balanced cables for Ethernet based CPs

Replacement:

Table C.4, Table C.5, and Table C.6 show the characteristics of different cable types based on the template given in IEC 61918:2018, Table 4.

Table C.4 – Information relevant to copper cable: CP 3/3, CP 3/4, CP 3/5 and CP 3/6 type A fixed cables

Characteristics	CP 3/3, CP 3/4, CP 3/5 and CP 3/6 Type A cable	CP 3/3, CP 3/4, CP 3/5 and CP 3/6 Type A cable
Nominal impedance of cable (tolerance)	100 Ω ± 15 Ω (IEC 61156-5)	100 Ω ± 15 Ω (IEC 61156-5)
Balanced or unbalanced	Balanced	Balanced
DCR of conductors	≤ 62 Ω/km	≤ 62 Ω/km
DCR of shield	-	-
Number of conductors	4	8
Shielding	S/FTP, S/FTQ, S/STP	S/FTP, S/FTQ, S/STP
Colour code for conductor	WH, BU / YE, OG	T568A or T568B
Jacket colour requirements	GN (RAL 6018)	GN (RAL 6018)
Jacket material	No requirement Application dependent	No requirement Application dependent
Resistance to harsh environment (e.g. UV, oil resist, LS0H)	No requirement Application dependent	No requirement Application dependent
Agency ratings	No requirement	No requirement
Cable marking (at least)	Type A	Type A
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz	≥ 80 dB at 30 MHz to 100 MHz
Installation type	Stationary, no movement after installation	Stationary, no movement after installation
Outer cable diameter	5,5 mm to 8 mm	10 mm max.
Wire cross section	AWG 22/1 (Ø 0,644 mm)/1	AWG 23/1(Ø 0,573 mm)/1
Wire diameter	1,5 mm ± 0,1 mm	1,0 to 1,6 mm
Delay skew [a]	≤ 20 ns/100 m	≤ 20 ns/100 m

[a] Relevant only for CP 3/6 networks.

Table C.5 – Information relevant to copper cable: CP 3/3, CP 3/4, CP 3/5 and CP 3/6 type B flexible cables

Characteristics	CP 3/3, CP 3/4, CP 3/5 and CP 3/6 Type B cable	CP 3/3, CP 3/4, CP 3/5 and CP 3/6 Type B cable
Nominal impedance of cable (tolerance)	100 Ω ± 15 Ω (IEC 61156-5)	100 Ω ± 15 Ω (IEC 61156-5)
Balanced or unbalanced	Balanced	Balanced
DCR of conductors	≤ 60 Ω/km	≤ 60 Ω/km
DCR of shield	-	-
Number of conductors	4	8
Shielding	S/FTP, S/FTQ, S/STP	S/FTP, S/FTQ, S/STP
Colour code for conductor	WH, BU / YE, OG	T568A T568B
Jacket colour requirements	GN (RAL 6018)	GN (RAL 6018)
Jacket material	No requirement Application dependent	No requirement Application dependent
Resistance to harsh environment (e.g. UV, oil resist, LS0H)	No requirement Application dependent	No requirement Application dependent
Agency ratings	Application dependent	Application dependent
Cable marking (at least)	Type B	Type B
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz	≥ 80 dB at 30 MHz to 100 MHz
Installation type	Flexible, occasionally movement or vibration	Flexible, occasionally movement or vibration
Outer cable diameter	5,5 mm to 8 mm	10 mm max.
Wire cross section	AWG 22/7(Ø 0,644 mm)	AWG 23/7 (Ø 0,573 mm)
Wire diameter	1,5 mm ± 0,1 mm	1,0 to 1,6 mm
Delay skew [a]	≤ 20 ns/100 m	≤ 20 ns/100 m
[a] Relevant only for CP 3/6 networks.		

Table C.6 – Information relevant to copper cable: CP 3/3, CP 3/4, CP 3/5 and CP 3/6 type C special cables

Characteristics	CP 3/3, CP 3/4, CP 3/5 and CP 3/6 Type C cable	CP 3/3, CP 3/4, CP 3/5 and CP 3/6 Type C cable
Nominal impedance of cable (tolerance)	100 Ω ± 15 Ω (IEC 61156-5)	100 Ω ± 15 Ω (IEC 61156-5)
Balanced or unbalanced	Balanced	Balanced
DCR of conductors	≤ 62 Ω/km	≤ 62 Ω/km
DCR of shield	-	-
Number of conductors	4	8
Shielding	S/FTP, S/FTQ, S/STP	S/FTP, S/FTQ, S/STP
Colour code for conductor	WH, BU / YE, OG	T568A or T568B
Jacket colour requirements	Application dependent	Application dependent
Jacket material	No requirement Application dependent	No requirement Application dependent
Resistance to harsh environment (e.g. UV, oil resist, LS0H)	No requirement Application dependent	No requirement Application dependent
Agency ratings	Application dependent	Application dependent
Cable marking (at least)	Type C	Type C
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz	≥ 80 dB at 30 MHz to 100 MHz
Installation type	Special applications (e.g. permanent movement as in drag chains or festoon systems)	Special applications (e.g. permanent movement as in drag chains or festoon systems)
Outer cable diameter	Application dependent	Application dependent
Wire cross section	AWG 22/x (x: e.g. 7 / 19) (Ø 0,644 mm)	AWG 24/x (x: e.g. 7 / 19) (Ø 0,511 mm)
Wire diameter	Application dependent	Application dependent
Delay skew [a]	≤ 20 ns/100 m	≤ 20 ns/100 m
[a] Relevant only for CP 3/6 networks.		

Table C.7 – Information relevant to copper cable: CP 3/3, CP 3/4, CP 3/5 and CP 3/6 of cabinet cord sets

Characteristics	CP 3/3, CP 3/4, CP 3/5 and CP 3/6 Cabinet cord sets
Nominal impedance of cable (tolerance)	100 Ω ± 15 Ω (IEC 61156-5)
Balanced or unbalanced	Balanced
DCR of conductors	≤ 62 Ω/km
DCR of shield	-
Number of conductors	4 / 8
Shielding	S/FTP, S/FTQ, S/STP
Colour code for conductor	TIA 568A / TIA 568B
Jacket colour requirements	GN (RAL 6018)
Jacket material	No requirement Application dependent
Resistance to harsh environment (e.g. UV, oil resist, LS0H)	No requirement Application dependent
Agency ratings	No requirement
Cable marking (at least)	Cabinet cord set 2 pair Cabinet cord set 4 pair
Coupling attenuation	≥ 80 dB at 30 MHz to 100 MHz
Outer cable diameter	n. a.
Wire cross section	2-pair: AWG 22 – 24 4-pair: 22 – 26
Wire diameter	n.a.
Delay skew	≤ 20 ns

Addition:

Table C.8 – Requirement data cable inside and outside cabinet: CP 3/3, CP 3/4, CP 3/5 and CP 3/6 type B flexible cables

Application	**Data Cabling** **Inside switching cabinet environment**	
Cabling type	2 pair [b]	4 pair [c]
Connector type	8 way connector compatible [a] with IEC 60603-7-series, at least compatible with 60603-7-3:2010	8 way connector compatible [a] with IEC 60603-7-series, at least compatible with 60603-7-3:2010
Mandatory Number of Contacts Data Power	 4 ---	 8 ---
Rated Voltage [e] 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 mm to 1,6 mm	1,0 mm to 1,6 mm
Wire Construction	Solid / Stranded [d]	
Category	ISO/IEC 11801:2017	
	Category 5	at least 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 6-1 "Inside enclosure"	

a) RJ45 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 RJ45 receptacle (Jack) for "Outside" applications has to be mating compatible with the RJ45 Plug, in accordance with IEC 60603-7.

b) 2 pair or 1 quad

c) 4 pair or 2 quad

d) If cables other than AWG 22/7 are used, the conformance to the IDC of the connector is mandatory.

e) As defined by IEC 61984:2008, 3.22.

Addition:

Table C.9 – Requirement to copper cable inside and outside cabinet: CP 3/3, CP 3/4, CP 3/5 and CP 3/6 type B flexible cables

	Inside enclosure	**Outside enclosure** [a]
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	−20 °C to +70 °C
Electromagnetic		
Transfer Impedance	See components selection	
Bump: the repetitive nature of the shock experienced by the channel shall be taken into account. An additional heating by POE has to be considered by the user. a) Used connectors of outside environment: • Variant 14 (IEC 61076-3-117) • Variant 4(IEC 61076-3-106 with RJ45 Connector as defined in IEC 60603-7) • Variant 5 (IEC 61076-3-106 with RJ45 Connector as defined in IEC 60603-7) • M12 D-coded(IEC 61076-2-101 Edition 2) • M12- X-coded(IEC 61076-2-109)		

C.4.4.1.2.2 Copper cables for non-Ethernet-based CPs

Not applicable.

C.4.4.1.3 Cables for wireless installation

C.4.4.1.4 Optical fibre cables

Replacement:

Table C.10 provides values based on the template given in IEC 61918:2018, Table 6.

Table C.10 – Information relevant to optical fibre cables

Characteristics CP 3/3, CP 3/4, CP 3/5 and CP 3/6	9..10/125 µm single mode silica	50/125 µm multimode silica	62,5/125 µm multimode silica	980/1 000 µm step index POF	200/230 µm step index hard clad silica
Standard	**IEC 60793-2**	**IEC 60793-2**	**IEC 60793-2**	**IEC 60793-2**	**IEC 60793-2**
Attenuation per km (650 nm)	**–**	**–**	**–**	**≤ 160 dB**	**≤ 10 dB**
Attenuation per km (820 nm)	–	–	–	–	–
Attenuation per km (1 310 nm)	≤ 0,5 dB	≤ 1,5 dB	≤ 1,5 dB	–	–
Number of optical fibres	2	2	2	2	2
Connector type (duplex or simplex)	SC-RJ, SC Duplex, BFOC [a]	SC-RJ, SC Duplex, BFOC [a]	SC-RJ, SC Duplex, BFOC [a], LC	SC-RJ, BFOC [a], LC	SC-RJ, BFOC [a]
Jacket colour requirements [b]	Green (RAL 6018)	Green (RAL 6018)	Green (RAL 6018)	Green (RAL 6018)	Green (RAL 6018)
Jacket material	No requirement. Application dependent				
Resistance to harsh environment (e.g. UV, oil resist, LS0H)	No requirement. Application dependent				

[a] BFOC connector recommended only for connection to existing networks.

[b] No requirements for Type C cables.

Addition:

Table C.11 shows requirements for plastic and hard clad silica optical fibre cables.

Table C.11 – Requirements for plastic and hard clad silica optical fibre cables

Cable type	Plastic optical fibre and hard clad silica optical fibre cables	
Design	Communication cable	Communication cable
Cable installation type	Stationary, flexible, depending on cable construction	Highly flexible, permanently movement or vibration or torsion (special applications)
System concept		
Minimum cable marking requirements	Type B + fibre type (i.e.: Type B 2P980/1000 Type B 2K200/230)	Type C + fibre type (i.e.: Type C 2P980/1000 Type C 2K200/230)
Outer cable diameter (cables for use with IP20 connections)	No requirements	No requirements
Outer cable diameter (cables for use with IP65/67 connectors in cable assemblies)	≤ 9,5 mm	≤ 9,5 mm
Diameter coating	POF: 2,2 mm PCF: 0,5 mm	POF: 2,2 mm PCF: 0,5 mm
Diameter subcable	POF: na PCF: 2,2 mm	POF: na PCF: 2,2 mm
Colour (outer sheath)	Green RAL 6018	Depending on the application
Colours (subcable)	OG + BK OG with arrow (pointing direction of data stream)	OG + BK OG with arrow (pointing direction of data stream)

Cable type	Plastic optical fibre and hard clad silica optical fibre cables	
Number of fibres	2	2
Ambient conditions		
Minimum tensile strength (cable, long term)	POF: 100 N PCF: 400 N	Depending on the application
Bending radius static long term	> 15 times cable diameter	Depending on the application see manufacturer's data sheet
Pollution degree shock vibration operating temperature range	See Table A.1 — Excerpt of MICE Definition – "Outside enclosure"	Depending on the application
Transmission performance requirements		
Relevant standard	IEC 60793-2	IEC 60793-2
Type (according to IEC 60793-2)	POF: A4a PCF: A3c	
Core/cladding diameter	POF: 980/1 000 µm PCF: 200/230 µm	
Nominal wavelength	650 nm	650 nm
Bandwidth MHz referred to 100 m at 650 nm; launch NA = 0,5	POF: ≥ 35 MHz PCF: ≥ 70 MHz	
Maximum attenuation at 650 nm; FWHM < 4 nm	POF: 160 dB/km PCF: 10 dB/km	POF: see manufacturer's data sheet PCF: 10 dB/km
Numerical aperture	POF: 0,50 ± 0,03 PCF: 0,37 ± 0,04	
Delay skew [a]	≤ 20 ns/100 m	
[a] Relevant only for CP 3/6 networks.		

Table C.12 shows requirements for multimode optical fibre cables.

Table C.12 – Requirements for glass multimode optical fibre cables

Cable type	Glass multimode optical fibre cables	
Design	Data cable	Data cable
Cable installation type	Stationary, flexible, depending on cable construction	Highly flexible, permanently movement or vibration or torsion (special applications)
System concept		
Minimum cable marking requirements	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 in cable assemblies)	≤ 9,5 mm	≤ 9,5 mm
Diameter secondary coating	1,4 mm	1,4 mm
Diameter subcable	2,9 mm	2,9 mm
Colour (outer sheath)	Green RAL 6018	Depending on the application
Colours (subcable)	OG + BK OG with arrow (pointing direction of data stream)	OG + BK OG with arrow (pointing direction of data stream)
Number of fibres	2	2
Ambient conditions		
Minimum tensile strength	600 N	Depending on the application
Bending radius static long term	> 15 times cable diameter	Depending on the application
Pollution degree Shock Vibration Operating temperature range	See Table A.1 — Excerpt of MICE Definition – "Outside enclosure"	Depending on the application
Transmission performance requirements		
Relevant standard Type according to IEC 60793-2-10	IEC 60793-2-10 A1a, A1b	
Core/cladding diameter	50/125 μm 62,5/125 μm	
Nominal wavelength	1 300 nm	
Bandwidth MHz referred to 1 km	≥ 500 MHz [a]	
Maximum attenuation	1,5 dB/km [a] at 1 300 nm	
Delay skew [b]	≤ 20 ns/2 000 m	

[a] Measured according to IEC 60793-1-40 and IEC 60793-1-41.

[b] Relevant only for CP 3/6 networks.

CP 3/3, CP 3/4, CP 3/5, CP 3/6 transmission performance requirements are supported by OM1, OM2 and OM3 fibre types as specified in ISO/IEC 11801.

Table C.13 shows requirements for glass singlemode optical fibre cables.

Table C.13 – Requirements for glass singlemode optical fibre cables

Cable type	**Glass singlemode optical fibre cables**	
Design	Data cable	Data cable
Cable installation type	Stationary, flexible depending on cable construction	Highly flexible, permanently movement or vibration or torsion (special applications)
System concept:		
Minimum cable marking requirements	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 (cables for use with IP20 connections)	No requirements	No requirements
Outer cable diameter (cables for use with PROFINET IP65/67 connectors in cable assemblies)	≤ 9,5 mm	≤ 9,5 mm
Diameter secondary coating	1,4 mm	1,4 mm
Diameter subcable	2,9 mm	2,9 mm
Colour (outer sheath)	GN RAL 6018	depending on the application
Colours (subcable)	OG + BK OG with arrow (pointing direction of data stream)	OG + BK OG 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
Bending radius static long term	> 15 times cable diameter	Depending on the application
Pollution degree shock vibration operating temperature range	See Table A.1 — Excerpt of MICE Definition – "Outside enclosure"	Depending on the application
Transmission performance requirements:		
Relevant standard Type according to IEC 60793-2	IEC 60793-2-50 B1	
Cladding diameter	125 µm ± 2 µm	
Nominal wavelength	1310 nm	
Maximum attenuation (at 1 310 nm)	0,5 dB/km [b]	
Cut-off wavelength	< 1 260 nm [a]	
Delay skew [c]	≤ 20 ns/14 000 m	

[a] According to IEC 60793-1-44.

[b] According to IEC 60793-1-40.

[c] Relevant only for CP 3/6 networks.