WorldFIP: Design and Installation Manual

ALS 50414 e–en

First issue: 03–1993
This edition: 11–2001

Meaning of terms that may be used in this document / Notice to readers

WARNING

Warning notices are used to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist or may be associated with use of a particular equipment.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

Caution

Caution notices are used where there is a risk of damage to equipment for example.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

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Index letter	Date	Nature of revision
b	**03–1998**	Major changes
c	**10–1999**	Use of: . a FIELDLT line termination, . a FIELDPROT spur protection, . a FIELDTRANS transformer.
d	**01–2001**	Use of: . a MICRODROP Cable.
e	**11–2001**	A MIC Serie 93 cable (Appendix F and G)

Revisions

1. PURPOSE OF MANUAL AND DOCUMENTED VERSION

This document is intended for engineers, technicians and electricians involved in the design and installation of a WorldFIP network system. It deals mainly with the wiring system (definition of network architecture, choice of components and accessories used in the wiring system and installation rules to be observed) and not with PLC architecture.

This document is divided into two parts:

For details concerning ...	read chapter ...
network definition	1
wiring system installation	2

2. CONTENT OF THIS MANUAL

Chapter 1: **Design:** describes the different topologies and media that can be used. This chapter describes power supply and grounding procedures and lists the characteristics of accessories required for network connection. Network designers with more specific requirements will find further information on advanced topologies at the end of this chapter.

Chapter 2: **Installation:** gives a list of checks to be carried out before beginning installation work.

Appendix A: **Trunk Cable Characteristics:** this is a list of the mechanical, electrical and environmental characteristics of the cable.

Appendix B: **Drop Cable Characteristics:** this is a list of the mechanical, electrical and environmental characteristics of the cable.

Appendix C: **MICRODROP cable characteristics:** this is a list of the mechanical, electrical and environmental characteristics of the cable.

Appendix D: **Multimode Silicon Optical Fibre Cable:** this is a list of the mechanical, optical and environmental characteristics of the cable.

Appendix E: **Single–mode Silicon Optical Fibre Cable:** this is a list of the mechanical, optical and environmental characteristics of the cable.

Appendix F: **Characteristics of the Serie 93 MIC TN1 Cable:** this is a list of the mechanical and electrical characteristics of the cable.

Appendix G: **Application example of free topology with MIC Serie 93 Cable**.

Glossary.

3. RELATED PUBLICATIONS

For more information, refer to these publications: The documents quoted in this manual are shown in square brackets in the text and listed below:

- EN50170 (Volume 3) Communication System – General Process.
- IEC 61158–2 Fieldbus standard for use in industrial control systems. Physical layer specification and service definition.
- DPS 50249 FIP Network General Introduction.
- ALS 50282 User Reference Manual: RP131 V2 Repeater.
- IEC 60332–1 Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable.
- IEC 60364–4 Electrical installations of buildings – Part 4: Protection for safety
- IEC 60364–5 Electrical installations of buildings – Part 5: Selection and erection of electrical equipment.

4. WE WELCOME YOUR COMMENTS AND SUGGESTIONS

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ALS 50414 e–en ***WorldFIP: Design and Installation Manual***

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- ☐ Installer
- ☐ Programmer
- ☐ Maintenance
- ☐ Operator
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Chapter 1 Design

1. STANDARD TOPOLOGIES – RULES AND CONSTRAINTS

1.1. Bit Rates

A WorldFIP network can operate at different bit rates: 31.25 kbits/s, 1 Mbit/s, 2.5 Mbits/s and 5 Mbits/s.

The following selection criteria may be applied:

A bit rate of ...	is used to meet the needs of ...	Remark
31.25 kbits/s	• large–scale topologies • topologies requiring easy wiring	This bit rate provides applications with only a limited level of performance
• 1 Mbit/s • 2.5 Mbits/s • 5 Mbits/s	topologies with a total length limited to a few kilometres.	

Table 1.1 – Choice of Bit Rate According to Network Topology

1.2. Solutions using a Wire Medium

1.2.1. Topologies

The copper wire medium is the most economical and versatile wiring solution and is therefore the most widespread.

1.2.1.1. Bus Topology

Communication on a bus–based system works according to a principle whereby each subscriber (S) transmits and receives on the same shielded pair.

This bus topology can be used at any bit rate and is compulsory for bit rates of 1 Mbit/s, 2.5 Mbits/s and 5 Mbits/s.

The bus consists of a single–pair trunk cable which wraps round to each subscriber via a dual–pair drop cable. The branch device between the trunk cable and drop cable is known as a TAP.

Each end of the trunk cable is connected to a line termination (LT).

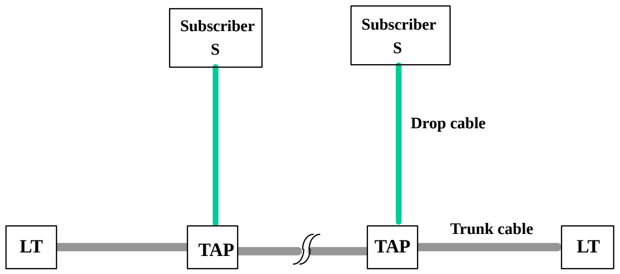


Figure 1.1 – Bus Topology with Wire Medium

Figure 1.2 illustrates the function of the TAP and drop cable which are used to connect a subscriber to the trunk cable. The trunk cable and drop cable have the same characteristic impedance which matches that of the line termination used. This principle guarantees optimised signal transmission between the different field bus subscribers and minimises parasitic reflections.

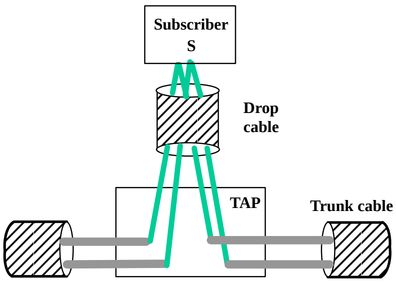


Figure 1.2 – TAP Function in a Bus Topology

1.2.1.2. Free Topology

Communication on a free–topology system works according to a principle whereby subscribers can be connected to a set of twisted pairs and these pairs are then interconnected.

A free topology simplifies wiring and implements general–purpose connection boxes. However, it can only be used at a low bit rate, i.e. 31.25 kbits/s.

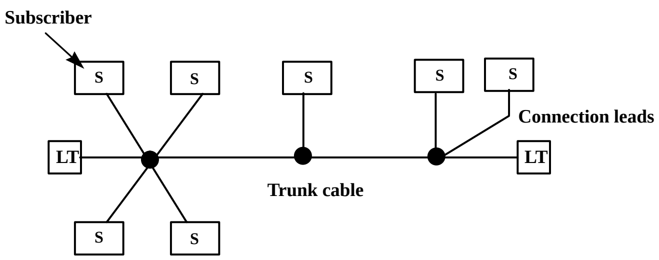


Figure 1.3 – Free Topology

The bus is composed of a single–pair trunk cable to which single–pair connection leads are connected in parallel, via connection boxes, to link up subscribers. Each end of the trunk cable is connected to a line termination (LT).

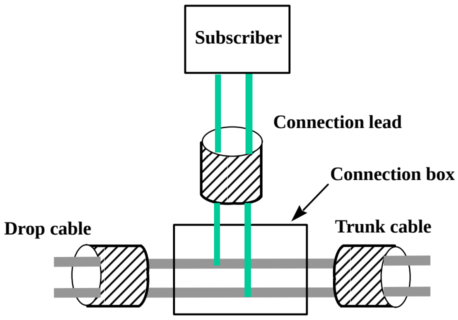


Figure 1.4 – TAP Function in a Free Topology

Fieldbus operation is ensured in the event of subscriber connection or failure of a subscriber connection lead. Figure 1.5 illustrates the implementation of a protective device, required to allow the network to tolerate a short–circuit on a subscriber connection lead.

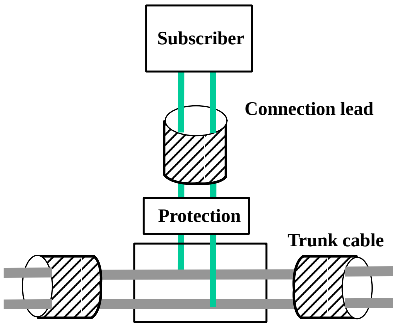


Figure 1.5 – Lead Protection in a Free Topology

The decision whether or not to install protective devices on connection leads must be applied uniformly to all network subscribers.

1.2.2. Connection

The connection to the trunk cable of a subscriber is generally permanent. For maintenance reasons, a connector has been installed, allowing disconnection of a local subscriber group in a cabinet, if necessary.

Figure 1.6 illustrates this connector.

Whatever the topology, a 9–pin SUB–D connector is generally used for this purpose. It is recommended to use:

- the 9–pin MicroSUB–D connector to meet miniaturisation requirements and
- the 4–pin circular connector to meet sealing requirements.

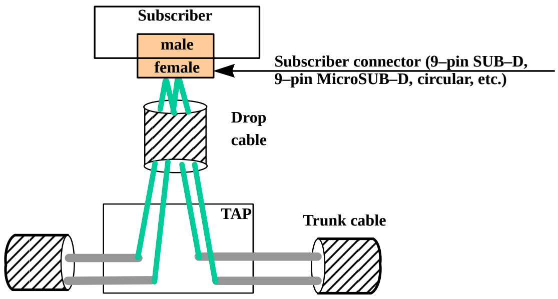


Figure 1.6 – Subscriber Connector with Wire Medium

The connector may also be installed at the trunk cable connection point. For bus topologies, a self–looping connector is required (Figure 1.7).

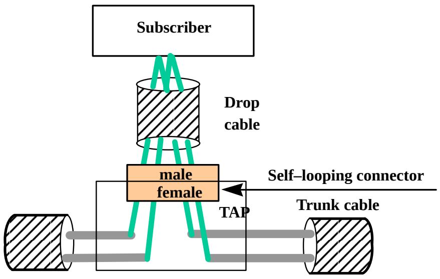


Figure 1.7 – Self–looping Connector for Wire Medium

Whatever the location of the connector, the global activity of the network must not be interrupted when a subscriber or subscriber group is disconnected. In the case of bus topologies, when a subscriber is disconnected at the TAP junction, the active self–looping mechanism inside the connector restores the continuity of the trunk cable within a guaranteed maximum time period compatible with the WorldFIP standard.

You may want to connect a monitoring unit. If so, you could do this by including, for example, one or two spare drop cables and subscriber connectors at strategic points.

1.2.3. Distances

The design limits of a wire–medium architecture are determined by a number of basic rules.

Signal attenuation and signal distortion increase with the length of the cable and the number of subscribers on the bus.

These constraints can be overcome by using repeaters (R) which regenerate the signal waveform, in terms of amplitude and phase, throughout the nework.

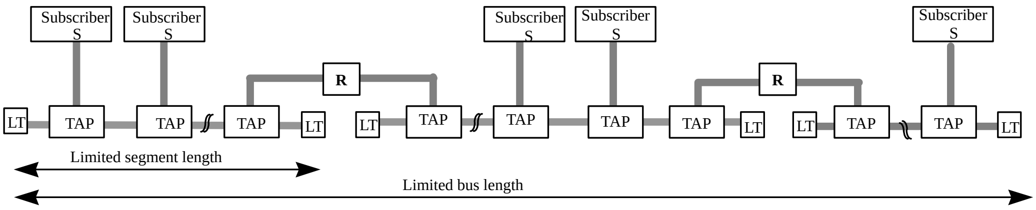


Figure 1.8 – Wire Medium – Repeater for Bus Expansions

Another constraint concerns the maximum propagation time between two network subscribers. This time is equal to the maximum propagation time of the electrical signal on the medium, plus the time required to cross the repeaters.

1.2.3.1. Characteristics of Bus Topologies on a Wire Medium

Table 1.2 provides a summary of the provided performance.

Bus Topology	31.25 kbits/s	1 Mbit/s	2.5 Mbits/s	5 Mbits/s
Maximum number of subscribers per segment	64	32	32	32
Drop lengths	0.5 to 10 m	0.5 to 10 m	0.5 to 10 m	0.5 to 10 m
Maximum segment length	5 km	1 km	500 m	400 m
Maximum time to cross a repeater	1 Tbit (32 µs)	2.5 Tbits (2.5 µs)	2.5 Tbits (1 µs)	not applicable
Maximum time to cross a star	not applicable	3 Tbits (3 µs)	3 Tbits (1.2 µs)	not applicable
Maximum propagation time between two subscribers	57 Tbits (1824 µs)	58 Tbits (58 µs)	70 Tbits (28 µs)	130 Tbits (26 µs)
Maximum number of subscribers on the network	256	256	256	32
Maximum total network length	160 km with 31 repeaters	8 km with 7 repeaters	4 km with 7 repeaters	400 m

Table 1.2 – Characteristics of Bus Topologies on a Wire Medium

Note

Appendix G describes an example of a 31.25 kbits/s free topology implementation with a MIC Serie 93 cable. The MIC Serie 93 features are given in Appendix F.

Note

In order to take into account the subscriber drop structure and the increased attenuation of drop cables, the total length of a wire segment is calculated using the following formula:

Total segment length = (length of trunk cable + (3 * (length of drop cables)).

This data is guaranteed for the following conditions of use: FIELDRIVE + FIELDTR transceiver, FIP DEVICE MANAGER basic software V4.5 or later and MICROFIP HANDLER basic software V1.3 or later.

Designers with specific application requirements which are incompatible with these standard recommendations should refer to Section 6., which provides the necessary instructions for creating more advanced topologies.

1.2.3.2. Characteristics of Free Topologies on a Wire Medium at 31.25 kbits/s

Table 1.3 provides a summary of the performance offered.

Free Topology	31.25 kbits/s
Maximum number of subscribers per segment	32
Length of leads	see Table 1.4
Maximum segment length	5 km
Maximum time to cross a repeater	1 Tbit (32 µs)
Maximum propagation time between two subscribers	57 Tbits (1824 µs)
Maximum number of subscribers on the network	256
Maximum total network length (protocol limit)	160 km with 31 repeaters

Table 1.3 – Characteristics of Free Topologies on Wire Medium

Free Topology	Valid With or Without Protection
Number of Subscribers on Segment	**Length of Leads**
25 –32	0.5 m
19–24	30 m
15–18	60 m
13–14	90 m
1–12	120 m

Table 1.4 – Recommended Length of Leads According to Number of Subscribers per Segment

Note

These characteristics ensure compatibility with standard IEC 61158–2 and are based on the assumption that:

- there is only one subscriber per drop,
- these lengths are reduced by 30 m for each additional subscriber connected.

In order to take into account the subscriber drop structure, the total length of a wire segment is calculated using the following formula:
Total segment length = total length of trunk cable + 240 m (i.e. two maximum lengths of a connection lead).

This data is guaranteed for the following conditions of use: FIELDRIVE + FIELDTR transceiver, FIP DEVICE MANAGER basic software V4.5 or later and MICROFIP HANDLER basic software V1.3 or later.

Designers with specific application requirements which are incompatible with these standard recommendations should refer to Section 6., which provides the necessary instructions for creating more advanced topologies.

1.3. Solutions Using a Multimode Optical Medium

1.3.1. Topologies

The multimode optical medium offers similar performance to the wire medium in terms of total length. It is ideal for applications in which the fieldbus crosses industrial facilities where electrical noise levels are high or where ground potentials are not uniform throughout the site.

Fully optical network installations are designed with a star topology as this type of medium demands point–to–point connections.

Subscribers (S) are connected around the edge of the optical network and data is exchanged via one or more active optical stars (AOS). Optical links are created between subscribers (S), equipped with an optical coupler, and optical stars (AOS), as well as between optical stars (AOS).

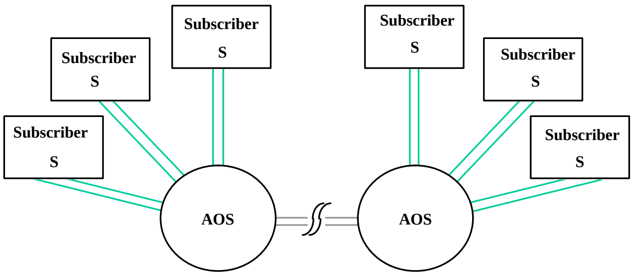


Figure 1.9 – Multimode Optical Medium – Star Topology

The star topology guarantees uninterrupted global communication throughout the network when a given subscriber is connected or disconnected, either at the active optical star (AOS) or at the subscriber (S) interface.

1.3.2. Distances

The design limits of an architecture based on the use of a multimode optical medium are determined by the same rules as those applicable to a wire–based architecture.

As with architectures using a wire medium, the maximum propagation time of the signal between two subscribers is limited. In this type of architecture, this limit is equal to the signal propagation time on the multimode optical medium, plus the time required to cross the active optical stars (AOS).

Another constraint, in this case specific to optical architectures, is the maximum propagation time of the signal between subscribers (S) and active optical stars (AOS).

Optical Topology	1 Mbit/s	2.5 Mbits/s
Maximum number of connections to each active optical star	See Subsection 5.2.	See Subsection 5.2.
Maximum distance between a subscriber and a star	1 km	1 km
Maximum distance between two stars	1 to 2.5 km depending on fibre and installation	1 to 2.5 km depending on fibre and installation
Maximum time to cross a star	0.5 Tbit (0.5 µs)	0.5 Tbit (0.2 µs)
Maximum propagation time between two subscribers	58 Tbits (58 µs)	70 Tbits (28 µs)
Maximum number of subscribers per network	256	256
Maximum total network length (protocol limit)	9.5 km with four stars	5.4 km with three stars

Table 1.5 – Characteristics of Optical Topologies

Note

This data is guaranteed for the following conditions of use: FIPOPTIC2/TS transceiver, FIP DEVICE MANAGER basic software V4.5 or later and MICROFIP HANDLER basic software V1.3 or later.

Designers with specific application requirements which are incompatible with these standard recommendations should refer to Section 6., which provides the necessary instructions for creating more advanced topologies.

1.4. Solutions Using a Single–mode Optical Medium

The single–mode optical medium provides greatly improved performance in terms of total length compared to wire and multimode optical media, while offering the same advantages as multimode optical fibre for industrial facilities where electrical noise levels are high or where ground potentials are not uniform throughout the site.

This type of medium is used only in making optical fibre sections within mixed topologies where, depending on the characteristics of the fibre used, it can offer total lengths of up to 45 km without a repeater.

1.5. Solutions Using Mixed Media

1.5.1. Topologies

Topologies are more generally designed combining different types of wire and multimode and/or single–mode medium within a global architecture in order to meet all requirements more effectively and at lower costs.

Mixed repeaters (MR) and active mixed stars (AMS) are used to implement this mixed technology. Mixed technology can be used effectively to combine the noise immunity offered by optical fibre with the lower costs offered by copper networks.

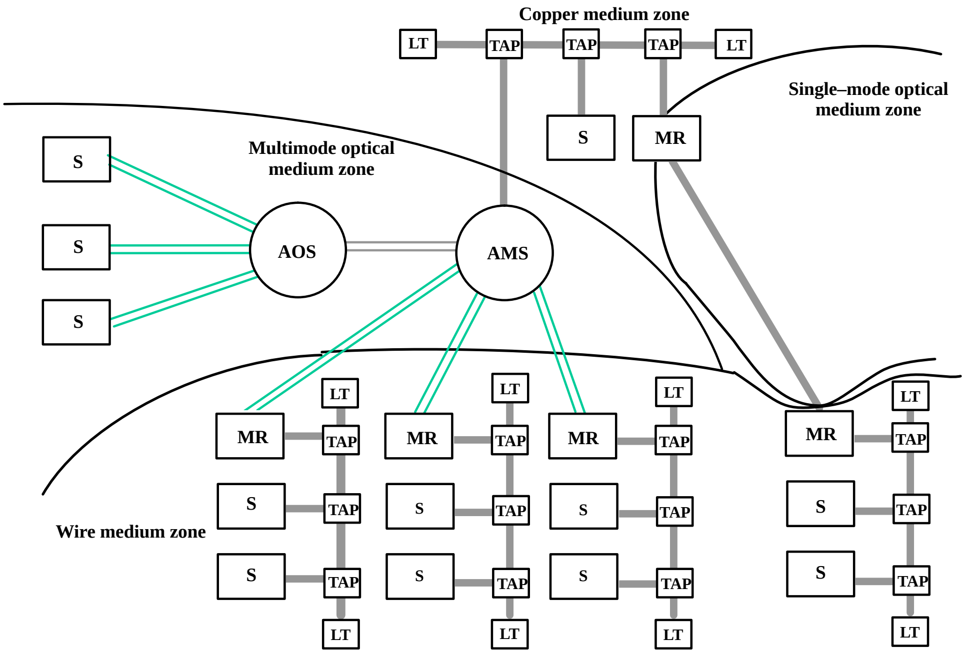


Figure 1.10 – Mixed–medium Topology

1.5.2. Distances

The topological constraints to be considered when designing a mixed–medium architecture depend on the specific constraints of the different media used.

Mixed Topology – High Speed	**1 Mbit/s**	**2.5 Mbits/s**
Maximum number of subscribers per copper segment	32	32
Maximum number of connections to each active optical star	See Subsection 5.2.	See Subsection 5.2.
Length of copper drops	0.5 to 10 m	0.5 to 10 m
Maximum distance between a subscriber and a star (protocol limit)	1 km	1 km
Maximum length of a copper segment	1 km	500 m
Maximum distance between two copper access points (technological limit)	1 km	500 m
Maximum distance between two multimode optical access points (technological limit)	1 to 2.5 km depending on the type of fibre and attenuation per unit length	1 to 2.5 km depending on the type of fibre and attenuation per unit length
Maximum distance between two single–mode optical access points (technological limit)	23 to 45 km depending on attenuation per unit length	23 to 45 km depending on attenuation per unit length
Maximum time to cross a mixed repeater/mixed star	2.5 Tbits (2.5 µs)/ 2 Tbits (2 µs)	2.5 Tbits (1 µs)/ 2 Tbits (0.8 µs)
Maximum propagation time between two subscribers	58 Tbits (58 µs)	70 Tbits (28 µs)
Maximum number of subscribers per network	256	256
Maximum total network length (protocol limit)	10 km using two single–mode copper repeaters	5.2 km using two single–mode copper repeaters

Table 1.6 – Characteristics of High–speed, Mixed–medium Topologies

Note

In order to take into account the subscriber drop structure and the increased attenuation of drop cables, the total length of a wire segment is calculated using the following formula:

Total segment length = (length of trunk cable + (3 * (length of drop cables)).

This data is guaranteed for the following conditions of use: FIELDRIVE + FIELDTR (copper) and FIPOPTIC2/TS (multimode optical) transceivers and FIP DEVICE MANAGER basic software V4.5 or later and MICROFIP HANDLER basic software V1.3 or later.

Before attempting to install the maximum length for an optical link, the installer should ensure that the attenuation is less than 3 dB/km.

Designers with specific application requirements which are incompatible with these standard recommendations should refer to Section 6., which provides the necessary instructions for creating more advanced topologies.

Mixed Topology – 31.25 kbit/s	Bus	Free (with protection)
Maximum number of subscribers per segment	64	32
Length of drops or leads	between 0.5 m and 10 m	see Table 1.4
Maximum segment length	5 km	5 km
Maximum distance between two copper–access repeaters (technological limit)	5 km	5 km
Maximum distance between two optical–access repeaters (technological limit)	23 to 45 km Depending on attenuation per unit length	23 to 45 km Depending on attenuation per unit length
Maximum time to cross a repeater	1 Tbit (32 µs)	1 Tbit (32 µs)
Maximum propagation time between two subscribers	57 Tbits (1824 µs)	57 Tbits (1824 µs)
Maximum number of subscribers per network	256	256
Maximum total network length (protocol limit)	• 160 km if there are 31 copper/copper repeaters to be crossed • 288 km if there are 12 copper/optical repeaters to be crossed, with a 45 km link between two repeaters	• 160 km if there are 31 copper/copper repeaters to be crossed • 288 km if there are 12 copper/optical repeaters to be crossed, with a 45 km link between two repeaters

Table 1.7 – Characteristics of 31.25 kbits/s Mixed–medium Topologies

Note

In order to take into account the subscriber drop structure and the increased attenuation of drop cables, the total length of a wire segment is calculated using the following formulas:

- Total segment length = (length of trunk cable + (3 * (length of drop cables)).
- Total segment length = total length of trunk cable + 240 m
  (i.e. two maximum lengths of a connection lead).

This data is guaranteed for the following conditions of use: FIELDRIVE + FIELDTR transceiver and FIP DEVICE MANAGER basic software V4.5 or later and MICROFIP HANDLER basic software V1.3 or later.

2. DESIGN OPTIONS

2.1. Medium Redundancy

When designing a network architecture with medium redundancy, each component of the physical layer must be duplicated to minimise the risk of damage to the network in the event of an incident.

The duplicated components include the connectors of each subscriber (S), cables, TAPs, line terminations (LT), repeaters (WR, OR, MR) and active stars (AOR, AMR).

The WorldFIP interfaces (subscribers) supporting medium redundancy can also be used in single–medium architectures by using only one of the two connectors.

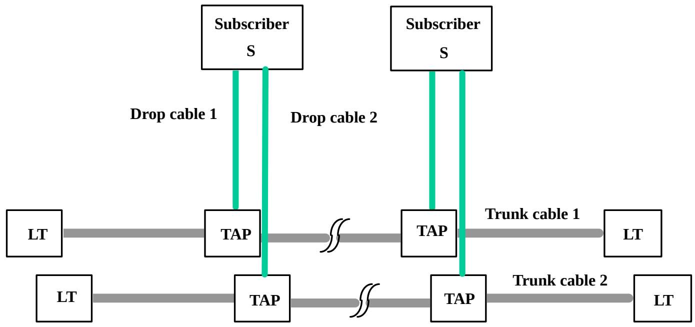


Figure 1.11 – Wire Medium – Redundant Bus Topology

Wherever possible, all components used to ensure redundancy of the physical layer must be physically separated to avoid any simultaneous material damage.

If the medium redundancy strategy is adopted, the entire network must be designed according to redundancy principles: all the subscribers (S) must be equipped with a coupling device designed to manage medium redundancy.

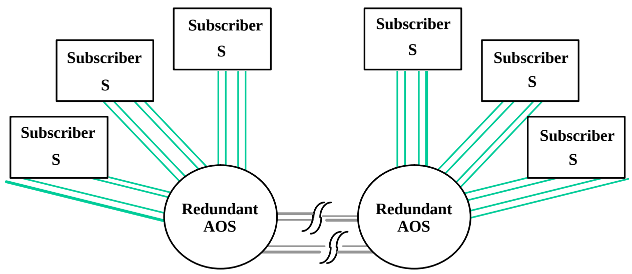


Figure 1.12 – Wire Medium – Redundant Star Topology

This design can make use of redundant active stars (AOS, AMS: each component of these products is redundant (coupling modules, power supply modules, interconnection backplane, etc.)).

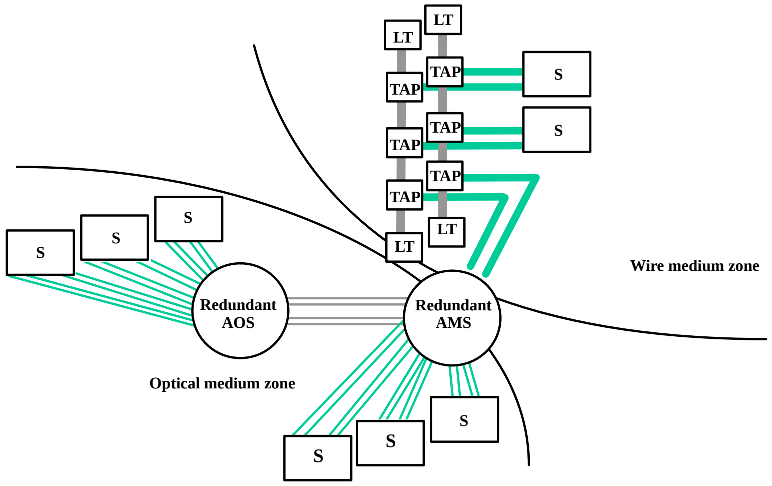


Figure 1.13 – Mixed Medium – Redundant Topology

Medium redundancy can be implemented on all types of optical– or wire–based topology whether in star or bus configuration.

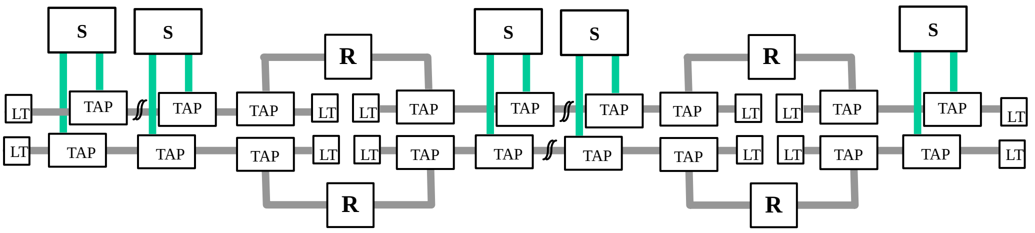


Figure 1.14 – Wire Medium – Redundant Network

It is forbidden to connect single–medium segments to dual–medium segments via repeaters (WR, OR, MR) or active stars (AOS, AMS).

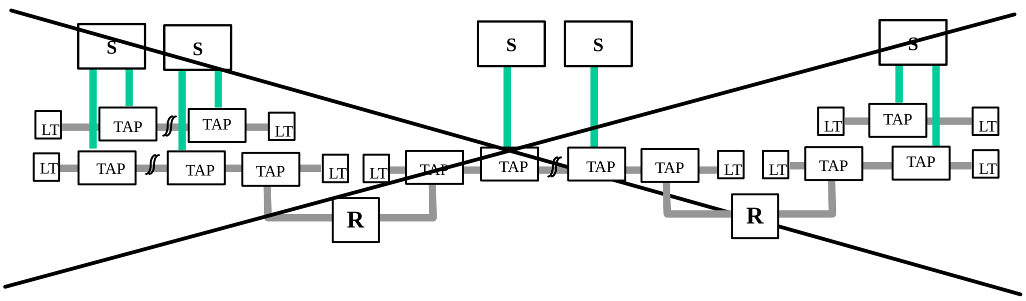


Figure 1.15 – Example of Forbidden Links on a Wire Medium

2.2. Powering via the Bus

2.2.1. Bus Powering on the Signal Pair

The relevant standards define the possible use of bus–powered devices. This type of device consumes the power it requires on the network. The pair of wires carrying the information signal of the fieldbus also conveys a DC voltage to provide power to subscribers.

This technique is referred to as “bus powering on the signal pair”. The power supply voltage range on the bus is between 9 and 32 VDC (always direct–current power supplies).

In this type of architecture, the fieldbus can include bus–powered subscribers as well as standalone devices. Bus–powered subscribers are generally sensors and actuators. Most ALSTOM devices are standalone devices.

ALSTOM subscribers can, however, be used on networks with the “bus powering on the signal pair” option, as the fieldbus runs across a series capacitor which provides protection against the DC voltage on the signal pair.

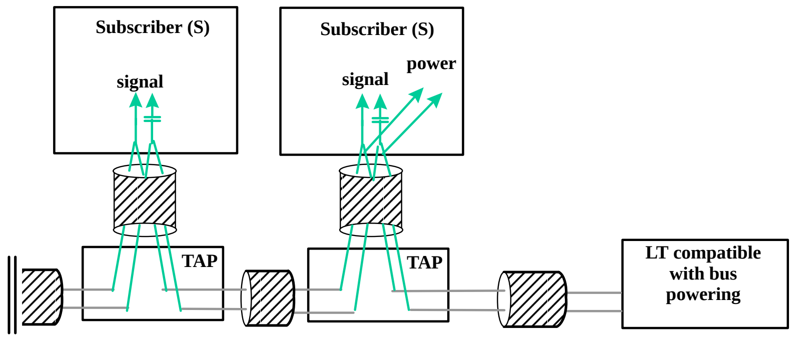


Figure 1.16 – Wire Medium – Bus Powering on the Signal Pair

On these networks, line terminations (LT) must include a series capacitor which insulates the terminating resistance of the DC voltage on the signal pair.

On networks without the “bus powering on the signal pair” option, it is possible to use line terminations (LT) composed of a single resistor.

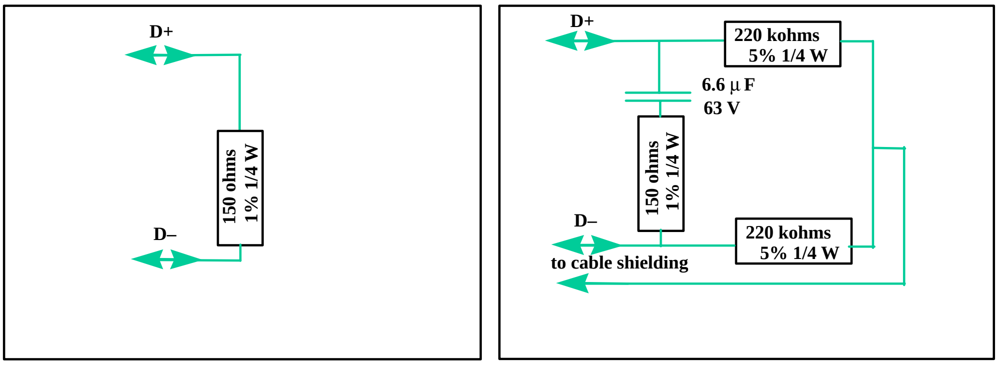


Figure 1.17 – Wire Medium – Line Termination

2.2.2. Bus Powering on a Dedicated Pair

This option is not included in the standards but is nevertheless used in standard versions of ALSTOM architectures.

This option uses trunk cables (and possibly drop cables) containing a pair dedicated to the power supply voltage (always a DC power supply) in addition to the pair(s) conveying the information signal of the fieldbus.

When the “bus powering on the signal pair” option is used specifically for remote powering of repeaters (WR, MR), the power supply voltage pair may only be implemented in the trunk cable. Repeaters have low power consumption and cable resistance requirements do not constitute a constraint. In this case, the standard IBM 1A cable can be used: one pair conveys the information signal of the fieldbus and the other pair conveys the power supply voltage to the repeater.

The small cross–sectional area of an IBM 1A cable (AWG 22) considerably restricts the possibility to supply power via the bus – the characteristic resistance of the cable is 65 ohms/meter. When defining networks which are incompatible with IBM 1A cable constraints, the cable must be selected defining the cross–sectional area of the pair of wires dedicated to the power supply voltage.

The voltage transmitted on the dedicated pair is 24 V +/–20% or 48 V +/–20% at the power supply source.

2.3. Grounding

The ground plane of an electrical system is designed to guarantee:

- the safety of personnel,
- the protection of sensitive devices and system facilities.

The ground plane is composed of a permanent ground connection which cannot be disconnected. It has a sufficiently low impedance and adequate carrying current to avoid any increase in voltage liable to present a risk for connected equipment or for personnel.

The ground plane is also referred to as the equipotential ground plane as it is designed to eliminate excessive differences in potential between two elements adjacent to the plane.

The ground connections of a WorldFIP network must comply with provisions relating to:

- the EMC directive,
- electrical shocks.

In theory, these two categories of provision are complementary since they are both aimed at equalising potential.

The standard technique used is to ground the shielding of the fieldbus cable at one point of the trunk cable of each segment.

This is why most devices (e.g. subscribers (S), active stars (AMS or AOS), repeaters (WR, MR), TAPs), especially devices manufactured by ALSTOM, provide for direct–current isolation between the cable shielding and ground. Furthermore, the direct connection between the fieldbus cable and ground can be located in a TAP device.

Creating a capacitive coupling between the shielding of the fieldbus cable and the local ground of each process device (subscribers (S), active stars (AMS or AOS), repeaters (WR, MR), TAPs) is considered a standard technique. The coupling in question is obtained using a sub–assembly made up of a capacitor and varistor located in the device (S).

2.3.1. Networks with an Equipotential Ground Plane

A network based on a uniform ground plane, in compliance with standards IEC 60364–4 and IEC 60364–5, can be defined as a network with a single ground plane.

The standard technique recommended in the standard physical layer and summed up above should be used whenever possible:

- connect a device (a TAP) on the length of cable directly to ground and
- couple the other devices to ground via a capacitor.

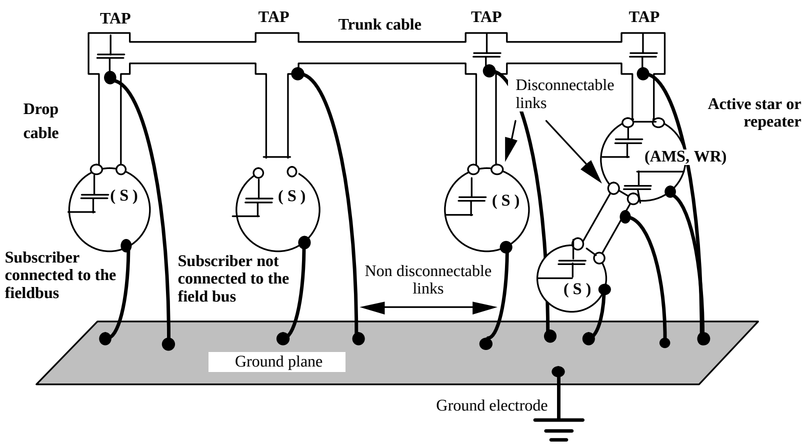


Figure 1.18 – Ground Plane – Standard Technique

If the network requires devices for which there is no choice other than direct grounding, you can use the following architecture in which each process device is grounded directly. The designer may also opt for a mixed approach using some devices which are directly grounded and others with a capacitive ground connection.

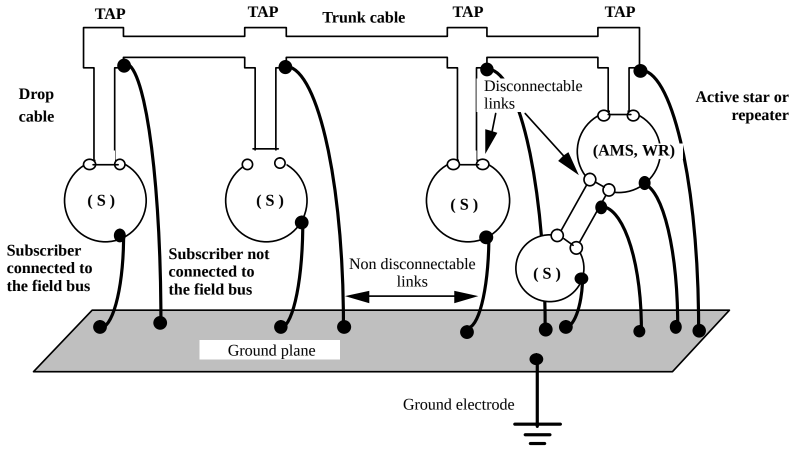


Figure 1.19 – Ground Plane – Direct Connection

2.3.2. Networks with no Equipotential Ground Plane

When designing a fieldbus type network covering several installations, it is sometimes impossible to create a uniform ground plane for the entire network.

Under these conditions, a DC connection between the shielding of the field bus cable and the local ground of several devices located in different buildings or installations would generate noise currents in the shielding, owing to the difference in potential between the local grounds of the devices.

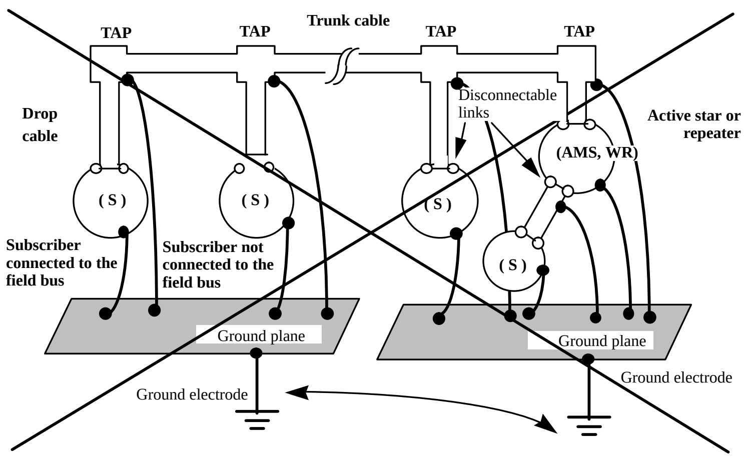


Figure 1.20 – Noise–generating Installation

In this case, it is strongly recommended to implement standard DC isolation on all the devices except one (connected directly), together with a capacitive coupling to the ground of the cable shielding.

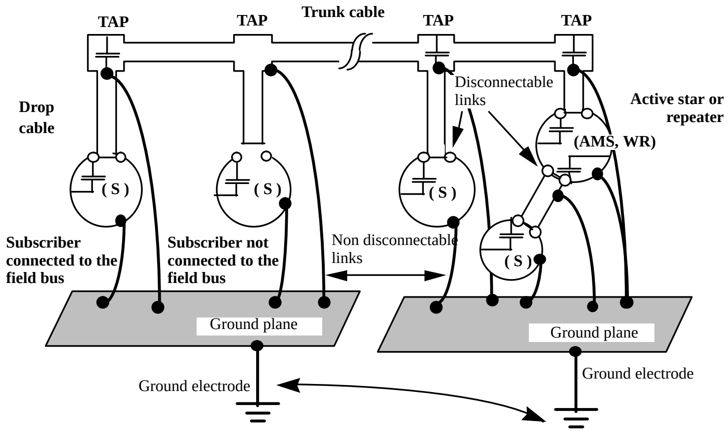


Figure 1.21 – Ground Plane

Another technique, recommended when the field bus covers several installations with high possible voltage differences on the corresponding ground planes, is to use mixed repeaters (MR) connected by an optical segment.

This technique also offers another advantage in terms of safety, because a permanent connection to the local ground is included in each installation.

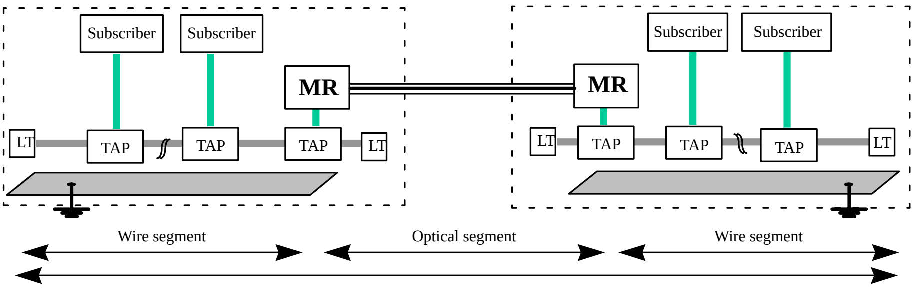


Figure 1.22 – Galvanic Isolation between Installations

3. ELECTRICAL CABLES AND CONNECTORS

3.1. Trunk Cable

Electrical characteristics of trunk cables derive from those of the standard IBM 1A cable. The standard characteristics of these cables are described in Appendix A of this document.

ALCATEL CABLE/BELDEN and SAGEM products are approved and covered by a technical procurement specification. Network designers may also choose suitable products made by other manufacturers. If this is the case, they must carefully compare manufacturer data sheets with the standard characteristics described in Appendix A.

Dual–pair Electrical Trunk Cables. IBM 1A Type		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
See Appendix A	ALCATEL CABLE (FILOTEX 33G2772), BELDEN (9688) SAGEM (SAT 15TB 1023/FP96107B)	Making a trunk cable with or without power supply on the second pair (may be used with a FIELDTAP device)

ACOME products are approved and covered by a technical procurement specification.

Single–pair cable with the same electrical characteristics as the IBM 1A.

Single–pair Electrical Trunk Cables: derived from IBM 1A Type.		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
	ACOME (M21537021)	Making a trunk cable.

3.2. Dual–pair Drop Cables

The electrical characteristics of this type of cable derive from those of the standard IBM 6A cable. The standard characteristics of these cables are described in Appendix B of this document.

ALCATEL CABLE/BELDEN and SAGEM products are approved and covered by a technical procurement specification. Network designers may also choose suitable products made by other manufacturers. If this is the case, they must carefully compare manufacturer data sheets with the standard characteristics described in Appendix B.

ACOME is also an approved supplier of dual–pair drop cables as it offers a product used in conjunction with a specific procurement specification.

Dual–Pair Electrical Drop Cables. IBM 6A Type		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
See Appendix B.	ALCATEL CABLE (FILOTEX 33G2772), BELDEN (9688) SAGEM (SAT 15TB 1023/FP96107B)	Making a drop cable without power supply.
	ACOME (M21537022)	Making a specific drop cable without power supply.

3.3. FIELDTAP Device

A FIELDTAP is a TAP device that can be used when environmental conditions allow the use of IP 20 compatible products.

The main advantages of this solution are its cost–effectiveness (in terms of its electrical characteristics which are ideal for signal management) and its EMC performance.

This product is manufactured by ALSTOM.

FIELDTAP Device		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
IP 20	ALSTOM (A418251–A)	Non–severe environments. Complies with level 3 (industrial level) of EMC directives.

3.4. FIELDROP Prewired Solution

FIELDROP includes a 9–pin SUB–D connector connected to a 3 m drop cable.

It reduces the installation procedure on site and simplifies the remaining task (i.e. connecting the drop cable to the TAP) through the use of a FIELDTAP device or sealed TAP.

FIELDROP is available from ALSTOM.

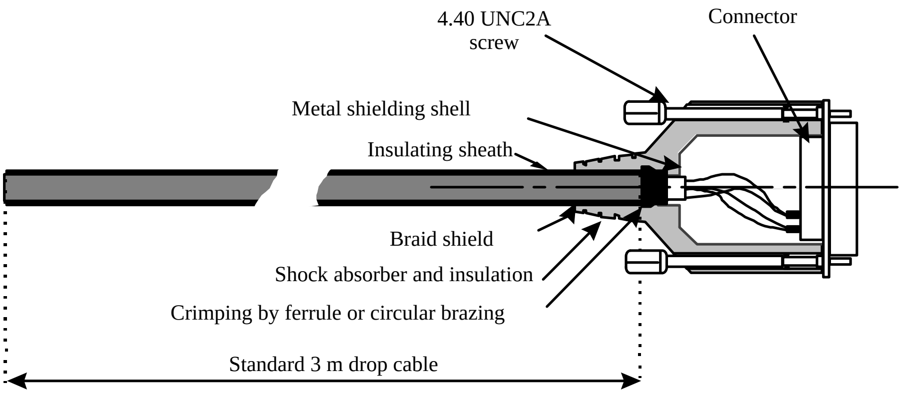


Figure 1.23 – FIELDROP Connection

Technical Definition		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
9–pin SUB–D connector connected to a 3 m long drop cable with metal shielding	ALSTOM (A416490–A)	Minimising the on–site wiring procedure for the customer. The standard length of 3 m corresponds to the standard product and is inexpensive. The wiring is identical to that proposed in Subsection 3.7.

3.5. MICRODROP Prewired Solution

MICRODROP includes a 9–pin SUB–D MDSN connector connected to a 3 m drop cable. It reduces the on–site installation procedure and simplifies the remaining task (i.e. connecting the drop cable to the TAP) through the use of a FIELDTAP device.

MICRODROP is available from ALSTOM

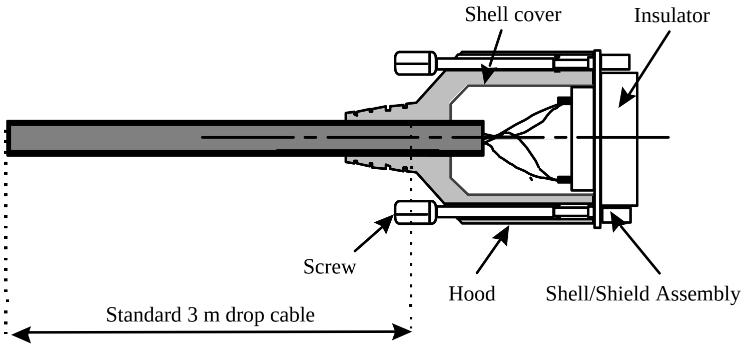


Figure 1.24 – MICRODROP Connection

Technical Definition		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
9–pin SUB–D MDSN connector connected to a 3 m long drop cable with metal shielding	ALSTOM (A420611–A)	Minimising the on–site wiring procedure for the customer. The standard length of 3 m corresponds to the standard product and is inexpensive. The wiring is identical to that proposed in Subsection 3.8.

3.6. DCTAP Daisy Chain Connector

A DCTAP device can be used when environmental conditions allow the use of IP 20 compatible products.

The DCTAP is designed to combine in a single device the functions of a TAP with those of a subscriber connector (9–pin SUB–D). In this case, the DCTAP is connected directly to the trunk cable.

This connector is approved subject to the following remarks:

- IBM 1A dual–pair trunk cables cannot be used with DCTAP connectors (their cross–sectional area is too large and they are not flexible enough). It is recommended to use a trunk cable with a single dedicated pair (see Subsection 3.1.) for daisy chain connection to the DCTAP.
- The other solution, considered as a standard, is to create subscriber drops made up of a TAP device, a drop cable and a dedicated subscriber connector. This solution is also considered more effective.

In the second case, the DCTAP device can be used as a subscriber connector, compatible with the standard 9–pin SUB–D connector. This method is approved on systems when used in conjunction with recommended IBM 6A drop cables.

The cable exits the connector at a 45° angle with respect to horizontal so as to minimise the space required when the equipment is installed in a cabinet.

This product is manufactured by ALSTOM.

DCTAP Daisy Chain Connector. IP 20		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
9–pin SUB–D connector (female)	ALSTOM (A416493–A)	Non–severe environments. The cable exits the connector at a 45° angle (60 mm clearance with respect to front panel) Complies with level 3 (industrial level) of EMC directives.

3.7. 9–pin SUB–D Connector

A 9–pin SUB–D connector device can be used when environmental conditions allow the use of IP 20 compatible products.

The use of this subscriber connector, compatible with the standard 9–pin SUB–D connector, is approved when used in conjunction with recommended IBM 6A drop cables.

The following table gives the wiring configuration of the 9–pin SUB–D connector:

Pin ...	is connected to the...
6 (+)	orange and red wires
7 (–)	green and black wires

The cable exits the connector horizontally.

9–pin SUB–D Connector. IP 20.		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
9–pin SUB–D connector (female)	ITT CANNON FBC 115434–3	Non–severe environments. The cable exits the connector horizontally. Complies with level 3 (industrial level) of EMC directives.

3.8. 9–pin SUB–D MDSN connector

9–pin SUB–D MDSN connector device can be used when environmental conditions allow the use of IP 20 compatible products.

The use of this subscriber connector, compatible with the standard 9–pin SUB–D MSDN connector, is approved when used in conjonction with recommended IBM9A drop cables.

The following table gives the wiring configuration of the 9–pin SUB–D connector:

Pin ...	is connected to the...
1 (+)	orange and red wires
5 (–)	green and black wires

The cable exits the connector horizontally.

9–pin SUB–D connector IP 20.		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
9–pin SUB–D MDSN connector (female)	ITT CANNON FBC – MDSN	Non–severe environments. The cable exits the connector horizontally. Complies with level 3 (industrial level) of EMC directives.

3.9. FIELDLT Line Termination

The FIELDLT device is used to match different cable segments with characteristic impedance values of 150 ohms for bit rates of 31.25 kbits/s to 5 Mbits/s.

The cable is connected as follows:

Connect the ...	to the ...
orange conductor	positive wire of the cable
black conductor	negative wire of the cable
green–yellow conductor	cable shielding.

This product is manufactured by ALSTOM.

FIELDLT Device		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
	ALSTOM (A418471–A)	Matching different cable segments with characteristic impedance values of 150 ohms for bit rates of 31.25 kbits/s to 5 Mbits/s.

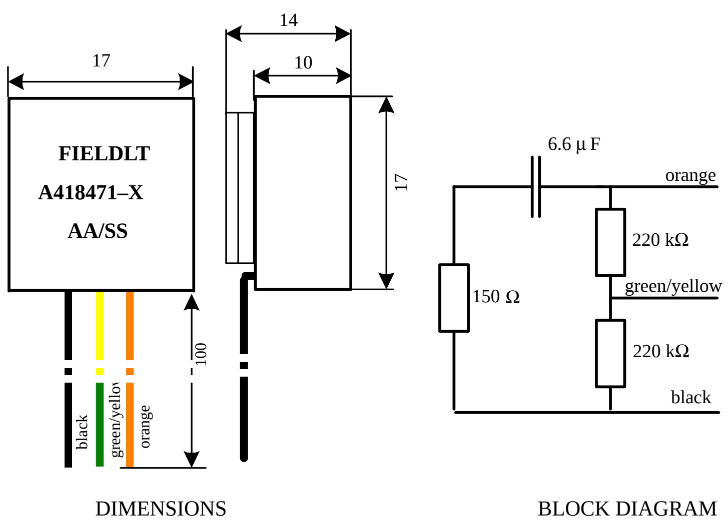


Figure 1.25 – FIELDLT Dimensions and Block Diagram

3.10. FIELDPROT Spur Protection

The FIELDPROT device is designed to allow operation, on condition that the installation is appropriately sized, in the event of a short–circuit on the subscriber link.

It is only available for a bit rate of 31.25 kbits/s.

It provides an attenuation of 4 dB on 75 ohms.

Dielectric strength at 50 Hz is 2000 V_{rms} for one minute between:

- R+/R– and D+/D–,
- R+/R– and the transformer shield,
- D+/D– and the transformer shield.

The cable is connected as follows:

Connect the ...	to ...
• orange (R+) and • black (R–) conductor	the trunk cable
• orange/white (D+) and • black/white (D–) conductor	the subscriber
green/yellow conductor	the transformer shield – can also be connected to the local ground

This product is manufactured by ALSTOM.

FIELDPROT Device		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
Only for bit rate of 31.25 kbits/s	ALSTOM (A418472–A)	Providing protection against short–circuits on the subscriber link

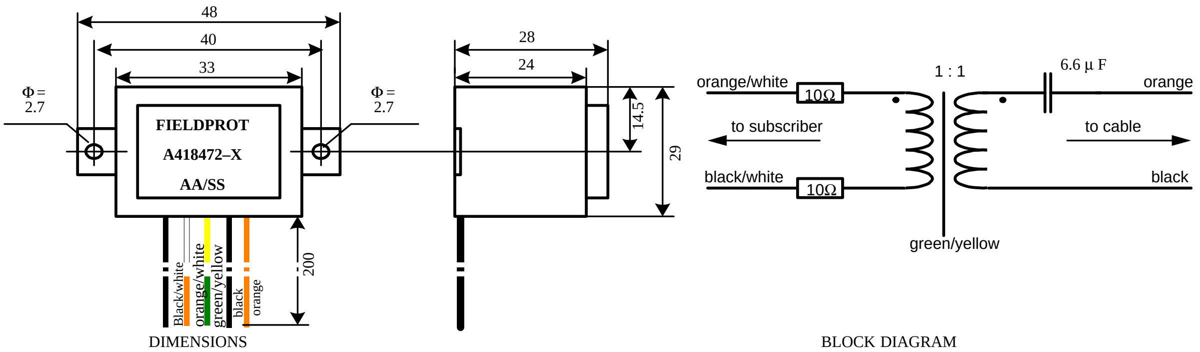


Figure 1.26 – FIELDPROT Dimensions and Block Diagram

3.11. FIELDTRANS

The FIELDTRANS device is used to ensure the galvanic isolation of two segments of trunk cable, on condition that the installation is appropriately sized.

It is only available for a bit rate of 31.25 kbits/s.

It provides a typical attenuation of 1.5 dB on 150 ohms.

Dielectric strength at 50 Hz is 2000 V_{rms} for one minute between:

- R+/R– and D+/D–,
- R+/R– and the transformer shield,
- D+/D– and the transformer shield.

The cables are connected as follows:

Connect the ...	to ...
• orange (R+) and • black (R–) conductor	trunk cable No. 1
• orange/white (D+) and • black/white (D–) conductor	trunk cable No. 2
green/yellow conductor	the transformer shield – can also be connected to the local ground

This product is manufactured by ALSTOM.

FIELDTRANS Device		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
Only for bit rate of 31.25 kbits/s	ALSTOM (A419443–A)	Providing galvanic isolation between two trunk cables

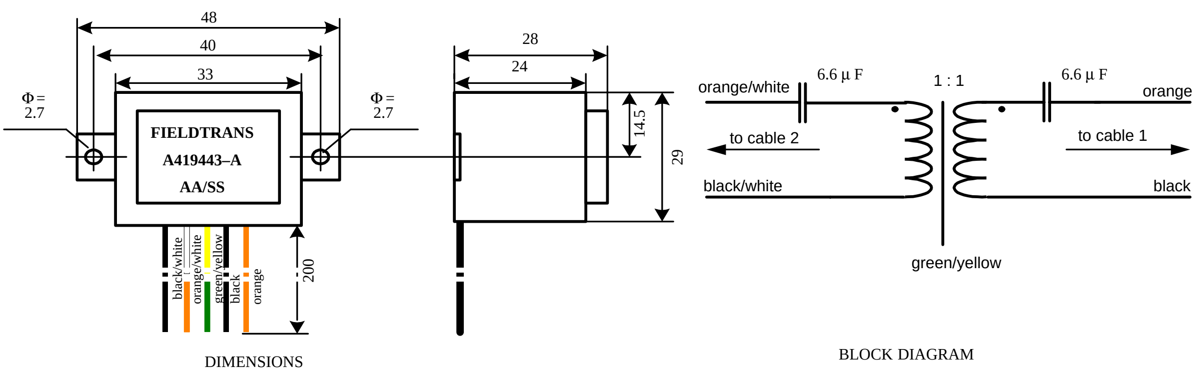


Figure 1.27 – FIELDTRANS Dimensions and Block Diagram

3.12. Sealed TAP Device

A sealed TAP device should be selected when a TAP function is required in a severe environment implying a protection class of IP 65.

The approved manufacturer for this product is ENTRELEC. All the options of this product are described in the following table:

Sealed TAP Device. IP 65. UL94–V0. Option for several drops and for disconnectable on–line drops.		
Characteristics	**Suppliers**	**Recommended Use**
1 fixed drop	ENTRELEC TAP: 19201–00	
2 fixed drops	ENTRELEC TAP 2: 19204–03	The most commonly used sealed TAP at ALSTOM (contractual agreement available)

3.13. Daisy Chains: Prewired Solution for Local Areas

Daisy chain products are dedicated to wiring several subscribers in a given local area. This type of product is used mainly for the internal wiring of cabinets.

A number of standard local wiring requirements have been identified and the use of these standard subassemblies optimises costs.

On the basis of these standard approved solutions, the network designer can define more daisy chains distinguished mainly by their dimensions (number of subscribers, length between micro–TAP couplers and the length between micro–TAP couplers and subscribers) and by whether or not they can be used in conjunction with line terminations. In view of these considerations, a daisy chain arrangement can be summed up in a panel containing the items shown in the figure below:

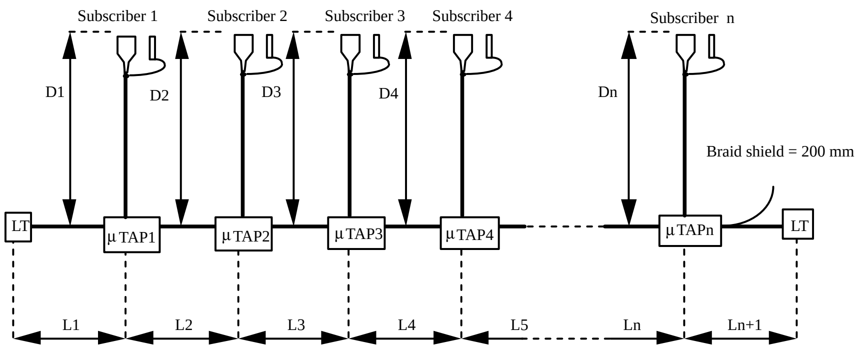


Figure 1.28 – Standard Definition of a Prewired Daisy Chain

Standard CR302–1 and CR304–1 products must be used whenever possible. Figure 1.29 and Figure 1.30 describe their configuration.

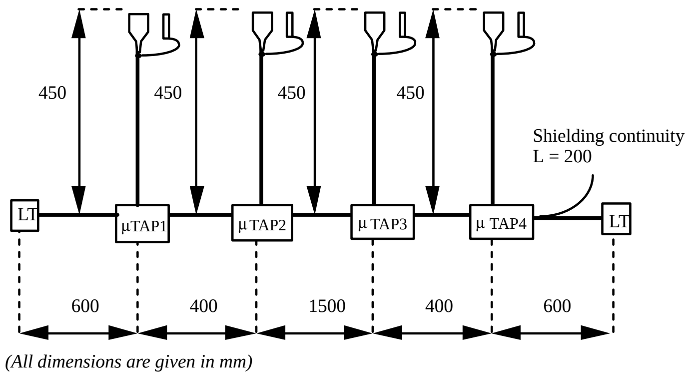


Figure 1.29 – CR302–1, 4 Subscribers with LT

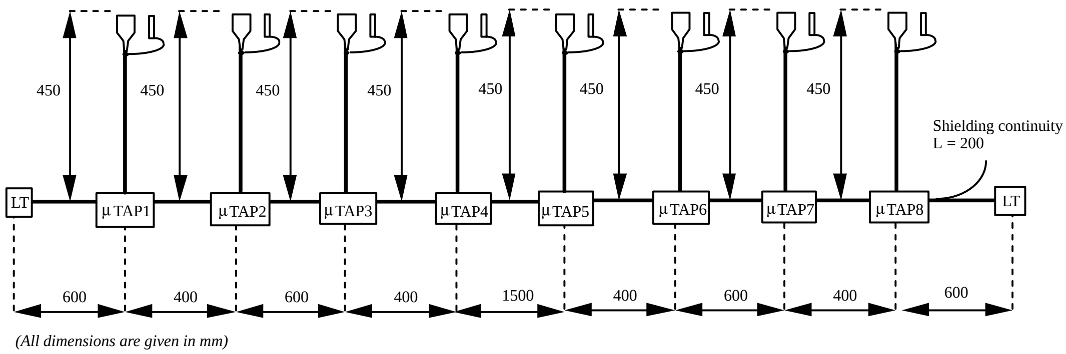


Figure 1.30 – CR304–1, 8 Subscribers with LT

Prewired Daisy Chain		
Characteristics	**Approved Suppliers/ Catalogue Reference**	**Recommended Use**
Fully specified by the user	LOGISTEL	Expensive solution reserved for specific requirements
CR302–1	LOGISTEL/CR302–1	Standardised product
CR304–1	LOGISTEL/CR304–1	Standardised product

3.14. Colour Chart

The following chart provides a summary of the standard colours used to identify the wires of the trunk cable and drop cable.

Type of Cable	First Signal Pair		Second Signal Pair		Power Supply Pair	
	D+	D–	D+	D–	A+	A–
Trunk with 1+1 pairs	Orange	Black			Red	Green
Trunk with 1 pair	Orange or Red	Black or Green				
Drop with 2 pairs	Orange	Black	Red	Green		
Drop with 2+1 pairs	Orange	Black	Red	Green	Pink	Light blue

Table 1.8 – Standard Colours

3.15. Examples

3.15.1. Plugs

Figure 1.31 shows an example of how conventional and customised connectors can be used.

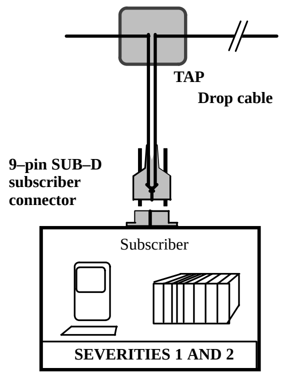


Figure 1.31 – Use of Conventional and Customised Connectors

3.15.2. Wiring Using a FIELDTAP Device

Figure 1.32 shows an example of wiring using a FIELDTAP device.

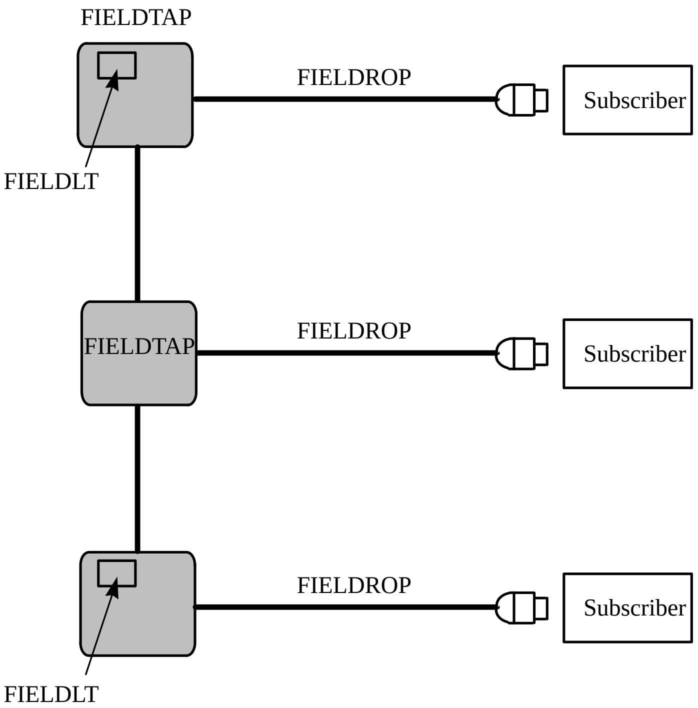


Figure 1.32 – Wiring Using a FIELDTAP Device

3.15.3. Wiring by DCTAP Daisy Chaining

Figure 1.33 gives an example of wiring by DCTAP daisy chaining.

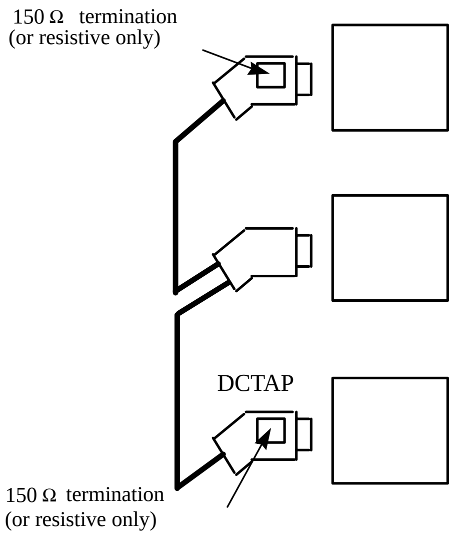


Figure 1.33 – Wiring by DCTAP Daisy Chaining

4. OPTICAL CABLES AND CONNECTORS

The characteristics of optical cables and connectors are given in Table 1.9.

Type of Optical Fibre	Multimode	Single–mode
Complies with industrial standard	• 62.5/125 µm (best solution currently on the market), • 50/125 µm	• 9/125 µm, • 10/125 µm
Characteristics given in Appendix …	D	E
Possible connections	• subscribers, • active stars, • repeaters via an ST connector	• copper/single–mode repeaters, via an FC connector

Table 1.9 – Characteristics of Optical Cables and Connectors

As the products offered by different manufacturers are of uniform quality, no manufacturer qualification has been carried out for this type of product.

5. REPEATERS AND ACTIVE STARS

5.1. RP131 V2 Repeater Range

The repeaters in the second–generation RP131 product range offer several options.

These repeaters can connect two field bus segments with wire media on both ends (wire repeaters, WR) or wire and multimode or single–mode optical media (mixed repeaters, MR).

The power supply voltage range covers rated voltages of 24 VDC and 48 VDC for a maximum consumption of 6 W.

The main environmental characteristics are:

- temperature range: –25/+70°C,
- protection class: IP 20,
- EMC level 3.

The physical dimensions are 150 x 45 x 120 mm and the unit is mounted on DIN rails.

The following table gives the references and characteristics of these repeaters.

Suppliers/Reference: ALSTOM Alspa RP131				
Product Code	**Power Supply Voltage**	**Type of Link**	**Bit Rate**	**Protocol**
IR178–3CC1	24/48 VDC	copper/copper	31.25 kbits/s	IEC
IR178–3CM1	24/48 VDC	copper/single–mode	31.25 kbits/s	IEC
IR178–1CC1	24/48 VDC	copper/copper	1 Mbit/s	UTE / IEC
IR178–1CM1	24/48 VDC	copper/single–mode	1 Mbit/s	UTE / IEC
IR178–1CO1	24/48 VDC	copper/multimode	1 Mbit/s	UTE / IEC
IR178–2CC1	24/48 VDC	copper/copper	2.5 Mbits/s	UTE / IEC
IR178–2CM1	24/48 VDC	copper/single–mode	2.5 Mbits/s	UTE / IEC
IR178–2CO1	24/48 VDC	copper/multimode	2.5 Mbits/s	UTE / IEC

Read [ALS 50282] for more information about RP131 V2.

5.2. OP130 V2 Active Star Range

The active stars in the second–generation OP130 product range offer several options.

OP130 active stars are modular signal regeneration devices designed mainly to connect multimode optical fibres, though they can also be used to connect wire media. The connection capacity of these stars depends on the choice of rack and on the type of board.

An active star is composed of several standard units (100 x 160 mm EUROPE format) assembled in a rack of the following dimensions:

- 19” x 3U x 290 mm rack or
- 4” x 3 U x 290 mm mini–rack.

The star is made up of modules that can be equipped with one or two copper or multimode optical transceivers so that the configuration may be adapted to meet requirements.

Modules	Function	Characteristics
Racks with a backplane (module capacity: 16 slots or 2 slots)		
AM147	Rack and backplane	Fasteners on front panel
AM148	Rack and backplane	Fasteners on rear panel
Power supply units (1 unit for 8 couplers max., 2 units for 16 couplers max., 2 units with a redundant configuration)		
AL123A	5 VDC power supplies	48 VDC power supply voltage
AL124A	5 VDC power supplies	24 VDC power supply voltage
AL127A	5 VDC power supplies	90 to 260 VDC power supply voltage
Coupling units (16 units max.: 32 single links or 16 double links max.)		
IR130A	Wire link coupling board	9–pin SUB–D connector on front panel
–1M	1 Mbit/s/Copper/ 1 channel	
–1B	1 Mbit/s/Copper/ 2 channels	
–2M	2.5 Mbits/s/Copper/ 1 channel	
–2B	2.5 Mbits/s/Copper/ 2 channels	
IR132A	Optical link coupling board	ST optical connector on front panel
–1M	1 Mbit/s/Optmul/ 1 channel	
–1B	1 Mbit/s/Optmul/ 2 channels	
–2M	2.5 Mbits/s/Optmul/ 1 channel	
–2B	2.5 Mbits/s/Optimul/ 2 channels	

In its maximum configuration, the OP130 V2 active star is equipped with 16 couplers, dedicated to a wire or multimode optical medium. A power supply module is connected to 8 couplers.

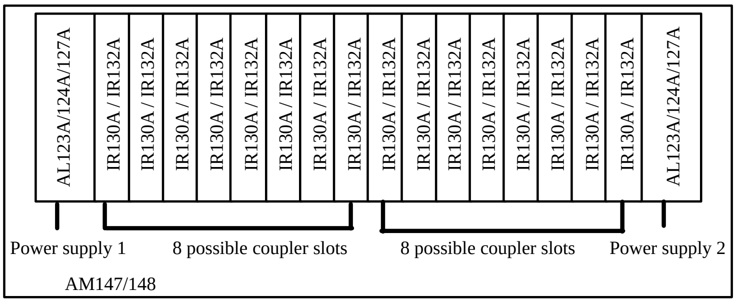


Figure 1.34 – OP130 V2 Active Star – 16 Modules

When the coupling capacity of the active star is not used to the full, the unused slots can be covered by blanking plates.

The second power supply unit:

- must always be included when the active star is used in redundant mode,
- is required when more than 8 couplers are used.

Read [ALS 50281] for more information about OP130 V2.

6. ADVANCED TOPOLOGIES

This paragraph is intended for network designers with specific requirements who cannot observe the standard topological rules defined in Section 1.

The detailed formula used to calculate the network topology is indicated below and takes into consideration the relevant characteristics of the devices making up the network link.

The length and maximum number of subscribers of a segment depend on the constraints described in Section 1.

The following calculation applies to the rules for defining the total distance of the network and indicates the best way to combine repeaters and optical stars when connecting standard network segments:

- the propagation time **Tp** between two subscribers of a network has a maximum value of Tpmax as shown below:

Tpmax	Bit Rate
57 Tbits	31.25 kbits/s
58 Tbits	1 Mbit/s
70 Tbits	2.5 Mbits/s

- the propagation time of the information signal on a copper or optical medium is as follows:

Tpco = Tpopt = 5 µs/km

- owing to the structure of drop cables, the distances covered by drop cables forming the drops must be multiplied by **3**,
- the maximum propagation time between RP131 repeaters is as follows:

The propagation time between...	referred to as...	equals...
wire repeaters	Tr_WR	2.5 Tbits
mixed repeaters	Tr_MR	2.5 Tbits
optical repeaters	Tr_OR	2.5 Tbits

- the maximum propagation time between OP130 active stars is as follows:

The propagation time between active stars from ...	to ...	referred to as...	equals...
a copper wire coupler	a copper wire coupler	Tr_AS_WW	3 Tbits
a copper wire coupler	an optical coupler	Tr_AS_WO	2 Tbits
an optical coupler	an optical coupler	Tr_AS_OO	0.5 Tbits

The complete formula can thus be summed up as follows:
Tp =
(length of wire trunk cable * Tpco)
+ (3 * length of wire drop cable * Tpco)
+ (length of optical fibre cable * Tpopt)
+ (number of intermediate repeaters * (Tr_WR, Tr_MR or Tr_OR))
+ (number of intermediate active stars * (Tr_AS_WW, Tr_AS_WO or Tr_AS_OO))

(If you use this formula, the number of repeaters or intermediate active stars may be greater.)

Designers with specific requirements who cannot observe the directives set out in this document should contact ALSTOM/CMF for a specific architecture definition study.

Chapter 2 Installation

1. CHECK LIST

The following points must be defined during the network design phase before starting installation itself:

- **Network topology**

Topological characteristics must be identified and must comply with the design rules set out in Chapter 1. The location of the different devices making up the network must also be defined. These devices include: subscribers, cables, connectors, TAPs, repeaters and active stars.

- **Environmental conditions**

The characteristics of each device must satisfy environmental installation constraints regarding the following points: temperature range, EMC protection, IP protection required, etc.

- **Grounding strategy**

The ground plane of the installation must be defined, as indicated in Chapter 1, Subsection 2.3.

- **Manuals**

You should always read the user reference manuals relating to the equipment so as to follow installation instructions closely.

- **Wiring and checking tools**

You should give preference to the wiring and checking tools recommended by equipment manufacturers.

- **Technologies**

Technicians involved in optical technology should have the necessary qualifications and use the very latest techniques and solutions available in this field.

2. ESSENTIAL RULES

Wiring quality depends on three main factors:

- The passive and active items making up the network must have been designed and approved with respect to the EMC recommendations corresponding to the EMC severity level demanded by the factory.

Choose wiring solutions offering the right EMC qualification level.

- Particular attention is required for signal conductor connections. The reliability of the entire automation process depends on the quality of the installation of the physical layer.

A defective “signal” conductor connection, at any point of the field bus network, will lead to an interruption in global communication either immediately or following installation. Furthermore, it is always more difficult to locate possible failures on a field bus type network than on an architecture based on point–to–point links.

Take care when handling “signal” conductor connections.

- Grounding is the last critical problem relating to wiring.

Cables, connectors and devices (TAPs, repeaters, active stars, subscribers) must be correctly grounded to guarantee the safety of personnel and ensure the reliability of the network with respect to electrical noise.

Low–impedance ground connections must be made and priority must be given to the total shielding of all wiring items. Incorrect grounding at any given point of the field bus network will affect the performance of the entire network.

The quality of ground connections guarantees the safety of personnel and the performance of automation processes.

3. WIRING VERIFICATION PROCEDURE

The wiring verification strategy is described below, step by step. It is easier to carry out a detailed check of wiring at the local level than to check the entire network from the beginning.

Moreover, the tools used to carry out checks on the global network are more sophisticated than the standard ohmmeter, especially when the network includes repeaters and active stars.

- **Wire connections. Local verification using an ohmmeter.**

Verification of optical wiring is not addressed in this document. Refer to the relevant specific technical instructions concerning this subject.

An ohmmeter can be used to check the quality of a subscriber connection between the TAP and the subscriber as well as the local wiring located in a cabinet. Connection polarity must be checked.

Caution

Field bus networks are sensitive to the polarity of bus connections.

Check continuity along a given conductor path and check the insulation between several conductors or between the conductors and the cable shielding. You can carry out these checks in a given local area before reconnecting the removed line terminations and disconnected subscribers to the field bus.

- **Wire connections. Global verification of each segment using test plugs, an ohmmeter, portable oscilloscope and FIP wiring test set.**

The verification of optical wiring is not addressed in this document. Refer to the relevant specific technical instructions concerning this subject.

During the global verification of the wiring system, each segment must be checked individually.

A simple ohmmeter cannot be used to check a segment stretching over several kilometres.

You may adopt the following method to test a wiring installation:

- leave all the subscribers disconnected
- connect the line terminations (LT) to each end of the segment
- apply a DC voltage (e.g. 9 V with battery) to a subscriber connection via a dedicated connector. Check all the other connectors (using an ohmmeter) to ensure that the polarity is correct and that there is no residual voltage on the shielding.
- then apply a square–wave signal (e.g. coming from a device based on a 1 MHz CMOS oscillator) to a subscriber connection via a dedicated connector. The square–wave signal can be analysed upon reception using a portable oscilloscope at all the other connectors. The attenuation of the initial square–wave test signal can be compared to the attenuation of the field bus cable (typically 15 dB/km on a TRUNK cable).
- **Verification of the global network, comprising several segments, repeaters and active stars**

At this stage, each segment should have been previously checked and declared satisfactory.

The repeaters and active stars can only propagate valid WorldFIP protocol frames, recognised as belonging to correct start–of–frame and end–of–frame sequences (these specific signal sequences are detected, checked and regenerated by the repeaters and active stars).

For this reason, the test input signal can no longer be supplied by a simple measuring oscillator. Instead, a WorldFIP station must regenerate the test signal. This measuring station must be equipped with a Bus Arbiter (BA) in order to communicate with the network.

It is recommended that the global network test be carried out with a measuring station equipped with the Bus Arbiter (BA) on one segment and that data exchanges take place with one or more dual stations connected to all the other stations.

On installations with a redundant medium, the global verification of the wiring should first be carried out on each medium individually (with the dual–medium connectors disconnected), then with both media in operation.

4. QUALITY FACTORS

Once all the wiring has been thoroughly checked, the installation can be considered ready for use.

The following indicators may be used for the final verification:

- **Physical transmission error rate**

This parameter is available on a WorldFIP subscriber (e.g. a FIPACCESS station or a FIPSPY) and is used to control frame flags, the Manchester code and the frame check sequences of incoming frames.

In order to meet the required error rate, the physical transmission error rate can be verified by checking continuous exchanges on the field bus; a value of 20 minutes without error should be obtained.

- **List of current subscribers**

A list of **current** subscribers can be provided by the subscriber supporting the bus arbiter function. This list contains all the subscribers which have exchanged a valid “presence” variable with the station supporting the bus arbiter function.

This verification is easy to carry out if the bus arbiter function is performed by a station equipped with FIPACCESS. This verification is also useful as the “presence” data item implements a significant part of the field bus processing capability; this presence is controlled on both media in a redundant–medium installation, thus allowing a specific test to be performed for each medium.

- **Subscriber identification**

The station supporting the bus arbiter function can collect identification variables from different subscribers and thus obtain information concerning each subscriber.

Identification variables can be collected easily using a station equipped with FIPACCESS software.

Appendix A — Characteristics of the Trunk Cable

1. MECHANICAL CHARACTERISTICS

Item	Referenced Value
Number of pairs	2
Colours	orange and black red and green
Gauge	one wire, 0.64 mm dia.: AWG22
Metal	copper
Conductor diameter	0.64 mm
Aluminium–tape sheath (metal foil surrounding the two pairs)	100%
Shielding sheath	35%
Outer insulating sheath. Type.	PVC
Static bend radius	11 cm
Dynamic bend radius	30 cm
Outer insulating sheath. Diameter	8 x 11 mm. 0.5 mm
Traction strength	60 N upon installation 40 N in service

2. ELECTRICAL CHARACTERISTICS

Item	Referenced Value
Attenuation	< 15 dB/km From 200 kHz to 3.125 MHz
Distortion	< 10 dB/km From 200 kHz to 3.125 MHz
Characteristic impedance	150 Ω ± 10% From 200 kHz to 3.125 MHz
Transfer impedance	< 2 mΩ/m up to 20 MHz (differential mode)
Conductor resistance	< 65 Ω/km at 20°C
Propagation speed	0.775 C (propagation speed of light C)
Capacitance between conductors	< 37 pF/m
Near–end crosstalk (differential mode)	–52 dB From 200 kHz to 3.125 MHz
Far–end crosstalk	–58 dB From 200 kHz to 3.125 MHz
Current per conductor	≥ 1 A
Shielding resistance	10 Ω/km at 20°C
Insulation resistance below 500 VDC between conductors and between the conductors and the shielding	≥ 5000 MΩ
Dielectric strength 1 min	500 VDC between conductors 1500 $\sqrt{2}$ VDC between the conductors and shielding

3. ENVIRONMENTAL CHARACTERISTICS

Item	Referenced Value
Storage temperature	–30 °C / +75°C
Operating temperature	–20 °C / +75°C
Outer insulating sheath	ULVW1 Test (IEC 60332– 1) UL746 (PVC 75°C)

Appendix B Characteristics of the Drop Cable

1. MECHANICAL CHARACTERISTICS

Item	Referenced Value
Number of pairs	2 (twisted per pair)
Colours	orange and black red and green
Gauge	7 conductors 0.16 mm dia.: AWG26
Metal	copper
Conductor diameter	0.48 mm
Aluminium–tape sheath (metal foil surrounding the two pairs)	100%
Shielding sheath	35%
Outer insulating sheath. Type.	PVC
Static bend radius	5 cm
Dynamic bend radius	20 cm
Outer insulating sheath. Diameter	9.1 ± 0.4 mm dia.
Traction strength	NA drop cable < 10 m

2. ELECTRICAL CHARACTERISTICS

Item	Referenced Value
Attenuation	< 33 dB/km From 200 kHz to 3.125 MHz
Distortion	
Characteristic impedance	150 Ω ± 10% From 200 kHz to 3.125 MHz
Transfer impedance	NA drop cable
Conductor resistance	< 130 Ω/km at 20°C
Propagation speed	≥ 0.775 C (propagation speed of light C)
Capacitance between conductors	< 37 pF/m
Near–end crosstalk (differential mode)	– 50 dB from 200 kHz to 3.125 MHz
Far–end crosstalk	– 56 dB from 200 kHz to 3.125 MHz
Current per conductor	≤ 1 A
Shielding resistance	20 Ω/km at 20°C
Insulation resistance below 500 VDC between conductors and between the conductors and the shielding	5000 MΩ
Dielectric strength 1 min	500 VDC between conductors 1500 √2 VDC between the conductors and shielding

3. ENVIRONMENTAL CHARACTERISTICS

Item	Referenced Value
Storage temperature	–30 °C / +75°C
Operating temperature	–20 °C / +75°C
Outer insulating sheath	ULVW1 Test (IEC 332– 1) UL746 (PVC 75°C)

Appendix C MICRODROP Cable Characteristics

1. MECHANICAL CHARACTERISTICS

Item	Referenced Value
Number of pairs	2 (twisted pair)
Colours	orange and black read and green
Gauge	AWG26 – solid
Metal	Copper
Conductor diameter	0.4 mm
Aluminium–tape sheath (metal foil surounding the two pairs)	100%
Shielding sheath	
Outer insulating sheath type	PDVF jacket
Bend radius static dynamic	
Outer insulating sheath	7.1 mm x 4.6 mm
Traction strength	NA drop cable < 10 m

2. ELECTRICAL CHARACTERISTICS

Item	Referenced Value
Attenuation per unit length	33 dB/km < 4 MHz
Distortion	
Characteristic impedance	150 Ω
Transfer impedance	NA – drop cable
Conductor resistance	< 131.5 Ω/km
Propagation speed	
Capacitance between conductors	
Near–end crosstalk (differential mode)	
Far–end crosstalk	
Current per conductor	
Shielding resistance	
Dielectric strength 1 min	

3. ENVIRONMENTAL CHARACTERISTICS

Item	Referenced Value
Storage temperature	
Operating temperature	
Outer insulating sheath	

Appendix D — Multimode Silicon Optical Fibre Cables

1. MECHANICAL CHARACTERISTICS

Item	Referenced Value
Cable composition Optical fibre (4) Carriers (1)	Glass fibre under tight–structure round sheath
Characteristics of sheathed fibre Outer diameter Primary protection diameter Fibre diameter	 2.6 +/–0.1 mm 500/900 µm 125 +/– 3 µm
Cable characteristics Outer diameter	 8.8 +/–0.2 mm
Fire resistance	IEC 332–3C
Bend radius static dynamic	 10 cm 150 cm
Crushing strength short period long period	 40 daN/cm 10 daN/cm

2. OPTICAL CHARACTERISTICS

Item	Referenced Value
Attenuation per unit length With 62.5/125 µm fibre	3.5 dB/km
Attenuation per unit length With 50/125 µm fibre	3 dB/km

3. ENVIRONMENTAL CHARACTERISTICS

Item	Referenced Value
Storage temperature	–30°C / +75°C
Operating temperature	–20°C / +75°C

Appendix E Single–mode Silicon Optical Fibre Cables

1. MECHANICAL CHARACTERISTICS

The mechanical characteristics of the cable must be at least equal to those of the fiber it contains.

2. OPTICAL CHARACTERISTICS

Item	Referenced Value
Attenuation per unit length (spectral band 1310 nm)	< 0.5 dB/km
Passband	> 2000 MHz/km

3. ENVIRONMENTAL CHARACTERISTICS

Characteristics	Referenced Value
Storage temperature	–30°C to + 75°C
Operating temperature	–25°C to + 70°C

These values are given as an example only. They depend on the environmental conditions specific to each application and assume that functional performance has not been modified.

Appendix F — Characteristics of the Serie 93 MIC TN1 cable

Specification: France Telecom CSEC 12–14 (CNET L130) NFC 93526 and 93527 Livre 5.

1. MECHANICALS CHARACTERISTICS

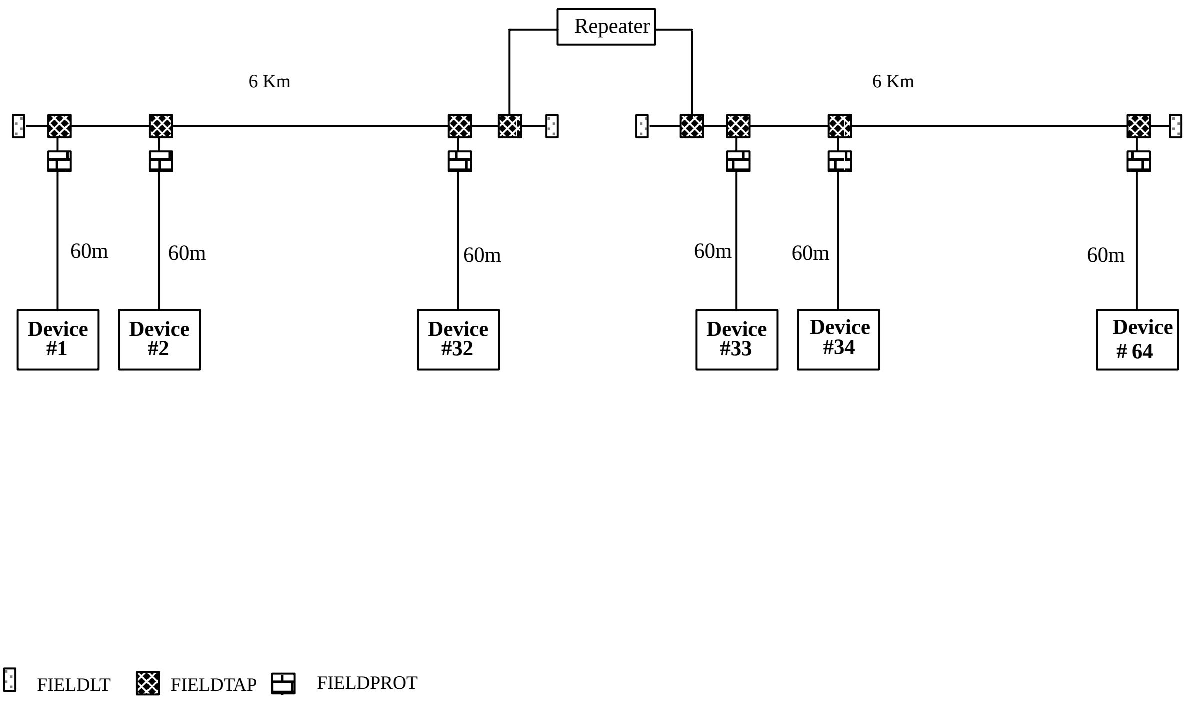
Item	Referenced value
Number of pairs	8/14/28
Colour	NA
Gauge	one wire; 0.8 mm dia.
Metal	copper
Aluminium tape shealth	splitting the cable in 2 pairs with a S or Z shape. Continuity copper wire, dia. 0.5 mm.
Outer insulating shealth	Aluminium tape cross fluted surrounded by a PVC coating
Outer insulating shealth diameter	– 8 pairs 20 mm – 14 pairs 22.5 mm – 28 pairs 28.5 mm

2. ELECTRICAL CHARACTERISTICS

Item	Referenced values
Attenuation	17 dB/km at 17 MHz
Distortion	NA
Characteristic Impedance	100 Ω at 1 MHz
Transfer Impedance	NA
Conductor resistance	37 Ω/km at 20°C
Propagation speed	NA
Capacitance between conductor	25 pairs at 800 Hz average value 55,0 nF/km
Near–end crosstalk	NA
Far–end crosstalk	NA
Current per conductor	NA
Shielding resistance	NA
Insulation resistance below 200 V	1500 MΩ/km
Dielectric strength	1.5 kV DC between conductors 2.25 kV DC between conductor/shielding

Appendix G

Application example of free topology with MIC Serie 93 Cable



Active Mixed Star (AMS) Active device used to regenerate the information signal between optical segments and copper wire segments.

Active Optical Star (AOS) Active device used to regenerate the information signal between several optical segments.

Active Star (AS) Active device used to regenerate the information signal between several segments, which may be composed of different media.

Active Wire Star (AWS) Active device used to regenerate the information signal between several electrical segments.

Daisy Chain Prewired passive device composed of moulded microTAP couplers and overmoulded connectors for local connection of subscribers.

Drop Field bus section, from a TAP coupler to a subscriber.

Drop cable Passive cable section of a bus, transporting the information signal on two pairs to a subscriber.

Line Termination (LT) Passive device installed at either end of a cable, in order to minimise reflection due to impedance mismatching.

Medium Conductor used for data transmission: copper or optical cable.

Mixed Repeater (MR) Active device used to regenerate the information signal between an electrical segment and an optical segment.

Optical Repeater (OR) Active device used to regenerate the information signal between two different optical segments.

Repeater (R) Active device used to regenerate the information signal between two different segments, which may be composed of different media.

Subscriber (S) Device with a field bus coupler.

TAP A passive coupling device for connecting a trunk cable to a drop cable with a view to creating a drop.

Trunk Cable

Trunk cable section of a bus, transporting the information signal on a single shielded copper pair.

Wire Repeater (WR)

Active device used to regenerate the information signal between two different electrical segments.