SIEMON™

Siemon Cabling System Training Manual

IS-1821-01 - Revision P

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1. INTRODUCTION

1.1. Introduction/Purpose

This manual defines the data communications cabling system for commercial office spaces, intelligent buildings and data centre environments. The methodology defined herein covers mandatory and recommended design principles and installation practices to ensure that a Siemon Certified Installer can both design and implement a project successfully, so that a Siemon Cabling System Applications Warranty can be successfully issued and maintained.

This manual is a living document and is subject to change in form and content as communication technical installation standards and the Siemon Cabling System products evolve. The material used in this manual is based on the published documents and non-published drafts of global and regional standards for telecommunications cabling. Standards used to develop this manual can be found in the References section of this manual.

The material covered in this manual is expected to be useful to a broad range of people who are actively involved in the design and implementation of commercial office spaces, intelligent buildings such as end users, building owners, consultants, certified and qualified Siemon Installation companies. The methodology described in this manual can be applied to not only new construction projects but also extends to encompass any execution of moves, adds and changes (MAC's) to the structured cabling infrastructure.

The primary purpose of this manual is the standardisation of design and installation methods and practices to ensure best practice design and installation of the structured cabling system. To provide further assurance of its compatibility to work with a broad range of data and PoE applications.

This manual identifies numerous minimum requirements, some of which exceed the minimum requirements of telecommunications standards that must be adhered to for registration of installations under the Siemon Cabling System Warranty.

1.2. Scope

Elements of the communications infrastructure covered in this manual include the following:

- Cabling Fundamentals
- Structured Cabling
- Converge-IT
- Installation Practices
- Grounding
- Data Centers
- Testing and Warranty
- Reference Information

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1.3. Mandatory and Advisory Criteria

Siemon specifications are provided in this manual as mandatory (normative) and advisory (informative).

Mandatory requirements are referenced with the word "*shall*".

Advisory recommendations, that may additionally influence the long-term performance or longevity of the cabling system, are referenced with the word "***should***".

In some cases, where the Siemon Cabling System requirements or recommendations of this manual differ from those of telecommunications standards, explanatory text is often provided.

ALL MANDATORY REQUIREMENTS LISTED IN THIS MANUAL, ALONG WITH ALL SYSTEMS UPDATES FOUND ON THE PARTNER SUPPORT WEBSITE (www.siemon.com/ally) **SHALL BE MET TO QUALIFY FOR SYSTEM REGISTRATION UNDER THE SIEMON CABLING SYSTEM WARRANTY. IN ADDITION, ALL APPLICABLE STANDARDS, CODES AND REGULATIONS SHALL BE MET**.

1.4. Disclaimer / Confidential Information

This manual has been prepared for use by certified installer companies of the Siemon Cabling System. It is provided as the basis for the Siemon Cabling System Warranty. This document is subject to change in form and technical content. As such, Siemon specifically reserves the right to add or revise, information contained herein.

This manual contains information on copyrighted standards and on the Siemon Cabling System. The manual is provided to certified installer companies on the expressed conditions that it is not to be reproduced in whole or part, without the expressed written consent of an authorized representative of Siemon.

1.5. Siemon Cabling System Benefits / Warranty

Siemon has developed patented advanced technologies to assure that transmission performance of its systems consistently exceeds the requirements of the latest published ISO/IEC and ANSI/TIA and their addendums and other regional telecommunications standards.

Siemon connecting hardware is designed to exceed the reliability specifications of these same telecommunications standards. These specifications include electrical, mechanical, and durability requirements and are intended to ensure long-lasting performance in physically demanding field environments.

Siemon offers various types/performance categories of system warranties for end users. These warranties offer different guaranteed levels of performance if the installation meets all the design and installation requirements of the Siemon Cabling System Training Manual. Information on each of the warranties is on the Siemon Partner website (www.siemon.com/ally).

An extended product only warranty is also available in place of a system warranty.

The installed components used in the Siemon Cabling System warranties may be configured as either a Permanent Link or a Channel model.

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1.5.1. Permanent Link

The permanent link covers all the cabling elements as defined in the Horizontal and Backbone sections of this manual. The permanent link configurations include Horizontal or Backbone cables and associated connecting hardware.

The permanent link does not include cross-connect jumpers/patch cords and equipment cables.

Figure 1-1: Permanent Link Example

1.5.1.1. *Warranty Coverage – Permanent Link*

When a Permanent Link is designed, installed, tested and registered in accordance with this manual, the following items are covered:

1.5.1.2. *Product*

Siemon warrants that each of its products is, at the time of delivery to the customer, free of material and workmanship defects. At the sole discretion of Siemon, provided no condition excluding warranty coverage exists, Siemon shall repair, replace or refund the purchase price of any non-conforming products based on the terms of the warranty.

The Certified Installer Company must use Siemon products or have written authorization from Siemon to use products other than Siemon products. Such other products are not covered by the warranty nor are any system failures attributable to them.

1.5.1.3. *Labor*

Under the terms of the agreement between Siemon and its Certified Installer Companies, Siemon will negotiate a reimbursement cost/method to the Certified Installer Company for resolving any warranty claim arising from a non-performing Siemon product or cable. It shall be noted that no warranty claim work shall be undertaken until formal approval has been received from The Siemon Company.

NOTE: A Permanent Link is not covered for applications assurance and is only therefore eligible for a product warranty.

All Permanent Link configurations are required to be 100% performance tested as defined in the Test. With the addition of cross-connect jumpers/patch cords and equipment cables that comply with the requirements of this manual, the Permanent Link can default to a Channel without re-testing.

Permanent Links that have compliant assemblies implemented at time of installation or during the warranty period automatically include warranty coverage as defined under the channel.

1.5.2. Channel

The Channel covers all the cabling elements of a Permanent Link with the addition of cross-connect jumpers/patch cords and equipment cables that comply with the requirements specified in this manual.

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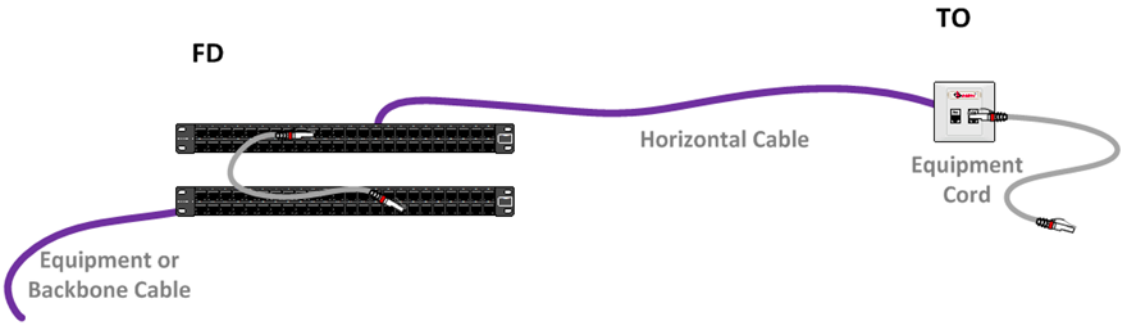

Figure 1-2: Channel Example

1.5.2.1. *Warranty Coverage – Channel*

When a Channel is designed, installed, tested and registered in accordance with this manual, the following items are covered:

1.5.2.2. *Product*

Siemon warrants that each of its products is, at the time of delivery to the customer, free of material and workmanship defects. At the sole discretion of Siemon, provided no condition excluding warranty coverage exists, Siemon shall repair, replace or refund the purchase price of any non-conforming products based on the terms of the warranty.

The Certified Installer Company must use Siemon products or have written authorization from Siemon to use products other than Siemon products. Such other products are not covered by the warranty nor are any system failures attributable to them

1.5.2.3. *Labor*

Under the terms of the agreement between Siemon and its Certified Installer Companies, Siemon will negotiate a reimbursement cost/method to the Certified Installer Company for resolving any warranty claim arising from a non-performing Siemon product or cable. It shall be noted that no warranty claim work shall be undertaken until formal approval has been received from The Siemon Company.

1.5.2.4. *Applications*

Siemon warrants that the compliant installation shall perform to the applicable 100 ohm twisted-pair, multimode and singlemode optical fiber cabling type specifications as per the latest published ISO/IEC and ANSI/TIA and their addendums and other regional telecommunications standards.

Applications assurance includes existing and future applications approved by IEEE, Fibre Channel, ANSI, ISO or other application or industry Standards that specify compatibility with the systems referenced above.

Either the Permanent Link or Channel configurations may be applied to the Horizontal and/or Backbone sub-systems of a Siemon Cabling System.

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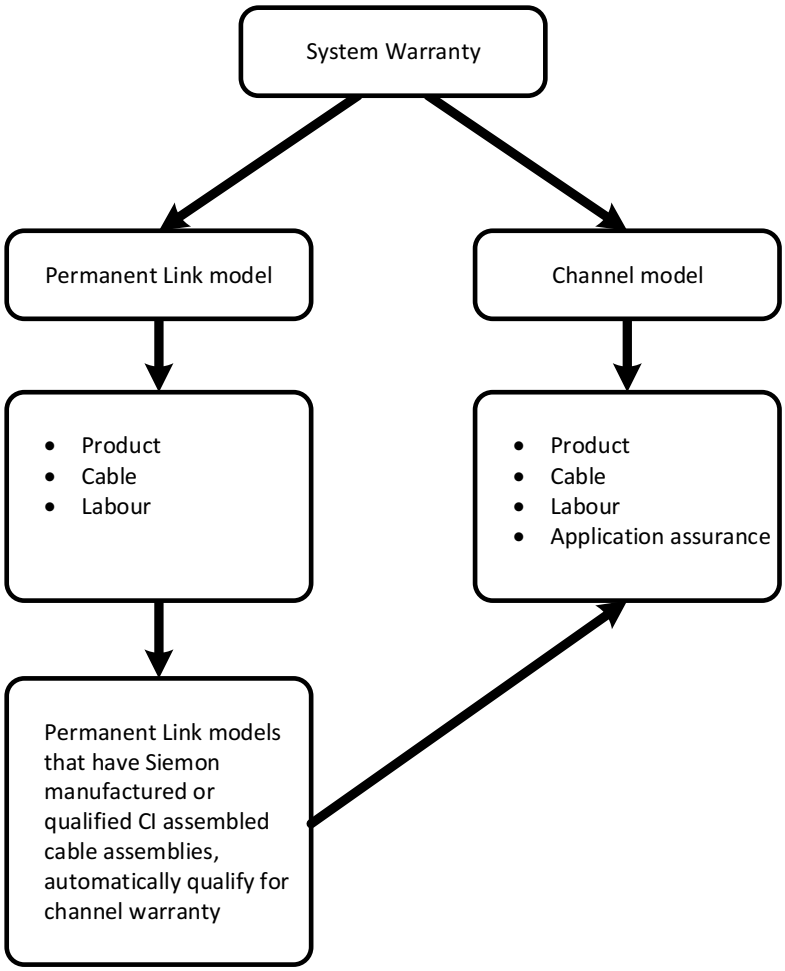

Figure 1-3: System Warranty Coverage

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2. CABLING FUNDAMENTALS

2.1. Structured Cabling Basics

'Structured Cabling' is a term widely used to describe a generic voice, data, and image (telecommunications) cabling system design that supports a multi-product, multi-vendor and multi-media environment. It is an information communications technology (ICT) infrastructure which provides direction for the cabling system design based upon the end-user's requirements. It enables cabling installations when there is little or no knowledge of the active equipment to be installed.

Suited to both campus and single-building installations, structured cabling consists of up to three sub-systems that can be joined to form a complete network in a star topology.

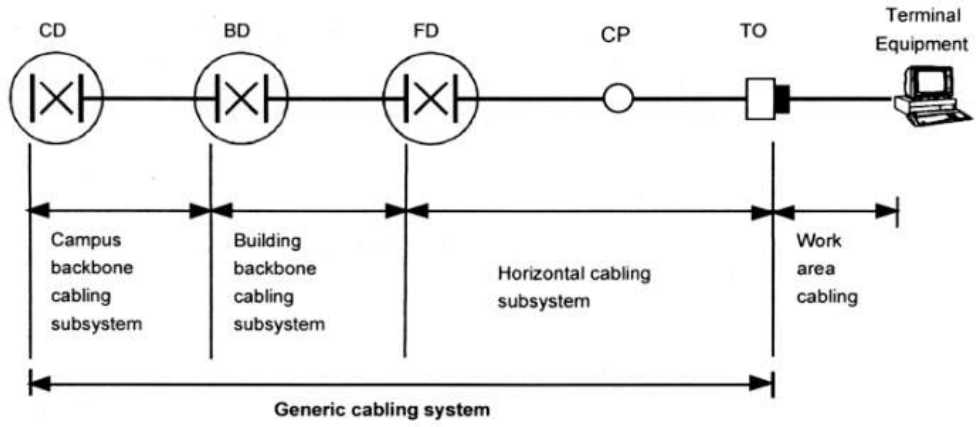

Figure 2-1: Generic Cabling System

2.2. Design Guidelines – Standards

The Siemon Cabling System may be applied from a single floor/building to a campus environment. This manual provides guidance with both requirements and recommendations for topology, cabling distances, acceptable media types, transmission performance for telecommunications cabling and components, as well as connector types and pin/pair assignments.

The scope of the Siemon Cabling System covers the cables and connecting hardware associated with the telecommunications and intelligent building infrastructure. Active equipment (including voice, data, image systems, LED light fixtures, etc.) is outside the scope of this manual, however, requirements and recommendations for the connection of active equipment to the cabling system are provided as they relate to cabling system performance.

2.3. Media Selection

Media type selection is always dependent on the following parameters:

- Application
- Channel lengths
- Construction
- Environment

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2.4. Copper

Balanced twisted pair copper cables allow the transmission of high frequency electrical signals to support telecommunications and other low voltage applications used on customer premises. Electrical and transmission performance parameters are defined by the IT industry standards.

Two different kinds of cables are used for balanced twisted pair cabling systems: solid and stranded. Solid cables have less attenuation and are used for fixed cabling between connecting hardware. Stranded cables are mainly used for the construction of cords intended to provide easier manipulation and routing.

Cables are covered by insulation to prevent direct contact to other conductors and to the environment. The dielectric material used for the insulation depends on installation environment and local standards, codes and regulations, but is integral for cable performance.

The purpose for twisting pairs of conductors is to minimize crosstalk by decreasing capacitance unbalance and mutual inductance coupling between pairs. Twisting conductors also improves the balance between conductors of a pair and reduces noise coupling from external noise sources, especially at low frequencies.

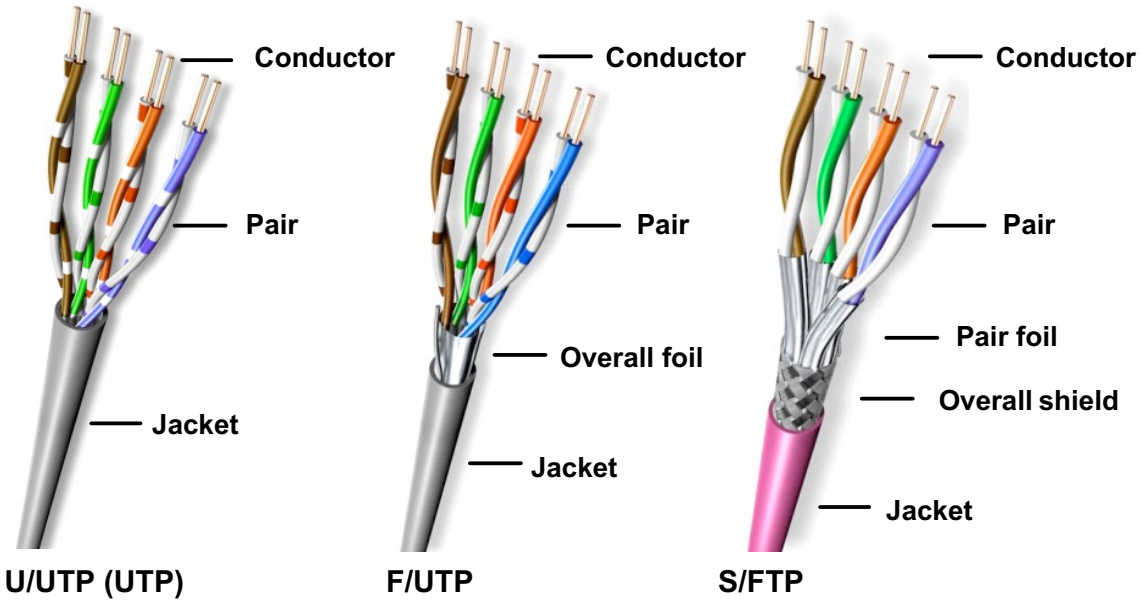

Figure 2-2: Examples of Twisted-pair Constructions

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2.4.1. Copper Categories / Classes

Table 2-1: Performance Designation for Balanced Twisted-pair Cabling and Components

Channel or Link		Components (cable and connecting hardware)		Bandwidth (Characterization Frequency)	Maximum Recommended Ethernet Application
ISO/IEC	ANSI/TIA	ISO/IEC	ANSI/TIA		
Class C	Category 3	Category 3	Category 3	16 MHz	10BASE-T
Class D	Category 5e	Category 5	Category 5e	100 MHz	1000BASE-T
Class E	Category 6	Category 6	Category 6	250 MHz	1000BASE-T
Class E_A	Category 6A	Category 6_A	Category 6A	500 MHz	10GBASE-T
Class F	--	Category 7	--	600 MHz	10GBASE-T and cable sharing
Class F_A	--	Category 7_A	--	1000 MHz	10GBASE-T, cable sharing and broadband video
Class I	Category 8	Category 8.1	Category 8	2 GHz	25/40GBASE-T
Class II	--	Category 8.2	--	2 GHz	25/40GBASE-T
Performance designations are based latest published on ISO/IEC and ANSI/TA standards					

2.4.2. Maximum Permanent Link & Channel Lengths

General restrictions apply for Category 5e (Class D), Category 6 (Class E), Category 6A (Class E_A), Category 7 (Class F) and Category 7_A (Class F_A).

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2.5. Optical Fiber

Compared to electrical conductors, optical fiber allows longer distance, higher bandwidth and EMI immunity; however, requires more expensive optoelectronic equipment for signal transmission.

Optical fiber allows the transmission of light pulses between transmitters and receivers of optoelectronic equipment. The light is "guided" down the centre of the fiber called the "core". The core is surrounded by an optical material called the "cladding" that traps the light in the core using an optical technique called "total internal reflection".

Both, core and cladding compose the optical fiber strand. An acrylate coating is used to protect bared optical fiber strand and the coated fiber should have a tight buffer protection or be grouped into a loose tube for protection.

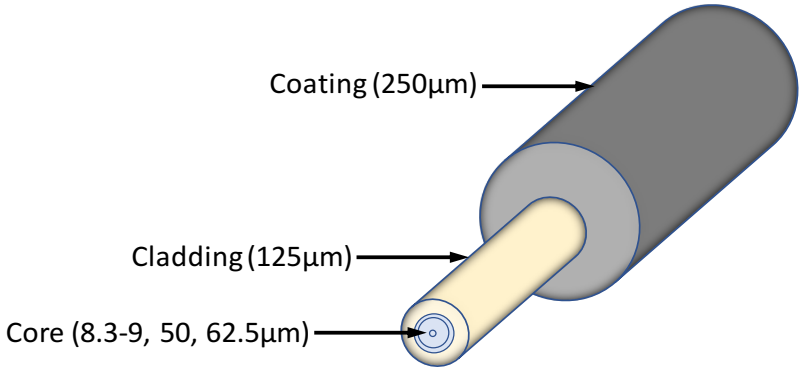

Figure 2-3: Optical Fiber Components

Tight buffer is mainly used for indoor and loose tube for outdoor environments; both can be used for indoor/outdoor environments.

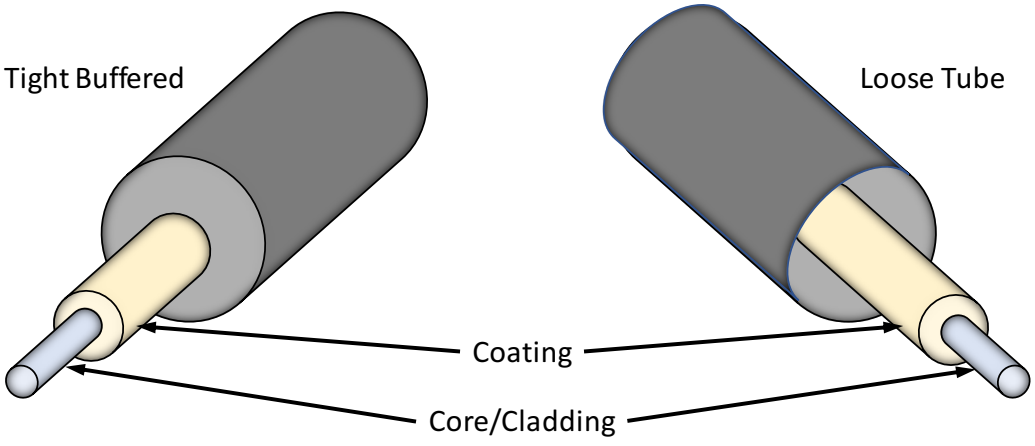

Figure 2-4: Optical Fiber Cable Construction

Optical fiber used in telecommunications should be multimode or singlemode. Multimode optical fiber allows the customer to use less expensive optical transmitters for shorter distances depending on the application transmission requirements. For those distances exceeding the capabilities of multimode fiber requirements singlemode is required.

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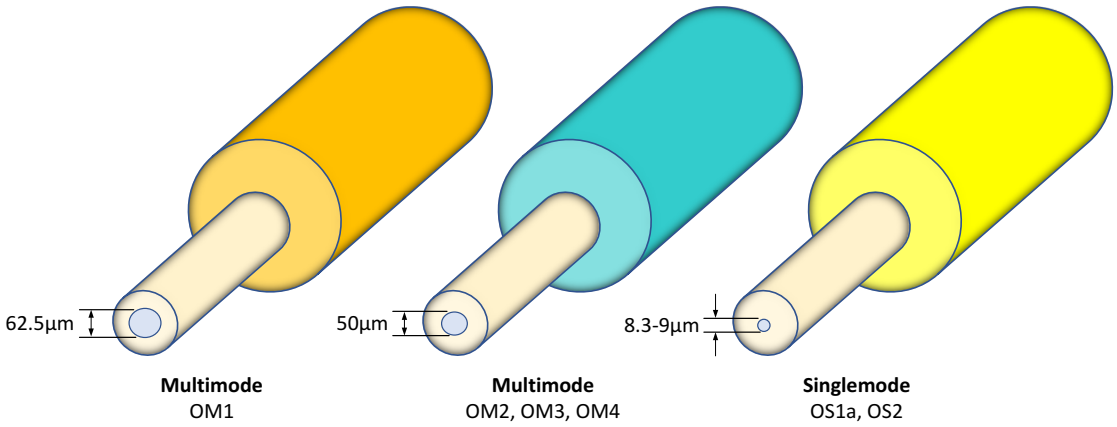

Figure 2-5: Optical Fiber Types

For ultra-high density fiber applications, constructions using ribbons of coated fibers provide the greatest amount of optical fibers for a given jacket size. This type of construction is preferred by many hyperscale operators who routinely deploy fiber counts of 864, 1728 and higher.

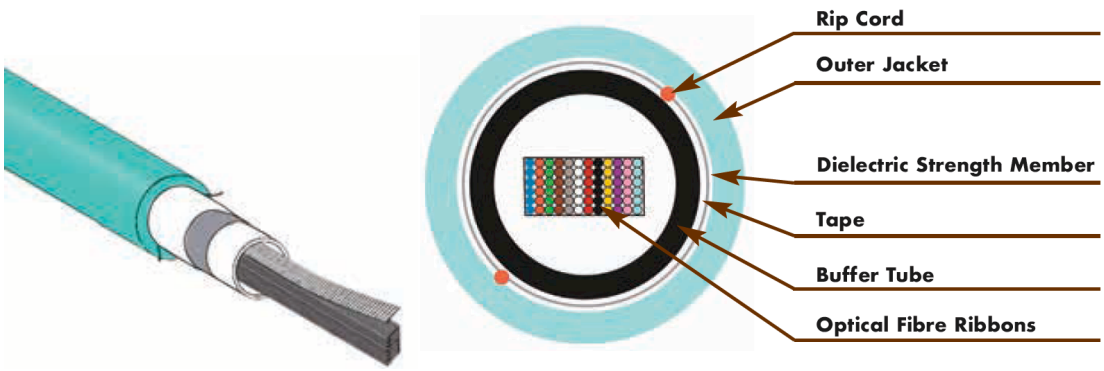

Figure 2-6: Ribbon Fiber Cable Construction

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Table 2-2: Optical Fiber Specifications

Optical Fiber Category	Wavelength (nm)	Maximum attenuation (dB/km) [1]	Minimum overfilled modal bandwidth (MHz•km) [1]	Minimum effective modal bandwidth (MHz•km) [1]
Multimode OM1 62.5/125 µm	850	3.5	200	Not required
	1300	1.5	500	Not required
Multimode OM2 50/125 µm	850	3.5	500	Not required
	1300	1.5	500	Not required
Multimode OM3 50/125 µm	850	3.5	1500	2000
	1300	1.5	500	Not required
Multimode OM4 50/125 µm	850	3.5	3500	4700
	1300	1.5	500	Not required
Multimode OM5 50/125 µm	850	3.0	3500	4700
	953	2.3	1850	2470
	1300	1.5	500	Not required
Singlemode OS1a	1310	1.0 [3]	--	--
	1550	1.0 [3]	--	--
Singlemode OS2	1310	0.4 [3]	--	--
	1383 [2]	0.4	--	--
	1550	0.4 [3]	--	--

[1] All performance parameters shown on this table are based on latest published ISO/IEC, ANSI/TIA technical standards. Other national standards may be different.

[2] ANSI/TIA-568.3-D does not provide specific attenuation requirements for 1383 nm.

[3] For singlemode categories, ANSI/TIA-568.3-D specifies a maximum attenuation of 1.0 dB for inside plant cables, 0.5 dB for indoor/outdoor cables and 0.4 dB for outside plant.

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2.5.1. Connectivity (LC, SC, MPO/ MTP)

The selection of optical fiber components and connectivity shall be determined by the channel lengths required and the applications to be supported. For Application Distances see Chapter 13.

2.5.1.1. *SC Connector*

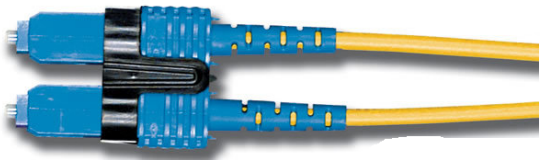

Figure 2-7: SC Connector

- Its design prevents incorrect insertion of the connector into the adapter to optimize the correct polarity of the optical connection
- Duplexing clip to create duplex connector – it consists of 2 x SC connectors
- Ferrule diameter 2.5mm

2.5.1.2. *LC Connector*

Figure 2-8: LC Connector

- Small Form Factor (SFF) design enables higher density than most legacy connector designs including SC
- Its design prevents incorrect insertion of the connector into the adapter to optimize the correct polarity of the optical connection
- Duplexing clip to create duplex connector – it consists of 2xLC connectors
- Ferrule diameter 1.25mm

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2.5.1.3. *MPO/MTP Connector*

Figure 2-9: MPO/MTP Connector

- MPO is the industry acronym for “multi-fiber push on”
- The MTP connector is a premium MPO connector with multiple engineered product enhancements to improve optical and mechanical performance (as used by Siemon) when compared to generic MPO connectors
- The MTP connector is in complete compliance with all MPO connector specifications
- Available in 8,12 & 24 fibers versions
- Pinned (male) and unpinned (female) versions for alignment
- Keyed connector ensures the correct polarity of the optical connection
- MTP-PRO options are available which allow for field changing of pins and keying

2.5.2. Polishing Types/Methods

PC (Physical Contact) and UPC (Ultra Physical Contact) polishing methods are widely used in Multimode and Singlemode connectors.

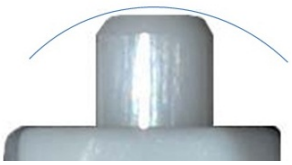

Figure 2-10: PC and UPC Connector

APC (Angled Physical Contact – Offset by 8 Degrees) polishing method is used in singlemode connectors primarily found in telco systems, video, PON and DAS applications, etc to improve RL (Return Loss) parameters. All singlemode MTP connectors are APC polished.

Figure 2-11: APC Connector

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2.5.3. Connector Color-coding

The following color-coding is the most common:

- Multimode: Beige (OM1/OM2), Aqua (OM3/OM4), Erica Violet (OM4), Lime Green (OM5)
- Singlemode PC & UPC: Blue
- Singlemode APC: Green

Figure 2-12: Color-coded LC Connectors

2.5.4. Maximum Cable Length

Maximum channel lengths supported by optical fiber depends on:

- Application (see Chapter 13 – Application Distances)
- Link optical loss/attenuation budget

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3. STRUCTURED CABLING

3.1. General topology

3.2. Horizontal

3.2.1. Horizontal Cabling

The horizontal cabling extends from the work area Telecommunications Outlet (TO) to the Telecommunications Room (TR), including the Floor Distributor (FD) / Horizontal Cross-connect (HC).

The horizontal cabling includes the horizontal cable, the TO in the Work Area, and the FD/HC inclusive of the mechanical termination's and the patch cords or jumpers located therein and may include multi-user Telecommunications Outlet Assemblies (MUTOA) and Consolidation Points (CPs).

The horizontal cabling system should facilitate ongoing maintenance and relocation while accommodating future equipment and service changes. This allows for a diversity of user applications and may reduce or eliminate fundamental changes to the horizontal cabling as user needs evolve.

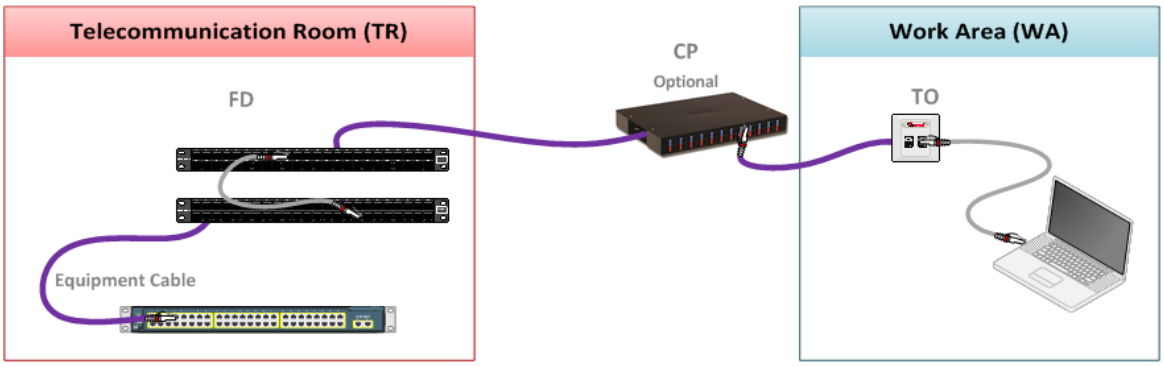

Figure 3-1: Diagram of Horizontal Distribution

The following requirements and recommendations are intended to assure that horizontal cabling systems can accommodate present and future information technologies and a minimum of two telecommunications services to each desk.

EMI Considerations for Cabling

Electromagnetic Interference (EMI) protection is an important consideration during the design and installation of the horizontal cabling and pathways.

3.1 To avoid problems caused by electromagnetic emissions from power cables and other premises equipment, the requirements of Annex C shall be met for all horizontal and backbone cabling and pathways.

Topology

3.2 The physical topology of the horizontal cabling shall be configured as a star with each TO connected to a FD/HC.

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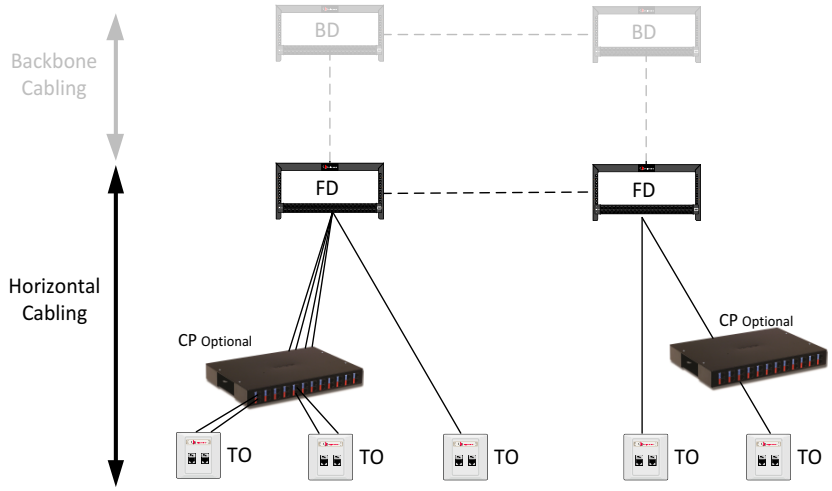

Figure 3-2: Horizontal Cabling Subsystem

3.2.1.1. *Floor Distributor/Horizontal Cross-connect*

The FD/HC is composed of cross-connections and interconnections.

Cross-Connections

The term 'cross-connect' is defined as a means to enable the termination of cables and their interconnection or cross-connection using jumpers/patch cords or equipment cables; a 'cross-connection' refers to a specific configuration in which equipment cables and jumper/patch cords are used to connect between separate distribution fields that serve horizontal cabling, backbone cabling and premises equipment.

3.3 Cross-connections shall be used for connections between horizontal and backbone cabling.

NOTE: The use of assemblies such as 'hydra cables' for the connections between horizontal cabling and premises equipment with multiple port outputs is outside the scope of the Siemon Cabling System.

Interconnections

Interconnections provide direct connections between premises equipment and horizontal or backbone distribution fields by way of equipment cables that serve a single output port.

3.1 *Interconnections may be used for connections between customer premises equipment (CPE) with output connections (such as modular jack or optical fiber connectors) and distribution fields that serve horizontal or backbone cabling.*

NOTE: Interconnections are not permitted to attach horizontal cabling directly to backbone cabling in a distributed cabling topology.

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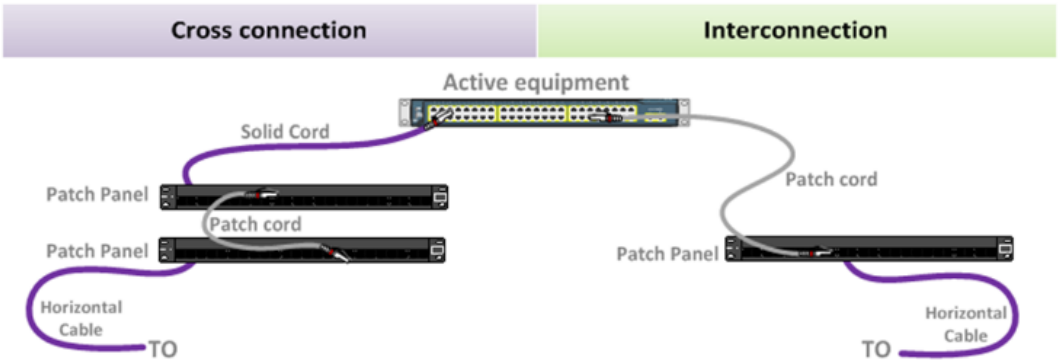

Figure 3-3: Cross-connections vs. Interconnections

3.2.1.2. *Locations of Floor Distributors/Horizontal Cross-connects*

3.2 *In order to provide an infrastructure that can accommodate a dynamic office environment a minimum of one FD/HC per floor is strongly recommended. Work areas (WA) should ideally only be served by the FD/HC on that floor. If a floor is sparsely populated (e.g. a lobby) it is permissible to serve this floor from an adjacent floor as long as distance limitations are met.*

3.4 Each WA shall be served by a FD/HC located on the same or adjacent floors.

Although this requirement and recommendation may be difficult to meet for installations with pre-existing pathways and spaces, it is important to provide easy access in sensible locations for the termination of horizontal cabling. New installations and building renovations should be planned such that each work area is served by a FD/HC on the same floor. Work areas served by FD/HC's on other floors should be treated as special situations and should be avoided whenever possible.

3.2.1.3. *Serving Area from a Floor Distribution/Horizontal Cross-Connect*

3.3 *The distance that can effectively be served from a FD/HC should not exceed 60 m (200 ft). Horizontal cable runs normally include an appropriate amount of cable slack and are typically confined to pathways that run parallel to building walls.*

3.2.1.4. *Application Specific Devices*

3.5 All devices that are specifically intended to support a given application shall be installed external to the TO and the FD/HC field.

This requirement assures that the implementation of new telecommunications applications will require minimal change to the horizontal cabling system. Examples of application-specific devices include media filters, baluns, MAUs, protection apparatus, splitters, adapters and face plates with incorporated hubs. The use of these devices is specifically outside the scope of the Siemon Cabling System as well as structured cabling standards.

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3.2.1.5. *Connecting Hardware Locations*

3.6 Connecting hardware shall not be installed in locations which may be in violation of applicable standards, codes and regulations or areas outside of the product rating.

Although it may sometimes be convenient to place connecting hardware in a ceiling or access floor space to service a group of work areas, this practice limits the serviceability of the cabling system and may violate electrical safety codes.

Other areas of violation could include: areas of wet locations, washrooms, water closets, elevator shafts etc to prevent the ingress of fluids, dust, flooding or other contaminants.

Bridged Taps

3.7 Bridged taps shall not be used in the horizontal cabling.

Bridged taps have been used to provide multiple appearances of the same cable pairs at different outlets for telephone applications. These multiple appearances significantly degrade transmission performance, and they also violate the requirement for a star topology. Therefore, they are not permitted in a structured cabling environment.

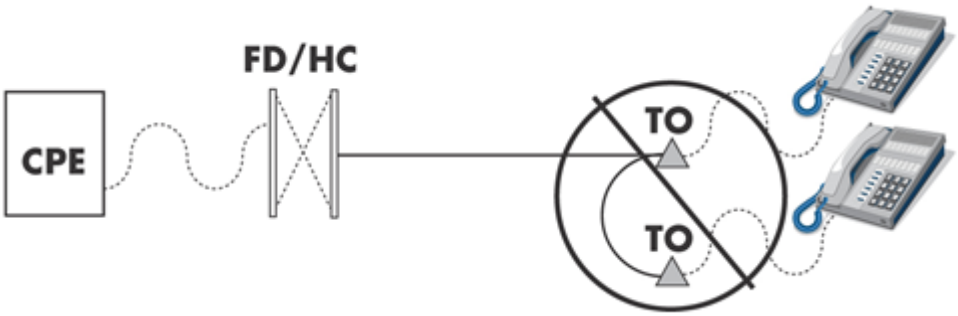

Figure 3-4: Diagram of a Bridged Tap

Multiple appearances of the same cable pairs on termination hardware used for attachment of customer premises equipment are not covered by the Siemon Cabling System warranty.

Splices

3.8 Copper splices shall not be used for horizontal balanced twisted-pair cabling.

Optical Fiber Splicing

The use of optical fiber splices in the horizontal cabling is permitted for the installation of pigtails in the FD/HC or work area.

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3.9 No more than two optical fiber splices (for the deployment of pigtails terminations) shall be permitted in the horizontal cabling between a given transmitter and receiver. Where a CP is used, four splices are permissible provided that the overall losses are within the link loss budget.

3.2.1.6. *Horizontal Cable Length*

3.10 The length of cable between the TO and the FD/HC shall not exceed 90m (295 ft) regardless of media type.

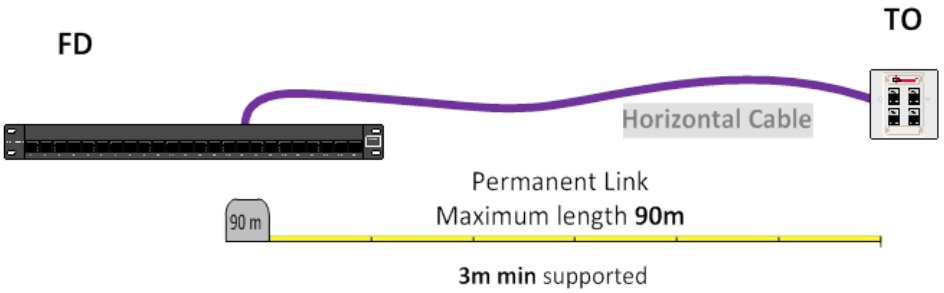

Figure 3-5: Permanent Link Lengths

The length of cable referred to above is commonly referred to as the Permanent Link. It is the actual physical jacketed length of the cable, not the electrically measured length as measured by a test device.

This distance limitation assures that data applications will function properly, provided that the appropriate connectors and installation practices are used. It also ensures balanced twisted-pair and optical fiber cables are terminated and administered in the same telecommunications space.

NOTE: If the ambient temperature in the building environment is 60ºC (140°F) or greater, the physical length of the cabling should be de-rated.

For example, a minimally compliant category 6A F/UTP cabling systems must be length de-rated by 7 meters at 60ºC (140°F) and a Siemon Z-MAX category 6A F/UTP cabling system only needs to be length de-rated by 3 meters at 60ºC (140°F) and is also capable of supporting remote powering applications up to 60ºC (140°F).

3.11 For the Siemon Z-MAX Category 6A system, a minimum distance of 3m (10 ft) is required between the FD/HC and the TO.

3.2.1.7. *Maximum Length of Jumpers/Patch Cords and Equipment Cables*

Equipment cord lengths are an integral part of the telecommunications network. Therefore, the following requirements shall be met to assure that applications will operate properly over the Horizontal cabling system.

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3.12 The combined length of balanced twisted-pair patch/equipment cords or optical fiber jumpers, which are used to form an interconnection or cross-connection shall not exceed 5m (16 ft) in the FD.

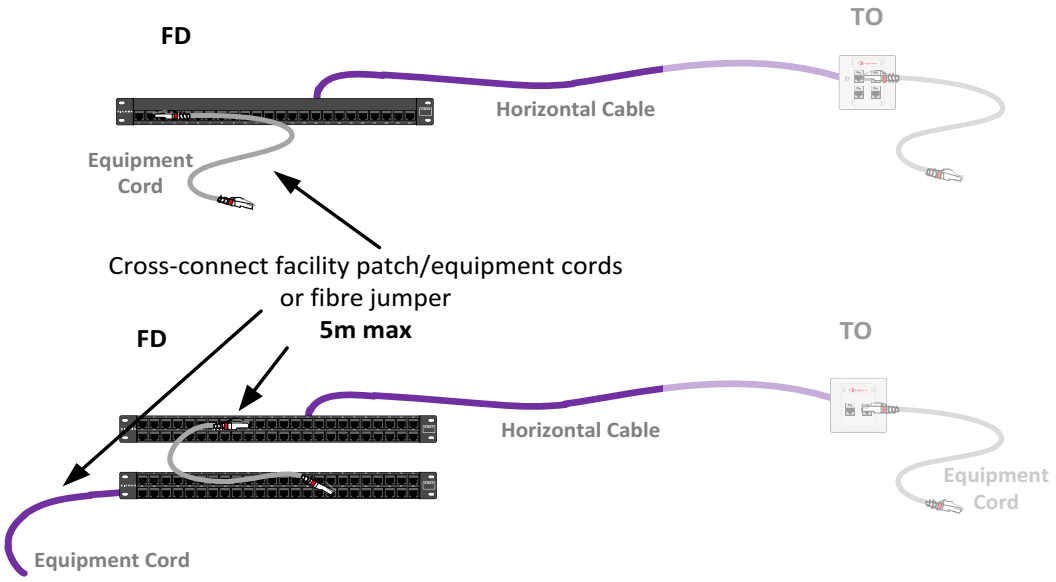

Figure 3-6: Maximum Length Equipment Cords

3.2.1.8. *Maximum Length of Work Area Cables*

3.13 The maximum length of balanced twisted-pair or optical fiber work area cables/cords shall not exceed 5m (16ft), when serving an individual users WA.

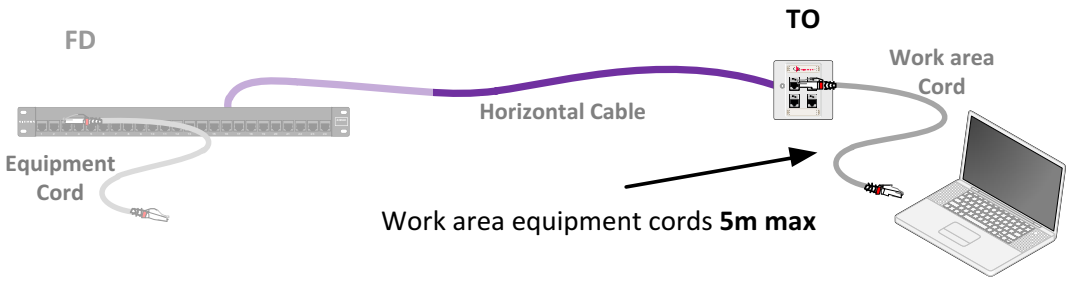

Figure 3-7: Maximum Length WA Cords

NOTE: If longer patch/equipment cord lengths are required, refer to page 3-13 or the calculators located on the Siemon Partner Support Center

3.2.1.9. *Minimum Cordage Length*

Dependent on the configuration of the channel (2, 3 or 4 connector models) there may a requirement for a minimum patch cord, work area or equipment cord length associated with Category/Class type.

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The potential concerns associated with the use of short length cords is that ISO/TIA modelled topologies use 1m (3ft.) patch cords at both the Work Area (WA) and the Telecommunications Room (TR) when they derive the worst case published channel limits.

Introducing shorter length patch cords results in connectors being in closer proximity to the near-end launch device. This can "stress" the channel because the connector contribution to the overall channel performance increases (becomes greater than predicted by the model) as it comes closer to the measurement device or active equipment. This in turn results in a more significant contribution of both return loss and crosstalk than those modelled by ISO/TIA which creates the potential for reduced channel performance.

The situation most likely to cause problems is when a short patch cord comes between two connectors in a cross-connect. In this situation, the phase contributions of crosstalk of connecting hardware in close proximity will add in a worst-case fashion. It has been demonstrated that patch cord lengths greater than 1m (3 ft) between connecting hardware will randomize these phase contributions of crosstalk and ensure margin to the channel limits.

3.14 Unless otherwise specified in the appropriate Siemon Cabling System warranty document, the minimum patch cord length shall be 1m (3 ft.).

For an example, a two-connector model using Category 6A cable and Z-MAX connectivity will require a combination of 1m (3ft) cords to be utilized when a 15 m (50 ft) horizontal link is employed. When the horizontal link is reduced to 3m (10 ft), 2m (7 ft) cordage is required.

For details on specific systems please to refer to the system warranty examples and planning and installations guides which can be found on the Siemon Partner Support Center.

3.2.1.10. *Maximum Combined Length of Horizontal Cabling Channels*

3.15 The maximum channel length of balanced twisted-pair or optical fiber cable including equipment cables at both ends plus the optional cross-connection (jumpers/patch cords) at the FD/HC, shall not exceed 100 m (328 ft) combined.

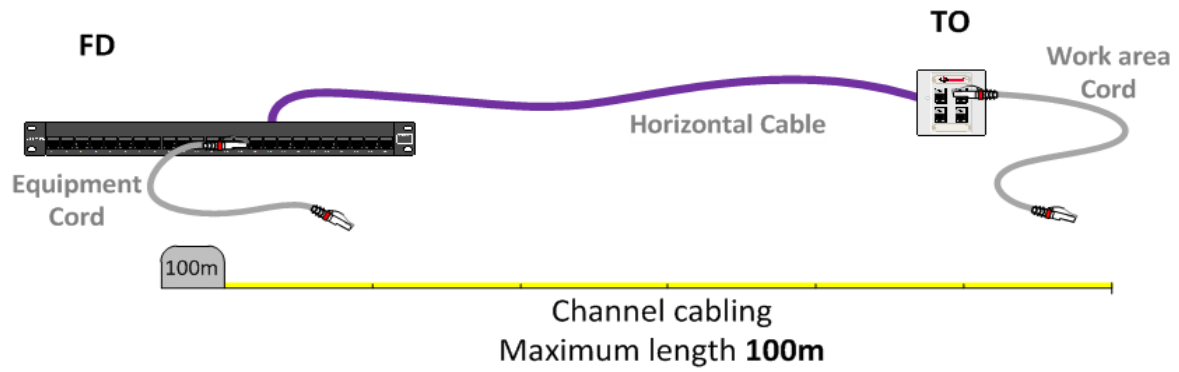

Figure 3-8: Maximum Horizontal Cable Length

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3.2.1.11. *Recognized Horizontal Cables*

The following types of horizontal cables are supported in the Siemon Cabling System:

a) Four-pair 100 Ω balanced twisted-pair.

b) Two-core fiber OM1, OM2, OM3 & OM4 multimode optical fiber.

c) Two-core fiber OS1a & OS2 singlemode optical fiber.

Other cable types used to serve special needs are in addition to the minimum requirements of this manual and are outside the scope of the Siemon Cabling System.

3.2.1.12. *Horizontal Cabling Component Specifications*

Components used in the horizontal Cabling System are subject to the following requirements:

3.2.1.13. *Horizontal Twisted-Pair & Optical Fiber Cables*

3.16 Balanced twisted-pair and optical fiber cables shall be Qualified Cables for use in the Siemon Cabling System. Refer to the Siemon Partner Support Center, for a listing of Qualified Cables.

When a qualified cable is not available to meet specific installation needs, the Authorized Designer/Installer is responsible for submitting a Request for Exception prior to installation for formal approval. Exception request submittals are done through the Siemon Partner Support Center

3.2.1.14. *Horizontal Connecting Hardware*

3.17 All connecting hardware used with 100 Ω balanced twisted-pair cables and all connecting hardware used with optical fiber cables shall be provided by Siemon.

3.2.1.15. *Horizontal Modular Cord Assemblies/Channel Model*

3.18 All patch cords and equipment cables used to cross-connect or interconnect 100 Ω balanced twisted-pair, multimode and singlemode optical fiber cabling for use in a Siemon Cabling System Warranty, shall be manufactured by Siemon.

For field terminated cable assemblies, see note below.

NOTE: The construction of patch cords and equipment cables incorporating double ended S110P, S210P, Z-PLUG or TERA plugs can be performed by the Certified Installer (Company). The use of which in a Channel Model qualifies the channel for applications assurance under the Siemon System Warranty. In respect to switch harness cords (IC Series) for Category 5e or higher modular to S110P or S210P, Z-MAX and TERA assemblies, the certified installer (company) can purchase these factory assembled or they may be purchased as double-ended modular-to-modular assemblies (typically double the length) cut in half and terminated to the S110P or S210P on the cut end leaving the factory assembled modular plug as it is. Siemon

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offers harness cords (IC-Series) assemblies that are factory assembled using solid or stranded cable for specific installation requirements.

3.2.1.16. *Choosing Horizontal Cabling*

3.19 A minimum of two TO's shall be provided for each individual Work Area for compliance in a Siemon Cabling System Warranty and as specified by applicable cabling standards. These outlets may be located in one or more faceplates in the Work Area.

NOTE: The definition of a work area is the area where the desk of a network user is located. Other areas like courtesy phones, wireless access points or other ancillary devices would only need a TO per location.

3.4 *A minimum of Category 6A or higher is recommended for each individual work area to support the current and future applications designed to operate over twisted-pair cabling.*

3.5 *Although optical fiber may be used as the second outlet, it is recommended that if optical fiber is used in the horizontal cabling, it is in addition to two balanced twisted-pair outlets for each individual work area.*

3.2.1.17. *Open Office Cabling*

Office design practices have introduced flexible layouts in order to accommodate small teams within the WA, which is frequently rearranged to meet the customer's changing requirements. In order to allow open office spaces to be reconfigured frequently without disturbing Horizontal cable runs, it may be desirable to use other methods of connectivity.

Two such methods are the Multi-user Telecommunications Outlet Assembly (MUTOA) and the Consolidation Point (CP.)

3.2.1.18. *Multi-user Telecommunications Outlet Assembly*

The MUTOA may be advantageous in open office spaces which are expected to be moved or reconfigured frequently. The MUTOA facilitates the termination of single or multiple horizontal cables in a common location within a furniture cluster or open area. The use of MUTOA's allows for the horizontal cable to remain intact when an open office change happens.

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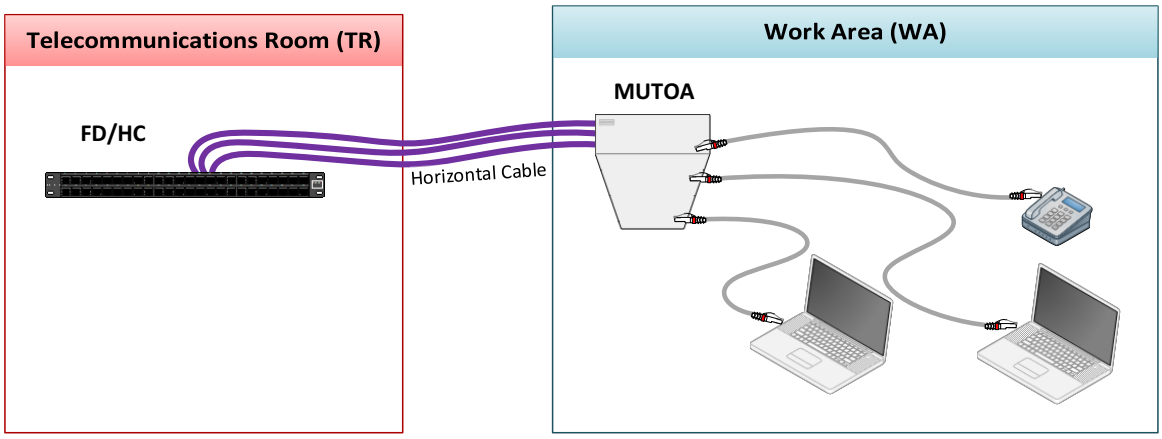

Figure 3-9: MUTOA

3.20 The cable that extends from the MUTOA in a WA is an equipment cable and:

- ***shall not terminate to an additional TO in the WA.***
- ***shall be connected directly to the WA station equipment (i.e. phone computer)***
- ***shall be labeled on both ends with a unique cord identifier***

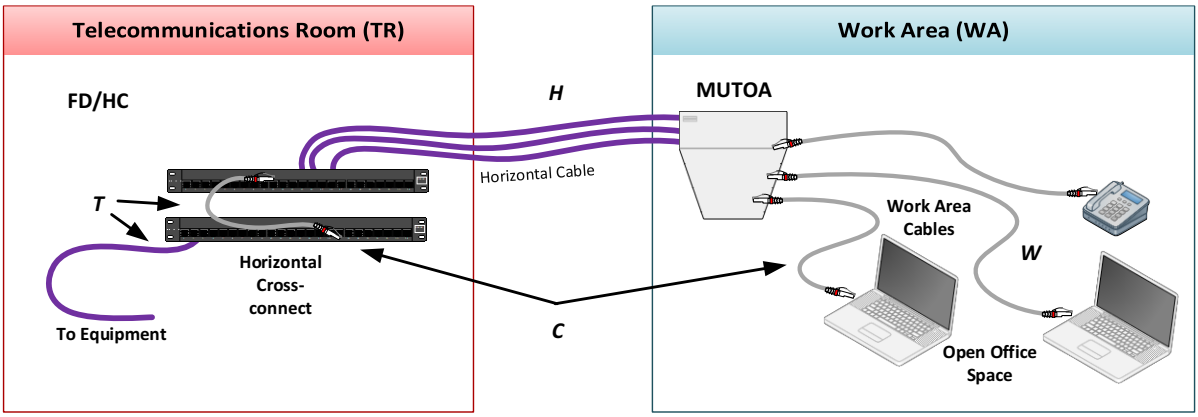

Figure 3-10: Open Office Cabling

3.21 The maximum combined length of work area cable, patch cord and equipment cables for use with a MUTOA shall be determined by using the following formula or table:
C = (102 - H) / (1 + D)

Where: C is the combined length in meters of the Work Area equipment cable (cord), equipment cable (cord) in the Telecommunications Room, and optional patch cable (cord) in a cross-connection

H is the length in meters of the horizontal cable

D is the insertion loss de-rating factor: 0 for solid conductor cords, 0.2 for 24 and 26 AWG stranded cords, or 0.5 for 28 AWG stranded cords

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Table 3-1: Maximum Cable Lengths in Open Office Cabling

Length of Horizontal Cable (H) m (ft)	Maximum Combined Length of Work Area Cable, Patch Cord and Equipment Cable (C) m (ft)	
	24/26 AWG	28 AWG
90 (295)	10 (33)	8 (26)
85 (279)	14 (46)	11 (35)
80 (262)	18 (59)	15 (49)
75 (246)	22 (72)	18 (59)
70 (230) or less	26 (85)	21 (70)

NOTE: For optical fiber cables, the length of Work Area equipment cables does not require a reduction of the 100 m (328 ft) channel distance.

3.22 The MUTOA shall be marked with the maximum allowable WA equipment cable length.

For WA equipment cables for use with a MUTOA, the maximum length is determined by using the following formula or the Siemon calculator on the Siemon Partner Support Center: W = C – T, where C is the combined length of the Work Area equipment cable (cord), equipment cable (cord) in the Telecommunications Room, and optional patch cable (cord) in a cross-connection [calculated above]

T is the maximum length of the patch and equipment cables in the TR

3.23 The MUTOA shall be located in fully accessible, permanent locations, such as building columns and permanent walls.

3.6 *Each MUTOA is recommended to serve a discrete (separate) open WA group of users.*

3.7 *The MUTOA should be limited to a manageable size, serving a maximum of twelve users.*

3.2.1.19. *Consolidation Point*

Whereas a MUTOA provides for a connection point within the WA between equipment cabling and horizontal cabling for frequent reconfigurations, the CP provides for an interconnection point within the horizontal cabling. A CP is not a splice point, it is the termination/connection of 2 segments of horizontal cabling using connecting hardware.

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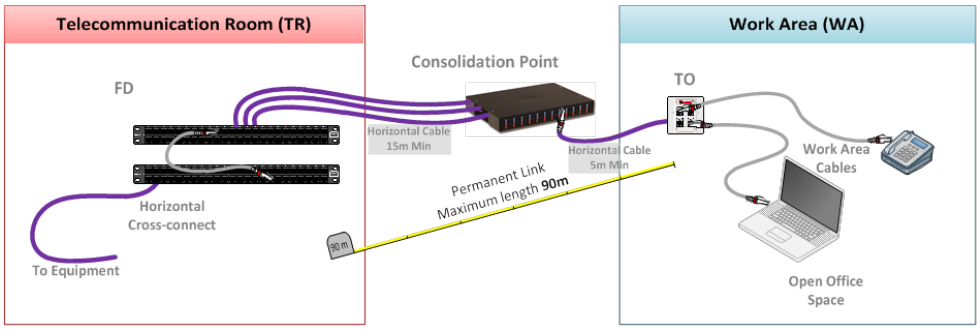

Figure 3-11: Consolidation Point Topologies

3.24 No more than one CP shall be permitted within the same horizontal cable run, in addition:

- ***Active equipment shall not be permitted at a CP.***
- ***Cross-connections shall not be used at a CP.***

NOTE: This requirement does not apply for some BAS topologies. See Annex B for additional information.

3.25 Each horizontal distribution cable entering/exiting the CP shall have all pairs terminated and shall comply with the following lengths:

- ***The minimum distance between the FD/HC and the CP shall be 15 m (50 ft).***
- ***The minimum distance between the CP and the TO shall be 5 m (16 ft).***
- ***The maximum channel distance shall not exceed 100 m (328 ft).***

These minimum distance requirements between the FD/HC and CP, and the CP and TO minimizes the potential for performance reduction when two pieces of connecting hardware are in close proximity and optimizes overall system performance.

3.26 Each cable extending to the TO from the CP shall be terminated to an TO or MUTOA; not for direct connection to active equipment.

NOTE: Cables which are terminated to the CP but do not extend to the TO or FD/HC cross-connect do not qualify for warranty. However, these cables should be verified to meet the appropriate class/category to facilitate connectivity needs.

NOTE: This requirement does not apply for some BAS topologies. See Annex B for additional information.

3.27 The CP shall be located in fully accessible, permanent locations, such as building columns, and permanent walls; not in obstructed areas nor within furniture systems unless that unit of furniture is permanently secured to the building structure.

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3.28 The use of suspended ceiling space or access floor space for CP's may be acceptable, provided that:

- ***The use of such space shall not violate applicable building codes,***
- ***It shall be accessible without moving building fixtures, equipment, or heavy furniture (e.g., file cabinets weighing 45 kg [100 lb] or more),***
- ***It does not disturb building occupants***

3.2.1.20. *Two, Three, Four Connector Channel models*

A two-connector model is comprised of a connector at each end of the link and does not include a consolidation point or cross-connect

Figure 3-12: 2-connector model

1. Equipment Cord
2. Patch Panel
3. Horizontal Cabling
4. Work Area Outlet
5. Work Area Cord

A three-connector model with cross-connect comprised of a connector at each end of the link with a cross-connect at one end.

Figure 3-13: 3-connector model

1. Equipment Cord
2. Patch Panel
3. Cross-connect Cord
4. Patch Panel
5. Horizontal Cabling
6. Work Area Outlet
7. Work Area Cord

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Another type of three-connector model is comprised of a connector at each end of the link as well as a consolidation point connection within the link with interconnect at one end.

Figure 3-14: 3-connector model

1. Equipment Cord
2. Patch Panel
3. Horizontal Cabling
4. Consolidation Point
5. Consolidation Point Cabling
6. Work Area Outlet
7. Work Area Cord

A four-connector model is comprised of a connector at each end of the link as well as a consolidation point connection within the link with a cross-connect at one end.

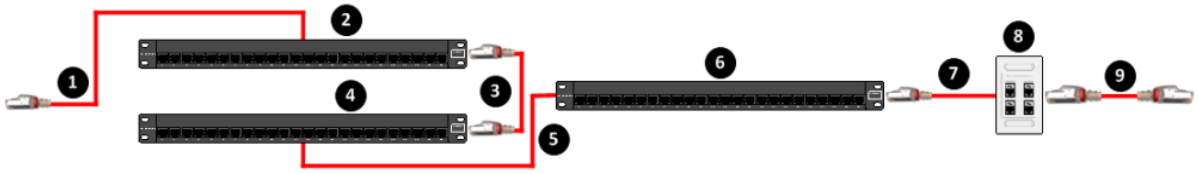

Figure 3-15: 4-connector model

1. Equipment Cord
2. Patch Panel
3. Cross-connect Cord
4. Patch Panel
5. Horizontal Cabling
6. Consolidation Point
7. Consolidation Point Cabling
8. Work Area Outlet
9. Work Area Cord

3.2.1.21. *Centralized Optical Fiber Cabling Topology*

Centralized optical fiber cabling is designed as an alternative to a distributed system with optical fiber cross-connections or active equipment located in the telecommunications room.

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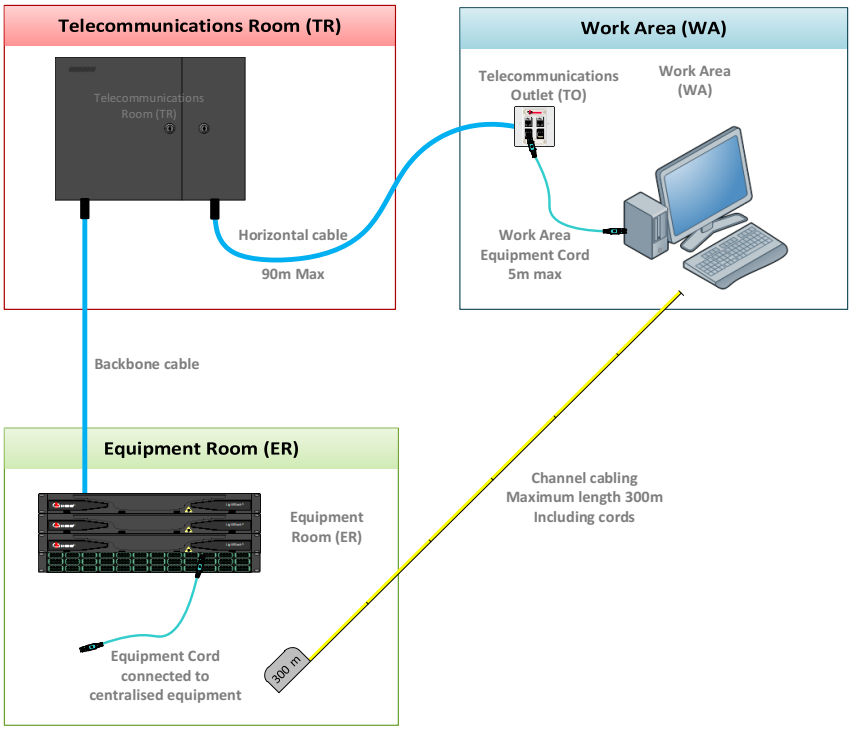
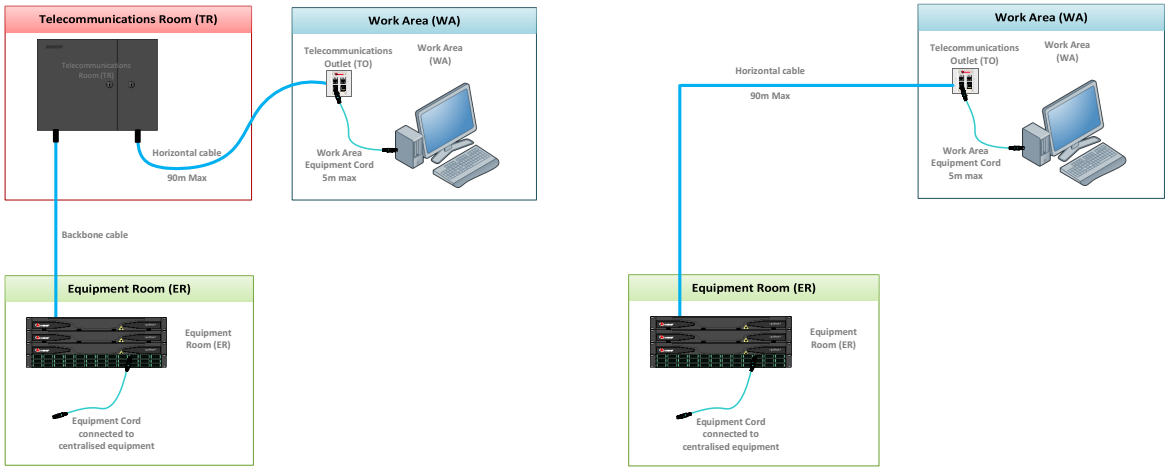


Figure 3-16: Centralized Optical Fiber

Centralized optical fiber cabling provides connections from work areas to the centralized cross-connect by means of an inter-connection, splice or pull-through in the telecommunications room.



Interconnection/Splice Method Pull Through Method

Figure 3-17: Centralized Optical Fiber Methods

NOTE: Centralized optical fiber cabling is restricted to intrabuilding design only. The use of an interconnection or splice located in the telecommunications room between the intrabuilding Backbone segment and the Horizontal segment is offered for increased flexibility, manageability and ease of migration to a distributed system.

3.29 The maximum allowable distance for centralized optical fiber cabling is dependent on the application and media chosen.

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NOTE: The intra-building Backbone segment should be designed with adequate spare capacity to serve additional TO/connectors from the centralized cross-connect without the requirement to pull additional intra-building backbone cables.

3.3. Work Area

WORK AREA ELEMENTS INCLUDE:

Telecommunications Outlet (TO)

This is the interface between the Work Area and horizontal cabling.

Work Area Equipment (WA)/Telecommunications Equipment (TE)

- Devices such as telephones, terminals, computers, etc.

Work Area Equipment Cords/Work Area Cords

- Modular cords or fiber jumpers used to connect Work Area equipment/TE to the TO

3.3.1. Work Area Cabling

Balanced Twisted-Pair Equipment/Work Area Cords

3.8 *The balanced twisted-pair equipment cables should be of the same category or higher as the horizontal balanced twisted-pair cables to which they connect.*

3.30 The balanced twisted-pair equipment cables shall be suitable for the environment in which it is installed (indoor, indoor/outdoor & OSP)

Optical Fiber Equipment/Work Area Cords

3.31 The optical fiber equipment cables shall be of:

- ***Duplex construction***
- ***The same fiber type as the cabling***
- ***Suitable for the environment in which it is installed (indoor, indoor/outdoor & OSP)***

3.32 The Siemon Cabling System requires keyed, duplex, optical equipment cords to be used at the WA. These would include:

- ***LC style***
- ***SC style***

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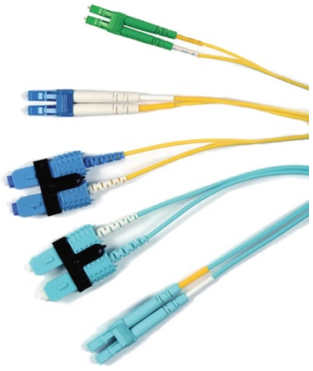

Figure 3-18: SC/LC Jumpers

These duplex connectors can establish and maintain the correct polarity of transmit and receive optical fibers in two optical fiber transmission systems, while still allowing transmission systems using other optical fiber counts (i.e. a single fiber system such as video cameras).

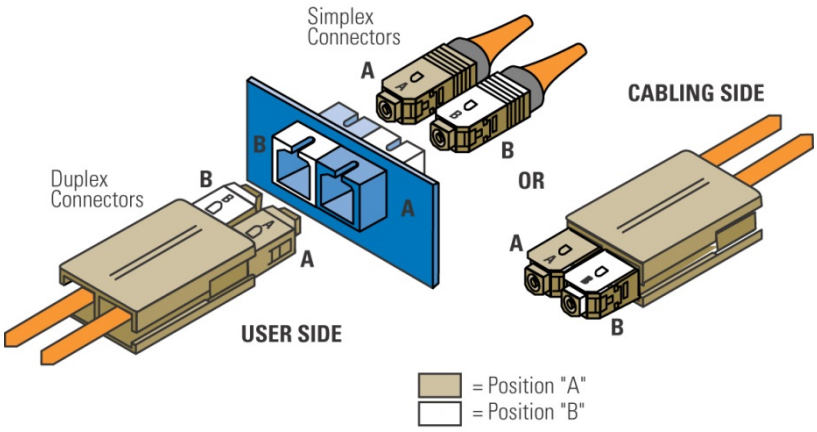

Figure 3-19: Duplex Polarity Orientation

3.3.2. Telecommunications Outlet (TO)

3.33 All 4-pair balanced twisted-pair cables wired to the TO shall have all 4-pairs fully terminated.

Note: Any un-terminated cables, i.e. those pulled for future use, will not be covered under the Siemon warranty until they have been terminated at both ends, tested and properly documented.

3.34 Optical fibers at the equipment outlet shall be terminated to a duplex connector or array connector. It is permissible to leave unused cores dark for future use.

The distance of the TO's from the actual WA is based on the limited length of the work area equipment cord. Refer to the Siemon Calculator on the Partner Support Center website for details.

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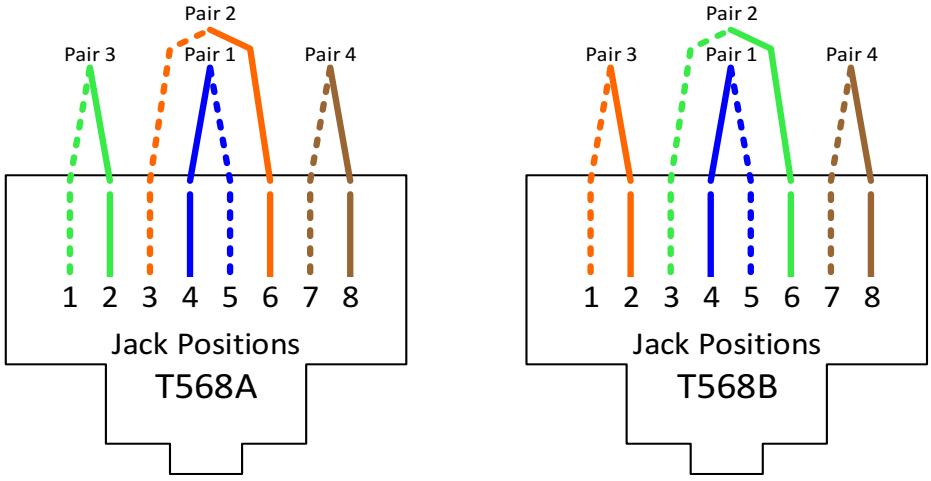

Figure 3-20: Wiring Schemes

3.35 Category 5e, 6 and 6A balanced twisted-pair pin and pair grouping assignments shall be T568A or T568B.

The colors indicated are associated with Horizontal distribution cable. These illustrations depict the front view of the outlet.

3.9 *The coexistence of outlets wired to T568A and those wired to T568B pin/pair schemes in the same installation is not recommended.*

Mounting

3.36 TO's shall be securely mounted at planned locations.

Note: Securely mounted hardware may include magnets or screws. Screws are the preferred method for mounting connecting hardware.

3.37 Warehouse/Assembly workbench locations, where a hanging box is used, shall be installed with mounting components made specifically for these locations.

Figure 3-21: Hanging Box Examples

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Location

3.10 *Telecommunications Outlet/connectors should be readily accessible allowing for ease of routine maintenance and reconfiguration.*

Cable Slack

3.11 *Appropriate slack should be left to allow the re-termination of the TO. This slack should not be coiled within the outlet box unless it is designed for this purpose meeting the appropriate bend radii requirements*

Orientation

The orientation of the TO is important to relieve WA cord stress. Siemon offers WA solutions to facilitate this. The actual orientation of the connectors will depend on the housing or faceplate selected.

Figure 3-22: Work Area Outlet Examples

3.38 The fiber outlet shall have the ability to secure the optical fiber cable, provide for a mechanism to ensure a minimum 25 mm (1.0 in) bend radius, and to store a minimum of 1m (3 ft) of two-fiber optical cable or two buffered optical fibers for termination purposes.

Figure 3-23: Work Area Slack Storage Example

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3.3.3. Work Area Pathways and Spaces

3.39 When using pathways incorporated into furniture or partitions, installed cabling shall comply with all applicable standards, codes and regulations.

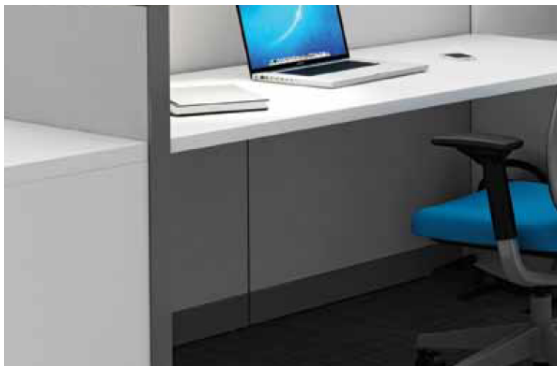

Figure 3-24: Modular Furniture Pathway

Modular furniture raceways that are closest to the floor are best suited and typically designed for power and not telecommunications cabling. Some modular furniture manufacturers have designed "beltways" into their furniture panels. These beltways are located above desk height and have been designed to route telecommunications cables to the desktop devices that they serve. There are optional baseline raceways designed to support both electrical and telecommunications cabling by using separated paths and cutouts within the raceway.

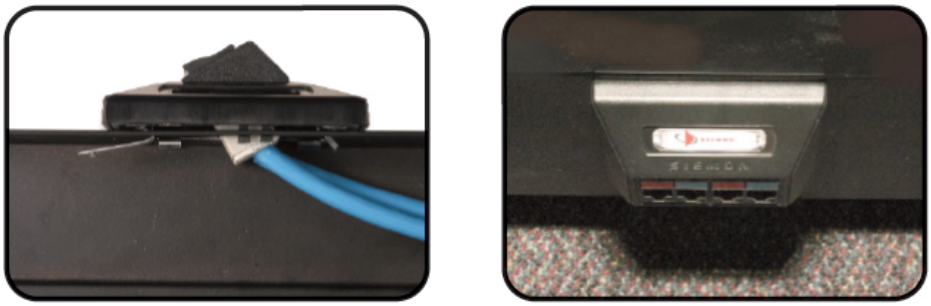

Figure 3-25: Modular Furniture Faceplate Examples

3.3.4. Telecommunications Outlet Boxes

3.12 *Recessed outlet boxes should be adequately sized to maintain the bend radii from the back of the terminated connector.*

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Figure 3-26: Outlet Box Example Showing Proper Bend Radius and Storage

3.13 *A bracket/ frame designed for faceplate mounting should be used in place of an outlet box where applicable standards, codes, and regulations permit.*

3.40 Horizontal cable that runs between the HC/FD and the TO shall not be exposed in the WA or other spaces with public access.

Locations

TO locations should be coordinated with the furniture layout. Wall-mounted outlets are typically installed at the same height as the power outlet. Outlet location should be within easy reach of power outlets to provide power to the Telecommunications Equipment

3.41 TO's shall be mounted in locations and at heights above the finished floor that are compliant to applicable standards, codes and regulations.

3.4. Backbone

3.4.1. Backbone Topology

The Backbone cabling extends from the CD/MC to the FD/HCs and includes the CD/MC, the BD/IC, the connecting hardware dedicated to the backbone cabling, and the cables that join them. The backbone cabling also includes the mechanical terminations and jumpers/patch cords used for backbone-to-backbone connectivity. The backbone cabling does not include cables in the Telecommunications Rooms (TR's), Equipment Rooms (ER's), or Building Entrance Facilities (BEF) that connect directly to customer premises equipment (CPE).

The following requirements and recommendations are intended to assure that the backbone cabling system can accommodate present and future information technologies that are introduced over its planning period.

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3.4.2. Backbone Cabling Structure

3.4.2.1. *Topology*

3.42 The backbone cabling shall use the conventional hierarchical star topology.

3.43 There shall be no more than two subsystems of cross-connects in the backbone cabling. From the FD/HC, no more than one cross-connect shall be passed through to reach the CD/MC.

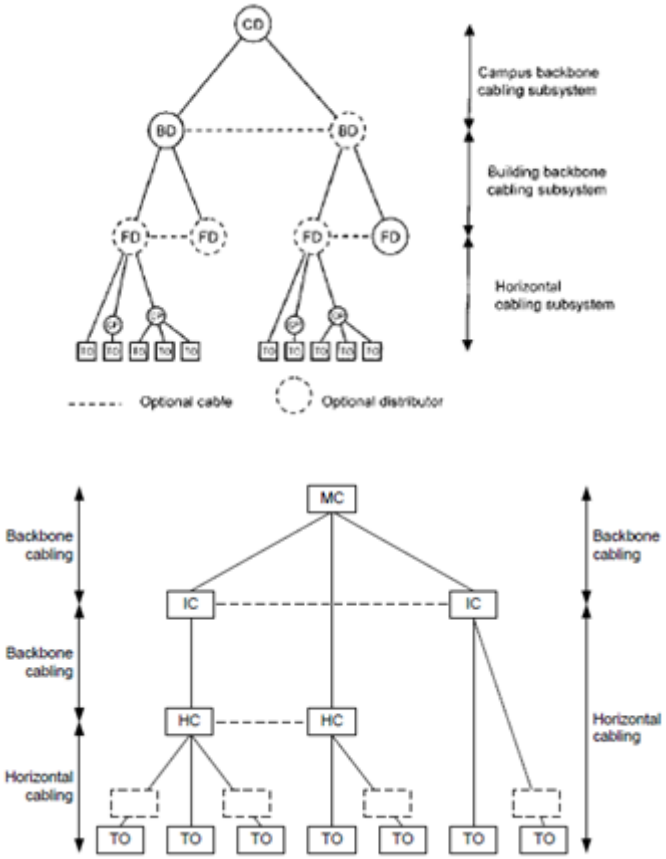

Figure 3-27: Backbone Cabling Structure

The first subsystem is the cabling coming from the CD/MC. The second subsystem is the cabling from the BD/IC Cross-connect. The Floor FD/HC is not considered to be part of the backbone cabling. The implication of the two levels of hierarchy in the backbone system is that no more than three cross-connects can exist along the cabling route between any two FD/HC.

The limitation of two levels of cross-connects is imposed to allow the implementation of most network architectures and to simplify moves, adds and changes. This limitation may not be suitable for facilities which have many buildings or those that cover a large geographical area, such as universities, industrial parks and military bases. In these cases, it may be acceptable to divide the entire facility into smaller areas within the scope of this document and then connect these areas together.

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The first figure shown above represents a typical backbone cabling star configuration with two buildings. If a logical bus, ring or tree is required, the star topology provides the flexibility needed to implement them through connections to the CD/MC/ IC.

The backbone cross-connect (CD/MC and/or BD/IC) is composed of cross-connections or interconnections.

3.4.2.2. *Cross Connections*

Whereas a "cross-connect" is defined as a means to enable the termination of cables and their interconnection or cross-connection using jumpers/patch cords or equipment cables, a "cross-connection" refers to a configuration in which cables or jumpers/patch cords are used to connect between separate distribution fields that serve horizontal cabling, backbone cabling and premises equipment.

3.44 Cross-connections shall be used for connections between horizontal and backbone cabling, between first level backbone and second level backbone cabling and for connections between backbone cabling and premises equipment with multiple port outputs (such as 25-pair connectors).

3.4.2.3. *Interconnections*

Interconnections provide direct connections between premises equipment and horizontal or backbone distribution fields by way of equipment cables that serve a single output port.

3.14 *Interconnections may be used for connections between premises equipment with single port output connectors (such as modular jack or optical fiber connectors) and distribution fields that serve horizontal or backbone cabling.*

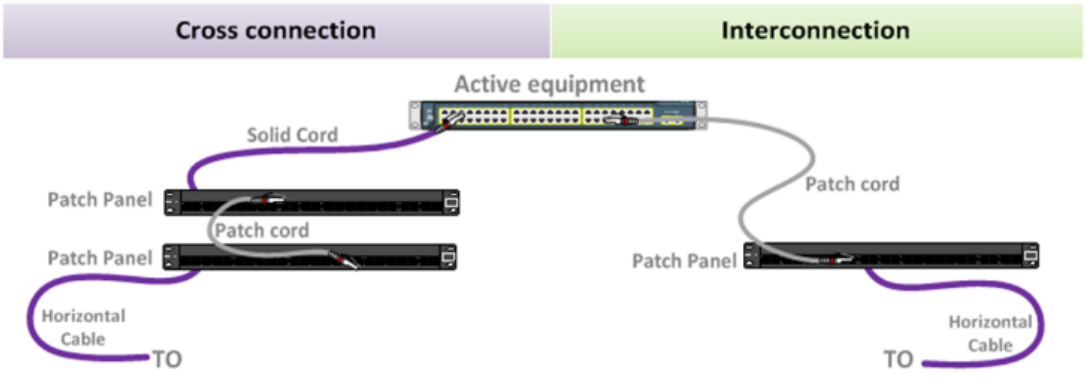

Figure 3-28: Cross-connections vs Interconnections

NOTE: Interconnections are not permitted for attachment of horizontal cabling directly to backbone cabling, and first and second level Backbone cabling.

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3.4.2.4. *Locations of Backbone Cross-Connects*

While a CD/MC typically serves an entire campus or building, BD/ICs serve only a portion of the overall installation. BD/ICs are useful for establishing backbone service zones based on occupancy or on the physical layout of the building, campus, or infrastructure. It should also be noted that CD/MC BD/IC Cross-connects often occupy the same spaces as FD/HC.

3.15 *In order to make optimum use of a star topology, it is recommended that the CD/MC be located near the geographic center of the area that it is intended to serve.*

3.45 Connecting hardware shall not be installed in locations which may be in violation of applicable standards, codes and regulations or areas outside of the product rating.

3.4.2.5. *Application Specific Devices*

3.46 All devices that are specifically intended to support a given application shall be installed external to the CD/MC or BD/IC.

This requirement assures that the implementation of new telecommunications applications will require minimal change to the telecommunications cabling infrastructure. Examples of application-specific devices include media filters, baluns, MAUs, protection apparatus, splitters and adapters. The use of these devices is specifically outside the scope of the Siemon Cabling System, as well as industry cabling standards.

Bridged Taps

3.47 Bridged taps shall not be used as part of the Backbone cabling.

As is the case with horizontal cabling, bridged taps (parallel connections of the same cable pairs) do not comply with the requirement for star topology and are severely detrimental to the transmission properties of the cabling system.

Balanced Twisted Pair Cable Splice Limitations

3.48 Splices shall not be used on four-pair balanced twisted pair cables.

3.49 Where multipair copper cable is used in the backbone (campus backbone and building backbone), the number of splices shall be kept to the minimum required by the physical system design or installation constraints.

3.50 When used, splices shall be constructed using insulation-displacement type connectors and housed in enclosures appropriate for the environment.

NOTE: Multipair cable splicing used in the backbone is acceptable when the cabling will be supporting voice applications only.

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Optical Fiber Splice Limitations

3.51 Optical fiber splices used in the backbone shall be limited to achieve an acceptable link attenuation budget.

Cabling Directly Between Telecommunications Rooms (aka Tie Cabling)

If requirements for 'bus' or 'ring' configurations are anticipated, tie cabling directly between distributors may be done. Tie cables providing direct peer-to-peer connections between distributors are optional and, when provided, shall be in addition to that required for the basic hierarchical topology.

3.4.2.6. *Recognized Backbone Cables*

The following types of cable are supported by the Siemon Cabling System. These types are:

- Four-pair 100 Ω balanced twisted-pair
- Multi-pair 100 Ω balanced twisted-pair (voice only)
- Multimode optical fiber cable OM1, OM2, OM3 & OM4
- Singlemode optical fiber cable OS1a and OS2

3.4.2.7. *Backbone Cabling Component Specifications*

Components used in the backbone Cabling system are subject to the following requirements:

Backbone Twisted-Pair & Optical Fiber Cables

3.52 Balanced twisted-pair and optical fiber cables shall be Qualified Cables for use in the Siemon Cabling System. Refer to the Siemon Partner Support Center, for a listing of Qualified Cables.

Other cable types used to serve special needs are in addition to the minimum requirements of this manual. Other media choices are outside the scope of the Siemon Cabling System.

When a qualified cable is not available to meet specific installation needs, the Authorized Designer/Installer is responsible for submitting Siemon Cabling System Request For Exception prior to installation for approval.

3.53 All connecting hardware used with 100 Ω balanced twisted-pair cables and all connecting hardware used with optical fiber cables shall be provided by Siemon.

3.54 All patch cords and equipment cables used to cross-connect or interconnect 100 Ω balanced twisted-pair, multimode and singlemode optical fiber cabling for use in a Siemon Cabling System Warranty, shall be manufactured by Siemon.

For field terminated cable assemblies, see note below.

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NOTE: The construction of patch cords and equipment cables incorporating double ended S110P, S210P, Z-PLUG or TERA plugs can be performed by the Certified Installer (Company). The use of which in a Channel Model qualifies the channel for applications assurance under the Siemon System Warranty.

In respect to switch harness cords (IC Series) for Category 5e or higher modular to S110P or S210P, Z-MAX and TERA assemblies, the certified installer (company) can purchase these factories assembled or they may be purchased as double-ended modular-to-modular assemblies (typically double the length) cut in half and terminated to the S110P or S210P on the cut end leaving the factory assembled modular plug as it is.

Choosing Backbone Cabling Media

Considerations that factor into the selection and quantity of backbone cable pairs and fibers include:

- The planning life of the backbone system
- The bandwidth requirements for current and future applications
- The number of Work Areas and/or services to be supplied to a given backbone segment served by a given segment
- Redundancy and high availability service planning

Whenever possible, the different service requirements should first be determined. It is often convenient to group similar services together in a few categories such as voice, display terminal, Local Area Networks (LAN) and other digital connections. Within each group, individual types should be identified and required quantities projected.

When uncertain, use 'worst case' scenarios when evaluating different Backbone cabling alternatives. The higher the uncertainty, the more flexible the Backbone cabling system needs to be.

Each recognized cable has individual characteristics that make it useful in a variety of situations. A single cable type may not satisfy all the user requirements at a site. It is then necessary to use more than one medium in the backbone cabling.

The following requirements and recommendations are provided for backbone cabling runs within a building.

Optical Fiber Cabling

3.55 For each building backbone channel that is greater than 100 m (328 ft) in length, optical fiber cable shall be provided to support data applications.

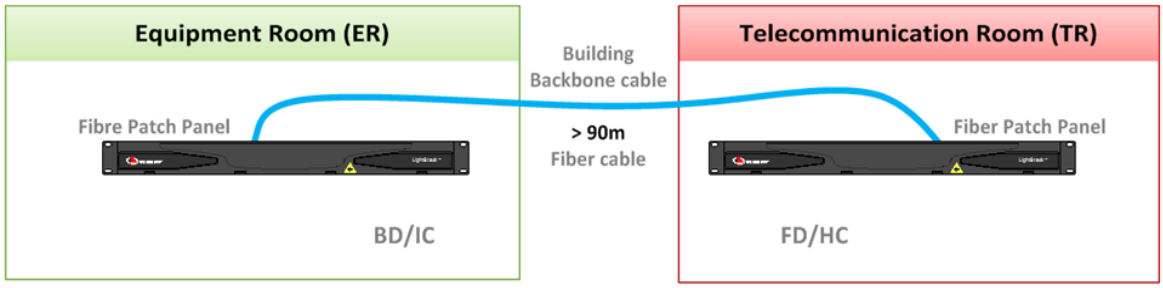

Figure 3-29: Optical Fiber Backbone

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3.16 *It is recommended that at least two optical fiber cores/strands be provided for every known application to be served by the building backbone over its planning period. A growth factor of 100% should be provided.*

Table 3-2: Fiber Building Backbone Sizing Example

APPLICATION	FIBER COUNT
Voice	2
Video (Security)	2
LAN (10GBASE-S)	2
Growth	6
TOTAL	**12**

For this example, a 12-fiber building Backbone cable is recommended. This number is in addition to fibers considered for redundancy.

Balanced Twisted-Pair Cabling

3.56 If the building backbone channel is less than or equal to 100 m (328 ft) in length, and optical fiber is not installed, 4-pair balanced twisted pair category 6 or higher Backbone cable shall be provided to support data applications.

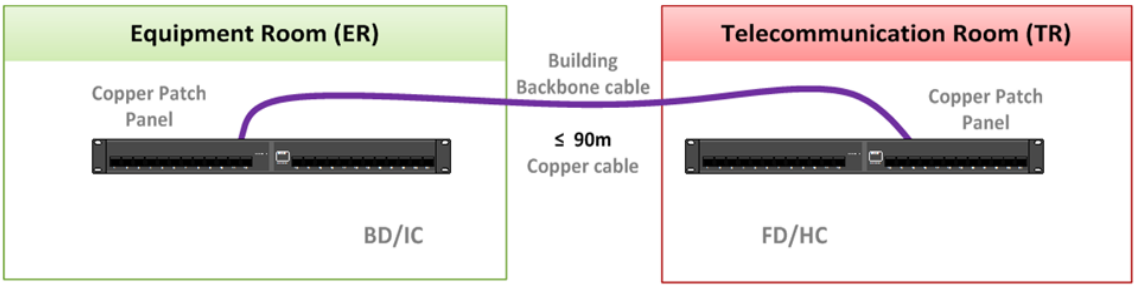

Figure 3-30: Balanced Twisted Pair Building Backbone Channel

3.17 *It is recommended for sizing multi-pair Backbone that at least one cable pair (category 3 or higher) be provided for each Work Area served by the building Backbone segment.*

This recommendation provides for a minimum of one pair per Work Area to support voice applications and at least one additional pair for growth or for ancillary devices.

Campus Backbone Cabling

The following requirements and recommendations are provided for all Backbone cabling runs that extend between buildings.

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Optical Fiber Cabling

3.57 For each campus Backbone run, optical fiber cable shall be provided to support data applications.

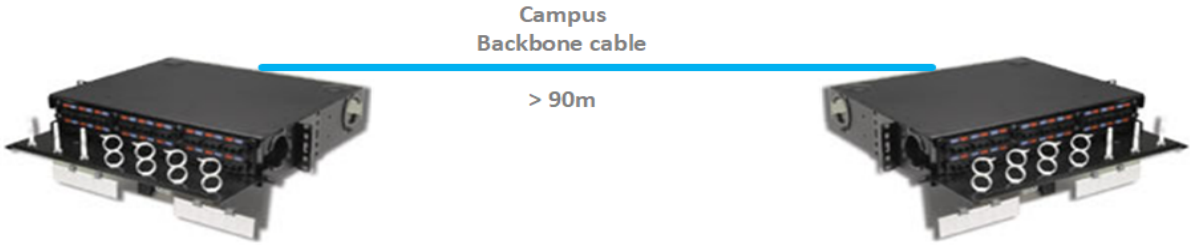

Figure 3-31: Optical Fiber Building Backbone Channel

Fiber is the preferred media for campus runs because it typically provides more bandwidth than twisted-pair cabling and is immune to ground loop problems that may occur between buildings for some types of metallic media.

3.18 *It is recommended that at least two optical fiber cores/strands be provided for every known application to be served by the campus Backbone over its planning period. A growth factor of 100% should be provided.*

Table 3-3: Fiber Campus Backbone Sizing Example

APPLICATION	FIBER COUNT
Voice	2
Video (Security)	2
Video (Interactive)	2
LAN (10GBASE-S)	2
LAN (FDDI)	4
Growth	12
TOTAL	**24**

For this example, a 24-fiber campus backbone cable is recommended. Although this is a recommendation, consideration should be given for the environment in which these additional strands will be stored.

Balanced Twisted-Pair Cabling

3.19 *It is recommended for sizing the multi-pair campus backbone a minimum of one cable pair (category 3 or higher) be provided for each WA served by the campus backbone segment.*

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This recommendation provides for a minimum of one pair per WA to support voice applications and at least one additional pair for growth or for ancillary devices. For the campus backbone the provision of extra pairs is highly recommended based on the potential difficulty of adding additional cable later.

3.4.2.8. *Backbone Cabling Distances*

The following requirements and recommendations apply to all portions of the backbone cabling. The connection of multiple campuses or buildings that extend beyond the distance limits specified in this section are outside the scope of the Siemon Cabling System. Equipment manufacturers, application standards and systems providers should be consulted before selecting the backbone medium.

Backbone Maximum Lengths Limits

Backbone cabling lengths are dependent upon the application and upon the specific media.

3.58 The maximum backbone channel length (balanced twisted-pair and optical fiber) shall be based on the application distance limits, type of media and optical loss budget (for optical fiber) as specified in Chapter 13 – Application Distances.

Backbone Cabling Links and Channels

For the purposes of this section, two terms are used to distinguish between backbone cabling segments with and without equipment cables. These terms are backbone permanent link model and backbone channel model.

Backbone Permanent Link Model

A backbone permanent link model includes the backbone connecting hardware and the cable between the connecting hardware.

Backbone Channel Model

A backbone channel model includes all components of the backbone permanent link including jumpers/patch cords and equipment cables.

Campus Distributor/Main Cross-Connect to Entrance Point

3.20 *Cable lengths between the entrance point and the CD/MC should be documented in the applicable cable records. For more information on cable records, see the Administration section of this manual.*

Equipment Connections

Although equipment cables are an integral part of the telecommunications network. Therefore, the following requirements must be met to assure that applications will operate properly over the backbone cabling system.

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Maximum Length of Cross-Connect Jumpers/Patch Cords and Equipment Cables

3.59 ***The total combined length of category 5e and higher balanced twisted-pair cross-connect jumpers/patch cords and equipment cables in a channel shall be determined by the following:***

C = (102 - B) / (1 + D)

where:

C = Combined length of patch cords/jumpers and equipment cables on both ends of a Backbone channel

B = Length of fixed Backbone cable

D = 0.2 for 24 and 26 AWG cables; 0.5 for 28 AWG cables

** ISO uses 105 for category 5e. The Siemon Company has chosen to be more stringent to provide better channel performance. This also allows for formula consistency.*

Table 3-4: Maximum Cable Lengths in Backbone Cabling

Length of Backbone Cable (B) m (ft)	Maximum Combined Length of Patch Cord and Equipment Cable (C) M (ft)	
	24/26 AWG	28 AWG
m (ft)	m (ft)	m (ft)
90 (295)	10 (33)	8 (26)
85 (279)	14 (46)	11 (35)
80 (262)	18 (59)	15 (49)
75 (246)	22 (72)	18 (59)
70 (230) or less	26 (85)	21 (70)

NOTE: For balanced twisted-pair, if the formula is not utilized, the total combined length of cross-connect jumpers/patch cords between the CD/MC and BD/IC, or BD/IC and FD/HC, or CD/MC and FD/HC, and equipment cables must not exceed 10 m (33 ft) in length if the backbone channel is ≤100 m (328 ft) if applications assurance is desired.

Example: If the length of the fixed balanced twisted pair cable (CD/MC to FD/HC) is 85 m (278 ft) long, then the combined length (both ends) of equipment cables and cross-connections may be up to 14 m (46 ft) long. However, if the length of the fixed cabling is 90 m (295 ft) long, then the combined length (both ends) of equipment cables and cross-connections may be up to only 10m (33 ft) long.

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3.4.3. Campus Topology

When present, the campus backbone cabling subsystem includes

- the campus backbone cables,
- components in building entrance facilities,
- the jumper and patch cords at the campus and building distributors (usually located in
- separate buildings),
- the connecting hardware on which the campus backbone cables are terminated (at the campus and building distributors).

This document is optimized for premises in which the maximum distance over which telecommunications services can be distributed is 2 000 m. The principles of this document can be applied to larger installations.

Installations in which the maximum distance used to support telecommunications services is over than 2000meters are not considered by standards for structural cabling, but the principles of these standards can be applied to larger installations.

Campus pathways interconnect separate buildings such as in campus environments. These consist of underground, buried, aerial, and tunnel pathways.

Note: Campus pathway design is outside the scope of the Siemon Cabling System, however, requirements involving the media choices, length, fill capacity and bend radii limitations shall be met

3.5. Telecommunications Spaces

3.5.1. Telecommunications / Distributor Room

General

The requirements and recommendations for Telecommunication Spaces are provided within this section. Telecommunications Spaces should be designed to be compatible with the worst-case environment to which they are exposed. Telecommunications spaces include a variety of rooms and locations that are used by a building's occupants to interact with telecommunications equipment, and are a location for the placement, termination, and interconnection of cabling and telecommunications equipment.

Common Requirements and Recommendations for all Spaces

Standards, Codes and Regulations

3.60 All applicable standards, codes and regulations shall be met.

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3.5.2. Pathways

3.61 Sleeves, slots and penetrations shall not be left open except during cable installation and shall be properly fire stopped per applicable standards, codes and regulations and designed such that they can re-opened and sealed without causing any damage to the installed cabling.

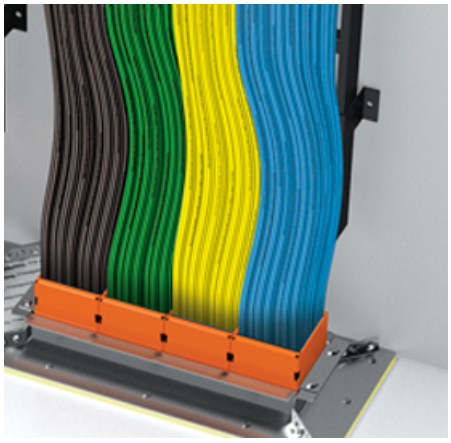

Figure 3-32: Firestopping Example

3.5.3. Cabling Practices

3.62 Appropriate means for cable management, cable routing, and the elimination of cable stress shall be used for effective organization and management of all cables and connecting hardware in the Telecommunication Space.

3.21 *All Horizontal cable terminations serving a Work Area should be terminated in the same Telecommunication Space.*

3.63 Telecommunications cabling and pathway systems contained within these spaces shall meet the requirements specified in this manual.

3.5.4. Security

3.22 *The design and location of the space should be developed in accordance with the security plan of the building.*

3.5.5. Location

Avoid locations that are restricted by building components that limit expansion such as elevators, core, outside walls, or other fixed building walls.

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3.64 Telecommunications spaces shall be located away from sources of electromagnetic interference as per the requirements. Special attention shall be given to electrical power supply transformers, motors and generators, X-ray equipment, radio or radar transmitters.

3.23 *In order to make optimum use of the horizontal star topology and to avoid the added expense of multiple rooms, it is recommended that floor serving Telecommunication spaces be located near the geographic center of the floor space that it is intended to serve.*

3.65 Telecommunications spaces shall not be located below water level unless preventive measures against water infiltration are employed. The telecommunications space shall be free of water or drain pipes not directly required in support of the equipment within the room.

3.5.6. Access/Function

Telecommunications spaces are best located in an accessible area such as a common hallway. Consideration must also be given to eliminate cable runs that may exceed maximum length requirements. Access to the space is best regulated by the building owner.

3.66 Telecommunication spaces shall be dedicated to the telecommunications function.

3.67 Access to the Telecommunications Room shall be restricted to authorized service personnel and not be shared with building services that may interfere with the telecommunications systems or be used for building maintenance services.

3.24 *The telecommunications space should not have exterior windows.*

Exterior windows may increase heat load within the space reducing the effectiveness of system controlling temperature and humidity.

Lighting

3.25 *Minimum and emergency lighting levels should be installed as per local standards and requirements, such as a minimum of 500 lx measured 1meter (3 ft) above the finished floor.*

Ceilings

3.26 *To facilitate the routing of Horizontal cables, Telecommunications Spaces should not have suspended/false ceilings. Minimum clear height in the space shall be 2.4 m (8 ft) without obstructions. The height between the finished floor and the lowest point of the ceiling should be a minimum of 3 m (10 ft) to accommodate taller frames and overhead pathways.*

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Door Recommendations

3.27 *The door should be a minimum of 0.9 m (36 in) wide and 2.0 m (80 in) high, without door sill, hinged to open outward (or slide side-to-side), and be fitted with a lock. This also applies to the Equipment Room and Entrance Facility.*

3.28 *The doorway to Telecommunications Spaces should be of adequate size to allow the installation of premises equipment. Consideration should also be given to its placement relative to sleeves and slots to facilitate cable installation.*

Protective Finishes

3.29 *Floors, walls, and ceiling should be treated to eliminate dust and should be designed to reflect laser emissions. Finishes should be light in color to enhance room lighting. This also applies to the Equipment Room and Entrance Facility.*

Electrical Power

3.30 *An adequate number of electrical outlets, each on a separate branch circuit, should be provided for equipment power.*

3.31 *Telecommunication spaces should not have electrical breaker panels that service areas other than the Telecommunications space they are contained within.*

As a minimum, two dedicated non-switched, AC duplex electrical receptacles, each on a separate branch circuit, should be provided for equipment power. In addition, identified and marked convenience duplex outlets should be placed at 1.8 m (6 ft) intervals around the perimeter walls, at a height in accordance with regional and or disability standards and requirements.

Environmental

3.32 *Consideration should be given on how to maintain the temperature and humidity as well as other environmental conditions to allow the continuous operation of active equipment.*

Other environmental factors that should be addressed include standby power facilities, mechanical vibration which could loosen connections over time, and airborne contaminates and pollutants that could affect operations and material integrity of the installed equipment.

Grounding Requirements

3.68 Grounding/Earthing and Bonding requirements shall comply with applicable standards, codes and regulations.

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TELECOMMUNICATIONS ROOM (AKA-Distributor Room):

The primary purpose of the Telecommunications Room is horizontal cable distribution, and as such, they are generally considered to be floor serving facilities. Formerly known as IDF rooms, wiring closets or satellite rooms, Telecommunications Rooms are used to connect Horizontal cabling to Backbone cabling and telecommunications equipment. They are specifically intended to house telecommunications equipment, cable terminations, and cross-connects. The Telecommunications Room may also contain information technology equipment and building automation systems (BAS) equipment and cabling.

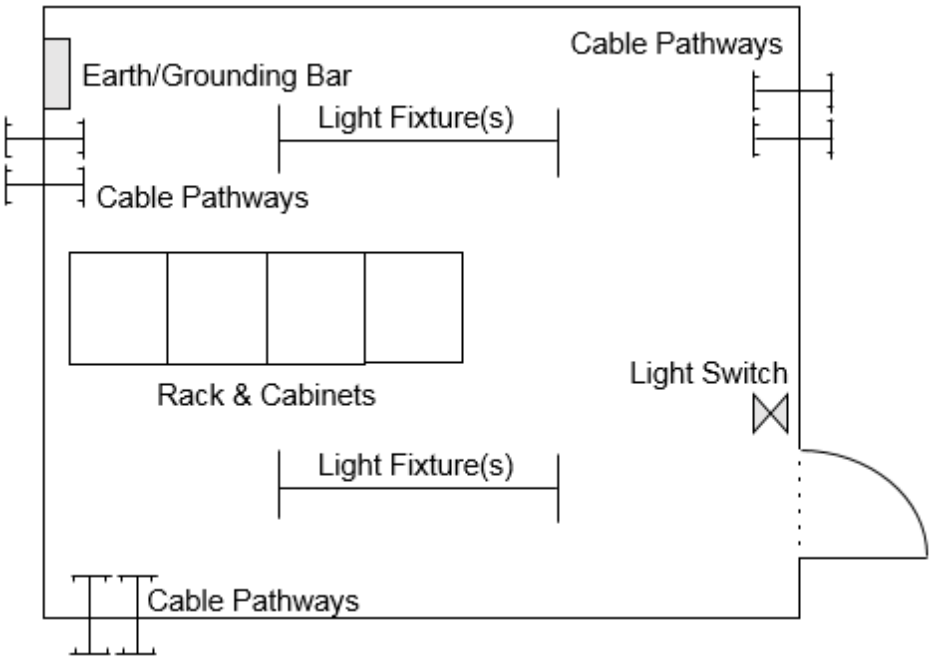

Figure 3-33 - Telecommunications Room Example (Typical)

General

3.69 The Telecommunications Room shall be dedicated to the telecommunications function and related support facilities. The Telecommunications Room shall not be shared with electrical installations or building services not related to telecommunications infrastructure.

3.70 Equipment not related to the support of the Telecommunications Room (e.g., piping and ductwork) shall not be installed in, pass through or enter the space.

Location

Locating Telecommunications Rooms near the center of the area served reduces cabling distances and should be a primary design criterion for new buildings and building renovations.

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3.33 *In order to provide an infrastructure that can accommodate a dynamic office environment a minimum of one Telecommunications Room per floor is strongly recommended. Work Areas should only be served by the room on that floor. Additional spaces per floor should be considered if the intended media will exceed its maximum length limitations.*

Room Linkage

3.34 *Backbone linkages between multiple rooms on the same floor are strongly recommended. This linkage is in addition to the minimum for a hierarchical star.*

Size

The Telecommunications Room should be sized to meet known requirements such as the function of the room, the amount of equipment, equipment racks and the number of TO's that it will serve. Sizing should include present as well as projected future requirements.

3.35 *It is recommended that the minimum dimension of the Telecommunications Room not be less than 3 m (10 ft) for length and width, which would should be adequate for up to 100 TO's. Room sizing to accommodate up to 2400 TO's should be 9 m (30 ft) x 12 m (40 ft).*

Alternative Spaces (Distributor Enclosure)

When a Telecommunications Room cannot be allocated because of building limitations or constraints, equipment rack enclosures or cabinets may be suitable replacements for Telecommunications Rooms. The distributor enclosure is a common access point for Cabling Subsystems and building pathways. The distributor enclosure must be able to contain telecommunications equipment, cable terminations, and associated cross-connect cabling.

3.71 The enclosure or cabinet shall be dedicated to the telecommunications function and related support facilities.

3.36 *Telecommunications enclosures should be centrally located within the area it is intended to serve*

3.72 Enclosures or cabinets used as alternative spaces shall meet the clearance requirements of applicable standards, codes and regulation as well as having a lockable door. The enclosure or cabinet shall also be mounted in a fixed location.

3.37 *Enclosures or cabinets used as alternative spaces should meet the lighting, power and environmental recommendations for Telecommunications Rooms.*

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The enclosure or cabinet door(s) should be hinged or removable. If the door(s) is hinged, the enclosure should be mounted so that the door(s) swings open a minimum of 90°, or otherwise provides unobstructed access to the inside of the enclosure or cabinet.

3.73 Sufficient working space shall be provided and maintained for a technician to gain unobstructed access to the enclosure or cabinet in order to perform proper terminations of connecting hardware in a safe working environment.

EQUIPMENT ROOM (Building distributor):

Equipment Rooms typically contain a vast portion of the telecommunications equipment, cable terminations, and cross-connects. They may be thought of as serving the entire building or campus.

Any or all of the functions of Telecommunications Rooms, Telecommunications Enclosures or Building Entrance Facility may alternatively be provided by an Equipment Room. Equipment Rooms are mainly used for Backbone and equipment terminations.

3.74 The equipment room shall house only equipment directly related to the telecommunications system and its environmental support systems.

Figure 3-34: Equipment Room Example (Typical)

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Location

3.38 *Equipment Room placement should avoid areas which could limit its expansion like elevators, fixed support walls and mechanical areas. When practical, in a multi-story building it is recommended that the Equipment Room be located on the middle floor of the building it is serving and in a location that provides easy access for the cabling pathways to Telecommunications Rooms on other floors.*

This enables optimum use of the Backbone topology and permits the use of a stacked vertical path between facilities. The Equipment Room should be located in an area that will allow future expansion and should be accessible to freight elevators for delivery of large equipment.

Size

The Equipment Room should be sized to meet known requirements such as the function of the room, the amount of equipment, equipment racks and the number of TO's that it will serve. Sizing should include present as well as projected future requirements. In addition, the Equipment Room should be based on the floor space served as well take into account both Backbone and Horizontal cross-connects, as well as equipment connections, work areas of service personnel, access clearances and passages

3.39 *An Equipment Room should be sized at a minimum of 11 m2 (120 ft2) for building with gross area of up to 50,000 m2 (500,000 ft2). In larger buildings the size of the room should be increased in increments of 1 m2 (10 ft2) for every increase of 10,000 m2 (100,000 ft2) in gross building area.*

3.5.7. Multi-Tenant Building Spaces

In multi-tenant buildings, a room or space may be allocated, that is common to a portion or all tenants.

3.40 *A common room or space should contain only those facilities that serve multiple tenants in a building. Tenant/customer equipment should not be located in a common room or space.*

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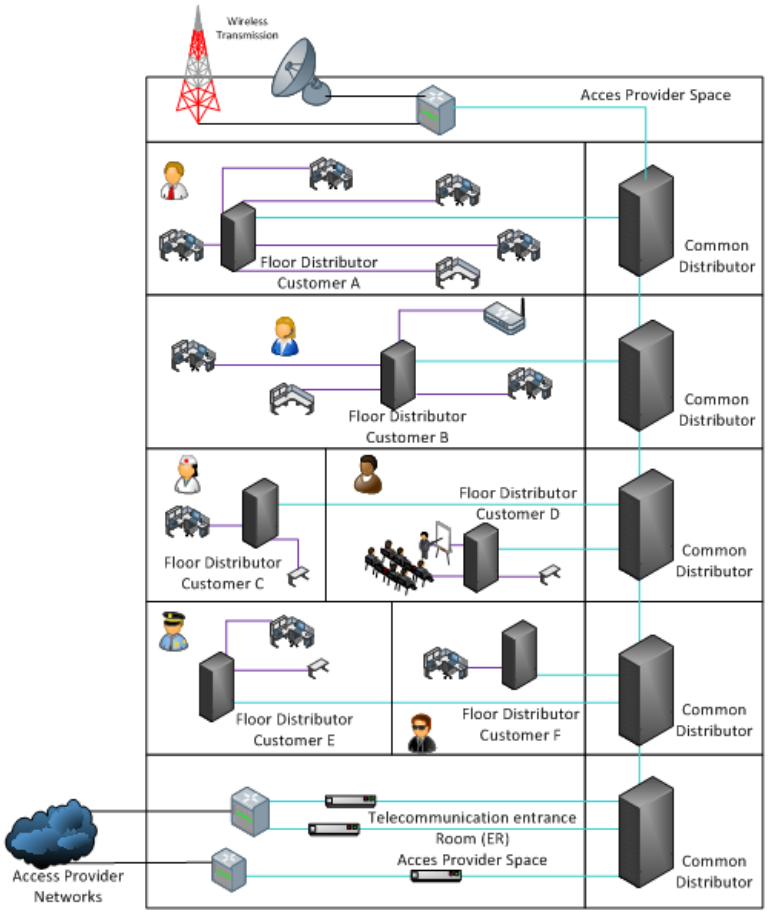

Figure 3-35: Multi-tenant Building Example

Location

3.41 *Whenever possible, common distributor rooms or spaces in multi-story buildings should be vertically aligned. Also, the common room or space should be located central to the area served and accessible.*

Access/Service Provider Spaces

The Access/Service Provider spaces are used for the location of transmission, reception and support equipment. When used, they may combine the features of an Entrance Facility and an Equipment Room. This space is usually used as a separate space in multi-tenant buildings to serve all tenants.

Access/Service provider equipment is often designed to operate in extreme environmental conditions such as temperature. Air handling requirements should be based on potential heating and cooling demand associated with the equipment.

3.75 When used, the Access/Service Provider space shall follow the same requirements of the Equipment Room and Building Entrance Facility as it relates to cable practices, terminations, EMI and grounding.

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3.42 *When Access/Service Providers share space, individual spaces should be segregated by means such as partitions like walls or cages.*

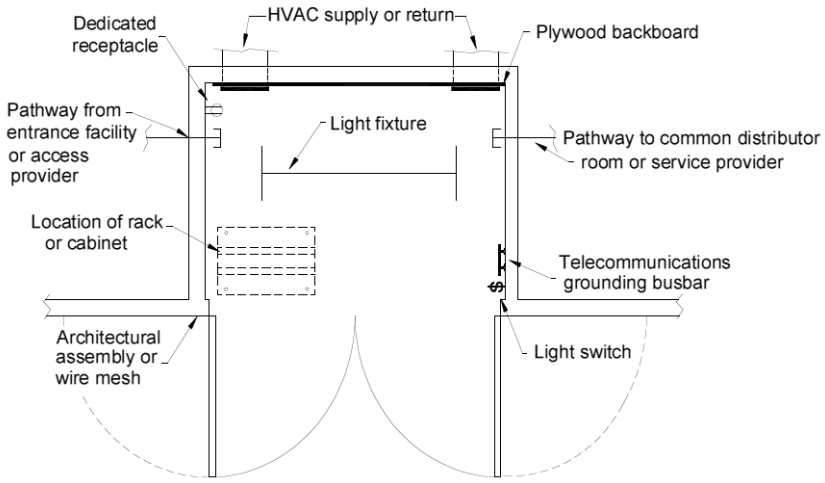

Figure 3-36: Access Equipment Provider Space Example (Typical)

3.5.8. Building Entrance Room / Space

The Building Entrance Facility typically contains the network demarcation point as well as campus and building Backbone facilities.

The network demarcation point is the location within a building where the access provider (AP) installs an interface device for the customer premises cabling. This is the point at which the AP is released from liability as far as transmission and or circuit integrity. This service is regulated by applicable standards, codes and local regulatory agencies.

The Building Entrance Room or Space is the component of the Entrance Facility that provides space for the termination of entrance and Backbone cable. It may contain network interface devices and telecommunications equipment. The decision whether a room or open area is provided as an entrance facility is based on security, quantity, type of protection, size of building and physical location within a building.

An alternate Entrance Facility should be provided where security, continuity of service, or other special needs exist (such as dual entry of services).

Location

3.76 The Entrance room or space shall be located in a dry area not subject to flooding.

3.43 *The Entrance room or space should be as close as practicable to the building entrance point and next to the space containing the main electrical distribution panel in order to reduce the length of bonding conductor to the electrical grounding system.*

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Considerations to the location of the Entrance Facility or space include: security, quantity and type of terminations and equipment, size of building, physical location within the building, and grounding and bonding per codes and regulations.

Size

3.44 *The entrance room or space should be sized to meet the known requirements and include projected future as well as present requirements.*

The size of the termination frame or wall terminations is based on the quantity of cable to be terminated, which includes, incoming service provider cables, protectors, campus cables and building cables.

3.45 *The size of the Entrance Facility should take into account all types of equipment required as well as any connecting hardware requirements, including present and future needs.*

In buildings with up to 10,000 m^2 (100,000 ft^2) of usable floor space, wall-mounted terminating hardware may be suitable along with free standing racks/cabinets for cable terminations.

3.77 Circuit protection (Primary Protection) for cabling which enters or exits a building shall comply with applicable standards, codes and regulations.

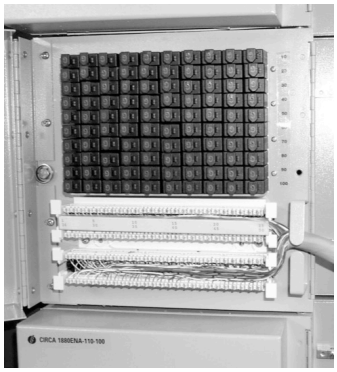

Figure 3-37: Primary Protection Example

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Layout

The layout for a typical underground access to a Building Entrance Facility is shown below.

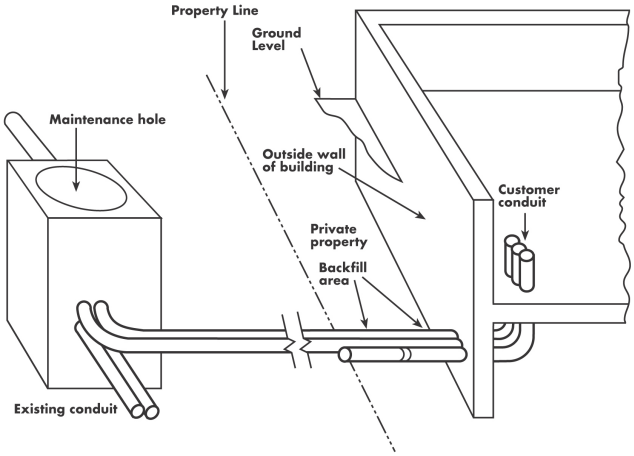

Figure 3-38: Underground Access to Building Entrance Facility Example

External Pathways

Entrance Facility external pathway design and installation are outside the scope of the Siemon Cabling System.

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NORMATIVE SUMMARY

3.1 To avoid problems caused by electromagnetic emissions from power cables and other premises equipment, the requirements of Annex C shall be met for all horizontal and backbone cabling and pathways.

3.2 The physical topology of the horizontal cabling shall be configured as a star with each TO connected to a FD/HC.

3.3 Cross-connections shall be used for connections between horizontal and backbone cabling.

3.4 Each WA shall be served by a FD/HC located on the same or adjacent floors.

3.5 All devices that are specifically intended to support a given application shall be installed external to the TO and the FD/HC field.

3.6 Connecting hardware shall not be installed in locations which may be in violation of applicable standards, codes and regulations or areas outside of the product rating.

3.7 Bridged taps shall not be used in the horizontal cabling.

3.8 Copper splices shall not be used for horizontal balanced twisted-pair cabling.

3.9 No more than two optical fiber splices (for the deployment of pigtails terminations) shall be permitted in the horizontal cabling between a given transmitter and receiver. Where a CP is used, four splices are permissible provided that the overall losses are within the link loss budget.

3.10 The length of cable between the TO and the FD/HC shall not exceed 90m (295 ft) regardless of media type.

3.11 For the Siemon Z-MAX Category 6A system, a minimum distance of 3m (10 ft) is required between the FD/HC and the TO.

3.12 The combined length of balanced twisted-pair patch/equipment cords or optical fiber jumpers, which are used to form an interconnection or cross-connection shall not exceed 5m (16 ft) in the FD.

3.13 The maximum length of balanced twisted-pair or optical fiber work area cables/cords shall not exceed 5m (16ft), when serving an individual users WA.

3.14 Unless otherwise specified in the appropriate Siemon Cabling System warranty document, the minimum patch cord length shall be 1m (3 ft.).

3.15 The maximum channel length of balanced twisted-pair or optical fiber cable including equipment cables at both ends plus the optional cross-connection (jumpers/patch cords) at the FD/HC, shall not exceed 100 m (328 ft) combined.

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3.16 Balanced twisted-pair and optical fiber cables shall be Qualified Cables for use in the Siemon Cabling System. Refer to the Siemon Partner Support Center, for a listing of Qualified Cables.

3.17 All connecting hardware used with 100 Ω balanced twisted-pair cables and all connecting hardware used with optical fiber cables shall be provided by Siemon.

3.18 All patch cords and equipment cables used to cross-connect or interconnect 100 Ω balanced twisted-pair, multimode and singlemode optical fiber cabling for use in a Siemon Cabling System Warranty, shall be manufactured by Siemon.

3.19 A minimum of two TO's shall be provided for each individual Work Area for compliance in a Siemon Cabling System Warranty and as specified by applicable cabling standards. These outlets may be located in one or more faceplates in the Work Area.

3.20 The cable that extends from the MUTOA in a WA is an equipment cable and:

- ***shall not terminate to an additional TO in the WA.***
- ***shall be connected directly to the WA station equipment (i.e. phone computer)***
- ***shall be labeled on both ends with a unique cord identifier***

3.21 The maximum combined length of work area cable, patch cord and equipment cables for use with a MUTOA shall be determined by using the following formula or table:

C = (102 - H) / (1 + D)

3.22 The MUTOA shall be marked with the maximum allowable WA equipment cable length.

3.23 The MUTOA shall be located in fully accessible, permanent locations, such as building columns and permanent walls.

3.24 No more than one CP shall be permitted within the same horizontal cable run, in addition:

- ***Active equipment shall not be permitted at a CP.***
- ***Cross-connections shall not be used at a CP.***

3.25 Each horizontal distribution cable entering/exiting the CP shall have all pairs terminated and shall comply with the following lengths:

- ***The minimum distance between the FD/HC and the CP shall be 15 m (50 ft).***
- ***The minimum distance between the CP and the TO shall be 5 m (16 ft).***
- ***The maximum channel distance shall not exceed 100 m (328 ft).***

3.26 Each cable extending to the TO from the CP shall be terminated to an TO or MUTOA; not for direct connection to active equipment.

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3.27 The CP shall be located in fully accessible, permanent locations, such as building columns, and permanent walls; not in obstructed areas nor within furniture systems unless that unit of furniture is permanently secured to the building structure.

3.28 The use of suspended ceiling space or access floor space for CP's may be acceptable, provided that:

- ***The use of such space shall not violate applicable building codes,***
- ***It shall be accessible without moving building fixtures, equipment, or heavy furniture (e.g., file cabinets weighing 45 kg [100 lb] or more),***
- ***It does not disturb building occupants***

3.29 The maximum allowable distance for centralized optical fiber cabling is dependent on the application and media chosen.

3.30 The balanced twisted-pair equipment cables shall be suitable for the environment in which it is installed (indoor, indoor/outdoor & OSP)

3.31 The optical fiber equipment cables shall be of:

- ***Duplex construction***
- ***The same fiber type as the cabling***
- ***Suitable for the environment in which it is installed (indoor, indoor/outdoor & OSP)***

3.32 The Siemon Cabling System requires keyed, duplex, optical equipment cords to be used at the WA. These would include:

- ***LC style***

3.33 SC style All 4-pair balanced twisted-pair cables wired to the TO shall have all 4-pairs fully terminated.

3.34 Optical fibers at the equipment outlet shall be terminated to a duplex connector or array connector. It is permissible to leave unused cores dark for future use.

3.35 Category 5e, 6 and 6A balanced twisted-pair pin and pair grouping assignments shall be T568A or T568B.

3.36 TO's shall be securely mounted at planned locations.

3.37 Warehouse/Assembly workbench locations, where a hanging box is used, shall be installed with mounting components made specifically for these locations.

3.38 The fiber outlet shall have the ability to secure the optical fiber cable, provide for a mechanism to ensure a minimum 25 mm (1.0 in) bend radius, and to store a minimum of 1m (3 ft) of two-fiber optical cable or two buffered optical fibers for termination purposes.

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3.39 When using pathways incorporated into furniture or partitions, installed cabling shall comply with all applicable standards, codes and regulations.

3.40 Horizontal cable that runs between the HC/FD and the TO shall not be exposed in the WA or other spaces with public access.

3.41 TO's shall be mounted in locations and at heights above the finished floor that are compliant to applicable standards, codes and regulations.

3.42 The backbone cabling shall use the conventional hierarchical star topology.

3.43 There shall be no more than two subsystems of cross-connects in the backbone cabling. From the FD/HC, no more than one cross-connect shall be passed through to reach the CD/MC.

3.44 Cross-connections shall be used for connections between horizontal and backbone cabling, between first level backbone and second level backbone cabling and for connections between backbone cabling and premises equipment with multiple port outputs (such as 25-pair connectors).

3.45 Connecting hardware shall not be installed in locations which may be in violation of applicable standards, codes and regulations or areas outside of the product rating.

3.46 All devices that are specifically intended to support a given application shall be installed external to the CD/MC or BD/IC.

3.47 Bridged taps shall not be used as part of the Backbone cabling.

3.48 Splices shall not be used on four-pair balanced twisted pair cables.

3.49 Where multipair copper cable is used in the backbone (campus backbone and building backbone), the number of splices shall be kept to the minimum required by the physical system design or installation constraints.

3.50 When used, splices shall be constructed using insulation-displacement type connectors and housed in enclosures appropriate for the environment.

3.51 Optical fiber splices used in the backbone shall be limited to achieve an acceptable link attenuation budget.

3.52 Balanced twisted-pair and optical fiber cables shall be Qualified Cables for use in the Siemon Cabling System. Refer to the Siemon Partner Support Center, for a listing of Qualified Cables.

3.53 All connecting hardware used with 100 Ω balanced twisted-pair cables and all connecting hardware used with optical fiber cables shall be provided by Siemon.

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3.54 All patch cords and equipment cables used to cross-connect or interconnect 100 Ω balanced twisted-pair, multimode and singlemode optical fiber cabling for use in a Siemon Cabling System Warranty, shall be manufactured by Siemon.

For field terminated cable assemblies, see note below.

3.55 For each building backbone channel that is greater than 100 m (328 ft) in length, optical fiber cable shall be provided to support data applications.

3.56 If the building backbone channel is less than or equal to 100 m (328 ft) in length, and optical fiber is not installed, 4-pair balanced twisted pair category 6 or higher Backbone cable shall be provided to support data applications.

3.57 For each campus Backbone run, optical fiber cable shall be provided to support data applications.

3.58 The maximum backbone channel length (balanced twisted-pair and optical fiber) shall be based on the application distance limits, type of media and optical loss budget (for optical fiber) as specified in Chapter 13 – Application Distances.

3.59 The total combined length of category 5e and higher balanced twisted-pair cross-connect jumpers/patch cords and equipment cables in a channel shall be determined by the following:

C = (102 - B) / (1 + D)

where:

C = Combined length of patch cords/jumpers and equipment cables on both ends of a Backbone channel

B = Length of fixed Backbone cable

D = 0.2 for 24 and 26 AWG cables; 0.5 for 28 AWG cables

**** ISO uses 105 for category 5e. The Siemon Company has chosen to be more stringent to provide better channel performance. This also allows for formula consistency.***

3.60 All applicable standards, codes and regulations shall be met.

3.61 Sleeves, slots and penetrations shall not be left open except during cable installation and shall be properly fire stopped per applicable standards, codes and regulations and designed such that they can re-opened and sealed without causing any damage to the installed cabling.

3.62 Appropriate means for cable management, cable routing, and the elimination of cable stress shall be used for effective organization and management of all cables and connecting hardware in the Telecommunication Space.

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3.63 Telecommunications cabling and pathway systems contained within these spaces shall meet the requirements specified in this manual.

3.64 Telecommunications spaces shall be located away from sources of electromagnetic interference as per the requirements. Special attention shall be given to electrical power supply transformers, motors and generators, X-ray equipment, radio or radar transmitters.

3.65 Telecommunications spaces shall not be located below water level unless preventive measures against water infiltration are employed. The telecommunications space shall be free of water or drain pipes not directly required in support of the equipment within the room.

3.66 Telecommunication spaces shall be dedicated to the telecommunications function.

3.67 Access to the Telecommunications Room shall be restricted to authorized service personnel and not be shared with building services that may interfere with the telecommunications systems or be used for building maintenance services.

3.68 Grounding/Earthing and Bonding requirements shall comply with applicable standards, codes and regulations.

3.69 The Telecommunications Room shall be dedicated to the telecommunications function and related support facilities. The Telecommunications Room shall not be shared with electrical installations or building services not related to telecommunications infrastructure.

3.70 Equipment not related to the support of the Telecommunications Room (e.g., piping and ductwork) shall not be installed in, pass through or enter the space.

3.71 The enclosure or cabinet shall be dedicated to the telecommunications function and related support facilities.

3.72 Enclosures or cabinets used as alternative spaces shall meet the clearance requirements of applicable standards, codes and regulation as well as having a lockable door. The enclosure or cabinet shall also be mounted in a fixed location.

3.73 Sufficient working space shall be provided and maintained for a technician to gain unobstructed access to the enclosure or cabinet in order to perform proper terminations of connecting hardware in a safe working environment.

3.74 The equipment room shall house only equipment directly related to the telecommunications system and its environmental support systems.

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3.75 When used, the Access/Service Provider space shall follow the same requirements of the Equipment Room and Building Entrance Facility as it relates to cable practices, terminations, EMI and grounding.

3.76 The Entrance room or space shall be located in a dry area not subject to flooding.

3.77 Circuit protection (Primary Protection) for cabling which enters or exits a building shall comply with applicable standards, codes and regulations.

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4. CONVERGEIT

4.1 Cabling for Intelligent Buildings

4.1.1 Structured Cabling Supporting Smart Buildings

There is a growing trend to utilize the structured cabling system to support Building Automation Systems (BAS) within Converged Intelligent Buildings and any other devices that can be controlled by IP interfaces or where low voltage applications/systems (including remote powering) are required.

Traditionally building control and management was managed by many different service and application providers each using application-specific media to control their own section of the building be it either power management or heating control systems. New buildings and refurbishment projects are now looking to develop a fully centralized, integrated platform where all of the BAS systems are connected by a single IP communication platform to ensure both the operational performance of the building is maintained as well as the safety and comfort of the building occupants.

It is advisable that the highest possible performance network cabling performance is installed to ensure that the cabling system will support all applications, including voice, data and BAS systems as needed thus reducing the need for remedial works for a minimum of ten years, so attention should be focussed towards supporting applications up to 10GBASE-T by utilizing a minimum of shielded category 6A/class E_A copper cabling systems.

4.1.2 BAS Related Terms

You may hear any of the following terms to describe the control or automation of buildings:

- Building Automation and Control Systems (BACS)
- Building Control System (BCS)
- Building Management System (BMS)
- Direct Digital Control (DDC)
- Energy Management System (EMS)
- Energy Management and Control System (EMCS)
- Smart or Intelligent Buildings

4.1.3 BAS Controlled Systems

Generally, building automation has traditionally been focussed on the control of the mechanical, electrical, and heating (HVAC) systems. New smart & intelligent IP enabled buildings with both monitor and control many different elements of the building including, but not limited to, the list below:

- Chiller plant
- Boilers
- Air Handling Units (AHUs)
- Roof-top Units (RTUs)
- Fan Coil Units (FCUs)
- Heat Pump Units (HPUs)

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- Variable Air Volume boxes (VAVs)
- Computer room air handling units (CRACS/CRAHS)
- Lighting control
- PoE lighting systems
- Power monitoring
- Building access control (card & keypad access)
- Paging systems
- Video & audio systems
- Digital signage
- IP close circuit video (IPCCTV)
- Fire alarm system
- Elevators/escalators
- Plumbing and water monitoring

4.1.4 Cabling Standards

Cabling standards have been developed to offer advice of the distribution of structured cabling systems to support the growth of the IP enabled smart and intelligent building.

- ISO/IEC 11801-6 ED 1.0 Information technology - Generic Cabling for Customer Premises - Part 6: Distributed Building Services
- EN 50173-6 *Information Technology – Generic Cabling Systems – Part 6: Distributed Building Services*
- ANSI/TIA-862-B *Structured Cabling Infrastructure Standard for Intelligent Building Systems*

4.1.5 Terminology and Abbreviations: ANSI/TIA

- Cabling Subsystem 1: Cabling from the equipment outlet to Distributor A, Distributor B or Distributor C
- Cabling Subsystem 2: Cabling between Distributor A and either Distributor B or Distributor C (if Distributor B) is not implemented
- Cabling Subsystem 3: Cabling between Distributor B and Distributor C
- Common Equipment Room (Telecommunications): An enclosed space used for backbone interconnections for more than one tenant in a building, which may also house equipment
- Coverage Area: The area served by a device
- Coverage Area Cable: Cable used for connecting the horizontal connection point to a building automation system device or the cable between two building automation systems
- Distributor A: Optional connection facility in a hierarchical star topology that is cabled between the equipment outlet and Distributor B or Distributor C
- Distributor B: Optional intermediate connection facility in a hierarchical star topology that is cabled Distributor C
- Distributor C: Central connection facility in a hierarchical star topology
- Equipment Outlet (EO): Outermost connection facility in a hierarchical star topology.
- HCP: Horizontal connection point

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- Terminal: (1) A point at which information may enter or leave a communications network. (2) The input-output associated equipment. (3) A device by means of which wires may be connected to each other
- Zone Box: An enclosure used to house one or more of the following; a) a consolidation point, b) a horizontal connection point (HCP), c) building automation system outlets

4.1.6 General

4.1 All telecommunications grounding/earthing and bonding shall comply with applicable standards, codes and regulations (see Annex C).

4.2 Telecommunications cables (fiber and copper) shall not be installed into any containment compartment where electrical cables are housed.

4.3 The installation requirements of this CI manual shall be applied to all twisted pair or fiber optic cabling distributing cables for structured wiring building automation control.

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4.1.7 Functional Elements

Table 4-1: Correlation of Functional Elements Specified by Standards

Generic cabling system		Commercial	BAS	
ISO/IEC 11801 Ed. 2.2	ANSI/TIA-568.0-E	ANSI/TIA-568.1-E	ANSI/TIA-862-B	EN50173-6
CD Campus Distributor	**DC** Distributor C	**MC** Main Cross-connect	**DC** Distributor C	**CD** Campus Distributor
Campus backbone cabling	Cabling Subsystem 3	Inter-building backbone	Cabling Subsystem 3	Campus backbone cabling
BD Building Distributor	**DB** Distributor B	**IC** Intermediate Cross-connect	**DB** Distributor B	**BD** Building Distributor
Building backbone cabling	Cabling Subsystem 2	Intra-building backbone	Cabling Subsystem 2	Building backbone cabling
FD Floor Distributor	**DA** Distributor A	**HC** Horizontal Cross-connect	**DA** Distributor A	**SD** Service Distributor
Horizontal cabling	Cabling Subsystem 1	Horizontal cabling	Cabling subsystem 1	Service Distribution Cabling
CP Consolidation Point (optional)	**CP** Consolidation Point (optional)	**CP** Consolidation Point (optional)	**HCP** Horizontal Connection Point (optional)	**SCP** Service Concentration Point
TO Telecommunications Outlet or MUTO (Multiuser TO)	**EO** Equipment Outlet	**TO** Telecommunications Outlet or MuTOA (Multiuser TO Assembly)	**EO** Equipment Outlet	**SO** Service Outlet

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4.1.8 Topologies

While using slightly different terminology, in regions where US standards apply, ANSI/TIA applies a similar topology.

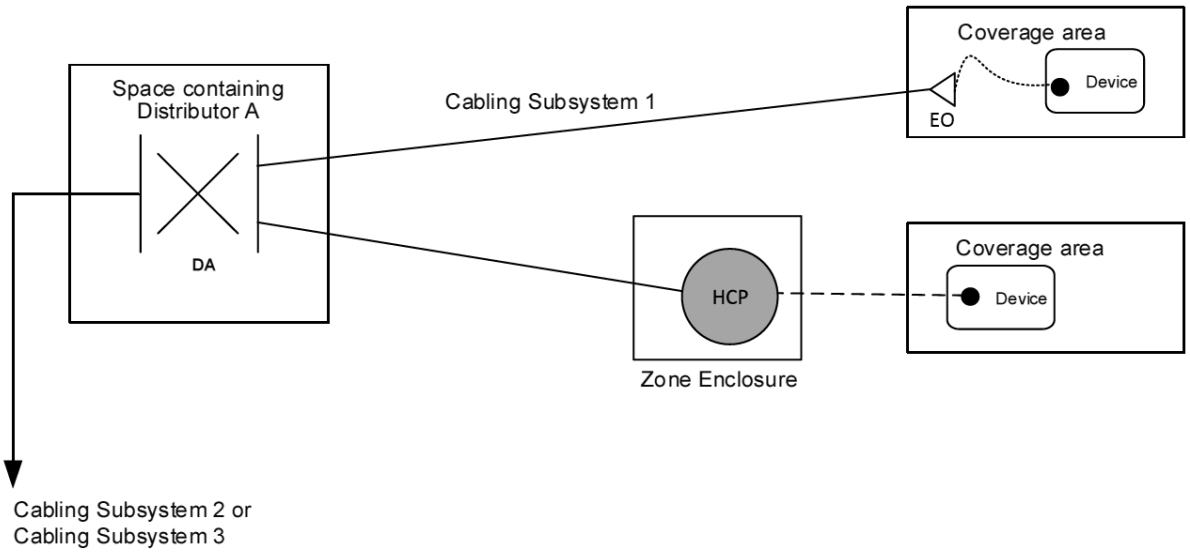

Figure 4-1: Sample ANSI/TIA Star Topology to Coverage Areas

- Cabling subsystem 2 refers to optional intermediate cabling between Distributor A and Distributor B (or Distributor C if Distributor B is not present)
- Cabling subsystem 3 refers intermediate cabling between Distributor B and Distributor C (if Distributor B is present)

4.1.9 Zone Box Enclosures

The Zone box may act either as a horizontal connection point, either as a SCP/HCP or as a connection point for application specific cabling to the building automation systems.

4.4 No more than one SCP/HCP shall be installed in the horizontal link.

NOTE: The SCP/HCP is included as one connection point in the structured cabling link (a maximum of 4 are permitted).

4.5 The SCP/HCP shall accommodate a minimum of 12 SOs/EOs.

4.1 To accommodate future additions, the SCP/HCP should accommodate a minimum of 24 SOs/Eos.

4.6 The SCP/HCP shall be installed in a fully accessible, fixed location that minimizes disturbing building occupants for the ease of routine maintenance and reconfiguration.

NOTE: An example of a location for mounting of an SCP/HCP that would not be acceptable would be within furniture systems - unless that unit of furniture is permanently secured to the building structure

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4.7 Each SCP/HCP shall be labeled and administered for identification as per Section 9 of this Training Manual.

4.8 The cordage from the SCP/HCP when using balanced twisted-pair and optical fiber structured cabling shall not exceed 5m in length to the SO/EO, unless the de-rating factors used for the MUTOA are applied.

4.9 A minimum distance of 15m shall be applied from the SCP/HCP to the SO/EO.

4.10 Each cable extending from the SCP/HCP shall be terminated to an SO/EO or directly to a device.

4.2 It is recommended to use a SO/EO to connect a device to the horizontal cabling.

4.3 Note: When used, a SO/EO must be connected to the FD/HC, either directly or through an HCP.

4.11 All connections from a SO/EO to a device shall be made using an equipment cord.

4.12 Cross-connections are allowed within the SCP/HCP. When cross-connections are used at the HCP, an SO/EO shall not be installed as part of the horizontal link.

An SCP/HCP may be used to insert transmission equipment. Any resulting cabling extending from the transmission equipment to the SO/EO is not considered to be generic (i.e. outside the scope of the Siemon Cabling System).

4.13 Application specific BAS systems that utilize baluns, adapters or power deliver apparatus shall be external to the SOs/EOs.

If the use of transmission equipment is anticipated, the location of the SCP/HCP should take into consideration the availability of an adequate power supply and local safety regulations relating to the positioning of the transmission equipment.

If the terminal equipment (e.g. a security camera) is to be connected without the use of a plug-socket configuration (type A cabling) then the SCP/HCP should be implemented in close proximity to the terminal equipment to simplify maintenance should damage occur at, or between the SO/EO, and the terminal equipment.

4.1.10 Coverage Area Planning

A coverage area refers to the space served by one device. Each intelligent building systems application required for the building project (e.g., HVAC application controller for temperature sensors) should be considered in determining the density of coverage areas and devices. Depending on their applications or function, devices may have overlapping coverage areas.

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Table 4-2: ANSI/TIA Coverage Area

Premises/Area	Coverage Area	Notes
Office	25m^2	In an open office environment, coverage sizes will typically be greater than in a dedicated office
Indoor Parking	50m^2	Identify fire, security, carbon monoxide and HVAC requirements. Note: May also require voice connections for security
Retail	25m^2	Security requirements may increase the coverage area density (e.g., CCTV, alarm, access)
Factory	50m^2	Coverage area requirements may vary according to manufacturing processes, environment and building design
Hotel	25m^2	Coverage area requirements may vary if BAS applications have centralised control (e.g., HVAC, fire alarm, safety systems, access)
Classroom	25m^2	Coverage area requirements may be centralized for security & access controls. Plan or the unique BAS requirements for each area type (e.g., fire alarm system, access control HVAC)
Hospital	25m^2	Coverage area density is averaged to compensate for a variety of environments (e.g., patient rooms, labs. emergency room and operating rooms) – Plan for the unique BAS requirements for each area type
Mechanical Room	5m^2	Determine location of air handlers, chillers, boilers, pumps, fans, compressors, etc. Air handlers will typically have a higher concentration of BAS devices
Note: Coverage area size depends on the BAS application & device. These coverage areas are based on average values from a study of Fire Life Safety, security and HVAC/EMS applications.		

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4.2 Wireless Building Automation Systems

Supported typical wireless application systems and their typical indoor ranges, it must be noted that certain proprietary wireless equipment may have a typical range of less than 15m.

Table 4-3: Wireless Application Ranges

Application	Standard Description	Typical Indoor Range (Radius)
IEEE 802.11	Wireless Local Area Networks (2Mb/s at 2.4GHz or infrared)	30m
IEEE 802.11a	Wireless Local Area Networks (54Mb/s at 5GHz or infrared)	12m
IEEE 802.11b	Wireless Local Area Networks (11Mb/s at 2.4 GHz or infrared)	30m
IEEE 802.11g	Wireless Local Area Networks (54Mb/s at 2.4GHz or infrared)	12m
IEEE 802.11n	Wireless Local Area Networks (600Mb/s at 2.4GHz & 5GHz)	12m
IEE 802.11ac	Wireless Local Area Networks (1000Mb/s at 5GHz)	12m
DECT	Digital European C Cordless Technology (1Mb/s at 1.8 GHz)	30m (ffs)
Bluetooth II	ISM Band 1Mb/s at 2.4 GHz	12m (ffs)

4.2.1 Testing

4.14 The testing of all distributed and building automated systems that utilize twisted-pair or fiber optic structured cabling shall be tested in accordance with the testing requirements as outlined within the testing section of this CI manual.

Where application specific devices are used, testing may only be possible over the twisted pair or fiber optic structured cabling up until the SCP/HCP. If further testing is required beyond this point advice should be sought form the BAS system manufacturer.

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4.2.2 Other Topologies

Older legacy BAS systems utilize topologies such as multipoint and ring. Examples of these topologies are shown below:

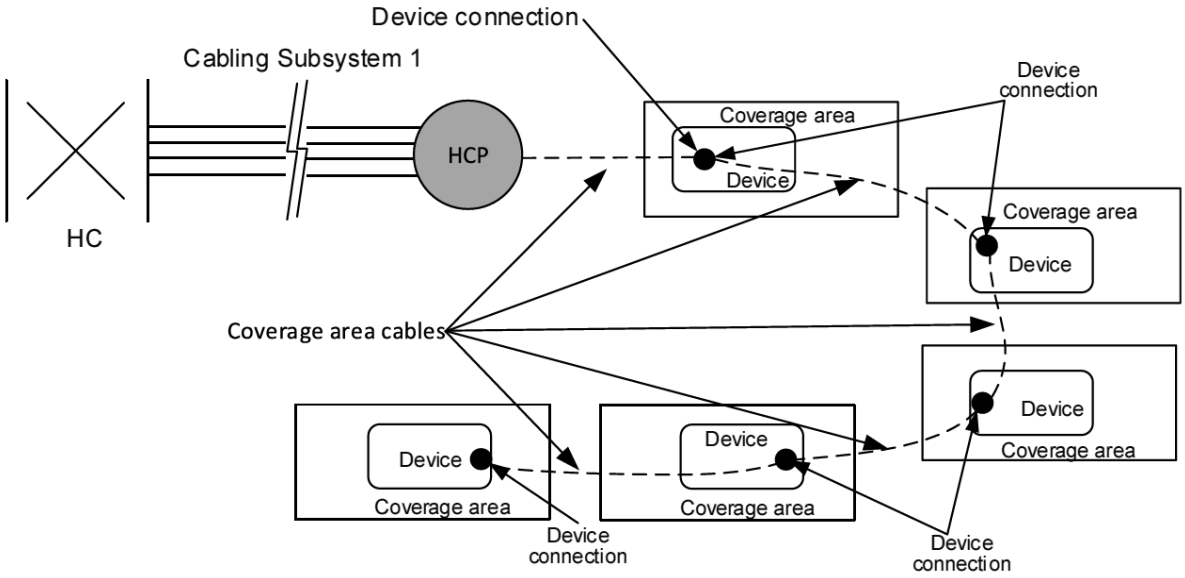

Figure 4-2: ANSI/TIA Multipoint Bus Example

While the ISO, EN and TIA standards each offer advice on these older configurations, it is important to note that the Siemon warranty will only be applicable to the star topology.

4.15 A minimum of one dedicated horizontal link shall be provided for each distinct intelligent building systems application (e.g., fire alarm system, HVAC).

It is important that the Certified Installer ensures that the topology implemented will support the proposed application or if further information will need to be sought from the BAS system manufacturer.

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NORMATIVE SUMMARY

4.1 All telecommunications grounding/earthing and bonding shall comply with applicable standards, codes and regulations (see Annex C).

4.2 Telecommunications cables (fiber and copper) shall not be installed into any containment compartment where electrical cables are housed.

4.3 The installation requirements of this CI manual shall be applied to all twisted pair or fiber optic cabling distributing cables for structured wiring building automation control.

4.4 No more than one SCP/HCP shall be installed in the horizontal link.

4.5 The SCP/HCP shall accommodate a minimum of 12 SOs/EOs.

4.6 The SCP/HCP shall be installed in a fully accessible, fixed location that minimizes disturbing building occupants for the ease of routine maintenance and reconfiguration.

4.7 Each SCP/HCP shall be labeled and administered for identification as per Section 9 of this Training Manual.

4.8 The cordage from the SCP/HCP when using balanced twisted-pair and optical fiber structured cabling shall not exceed 5m in length to the SO/EO, unless the de-rating factors used for the MUTOA are applied.

4.9 A minimum distance of 15m shall be applied from the SCP/HCP to the SO/EO.

4.10 Each cable extending from the SCP/HCP shall be terminated to an SO/EO or directly to a device.

4.11 All connections from a SO/EO to a device shall be made using an equipment cord.

4.12 Cross-connections are allowed within the SCP/HCP. When cross-connections are used at the HCP, an SO/EO shall not be installed as part of the horizontal link.

4.13 Application specific BAS systems that utilize baluns, adapters or power deliver apparatus shall be external to the SOs/EOs.

4.14 The testing of all distributed and building automated systems that utilize twisted-pair or fiber optic structured cabling shall be tested in accordance with the testing requirements as outlined within the testing section of this CI manual.

4.15 A minimum of one dedicated horizontal link shall be provided for each distinct

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5. INSTALLATION PRACTICES

The purpose of this section is to enable the proper installation of a structured cabling system for commercial buildings, based on the design, component requirements and recommendations provided in the other sections of this manual. While these installation practices may be applied to new or existing installations, it should be noted that the installation of cabling systems during building construction or renovation is significantly less expensive and less disruptive than while the building is occupied. Because they relate to the manner and care with which connections and cable management are carried out, cabling practices are a significant factor in the performance of an installed cabling systems.

5.1. Performance

5.1 At a minimum, the installation practices contained in this manual as well as Siemon installation instructions shall be observed for Horizontal and Backbone cabling to ensure initial and continuing performance of the cabling system over its warranty period and life cycle.

This is especially true for higher performance cables, including both copper and optical fiber cabling. High performance copper cables are sensitive to external anomalies. For example, excessively untwisting a pair may adversely affect the transmission characteristics of the pair or pairs involved. Violating the minimum bend radius requirements may also affect the transmission performance characteristics of the cable. As the frequency of transmission increases, the greater the risk an improperly installed cable may affect system performance.

Note: Improper installation techniques may not be as discernible when a cabling system is supporting 10BASE-T Ethernet. However, this same cabling system supporting 100BASE-T, 1000BASE-T and 10 Gigabit Ethernet may not properly support the applications. (Refer to the Z-MAX Planning and Installation Guide found on the Siemon Partner Support Center for specific design/installation practices for 10 Gigabit Ethernet installations).

Optical fiber cables are also sensitive to external anomalies. Compressive tie-wraps and over-loading the raceways can cause bending-loss. Understanding the sensitivity of high-performance cable makes it easy to understand why proper installation is critical.

5.1 Horizontal and Backbone balanced twisted-pair cables should be installed with connecting hardware, cross-connect jumpers and patch cords of the same category or higher.

5.2 Mixing different categories/classes of components within a Permanent Link or Channel means the Permanent Link / Channel shall be classified to the least performing component.

5.3 All fiber components installed within a Permanent Link/Channel shall be of the same optical type/size and performance.

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Note: An optical signal will attenuate significantly when transmitting from one core size to a different core size (i.e. 50 µm core to 62.5 µm core).

5.2. Clearance

5.4 Unless specified otherwise by applicable Standards, codes or regulations, equipment racks, cabinets, and closures shall be installed to provide for a minimum of 1.2m (4 ft.) where service access is required.

Clearances allow for access to maintain and service equipment and cable dressing space. Multiple racks in series require a single pathway around one end, while multiple racks in parallel can share clearance spaces.

Figure 5-1: Clearances in Equipment Cabinets

5.3. Fiber Safety

5.5 Safety in fiber optic installations includes avoiding exposure to invisible light radiation carried in the fiber, proper disposal of fiber scraps produced in cable handling and termination and safe handling of hazardous chemicals used in termination, splicing or cleaning.

- Always wear safety glasses with side shields. Ensure that safety eyewear complies with relevant safety standard.
- Never look directly into the end of any optical fiber unless it is certain that no light is present in the fiber.
- Small scraps of bare fiber produced as part of the termination and splicing process must be disposed of properly in a safe container and marked according to local regulations.
- Do not eat, drink or smoke near the working area. Fiber particles can be harmful if ingested.

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Note: For most of the world the applicable laser safety standard is the International Electro-technical Commission Standard titled IEC 60825. The US standard is separated into two parts for the manufacturer (CDRH 21 CFR parts 1040.10 and 1040.11). The CDRH (Center for Devices and Radiological Health) Standard is administered under the auspices of the FDA (Food and Drug Administration).

5.4. Pathways

It is often perceived a convenience by the installation contractor to attach telecommunication cables to the components/structures of existing services (i.e., air ducts or EMT). This improper practice raises these concerns:

- The cable is at risk of being damaged when tradesmen perform maintenance on that service.
- The components/structure may be the distribution network for a service that may cause degradation to the cable or interfere with the performance of the telecommunications network. The service may pose thermal, electrical or moisture hazards.
- The components/structures have load limitations. Attaching cables may violate those load conditions.
- It may violate standards, codes and regulations.

5.6 All manufactured pathway systems shall be installed as per manufacturer's installation instructions. In addition, all sharp edges are to be removed or protected, prior to the installation of cables.

Note: Conduit fill tables can be found in the Horizontal and Backbone sections of this manual. (refer to the Z-MAX Planning & Installation Guide found on Siemon Partner Support Center for category 6A conduit fill ratios).

5.7 Sharp edges or burs on pathways shall not come into contact with cables. Exposed metal edges shall be fitted with bushings or other means of protection so that cable jackets are not damaged during or after installation.

Figure 5-2: Bushing for EMT conduit

5.8 Non-continuous cable supports, such as hangers and hooks shall be located at intervals not to exceed 1.5 m (5 ft) apart.

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Figure 5-3: J-Hook Installation

5.9 Telecommunications cables shall be supported with devices designed for this purpose and shall be installed independently of any other structural component.

5.10 Cables routed vertically shall be supported with appropriate hardware to properly support the media type and quantity of cables being installed. These supports shall occur at least two times per floor.

5.11 The number of cables, regardless of media type, placed in a pathway system (hangers, trays, raceways etc.) shall be limited, such that the geometric shape of the cables is not altered during the warranty period.

Note: It is recommended to minimize the effects of "cable set" by reducing cable bundle size and weight and by using wide supports which do not change the geometric shape of the cables. The size of individual cable bundle should be limited to a maximum of 24 4-pair balanced twisted pair cables.

5.12 Maximum pathway (cable tray/wireway) capacity shall not exceed a calculated fill ratio of 50% to a maximum of 150 mm (6 in) inside depth.

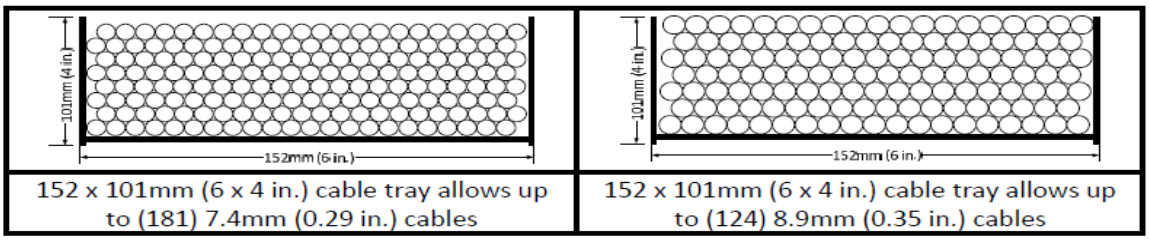

Figure 5-4: Cable tray capacity and cable diameter

To allow room for future expansion, and to facilitate additions and removal of cables, a lesser fill (25%) is recommended.

A calculated fill ratio of 50% will physically fill the entire tray due to spaces between cables and random.

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5.13 Maximum perimeter and furniture pathway capacity shall not exceed a 60% fill ratio.

Note: This allowance accommodates perimeter and furniture pathways which have lids that open up allowing for the placement of cables. Because conduit systems are sealed or closed over their length, the percentage of fill must be less than that of perimeter and furniture pathways. Please refer to the Horizontal Pathway Section of this manual for recommendations on conduit fill.

5.14 Open ceiling pathway systems shall be mounted/installed to be a minimum of 75 mm (3 in) above the ceiling grid which supports the tiles.

This practice along with having cable supports close together prevents the cables from resting on ceiling tiles and allows easy access to the ceiling cavity.

5.15 A minimum clearance of 300mm (12in) shall be provided above the open pathway system.

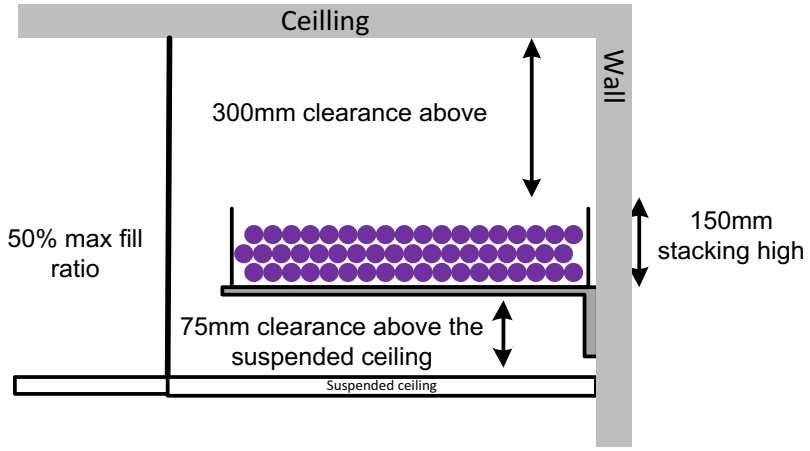

Figure 5-5: Open Ceiling Pathway

5.5. Environment

Cables are used in a wide variety of environments, (e.g., both indoors and outdoors, air handling and non-air handling spaces) it is important to select a cable that is suited for the environment in which it will be installed.

5.16 All cables shall be suitable for the environment in which they are installed.

Note: Riser, plenum and LSOH cables are not suitable for wet locations and can also be affected when laid directly on untreated concrete floors.

Note: "Slab-on-Grade" building designs wherein pathways are installed underground or in the poured concrete slabs that are in direct contact with soil are considered wet locations.

5.17 All cables installed in wet locations shall be rated for that environment.

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Note: In building locations considered to be "wet" a cable with a water/moisture blocking agent (gel) or absorbent dry element must be used. In many cases these cables are un-listed and cannot be installed exposed in a building. For compliance to standards, codes and regulations on installing un-listed cables within a building, contact the AHJ "Authority Having Jurisdiction" in your area.

Note: Cables containing a water/moisture blocking agent (gel) may not have the same performance characteristics as a similar cable without such an agent. This may require the Permanent Link length be reduced from the maximum distance of 90m (295 ft) to meet the appropriate electrical requirements.

5.18 Cables shall not be laid directly on concrete floors that are or may become wet or damp.

Note: If a concrete floor is/becomes wet or damp, negative thermal interactions between the cable jacket and the concrete will occur which can result in cable degradation.

5.19 Cables shall not be stored, installed or in operation in locations that exceed the temperature ratings of that cable.

Cables temperature ratings are typically provided for 3 different scenarios; Storage, Installation and Operating. It is important to know these ratings, as cables can lose their integrity if the conditions exceed these temperature ratings. These ratings are provided on the manufacturer's Spec sheet. The standard operating environment for structured cabling is -20°C to 60°C (-4°F to 140°F). Compliance to industry standards ensures reliable long term mechanical and electrical operation of cables and connectors in environments within these temperature limits. Exceeding the specified operating range can result in degradation of the jacket materials and loss of mechanical integrity that may have an irreversible effect on transmission performance that is not covered by a manufacturer's product warranty. Since deployment of certain remote powering applications can result in a temperature rise of up to 10°C (50°F) within bundled cables, the typical rule of thumb is to not install minimally compliant cables in environments above 50°C (122°F).

This restriction can be problematic in regions such as the American Southwest, Africa, the Middle East, or Australia's Northern Territory, where temperatures in enclosed ceiling, plenum, and riser shaft spaces can easily exceed 50°C (122°F).

5.2 To overcome this obstacle, Siemon recommends the use of shielded category 6A and 7A cables that are qualified for mechanical reliability up to 75°C (167°F).

Not only do these cables inherently exhibit superior heat dissipation, but they may be installed in high temperature environments up to the maximum 60°C (140°F) specified by TIA and ISO/IEC structured cabling standards without experiencing mechanical degradation caused by the combined effects of high temperature environments and heat build-up inside cable bundles due to remote power delivery.

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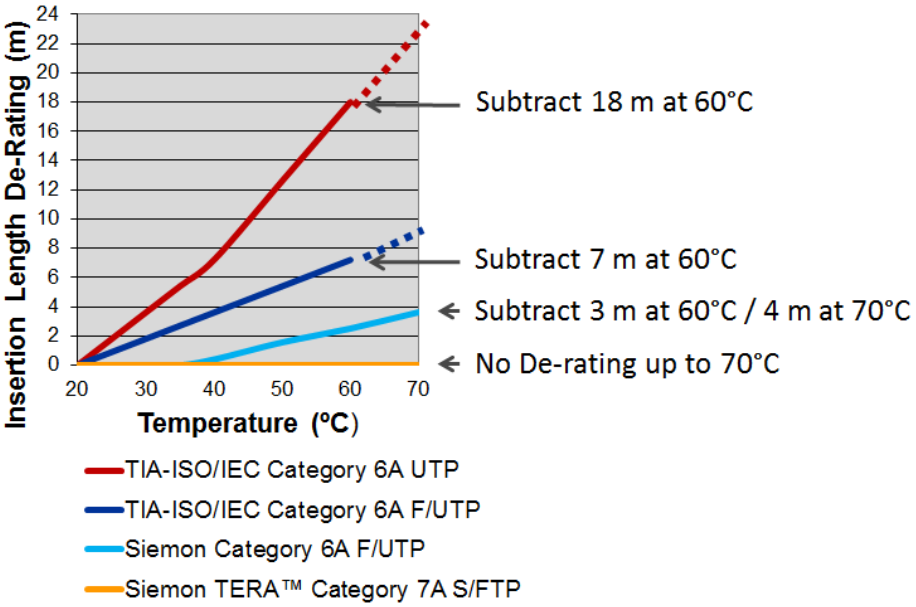

Figure 5-6: Horizontal Cable Length De-rating vs Temperature

Note: See the Cable Bundling section of this chapter for information associated with maximum bundle sizes for remote powered applications.

5.5.1. Indoor/outdoor Fiber Cable

5.20 Indoor/Outdoor tight buffered fiber cable shall be installed in outdoor ducts that may have temporary moisture or water present, as well as meeting the indoor rating requirements needed to comply with codes, standards and regulations.

Note: Although Indoor/Outdoor tight buffered fiber cable can be installed in outdoor ducts that may have temporary water or moisture present, they are not recommended to be installed in underground or direct buried outdoor ducts as they are much more susceptible to containing permanent water. For outdoor ducts that are direct buried or underground a loose tube (gel filled) cable is recommended.

5.6. Cable Handling

A cables performance can be significantly impacted by bends, compression, kinks, pulling force and improper pulling techniques. The following requirements and recommendations have been provided to assist in the proper installation of balanced twisted pair and optical fiber cable.

5.21 Both balanced twisted pair and optical fiber cable shall be pulled from the packaging they were provided on (i.e. reel-ex boxes, reel in box, reels).

Note: Cable removed from its original packaging and laid on the floor/ground to be installed can easy become damaged from kinking, abrasions and excessive bending.

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5.6.1. Pulling Tension/Bend Radius

5.22 The specified maximum cable pulling tensions and minimum bend radii shall not be exceeded.

5.6.2. Bend Radius

5.23 Cables shall not be placed over the edges of raceways, cabinets, enclosures, or other fixtures, where the cable can be bent beyond the cables bend radius requirements. Some type of bend delimiter shall be used to help maintain the geometric shape of the cable(s).

Note: Be careful to load the cable raceways according to the raceway manufacturer's instructions. Too many cables in a raceway may create excessive weight (load) on the other cables beneath them against some sort of edge. Raceways, cabinets, etc. that have carefully designed bend delimiters are also subject to cable set. Cable set may cause "kinking" by compression which may occur to a cable over time due to the weight of the cables laying on top of them in the raceway. Cable set occurs due to the improper design of the bend delimiters and/or excessive loading. The use of devices such as "waterfalls" are very helpful to reduce/eliminate the excessive bending of cables.

5.6.3. Cable Bend Radius (Balanced Twisted-Pair)

5.24 The minimum bend radius under no load conditions for 4-pair balanced twisted pair cable shall not be less than four times the cable diameter.

5.25 The minimum bend radius under no load conditions for multi-pair cables shall not be less than that recommended by the manufacturer.

Note: Minimum bend radius under no load conditions, means no pulling force is applied to the cable. If pulling cables around a radius when under load/pull force, appropriate pulleys or another technician should be located at the location of a bend/transition to eliminate violating the minimum bend radius. Excessive bending of cables will likely result in performance deficiencies.

5.26 The minimum bend radius of balanced twisted pair patch cords/equipment cords shall not be less than four times the cable diameter.

Note: Always refer to the manufacturers specifications as minimum bend radius requirements may be more stringent.

5.6.4. Cable Bend Radius (Optical Fiber)

5.27 The minimum bend radius under no-load conditions for Horizontal 2 -strand/core fiber cable shall not be less than 25 mm (1 in). Under a maximum tensile load of 222 N (50 lbf), the minimum bend radius shall not be less than 50 mm (2 in).

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5.28 The minimum bend radius for building or campus optical fiber Backbone cable shall not be less than that recommended by the manufacturer.

Table 5-1: Maximum Tesile Load and Minimum Inside Bend Radius

Cable Type and Installation Details	Maximum Tensile Load During Installation	Minimum Inside Bend Radii While Subjected to	
		Maximum Tensile Load (during installation)	No Tensile Load (after installation)
Inside plant cable with 2 or 4 fibers installed in Cabling Subsystem 1	220 N (50 lbf)	50 mm (2 in)	25 mm (1 in)
Inside plant cable with more than 4 fibers	Per manufacturer	Twenty times the cable outside diameter	Ten times the cable outside diameter
Indoor/outdoor cable with up to 12 fibers	1335 N (300 lbf)	Twenty times the cable outside diameter	Ten times the cable outside diameter
Indoor/outdoor cable with more than 12 fibers	2670 N (600 lbf)	Twenty times the cable outside diameter	Ten times the cable outside diameter
Outside plant cable	2670 N (600 lbf)	Twenty times the cable outside diameter	Ten times the cable outside diameter
Drop cable installed by pulling	1335 N (300 lbf)	Twenty times the cable outside diameter	Ten times the cable outside diameter
Drop cable installed by directly buried, trenched or blown into ducts	440 N (100 lbf)	Twenty times the cable outside diameter	Ten times the cable outside diameter

5.6.5. Pulling Tension

5.29 The minimum pulling tension for 4-pair balanced twisted-pair or optical fiber cable shall not be less than that recommended by the manufacturer.

5.6.6. Cable Bundling

5.30 When using Velcro cable managers or cable ties to bundle cables, no force shall be used to tighten the device, that causes a change to the geometric shape of the cable.

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Note: The use of cable ties / tie wraps is not recommended, as they can be easily over tightened, resulting in performance deficiencies. Siemon recommends the use of Velcro Cable Managers for the bundling of cable.

Note: Number of cables in a bundle and cabling category that should be considered in order to support the highest possible POE current due to temperature rise

Cable bundle count

Cabling category

Limiting cable bundle size

Mixing cable categories within a bundle

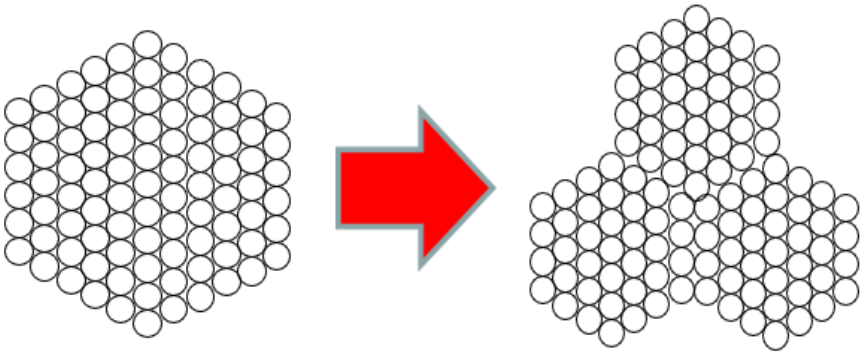

Figure 5-7: Larger bundle to smaller bundles

5.6.7. Cable Slack

5.3 Sufficient cable slack should be provided to accommodate cable routing, cable management, re-terminations and minor relocations. When such slack is provided, appropriate measures should be taken to manage the slack.

5.4 Management of slack should not include the coiling of cable. The implementation of a serpentine method should be used to manage cable slack.

Note: Although service loops/service coils are typically used to manage cable slack, they can result in performance deficiencies based on how tight the loop or coil is arranged. Managing cable slack using a serpentine method reduces many of the potential issues as compared to a service loop/service coil.

5.6.8. Exposed Cabling

5.31 All horizontal or backbone cables installed in areas of public access shall not be exposed.

Note: When installing cables in areas such as modular furniture, any cables routing from a floor penetration to the modular furniture pathway must be installed in flex tubing or flexible conduit, so the cable is protected from accidental damage. Exposed cables in areas of public access can also be a violation to codes, standards and regulations.

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5.7. Connecting Hardware/Termination

Properly installed connecting hardware provides:

- Optimum performance of the Permanent Link/Channel;
- Orderly cable management;
- Protection against physical damage and ingress of contaminants that may affect continuity;
- A termination density that is space efficient, but that also provides ease of cable management and ongoing administration of the cabling system.

5.32 Connecting hardware and all other cabling system components shall be installed to provide optimal signal performance.

This is achieved by proper cable preparation, termination practices, orientation, and mounting in accordance with the product installation instructions.

5.33 Connecting hardware shall be installed to provide orderly, well-organized cable management.

5.34 All connecting hardware shall be installed in compliance with the manufacturer's installation instructions

Product specific installation instructions are available on the installation instruction sheets included with the product, and on The Siemon Partner Support Center.

5.35 All tools used to terminate cable to connecting hardware shall be in excellent working condition and be free from any wear or damage

The uses of proper cable preparation tools, such as "strip tools" are key in scoring the jacket without nicking the copper conductors, which can create a short between two conductors. It is important to be sure that the cutting blade in your punch/impact tool is not dull or pitted.

5.7.1. Mounting

5.36 Connecting hardware shall be securely mounted on walls, floors, modular furniture, racks, cabinets and frames, or other stable and accessible surfaces.

5.7.2. Balanced Twisted Pair

5.7.2.1. *Cable Sheath/Jacket Removal*

5.37 For balanced twisted-pair cable, only the minimum amount of sheath/jacket to terminate the pairs/conductors to the connecting hardware shall be removed.

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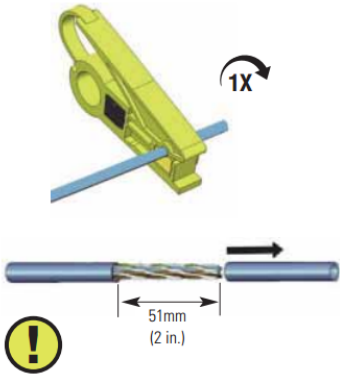

Figure 5-8: Cable Jacket Removal

5.7.2.2. *Wiring Scheme*

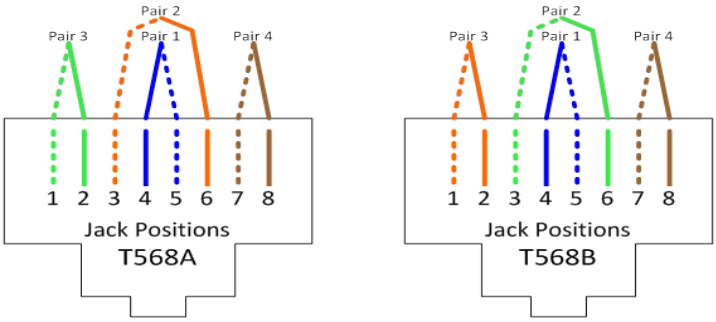

Figure 5-9: Wiring Schemes

5.38 Category 5e, 6 and 6A balanced twisted-pair pin and pair grouping assignments shall be T568A or T568B.

Note: The colors listed are associated with 4-pair balanced twisted pair cable. These illustrations depict the front view of the outlet and not the positions of the conductors/pairs on the IDC they are terminated onto. For proper positioning of the conductors/pairs on the IDC, refer to the wiring template provided on the connecting hardware. These two wiring schemes have been adopted based on the transmission of Ethernet applications

5.5 The coexistence of outlets wired to T568A and those wired to T568B pin/pair schemes in the same installation is not recommended.

5.7.2.3. *Pair Untwisting*

5.39 The cable pair twist shall be maintained as close as possible to the point of mechanical termination by not changing the original twist.

Note: Cable pairs that have become untwisted should not be re-twisted during installation. Proper pair twisting is controlled by the cable manufacturer and incorrect twisting can negatively affect cable performance.

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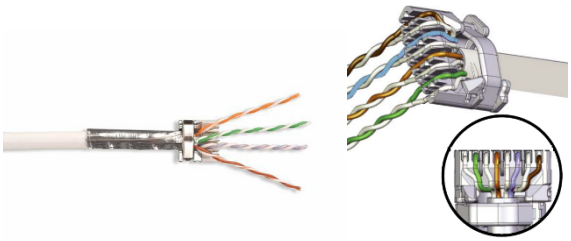

Figure 5-10: Cable pair termination on Z-Max outlet

5.7.2.4. *Multiple Connections in Close Proximity*

5.40 For balanced twisted pair systems, there shall be no more than two pieces of connecting hardware within the cross connect.

5.7.3. Optical Fiber

5.7.3.1. *Protection*

5.41 Optical fiber connecting hardware shall be protected from physical damage and from direct exposure to contaminants.

5.7.3.2. *Cable Sheath/Jacket Removal*

5.42 Only enough jacket/sheath shall be removed to store the buffered strands/cores within the fiber enclosure/box.

Note: Buffered strands/cores exposed outside the fiber enclosure/box can be damaged very easily and likely resulting in fiber breakage. For proper fiber cabling positioning in the fiber enclosure/box, see the associated Siemon product installation instructions for that particular product.

5.7.3.3. *Maintaining Proper Polarity*

For network applications to function, it is crucial to maintain the correct polarity of fiber cabling. The use of reverse pair positioning was developed so that the administration of transmit and receive fibers will not be the concern of the end-user. Reverse pair positioning ensures the proper polarity by using identical adapter orientation on both ends of the cable and reversing the order of the fiber within each pair. This method can be used regardless of the connector type, the number of cross-connects or the inclusion of a consolidation point.

5.7.3.4. *Implementing Reverse-Pair Positioning*

Optical fiber cable color-coded buffers are used for reverse-pair positioning. This color-code is used for ease of identification and numbering of the individual fibers as reflected in the table below.

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Table 5-2: Fiber Number and Color Identification

Fiber Number	Color	Fiber Number	Color
1	Blue	7	Red
2	Orange	8	Black
3	Green	9	Yellow
4	Brown	10	Violet
5	Slate	11	Rose
6	White	12	Aqua

5.43 Optical fiber terminations shall be performed using reverse-pair positioning

Note: From the installer's point of view, Fiber 1- blue will appear on the left on one end and on the right on the other end. Fiber 2- orange will appear in the opposite manner, right on one end of the link and left on the other end of the link. Reverse-pair positioning may be obtained by installing the fibers on the connectors in this manner or by installing connectors into the adapters in this orientation.

5.44 Once completed, optical fiber terminations shall have dust caps placed into each unused adaptor port or on the end of the terminated fiber connector.

Note: Shuttered adapters may be used as an alternative to dust caps

5.45 Prior to the installation of any fiber connector into adapter ports, both the end-face of the connector and the adapter shall be properly cleaned.

Contaminants are the leading cause of high system loss and can be easily transferred between connectors. Even everyday particles can have detrimental results on optical fiber end faces.

Fortunately, by employing proper cleaning procedures and utilizing good preventative measures such as dust caps, many cases of high loss can be improved or eliminated. Of greatest importance is to ensure all connector end faces are clean prior to insertion into the adapter.

5.46 Dry cleaning methods should use static minimizing cleaning sticks which are specially designed to clean optical fiber end faces and are available for multi-fiber MPO connectors as well as LC and SC fiber connectors for both connector end face and bulkhead adapters.

5.47 For significantly contaminated end faces, "wet" solvent methods should be used. The static bond breaking properties makes it an ideal method to remove heavy or persistent contamination.

For additional information on proper fiber cleaning practices, reference Siemon's Optical Fiber Field Testing Guide on the Ally website.

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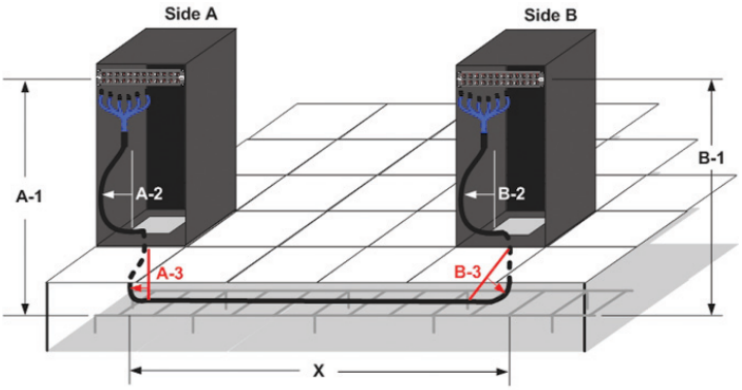
5.7.4. Trunk Cable Assemblies

Trunk cables are pre-terminated copper or fiber assemblies ordered to specific lengths, ideal for data center and backbone applications where cable distances are reasonably predictable and can be easily determined. They can be ordered with a variety of termination and performance configurations. Figure 6-11 below illustrates how to calculate a trunk cable length in a Data Center environment, but similar dimensions would be considered when using a copper or fiber trunk in a backbone/riser application.



Trunk Cable Length = (A1+A2+A3) + X + (B1+B2+B3)
where:
X —Horizontal Distance
A1 —Vertical Distance (**side A**)
A2 —Cable Slack within the cabinet (**side A**)
A3 —Cable Radius transitioning out of the floor (**side A**)
B1 —Vertical Distance (**side B**)
B2 —Cable Slack within the cabinet (**side B**)
B3 —Cable Radius transitioning out of the floor (**side B**)

Figure 5-11: Calculating Trunk Cable Length

Shorter length copper trunk cables, i.e. - less than 25m (100 ft.), are shipped coiled flat within a box. Fiber trunk cables and longer length copper trunk cables are shipped on wooden reels.

For trunks shipped in boxes, it's best to remove the cable completely from the box before installing. This will eliminate any potential kinking of the outer jacket and allow the assembly to transition more easily into the pathway space.

5.48 The process of installing trunk cables assemblies is similar to typical cable installations. However, special care shall to be taken to avoid damage to the connectors on the ends of the assemblies.

5.49 Pathways for distributing the trunk assemblies shall be sized to ensure that there is sufficient space for the pulling grip to pass through without damaging the connectors covered elsewhere.

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Note: When installing trunk cable, it is imperative that the length of trunk assembly ordered, meets the distance between the origination (A) and destination (B) points with a minimal amount of slack to be stored. Excessive slack can be very difficult to store, which can create difficulties in managing the extra cable in an appropriate manner. Based on the length of the trunk cable assembly, it can be provided in a boxed packaging (used for short length copper trunks) or reel packaging (used for longer length copper trunks and all fiber trunks).

Figure below illustrates a typical crew deployment for a trunk installation. As the distance between points A and B of the cable run grows (typically anything over 100 ft.), or if there are direction changes in the cable pathway, it is recommended that an additional technician be used at the middle of the cable path and/or at each point of the direction change.

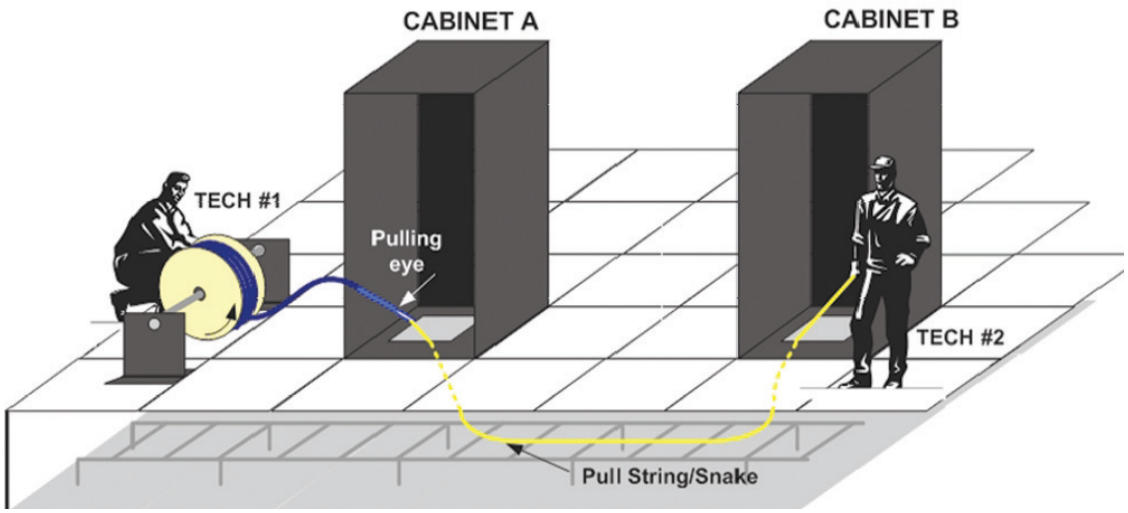

Figure 5-12: Installation Technician Deployment for Trunking Installations (typical)

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NORMATIVE SUMMARY

5.1 At a minimum, the installation practices contained in this manual as well as Siemon installation instructions shall be observed for Horizontal and Backbone cabling to ensure initial and continuing performance of the cabling system over its warranty period and life cycle.

5.2 Mixing different categories/classes of components within a Permanent Link or Channel means the Permanent Link / Channel shall be classified to the least performing component.

5.3 All fiber components installed within a Permanent Link/Channel shall be of the same optical type/size and performance.

5.4 Unless specified otherwise by applicable Standards, codes or regulations, equipment racks, cabinets, and closures shall be installed to provide for a minimum of 1.2m (4 ft.) where service access is required.

5.5 Safety in fiber optic installations includes avoiding exposure to invisible light radiation carried in the fiber, proper disposal of fiber scraps produced in cable handling and termination and safe handling of hazardous chemicals used in termination, splicing or cleaning.

5.6 All manufactured pathway systems shall be installed as per manufacturer's installation instructions. In addition, all sharp edges are to be removed or protected, prior to the installation of cables.

5.7 Sharp edges or burs on pathways shall not come into contact with cables. Exposed metal edges shall be fitted with bushings or other means of protection so that cable jackets are not damaged during or after installation.

5.8 Non-continuous cable supports, such as hangers and hooks shall be located at intervals not to exceed 1.5 m (5 ft) apart.

5.9 Telecommunications cables shall be supported with devices designed for this purpose and shall be installed independently of any other structural component.

5.10 Cables routed vertically shall be supported with appropriate hardware to properly support the media type and quantity of cables being installed. These supports shall occur at least two times per floor.

5.11 The number of cables, regardless of media type, placed in a pathway system (hangers, trays, raceways etc.) shall be limited, such that the geometric shape of the cables is not altered during the warranty period.

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5.12 Maximum pathway (cable tray/wireway) capacity shall not exceed a calculated fill ratio of 50% to a maximum of 150 mm (6 in) inside depth.

5.13 Maximum perimeter and furniture pathway capacity shall not exceed a 60% fill ratio.

5.14 Open ceiling pathway systems shall be mounted/installed to be a minimum of 75 mm (3 in) above the ceiling grid which supports the tiles.

5.15 A minimum clearance of 300mm (12in) shall be provided above the open pathway system.

5.16 All cables shall be suitable for the environment in which they are installed.

5.17 All cables installed in wet locations shall be rated for that environment.

5.18 Cables shall not be laid directly on concrete floors that are or may become wet or damp.

5.19 Cables shall not be stored, installed or in operation in locations that exceed the temperature ratings of that cable.

5.20 Indoor/Outdoor tight buffered fiber cable shall be installed in outdoor ducts that may have temporary moisture or water present, as well as meeting the indoor rating requirements needed to comply with codes, standards and regulations.

5.21 Both balanced twisted pair and optical fiber cable shall be pulled from the packaging they were provided on (i.e. reel-ex boxes, reel in box, reels).

5.22 The specified maximum cable pulling tensions and minimum bend radii shall not be exceeded.

5.23 Cables shall not be placed over the edges of raceways, cabinets, enclosures, or other fixtures, where the cable can be bent beyond the cables bend radius requirements.

5.24 The minimum bend radius under no load conditions for 4-pair balanced twisted pair cable shall not be less than four times the cable diameter.

5.25 The minimum bend radius under no load conditions for multi-pair cables shall not be less than that recommended by the manufacturer.

5.26 The minimum bend radius of balanced twisted pair patch cords/equipment cords shall not be less than four times the cable diameter.

5.27 The minimum bend radius under no-load conditions for Horizontal 2 -strand/core fiber cable shall not be less than 25 mm (1 in). Under a maximum tensile load of 222 N (50 lbf), the minimum bend radius shall not be less than 50 mm (2 in).

5.28 The minimum bend radius for building or campus optical fiber Backbone cable shall not be less than that recommended by the manufacturer.

5.29 The minimum pulling tension for 4-pair balanced twisted-pair or optical fiber cable shall not be less than that recommended by the manufacturer.

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5.30 When using Velcro cable managers or cable ties to bundle cables, no force shall be used to tighten the device, that causes a change to the geometric shape of the cable.

5.31 All horizontal or backbone cables installed in areas of public access shall not be exposed.

5.32 Connecting hardware and all other cabling system components shall be installed to provide optimal signal performance.

5.33 Connecting hardware shall be installed to provide orderly, well-organized cable management.

5.34 All connecting hardware shall be installed in compliance with the manufacturer's installation instructions

5.35 All tools used to terminate cable to connecting hardware shall be in excellent working condition and be free from any wear or damage

5.36 Connecting hardware shall be securely mounted on walls, floors, modular furniture, racks, cabinets and frames, or other stable and accessible surfaces.

5.37 For balanced twisted-pair cable, only the minimum amount of sheath/jacket to terminate the pairs/conductors to the connecting hardware shall be removed.

5.38 Category 5e, 6 and 6A balanced twisted-pair pin and pair grouping assignments shall be T568A or T568B.

5.39 The cable pair twist shall be maintained as close as possible to the point of mechanical termination by not changing the original twist.

5.40 For balanced twisted pair systems, there shall be no more than two pieces of connecting hardware within the cross connect.

5.41 Optical fiber connecting hardware shall be protected from physical damage and from direct exposure to contaminants.

5.42 Only enough jacket/sheath shall be removed to store the buffered strands/cores within the fiber enclosure/box.

5.43 Optical fiber terminations shall be performed using reverse-pair positioning

5.44 Once completed, optical fiber terminations shall have dust caps placed into each unused adaptor port or on the end of the terminated fiber connector.

5.45 Prior to the installation of any fiber connector into adapter ports, both the end-face of the connector and the adapter shall be properly cleaned.

5.46 Dry cleaning methods should use static minimizing cleaning sticks which are specially designed to clean optical fiber end faces and are available for multi-fiber MPO connectors as well as LC and SC fiber connectors for both connector end face and bulkhead adapters.

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5.47 For significantly contaminated end faces, "wet" solvent methods should be used. The static bond breaking properties makes it an ideal method to remove heavy or persistent contamination.

5.48 The process of installing trunk cables assemblies is similar to typical cable installations. However, special care shall to be taken to avoid damage to the connectors on the ends of the assemblies.

5.49 Pathways for distributing the trunk assemblies shall be sized to ensure that there is sufficient space for the pulling grip to pass through without damaging the connectors covered elsewhere.

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6. BONDING AND GROUNDING

6.1. Overview

Bonding and grounding systems contained within a building are intended to have one electrical potential. Although the bonding and grounding of the electrical service entrance is outside the scope of this manual, coordination between electrical and telecommunications bonding and grounding is essential. It is imperative to become familiar with a generic telecommunications bonding infrastructure and all of its elements per appropriate industry standards, codes and regulations

6.2. Electrical Safety, Electromagnetic

6.2.1. Interference Considerations, Grounding and Bonding

6.1 All telecommunications bonding and grounding (earthing) shall comply with applicable standards, codes and regulations.

6.2.2. Power Separation for Safety

6.2 Telecommunications cables (fiber or copper) shall not be installed into any containment compartment where electrical cables are housed.

6.3 Power cables shall be physically separated from the telecommunications cables in accordance with applicable standards, codes and regulations.

6.2.3. Electromagnetic Protection

EMI is an important consideration in the design of telecommunication pathways and spaces. Providing separation distance from EMI sources for these elements of telecommunications infrastructure inherently provides separation of their contents (i.e., the equipment, cable and connecting hardware).

Locate telecommunications pathways, spaces and copper cables as far away as possible from sources of EMI such as electrical power wiring and transformers, electronic ballasts, copiers, RF sources and transmitters, large motors and generators, induction heaters, arc welders and x-ray equipment. Providing maximum separation will favor improved application performance.

Due to building structure limitations the installation of pathways and spaces in proximity to EMI is difficult to control. Although Siemon provides applications assurance as part of their warranty offerings, if the signal is influenced by the ingress of EMI, Siemon is not liable for application failures due to electromagnetic interference.

The following requirements apply to all telecommunications cabling, spaces and pathways used to carry or house telecommunications cabling.

6.4 The proximity of cabling to electrical facilities and equipment that generate high levels of electromagnetic interference (EMI) shall be taken into account for telecommunications cabling.

Note: Sources of EMI include: power cables, photocopy equipment, electric motors, transformers, fluorescent lighting, arc welders, etc.

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6.5 In addition to the requirements as stated for electrical safety the structured cabling designer shall take into account electromagnetic protection for the system to protect the transfer of data.

6.2.4. Basic Bonding Overview

Although much of the bonding and grounding for telecommunications spaces is outside the scope of the Siemon Cabling System some requirements must be considered. Also contained in this section are bonding requirements for metal enclosures, racks, cabinets and pathway which do have specific requirements for compliance in a Siemon Cabling System warranted installation. It is imperative that the designer and installer of bonding and ground for the telecommunications infrastructure be well educated in the applicable standards, codes and regulations.

6.2.5. Telecommunications Entrance Facility

The Telecommunications entrance facility is the room or space were the telecommunications facilities enter, all campus and building backbone cabling join and grounding of these facilities occurs.

6.6 The Telecommunications Entrance Facility shall contain the PBB or a minimum of one SBB's.

6.2.6. Telecommunications Rooms

6.7 Each Telecommunication Room shall contain a SBB which is located within the room.

6.2.7. Metallic Pathways

In order to reduce the potential between telecommunications pathways or telecommunications pathways and power pathways all telecommunication pathways the following requirements must be followed.

6.8 All telecommunications pathways must be bonded to the SBB or PBB

6.9 All cable tray sections shall be bonded together and bonded to the SBB or PBB

6.2.8. Structural Metal

Where structural metal is available and accessible in the same room as the SBB or PBB it may be possible to bond the SBB or PBB to the structure metal.

6.10 When bonding the SBB or PBB to structural steel a 6 AWG bonding conductor is required

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6.2.9. Shielded Cabling

6.11 Shielded cabling shall maintain the shield coverage throughout the Permanent Links or Channels such that only shielded cable and shielded connecting hardware are used and properly installed.

To maintain high frequency shield effectiveness while avoiding ground loop difficulties associated with shield grounding at multiple locations, the following requirements must be met.

6.12 Shielded horizontal and backbone connecting hardware and cabling shall be correctly bonded and grounded.

Note: To avoid ground loops, it is common practice for network equipment to be designed such that its internal circuitry does not provide a DC path between the cabling shield and the chassis ground, building ground or shielded ports. This DC shield isolation is commonly accomplished within a shielded equipment enclosure through the use of AC coupling capacitors connected between the cabling shield and the equipment ground.

6.13 For warranted cabling channels, shield effectiveness shall be maintained throughout the cabling channel.

6.2.10. Cabinets, Racks

6.14 Metallic enclosures including all cabinets and racks shall be bonded to the mesh, SBB or PBB using a minimum conductor size of 6 AWG.

6.15 Metallic enclosures identified in normative 7-13 shall have a dedicated bonding conductor to the mesh, SBB or PBB.

6.2.11. Equipment and Patch Panels

6.16 Equipment containing metallic parts and patch panels for shielded cabling, shall be bonded to the telecommunications grounding system in accordance with the manufacturer's instructions using a minimum 12 AWG bonding conductor.

Three bonding methods for Telecommunications Equipment and/or Patch Panels as provided by ANSI/TIA-607-D are highly recommended by Siemon.

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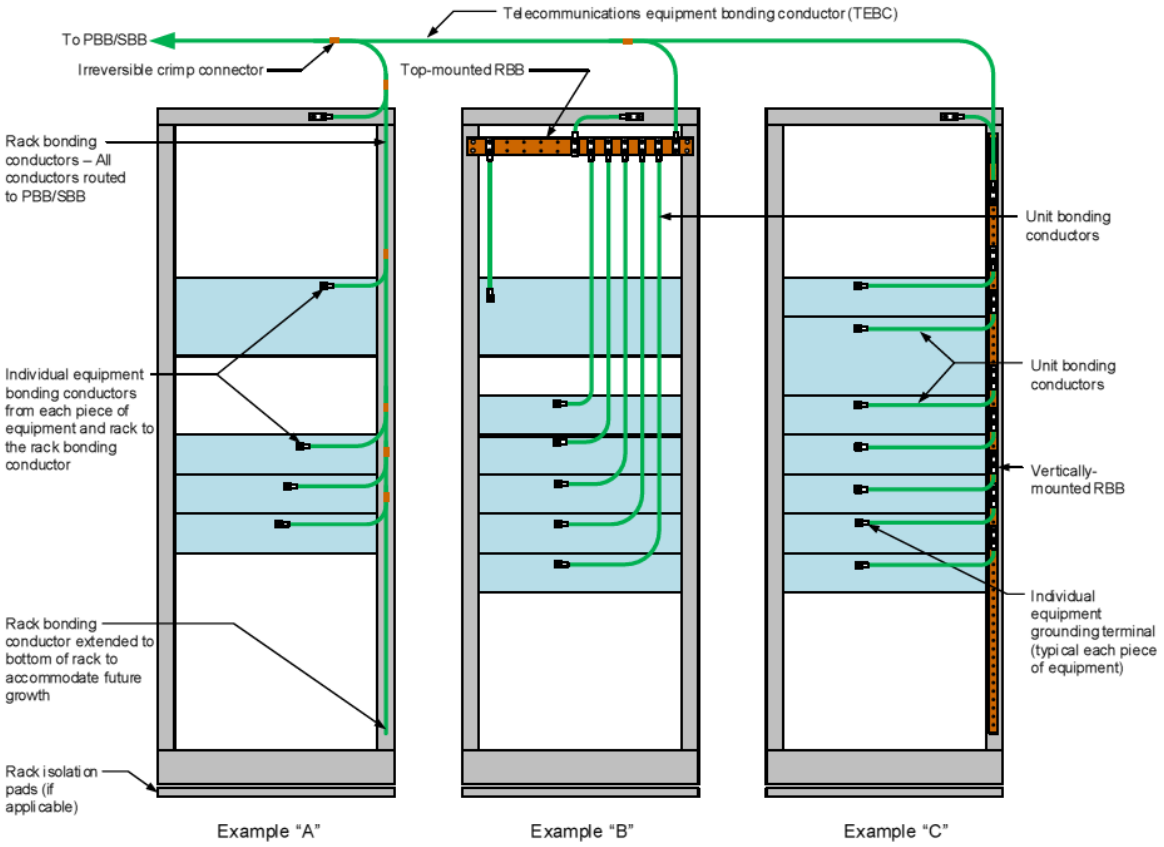

Figure 6-1: Examples of Methods to Bond Equipment and Racks

Rack bonding busbars (RBBs) are recommended for cabinets and racks that need to support multiple unit bonding conductors.

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NORMATIVE SUMMARY

6.1 All telecommunications bonding and grounding (earthing) shall comply with applicable standards, codes and regulations.

6.2 Telecommunications cables (fiber or copper) shall not be installed into any containment compartment where electrical cables are housed.

6.3 Power cables shall be physically separated from the telecommunications cables in accordance with applicable standards, codes and regulations.

6.4 The proximity of cabling to electrical facilities and equipment that generate high levels of electromagnetic interference (EMI) shall be taken into account for telecommunications cabling.

6.5 In addition to the requirements as stated for electrical safety the structured cabling designer shall take into account electromagnetic protection for the system to protect the transfer of data.

6.6 The Telecommunications Entrance Facility shall contain the PBB or a minimum of one SBB's.

6.7 Each Telecommunication Room shall contain a SBB which is located within the room.

6.8 All telecommunications pathways must be bonded to the SBB or PBB

6.9 All cable tray sections shall be bonded together and bonded to the SBB or PBB

6.10 When bonding the SBB or PBB to structural steel a 6 AWG bonding conductor is required

6.11 Shielded cabling shall maintain the shield coverage throughout the Permanent Links or Channels such that only shielded cable and shielded connecting hardware are used and properly installed.

6.12 Shielded horizontal and backbone connecting hardware and cabling shall be correctly bonded and grounded.

6.13 For warranted cabling channels, shield effectiveness shall be maintained throughout the cabling channel.

6.14 Metallic enclosures including all cabinets and racks shall be bonded to the mesh, SBB or PBB using a minimum conductor size of 6 AWG.

6.15 Metallic enclosures identified in normative 7-13 shall have a dedicated bonding conductor to the mesh, SBB or PBB.

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6.16 Equipment containing metallic parts and patch panels for shielded cabling, shall be bonded to the telecommunications grounding system in accordance with the manufacturer's instructions using a minimum 12 AWG bonding conductor.

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7. DATA CENTERS

7.1 DC Fundamentals, classification

The data center is the location where most of the resources necessary for processing information in an organization are concentrated. In the data center, as well as other types of buildings, the cabling system for information communications & technology is as important as precision air systems, electric power, lighting and security, among others. As with the other systems, an interruption in service can have serious consequences. The effectiveness may be threatened by poor service quality, caused by:

- the absence of a well-planned design
- use of inappropriate components
- Improper installation
- mismanagement
- inadequate support

7.2 Data Center Cabling

Cabling systems within a data center, whether generic or specific application, have the difficult task of providing the highest degree of availability and performance without sacrificing flexibility to support communications technologies, storage and processing of data, which are in constant evolution.

Proper design of a data center cabling system should be based on international standards ISO/IEC 11801-5 (Information technology – Generic cabling for customer premises – Part 5: Data centers) and ANSI/TIA-942-B (Telecommunications Infrastructure Standard for Data Centers).

In order to provide the longest operational life while minimizing disruption and cost associated with re-cabling, the fixed installed cabling should be designed to support the broadest set of existing and emerging applications and accommodate the anticipated growth in volume of supported applications throughout the predicted lifetime of the installation. In addition, the provision of redundancy within a cabling design should be considered.

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7.3 Functional Elements

The functional elements of a structured cabling system for data centers are described on the following table with their correspondence to generic cabling standards and illustrated on the subsequent figures. Note that terminology varies across ISO & TIA and other regional technical standards applicable global Standards.

Generic Cabling System	Data Center Cabling System	Generic Cabling Systems	Data Center Cabling Systems
ISO/IEC 11801-2	ISO/IEC 11801-5	ANSI/TIA-568.0-D	ANSI/TIA-942-B
	External Network Interface (ENI)		External Network Interface (ENI) [Located in Entrance Room]
	Network Access Cabling		
Campus Distributor (CD)	Main Distributor (MD)	Distributor C	Main Cross-connect (MC) Located within Main Distribution Area (MDA)
Campus backbone cabling	Main Distribution Cabling	Cabling Subsystem 3	Backbone Cabling
Building Distributor (BD)	Intermediate Distributor (ID)	Distributor B	Intermediate Cross-connect (IC) Located within Intermediate Distribution Area (IDA)
Building backbone cabling	Intermediate Distribution Cabling	Cabling Subsystem 2	Backbone Cabling
Floor Distributor (FD)	Zone Distributor (ZD)	Distributor A	Horizontal Cross-connect (HC) Located within Horizontal Distribution Area (HDA)
	Zone Distribution Cabling	Cabling Subsystem 1	Horizontal Cabling
Consolidation Point (CP) [optional]	Local Distribution Point (LDP)	Consolidation Point [Optional]	Consolidation Point (CP) Located within Zone Distribution Area (ZDA) [Optional]
Telecommunications Outlet (TO)	Equipment Outlet (EO)	Equipment Outlet (EO)	Equipment Outlet (EO) Located within Equipment Distribution Area (EDA)

Table 7-1 - Equivalent Cabling Functional Elements

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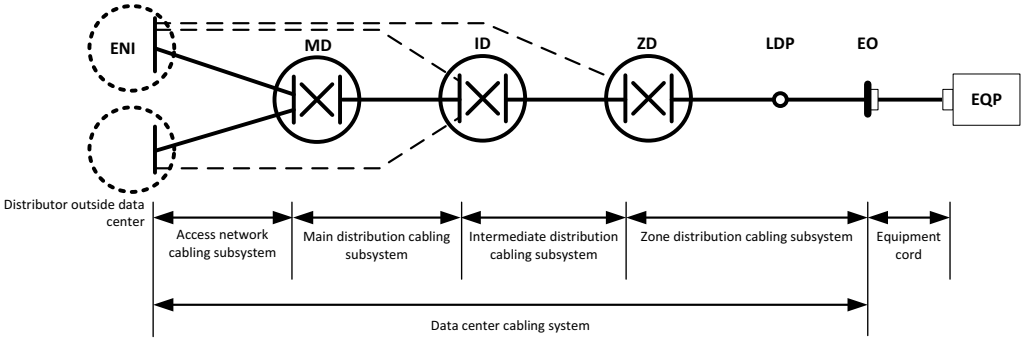

Figure 7-1: Data Center Cabling Functional Elements (ISO/IEC 11801-5)

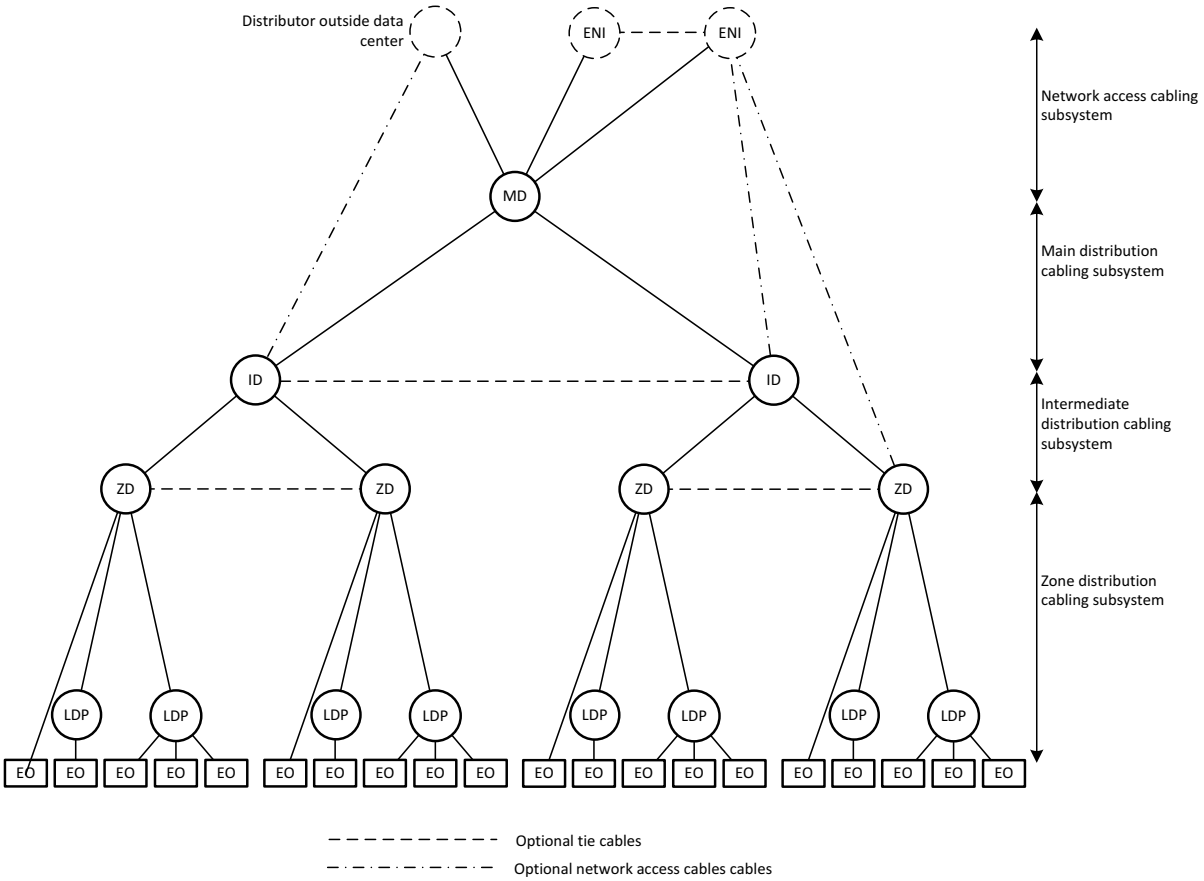

Figure 7-2: Hierarchical structure of generic cabling within a data center

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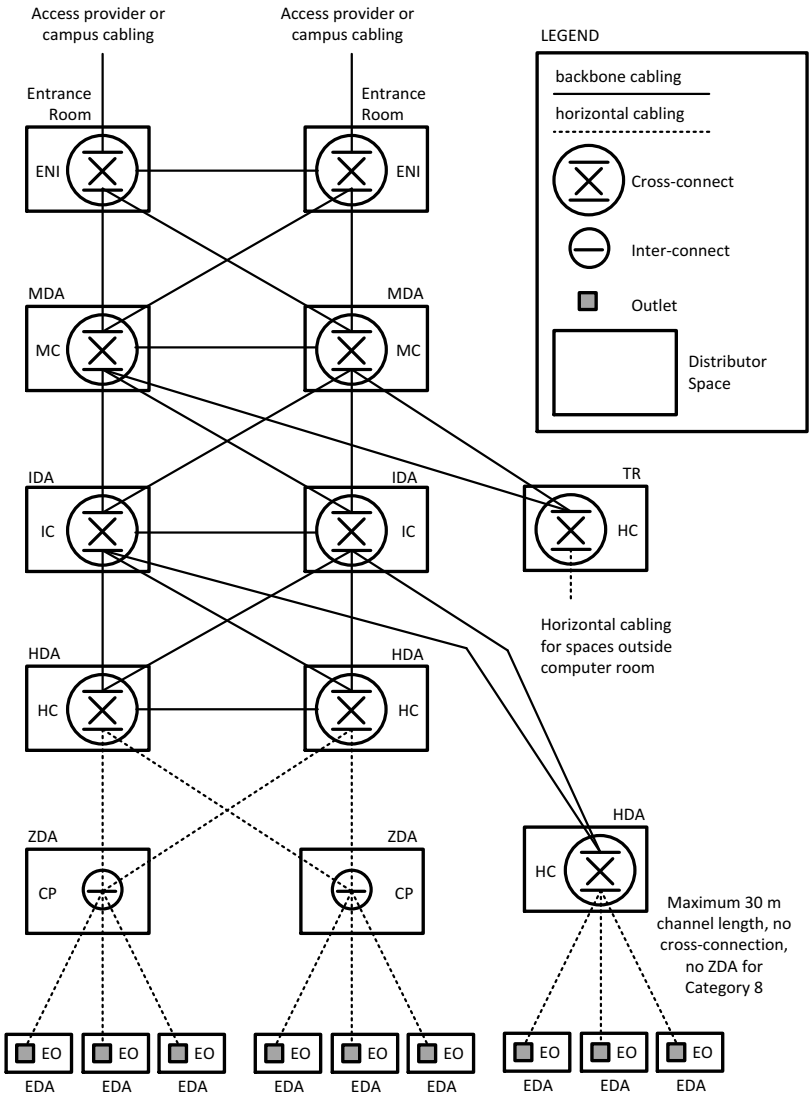

Figure 7-3: Example of a typical data center topology (ANSI/TIA-942-B)

7.3.1. Network Access Cabling Subsystem

The network access cabling subsystem extends from an MD/MC (or ID/IC, or ZD/HC) to the ENIs or to a distributor outside of computer room. The subsystem includes:

- Network access cables,
- Mechanical termination of the network access cables at the ENI(s),
- Mechanical termination of the network access cables at the MD/MC, ZD(s)/HCs or other distributors outside the computer room.

7.3.2. Main Distribution Cabling Subsystem

The main distribution cabling subsystem extends from an MD/MC to the ID(s)/IC(s) connected to it. The subsystem includes:

- Main distribution/Backbone cables

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- Mechanical termination of the main distribution cables at the MD/MC together with associated patch cords and/or jumpers at the MD/MC
- Mechanical termination of the main distribution cables at the ID(s)/IC(s)

7.3.3. Intermediate Distribution Cabling Subsystem

The Intermediate Distribution cabling subsystem extends from an ID/IC to the ZD(s)/HC(s) connected to it. The subsystem includes:

- Intermediate distribution cables
- Mechanical termination of the intermediate distribution cables at the ID/IC together with associated patch cords and/or jumpers at the ID
- Mechanical termination of the intermediate distribution cables at the ZD(s)/HC(s)

7.3.4. Zone Distribution Cabling Subsystem

The zone distribution cabling subsystem extends from a ZD/HC to the EO(s) connected to it. The subsystem includes

- Zone distribution cables
- Mechanical termination of the zone distribution cables at the EO(s) and the ZD/HC together with associated patch cords and/or jumpers at the ZD/HC, LDP(s)/CP(s) (optional), LDP/CP cable(s) (optional), EO(s)

7.3.5. Distributors

The number and type of subsystems that are included in a generic cabling implementation depends upon the layout and size of the data center and upon the strategy of the user.

7.1 ***The design of data center distributors shall ensure that the length of patch cords, jumpers and equipment cords are optimized to avoid excess slack, and administration should ensure that the design lengths are maintained during operation.***

7.2 ***Every data center shall have at least one Main Distributor/Main Cross-connect.***

The functions of multiple distributors may be combined into a single distributor. For example, an MD/MC may serve the function of a ZD/HC.

7.3.6. Equipment Outlets

The design of generic cabling should provide for EOs to be installed with a high density and located near the application-specific equipment to which they are to be connected.

7.3.7. Local Distribution Point/Consolidation Point

The installation of an LDP/CP in the cabling subsystem between the ZD/HC and the EO may be useful where frequent additions or movements of equipment are required. The LDP/CP adds one connection per channel or link.

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7.3 ***Only one LDP/CP shall be permitted between a ZD/HC and any EO.***

7.4 ***The LDP/CP shall be an interconnect, not a cross-connect.***

7.5 ***There shall be no active equipment in the LDP/CP area.***

7.6 ***Where an LDP/CP is used, it shall have enough capacity to support the area of the data center which it is designed to serve during its intended operational life.***

NOTE: The area served may be defined in terms of number of frames/cabinets/closures to be supported and should include allowance for growth.

NOTE: LDP(s)/CP(s) may be located in ceiling voids or under floors

7.4 Equipment Interfaces

The connection between two equipment interfaces should have some key features:

Compatibility – this could imply a number of options:

- physical layer (media): whenever two equipment have different media interfaces, a converter is required. This could e.g. be cable (copper / fiber) vs wireless (cable / radio)
- protocol: as an example, storage systems might utilize Fibre Channel over Ethernet (FCoE) to properly communicate with all the other Ethernet Systems in the Data Center
- speed: some equipment/network cards can communicate with older equipment – backward compatibility is a great benefit to prevent full replacements of the installed base

Equipment interfaces for data centers are located at the ends of the cabling subsystems.

NOTE: An LDP/CP does not provide an equipment interface to the generic cabling system.

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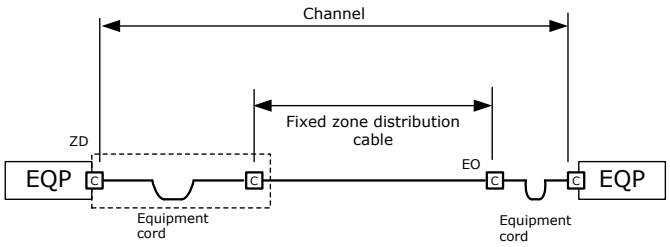
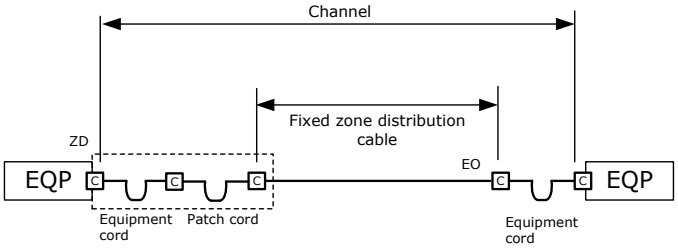
7.5 Topology / Redundancy

Consideration should be given to the resilience of the data center with respect to the cabling infrastructure. Measures that can be taken to improve the resiliency include:

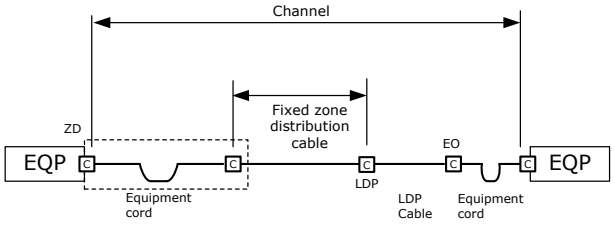
- Redundant and physically separated building entrance facilities,
- Redundant and physically separated ENIs with service provisioned in the ENIs by multiple service providers,
- Provision of redundant and physically separated distributors (MD/MC, ID/IC, ZD/HC),
- Provision of tie cables between peer level distributors (i.e., MD/MC-to-MD/MC, ID/IC-to-ID/IC, ZD(CP)-to-ZD(CP)),
- Diversely routed cabling between distributors (preferably with different colored jackets or labels).



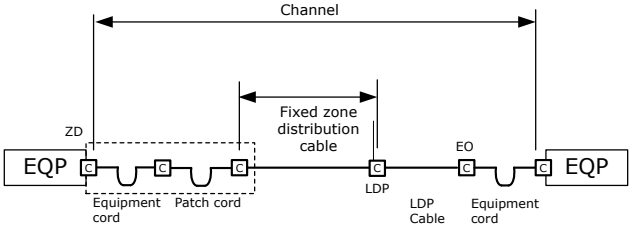
Interconnect – EO model



Cross-connect – EO model



Interconnect – LDP/CP – EO model



Cross-connect – LDP – EO model

Figure 7-4: Data Center Topologies (ISO/IEC 11801-5)

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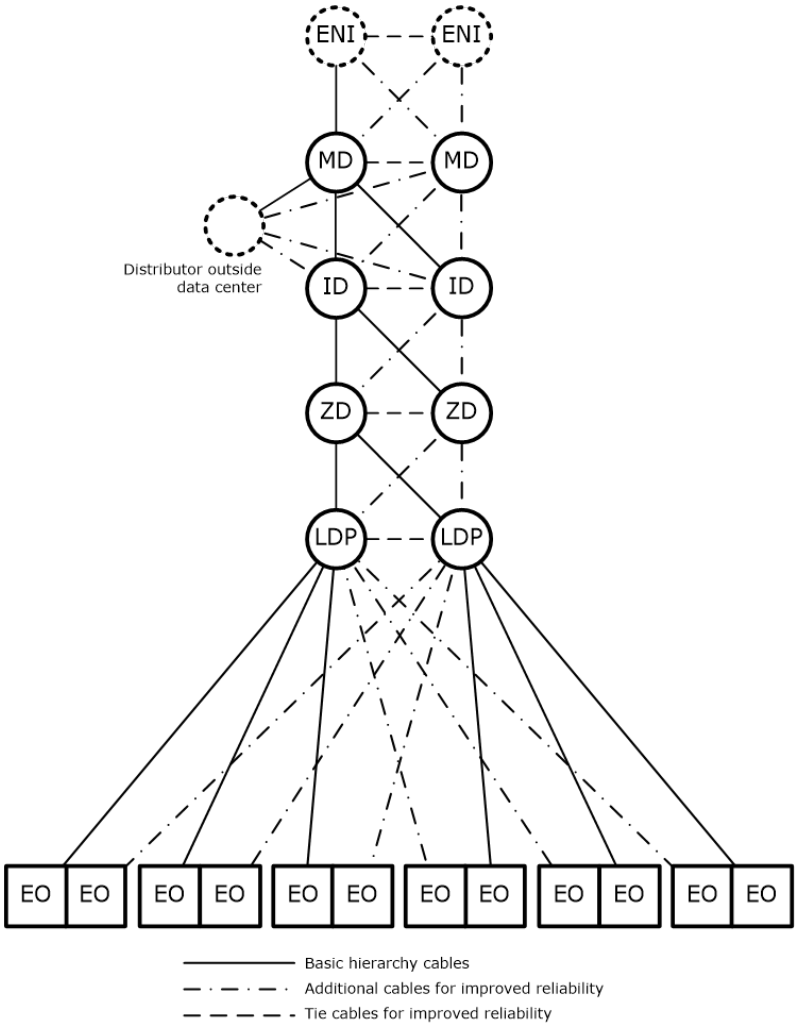

Figure 7-5: Redundancy of functional elements (ISO/IEC 11801-5)

7.5.1. Direct attach cord recommendations

Equipment cords connect the generic cabling to transmission equipment at distributors and to terminal equipment at the EO. Equipment cords are non-permanent and can be application specific.

As per standard structured cabling system the use of direct-attach cords is restricted:

- within a distributor,
- within a single cabinet, frame, or rack,
- between adjacent cabinets, frames, or racks in the same row.

7.5.2. Minimal Category / Class in DC

The below table identifies the various channel configurations and applications for the cabling categories/classes typically found in data centers.

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Channel Performance	Components Performance	Bandwidth	Maximum Application Supported	Maximum Channel Length	Maximum Number of Connectors
Class E_A / Category 6A	Category 6_A	500 MHz	10GBASE-T	100m (a)	4(b)
Class F	Category 7	600 MHz	10GBASE-T	100m (a)	4(b)
Class F_A	Category 7_A	1000 MHz	25GBASE-T(c)	30m (e)	2
Class I / Category 8	Category 8.1(d)	2000 MHz	40GBASE-T	30m (e)	2
Class II	Category 8.2	2000 MHz	40GBASE-T	30m (e)	2

Table 7-2: Channel performance of balanced cabling

(a) 10GBASE-T in short reach mode specifies a maximum channel length of 30m.

(b) 10GBASE-T in short reach mode specifies a maximum of two connectors in the channel.

(c) Based on ISO/IEC TR 11801-9905.

(d) Category 8.1 components cannot be used to provide a Class F, FA or II balanced cabling performance

(e) Maximum PL length of 26m with max cordage length of 4m

7.7 ***At a minimum, class EA/category 6A cabling shall be installed for a new (greenfield) data center.***

NOTE: It is recommended to design data center spaces so that balanced cabling channel lengths are limited to 30m (98 ft.) to take advantage of the power savings of short reach 10GBASE-T as well as future 25 and 40GBASE-T topologies.

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7.5.3. Cabling Length in Data Center

The following tables show the minimum and maximum length of zone/horizontal distribution cabling for the different standardized categories

7.5.3.1 *Copper links*

Segment	Minimum length (m)	Maximum length (m)
ZD/HC-LDP/CP	15	85
LDP/CP-EO	5	–
ZD/HC-EO (no LDP/CP)	15	90
Equipment cord at the EO	2[(a)]	5
Patch cord	2	–
Equipment cord at the ZD/HC	2[(b)]	5
All cords	–	10[(c)]

Table 7-3: Copper link lengths

(a) If there is no LDP/CP, the minimum length of the equipment cord is 1 m.
(b) If there is no cross-connect, the minimum length of the equipment cord is 1 m.
(c) If longer cord distances are required, length equations of Table 3-1 shall be applied.

Segment	Minimum length (m)	Maximum length (m)
ZD/HC-EO	5	26
Equipment cord at the EO	1	2
Equipment cord at the ZD/HC	1	2
All cords	–	4[(a)]

Table 7-4: Zone/horizontal distribution cabling –
Length assumptions for balanced cabling using Category 8, Class I and Class II

(a) If longer cord distances are required, the length shall be determined by the following:
F = (32-Z) / X
where:
F = combined length of patch cords and equipment cords (m)
Z = maximum length of the fixed horizontal distribution cable (m)
X = ratio of cordage insertion loss (dB/m) to horizontal distribution cable insertion loss (dB/m)
Typical values of X are according to cable gauge and construction:
Stranded 26 AWG = 1.5
Stranded 23 or 24 AWG = 1.2
Solid 23 or 24 AWG = 1.0

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7.5.3.2 *Fiber links*

The consolidated models based on 2, 3 and 4 connectors applicable to copper links are also applicable to optical fiber cabling for zone distribution cabling, cabling between distributors and network access cabling. Additional connections can be used if the maximum channel insertion loss of the selected application allows.

7.8 ***Optical fiber cabling shall be installed for new (greenfield) data centers:***

Multimode: OM3, OM4 or OM5

Singlemode: OS1a or OS2

7.9 ***The following optical fiber connectivity shall be installed for new (greenfield) data centers:***

Channels with 1 or 2 fiber: LC connector

Channels with more than 2 fibers: array (MPO/MTP) connector

7.10 ***Fiber channel length will be limited by the selected application (see Chapter 11 Application Distances)***

7.5.4. Topologies

The following figures show some examples of typical configurations in compliance with standard (ISO) recommendations:

These configurations, in any different combinations and/or redundancy levels, allow for the implementation of either traditional and modern networking architectures based on "fabric switches" (e.g. fat-tree, fabric full-mesh, interconnected meshes, centralized and virtual switch). For further details please refer to the latest published international standards ISO/IEC 11801-5 and ANSI/TIA-942-B and other relevant regional standards.

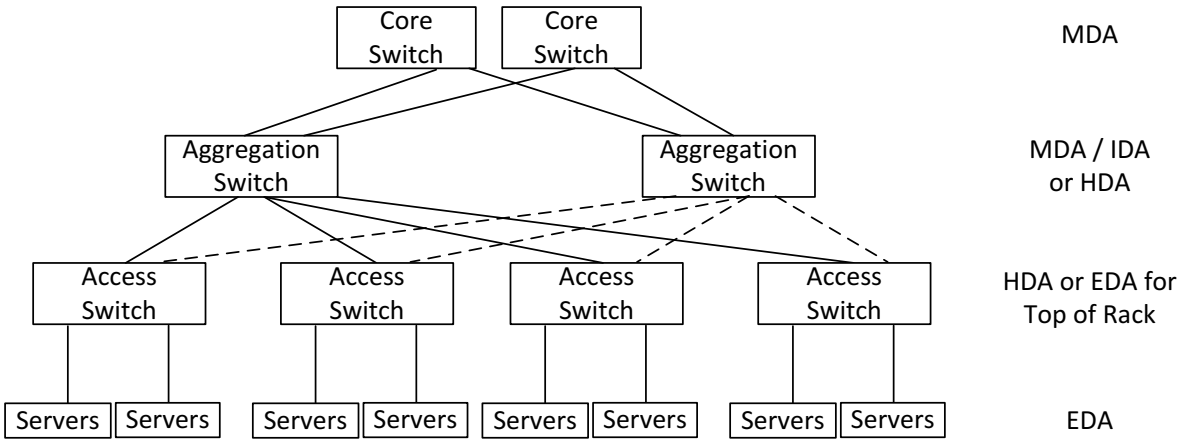

Figure 7-6: Three Layer Architecture

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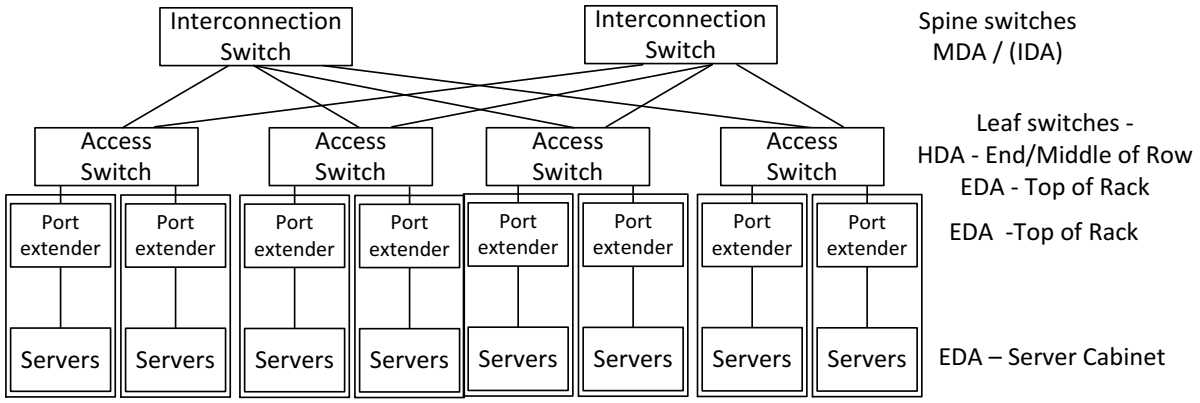

Figure 7-7: Fat-tree (Spine-Leaf) Fabric Two-Layer Architecture

It is worth noticing that a small data center consisting of one distributor serving one rack of servers and one rack of storage would often utilize direct connect patch cords, but this is not recommended by international standards (e.g. ISO/IEC 11801-5). The structure would contain no structured cabling, but only patch cords or direct-attach cables, which serve as the telecommunications cabling.

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7.5.4.1 *End of Row*

In this configuration each row has one or more Networking Cabinets (with Access Switches) positioned at each end of the row, connected to all the Server Cabinets of the same row with copper links. The Access Switch uplinks to the Core/Aggregation Switches and the SAN interfaces of the servers are connected to the MD/MC/ID/IC with fiber links. Each MD/MC/ID/IC has fiber connections to either Core or SAN cabinets.

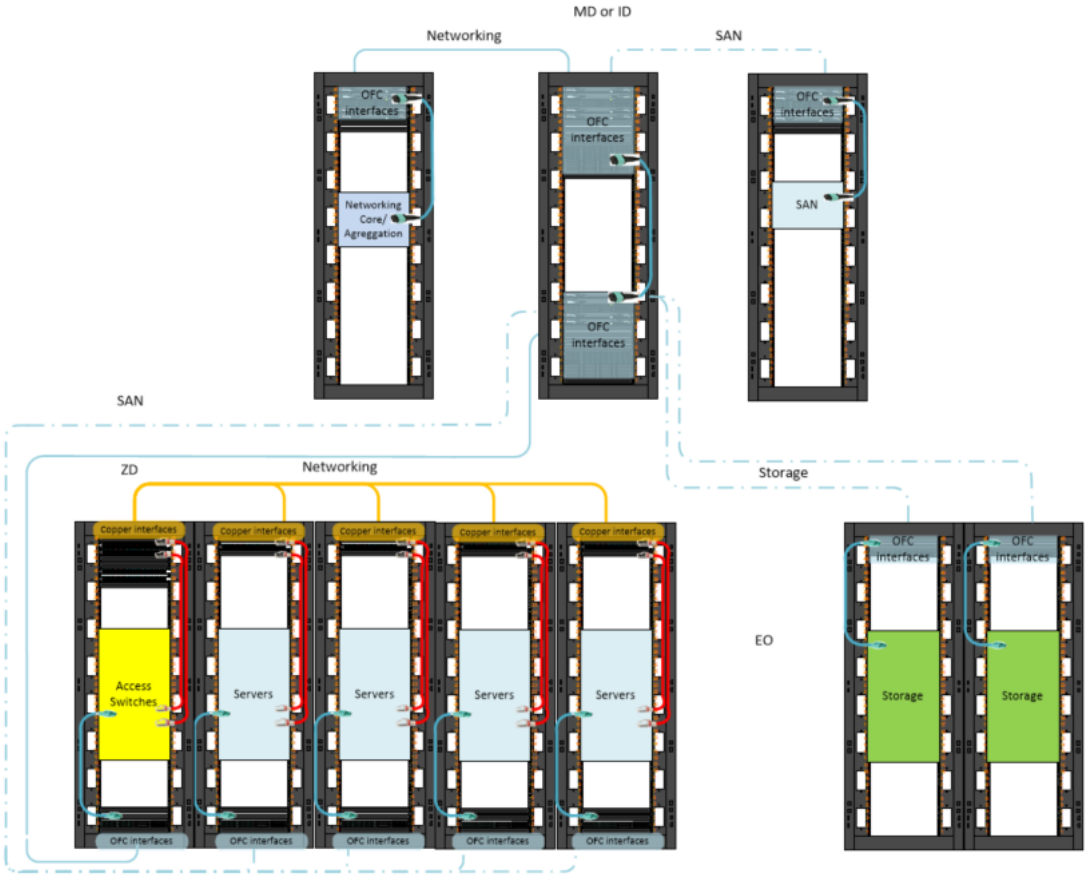

Figure 7-8: End of Row Architecture

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7.5.4.2 *Middle of Row*

In this configuration each row has one or more Networking Cabinets (with Access Switches) positioned at the middle of the row, connected to all the Server Cabinets of the same row with copper links. The Access Switch uplinks to the Core/Aggregation Switches and the SAN interfaces of the servers are connected to the MD/MC/ID/IC with fiber links. Each MD/MC/ID/IC has fiber connections to either Core or SAN cabinets.

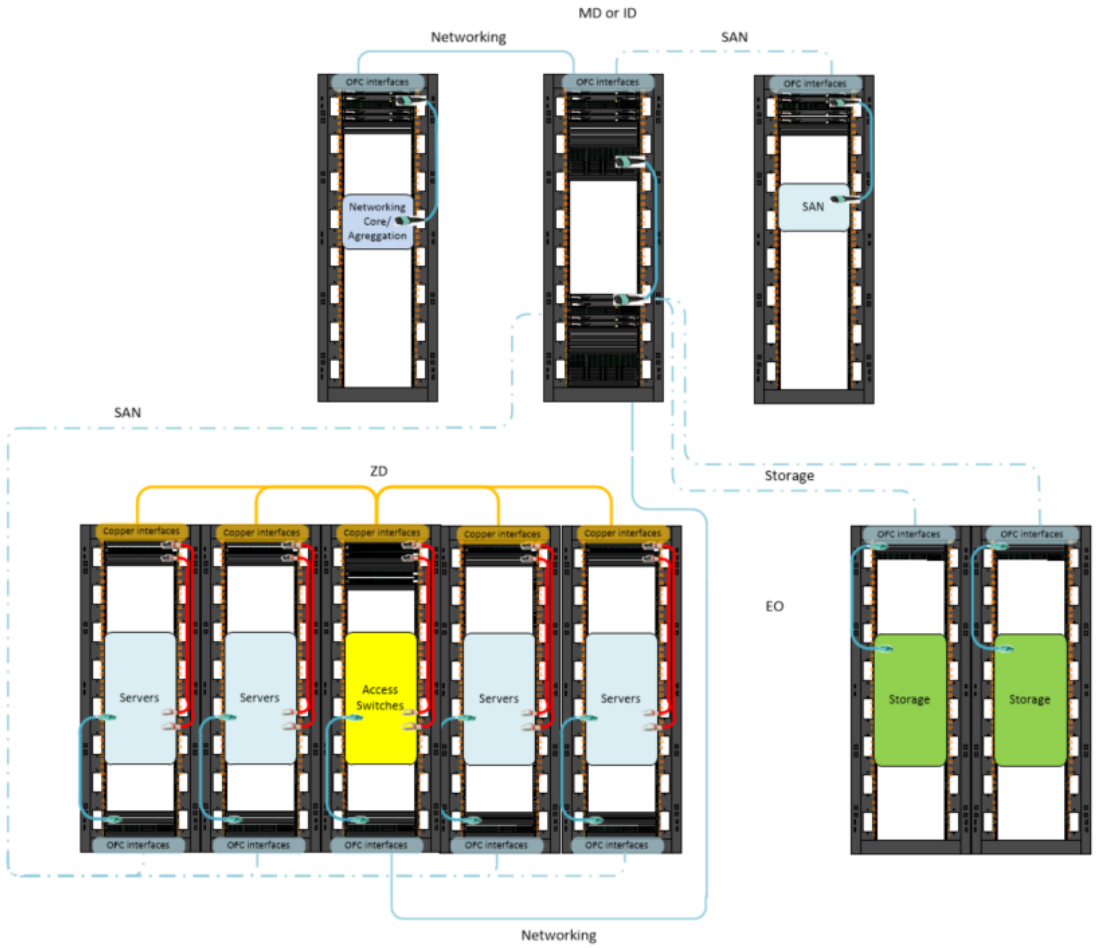

Figure 7-9: Middle of Row Architecture

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7.5.4.3 *Top of Rack*

In this configuration each Server Cabinets has 2 (or more) Top-of-Rack switches whose uplinks to the Core/Aggregation Switches, and the SAN interfaces of the servers are connected to the MD/MC/ID/IC with fiber links. Each MD/MC/ID/IC has fiber connections to either Core or SAN cabinets.

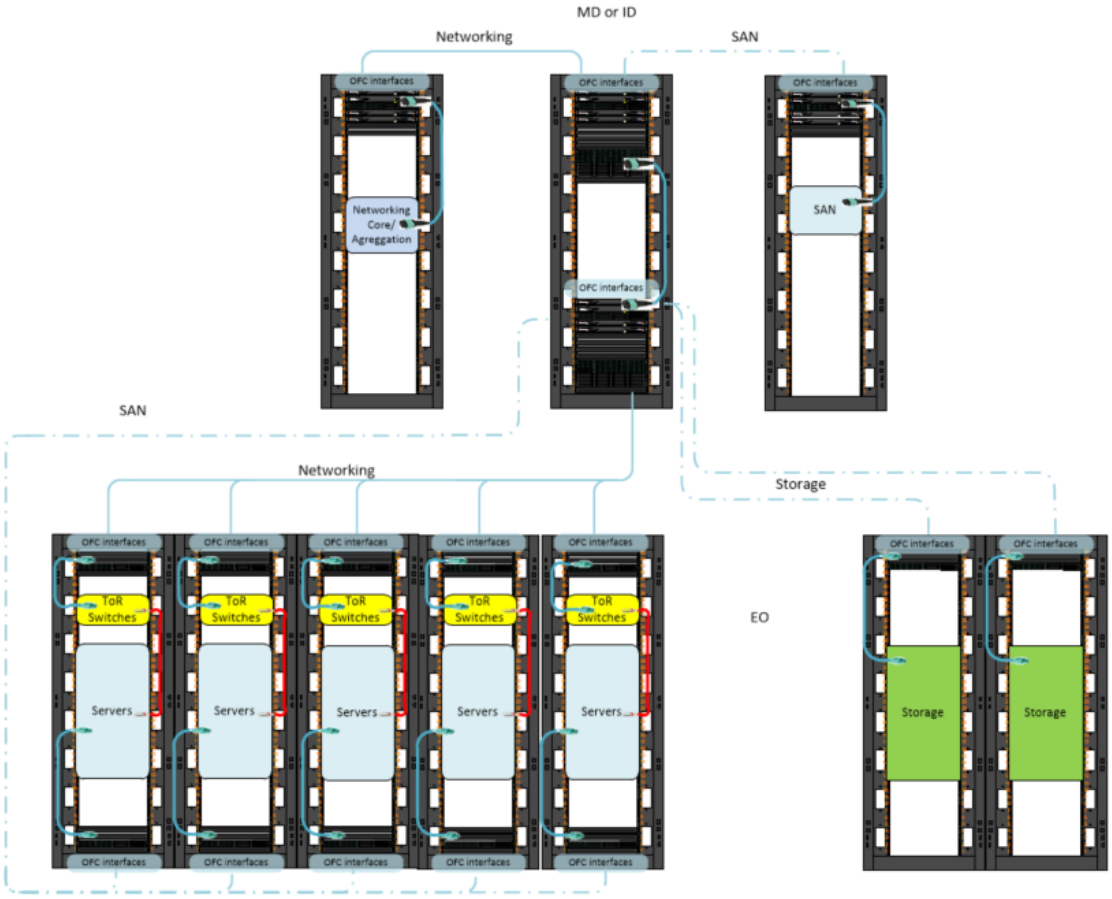

Figure 7-10: Top of Rack Architecture

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7.5.5. Polarity

When using "Duplex", "Parallel" or "Mixed" fiber optic systems, it is necessary to maintain polarity throughout the link to ensure the operation of the active devices. This means each transmitter should properly match the corresponding receiver.

In duplex transmission (i.e. typically 10Gb/s), each active equipment is provided with one Tx port and one Rx, which should be connected respectively with one Rx port and one Tx at each end of the transmission link.

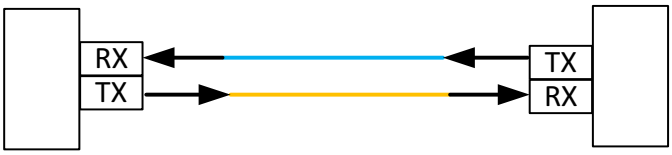

Figure 7-11: Duplex Transmission Polarity

Reversing polarity for correct data transmission is critical and that transmit is connected to receive and vice-versa to ensure duplex communication.

Multi-fiber transmission (parallel optic) systems (e.g. 40GBASE-SR4) are now more generally based on MPO/MTP array cables and connectors. Industry standards follow three different polarity methods for MPO/MTP: Method A, Method B and Method C.

Each polarity method offers advantages and disadvantages in implementing duplex transmission via cassettes or when transitioning to multi-fiber transmission (based on the end client's requirements).

NOTE: The deployment of non-standard polarity methods can result in vendor-lock in.

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7.5.5.1 *Method A*

For duplex transmission, Method A uses the same type of MPO-LC cassettes at each end and two different types of LC-LC cords (A-B at one end and A-A at the other).

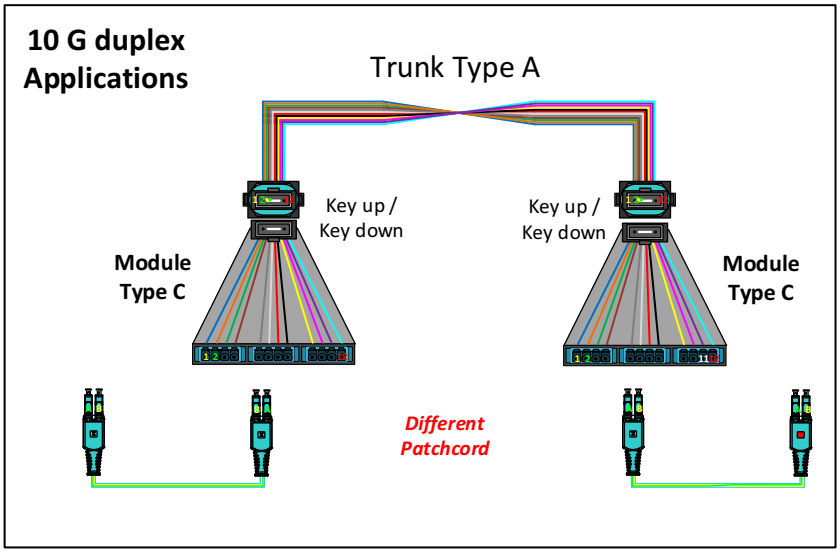

Figure 7-12

For parallel signal transmission, Method A uses two different types of MPO cord (A type at one end and B type at the other).

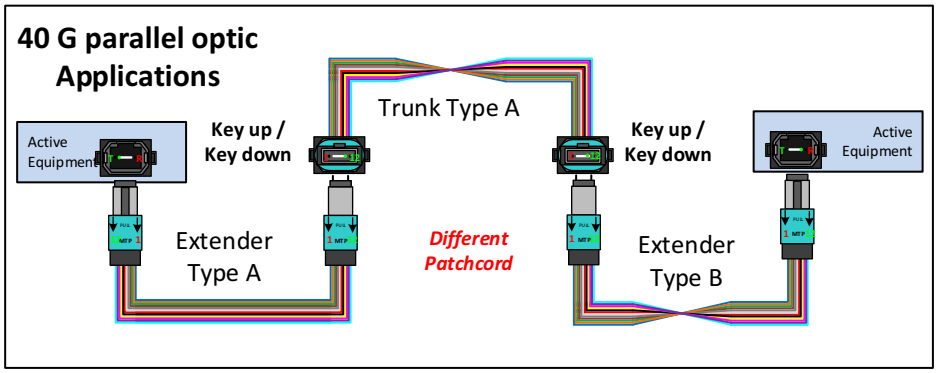

Figure 7-13

A summary of Method A polarity is as follows:

Duplex Applications

- Requires different polarity duplex patch cords on each end

Parallel Applications

- Requires different polarity array patch cords on each end

Summary

- Not ideal for duplex or parallel system applications
- Multiple polarity cords must be managed on user interface

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7.5.5.2 *Method B*

For duplex transmission, Method B uses two different types of MPO-LC cassettes (B1 at one end, B2 at the other) and the same type of LC-LC cord at each end.

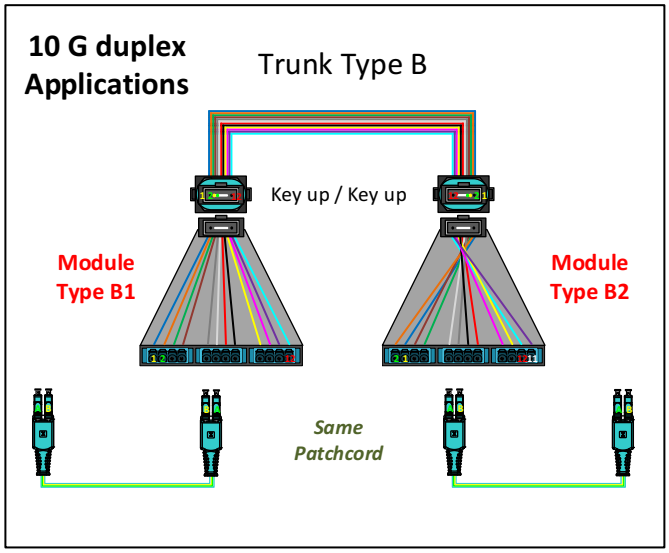

Figure 7-14

For parallel signal transmission, Method B uses the same type of MPO cord (B type) at each end.

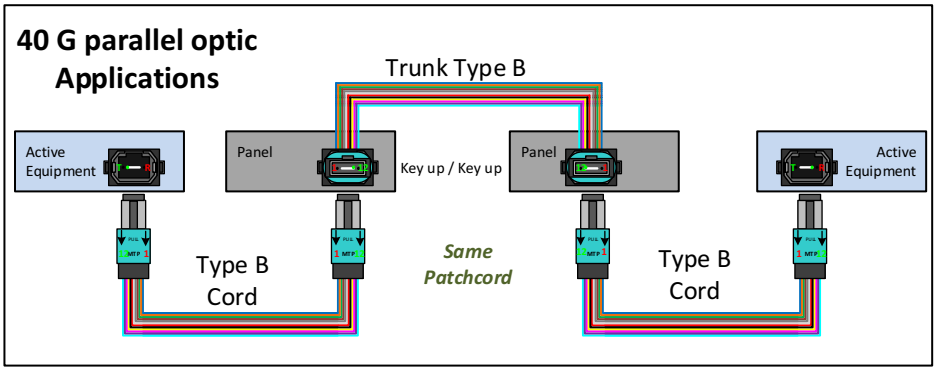

Figure 7-15

A summary of Method B polarity is as follows:

Duplex Applications

- Requires different polarity modules on each end

Parallel Applications

- All common polarity components in channel

Summary

- Not ideal for duplex applications, but polarity is managed within infrastructure, not at user interface
- Ideal for parallel applications

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7.5.5.3 *Method C*

For duplex transmission, Method C uses the same type of MPO-LC cassettes (C) and the same type of LC-LC cord at each end.

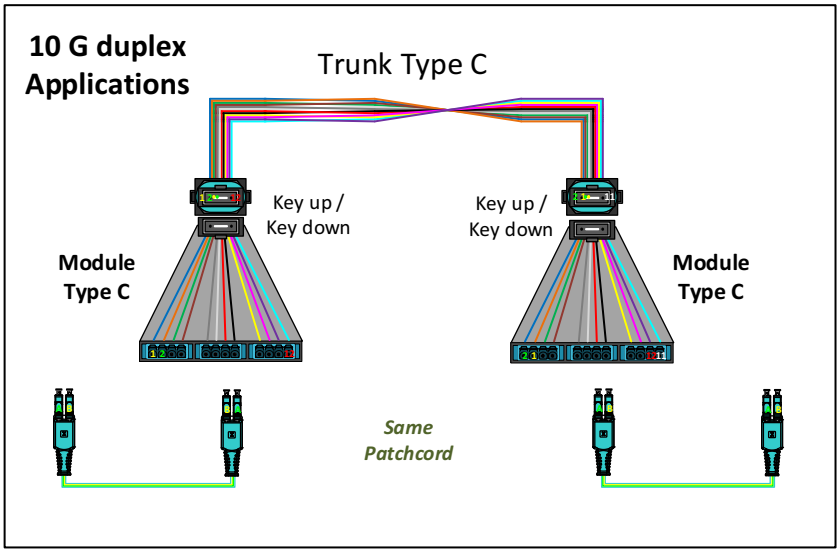

Figure 7-16

For parallel signal transmission, Method C uses two different types of MPO cord (B type at one end, C type at the other).

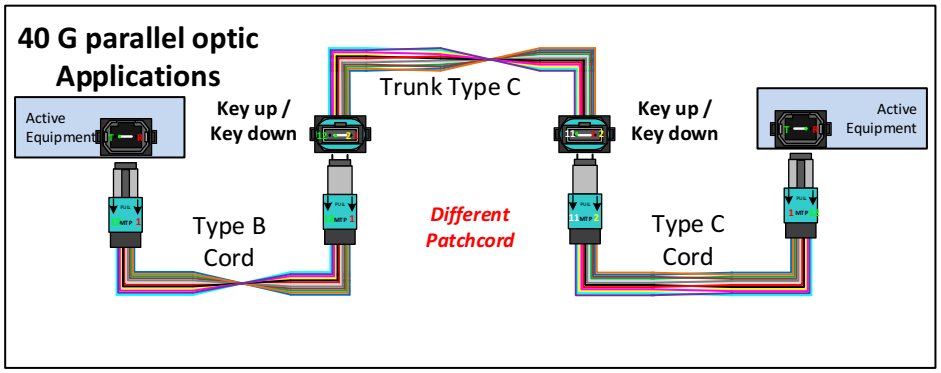

Figure 7-17

A summary of Method C polarity is as follows:

Duplex Applications

- All common polarity components in channel

Parallel Applications

- Requires different polarity array patch cords on each end

Summary

- Ideal for duplex applications
- Not ideal for parallel applications as polarity must be managed at user interface

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7.5.5.4 *Array Polarity Summary*

- Method A has no benefit for duplex or parallel systems
- Method B is manageable within infrastructure for duplex systems and ideal for parallel systems
- Method C is ideal for duplex system, but must be managed at user interface for parallel systems

Siemon Recommendation

- Use Method B if using duplex today with plans to migrate to parallel system
- Use Method C if using duplex today and no plans to migrate to parallel system

7.5.5.5 *Connector Gender Considerations for Array Systems*

It is recommended to use male-to-male (pinned) backbone cable to allow the use of female-to-female (non-pinned) jumpers at equipment

- Active equipment is male (pinned)
- To avoid using male-to-female jumpers where plugging of incorrect ends can damage equipment

Note that this would require specifying female (non-pinned) MTP/MPO connectors when using MPO/MTP-to-LC modules.

7.6 High Speed Interconnect (HSI)

High-speed interconnect assemblies or Direct Attach Cables (DAC) are used for direct attach point-to-point applications in the data center and support up to 100G across an array of applications.

There are different types of DAC cables; direct and breakout, passive and active. A direct connect DAC cable will connect one port/line card to another. A breakout DAC cable will allow one port to be connected to up to 4 other ports. An active DAC cable will offer slightly longer transmission distance than a passive DAC cable as it uses electronics within the modules at each end to boost the signals.

DAC copper cables are made from twinax copper and are factory terminated with modules that provide an electrical connection directly into active equipment. The modules cannot be removed from the cable and so all DAC cables are a fixed length. These twinax cable assemblies are especially beneficial in data centers utilizing top of rack and some middle or end of row architectures directly connecting switches to servers.

Active Optical Cables (AOC) are fixed fiber assemblies of two optical “engines” and a fiber patch cord, providing a more cost-effective alternative to transceivers. AOCs offer an extended reach option that offers the flexibility of traditional optical modules and are typically available in 10G, 25G, 40G and 100G configurations.

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7.7 Power Distribution Units (PDU)

A rack mount power strip, or rack power distribution unit (PDU), is a device fitted with many outlets that distribute electric power to servers, storage devices, and networking equipment located within racks or cabinets in a data center.

While Basic PDUs only provide reliable power distribution, Intelligent PDUs provide advanced real time power information with varying degrees of intelligent functionality for valuable troubleshooting, control and monitoring of power usage, capacity and environmental conditions.

Intelligent PDUs functions can be listed as follows:

- Built-In Display for Local Use
- Remote Monitoring
- Device-Level Monitoring
- Outlet Level Monitoring
- Outlet Level Switching/Control

Each subcategory of Intelligent PDU has features that can help data centers to reduce operating costs, increase uptime/availability, improve mean time to repair (MTTR), become energy efficient, and manage existing capacity.

Whenever a wider range of information is needed (i.e. not only power, but also server, storage and network systems, cooling and sometimes even service systems for the buildings that house it), with statistic data, trends, etc., a Data Center Infrastructure Management (DCIM) software should be considered.

7.8 Data Center Infrastructure Management

A DCIM software is a product, or more often a suite of products, designed to allow IT infrastructure administrators to perform their job more efficiently and effectively. In practice, the DCIM software collects data on the status and operation of all the elements that make up the infrastructure, consolidates this data in order to extract information and reports this information in a form suitable for rapid interpretation by the human operator. As this monitoring occurs in real time, it provides trending information which helps to avoid failures and provides for preventive interventions.

It is easy to understand how the Data Center Infrastructure Management software has developed following the parallel evolution of the complexity of the infrastructures and has become an essential tool for Infrastructure and Operations managers. The market today offers a choice of solutions that are sometimes very different from each other in capabilities, implementation and cost.

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7.9 Cabinets, Racks and Cable management

Cabinets, frames and racks (or openings inside them) shall provide the required levels of physical and environmental protection for the cabling and mounted equipment of information technology. Cabinets, frames and racks, by their location, design features or a combination of both, should achieve the required security. Environmental protection shall be provided in the space and/or where appropriate.

The design / position of cabinets, frames and racks shall

- be consistent with the space, floor loading, power, and cooling required for the installed equipment,
- allow the installation of the necessary cabling (trunks, panels, patch cords) and active equipment

7.11 ***Wherever cables are going to be routed using overhead pathway systems, the height of cabinets, frames and racks shall not exceed 75 % of the room height.***

The design and dimensions of the cabinets, frames and racks, together with clearances shall ensure that

- the initial and any subsequent quantity of cables will comply with the required minimum bend radius
- both horizontal and vertical management of all cords and jumpers will be allowed to the maximum planned fill ratio
- fittings are provided for the functional and protective earthing of information technology equipment and cabling
- adequate ventilation is provided for the expected amount of active equipment,
- cable segregation requirements are met.

7.12 ***Should an access floor be present in the DC, several technical standards will require 1.2 m from the front/rear of a cabinet when bayed together in a row (aisle width).***

7.1 *The capacity of the vertical cable management within cabinets, frames and racks should be twice the cross-sectional area of the cables to be installed when the cabinets or frames are at full capacity.*

Penetrations into cabinets and in vertical wire managers from external locations should be restricted both when occupied and when unoccupied by cabling. Electrostatic free brush strips or cable socks should be utilized on all cable entrance points or floor penetrations.

7.9.1. Thermal management (containment)

For maximum cooling efficiency, cabinets, frames/racks should be arranged in rows facing each other to create an alternating pattern of hot and cold aisles.

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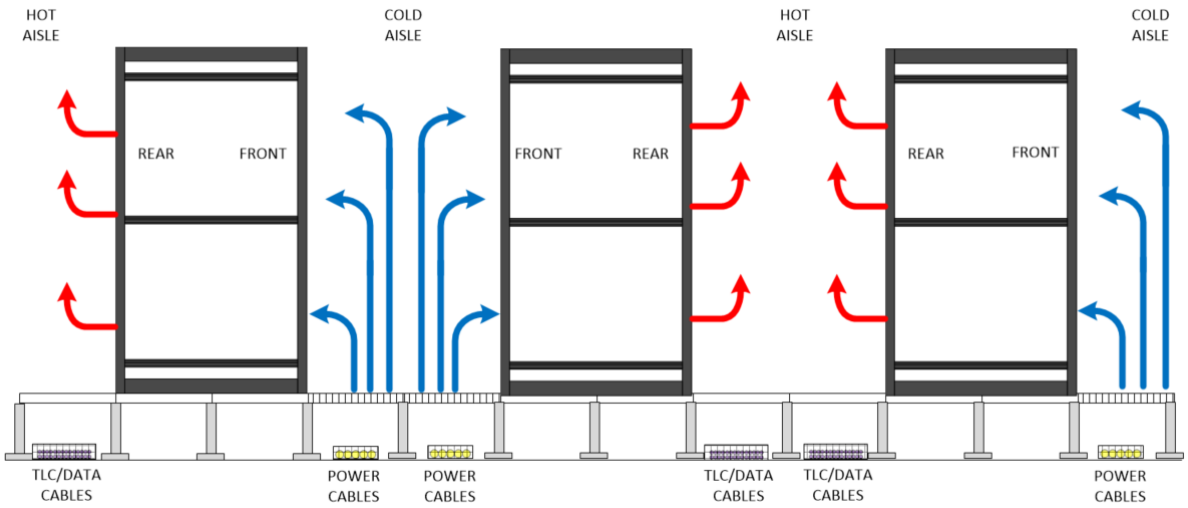

Figure 7-18: Raised Floor Cold Aisle / Hot Aisle scheme

NOTE It is assumed that equipment is installed with the cold air intake at the front of the cabinet, frame of rack, and the hot air exhaust at the back.

To avoid mixing of hot and cold air

- blank panels should be installed in unused cabinets, frames and rack positions
- cabinets, frames and racks should only be located within equipment rows
- there should be no empty cabinet, frame or rack positions within an equipment row (i.e. place empty cabinets or racks fully filled with blank panels instead of leaving an empty cabinet/rack position).

To prevent the mixing of cold or hot air above the cabinets, frames or racks, it is necessary to coordinate the need and position of the ventilation with the HVAC engineering. It may be required to install a containment system, i.e. fixtures and/or fittings (e.g. curtains or dividers, doors and roofs) to maintain the separation of cold and hot air.

7.2 *The distance between cabinets, frames and racks across a cold/hot aisle should not be less than 1.2 m.*

7.3 *If placement of cabinets creates unequal aisle sizes, the front aisle should be the larger one to provide more working space for installation of equipment and a greater area to supply cool air to cabinets.*

7.4 *To provide adequate space for proper management of telecommunications cabling and power strips and, also factoring for the increasing depths of equipment, cabinets and racks should be 1200 mm (48 in) deep for new installations.*

7.5 *To accommodate management of cabling and avoid routing of cabling behind equipment exhausts where they may obstruct proper airflow, cabinets should be greater than 600mm (24 in) wide.*

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NORMATIVE SUMMARY

7.1. ***The design of data center distributors shall ensure that the length of patch cords, jumpers and equipment cords are optimized to avoid excess slack, and administration should ensure that the design lengths are maintained during operation.***

7.2. ***Every data center shall have at least one Main Distributor/Main Cross-connect.***

7.3. ***Only one LDP/CP shall be permitted between a ZD/HC and any EO.***

7.4. ***The LDP/CP shall be an interconnect, not a cross-connect.***

7.5. ***There shall be no active equipment in the LDP/CP area.***

7.6. ***Where an LDP/CP is used, it shall have enough capacity to support the area of the data center which it is designed to serve during its intended operational life.***

7.7. ***At a minimum, class E_A/category 6A cabling shall be installed for a new (greenfield) data center.***

7.8. ***Optical fiber cabling shall be installed for new (greenfield) data centers:***
Multimode: OM3, OM4 or OM5
Singlemode: OS1a or OS2

7.9. ***The following optical fiber connectivity shall be installed for new (greenfield) data centers:***
Channels with 1 or 2 fiber: LC connector
Channels with more than 2 fibers: array (MPO/MTP) connector

7.10. ***Fiber channel length will be limited by the selected application (see Chapter 11 Application Distances)***

7.11. ***Wherever cables are going to be routed using high-level or ceiling-mounted pathway systems, the height of cabinets, frames and racks shall not exceed 75 % of the room height.***

7.12. ***Should an access floor be present in the DC, several technical standards will require 1.2 m from the front/rear of a cabinet when bayed together in a row (aisle width).***

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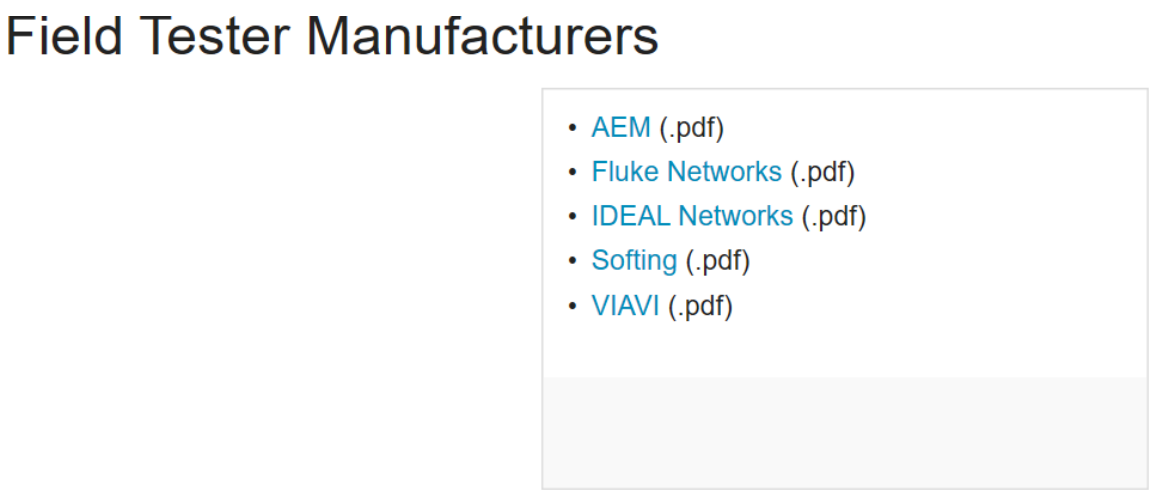
8. SYSTEM TESTING & WARRANTY REGISTRATION

8.1. Testing Equipment

8.1.1 Approved Copper Tester List (Siemon website)

8.1 ***All transmission testing shall be performed with an approved balanced twisted-pair tester as provided on the Siemon Partner Support Center website at www.siemon.com/ally.***



NOTE: Field testers from the manufacturers listed have been approved by Siemon for use in qualifying the installed cabling in a Siemon Cabling System Warranty. This list is subject to change. Not all testers are approved for testing all Siemon Cabling Systems. Be sure to check the list of approved Field Testers prior to testing a project.

8.2 ***All field testers shall have the latest version of software installed in order to provide the most accurate and current testing parameters and values.***

NOTE: Verification of the version of software installed in the field testers being used, compared to the latest version available from the test equipment manufacturer, needs to be checked on a regular basis. Older versions of software in field testers may not provide the testing parameters and accuracy required by Siemon.

8.1.2 Proper Use

8.3 ***Requirements and recommendations for connections, test configuration, measurement procedures and precautions that are specified in the manuals provided with the tester shall be followed.***

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8.1. It is recommended that users receive training by the field tester manufacturer to ensure proper use of the field tester.

NOTE: It is important that users of these field testers are familiar with the proper set-up and use of the field testers for accurate test results.

8.1.3 Factory Calibration

8.4 ***All field testers shall be factory calibrated by the field tester manufacturer in accordance with the manufacturer's requirements. The field tester shall also report the date and time of its current calibration.***

NOTE: The test instrument certification of calibration according to the manufacturer's requirements may be required upon request.

NOTE: One method to check the field tester repeatability is to construct a reference link. This may be used to check for variations in the tester's accuracy due to wear and tear of the Link Interface Adapters.

8.1.4 Testing Options

8.5 ***Autotest settings provided in the field tester for testing the installed cabling shall be set to the default parameters. Any autotest settings that have been modified to change testing parameters may disqualify the test results.***

8.6 ***Test settings selected from options provided in the field testers shall be compatible with the installed cabling under test.***

NOTE: It is important to select the proper test settings based on the installed components and configuration of the cabling system to be tested. Tester settings that need to be reviewed for proper testing include Permanent Link or Channel, type of cable, NVP and performance of the class/category to be qualified.

8.7 ***Continuity testing shall be performed using any of the approved testers as indicated on the Siemon Ally Website. The STM-8-S may also be used.***

NOTE: Balanced twisted-pair multi-pair cables used in the Backbone are intended to support voice applications only. All Backbone copper cable channels of up to 2000 m (6550 ft) in length intended for voice applications require continuity testing only.

8.1.5 Test Cords/Test Adapters

8.8 ***All balanced twisted-pair test cords used to test for Permanent Link model certification shall be approved by Siemon and supplied and verified by the test equipment manufacturer to meet or exceed the requirements of ISO/IEC 11801 and ANSI/TIA - 568.1-E and qualified to test the appropriate category of cabling under test.***

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NOTE: Link adapter cables and plugs may deteriorate with use affecting the accuracy level and reliability of associated test results. The manufacturer's guidelines of the useful life-cycle of these components should be followed.

8.9 ***Balanced twisted-pair adapters needed to attach test cords to connecting hardware shall meet or exceed the performance category of the Permanent Link model to which they connect.***

Figure 8-1: TAP Adapters A

8.2. Balanced Twisted-Pair Testing

8.2.1 Balanced twisted-pair cabling parameters: Permanent Link, Channel

The following specifications are provided for qualification testing of installed balanced twisted-pair cabling. It should be noted that the test requirements of this section are not sufficient in themselves to qualify a system for the Siemon Cabling System Extended Warranty.

8.10 ***Horizontal or Backbone Permanent Link model test results shall be recorded using the Permanent Link setting in the field tester.***

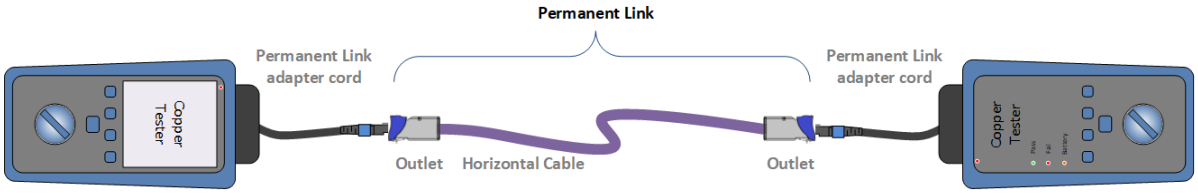

Figure 8-2: Permanent Link Test

The permanent link test configuration is to be used by installers and users of data telecommunications systems to verify the performance of permanently installed cabling. The permanent link consists of up to 90 m (295 ft) of horizontal cabling and one connection at each end and may also include an optional transition/consolidation point connection. The permanent link excludes both the cable portion of the field test instrument cord and the connection to the field test instrument.

8.11 ***Horizontal or Backbone Permanent Link model test results shall be recorded using the right Permanent Link setup in the field tester.***

8.12 ***Horizontal or Backbone Channel model test results shall be recorded using the Channel setting in the field tester.***

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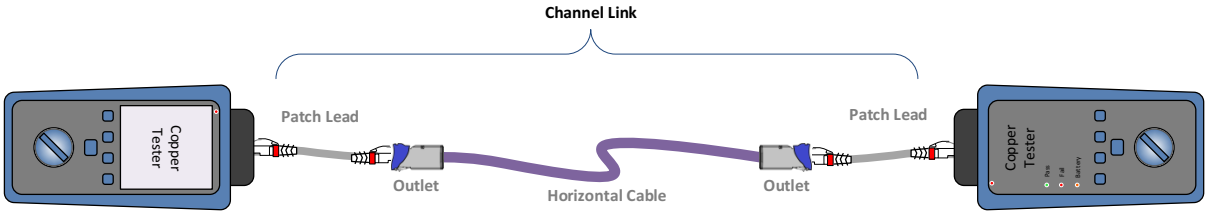

Figure 8-3: Channel Test included Patch Leads

The channel test configuration is to be used by system designers and users of data communications systems to verify the performance of the overall channel. The channel includes up to 90 m (295 ft) of horizontal cable, a work area equipment cord, a telecommunications outlet/connector, an optional consolidation point, and two connections in the telecommunications room. The connections to the equipment at each end of the channel are not included in the channel definition.

The channel definition does not apply to those cases where the horizontal cabling is cross-connected to the backbone cabling.

Note: Siemon does not require unique, dedicated patch cords to be used for each channel test. Due to the consistent performance of Siemon patch cords, Siemon allows for any Siemon patch cords that match the category and construction of cords for the installation to be used for channel testing.

8.2.2 Z-MAX full system warranty

Refer to the Z-MAX Planning and Installation Guide found on the Siemon Partner Support Center for specific design/installation practices for 10 Gigabit Ethernet installations

The Z-MAX Planning and Installation Guide include minimum and maximum length of horizontal cable, cross-connect cable, consolidation cable, equipment cords and Work area cords for Full margin Warranty as well as for compliant warranty including smaller AWG cords.

8.2.3 Balanced Twisted-Pair Cabling Parameters: MPTL

The widespread proliferation of IP enabled devices such as security cameras, PoE lighting and wireless access points has resulted in a unique cabling environment that does not always benefit or allow for the additional cost and flexibility provided by Telecommunications Outlets (TOs) or Service Outlets (SOs). This can be attributed to many variables including device density and mounting environments.

In response, TIA has introduced in the TIA-568.2-D (Annex F) an alternate topology entitled the Modular Plug Terminated Link (MPTL) to address this environment. ISO is also developing a standard to enable this topology. The topology for the MPTL is shown below in Figure 1. The MPTL is constructed by direct field termination of horizontal cabling at the device end with a modular plug - replacing the TO/SO and associated Work Area (WA) cord.

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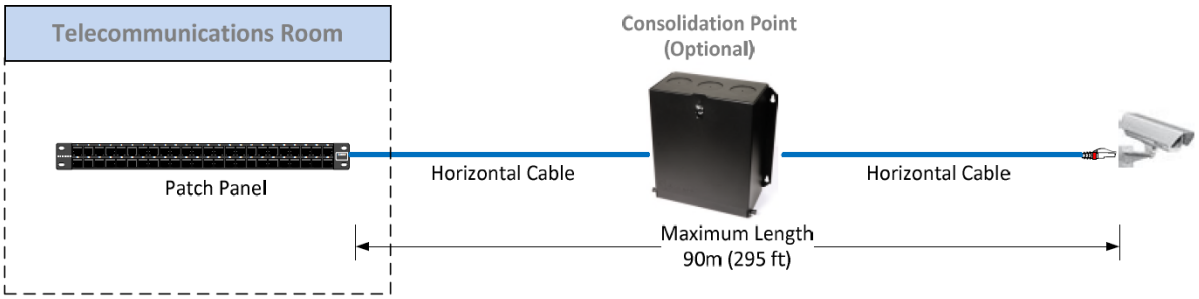

Figure 8-4: Modular Plug Terminated Link (MPTL) Topology

To verify the performance of the MPTL, including the far-end plug, testing will use a Permanent Link Adapter on the main unit and a Patch Cord adapter on the remote unit at the far end as shown in Figure 10-2. This method is the recommended test method. Work with your field test manufacturer to ensure you have the latest firmware and information prior to testing.

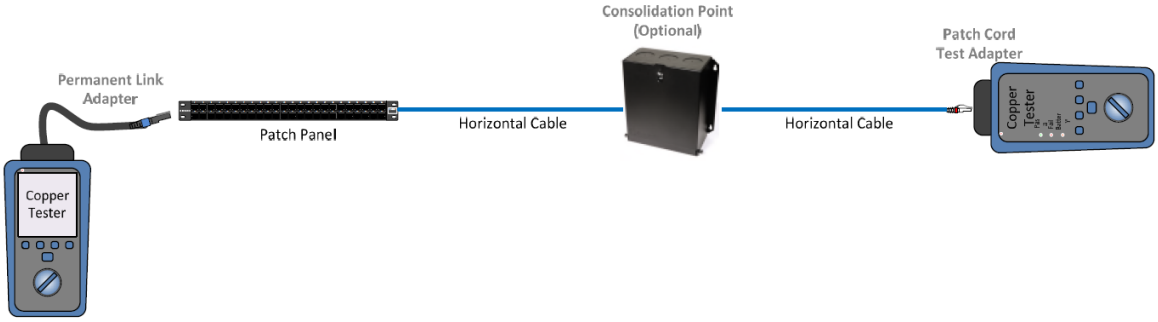

Figure 8-5: MPTL Recommended Test Configuration

An alternate to the MPTL test configuration shown in Figure 2 is the use of channel testing as shown below in Figure 3. Note that this configuration doesn't test the mated NEXT of the plug and jack in the measurement, and therefore not the recommended test method.

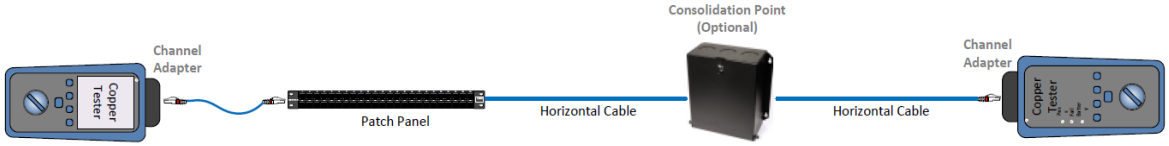

Figure 8-6: MPTL Channel Test Configuration with Channel Adapters

The following Siemon Cabling System requirements apply to the use of MPTLs:

8.13 ***Support of MPTLs is limited to Intelligent Building and Wireless Access Point (WAP) applications***

8.14 ***The modular plug must be of the same or higher category as the horizontal cable***

8.15 ***The MPTL shall comply with the permanent link transmission requirements of the category of cabling being used***

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8.2.4 Test requirements (copper)

8.16 ***All Horizontal and Backbone balanced twisted-pair Permanent Link models with fixed cable lengths of no more than 90 m (295 ft) and balanced twisted-pair Channel models with total cable lengths, including patch cords/cross-connect jumpers and equipment cables, of no more than 100 m (328 ft) shall be 100% tested.***

8.17 ***All Siemon factory Trunking Cable Assemblies (Copper) installed as part of the Link or Channel shall be field tested after installation.***

8.18 ***Test performance requirements for class D, E, EA, F and FA/category 5e, 6, 6A, 7 and 7A cabling Permanent Link or Channel models shall include the following parameters as required by ISO/IEC 11801 or ANSI/TIA-568.0-E:***

- ***WIRE MAP plus Shield Continuity (when present)***
- ***LENGTH***
- ***INSERTION LOSS***
- ***NEXT Loss (pair-to-pair)***
- ***NEXT Loss (power sum)***
- ***ACR* (pair-to-pair)***
- ***ACR* (power sum)***
- ***ELFEXT (pair-to-pair)***
- ***ELFEXT (power sum)***
- ***RETURN Loss***
- ***PROPAGATION DELAY***
- ***DELAY SKEW***
- ***D.C. LOOP RESISTANCE****
- ****Note: not a required test parameter by The TIA Standards***

Balanced Twisted-Pair Cabling Parameters Defined

The following transmission parameters for field testing of the installed cabling has been defined to better understand the test results provided by the field tester and as a tool to take corrective action if any of the test parameters fail. The performance parameters listed below are based on the requirements as defined in industry standards.

Wire Map

The Wire Map test verifies pin to pin termination at each end of a Horizontal or Backbone cable for an acceptable wiring scheme. Each of the eight conductors in the cable is checked for continuity, shorts, crossed pairs, reversed pairs, split pairs, and other miss-wires.

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Shied Continuity

Shield continuity is determined during the wire map testing. If using shielded cable and shielded connecting hardware it is important to verify if the shield of the cable is properly terminated to the connecting hardware.

8.19 ***All shielded Permanent Links and Channels shall be tested for shield continuity and indicated with a PASS by the field tester.***

Length

The maximum physical length of the Permanent Link is 90 m (295 ft). The maximum physical length of the Channel is 100 m (328 ft), which includes equipment and patch cords.

8.20 ***All testers shall have the Nominal Velocity of Propagation (NVP) properly set for the type of cable being tested.***

Note: Properly setting the NVP or selecting the cable under test in the field tester database will provide accurate length measurements.

Insertion Loss (Attenuation)

Insertion Loss is a measure of signal loss in the Permanent Link or Channel. Total insertion loss includes the cumulative insertion loss of each of the following elements: connecting hardware, fixed cable, patch cords, jumpers, and equipment cables.

Crosstalk Parameters

NEXT Loss (pair-to-pair)

Near-end crosstalk is a measure of the unwanted signal coupling from a transmitter at the near-end into an adjacent pair measured at the near-end.

Pair-to-pair NEXT testing provides results for six (6) (pair-to-pair) combinations for a 4-pair cable.

Since telecommunications systems transmit from both ends of the cabling, it is necessary to provide NEXT results for both ends of the cabling. All approved testers provide NEXT results for both ends with one test. These test devices have bi-directional remotes to perform these measurements.

NEXT Loss (power sum)

Power sum near-end crosstalk is a computation of the unwanted signal coupling from multiple transmitters at the near-end into a pair measured at the near-end.

Power sum NEXT testing provides results as one (1) computation per cable pair.

Since telecommunications systems transmit from both ends of the cabling and may use all 4-pairs of a cable (Full-Duplex), it is necessary to provide power sum NEXT results for both ends of the cabling. All qualified testers provide NEXT results for both ends with one test. These test devices have bi-directional remotes to perform these measurements.

Attenuation to Crosstalk Ratio (ACR) (pair-to-pair)

ACR requirements are applicable to class D, E, and F only. Pair-to-pair ACR is a computation of the difference between the pair-to-pair NEXT and the Insertion Loss (IL) of the cabling measured in dB.

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Since telecommunications systems transmit from both ends of the cabling and may use all four pairs of a cable (Full-Duplex), it is necessary to provide pair-to-pair ACR results for both ends of the cabling. All qualified testers provide pair-to-pair ACR results for both ends of the cable under test.

Attenuation to Crosstalk Ratio (power sum ACR)

Power Sum Attenuation to Crosstalk Ratio (PS ACR) is a computation of the difference between PS NEXT and the Insertion Loss (IL) of each pair of a channel.

Since telecommunications systems transmit from both ends of the cabling and may use all four pairs of a cable (Full-Duplex), it is necessary to provide Power Sum ACR results for both ends of the cabling. All qualified testers provide PS ACR results for both ends of the cable under test.

FEXT and ACRF

Far-end crosstalk is a measure of the unwanted signal coupling from a transmitter at the near-end into an adjacent pair measured at the far-end.

Equal level far-end cross talk is expressed in dB as the difference between the measured FEXT loss and the insertion loss of the disturbed pair.

ACRF = FEXT - INSERTION LOSS

ACRF Loss (pair-to-pair)

Pair-to-pair ACRF testing provides results for six (6) (pair-to-pair) combinations for a 4-pair cable.

Since telecommunications systems transmit from both ends of the cabling, it is necessary to provide ACRF results for both ends of the cabling. All approved testers provide ACRF results for both ends with one test. These test devices have bi-directional remotes to perform these measurements.

PSACRF Loss (power sum)

Power sum attenuation to cross-talk ratio far end is a computation of the unwanted signal coupling from multiple transmitters at the near-end into a pair measured at the far-end relative to the received signal level measured on that same pair.

Power sum PSACRF testing provides results as one (1) computation per cable pair.

Since telecommunications systems transmit from both ends of the cabling system and may use all four pairs of a cable (Full-Duplex), it is necessary to provide power sum ELFEXT results for both ends of the cabling. All qualified testers provide ELFEXT results for both ends with one test. These test devices have bi-direction remotes to perform these measurements.

Return Loss

Return loss is a measure of reflected signals caused by impedance mismatches in the cabling Permanent Link or Channel. Return loss is especially important for applications that use simultaneous bi-directional transmission.

Propagation Delay

Propagation delay is a measure in time of 100 Ω 4-pair cable. It is the difference in time between when a signal is transmitted and when it is received across a 100 Ω 4-pair cable.

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Delay Skew

Delay skew is the difference in the propagation delay between any two pairs within the same cable sheath. It is the measure in time of the difference in propagation delay between the fastest and slowest transmission paths in a Permanent Link or Channel. Delay skew is required for applications that use multiple pairs for parallel transmission.

D.C. Loop Resistance

D.C. loop resistance is applicable to class D, E, E_A, F and F_A only. The DC loop resistance is a measure of the total sum of the DC resistance of the wires of a wire pair. The tester measures the loop resistances of each wire pair separately.

8.2.5 Test Results

8.21 ***Field testers that report a PASS result for each of the parameters based on the appropriate test requirements shall be saved into the field tester memory and submitted for warranty.***

8.22 ***Field testers that report a PASS*, FAIL*, or FAIL result shall not be submitted for warranty.***

NOTE: Test results that contain an asterisk are within the accuracy range of the field tester. Any results reported with an asterisk may be used to inform the installer to take corrective actions.

When experiencing continued marginal results PASS* or FAIL* on links that have had corrective action performed, contact a Siemon Company technical representative for assistance/resolution.

8.23 ***All PASS test results shall be downloaded into the database software that has been provided by the manufacturer of the field tester. Test results that are not submitted in the software format compatible with the field tester will not be accepted.***

8.3. Optical Fiber Testing

This section specifies the minimum performance requirements for the field testing of optical fiber cabling systems. The objective of this section is to provide the test procedures and acceptance values for 62.5/125µm, 50/125µm multimode Horizontal link performance requirements as well as 62.5/125µm and 50/125µm multimode and singlemode Backbone link performance requirements.

NOTE: OTDRs are useful tools for locating fiber faults and characterizing the loss in installed fiber connections. When used correctly, they can pinpoint the causes for excess loss and verify that splices and connections are within appropriate tolerances. However, the most accurate, repeatable, and reliable method for measuring overall link loss is to use a power meter and light source. OTDRs measure length and loss via backscatter reflection. This technique is not a "through" measurement, but rather a reflection measurement. Conditions in the link that significantly affect backscatter may have a negligible effect on a multimode source. Such conditions include variations in core diameter and changes in attenuation when fibers of different characteristics are connected together.

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8.3.1 Cleaning

Contaminants are the leading cause of high system loss and can be easily transferred between connectors. Even everyday particles can have detrimental results on optical fiber end faces.

Fortunately, by employing proper cleaning procedures and utilizing good preventative measures such as dust caps, many cases of high loss can be improved or eliminated. **Of greatest importance is to ensure all connector end faces are clean prior to testing.** This includes both the optical fiber system as well as the test cords used for system testing.

8.24 ***Dry cleaning methods shall use static minimizing cleaning sticks are specially designed to clean optical fiber end faces and are available for multi-fiber MPO/MTP connectors as well as LC and SC fiber connectors for both connector end face and bulkhead adapters.***

8.25 ***For significantly contaminated end faces, "wet" solvent methods shall be used. The static bond breaking properties which do not leave a residue makes it an ideal tool to remove heavy or persistent contamination.***

NOTE: If used, "wet" solvents should be used prior to "dry" cloth cleaning tools as a "wet" to "dry" cleaning process is the most effective.

8.3.2 Approved or recommended fiber tester list

8.26 ***Testing of the optical fiber shall be performed with a calibrated optical loss test set (OLTS), which is Encircled Flux (EF) compliant.***

NOTE: Encircled Flux (EF) is a metric for defining launch conditions on multimode fiber. It was developed by optical experts to reduce variability in link loss measurements shown by different test equipment and to correlate test results to conservative launch-condition performances in Gigabit Ethernet fiber transceivers. Compared to previous launch conditions and standards, EF will greatly improve link loss measurement consistency. It was not until high-speed transmission over multimode fiber became a reality that EF measurements became important. High-speed 850nm VCSELs and OM3 laser-optimized, high-bandwidth fiber came together to create this need. EF targets 850nm and 50µm cabling because that is where the Gigabit Ethernet components are used.

Please contact your local Siemon Company office for guidance on "qualified/calibrated test equipment."

8.3.3 Proper Use

8.27 ***Guidelines and requirements for connections, test configuration and measurement procedures specified in the manuals provided with the optical loss test set (OLTS) shall be followed.***

NOTE: It is important that users of the optical loss test set (OLTS) be familiar with the proper set-up and use of the field testers for obtaining accurate test results.

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8.3.4 Factory Calibration

8.28 ***All optical loss test sets (OLTS) shall be factory calibrated by the field tester manufacturer per the requirements in the tester manufacturers manual provided with the field tester. Proof of factory calibration shall be provided to Siemon upon request.***

8.3.5 Test Cords (Fiber)

8.29 ***All optical fiber test cords used to test multimode optical fiber links for warranty shall be: provided by the field test manufacturing, EF compliant and of reference quality and not be constructed with bend insensitive fiber.***

NOTE: The use of standard fiber jumpers for the purpose of testing the optical fiber link is not permitted in qualifying a Siemon optical fiber link for certification.

8.3.6 Fiber Test requirements

8.30 ***All Horizontal and Backbone optical fiber Links shall be 100% tested for attenuation, length and polarity. This includes all Siemon Trunking Cable Assemblies.***

8.31 ***Attenuation of the horizontal and backbone optical fiber Link shall be determined using the one reference-cord method. Other reference cord methods can be considered for array systems – consult with field test manufacturers for recommended procedures.***

NOTE: Bandwidth (multimode) and dispersion (singlemode) are important performance parameters, but because installation practices cannot adversely affect them, they are only tested in the factory.

The following diagrams have been provided for reference to assist in defining the proper reference method to use based on the fiber system installed. Consult with field test manufacturers for recommended procedures.

Figure 8-7 shows the Optical Fiber Link under test as well as the optical fiber test cords that will be used to for testing.

Figure 8-7: Optical Fiber Link Test

Step 1

Connect light source and power meter with Test Cord No. 1 (see Figure 8-8). Measure the power value and record it as P_1. P_1 is the reference launch power.

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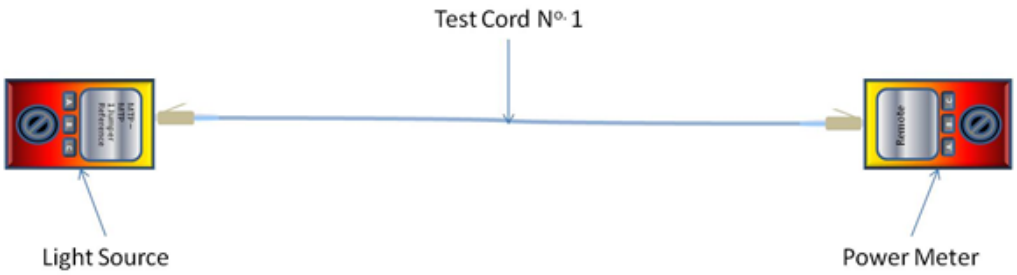

Figure 8-8: Optical Fiber Link Test Cord No 1

Step 2

Remove Test Cord No.1 from the power meter. Connect to the power meter Test Cord No. 2. With the help of an appropriate connecting hardware (adapter), connect Test Cord No. 1 with Test Cord No. 2 (see Figure 8-9).

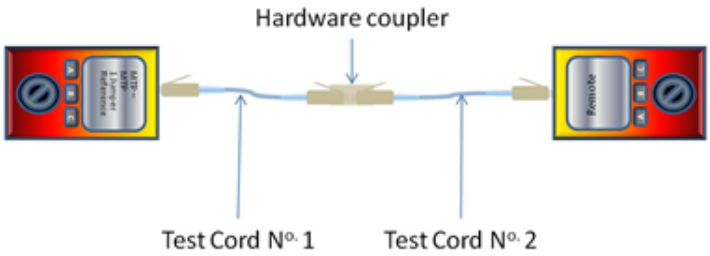

Figure 8-9: Optical Fiber Link Test Cord No 1 & 2

Step 3

Measure the power value and record it as $P_{1\text{-}2}$. Disconnect the test cords from each other, then connect them and measure the power value again. Repeat this procedure several times (3-5). All the measured values must be less than 0.75 dB ($P_{1\text{-}2}$ - P_1) and differ very slightly from each other. The measured values above 0.75 dB mean that one or both of the test cords are defective.

Note: While performing all measurements do not disconnect Test Cord No. 1 from the light source and Test Cord No. 2 from the power meter, and do not switch off the light source and power meter. When occasionally one of these actions takes place, repeat the steps 1 through 3.

Step 4

Disconnect the test cords from each other. Connect Test Cords No. 1 & No. 2 to the corresponding end of the optical fiber Link to be tested (see Figure 8-10).

Measure and record the power value as P_2.

Optical power loss (dB) = P_1 - P_2.

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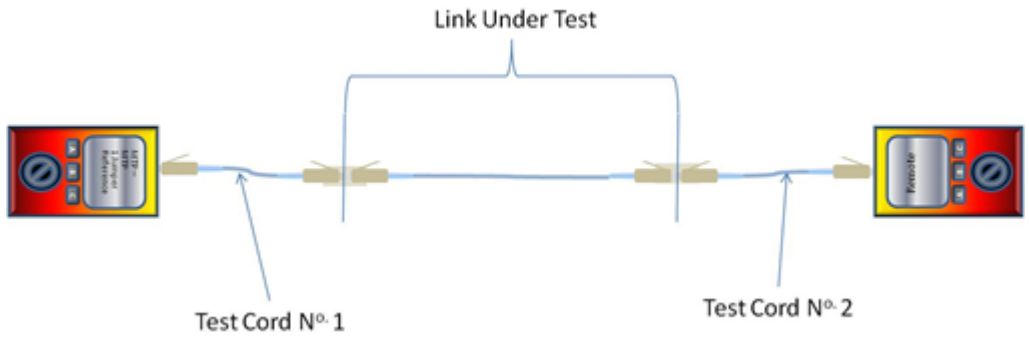

Figure 8-10: Optical Fiber Link under Test

NOTE: The information on the 1-jumper reference method provides verification of the test cords used for testing the optical fiber link. The use of qualified optical fiber test cords and a light source and power meter (LSPM) that contains a reference button feature can eliminate some of the qualification steps.

When using the field testers for measuring length and attenuation, refer to test equipment manufacturers' instructions for test set up.

8.3.7 MPO/MTP test

This section describes some field test procedures required for array fiber links including MPO/MTP connectors. This type of connectivity is more and more often adopted in Data Centre environment, in order to implement some multi-fiber inter-cabinet fiber trunks able to support high speed duplex and parallel optics protocols (i.e. 40GBASE-SR, 100GBASE-SR).

In the following pages, 4 different configurations will be described, as they correspond to the most commonly adopted in DC design and implementation.

Configuration 1: LC-to-LC Permanent Link– Field tester with LC interface

Note that this methodology would also apply to systems using SC interfaces. We can consider two optional configurations here:

Configuration 1a: cassette-to-cassette link with duplex jumpers/equipment cords at both ends

Figure 8-11

This case does not differ from the traditional duplex link, then a 1-jumper reference method is applicable.

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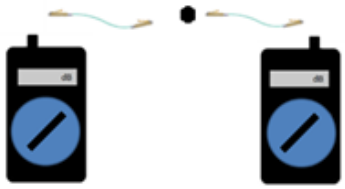

Figure 8-12

After the reference is set, the link would be measured - without disconnecting the test cord n. 1 from the source and test cord n. 2 from the remote.

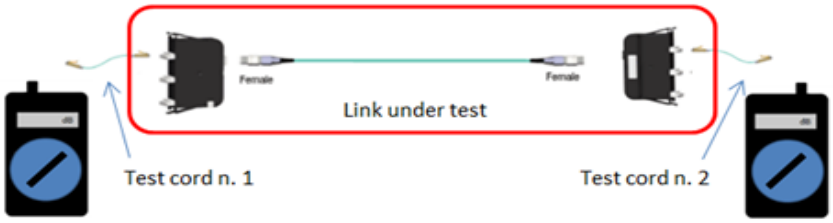

Figure 8-13

Configuration 1b: cassette-to-adapter/hybrid link, which can be adopted for connections of high density fiber racks (e.g. to connect SAN cabinets)

Figure 8-14

This will save one connection and some insertion loss. However, as the hybrid assembly would be an equipment cord, only its MPO/MTP connector should be tested as part of the Permanent Link.

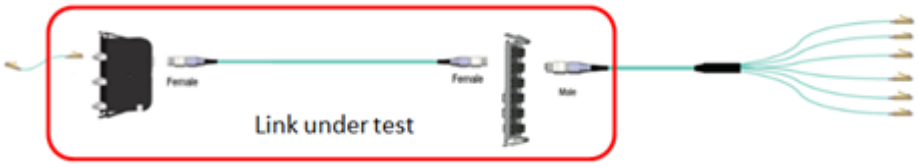

Figure 8-15

Also in this case a 1-jumper method is applicable

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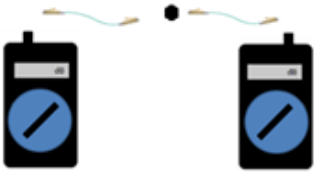

Figure 8-16

After the reference is set, the link is measured - without disconnecting the test cord n. 1 from the source and test cord n. 2 from the remote end. Test is passed if the insertion loss of each link is equal or less than the values of the Siemon Calculator available from the Partner Support Center.

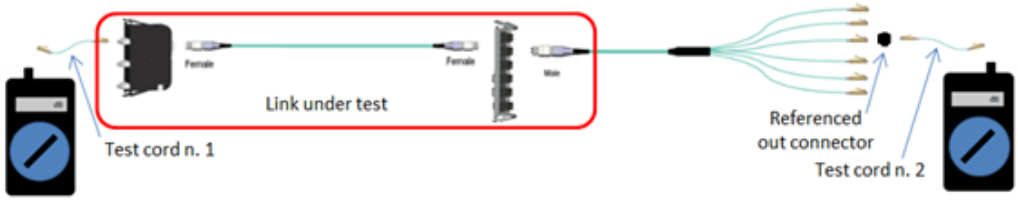

Figure 8-17

Configuration 2: MPO/MTP-to-MPO/MTP Permanent Link - Field Tester with MPO/MTP interface

This is a 40G/100G configuration, which can be implemented by using pinned-to-pinned MPO/MTP trunks with female-to-female equipment cords (with the correct polarity).

In this case, a very quick test could be done by using an optical tester with an MPO/MTP interface – some commercial devices of this type are currently available. They also allow for a quick check of the trunk polarity.

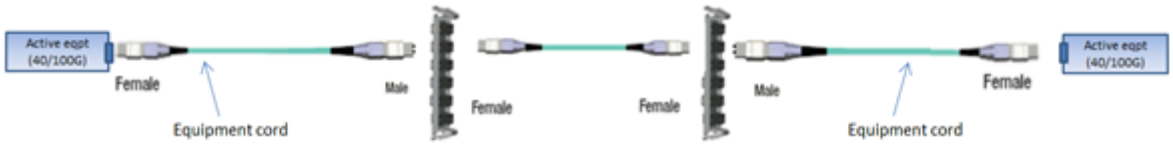

Figure 8-18

This configuration allows for a 1-Jumper Reference method.

Two female-to-female MTP jumpers should be independently and sequentially connected to the tester and its remote in order to check their compliance with manufacturer's specifications, the second one should be referenced (= 0 dB IL).

Figure 8-19

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While keeping one end of the last referenced jumper connected to the source tester, the other (previously checked) jumper should be connected to the remote end, and the channel should be tested for its compliance with the values of the Siemon Calculator available from the Partner Support Center.

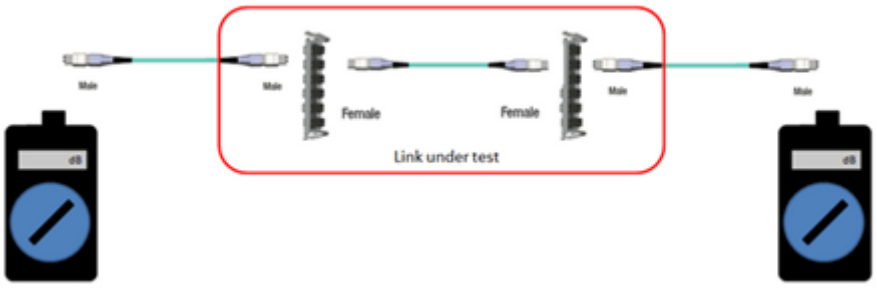

Figure 8-20

Configuration 3: MPO/MTP-to-MPO/MTP Permanent Link - Field Tester with LC interface

This is exactly the same as Configuration 3 but should be adopted in those cases when the available tester has a traditional duplex interface.

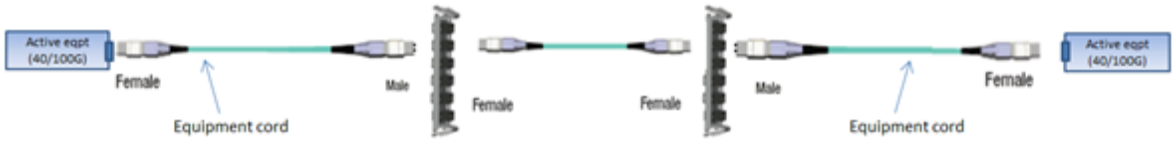

Figure 8-21

This implies the need of implementing a 3-jumper reference method.

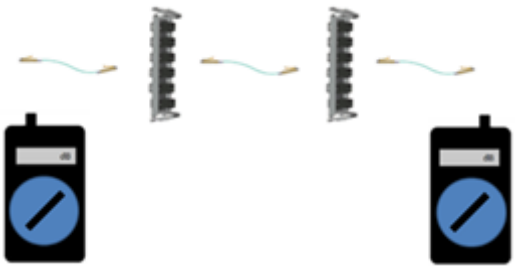

Figure 8-22

Two female MPO/MTP-to-LC hybrid assemblies should be added at both ends of the link under test.

Figure 8-23

After removing the central referenced duplex jumper, the test would be exactly the same shown for Configuration 2.

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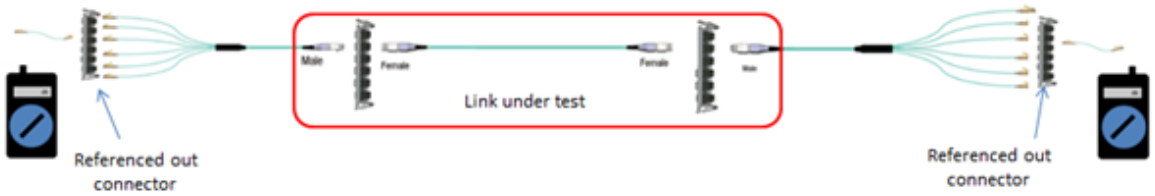

Figure 8-24

8.3.7.1. *Attenuation*

8.32 ***All Horizontal 62.5/125µm or 50/125µm multimode optical fiber Links shall be 100% tested for attenuation at either 850nm or 1300nm in at least one direction with an optical loss test set (OLTS).***

8.33 ***All Backbone 62.5/125µm, 50/125µm multimode or singlemode optical fiber Links shall be 100% tested for attenuation at both 850nm and 1300nm for multimode or 1310nm and 1550nm for the appropriate singlemode in at least one direction with an optical loss test set (OLTS).***

8.34 ***Link attenuation allowance shall be calculated as:***

Link attenuation = cable attenuation plus
connector insertion loss plus
splice insertion loss

8.35 ***Optical fiber links shall have the attenuation acceptance based on Siemon optical fiber calculation for the appropriate fiber solution. Optical fiber calculation shall be determined using the Fiber Budget Calculator located on the Siemon Partner Support Center at www.siemon.com/ally.***

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SIEMON™
CABLING SYSTEM

Fiber System Loss Calculator (Duplex Systems)

LightSystem Multimode			
Cable Length	==>		m
Cable Loss @850nm		0.00	dB
Cable Loss @1300nm		0.00	dB
No. of Connections	==>	0	
No. of Splices	==>	0	
Connectivity Loss		0.00	dB
System Loss @850nm		0.00	dB
System Loss @1300nm		0.00	dB

XGLO 300 Multimode			
Cable Length	==>	0	m
Maximum cable length not to exceed 300m (984 ft.)			
Cable Loss @850nm		0.00	dB
Cable Loss @1300nm		0.00	dB
No. of Connections	==>	0	
No. of Splices	==>	0	
Connectivity Loss		0.00	dB
System Loss @850nm		0.00	dB
System Loss @1300nm		0.00	dB

XGLO 550 Multimode			
Cable Length	==>	0	m
Maximum cable length not to exceed 550m (1804 ft.)			
Cable Loss @850nm		0.00	dB
Cable Loss @1300nm		0.00	dB
No. of Connections	==>	0	
No. of Splices	==>	0	
Connectivity Loss		0.00	dB
System Loss @850nm		0.00	dB
System Loss @1300nm		0.00	dB

XGLO Singlemode			
Cable Length	==>	0	m
Cable Loss @1310nm		0.00	dB
Cable Loss @1550nm		0.00	dB
No. of Connections	==>	0	
No. of Splices	==>	0	
Connectivity Loss		0.00	dB
System Loss @1310nm		0.00	dB
System Loss @1550nm		0.00	dB

Fiber Loss Budget - Duplex | Fiber Loss Budget - Array | Conduit Fill | Cable Tray Fill | Open Office WA Cord | Backbone Patchcord | TERA System Loss

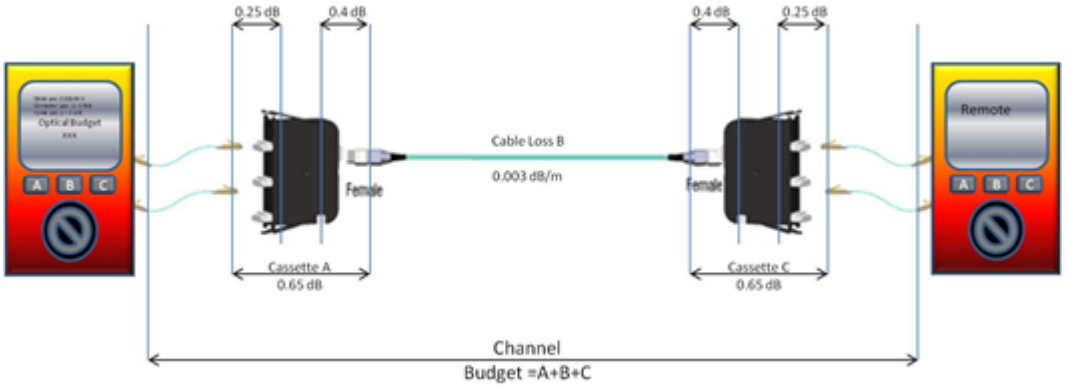

Figure 8-25

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8.3.7.2. *Length*

8.36 ***Length of the horizontal and backbone optical fiber Links shall be determined using one of the following:***

- ***An OTDR***
- ***Optical test measurement device capable of providing length***
- ***Sequential measurement markings provided on the optical fiber cables.***

8.37 ***The measured length of the fixed cable portion of any optical fiber link shall not exceed the lengths specified for Horizontal or Backbone cabling in the Horizontal Distribution and the Backbone Distribution sections of this manual.***

This length may be based on the physical length of the cable as identified by the factory-labeled markings in uninterrupted segments.

8.3.8 Cable Verification

All optical fiber cable should be tested for length on the reel, prior to installation, to determine if there are any breaks in the optical fiber cable.

8.4. The Siemon Cabling System Warranty Program

8.5. Warranty Registration

The following requirements are provided for system registration in order to obtain a Siemon Cabling System Warranty.

8.38 ***All registration procedures specified in the Certified Installer Agreement and this manual shall be followed.***

This section is not intended to replace or supersede the Certified Installer Agreement. In case of conflict, the Certified Installer Agreement takes precedence over the requirements specified in this manual.

8.39 ***Installations shall only qualify for system registration under the System Warranty program if:***

- ***At least one Authorized Designer/Installer was on site for the duration of the installation and confirms compliance of the installation to Siemon Specifications.***
- ***Their certification has not expired.***

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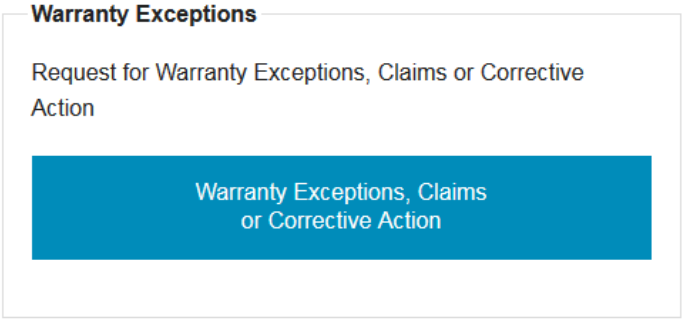
8.5.1. Prior to Installation

8.40 ***Exceptions to any Normative in any section of this manual for registered installations shall be submitted to The Siemon Company by completing the on-line Exception Form located on the Siemon Partner Support Center website.***

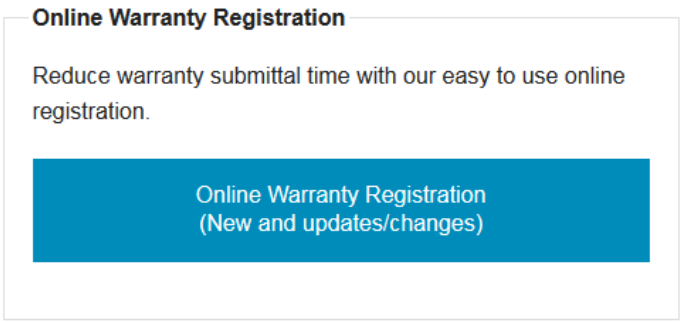
Note: All exceptions must be approved by Siemon prior to the start of the installation. Siemon will review the exception request upon receipt from the Certified Installer Company. Approval or denial will be sent back to the Certified Installer Company.

Visit (http://www.siemon.com/ally/warranty/forms/) and enter the Username: Ally and the current Password. Select the relevant language and then the relevant option to start the process.



8.5.2. Registration Package

8.41 ***The Warranty Registration Application and test results shall be completed/submitted by an Authorized Designer/Installer whose certification has not expired and was directly involved on site for the duration of the installation using the on-line warranty submittal process located on the Siemon Partner Support Center website.***



8.42 ***Once the warranty is reviewed and processed, Siemon will email the warranty documents to the submitting Certified Installer contact whose name appears within the Warranty Registration Application. The Certified Installer Company shall then:***

- ***Forward the warranty documentation to the enduser.***
- ***Retain a copy for their files for the duration of the warranty.***

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8.5.3. Test Data

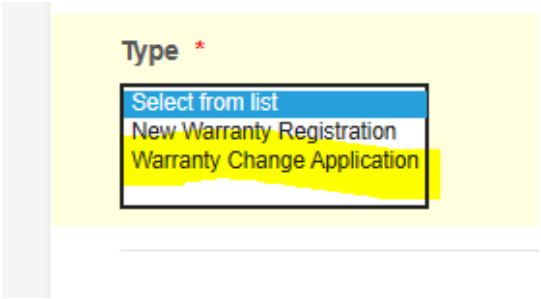
8.43 ***All Balanced twisted-pair and optical fiber test data for each Permanent Link/Channel shall be submitted using the native database software provided by the field tester manufacturer.***

Note: Test results submitted in PDF, WORD, CSV, hard copy, or any other format other than the native database software provided by the field tester manufacturer will not be accepted.

8.5.4. System Changes

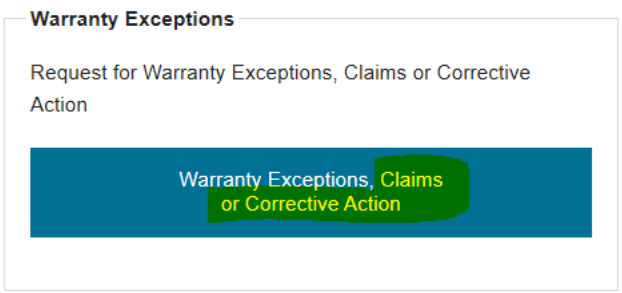
8.44 ***Moves, additions, or changes to/for any Permanent Link/Channel shall be registered using the Warrany Change Application found on-line at www.siemon.com/ally if:***

- ***At least one Authorized Designer/Installer was on site for the duration of the installation.***
- ***Their certification has not expired.***



8.5.5. Warranty Claims

8.45 ***All warranty claims shall be processed in accordance with the Cabling System Warranty and the Certified Installer agreement, using the on-line Siemon Cabling System Claim Form and the Siemon Cabling System Corrective Action Form found at www.siemon.com/ally.***



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NORMATIVE SUMMARY

8.1 ***All transmission testing shall be performed with an approved balanced twisted-pair tester as provided on the Siemon Partner Support Center website at www.siemon.com/ally.***

8.2 ***All field testers shall have the latest version of software installed in order to provide the most accurate and current testing parameters and values.***

8.3 ***Requirements and recommendations for connections, test configuration, measurement procedures and precautions that are specified in the manuals provided with the tester shall be followed.***

8.4 ***All field testers shall be factory calibrated by the field tester manufacturer in accordance with the manufacturer's requirements. The field tester shall also report the date and time of its current calibration.***

8.5 ***Autotest settings provided in the field tester for testing the installed cabling shall be set to the default parameters. Any autotest settings that have been modified to change testing parameters may disqualify the test results.***

8.6 ***Test settings selected from options provided in the field testers shall be compatible with the installed cabling under test.***

8.7 ***Continuity testing shall be performed using any of the approved testers as indicated on the Siemon Ally Website. The STM-8-S may also be used.***

8.8 ***All balanced twisted-pair test cords used to test for Permanent Link model certification shall be approved by Siemon and supplied and verified by the test equipment manufacturer to meet or exceed the requirements of ISO/IEC 11801 and ANSI/TIA -568.1-E and qualified to test the appropriate category of cabling under test.***

8.9 ***Balanced twisted-pair adapters needed to attach test cords to connecting hardware shall meet or exceed the performance category of the Permanent Link model to which they connect.***

8.10 ***Horizontal or Backbone Permanent Link model test results shall be recorded using the Permanent Link setting in the field tester.***

8.11 ***Horizontal or Backbone Permanent Link model test results shall be recorded using the right Permanent Link setup in the field tester.***

8.12 ***Horizontal or Backbone Channel model test results shall be recorded using the Channel setting in the field tester.***

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8.13 Support of MPTLs is limited to Intelligent Building and Wireless Access Point (WAP) applications

8.14 The modular plug must be of the same or higher category as the horizontal cable

8.15 The MPTL shall comply with the permanent link transmission requirements of the category of cabling being used

8.16 All Horizontal and Backbone balanced twisted-pair Permanent Link models with fixed cable lengths of no more than 90 m (295 ft) and balanced twisted-pair Channel models with total cable lengths, including patch cords/cross-connect jumpers and equipment cables, of no more than 100 m (328 ft) shall be 100% tested.

8.17 All Siemon factory Trunking Cable Assemblies (Copper) installed as part of the Link or Channel shall be field tested after installation.

8.18 Test performance requirements for class D, E, EA, F and FA/category 5e, 6, 6A, 7 and 7A cabling Permanent Link or Channel models shall include the following parameters as required by ISO/IEC 11801 or ANSI/TIA-568.0-E:

- ***WIRE MAP plus Shield Continuity (when present)***
- ***LENGTH***
- ***INSERTION LOSS***
- ***NEXT Loss (pair-to-pair)***
- ***NEXT Loss (power sum)***
- ***ACR* (pair-to-pair)***
- ***ACR* (power sum)***
- ***ELFEXT (pair-to-pair)***
- ***ELFEXT (power sum)***
- ***RETURN Loss***
- ***PROPAGATION DELAY***
- ***DELAY SKEW***
- ***D.C. LOOP RESISTANCE****
- ****Note: not a required test parameter by The TIA Standards***

8.19 All shielded Permanent Links and Channels shall be tested for shield continuity and indicated with a PASS by the field tester.

8.20 All testers shall have the Nominal Velocity of Propagation (NVP) properly set for the type of cable being tested.

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8.21 ***Field testers that report a PASS result for each of the parameters based on the appropriate test requirements shall be saved into the field tester memory and submitted for warranty.***

8.22 ***Field testers that report a PASS*, FAIL*, or FAIL result shall not be submitted for warranty.***

8.23 ***All PASS test results shall be downloaded into the database software that has been provided by the manufacturer of the field tester. Test results that are not submitted in the software format compatible with the field tester will not be accepted.***

8.24 ***Dry cleaning methods shall use static minimizing cleaning sticks are specially designed to clean optical fiber end faces and are available for multi-fiber MPO/MTP connectors as well as LC and SC fiber connectors for both connector end face and bulkhead adapters.***

8.25 ***For significantly contaminated end faces, "wet" solvent methods shall be used. The static bond breaking properties which do not leave a residue makes it an ideal tool to remove heavy or persistent contamination.***

8.26 ***Testing of the optical fiber shall be performed with a calibrated optical loss test set (OLTS), which is Encircled Flux (EF) compliant.***

8.27 ***Guidelines and requirements for connections, test configuration and measurement procedures specified in the manuals provided with the optical loss test set (OLTS) shall be followed.***

8.28 ***All optical loss test sets (OLTS) shall be factory calibrated by the field tester manufacturer per the requirements in the tester manufacturers manual provided with the field tester. Proof of factory calibration shall be provided to Siemon upon request.***

8.29 ***All optical fiber test cords used to test multimode optical fiber links for warranty shall be: provided by the field test manufacturing, EF compliant and of reference quality and not be constructed with bend insensitive fiber.***

8.30 ***All Horizontal and Backbone optical fiber Links shall be 100% tested for attenuation, length and polarity. This includes all Siemon Trunking Cable Assemblies.***

8.31 ***Attenuation of the horizontal and backbone optical fiber Link shall be determined using the one reference-cord method. Other reference cord methods can be considered for array systems – consult with field test manufacturers for recommended procedures.***

8.32 ***All Horizontal 62.5/125µm or 50/125µm multimode optical fiber Links shall be 100% tested for attenuation at either 850nm or 1300nm in at least one direction with an optical loss test set (OLTS).***

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8.33 ***All Backbone 62.5/125µm, 50/125µm multimode or singlemode optical fiber Links shall be 100% tested for attenuation at both 850nm and 1300nm for multimode or 1310nm and 1550nm for the appropriate singlemode in at least one direction with an optical loss test set (OLTS).***

8.34 ***Link attenuation allowance shall be calculated as:***

Link attenuation = cable attenuation plus

connector insertion loss plus

splice insertion loss

8.35 ***Optical fiber links shall have the attenuation acceptance based on Siemon optical fiber calculation for the appropriate fiber solution. Optical fiber calculation shall be determined using the Fiber Loss Calculator located on the Siemon Partner Support Centre at www.siemon.com/ally.***

8.36 ***Length of the horizontal and backbone optical fiber Links shall be determined using one of the following:***

- ***An OTDR***
- ***Optical test measurement device capable of providing length***
- ***Sequential measurement markings provided on the optical fiber cables.***

8.37 ***The measured length of the fixed cable portion of any optical fiber link shall not exceed the lengths specified for Horizontal or Backbone cabling in the Horizontal Distribution and the Backbone Distribution sections of this manual.***

8.38 ***All registration procedures specified in the Certified Installer Agreement and this manual shall be followed.***

8.39 ***Installations shall only qualify for system registration under the System Warranty program if:***

- ***At least one Authorized Designer/Installer was on site for the duration of the installation and confirms compliance of the installation to Siemon Specifications.***
- ***Their certification has not expired.***

8.40 ***Exceptions to any Normative in any section of this manual for registered installations shall be submitted to The Siemon Company by completing the on-line Exception Form located on the Siemon Partner Support Center website.***

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8.41 ***The Warranty Registration Application and test results shall be completed/submitted by an Authorized Designer/Installer whose certification has not expired and was directly involved on site for the duration of the installation using the on-line warranty submittal process located on the Siemon Partner Support Center website.***

8.42 ***Once the warranty is reviewed and processed, Siemon will email the warranty documents to the submitting Certified Installer contact whose name appears within the Warranty Registration Application. The Certified Installer Company shall then:***

- ***Forward the warranty documentation to the enduser.***
- ***Retain a copy for their files for the duration of the warranty.***

8.43 ***All Balanced twisted-pair and optical fiber test data for each Permanent Link/Channel shall be submitted using the native database software provided by the field tester manufacturer.***

8.44 ***Moves, additions, or changes to/for any Permanent Link/Channel shall be registered using the Warrany Change Application found on-line at www.siemon.com/ally if:***

- ***At least one Authorized Designer/Installer was on site for the duration of the installation***
- ***Their certification has not expired.***

8.45 ***All warranty claims shall be processed in accordance with the Cabling System Warranty and the Certified Installer agreement, using the on-line Siemon Cabling System Claim Form and the Siemon Cabling System Corrective Action Form found at www.siemon.com/ally.***

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9. ANNEX A: REFERENCES

9.1. References

The following standards and codes contain provisions that, through reference in this text, constitute provisions of this Training Manual. At the time of publication, the editions indicated were valid. All standards are subject to revision; parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standard indicated.

9.2. Standards, Codes and Regulations

9.2.1. ISO/IEC

- ISO/IEC 11801-1:2017 Ed. 1.0
  Information technology – Generic cabling for customer premises – Part 1: General requirements
- ISO/IEC 11801-2:2017 Ed. 1.0
  Information technology – Generic cabling for customer premises – Part 2: Office premises
- ISO/IEC 11801-3:2017 Ed. 1.0
  Information technology – Generic cabling for customer premises – Part 1: Industrial premises
- ISO/IEC 11801-4:2017 Ed. 1.0
  Information technology – Generic cabling for customer premises – Part 1: Single-tenant homes
- ISO/IEC 11801-5:2017 Ed. 1.0
  Information technology – Generic cabling for customer premises – Part 1: Data centres
- ISO/IEC 11801-6:2017 Ed. 1.0
  Information technology – Generic cabling for customer premises – Part 6: Distributed building services
- ISO/IEC 14763-2:2019 Ed. 2.0
  Information technology — Implementation and operation of customer premises cabling — Part 2: Planning and installation
- ISO/IEC 14763-3:2014 Ed. 2.0
  Information technology — Implementation and operation of customer premises cabling — Part 3: Testing of optical fibre cabling
- ISO/IEC 14763-3 AMD 1:2018
  Information technology — Implementation and operation of customer premises cabling — Part 3: Testing of optical fibre cabling - Amendment 1
- ISO/IEC 18598:2016
  Information technology – Automated infrastructure management (AIM) systems – Requirements, data exchange and applications

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- ISO/IEC TR 24746:2005
  Information technology – Generic cabling for customer premises – Mid-span DTE power insertion
- ISO/IEC TR 29106:2007+AMD1:2012+AMD2:2019
  Information technology - Generic cabling - Introduction to the MICE environmental classification
- ISO/IEC TS 29125:2017+AMD1:2020
  Information technology – Telecommunications cabling requirements for remote powering of terminal equipment

9.2.2. IEC

- IEC 60332-1-1:2004+AMD1:2015
  Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus (and other parts of IEC 60332-1 and IEC 60332-2 family [single cable))
- IEC 60332-3-10:2018
  Tests on electric and optical fibre cables under fire conditions - Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus (and other parts of IEC 60332-3 family [bunched cables])
- IEC 60364-1:2005
  Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions (and other parts of IEC 60364 family)
- IEC 60529:1989/AMD2:2013/COR1:2019
  Degrees of protection provided by enclosures (IP Code)
- IEC 60603-7:2020 Ed 4.0
  Connectors for electronic equipment – Part 7: Detail specification for 8-way, unshielded, free and fixed connectors (and other parts of IEC 60603-7 family)
- IEC 60754-1:2011+AMD1:2019 Ed. 3.1
  Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content
- IEC 60793-2:2019 Ed. 9.0
  Optical fibres – Part 2: Product specifications – General (and other parts of IEC 60793-2 family)
- IEC 60794-2:2017 Ed. 4.0
  Optical fibre cables - Part 2: Indoor cables - Sectional specification (and other parts of IEC 60794-2 family)
- IEC 60794-3:2014 Ed. 3.0
  Optical fibre cables - Part 3: Sectional specification - Outdoor cables (and other parts of IEC 60794-3 family)

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- IEC 60874-1:2011 Ed. 6.0
  Fibre optic interconnecting devices and passive components - Connectors for optical fibres and cables - Part 1: Generic specification (and other parts of IEC 60874 family)
- IEC 60950-1:2005+AMD1:2009+AMD2:2013 Ed. 2.2
  Information technology equipment - Safety - Part 1: General requirements
- IEC-TR 61000-5-1:1996
  Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 1: General considerations (and other parts of IEC 61000-5 family)
- IEC 61000-6-1:2016
  Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments (and other parts of IEC 61000-6 family)
- IEC 61034-1:2005+AMD1:2013+AMD2:2019 Ed. 3.2
  Measurement of smoke density of cables burning under defined conditions - Part 1: Test apparatus (and other parts of IEC 61034 family)
- IEC 61076-3-104:2017 Ed. 3.0
  Connectors for electrical and electronic equipment - Product requirements - Part 3-104: Detail specification for 8-way, shielded free and fixed connectors for data transmissions with frequencies up to 2 000 MHz
- IEC 61156-1:2007+AMD1:2009 Ed 3.1
  Multicore and symmetrical pair/quad cables for digital communications - Part 1: Generic Specification (and other parts of IEC 61156-1 family)
- IEC 61280-1-4:2019 Ed. 3.0
  Fibre-optic communication subsystem test procedures - Part 4-1: Installed cabling plant - Multimode attenuation measurement. (Light source encircled flux measurement method)
- IEC 61300-3-35:2015
  Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-35: Examinations and measurements - Visual inspection of fibre optic connectors and fibre-stub transceivers
- IEC 61537:2006 Ed. 2.0
  Cable management - Cable tray systems and cable ladder systems
- IEC 61754-2:1996
  Fibre optic connector interfaces - Part 2: Type BFOC/2,5 connector family
- IEC 61754-4:2013 Ed. 2.0
  Fibre optic connector interfaces - Part 4: Type SC connector family (and other parts of IEC 61754-4 family)
- IEC 61754-7-1:2014 Ed. 3.0
  Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 7: Type MPO connector family

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- IEC 61754-20:2012 Ed. 2.0
  Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 20: Type LC connector family (and other parts of IEC 61754-20 family)

9.2.3. IEEE

- IEEE Std 142™-2014
  Recommended Practice for Grounding of Industrial and Commercial Power Systems
- IEEE Std 802.3™-2018 and its amendments
  Standard for Ethernet
- IEEE Std 802.11™-2016 and its amendments
  Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
- IEEE Std 1100™-2005
  The Emerald Book™ Recommended Practice for Powering and Grounding Electronic Equipment

9.2.4. CENELEC

- EN 50173-1:2007
  Information technology - Generic cabling systems - Part 1: General requirements
- EN 50173-2:2007
  Information technology - Generic cabling systems - Part 2: Office premises
- EN 50173-3:2007
  Information technology - Generic cabling systems - Part 3: Industrial premises
- EN 50173-4:2007
  Information technology - Generic cabling systems - Part 4: Homes
- EN 50173-5:2007
  Information technology - Generic cabling systems - Part 5: Data centres
- EN 50174-1:2009/A1:2011
  Information technology - Cabling installation - Part 1: Installation specification and quality assurance
- EN 50174-2:2009
  Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings
- EN 50174-3:2013
  Information technology - Cabling installation - Part 3: Installation planning and practices outside buildings

9.2.5. TIA

- ANSI/TIA-455-203-A-2014
  Light Source Encircled Flux Measurement Method

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- ANSI/TIA-455-240-2009
  Fibre Optic Connector Endface Cleaning System Evaluation
- ANSI/TIA-492AAAA-B-2009
  Detail Specification for 62.5 µm Core Diameter/125 µm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibres
- ANSI/TIA-492AAAB-A-2009
  Detail Specification for 50 µm Core Diameter/125 µm Cladding Diameter Class Ia Multimode, Graded-Index Optical Waveguide Fibres
- ANSI/TIA-492AAAC-B-2009
  Detail Specification for 850-nm Laser-Optimized, 50 µm Core Diameter/125-µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibres
- ANSI/TIA-492AAAD-2009
  Detail Specification for 850-nm Laser-Optimized, 50 µm Core Diameter/125 µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibres Suitable for Manufacturing OM4 Cabled Optical Fibre
- ANSI/TIA-492AAAE-2016
  Detail Specification for 50-µm Core Diameter/125-µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers with Laser-Optimized Bandwidth Characteristics Specified for Wavelength Division Multiplexing
- ANSI/TIA -526-7-A-2015
  Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures– Part 4-2: Installed Cable Plant –Single-Mode Attenuation and Optical Return Loss Measurement
- ANSI/TIA-526-14-C-2015
  Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant; Modification of IEC 61280-4-1 edition 2, Fiber-Optic Communications Subsystem Test Procedures- Part 4-1: Installed Cable Plant-Multimode Attenuation Measurement
- ANSI/TIA-568.0-E-2020
  Generic Telecommunications Cabling for Customer Premises
- ANSI/TIA-568.1-E-2020
  Commercial Building Telecommunications Cabling Standard
- ANSI/TIA-568.2-D-2018
  Balanced Twisted Pair Telecommunications Cabling and Components Standard
- ANSI/TIA-568.3-D-2015
  Optical Fibre Cabling Components Standard
- ANSI/TIA-569-E-2019
  Telecommunications Pathways and Spaces
- ANSI/TIA-570-D-2018
  Residential Telecommunication Infrastructure Standard

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- ANSI/TIA-598-D-2014
  Optical Fibre Cable Colour Coding
- ANSI/TIA-604-2-B-2004
  FOCIS 2 Fibre Optic Connector Intermateability Standard, Type ST
- ANSI/TIA-604-3-B-2004
  FOCIS-3 Fibre Optic Connector Intermateability Standard, Type SC and SC-APC
- ANSI/TIA-604-5-F-2019
  FOCIS 5 Fibre Optic Connector Intermateability Standard, Type MPO
- ANSI/TIA-604-10-B-2008
  FOCIS 10 Fibre Optic Connector Intermateability Standard, Type LC
- ANSI/TIA-604-18-2018
  FOCIS 18 Fibre Optic Connector Intermateability Standard, Type MPO-16
- ANSI/TIA-606-C-2017
  Administration Standard for Telecommunications Infrastructures
- ANSI/TIA-607-D-2019
  Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises
- ANSI/TIA-758-B-2012
  Customer-Owned Outside Plant Telecommunications Infrastructure Standard
- ANSI/TIA-862-B-2016
  Structured Cabling Infrastructure Standard for Intelligent Building Systems
- ANSI/TIA-942-B-2017
  Telecommunications Infrastructure Standard for Data Centres
- ANSI/TIA-1005-A-2012
  Telecommunications Infrastructure Standard for Industrial Premises
- ANSI/TIA-1179-A-2017
  Healthcare Facility Telecommunications Cabling Standard
- TIA-4966-2014
  Telecommunications Infrastructure Standard for Educational Facilities
- TIA-5017-2016
  Telecommunications Physical Network Security Standard
- TIA TSB-162-A-2013
  Telecommunications Cabling Guidelines for Wireless Access Points
- TIA TSB-184-A-2017
  Guidelines for Supporting Power Delivery over Balanced Twisted-Pair Cabling
- TIA TSB-185-2009
  Environmental Classification (MICE) Tutorial

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- TIA TSB-5018-2016
  Structured Cabling Infrastructure Guidelines to Support Distributed Antenna Systems

9.2.6. Insulated Cable Engineers Association (ICEA)

- ICEA S-84-608-2017
  Telecommunications Cable Filled, Polyolefin Insulated Copper Conductor Technical Requirements
- ICEA S-90-661-2012
  Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cables (With or Without an Overall Shield) for Use in General Purpose and LAN Communication Wiring Systems Technical Requirements
- ICEA S-102-732-2019
  Standard for Category 6 and 6A, 100 Ohm Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in LAN Communication Wiring Systems Technical Requirements
- ICEA S-83-596-2016
  Fibre Optic Premises Distribution Cable
- ICEA S-87-640-2016
  Fibre Optic Outside Plant Communications Cable
- ICEA S-104-696-2019
  Standard for Indoor-Outdoor Optical Fiber Cable
- ICEA S-110-717-2019
  Optical Fiber Drop Cables

9.2.7. Underwriters Laboratory (UL)

- UL 1581-2001 Ed. 4.0
  Reference Standard for Electrical Wires, Cables, and Flexible Cords
- UL 1666-2007 Ed. 5.0
  Test for Flame Propagation Height of Electrical and Optical-Fibre Cables Installed Vertically in Shafts

9.2.8. BICSI

- BICSI 001-2017
  Information and Communications Technology Systems Design and Implementation Best Practices for Educational Instituations and Facilities
- BICSI 002-2019
  Data Centre Design and Implementation Best Practices

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- BICSI 004-2018
  Information Communication Technology Systems Design and Implementation Best Practices for Healthcare Institutions and Facilities
- BICSI 005-2013
  Electronic Safety and Security (ESS) System Design and Implementation Best Practices
- BICSI 006-2020
  Distributed Antenna System (DAS) Design and Implementation Best Practices
- BICSI 007-2020
  Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises
- BICSI 008-2020
  Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices

9.2.9. Electronic Industries Association (EIA)

- EIA/ECA-310-E-2005
  Cabinets, Racks, Panels, and Associated Equipment

9.2.10. National Electrical Manufacturers Association (NEMA)

- NEMA 250-2018
  Enclosures for Electrical Equipment (1000 Volts Maximum)
- ANSI/NEMA WC 66
  Standard for Category 6 and 6A, 100 Ohm Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in LAN Communication Wiring Systems Technical Requirements

9.2.11. National Fire Protection Agency (NFPA)

- NFPA-70®-2020
  National Electrical Code®
- NFPA 72®-2019
  National Fire Alarm Code®
- NFPA 75-2020
  Standard for the protection of Information Technology Equipment
- NFPA 101®-2021
  Life Safety Code®
- NFPA 262-2019
  Standard Method of Test for Flame travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

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9.2.12. Australia

- AS/CA S008:
  Requirements for customer cabling products
- AS/CA S009
  Installation requirements for customer cabling (Wiring rules)
- AS/NZS 11801.1
  Information technology – Generic cabling for customers premises Part 1: General requirements.
- AS 11801.2
  Information technology – Generic cabling for customers premises Part 2: Office premises.
- AS 11801.3
  Information technology – Generic cabling for customers premises Part 3: Industrial premises.
- AS 11801.4
  Information technology – Generic cabling for customers premises Part 4: Single Tenant Homes.
- AS 11801.5
  Information technology – Generic cabling for customers premises Part 5: Data Centres.
- AS 11801.6
  Information technology – Generic cabling for customers premises Part 6: Distributed building services.
- AS 30129
  Information technology - Telecommunications bonding networks for buildings and other structures
- AS/NZS 14763.2
  Information technology - Implementation and operation of customer premises cabling - Planning and installation
- AS/NZS 14763.3
  Information technology - Implementation and operation of customer premises cabling, Part 3: Testing of optical fibre cabling
- AS/NZS 3084
  Telecommunications installations - Telecommunications pathways and spaces for commercial buildings
- AS/NZS 3085
  Telecommunications installations - Administration of communications cabling systems
  Information technology - Telecommunications cabling requirements for remote powering of terminal equipment.

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9.2.13. China

- GB 51348-2019

  Code for Electrical Design of Civil Buildings

- GB 50174-2017

  Code for Design of Data Centers

- GB 50311-2016

  Code for Engineering Design of Generic Cabling System

- GB/T 50312-2016

  Code for Engineering Acceptance of Generic Cabling System

9.2.14. Colombia

- NTC 6064
  Tecnología de la información Cableado Genérico para Instalación de Clientes. Information Technology – Generic cabling for customer premises Part 1: General requirements).
- NTC-IEC 6064-2
  Tecnología de la información Parte 2 Instalación en Oficinas.(Part 2: Office premises).
- NTC-IEC 61034-1
  Medida de la densidad de los humos emitidos por cables en combustión bajo condiciones definidas Parte 1: Equipo de Ensayo. Measurement of smoke density of cables burning under defined conditions - Part 1: Test apparatus
- NTC-IEC 61034-2
  Medida de la densidad de los Humos emitidos por cables en combustión bajo condiciones definidas Parte 2: Procedimiento de ensayo y requisitos Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements
- NTC-IEC 60754-1
  Ensayo de los gases expedidos durante la combustión de materiales procedentes de los cables Parte 1: Determinación del contenido de gases halógenos ácidos. (Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content).
- NTC-IEC 60754-2
  Ensayo de los gases expedidos durante la combustión de materiales procedentes de los cables Parte 2: Determinación de la acidez (Por medida del PH) y la conductividad. (Test on gases evolved during combustion of materials from cables - Part 2: Determination of acidity (by PH measurement) and conductivity.

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- NTC 6186
  Ensayos para cables (Energía y Comunicaciones) sometidos a condiciones de fuego. Ensayo de resistencia a la propagación vertical de la llama para un alambre o cable individual aislado. Equipo de Ensayo. (Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus.

- NTC 6187
  Ensayos para cables (Energía y Comunicaciones) sometidos a condiciones de fuego. Ensayo de resistencia a la propagación vertical de la llama para un alambre o cable individual aislado. Procedimiento para llama premezclada de 1KW. (Tests on electric and optical fibre cables under fire conditions - Part 1-2: Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW pre-mixed flame).

- NTC-IEC 60332-3-22
  Método de ensayo para cables (Energía y Comunicaciones) sometidos a condiciones de fuego Parte 3-22 Ensayo de propagación vertical de la llama de cables agrupados en posición vertical Categoría A. (Tests on electric cables under fire conditions - –Part 3-22: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category A).

- NTC-IEC 60332-3-23
  Método de ensayo para cables (Energía y Comunicaciones) sometidos a condiciones de fuego Parte 3-23 Ensayo de propagación vertical de la llama de cables agrupados en posición vertical Categoría B. (Tests on electric cables under fire conditions -Part 3-23:Test for vertical flame spread of vertically-mounted bunched wires or cables - Category B)

- NTC-IEC 60332-3-24
  Método de ensayo para cables (Energía y Comunicaciones) sometidos a condiciones de fuego Parte 3-24 Ensayo de propagación vertical de la llama de cables agrupados en posición vertical Categoría C . (Tests on electric cables under fire conditions -Part 3-24:Test for vertical flame spread of vertically-mounted bunched wires or cables - Category C)

- NTC-IEC 60332-3-25
  Método de ensayo para cables (Energía y Comunicaciones) sometidos a condiciones de fuego Parte 3-25 Ensayo de propagación vertical de la llama de cables agrupados en posición vertical Categoría D (Tests on electric cables under fire conditions -Part 3-25:Test for vertical flame spread of vertically-mounted bunched wires or cables - Category D)

9.2.15. Россия (Russia)

- ГОСТ Р 53245-2008
  Информационные технологии. Системы кабельные структурированные. Монтаж основных узлов системы. Методы испытания (GOST R 53245-2008: Information Technologies. Structured Cabling Systems. Main System Elements Installation. Methods of Testing)

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- ГОСТ Р 53246-2008
  Информационные технологии. Системы кабельные структурированные. Проектирование основных узлов системы. Общие требования (GOST R 53246-2008: Information Technologies. Structured Cabling Systems. Main System Elements Design. General Requirements)
- ГОСТ Р 50571.1-93 – ГОСТ Р 50571.15-97
  Электроустановки зданий (GOST R 50571.1-93 – GOST R 50571.15-97:Electrical Installations of Buildings)
- ГОСТ Р 50571.16-2007
  Электроустановки низковольтные. Часть 6. Испытания (GOST R 50571.16-2007: Low Voltage Electrical Installations. Part 6. Tests)
- ГОСТ 30331.1-95 – ГОСТ 30331.9-95
  Электроустановки зданий (GOST R 30331.1-95 – GOST 30331.9-95: Electrical Installations of Buildings)
- ГОСТ Р 53315-2009
  Кабельные изделия. Требования пожарной безопасности (GOST R 53315-2009: Cable Products. Requirements of Fire Safety)
- ГОСТ Р 53316-2009
  Электрические щиты и кабельные линии. Сохранение работоспособности в условиях пожара. Метод испытания (GOST R 53316-2009: Electric Equipment and Cable Lines. Circuit Integrity under Fire. Tests Methods)
- ГОСТ Р МЭК 60332-3-22-2005
  Испытания электрических и оптических кабелей в условиях воздействия пламени. Часть 3-22. Распространение пламени по вертикально расположенным пучкам проводов или кабелей. Категория А (GOST R IEC 60332-3-22-2005: Tests on Electric and Optical Cables under Fire Conditions. Part 3-22. Flame Spread of Vertically Mounted Bunched Wires or Cables. Category A)
- ГОСТ 12.1.030-81
  Система стандартов безопасности труда. Электробезопасность. Защитное заземление зануление (GOST 12.1.030-81: Occupational Safety Standards System. Electric Safety. Protective Conductive Earth Neutralling)
- ГОСТ 12.1.019-79
  Система стандартов безопасности труда. Электробезопасность. Общие требования и номенклатура видов защиты (GOST 12.1.019-79: Occupational Safety Standards System. Electric Safety. General Requirements and Nomenclature of Kinds of Protection)
- ГОСТ 21.406-88
  СПДС. Проводные средства связи. Обозначения условные графические на схемах и планах (GOST 21.406-88: System of Design Documents for Construction. Wire Communication Facilities. Graphical Symbols in Diagrams and Layouts)

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- ГОСТ 21.614-88
  СПДС. Система проектной документации для строительства. Изображения условные графические электрооборудования и проводок на планах. (GOST 21.614-88: System of Design Documents for Construction. Graphic Symbols of Electrical Equipment and Wiring on Plans)
- НПБ 238-97
  с изменениями от 2001 г.: Огнезащитные кабельные покрытия. Общие технические требования и методы испытаний (NPB 238-97
  Fire Resistant Cable Coatings. General Technical Requirements and Test Methods)
- НПБ 240-97
  Противодымная защита зданий и сооружений. Методы приемосдаточных и периодических испытаний (NPB 240-97: The Smoke Control Systems of Buildings. Methods of Acceptance and Routine Tests)
- НПБ 242-97
  Классификация и методы определения пожарной опасности электрических кабельных линий. (NPB 242-97: Classification and Test Methods of Electrical Cable Lines Fire Hazard)
- НПБ 246-97
  Арматура электромонтажная. Требования пожарной безопасности. Методы испытаний. (NPB 246-97: Electrical Mounting Appliances. Requirements of Fire Safety. Test Methods)
- НПБ 248-97
  Кабели и провода электрические. Показатели пожарной опасности. Методы испытаний. (NPB 248-97: Cables and Wires Electrical. Indexes of Fire Hazard. Test Procedures)
- ПУЭ
  Правила устройства электроустановок. Издание 7 (PUE: Electrical Installations Requirements. Edition 7)
- РД 25.953-90
  Системы автоматические пожаротушения пожарной охранной и охранно-пожарной сигнализации. Обозначения условные графические элементов связи. (RD 25.953-90: Automatic Fire Extinguishing Systems
  Fire Alarm Security and Fire/Security Alarm Systems. Graphic Symbols of Communication Elements)
- РД 34.21.122-87 (а также СО 153-34.21.122-2003)
  Инструкция по устройству молниезащиты зданий сооружений и промышленных коммуникаций. (RD 34.21.122-87 Building Lightning Protection and Industrial Communication Installation Guidelines)
- СН 512-78
  Инструкция по проектированию зданий и помещений для электронновычислительных машин. (SN 512-78: Computing Equipment Rooms and Buildings Design Guidelines)

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- СНиП 2.04.09-84
  Пожарная автоматика зданий и сооружений. (SNIP 2.04.09-84: Building Fire Protection Automatics)
- СТО 11233753-001-2006-10-29 (вместо СНиП 3.05.07-85)
  Системы автоматизации. Монтаж и наладка (Automation Systems. Installation and Engineering Setup)
- ВСН 60-89
  Устройства связи сигнализации и диспетчеризации жилых и общественных зданий. Нормы проектирования. (BCN 60-89: Communications
  Signaling and Control Systems in Commercial and Residential Buildings. Design Requirements)

9.2.16. United Kingdom

- BS 6701:2016+A1:2017
  Telecommunications equipment and telecommunications cabling – Specification for installation operation and maintenance
- BS 7671:2018+A1:2020
  Requirements for Electrical Installations. IET Wiring Regulations
- BS 8492:2016+A1:2017
  Telecommunications equipment and telecommunications cabling – Code of practice for fire performance and protection

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10. ANNEX B: GLOSSARY

10.1. Acronyms and Abbreviations

(The acronyms and abbreviations listed in this section relate specifically to the information provided in this manual)

ACR-F	attenuation-to-crosstalk ratio - far end
ACR-N	attenuation-to-crosstalk ratio - near end
AFEXT	alien far-end crosstalk
ANEXT	alien near-end crosstalk
ANSI	American National Standards Institute
AP	access point
AWG	American wire gauge
BBC	Backbone bonding conductor
BD	building distributor
BEF	building entrance facilities
CATV	community antenna television; cable television
CBN	common bonding network
CCTV	closed-circuit television
CD	campus distributor
CMET	customer main earth terminal
CP	consolidation point
DP	demarcation point
EDA	equipment distribution area
EF	entrance facility
EIA	Electronic Industries Alliance
ELFEXT	equal level far-end crosstalk
EMI	electromagnetic interference
EMT	electrical metallic tubing
ENI	external network interface
EO	equipment outlet

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ER	equipment room
FD	floor distributor
FE	functional earth
FEXT	far-end crosstalk
F/FTP	overall foil screened cable with foil screened twisted pair
F/UTP	unshielded twisted pair with overall foil
HC	horizontal cross-connect
HDA	horizontal distribution area
IC	intermediate cross-connect
ID	intermediate distributor
IDA	Intermediate Distribution Area
IDC	insulation displacement connector
IEC	International Electrotechnical Commission
IEEE	The Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
IT	information technology
ITU-T	International Telecommunications Union
LAN	local area network
LC	load coil (optical fiber connector)
LDP	local distribution point
LEC	local exchange carrier
MAC	moves, adds and changes
MC	main cross-connect
MD	main distributor
MDA	main distribution area
MDF	main distribution frame
MET	Main Earthing Terminal
MH	maintenance hole
MuTO(A)	multi-user telecommunications outlet (assembly)
NEXT	near-end crosstalk

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NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NVP	nominal velocity of propagation
OSP	outside plant
OTDR	optical time domain reflectometer
PBB	Primary bonding busbar
PE	protective earth
PSACR-F	power sum attenuation-to-crosstalk ratio far end
PSACR-N	power sum attenuation-to-crosstalk ratio near end
PSAACR-F	power sum alien attenuation-to-crosstalk ratio far end
PSAFEXT	power sum alien far-end crosstalk
PSANEXT	power sum alien near-end crosstalk
PSFEXT	power sum far-end crosstalk
PSNEXT	power sum near-end crosstalk
PVC	polyvinyl chloride
RBB	rack bonding busbar
RBC	rack bonding conductor
RL	return loss
RMS	rack mount space
SC	(optical fiber connector) subscriber connector
SC-D	duplex SC optical fiber connector
SCP	service concentration point
SBB	secondary bonding busbar
SO	service outlet
SP	service provider
S/FTP	overall braid screened cable with foil screened twisted pair
ST	straight tip connector (bayonet fiber optic connector 2.5mm ferrule)
STP	shielded twisted pair
TBB	telecommunications bonding backbone
TBC	telecommunications bonding conductor

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TE	telecommunications enclosure
TIA	telecommunications industry association
TO	telecommunications outlet
TR	telecommunications room
TS	telecommunications space
UL	Underwriters Laboratories
UTP	unshielded twisted pair
WA	work area
WAN	wide area network
ZD	zone distributor
ZDA	zone distribution area

Note: **Capitalization is used on proper titles only**

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10.2. Units of measure

A	ampere
dB	decibel
°C	degrees Celsius
°F	degrees Fahrenheit
ft	foot
Hz	hertz
in	inch
kg	kilogram
kHz	kilohertz
km	kilometer
kN	kilonewton
kV	kilovolt
kVA	kilovolt amp
lbf	pounds force
lx	lux
m	meter
mA	milliampere
Mb/s	megabit per second
MHz	megahertz
mm	millimeter
N	newton
V	volts
Vrms	volts root mean square
µA	microamp
µm	micrometer or micron
Ω	ohm

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10.3. Definitions

Access Floor

A system consisting of completely removable and interchangeable floor panels that are supported on adjustable pedestals or stringers (or both) to allow access to the area beneath. (Source ANSI/TIA-569-E)

Access Provider

The operator of any facility that is used to convey telecommunications signals to and from a customer's premises. (Source ANSI/TIA-568.0-D)

Adapter

A device that enables any or all of the following:

1. different sizes or types of plugs to mate with one another or to fit into a telecommunications outlet,
2. the rearrangement of leads,
3. large cables with numerous wires to fan out into smaller groups of wires, and
4. interconnection between cables. (Source ANSI/TIA-568.0-E)

Adapter, Optical Fiber Duplex

A mechanical device designed to align and join two duplex optical fiber connectors (plugs) to form an optical duplex connection. (Source ANSI/TIA-568.3-D)

Administration

The method for labelling, identification, documentation and usage needed to implement moves, additions and changes of the telecommunications infrastructure. (Source ANSI/TIA-568.0-E)

The methodology defining the documentation requirements of a cabling system and its containment, the labelling of functional elements and the process by which moves, additions and changes are recorded. (Source ISO/IEC 11801-1)

ANEXT (Alien Near-end Crosstalk) Loss

Signal coupling between a distributing pair of a channel and a distributed pair of another channel, measured at the near-end. (Source ISO/IEC 11801-1)

AFEXT (Alien Far-end Crosstalk) Loss

Signal coupling between a distributing pair of a channel and a distributed pair of another channel, measured at the far-end. (Source ISO/IEC 11801-1)

Alien Crosstalk

Signal coupling from a disturbing pair of a channel to a disturbed pair of another channel. (Source ISO/IEC 11801-1)

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Application

System, including its associated transmission method and power feeding method, which is supported by telecommunications cabling. (Source ISO/IEC 11801-1)

Attenuation

Reduction in strength of a signal. (Source ANSI/TIA-568.0-D)

The decrease in power between two points, expressed in dB. (Source ANSI/TIA-568.3-D)

Decrease in magnitude of power of a signal in transmission between points. (Source ISO/IEC 11801-1)

Backbone

A facility (e.g. pathway, cables or conductors) between telecommunications rooms, or floor distribution terminals, the entrance facilities and the equipment rooms within or between buildings.

Balanced Cable

A cable consisting of one or more metallic symmetrical cable elements (twisted pairs or quads). (Source ISO/IEC 11801-1)

Balun

A device for transforming an unbalanced voltage to a balanced voltage or vice-versa.

Building Automation System

Equipment and telecommunications infrastructure that supports monitoring, control, operation and management of building services. (Source ANSI/TIA-862-B)

Bonding

The joining of metallic parts to form an electrically conductive path. (Source ANSI/TIA-568.0-E)

Bonding Conductor for Telecommunications

A conductor that joins metallic parts to form an electrically conductive path. (Source ANSI/TIA -607.C)

Bridged Tap

A connection that enables multiple appearances of the same cable pair at several distribution points.

Building Backbone Cable

Fixed cable connecting distributors within the building backbone cabling subsystem. (Source ISO/IEC 11801-1)

Building Distributor

A distributor in which the building backbone cable(s) terminate(s) and at which connections to the campus backbone cable(s) may be made. (Source ISO/IEC 11801-1)

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Building Entrance Facility

A facility that provides all necessary mechanical and electrical services, that complies with all relevant regulations, for the entry of telecommunications cables into a building. (Source ISO/IEC 11801-1)

Bundled Cable

An assembly of two or more cables continuously bound together to form a single unit. (Source ANSI/TIA-569E)

Buried Cable

A cable installed under the surface of the ground in such a manner that it cannot be removed without disturbing the soil. (Source ANSI/TIA758-B)

Cabinet

A container that may enclose connection devices, terminations, apparatus, wiring, and equipment. (Source ANSI/TIA-569-E)

An enclosed construction intended for housing information technology components and equipment. (Source ISO/IEC 14763-2)

Cable

An assembly of one or more insulated conductors or optical fibers within an enveloping sheath. (Source ANSI/TIA-568.0-E)

Assembly of one or more cable units in an overall sheath. (Source ISO/IEC 11801-1)

Cable Run

A length of installed media which may include other components along its path. (Source ANSI/TIA-568.0-E)

Cable Sheath

A covering over the optical fiber or conductor assembly that may include one or more metallic members, strength members, or jackets. (Source ANSI/TIA-568.0-E)

Cabling

A combination of all cables, jumpers, cords and connecting hardware. (Source ANSI/TIA-568.0-D)

A system of telecommunications cables, cords, and connecting hardware that can support the connection of information technology equipment. (Source ISO/IEC 11801-1)

Campus

The buildings and grounds having legal contiguous interconnection. (Source ANSI/TIA-568.0-E)

Premises containing one or more buildings. (Source ISO/IEC 11801-1)

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Campus Backbone Cable

Fixed cable connecting distributors within the campus backbone cabling subsystem. (Source ISO/IEC 11801-1)

Campus Distributor

The distributor from which the campus backbone cabling starts. (Source ISO/IEC 11801-1)

Ceiling Distribution system

A distribution system that utilizes the space between a suspended or false ceiling and the structural surface above.

Centralized Cabling

A cabling configuration using a continuous cable, an interconnect, or a splice from an equipment outlet to a centralized cross-connect in Distributor B or Distributor C.. (Source ANSI/TIA-568.0-E)

Centralized Optical Fiber Cabling

Cabling technique that creates a combined backbone/horizontal channel from the equipment areas to the centralized cross-connect or interconnect by allowing the use of pull-through cables or splices. (Source ISO/IEC 11801-1)

Channel

The end-to-end transmission path between two points at which application-specific equipment is connected. (Source ANSI/TIA-568.0-E)

The end-to-end transmission path connecting any two pieces of application-specific equipment. Equipment and work area cords are included in the channel, but not the connecting hardware into the application-specific equipment. (Source ISO/IEC 11801-1)

Civil Works

Activities required to prepare pathways and pathway systems, particularly external to buildings, prior to the installation of cabling.

Closure

Fixture or fitting of either open or closed construction intended to contain connecting hardware. (Source ISO/IEC 14763-2)

Commercial Building

A building or portion thereof that is intended for office use. (Source ANSI/TIA-568.0-E)

Common Equipment Room (telecommunications)

An enclosed space used for equipment and backbone interconnections for more than one tenant in a building or campus.

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Common Telecommunications Room

An enclosed space used for backbone interconnections for more than one tenant in a building, which may also house equipment.

Conduit

(1) A raceway of circular cross-section.

(2) A structure containing one or more ducts. (Source ANSI/TIA-569-E)

NOTE: The term conduit includes electrical metallic tubing (EMT) or electrical non-metallic tubing (ENT).

Connecting Hardware

A device providing mechanical cable terminations. (Source ANSI/TIA-568.0-E)

Connecting hardware is considered to consist of a device or a combination of devices used to connect cables or cable elements. (Source ISO/IEC 11801-1)

Connecting Hardware Field

A single unit or element which contains one or more rows or columns for termination of cabling. Examples of connecting hardware fields include an individual:

- 24-port patch panel,
- 100-pair, S110 connecting block,
- 50-pair, S66M1-50,
- optical fiber patch panel.

Connection

Mated device or combination of devices including terminations used to connect cables or cable elements to other cables, cable elements or application-specific equipment. (Source ISO/IEC 11801-1)

Connector, Small Form Factor

An optical fiber duplex connector with a size approximating that of an 8-position modular outlet/connector.

Consolidation Point (CP)

A connection facility within Cabling Subsystem 1 for interconnection of cables extending from building pathways to the equipment outlet. (Source ANSI/TIA-568.0-D)

Cord

Cable, cable unit or cable element with a minimum of one termination. (Source ISO/IEC 11801-1)

Cord, Telecommunications

1) An assembly of cord cable with a plug on one or both ends.

2) An assembly of optical fiber cable with a connector on each end.

(Source ANSI/TIA-568.0-D)

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Coupling Attenuation

Ratio, in decibels, of the differential power in the signal pairs to the power generated by the excited common mode currents. (Source ISO/IEC 11801-1)

CP Cable

A cable connecting the consolidation point to the telecommunications outlet(s).

CP Link

The part of the permanent link between the floor distributor and the consolidation point, including the connecting hardware at each end. (Source ISO/IEC 11801-1)

Cross-connect IXI

A facility enabling the termination of cable elements and their interconnection, or cross-connection. (Source ANSI/TIA-568.0-E)

Passive connection between cabling subsystems using a patch cord or jumper. (Source ISO/IEC 11801-1)

Cross-connect, Horizontal

A cross-connect of horizontal cabling to other cabling (e.g. horizontal, backbone, equipment).

Cross-connection

A connection scheme between cabling runs, subsystems and equipment using patch cords or jumpers that attach to connecting hardware on each end. (Source ANSI/TIA-568.0-E)

Connection by means of a cross-connect. (Source ISO/IEC 11801-1)

Crossover

The junction unit at the point of intersection of two cable trays, raceways, or conduit (pathways) on different planes.

Crosstalk

Noise or interference caused by electromagnetic coupling from one signal path to another. Crosstalk performance is generally expressed in decibels.

Customer Premises

Building(s), grounds and appurtenances (belongings) under the control of the customer. (Source ANSI/TIA-568.0-E)

Customer Premises Equipment

Telecommunications equipment located on the customer's premises.

Data

Electronically encoded information.

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Data Centre

A building or portion of a building whose primary function is to house a computer room and its support areas. (Source ANSI/TIA-942-B)

Structure, or group of structures, dedicated to the centralized accommodation, interconnection and operation of information technology and network telecommunications equipment providing data storage, processing and transport services, together with all the facilities and infrastructures for power distribution and environmental control, together with the necessary levels of resilience and security required to provide the desired service availability. (Source ISO/IEC 11801-1)

DC Resistance

The measure of a component's inherent capability to impede the flow of DC current.

DC Resistance Unbalance

The measure of the difference in resistance values between adjacent pairs of objects.

Decibel (dB)

A standard unit for expressing transmission gain or loss and relative power levels.

Delay Skew

The difference in propagation delay between any two pairs within the same cable sheath.

Demarcation Point

A point where the operational control or ownership changes. (Source ANSI/TIA-568.0-E)

Device (protection)

A protector, protector mount, protector unit or protector module.

Device (work area)

An item, such as a telephone, personal computer or graphic/video terminal.

Direct-Buried Cable

A cable installed under the surface of the ground in such a manner that it cannot be removed without disturbing the soil.

Distribution Frame

A structure with terminations for connecting the permanent cabling of a facility in such a manner that connection or cross-connections may be readily made.

Distributor

Functional element enabling the termination and connection of cabling subsystems to other

cabling subsystems or transmission equipment. (Source ISO/IEC 11801-1)

Drain Wire

A non-insulated conductor placed in electrical contact with a shield.

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Duct

1. A single enclosed raceway for conductors or cables. See also conduit, raceway.
2. A single enclosed raceway for wires or cables usually used in soil or concrete.
3. An enclosure in which air is moved. Generally, part of the HVAC system of a building. (Source ANSI/TIA-569-E)

Earthing

See grounding

Effectively Grounded

Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current carrying capacity to prevent the build-up of voltages which may result in undue hazard to connected equipment or to persons.

Electromagnetic Interference (EMI)

The interference in signal transmission or reception caused by the radiation of electrical and magnetic fields.

Radiated or conducted electromagnetic energy that has an undesirable effect on electronic equipment or signal transmission. (Source ANSI/TIA-568.0-E, ANSI/TIA-569-E)

Electrical Closet

A floor-serving facility for housing electrical equipment, panel boards, and controls. The closet is the recognised interface between the electrical backbone riser and its associated pathway.

Electronic Industries Alliance (EIA)

A standards organization that specializes in the electrical and functional characteristics of interface equipment. The organization sets standards for interfaces to ensure compatibility between data communications equipment and data terminal equipment.

Enclosure, Telecommunications

A case or housing for telecommunications equipment, cable terminations and cross-connect cabling.

End User

The owner or user of the premises cabling systems. (Source ANSI/TIA-568.0-D)

Entrance Facility, Telecommunications

An entrance to a building for both public and private network service cables (including wireless [antennae]) including the entrance point of the building (wall) and continuing to the entrance room or space. (Source ANSI/TIA-569-E)

Entrance Point, Telecommunications

The point of emergence of telecommunications cabling through an exterior wall, a floor, or from a conduit. (Source ANSI/TIA-569-E)

Entrance Room or Space, Telecommunications

A space in which the joining of inter- or intrabuilding telecommunications backbone facilities takes place. (Source ANSI/TIA-569-E)

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Equal Level Far-End Crosstalk Loss

A measure of the unwanted signal coupling from a transmitter at the near-end into another pair measured at the far-end, and relative to the received signal level.

Equipment Cable

A cable or cable assembly used to connect telecommunications equipment to horizontal or backbone cabling systems.

Equipment Distributor Area

The computer room space occupied by equipment racks or cabinets.

Equipment Cord

Cord connecting one end of the cabling subsystem in a distributor to transmission equipment. (Source ISO/IEC 11801-1)

Equipment Outlet

Outermost connection facility in a hierarchical star topology. (Source ANSI/TIA-568.0-E)

Equipment Room

A room dedicated to housing distributors and application specific equipment.

Equipment Room, Telecommunications

An environmentally controlled centralized space for telecommunications equipment that usually houses a main or intermediate cross-connect. An equipment room is considered distinct from the telecommunications closet because of the nature and complexity of the equipment it houses.

External Network Interface

Termination point providing demarcation of external telecommunications service provision. (Source ISO/IEC 11801-1)

False Ceiling

See suspended ceiling.

Fire Stop

A fire-rated material, device, or assembly of parts installed in a penetration of a fire-rated barrier.

Fire Stopping

The process of installing listed, fir-rated materials into penetrations in fire-rated barriers to re-establish the fire-resistance rating of the barrier.

Fire Stop System

A specific construction consisting of the material(s) that fill the opening where any items penetrate the wall or floor (e.g. cables, cable trays, conduit, ducts, pipes, termination devices, outlet boxes) along with their means of support.. (Source ANSI/TIA-569-E)

Floor Distributor

The distributor used to connect between the horizontal cable and other cabling subsystems or equipment. (See Telecommunications Room).

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Floor Slab

That part of a reinforced concrete floor, which is carried on beams below.

Frame

Open construction, typically self-supporting and floor-mounted, intended for housing closures and other telecommunications equipment. (Source ISO/IEC 14763-2)

Generic Cabling

A structured telecommunications cabling system, capable of supporting a wide range of standardized applications. (Source ISO/IEC 11801-1)

It can be installed without prior knowledge of the required applications. Application specific hardware is not part of generic cabling.

Ground

A conducting connection, whether intentional or accidental, between an electrical circuit (telecommunications) or equipment and earth, or to some conducting body that serves in place of the earth. (Source ANSI /TIA-569-E)

Grounding

The act of creating a ground intentionally or unintentionally

Grounding Conductor

A conductor used to connect the facilities grounding electrode to the buildings main grounding busbar

Hand Hole

Point of access to a pathway that is too small for a person to enter to perform work but that allows the routing of cables during the cable installation process such that bending and pulling requirements are met (Source ISO/IEC 14763-2)

Home-Run

A pathway or cable between two locations without a point of access in between.

Horizontal Cabling (Fixed)

A cable connecting the floor distributor to the consolidation point (CP) when a CP is present, or to the telecommunications outlet (TO) when a CP is not present.

Horizontal Cabling

A cable connecting the floor distributor to the telecommunications outlet(s).

Cabling Subsystem 1. (Source ANSI/TIA-568.1-E) (TIA-942-B)

The cabling between and including the building automation system outlet or the first mechanical termination of the horizontal connection point and the horizontal cross-connect.

Horizontal Connection Point

A location for connections between horizontal cables that extend from building pathways and horizontal cables that extend to building automation systems devices and equipment.

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Horizontal Cross-connect

A cross-connect of horizontal cabling to other cabling (e.g. horizontal, backbone or equipment). (Source ANSI/TIA-568.0-D)

Horizontal Distribution Area

A space in a computer room where a horizontal cross-connect is located. (Source TIA 942-B)

Horizontal Pathways

Pathways for the installation of cables from the telecommunications room to the work area telecommunications outlet/connector. A horizontal pathway facility can be composed of several components including cable tray, conduit, underfloor, access floor, non-continuous fasteners, and perimeter systems.

Hybrid Cable

Hybrid cable assembly of two or more cable units of different types in an overall sheath. It may include an overall screen. (Source ISO/IEC 11801-1)

Identifier

An item of information that links a specific element of the telecommunications infrastructure with its corresponding record.

Infrastructure, Telecommunications

A collection of those telecommunications components, excluding equipment, that together provide the basic support for the distribution of all information within a building or campus. (Source ANSI/TIA-568.0-E)

Individual Work Area

The minimum building space that would be reserved for an occupant.

Inner Duct

A non-metallic pathway, usually circular, placed within a larger pathway. Also known as sub-duct.

Insertion Loss

Loss incurred by inserting a device between a source and load of equal impedance. (Source ISO/IEC 11801-1)

Insertion Loss Deviation

The difference between the measured insertion loss of cascaded components and the insertion loss as determined by simply adding their individual component losses. (Source ISO/IEC 11801-1)

Interbuilding Backbone

The backbone telecommunications cable(s) that are part of the campus subsystem that connect from one building to another. Inter-building backbone may be installed using underground (in conduit), direct buried, aerial or tunnel methods.

Interbuilding Backbone Pathways

A pathway facility for interconnecting telecommunications entrance rooms or spaces in different buildings, as in a campus environment, as well as to the property line for connection off the premises.

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Interconnect

Passive connection to a cabling subsystem not using a patch cord or jumper. (Source ISO/IEC 11801-1)

Interconnection

A connection scheme that employs connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper, or employs a patch cord or jumper to make a connection between connecting hardware and equipment.. (Source ANSI/TIA-568.0-E)

Interface

A point at which connections are made to the generic cabling. (Source ISO/IEC 11801-1)

Intermediate Cross-connect

Distributor B. A cross-connect between first and second level backbone cabling. (Source ANSI/TIA-568.0-E)

Intrabuilding Backbone

The backbone telecommunications cable(s) that are part of the building subsystem that connect one closet to another. Installation methods include ceiling, cable tray and conduit.

Intrabuilding Backbone Pathways

A pathway facility for interconnecting telecommunications entrance rooms, equipment rooms and telecommunications closets within a building.

Junction Box

A location in the pathway system that allows transition of pathways and access to cables.

Jumper

A cable, cable unit or cable element without connectors used to make a connection on a cross-connect. (Source ISO/IEC 11801-1)

Keying

The mechanical feature of a connector system which guarantees polarization or prevents the connection to an incompatible socket or optical fiber adapter. (Source SO/IEC 11801-1)

Link

A transmission path between two points, not including equipment and cords. (Source ANSI/TIA-568.0-E)

Transmission path between two cabling system interfaces, including the connections at each end. (Source ISO/IEC 11801-1)

Listed

Equipment included in a list published by an organization, acceptable to the authority having jurisdiction, that maintains periodic inspection of production of listed equipment, and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Local Exchange Carrier (LEC)

The local regulated telecommunications provider of public switched network access services.

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Main Cross-connect

Distributor C. A cross-connect for 1st level backbone cables, entrance cables, and equipment cables. (Source ANSI/TIA-568.0-E)

Main Distribution Area

The space in a computer room where the main cross-connect is located. (Source TIA 942-B)

Maintenance Hole (telecommunications)

Vault or chamber located in the ground or earth as part of an underground conduit system and used to facilitate placing, connectorization, and maintenance of cables as well as the placing of associated equipment, in which it is expected that a person will enter to perform work. Note: This term was previously called “manhole”. (Source ISO/IEC 14763-2)

Mechanical Room

An enclosed space serving the needs of the mechanical building/facility systems.

Media, Telecommunications

Wire, cable, or conductors used for telecommunications. (Source ANSI/TIA-568.0-E)

Minimum Operating Dynamic Bend Radius

Minimum radius, as defined by the cable manufacturer, supplier or relevant product standard, to which a cable or cable element is allowed to be subjected under conditions where the cable or cable element is subject to movement during operation. (Source ISO/IEC 14763-2)

Minimum Point of Entry

Either (1) the closest practicable point to where the carrier facilities cross the property line, or (2) the closest practicable point to where the carrier facilities enter a multi-tenant building.

Minimum Operating Static Bend Radius

Minimum radius, as defined by the cable manufacturer, supplier or relevant product standard, to which a cable or cable element is allowed to be subjected following installation and when fixed in its final operating position. (Source ISO/IEC 14763-2)

Modular Jack

A female telecommunications outlet/connector that may be keyed or unkeyed as defined in the FCC Part 68 Subpart F. Modular jacks can have 6 or 8 contact positions, but not all the positions need be equipped with contacts.

Modular Plug

A male telecommunications connector for cables or cords that may be keyed or unkeyed, as defined in the FCC Part 68 Subpart F. Modular plugs can have 4, 6 or 8 contact positions, but not all the positions need be equipped with contacts.

Multimedia

Applications that communicate information by more than one means.

Multimode Optical Fiber

An optical fiber that carriers many paths of light. (Source ANSI/TIA-568.3-D)

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Multi-pair Cable

A cable having more than four pairs.. (Source ANSI/TIA-568.0-E)

Multi-user Telecommunications Outlet Assembly

A grouping in one location of several equipment outlets. (Source ANSI/TIA-568.0-D)

Near-End Crosstalk (NEXT)

The undesired coupling of a signal from one pair of wires to another. Signal distortion as a result of signal coupling from one pair to another at various frequencies.

Network Demarcation Point

The point of interconnection between the local exchange carrier's telecommunication facilities and the telecommunications systems wiring and equipment at the end user's facility. This point shall be located on the subscriber's side of the telephone company's protector or the equivalent thereof in cases where a protector is not required.

Nominal Velocity of Propagation (NVP)

The coefficient used to determine the speed of transmission along a cable relative to the speed of light in a vacuum.

Optical Fiber Cable

An assembly consisting of one or more optical fibers. (Source ANSI/TIA-568.0-E)

A cable comprising of one or more optical fiber cable elements. (Source ISO/IEC 11801-1)

Optical Fiber Duplex Adapter

A mechanical device designed to align and join two duplex optical fiber connectors (plugs) to form an optical duplex connection.

Optical Fiber Duplex Connection

A mated assembly of two duplex connectors and a duplex adapter.

Optical Fiber Duplex Connector

A mechanical media termination device designed to transfer optical power between two pairs of optical fibers.

Optical Fiber Polarity

Optical fiber networks usually transmit on one fiber and receive on a second. Hence the term polarity. However, the description of transmit and receive depends on the geographic origin. From a given point, the transmit fiber ultimately becomes the receive fiber at the far end.

Outlet Box, Telecommunications

A housing used to hold telecommunications outlet/connectors.

Outlet/Connector, Telecommunications

A connecting device in the work area on which horizontal cable or outlet cable terminates.

Overfill Launch

A controlled launch where the test fiber is overfilled with respect to both angle and position to simulate LED launches.

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Pair

Two conductors of a balanced transmission line. (Source ISO/IEC 11801-1)

Patch Cord

Cord used for a cross-connection. (Source ISO/IEC 11801-1)

Patch Panel

Panel at a distributor presenting the interface(s) of cabling subsystems to facilitate administrative moves and changes using patch cords or jumpers. (Source ISO/IEC 11801-1)

Pathway

A facility for the placement of telecommunications cable. (Source ANSI/TIA-569-E)

Pathway System

Cable management system or other area or volume defined by markings or fittings used to protect and/or support the cabling in order that its desired performance is maintained. (Source ISO/IEC 14763-2)

Penetration

An opening in a fire-rated barrier.

Permanent Link

Transmission path between distributors or between distributor 1 and the terminal equipment outlet including the connections at both ends. (Source ISO/IEC 11801)

It excludes equipment cords, work area cords, patch cords and jumpers. It can include a CP link

Plenum

A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system. (Source ANSI/TIA-569-E)

Poke-Thru Device

An assembly that allows through-penetration of floor decking with telecommunications cables, or power, or both, while maintaining the fire-rating integrity of the floor. (Source ANSI/TIA-569-E)

Poke-Thru System

Penetrations through the fire resistive floor structure to permit the installation of horizontal telecommunications cables.

Power Sum Alien Near-end Crosstalk (PSANEXT) Loss

A computation of signal coupling from multiple near-end distributing channel pairs into a distributed pair of a neighbouring channel or part thereof, measured at the near-end.

Power Sum Alien Far-end Crosstalk (AFEXT) Loss

A computation of signal coupling from multiple near-end distributing channel pairs into a distributed pair of a neighbouring channel or part thereof, measured at the far-end.

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Primary Bonding Busbar (PBB)

A busbar placed in a convenient and accessible location and bond by means of the telecommunications bonding conductor, to the buildings service equipment (power) ground (formerly known as the telecommunications main grounding busbar).

Private Branch Exchange (PBX)

A private switching system usually serving an organization, such as a business, located on the customer's premises. It switches calls both inside a building or premises and outside to the telephone network, and can sometimes provide access to a computer from a data terminal.

Public Network Interface

A point of demarcation between public and private network. In many cases the public network interface is the point of connection between the network provider's facilities and the customer premises cabling.

Pull Box

A housing located in a pathway run used to facilitate the placing of wire or cables.

Pull Cord; Pull Wire

Cord or wire placed within a raceway and used to pull wire and cable through the raceway.

Pull Strength

See pull tension.

Pull Tension

The pulling force that can be applied to a cable. (Source ANSI/TIA-568.0-E)

Punch Down

A method of securing wire to a wiring terminal in which the insulated wire is placed in the terminal groove and pushed down with a special tool. As the wire is seated, the terminal displaces the conductor insulation to make an electrical connection, and the tool's blade trims the wire flush with the terminal. Also called "cut down."

Radio Frequency Interference

Electromagnetic interference within the frequency band of radio transmissions.

Raceway

Any enclosed channel designed for holding wires or cables. (Source ANSI/TIA-569-E)

Return Loss

A ratio expressed in dB of the power of the outgoing signal to the power of the reflected signal.

Screen

An element of a cable formed by a shield.

Screened Twisted Pair (ScTP)

A balanced cable with an overall screen.

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Screened Balanced Cable

A balanced cable with an overall screen and/or screens for the individual elements. (Source ISO/IEC 11801-1)

Secondary bonding busbar

A common point of connection for telecommunications system and equipment bonding to ground, and located in the distributor room (formerly known as the telecommunications grounding busbar).

Service Entrance

See Entrance Facility (Telecommunications)

Service Fitting

An outlet box to house the connections for telecommunications in the service area. (Source ANSI/TIA-569-E)

Service Outlet

fixed connecting device where the service distribution cabling terminates. (Source ISO/IEC 11801-6)

Service Pole

See Utility Column.

Service Provider

The operator of any service that furnishes telecommunication content (transmissions) delivered over access provider facilities.

Sheath

See Cable Sheath. (Source ANSI/TIA-569-E)

Shield

A metallic layer placed around a conductor or group of conductors.

The cylindrical outer conductor with the same axis as the centre conductor that together form a coaxial transmission line.

Shielded Cables

An assembly of two or more balanced twisted pair cable elements or one or more quad cable elements wrapped by an overall screen or shield contained within a common sheath or tube.

Shielded Twisted Pair (STP)

A cable medium with one or more pairs of twisted insulated copper conductors surrounded by metallic braid or foil and bound in a single plastic sheath.

Shielded Twisted Pair Cables

An electrically conducting cable comprising one or more elements, each of which is individually shielded. There may be an overall shield, in which case the cable is referred to as a shielded twisted pair cable with an overall shield.

Singlemode Optical Fiber

An optical fiber that carries only one path of light. (Source ANSI/TIA-568.3-D)

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Slab on grade

Concrete floor placed directly on soil, without basement or crawlspace. (Source ANSI/TIA-569-E)

Sleeve

An opening, usually circular, through the wall, ceiling, or floor to allow the passage of cables. (Source ANSI/TIA-569-E)

Slot

An opening through a wall, floor, or ceiling, usually rectangular, to allow the passage of cables. (Source ANSI/TIA-569-E)

Small Form Factor Connector

An optical fiber connector designed to accommodate two or more optical fibers with at least the same mounting density as the connector used for balanced cabling.

Space, Telecommunications

An area used for housing the installation and termination of telecommunications equipment and cable, e.g. common equipment rooms, equipment rooms, common telecommunications rooms, telecommunications rooms, work areas, and maintenance holes/handholds. (Source ANSI/TIA-569-E)

Splice

A joining of conductors or optical fibers, generally from separate sheaths. (Source ISO/IEC 11801-1)

Splice Box

A box, located in a pathway run, intended to house a cable splice.

Splice Closure

A device used to protect a splice.

Support Strand

A strength element used to carry the weight of the telecommunications cable.

Suspended Ceiling

A ceiling that creates an area or space between ceiling material and the structure above. (Source ANSI/TIA-569-E)

Star Topology

A topology in which telecommunications cables are distributed from a central point (Source ANSI/TIA-568.0-E)

Telecommunications

The transmission and reception of information by cable, radio, optical or other electromagnetic systems. (Source ANSI/TIA-568.0-E)

Technology concerned with the transmission, emission and reception of signs, signals, writing, images and sounds by cable, radio, optical or other electromagnetic systems. (Source ISO/IEC 11801-1)

Telecommunications Entrance Facility

See Entrance Facility, Telecommunications. (Source ANSI/TIA-569-E)

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Telecommunications Equipment Room

See Equipment Room, Telecommunications. (Source ANSI/TIA-569-E)

Telecommunications Industry Association (TIA)

A standards organization that, among other activities, specializes in the electrical and functional characteristics of interface equipment. The organization sets standards for interfaces to ensure compatibility between data communications equipment and data terminal equipment.

Telecommunications Infrastructure

See Infrastructure, Telecommunications. (Source ANSI/TIA-568.0-E)

Telecommunications Outlet

Fixed connecting device which provides an interface to the terminal equipment. (Source ISO/IEC 11801-1)

Telecommunications Room

An enclosed space for housing telecommunications equipment, cable terminations, interconnect and cross-connect.

Topology

The physical or logical arrangement of a telecommunications system. (Source ANSI/TIA-568.0-E)

Transition Point

A connection between round cable and flat undercarpet cable in Cabling Subsystem 1. (Source ANSI/TIA-568.0-E)

Trough

A pathway for the containment of cable typically provided with a removable cover.

Trunk

A communication line between two switching systems. The term “switching system” typically includes equipment in a central office (the telephone company) and PBXs. A tie trunk connects PBXs. Central office trunks connect a PBX to the switching system at the central office.

Twisted Pair

Cable element that consists of two insulated conductors twisted together in a determined fashion to form a balanced transmission line. (Source ISO/IEC 11801-1)

Uninterruptible Power Supply (UPS)

A buffer between the utility power or other power source and a load that requires continuous precise power.

Unscreened Balanced Cable

Balanced cable without any screens. (Source ISO/IEC 11801-1)

Unshielded Twisted Pair (UTP)

A cable medium with one or more pairs of twisted insulated copper conductors bound in a single plastic sheath.

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Usable Floor Space

Floor space which is capable of being used as a work area.

Utility Column

An enclosure extending from the ceiling to furniture or to the floor that forms a pathway for electrical wiring, telecommunications cable or both. (Source ANSI/TIA-569-E) Note: It may also be used to mount or contain connecting hardware.

Wire

An individually insulated solid or stranded metallic conductor. (Source ANSI/TIA-568.0-E)

Wireless

The use of radiated electromagnetic energy (e.g. radio frequency, microwave signals, light) traveling through free space to convey information.

Wireless Access Point

A device that is a transmitter and receiver to facilitate wireless communications.

Work Area

A building space where the occupants interact with telecommunications terminal equipment. (Source ISO/IEC 11801-2) and (Source ANSI/TIA-568.0-E)

Work Area Cable (Cord)

A cable (cord) connecting the telecommunications outlet to the terminal equipment.

Work Area Cluster

A contiguous group of work areas that does not span aisles.

Zone Box

An enclosure used to house one or more of the following: a) a consolidation point, b) a horizontal connection point, c) building automation system outlets.

Zone Distribution Area

A space in a computer room where a zone outlet or consolidation point is located.

Zone Outlet

A connecting device in the zone distribution area terminating the horizontal cable enabling equipment cable connections to the equipment distribution area.

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11. ANNEX C: APPLICATION DISTANCES

Table 11-1: Maximum Channel Attenuation and Supportable Distances for Multimode Fibre Applications

Application	Support Distance (m) (Channel Attenuation) (dB)							
	OM1		OM2		OM3		OM4/OM5	
	850 nm	1300 nm	850 nm	1300 nm	850 nm	1300 nm	850 nm	1300 nm
ATM 52 Mb/s	N/A	2000 (10.0)	N/A	2000 (5.3)	N/A	2000 (5.3)	N/A	2000 (5.3)
ATM 155 Mb/s	1000 (7.2)	2000 (10.0)	1000 (7.2)	2000 (5.3)	1000 (7.2)	2000 (5.3)	1000 (7.2)	2000 (5.3)
ATM 622 Mb/s	300 (4.0)	500 (6.0)	300 (4.0)	330 (2.0)	300 (4.0)	330 (2.0)	300 (4.0)	330 (2.0)
1000BASE-SX	275 (2.6)	N/A	550 (3.6)	N/A	[1]	N/A	[1]	N/A
1000BASE-LX	N/A	550 (2.3)	N/A	550 (2.3)	N/A	550 (2.3)	N/A	550 (2.3)
10GBASE-SR	33 (1.6)	N/A	82 (1.8)	N/A	300 (2.6)	N/A	400 (2.9)	
10GBASE-LX4	N/A	300 (2.5)	N/A	300 (2.0)	N/A	300 (2.0)	N/A	300 (2.0)
10GBASE-LRM	N/A	220 (1.9)	N/A	220 (1.9)	N/A	220 (1.9)	N/A	220 (1.9)
25GBASE-SR	N/A	N/A	N/A	N/A	70 (1.8)	N/A	100 (1.9)	N/A
40GBASE-SR4	N/A	N/A	N/A	N/A	100 (1.9)	N/A	150 (1.5)	N/A
100GBASE-SR4	N/A	N/A	N/A	N/A	70 (1.8)	N/A	100 (1.9)	N/A
100GBASE-SR10	N/A	N/A	N/A	N/A	100 (1.9)	N/A	150 (1.5)	N/A
FDDI PMD ANSI X3.166	N/A	2000 (11.0)	N/A	2000 (6.0)	N/A	2000 (6.0)	N/A	2000 (6.0)
1GFC 100-MX-SN-I	300 (3.0)	N/A	500 (3.9)	N/A	860 (4.6)	N/A	860 (4.6)	N/A
2GFC 200-MX-SN-I	150 (2.1)	N/A	300 (2.6)	N/A	500 (3.3)	N/A	500 (3.3)	N/A
4GFC 400-MX-SN	N/A	N/A	150 (2.1)	N/A	380 (2.9)	N/A	400 (3.0)	N/A
8GFC 800-MX-SN	N/A	N/A	50 (1.7)	N/A	150 (2.0)	N/A	190 (2.2)	N/A

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8GFC 800-MX-SA	N/A	N/A	100 (1.9)	N/A	300 (2.6)	N/A	300 (2.2)	N/A
16GFC 1600-MX-SN	N/A	N/A	35 (1.6)	N/A	100 (1.9)	N/A	125 (2.0)	N/A
32GFC 3200-MX-SN-S/I	N/A	N/A	20 (2.0)	N/A	70 (1.9)	N/A	100 (1.9)	N/A

[1] At the time 1000BASE-SX was developed, OM3 and OM4 had not been standardized -see entries for 1GFC 100-MX-SN-I for guidance

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Table 11-2: Maximum Channel Attenuation and Supportable Distances for Singlemode Fibre Applications

Application	Support Distance (m) (Channel Attenuation) (dB)	
	OS1a/OS2	
	1310 nm	1550 nm
ATM 52 Mb/s	15000[1] (10.0)	N/A
ATM 155 Mb/s	15000[1] (7.0)	N/A
ATM 622 Mb/s	15000[1] (7.0)	N/A
1000BASE-LX	5000[1] (4.5)	N/A
10GBASE-LR	10000[1] (6.2)	N/A
10GBASE-LX4	10000[1] (6.2)	N/A
10GBASE-ER	N/A	30000[1] (10.9)
40GBASE-LR4	10000[1] (6.7)	N/A
100GBASE-LR4	10000[1] (6.3)	N/A
100GBASE-ER4	30000[1] (15.0)	N/A
FDDI SMF-PMD	10000[1] (10.0)	N/A
1GFC 100-SM-LC-L	10000[1] (7.8)	N/A
2GFC 200-SM-LC-L	10000[1] (7.8)	N/A
4GFC 400-SM-LC-M	4000[1] (4.8)	N/A
4GFC 400-SM-LC-L	10000[1] (7.8)	N/A
8GFC 800-SM-LC-I	1400 (2.6)	N/A
8GFC 800-SM-LC-L	10000[1] (6.4)	N/A
16GFC 1600-SM-LC-L	10000[1] (6.4)	N/A
32GFC 3200-SM-LC-L	10000[1] (6.3)	N/A

[1] Lengths beyond 3000m are outside the scope of the Siemon Cabling System

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Table 11-3: Balanced Copper Applications and Supportable Distances

Application	Category	Class	Distance, m (ft)
10BASE-T	≥ Category 3	≥ Class C	100 (328)
100BASE-T	≥ Category 5	≥ Class D	100 (328)
1000BASE-T	≥ Category 6	≥ Class E	100 (328)
10GBASE-T	≥ Category 6A	≥ Class E_A	100 (328)
25GBASE-T	≥ Category 8	≥ Class I/II	30 (100)
40GBASE-T	≥ Category 8	≥ Class I/II	30 (100)
ADSL[1]	≥ Category 3	≥ Class C	5000 (16404)
VDSL	≥ Category 3	≥ Class C	5000 (16404)[2]
Analog Phone	≥ Category 3	≥ Class C	800 (2625)
Fax	≥ Category 3	≥ Class C	5000 (16404)
ATM 25.6	≥ Category 3	≥ Class C	100 (328)
ATM 51.84	≥ Category 3	≥ Class C	100 (328)
ATM 155.52	≥ Category 3	≥ Class C	100 (328)
ATM 1.2G	≥ Category 6	≥ Class E	100 (328)
ISDN BRI (129 Kb/s)	≥ Category 3	≥ Class C	5000 (16404)
ISDN PRI (1.472 Mb/s)	≥ Category 3	≥ Class C	5000 (16404)

[1] 1.5-9 Mb/s

[2] 1500m (4900 ft) for 12.9 Mb/s; 300m (1000 ft.) for 52.8 Mb/s

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