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Structured Cabling System Workshop

15 March, 2006

Nicholas Yeo

Workshop Agenda

AMP NETCONNECT

- Tyco Introductions
- Structured Cabling System Introductions
- Structured Cabling Standards Update
- Understanding Structured Cabling Infrastructure In-depth
- Optional
  - 10GBase-T Cabling System
  - Data Center Cabling System
  - Power over Ethernet
  - AMPTRAC Cabling Management System
  - EtherSeal Cabling System
  - Residential Cabling System

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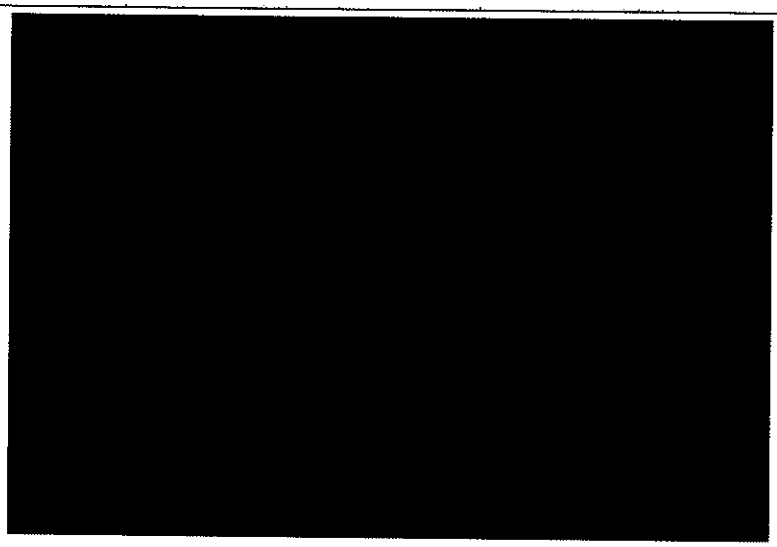
Tyco Electronics Introductions



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What is a Structured Cabling System ?

A Structured Cabling System is a complete collective configuration of cabling and associated hardware on a premises which, when installed, provides a comprehensive telecommunications infrastructure.

Network Specific Cabling System

A specified cabling system designed to be installed according to a manufacturer's or network's standard set of rules. i.e.. IBM Cabling Systems and IEEE 802.3, 10 Base 2

Open Cabling System

A generic telecommunications cabling system that will support a multi-services, multi-product and multi-vendor environment

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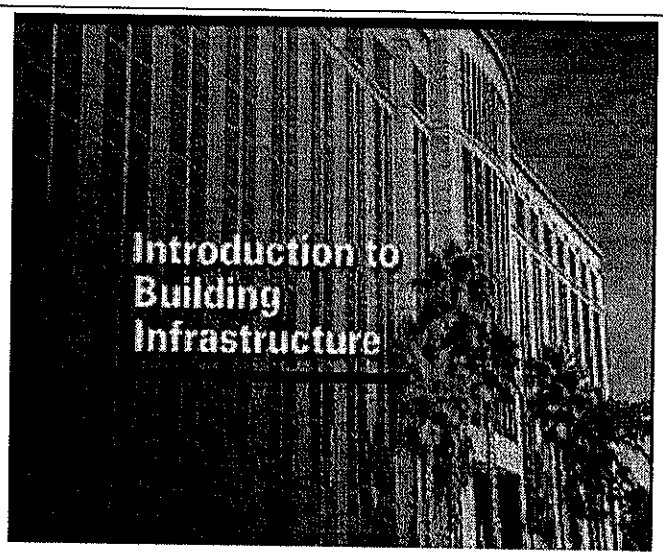
Introduction to Building Infrastructure



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AMP Netconnect Cabling Solutions

To jump, click on desired Topic

- Structured Cabling Standards Update
- Understanding Structured Cabling Infrastructure In-depth
- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
- AMPTRAC Cabling Management System
- EtherSeal Cabling System
- Residential Cabling System
- The END

Else, follow agenda sequence...

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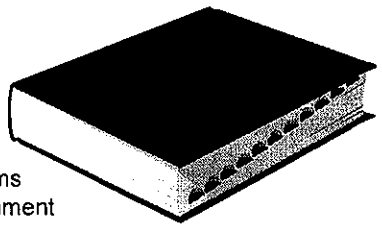
Industry Cabling Standards

A document that describes a well defined subject
Living document and grows – subjected to revision and updates

- Advances in building construction techniques
- Advances in telecommunication technology
- Ever increasing demand for bandwidth

Note : A standard has no legal implications



Benefits of standards :

- Enable the planning and installation of systems
- Support a multi-product, multi-vendor environment
- Support standards-based applications
- Establish performance and technical criteria
- Simplify administration and management
- Accommodate future growth

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What Do Cabling Standards Cover?

- Minimum requirements for Telecommunications cabling
  (Campus, Commercial Building, Office, Residential, Industrial, Data Centers etc)
- Cabling requirements
- Cabling Distances
- Telecommunications outlet/connector configurations
- Topology of the cabling system
- Component performance specifications
- Choice of components
- Installation practices
- Cabling system testing methodology
- Administration & Management

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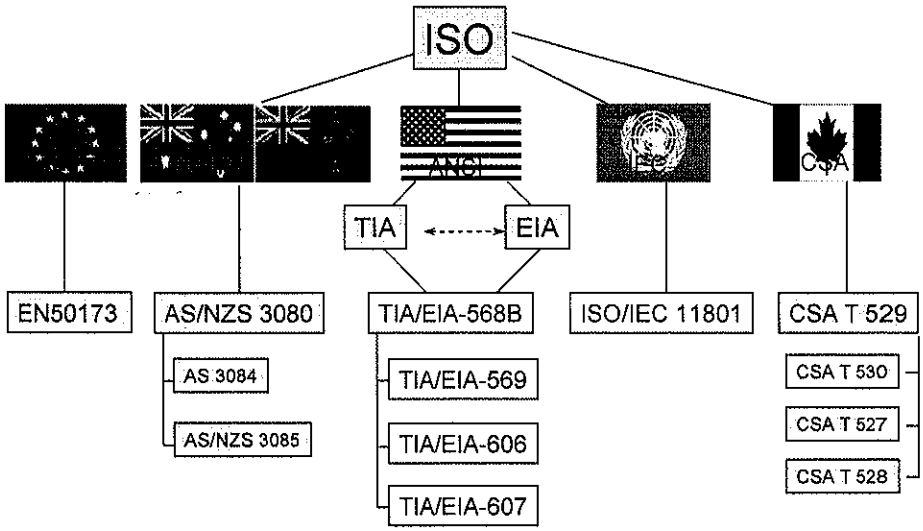
Industry Cabling Standards



Standard Forums of Interest

- Two primary standards development groups relate to premises cabling
  - TIA TR-42 - User Premises Telecommunications Infrastructure (UTPI)
  - IEEE 802.3 - Ethernet
- Others worth paying attention to
  - ICEA – Insulated Cable Engineering Assoc.
  - Fibre Channel
  - CENELEC
  - ISO

TIA TR-42 UPTI

- Nine Subcommittees
  - 42.1 Commercial Building Cabling
  - 42.2 Residential
  - 42.3 Pathways & Spaces
  - 42.4 Outside Plant
  - 42.5 Terms, Definitions and Abbreviations
  - 42.6 Administration
  - 42.7 Copper Components
  - 42.8 Optical Fiber Components
  - 42.9 Industrial

TIA/EIA 568-B Standard

Telecommunications Industry Association (TIA) Engineering Committee TR-42.1:

ANSI/TIA/EIA 568B Series Standard - Commercial Building Telecommunications Cabling Standard



- TIA/EIA 568B.1 (Part 1), General Requirements
  - General requirements for system design, installation, performance and testing
- TIA/EIA 568B.2 (Part 2), Balanced Twisted-Pair Cabling Components
  - Performance and testing requirements
- TIA/EIA 568B.3 (Part 3), Optical Fiber Cabling Components Standard
  - Performance and testing requirements

www.tiaonline.org

Standard Addendums & TSBs

- ANSI/EIA/TIA-568-B.1(2001), General Requirements
  - Addendum 1 - Minimum 4-Pair UTP and 4-Pair ScTP Patch Cable Bend Radius
  - Addendum 2 - Grounding and Bonding Requirements for Screened Balanced Twisted-Pair Horizontal Cabling
  - Addendum 3 - Supportable Distances and Channel Attenuation for Optical Fiber Applications by Fiber Type
  - Addendum 4 - Recognition of Category6 and 850 nm Laser-Optimized 50/125 µm Multimode Optical Fiber Cabling
  - Addendum 5 - Telecommunications Cabling for Telecommunications Enclosures
  - Addendum 6 - Additional Cabling Guidelines for DTE Power
  - Addendum 7 - Array Connector Polarity
  - Addendum 8 - Additional Component Requirements for DTE Power

Standard Addendums & TSBs

- ANSI/TIA/EIA-568-B.2 (2001), Balanced Twisted-Pair Cabling Components Standard
  - Addendum 1 – Transmission Performance Specifications for 4-Pair 100 Ohm Category 6 Cabling
  - Addendum 2 - Corrections to TIA/EIA-568-B.2
  - Addendum 3 - Additional Considerations for Insertion Loss and Return Loss Pass/Fail Determination
  - Addendum 4 - Solderless Connection Reliability Requirements for Copper Connecting Hardware
  - Addendum 5 - Corrections to TIA/EIA- 568-B.2
  - Addendum 6 - Category 6 Related Component Test Procedures
  - Addendum 7 – Reliability Specification Requirements for Copper Connecting Hardware
  - Addendum 10 – "Augmented" Cat6 Cabling

Standard Addendums & TSBs

- ANSI/TIA/EIA-568-B.3 (1999), Optical Fiber Cabling Components Standard
  - Addendum 1 - Additional Transmission Performance Specifications for 50/125 um Laser Optimized Optical Fiber Cables
  - TSB153, Static Discharge Between LAN Cabling and Data Terminal Equipment
  - TSB140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems
  - TSB125, Guidelines for Maintaining Optical Fiber Polarity Through Reverse-Pair Positioning

Other TIA/EIA Standard Documents

- ANSI/TIA/EIA-569-B, Commercial Building Standards for Telecommunications Pathways and Spaces
- TIA/EIA 607-A, Grounding and bonding requirements for telecommunications industry
- TIA/EIA 606-A, Administration standard for telecommunications infrastructure
- ANSI/TIA/EIA 570-B, Residential Telecommunications Infrastructure Standard
- ANSI/TIA/EIA-942, Telecommunications Infrastructure Standard for Data Centers
- ANSI/TIA/EIA-758-A, Customer-owned Outside Plant Telecommunications Cabling Standard
- ANSI/TIA/EIA-862, Building Automation Systems for Commercial
- ANSI/TIA/EIA-1005, Industrial Telecommunications Infrastructure

ISO/IEC Standard Documents

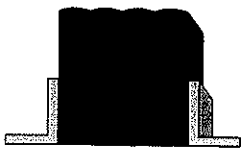
ISO/IEC 11801, 2nd Edition, 2002-09
Information Technology - Generic Cabling for Customer Premises

ISO/IEC 14763-1
Administration

ISO/IEC 14763-2
Planning and Installation)

ISO/IEC 14673-3
Testing of Optical fiber cabling)

ISO/IEC 61935
Test methods for Copper cabling



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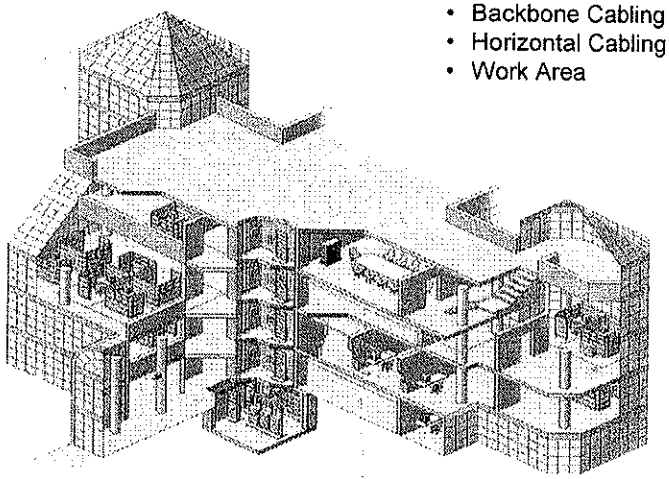
Telecommunications Structured Cabling System

- Backbone Cabling Subsystem
- Horizontal Cabling Subsystem
- Work Area



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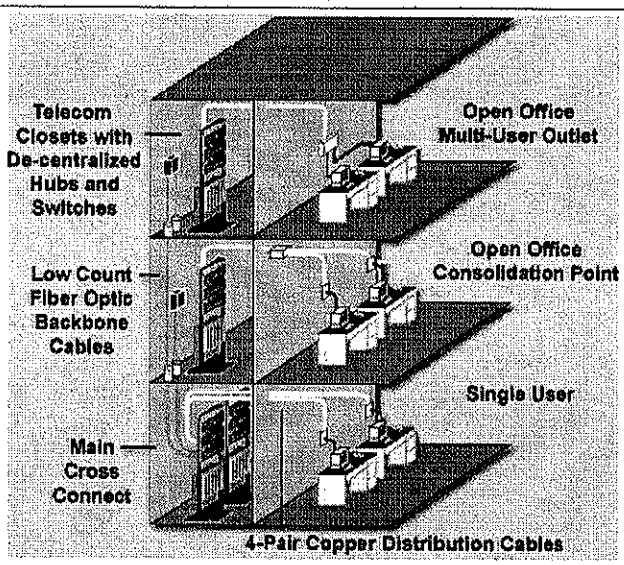
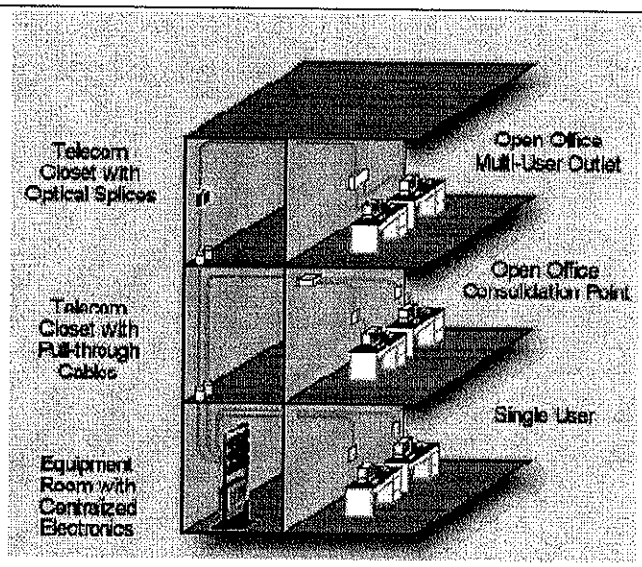
Premise Cabling Market - Trends

- Predominantly based on balanced twisted pair cabling in the horizontal and optical fiber in the backbone
- In the horizontal
  - Category 5e has become the minimum recommended performance grade for data cabling.
  - Cat 6 is gaining ground
  - With hype about Augmented Cat6 bringing up the rear
  - Shielded system has proven itself
- In the backbone
  - 62.5/125 micron (OM1) used to dominate
  - 50/125 micron (OM2) is the current trend
  - 50/125 micron, laser optimized fiber (OM3) is quickly gaining ground for its superior performance with laser sources
  - Singlemode

Distributed Network Administration



Centralized Cabling Administration



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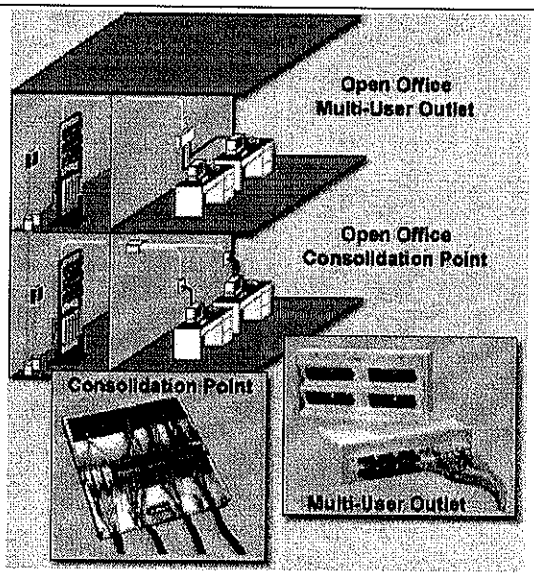
Open Office Cabling Systems



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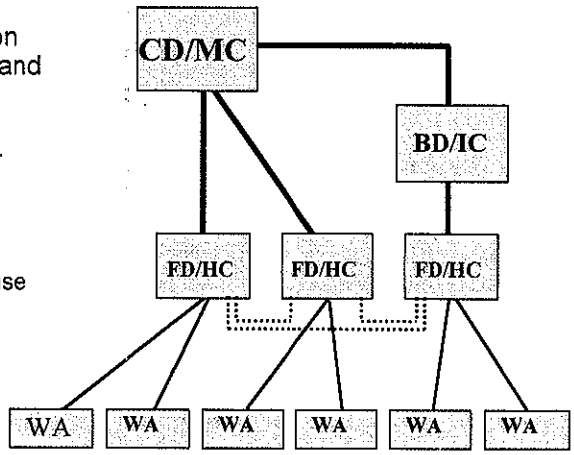
Backbone Cabling Subsystem

- To provide connectivity between telecommunication rooms, equipment rooms, and entrance facilities.
- Two-level hierarchical star.
- Non-star configurations
  - Ring, Bus, Tree can be accommodated through use of interconnections, electronics and adapters.
  - Fault Tolerance
  - Redundancy



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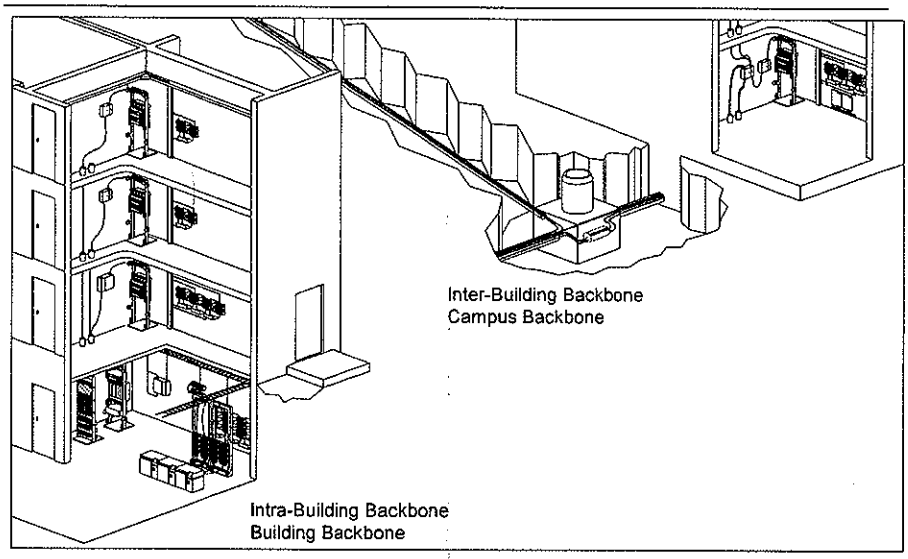
Backbone Cabling Subsystem



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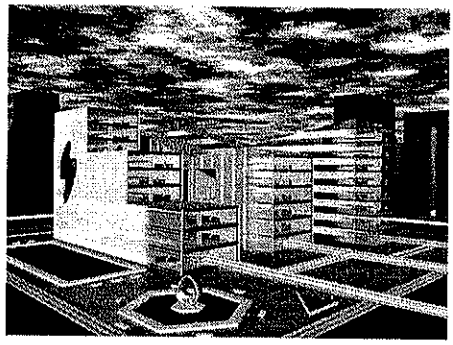
Recognized Backbone Media

TIA/EIA 568-B.1 Specified :

- 100Ω Twisted Pair Cable
  - 4 pair or multi-pair cable construction
  - Unshielded or Shielded Twisted Pair Cable
  - Voice application – min. Cat 3
  - Data application – min. Cat 5e system
- Optical Fiber Cable
  - Multimode optical fiber
    - 62.5/125 µm GI
    - 50/125 µm GI
  - Singlemode optical fiber
  - 850nm Laser Optimized 50/125m multimode fiber



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TIA-568-B.1 Application Annex for Fiber

Table E-1
Supportable distance and channel attenuation for optical fiber application by fiber type

Application	Wavelength (nm)	Max Supportable Distance (m)			Max Channel Attenuation (dB)		
		62.5 µm	50 µm	Singlemode	62.5 µm	50 µm	Singlemode
10 Base-FL (Ethernet)	850	2 000		NST	12.5	7.6	NST
Token Ring M16	850	2 000		NST	13.0	8.3	NST
Demand Priority (100 VG-AnyLAN)	1300 850	2 000 500		NST	7.0 7.5	2.3 2.8	NST
100 Base-Eyes (Fast Ethernet)	1300	2 000		NST	11.0	6.3	NST
FDDI (W-Cable)	1300	500		NST	7.0	2.3	NST
FDDI (Original)	1300	2 000		40 000	11.0	6.3	10.0 to 32.0
ATM 155 155 622 622	1300 850 1300 850	2 000 1 000 500 300		15 000 - 15 000 -	10.0 7.2 6.0 4.0	5.3 7.2 1.3 4.0	7.0 to 12.0 - 7.0 to 12.0 -
Fiber Channel 266 266 1062 1062	1300 850 850 1300	1 500 700 300 -	1 500 2 000 500 -	10 000 - - 10 000	6.0 12.0 4.0 -	5.5 12.0 4.0 -	6.0 to 14.0 - - 6.0 to 14.0
1000 Base-SX (Gigabit Ethernet)	850	220	550	-	3.2	3.9	-
1000 Base-LX (Gigabit Ethernet)	1300	550	550	5 000	4.0	3.6	4.7

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Advantages of Optical Fiber

Extensive Bandwidth

No EMI/RFI

Easy and Dependable Installation

Enhanced Security

No

Increased Distance

Low Attenuation

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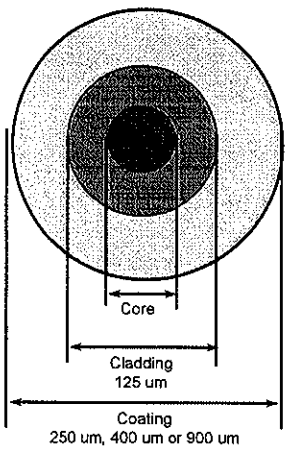
Advantages of Optical Fiber

CORE
Carries the light signal
(Germania Doped Silica Glass)

CLADDING
Keeps light signal within core
(Pure Silica Glass)

COATING
Protects Optical Fiber From Abrasion and EYesternal Pressures
(UV Cured Acrylate)



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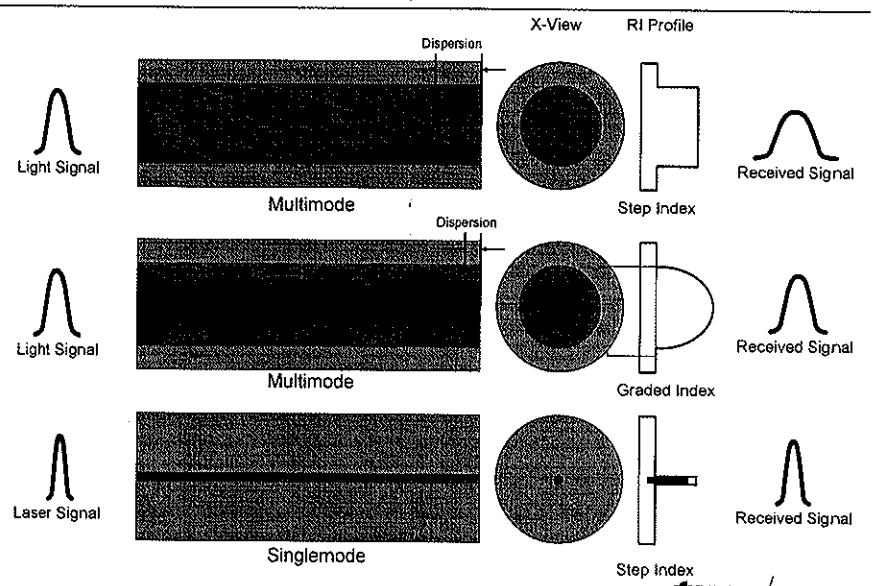
Types of Optical Fiber



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TIA/EIA Specified Optical Fiber Cable

Optical Fiber Cable Type	Wavelength (nm)	Maximum Attenuation (dB/Km)	Minimum Bandwidth (MHz@Km)
50/125 mm	850	3.5	500
62.5/125 mm	850	3.5	160
Singlemode Indoor Cable	1310	1.0	N/A
Singlemode Outdoor Cable	1310	0.5	N/A

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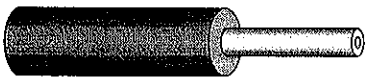
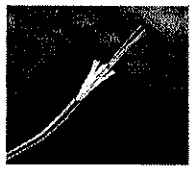
AMP Netconnect Fiber Cables

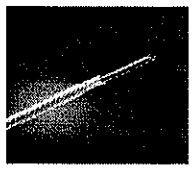
Product Range : 'Tight Buffered'
Application : Mostly Indoor



- Key Advantages :-
  - Ruggerdised fibre provides mechanical protection
  - Dry construction - easy handling
  - Easy to terminate and connectorise
  - Flexible, lightweight, non-metallic cables ideally suited to indoor applications e.g. Building Backbone, FTTD, Patchcords etc.

- Cable Construction :-
  - Strength Member
    - Aramid Yarn strength member
    - E-Glass (Rodent Resistance)
  - Jacket Flammability Rating
    - PVC
    - Riser Rated
    - Plenum
    - LSZH





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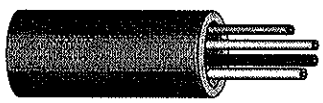
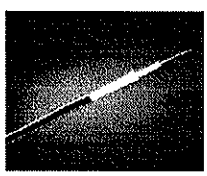
AMP Netconnect Fiber Cables

Product Range : 'Loose Tube'
Application : Indoor & Universal



- Key Advantages :-
  - Maximum mechanical protection for fibres leading to long fibre reliability
  - Dry and Gel filled options
  - Uni-tube or Multiple Stranded Tubes
  - Wider operating temperature range possible
  - Higher packing density of fibres - high fibre count cables

- Cable Construction : -
  - Strength Member
    - Aramid Yarn strength member
    - E-Glass (Rodent Resistance)
    - Steel Wire
  - Jacket Flammability Rating
    - Riser Rated
    - Plenum
    - LSZH
    - LDPe
    - HDPe



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AMP Netconnect Fiber Cables

Product Range : 'Armoured Type'
Application : Mostly Outdoor

Cable Construction : -

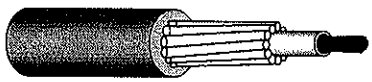
- STEEL TAPE ARMOUR
  Increased Crush resistance
  Enhanced moisture protection



- STEEL WIRE ARMOUR
  Increased Mechanical strength & Crush resistance
  Increased weight and bigger bend diameter



- GRP Armour
  Non-metallic
  Increased cable rigidity - bigger cable bend diameter
  Lightweight
  Increased Mechanical strength & Crush resistance
  Better Rodent protection over glass yarns



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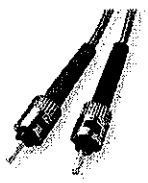
TIA/EIA 568-B.1- Fiber Connectors

Connectors allowed

- SC Duplex
- BFOC (ST-style)





Connector selection in 568-B.1

- Horizontal optical fibers at the work area outlet shall be terminated to an optical fiber outlet/connector meeting the requirements of ANSI/TIA/EIA-568-B.3
- To facilitate inter-office moves, consider use of one style of duplex connector for the work area outlet.
- The 568SC connector was previously specified by ANSI/TIA/EIA-568-A and should continue to be considered for the work area outlet. Other connector styles, including those of a small form factor, may also be considered.

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SFF Connectors

What is a Small Form Factor (SFF) Connector?

- An Optical Fiber Duplex Connector with a size approximating that of an 8-position Modular Outlet/connector typically used for terminating 4-pair Copper Cable

MT-RJ



Opti Jack



LC



VF-45



What Does 568 B.3 Allow?

Any Connector Which Meets the Following:

- Compliance With an Approved FOCIS Document
- Performance Requirements of Annex A

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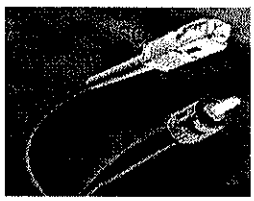
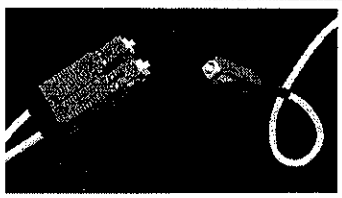
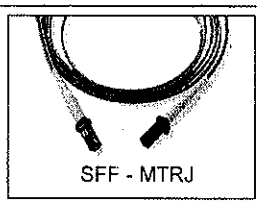
AMP Netconnect Fiber Connectors







SFF - MTRJ

Types of Ferrule

Ceramic Ferrule

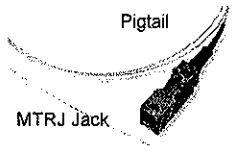
Polymer Ferrule

Stainless Steel Ferrule



Types of Connector

- Multimode or Singlemode
  - ST
  - SC
    - Simplex
    - Duplex
  - SFF



Pigtail

MTRJ Jack

Termination Methods

- Adhesive, Polish required
- No Adhesive, Polish required
- No Adhesive, No Polish required
- Splice

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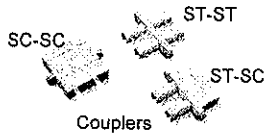
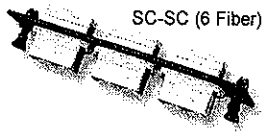
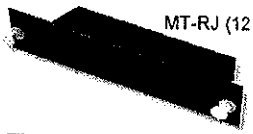
AMP Fiber Connector Coupling Adapter Plates

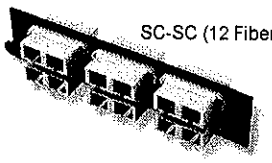














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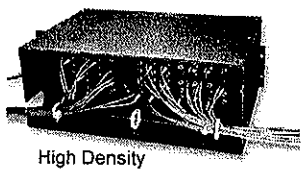
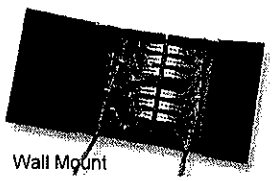
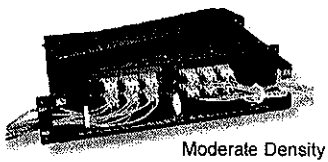
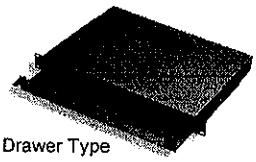
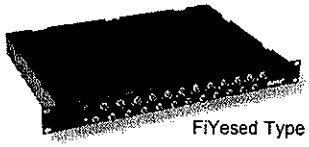
AMP Netconnect Fiber Enclosures

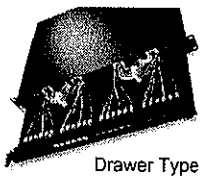












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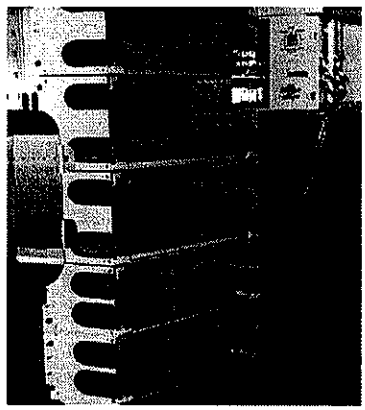
AMP Fiber Accessories

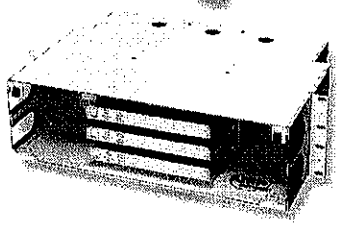
Corelink Spice





Spice Tray





Spice Enclosure

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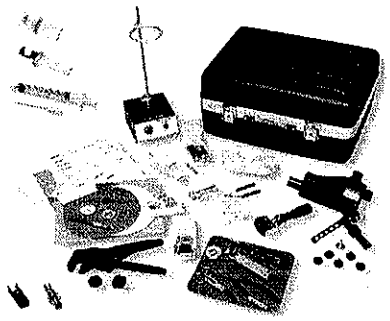
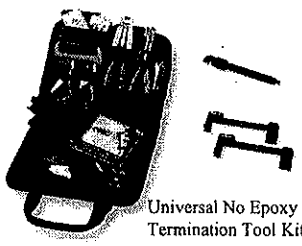
AMP Optical Fiber Termination Tools



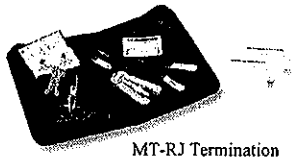
Professional Installer Kit



Universal No Epoxy Termination Tool Kit



Fiber Optic Cleave Tool



MT-RJ Termination Tool Kit

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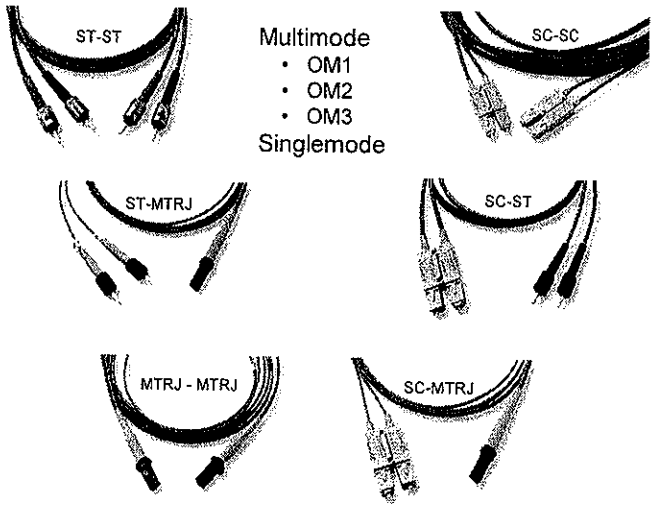
AMP Optical Fiber Patch Cords



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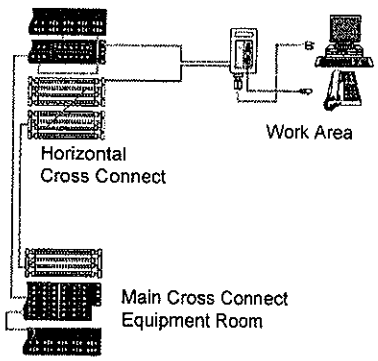
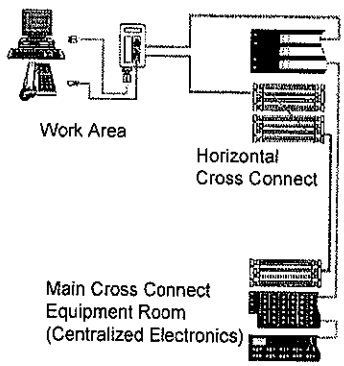
AMP Fiber Solutions

Distributed Network Administration
- Campus Backbone (Fiber)
- Building Backbone (Fiber)
- Horizontal (Fiber)



Centralized Network Administration
- Fiber to the Desk (FttD)
- Building Backbone (Fiber)



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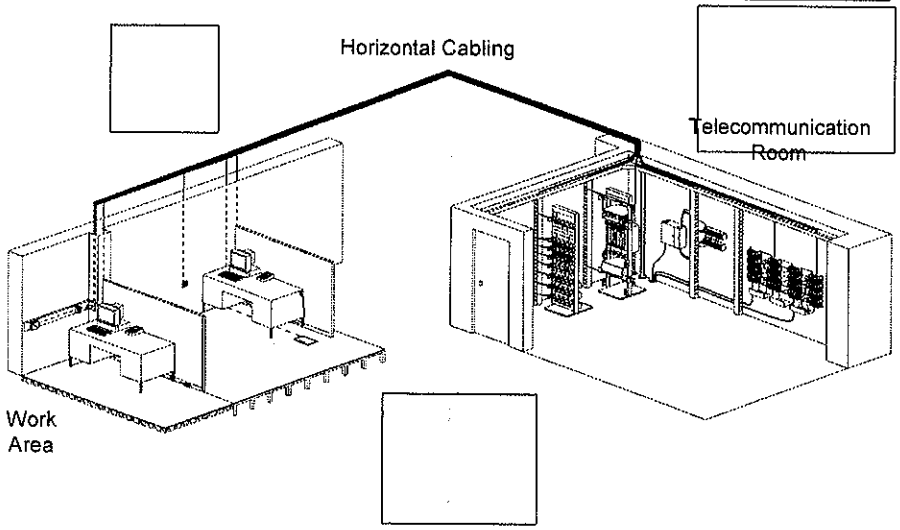
Horizontal Cabling Subsystem



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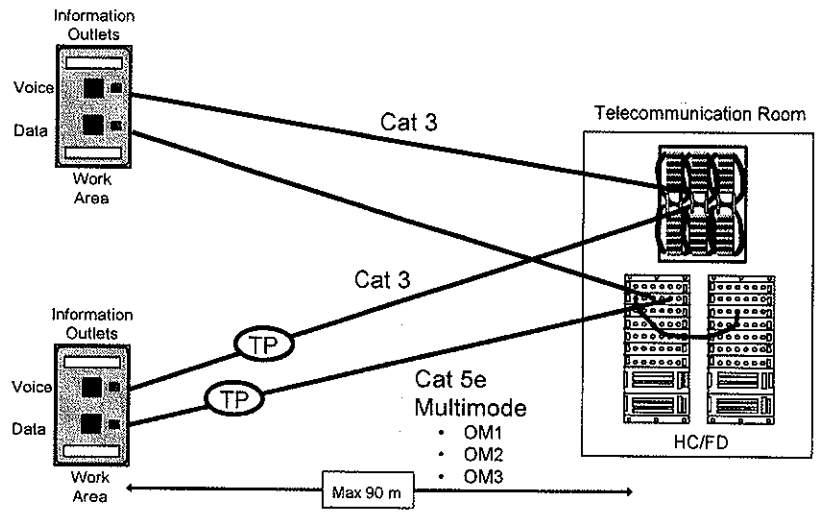
Horizontal Subsystem



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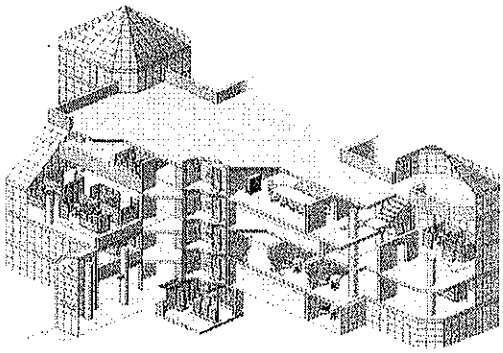
ANSI/TIA/EIA 568-B.1

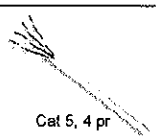
Recognized Horizontal Media

- 100 Ohm, 4 Pair Balanced Cables
  - Category 3, 5e, 6, 6A*, 7
    - UTP
    - ScTP
- Multimode Fiber
  - OM1
  - OM2
  - OM3

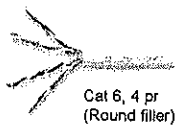


AMP Netconnect 100 ohm Twisted Pair Cables


Cat 3, 4 pr

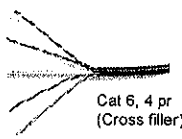

Cat 5, 4 pr


Cat 5e, 4 pr


Cat 6, 4 pr
(Round filler)


Cat 3, Multi-pair

Cable Flame Rating
- CM – Communication Multi Purpose
- CMR – Communication Riser Rated
- CMP – Communication Plenum
- LSZH – Low Smoke Zero Halogen


Cat 6, 4 pr
(Cross filler)


Pull Box


Wooden Box

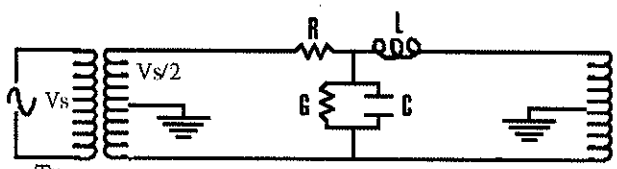

Reel-In-Box



Balanced Signal Transmission

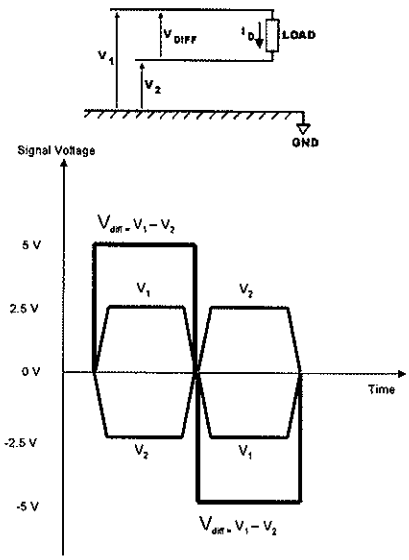


- Balanced circuit uses 2 wires (Tip & Ring) to carry the signal.
- Each leg of the twisted pair and all circuits connected to them have the same impedance with respect to ground
- Ground serve as a reference potential, rather than a signal return.



Balanced Pair Differential Mode Transmission Model

Balanced Signal Transmission

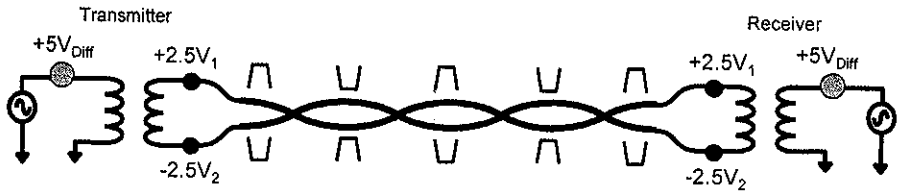


- Balanced Mode Transmission is also known as Differential Mode Transmission
- $+V_1$ and $-V_2$ has equal magnitude but phase difference of 180^0
- The difference $V_{DIFF} = V_1 - V_2$ is the "wanted" signal that carries information.
- The instantaneous sum of the two voltages ($V_1 + V_2$) is ideally zero

All Physical Layer (PHY) transceivers for LAN and Telecom applications are differential mode devices.

Balanced Mode Transmission Over TP

The signal is fed into the wire pair (Tip and Ring) using differential mode transmission scheme



The two conductors of a pair carry the opposite transmitted signal :

The difference of the signals carries all the data

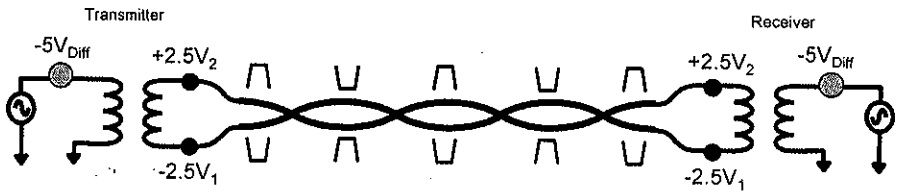
$+ 2.5V_1 - (- 2.5V_2) = + 5.0V_{Diff}$

The sum of the signals is ideally zero resulting in no net emissions

$+ 2.5V_1 + (- 2.5V_2) = 0V_{Emission}$

Balanced Mode Transmission Over TP

The signal is fed into the wire pair (Tip and Ring) using differential mode transmissio scheme



The two conductors of a pair carry the opposite transmitted signal :

The difference of the signals carries all the data

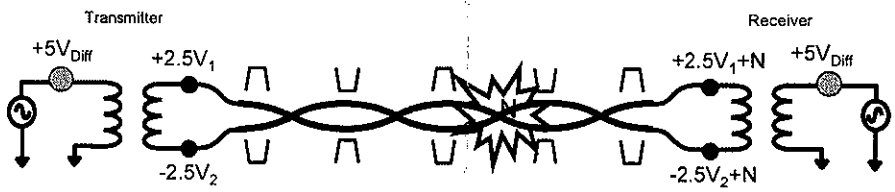
$- 2.5V_1 - (+ 2.5V_2) = - 5.0V_{Diff}$

The sum of the signals is ideally zero resulting in no net emissions

$- 2.5V_1 + (+ 2.5V_2) = 0V_{Emission}$

Balanced Mode Transmission Over TP

The signal is fed into the wire pair (Tip and Ring) using differential mode transmission scheme



Only the differential (opposite on the two conductors) data signal Noise is let into the receiver

$$+2.5V_1 + N - (-2.5V_2 + N) = +5.0V_{Diff}$$

External noise pickup is *ideally* the same on the two conductors (zero difference) and ignored by the receiver resulting in total noise suppression

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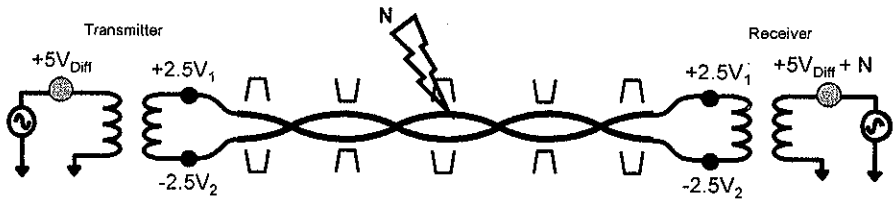
Balanced Mode Transmission Over TP

The signal is fed into the wire pair (Tip and Ring) using differential mode transmissio scheme



The differential (opposite on the two conductors) data signal and Noise is let into the receiver

$$+2.5V_1 + N - (-2.5V_2) = +5.0V_{Diff} + N$$

External noise pickup on either of the two conductors cannot be neutralized and will interfere with desired signal received.

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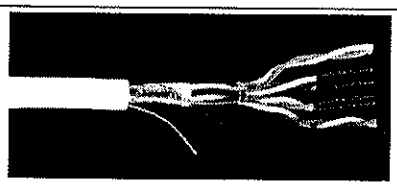
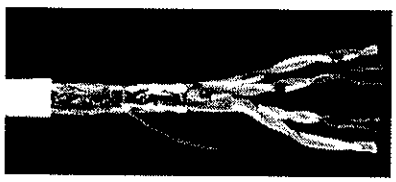
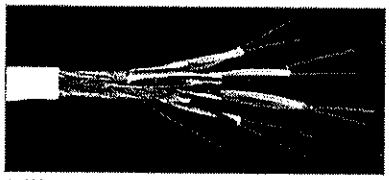
AMP Netconnect
100 Ohm Screened TP Cables



Foiled Twisted Pair (FTP)
- Category 5, 4 pr
- Category 5e, 4 pr
- Category 6, 4pr



Screened, Foiled Twisted Pair (S-FTP)
- Category 5, 4 pr
- Category 5e, 4 pr
- Category 6, 4 pr



Pair in Metal Foil (PiMF)
- Category 6, 4 pr
- Category 7, 4 pr
- Category 8, 4 pr

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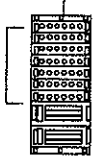
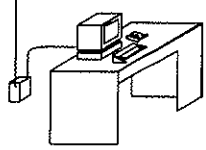
Systems Focus

System Solution



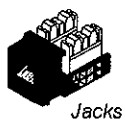


Cable
PVC
Plenum
LSZH

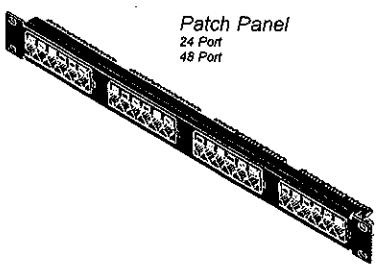




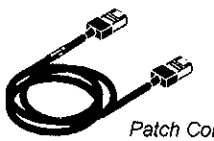
Country Specific Faceplates



Jacks



Patch Panel
24 Port
48 Port



Patch Cords

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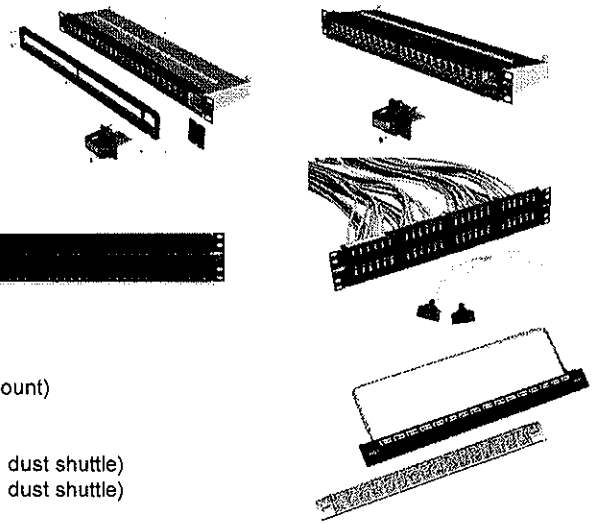
AMP Netconnect Patch Panels

Type
- Unshielded
- Shielded
- Amptrac ready
- Amptrac enabled

Category
- Cat 3
- Cat 5
- Cat 5e
- Cat 6
- Cat 7

Density
- 12 Ports loaded (Wall Mount)
- 24 Ports loaded (1U)
- 48 Ports loaded (2U)
- 16 Ports unloaded (With dust shuttle)
- 24 Ports unloaded (With dust shuttle)



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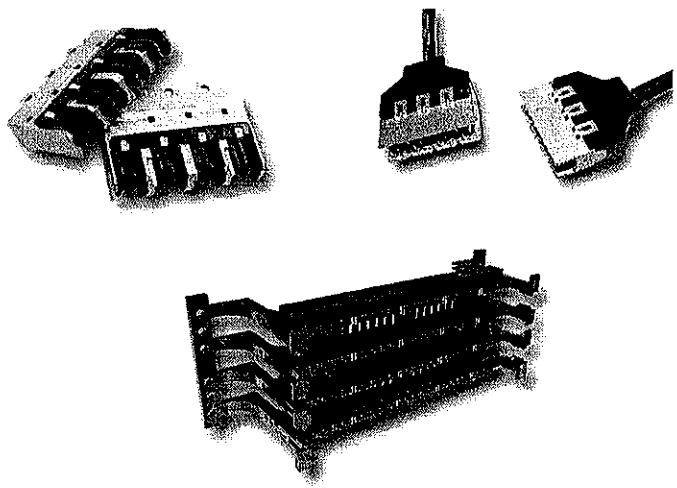
AMP Netconnect 610 XC System



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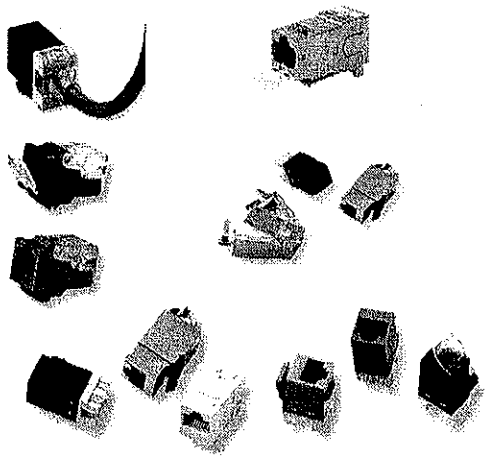
AMP Netconnect
110 IDC Jacks

Type
- Unshielded
- Shielded

Category
- Cat 3,
- Cat 5,
- Cat 5e,
- Cat 6

Design
- 110 Punch down
- Slim Line Series
- Toolless



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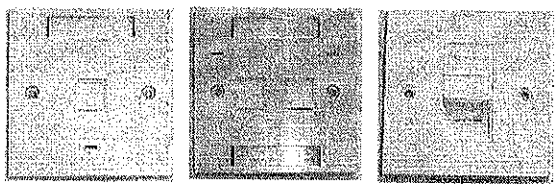
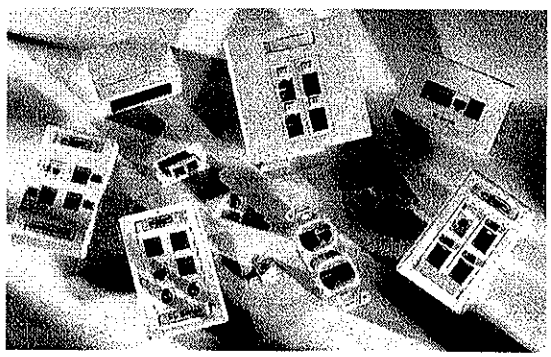
AMP Netconnect
Faceplates

UK Version



US Version



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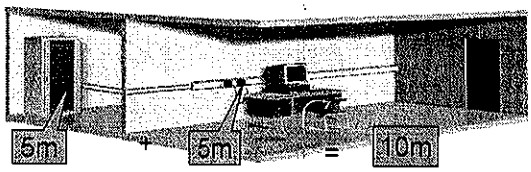
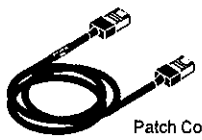
ANSI/TIA/EIA 568-B.1

Patch Cord Length Requirements

Patch Cord lengths are now 5m max in the TR and the work area to maintain a maximum patch cord overall length of 10m in the channel.





Patch Cords

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AMP Netconnect Copper Patch Cords



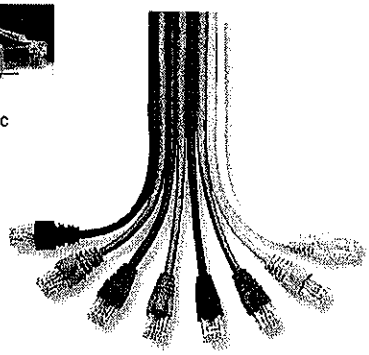
Unshielded Plug



Shielded Plug



Amptrac

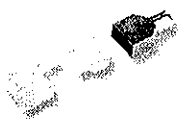




High Performance Plug

Type
- Unshielded
- Shielded
- Amptrac

Category
- Cat 3
- Cat 5
- Cat 5e
- Cat 6
- Cat 7



Cat 6 Plug

Various Color
Different Length



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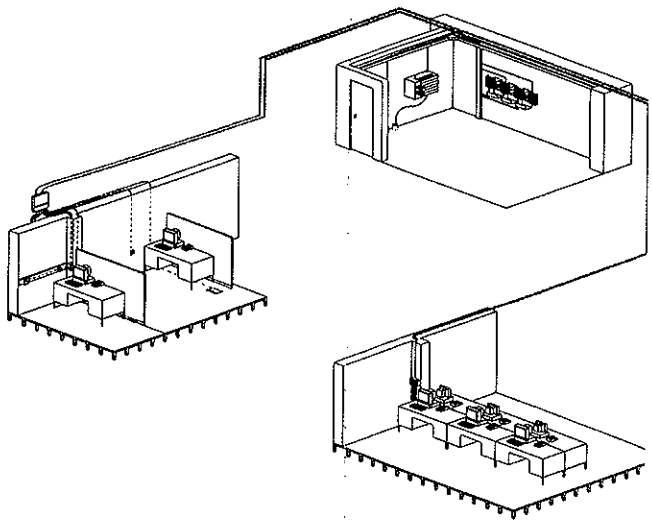
Zone / Open Office Cabling



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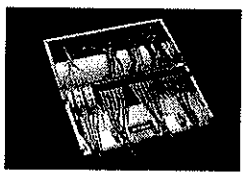
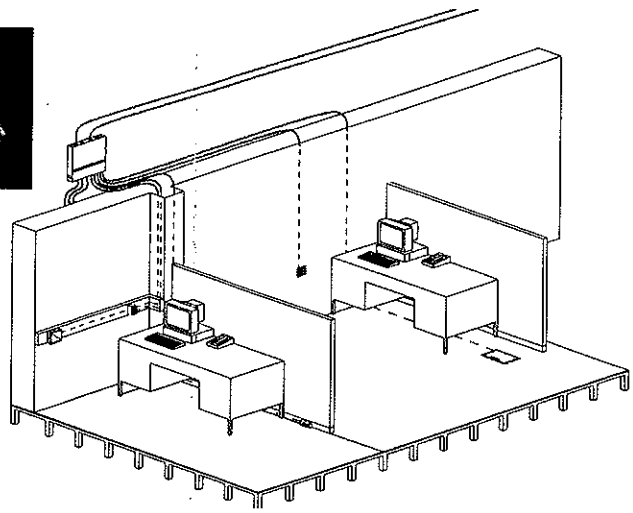
Zone / Open Office Cabling





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Zone / Open Office Cabling



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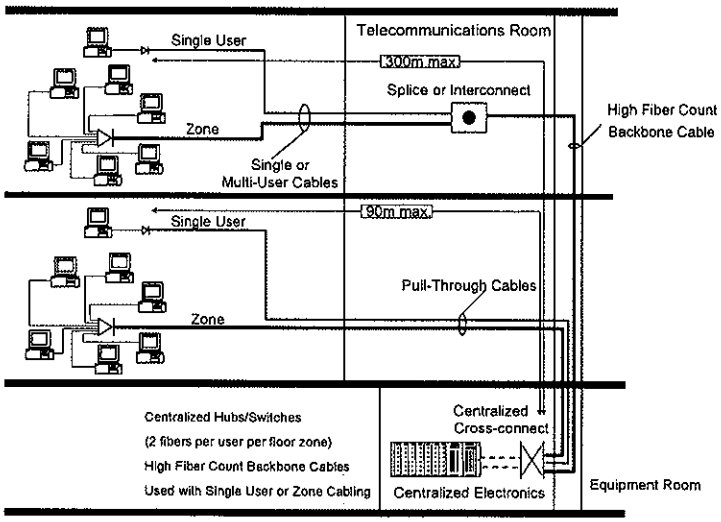
ANSI/TIA/EIA 568-B.1 - Centralised Optical Cabling



CNA Network Diagram

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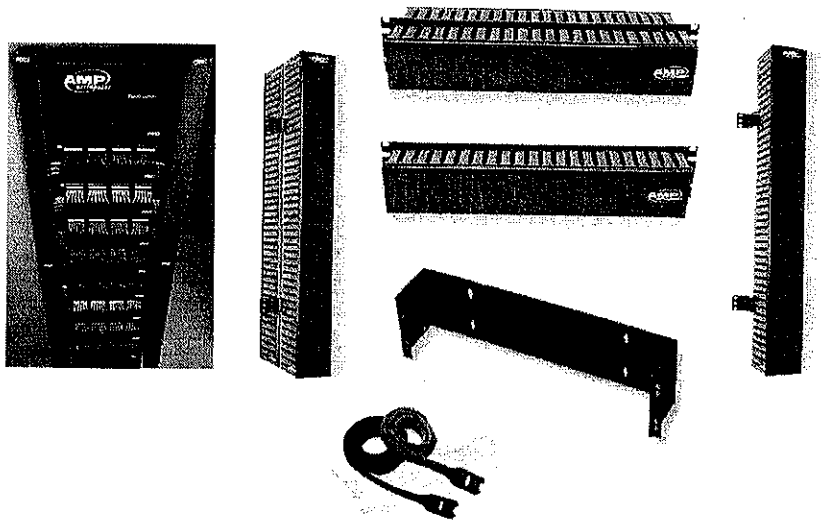
AMP Netconnect
Cable Management Products



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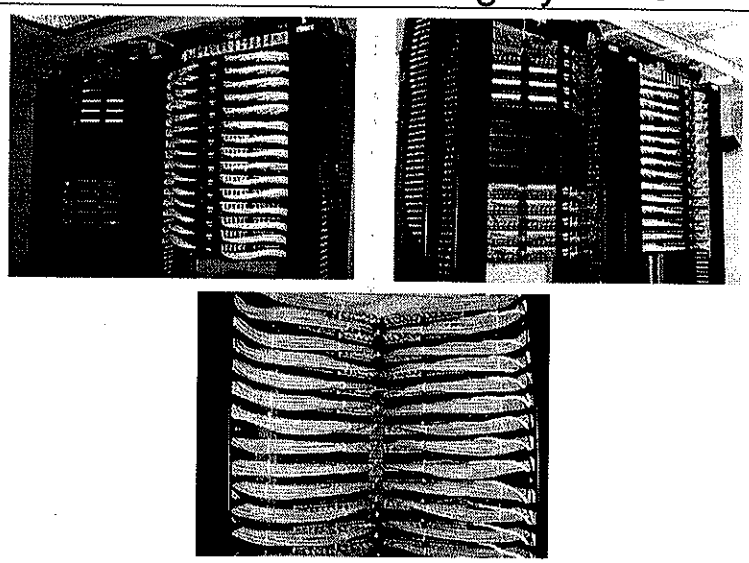
AMP Netconnect
STRUCTURED Cabling Systems



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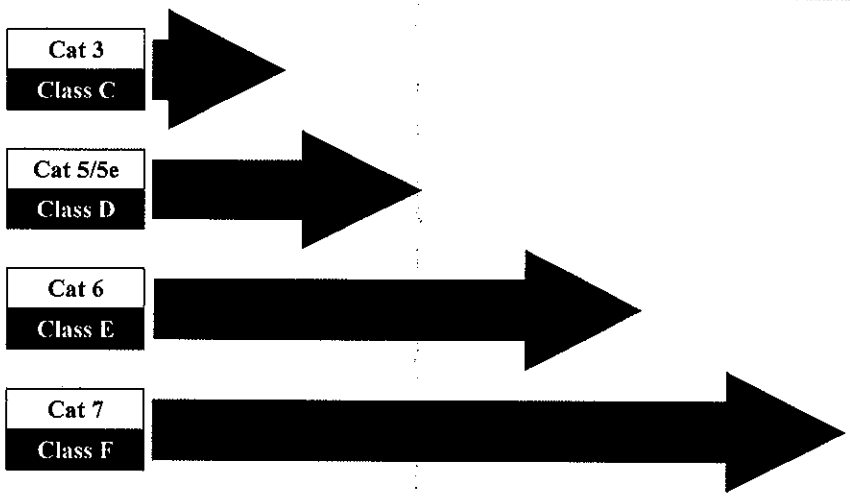
The Different Classes \ Categories (Bandwidth)



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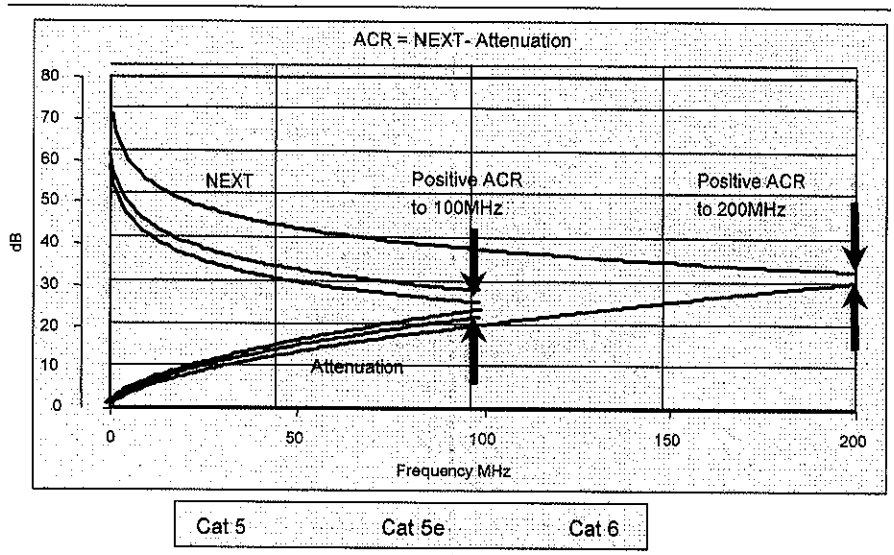
Bandwidth Performance



Cat 5 Cat 5e Cat 6

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Infrastructure Options

Media Type	Cat 5e	Cat 6	Cat 7	MM FO	SM FO	Wireless
Bandwidth	100 MHz	250 MHz	600 MHz	Mega Hz@Km	Tera Hz@Km	11/54 MHz
Applications						
10 Base-T Ethernet	Yes	Yes	Yes	Yes	Yes	Yes (shared)
Fast Ethernet	Yes	Yes	Yes	Yes	Yes	Yes (shared)
Gigabit Ethernet	Yes	Yes	Yes	Yes	Yes	
10 Gigabit Ethernet		Yes (shielded)	Yes	Yes	Yes	
155 Mbps ATM	Yes	Yes	Yes	Yes	Yes	
622 Mbps ATM				Yes	Yes	
1.2 Gbps ATM				Yes	Yes	

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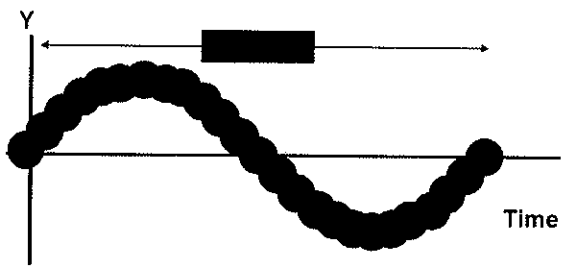
Bandwidth - Hertz

- The frequency range across which components and systems are specified in cycles per second.
- 1 cycle per second = 1 hertz (Hz)



One cycle

- 1,000,000 cycles per second = 1 MHz

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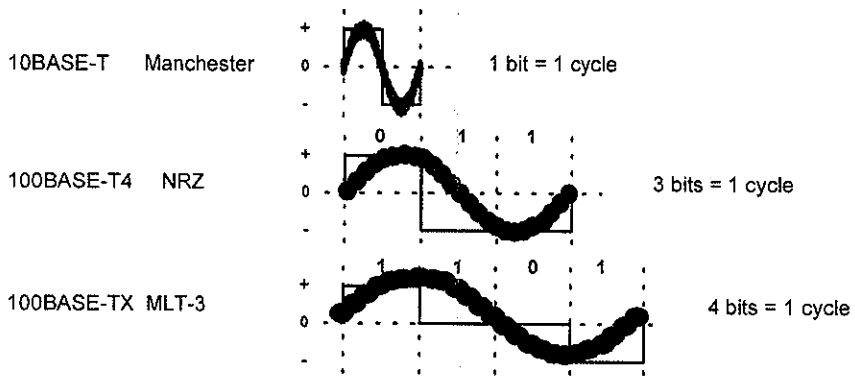
Data Rate - Bits per sec

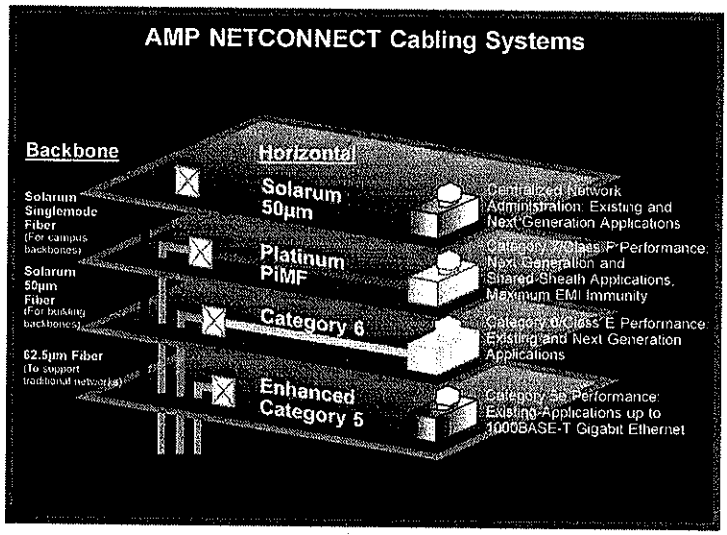
- The number of 'bits' (binary digits) transmitted per second.
- Dependent on the standard coding scheme for the application
- 1,000,000 bits per second = 1 Mbps



Coding - Summary

LAN	Bit	Byte
10 Base-X	Manchester	
100 Base-TX	MLT-3	4B5B
100 Base-T4	NRZ	8B6T
100 Base FX	NRZI	4B5B
1000 Base-T	PAM-5	4D/PAM-5
Token Ring	Differential Manchester	
100 VG-AnyLAN	NRZ	5B6B
TP/PMD	MLT-3	4B5B
FDDI	NRZI	4B5B

NETCONNECT Systems Overview



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AMP NETCONNECT

- **Complete end-to-end cabling and connectivity systems**
  - Copper Cabling Systems
  - Fiber Optic Systems
  - Premises cabling, components, connecting hardware, systems and services
  - Designed and manufactured by a single-source
  - Recognized in the industry for dependability and engineering excellence
- **One of the only Manufacturers that can provide complete end-to-end Copper and Fiber Optic Systems**

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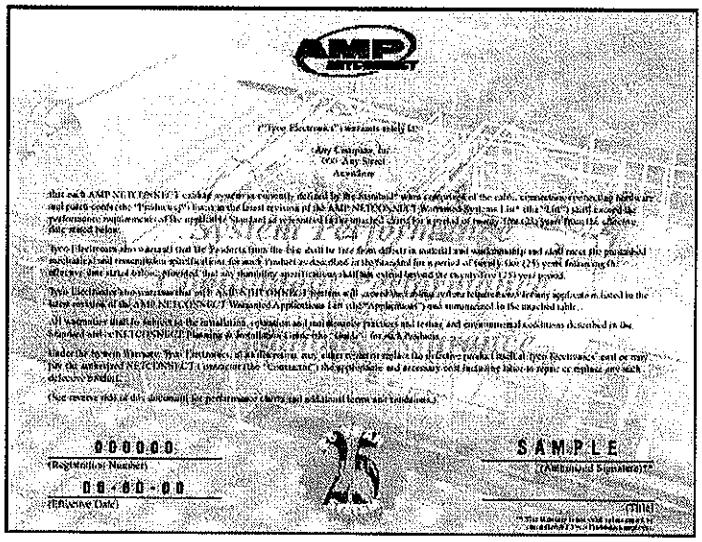
Performance Warranties



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Questions to Clarify the need For a Cabling System

- What type of cabling system do you have currently?
- What's the brand of your current cabling system?
- Who is your current cabling contractor?
- Are you working with a consulting engineer or architect for the design of your new cabling system? If not we can assist you with the design of your network?
- Are you aware that we can provide a complete end-to-end, copper or fiber optic structured cabling system along with cabling management capabililties?
- Did you know that we can also provide a 25 Year System Performance warranty? What are your warranty requirements?
- We can be your single source for all of these systems saving you from having to deal with multiple vendors and contractors.
- Would you be interested in learning more about other AMP NETCONNECT system solution?

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AMP Netconnect Cabling Solutions

To jump, click on desired Topic

- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
- AMPTRAC Cabling Management System
- EtherSeal Cabling System
- Residential Cabling System
- The END

Else, follow agenda sequence...

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What is the hottest cabling topic now ?

- 10GBase-T Cabling System
- IEEE 802.3an – 10 Gigabit Ethernet over balanced twisted pair structured cabling system
  - Draft Standard 2.3 (Final by July 2006)
  - Performance
  - AMP Netconnect XG Copper Cabling solutions

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10GBase-T Cabling Overview

- 10GBASE-T signaling requires four pairs of balanced cabling, as specified in ISO/IEC 11801:2002 with appropriate augmentation as specified in 55.7.
- It is recommended that the guidelines (proposed) in ANSI/TIA TSB 155 and ANSI/TIA 568-B.2-10 and ISO/IEC 11801 Edition 2.1 be considered before the installation of 10GBASE-T equipment for any cabling system.

IEEE 802.3an Objectives

- Support full duplex operation only
- Support star-wired local area networks using point-to-point links and structured cabling topologies
- Support a speed of 10.000 Gb/s at the MAC/PLS service interface
- Support copper medium from ISO/IEC 11801:2002, with appropriate augmentation as specified in 55.7
- Support operation over 4-connector structured 4-pair, twisted copper cabling for all supported distances and Classes
- Define a single 10 Gb/s PHY that would support links of up to 100 m on four pair balanced copper cabling as specified in 55.7
- Preserve the 802.3/Ethernet frame format at the MAC client service interface
- Preserve minimum and maximum frame size of the current 802.3 Standard
- Support Auto-Negotiation (Clause 28)
- Meet CISPR/FCC Class A EMC requirements
- Support a BER of less than or equal to 10-12 on all supported distances and Classes

10G Standard Activities - TIA TR42.7

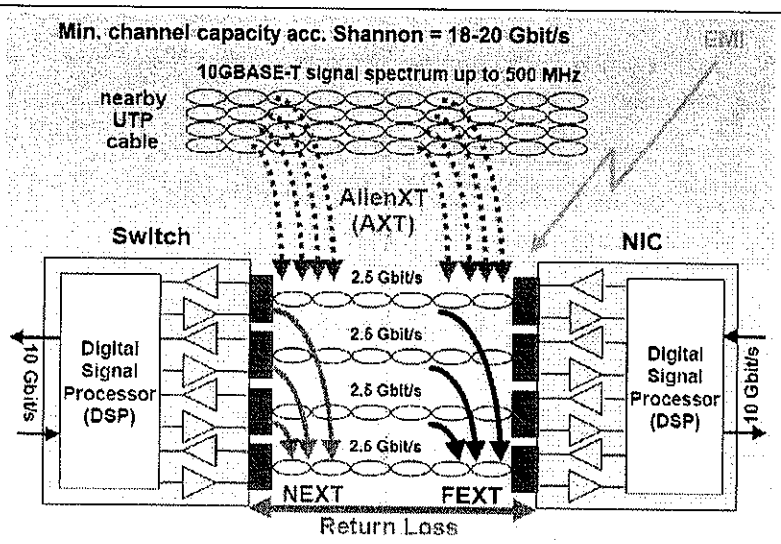
- B-2-10 Addendum on Augmented Category 6 (Cat 6A)
  - New Installations
  - 10 GbE operation over 100-meter, 4-connector channels
  - Specifications for twisted pair (shielded and unshielded)
- TSB-155 on Installed Base for 10GBASE-T
  - Legacy Cabling
  - 10 GbE operation on 55 meters of installed 568-B.1 category 6
  - Field testing requirements
  - ANEXT Mitigation techniques
- B-2-11 Addendum on Cable Outside Diameter
  - Outside diameter for cable is 9 mm (0.354").

10G Standard Activities - ISO 11801

NWIP in ISO is approved (Jan. 2005)

- In 2007 the standard will define
  - a "New Cat6" to a frequency of 500 MHz
  - A "New Cat7" up to 1 GHz
  - Channel IL for Cat6 will be raised to Cat7 limit
  - All other channel parameters will be extrapolated up to 500 MHz
  - New parameter : Alien Crosstalk !!!
  - Connecting Hardware limits still to be defined

10GBase-T Technology



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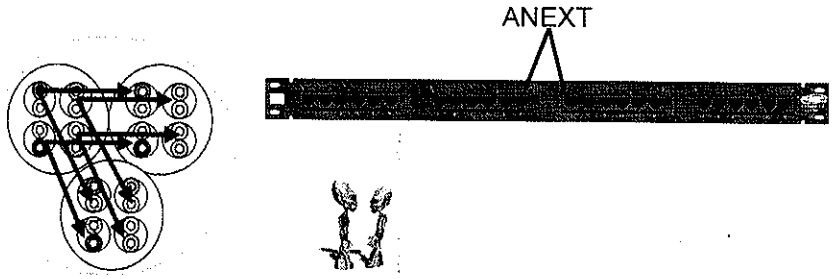
Alien NEXT

- Crosstalk between bundled adjacent 4-Pair cables and patch cords
- Crosstalk between adjacent patch panel ports



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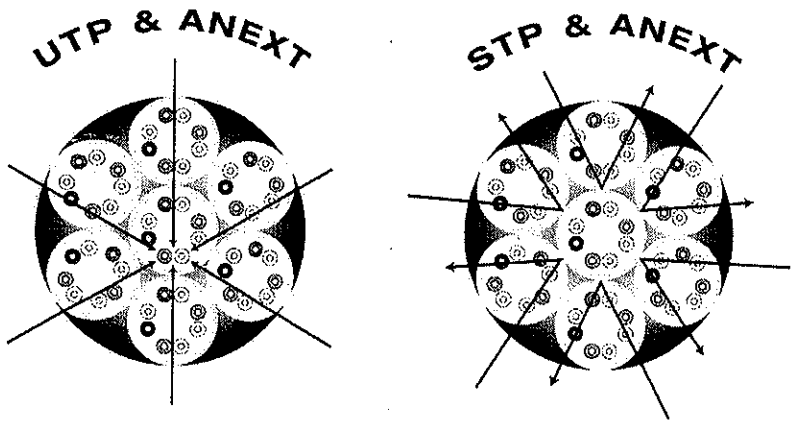
Alien NEXT



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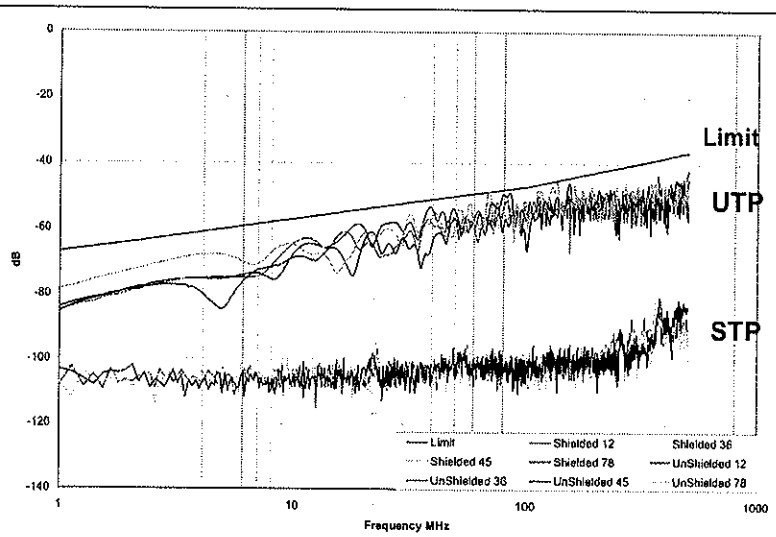
ANEXT Comparisons



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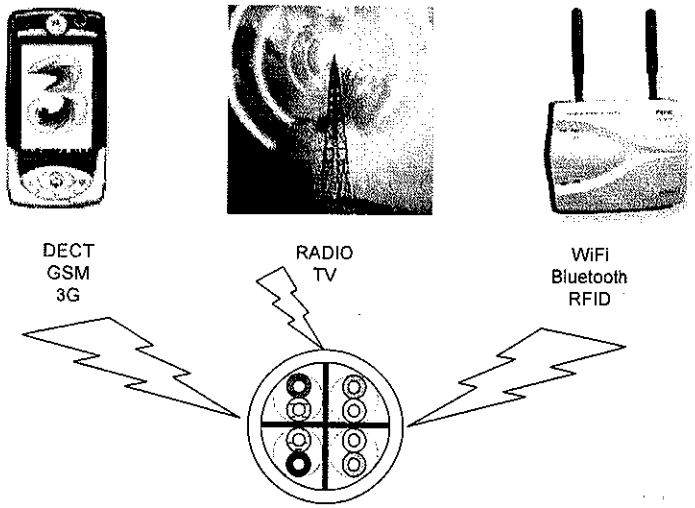
Background Noise



Background Noise shall be less than -150 dBm/Hz

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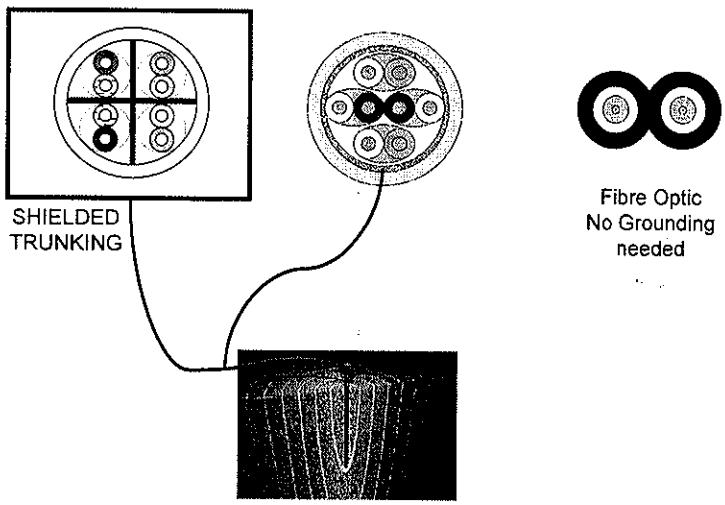
Background noise protection



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10GBASE-T : Applications

Application	10 GBase-F Fibre (IEEE-802.3ae)	10 GBase-T (IEEE-802.3an)	10GBase-CX4 (IEEE-802.3ak)
Data Center Server Clustering	Yes	Yes	Yes (< 15 m)
Horizontal In building incl. wiring closet	No	Yes	
Vertical Risers / BB links within building	Yes	No	
Campus & Metro	Yes	No	

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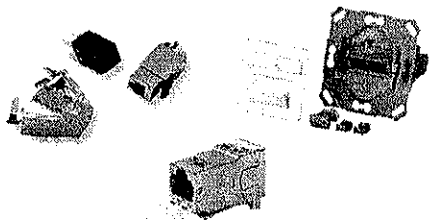
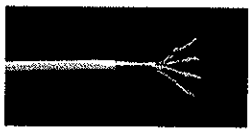
AMP NETCONNECT XG STP System

- Components:
  - 24Port Shielded Category 6 Panel
    - PCB-Design or discrete jacks
    - AMPTRAC-ready
  - AMP-TWIST, DIN outlet, category 6
  - Category 6 SL Jack
  - 600 MHz PiMF cable
  - PiMF patch cords







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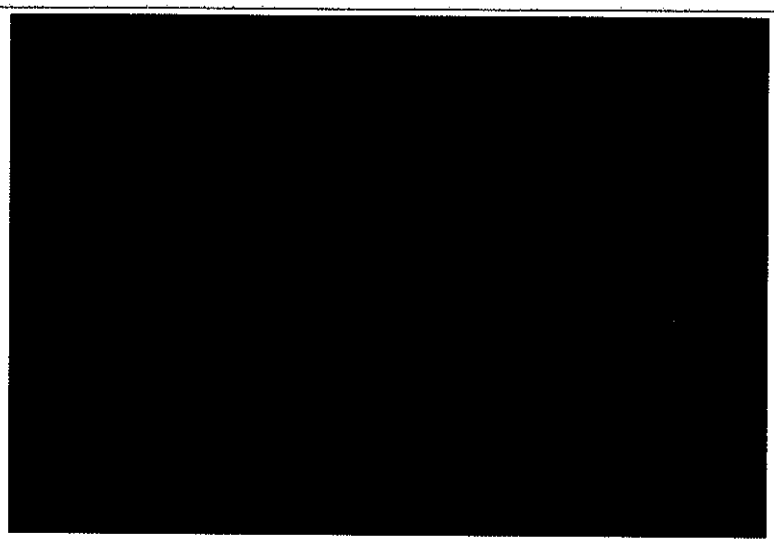
AMP NETCONNECT XG Systems



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AMP Netconnect Cabling Solutions

To jump, click on desired Topic

- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
- AMPTRAC Cabling Management System
- EtherSeal Cabling System
- Residential Cabling System
- The END

Else, follow agenda sequence...

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Data Center

What is a Data Center ?

- "Hardened" facility, dedicated to provide uninterrupted service to mission-critical data processing operations.
- Nerve Centers of the new economy
- Centralize and Consolidate Information Technology (IT) Resources
- A very important resource that enable Organizations to conduct business round-the-clock and around the world

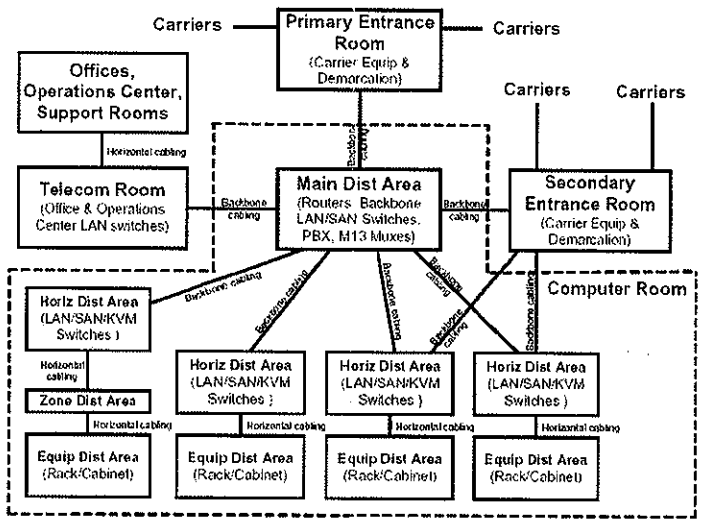
Types of Data Center

- Private Data Centers
  - Owned and operated by private corporations, institutions or government agencies
  - Purpose of supporting data processing and web oriented services for their own organizations.
  - Maintenance are performed by in-house IT departments
- Internet Data Centers
  - Owned and operated by Telcos, service providers & commercial operators
  - Purpose to provide outsourced information technology (IT) services, accessed through Internet connectivity. Like wide-area communications, Internet access, web or application hosting, collocation, managed servers and storage networks.

Data Center Standard

- TIA-942
  - "Telecommunications Infrastructure Standards for Data Centers"
- The Purpose
  - Provides requirements and guidelines for the design and installation of a data center telecommunications infrastructure
  - Establish a standard for data center tiers to replace proprietary standards
- The Scope
  - Specifies the minimum requirements for telecommunications cabling, pathways and spaces of data centers including single tenant enterprise data centers and multi tenant internet data centers

Data Center Topology



Data Center Cabling Media

Recognized cabling media per the standard

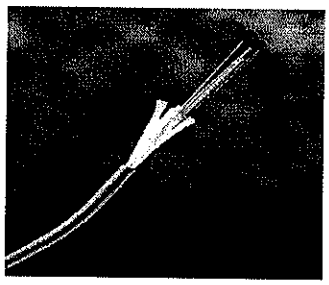
- 4pair UTP, Cat 5E, Cat 6 and Cat6A ?
- 4pair ScTP, Cat 5E, Cat 6 and Cat 7
- 75 Ohm coaxial cable, two per circuit
  - Types 734 and
  - 735 (E-1/E-3/DS-3)
- Multimode fiber,
  - 62.5/125 (OM1),
  - 50/125 (OM2)
  - 850-nm LO 50/125µm recommended (OM3)
- Singlemode fiber

Data Center Cabling Infrastructure

- Choices between fiber or copper or both depend on variety of criteria
  - Bandwidth and performance
  - Immunity-to-Electromagnetic Interference (EMI)
  - Need for density and space saving connectivity
  - Flexibility and speed of reconfiguration
  - Device media interface considerations
  - Standardization
  - Future vision and tolerance for re-cabling

Cabling infrastructure – Optical Fiber

- Advantages
  - Greater Bandwidth and error free transmission
  - Optical DC solutions are designed for simple and easy handling and installation
  - Easier to test
  - Immune to EMI/RFI
  - High Density – maximize space
  - Provides future vision



Cabling infrastructure – Optical Fiber

Optical Fiber

- In Traditional DC solution, Fiber being used in Backbone and Copper to connect the server
- New trend is to take fiber near to the end devices like servers due to
  - Multimode supporting up to 10Gbps
  - Free space
  - Flexible patching
  - Easy Growth
- Fiber over copper is no longer a cost consideration due to error free transmission, headroom and performance criteria.

Cabling infrastructure – Copper

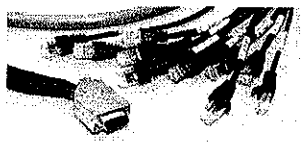
- High Performance copper cabling solutions are capable of supporting higher bandwidth and applications
- System performance – copper distribution system with components designed to work together and provide error free transmission.

The MRJ21 Solution

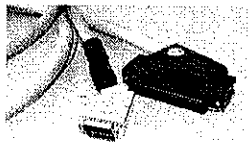
- MRJ21 – high density, gigabit solution
- Tested and verified : BER testing to IEEE802.3z, DTE Power to IEEE 802.3af
- Handles 10/100/1000BASE-T applications
- Savings on
  - Labour
  - Space
  - Time
  - Maintenance

MRJ21 Products

- MRJ 21* to 4pr Modular connectors (RJ45)
  - 6 4pr (10/100/1000BASE-T) or 12 2pr (10/100BASE-T) Breakouts
  - Used primarily for test labs and static environments



- MRJ 21* to RJ21 (25-pr. Telco connector)
  - Used primarily to transition to legacy equipment or panels (NB: legacy RJ21 patch panels were 2-pr applications)



- MRJ 21 to MRJ 21*
  - Highest density, most-efficient option when matched with application breakout panels.
  - Not application specific – provides powersum throughput



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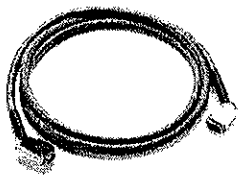
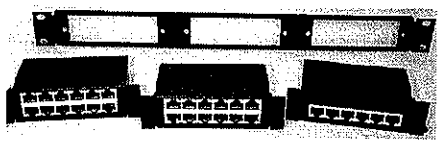
MRJ21 Products

- Cable assemblies:
  - MRJ 21 Connector System common volume sizes
  - Customs as necessary
  - PVC & Plenum



- Application specific cassettes
  - 2-pair or 4-pair
  - Straight 3-port panel
  - Manages 3 cassettes



- 1u angled panel
  - 48 10/100 ports
  - 48 10/100/1000 ports
  - AMPTRAC Versions available



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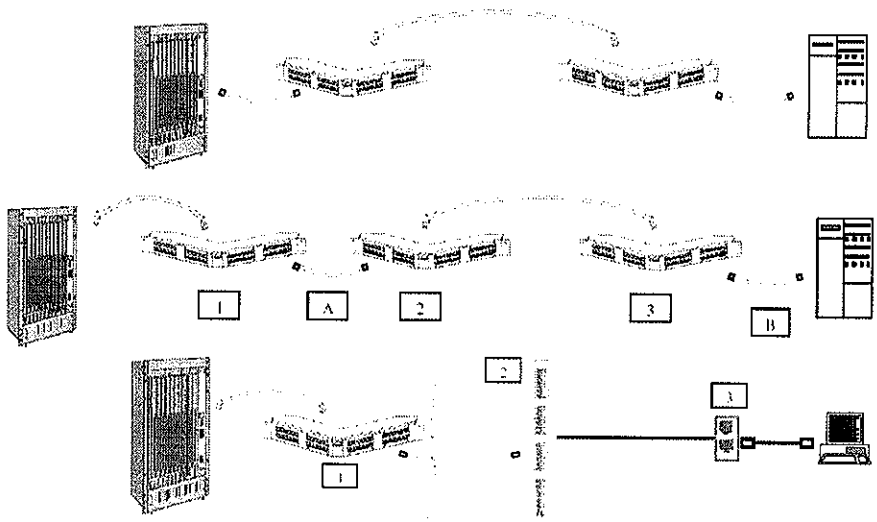
Applicable Configurations



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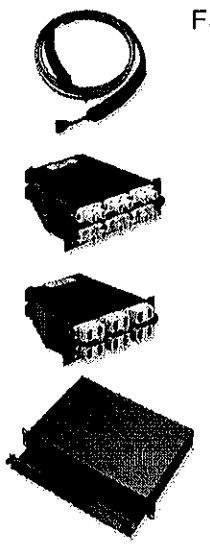
High Density Fiber Solution



Fully-modular fiber optic solution - MPO

Reduces fiber installation time from weeks to a weekend

- Reduces total installed cost
  - Labor trade-off factory vs. craft
- Enables DC availability sooner
  - Revenue production or cost reduction
- Factory-terminated and tested high fiber count cable assemblies.
  - Up to 144 fibers per cable (12x12)
  - All versions of singlemode and multimode fiber optics available
- Uses high-density 12-fiber connector
- Termination of 12-fibers as fast as plugging in a connector
- Cassettes break-out fibers into standard MT-RJ, SC, ST and LC connectors
- Cassettes snap into full variety of panels and enclosures

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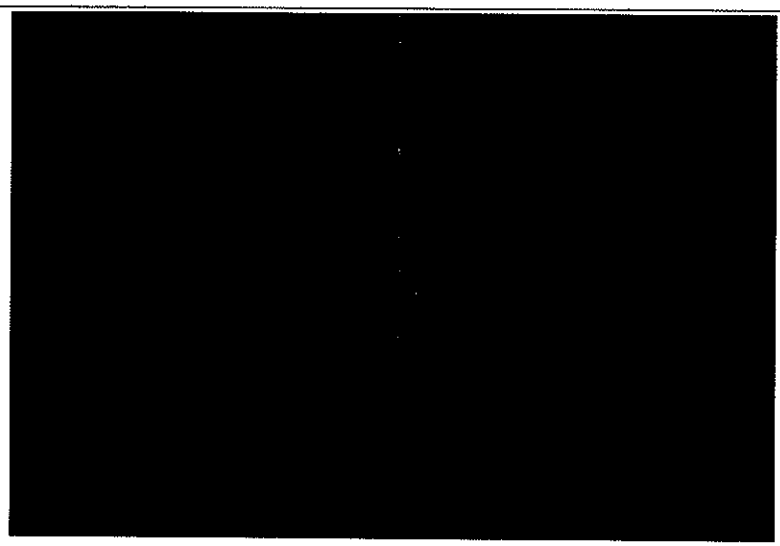
AMP Netconnect Data Center Solutions



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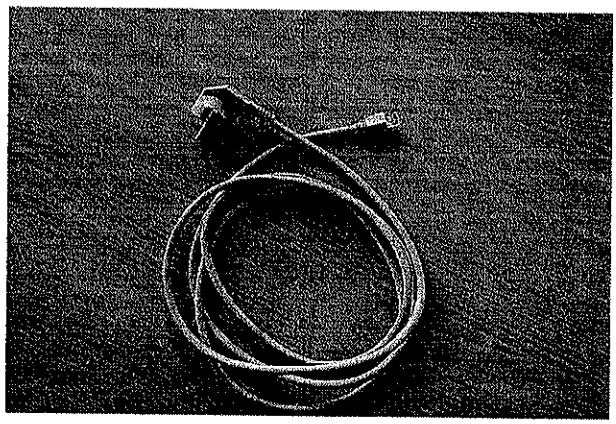
Power over Ethernet (PoE)



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What is Power over Ethernet (PoE) ?

A technology that deliver 48 volts DC power along with Ethernet data on 4 pair balanced or twisted pair cable

- UTP
- STP

Implications of PoE

- RJ-45 connector becomes a universal connector
  - Data
  - Power

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Why use PoE?

- Market drivers
  - Rapid adoption of VoIP
  - Increased security cameras deployment
  - Increased WiFi installations / HotSpots
  - Building Automation System remote controllers
- Lower cost
  - No requirement for AC outlet at each device location
  - No need to run a/c power wires
  - Maximize existing IT infrastructure investment
- Centralized power backup for remote devices with one uninterruptible power supply (UPS) during mains failure possible
- Safer – Keep away from danger posed by AC mains
- SNMP control of remote powered devices possible

The Standard – IEEE 802.3af

- 802.3af - Data Terminal Equipment (DTE) via Media Dependent Interface (MDI)
  - Approved for publication June 2003
  - Supports familiar technologies
    - Twister pair and RJ-45 connectors
    - Ethernet
- DC POWER and DATA on UTP & ScTP
  - 350 mA; 48 Vdc; 15 W
  - DC current is delivered in common mode on two pairs
- Only delivers power to devices that identify themselves as power devices
  - The "not blow things up" objective
  - Detection precedes any power application
  - Powers down when device disconnected

The Cabling Standard - TIA

Ongoing Work

- 568-B.1 Addendum 6 (DC Power) is out for third industry ballot
  - "Commercial Building Telecommunication Cabling Standard. Part 1: General Requirements. Addendum 6: Additional Cabling Guidelines for DC Power"
  - Supports power-over-structured-cabling applications like DTE (IEEE)

The Standards: IEEE and TIA

Cabling Challenges...

- Power results in heat generation
- Excessive heat may affect insertion loss
- Follow Standard Installation Practices
  - Comply with Standard Fill Ratios
  - Avoid Tight Bundling
- Ensures support of IEEE 802.3af

PSEs and PDs

PSE: Power Source Equipment
- A device capable of supplying power over Ethernet
  - Powered switches
  - Mid-span Power Supplies
  - Power Injectors
- Typically located at the wiring closet in the TR

PD: Powered Device
- End devices that receives and utilizes PoE type power
  - VoIP phones
  - WAPs
  - Security cameras
  - Clocks
  - Building automation controllers
- Typically located in the user application area

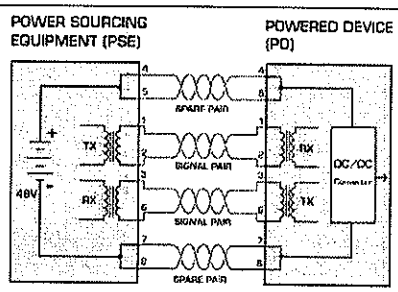
PoE Technology

Two ways to apply the power
- End span (switch)
  - IEEE defines 10/100/1000
- Midspan
  - IEEE defines 10/100

How is power supplied?

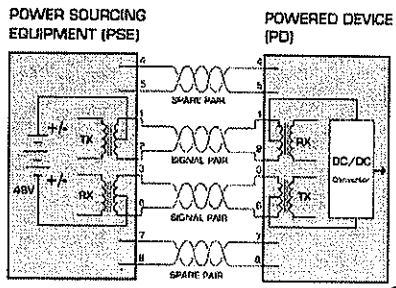
Mode B

Via Spare Pairs
(Pins 4-5 and 7-8)



Mode A

Via Data Pairs
(Pins 3-6 and 1-2)



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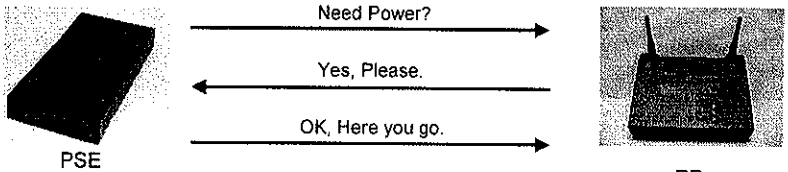
How PoE Works ?

Upon connection of <u>any</u> device, PSE will determine if device is PD or not

Ensures non-PoE compliant equipment is <u>not</u> given power



PSE
Power Sourcing Equipment

PD
Power Device

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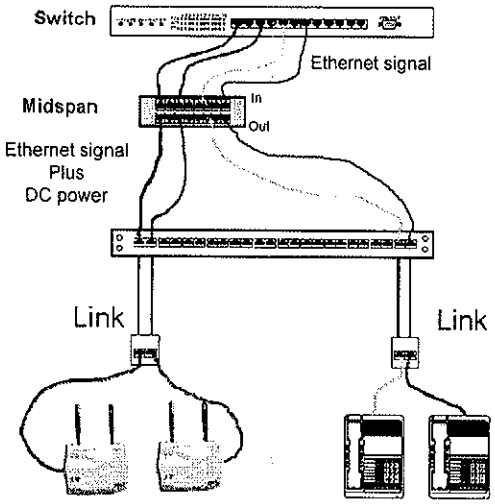
PoE Midspan Implementation



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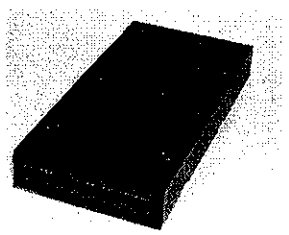
AMP NETCONNECT 8-Port Midspan

- 8-port module offers
  - 8-port standalone capability
    - Modular
  - 8, 16 or 24 ports in a 1U 19" frame
    - Add as you need
- Fully IEEE 802.3af compliant
- Unique features
  - Full Power on every port, even when fully loaded
  - 10/100/1000 MBit/s Ethernet in a midspan
- NETCONNECT warranty
  - except Fan/Power Supply (2 years)





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AMP NETCONNECT 8-Port Midspan

Compliance:	Fully compliant with 802.3af
No. of Ports:	8 LAN (input) and 8 powered (output) ports
Physical configuration:	Stand-alone or up to three in a rack-mount 1U panel
Per Port Data Rates:	10/100/1000 Mbps
Disconnect Method:	Supports both genuine AC impedance and DC current sensing
Output Voltage:	-48 V dc
Ethernet Pin Assignment:	Mid-span assignment: Pin 4/5 = +Rail: Pins 7/8 = -Rail
Output Power:	15.4 W each (non-power managed)
Additional features:	Additional port resetable fuses for extra protection over normal overload or short-circuit 802.af conditions
Total Power:	125 W Total (8 ports)
Input Power AC:	Input Voltage: 90 to 264 V ac
AC Frequency:	47 to 63 Hz
AC Input current:	2.2 Amps @ 110 V ac / 1 Amp @ 240 Vac
Hold up time:	22ms at all input voltages
Cut-out:	PSU thermal overload protection
PSU fuse (internal):	3.15 Amps
Power Factor correction:	Active PFC meets EN61000-3-2
Isolation:	3000VAC Io output / 1500 VAC to earth
Dimensions:	(H) 1.6 in. X (W) 5.6 in. X (D) 11in. (H) 4 cm X (W) 14.2 cm X (D) 28 cm
Weight:	1.5 Kg / 3.3 Lbs
MTBF:	> 200,000 hours at 30°C
User Indicator:	Each port has a green LED indicating power to user port Green LED indicates AC power available
Connectors:	Shielded RJ-45, mains IEC 3 pin DIN
Environmental:	Operating Ambient Temperature: 0 to 40 °C
Operating Humidity:	Maximum 90%, non-condensing
Storage Temperature:	-20 ° to 70 °C
Storage Humidity:	Maximum 95%, non-condensing
Operating Altitude:	-1000 to 10,000 ft. (-300 to 3000 m)
Overall Typical Efficiency:	80% @ full load
Regulatory Compliance:	CE
Electromagnetic:	FCC Part 15 Class B with FTP cabling Emission & immunity EN55022 (CISPR 22) class B with FTP EN55024 (CISPR 24)
AC input:	UL/cUL Per EN60950
Safety Approval:	GS Mark Per EN60950

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Why Midspan PoE?

- Independence from switch manufacturers
  - Customer can choose switches without looking at only those switch vendors offering PoE capability
- No additional external power supplies at the switches
- No heat generation issues within the switch boxes
- Effectively manage the powered port utilization
  - No need to pay for PoE each time a new switch is purchased

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AMP Netconnect Cabling Solutions

- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
- AMPTRAC Cabling Management System
- EtherSeal Cabling System
- Residential Cabling System
- The END

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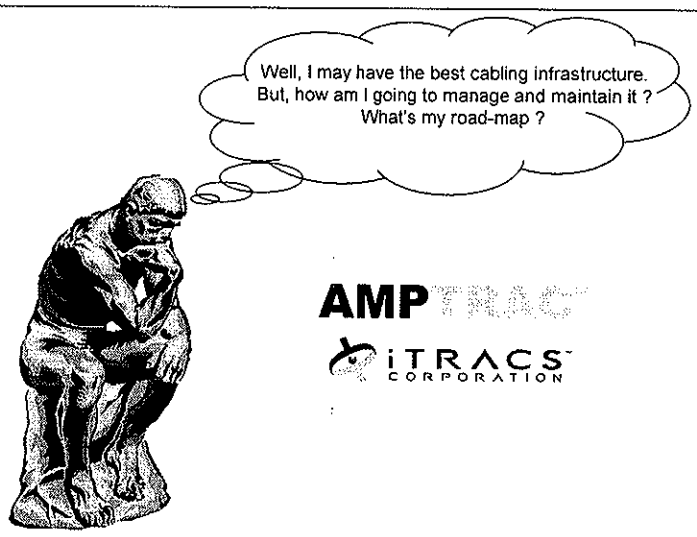
What's on your mind, Dude ?



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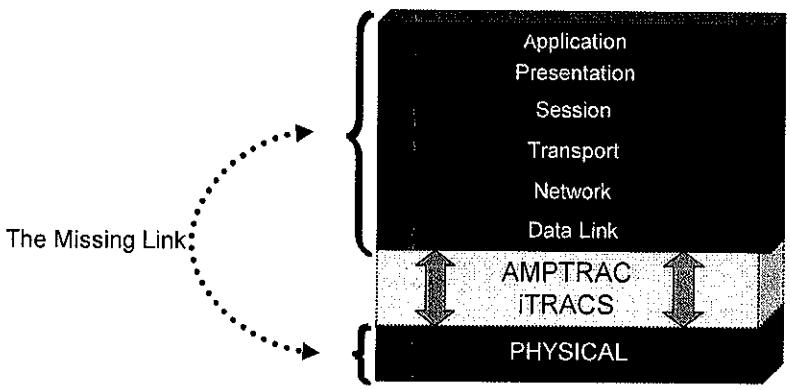
What does AMPTRAC do?

- Map and document the physical infrastructure 'end-to-end'
- Monitor all connections for real-time updates
- Discover all SNMP devices connected to the network
- Automate Work Order Process
- Extend enterprise management to 'layer-one' using existing tools and services
- Apply business policies, rules, and processes for intelligent real-time physical infrastructure management
- Log, report, alarm and alert all changes to assets and physical layer connections and disconnections

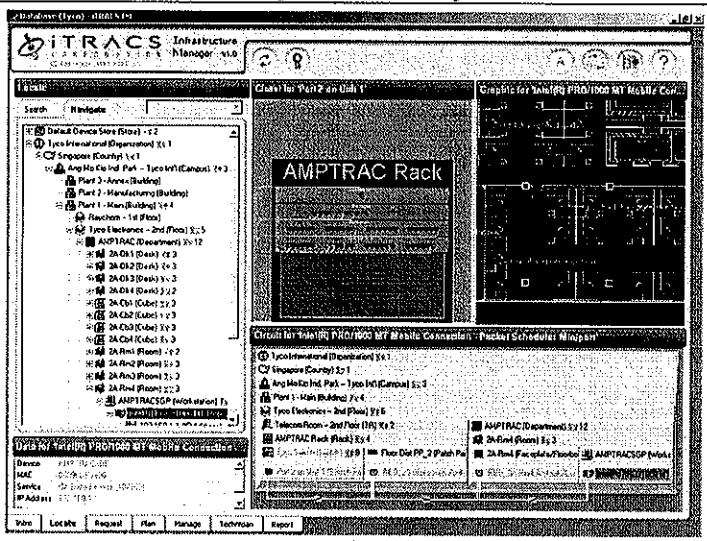
AMPTRAC Capabilities

AMPTRAC bridge the physical layer with the rest of the OSI Protocol stack



End to end infrastructure management involves all 7 layers

AMPTRAC
Cabling Management System



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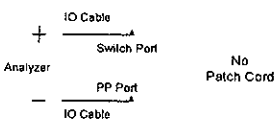
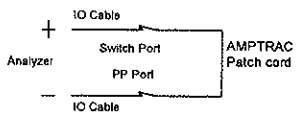
How AMPTRAC Works ?

Basic Operating Principle



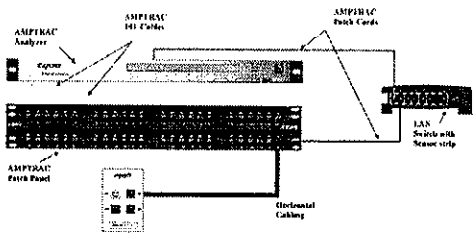
Open Circuit

- 9th wire technology in patch cord establishes open and closed circuit
- Analyzer monitors open/closed circuit and tracks connectivity
- Analyzer sends data to IM data base



Closed Circuit

AMPTRAC Hardware Diagram



AMPTRAC Hardware Connectivity in Telecommunications Closet

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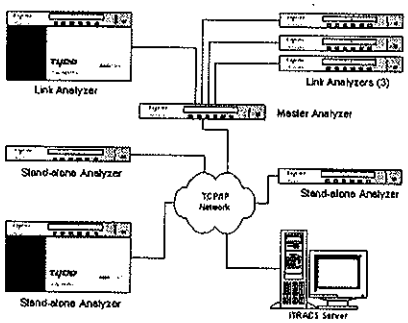
How AMPTRAC Works ?

AMPTRAC Network Diagram



- Analyzers established in telecommunications closets
- Network of analyzers is established with IM data base via existing LAN or WAN via Ethernet connection

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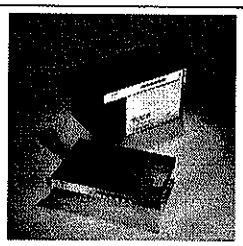
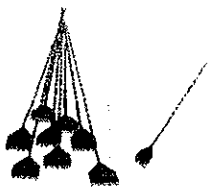
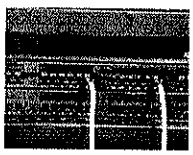
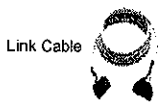
AMPTRAC components


Analyzer


Sensor Strip - Retrofit


AMPTRAC Patch Panel


Link Cable


Sensor Pen


I/O Cable


Software


Patch Cord


Serial Cable


Extension Cable

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AMPTRAC Cabling Management System Demonstrations

- Monitor all connections for real-time updates
  - Alert unplanned events via email
- Discover all SNMP devices connected to the network
  - iDiscover
- Automate Work Order Process

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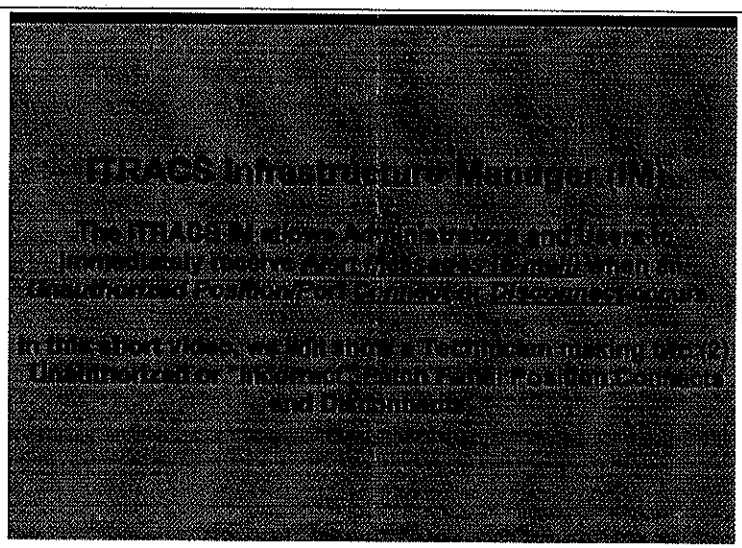
Real-time Monitoring and Update with Email Alerts Demonstrations



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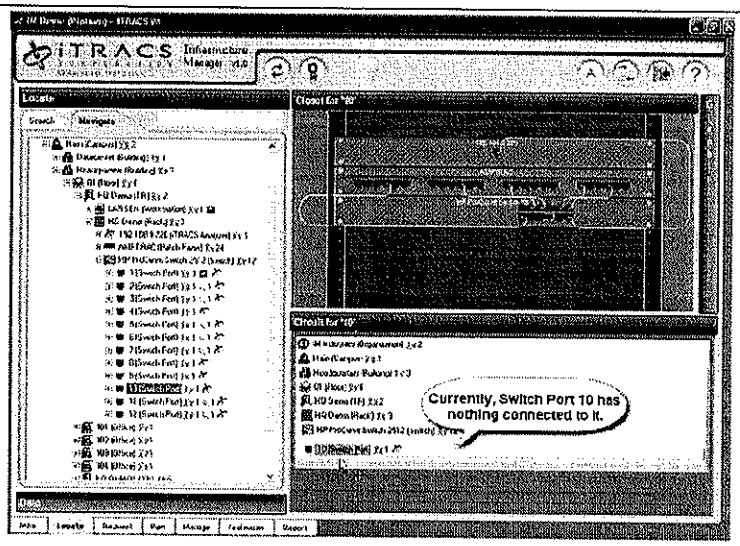
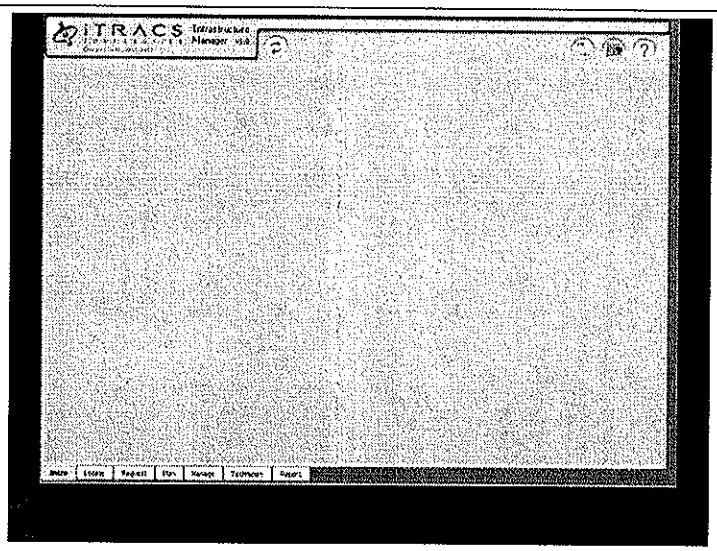
iITRACS Infrastructure Manager iDiscover Demonstrations

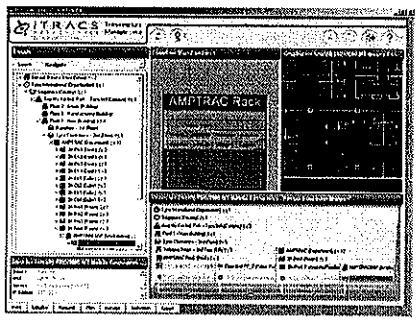


iITRACS Infrastructure Manager Automated Work Processing Demonstrations



AMPTRAC
Cabling Management System

- Accurate Network Documentation
  - Means no more...
    - 3x5 cards
    - magic marker notes on walls
    - undecipherable pencil notes on prints
    - monster spreadsheets
- Automated Work Order Process
  - Means no more...
    - post-it notes
    - laboriously typed email instructions
    - mistakes and errors
    - lack of information
    - tugging of cables to find the right one
    - pulling unnecessary new cable runs



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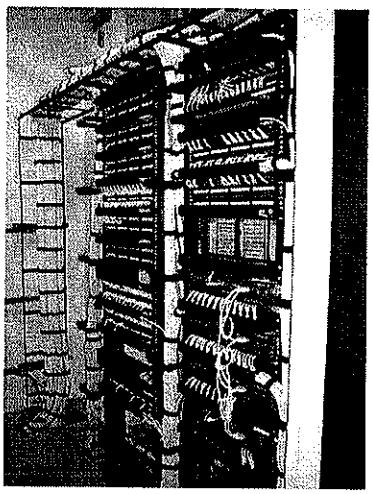
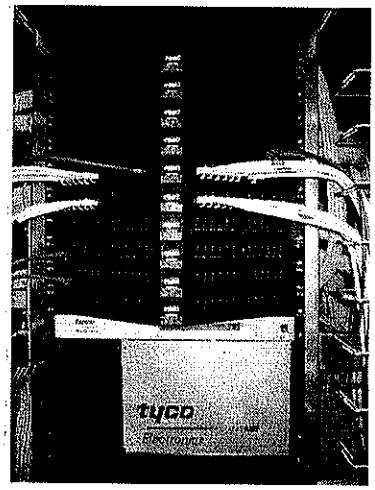
AMPTRAC
Cabling Management System





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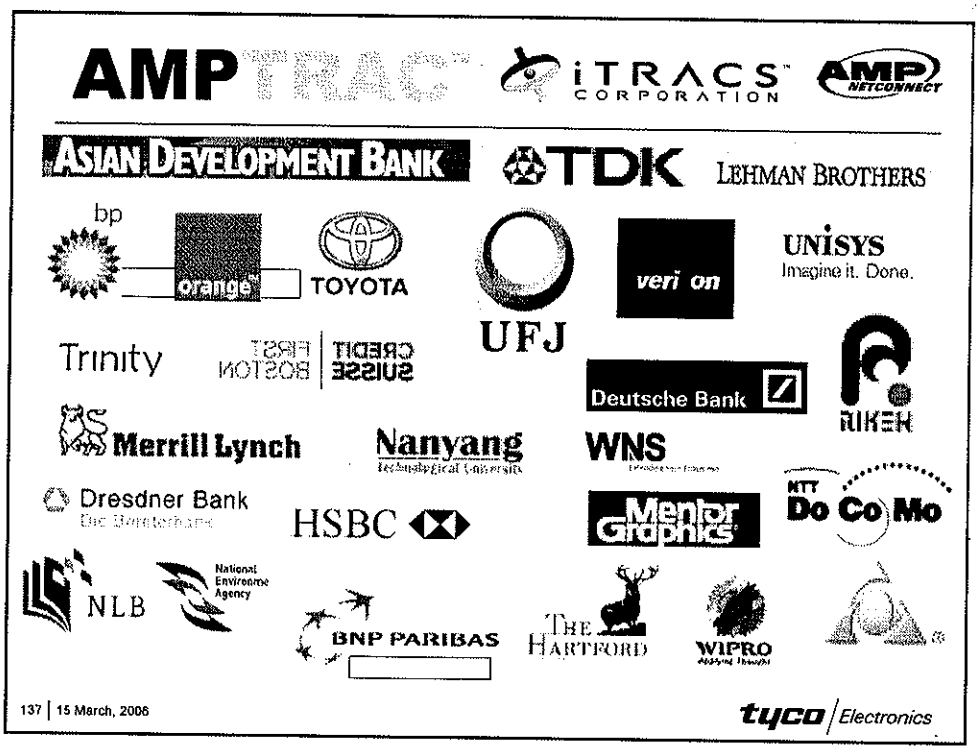

AMPTRAC Cabling Management System
What is it all about ?

AMP NETCONNECT

It's all about intelligence...

- Reduced costs thru improved productivity
- Reduced downtime
- Simplified work order process
- Improved asset utilization
- Enhanced security
- Bridge physical to logical infrastructure management

AMPTRAC iTRACS CORPORATION

138 | 15 March, 2006

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AMP Netconnect Cabling Solutions

To jump, click on desired Topic

- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
- AMPTRAC Cabling Management System
- EtherSeal Cabling System
- Residential Cabling System
- The END

Else, follow agenda sequence...

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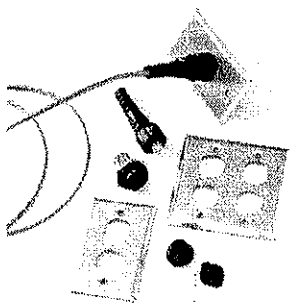
Cabling in a harsh environment ? No Problem !!!



The AMP NETCONNECT™ EtherSeal™ Connectivity System:
A Complete Cabling System for Harsh Environments with a easy latching system

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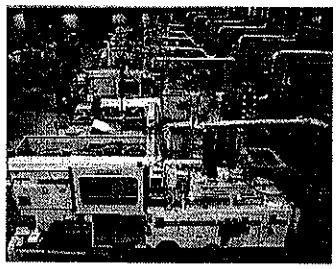
Industrial Ethernet

Running the same Ethernet network as in the front office simplifies the IT effort, but Ethernet media is designed for the office, not a harsh industrial environment.



Production Information



Ethernet is

- Inexpensive
- Universal
- Understood
- Non-propriety

Industrial Ethernet Adoption

- Fastest growing network globally
- Estimated annual node growth rate > 200%
- Compliments current Device Networks
- Will eventually migrate to the I/O level
- Major Device Networks incorporate into topology

Fieldbus	Ethernet Implementation
DeviceNet	EtherNet/IP
Modbus	Modbus TCP
PROFIBUS	PROFInet
Foundation	HSE

- OPC is establishing an application layer protocols to share information across multiple platforms

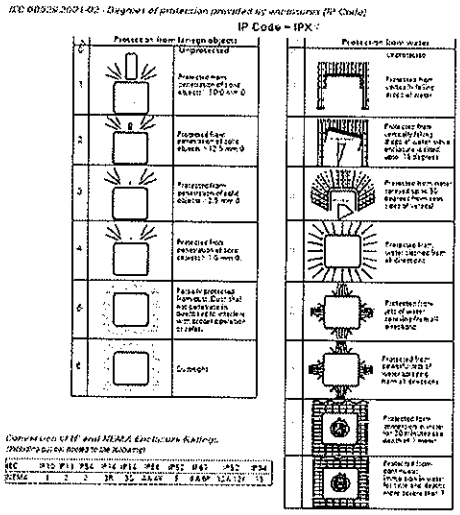
Harsh Environment – Non Factory Automation

- Ethernet is also being adopted in a number of harsh environments in addition to the factory floor
- Ethernet is utilized in any and all industries
  - Military
  - Medical
  - Instrumentation
  - Outdoor applications
  - Retail
  - Etc...

Non-Factory Automation Applications Examples

- Hospitals/Health Care
  - Health care equipment
  - Patient Rooms
  - Emergency Rooms
  - Treatment Rooms
- Outdoor Environments
  - K-12 Mobile Units
  - Outdoor Signs/Displays/Cameras
  - Outdoor Connection Points
- Want more than that flimsy latch!
  - Retail Displays
  - Conference/Convention Centers

What is IP67 ?



IP (Ingress Protection) is an International Standard used to rate protection against dust and water.

IP67 is the most requested specification for harsh environment applications

IP6#: Is totally protected from dust.

IP#7: Is protected from temporary immersion (30 minutes) for upto a depth of 1 meter.

Other Common ratings:

IP#6: Jet Spray

IP#5: Low pressure spray

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EtherSeal Connector Features and Benefits



- Product Values
  - Positive mating confirmation
  - Quick Couple/Release
  - Reduced / eliminated intermittency
  - Use high performance AMP NETCONNECT products
  - Available in 110 and Toolless termination methods
  - Shielded and Unshielded systems available
  - Ability to change EtherSeal patch cord to conventional in the field
  - Ability for jack/receptacle to mate with traditional RJ-45 plug
- Market values
  - One source for system – cable, connectors and cable assemblies
  - One source for enterprise customer needs – commercial and industrial

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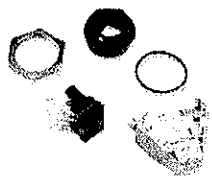
EtherSeal Cat 5e Jacks

- Front Mount design
  - Retaining hex nut mounts on backside
- 110 SL and Toolless
- UTP and FTP
- Jack Sealing Cap with tether sold separately
- Exceeds Cat 5e performance requirements
- Meets IP67 requirements

SL 110 Jack



Toolless Jack



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EtherSeal Cat 5e Plug Kits

- UTP and Shielded
- Solid and Stranded
- Flexible Strain Relief
- For use in direct connections to equipment
- Plug Sealing Cap with tether sold separately
- Exceeds Cat 5e performance requirements
- Meets IP67 requirements

UTP Plug Kit



Shielded Plug Kit



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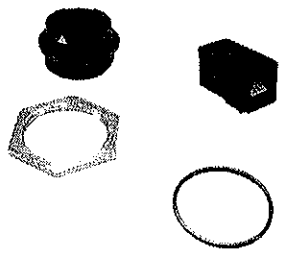
EtherSeal Cat 5e In-Line Coupler

- Front Mount
- UTP and Shielded
- For use in plug to plug connections and equipment interface
- Jack/Coupler Sealing Cap with tether sold separately
- Exceeds Cat 5e performance requirements
- Meets IP67 requirements



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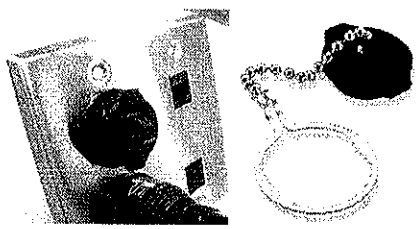
EtherSeal Connector Sealing Kits

- Comes with tether to prevent loss
- Sold separately
- Meets IP67 when installed
- Jack/Coupler/Receptacle Sealing Cap with Tether: 1479591-2
- Plug Sealing Cap with Tether: 1479592-2





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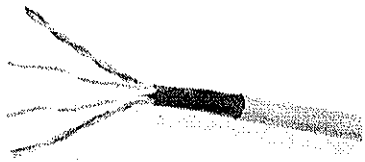
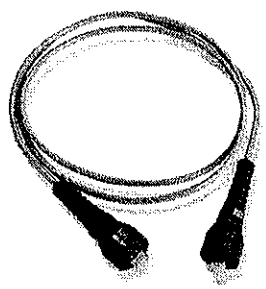
EtherSeal Cat 5e Cable

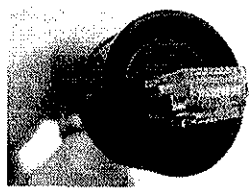
- Standard Cat 5e cable with second PVC outer jacket to provide:
  - Sun resistance
  - Oil resistance, Level II
  - Increased resistance to noise
- CMR (Riser) listing
- Diameter: 0.26 to 0.27
- Gray color, reel
- EtherSeal Cat 5e Cable:
  - Solid, UTP: 1499447
  - Stranded, UTP: 1499448
  - Solid, Shielded: 1499449
  - Stranded, Shielded: 1499450



EtherSeal Cat 5e Cable Assemblies

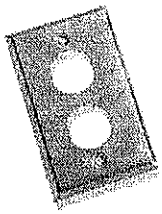
- Factory installable
- Quality exceed Cat 5e performance requirements
- Industrial stranded cable
- UTP or Shielded
- UTP EtherSeal Connector to EtherSeal Connector: 1479601-x
- UTP EtherSeal Connector to Commercial: 1479602-x
- Shielded EtherSeal Connector to EtherSeal Connector: 1479603-x
- Shielded EtherSeal Connector to Commercial: 147904-x

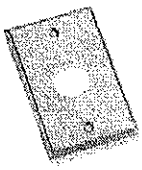


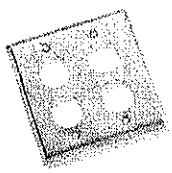


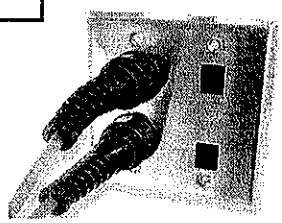
Stainless Steel Faceplates

# Ports	Size	With Gasket	Without Gasket
1	Single Gang	1479593-2	1479593-1
2	Single Gang	1479594-2	1479594-1
4	Double Gang	1479595-2	1479595-1
2 EtherSeal Connectors/ 2 Standard	Double Gang	1479596-2	1479596-1









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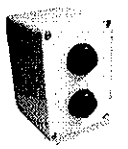
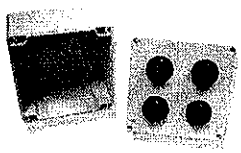
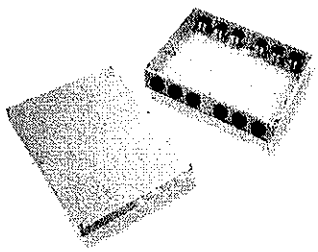
EtherSeal Connectivity System Enclosures









- IP 67 Rated
- Enclosures come with pre-drilled knock-outs for EtherSeal connection and either cable or conduit installation
- Cable and conduit glands available
- Enclosure sizes
  - 2-port
  - 4-port
  - 12-port

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AMP Netconnect Cabling Solutions

To jump, click on desired Topic

- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
- AMPTRAC Cabling Management System
- EtherSeal Cabling System
- Residential Cabling System
- The END

Else, follow agenda sequence...

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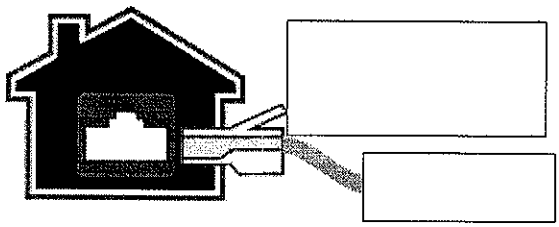
Wiring up your home ?

AMP Netconnect Residential Cabling System Solutions



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Why Residential Cabling ?

Market drivers for Networking in Homes

- High-Speed Internet sharing
- High-end peripherals sharing
  - Color laser printers, Scanners, DVD R/W devices
- Home Security Surveillance
- Home Entertainment
- Lighting & Climate Control with HCMS
- Digital Convergence
  - Video and Telephony Over IP
- Small/Home Offices (SOHO) Telecommuting

Residential Cabling Standard

TIA/EIA-570-B,

- Residential Telecommunications Cabling Standard,
  - published in April 2004
  - TIA TR 42.2
- Establishes common terminology
- Types of cable media that can be used in residential cabling
- Design guidelines for single- and multi-dwelling residential units
- General requirements for installation and field testing of the residential cabling system.
- Establishes a grading system based on telecommunications services that are or may be needed by the homeowner or tenant today and in the future.
  - Grade 1 and Grade 2.

Residential Cabling - Grade 1

Feature	Description
Supported Services:	Telephone, fax, modem; Satellite TV; Cable and Antenna Television; Data (up to 1000 Mbit/s with Category 5E cabling, up to 10Gbit/s with Category 6 cabling*). *-10GBit/s based on IEEE standards no yet approved at the time of this publication
Recognized Cable Types:	Category 5E (CAT5E) 4-pair UTP cable and components; Category 6 (CAT6) 4-pair UTP cable and components; 75-Ohm RG-6 coaxial cable and components. 75-Ohm RG59 coaxial cable for closed-circuit television (CCTV, commonly referred to as security video) only
Topology:	Star
Minimum requirements per outlet location:	1 x 4-pair Category 5E UTP cable (Category 6 recommended); 1 x 75-Ohm RG-6 coaxial cable.

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Residential Cabling - Grade 1

Grade 1 provides the following functionality:

- Distributing incoming phone lines to multiple rooms;
- Building a high-speed home LAN with speeds up to 1000 Mbit/s;
- Viewing antenna and cable TV at multiple outlet locations;
- Viewing satellite TV at an outlet location where the satellite receiver is placed.

Grade 1 does not provide the following functionality:

- Using one outlet location for voice and data at the same time
- Whole-house video distribution from internally generated sources (like VCR, DVD, satellite receiver)
- Whole-house audio distribution
- Whole-house infrared control signal distribution;

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Residential Cabling - Grade 2

Feature	Description
Supported Services:	Telephone, fax, modem; Satellite TV; Cable and Antenna Television; Data (up to 1000 Mbit/s with Category 5E cabling, up to 10Gbit/s with Category 6 cabling*). Video monitoring; Video intercom and teleconferencing; Other multimedia applications. *-10GBit/s based on IEEE standards no yet approved at the time of this publication VCR , DVD and laser disc output distribution;
Recognized Cable Types:	Category 5E (CAT5E) 4-pair UTP cable and components; Category 6 (CAT6) 4-pair UTP cable and components; 75-Ohm RG-6 coaxial cable and components. 75-Ohm RG59 coaxial cable for closed-circuit television (CCTV, commonly referred to as security video) only; Fiber optic cables and components (50/125µm; 62.5/125µm multimode as well as singlemode)
Topology:	Star
Minimum requirements per outlet location:	2 x 4-pair Category 5E UTP cable (Category 6 recommended); 2 x 75-Ohm RG-6 coaxial cable; 1 x 2-fiber optical fiber cable (optional).

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Residential Cabling - Grade 2

Grade 2 provides the following functionality:

- Distributing incoming phone lines to multiple rooms;
- Building a high-speed home LAN with speeds up to 1000 Mbit/s;
- Viewing antenna and cable TV at multiple outlet locations;
- Viewing satellite TV at an outlet location where the satellite receiver is placed.
- Whole-house video distribution from internally generated sources (like VCR, DVD, satellite receiver)

Grade 2 does not provide the following functionality:

- Whole-house audio distribution
- Whole-house infrared control signal distribution;

Grade 2 wiring supports advanced telecommunications applications such as high-speed Local Area Networks (LANs), multimedia, Internet etc and is recommended for a "Smart House".

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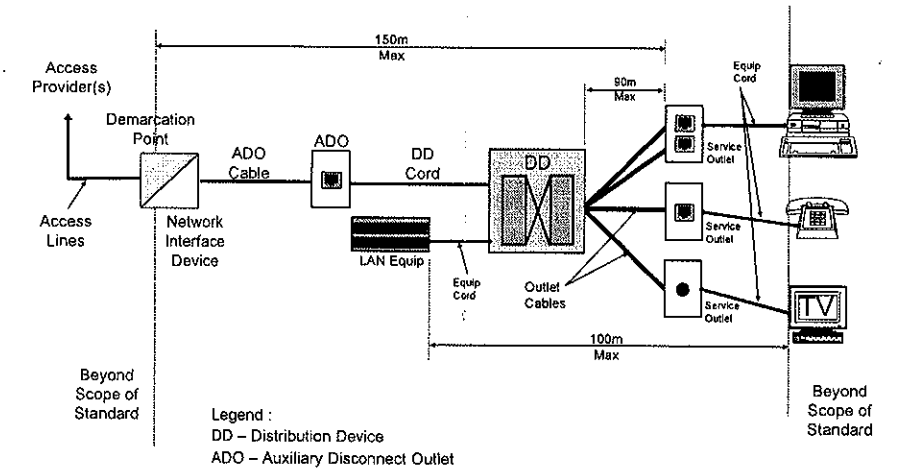
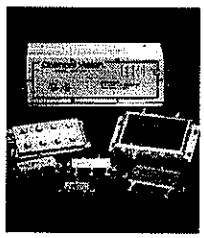
Typical Components of a Single Residential Unit



System Components

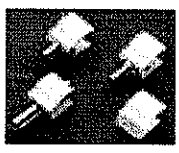
- SL Series Cat.5e Tool-less Jacks
- Standard RJ45 Jacks
- Multi-media Inserts
- Cat.5e/6 UTP Cabling
- Faceplates
- Patch Cords

Video Products (Amplifiers, Splitters/Combiners) Available From Outside Vendors



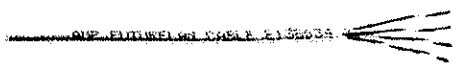






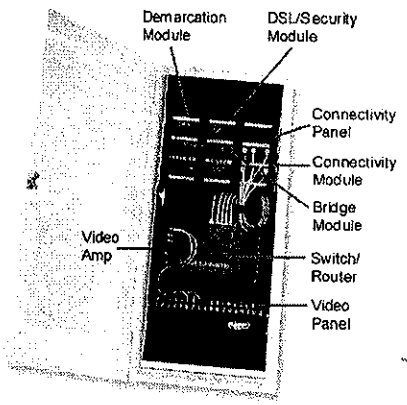




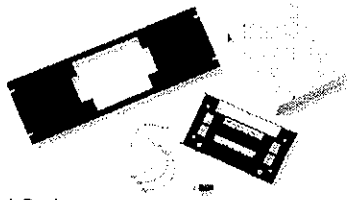


Media Convergence Center
Supports voice, data and video applications

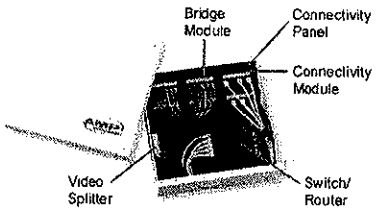
RCS 36 Series
(14" X 36" Enclosure)



RCS 6 Series
Based on Multimedia Security Outlet



RCS 14 Series
(14" X 14" Enclosure)



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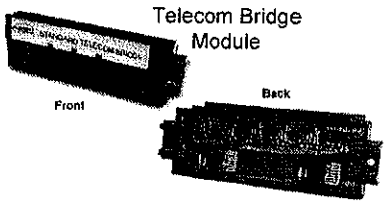
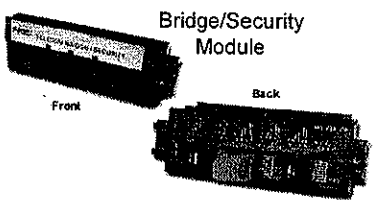
RCS Modules
for Media Convergence Center

Telecom Bridge Module



- Provided with all three RCS series
- Supports up to 4 telephone lines across 6 jacks with input and output jacks on back
- T568A wired

Bridge/Security Module



- Provides function of Standard Bridge
- Also provides RJ31 interface to security system
- Red shorting plug bypasses RJ31 and provides line 1 service when no security system is present

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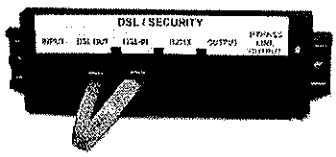
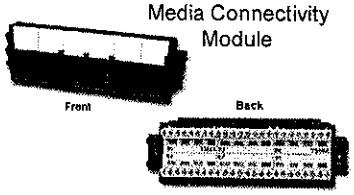
RCS Modules
for Media Convergence Center

DSL/Security Module



- Provides RJ31 interface to security system
- Also provides In/Out jacks for DSL modem
- Other systems require DSL filter at each phone outlet
- Bypass jack can be used in the event of a DSL or security system failure
  - Use only in the event of a failure

Media Connectivity Module



- It's a 6-pack from a Cat 5e patch panel

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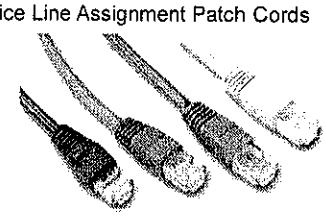
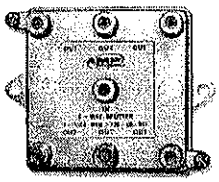
Accessories
for Media Convergence Center

Voice Line Assignment Patch Cords

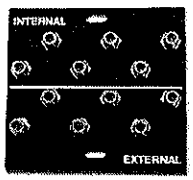


- Primary line at each outlet is determined by patch cord

Passive Video Splitter



F-connector coupler panels



- "Internal" video is from source(s) inside the residence (DVDs, cameras, etc.)
- "External" is CATV, DSS, etc.
- Splitter/amp furnished by installer or user

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AMP Netconnect Cabling Solutions

To jump, click on desired Topic

- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
- AMPTRAC Cabling Management System
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- Residential Cabling System
- The END

Else, follow agenda sequence...

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Thank You

We're AMP NETCONNECT

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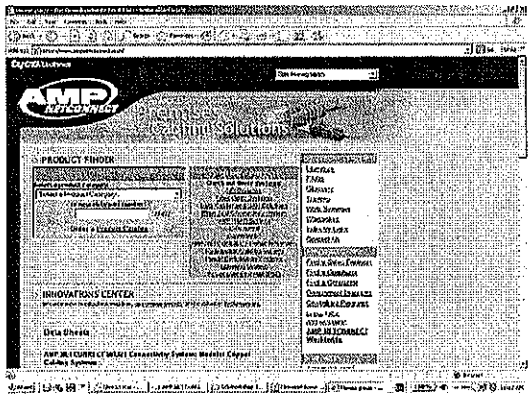
Lost in the Cabling World ?



AMP Netconnect online resource will help you find your way !!!

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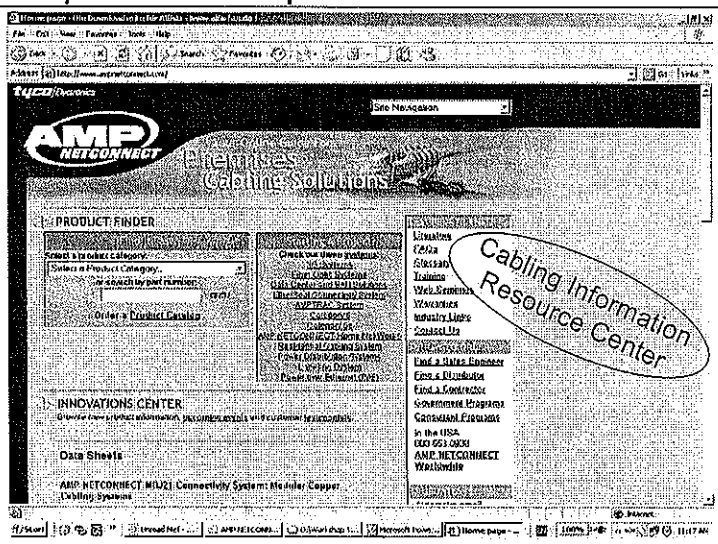
AMP Netconnect Website
http://www.ampnetconnect.com



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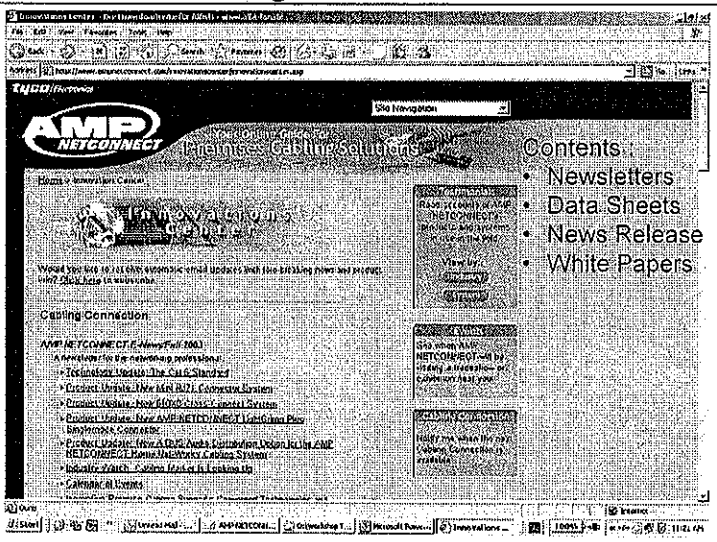
AMP Netconnect Innovations Center
Featuring the latest innovations....



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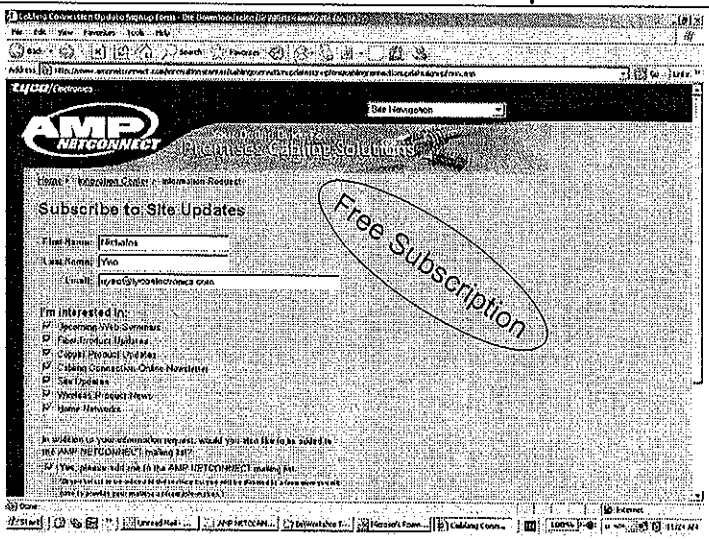
AMP Netconnect Innovations Center
Updates ....



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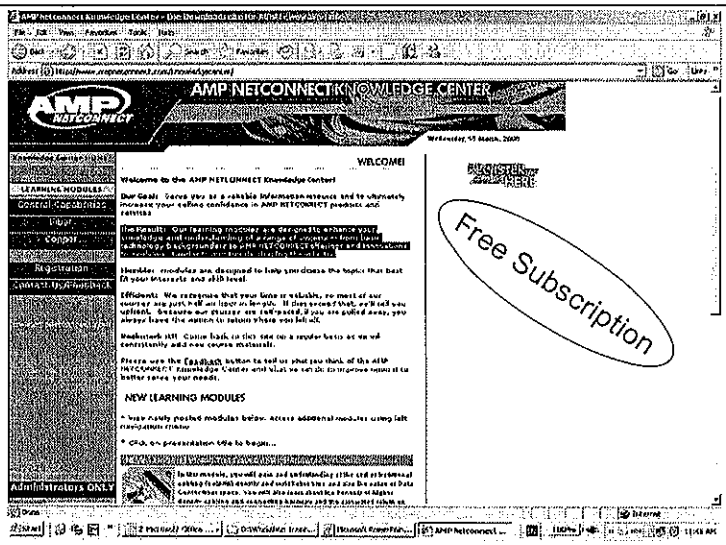
AMP Netconnect Knowledge Center
http:// ampnetconnect.com/knowledgecenter



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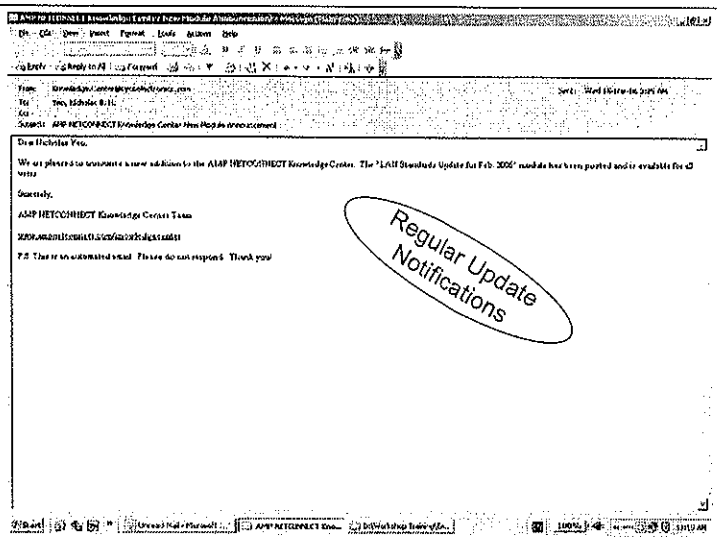
AMP Netconnect Knowledge Center



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AMP Netconnect Cabling Solutions

To jump, click on desired Topic

- 10GBase-T Cabling System
- Data Center Cabling System
- Power over Ethernet
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- EtherSeal Cabling System
- Residential Cabling System
- AMP Netconnect Online Resource
- The END

Else, follow agenda sequence...

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Introduction to Field Testing

Jimmy Tan, RCDD
GEIC Pte Ltd

BICSI

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Differences in Testers

- Verification Tester
  - Continuity Test, LED Based
  - Length, Wiremap
- Qualification Tester
  - Qualify cable to run existing or new technology, like 100BaseTX, 1000BaseT
- Certification Tester
  - Future proofing Cabling System to run up to a certain bandwidth (MHz) requirement
  - Required to report NEXT, RL, Insertion Loss, ELFEXT....







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Levels of Field Testing

- Verification
  - The installed link meets basic continuity requirements
  - Does not imply any bandwidth or transmission quality measure
- Qualification
  - The installed cabling link successfully transmits data using a specific network technology (i.e. 100BASE-TX or 1000BASE-T)
  - Does not imply compliance with other technologies than the one used in the test



Levels of Field Testing (Cont'd)

- Certification
  - The installed cabling link meets the transmission performance criteria as defined by the applicable industry standard; the test results are documented and reported in compliance with the standard
  - The definition of performance and the level ("category") of performance is defined by industry standards
    - TIA-568-B defines Cat 5e, Cat 6
    - ISO 11801 and ISO/IEC 61935 define Class C, D , E and F



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Verification Tools

- Verification tools provide a simple check of continuity
- Typical functions may include wiremap, length, and tone generation
- They are used primarily by network support technicians or end users to quickly and easily verify that existing cabling does not have an open or wiring fault
- They are low cost, typically < $500.
- They do NOT provide pass/fail indications. The user must know what result to expect
- They do NOT provide data storage or printout

MicroMapper™



MicroScanner™



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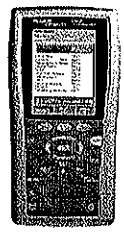
Certification Tools

- Certification tools make measurements and compare the results to industry cabling standards.
- They measure NEXT, Return Loss, Propagation Delay, PSELFEXT, and many other parameters across a preset frequency band
- They provide PASS or FAIL results
- They store detailed measurement data, and are essential tools for datacom contractors
- Because of their necessary sophistication, and the hardware necessary to make > 35,000 accurate measurements in only a few seconds, they cost over $6000



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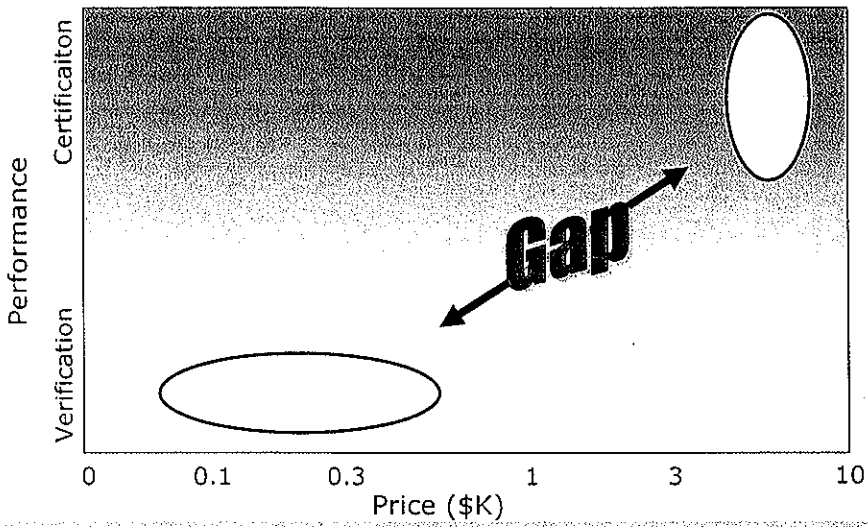
Cable Test Tools Price/Performance



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Enter Qualification

- Qualification is less than certification, but more than verification
- Qualification testing approved in TIA-570B for residential structured cabling applications (Certification preferred)
- Qualification 'qualifies' the cabling for a particular network application (e.g. 100BASE-T)
- Qualification may support limited useful troubleshooting
- Qualification tools may include additional network testing functionality
- Qualification does NOT comply with TIA-568B, ISO 11801, or CENELEC 50173
- Qualification does NOT conform to the permanent link model
- Qualification is NOT a substitute for a certification tester



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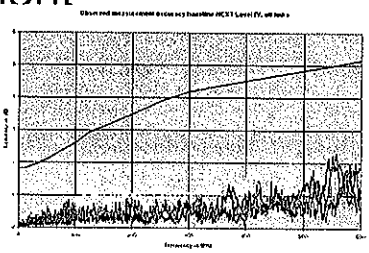
CertificationTester Accuracy Requirement

- IEC61935-1 (Level IV) 600MHz
- TIA/EIA-TSB-155 (Level IIIe) 500MHz
- Specification for Noise Floor, NEXT, IL, RL, FEXT
- Specification for DC Loop Resistance, Propagation Delay
- Certification by well known independent labs.



Underwriters Laboratories Inc.®

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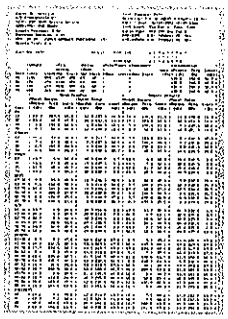
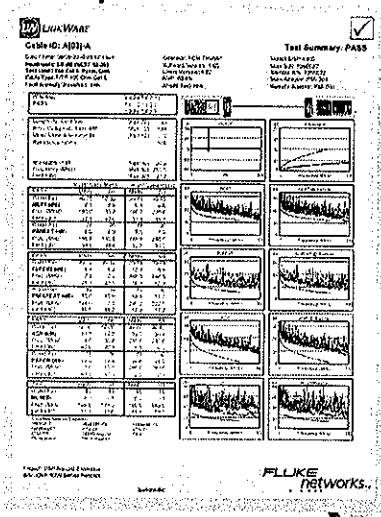
Certification Report Requirement





- **Graphical Report provide More details**
- **Cater to change in Test limits**
- **Provide Diagnostic Features**
- **More difficult to be "tempered"**

April 2005, Ngee Ann Polytechnic

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Reason for Cabling Certification

- Its All About Confidence
  - The components delivered meet the specified performance requirements
  - The installation has been performed with quality workmanship
  - Affirmation that the user receives a cabling system that meets the quality and performance he/she expects (Meeting TIA568B Standard ?)
  - Customer satisfaction



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Field Test Procedures

- Channel Certification Test
- Permanent Link Certification Test



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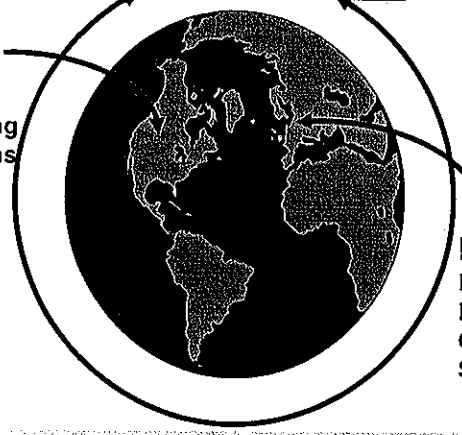
Cabling Standards Around the World

ISO/IEC 11801:2002
IT Generic Cabling for Customer Premises

ANSI/TIA/EIA 568-B
Commercial Building Telecommunications Wiring Standard



EN50173:2002
Performance Requirements Of Generic Cabling Systems

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Copper Test Standards

- TIA TSB67 (1995) / ISO Class D (1995)
- TIA TSB95 (1999) / ISO Class D (2000)
- TIA 568-B.2 (2001) / ISO Class D (2002)
- TIA 568-B.2 Addendum (2002)

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TIA/EIA Standards

- ANSI/TIA/EIA 568-B Series
  - ANSI/TIA/EIA 568-B.1
    Commercial Building Telecommunications Cabling standard
  - ANSI/TIA/EIA 568-B.2
    100 Ohm Twisted Pair Cabling Standard
  - ANSI/TIA/EIA 568-B.3
    Optical Fiber Standards
- What 's new in Certification ?
  - Category Augmented (AC6 or Cat 6a)
  - Alien NEXT and alien ELFEXT



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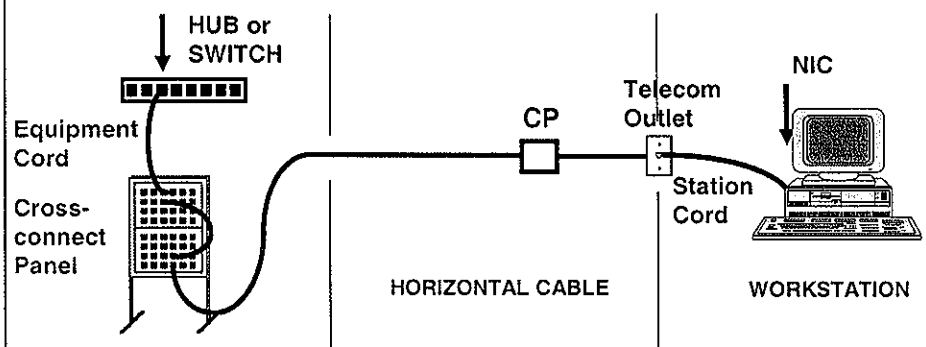
An Installed "Cabling Link"



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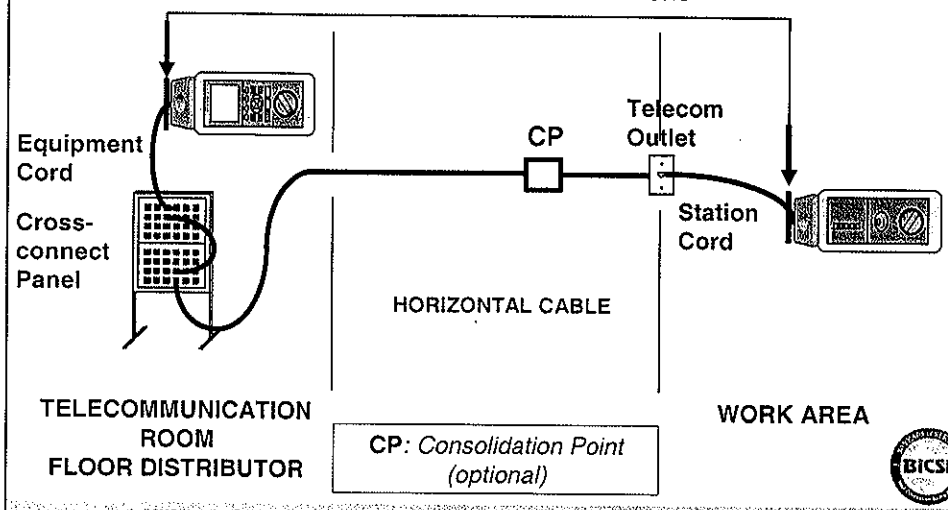
The Channel Measurement

Channel excludes end-connections



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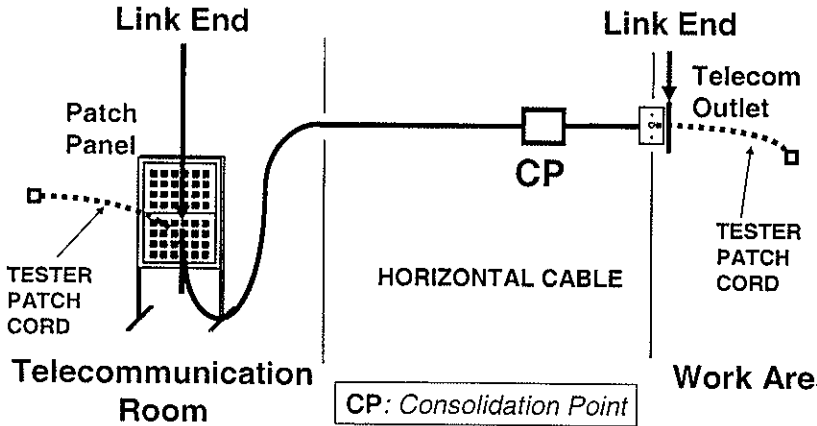
The Permanent Link Measurement

Test results must not include any contributions made by the tester patch cables



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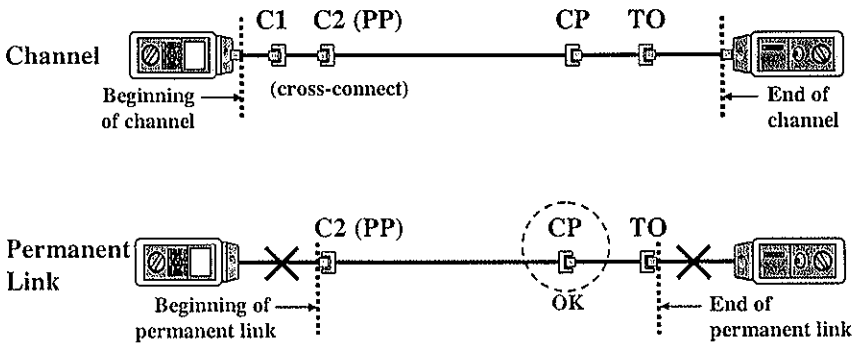
Review of the Test Methods



Consolidation point is OK

Tester cable is not included

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TSB67 Test Parameters

- Wire Map
- Resistance
- Length
- Delay Skew
- Insertion Loss
- NEXT

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TSB95 Test Parameters

- Wire Map
- Resistance
- Length
- Propagation Delay
- Delay Skew
- Insertion Loss
- NEXT
- ELFEXT / PSELFEXT
- ACR
- Return Loss



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TIA568-B.2 Test Parameters

- Wire Map
- Resistance
- Length
- Propagation Delay
- Delay Skew
- Insertion Loss
- NEXT / PSNEXT
- ELFEXT / PSELFEXT
- ACR / PSACR
- Return Loss




Any Questions?

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DTX CableAnalyzer™

It's All About Time



Jimmy Tan, RCDD
GEIC Pte Ltd

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A New Generation

- Based on breakthrough technology
- Speed **AND** Accuracy
- Significantly reduces the

Total Time To Certify

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The New DTX CableAnalyzer™

- Improving every aspect of the testing process
  - Set up
  - Testing
  - Troubleshooting
  - Reporting
  - Switching between media
  - Even moving link to link

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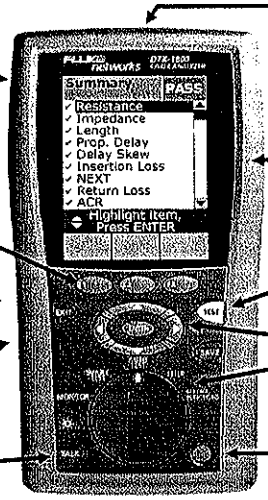
Familiar User Interface



Rugged overmold bonded to case

Soft key labels (e.g. Fault Info)

MMC card slot

USB and Serial Interface connectors

Talk button

High performance connector for Copper adapters

Bright color display

Test

Keypad and rotary knob make learning easy

Power On button

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Endorsements = Instant Credibility



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Significantly Reduce the Total Time To Certify

- Zero to certified in 9 seconds
  - Move from link to link three times faster than with previous testers
- Level IV Accuracy + Field Tough Permanent Link Adapters + PM06
  - Get the most accurate test results in the shortest possible time
  - Confidence in test results

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Significantly Reduce the Total Time To Certify

- **Level IV Accuracy + Field Tough Permanent Link Adapters + PM06**
  - **Get the most accurate test results in the shortest possible time**
- **900 MHz Frequency Range = Future Proof**
  - **Future proof your tester for future applications such as 10GbE**
- **Advanced time-saving diagnostics**
  - **DTX pinpoints location of failure – the only tester that suggests corrective action**

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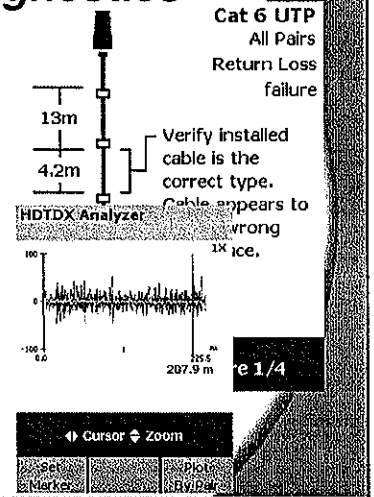
Advanced Time Saving Diagnostics

- Fault info key ("soft key") =
  - Intuitive, plain language explanation of the defect
  - Suggested corrective action
- Deeper level diagnostics still available: e.g. HDTDX and HDTDR



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Significantly Reduce the Total Time To Certify

- 900 MHz Frequency Range = Future Proof
  - Future proof your tester for future applications such as 10GbE
- Advanced time-saving diagnostics
  - DTX pinpoints location of failure – the only tester that suggests corrective action
- Record-fast fiber Certification
  - Certify a pair of fibers in 9 seconds with DTX Fiber Test Modules. 5X Faster!

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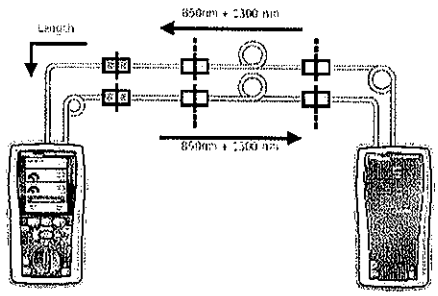
Record-fast certification

- One Press of the DTX Autotest button =
  - Test two fibers (a transmit/receive pair)
  - Two Wavelengths
  - Plus Length
- 5 Measurements in only *9 seconds*
  - 5X faster than any other tester



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Significantly Reduce the Total Time To Certify

- Advanced time-saving diagnostics
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- On-Board Fiber with integrated VFL
  - Switch between media with one-button touch and troubleshoot

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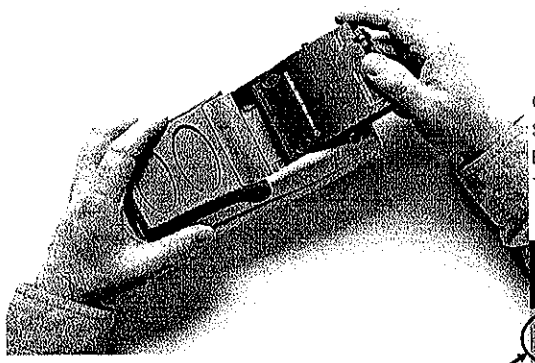
Insert and leave



Switch between copper and fiber media with a button push

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Significantly Reduce the Total Time To Certify

- Zero to certified in 12 seconds
  - Move from link to link three times faster than with previous testers
- Level IV Accuracy + Field Tough Permanent Link Adapters + PM06
  - Get the most accurate test results in the shortest possible time Record-fast, on-board fiber certification
- 900 MHz Frequency Range = Future Proof
  - Future proof your tester for future applications such as 10GbE
- Advanced time-saving diagnostics
  - DTX pinpoints location of failure – the only tester that suggests corrective action
- Record-fast fiber Certification
  - Certify a pair of fibers in 12 seconds with DTX Fiber Test Modules
- On-Board Fiber with integrated VFL
  - Switch between media with one-button touch and troubleshoot

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Want to see what a 9 second Cat 6 Autotest looks like?

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Significantly Reduce the Total Time To Certify

- Zero to certified in 12 seconds
  - Move from link to link three times faster than with previous testers
- Level IV Accuracy + Field Tough Permanent Li[illegible]
  - Get the most a[illegible]
- 9[illegible] – Future Proof
  - Future proof your tester for future applic[illegible]
- Advanced tim[illegible]
  - [illegible] tester that suggests
- Record-fast fiber Certification
  - Certify a pair of fibers in 12 seconds with DTX Fiber Test Modules
- On-Board Fiber with integrated VFL
  - Switch between media with one-button touch and troubleshoot

Great Features & Benefits that Translate into Value'

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Test Results Management – Removable Memory Card

- Utilizes standard Sandisk MMC's
  - Standard card - 32 Mbytes
  - Optional card – up to 256 Mbytes
- Eliminate the need to re-test in the field
  - Store and transfer *every data point* with the DTX
  - Re-certify to a new standard at a later date with LinkWare



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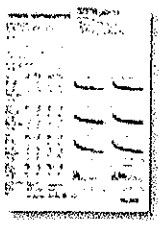

DTX Test Data Capacity

How many graphical tests will the DTX Series store?

	DTX LT	DTX-1200 and DTX-1800		
	Internal	Internal	SD/MMC 16MB	SD/MMC 32MB
Category 5e:	500	500	1,280	2,560
Category 6:	400	400	760	1,520
10GBase-T:	230	230	470	940

Why is there more test results capacity for Cat 5e than for Cat 6 and Proposed 10GBase-T?

Cat 6 & proposed 10GBase-T have more data points to test and report than Cat 5e
(100,000 test points for Cat6 within 9 seconds)

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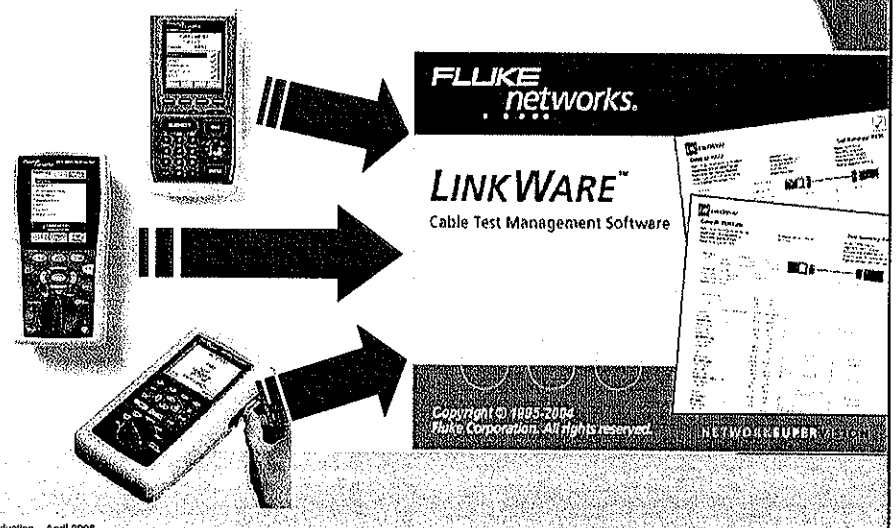
Test Results Management – LinkWare PC Software



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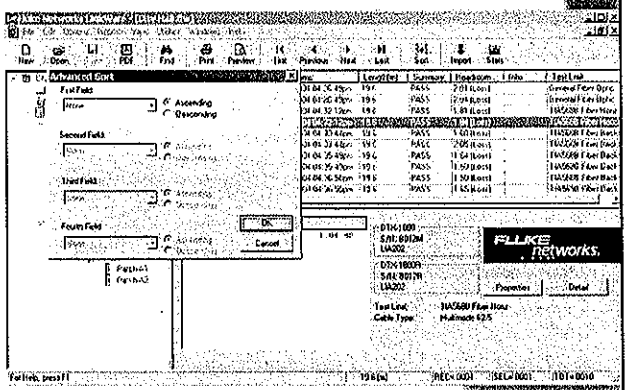
Test Results Management --
LinkWare PC Software

- Create ANSI/EIA/TIA 606-A compliant projects
- Import data from Fluke Networks testers into a common database
- Easily sort through test reports
- Append files with test reports from another project



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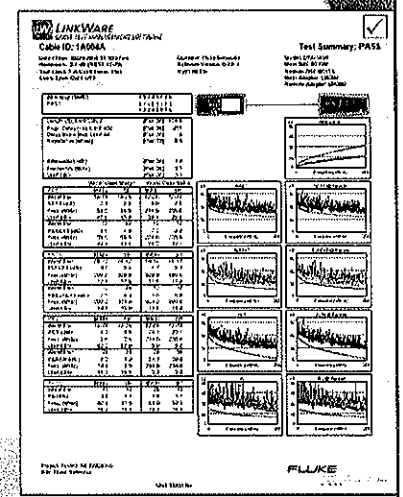
Test Results Management --
Printed and Electronic PDF Reports

LinkWare Software supports several formats to provide test results information to your customer:

- Graphical color report with measured test points over full frequency range
- Text format with worst case and worst value data
- Summary report which provides a list of the cabling links tested and key information
- Reports can be printed on paper or sent to an electronic PDF file.



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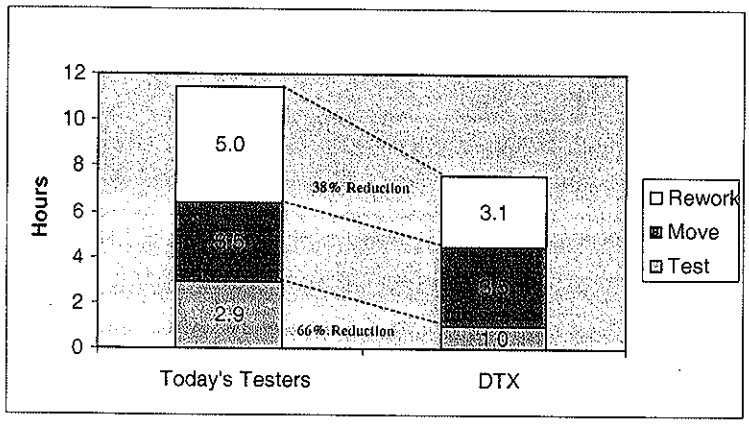
Total Time To Certify 300 Links



4 Hour Reduction with DTX CableAnalyzer

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DSP-4300 and DTX-1800 comparision

- Bandwidth: 350MHz / 900MHz
- Accuracy: Level 3 / Level 4
- Autotest Speed: 35 Sec / 9 Sec
- Screen: Gray / Colour
- Data transfer: Serial / Serial & USB
- Fiber Test: / VFL included

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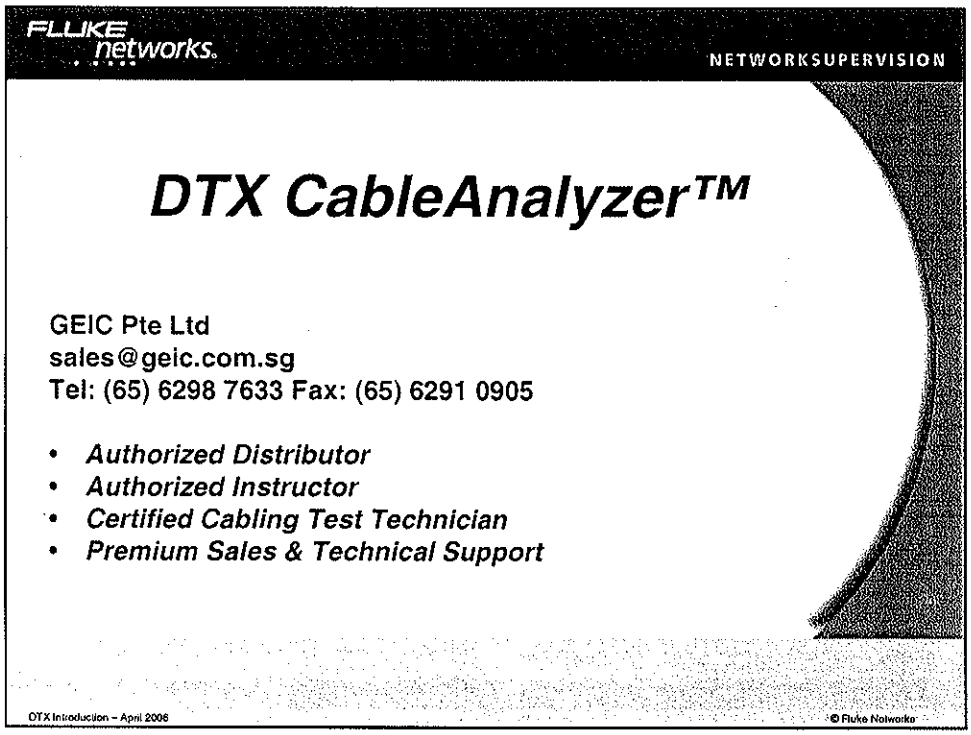
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GEIC Pte Ltd
sales@geic.com.sg
Tel: (65) 6298 7633 Fax: (65) 6291 0905
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• Authorized Instructor
• Certified Cabling Test Technician
• Premium Sales & Technical Support
DTX Introduction – April 2006
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OptiFiber™ Certifying OTDR



A Multi-Function Fiber Tester

Jimmy Tan, RCDD
GEIC Pte Ltd

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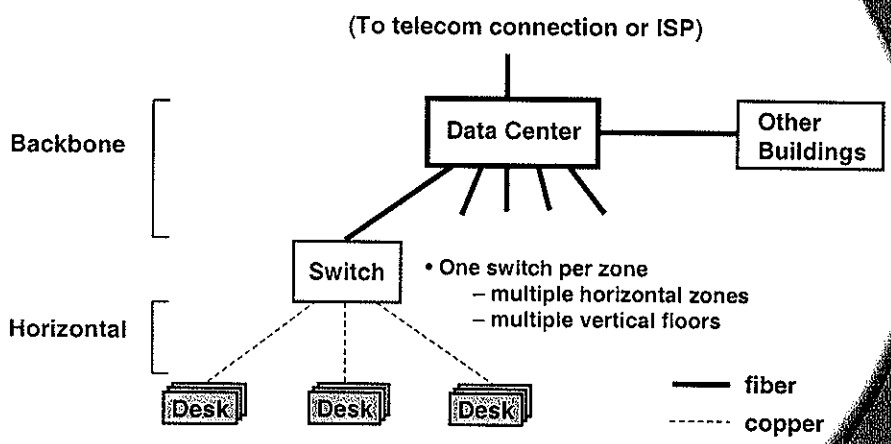
Where Fiber Is Used (Premises)



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OptiFiber

A Multi-Function Fiber Tester

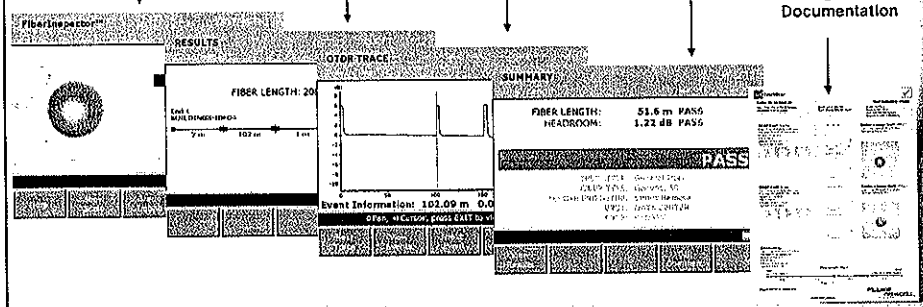
ChannelMap

Endface Inspection and SAVE

OTDR Trace & Analysis

Loss/Length Certification

LinkWare Records Management & Documentation



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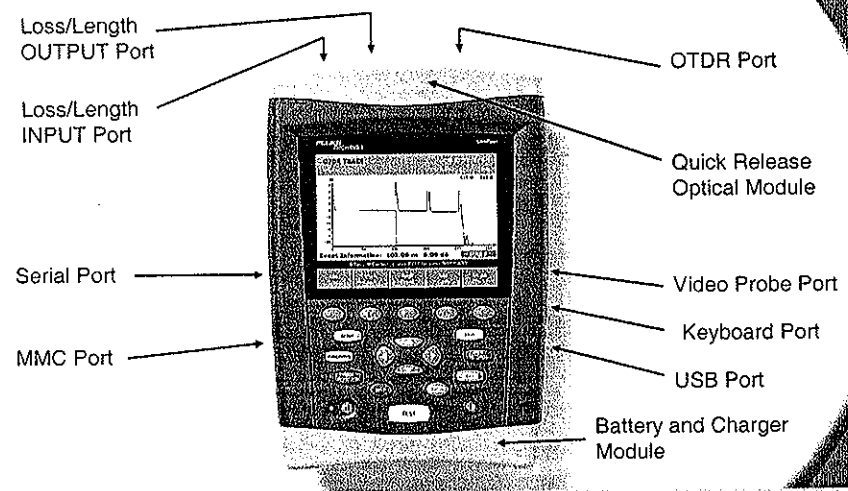
OptiFiber

A Multi-Function Fiber Tester



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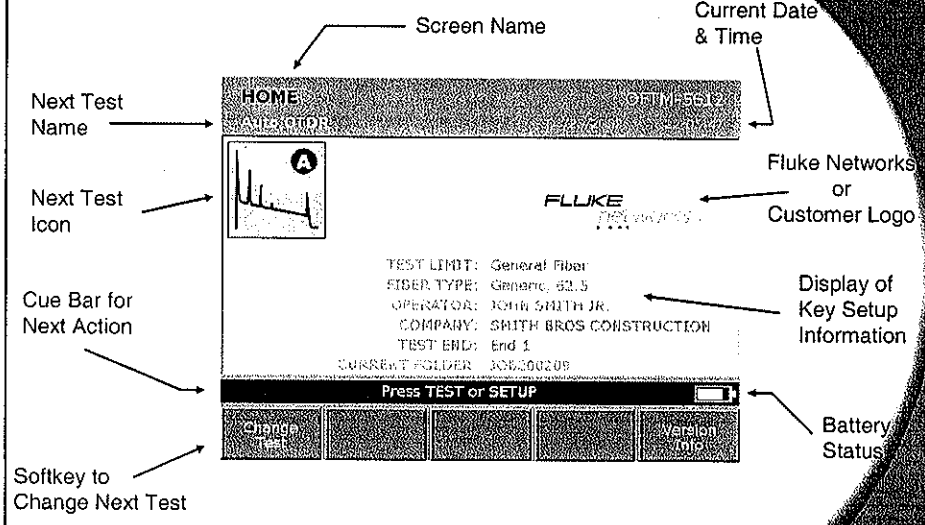
OptiFiber NETWORKSUPERVISION

Home Screen



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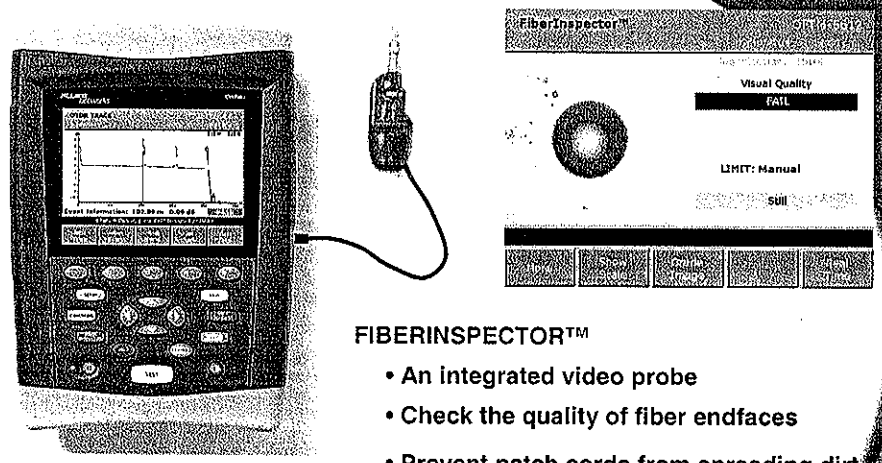
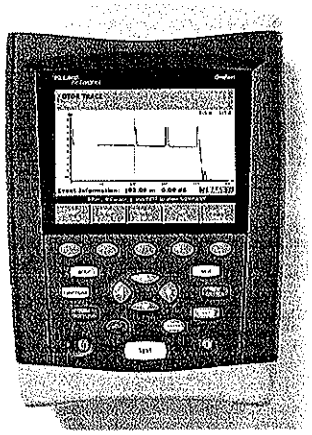
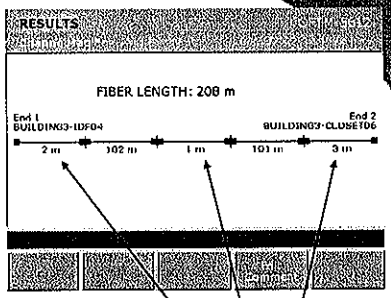
OptiFiber NETWORKSUPERVISION



FIBERINSPECTOR™

- **An integrated video probe**
- **Check the quality of fiber endfaces**
- **Prevent patch cords from spreading dirt**
- **Verify cleanliness of the OTDR port**
- **SAVE images as proof of quality**





ChannelMap™

- Graphic display of all links in a channel
- Anyone can understand ChannelMap
- ChannelMap can see patch cords
- Shows the location at each end of the fiber
- You can SAVE ChannelMap along with other test results

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TSB-140

TIA/TSB-140:

Additional Guidelines For Field-Testing Length, Loss And Polarity Of Optical Fiber Cabling Systems

Approved in February 2004

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Two-Tier Testing

- **Tier 1: OLTS (Optical Loss Test Set)**
  - Conforms to TIA-526-14A and TIA-526-7
    - Most closely simulates system
  - Measures the total loss of a fiber channel
  - Verify polarity using OLTS or VFL
- **Tier 2: OTDR Trace**
  - Can show segment lengths, connector locations & losses, and losses not at a connector
  - Provides evidence that cable is installed without degrading events (e.g., bends, connection, splice)
  - Can do single-ended testing

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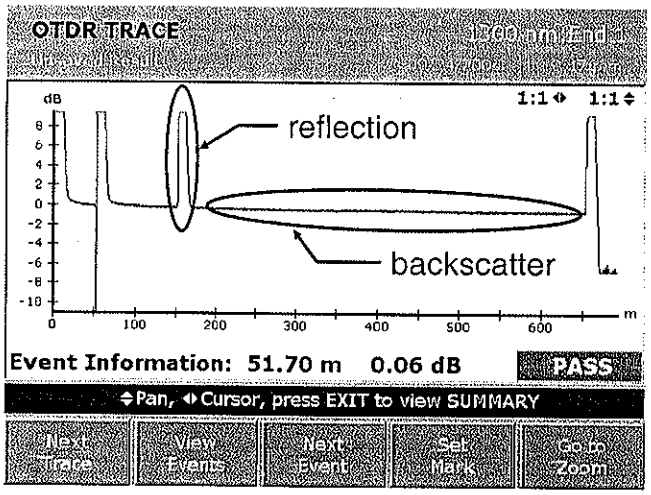
A Typical OTDR Trace



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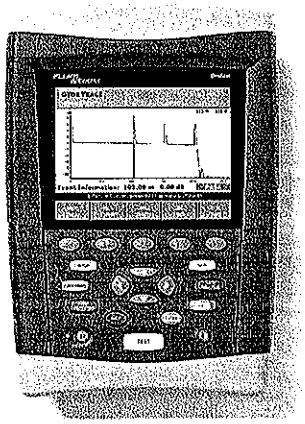

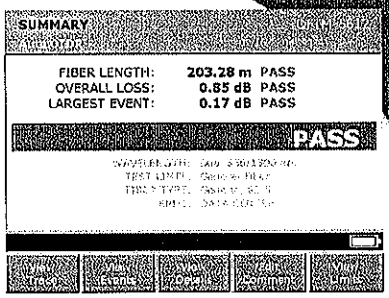

OTDR Results Summary

- Easy-to-read summary of OTDR results
- PASS or FAIL based on customer limits
- Measures overall loss
- Shows size of largest event

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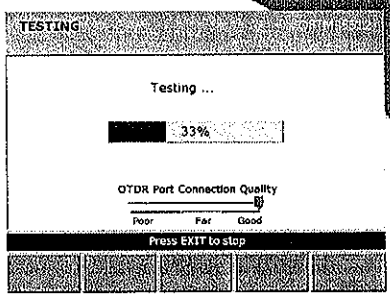
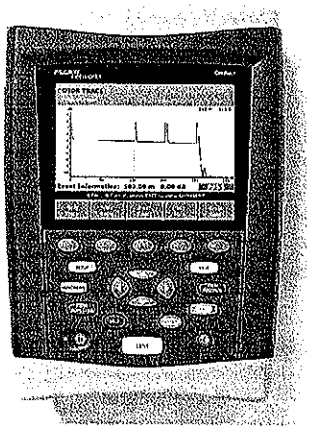
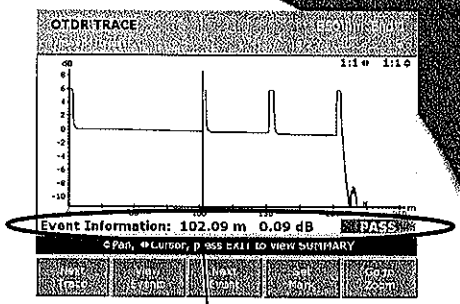
Another ease-of-use first from Fluke Networks



OTDR Port Quality Check

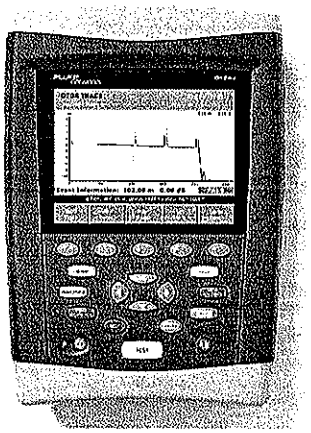
- Good OTDR traces require a clean OTDR port
- OptiFiber easily lets you know how clean your OTDR port is
- The check automatically happens at the start of each OTDR test
- Tells you if you need to clean the OTDR port
- Gives you confidence that your OTDR traces are valid

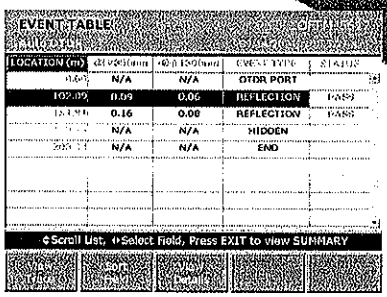




OTDR Trace

- Trace automatically scaled to fit screen
- Cursor automatically placed at first event
- Automated event measurement & display
- Easy movement of cursor to next event
- Easy access to both wavelengths





OTDR Event Table

- Shows location of all events
- Identifies events: END, REFLECTION, LOSS, GHOST and others
- Shows status of each event (and following segment of fiber)
- Many more test details are available

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HELP Screen For Event Table

HELP

EVENT TYPE
Tells what the event appears to be:

- **REFLECTION**
  A pulse of light reflected back to the OTDR.

  Causes
  A connector, tight bend, or crack in the fiber. Small reflective events may actually be ghosts.

  Solutions
  If the reflection is not caused by a connector, inspect the cable for tight bends or damage. Use a visual fault locator to verify the fault.

◆ Scroll, ◆ Highlight Link, Press HELP for Index

Set Bookmark | Go To Bookmark | Back | Page Up | Page Down

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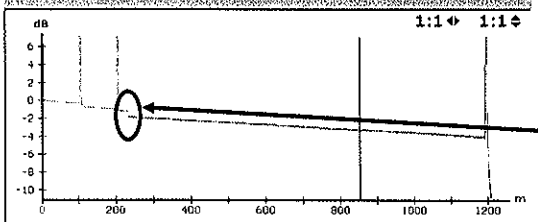
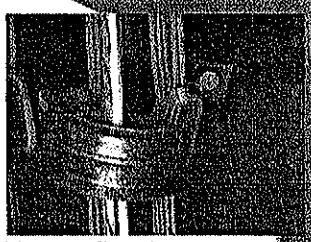
Loss Event

OTDR TRACE



Cursor Position: 851.63 m



Non-reflective event
Splice or severe bend

EVENT TABLE

LOCATION (m)	dB@850nm	dB@1300nm	EVENT TYPE	STATUS
[illegible]	0.39	0.43	REFLECTION	PASS
[illegible]	0.19	0.11	REFLECTION	PASS
[illegible]	0.64	0.76	LOSS	FAIL
1194.5	N/A	N/A	END	

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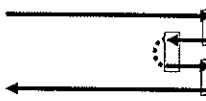
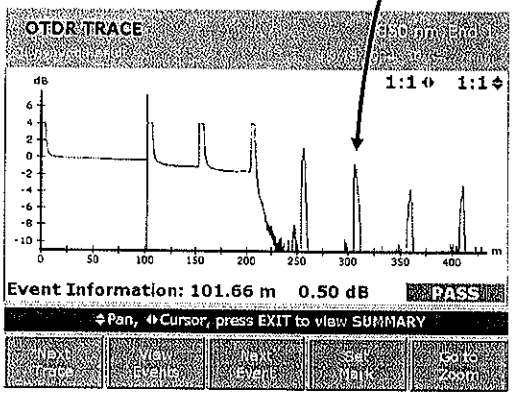


Ghost Event



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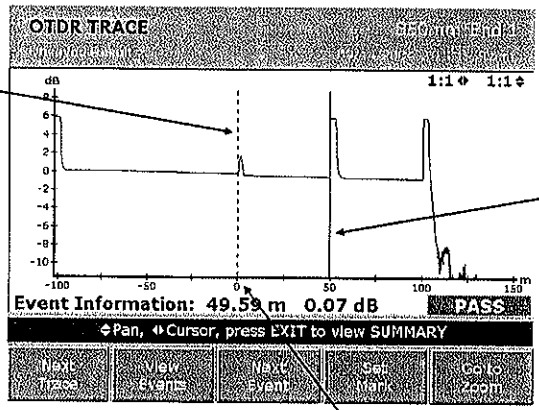
Launch Fiber Compensation

Shows the end of the launch fiber

Event information is now with reference to the end of the launch fiber



Cursor

The zero point is now shifted to the end of the launch fiber

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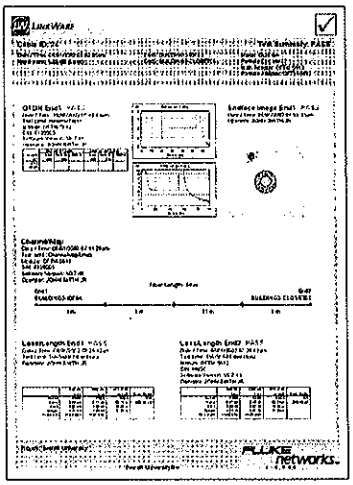

LINKWARE

Cable Test Management Software

Comprehensive, professional-quality documentation of the test results of installed network cabling.

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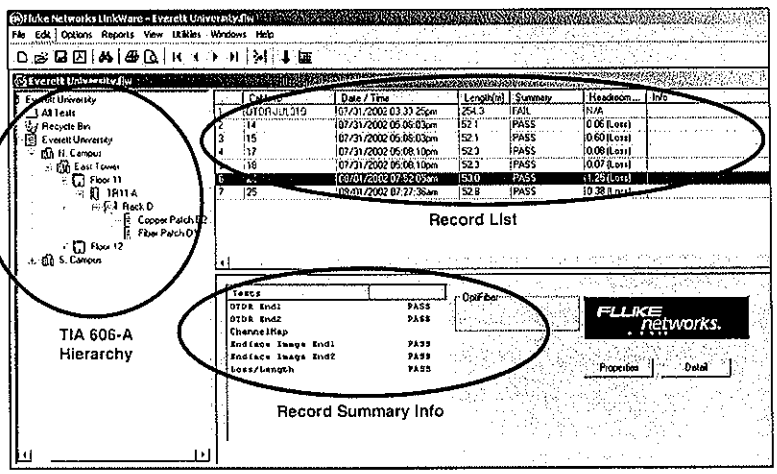
LinkWare at a Glance



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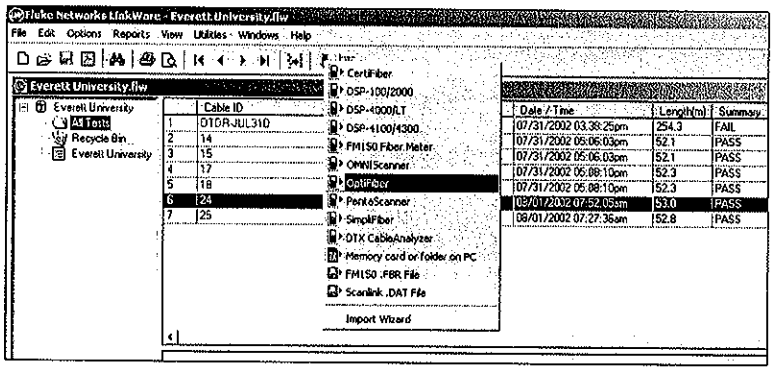
LinkWare Works With Multiple Testers



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OptiFiber

A Multi-Function Fiber Tester

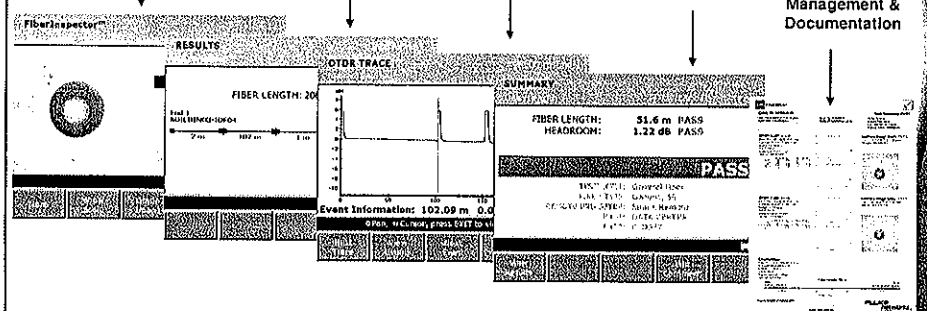
ChannelMap

Endface Inspection and SAVE

OTDR Trace & Analysis

Loss/Length Certification

LinkWare Records Management & Documentation



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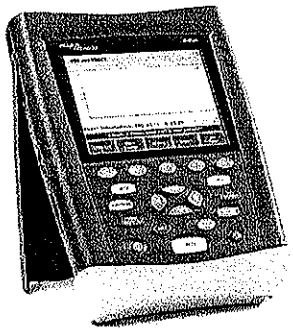
The Complete Solution



OptiFiber

Multi-Function Fiber Tester

For installers and owners of premises, campus and metro networks who need to quickly certify, document and troubleshoot optical fiber cabling.

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OptiFiber OTDR™

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- *Authorized Instructor*
- *Certified Cabling Test Technician*
- *Premium Sales & Technical Support*

Welcome To

AMP Netconnect Structured Cabling System Workshop

Nicholas Yeo,
RCDD LAN Specialist

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<<<<<<<< Cabling Standards >>>>>>>>

A useful standard is a living document.

It grows to meet the needs of the industry it serves.

- **Advances in building construction techniques**
- **Advances in telecommunication technology**
- **Ever increasing demand for bandwidth**



Benefits of standards

- **Enable the planning and installation of systems**
- **Support a multi-product, multi-vendor environment**
- **Support standards-based applications**
- **Establish performance and technical criteria**
- **Simplify administration and management**
- **Accommodate future growth**

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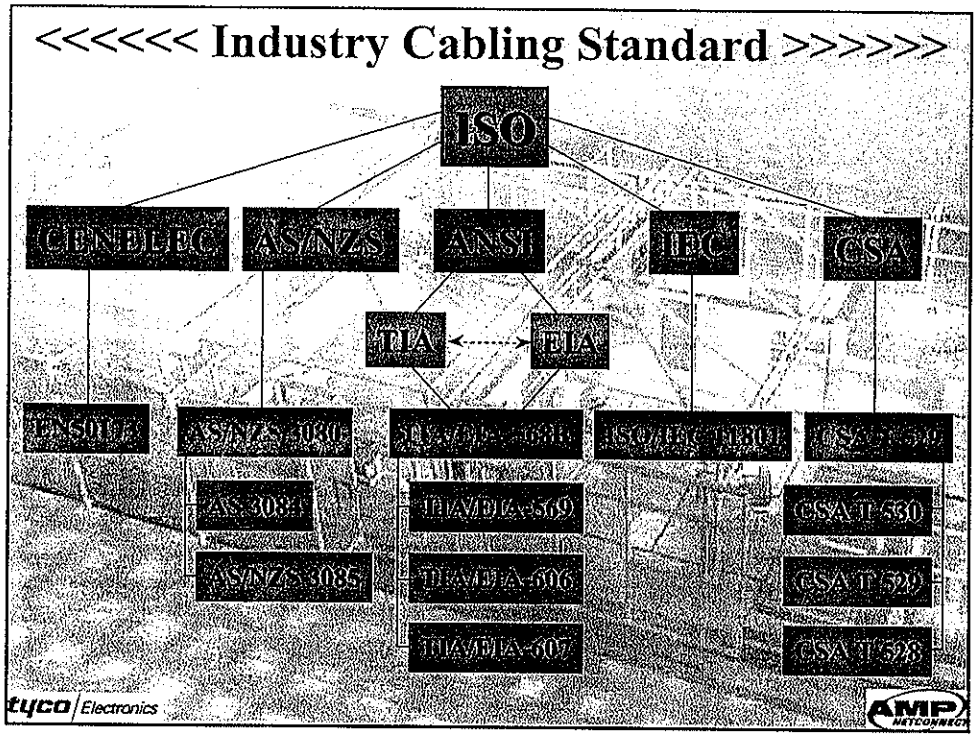
<<<<<< Industry Cabling Standard >>>>>>
ISO
CENELEC
AS/NZS
ANSI
IEC
CSA
TIA
EIA
EN 50173
AS/NZS 3080
ISO/IEC 11801
AS 3084
TIA/EIA-569
CSA T 530
AS/NZS 3085
TIA/EIA-606
CSA T 529
TIA/EIA-607
CSA T 528
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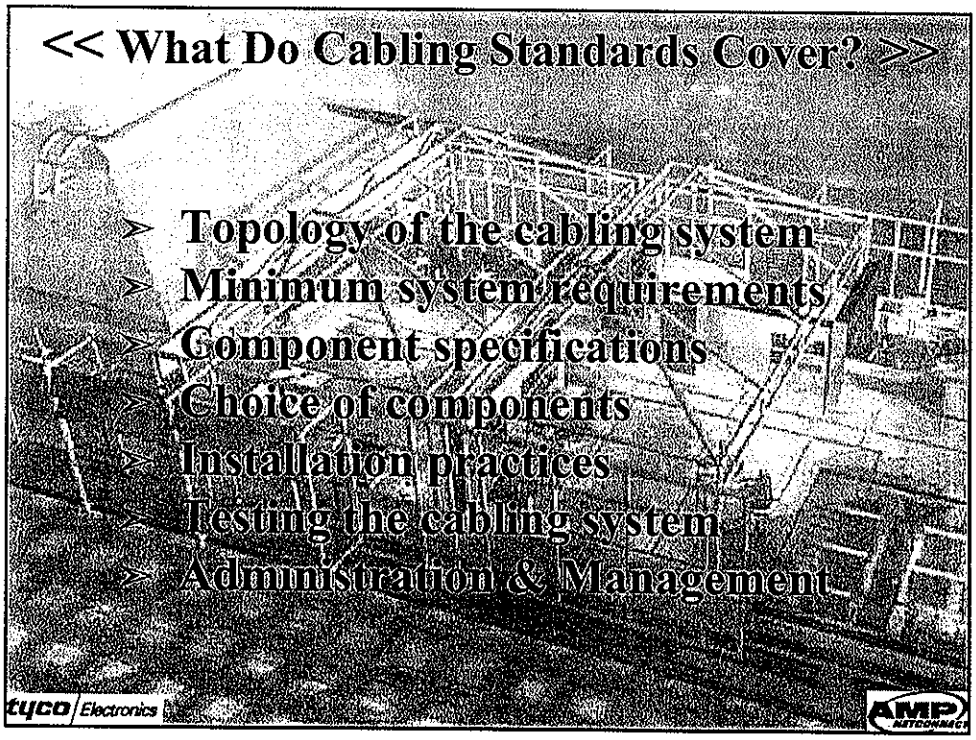
<< What Do Cabling Standards Cover? >>
> Topology of the cabling system
> Minimum system requirements
> Component specifications
> Choice of components
> Installation practices
> Testing the cabling system
> Administration & Management
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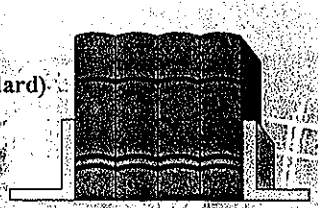
<<<< TIA/EIA Standard Documents >>>>



TIA/EIA 568-B.1 (Main Document)
(Commercial Building Telecommunications Cabling Standard)

TIA/EIA 568-B.2
(100 ohm Balanced Twisted-Pair Components)

TIA/EIA 568-B.3
(Optical Fibre components)

TIA/EIA 568-B.2-1
Category 6

TIA/EIA 569-A
(Commercial building standard for telecommunications pathways and spaces)

TIA/EIA 607-A
(Grounding and bonding requirements for telecommunications industry)

TIA/EIA 606-A
(Administration standard for telecommunications infrastructure)

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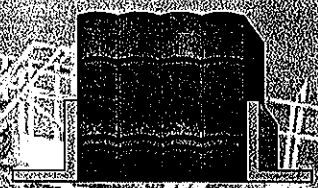
<<<< ISO/IEC Standard Documents >>>>



ISO/IEC 11801 AM-2
(Generic cabling for customer premises Standard)

ISO/IEC 14763-1
(Administration)

ISO/IEC 14763-2
(Planning and Installation)

ISO/IEC 14673-3
(Testing of Optical fiber cabling)

ISO/IEC 61935
(Test methods for Copper cabling)

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<<<<<<< TIA/EIA vs ISO/IEC >>>>>>>

- No coaxial or Category 5 cabling
- Screened (ScTP) cabling
- Category 5e cabling
  - Class D 2000
- 50/125 micron optical fibre cabling
- Small form factor optical fibre connectors
  - SC Duplex at the telecommunications outlet
- Open office and centralised optical fibre cabling
  - Not multi-user telecommunications outlet assembly
- Cabling installation requirements
  - ISO/IEC 14763
- Transmission performance and test requirements
  - Same characteristics, some detail differences

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<<<<<<< TIA/EIA vs ISO/IEC >>>>>>>

ISO/IEC 11801

- Allows 120Ω cable and STP-A cabling
- Backbone distances unchanged
- Work area plus cross-connect cords
  - Total 10 m for "interconnect", 9 m for cross-connect

Terminology

TIA/EIA 568-B	ISO/IEC 11801-2000
Main Cross Connect	Campus Distributor
Intermediate Cross Connect	Building Distributor
Horizontal Cross Connect / Telecommunications Room	Floor Distributor
Entrance Facility	Building Entrance Facility
Interbuilding Backbone	Campus Backbone
Intrabuilding Backbone	Building Backbone

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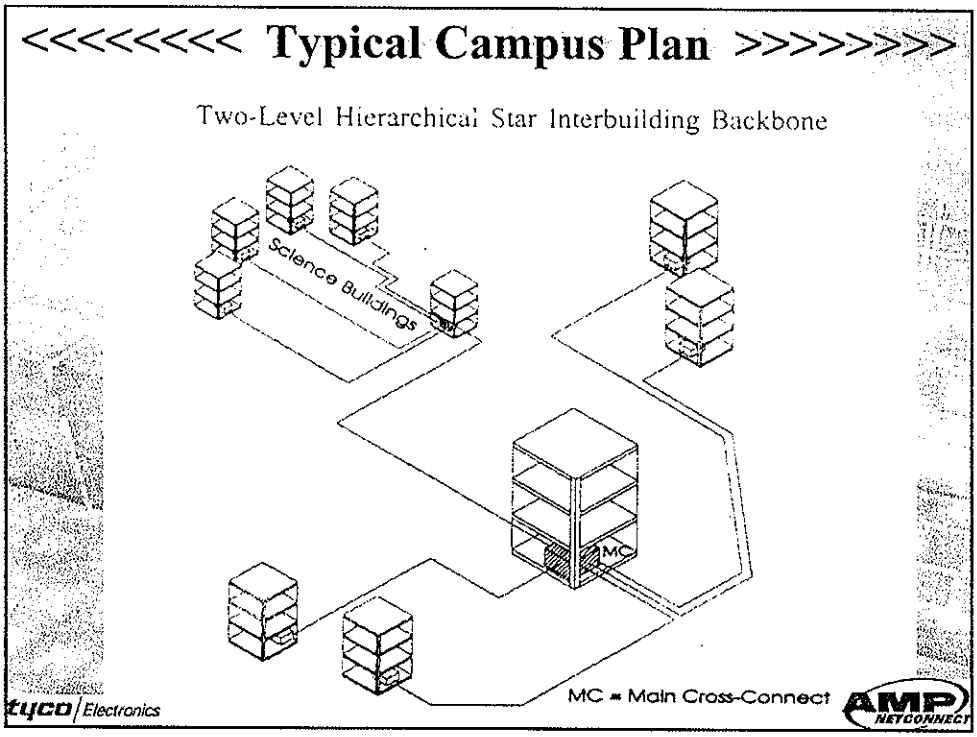
<<<<<<<< Typical Campus Plan >>>>>>>>
Two-Level Hierarchical Star Interbuilding Backbone
Science Buildings
MC
MC = Main Cross-Connect
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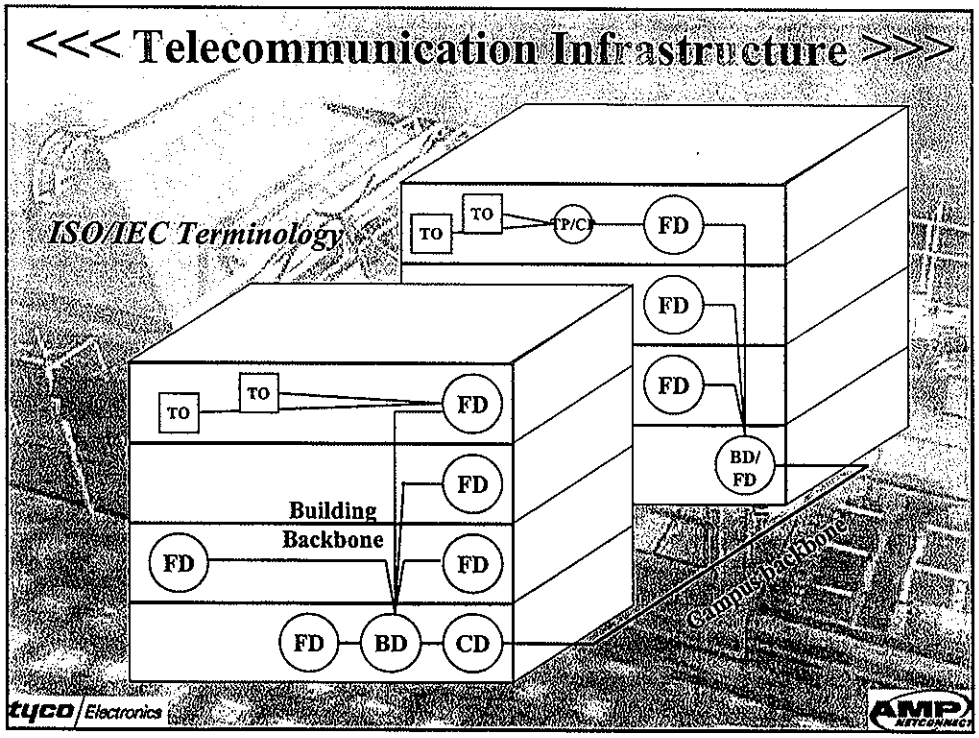
<<< Telecommunication Infrastructure >>>
ISO/IEC Terminology
TO
TP/CP
FD
BD/
FD
Building
Backbone
BD
CD
Campus backbone
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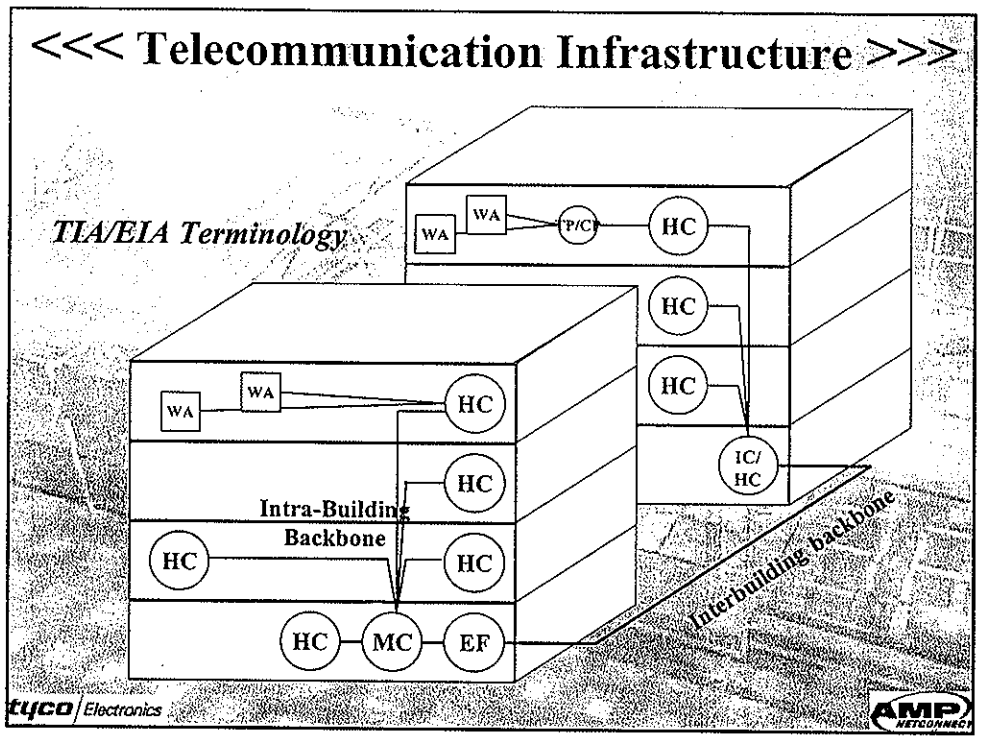
<<< Telecommunication Infrastructure >>>
TIA/EIA Terminology
WA
WA
P/C
HC
HC
HC
WA
WA
HC
HC
Intra-Building
Backbone
HC
HC
HC
MC
EF
IC/
HC
Inter-building backbone
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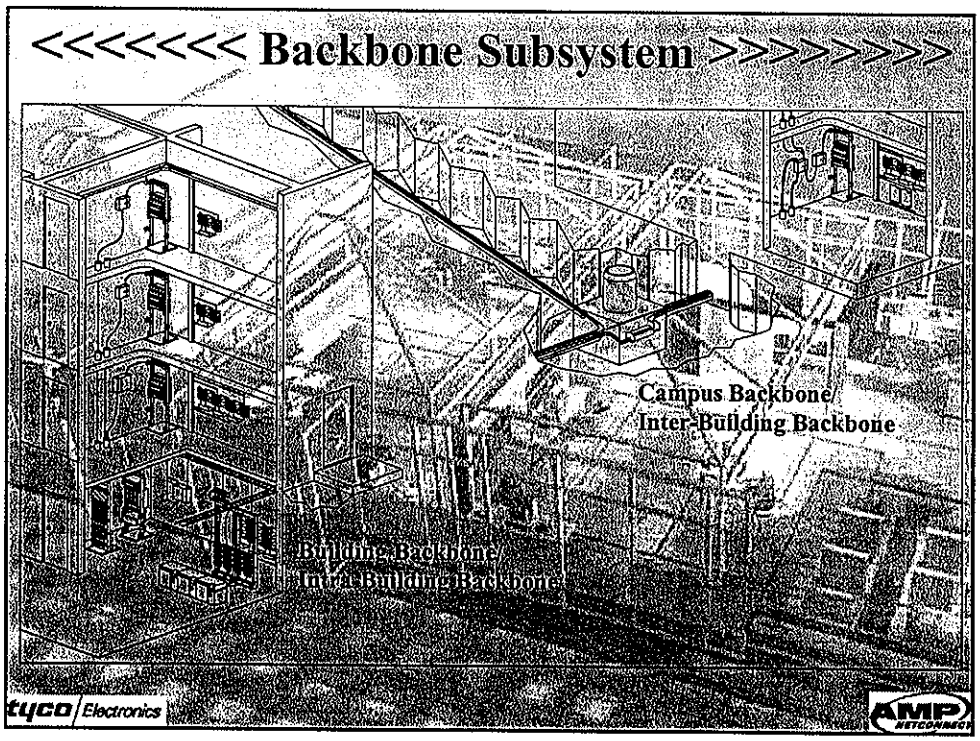
<<<<<<< Backbone Subsystem >>>>>>>
Campus Backbone/
Inter-Building Backbone
Building Backbone/
Intra-Building Backbone
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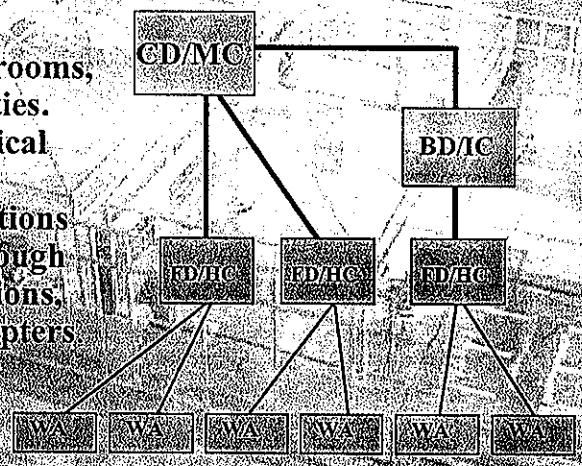
<<<<<<< Backbone Subsystem >>>>>>>

- To provide connectivity between telecommunication rooms, equipment rooms, and entrance facilities.
- Two-level hierarchical star.
- Non-star configurations accommodated through use of interconnections, electronics and adapters



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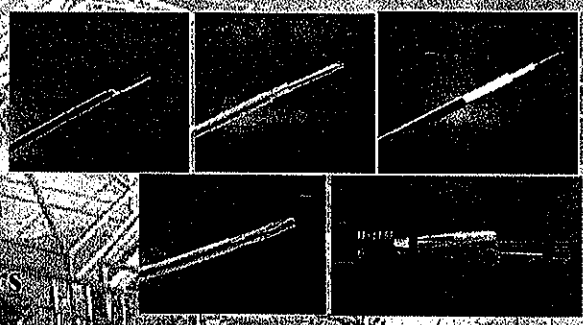
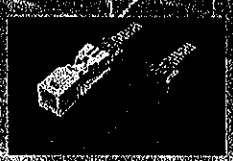
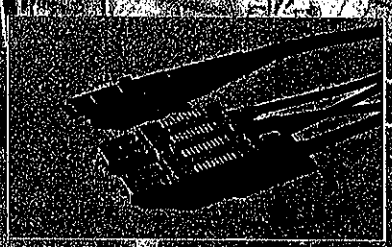
<<<<<<< Backbone Subsystem >>>>>>>

Fiber backbone considerations

- Indoor fiber
- Outdoor fiber
- Singlemode
- Multimode
  - 62.5/125µ
  - 50/125µ
- Fiber Connectors
  - SC Duplex
  - SMI e.g. MHRJ







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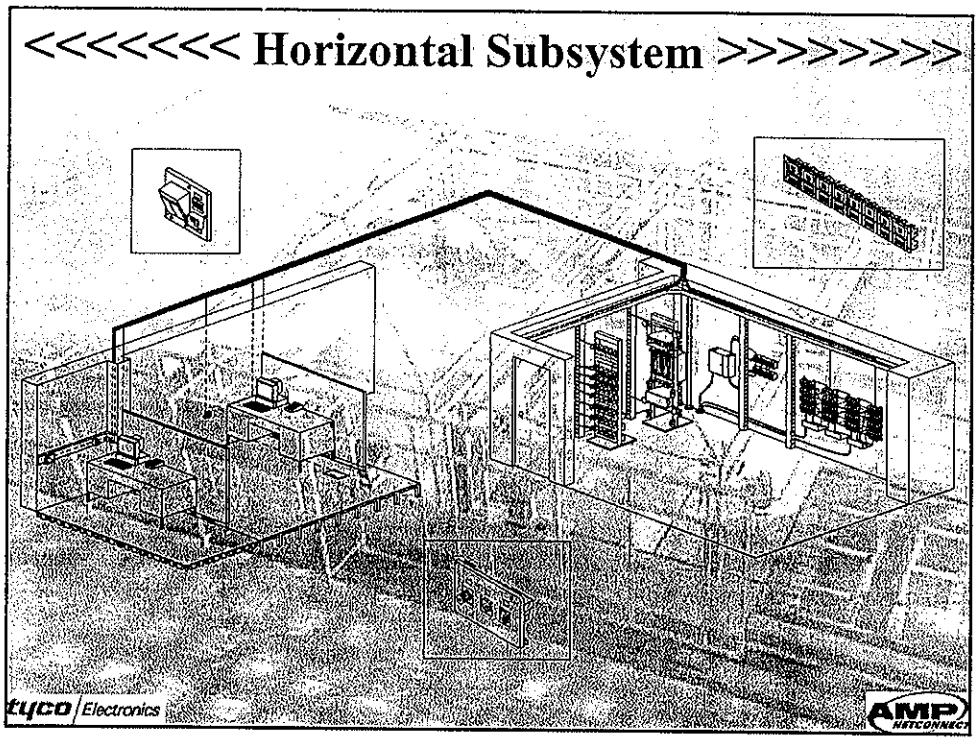
<<<<<<< Horizontal Subsystem >>>>>>>
tyco Electronics
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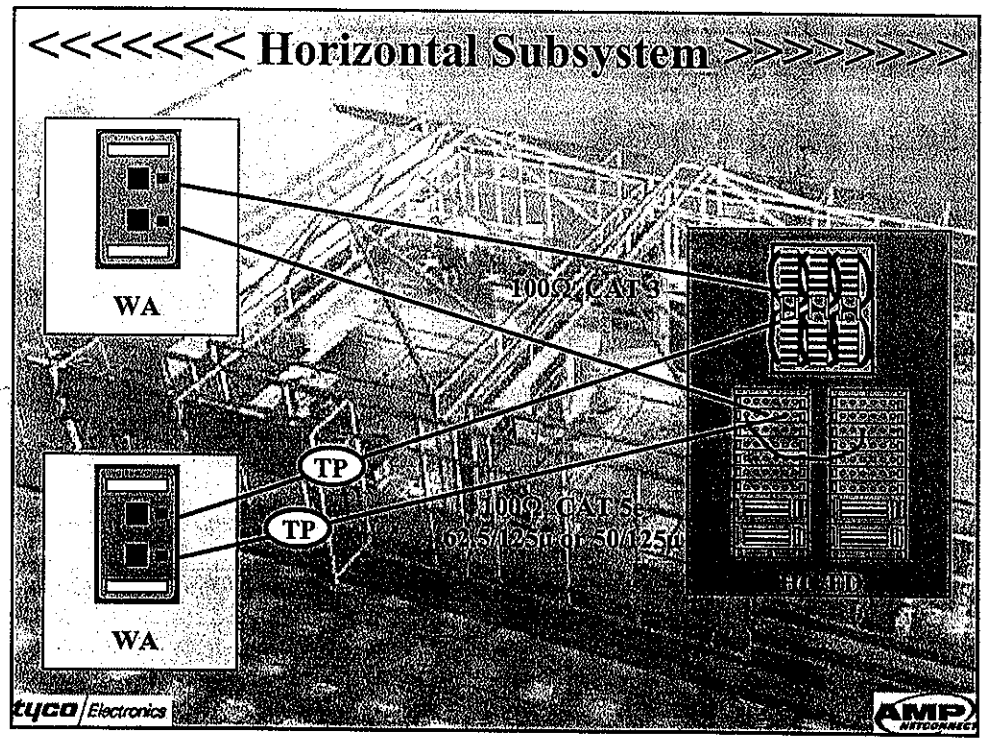
<<<<<<< Horizontal Subsystem >>>>>>>
WA
100Ω CAT 3
TP
TP
100Ω CAT 5
62.5/125µ or 50/125µ
WA
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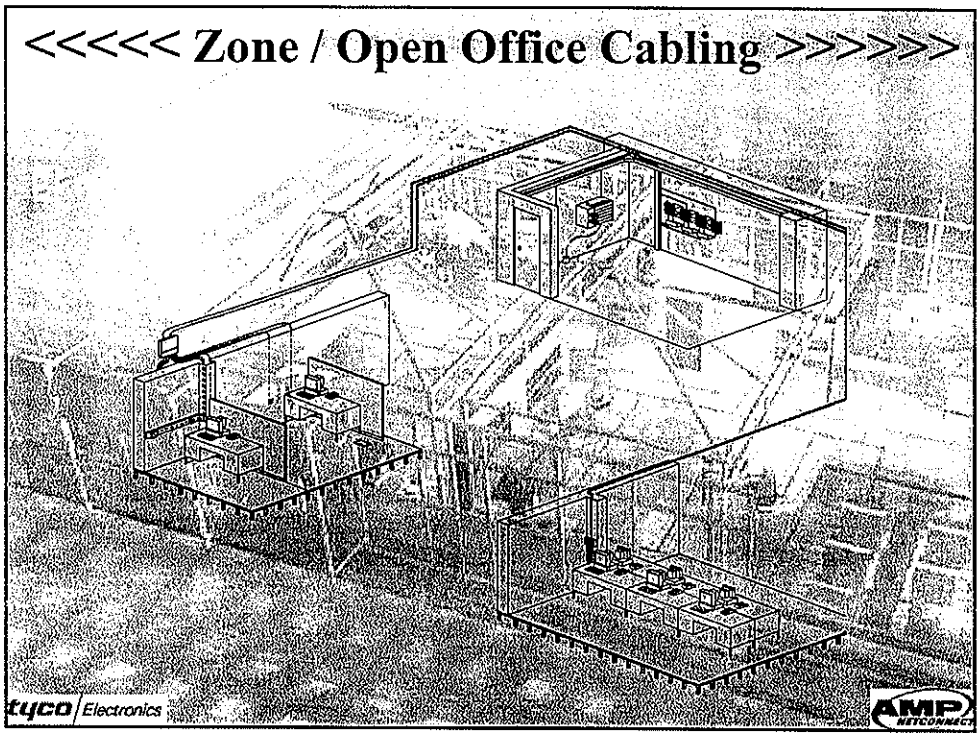
<<<<<< Zone / Open Office Cabling >>>>>>
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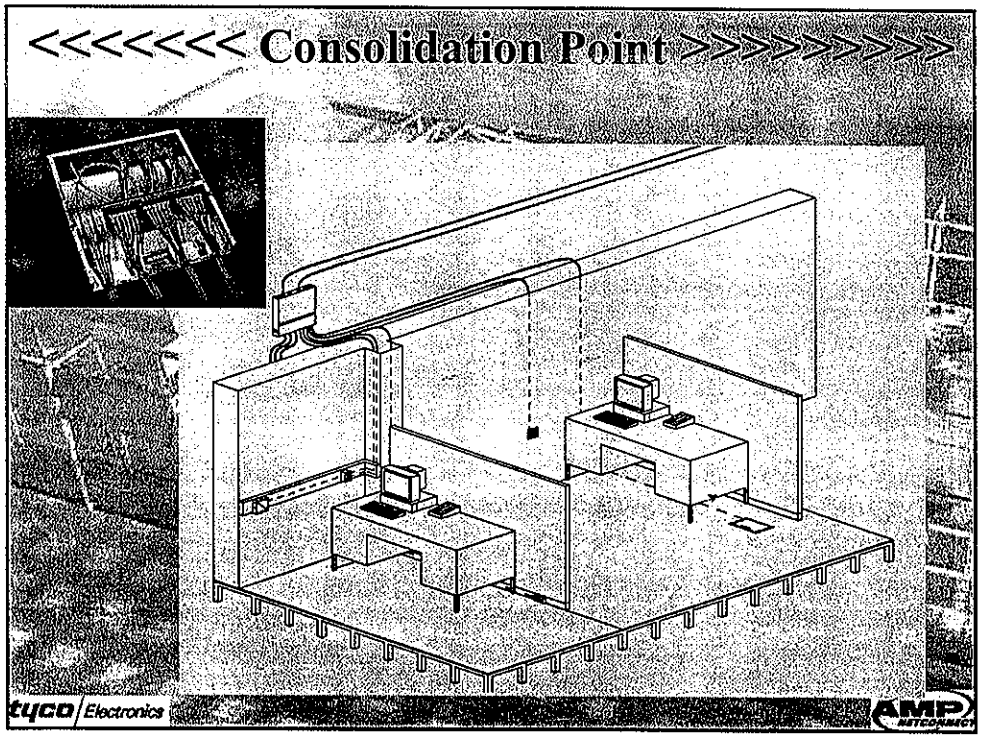
<<<<<<< Consolidation Point >>>>>>>>>
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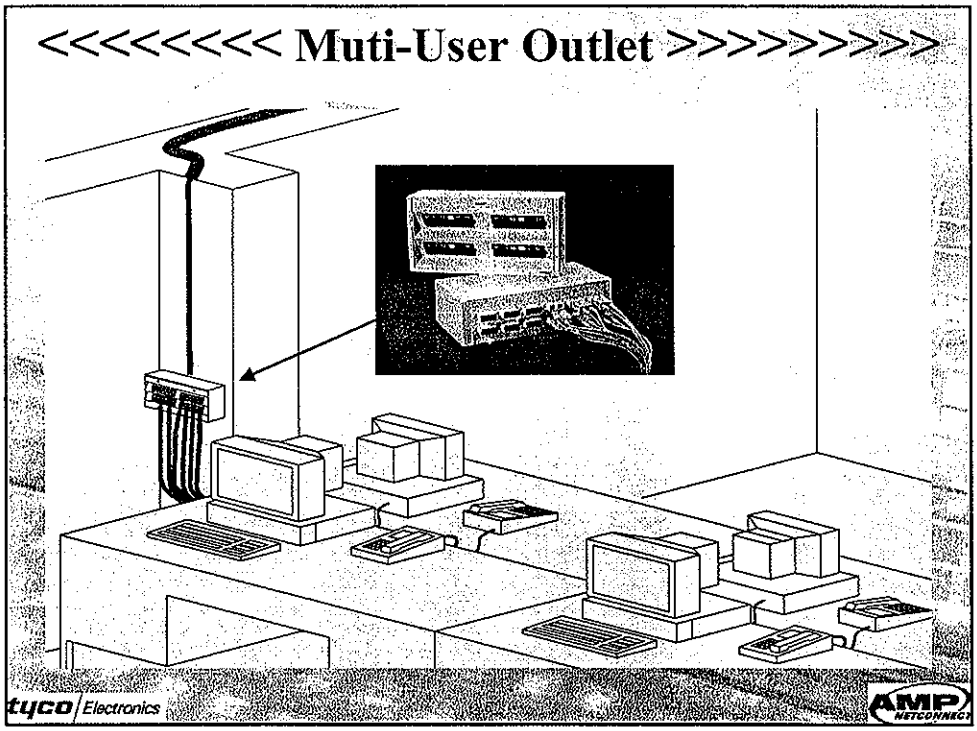
<<<<<<<< Muti-User Outlet >>>>>>>>>
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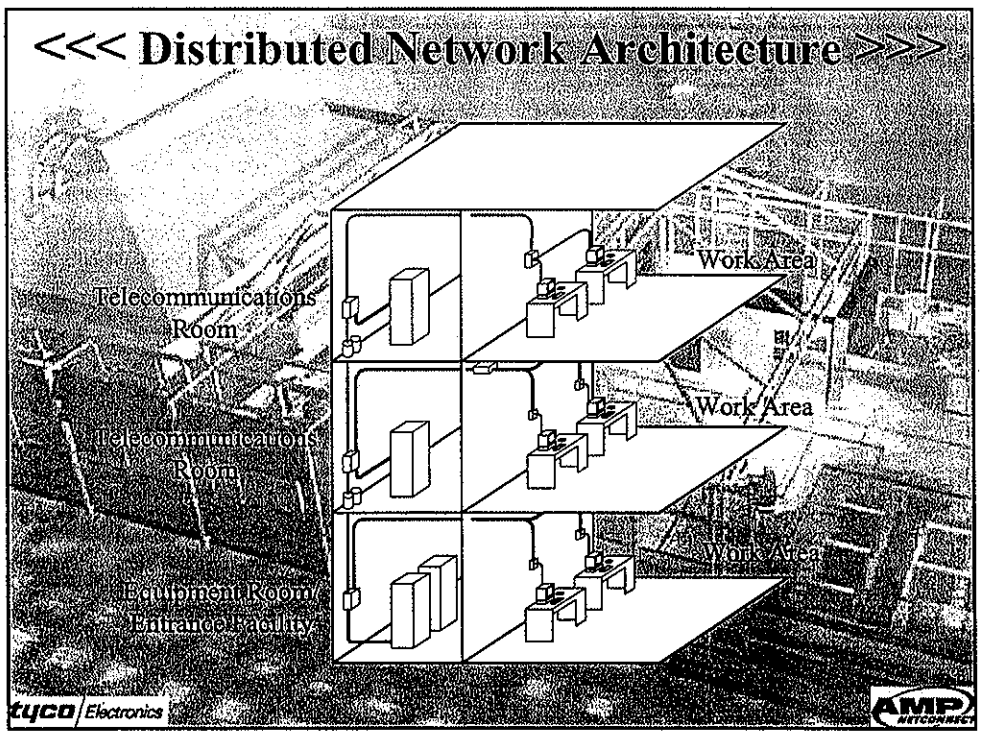
<<< Distributed Network Architecture >>>
Telecommunications Room
Telecommunications Room
Equipment Room/ Entrance Facility
Work Area
Work Area
Work Area
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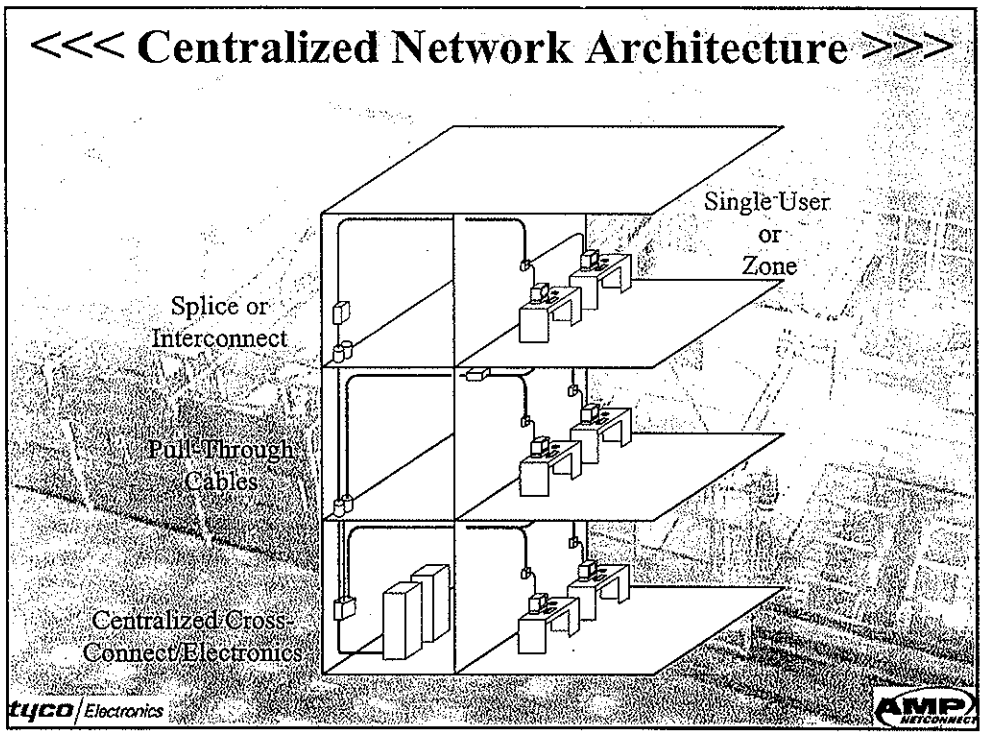
<<< Centralized Network Architecture >>>
Single User
or
Zone
Splice or
Interconnect
Pull-Through
Cables
Centralized Cross-
Connect/Electronics
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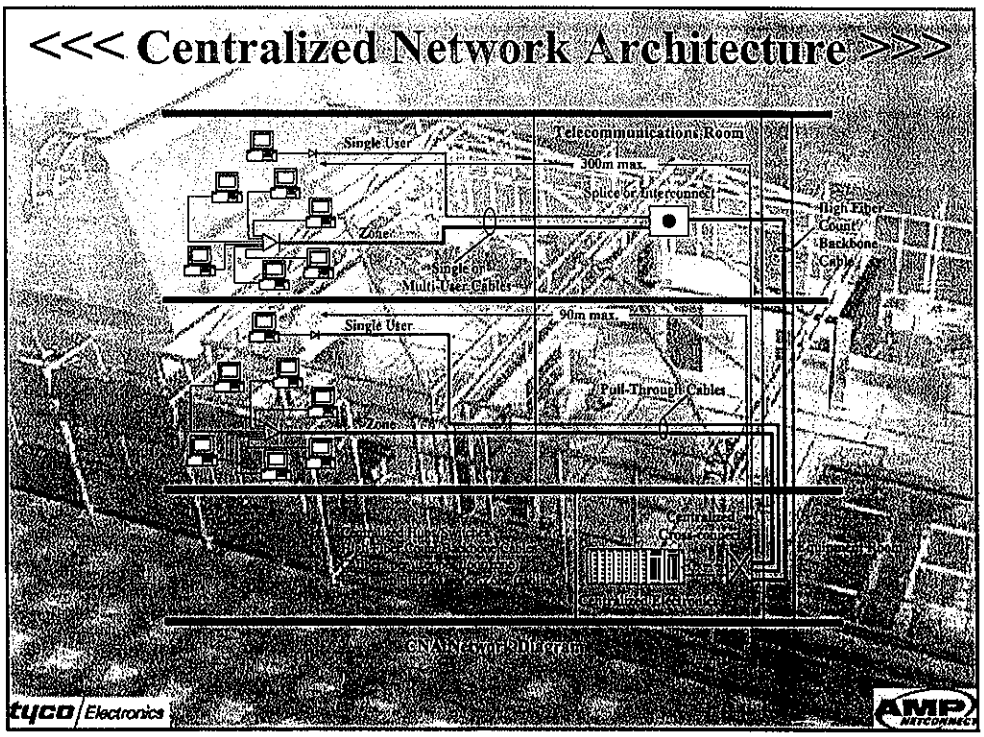
<<< Centralized Network Architecture >>>
Telecommunications Room
Single User
300m max.
Splice or Interconnect
High Fiber
Count
Backbone
Cable
Zone
Single or
Multi-User Cables
Single User
90m max.
Pull-Through Cables
Zone
Centralized
Cross-Connect
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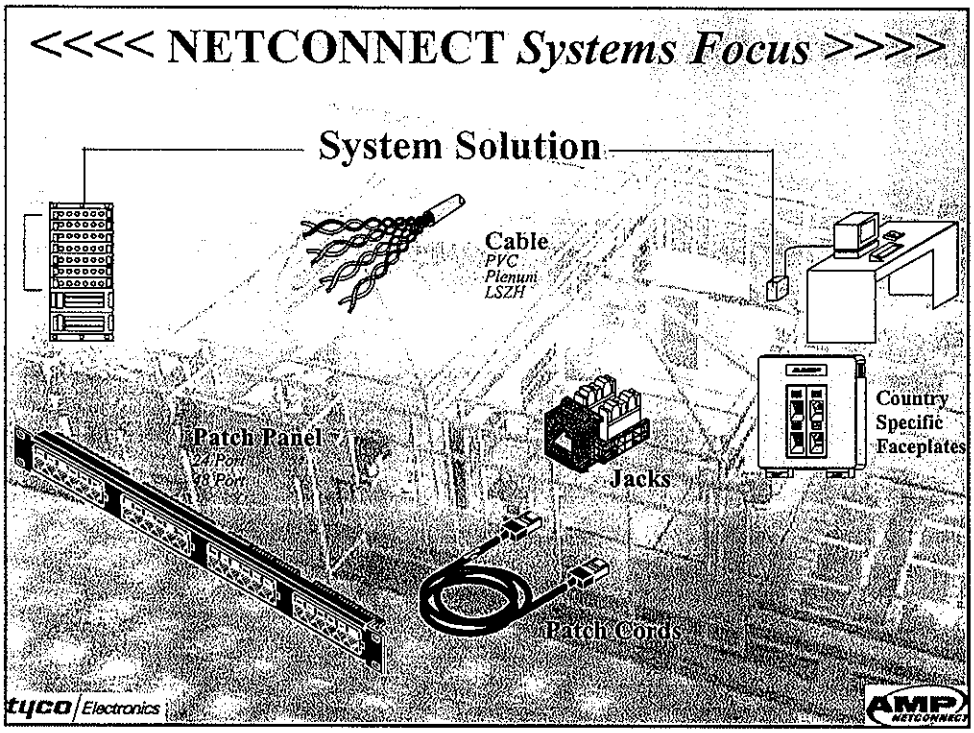
<<<< NETCONNECT Systems Focus >>>>
System Solution
Cable
PVC
Plenum
LSZH
Patch Panel
24 Port
48 Port
Jacks
Country
Specific
Faceplates
Patch Cords
tyco Electronics
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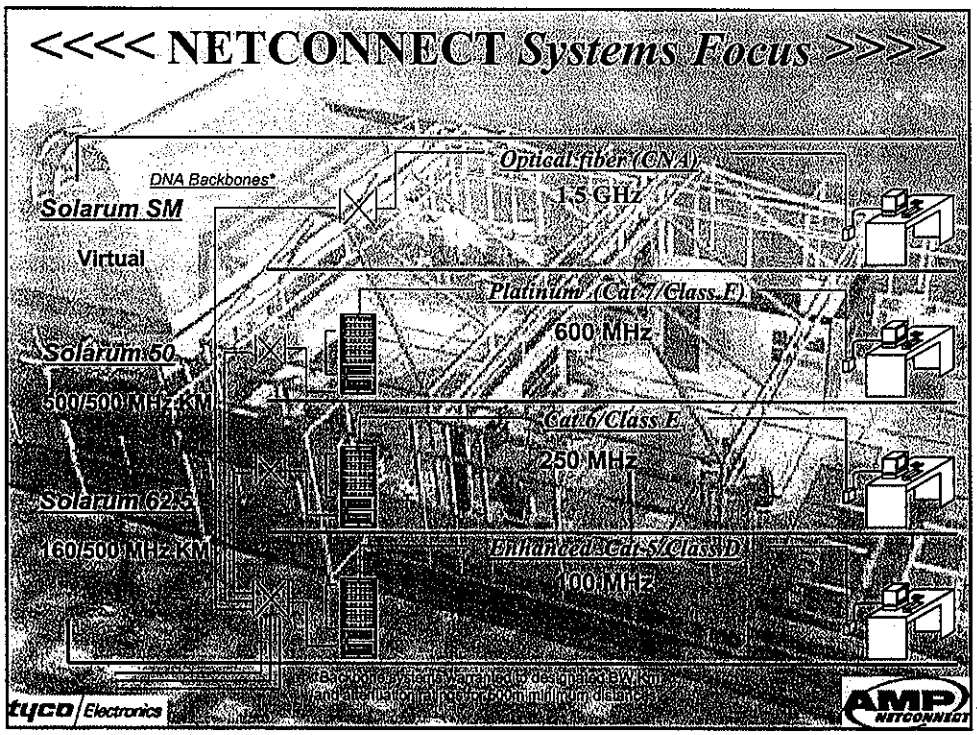
<<<< NETCONNECT Systems Focus >>>>
DNA Backbones*
Optical fiber (CNA)
1.5 GHz
Solarum SM
Virtual
Platinum (Cat.7/Class.F)
600 MHz
Solarum 50
500/500 MHz.KM
Cat.6/Class E
250 MHz
Solarum 62.5
160/500 MHz.KM
Enhanced Cat.5/Class D
100 MHz
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<<<<<<< Channel Specifications >>>>>>>

Standard	Specification	Frequency Range
ISO/IEC ISO/IEC	Class A Class B	up to 100 kHz up to1 MHz
TIA/EIA ISO/IEC	Cat 3 Class C	1 - 16 MHz
TIA/EIA ISO/IEC	Cat 5 Class D (1995)	1 - 100 MHz
TIA/EIA ISO/IEC	Cat 5e Class D (2000)	1 - 100 MHz
TIA/EIA ISO/IEC	Cat 6 Class E	1 - 250 MHz

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<<<<<<<<<< MHz vs. Mbps >>>>>>>>>>

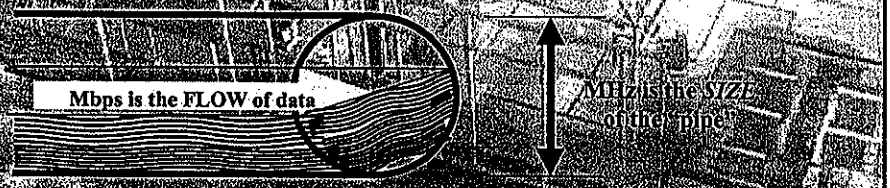
Bandwidth (MHz) is:

- The frequency range across which components and systems are specified
- Not based on a particular application or data rate

Data Rate (Mbps) is:

- How fast you can pump data through a system with a given bandwidth
- Dependent on the application and encoding scheme

Example:



Maximum flow is limited by size and pressure

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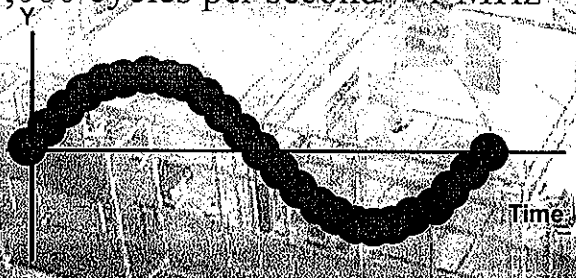
<<<<<<<< Bandwidth - Hertz >>>>>>>>

- The frequency range across which components and systems are specified in cycles per second.
- 1 cycle per second = 1 hertz (Hz)
- 1,000,000 cycles per second = 1 MHz



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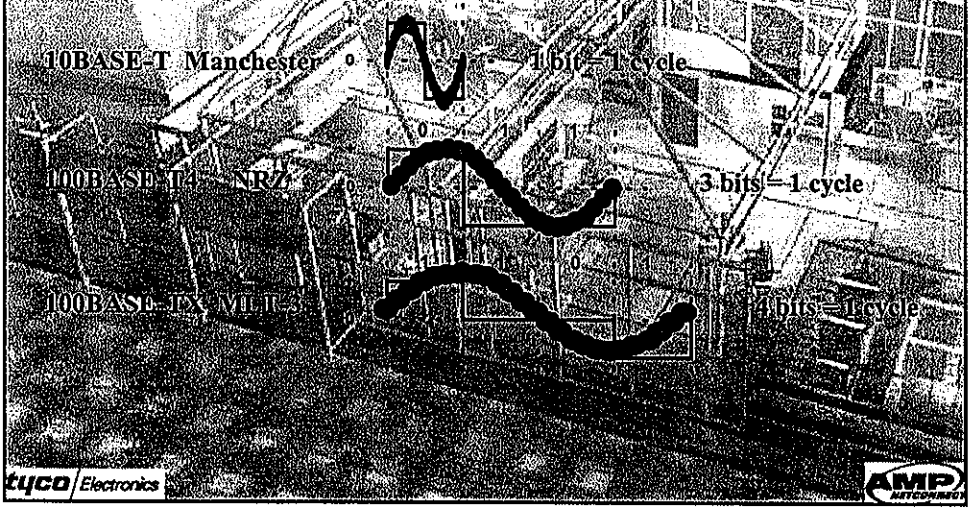
<<<<<<< Data Rate - Bits per sec >>>>>>>

- **The number of 'bits' (binary digits) transmitted per second.**
- **Dependent on the standard coding scheme for the application**
- **1,000,000 bits per second = 1 Mbps**



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<<<< Cat 5 and Cat 5e – Bottom Line >>>>

- Cat 5 is *not* recommended in TIA/EIA-568-B.
  - *It's been relegated to an annex..*
- Cat 5e/Class D (2000) is the minimum recommendation for data cabling in TIA/EIA-568-B and ISO/IEC 11801:2000.
- 80% of Cat 5/Class D (1995) installations will run Gigabit Ethernet.
  - *But maybe with only two connectors (IEEE optimized channel)*
- Cat 5e/Class D (2000) provides the extra margin required for Gigabit Ethernet on four connector channels.
- TIA Cat 5e and ISO/IEC Class D (2000) are equivalent.

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<<< Why Category 6/Class E Cabling? >>>

- Operating margin over Gigabit Ethernet needs
  - *Robust system*
- Future-proof
  - *Twice as much bandwidth as Cat 5 and Cat 5e*
  - *Possibility of higher-speed applications in the future*
- Lower cost LAN electronics are possible
  - *Utilize bandwidth to design more cost effective electronic solutions*
- Must establish an installed base of Category 6/Class E before LAN applications are designed for this performance

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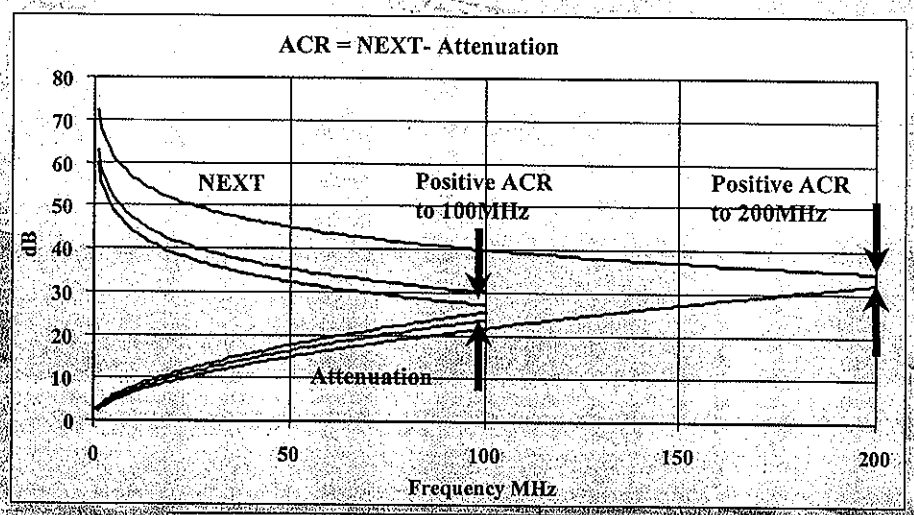
<<<<< Channel Performance (ACR) >>>>>



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One Industry Expert's Prediction

<<<<<<<<<< Gartner Group >>>>>>>>>>

"Bottom Line: Economic factors and the long-term nature of cabling solutions point to a rapid transition to Category 6. As the price differential between Category 6 and Category 5e continues to decline, Category 6 becomes a more attractive alternative. By 2003, 90% of all new enterprise copper cabling installations will be based on Category 6 (0.8 probability)."

"Category 5e or Category 6 Cabling — Which to Bet On?"
SPA-10-3158 Research Note - March 2000

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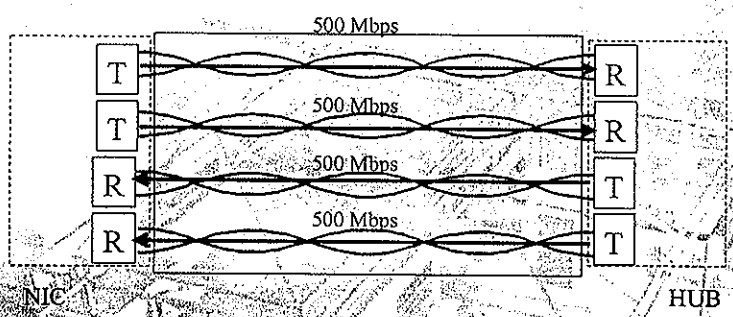
<<< TIA SP-4657 GE on Cat 6/Class E >>>



- A full duplex Ethernet physical layer specification for 1000 Mbps operating over Category 6 balanced twisted pair (1000 Base-TX); Draft – 4 November 2000
- Increased Cat 6 bandwidth (250MHz) allows for possible use of a single-direction 500Mbps signal.
  - Eliminates need for echo canceller
  - Eliminates need for NEXT canceller
  - Overall silicon count can be cut by 50%

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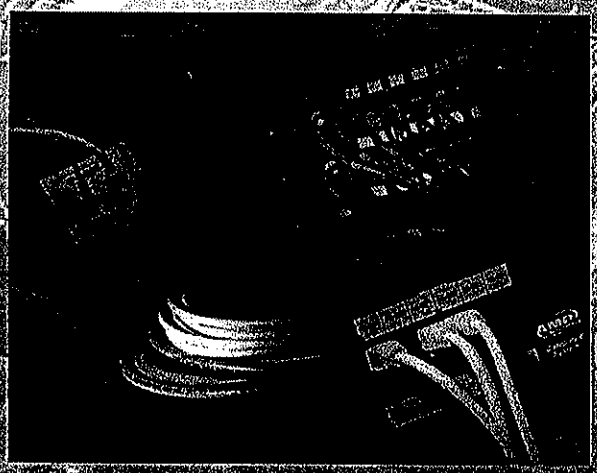
<< AMP Netconnect Cat 6 UTP System >>



- Available from March 2001
- Replaces AMP-NETCONNECT Quantum System
- To meet newly defined component (jack/plug) specifications
- Increased channel and link performance
- Exceeds draft Category 6 component specifications
- New form factor for jacks and patch panels

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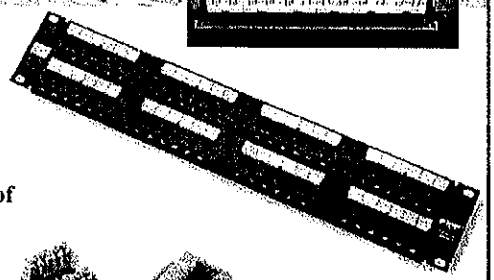
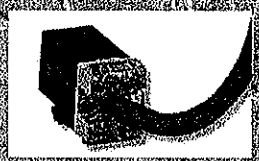
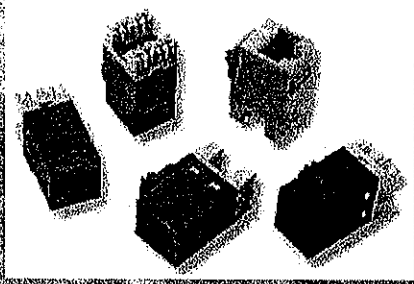
<<< Category 6 Jack and Patch Panel >>>>

- New punchdown orientation
- Smaller form-factor increasing density for outlets
- Patch panel uses pre-loaded jacks for equal performance at both ends of the channel
- Patch panel retains same density as Category 5 and 5e
- Jack exceeds component requirements of draft TIA Category 6 specification









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<<<<<< Netconnect Cat 6 Cables >>>>>>



- New cable design
  - Round
  - Center filler & Star filler design available
- Non-bonded conductors
- Increased performance without sacrificing installability
  - Flexible
  - Light weight
  - No special stripping tools

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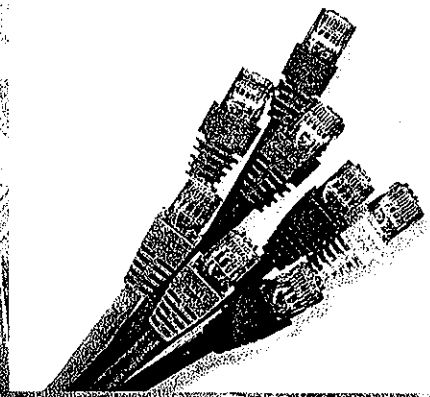
<<< Category 6 Patch Cable Assemblies >>>

- Designed to provide optimum performance when combined with AMP NETCONNECT Cat 6 jacks, panels and cable
- Flexible, robust stranded cable
- Color matched snagless boots
- ½ Ft. to 50 ft. lengths



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<<<<<<<<<< The Channel >>>>>>>>>>



- The most important performance characteristics are those of the *channel*. The channel numbers represent the performance of the entire cabling system.

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<<<<<<< Channel Performance >>>>>>>

- In order to be Cat 6 compliant, the entire cabling system must meet all of the requirements when configured in the worst-case configuration.
- The worst-case configuration allowed by the TIA is the 100-meter, 4-connector channel.
- On March 5, 2001 Intertek Testing Services tested AMP NETCONNECT plenum and non-plenum channels constructed from production Category 6 products.
- The following slides show the absolute worst performance at each frequency point from those tests.

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AMP Netconnect Cat 6 Channel Performance

Freq. MHz	Attenuation, dB		Return Loss, dB		NEXT, dB		PSNEXT, dB	
	Spec	AMP	Spec	AMP	Spec	AMP	Spec	AMP
1	2.1	2.0	19.0	26.0	65.0	83.1	62.0	80.9
4	4.0	3.8	19.0	28.0	63.0	75.9	60.5	72.6
8	5.7	5.4	19.0	27.8	58.2	67.3	55.6	66.0
10	6.3	6.1	19.0	28.2	56.6	66.0	54.0	64.8
16	8.0	7.7	18.0	28.6	53.2	64.7	50.6	63.0
20	9.0	8.7	17.5	25.7	51.6	60.4	49.0	58.7
25	10.1	9.7	17.0	25.5	50.0	59.8	47.3	56.7
31.25	11.3	10.9	16.5	26.9	48.4	60.0	45.7	57.4
62.5	16.5	15.7	14.0	24.2	43.4	52.1	40.6	50.7
100	21.4	20.2	12.0	20.4	39.9	50.4	37.1	48.4
200	31.5	29.2	9.0	18.2	34.8	44.4	32.0	42.6
250	36.0	33.2	8.0	15.2	33.1	41.3	30.3	39.3

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AMP Netconnect Cat 6 Channel Performance

Freq. MHz	ELFEXT, dB		PSELFEXT, dB		ACR, dB		PSACR, dB	
	Spec	AMP	Spec	AMP	Spec	AMP	Spec	AMP
1	63.3	73.6	60.3	72.3	62.9	81.2	59.9	79.0
4	51.2	63.4	48.2	62.2	59.0	72.4	56.5	69.1
8	45.2	58.8	42.2	57.6	52.5	62.3	49.9	60.8
10	43.3	57.3	40.3	56.3	50.3	60.2	47.7	59.1
16	39.2	56.8	36.2	55.2	45.2	57.6	42.6	55.3
20	37.2	55.5	34.2	53.7	42.6	52.2	40.0	50.1
25	35.3	53.3	32.3	51.0	39.9	50.6	37.2	47.6
31.25	33.4	50.6	30.4	48.0	37.0	49.7	34.3	46.5
62.5	27.3	43.0	24.3	41.1	26.9	37.2	24.1	35.3
100	23.3	40.0	20.3	39.0	18.6	31.6	15.8	28.4
200	17.2	33.3	14.2	31.7	3.3	16.4	0.4	14.4
250	15.3	27.5	12.3	27.2	-2.9	9.5	-5.8	7.5

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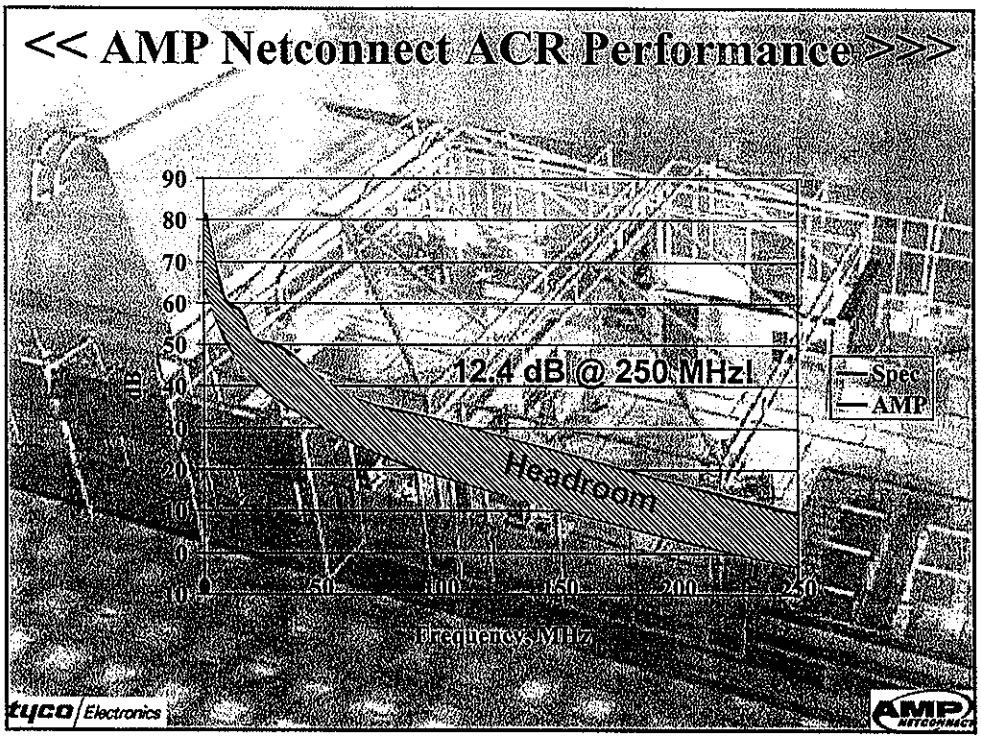
<< AMP Netconnect ACR Performance >>>



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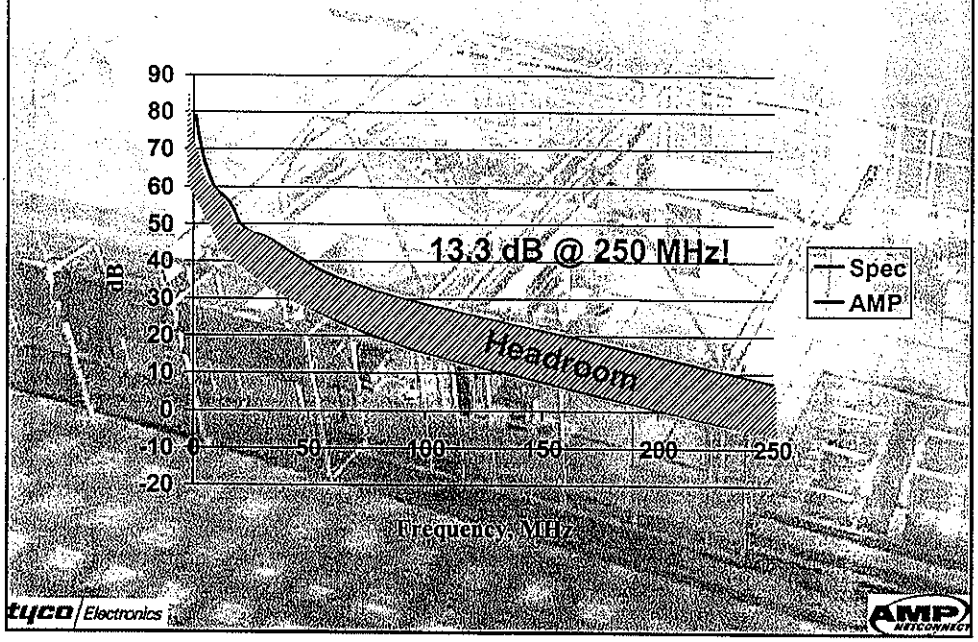
AMP NETCONNECT

AMP NETCONNECT PSACR Performance



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<<<<<< Why a System Approach ? >>>>>>

- Piecemealing cabling infrastructure components is no longer a viable approach to delivering reliable, high performance networks
- The entire system must be evaluated as a whole to ensure the best performance
- The AMP NETCONNECT Category 6 System has been independently tested to confirm 250 MHz bandwidth performance
- Customers attempting to assemble cabling systems through so-called 'best of breed' components are not guaranteed the best system performance levels

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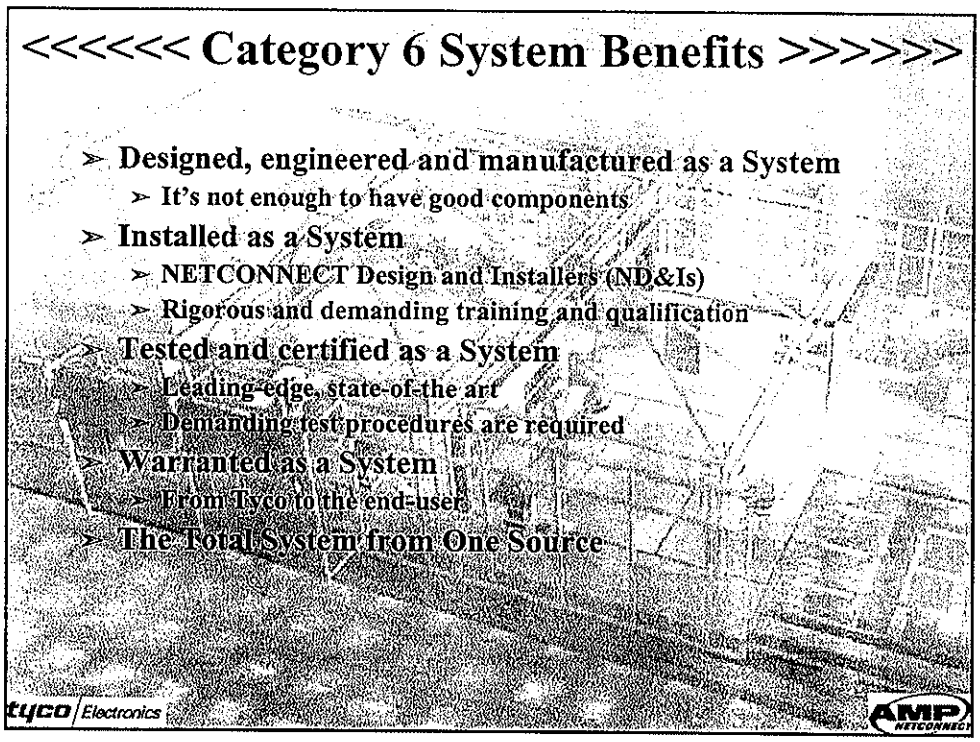
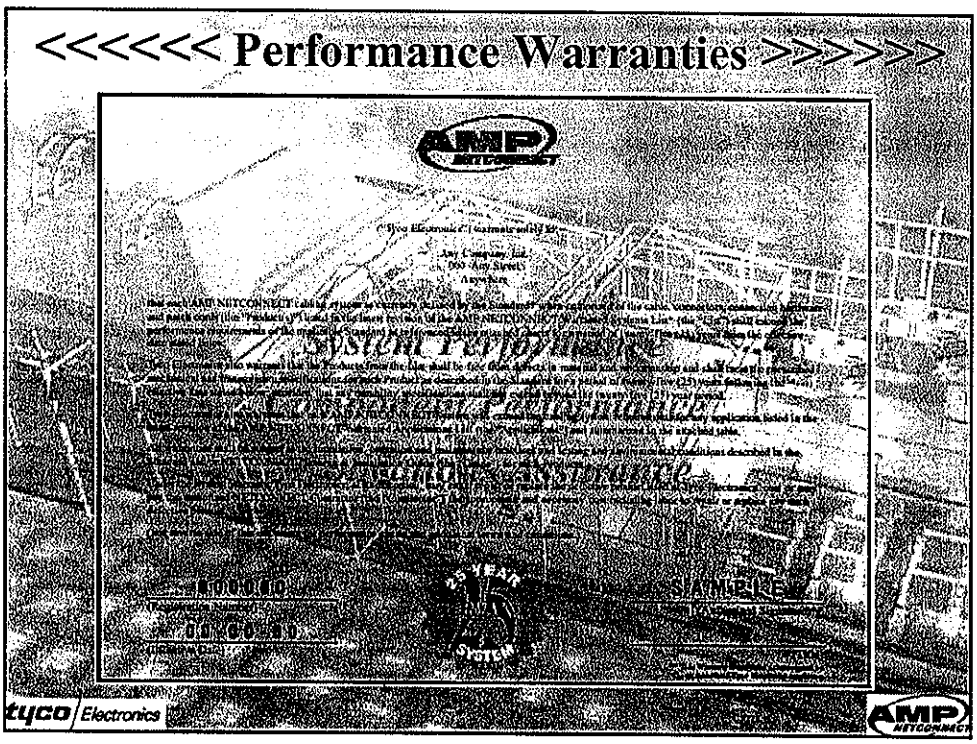

<<<<<< Category 6 System Benefits >>>>>>
➢ Designed, engineered and manufactured as a System
➢ It's not enough to have good components
➢ Installed as a System
➢ NETCONNECT Design and Installers (ND&Is)
➢ Rigorous and demanding training and qualification
➢ Tested and certified as a System
➢ Leading-edge, state-of-the art
➢ Demanding test procedures are required
➢ Warranted as a System
➢ From Tyco to the end-user
➢ The Total System from One Source
tyco Electronics
AMP NETCONNECT


<<<<<< Performance Warranties >>>>>>
AMP NETCONNECT
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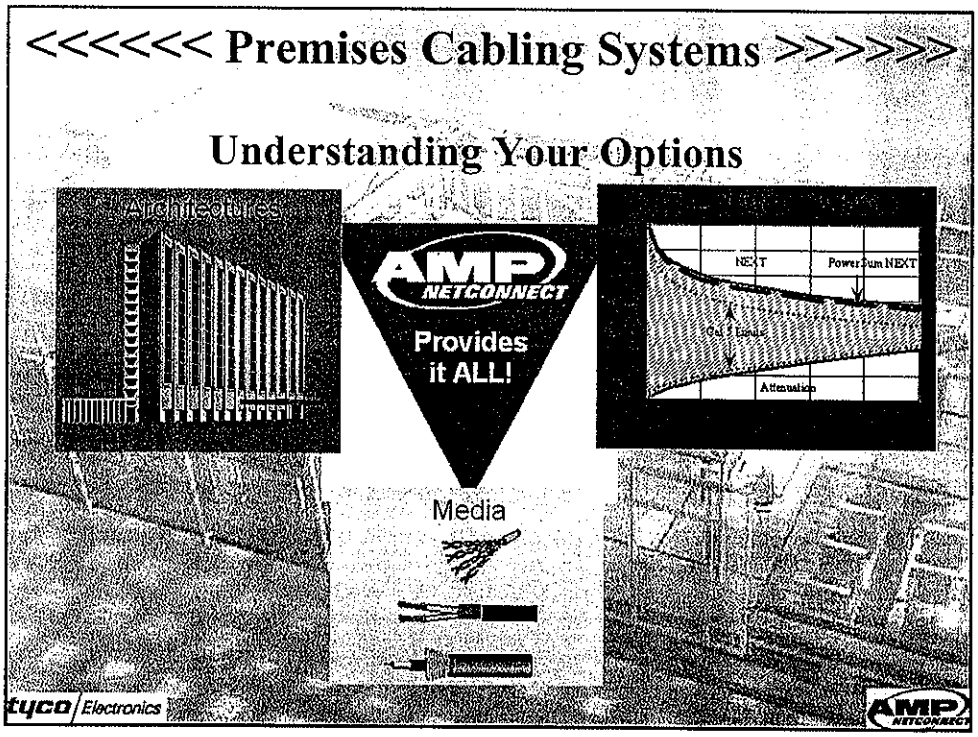
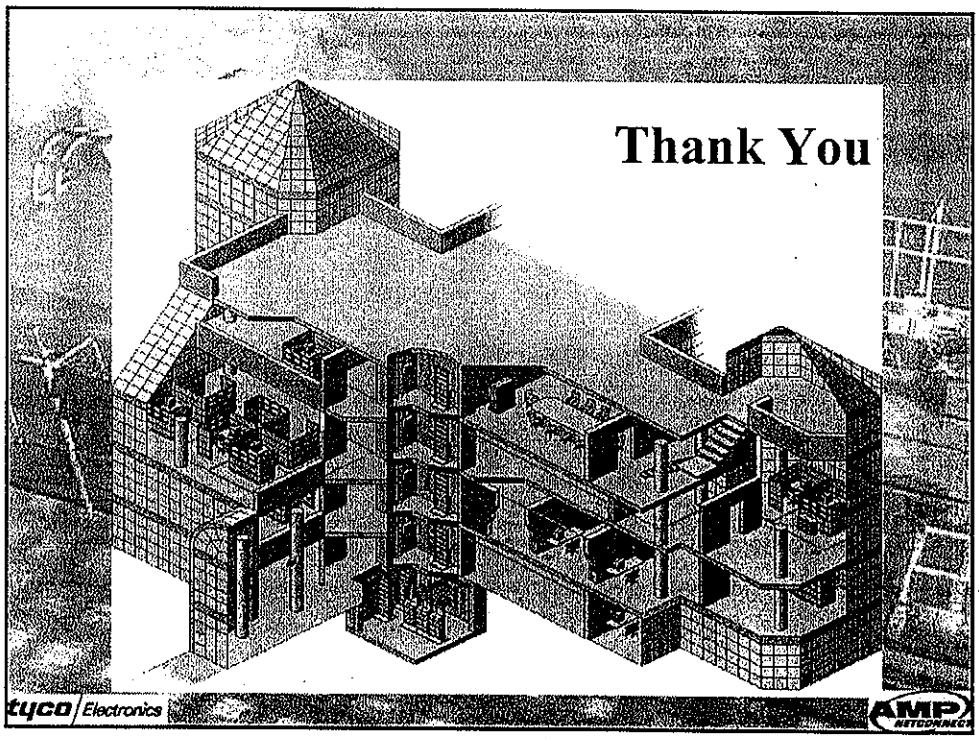
AMP NETCONNECT


<<<<<< Premises Cabling Systems >>>>>>
Understanding Your Options
Architectures
AMP NETCONNECT
Provides it ALL!
Media
NEXT
Power Sum NEXT
Attenuation
tyco Electronics
AMP NETCONNECT


Thank You
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AMP NETCONNECT



CHAPTER 4

LAN and Internetwork Cabling

De Facto vs. De Jure Standards

Structured Cabling Standards Organizations

Overview of Telecommunications Cabling Standards

ANSI/TIA/EIA-568-A

Unshielded Twisted-Pair (UTP) Cabling Systems

Shielded Twisted-Pair (STP) Cabling Systems

Optical Fiber Cabling Systems

International Standard ISO/IEC 11801

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De Facto vs. De Jure Standards

Introduction

The computing environment has always been an area of rapid growth, especially since the introduction of the personal computer (PC). A revolutionary new innovation seems to surface every six to nine months. These new technologies are often proprietary in nature—the developer of the technology holds all claims to its ownership.

While proprietary products and systems can perform their tasks as expected, they may prove to be difficult to work with when changes, updates, and interoperability with other components are required. This is a problem that has plagued the PC industry from its beginnings and subsequently has become a problem in the local area network (LAN) environment as well.

In the early days of personal computing, a particular printer was purchased because it worked with a particular PC—not necessarily because it was the best printer. When individuals who were not PC hobbyists began buying PCs in large numbers for business use, they demanded greater choice as consumers. It was only then that product compatibility became an issue.

Significant improvements have been made regarding compatibility. Unfortunately, in any industry predominated by new technologies, there is always an ongoing problem getting devices made by different vendors to work together.

The improvements that have been made, and are continuing to be made, can be largely attributed to the existence of standards. Putting clearly defined guidelines into place can significantly decrease the problem of incompatibility.

LAN components are not yet at the point where they will all work readily with each other. It is hoped that at some point in the future, installing LAN components will be like buying a home appliance—not bought because it alone has the one type of electrical plug that is needed to connect to the electrical outlets found at home. It is not necessary to replace an appliance when a move is made to a new home—the new home has compatible electrical outlets. For LAN components, such an environment would greatly simplify upgrades and changes to the network—changing one component would not require changing others.

De Facto Standards

A *de facto* standard is created every time buyers accept and continue to purchase given products in large quantities.

One common example of a *de facto* standard is the layout of keys on a computer keyboard.

If enough people like a particular product and keep buying it, the product is considered to be a *de facto* standard in its category.

De Jure Standards

De jure standards come into existence in a much more formal manner.

Typically, a committee is formed. This committee is made up of knowledgeable members from the industry. They meet on a regular basis, develop opinions and draft documents, vote, and eventually produce a publication that details the standard. Such committees are found in every industry and at all levels of government.

NOTE: *The National Electrical Code®* (*NEC®*) in the United States for wiring is one example of a *de jure* standard.

In the computer industry, vendors take active steps to have their products adopted as standards, *de facto* or *de jure*. Many technologies are rejected, either by buyers or by standards committees, but many are adopted.

A standard permits a buyer to obtain a given product from a variety of vendors with few worries about compatibility.

The PC industry today has thousands of vendors. Although some of these vendors are very large companies, no single one exercises absolute control over standards in any segment of the market. In the PC industry, constant innovation and customer satisfaction are the only guarantees for growth and long-term success.

With the reassurance of standards, both *de facto* and *de jure*, many organizations have adopted LANs as their primary computing environment. For an organization, the ability to add devices to the LAN as needed and the availability of a wide variety of low-cost compatible equipment make LANs attractive. For employees, a PC provides the flexibility to choose from a wide variety of popular software. They gain all of the benefits of a minicomputer or mainframe environment—access to centralized data, security, centralized backups, and software support—while at the same time keeping control of the operations of their own PCs.

The next section presents the organizations responsible for *de jure* standards for LAN cabling systems.

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Structured Cabling Standards Organizations

American National Standards Institute (ANSI)

ANSI is a United States-based national organization founded in 1918. It is responsible for the coordination, formalization, and adoption of U.S. national standards. It also represents the United States at gatherings where international standards are formulated, such as the International Organization for Standardization (ISO).

For example, upon its adoption, the EIA/TIA-568 *Commercial Building Telecommunications Cabling Standard* was forwarded to ANSI, which approved it as ANSI/EIA/TIA-568, an American National Standard. This document was reissued in 1995 as ANSI/TIA/EIA-568-A.

Electronics Industries Alliance (EIA)

EIA is a trade organization for manufacturers in the electronics industry. Its function is to set standards for use by its member organizations.

One of the groups of standards established by EIA is the EIA Interface. This is a set of signal characteristics—time, duration, voltage, and current—to standardize the physical transfer of information between different electronic devices. These devices include printers, modems, and computers. A well-known EIA interface is the EIA-232 (formerly RS-232).

Telecommunications Industry Association (TIA)

The TIA was formed in April 1988 through a merger between the United States Telecommunications Suppliers Association (USTSA) and the Electronics Industries Alliance's (formerly Association) Information and Telecommunications Technologies Group (EIA/ITTG).

TIA represents the telecommunications sector of the EIA. It works with EIA industry groups and divisions developing technical standards. Its best known standards are ANSI/TIA/EIA-568-A—*Commercial Building Telecommunications Cabling Standard*; ANSI/TIA/EIA-569-A—*Commercial Building Standard for Telecommunications Pathways and Spaces*; ANSI/EIA/TIA-570-A—*Residential and Light Commercial Telecommunications Wiring Standards*; ANSI/TIA/EIA-606—*Administration Standards for the Telecommunications Infrastructure of Commercial Buildings*; and ANSI/TIA/EIA-607—*Commercial Building Grounding and Bonding Requirements for Telecommunications*, all described in the following pages.

Canadian Standards Association (CSA)

The CSA is a nonprofit, independent organization operating a listing service for electrical and electronic materials and equipment destined for use in Canada.

The CSA also has the responsibility for developing and publishing the Canadian equivalents of the ANSI/TIA/EIA telecommunications standards. For telecommunications cabling systems, the CSA and the ANSI/TIA/EIA cabling-related standards discussed in this chapter were co-developed.

These U.S. standards and their Canadian counterparts are as follows:

Table 4.1
ANSI/TIA/EIA telecommunications cabling standards and their CSA counterparts

ANSI/TIA/EIA Standard	CSA Standard
ANSI/TIA/EIA-568-A	CSA T529
ANSI/TIA/EIA-569-A	CSA T530
ANSI/EIA/TIA-570-A	CSA T525
ANSI/TIA/EIA-606	CSA T528
ANSI/TIA/EIA-607	CSA T527

These documents are described later in this chapter.

International Organization for Standardization/International Electrotechnical Commission (ISO/IEC)

ISO/IEC together form a specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of international standards through joint technical committees. These committees are established to deal with particular fields of technical activity. ISO/IEC technical committees collaborate in fields of mutual interest. Other international organizations, together with ISO/IEC, also take part in the work.

In the area of information technology, ISO and IEC have established a joint technical committee—ISO/IEC JTC 1. The International Standard ISO/IEC 11801—*Generic Cabling for Customer Premises*—was prepared by the Joint Technical Committee ISO/IEC JTC 1/SC 25/WG 3—Interconnection of Information Technology Equipment/Customer Premises Cabling.

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Overview of Telecommunications Cabling Standards

History

Until 1985, there was a lack of standards for building telecommunications cabling systems. At that time, the Computer Communications Industry Association (CCIA) requested the EIA to develop a standard for building telecommunications cabling systems.

EIA accepted the request and assigned the project to Engineering Committee TR-41. The TR-41 Committee established the following working groups to develop building telecommunications cabling system standards.

- TR-41.7.2 Working Group for Grounding and Bonding
- TR-41.7.3 Working Group on Electromagnetic Compatibility Considerations
- TR-41.8.1 Working Group on Commercial and Industrial Building Wiring Standard
- TR-41.8.2 Working Group on Residential and Light Commercial Building Wiring Standard
- TR-41.8.3 Working Group on Telecommunications Pathways and Spaces, and on Telecommunications Administration
- TR-41.8.4 Working Group on Backbone Cabling Systems for Residential and Light Commercial Buildings
- TR-41.8.5 Working Group for Definitions

In November 1998, the TR-41.8 subcommittee was reorganized to form the new TR-42 User Premises Telecommunications Infrastructure Engineering Committee. The following subcommittees have been established within this committee:

- TR-42.1 Commercial Building Telecommunications Cabling
- TR-42.2 Residential Telecommunications Infrastructure
- TR-42.3 Commercial Building Telecommunications Pathways and Spaces
- TR-42.4 Outside Plant Telecommunications Infrastructure
- TR-42.5 Telecommunications Infrastructure Terms
- TR-42.6 Telecommunications Infrastructure Administration
- TR-42.7 Telecommunications Copper Cabling Systems
- TR-42.8 Telecommunications Optical Fiber Cabling Systems

Cabling Standards

The above-mentioned working groups, under the jurisdiction of the TR-41.7 and TR-41.8 Subcommittees and approved by the Technical Committee TR-41, have developed a series of technical standards on building cabling for telecommunications products and services.

These documents are meant to fill a recognized need in the telecommunications industry brought about by the evolving industry structure.

Currently available telecommunications standards are:

ANSI/TIA/EIA-568-A	*Commercial Building Telecommunications Cabling Standard.*
ANSI/TIA/EIA-569-A	*Commercial Building Standard for Telecommunications Pathways and Spaces.*
ANSI/EIA/TIA-570-A	*Residential and Light Commercial Telecommunications Wiring Standard.*
ANSI/TIA/EIA-606	*Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.*
ANSI/TIA/EIA-607	*Commercial Buildings Grounding and Bonding Requirements for Telecommunications.*
ANSI/TIA/EIA-758	*Customer-Owned Outside Plant Telecommunications Cabling Standard.*
TIA/EIA TSB-67	*Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems.*
TIA/EIA TSB-72	*Centralized Optical Fiber Cabling Guidelines.*
TIA/EIA TSB-75	*Additional Horizontal Cabling Practices for Open Offices.*
ANSI/TIA/EIA-568-A-1	*Propagation Delay and Delay Skew Specifications for 100 Ohm 4-pair Cable (Addendum 1).*
ANSI/TIA/EIA-568-A-2	*Corrections and Additions to TIA-568-A (Addendum 2).*
ANSI/TIA/EIA-568-A-3	*Hybrid Cables (Addendum 3).*

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Cabling Standards, continued

ANSI/TIA/EIA-568-A (CSA T529)

Commercial Building Telecommunications Cabling Standard

This standard provides requirements and recommendations for the selection and installation of the premises telecommunications cabling system.

This standard is currently under revision. The revised version will be known as ANSI/TIA/EIA-568-B and at the time of this writing, is expected to be issued in the year 2000.

The requirements and recommendations made in this document are detailed later in this chapter.

ANSI/TIA/EIA-569-A (CSA T530)

Commercial Building Standard for Telecommunications Pathways and Spaces

The focus of this standard is the proper design of those building components relevant to the premises telecommunications infrastructure.

It provides requirements and recommendations for the physical spaces and pathways used by modern telecommunications cabling systems and equipment.

Requirements and recommendations are made in the following areas:

- Telecommunications spaces, including work areas, telecommunications closets, equipment rooms, and entrance facilities. Specifications provided include:
  - The sizing of telecommunications spaces.
  - Floor loading requirements—dynamic and static.
  - Environmental considerations—acceptable floor coverings, lighting requirements, etc.
- Telecommunications pathways, including horizontal and backbone cable distribution systems—conduits, sleeves, trays, etc.—and grounding pathways. Specifications provided include:
  - The number of cable pathways to install.
  - Acceptable types of pathways.
  - Installation procedures.

Cabling Standards, continued

ANSI/EIA/TIA-570-A (CSA T525)

Residential and Light Commercial Telecommunications Wiring Standard

The focus of this standard is to provide recommendations and requirements for the selection and installation of cabling systems used in residential and smaller commercial premises.

It recognizes residential properties as environments that may have computing equipment such as those found in commercial offices. There is an increasing need for individuals to work at home and access remote networks. This standard suggests preparing the telecommunications cabling systems of residences, and smaller commercial properties, for LANs and for access to remote systems.

ANSI/TIA/EIA-606 (CSA T528)

Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

This standard provides requirements and recommendations for the documentation and administration of the premises telecommunications infrastructure. It promotes the use of an administration scheme independent of the applications using this infrastructure.

This standard specifies documenting the cabling system in the following manner:

- Assign a unique identifier to each element of the cabling system.
- Create a record for each of the identified elements.
- Link related records to each other.

Once all of the elements of the cabling system have been documented, the information gathered can be used to produce a number of reports.

One of the most important challenges for network managers is to keep records up-to-date. If changes are made to the cabling system and these changes are not registered, it is as if the system was never documented in the first place.

Documenting the cabling system is of great benefit to the LAN administrator. LAN cabling is often blamed for network problems. Being able to track individual components of the cabling system greatly simplifies troubleshooting.

A revision for this standard is planned. The revised version will be known as ANSI/TIA/EIA-606-A.

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Cabling Standards, continued

ANSI/TIA/EIA-607 (CSA T527)

Commercial Buildings Grounding and Bonding Requirements for Telecommunications

This standard provides bonding and grounding requirements and recommendations for the premises telecommunications infrastructure.

It must be noted that these specifications do not supersede the bonding and grounding requirements of national and local electrical codes and safety regulations. This document makes bonding and grounding recommendations for the purpose of meeting telecommunications performance requirements.

A revision for this standard is planned. The revised version will be known as ANSI/TIA/EIA-607-A.

ANSI/TIA/EIA-758

Customer-Owned Outside Plant Telecommunications Cabling Standard

This standard provides requirements and recommendations for the design of customer-owned outside plant (CO-OSP). CO-OSP is the cabling infrastructure located on a customer's property used to transfer information between buildings and other structures.

ANSI/TIA/EIA-568-A

Introduction

This standard is intended to be a comprehensive set of requirements and recommendations for designing and installing the telecommunications infrastructure in commercial environments. It is not possible to go into detail for each topic presented in ANSI/TIA/EIA-568-A. The focus here is to examine those aspects of the standard most relevant to the design of cabling systems for the LAN environment.

It is highly recommended that individuals involved in the design of premises cabling systems obtain and study this standard.

ANSI/TIA/EIA-568-A Objectives

This standard replaces the ANSI/EIA/TIA-568 standard published July 1991.

Since that time, the modern office environment has experienced many changes. PC-based LANs are increasingly more powerful. Applications software has even greater capabilities and network bandwidth requirements. Furthermore, there is an ever greater need for systems to interconnect with each other.

Definition

The purpose of ANSI/TIA/EIA-568-A is described as follows:

> This standard specifies a generic telecommunications cabling system for commercial buildings that will support a multiproduct, multivendor environment. It also provides information that may be used for the design of telecommunications products for commercial enterprises.
>
> The purpose of this standard is to enable the planning and installation of a structured cabling system for commercial buildings with little knowledge of the products that will subsequently be installed. Installation of cabling systems during building construction or renovation is significantly less expensive and less disruptive than after the building is occupied.

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Scope

ANSI/TIA/EIA-568-A specifies minimum requirements for telecommunications cabling for commercial establishments made up primarily of office space.

Recommendations are made for:

- Topologies.
- Maximum cabling distances.
- Component performance.
- Telecommunications outlets and connectors.

The telecommunications cabling specified is intended to support a variety of building types and user applications.

Building sites are assumed to have the following characteristics:

- A geographical distance of up to 3000 m (9840 ft)
- Office space of up to 1,000,000 m^2 (approximately 10,000,000 ft^2)
- A population of up to 50,000 individual users

Applications using the telecommunications cabling system include, but are not limited to:

- Voice.
- Data.
- Text.
- Video.
- Image.

Telecommunications cabling systems specified by this standard are intended to have a useful life in excess of ten years.

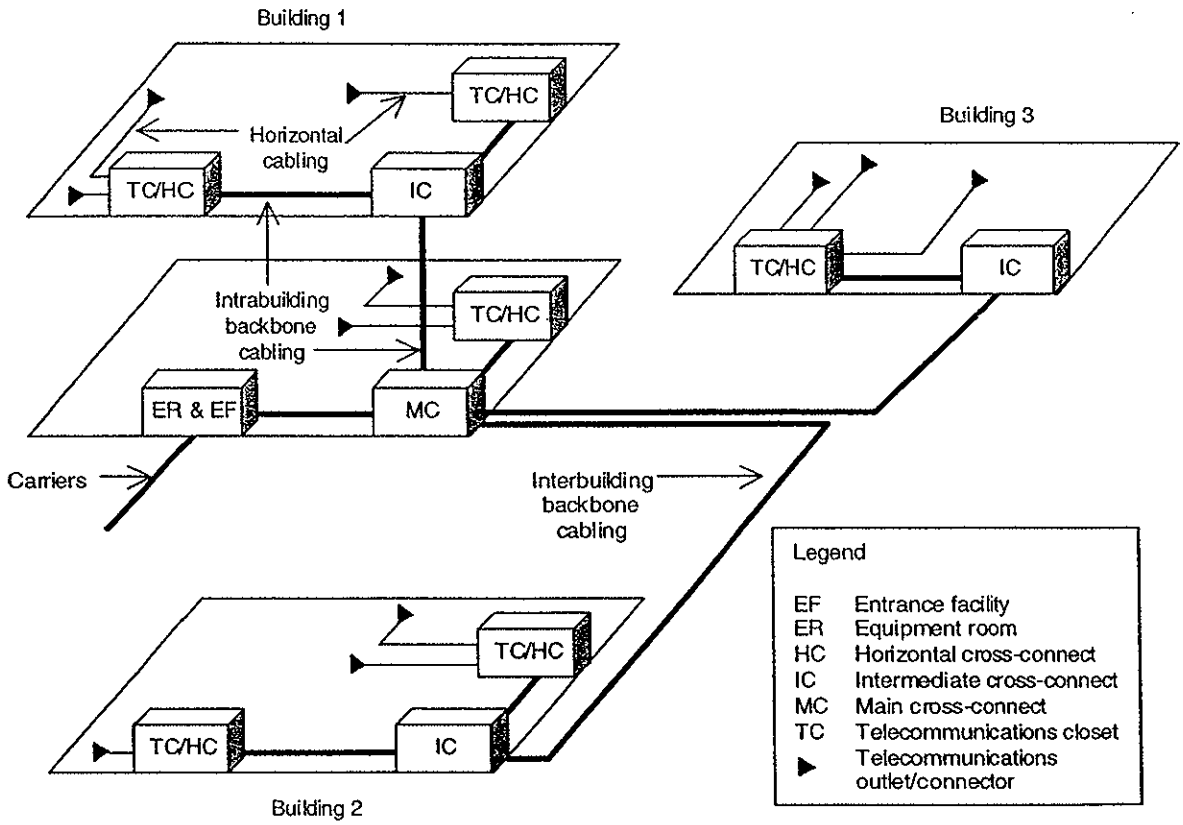
Defining Cabling System Structure

ANSI/TIA/EIA-568-A views the telecommunications cabling system as consisting of the following elements:

- Horizontal cabling
- Backbone cabling
- Work area
- Telecommunications closet (TC)
- Equipment room (ER)
- Entrance facility (EF)
- Administration

NOTE: Basic administration is covered in various sections throughout the ANSI/TIA/EIA-568-A document. Refer to ANSI/TIA/EIA-606 for more information regarding administration.

Figure 4.1
Telecommunications cabling system structure



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Horizontal Cabling System Structure

General

The term horizontal is used since this part of the cabling system typically runs horizontally along the floors, walls, or ceilings of a building.

ANSI/TIA/EIA-568-A describes horizontal cabling as follows:

> The horizontal cabling system is the portion of the telecommunications cabling system that extends from the work area telecommunications outlet/connector to the horizontal cross-connect in the TC. The horizontal cabling includes the horizontal cables, the telecommunications outlet/connector in the work area, the mechanical termination, and patch cord or jumpers located in the TC.

Certain considerations for horizontal cabling include:

- Contains the greatest quantity of individual cables in the building.
- Not very accessible—the time, effort, and skills required for changes can be very high.
- Should accommodate a variety of user applications to minimize the changes required as needs evolve.
- Placing copper cable in close proximity to potential sources of electromagnetic interference (EMI) must be avoided by installers.

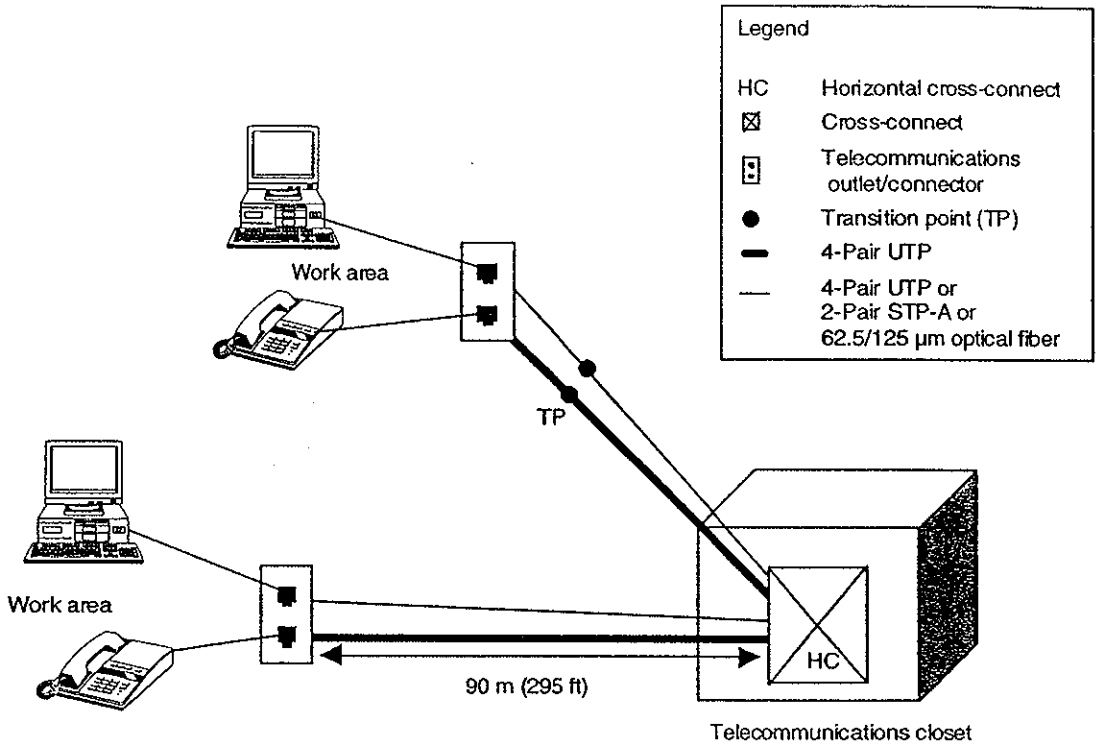
Topology

ANSI/TIA/EIA-568-A specifications regarding horizontal cabling topology include the following:

- Horizontal cabling follows a star topology.
- Each work area telecommunications outlet/connector connects to a horizontal cross-connect in the TC.
- Horizontal cabling in an office should terminate in a TC located on the same floor as the work area being served.
- Application-specific electrical components (such as impedance-matching devices) are not installed as part of the horizontal cabling. When needed, such components are placed external to the telecommunications outlet/connector.
- Horizontal cabling shall not have more than one transition point (TP) between flat undercarpet cable and a recognized horizontal cable.
- Bridged taps and splices are not permitted as part of the copper horizontal cabling.

Horizontal Cabling System Structure, continued

Figure 4.2
Typical horizontal and work area cabling



Distances

Regardless of media type, the maximum horizontal distance is not to exceed 90 m (295 ft). Distance is measured from the mechanical termination of the media at the horizontal cross-connect to the telecommunications outlet/connector in the work area and is based on the physical cable length.

In addition, the following distances are recommended:

- An allowance of 10 m (33 ft) total for the channel is made for work area cables and cables in the TC (patch cables, jumper cords, and equipment cables).
- Cross-connect jumpers and patch cords that connect horizontal cabling with equipment or backbone cabling in the cross-connect facilities should not exceed 6 m (20 ft) in length.
- At the work area, a maximum distance of 3 m (10 ft) is recommended from the station device to the telecommunications outlet/connector.

NOTE: Design recommendations based on TIA/EIA TSB-72, *Centralized Optical Fiber Cabling Guidelines* and TIA/EIA TSB-75, *Additional Horizontal Cabling Practices for Open Offices* are discussed later in this chapter.

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Horizontal Cabling System Structure, continued

Recognized Media

Three types of cables are recognized in the horizontal cabling system:

- Four-pair 100 Ω unshielded twisted-pair (UTP) cables
- Two-fiber 62.5/125 μm multimode optical fiber cables
- Two-pair 150 Ω shielded twisted-pair (STP-A) cables

Currently, 50 Ω coaxial cable is recognized as a cable, which may be found at existing sites. It is not recommended for new cabling installations and is expected to be removed from the next revision of this standard.

Hybrid cables consisting of more than one of the above recognized cables under a common sheath may be used providing they meet additional performance specifications as defined in ANSI/TIA/EIA-568-A-3 (Addendum 3).

Choosing Media

A minimum of two telecommunications outlet/connectors shall be provided for each individual work area. One may be associated with a voice service and the other with a data service.

The two telecommunications outlet/connectors are configured as follows:

- One telecommunications outlet/connector must be supported by a four-pair 100 Ω UTP cable—Category 3 or higher.
- The second/other telecommunications outlet/connector is to be supported by a minimum of one of the following media:
  - Four-pair 100 Ω UTP cable—Category 5 recommended.
  - Two-fiber 62.5/125 μm multimode optical fiber cable.
  - Two-pair 150 Ω STP-A cable.

Installation Practices

Proper practices must be observed to ensure initial and continuing performance of the cabling system over its life cycle.

Grounding Considerations

Grounding shall meet the requirements and practices of applicable authorities and codes. In addition, telecommunications grounding/bonding shall conform with ANSI/TIA/EIA-607 requirements.

Additional Cabling Specifications

Addendum 1 - Propagation Delay and Delay Skew

Addendum 1—*Propagation Delay and Delay Skew Specifications for 100 Ohm 4-Pair Cable*—specifies additional performance requirements for UTP and screened twisted-pair (ScTP) cables. These performance parameters—propagation delay and delay skew—are important for those applications using multiple pairs in a cable for the purpose of parallel transmission.

Propagation delay represents the length of time a signal is delayed when propagating (moving) through a length of wire. This delay time is measured in nanoseconds (ns). Propagation delay is affected by both the geometry and the materials of an insulated pair of conductors.

Delay skew is the maximum difference in propagation delay between any two pairs located in a common cable sheath. The delay skew between pairs insulated with different materials can be greater than between pairs insulated with the same material.

Insulating material affects the speed at which a signal travels along a copper wire. Network technologies that use more than one pair to transmit signals may experience transmission errors if the signals travel at substantially different speeds over the wire pairs. In some cases, signals transmitted simultaneously over different pairs may not arrive at the receiver at the same time because of excessive delay skew.

Some of the requirements found in Addendum 1 include the following:

- The delay skew between the fastest and slowest pair in a cable shall not exceed 45 ns per 100 m (328 ft) over a temperature range of 20 °C to 60 °C (68 °F to 140 °F).
- The delay skew between all pair combinations in a cable shall not vary more than 10 ns over a temperature range of 20 °C to 60 °C (68 °F to 140 °F).
- Values for maximum delay, delay skew, and minimum velocity of propagation along a cable are provided in this document. These values cover Category 3, 4, and 5 cables over a frequency range of 1 to 100 MHz.

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Additional Cabling Specifications, continued

Addendum 3 - Hybrid Cables

The purpose of Addendum 3, *Hybrid Cables,* is to define the specifications for hybrid cables.

A hybrid cable is defined as a grouping of multiple cables covered by a single overall sheath. These cables may be of the same or different types or categories. Examples of hybrid or bundled cables include mixed Category 3 and 5 UTP and mixed optical fiber and copper cables.

A clarification is made between hybrid cables and bundled cables. While a bundled cable is also a grouping of multiple cables, it does not have a single overall sheath. Bundled cables are created when a group of individual cables are bound together to form a single unit prior to installation. Other names used to describe bundled cable include loomed cable, speed-wrap cable, and whip cable.

The second purpose of Addendum 3 is to define minimum power-sum near-end crosstalk (PS-NEXT) loss values between recognized copper cable types in a hybrid or bundled cable. This PS-NEXT value between the cables inside the common sheath of a hybrid or bundled cable must be better than the specified pair-to-pair NEXT losses for the individual cables by themselves—by at least 3 dB.

Screened Twisted-Pair (ScTP) Specifications

The purpose of this document, TIA/EIA IS-729, *Technical Specifications for 100 Ohm Screened Twisted Pair Cabling,* is to define the specifications for 100 Ω ScTP cabling systems.

The general recommendations call for the 100 Ω ScTP cabling systems to meet the requirements specified for 100 Ω UTP cabling systems, with the addition of shield grounding requirements. Also, the installed 100 Ω ScTP cabling must meet the transmission performance specifications of TIA/EIA TSB-67.

Additional Cabling Specifications, continued

TIA/EIA TSB-95 - Specifications for Category 5 UTP Cabling

The purpose of TIA/EIA TSB-95, *Additional Transmission Performance Specification for 4-Pair 100 Ohm Category 5 Cabling,* is to provide information concerning the expected performance of the installed base of Category 5 cabling in a two-connector channel for:

- Return loss.
- Equal-level far-end crosstalk (ELFEXT) loss.

NOTE: At the time of this writing, TIA/EIA TSB-95 was not finalized.

The recommendations in TIA/EIA TSB-95 assist in verifying the performance of existing, or legacy, Category 5 UTP cabling systems. The purpose of this verification is to ensure such systems can support Gigabit Ethernet applications.

NOTE: This TSB is considered to be informative in nature—its information is not mandatory.

TIA/EIA TSB-95 specifications assume a two-connector transmission channel topology. This means that the installed cabling system is terminated using an interconnect field in place of a cross-connect field at the TC end, and that there are no consolidation or transition point (TP) connections in the runs to the work areas. However, transmission channel configurations using three or four connectors are allowed, provided they are able to satisfy the return loss and ELFEXT loss requirements for Gigabit Ethernet.

NOTES: A consolidation point (CP) is similar to a TP; however, a transition from round to flat cable does not occur. The CP will be explained in greater detail later in this section.

The recommendations made in TIA/EIA TSB-95 are for the qualification of existing Category 5 cabling systems. These recommendations are not intended to be used as the minimum performance criteria for new Category 5 cabling system installations.

TIA/EIA TSB-95 was originally scheduled to be released as Addendum 4 to ANSI/TIA/EIA-568-A.

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Additional Cabling Specifications, continued

Addendum 5 - Specifications for Enhanced Category 5 (Category 5e) UTP Cabling

The purpose of addendum 5, *Additional Transmission Performance Specifications for 4-Pair 100 Ohm Enhanced Category 5 Cabling,* is to specify the performance requirements for Category 5e cabling systems.

NOTE: At the time of this writing, Addendum 5 was not finalized.

Addendum 5 specifies the minimum return loss and ELFEXT loss requirements needed to support emerging networking technologies—including Gigabit Ethernet. This addendum defines the minimum performance levels a transmission channel, with a maximum four-connector topology, requires to support high bit-rate applications using full-duplex transmission schemes.

In addition, Addendum 5 also specifies PS-NEXT loss and power-sum equal-level far-end crosstalk (PS-ELFEXT) loss performance for Category 5e cables, links, and channels.

It is recommended that all new high-performance UTP cabling installations conform to the requirements specified in this document.

NOTE: This addendum is considered to be normative in nature—its requirements are mandatory.

Additional Cabling Specifications, continued

Next-Generation Cabling Systems

Next-generation cabling systems are also under study. These are cabling systems whose characteristics are specified for frequencies up to 250 MHz. Currently, consideration is being given to defining cable categories and connecting hardware that perform up to 250 MHz. Preliminary information indicates that both unshielded and shielded (screened) systems are being considered.

Next-generation UTP cabling systems are expected to be backwards-compatible with existing Category 5 systems. This will provide, at a minimum, Category 5 performance when both newer next-generation and older Category 5 components are used in a channel. Some of the expected characteristics of next-generation UTP systems are summarized as follows:

- The modular jack interface will be maintained for all work area interfaces.
- Next-generation components will be electrically compatible with other categories.
- In cases of mixed combinations of categories the resulting system will, at a minimum, meet the transmission requirements associated with the least performing component.

Next generation media for 100 Ω, 4-pair cabling are expected to include:

- Category 6/ISO Class E—UTP and ScTP components and cabling specified up to 250 MHz.
- Category 7/ISO Class F—individually shielded twisted-pair components and cabling specified up to 600 MHz.

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TIA/EIA TSB-75 - Additional Horizontal Cabling Practices

The purpose of TIA/EIA TSB-75, *Additional Horizontal Cabling Practices for Open Offices,* is to provide additional guidelines for horizontal cabling practices in open office environments. This document further develops concepts; specifically, it builds on the concepts of the multi-user telecommunications outlet assembly (MUTOA) and the CP.

TIA/EIA TSB-75 specifies optional practices, which may be used in open office environments requiring frequent reconfiguration. These practices may be used with any horizontal cabling recognized by ANSI/TIA/EIA-568-A.

The connection schemes and topologies recommended can be easily changed when reconfiguration of office furniture or movable partitions occurs.

Multi-User Telecommunications Outlet Assembly (MUTOA)

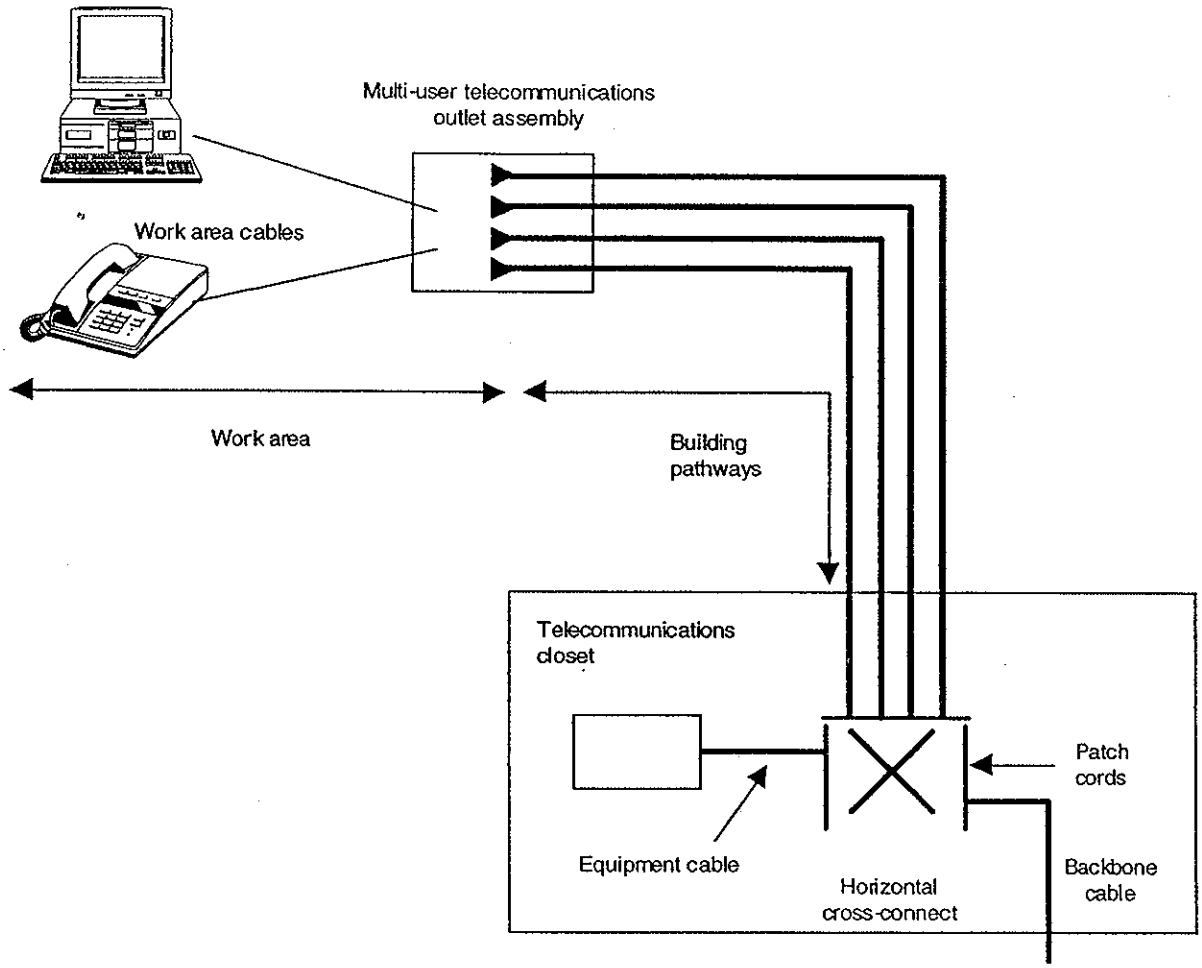
TIA/EIA TSB-75 defines a multi-user telecommunications outlet assembly as follows:

> A grouping in one location of several telecommunications outlet/ connectors.

Using this type of assembly allows an open office layout to be changed without needing to reconfigure the horizontal cabling. Single or multiple horizontal cables are terminated in a common location, within a furniture cluster or similar open area. Work area cables are connected to the work area equipment without additional intermediate connections. These cables originate at the MUTOA and are routed through work area pathways such as furniture pathways.

TIA/EIA TSB-75 - Additional Horizontal Cabling Practices, continued

Figure 4.3
Horizontal cabling with multi-user telecommunications outlet assembly



Planning and Design

Assemblies should be located so that each furniture cluster—a contiguous group of work areas—is served by at least one MUTOA. No more than 12 work areas should be served by a single assembly.

Considerations made during the planning should include:

- Maximum work area cable length requirements.
- Spare capacity.

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TIA/EIA TSB-75 - Additional Horizontal Cabling Practices, continued

Installation Practices

The MUTOA shall be located in a fully accessible, permanent location—building columns, permanent walls, and/or furniture permanently secured to the building structure. They shall not be placed in ceiling spaces.

Administration

Administration should follow recommendations made in ANSI/TIA/EIA-606. Label components as follows:

- Work area cables connecting the MUTOA to the work area shall be labeled at both ends with a unique cable identifier.
- The end of the work area cable at the MUTOA shall be labeled identifying the work area it serves.
- The end of the work area cable at the work area shall be labeled identifying the MUTOA and the port occupied.

Horizontal Distances - Copper Links

Copper cables to be used as work area cables shall meet or exceed the requirements specified in ANSI/TIA/EIA-568-A. The maximum length of the work area cable is determined using the following formula:

$C = (102 - H)/1.2$

$W = C - 7 \leq 20$

where:

H = The length of the horizontal cable (in meters).

C = The maximum combined length of work area cable, equipment cable, and patch cord (in meters).

W = The maximum length of the work area cable (in meters).

It is assumed that a total of 7 m (23 ft) of patch and equipment cables is used in the equipment closet (EC).

Work area cables shall not exceed 20 m (66 ft).

The MUTOA shall be marked with the maximum allowable work area cable length.

The following table shows the results of some calculations using the above formula.

TIA/EIA TSB-75 - Additional Horizontal Cabling Practices, continued

Table 4.2
Maximum length of horizontal and work area cables

Length of Horizontal Cable	Maximum Combined Length of Work Area Cable, Patch Cords, and Equipment Cable	Maximum Length of Work Area Cable
H	C	W
90 m (295 ft)	10 m (33 ft)	3 m (10 ft)
85 m (279 ft)	14 m (46 ft)	7 m (23 ft)
80 m (262 ft)	18 m (59 ft)	11 m (36 ft)
75 m (246 ft)	22 m (72 ft)	15 m (49 ft)
70 m (230 ft)	27 m (89 ft)	20 m (66 ft)

Horizontal Distances - Optical Fiber Links

When using optical fiber cables, any length of horizontal cables, work area cables, patch cords, and equipment cables is acceptable so long as the total of the combined lengths does not exceed 100 m (328 ft).

Consolidation Point (CP)

TIA/EIA TSB-75 defines a CP as follows:

> A location for interconnection between horizontal cables that extend from building pathways and horizontal cables that extend into work area pathways.

The CP acts as an interconnection point in the horizontal cabling system. ANSI/TIA/EIA-568-A compliant hardware is to be used—it must be rated for at least 200 cycles of reconnection.

A CP is different from a MUTOA in that the CP requires an additional connection for each horizontal cable run. It is assumed that a CP will be used where reconfiguration is frequent, but not as frequent as when the flexibility of the MUTOA is required.

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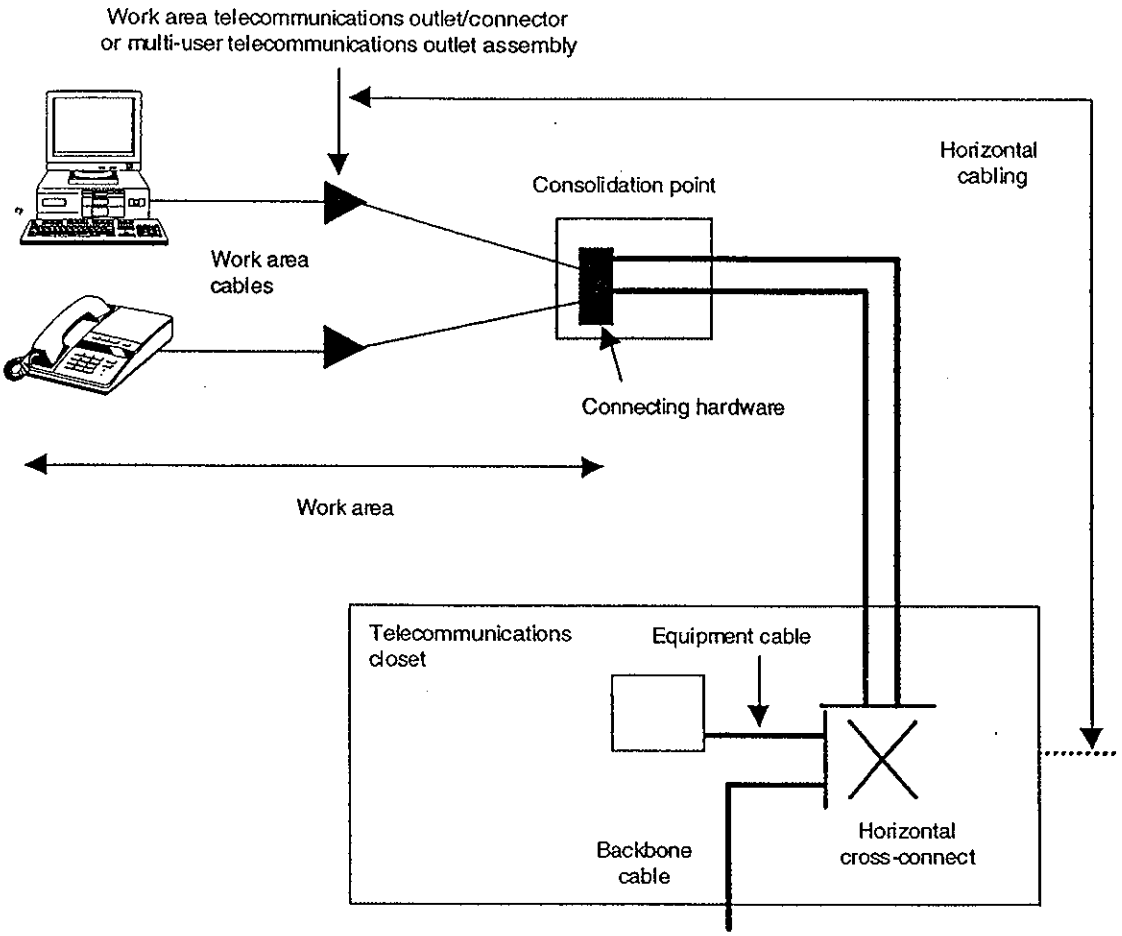
TIA/EIA TSB-75 - Additional Horizontal Cabling Practices, continued

The following recommendations are made regarding CPs:

- Cross-connections shall not be permitted at a CP.
- Only a single CP shall be permitted within a horizontal cable run.
- It is not permitted to use both a TP and a CP in a horizontal cabling link.
- Each horizontal cable exiting a CP shall be terminated at a telecommunications outlet/connector or a MUTOA.
- All cables and connections used at a CP shall meet the specifications of ANSI/TIA/EIA-568-A.
- It is recommended that a CP be located no closer than 15 m (49 ft) from the TC to reduce the potential interference caused by multiple connections in close proximity.
- Use of solid conductor cable is required from the CP to the telecommunications outlet/connector.

TIA/EIA TSB-75 - Additional Horizontal Cabling Practices, continued

Figure 4.4
Horizontal cabling with consolidation point



Planning and Design

CPs should be located so that each furniture cluster is served by at least one CP. No more than twelve work areas should be served by a single CP.

Considerations to be made during the planning should include spare capacity.

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TIA/EIA TSB-75 - Additional Horizontal Cabling Practices, continued

Installation Practices

The CP is to be located in a fully accessible, permanent location—building columns, permanent walls, furniture permanently secured to the building structure. Locations not to be considered for installation of the CP include obstructed areas and furniture not permanently secured to the building structure.

Administration

Administration should follow recommendations made in ANSI/TIA/EIA-606.

Any moves, adds, or changes of service not associated with rearranging the open office should be made at the horizontal cross-connect in the TC.

Backbone Cabling System Structure

General

The term backbone is used in place of the outdated terms vertical or riser. Backbone cabling is used to provide connections between EFs, TCs, and ERs within a building and in campus environments where the cable runs between buildings.

ANSI/TIA/EIA-568-A describes backbone cabling as follows:

> The function of the backbone cabling is to provide interconnections between TCs, ERs, and EFs in the telecommunications cabling system structure. Backbone cabling consists of the backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection. Backbone cabling also includes cabling between buildings.

Certain considerations should be made when selecting backbone cabling:

- The useful life of the backbone cabling system is expected to consist of several planning periods (typically, three to ten years). This is shorter than the overall life of the premises telecommunications cabling system (typically, several decades).
- Prior to the start of a planning period, the maximum amount of backbone cabling required for the period should be projected. Growth and changes during this period should be accommodated without installing additional backbone cabling.
- Planning the routing and support structure for copper backbone cabling should avoid areas where potential sources of EMI may exist.

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Backbone Cabling System Structure, continued

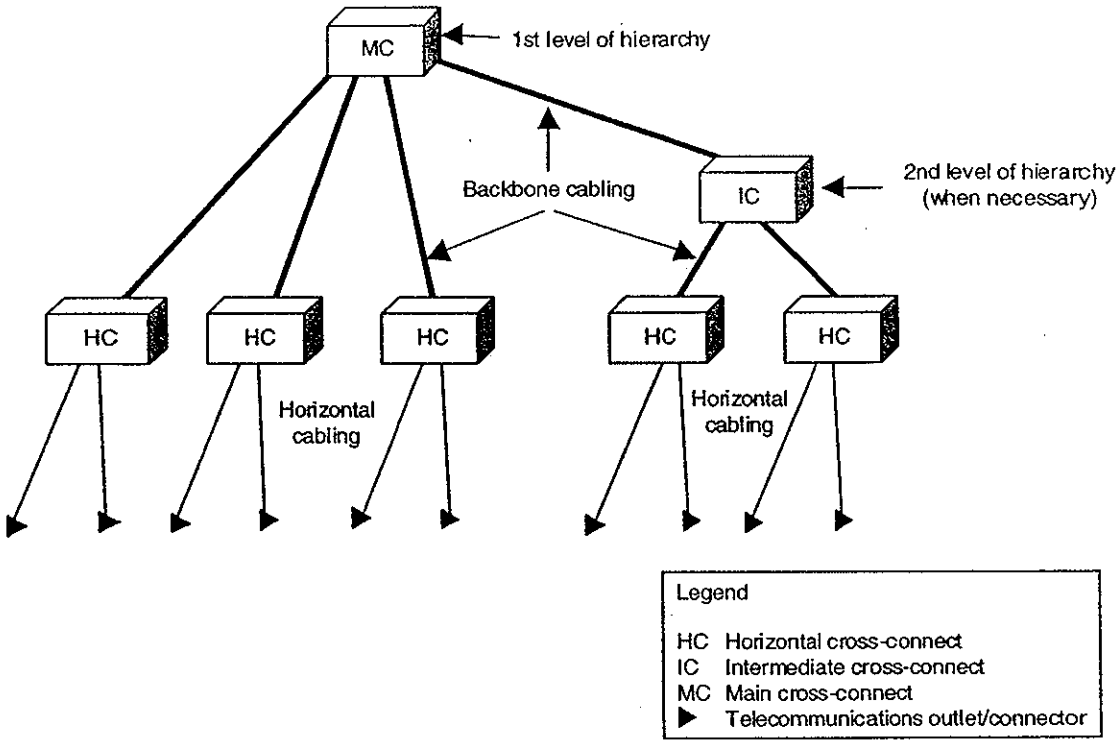
Topology

ANSI/TIA/EIA-568-A provides the following specifications regarding backbone cabling topology:

- The backbone cabling shall follow the hierarchical star topology.
- Each horizontal cross-connect in a TC is cabled to a main cross-connect or to an intermediate cross-connect and then to a main cross-connect with the following exception:
  - If requirements for a bus or ring network topology are anticipated, cabling direct connections between TCs is allowed in addition to connection with the main or intermediate cross-connect.
- There shall be no more than two hierarchical levels of cross-connect in the backbone cabling to limit signal degradation for passive systems and to simplify moves, adds, and changes.
  - Facilities that have a large number of buildings or cover a large geographical area may elect to subdivide the entire facility into smaller areas within the scope of ANSI/TIA/EIA-568-A. In this case, there are multiple distinct areas that are served by the two-level backbone hierarchy.
- Backbone cabling between any two TCs shall pass through three or fewer cross-connects.
- No more than one cross-connect shall be passed through to reach the main cross-connect from any horizontal cross-connect.
- In certain installations, a single backbone cabling cross-connect (the main cross-connect) may meet all cross-connect needs.
- Backbone cabling cross-connects may be located in TCs, ERs, or at EFs.
- Bridged taps shall not be permitted as part of the backbone cabling.

Backbone Cabling System Structure, continued

Figure 4.5
Backbone hierarchical star topology



Recognized Cables

ANSI/TIA/EIA-568-A recognizes four backbone transmission media, which can be used individually or in combination:

- 100 Ω UTP backbone cable
- 62.5/125 µm multimode optical fiber cable
- Singlemode optical fiber
- 150 Ω STP-A cable

Currently, 50 Ω coaxial cable is recognized as a backbone cable, which may be found at existing sites. It is not recommended for new cabling installations and is expected to be removed from the next revision of the standard.

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Backbone Cabling System Structure, continued

Choosing Media

Factors to consider when making a choice include:

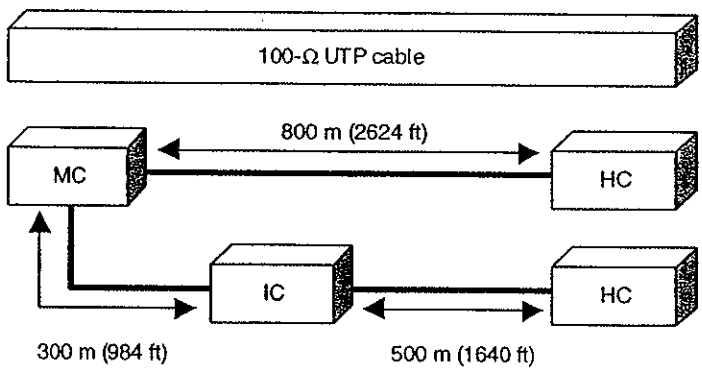
- Flexibility with respect to supported services.
- Required useful life of backbone cabling.
- Site size and user population.

When possible, service requirements should be grouped into categories such as voice, display terminal, LAN, and other digital connections. Within each group, individual backbone cabling types should be identified and required quantities projected. Where uncertainty exists, worst-case scenarios should be used. The greater the uncertainty, the more flexible the backbone cabling system should be.

Cabling Distances

Maximum distances are application dependent. Those provided in the standard are based on typical applications for the given type of media.

Figure 4.6
Maximum UTP backbone distances



NOTE: These distances are based on voice or low-speed data applications only. UTP or STP-A backbone cables used for high-speed data applications must be limited to 90 m (295 ft) between cross-connects that contain active equipment.

Backbone Cabling System Structure, continued

Figure 4.7
Maximum 62.5/125 µm optical fiber backbone distances

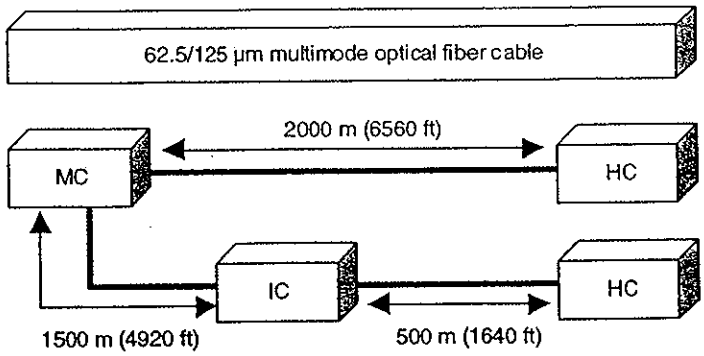
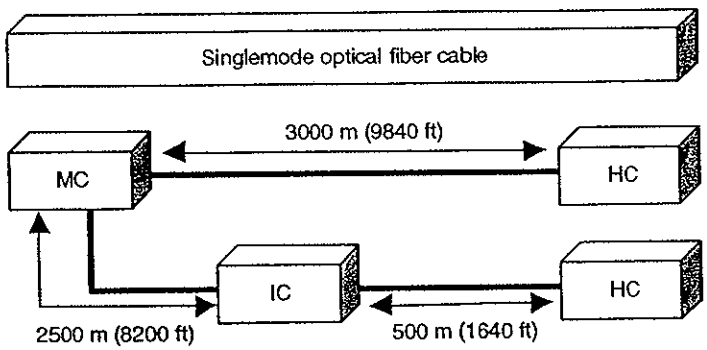


Figure 4.8
Maximum singlemode optical fiber backbone distances



NOTE: While it is recognized that the capabilities of singlemode optical fiber allow for end-to-end distances in excess of 60 km (37 mi), such distances are generally considered to be outside the scope of the ANSI/TIA/EIA-568-A standard.

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Backbone Cabling System Structure, continued

To minimize cabling distance, the main cross-connect should be located near the center of a site. Installations exceeding distance limits may be divided into areas, each of which can be supported by backbone cabling within the scope of ANSI/TIA/EIA-568-A. Interconnections between the individual areas, which are outside the scope of this standard, may be done by employing equipment and technologies normally used for wide area applications.

- Main cross-connect to entrance point

  The distance between the main cross-connect and the entrance point shall be included in the total distance calculations.

- Cross-connections

  In the main cross-connect, jumper and patch cord lengths should not exceed 20 m (66 ft). In the intermediate cross-connect, jumper and patch cord lengths shall not exceed 20 m (66 ft).

- Cabling to telecommunications equipment

  Telecommunications equipment that connects directly to main or intermediate cross-connects should do so via cables of 30 m (98 ft) or less.

Installation Practices

Proper practices must be observed to ensure initial and continuing performance of the cabling system over its life cycle.

Grounding Considerations

Grounding shall meet the requirements and practices of applicable authorities and codes. In addition, telecommunications grounding/bonding shall conform with ANSI/TIA/EIA-607 requirements.

TIA/EIA TSB-72 - Centralized Optical Fiber Cabling Guidelines

Overview

Many network administrators prefer centralizing all LAN concentrators, such as hubs and switches, in place of distributing them throughout the building, for security or convenience. These guidelines describe how to deploy centralized optical fiber cabling. This is designed to provide an alternative to an optical cross-connect in the TC. It would be used when 62.5/125 μm multimode optical fiber is used for horizontal cabling.

With proper planning and installation, a centralized optical fiber cabling system can provide a high level of flexibility and manageability.

All information provided in TIA/EIA TSB-72 is meant to supplement recommendations made in ANSI/TIA/EIA-568-A and ANSI/TIA/EIA-569-A. Specifically, these guidelines are to be used in addition to the horizontal cabling and optical connecting hardware requirements made in ANSI/TIA/EIA-568-A.

TIA/EIA TSB-72 guidelines are aimed to those users meeting the following requirements:

- Single-tenant users
- Users wishing to centralize network electronics
- Users looking for an alternative to using optical cross-connects in the TC

Design Options

TIA/EIA TSB-72 describes three options to provide a centralized optical fiber cabling system. These are as follows:

- The use of pull-through cable connecting the centralized cross-connect in the ER through the TC to the telecommunications outlet/connector in the work area. Pull-through cables are continuous sheath cables and are limited to a total length of 90 m (295 ft).
- The use of a splice between horizontal and intrabuilding backbone cables in the TC.
- The use of an interconnect between horizontal and intrabuilding backbone cable in the TC. This option is seen as offering greater flexibility, manageability, and ease of migration to a cross-connect than either the pull-through or splice options.

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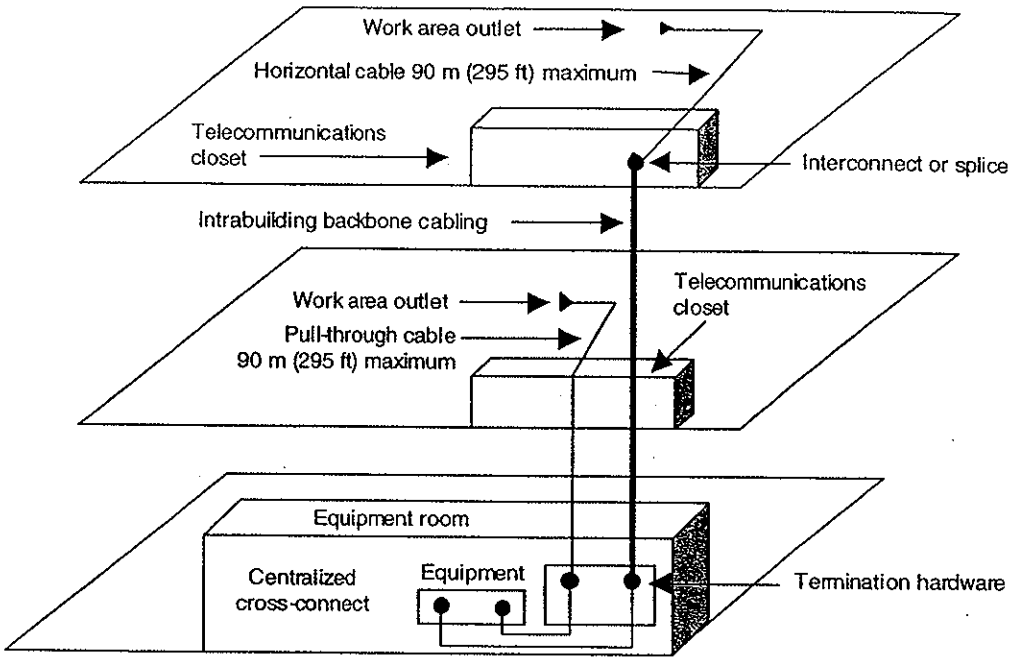
TIA/EIA TSB-72 - Centralized Optical Fiber Cabling Guidelines, continued

Figure 4.9
Centralized optical fiber cabling



For all options, the design must allow for migration to a cross-connection implementation—in total or in part. Enough room should be left in the TC for the addition of patch panels required for migration to a cross-connection scheme. The layout of termination hardware, rack- or wall-mounted, must be able to accommodate modular growth.

There must be enough cable slack available in the TC to permit movement of the cables in the case of migration to cross-connection scheme. The slack can be stored as either cable or unjacketed fiber (buffered or coated) with bend radius control to ensure that cable and fiber bend radii limitations are not violated. If the slack is stored as unjacketed fiber, it must be stored in protective enclosures. If it is stored as cable, it may be stored in protective enclosures or on the walls of the TC.

TIA/EIA TSB-72 - Centralized Optical Fiber Cabling Guidelines, continued

Cable Distances

The horizontal cable segment distance is limited to 90 m (295 ft).

The total combined length of horizontal cable, intrabuilding backbone cable, and patch cords shall not exceed 300 m (984 ft). This distance represents the total length of cable from the equipment in the work area to the equipment in the centralized cross-connect.

In the case of pull-through cables, the total cable length is not to exceed 90 m (295 ft).

Number of Fibers

The intrabuilding backbone should have spare capacity. It should be sufficient to service additional telecommunications outlet/connectors from the centralized cross-connect without needing to pull additional backbone cables. Backbone cable planning should consider both present and future requirements. Most applications will require two fibers each to the work area.

The design must permit adding and moving horizontal and intrabuilding backbone fibers.

Fiber Polarity

The correct polarity of the fibers, as specified in ANSI/TIA/EIA-568-A, must be maintained at the telecommunications outlet/connector and at the centralized cross-connect. The orientation of the fibers should be A-B at the outlet/connector and B-A at the centralized cross-connect.

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TIA/EIA TSB-72 - Centralized Optical Fiber Cabling Guidelines, continued

Connecting Hardware

Connecting hardware joins the horizontal cables to the intrabuilding backbone cables. Remateable connectors with the 568SC interface or splices—mechanical or fusion—may be used. In either case, the recommendations for connectors or splices made in ANSI/TIA/EIA-568-A are to be followed. It is recommended that only one of these two methods be used in a facility. Fibers may be joined as single fibers or in fiber pairs; however, fiber circuits are to be organized and managed as fiber pairs.

Additional information or specifications for optical fiber connecting hardware are as follows:

- Each joining position shall be uniquely identified.
- It must be possible to add new horizontal connections and remove existing ones.
- There shall be a mechanism for storing and identifying fibers not yet connected—from horizontal and/or backbone cables.
- It shall be possible to add horizontal and/or backbone cables.
- It shall be possible to migrate from an interconnect-based installation to a cross-connect installation.
- It shall be possible to test the optical fiber cables from the connecting hardware.
- There shall be protection for the connections to ensure optical continuity.

Administration

Adding or removing horizontal links is to be done at the TC.

Administration of moves and changes shall be done at the centralized cross-connect.

The labeling requirements specified in ANSI/TIA/EIA-606 shall be supported. Splice and interconnect hardware in the TC shall be labeled with unique identifiers.

Work Area Structure

General

Work area components extend from the telecommunications outlet/connector end of the horizontal cabling system to the station equipment and are outside the scope of ANSI/TIA/EIA-568-A. The station equipment can include, but is not limited to, telephones, data terminals, and computers.

Certain considerations should be made when designing work area cabling:

- Work area cabling is generally nonpermanent and designed to be easy to change.
- The maximum horizontal cable length has been specified with the assumption that a maximum length of 3 m (10 ft) of work area cable has been used in the work area.
- A cord with identical connectors on both ends is commonly used.
- When application-specific adaptations are needed at the work area, they shall be external to the telecommunications outlet/connector.

NOTE: Cabling adapters in the work area may have detrimental effects on the transmission performance of the telecommunications cabling system. It is important that adapter compatibility with premises cabling and equipment be considered before they are connected to the telecommunications network.

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Telecommunications Closet (TC) Structure

General

TCs provide many different functions for the cabling system and are often treated as a distinct subsystem within the hierarchical cabling system whose primary purpose is to be floor serving, as opposed to building or campus serving facilities.

Design

TCs shall be designed and provisioned according to the requirements in ANSI/TIA/EIA-569-A.

Functions

A TC can have many functions:

- The primary function of a TC is for the termination of horizontal cabling. Horizontal cables of all recognized types are terminated in the TC on compatible connecting hardware.
- Recognized types of backbone cable are also terminated in the TC on compatible connecting hardware.
- The cross-connection of horizontal and backbone cable terminations to each other and equipment located within the TC using jumpers or patch cords allows flexible connectivity when extending various services to work area telecommunications outlet/connectors. Connecting hardware, jumpers, and patch cords used for this purpose are collectively referred to as the horizontal cross-connect.
- A TC may also contain the intermediate cross-connect or the main cross-connect for different portions of the backbone cabling system.
- On occasion, backbone-to-backbone cross-connections in the TC are used to tie different TCs in a ring, bus, or tree configuration.
- A TC also provides a controlled environment to house telecommunications equipment, connecting hardware, and splice closures serving a portion of the building.
- On occasion, the demarcation point and associated protection apparatus may be located in the TC.

Telecommunications Closet (TC) Structure, continued

Cabling Practices

Cable management practices should be observed (including the elimination of cable stress) by the following precautions:

- Residual tension on installed cables should be avoided.
- Cables should not be routed in tightly cinched bunches (do not use staples).
- Appropriate cabling system routing and dressing fixtures should be used for effective organization and management of the different types of cables in TCs.

Cross-Connections and Interconnections

ANSI/TIA/EIA-568-A specifications include the following:

- Horizontal and backbone cabling shall be permanently terminated on connecting hardware that meets the requirements of ANSI/TIA/EIA-568-A.
- All connections between horizontal and backbone cables shall be cross-connections.
- Equipment cables that consolidate several ports on a single connector shall be terminated on dedicated connecting hardware.
- Equipment cables that extend a single port may either be permanently terminated or interconnected directly to horizontal or backbone terminations.
- Direct interconnections reduce the number of connections required to configure a link, but this may reduce flexibility.

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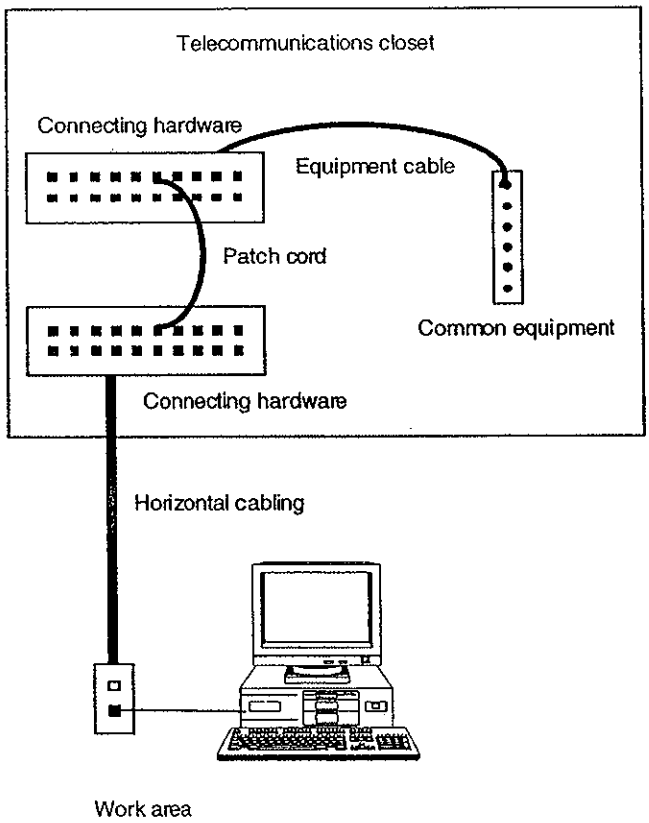
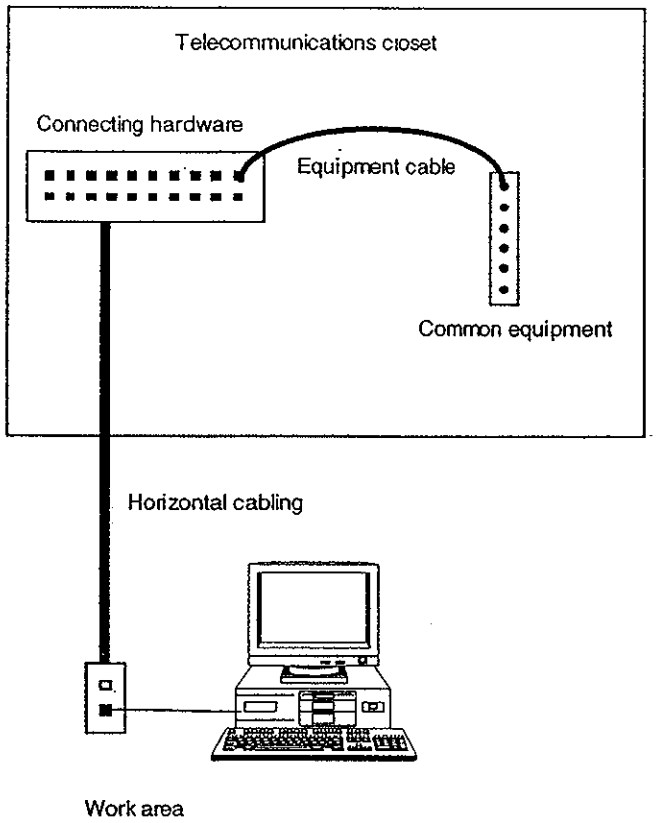
Telecommunications Closet (TC) Structure, continued

Figure 4.10
Cross-connection scheme



Telecommunications Closet (TC) Structure, continued

Figure 4.11
Interconnection scheme



NOTE: Whereas a cross-connect is a facility, a cross-connection is a type of connection scheme. A cross-connect (facility) may house both cross-connections and interconnections.

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Equipment Room (ER) Structure

General

ERs are considered distinct from TCs due to the nature or the complexity of the equipment they contain. They are generally considered to be building or campus-serving facilities.

Any or all of the functions of the TC may be provided by an ER.

Design

ERs shall be designed and provisioned according to the requirements in ANSI/TIA/EIA-569-A.

Functions

An ER is meant to provide the following:

- A controlled environment for the housing of telecommunications equipment, connecting hardware, splice enclosures, grounding and bonding facilities, and protection apparatus, where needed.
- From a cabling perspective, either the main cross-connect or the intermediate cross-connect is used in the backbone cabling hierarchy.
- May house equipment terminations and may contain horizontal terminations for a portion of the building.
- Often contains network trunk/auxiliary terminations under the control of the premises cabling administrator.

Cabling Practices

Cabling practices described for TCs are also applicable to ERs.

Entrance Facility (EF) Structure

General

The EF consists of the cables, connecting hardware, protection devices, transition hardware, and other equipment needed to connect the outside services facilities to the premises cabling.

The demarcation point between regulated carriers or service providers and the customer premises cabling may be part of the EF.

Design

EF pathways and spaces shall be designed and installed according to the requirements in ANSI/TIA/EIA-569-A.

Functions

An EF is meant to provide the:

- Network demarcation point between the service providers and customer premises cabling.
- Placement of electrical protection governed by the applicable electrical codes.
- Transition between cabling used in the outside plant to cabling approved for intrabuilding distribution. This usually involves a transition to fire-rated cable.

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ANSI/TIA/EIA-568-B

At the time of this writing, the *Commercial Building Telecommunications Cabling Standard* is being revised. This revised document will be known as ANSI/TIA/EIA-568-B and is expected to be issued in the year 2000.

ANSI/TIA/EIA-568-B will include the contents of ANSI/TIA/EIA-568-A, TIA/EIA TSB-67 (testing), TIA/EIA TSB-72 (centralized optical fiber), TIA/EIA TSB-75 (additional horizontal cabling practices), and the various addenda to ANSI/TIA/EIA-568-A. It will also specify the cable, connecting hardware, and test instrument requirements for UTP/ScTP, optical fiber, and STP cabling systems.

NOTE: The information provided here for ANSI/TIA/EIA-568-B is preliminary and subject to revision.

Some of the major changes anticipated in ANSI/TIA/EIA-568-B include:

- Inclusion of recommendations for equipment and work area cords.
- Specifications for enhanced Category 5 (Category 5e) UTP cabling systems, including two new parameters—return loss and ELFEXT loss.
- Technical specifications for 100 Ω ScTP cabling systems.
- Recommendations for nondestructive testing methods for modular plug cords.
- Removal of Category 4 UTP from the list of recognized cables.
- Removal of 150 Ω STP-A as a recommended media for new installations.
- Inclusion of 50/125 μm multimode fiber to the list of recognized cables for both horizontal and backbone distribution.
- Allowance of alternate optical fiber connector styles in addition to the 568SC at all locations in the network except at the telecommunications outlet.

Unshielded Twisted-Pair (UTP) Cabling Systems

Introduction

Unshielded twisted-pair cable has been used for a long time for both voice and data networking. Often as LAN performance requirements increase, so must the transmission capabilities of the network. This need has led to significant performance improvements for UTP cabling.

With these high-performance UTP cables, it is especially important to ensure that the mechanical properties and categories of UTP cable and connecting hardware are properly matched. To assure an acceptable level of dependability and transmission quality, it is essential to look at the cabling system as a whole instead of viewing it as a collection of cables and attachment accessories.

Any individual involved in the design, installation, and maintenance of a LAN should be aware of those characteristics of UTP that may affect the performance of the LAN.

The focus of the following discussion is on the specifications provided in ANSI/TIA/EIA-568-A that address the characteristics of 100 Ω UTP.

It is recommended that individuals requiring detailed performance attributes consult the ANSI/TIA/EIA-568-A standard and any other documentation or standards associated with the planned service or equipment.

UTP Cabling Categories

Until late 1991, it was not possible to distinguish between the different qualities of UTP cabling available on the market. Users had to rely on manufacturer claims as to the performance capabilities of a given product.

The recognized categories of UTP components and cabling are as follows:

- Category 3—this designation applies to UTP cables, associated connecting hardware, and cabling systems whose transmission characteristics are specified up to 16 MHz.
- Category 4—this designation applies to UTP cables, associated connecting hardware, and cabling systems whose transmission characteristics are specified up to 20 MHz.
- Categories 5 and 5e—these designations apply to UTP cables, associated connecting hardware, and cabling systems whose transmission characteristics are specified up to 100 MHz.

For each of the recognized categories of cable and connecting hardware, ANSI/TIA/EIA-568-A provides acceptable performance levels.

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UTP Transmission Measurements

Characteristic Impedance and Structural Return Loss (Cable Only)

Impedance is defined as the total opposition a circuit offers to the flow of current. It is measured in ohms (Ω).

Characteristic impedance is the input impedance of an ideal transmission line of infinite length. The different categories of UTP cable are specified to have a characteristic impedance of 100 Ω ± 15% in the frequency range from 1 MHz up to the highest referenced frequency.

Reflections of the transmitted signal are caused by nonuniform wire structure. These reflected signals result in a decreased signal-to-noise ratio on the transmission line and are characterized by structural return loss (SRL).

The relevance of SRL as a design parameter in premises cabling has only become apparent with the increasing performance demands of high-speed networks.

Attenuation

Attenuation is defined as the ratio of input power to output power when, and only when, the load and source impedance are equal to the characteristic impedance of the cable. In cases where the load and source impedance do not equal the characteristic impedance, the ratio of input to output power is called insertion loss. Although this distinction exists, the terms attenuation and insertion loss are often used interchangeably.

Attenuation is measured in decibels (dB). The smaller the dB measurement, the lower the impact of attenuation. A smaller dB value indicates low losses due to attenuation.

Attenuation is directly proportional to the length of the cable—the longer the cable, the greater the attenuation. Attenuation is also affected by the frequency of transmission—the higher the transmission frequency, the greater the attenuation for a given length of cable.

In degree of importance, attenuation is a more significant consideration for UTP cable than it is for UTP connecting hardware, since the attenuation of cable increases with additional distance.

UTP Transmission Measurements, continued

Near-End Crosstalk (NEXT) Loss

Near-end crosstalk is defined as the unwanted reception of signals by one wire pair from another wire pair at the same end of the link. In extreme cases, a strong signal being transmitted on one pair can totally overpower a weaker signal being received on a nearby pair.

NEXT loss is measured in dB. The higher the dB value, the lower the disruptive effect of crosstalk. In other words, there is less unwanted electrical coupling between the pairs.

While NEXT coupling increases with the length of cable under measurement and the applied frequency, the relationship is not linear. The effects of attenuation and NEXT have been incorporated into applicable ANSI/TIA/EIA documents through assignment of categories and length restrictions.

Propagation Delay and Delay Skew

The development of some high-speed LAN applications using multiple pairs simultaneously in a four-pair UTP cable has brought forward the need for additional transmission requirements for 100 Ω, four-pair UTP cabling systems. These parameters are referred to as propagation delay and delay skew.

Propagation delay is the amount of time needed for the transmission of a signal over a single pair of 100 Ω four-pair UTP cable.

Delay skew is the difference in the propagation delay between any two pairs within the same cable sheath. This parameter is important to those applications using multiple pairs simultaneously for parallel transmission.

The difference in the delay between the fastest and the slowest simplex link segment, between cable pairs, is critical to the proper decoding of the signal by the receiver. This difference in delay (skew) is specified by some applications standards as not exceeding 50 nanoseconds (ns) under worst-case conditions for all frequencies between 2.0 MHz and 12.5 MHz. Cable skew should not exceed 45 ns per 100 m (328 ft) at a temperature of 20 ^{0}C (68 ^{0}F), 40 ^{0}C (104 ^{0}F), and 60 ^{0}C (140 ^{0}F). This provides an allowance of 5 ns for the connecting hardware and installation variances.

Propagation delay and delay skew are now specified in ANSI/TIA/EIA-568-A-1 with the approval and publication of Addendum 1.

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UTP Transmission Measurements, continued

Specifications

ANSI/TIA/EIA-568-A makes the following recommendations for UTP cable to be used in the horizontal cabling system. These specifications are applicable to all cable types described under horizontal cabling earlier in this chapter.

- The cable consists of 24 AWG thermoplastic insulated solid conductors.
- Conductors are formed into four individually twisted pairs and enclosed by a thermoplastic jacket.
- Four-pair, 22 AWG cable meeting or exceeding transmission requirements may be used.
- Four-pair, ScTP cable meeting transmission requirements may be used.
- The cable will be restricted to four-pair size.
- Pair twist lengths are selected by the cable manufacturer to ensure compliance with transmission requirements.
- Hybrid cable constructions are allowed in the horizontal cabling provided that additional crosstalk requirements needed to prevent interference between adjacent hybrid units are met (see ANSI/TIA/EIA-568-A-3).

Color Codes for Horizontal 100 Ω UTP Cable

Table 4.3
Color codes for horizontal UTP cable

Pair Identification	Color Code	Abbreviation
Pair 1	White-Blue*	W-BL
	Blue†	BL
Pair 2	White-Orange*	W-O
	Orange†	O
Pair 3	White-Green*	W-G
	Green†	G
Pair 4	White-Brown*	W-BR
	Brown†	BR

* The wire insulation is white with a colored marking added for identification. For cables with tightly twisted pairs (all less than 38 mm [1.5 in] per twist), the mate conductor may serve as the marking for the white conductor.

† A white marking is optional.

Backbone UTP Cable

Specifications

The following specifications are for cables in pair sizes greater than four pairs for use in the backbone cabling system:

- Backbone cables consists of 24 AWG thermoplastic insulated copper conductors.
- Conductors are formed into one or more units of unshielded twisted pairs.
- Units are assembled into binder groups of 25 pairs or part thereof following the standard industry color code.
- Groups are identified by distinctly colored binders and assembled to form a single compact core.
- The core is covered by a protective sheath consisting of an overall thermoplastic jacket and may contain an underlying metallic shield and one or more layers of dielectric material applied over the core.
- 22 AWG cable meeting or exceeding transmission requirements may be used.
- ScTP cable meeting transmission requirements may be used.
- The pair twist lengths are selected by the manufacturer to ensure compliance with the requirements of the standard.
- Maximum UTP backbone distances are as follows:
  - 800 m (2624 ft) from the horizontal cross-connect to the main cross-connect.
  - 500 m (1640 ft) from the horizontal cross-connect to the intermediate cross-connect.
  - 300 m (984 ft) from the intermediate cross-connect to the main cross-connect.
- Backbone cables can be obtained in Categories 3, 4, and 5.
- Backbone cables are qualified for near-end crosstalk performance based on a power-sum characterization. This requirement ensures trouble-free transmissions of multiple signals of the same type within the same binder group.

NOTE: Backbone UTP cables intended for use with high-speed LAN applications are recommended to not exceed 90 m (295 ft) in length.

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UTP Connecting Hardware

Specifications

The following specifications for UTP connecting hardware are provided to assure that properly installed connectors will have minimal effects on cable performance:

- Requirements apply only to individual UTP connectors and connector assemblies.
- Connecting hardware includes but is not limited to telecommunications outlet/ connectors; patch panels; transition connectors; consolidation point connectors; and cross-connect blocks.
- It is desirable that hardware used to terminate UTP cables be of the insulation displacement contact (IDC) type.
- At the work area, each four-pair cable is to be terminated in an unkeyed eight-position modular jack.
- The recommended pin/pair assignment is designated as T568A; if necessary to accommodate certain eight-pin cabling systems, the optional T568B pin/pair assignment is permitted. Both of these configurations are shown below. The colors shown are associated with the horizontal distribution cable.
- Horizontal cables should be terminated with connecting hardware of the same category or higher.

It should be noted that meeting connector requirements for Category 3, 4, or 5 performance is not sufficient in itself to ensure desired system performance. End-to-end performance between a transmitter and a receiver also depends on cable characteristics, the total number of connections between the ends, and the quality of installation and maintenance.

Figure 4.12
T568A pin/pair assignment

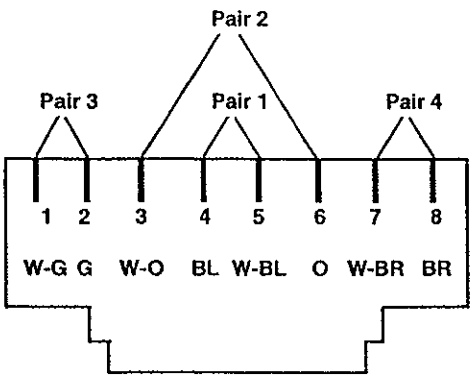
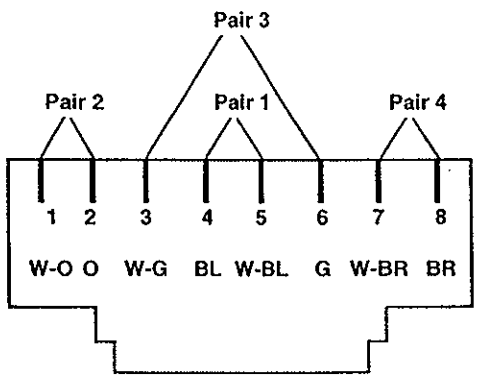


Figure 4.13
T568B optional pin/pair assignment



NOTE: Refer to Table 4.3 for color code abbreviations.

UTP Connecting Hardware, continued

UTP Patch Cords and Cross-Connect Jumpers

Patch cords and cross-connect jumpers used for system moves, adds, and changes are as important to system performance as the horizontal cable.

ANSI/TIA/EIA-568-A provides the following information:

- For the purpose of an adequate flex-life, the cable used to construct UTP patch cords shall have stranded conductors.
- Patch-cord color codes shall conform to either Color Code Option 1 or Color Code Option 2. These color codes are indicated below.
- Since pair groupings are identical, patch cords wired per T568A or T568B pair assignments may be used interchangeably, provided both ends of the cord are wired with the same pin/pair scheme.
- Cross-connect jumper wire pairs shall consist of one conductor with white insulation and the other conductor with a visibly distinct color.
- Cables used for patch cords and cross-connect jumpers should be of an equal or higher performance category as the horizontal cables they connect to.

Table 4.4
Color codes for stranded UTP patch cord

Pair Identification	Color Code Option 1 (Abbreviation)	Color Code Option 2 (Abbreviation)
Pair 1	White-Blue (W-BL) Blue (BL) *	Green (G) Red (R)
Pair 2	White-Orange (W-O) Orange (O) *	Black (BK) Yellow (Y)
Pair 3	White-Green (W-G) Green (G) *	Blue (BL) Orange (O)
Pair 4	White-Brown (W-BR) Brown (BR) *	Brown (BR) Slate (S)

* A white marking is optional.

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TIA/EIA TSB-67 - Field Testing UTP

Overview

With the evolution of UTP-based telecommunications cabling systems has come the need for comprehensive verification testing. The focus of TIA/EIA TSB-67, *Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems,* is to provide field-testing specifications for post-installation performance measurements of UTP cable plant designed according to ANSI/TIA/EIA-568-A specifications.

The overall transmission performance of the cabling system depends on the following:

- Cable characteristics
- Connecting hardware
- Patch cords and cross-connect wiring
- Total number of connections
- Quality of installation and testing

The transmission performance requirements specified in TIA/EIA TSB-67 apply to UTP cabling links consisting of 100 Ω, four-pair UTP cable and connecting hardware as specified in ANSI/TIA/EIA-568-A. This TSB may also be used for 100 Ω ScTP links meeting the transmission performance requirements of ANSI/TIA/EIA-568-A.

TIA/EIA TSB-67 - Field Testing UTP, continued

Test Configurations

TIA/EIA TSB-67 defines two test configurations—the channel test configuration and the basic link test configuration.

Channel Test Configuration

The channel test configuration is used to verify the performance of the overall channel. Transmission requirements for the channel are based on a model that is made up of the following elements:

- Up to 90 m (295 ft) of horizontal cable
- A work area equipment cord, an equipment cord in the TC, and a patch cord (or jumper) whose total combined length does not exceed 10 m (33 ft).
- A telecommunications outlet/connector
- An optional transition or consolidation point connection close to the work area
- Two pieces of connecting hardware in the TC

Plug connections to equipment at the ends of the channel are not included in the definition of the channel.

NOTES: The total combined length of the equipment cords, patch cords, and jumper wires shall not exceed 10 m (33 ft).

The channel definition does not apply to those situations where the horizontal cabling is cross-connected to the backbone cabling.

In all cases, NEXT measurements must be performed at both ends of the channel.

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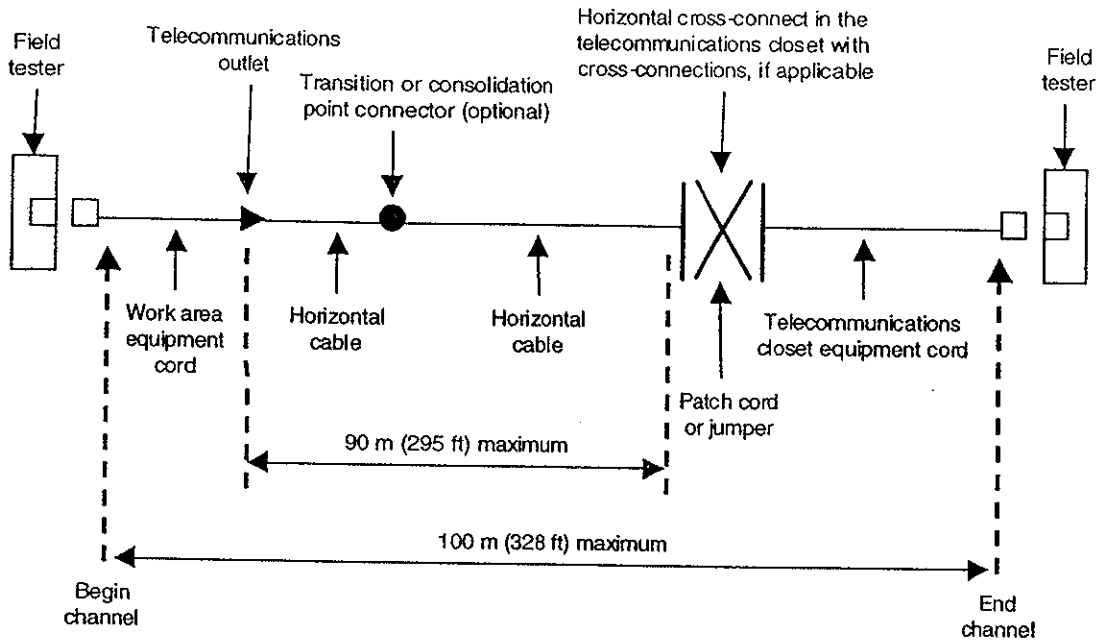
TIA/EIA TSB-67 - Field Testing UTP, continued

Figure 4.14
Channel test configuration



Basic Link Test Configuration

The basic link test configuration is meant to be used to verify the performance of permanently installed cabling. Transmission requirements for the basic link are based on a model that is made up of the following elements:

- Up to 90 m (295 ft) of horizontal cabling
- A connection at each end of the cable
- Up to 2 m (6.5 ft) of test equipment cord from the main unit of the field tester to the local connection
- Up to 2 m (6.5 ft) of test equipment cord from the remote connection to the remote unit of the field tester

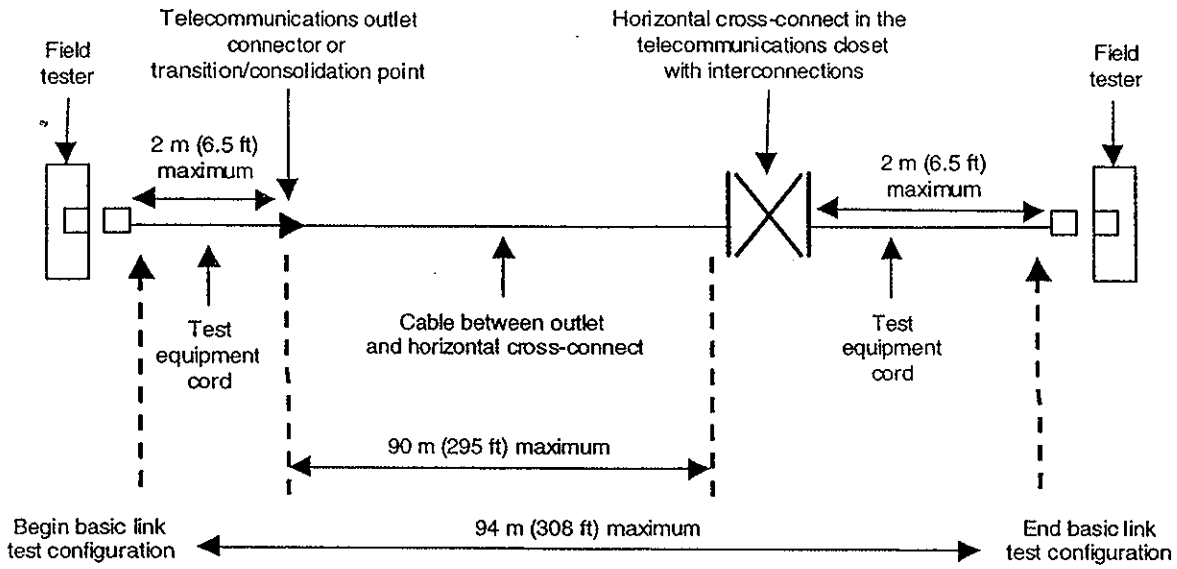
Plug connections to equipment at the ends of the basic link are not included in the definition of the basic link.

NOTE: The basic link assumes one connection at each end of the link.

TIA/EIA TSB-67 - Field Testing UTP, continued

In all cases, near-end crosstalk (NEXT) measurements must be performed at both ends of the basic link.

Figure 4.15
Basic link test configuration



Test Parameters

There are four primary field test parameters—wire map, length, attenuation, and near-end crosstalk loss. Other parameters that may be of importance to certain networking applications—return loss, far-end crosstalk, and balance—are still under study and expected to be specified in TIA/EIA TSB-95 and ANSI/TIA/EIA-568-A-5.

Wire Map

The wire map is meant to verify pair to pin termination at each end. It is also used to check for installation connectivity errors.

For each of the eight conductors in the cable, the wire map indicates:

- Continuity to the remote end.
- Shorts between any two or more conductors.
- Crossed pairs.
- Reversed pairs.
- Split pairs.
- Any other miswiring.

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TIA/EIA TSB-67 - Field Testing UTP, continued

Length

It is necessary to consider both the physical length of the cable and the electrical length of the cable.

The physical length of the channel/basic link is the sum of the individual physical lengths of the cables between the end points. The physical length can be determined as follows:

- Physically measuring the cable length(s)
- From length markings on the cable(s)
- Estimated from the electrical length measurement

The maximum physical length of the channel is 100 m (328 ft)—this includes work area cables, equipment cords, and patch cords. The maximum physical length of the basic link is 94 m (308 ft)—this includes test equipment cords.

NOTE: Because of twisting, actual physical length of the wire pairs is greater than the physical length of the cable. For simplicity and consistency, physical length generally refers to the cable rather than the individual pairs.

The electrical length of the channel/basic link is derived from the propagation delay of signals. The electrical length is dependent on the twist helix (pair twist) and dielectric material.

Attenuation

Attenuation is a measure of signal loss. The worst-case attenuation of all pairs within a link or channel, relative to the maximum attenuation permitted, is to be determined.

The link attenuation is the total of the combined attenuation of all connecting hardware and cable that comprise the link or channel.

NOTE: Refer to TIA/EIA TSB-67 for examples of worst-case attenuation at selected frequencies for channel and basic link testing.

NEXT Loss

NEXT loss is a measure of signal coupling from one pair to another within a UTP cabling link or channel. A balanced input signal is applied to a disturbing pair at the near end of the link while the induced differential signal on the disturbed pair is measured at the near end. All pair combinations are to be measured.

NOTE: Refer to TIA/EIA TSB-67 for values of worst-pair NEXT loss for a channel and a basic link at specific frequencies.

TIA/EIA TSB-67 - Field Testing UTP, continued

Data Reporting and Accuracy

Each test will result in a Pass or a Fail. The Pass/Fail result is determined by the allowable limits for the parameter being tested. A test result is to be marked with an asterisk (*) if the result is closer to the test limit than the accuracy of the field tester.

The results of the individual tests are used to determine the overall test result. If any test results indicate a Fail or Fail* then the overall test result is a Fail. To achieve an overall test result of Pass, all individual tests must result in a Pass or Pass*.

The accuracy of a test is the difference between the measured value as reported by the tester and the actual value. All measurements reported by the field tester must have a specified accuracy. These accuracy specifications can be found in Annex A.1 of TIA/EIA TSB-67.

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Shielded Twisted-Pair (STP) Cabling Systems

Introduction

STP cable was developed at a time when unshielded twisted-pair cable was considered unsuitable for high-speed data transmission. By shielding the individual pairs of conductors, immunity to EMI was improved substantially, reducing the instances of interference-related network problems.

Transmission specifications for 150 Ω STP cabling were originally made to support transmission signals up to 20 MHz. Until recently, these specifications were adequate. As LAN speeds and corresponding transmission frequencies increased, STP specifications needed to be extended to ensure stable performance for the high-frequency applications.

Improved cable specifications and a new connector have been introduced to meet the additional specifications. The new connector is intermateable with the original connector. The new cable is referred to as STP-A.

These specifications are included in ANSI/TIA/EIA-568-A.

It is recommended that individuals requiring detailed performance attributes consult the ANSI/TIA/EIA-568-A standard and any other standards associated with the planned service or equipment.

STP-A Transmission Measurements

Please see UTP transmission measurements for the definitions of the following transmission measurements.

Characteristic Impedance and Structural Return Loss

STP-A cable has a characteristic impedance of 150 Ω ± 10% for the frequency range from 3 MHz to 20 MHz.

Attenuation

Maximum acceptable attenuation in STP-A cabling systems should be measured up to a frequency of 300 MHz.

NEXT Loss

NEXT loss measurements are made for two different frequency ranges—for the range of 9.6 kHz to 20 MHz for test cable lengths at 305 m (1000 ft) or greater and for the range from 20 MHz to 300 MHz for test cable lengths ranging from 100 m (328 ft) to 305 m (1000 ft).

Horizontal STP-A Cable

Specifications

ANSI/TIA/EIA-568-A makes the following recommendations for STP cable to be used in the horizontal cabling system:

- Cables consist of two individually twisted pairs of 22 AWG thermoplastic insulated solid conductors enclosed by a shield and an overall thermoplastic jacket.
- The cable is restricted to a two-pair size.
- Pair twist lengths are selected by the cable manufacturer to ensure compliance with the requirements of the standard.
- Conductor color coding may be accomplished by using helical striping, band marking, a solid-color skin, or pigment in the insulation itself. The color codes for horizontal STP-A cable are indicated below.
- An electrically continuous shield consisting of a plastic and aluminum laminated tape—with the aluminum side facing out—and a braid of tin-coated copper wire with a minimum of 65 percent coverage in contact with the aluminum shall be applied over the core wrap.
- The core shield may be applied to isolate the two pairs within the cable core.
- The braided shield must be properly bonded to ground in the TC.
- Cables used for STP-A patching are specified to be 26 AWG stranded with an overall shield.

Table 4.5
Color codes for horizontal STP-A cable

Conductor Identification	Color Code
Pair 1	Red Green
Pair 2	Orange Black

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Backbone STP-A Cable

Specifications

The requirements for the backbone 150 Ω STP-A cable shall be the same as the requirements for horizontal STP-A cable.

NOTE: Backbone STP-A cable shall not exceed 90 m (295 ft).

An optional backbone 150 Ω STP-A cable, suitable for outdoor applications, shall have the following characteristics:

- A single aluminum tape shield with an insulation coating on both sides wrapped around and separating each pair
- A filled core
- An aluminum tape armor over the shield
- A black polyethylene jacket

STP-A Connecting Hardware

Specifications

The following recommendation for STP-A connecting hardware assures that properly installed connecting hardware will have minimal effects on performance:

- The 150 Ω telecommunications outlet/connector must meet all the transmission requirements of and be mateable with the 150 Ω STP-A connector. Connectors that are compatible with STP-A compliant extended performance cables are marked with the symbol Ⓔ.

Optical Fiber Cabling Systems

Introduction

Optical fiber is by no means a new invention. The idea of using glass to transmit signals dates back to the late 1800s. Initially, the problem was to keep the light from escaping, which it did whenever the glass made contact with any other substance. In the 1950s, two-layer glass was introduced. This proved to be an effective way to keep a signal inside the central first layer of glass. The second layer acted as a protective barrier, but there was no efficient way to get the light into the center layer. The 1960s saw the invention of the laser, which provided a method to get sufficient light into the fiber's core. At the same time, improvements were made in fiber purification to reduce impurities in the glass that were causing excessive light loss. By the early 1970s the use of optical fiber for telecommunications purposes was technically feasible; unfortunately, the cost was prohibitive.

By 1979, the basic cost of copper and optical fiber systems crossed and the use of optical fiber in the long-haul portion of telephone networks began. Today, the amount of installed optical fiber worldwide is measured in millions of kilometers (miles).

ANSI/TIA/EIA-568-A recognizes optical fiber as an acceptable transmission medium for both horizontal and backbone cabling systems.

Classifying Optical Fiber

Overview

Optical fibers consist of two layers of glass, each with a different refractive index. The light pulses travel in an inner layer of glass called the core. The outer layer of glass called the cladding has a lower refractive index than the core and contains the light pulses within the core.

Optical fiber is usually described in terms of its diameters—for example, 50/125 μm, 62.5/125 μm, or 100/140 μm optical fiber. The first number indicates the diameter of the fiber core. The second number indicates the overall diameter of the combined core and cladding. In multimode optical fiber, light pulses travel through the core following many different paths, or modes.

Small-core optical fiber is referred to as singlemode optical fiber. There is only one path or mode that light pulses can follow through the core.

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Classifying Optical Fiber, continued

While there is a practical manufacturing limit to how small the overall fiber diameter can be—typically 125 µm, for handling reasons—there has been a variety of core diameters available over the years. Through standardization, 62.5/125 µm has become the most common type of multimode optical fiber used. The most common type of singlemode optical fiber used has a core diameter of 8.3–9.5 µm with an overall 125 µm core/cladding diameter.

ANSI/TIA/EIA-568-A specifies 62.5/125 µm multimode optical fiber for horizontal cables. It also recommends 62.5/125 µm multimode optical fiber and singlemode optical fiber for backbone cable.

It is recommended that individuals requiring detailed performance attributes consult the ANSI/TIA/EIA-568-A standard and any other standards associated with the planned service or equipment.

Optical Fiber Transmission Characteristics

Introduction

Optical fiber transmits signals as light pulses. For this reason, electrical codes do not normally cover handling procedures for optical fiber. Media transmission characteristics for optical fiber vary somewhat from those for copper-based transmission systems.

Wavelength

The length of a wave is the distance from any point on one wave to the corresponding point on the next wave. Wavelengths of light are measured in nanometers (nm)—where 1 nm = 10^{-9}m.

The performance of different types of optical fiber varies with the wavelength used for transmission. Some common transmission wavelengths are as follows:

- Transmission is typically at 850 or 1300 nm for 62.5/125 µm multimode optical fiber.
- Transmission is typically at 1310 or 1550 nm for singlemode optical fiber.

Optical Fiber Transmission Characteristics, continued

Attenuation

Optical fiber attenuation can be considered as the dimming of the light as it travels down the fiber's core. It is a measure of the reduction in signal strength made by comparing the power level of the output to that of the input.

Attenuation in optical fiber can be caused by any or all of the following:

- Absorption by impurities in the fiber
- Scattering of light out of the fiber core due to the molecular structure of the glass
- Macrobending—large bends in the fiber—caused by mishandling of the fiber
- Microbending—small-scale distortions of the glass

Losses caused by attenuation over distance are expressed as decibels/kilometer (dB/km). That is, like copper cables, the loss is directly proportional to the length of the fiber.

For example, an optical fiber with an attenuation loss rating of 3.0 dB/km would show the following losses:

- 1.5 dB loss over 0.5 kilometers of fiber
- 3.0 dB loss over a 1 kilometer length of fiber
- 6.0 dB loss over 2 kilometers of fiber

Decibel Measurements

Decibels are measurements made on a logarithmic scale. The dB transmission loss can also be expressed as the percent of light being transmitted.

Table 4.6
dB transmission losses vs. percent of light transmitted

Transmission Loss	Percent of Light Transmitted
0.0 dB	100%
0.5 dB	89%
1.0 dB	79%
2.0 dB	63%
3.0 dB	50%
10.0 dB	10%
20.0 dB	1%
40.0 dB	0.01%

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Optical Fiber Transmission Characteristics, continued

Bandwidth

Optical fiber bandwidth is a measure of the information-carrying capacity of the fiber. The bandwidth is typically expressed in frequency-distance form—MHz•km (megahertz•kilometer). The information-carrying capacity of an optical fiber is inversely proportional to the length of fiber. That is, the longer the fiber system, the less bandwidth the system has.

Actual system bandwidth is not only a function of the fiber bandwidth but also the performance of the transmitter, specifically wavelength, spectral width, and rise/fall time. Designers should rely on application standards or original equipment manufacturer (OEM) recommendations for the maximum distance supported at various data rates.

Dispersion

Dispersion is defined as the spreading out of light pulses as they travel through an optical fiber which determines the bandwidth of the fiber. It is proportional to the length of the fiber—the longer the fiber, the greater the problem of dispersion. It is possible that transmitted pulses may broaden so much that they cannot be distinguished from each other at the receiving end of the system.

Total dispersion consists of modal dispersion and chromatic dispersion.

Modal Dispersion

Modal dispersion is the prime limiting parameter with multimode optical fiber. It is the result of different light pulses taking slightly different paths—following different modes—through the core. The light pulses actually bounce back and forth in the core and sometimes arrive at their destination slightly out of phase. That is, different paths do not arrive at exactly the same time and, in some cases, two pulses may overlap, appearing to be only one pulse to the receiver.

NOTE: Differential mode delay is a form of dispersion identified in some multimode optical fiber when supporting laser transmissions. Differential mode delay is presently being accounted for with conditioning of the launch state of the light either at the source for vertical cavity surface emitting lasers (VCSELs) or with a special patch cord for 1300 nm lasers.

Optical Fiber Transmission Characteristics, continued

Chromatic Dispersion

Chromatic dispersion is the result of different wavelengths of light traveling at different speeds through the optical fiber. All optical transmitters emit light containing a range of wavelengths and each of these wavelengths travels at a slightly different speed. These different wavelengths will arrive at the receiver at different times, causing the transmitted pulse to spread as it travels through the optical fiber. Chromatic dispersion is mostly a consideration when designing singlemode optical fiber systems. It is proportional to the length of the fiber; the longer the fiber, the greater the dispersion.

Horizontal Optical Fiber Cable

Specifications

ANSI/TIA/EIA-568-A provides the following information for optical fiber used in horizontal cable distribution systems:

- The optical fiber cable shall consist of a minimum of two 62.5/125 µm optical fibers enclosed by a protective sheath.
- The cable will be capable of supporting applications using a bandwidth in excess of 1 GHz over the 90 m (295 ft) specified for horizontal cabling.
- The optical fiber shall be multimode, graded-index with a nominal 62.5/125 µm core/cladding diameter.
- The mechanical and environmental specification for the optical fiber cable will be in accordance with ANSI/ICEA-S-83-596, *Fiber Optic Premises Distribution Cable.*

The transmission performance parameters for the cable are indicated below.

Table 4.7
62.5/125 µm optical fiber cable transmission performance parameters

Wavelength (nm)	Maximum Attenuation (dB/km)	Minimum Information Transmission Capacity (MHz•km)
850	3.75	160
1300	1.50	500

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Backbone Optical Fiber Cable

Specifications

ANSI/TIA/EIA-568-A provides the following information for optical fiber used in backbone cable distribution systems:

- The optical fiber cable shall consist of 62.5/125 μm optical fiber and/or singlemode optical fibers.
- Optical fibers are typically grouped into units of 6 or 12 fibers each.
- Individual fibers and groups of fibers shall be identifiable in accordance with ANSI/EIA/TIA-598-A, *Color Coding of Fiber Optic Cables.*
- The cable may contain a metallic shield and one or more layers of dielectric material applied over the core.
- The transmission performance parameters for backbone 62.5/125 μm multimode optical fiber are the same as those specified for horizontal 62.5/125 μm multimode optical fiber.
- The mechanical and environmental specifications on the optical fiber cable shall be in accordance with ANSI/ICEA-S-83-596 for indoor cable and ANSI/ICEA-S-83-640 for outdoor cable.

The transmission performance parameters for backbone singlemode optical fiber are indicated below.

Table 4.8
Singlemode optical fiber transmission performance parameters

Wavelength (nm)	Maximum Attenuation (dB/km)	
	Indoor Cable	Outdoor Cable
1310	1.0	0.5
1550	1.0	0.5

Optical Fiber Connections

Connector/Adapters Recommendations

The ANSI/TIA/EIA-568-A specifications on fiber connectors and adapters apply to both backbone and horizontal cabling and connecting hardware at the main cross-connect, intermediate cross-connect, horizontal cross-connect, and telecommunications outlet/connector.

- The adapter and connector specified by ANSI/TIA/EIA-568-A is referred to as 568SC.
- The recommended connector and adapter shall be capable of simplex or duplex optical fiber connection.
- Users with an installed base of bayonet fiber optic connector (BFOC) connectors and adapters—commonly referred to as ST connectors—may continue to use these connectors and adapters for both existing and future additions to their optical fiber networks.
- Both the 62.5/125 μm and singlemode 568SC connector and adapter shall be of the same dimensions. To distinguish between the two optical fiber types, the following connector/adapter colors shall be used:
  - The 62.5/125 μm connector and adapter shall be identified with the color beige.
  - The singlemode connector and adapter shall be identified with the color blue.

Transmission Parameters

ANSI/TIA/EIA-568-A specifies the following transmission parameters for the 568SC connector/adapter:

- The maximum optical attenuation per each mated field-installed 568SC connector pair shall not exceed 0.75 dB.
- The maximum optical attenuation through the cross-connect from any terminated optical fiber to any other terminated optical fiber shall not exceed 1.5 dB.
- The 568SC connector shall have a return loss $\geq$ 20 dB on 62.5/125 μm optical fiber and a return loss $\geq$ 26 dB on singlemode optical fiber.
- The 568SC connectors shall be able to sustain at least 500 mating cycles without violating performance specifications.

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Optical Fiber Connections, continued

Optical Fiber Patch Cords

The optical fiber patch cord shall be a two-fiber cable of the same type as the optical fiber cabling. The connector on an optical fiber patch cord shall:

- Allow for easy connection and reconnection.
- Ensure polarity is maintained.
- Offer high pull-proof capabilities.

Optical fiber patch cords shall follow a crossover orientation such that Position A goes to Position B on one fiber and Position B to Position A on the other fiber.

Optical Fiber Splices

Whether fusion or mechanical, optical fiber splices shall not exceed a maximum optical attenuation of 0.3 dB.

Optical Fiber Field Testing

Attenuation testing is the only required test parameter for an installed optical fiber system. This test is performed using power meters and light sources. Recommendations, methods, and performance values for both horizontal and backbone cables are found in ANSI/TIA/EIA-568-A.

International Standard ISO/IEC 11801

This standard is intended to be a comprehensive set of recommendations for the purpose of designing and installing the telecommunications infrastructure in commercial environments. It is not possible to go into detail for each topic presented in ISO/IEC 11801. The focus here is to examine those aspects of the document most relevant to the design of cabling systems for the LAN environment.

It is highly recommended that individuals involved in the design of premises cabling systems in the international marketplace obtain and study this standard.

Introduction

The international standard ISO/IEC 11801, *Information technology - Generic cabling for customer premises,* is the result of work done by the Joint Technical Committee ISO/IEC JTC 1/SC 25/WG 3. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) form a system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of international standards.

The purpose of ISO/IEC 11801 is to enable a controlled migration to generic cabling from a combination of application-specific and multipurpose network cabling.

The international standard provides:

- An application-independent generic cabling system leading to an open market for cabling components.
- A flexible cabling scheme that makes modifications easier and more economical.
- Guidelines for building professionals such as architects. This allows for cabling system planning before detailed requirements are known for both the initial construction and later renovations.
- A cabling system which supports current products and provides a basis for future developments.

NOTES: There are similarities between the international standard ISO/IEC 11801 and ANSI/TIA/EIA-568-A. The focus of this discussion is to review the recommendations and requirements made in the ISO/IEC 11801 standard.

The terminology used in this section is that used in the international standard.

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Generic Cabling System Structure

System Components

The generic cabling system is made up of three cabling subsystems—the campus backbone, the building backbone, and the horizontal cabling. These cabling subsystems are made up of the following functional elements:

- Campus distributor (CD)
- Campus backbone cable
- Building distributor (BD)
- Building backbone cable
- Floor distributor (FD)
- Horizontal cable
- Transition point (TP) which is optional
- Telecommunications outlet (TO)

NOTE: A distributor is the term used to describe the functions performed by a collection of components—patch panels, patch cords—used to connect cables. The terms cross-connect and distributor can be used interchangeably.

The distributors are located in equipment rooms (ER) or telecommunications closets (TC). They are used to configure the cabling to support different topologies such as bus, star, and ring.

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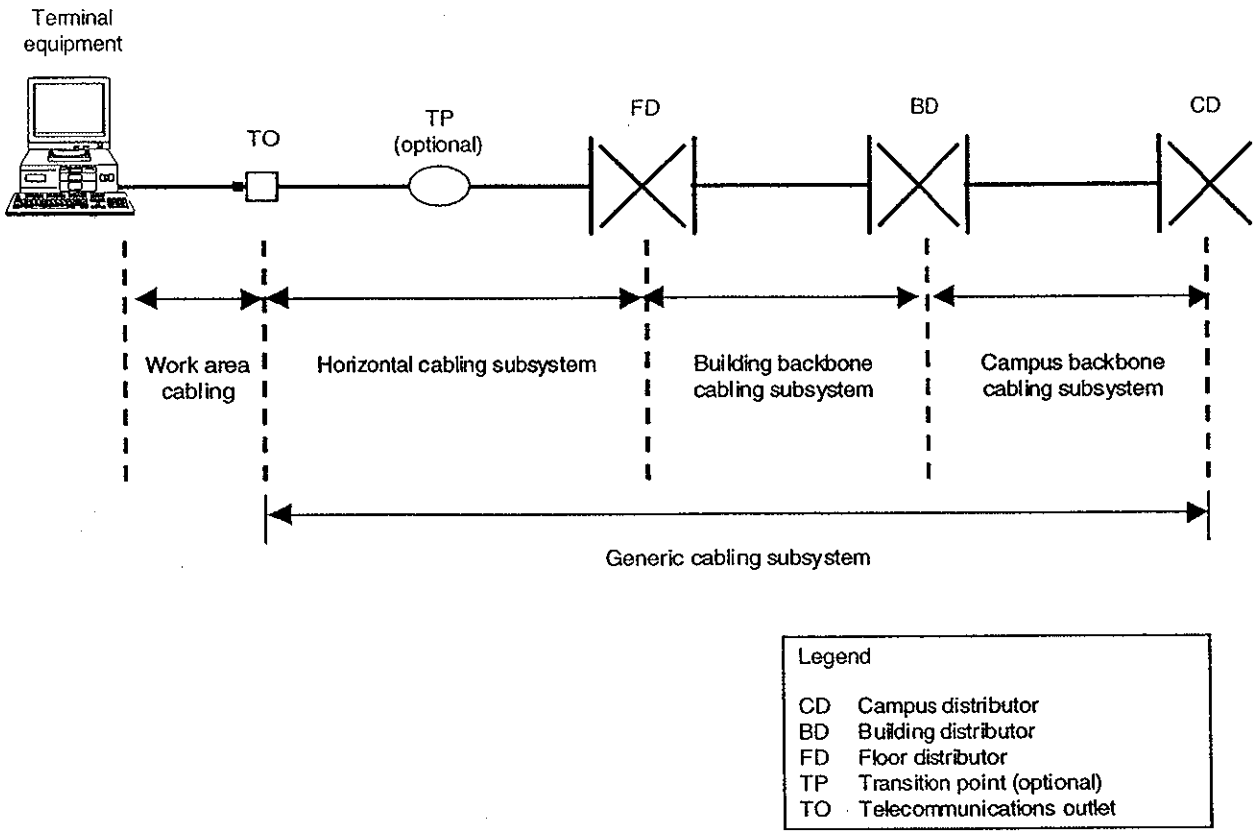
Generic Cabling System Structure, continued

Figure 4.16
Generic cabling system



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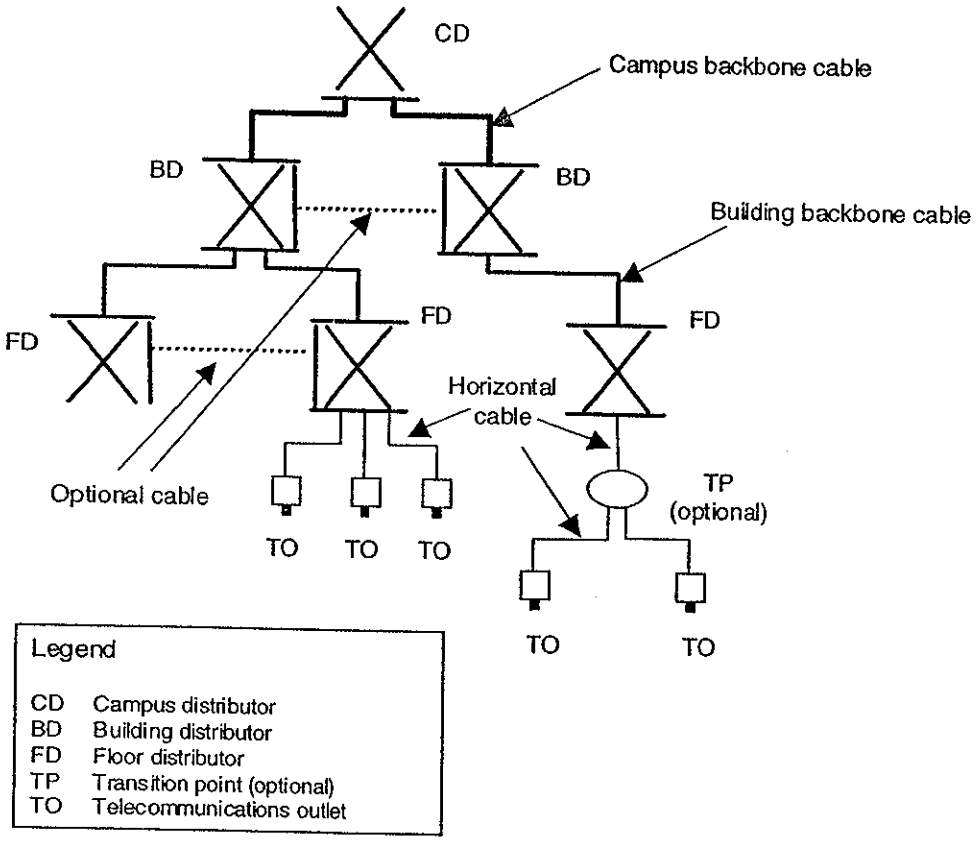
Generic Cabling System Structure, continued

System Structure

The generic cabling system follows a hierarchical star structure. The number and type of subsystems to include will vary from installation to installation.

To form the hierarchical star, cables are installed between adjacent levels in the structure. For some applications, additional direct connections between FDs or BDs are permitted. These connections are in addition to those required for the basic hierarchical star topology.

Figure 4.17
Generic cabling hierarchical star topology



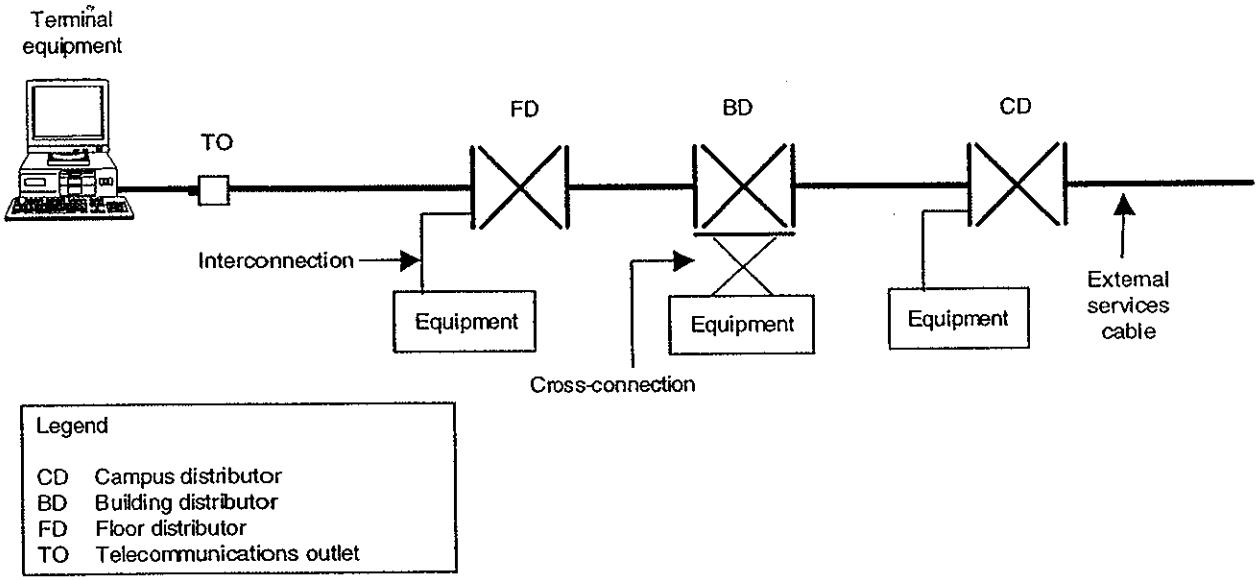
The functions of multiple distributors, such as a BD and a FD, can be combined into a single distributor.

Generic Cabling System Structure, continued

System Interfaces

Interfaces to the generic cabling system are at the ends of each subsystem—horizontal, backbone, and campus. It is at these points that application-specific equipment can be connected.

Figure 4.18
Interfaces to the generic cabling system



Connections to the public network are made at the public network interface. The location of this public network interface is regulated by national, regional, and local regulations. In those cases where the public network interface is not directly connected to a generic cabling interface, it is important to consider the performance of the intermediate cabling. The type of connection (network interface) and intermediate cable used to connect to the public network may be governed by national regulations.

Configuring the System

The following describes some of the design and configuration recommendations made in ISO/IEC 11801.

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Generic Cabling System Structure, continued

Floor Distributor (FD)

A minimum of one FD is recommended for every 1000 m^2 of floor area to be used as office space.

At least one FD should be located on each floor. An exception to this would be those cases where a floor is sparsely populated—for example, a lobby. In these cases it is permissible to serve the sparsely populated floor from an FD located on an adjacent floor.

Cabling Media

The international standard ISO/IEC 11801 uses somewhat different terminology in the description of cabling media than the ANSI/TIA/EIA documents. The following definitions are important to the understanding of the terminology used in ISO/IEC 11801.

balanced cable	A cable made up of one or more metallic cable elements. These cable elements may be in the form of twisted-pairs or quads. ISO/IEC 11801 chose this term along with unshielded/shielded cable and unshielded/shielded cable element to describe various cable constructions.
cable element	A cable element is considered the smallest unit of construction in a cable. It may be a pair, quad, or single optical fiber. A cable element may be shielded.
cable unit	A cable unit is an assembly of one or more cable elements of the same type or category. An example of a cable unit is a binder group. A cable unit may be shielded.
pair	A pair is a twisted-pair or one side circuit in a star quad. A side circuit is two diametrically facing conductors.
shielded cable	A shielded cable is an assembly of two or more balanced twisted-pair cable elements or one or more quad cable elements wrapped in an overall screen or shield contained in a common sheath or tube.
shielded twisted-pair cable	A shielded twisted-pair cable is an electrically conducting cable made up of one or more elements—pair or quad—each of them shielded. The cable may have an overall shield. If so, it is then referred to as a shielded twisted-pair cable with an overall shield.

Generic Cabling System Structure, continued

star quad	Star quad is a cable element made up of four insulated conductors twisted together. A transmission pair is formed by diametrically facing conductors. A cable containing star quads can be used interchangeably with cables containing pairs—providing the electrical characteristics meet the same specifications.
twisted-pair	A twisted-pair is a cable element made up of two insulated conductors twisted together in a regular fashion to form a balanced transmission line.
unshielded twisted-pair (UTP) cable	An unshielded twisted-pair cable is an electrically conducting cable made up of one or more pairs—none of them shielded. The cable may have an overall shield. If so, it is then referred to as UTP cable with an overall shield.

Media Choices

The following are the recommended media choices when pre-cabling:

- In the horizontal subsystem, balanced cables are recommended for voice and data applications with optical fiber to be considered under certain conditions, such as those involving security or environmental concerns.
- In the building backbone subsystem, balanced cables are recommended for voice and low to medium-speed data applications. Optical fiber is recommended for medium to high-speed data applications.
- In the campus backbone subsystem, optical fiber is recommended for most applications. Balanced cables may be used as required by applications not needing the bandwidth of optical fiber.

NOTE: Mechanical and electrical characteristics for the various cables and associated connecting hardware can be found in Clauses 8 and 9 of the international standard ISO/IEC 11801.

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Generic Cabling System Structure, continued

Horizontal Subsystem Recommendations

Regardless of media type, the maximum allowable length for horizontal cable is 90 m (295 ft). This is the distance from the cable termination in the FD to the TO in the work area. Each horizontal segment is permitted a total length of 10 m (33 ft) for work area cables, patch cords or jumpers, and equipment cables. It is also specified that the FD jumper or patch cords not exceed 5 m (16 ft) in length.

The preferred cable types for use in the horizontal cabling subsystem are:

- 100 Ω balanced cable.
- 62.5/125 μm multimode optical fibers.

Alternative choices are:

- 120 Ω balanced cable.
- 150 Ω balanced cable.
- 50/125 μm multimode optical fibers.

Hybrid and multiunit cables may be used to serve more than one TO if the cables meet specified requirements.

NOTE: Coaxial cable is not recognized by the international standard as an acceptable transmission media.

Backbone Subsystem Recommendations

A maximum of two hierarchical levels of cross-connect in the backbone is permitted. This limits signal degradation for passive systems and simplifies administration of the system. A maximum of one cross-connect is to be passed through to reach a CD from a FD. It is possible that a single backbone cross-connect may meet the requirements for the whole backbone subsystem—building backbone and campus backbone.

The international standard recognizes five transmission media as acceptable for backbone cabling. One or more of these may be present in the backbone subsystems. The five recognized transmission media are as follows:

- Multimode optical fiber
- Singlemode optical fiber
- 100 Ω balanced cable
- 120 Ω balanced cable
- 150 Ω balanced cable

Generic Cabling System Structure, continued

The preferred media choices are 62.5/125 μm multimode optical fiber and 100 Ω balanced cable.

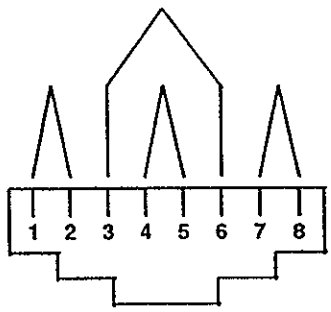
The maximum distance between the BD and FD is not to exceed 500 m (1640 ft) and the maximum distance between the CD and FD is not to exceed 2 km (1.25 mi). This 2000 m (6560 ft) length between CD and FD may be extended by using singlemode optical fiber cabling. However, distances exceeding 3 km (1.9 mi) are considered beyond the scope of ISO/IEC 11801. All high-speed applications on copper are limited to the distances specified for horizontal cabling.

Telecommunications Outlets (TOs)

The recommendations for TOs are as follows:

- Depending on the design of the building, TOs may be located on the wall, floor, or elsewhere in the work area.
- Each work area must be served by a minimum of two TOs, installed singly or in groups.
- At least one of the TOs is to be served by a Category 3 or higher 100 Ω or 120 Ω cable—100 Ω is preferred. The other TOs may be served by either Category 5 100 Ω or 120 Ω balanced cable, 150 Ω balanced cable, or by optical fiber cable.
- When balanced cable supports a TO, two or four pairs must be provided at each TO with all pairs to be terminated. If fewer than four pairs are provided, the outlet must be marked accordingly.
- All outlets must be marked with a permanent label that is visible to the user. Any baluns and impedance-matching devices used must be external to the outlet.
- All 100 Ω and 120 Ω horizontal cables are to be terminated with an unkeyed jack. Pin and pair grouping assignments are as shown below.

Figure 4.19
100 Ω and 120 Ω horizontal cable pin and pair assignments



(front view of connector)

If two pairs are provided at the TO, the default pair assignment is pins 4-5 and 3-6.

NOTE: The international standard 11801 does not specify pair numbers, only which pins constitute a pair.

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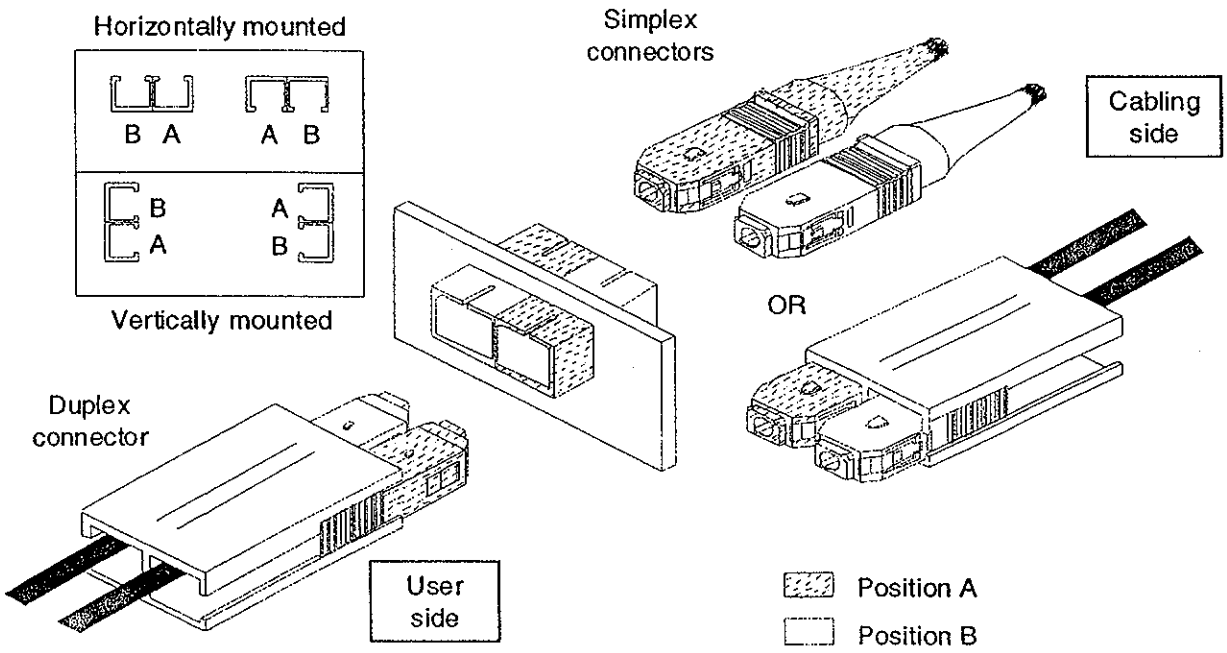
Generic Cabling System Structure, continued

When optical fiber is used in the horizontal distribution and there is no installed base of optical fiber, it is recommended to use SC connectivity at the TO. The connector should be keyed to define polarity.

If premises have an installed base of BFOC (ST-type) connectivity, other TO connections may be made using this connector.

Figure 4.20
Optical fiber SC connectivity



NOTE: Shading is for clarification only.

The recommendations for optical fiber connectivity may be extended to the connecting hardware at the distributors.

NOTE: The connecting hardware recommended does not prevent mating of different types of fiber. Therefore, color coding of connectors and adapters is suggested to distinguish between different fiber types.

Generic Cabling System Structure, continued

Telecommunications Closets (TCs) and Equipment Rooms (ERs)

A TC should provide all facilities for passive components, active devices, and public network interfaces found in the TC. This includes adequate space, power, and environmental controls. Each TC should have direct access to the backbone.

An ER is an area in a building housing telecommunications equipment. It may house no distributors or it may house one or more distributors. The ER is considered different from a TC because of the nature or complexity of the equipment it houses.

NOTE: Any telecommunications space that houses more than one distributor should be considered an ER.

Building Entrance Facilities (EFs)

Building EFs are required when campus backbone, public, and/or private network cables enter buildings and a transition is made to internal cables. These facilities are made up of an entrance point at a building wall and a pathway leading to the CD or BD.

NOTE: It is possible that special facilities for terminating external cables and changing to internal cable may be required by some local regulations.

Link Specifications

Link specifications define the performance requirements of the installed generic cabling. Cabling performance is specified for individual links and for two different media types—balanced cables and optical fiber.

The performance requirements described may be used:

- As verification tests for any implementation of the international standard using test methods referred to or defined in the document.
- As qualification testing of existing cabling.
- For diagnosis at the cabling link level.
- As the basis for an alternative implementation.

A cabling link's performance is specified at and between interfaces to the link. The cabling link includes only passive sections of cable, connecting hardware, and patch cords. Active and passive application-specific hardware is not included as part of the link. The interfaces to the cabling are at each end of a link—the TO and any point where application-specific equipment is connected to the cabling. Work area and equipment cabling are not included in the link.

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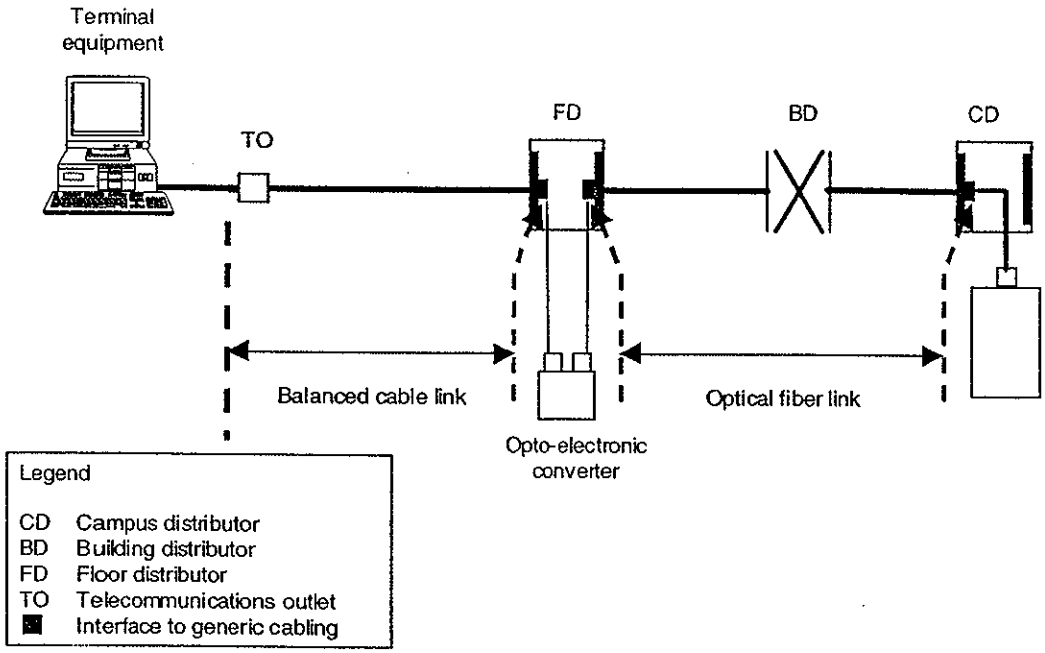
Link Specifications, continued

Example 4.1
Locating cable links and interfaces

The illustration below shows a work area device connected to another device in the CD. This connection uses two links—a balanced cable link from the TO to the FD and an optical fiber link from the FD to the CD. The two links are connected using an optical fiber-to-balanced cable converter.



In this example there are four link interfaces—one at each end of the copper link and one at each end of the optical fiber link.

Link Specifications, continued

Application Classification

The international standard classifies five application classes. This ensures that the limiting requirements of one system does not unduly restrict other systems.

These five classes are as follows:

- Class A

  Class A applications include speech band and low frequency applications. Copper cabling links able to support Class A applications are specified up to 100 kHz.

- Class B

  Class B applications include medium bit rate data applications. Copper cabling links able to support Class B applications are specified up to 1 MHz.

- Class C

  Class C applications include high bit rate data applications. Copper cabling links able to support Class C applications are specified up to 16 MHz.

- Class D

  Class D applications include very high bit rate data applications. Copper cabling links able to support Class D applications are specified up to 100 MHz.

- Optical Class

  Optical class applications include high and very high bit rate data applications. Optical fiber cabling links are specified at 10 MHz and above. Generally, bandwidth is not a limiting factor.

NOTE: For examples of applications that fall within these classes, see Annex G of the international standard.

It has been proposed that the next edition of ISO/IEC 11801 include two additional link/performance classes:

- Class E

  Class E specifies transmission parameters up to 250 MHz. The design under consideration uses unshielded pairs, with an optional overall screen.

- Class F

  Class F specifies transmission parameters up to 600 MHz. The design under consideration uses individually shielded pairs, with an additional shield over all pairs.

NOTE: This information is based on preliminary information and is subject to change.

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Link Specifications, continued

Link Classification

Generic cabling, when configured to support particular applications, is made up of one or more links. A link is classified to reflect the minimum application class that it is capable of supporting. For example, a Class A cabling link is specified so that it can provide the minimum transmission performance to support Class A applications. Similarly, Class B, C, and D cabling links provide the minimum transmission performance to support Class B, C, and D applications respectively.

Class A is regarded as the lowest class. Class C links correspond approximately to a full implementation of the Category 3 horizontal cabling subsystem. Class D links correspond approximately to a full implementation of the Category 5 horizontal cabling subsystem. Links of a given class are able to support applications of a lower class.

Optical fiber cabling links are specified to permit the minimum transmission performance for applications that operate at 10 MHz and above. Parameters are specified for singlemode and multimode optical fiber links.

When specifying and designing cabling, it is important to consider the possibility of connecting cabling subsystems to form longer links. The performance of the longer links will be lower than the performance of any of the individual subsystem links used to construct the longer link.

Balanced Cabling Link Parameters

The parameters specified apply to cabling links made up of shielded or unshielded cable elements. They may or may not have an overall shield.

Detailed parameter specifications for Class A, B, C, and D cabling links are provided in the international standard for the following:

- Characteristic impedance*
- Return loss*
- Attenuation
- Near-end crosstalk loss
- Attenuation to crosstalk loss ratio
- DC resistance
- Propagation delay
- Longitudinal to differential conversion loss (balance)*
- Transfer impedance of shield (shielded cable only)*

* These transmission parameters are identified for further study (f.f.s.).

Link Specifications, continued

Optical Fiber Cabling Link Parameters

Performance requirements for optical fiber links assume that each link uses only a single optical wavelength in one transmission window. The performance of both multimode and singlemode fiber is considered here.

Detailed parameter specifications for optical class cabling links are provided in the international standard for the following:

- Optical attenuation
- Multimode modal bandwidth
- Return loss
- Propagation delay

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