



ATT-TP-76440

Ethernet Copper Cable & Ethernet Copper Assembly Specification

Abstract

Presented in this document are the standards to implement Electrical & Optical Ethernet components, cabling, connections, panels and bays that will meet Ethernet Specifications.

Audience: The primary audience for this document are AT&T LOCAL EXCHANGE companies in the following disciplines: Switch Capacity Planner/Engineer, Transport Equipment Engineer (TEE), Facility Equipment Engineer (FEE), Digital Transport Engineer (DTE), Maintenance Engineer, Space Planner, Frame Planner, Long Range Technical Planners, Outside Plant and Fundamental Network Planners. This document is to be used internally within AT&T LOCAL EXCHANGE companies and their Authorized Vendors and has a limited distribution subject to the header/footer information.

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2. Reasons for Reissue

This section will be updated with future issues highlighting changes to this document.

3. Introduction

AT&T LOCAL EXCHANGE companies require the use of Category 5t/Category 6t Ethernet Cabling in order to provide, for its deployment use, an improved quality of cabling product over that of the TIA/EIA-568-B standard which is applicable to Category 5/Category 5e/Category 6 Ethernet Cabling.

Category 5t Ethernet Cable is available in both 4 pair (horizontal cable) and 25 pair (backbone cable) constructions, while Category 6t Ethernet Cable is only available as a 4 pair (horizontal or backbone cable) construction.

It is understood that Category 5t Ethernet Cabling will support bi-directional rates up to 1000 Base T, 1 Gigabit, over a maximum of 90 meters of copper cable transmission and also assumes that the hardware and connectors used to complete Category 5t Ethernet circuits are fully Category 5t compliant. Category 6t Ethernet Cabling is intended to support bi-directional rates of 1000 Base T, 1 Gigabit, over a maximum of 90 meters of copper cable transmission and will also support futuristic rates well in excess of 1000 Base T (1 Gigabit) when such rates become available and are fully supported by transport compliant operational network elements.

Due to their particular construction, Ethernet Cables for Category 5t and Category 6t transport do not require internal shielding except under very unusual circumstances involving very high radiation fluxes from EMI (electromagnetic interference). Such High Flux EMI sources may include: Electric motors, Transformers, AC Voltages, Heaters, Fluorescent Lights, Copiers, Power Cables, Radio Transmitters, Cellular Phones, Power Supplies, Rectifiers, Oscillators, etc. Shielded Ethernet Cables, if required, must utilize only an aluminum-mylar foil wrap with tinned copper drain wire for the shield.

For required background information, as mandated by the Telecommunications Industry Association, all manufacturers of Ethernet Cables or Ethernet Cable Assemblies, all Contracted Installation Vendors or other personnel providing Ethernet-related products or services within AT&T LOCAL EXCHANGE companies Central Offices or Customer Premises must comply with the requirement of purchasing a copy of the TIA/EIA-568-B Commercial Building Telecommunications Cabling Standard/Optical Fiber Cabling Components Standard from the following source(s):

Refer to the current Catalog of EIA Electronic Industries Alliance Standards and Engineering Publications or call Global Engineering Documents, USA and Canada (1-800-854-7179) International (303-397-7956).

The TIA/EIA-568-B Documents are published by: Telecommunications Industry Association 2001
Standards and Technology Department
2500 Wilson Boulevard
Arlington, VA 22201

4. Category 5t Electrical Ethernet Cables

4.1 General

The cable must meet the mechanical and transmission performance specifications for twisted pair cables. The nominal, purely resistive, impedance of these cables must be 100 ohms over the frequency range of 1 MHz to 100 MHz.

4.2 Cable Transmission Performance

4.2.1 Recognized Categories

Only Category 5t or higher frequency-rated cable, such as Category 6t cable, is recognized in this document. Category 5t cable means 100-ohm cable that will perform with transmission characteristics as specified in this document up to a frequency of 100MHz, while Category 6t means 100-ohm cable that will perform with transmission characteristics as specified in this document up to a frequency of 250MHz.

4.2.2 Multi-Disturber Environment

To be applicable to a multiple disturber environment, this specification sets forth transmission performance requirements as both worse case pair to pair measurements and also power sum calculations that approximate the impacts from multi-disturbers.

4.2.3 Measurements: Pointing and Spacing

The total number of points that are measured within the frequencies as required will be a minimum of 100 times the number of decades that are covered within the specified frequency range. For example, for a DC to 100MHz specified frequency range, 1×10^7 decades of measurement points, or one billion points, is covered.

4.3 Horizontal Cable (Category 5t)

4.3.1 General

The requirements for balanced twisted-pair cables which are used in Category 5t horizontal cabling are detailed as follows: The horizontal cable will consist of 22 AWG to 24 AWG Insulated Thermoplastic Solid Conductors that are made into four (4) separate twisted pairs and are surrounded by a thermoplastic outer jacket. This cable will meet all the mechanical requirements of ANSI/ICEA S80-576 that are relevant to inside wiring, 4 pair, cable for both plenum or general (riser) cabling within a building.

4.3.2 Applicability

These horizontal cables will be constructed of four (4) balanced twisted pairs of 24 AWG, minimum, insulated thermoplastic solid conductors surrounded by a thermoplastic jacket. Larger conductors of 22 AWG may also be used.

4.3.3 Mechanical

The horizontal cables will meet applicable requirements of ANSI/ICEA S-90-661-1994 as well as the physical design requirements within this document (see clauses 4.3.3.1 to 4.3.3.6).

4.3.3.1 Insulated Conductor

The insulated conductor will be 1.22mm(0.048 in) maximum in diameter.

4.3.3.2 Pair Assembly

The cable will be limited to four (4) twisted pair conductors in construction.

4.3.3.3 Color Codes

The color code of the horizontal cable will conform to that of Table 1.

Table 1 - Category 5t - 4 Pair Horizontal Cable Color Code

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

4.3.3.4 Cable Diameter

The completed cable outer diameter will be less than 6.35mm(0.25 in).

4.3.3.5 Breaking Strength

The ultimate breaking strength of the cable will be a minimum of 400 N (90 lbf), when measured in accordance with ASTM D4565.

4.3.3.6 Bending Radius

Twisted Pair cables will be capable of withstanding a bend radius of 25.4mm(1.0 inch) at a temperature of -20 degrees C +/- 1 degree C, without any cracking of the jacket or insulation, when tested in accordance with ASTM D4565, Wire and Cable Bending Test.

4.3.3.7 Core Shield

When specified, Category 5t horizontal cables will be manufactured with an electrically continuous aluminum-mylar core shield, and tinned copper drain wire, that complies to the following standard: The DC Resistance of the core shield will not exceed the value per the following equation: $R \text{ (ohms/km)} = 62.5/D \text{ (mm)}$, where R equals the maximum resistance of the core shield and where D equals the outside diameter of the shield.

4.3.4 Transmission

4.3.4.1 DC Resistance

The resistance of any conductor, when measured in accordance with ASTM D4566 will not be greater than 9.38 ohms per 100 m (328 ft) at, or corrected to, a temperature of 20 degrees C.

4.3.4.2 DC Resistance Unbalance

The DC resistance unbalance between any two paired conductors, measured according to ASTM D4565, will not exceed 5% when measured at, or corrected to, a temperature of 20 degrees C.

4.3.4.3 Mutual Capacitance

The mutual capacitance of all horizontal cable pairs, measured at 1kHz, at or corrected to a temperature of 20 degrees C, should not exceed 5.6nF per 100m(328 ft) for category 5t cables. Measurements will be performed in accordance with ASTM D4566.

4.3.4.4 Capacitance Unbalance: Pair to Ground

The capacitance unbalance to ground of any cable pair in the horizontal cable measured at 1kHz and in accordance to ASTM D4566, at or corrected to a temperature of 20 degrees C, will not exceed 330 pF per 100m(328 ft).

4.3.4.5 Return Loss

Return loss is a measurement of the reflected energy resulting from varying impedance fluctuations in the cable and is important in controlling for purposes of bi-directional transmission. Table 2 lists the requirements of horizontal cable for return loss as measured over a length of 100 m (328 ft).

Table 2 - Category 5t Horizontal Cable Return Loss @20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worst pair

Frequency(MHz)	Category 5t(dB)
1 to 10	20 + 5log(f)
10 to 20	25
20 to 100	25 - 7log(f/20)

4.3.4.6 Insertion Loss

Insertion loss is a measure of the signal loss that occurs due to the termination of a length of cable between a transmitter and receiver and is often called attenuation. Insertion loss is expressed in dB relative to the received signal level and will be measured for all cable pairs in accordance with ASTM D4566 and 4.3.4.14 at 20 +/- 3 degrees C or corrected to a temperature of 20 degrees C. A correction factor amounting to 0.4%/degree C for category 5t cables will be applied. Table 3 lists the horizontal cable insertion losses for specified frequencies, with 100 resistive ohms of source/load terminations.

Table 3 - Category 5t Horizontal Cable Insertion Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair, for a cable length of 100m(328 ft.)

Frequency(MHz)	Category 5t(dB)
0.772	1.8
1.0	2.0
4.0	4.0
8.0	5.7
10.0	6.4
16.0	8.0
20.0	9.1
25.0	10.2

31.25	11.4
62.5	16.6
100.0	21.5

4.3.4.7 Near End Crosstalk (NEXT) Loss

Near end crosstalk quantifies, via measurement, the undesired signal coupling from a transmitter at the near-end of a copper cable into neighboring pairs of the same copper cable as measured at the near end. NEXT is expressed in dB relative to the launched signal level and will be measured for all cable pair combinations in accordance with ASTM D4566. NEXT loss for Category 5t cables will be measured at 100 meter or longer horizontal cable lengths.

Table 4 - Category 5t Horizontal Cable NEXT Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair to pair

Frequency(MHz)	Category 5t(dB)
0.772	69.2
1.0	67.5
4.0	58.5
8.0	54.0
10.0	52.5
16.0	49.4
20.0	48.0
25.0	46.5
31.25	45.1
62.5	40.6
100.0	37.5

4.3.4.8 Category 5t Power Sum Near End Crosstalk (PSNEXT) Loss

PSNEXT loss is a required parameter of measure since each duplex channel is capable of being disturbed by more than one duplex channel. The PSNEXT loss is calculated in accordance with ASTM D4566 as a power sum on a selected pair from all other pairs for a 4 pair cable. A cable length of 100m(328 feet) will be used for the PSNEXT measurement.

Table 5 - Category 5t Horizontal Cable PSNEXT loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency(MHz)	Category 5t(dB)
0.150	77.2
0.772	66.5
1.0	64.8
4.0	55.8
8.0	51.3
10.0	49.8
16.0	46.7
20.0	45.3
25.0	43.8
31.25	42.4
62.5	37.9
100.0	34.8

4.3.4.9 Equal Level Far End Crosstalk (ELFEXT)

FEXT loss measures the unwanted signal which is coupled from a transmitter at the far end of a copper cable into neighboring pairs as measured at the near end of the same copper cable. FEXT loss is measured in dB as the difference between the measured FEXT loss and the insertion loss of the disturbed pair. FEXT loss will be measured and ELFEXT calculated for all cable pair combinations in accordance with the FEXT measurement procedure found in ASTM D4566. The cable length used for the evaluation of ELFEXT will be 100m (328 ft).

Table 6 details the horizontal cable ELFEXT.

Table 6 - Category 5t Horizontal Cable ELFEXT @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair to pair

Frequency (MHz)	Category 5t(dB)
1.0	64.8
4.0	52.8
8.0	46.7
10.0	44.8
16.0	40.7
20.0	38.8
25.0	36.8
31.25	34.9
62.5	28.9
100.0	24.8

4.3.4.10 Power Sum Equal Level Far End Crosstalk (PSELFEXT)

Equal level far end crosstalk is specified for horizontal cables since each duplex channel can be disturbed by more than one duplex channel. Power sum equal level far end crosstalk loss takes into account the combined crosstalk (statistical) on a receive pair from all far end disturbers operating simultaneously and is calculated in accordance with ASTM D4566 as a power sum on a selected pair from all other pairs for a 4 pair cable. A cable length of 100m (328 ft.) will be used to measure the PSELFEXT.

Table 7 lists the PSELFEXT requirements for horizontal cable.

Table 7 - Category 5t Horizontal Cable PSELFEXT @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency(MHz)	Category 5t(dB)
1.0	61.8
4.0	49.8
8.0	43.7
10.0	41.8
16.0	37.7
20.0	35.8
25.0	33.8
31.25	31.9
62.5	25.9
100.0	21.8

4.3.4.11 Propagation Delay for 4 Pair Horizontal Cables

Propagation delay is the time it takes for a signal to move or propagate from one end of the cable to the other end and is expressed in nanoseconds (ns). It shall be measured for all cable pairs in accordance with ASTM D4566.

Table 8 lists the requirements for propagation delay using a cable length of 100m(328 ft).

Table 8 - Category 5t Propagation Delay, Velocity of Propagation and Propagation Delay Skew for 4 Pair Horizontal Cables @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency (MHz)	Maximum Propagation Delay (ns/100m)	Minimum Velocity of Propagation (%)	Maximum Propagation Delay Skew (ns/100m)
1	570	58.5	45
10	545	61.1	45
100	538	62.0	45

4.3.4.12 Propagation Delay Skew for 4 Pair Horizontal Cables

Propagation delay skew is a calculation of the difference of signal delay from the fastest cable pair to the slowest cable pair. It will be measured for all cable pairs in accordance with ASTM D4566. (See table 8, above, for the requirements of maximum propagation delay skew). For every frequency between 1MHz and the highest frequency of reference in MHz, Category 5t cable propagation delay skew will not exceed 45 ns/100m at 20 degrees C, 40 degrees C and 60 degrees C.

4.3.4.13 Measurement Precautions

Mutual capacitance, capacitance unbalance, characteristic impedance, return loss, insertion loss, SRL, NEXT loss and ELFEXT measurements and calculations will be performed on copper cable samples of 100 m (328 ft) which will be removed from the reel or packaging. The test sample will be placed out along a non-conducting surface, loosely coiled or supported in aerial spans and all pairs will be terminated in 100 resistive ohms.

4.3.5 Performance Marking

Horizontal cables should be marked to designate transmission performance. Such markings do not replace other markings required by listing agencies or those needed to satisfy electric code or local building/fire code requirements.

4.3.6 Bundled and Hybrid Cables

Under Consideration; but not approved, at this time.

4.4 Backbone Cable (Category 5t)

4.4.1 General

The requirements for balanced twisted-pair cables which are used in Category 5t backbone cabling are detailed as follows: The backbone cable will consist of 22 AWG to 24 AWG Insulated Thermoplastic Solid Conductors that are made into one or more units of balanced twisted pairs. The units are to be formed into binder groups of 25 pairs and must follow the standard industry color code of ANSI/ICEA S-80-576. The groups are distinguished by colored binders and assembled together to form the core of this cable. These pairs are to be surrounded by a thermoplastic outer jacket. This cable will meet all the mechanical requirements of ANSI/ICEA S80-576 that are relevant to 25 pair, and larger, cable for both plenum or general (riser) cabling within a building.

4.4.2 Applicability

These backbone cables will be constructed of 25 pair groups of balanced twisted pairs of 24 AWG, minimum, insulated thermoplastic solid conductors surrounded by a thermoplastic jacket. Larger conductors of 22 AWG may also be used.

4.4.3 Mechanical

The backbone cables will meet applicable requirements of ANSI/ICEA S-90-661-1994 as well as the physical design requirements within this document (see clauses 4.3.3.1 to 4.3.3.6).

4.4.3.1 Insulated Conductor

The insulated conductor will be 1.22mm(0.048 in) maximum in diameter.

4.4.3.2 Pair Assembly

The cable will be limited to twenty-five (25) twisted pair conductors in construction per binder group.

4.4.3.3 Color Codes

The color code of the backbone cable will conform to the industry standard color code of 10 distinct colors that identify 25 pairs as detailed in ANSI/ICEA S-80-576

4.4.3.4 Breaking Strength

The ultimate breaking strength of the cable will be a minimum of 400 N (90 lbf), when measured in accordance with ASTM D4565.

4.4.3.5 Bending Radius

Twisted Pair cables will be capable of withstanding a bend radius of 25.4mm(1.0 inch) at a temperature of -20 degrees C +/- 1 degree C, without any cracking of the jacket or insulation, when tested in accordance with ASTM D4565, Wire and Cable Bending Test.

4.4.3.6 Core Shield

When specified, Category 5t backbone cables will be manufactured with an electrically continuous aluminum-mylar core shield, and tinned copper drain wire, that complies to the following standard: The DC Resistance of the core shield will not exceed the value per the following equation: $R \text{ (ohms/km)} = 62.5/D \text{ (mm)}$, where R equals the maximum resistance of the core shield and where D equals the outside diameter of the shield.

4.4.4 Transmission

4.4.4.1 DC Resistance

The resistance of any conductor, when measured in accordance with ASTM D4566 will not be greater than 9.38 ohms per 100 m (328 ft) at, or corrected to, a temperature of 20 degrees C.

4.4.4.2 DC Resistance Unbalance

The DC resistance unbalance between any two-paired conductors, measured according to ASTM D4565, will not exceed 5% when measure at, or corrected to, a temperature of 20 degrees C.

4.4.4.3 Mutual Capacitance

The mutual capacitance of all backbone cable pairs, measured at 1kHz, at or corrected to a temperature of 20 degrees C, should not exceed 5.6nF per 100m(328 ft) for category 5t cables. Measurements will be performed in accordance with ASTM D4566.

4.4.4.4 Capacitance Unbalance: Pair to Ground

The capacitance unbalance to ground of any cable pair in the backbone cable measured at 1kHz and in accordance to ASTM D4566, at or corrected to a temperature of 20 degrees C, will not exceed 330 pF per 100m(328 ft).

4.4.4.5 Return Loss

Return loss is a measurement of the reflected energy resulting from varying impedance fluctuations in the cable and is important in controlling for purposes of bi-directional transmission. Table 9 lists the requirements of backbone cable for return loss as measured over a length of 100 m (328 ft).

Table 9 - Category 5t Backbone Cable Return Loss @20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worst pair

Frequency(MHz)	Category 5t(dB)
1 to 10	20 + 5log(f)
10 to 20	25
20 to 100	25 - 7log(f/20)

4.4.4.6 Insertion Loss

Insertion loss is a measure of the signal loss that occurs due to the termination of a length of cable between a transmitter and receiver and is often called attenuation. Insertion loss is expressed in dB relative to the received signal level and will be measured for all cable pairs in accordance with ASTM D4566 and 4.4.4.15 at 20 +/- 3 degrees C or corrected to a temperature of 20 degrees C. A correction factor amounting to 0.4%/degree C for category 5t cables will be applied. The resistive source/load termination will be 100 ohms.

Table 10 lists the backbone cable insertion losses for specified frequencies.

Table 10 - Category 5t Backbone Cable Insertion Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair, for a cable length of 100m(328 ft.)

Frequency(MHz)	Category 5t(dB)
0.772	1.8
1.0	2.0
4.0	4.0
8.0	5.7
10.0	6.4
16.0	8.0
20.0	9.1
25.0	10.2
31.25	11.4
62.5	16.6
100.0	21.5

4.4.4.7 Near End Crosstalk (NEXT) Loss

Near end crosstalk quantifies, via measurement, the undesired signal coupling from a transmitter at the near-end of a copper cable into neighboring pairs of the same copper cable as measured at the near end. NEXT is expressed in dB relative to the launched signal level and will be measured for all cable pair combinations in accordance with ASTM D4566. NEXT loss for Category 5t cables will be measured at 100-meter backbone cable lengths. For all frequencies from 0.772 MHz to 100MHz, NEXT loss for any pair-to-pair combination within each Category 5t cable 4-pair group will meet the values stated in Table 11.

Table 11 - Category 5t Backbone Cable NEXT Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair to pair

Frequency(MHz)	Category 5t(dB)/within 4-pair group	Category 5t(dB)/(25 th to all other pairs)
0.772	69.2	69.2
1.0	67.5	67.5
4.0	58.5	58.5
8.0	54.0	54.0
10.0	52.5	52.5
16.0	49.4	49.4
20.0	48.0	48.0
25.0	46.5	46.5
31.25	45.1	45.1
62.5	40.6	40.6
100.0	37.5	37.5

4.4.4.8 Power Sum Near End Crosstalk (PSNEXT) Loss

PSNEXT loss is a required parameter of measure since each duplex channel is capable of being disturbed by more than one duplex channel. The PSNEXT loss is calculated in accordance with ASTM D4566 as a power sum on a selected pair from all other pairs for a 25 pair cable. A cable length of 100m(328 feet) will be used for the PSNEXT measurement.

Table 12 details the backbone cable PSNEXT Loss.

**Table 12 - Category 5t Backbone Cable PSNEXT loss @ 20 degrees C +/- 3 degrees C
(68 degrees F +/- 5.5 degrees F)**

Frequency(MHz)	Category 5t(dB)
0.150	77.2
0.772	66.5
1.0	64.8
4.0	55.8
8.0	51.3
10.0	49.8
16.0	46.7
20.0	45.3
25.0	43.8
31.25	42.4
62.5	37.9
100.0	34.8

4.4.4.9 Equal Level Far End Crosstalk (ELFEXT)

FEXT loss measures the unwanted signal which is coupled from a transmitter at the far end of a copper cable into neighboring pairs as measured at the near end of the same copper cable. FEXT loss is measured in dB as the difference between the measured FEXT loss and the insertion loss of the disturbed pair. FEXT loss will be measured and ELFEXT calculated for all cable pair combinations in accordance with the FEXT measurement procedure found in ASTM D4566. The cable length used for the evaluation of ELFEXT will be 100m (328 ft).

Table 13 details the backbone cable ELFEXT.

Table 13 - Category 5t Backbone Cable ELFEXT @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair to pair

Frequency (MHz)	Category 5t(dB) (within 4-pair group)	Category 5t(dB) (25 th to all other pairs)
1.0	64.8	64.8
4.0	52.8	52.8
8.0	46.7	46.7
10.0	44.8	44.8
16.0	40.7	40.7
20.0	38.8	38.8
25.0	36.8	36.8
31.25	34.9	34.9
62.5	28.9	28.9
100.0	24.8	24.8

4.4.4.10 Power Sum Equal Level Far End Crosstalk (PSELFEXT)

Equal level far end crosstalk is specified for backbone cables since each duplex channel can be disturbed by more than one duplex channel. Power sum equal level far end crosstalk loss takes into account the combined crosstalk (statistical) on a receive pair from all far end disturbers operating simultaneously and is calculated in accordance with ASTM D4566 as a power sum on a selected pair from all other pairs for a 25 pair cable. A cable length of 100m(328 ft.) will be used to measure the PSELFEXT.

Table 14 lists the PSELFEXT requirements for backbone cable.

Table 14 - Category 5t Backbone Cable PSELFEXT @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency(MHz)	Category 5t(dB)
1.0	61.8
4.0	49.8
8.0	43.7
10.0	41.8
16.0	37.7
20.0	35.8
25.0	33.8
31.25	31.9
62.5	25.9
100.0	21.8

4.4.4.11 Propagation Delay for Backbone Cables

Propagation delay is the time it takes for a signal to move or propagate from one end of the cable to the other end and is expressed in nanoseconds (ns). It shall be measured for all cable pairs in accordance with ASTM D4566.

Table 15 lists the requirements for propagation delay for backbone cable using a cable length of 100m(328 ft).

Table 15 - Category 5t Propagation Delay, Velocity of Propagation and Propagation Delay Skew for Backbone Cables @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency (MHz)	Maximum Propagation Delay (ns/100m)	Minimum Velocity of Propagation (%)	Maximum Propagation Delay Skew (ns/100m)
1	570	58.5	45
10	545	61.1	45
100	538	62.0	45

4.4.4.12 Propagation Delay Skew for Backbone Cables

Propagation delay skew is a calculation of the difference of signal delay from the fastest cable pair to the slowest cable pair. It will be measured for all cable pairs in accordance with ASTM D4566. (See table 15, above, for the requirements of maximum propagation delay skew). For every frequency between 1MHz and the highest frequency of reference in MHz, Category 5t cable propagation delay skew will not exceed 45 ns/100m at 20 degrees C, 40 degrees C and 60 degrees C.

4.4.4.13 Dielectric Strength

The insulation between every conductor and the core shield, if present, will be able to withstand a minimum DC Voltage Potential of 5kV for 3 seconds in accordance with ASTM D4566.

4.4.4.14 Core Shield Resistance

When a shield surrounds a core, the DC resistance of the core shield will not exceed the value given by the following equations:

$R \text{ (ohms/km)} = 62.5/D \text{ (mm)}$ or $R \text{ (ohms/1000 ft)} = 0.75/D \text{ (in)}$, where:

R = maximum core shield resistance and D = outside diameter of the shield

4.4.4.15 Measurement Precautions

Mutual capacitance, capacitance unbalance, characteristic impedance, return loss, insertion loss, SRL, NEXT loss and ELFEXT measurements and calculations will be performed on copper cable samples of 100 m (328 ft) which will be removed from the reel or packaging. The test sample will be placed out along a non-conducting surface, loosely coiled or supported in aerial spans and all pairs will be terminated with 100 resistive ohms.

4.4.5 Performance Marking

Horizontal cables should be marked to designate transmission performance. Such markings do not replace other markings required by listing agencies or those needed to satisfy electric code or local building/fire code requirements.

4.4.6 Bundled and Hybrid Cables

Under Consideration; but not approved, at this time.

4.5 Patch Cord Cables (Category 5t)

Patch cords are primarily used for establishing cross-connections or patches from one patch panel to another patch panel. These patch cords will be made only of stranded copper conductors in order to maximize the flexibility of the cords as they will be subject to repetitive flexing movements. The cables that are used to fabricate patch cords terminated with modular plug connectors as described in IEC 60603-7 should have insulated copper diameters that range from 0.8mm(0.031in) to 1mm(0.039in) and must not be greater than 1.22mm(0.048in) in diameter. These patch cords will meet the pertinent requirements of ANSI/CEA-S-90-661-1994. The typical size of the wire gauge of the stranded patch cords will be the equivalent of 24AWG.

4.5.1 Color Code

Patch cords will be constructed with each pair having one conductor of white insulation -band marked with a visually distinct color such as blue or green and the other conductor of the same visually distinct color such as blue or green.

Table 16 lists the color code for stranded patch cords that are applicable for Cat 5t use.

Table 16 - Category 5t Color-Codes for Stranded Patch Cords

Conductor 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)

4.5.2 Return Loss

Return loss values indicate the amount of reflected energy that is caused by the variations in the impedance within a cable and is especially important to measure when cables are used for simultaneous transmission in both directions.

Table 17 lists the Return Loss for Stranded Copper Patch Cords.

Table 17 - Category 5t Stranded Cable Return Loss @ 20 degrees C +/- 3 degrees C(68 degrees F +/- 5.5 degrees F), worst pair

Frequency(MHz)	Category 5t(dB)
1.0	20.0
4.0	22.7
8.0	24.0
10.0	24.5
16.0	24.6
20.0	24.7
25.0	24.2
31.25	23.2
62.5	20.5
100.0	18.8

4.5.3 Insertion Loss

Insertion Loss is a measure of the signaling loss resulting from the insertion of a cable length, greater than or equal to 100m(328ft), between a transmitter and receiver and is often also called attenuation. It should be measured in concert with ASTM D 4566 at or corrected to a temperature of 20 degrees C, with 100 resistive ohms of source/load terminations.

Table 18 lists the Insertion Loss for Stranded Copper Patch Cords

Table 18 - Category 5t Stranded Cable Insertion Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair

Frequency(MHz)	Category 5t(dB)
1.0	2.4
4.0	4.8
8.0	6.8
10.0	7.6
16.0	9.7
20.0	10.9
25.0	12.2
31.25	13.8
62.5	19.9
100.0	25.8

4.5.4 Flexibility of Patch Cords

Patch cords will meet both the return loss and insertion loss requirements as described previously in sections 4.5.2 and 4.5.3, respectively, after having being subjected to 500 flex cycles. The flex testing will be performed on a minimum of 1/3 meter (13in) lengths of non-terminated patch cord cables. Cable samples will be clamped to a rotatable arm and will be suspended between two 51mm (2in) diameter mandrels located to either side of the center of arm rotation and spaced in such a manner so as to touch but not hold the cable sample. A weight that exerts greater than 10N(2lb) will be attached to the free end of the cable. A flexing cycle consisting of one +90 degree rotation around the mandrel, with a cycling rate of 10 cycles +/- 2 cycles per minute, will be applied.

5. Category 6t Electrical Ethernet Cables

5.1 General

The cable must meet the mechanical and transmission performance specifications for twisted pair cables. The nominal, purely resistive, impedance of these cables must be 100 ohms over the frequency range of 1 MHz to 250 MHz.

5.2 Cable Transmission Performance

5.2.1 Recognized Categories

Only Category 6t or higher frequency-rated cable, such as Category 7, will be used to fulfill the requirements for Category 6t usage within this document. Category 6t cable means 100-ohm cable that will perform with transmission characteristics as specified in this document up to a frequency of 250MHz.

5.2.2 Multi-Disturber Environment

To be applicable to a multiple disturber environment, this specification sets forth transmission performance requirements as both worse case pair to pair measurements and also power sum calculations that approximate the impacts from multi-disturbers.

5.2.3 Measurements Pointing and Spacing

The total number of points that are measured within the frequencies as required will be a minimum of 100 times the number of decades that are covered within the specified frequency range. For example, for a DC to 100MHz specified frequency range, 1 X10 exp 7 decades of measurement points, or one billion points, is covered

5.3 Horizontal Cable and Backbone Cable (Category 6t)

5.3.1 General

Only four-pair, 100 ohm, cables are allowed for Category 6t use, which applies to both horizontal cables and as well as backbone cables. These cables will be constructed of 22AWG to 24AWG Insulated Thermoplastic Solid Conductors that are made into four (4) separate twisted pairs and are surrounded by a thermoplastic outer jacket. These cables will meet all the mechanical requirements of ANSI/ICEA S80-576 that are relevant to inside wiring, 4 pair, cable for both plenum or general (riser) cabling within a building.

5.3.2 Applicability

These horizontal and backbone cables will be constructed of four (4) balanced twisted pairs of 24 AWG, minimum, insulated thermoplastic solid conductors surrounded by a thermoplastic jacket. Larger conductors of 22 AWG may also be used.

5.3.3 Mechanical

These horizontal and backbone cables will meet applicable requirements of ANSI/ICEA S-90-661-1994 as well as the physical design requirements within this document (see clauses 5.3.3.1 to 5.3.3.6).

5.3.3.1 Insulated Conductor

The insulated conductor will be 1.22mm(0.048 in) maximum in diameter.

5.3.3.2 Pair Assembly

These cables will be limited to four (4) twisted pair conductors in construction.

5.3.3.3 Color Codes

The color code of both the horizontal cable and the backbone cables will conform to that of Table 19.

Table 19 - 4 Pair Horizontal and 4 Pair Backbone Cable Color Code (Category 6t)

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

5.3.3.4 Cable Diameter

The completed outer diameter for these cables will be less than 6.35mm(0.25 in).

5.3.3.5 Breaking Strength

The ultimate breaking strength of these cables will be a minimum of 400N(90 lbf), when measured in accordance with ASTM D4565.

5.3.3.6 Bending Radius

These Twisted Pair cables will be capable of withstanding a bend radius of 25.4mm(1.0 inch) at a temperature of -20 degrees C +/- 1 degree C, without any cracking of the jacket or insulation, when tested in accordance with ASTM D4565, Wire and Cable Bending Test.

5.3.3.7 Core Shield

When specified, Category 6t horizontal cables and Category 6t backbone cables will be manufactured with an electrically continuous aluminum-mylar core shield, and tinned copper drain wire, that complies to the following standard: The DC Resistance of the core shield will not exceed the value per the following equation: $R \text{ (ohms/km)} = 62.5/D \text{ (mm)}$, where R equals the maximum resistance of the core shield and where D equals the outside diameter of the shield.

5.3.4 Transmission

5.3.4.1 DC Resistance

The resistance of any conductor, when measured in accordance with ASTM D4566 will not be greater than 9.38 ohms per 100 m (328 ft) at, or corrected to, a temperature of 20 degrees C.

5.3.4.2 DC Resistance Unbalance

The DC resistance unbalance between any two paired conductors, measured according to ASTM D4565, will not exceed 5% when measured at, or corrected to, a temperature of 20 degrees C.

5.3.4.3 Mutual Capacitance

The mutual capacitance of all horizontal cable pairs and backbone cable pairs, measured at 1kHz, at or corrected to a temperature of 20 degrees C, should not exceed 5.6nF per 100m(328 ft) for category 6t cables. Measurements will be performed in accordance with ASTM D4566.

5.3.4.4 Capacitance Unbalance: Pair to Ground

The capacitance unbalance to ground of any cable pair in the horizontal cable or in the backbone cable measured at 1kHz and in accordance to ASTM D4566, at or corrected to a temperature of 20 degrees C, will not exceed 330 pF per 100m(328 ft).

5.3.4.5 Return Loss

Return loss is a measurement of the reflected energy resulting from varying impedance fluctuations in the cable and is important in controlling for purposes of bi-directional transmission. Table 20 lists the requirements of both horizontal cable and backbone cable for return loss as measured over a length of 100 m (328 ft).

Table 20 - Category 6t Horizontal Cable and Backbone Cable Return Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair

Frequency(MHz)	Category 6t(dB)
1 to 10	20 + 5log(f)
10 to 20	25
20 to 250	25 - 7log(f/20)

5.3.4.6 Insertion Loss

Insertion loss is a measure of the signal loss that occurs due to the termination of a length of cable between a transmitter and receiver and is often called attenuation. Insertion loss is expressed in dB relative to the received signal level and will be measured for all cable pairs in accordance with ASTM D4566 and 5.3.4.14 at 20 degrees +/- 3 degrees C or corrected to a temperature of 20 degrees C. A correction factor amounting to 0.4% increase per degree C from 20 degrees C to 40 degrees C and a corrector factor amounting to 0.6% increase per degree C from 40 degrees C to 60 degrees C will be applied. The insertion loss measured with 100 resistive ohms of source/load terminations.

Table 21 lists the horizontal cable and backbone cable insertion losses for specified frequencies.

Table 21 - Horizontal Cable and Backbone Cable (Category 6t) Insertion Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair, for a cable length of 100m(328 ft)

Frequency(MHz)	Category 6t (dB)
0.772	1.7
1.0	1.9
4.0	3.6
8.0	5.0
10.0	5.7
16.0	7.2
20.0	8.1
25.0	9.0
31.25	10.2
62.5	14.6
100.0	18.8
200.0	27.6
250.0	31.2

5.3.4.7 Near End Crosstalk (NEXT) Loss

Near end crosstalk quantifies, via measurement, the undesired signal coupling from a transmitter at the near-end of a copper cable into neighboring pairs of the same copper cable as measured at the near end. NEXT is expressed in dB relative to the launched signal level and will be measured for all cable pair combinations in accordance with ASTM D4566. NEXT loss for Category 6t cables will be measured at 100 meter or longer horizontal cable lengths and backbone cable lengths.

Table 22 - Horizontal Cable and Backbone Cable NEXT Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degree F), worse pair to pair

Frequency(MHz)	Category 6t(dB)
0.150	91.0
0.772	79.8
1.0	78.0
4.0	68.6
8.0	63.8
10.0	62.3
16.0	59.0
20.0	57.5
25.0	56.0
31.25	54.5
62.5	49.8
100.0	46.5
200.0	41.8
250.0	40.2

5.3.4.8 Power Sum Near End Crosstalk (PSNEXT) Loss

PSNEXT loss is a required parameter of measure since each duplex channel is capable of being disturbed by more than one duplex channel. The PSNEXT loss is calculated in accordance with ASTM D4566 as a power sum on a selected pair from all other pairs for a 4 pair cable. A cable length of 100m(328 ft) will be used for the PSNEXT measurement.

Table 23 - Horizontal Cable and Backbone Cable PSNEXT Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency(MHz)	Category 6t(dB)
0.150	88.9
0.772	77.7
1.0	75.9
4.0	66.5
8.0	61.7
10.0	60.2
16.0	56.9
20.0	55.4
25.0	53.9
31.25	52.4
62.5	47.7
100.0	44.4
200.0	39.7
250.0	38.1

5.3.4.9 Equal Level Far End Crosstalk (ELFEXT)

FEXT loss measures the unwanted signal which is coupled from a transmitter at the far end of a copper cable into neighboring pairs as measured at the near end of the same copper cable. FEXT loss is measured in dB as the difference between the measured FEXT loss and the insertion loss of the disturbed pair. FEXT loss will be measured and ELFEXT calculated for all cable pair combinations in accordance with the FEXT measurement procedure found in ASTM D4566. The cable length used for the evaluation of ELFEXT will be 100m(328 ft).

Table 24 details the horizontal and backbone cable ELFEXT.

Table 24 - Horizontal Cable and Backbone Cable ELFEXT @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F) worse pair to pair

Frequency(MHz)	Category 6t(dB)
0.772	73.5
1.0	71.2
4.0	58.6
8.0	52.2
10.0	50.2
16.0	45.9
20.0	43.9
25.0	41.8
31.25	39.8
62.5	33.5
100.0	29.2
200.0	22.9
250.0	20.8

5.3.4.10 Power Sum Equal Level Far End Crosstalk (PSELFEXT)

Equal level far end crosstalk is specified for horizontal cables and backbone cables since each duplex channel can be disturbed by more than one duplex channel. Power sum equal level far end crosstalk loss takes into account the combined crosstalk (statistical) on a receive pair from all far end disturbers operating simultaneously and is calculated in accordance with ASTM D4566 as a power sum on a selected pair from all other pairs for a 4 pair cable. A cable length of 100m(328 ft) will be used to measure the PSELFEXT.

Table 25 lists the PSELFEXT requirements for horizontal and backbone cable.

Table 25 - Horizontal Cable and Backbone Cable PSELFEXT @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency(MHz)	Category 6t(dB)
0.772	70.4
1.0	68.0
4.0	55.4
8.0	49.0
10.0	47.0
16.0	42.7
20.0	40.7
25.0	38.6
31.25	36.6
62.5	30.3
100.0	26.0
200.0	19.7
250.0	17.6

5.3.4.11 Propagation Delay for 4 Pair Horizontal Cables and 4 Pair Backbone Cables

Propagation delay is the time it takes for a signal to move or propagate from one end of the cable to the other end and is expressed in nanoseconds (ns). It shall be measured for all cable pairs in accordance with ASTM D4566.

Table 26 lists the requirements for propagation delay using a cable length of 100m(328 ft).

Table 26 - Category 6t Propagation Delay, Velocity of Propagation and Propagation Delay Skew for 4 Pair Horizontal Cables and 4 Pair Backbone Cables @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F)

Frequency(MHz)	Maximum Propagation Delay (ns/100m)	Minimum Velocity of Propagation (%)	Maximum Propagation Delay Skew(ns/100m)
1	570	58.5%	45
10	545	61.1%	45
100	538	62.0%	45
250	536	62.1%	45

5.3.4.12 Propagation Delay Skew for 4 Pair Horizontal Cables and 4 Pair Backbone Cables

Propagation delay skew is a calculation of the difference of signal delay from the fastest cable pair to the slowest cable pair. It will be measured for all cable pairs in accordance with ASTM D4566, (see Table 26, above, for the requirements of maximum propagation delay skew). For every frequency between 1MHz and the highest frequency of reference in MHz, Category6t cable propagation delay skew will not exceed 45 ns/100m at 20 degrees C, 40 degrees C and 60 degrees C.

5.3.4.13 Measurement Precautions

Mutual capacitance, capacitance unbalance, characteristic impedance, return loss, insertion loss, SRL, NEXT loss and ELFEXT measurements and calculation will be performed on copper cable samples of 100m(328 ft) which will be removed from the reel or packaging. The test sample will be placed out along a non-conducting surface, loosely coiled or supported in aerial spans and all pairs will be terminated with 100 resistive ohms.

5.3.4.14 Performance Marking

Horizontal Cables and Backbone Cables should be marked to designate transmission performance. Such markings do not replace other markings required by listing agencies or these needed to satisfy electric code or local building/fire code requirements.

5.3.5 Bundled and Hybrid Cables

Under Consideration; but not approved, at this time.

5. 4 Patch Cord Cables (Category 6t)

Patch cords are primarily used for establishing cross-connections or patches from one patch panel to another patch panel. These patch cords will be made only of stranded copper conductors in order to maximize the flexibility of the cords, as they will be subject to repetitive flexing movements. These cables that are used to fabricate patch cords terminated with modular plug connectors as described in IEC 60603-7 should have insulated copper diameters that range from 0.8mm(0.031in) to 1mm(0.039in) and must not be greater than 1.22mm(0.048 in) in

diameter. These patch cords will meet the pertinent requirements of ANSI/ICEA-S-90-661-1994. The typical size of the wire gauge of the stranded patch cords will be the equivalent of 24 AWG.

5.4.1 Color Code

Patch cords will be constructed with each pair having one conductor of white insulation -band marked with a visually distinct color such as blue or green and the other conductor of the same visually distinct color such as blue or green.

Table 27 lists the color code for stranded patch cords that are applicable to Cat 6t use.

Table 27 - Category 6t Color-Codes for Stranded Patch Cords

Conductor 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)

5.4.2 Return Loss

Return loss values indicate the amount of reflected energy that is caused by the variations in the impedance within a cable and is especially important to measure when cables are used for simultaneous transmission in both directions.

Table 28: lists the Return Loss for Stranded Copper Patch Cords.

Table 28 - Category 6t Stranded Cable Return Loss @ 20 degrees C +/- 3 degrees C (68 degrees F +/- 5.5 degrees F), worse pair

Frequency(MHz)	Category 6t(dB)
1.0	20.2
4.0	23.2
8.0	24.7
10.0	25.3
16.0	25.3
20.0	25.3
25.0	24.4
31.25	23.5
62.5	20.9
100.0	19.2
200.0	16.6
250.0	15.8

5.4.3 Insertion Loss

Insertion loss, as measured with 100 resistive ohms of source/load terminations, is a measure of the signal loss resulting from the insertion of a cable length greater than or equal to 100m(328 ft), between a transmitter and receiver and is often also called attenuation. It should be measured in concert with ASTM D 4566 at or corrected to a temperature of 20 degrees C.

Table 29 lists the Insertion Loss for Stranded Copper Patch Cords

Table 29 - Category 6t Stranded Cable Insertion Loss @ 20 degrees C +/- 3 degree C (68 degree F +/- 5.5 degrees F), worse pair

Frequency(MHz)	Category 6t(dB)
1.0	2.4
4.0	4.5
8.0	6.3
10.0	7.0
16.0	9.0
20.0	10.1
25.0	11.3
31.25	12.7
62.5	18.3
100.0	23.6
200.0	34.5
250.0	39.0

5.4.4 Flexibility of Patch Cords

Patch cords will meet both the return loss and insertion loss requirements as described previously in sections 5.4.2 and 5.4.3, respectively, after having been subjected to 500 flex cycles. The flex testing will be performed on a minimum of 1/3 meter (13 in) lengths of non-terminated patch cord cables. Cable samples will be clamped to a rotatable arm and will be suspended between two 51mm(2in) diameter mandrels located to either side of the center of arm rotation and spaced in such a manner so as to touch but not hold the cable sample. A weight that exerts greater than 10N(2lb) will be attached to the free end of the cable. A flexing weight consisting of one +90 degree rotation around the mandrel, with a cycling rate of 10 cycles +/- 2 cycles per minute, will be applied.

6. RJ-21X and RJ-45 Cable and Connector Assembly Specification

NOTE: RJ-21X is applicable only to Category 5t, while RJ-45 is applicable to both Categories 5t and 6t

6.1 Mechanical Requirements

6.1.1 RJ-45 Plug and Jacks

Plug and Jacks are mechanically defined in IEC 60603-7 and FCC Part 68. These standards are widely accepted and implemented. As such, many manufacturers are capable of manufacturing plugs to the varying categories including categories 5t and 6t.

Test	Requirements
Durability	750 cycles
Wire Size - Termination	24-26 AWG
Plating	50 microinches gold in contact area minimum
Vibration	MIL-STD-202
Mechanical Shock	MIL-STD-202
Dimensional and Mechanical Compliance	IEC 60603-7
Un-Packaged Drop	Per NEBS GR-63-Core, Section 5.3.2

6.1.2 RJ-21X Plugs

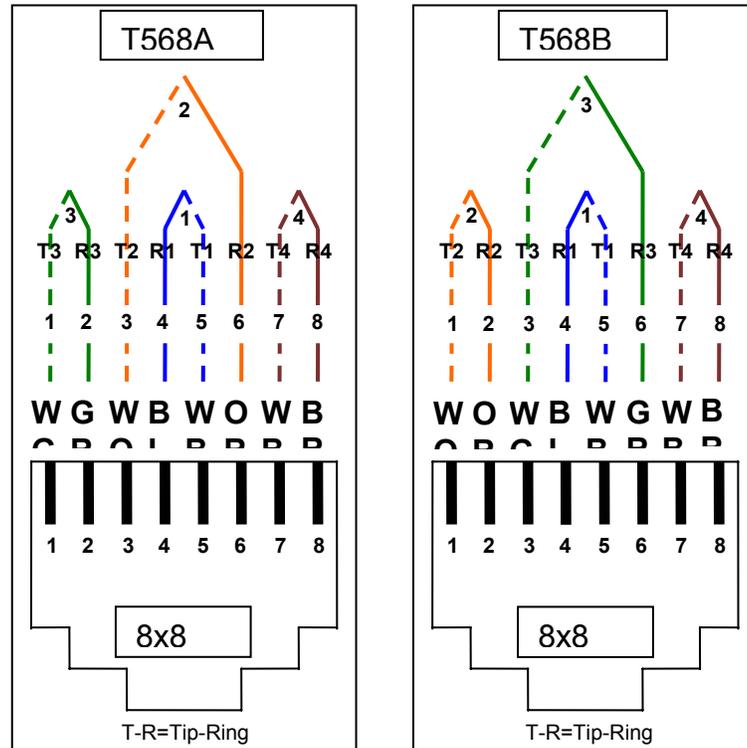
The RJ-21X mechanical requirements are consistent with any RJ-21X, 50 pin, or 25 pair connector. However, the electrical properties required to comply with category 5t in a permanent link and a channel require the plug and cable assembly to be used with a patch panel in which the NEXT in the RJ-21X plug is cancelled out in the circuit board of the panel. This requires the RJ-21X plug to be electrically consistent in design. Because of this requirement, the RJ-21X plug must be the Avaya 525 connector.

Test	Requirements
Durability	200 cycles
Wire Size - Termination	24 AWG
Plating	50 microinches gold in contact area minimum
Vibration	MIL-STD-202
Mechanical Shock	MIL-STD-202
Dimensional and Mechanical Compliance	Must be electrically equivalent to Avaya 525 connector
Un-Packaged Drop	Per NEBS GR-63-Core, Section 5.3.2

6.1.3 Wiring Schemes

6.1.3.1 RJ-45 Wiring Scheme

Two wiring schemes are allowed by the TIA for RJ-45 connectors: T568A and T568B. The only difference between the two schemes is the location of the green and orange pair combinations (see figure below). T568B is the dominant and recommended wiring scheme in the United States.



There is no performance difference between the two schemes, but it is of critical importance that the same exact wiring scheme be used consistently throughout a system or errors will occur. Because of this, it is recommended that the wiring scheme chosen be T568B for all installations in the United States.

Many products do not need a designation for the wiring scheme because by design they are universal. Examples include the RJ to RJ coupler panels and RJ-45 Patch Cords.

Hydra RJ-21X cable assemblies with RJ-45 connectors on one end must be designated with a wiring scheme and this wiring scheme must match the wiring scheme of the panel it is used with. For example, a T568B wired Hydra RJ-21X cable assembly must be mated to a T568B wired data panel to work properly.

6.1.3.2 RJ-21X Wiring Scheme

A RJ-21X to RJ-21X cable assembly can be wired to either a 5800 or 5100 panel. A hydra cable assembly with 6 RJ-45 plugs on the opposite end must be used with the 5800 panel for the wiring to make sense. A hydra cable assembly for the 5100 panel would have a breakout to 12 RJ-45 with pins 1,2 and 3,6 only wired.

5800 Panel Wiring (T568B)			
RJ-21 Pin Number	Wire Color	RJ-45 Pin Number	Port Number
26	White/Blue	5	1
1	Blue/White	4	
27	White/Orange	1	
2	Orange/White	2	
28	White/Green	3	
3	Green/White	6	
29	White/Brown	7	
4	Brown/White	8	
30	White/Slate	5	2
5	Slate/White	4	
31	Red/Blue	1	
6	Blue/Red	2	
32	Red/Orange	3	
7	Orange/Red	6	
33	Red/Green	7	
8	Green/Red	8	
34	Red/Brown	5	3
9	Brown/Red	4	
35	Red/Slate	1	
10	Slate/Red	2	
36	Black/Blue	3	
11	Blue/Black	6	
37	Black/Orange	7	
12	Orange/Black	8	
38	Black/Green	5	4
13	Green/Black	4	
39	Black/Brown	1	
14	Brown/Black	2	
40	Black/Slate	3	
15	Slate/Black	6	

41	Yellow/Blue	7	
16	Blue/Yellow	8	
42	Yellow/Orange	5	5
17	Orange/Yellow	4	
43	Yellow/Green	1	
18	Green/Yellow	2	
44	Yellow/Brown	3	
19	Brown/Yellow	6	
45	Yellow/Slate	7	
20	Slate/Yellow	8	
46	Violet/Blue	5	6
21	Blue/Violet	4	
47	Violet/Orange	1	
22	Orange/Violet	2	
48	Violet/Green	3	
23	Green/Violet	6	
49	Violet/Brown	7	
24	Brown/Violet	8	
50	Violet/Slate	NA	NA
25	Slate/Violet	NA	NA

Data Panel Wiring (10/100Base-T wiring)			
RJ-21 Pin Number	Wire Color	RJ-45 Pin Number	Port Number
26	White/Blue	1	1
1	Blue/White	2	
27	White/Orange	3	
2	Orange/White	6	
28	White/Green	1	2
3	Green/White	2	
29	White/Brown	3	
4	Brown/White	6	
30	White/Slate	1	3
5	Slate/White	2	
31	Red/Blue	3	
6	Blue/Red	6	
32	Red/Orange	1	4
7	Orange/Red	2	
33	Red/Green	3	
8	Green/Red	6	

34	Red/Brown	1	5
9	Brown/Red	2	
35	Red/Slate	3	
10	Slate/Red	6	
36	Black/Blue	1	6
11	Blue/Black	2	
37	Black/Orange	3	
12	Orange/Black	6	
38	Black/Green	1	7
13	Green/Black	2	
39	Black/Brown	3	
14	Brown/Black	6	
40	Black/Slate	1	8
15	Slate/Black	2	
41	Yellow/Blue	3	
16	Blue/Yellow	6	
42	Yellow/Orange	1	9
17	Orange/Yellow	2	
43	Yellow/Green	3	
18	Green/Yellow	6	
44	Yellow/Brown	1	10
19	Brown/Yellow	2	
45	Yellow/Slate	3	
20	Slate/Yellow	6	
46	Violet/Blue	1	11
21	Blue/Violet	2	
47	Violet/Orange	3	
22	Orange/Violet	6	
48	Violet/Green	1	12
23	Green/Violet	2	
49	Violet/Brown	3	
24	Brown/Violet	6	
50	Violet/Slate	NA	NA
25	Slate/Violet	NA	NA

6.2 Electrical Requirements

The following electrical requirements apply to both the RJ-21X and RJ-45 type of connectors. Currently, RJ-21X connectors do not comply with the standards for Category 6t. Also there is currently no 24 or 25 pair cables that meet the cable requirements for category 6t. Category 6t is currently only available in a RJ-45 four pair system.

Note: The electrical requirements as defined by the TIA are subdivided into three groups: component, permanent link, and channel.

6.3 Common Definitions

Component: A component is a mated combination of plug and jack.

Permanent Link: The permanent cabling in a cabling system. Does not include the patch cords on either end of the system. Performance can be verified by a field tester.

Channel: All passive components between two active network elements, includes all cable assemblies, panels and patch cords. Performance can be verified by a field tester.

Attenuation: Signal Loss due primarily to cable resistance. Measured in dB.

NEXT: Near End Crosstalk. Measurement of crosstalk (noise) injected on a signal pair from an adjacent pair on the near end of the cable or connector. Measured in dB.

PSNEXT: Power Sum Near End Crosstalk. Mathematical calculation of the total NEXT injected on a signal pair from all adjacent pairs. Measured in dB.

FEXT: Far End Crosstalk. Measurement of noise injected on a signal pair from an adjacent pair on the far end of the connector. Measured in dB.

ELFEXT: Equal Level Far End Crosstalk. FEXT for cabling with corrected attenuation between the near and far end. Measured in dB.

PSELFEXT: Power Sum Equal Level Far End Crosstalk. Mathematical calculation of the total ELFEXT on a signal pair from all adjacent pairs. Measured in dB.

RL: Return Loss. Measurement of reflected signal power caused by impedance mismatches in the cable system. Measured in dB.

Delay: Time in nanoseconds for a signal to travel from one end of the cable system or connector to the other.

Skew: Difference in time in nanoseconds between the fastest signal pair and the slowest signal pair. (Twisted pair cabling is twisted at different rates for each of the pairs to improve crosstalk, and thus causes some pairs to be "faster" than others)

6.4 Category 5t Connecting Hardware Specifications

Category 5t Connecting Hardware Specifications (TIA/EIA-568-B)						
Frequency (MHz)	Attenuation	NEXT	FEXT	RL	DELAY	SKEW
1.00	0.10	67.5	67.50	30.00	2.13	1.06
4.00	0.10	67.5	65.10	30.00	2.13	1.06
8.00	0.10	67.4	59.00	30.00	2.13	1.06
10.00	0.10	65.8	57.00	30.00	2.13	1.06
16.00	0.18	61.4	53.00	30.00	2.13	1.06
20.00	0.18	59.8	51.10	30.00	2.13	1.06
25.00	0.18	57.8	49.10	30.00	2.13	1.06
31.25	0.18	55.9	47.20	30.00	2.13	1.06
62.50	0.27	49.9	41.20	25.10	2.13	1.06
100.00	0.35	45.8	37.10	21.00	2.13	1.06

6.5 Category 5t Permanent Link Specifications

Category 5t Permanent Link Specifications (TIA/EIA-568-B)						
Frequency (MHz)	Attenuation	NEXT	PSNEXT	ELFEXT	PSELFEXT	Return Loss
1.00	2.1	59.0	58.3	60.0	57.0	19.0
4.00	3.8	53.9	54.3	48.0	45.0	19.5
8.00	5.4	49.1	49.5	42.0	38.9	19.5
10.00	6.1	47.5	48.0	40.0	37.0	19.5
16.00	7.7	44.1	44.7	35.9	32.9	19.3
20.00	8.7	42.5	43.2	34.0	31.0	19.1
25.00	9.7	40.9	41.6	32.1	29.1	18.3
31.25	10.9	39.3	40.0	30.2	27.1	17.5
62.50	15.8	34.2	35.2	24.1	21.1	14.6
100.00	20.4	30.8	31.8	20.0	17.0	12.5

6.6 Category 5t Channel Specifications

Category 5t Channel Specifications (TIA/EIA-568-B)						
Frequency (MHz)	Attenuation	NEXT	PSNEXT	ELFEXT	PSELFEXT	Return Loss
1.00	2.4	61.3	58.3	58.9	55.9	17.5
4.00	4.4	55.9	53.0	46.9	43.9	17.5
8.00	6.2	51.0	48.1	40.8	37.8	17.5
10.00	6.9	49.4	46.5	38.9	35.9	17.5
16.00	8.8	46.0	43.1	34.8	31.8	17.3
20.00	10.0	44.4	41.5	32.9	29.9	17.1
25.00	11.1	42.7	39.8	30.9	27.9	16.3
31.25	12.5	41.1	38.2	29.0	26.0	15.5
62.50	18.1	36.1	33.1	23.0	20.0	12.6
100.00	23.3	32.6	29.6	18.9	15.9	10.5

6.7 Category 6t Connecting Hardware Specifications

Category 6t Connecting Hardware Specifications (TIA/EIA-568-B)						
Frequency (MHz)	Attenuation	NEXT	FEXT	RL	DELAY	SKEW
1.00	0.10	78.8	78.8	30.0	1 ns	0.5 ns
4.00	0.10	78.8	74.7	30.0	1 ns	0.5 ns
8.00	0.10	78.8	68.3	30.0	1 ns	0.5 ns
10.00	0.10	77.7	66.3	30.0	1 ns	0.5 ns
16.00	0.10	73.4	62.0	30.0	1 ns	0.5 ns
20.00	0.10	71.4	60.0	30.0	1 ns	0.5 ns
25.00	0.10	69.3	57.9	30.0	1 ns	0.5 ns
31.25	0.10	67.3	55.9	30.0	1 ns	0.5 ns
62.50	0.15	61.0	49.6	28.1	1 ns	0.5 ns
100.00	0.19	56.7	45.3	24.0	1 ns	0.5 ns
200.00	0.27	50.4	39.0	18.0	1 ns	0.5 ns
250.00	0.30	48.3	36.9	16.0	1 ns	0.5 ns

6.8 Category 6t Permanent Link Specifications

Category 6t Permanent Link Specifications (TIA/EIA-568-B)						
Frequency (MHz)	Attenuation	NEXT	PSNEXT	ELFEXT	PSELFEX T	Return Loss
1.00	1.8	68.3	65.1	67.4	64.3	19.1
4.00	3.3	67.3	64.9	54.7	51.6	21.0
8.00	4.8	62.4	59.9	48.4	45.3	21.0
10.00	5.3	60.7	58.3	46.4	43.3	21.0
16.00	6.7	57.3	54.8	42.1	39.0	20.0
20.00	7.5	55.8	53.2	40.1	37.0	19.5
25.00	8.5	54.1	51.6	38.0	34.9	19.0
31.25	9.5	52.6	49.9	36.4	32.9	18.5
62.50	13.7	47.4	44.8	27.9	26.6	16.0
100.00	17.6	43.9	41.3	25.4	22.3	14.0
200.00	25.7	38.7	36.0	19.1	16.0	11.0
250.00	29.2	37.3	34.3	17.0	13.9	10.0

6.9 Category 6t Channel Specifications

Category 6t Channel Specifications (TIA/EIA-568-B)						
Frequency (MHz)	Attenuation	NEXT	PSNEXT	ELFEXT	PSELFEX T	Return Loss
1.00	2.0	68.3	65.1	66.5	63.3	19.0
4.00	3.8	66.2	63.5	53.8	50.6	19.0
8.00	5.4	61.1	58.4	47.5	44.3	19.0
10.00	6.0	59.4	56.7	45.5	42.3	19.0
16.00	7.6	55.9	53.1	41.2	38.0	18.0
20.00	8.6	54.2	51.5	39.1	35.9	17.5
25.00	9.6	52.5	49.7	37.1	33.9	17.0
31.25	10.8	50.8	48.0	35.1	31.9	16.5
62.50	15.7	45.6	42.6	28.7	25.5	14.0
100.00	20.2	41.9	39.0	24.5	21.3	12.0
200.00	29.9	36.5	33.5	18.1	14.9	9.0
250.00	34.2	34.8	31.7	16.1	12.9	8.0

7. References

Document	Description	Issue & Date
ATT-TP76200-000	Network Equipment – Building Systems (NEBS)	Current
ATT-TP76300-000	Installation Guide within the Central Office	Current
ATT-TP76400-000	Detail Engineer Requirements for the C.O.	Current
ATT-TP76412-000	Ethernet Standards for the Telecommunications Industry	Mar 2003
ATT-TP76450-000	Common Systems Standards for the AT&T Communications Network	Pending
ATT-TP76412-001	Ethernet Testing Using the Sunset Test Set	Dec 2003
ATT-TP76412-002	Ethernet Testing Using the Acterna Test Set	Dec 2003

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