

1000BASE-T Gigabit Ethernet Tutorial



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U.S.A.

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Introduction

1000BASE-T provides the greatest cost advantage for reliable Gigabit Ethernet (GbE) connectivity because it works equally well over UTP Category 5 cable (CAT5) installed after 1995 and UTP Category 5e cable (CAT5e).

This long-haul, copper-based standard is ideally suited for use within the data center because its topology rules are identical to those of the Fast Ethernet 100BASE-TX standard.

The purpose of this tutorial is to introduce basic 1000BASE-T deployment concepts:

- **IEEE 802.3 Working Group:** This workgroup was responsible for developing the current IEEE 802.3z and IEEE 802.3ab Gigabit Ethernet standards. Both standards are discussed.
- **1000BASE-T vs. 1000BASE-SX:** HP Fiber and Copper GbE NICs are compared.
- **UTP CAT5 and CAT5e Cable:** Specific cabling recommendations are presented.
- **100BASE-TX vs. 1000BASE-T:** Fast Ethernet 100BASE-TX and 1000BASE-T are compared.
- **Taking the Next Step:** Specific 1000BASE-T deployment suggestions are presented.

Gigabit Ethernet can be deployed using four different physical layers. Two of these layers use copper cable (1000BASE-T and 1000BASE-CX) and the other two use fiber optic cable (1000BASE-LX and 1000BASE-SX). The table below summarizes the major differences between 1000BASE-T and the other GbE physical layer standards.

IEEE Designation	Description	Cabling	Maximum Distance
1000BASE-T (IEEE 802.3ab)	Long Haul Copper Physical Layer	UTP CAT5 and CAT5e	100m
1000BASE-CX (IEEE 802.3z)	Short Haul Copper Physical Layer	Shielded Copper	25m
1000BASE-LX (IEEE 802.3z)	Long Haul Fiber Physical Layer	9 micron Single-mode Fiber	up to 5km
1000BASE-SX (IEEE 802.3z)	Short Haul Fiber Physical Layer	62.5 micron Multi-mode Fiber or 50 micron Multi-mode Fiber	Up to 275m or 550m respectively.

The IEEE 802.3 Working Group

The IEEE 802.3 Working Group started work on the current GbE standard in 1995. The goal of the IEEE 802.3 Working Group was to give the current Fast Ethernet base a cost-effective way to upgrade their systems to GbE, while leveraging their existing investment in hubs, switches, and routers. Consequently, two teams were formed with two very specific missions. The results of those efforts culminated in the establishment of IEEE 802.3z standards in 1998 and IEEE 802.3ab standards in 1999.

IEEE 802.3z Summary

The IEEE 802.3z standard addresses the overall requirements for 1000 Mbps operation, plus three of the four physical layer interfaces using existing Fibre Channel technology.

- **1000BASE-CX:** (Copper-based media, short haul) supporting distances up to 25 meters.
- **1000BASE-LX:** (1300nm LWL - long wavelength) single-mode fiber (SMF) supporting distances up to 5km.
- **1000BASE-SX:** (850nm SWL - short wavelength) 62.5 micron or 50 micron multimode fibre (MMF) supporting distances up to 275 meters or 550 meters respectively.

IEEE 802.3ab Summary

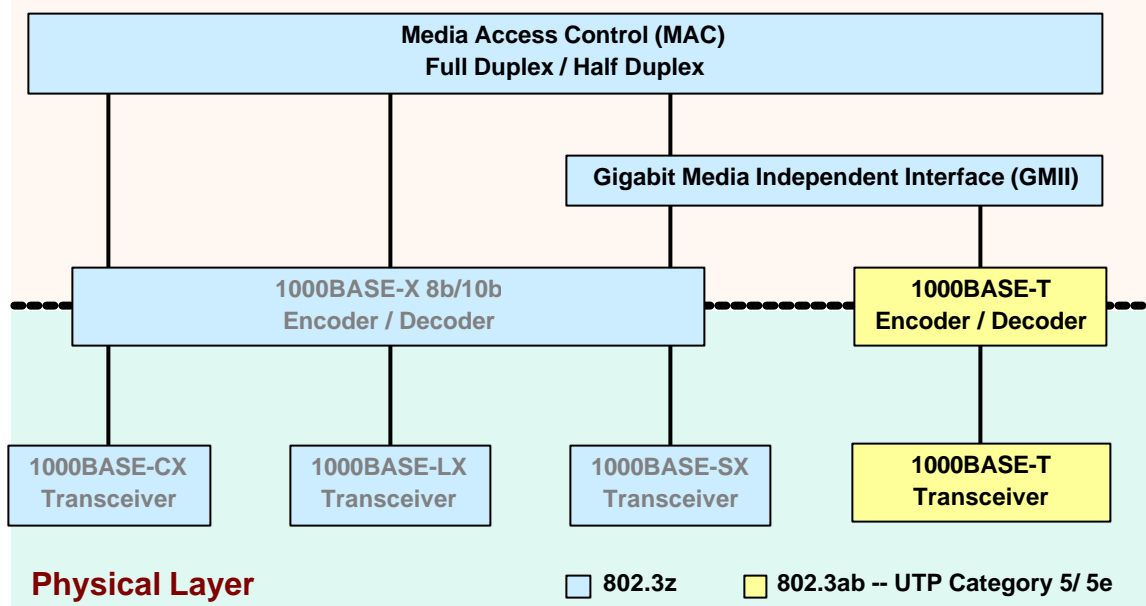
The IEEE 802.3ab standard deals with one of the four physical layer specifications. It gives GbE customers the ability to use existing 100BASE-TX CAT5 cabling with 1000BASE-T.

UTP CAT5 cable was chosen because it represents the majority of all existing horizontally installed UTP cable. The designation for this physical layer interface is **1000BASE-T**. It supports distances up to 100 meters.

1000BASE-T implementation uses a sophisticated Digital Signal Processing (DSP) design to address specific challenges in transmitting 1000 Mbps over CAT5 UTP cable.

MAC Layer

Gigabit Ethernet Technology Family



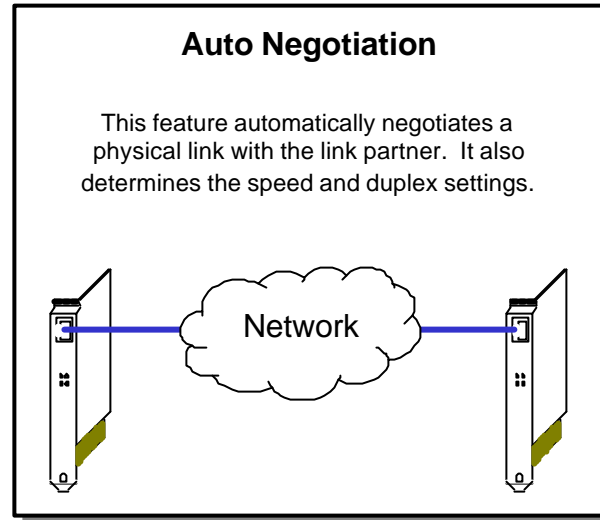
1000BASE-T vs. 1000BASE-SX

There are two available options when deploying Gigabit Ethernet using HP GbE NIC products.

1000BASE-T (A4929A)

IEEE 802.3ab compliant NICs for the PCI bus.

HP PCI 1000BASE-T NICs support link speeds of 10/100/1000 Mbps with auto-negotiation. This feature automatically detects the maximum link rate and duplex mode supported by the remote link partner. It also adjusts the speed and duplex of the HP NIC to the most optimal operating condition.



1000BASE-SX (A4926A)

IEEE 802.3z compliant fiber-based NICs for the HSC and PCI buses.

The table shown below compares the two standards and discusses relevant HP product features.

HP Product	Typical Use	HSC	PCI	Jumbo Frames	Link Modes
1000BASE-T Long-haul Copper	Horizontal copper cabling for distances up to 100m. HP's 10/100/1000 Mbps support makes this NIC an ideal choice for easy migrations.		✓	9000 byte MTU supported in 1000 Mbps Full Duplex Only	<ul style="list-style-type: none"> Auto-negotiation at 10/100/1000 Mbps Link Speeds Half Duplex support for 10/100 Mbps Only Full Duplex Support For 10/100/1000 Mbps Manual Override
1000BASE-SX Short-haul Fiber	For distances up to 550m over multi-mode fiber. Ideal for horizontal or shorter distances backbone applications within a data center.	✓	✓	9000 byte MTU supported in 1000 Mbps Full Duplex Only	<ul style="list-style-type: none"> 1000 Mbps Link Speed Full Duplex Only Auto-negotiation Manual Override

UTP CAT5 and CAT5e Cable

The 1000BASE-T GbE physical layer is designed for use on all UTP CAT5e cable. It is also suitable for use with all CAT5 cable manufactured after 1995 in accordance with the ANSI/TIA/EIA-568-A (1995) standard.

UTP Cable Category 1000 BASE-T Recommendations	
Category 5 Installed Before 1995	<p>UTP CAT5 cabling installed prior to 1995 is totally suitable for Fast Ethernet 100BASE-TX. However, it may not yield consistent performance results when used with 1000BASE-T GbE. This is because the standard was first established in 1991 and then modified in 1995.</p> <p>NOTE: If your existing CAT5 cable was installed before 1995, make sure that it has been fully tested for use with 1000BASE-T. For the most current test procedures and 1000BASE-T installation recommendations, please refer to the Gigabit Ethernet Alliance web site at: www.gigabit-ethernet.org.</p>
Category 5 Installed After 1995	<p>When the IEEE first began work on the 1000BASE-T physical layer standard, it based its specifications on the CAT5 standard 1995 update. All cable installed after 1995 is ideally suited for use with 1000BASE-T.</p>
Category 5e (Enhanced)	<p>1000BASE-T works equally well over CAT5 and CAT5e cable. The principal difference between the two cables is that CAT5e includes performance enhancements.</p> <p>NOTE: Use your on-hand supply of CAT5 cable, produced after 1995, with confidence. When it comes time to replenish your supply be sure to ask for CAT5e (Enhanced) cable.</p>

1000BASE-T Topology Rules

The topology rules for GbE 1000BASE-T and Fast Ethernet 100BASE-TX are identical. CAT5 and CAT5e link lengths are limited to 100 meters by the ANSI/TIA/EIA-568-A (1995) cabling standard.

100BASE-TX vs. 1000BASE-T

The Fast Ethernet 100BASE-TX and Gigabit Ethernet 1000BASE-T physical layer standards are both designed for the same 4-pair Category 5 cable. The difference between them is how they each use it.

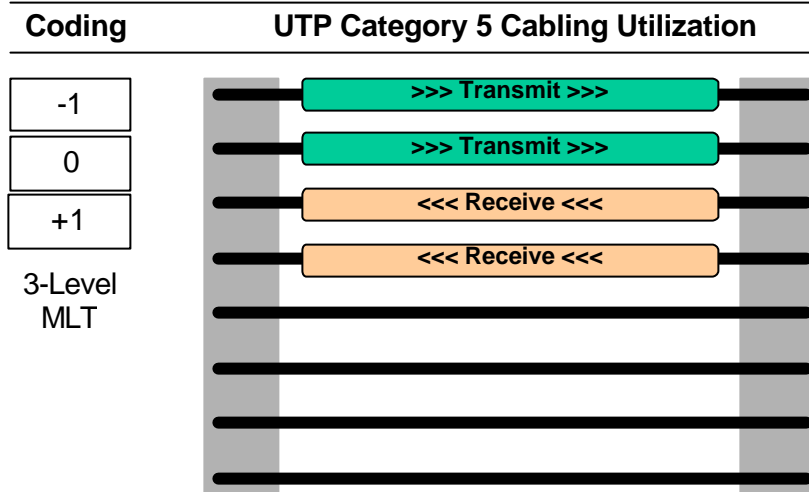
100BASE-TX

This standard uses two pairs of wires. One pair is used for transmit and the other for receive.

100BASE-TX utilizes 3-level MLT signaling.

With this coding system, each transmitted symbol represents one of three different levels (-1, 0, +1).

100BASE-TX

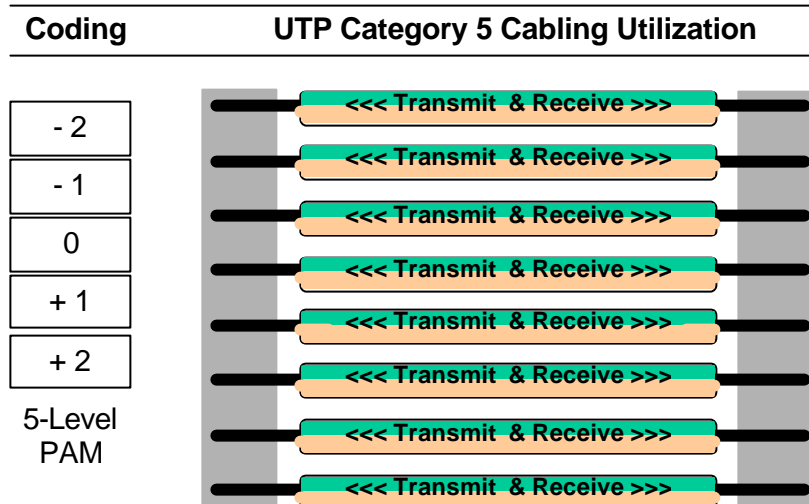


1000BASE-T

1000BASE-T

All four pairs of wires are used with this standard. Each pair is used for both transmit and receive.

1000BASE-T utilizes 5-level pulse amplitude modulation (PAM-5) technique for transmission, which offers better bandwidth usage.



With this coding system, each transmitted symbol represents one of five different levels (-2, -1, 0, +1, +2).

Taking the Next Step

When deploying Gigabit Ethernet within the data center, the most cost-effective solution is 1000BASE-T.

The key factors to remember with 1000BASE-T are:

- **HP 1000BASE-T IS AVAILABLE TODAY:** HP offers IEEE 802.3ab compliant PCI 1000BASE-T NICs for the HP 9000 servers and workstations.
- **EASY MIGRATION:** All HP 1000BASE-T NICs feature 10/100/1000 auto-negotiation. When an HP 1000BASE-T NIC is linked to a slower link partner, it automatically throttles back to the appropriate speed. *(Note: This feature is not available on fiber-based 1000BASE-SX NICs.)*
- **THE ONLY DIFFERENCE IS DISTANCE:** There is no difference between copper or fiber standards in terms of speed and reliability. The only differences are cost, distance, and auto-negotiation of the link speed.
- **COMMON TOPOLOGY:** The topology rules for GbE 1000BASE-T and Fast Ethernet 100BASE-TX are identical. CAT5 and CAT5e link lengths are limited to 100 meters by the ANSI/TIA/EIA-568-A (1995) cabling standard.
- **USE UTP CAT5 CABLE INSTALLED AFTER 1995 WITH CONFIDENCE:** The IEEE 802.3ab standard was developed for Category 5 cabling that complies with the specifications of the ANSI/TIA/EIA-568-A (1995) standard.
- **TEST CAT5 CABLE INSTALLED BEFORE 1995:** If your existing CAT5 cable was installed before 1995, make sure that it has been fully tested for use with 1000BASE-T. For the most current test procedures and 1000BASE-T installation recommendations, please refer to the Gigabit Ethernet Alliance web site at: www.gigabit-ethernet.org.
- **ASK FOR CAT5e (Enhanced) WHEN REPLENISHING YOUR CABLE SUPPLY:** 1000BASE-T works equally with post-1995 CAT5 and CAT5e cable. When your on-hand supply of post-1995 CAT5 runs out, we suggest you replenish your supply with CAT5e cable.

For a current list of tested products and a detailed analysis of your specific requirements regarding HP 1000BASE-T products and cabling issues, contact your HP Sales Representative.