

Cabling Guide for 10GbE Network Adapters

At a Glance

Cables and connectors can cause some confusion when purchasing new adapters for servers. There are many options across many vendors. This technical brief provides generic information about cables and connectors for adapters in a 10Gb Ethernet (10GbE) network environment. Note that the cable you select is determined by the switch, not the adapter, in your environment.

10GbE has been in existence since 2002, yet it seems only recently that serious interest in 10GbE has taken hold. Due to the history of 10GbE, it has not been completely backward compatible with previous generations of Ethernet technology, which has contributed to some confusion about the cables and connectors required for 10GbE.

10GbE cables

There are two basic cable types available for 10GbE applications: copper and fiber-optic cables. As interface speeds increase, expect increased usage of fiber optic cables and connectors for most interfaces. At higher Gigabit speeds (10Gb+), copper cables and interconnects generally have too much amplitude loss except for short distances, such as within a rack or to a nearby rack. This amplitude loss is sometimes called a poor signal-to-noise ratio or simply “too noisy”.

Fiber-optic cables

There are two general types of fiber optic cables available: single-mode fiber and multi-mode fiber.

- **Single-mode fiber (SMF)**—typically with an optical core of approximately 9 μm (microns), has lower modal dispersion than multi-mode fiber and can support distances of at least 10 Km and as high as 80-100 Km (Kilometers) or more, depending on transmission speed, transceivers and the buffer credits allocated in the switches.
- **Multi-mode fiber (MMF)**—with optical core of either 50 μm or 62.5 μm , supports distances up to 600 meters, depending on transmission speeds and transceivers.

Meter-for-meter, single-mode and multi-mode cables are similarly priced. However, some of the other components used in single-mode links are more expensive than their multi-mode equivalents.

When planning data center cabling requirements, be sure to consider that a service life of 15 to 20 years can be expected for fiber optic cabling, so the choices made today need to support legacy, current and emerging data rates. Also note that deploying large amounts of new cable in a data center can be labor-intensive, especially in existing environments.

Cabling Guide for 10GbE Network Adapters



There are different designations for fiber-optic cables depending on the bandwidth supported.

- Multi-mode: OM1, OM2, OM3, OM4
- Single-mode: OS1

10GBASE-SR—Currently, the most common type of fiber-optic 10GbE cable is the 10GBase-SR cable that supports an SFP+ connector with an optical transceiver rated for 10Gb transmission speed. These are also known as “short reach” fiber-optic cables.

10GBASE-LR—These are the “long reach” fiber optic cables that support single-mode fiber optic cables and connectors.

OM3 and OM4 are newer multi-mode cables that are “laser optimized” (LOMMF) and support 10GbE applications. OM3 and OM4 cables are also the only multi-mode fibers included in the IEEE 802.3ba 40G/100G Ethernet standard that was ratified in June 2010. The 40G and 100G speeds are currently achieved by bundling multiple channels together in parallel with special multi-channel (or multi-lane) connector types. This standard defines an expected operating range of up to 100m for OM3 and up to 150m for OM4 for 40GbE and 100GbE. These are estimates of distance only and supported distances may differ when 40GbE and 100GbE products become available in the coming years. See the Connector Types section below for additional detail.

Newer multi-mode OM2, OM3 and OM4 (50 μm) and single-mode OS1 (9 μm) fiber-optic cables have been introduced that can handle tight corners and turns. These are known as “bend optimized,” “bend insensitive,” or have “enhanced bend performance.” These fiber-optic cables can have a very small turn or bend radius with minimal signal loss or “bending loss.” The term “bend optimized” multi-mode fiber (BOMMF) is sometimes used.

OS1 single-mode fiber optics are used for long distances, up to 10,000m (6.2 miles) with the standard transceivers and have been known to work at much longer distances with special transceivers and switching infrastructure.

Each of the multi-mode and single-mode fiber optic cable types includes two wavelengths. The higher wavelengths are used for longer-distance connections.

Indoor vs. outdoor cabling

Indoor fiber-optic cables are suitable for indoor building applications. Outdoor cables, also known as outside plant or OSP, are suitable for outdoor applications and are water (liquid and frozen) and ultra-violet resistant. Indoor/outdoor cables provide the protections of outdoor cables with a fire-retardant jacket that allows deployment of these cables inside the building entrance beyond the OSP maximum distance, which can reduce the number of transition splices and connections needed.

Fiber-optic cable characteristics

	Mode	Core Diameter	Wavelength	Modal Bandwidth	Cable Jacket Color
OM1	Multi-mode	62.5 μm	850 nm / 1300 nm	200 MHz	● Orange
OM2	Multi-mode	50 μm	850 nm / 1300 nm	500 MHz	● Orange
OM3	Multi-mode	50 μm	850 nm / 1300 nm	2000 MHz	● Aqua
OM4	Multi-mode	50 μm	850 nm / 1300 nm	4700 MHz	● Aqua
OS1	Single-mode	9 μm	1310 nm / 1550 nm	—	● Yellow

Fiber-optic cable distance and speed

	OM1	OM2	OM3	OM4
10 Gbps	33m	82m	Up to 300m	Up to 400m

The distances shown above are for 850 nm wavelength multi-mode cables. The 1300 nm wavelength cables can support longer distances.

Cabling Guide for 10GbE Network Adapters



Copper cables

Common forms of 10GbE copper cables are as follows:

10GBASE-CR—Currently, the most common type of copper 10GbE cable is the 10GBase-CR cable that uses an attached SFP+ connector, also known as a Direct Attach Copper (DAC). This fits into the same form factor connector and housing as the fiber-optic cables with SFP+ connectors. Many 10GbE switches accept cables with SFP+ connectors, which support both copper and fiber-optic cables. These cables are available in 1m, 3m, 5m, 7m, 8.5m and longer distances. The most commonly deployed distances are 3m and 5m.

Passive and Active DAC—Passive copper connections are common with many interfaces. The industry is finding that as the transfer rates increase, passive copper does not provide the distance needed and takes up too much physical space. The industry is moving towards an active copper type of interface for higher speed connections. Active copper connections include components that boost the signal, reduce the noise and work with smaller gauge cables, improving signal distance, cable flexibility and airflow.

10GBASE-T—These cables and connectors are similar to, but not the same as the cables used for 1000BASE-T. 10GBASE-T cables are Cat6a (Category 6 augmented), also known as Class EA cables. These support the higher frequencies required for 10Gb transmission up to 100 meters (330 feet). Cables must be certified to at least 500MHz to ensure 10GBASE-T compliance. Cat7 (Category 7, Class F) cable is also certified for 10GBASE-T compliance, and is typically deployed in Europe. Cat6 cables may work in 10GBASE-T deployments up to 55m, but should be tested first. Some newer 10GbE switches support 10GBASE-T (RJ45) connectors.

Connectors

Several types of connectors are available for 10GbE cables. Each of the connector types includes a specific number of lanes, or channels.

As of early 2011, the fastest generally available connector speeds supported were 10 Gbps per lane. Significantly higher speeds are currently achieved by bundling multiple lanes in parallel, such as 4x10 (40Gbps), 10x10 (100Gbps), 12x10 (120Gbps), etc. Most of the current implementations of 40GbE and 100GbE use multiple lanes of 10GbE and are considered “channel bonded” solutions.

	Type	Lanes	Max. speed per lane (Gbps)	Max. speed total (Gbps)	Cable type	Usage
Copper CX4	CX4	4	5	20	Copper	10GbE, SDR and DDR Infiniband
Small Form-factor Pluggable	SFP	1	4	4	Copper, Optical	1GbE, Fibre Channel: 1, 2, 4Gb
Small Form-factor Pluggable enhanced	SFP+	1	16	16	Copper, Optical	10GbE, 8Gb & 16Gb Fibre Channel, 10Gb FCoE
Quad Small Form-factor Pluggable	QSFP	4	5	20	Copper, Optical	Various
Quad Small Form-factor Pluggable enhanced	QSFP+	4	16	64	Copper, Optical	40GbE, DDR, QDR & FDR Infiniband, 64Gb Fibre Channel

Cabling Guide for 10GbE Network Adapters



	Type	Diagram
Copper CX4	CX4	
Small Form-factor Pluggable	SFP, SFP+	
Quad Small Form-factor Pluggable	QSFP, QSFP+	

When to use different types of 10GbE cables

To summarize, the most common types of 10GbE cables currently use SFP+ connectors.

- For short distances, such as within a rack or to a nearby rack, use DAC with SFP+ connectors, also known as 10GBASE-CR.
- For mid-range distances, use laser optimized multi-mode fiber (LOMMF) cables, either OM3 or OM4, with SFP+ connectors.
- For long-range distances, use single-mode fiber-optic cables (OS1), also known as 10GBASE-LR.
- If your Ethernet switching infrastructure and network adapters support 10GBASE-T (RJ45) cables and connectors, use Cat6 or Cat6a cables.

Remember, the cable you select is determined by the switch, not the adapter, in your environment.

*Some of these products may not be available in the U.S.
Please contact your supplier for more information.*



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