Guide to Cat5 and Cat6 Networking Cables

Understanding network cable infrastructure can be a significant challenge. What type of network cabling is required for your application? Cat5E? Cat6? Shielded? Unshielded? Should you run Gigabit Ethernet or 100BASE-T? The answer isn’t always quite so simple. This exclusive Guide to Networking Cables is intended to demystify the confusion around this question. Whether you have a new network installation planned or simply an upgrade, Amphenol Cables on Demand has thousands of networking cables in stock and ready to ship.

This Guide will cover several key topics. First we will explore how twisted pair cable functions and why it is the preferred cable technology for network applications. This will be followed by an exploration of the different styles of Cat5 and Cat6 cabling available today and how well they perform. Finally, we will discuss some of the top Do’s and Don’ts of network cable installation.

Twisted pair cabling is a form of wiring in which two conductors are wound together for the purposes of canceling out electromagnetic interference (EMI) from external sources and crosstalk from neighboring wires. Twisted pair cabling is usually made of copper alloy, but silver and other exotic versions have been known to exist. Twisted pair cabling is perhaps one of the oldest types of cable ever invented. Alexander Graham Bell patented twisted pair cabling along with his first telephone circuit on October 21, 1879!
Twisted pair cabling is sometimes referred to as a differential system. With the differential system each signal is transmitted on two lines at the same time. On one, the signal is transmitted as a POSITIVE (+) signal, on the other as a NEGATIVE (-) signal. At the receiving end of the cable the receiver device gets two signals. Both of them however, have been charged by the EMI noise that penetrated the cable. The changes came in the form of unwanted voltage added to the wanted signal. At this point it is important to note that the unwanted voltage got added to both lines at the same time and by the same amount because the cable is uniformly twisted. The essence of the differential system is that the receiver is designed to take the difference between the two signals on the two lines. In doing that, the noise part of the signal, equal on both lines, gets eliminated, and what remains is clear signal. This same concept helps prevent the signal of one line from interfering with the signal on an adjacent line. This adjacent interference is known as crosstalk.

The interference canceling aspects of twisted pair cabling is generally adequate. That is why Unshielded Twisted Pair (UTP) cabling is the most common. Sometimes, however, electromagnetic interference can be so pervasive in certain environments, that an additional level of shielding is required. This is why Shielded Twisted Pair (STP) cabling is used as an alternative. STP cabling comes in two flavors. Foiled Twisted Pair (FTP) adds a single mylar/foil shield over the entire cable body.

This protects mainly against EMI. Extremely sensitive installations often use Screened Shielded Twisted Pair (S/STP) cabling. This includes the mylar/foil shield in addition to separate shields over each individual pair. This provides added protection against cross-talk. This type of cable is extremely bulky and hard to terminate, so its use is somewhat limited.
We’ll explore the merits of shielded cables more in the next section. For now, we’ve established that twisted pair cabling is a proven technology which naturally suppresses interference due to its inherent design characteristics. Twisted pair cabling, especially the unshielded variety, is perhaps most popular due to its favorable cost. Competing technologies such as coaxial and fiber optic cabling must adhere to extremely strict tolerances to maintain signal integrity; a costly requirement. Twisted pair cabling tends to have more “wiggle room” in its design, thereby bringing costs down considerably. This partially explains why twisted pair cabling is increasingly being used for consumer applications such as the HDMI interface for HDTV.

Technical Primer: Terminating Twisted Pair Cable

An often over-looked but all-to-critical aspect of twisted pair cabling is how the cable is terminated to a connector. Twisted pair cabling is designed to maintain an impedance of 100 ohms. The precise distance or space between wire pairs determines a cable’s impedance. The industry standard RJ-45 type networking connector also maintains this spacing and 100 ohm impedance. This versatile connector works with all types of Cat5 and Cat6 twisted pair cabling.

**Standard RJ-45 Connector**

**Network Cable Crimp Tool**
The challenge comes in terminating this connector to the twisted pair cabling, because unwinding the cable will automatically alter this critical spacing. Here at Amphenol Cables on Demand, our networking patch cables are assembled by factory trained professionals with over a million feet worth of combined network cable assembly experience. All cables are electrically screened at the factory before shipment, thereby ensuring the integrity of your network cable infrastructure.

If you elect to wire your own networking cables using bare UTP cabling, RJ-45 connectors, and a crimp tool, you may have questions about properly mapping the different colored wire pairs. The answer to this question has a lot to do with your particular network installation. Generally, networks are made up of two types of cables: patch cables and crossover cables.

### T568A/B RJ45 Wiring

<table>
<thead>
<tr>
<th>Pin</th>
<th>T568A Pair</th>
<th>T568B Pair</th>
<th>Wire</th>
<th>T568A Color</th>
<th>T568B Color</th>
<th>Pins on plug face (jack is reversed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>2</td>
<td>tip</td>
<td>white/green stripe</td>
<td>white/orange stripe</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>2</td>
<td>ring</td>
<td>green solid</td>
<td>orange solid</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3</td>
<td>tip</td>
<td>white/orange stripe</td>
<td>white/green stripe</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>ring</td>
<td>blue solid</td>
<td>blue solid</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1</td>
<td>tip</td>
<td>white/blue stripe</td>
<td>white/blue stripe</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>3</td>
<td>ring</td>
<td>orange solid</td>
<td>green solid</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>4</td>
<td>tip</td>
<td>white/brown stripe</td>
<td>white/brown stripe</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4</td>
<td>ring</td>
<td>brown solid</td>
<td>brown solid</td>
<td></td>
</tr>
</tbody>
</table>

#### T568A and T568B Patch Cable Wiring Diagram

A networking patch cable is the most common cable type in any network. Patch cables are used to connect any two different network devices. Examples include connecting a computer to a router or connecting a cable modem to an X-Box. A patch cable is often referred to as a straight through cable, because a pin on one end of the cable will always connect to its corresponding pin on the other end of the cable. So how do you know what color wire goes to what pin? Technically it doesn’t matter. As long as each wire goes straight through from one end to the other, the signal will get through just the same. Regardless, there are some standards out there that tend to be followed.
takes advantage of the unused brown and blue wire pairs for its additional throughput. For crossover purposes, the blue wire pair must therefore also be swapped with the brown pair. The striped/solid wires within each of those pairs must also be swapped. Please refer to the chart above for guidance.

**Article Continues – Network Cable Selection**

Before we go into the merits of the various cable types, it is critical to first establish what your bandwidth demands are. These bandwidth demands will help determine whether Gigabit Ethernet (1000BASE-T) or Fast Ethernet (100BASE-T) is the appropriate system for you.

Fast Ethernet, AKA 100BASE-T or 100 Megabit Ethernet, has long been the industry standard form of network communications over twisted pair cabling. All new PC’s will have 100 Megabit Ethernet ports built into them. Networking equipment operating at this 100Mbit speed is also extremely affordable due to it being a mature technology. Fast Ethernet connections only require Category 5 networking cable, another cost advantage. Your average residence or small office today will rarely demand more bandwidth than what’s available from a 100 Megabit network. Within the next 5 years, however, Fast Ethernet networks will be taxed to capacity by high bandwidth content.

To prepare for future bandwidth needs, we recommend installing Gigabit Ethernet (1000BASE-T) equipment exclusively. Gigabit Ethernet transfers data at a whopping 1 billion bits per second and is up to ten times faster than Fast Ethernet. Category 5E (enhanced) networking cable is required to support Gigabit speeds. Cat 5e cable is an enhanced version of Cat 5 that improves cross-talk performance, a critical issue with Gigabit data transmission. Gigabit Ethernet functions even better using Category 6 cable due to its inherent design characteristics.

Fortunately, you can always upgrade your networking equipment later and build your network around the cable. Cat6 cable, for instance, is designed to support a future version of 10 Gigabit Ethernet when it becomes available. So designing your network using Cat6 cable is a safe bet, especially considering Cat6 cable supports 100 Megabit Ethernet better than Cat5e. Contractors nation-wide are so confident in Cat6, they are installing their Cat6 cables with a 25 year guarantee against obsolescence.
Networking Cable Comparison

Category 5e Unshielded Twisted Pair (UTP)

Currently, Category 5e UTP cabling is the de-facto standard for networking infrastructure worldwide. Category 5e has replaced standard Category 5 cabling in the marketplace over the past several years, so the terms Cat5 and Cat5e have become somewhat interchangeable. Although Category 5e UTP cabling will support Gigabit Ethernet, especially over short runs, this cable type really shines with 100 Megabit network traffic. Typical devices using this cable type include PC’s, current generation gaming platforms, internet appliances, 10/100 and Gigabit network cards, hubs, routers, and switches.

This type of cable is unshielded, but this is not usually a problem. If your network environment meets the following criteria, Cat5e Unshielded Twisted Pair will work just fine:

- Any residence that meets NEC electrical requirements for earth grounding
- Most commercial office buildings with conduit and a central office ground
- Light duty industrial factories with limited interference potential

Amphenol Cat5e cables are available in multiple colors so that you can better identify your connections. Some companies for instance require each IT person to install their own unique color cable for each installation to improve troubleshooting and response time. You can also use a different color cable based on functionality, i.e. red cables for connections to PC’s and blue cables for connections between access points.

To browse our full selection of Cat5e Unshielded Twisted Pair (UTP), please click here.
Category 5e Foil-screened Twisted Pair (FTP)

Certain environments are chock full of harmful EMI/RFI interference. This interference can rapidly degrade the integrity of high speed data over standard Unshielded Twisted Pair cabling. Despite the interference rejecting benefits of twisted pair cabling and the latest digital signal processing technology, a shielded cable is sometimes required.

Foil-screened Twisted Pair (FTP)

cabling has the simplest of shield designs, consisting of a mylar/aluminum foil sleeve that covers the four twisted wire pairs. This shield primarily fights interference coming into the cable from the outside. FTP cables tend to cost significantly more than UTP cables, because the addition of the foil shield is a labor intensive process. The foil shield provides the added benefit of further protecting the inner wire pairs from physical damage. This is why shielded Cat5e cables are often chosen for permanent structure cabling.

We recommend Cat5e FTP cabling in the following environments:

- Any residence lacking a proper earth ground or in proximity to high voltage lines
- Commercial office buildings without an isolated central office ground
- Industrial facilities and factories using high current / high voltage equipment
- Broadcast facilities, military installations, financial institutions, hospitals
- Any sensitive areas where data reliability is of the utmost importance

All FTP cables from Cables on Demand feature shielded, impedance matched, and precision-terminated RJ-45 connectors for the most reliable connection possible. Cat5e FTP cables should preferably be used with networking equipment featuring shielded RJ-45 jacks to maintain their full benefit. There are also instances in which networks, having operated poorly due to excessive cable lengths or other challenges, can be fully restored by simply switching to an FTP cable.

To browse our full selection of Cat5e Foil-Screened Twisted Pair (FTP), please click here.
Category 6 Unshielded Twisted Pair (UTP)

Category 6 UTP cabling is presently the choice of installers world-wide who want to “future proof” their networks. You may not realize just how dependent we are becoming on network bandwidth. Our cell-phones, home phones, cable boxes, computers, mp3 players, security systems, and other technologies are all consuming up valuable bandwidth at an alarming rate.

Nearly all emerging technologies are utilizing the internet to deliver their content. High Definition Television will soon be delivered via the internet. HDTV alone will significantly tax the capacity of our networks in the near future. By 2010, nearly 90% of network traffic could be devoted to HDTV, as seen below:

![Bandwidth Requirements - Current Compression](image)

*Category 6 = Protection from future bandwidth requirements*
Installing Category 6 cabling for your home or office network is an investment in the future. Cat6 cabling is considered universal. It supports 100 Megabit and Gigabit data rates far better than Cat5e and it is reverse compatible with all 10/100 Ethernet equipment. Because of its improved transmission performance and superior immunity from external noise, systems operating over category 6 cabling will have fewer errors versus category 5e for current applications. How many fewer errors? It is significant as shown below:

<table>
<thead>
<tr>
<th>Cabling System</th>
<th>Typical Frame Errors</th>
<th>Percent of Errors</th>
<th>Improvement over Cat-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat-5</td>
<td>200,000</td>
<td>5.0%</td>
<td></td>
</tr>
<tr>
<td>Cat-5e</td>
<td>100,000</td>
<td>3.5%</td>
<td>50%</td>
</tr>
<tr>
<td>Cat-6</td>
<td>17,000</td>
<td>0.4%</td>
<td>92%</td>
</tr>
</tbody>
</table>

**Table: Error Rates of Cat5, Cat5e, and Cat6 Cabling**

Cat6 cabling may look identical on the periphery to Cat5 cabling, but there are significant differences between the two. Cat6 cables are built to much tighter tolerances. The precision of the cable twists significantly punch down interference without the need for shielding. The problem of cross talk is dealt with by using an insulator between the wire pairs. These subtle nuances will permit Cat6 cabling to handle 10 Gigabit data rates in the near future.

In essence, using Cat6 as your network cable of choice will allow you to use equipment 10X faster than what’s on the market today. There is a minor initial cost premium associated with using Category 6 cable, but the long term cost savings associated with avoiding future upgrades is worth it. We recommend using Category 6 cabling whenever possible on all new residential and commercial installations. Estimates place Cat6 as still being a viable cable technology 25 years from now!

To browse our full selection of Cat6 Unshielded Twisted Pair (UTP), please click here.

*Cat6 will support speeds up to 10X faster than Gigabit Ethernet*
If you follow these general ground rules, chances are your network upgrade will be seamless process:

**DO:** Limit the length of your cable runs to 300 feet or less to avoid problems  
**DO NOT:** Mix Category 5 and Category 6 cables on the same network

**DO:** Bend the cable gradually when needed and never exceed a 1” bend radius  
**DO NOT:** Untwist more than ½” of each wire pair when building your own cables

**DO:** Keep your cables away from any potential sources of EMI/RFI  
**DO NOT:** Use heavy pressure when using zip ties for cable management

**DO:** Always use Category 6 rated jacks with Category 6 cabling  
**DO NOT:** Ever under any circumstance splice or bridge a Cat5e or Cat6 cable

**DO:** Always accommodate at least 5 feet of slack in each cable whenever possible  
**DO NOT:** Use standard staples to secure Cat5 or Cat6 cabling as damage can result

**DO:** If you build your own cables, always verify them with a tester  
**DO NOT:** Ever tug or pull excessively on a networking cable

**Do’s and Don’ts Explained**

The length limit on Cat5 and Cat6 cables is technically 100 meters (330 feet). 100 meters is
the total length limit of all patch cables installed in-line with one another. Remember, patch bays can add to this overall length. It is generally safe to limit your cable lengths to no more than 300 feet as a best practice.

You must never mix Cat5 and Cat6 cables on the same network. The network speed will be limited by the lowest grade of cable installed within it. Therefore, if you outfit your network using Category 6 cabling, make sure you’re using exclusively Cat6 and nothing else.

The bending of cables, especially Unshielded Twisted Pair (UTP), can create serious problems internally. Avoid sharp bends at all costs. When building your own cables, never untwist more than a half inch of each wire pair when terminating to a connector. Untwisting will affect the impedance of the cable.

One should always avoid positioning cables near heavy sources of electromagnetic or RF interference such as microwave ovens, power supplies, transformers, refrigerators, fluorescent lighting, dimmer switches, transmitters, and antennas.

Although the RJ-45 connectors look identical on both Cat5 and Cat6 cabling, they are not. The same applies to the jacks these cables plug into. If you are using Category 6 cabling, all cable patch bays must include Category 6 rated connectors in order to maintain Gigabit data rates.

You must never splice or split a Category 5 or 6 cable, never. Hubs, switches, and routers are built to perform this task electronically. You must also only use an insulated staple gun when securing the cable to the wall or ceiling.

**The Future of Twisted Pair Cabling:**

So what does the future have in store for twisted pair cabling? With a century long track record, we don’t expect this type of cable to go away anytime soon. Category 6a is being developed much in the same way that Cat5e was in its time. Category 7 cable is already in the process of being developed. Cat7 is a version of Cat6 with even tighter manufacturing tolerances. Cat7 adds a foil shield around the entire cable as well as individual shields around each pair. These cables will be optimized for 10 Gigabit network traffic.

Regardless of which direction the technology migrates towards, Amphenol Cables on Demand will be sure to bring this technology to you. This guide will be updated regularly to reflect the latest technology trends. We will also be releasing the results of our comprehen-
sive Cat5 and Cat6 cable compliance tests in the near future. Best of luck with your planned network upgrades!

To link directly to our selection of Cat5 and Cat6 networking cables, please anywhere on the image below:

![Category 6](image1.png)
![Category 5E](image2.png)