Patch Cables

How to Make Network Cables

2003-05-05 (updated: 2011-10-02) by Philip
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The purpose of this article is to simply explain how to make your own Cat5 (Cat5e, Cat6 or whatever) Network cables while also providing a quick reference for those more advanced users who don't terminate UTP cables every day and simply need a reminder of the exact color codes...

Background and Some Specs

Since the early 1990s UTP cabling has become much more popular than coaxial cable (that was previousy used for 10-Mbps Ethernet networks) because it is easier to install and less expensive. UTP CAT3 and CAT4 were used for a limited time in networking (they're still used for telephone cables), since the emergence of 100Base-Tx networks required a shift to CAT5. Gigabit Ethernet (1000Base-T) needed yet another CAT5e Standard (now superseeded by CAT6) and there is a developing CAT7 standard in the works.

The below table includes Industry Standard Specs for the newer twisted-pair network cables.

Category	**CAT5**	**CAT5e**	**CAT6**	**CAT7**
Type	UTP	UTP	UTP	ScTP
Frequency	100 MHz	100 MHz	250 MHz	600 MHz
Max length	100m	100m	100m	100m
LAN Applications	100Base-Tx, CDDI 52-155Mbps ATM	1000Base-T 52-155Mbps ATM	1000Base-T 155-622 Mbps ATM	
Atten. dB/100m (MAX@100MHz)	22 dB	22 dB	19.8 dB	
Charcteristic Impedance (ohms)	100 ohms ±15%	100 ohms ±15%	100 ohms ±15%	100 ohms ±15%
NEXT dB (MIN@100MHz)	32 dB	35 dB	44 dB	
PS-NEXT dB (MIN@100MHz)	---	32 dB	42 dB	
PS-ELFEXT dB (MIN@100MHz)	---	21 dB	25 dB	
Return Loss dB (MIN@100MHz)	16 dB	20 dB	20 dB	
Delay Skew (Max per 100m)	---	45 ns	45 ns	

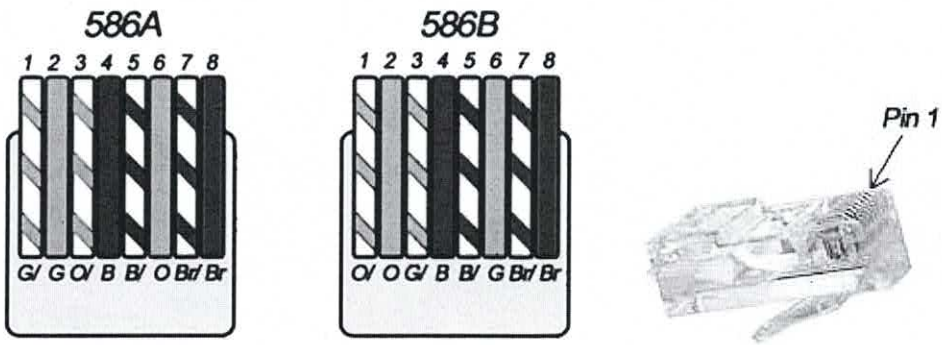
If you want your network to be future-proof, go for the UTP CAT6 standard, otherwise CAT5 will do just fine (with the exception of Gigabit Ethernet). There are several classifications of twisted-pair cable that use different insulation as well, the most common being CMR cable (riser cable). You should probably also be aware of CMP (plenum cable) which is a bit more expensive and required by code in some installations where cable runs through ducts, suspended ceilings or other areas that act as an air passage in any way. Other than that, CMR cable is generally acceptable for most internal use. There are other types of shielded/grounded cables that are beyond the scope of this article.

UTP cables consist of 8 individually insulated wires, forming 4 twisted pairs. Each pair is color-coded with one of the wires having a solid color, and the other with a white background and a stripe of the same color. There are two types of patch cables based on the way wires are connected: straight through (often simply refered to as patch cable) and crossover cable. Both use the same RJ45 connectors, however there is a difference in the wiring of the two, and their use.
And now that the boring background is out of the way, let's look at the cable itself...

Color Codes

There are two color layouts specified by the Ethernet standard:

568A	**568B**
1. White-Green	1. White-Orange
2. Green	2. Orange
3. White-Orange	3. White-Green
4. Blue	4. Blue
5. White-Blue	5. White-Blue
6. Orange	6. Green
7. White-Brown	7. White-Brown
8. Brown	8 Brown



You might see either of those two standards in network cables. Just remember:

Straight through cables - make both ends exactly the same, use only one of the two color codes above for both ends of the cable.

Crossover cables - make both ends different, one end with 568A and the other with 568B.
Crossover cables have different ends, since they have the send and receive pairs switched.

Actually, you can get away with remembering only one of the 568 types above to make straight through cable. You then need to also remember that the green and orange pairs are swapped to make a crossover cable.

Remember:

- 568A on both ends is a straight through cable.
- 568B on both ends is a straight through cable.
- 568A on one end and 568B at the other is a crossover cable.

Pin Numbers and Their Use

Color	568A Pin	568B Pin	Description
White / Green	1	3	RcvData +
Green	2	6	RcvData -
White / Orange	3	1	Tx Data +
Blue	4	4	unused
White / Blue	5	5	unused
Orange	6	2	Tx Data -
White / Brown	7	7	unused
Brown	8	8	unused

Terminating

Now that we're done with the theory, how do you actually make the cables? First of all, use a quality crimper; cheap ones will simply end up costing you a lot more time and frustration. Have more RJ45 plugs than needed, a bad termination at times is inevitable. If you are going to be terminating a number of cables, an unexpensive network cable tester might help ensure cables are terminated properly and avoid any shorts. Simple testers have LEDs on one side, showing the state of each wire, and even detect straight-through vs. crossover cables.

To terminate the cable, take a freshly cut end and strip no more than 0.5 inch of the jacket, while leaving the insulations on the 4 pairs of wires intact. Make sure there are no nicks in the wires and insert a snagless boot if you are using one.

Now that the jacket is off, straighten out the individual wires as needed in the order explained above (hint: look at the pretty pictures with the color codes, it took a while to make those). You should only untwist as much of the wires as needed to avoid unnecessary crosstalk. Once the wires are aranged, use the cutter on your crimper to cut all 8 wires so that their ends form a straight line. Do not strip the individual wires! (yes, I've seen it done)

Insert all the wires together in the RJ45 connector, while keeping them in the same order. Before crimping, double-check the order, and make sure all 8 reach the end of the plug. Once you're sure of the order and that all wires are in place, crimp the cable. Repeat for the other end, with the same color code for straight through, and different color code if making a crossover cable.

Additional Notes:

- In the most general sense, crossover cables are used to connect like equipment, such as two computers, or two hubs directly to each other. Straight through cables, on the other hand are used to connect a computer to a hub, router or a cable modem.
- Uplink ports - an uplink port on a network device, such as switch or a router acts as a crossover. In other words, a straight through cable connected to an uplink port is the same as a crossover cable connected to a regular port.
- To further confuse consumers, some modern hubs/switches can automatically detect and switch ports to accomodate either crossover or straight-through cables.
- Although there are 8 wires in an UTP cable, Ethernet only uses 4 of them (one pair for sending and one pair for receiving information), the other 4 wires are actually wasted (or can be used for another run, or other wiring wonders)
- Punchdowns of all types are made with the pairs in order 1. w/blue-blue, 2. w/orange-orange, 3. w/green-green & 4. w/brown-brown

Cautions:

- Do not run network cables parallel to, or in close proximity to electrical wires, fluorescent lights, computer monitors, TVs, power supplies, UPS units, speakers, printers, copy machines, RF antennas/transmission lines, electric motors (refrigerator compressor motors, dishwasher motors), microwave ovens... In generall anything that can introduce EMI.
- Never make bends tighter than 1" for Cat5 and 5" for Cat5e cable.
- For minimum crosstalk, never strip away more of the cable sheath than necessary.
- Don't retwist cable ends once they've been untwisted. This can cause near end crosstalk.
- Don't use Cat3 RJ45 jack modules on Cat5 cable.
- When pulling cable, don't exceed 25lbs of pressure.