

THE ETHERNET CROSSOVER CABLE

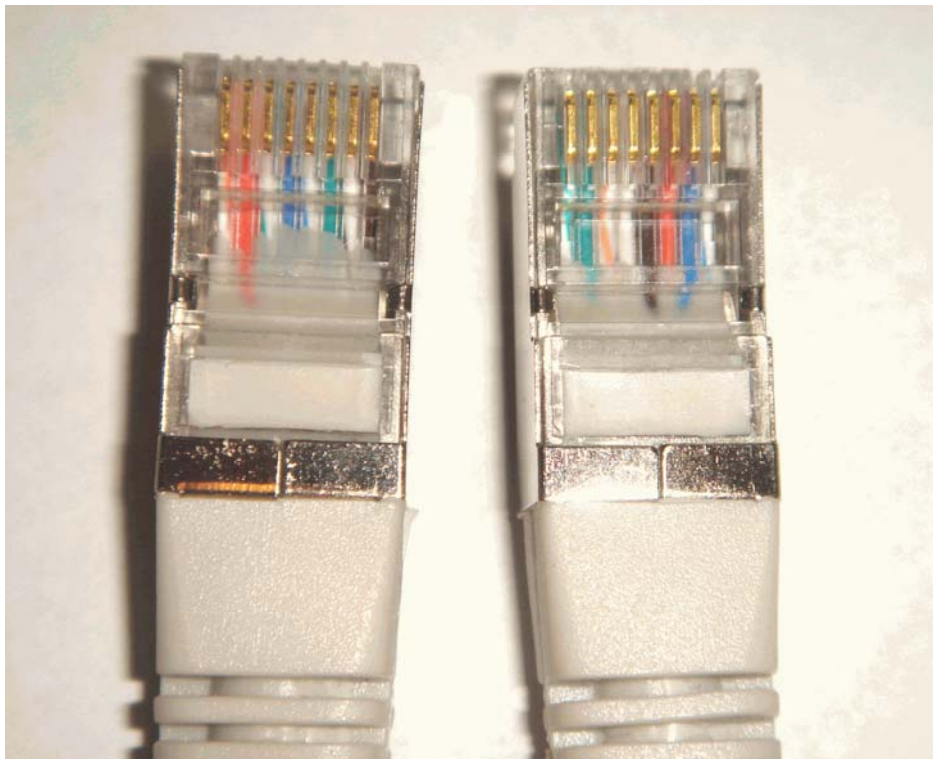
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An **Ethernet crossover cable** is a type of Ethernet cable used to connect computing devices together directly where they would normally be connected via a network switch, hub or router, such as directly connecting two personal computers via their network adapters. Typical uses are: router to router, switch to switch, pc to pc, router to pc (Note: router and pc are LIKE devices, because both are DTE. Caution: home routers already have built-in adapter,so you can use straight through cable directly)

The 10BASE-T and 100BASE-TX Ethernet standards use one wire pair for transmission in each direction. The Tx+ line from each device connects to the tip conductor, and the Tx- line is connected to the ring. This requires that the transmit pair of each device be connected to the receive pair of the device on the other end. When a terminal device is connected to a switch or hub, this crossover is done internally in the switch or hub. A standard *straight through* cable is used for this purpose where each pin of the connector on one end is connected to the corresponding pin on the other connector.

One terminal device may be connected directly to another without the use of a switch or hub, but in that case the crossover must be done externally in the cable. Since 10BASE-T and 100BASE-TX use pairs 2 and 3, these two pairs must be swapped in the cable. This is a *crossover cable*. A crossover cable must also be used to connect two internally crossed devices (e.g., two hubs) as the internal crossovers cancel each other out. This can also be accomplished by using a straight through cable in series with a modular crossover adapter.



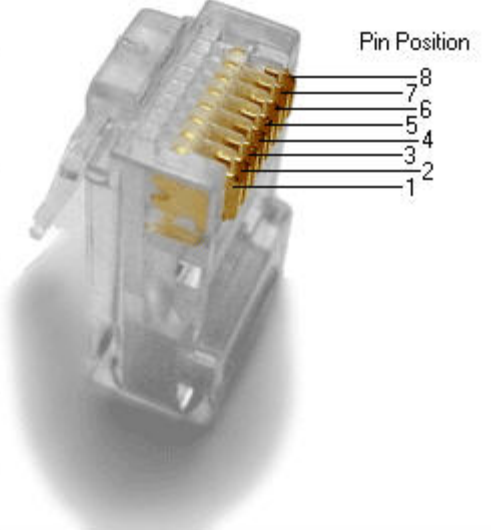














Because the only difference between the TIA/EIA-568-A and T568B pin/pair assignments are that pairs 2 and 3 are swapped, a crossover cable may be envisioned as a cable with one connector following T568A and the other T568B. Such a cable will work for 10BASE-T or 100BASE-TX. 1000BASE-T4 (Gigabit crossover), which uses all four pairs, requires the other two pairs (1 and 4) to be swapped and also requires the solid/striped within each of those two pairs to be swapped.



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Two pairs crossed, two pairs uncrossed 10baseT/100baseTX crossover (T568A)

Pin	Connection 1 pair	Connection 2 pair	Connection 1	Connection 2	Pins on plug face (jack is reversed)
1	3	2	 white/green stripe	 white/orange stripe	
2	3	2	 green solid	 orange solid	
3	2	3	 white/orange stripe	 white/green stripe	
4	1	1	 blue solid	 blue solid	
5	1	1	 white/blue stripe	 white/blue stripe	
6	2	3	 orange solid	 green solid	
7	4	4	 white/brown stripe	 white/brown stripe	
8	4	4	 brown solid	 brown solid	

Certain equipment or installations, including those in which phone and/or power are mixed with data in the same cable, may require that the "non-data" pairs 1 and 4 (pins 4, 5, 7 and 8) remain un-crossed.

In practice, it does not matter if your Ethernet cables are wired as T568A or T568B, just so long as both ends follow the same wiring format. It is just as valid to make a four-pair crossover using T568A, or a two pair crossover using T568B, as it is to wire them the way shown here. Typical commercially available "pre-wired" cables can follow either format depending on who made them. What this means is that you may discover that one manufacturer's cables are wired one way and another's the other way, yet both are "correct" and will work. In either case, T568A or T568B, a normal (un-crossed) cable will have **both** ends wired according to the layout in the *Connection 1* column.



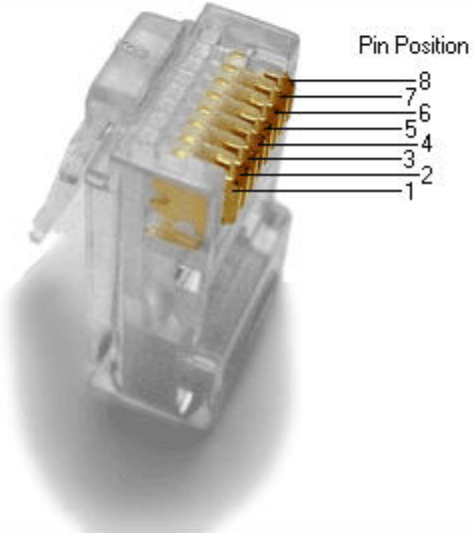











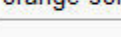


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Gigabit Crossover

All four pairs Crossed

10base-T/100base-TX/1000base-TX/T4 Crossover (T568B)

Pin	Connection 1 pair	Connection 2 pair	Connection 1	Connection 2	Pins on plug face (jack is reversed)
1	2	3	 white/orange stripe	 white/green stripe	
2	2	3	 orange solid	 green solid	
3	3	2	 white/green stripe	 white/orange stripe	
4	1	4	 blue solid	 white/brown stripe	
5	1	4	 white/blue stripe	 brown solid	
6	3	2	 green solid	 orange solid	
7	4	1	 white/brown stripe	 blue solid	
8	4	1	 brown solid	 white/blue stripe	

A **crossover cable** is a cable that maps all output signals on one electrical connector to the input signals on the other connector, allowing two electronic devices to perform full-duplex communication. Most commonly, the term refers to the Ethernet crossover cable, but other cables follow the same principle. It also allows devices to communicate without a switch, hub, or router. Cross-Over cables are used to connect two computers directly through NICs without the use of a Hub or Switch or to uplink two or more hubs, switches or routers. A cross-over cable is wired as follows:

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White/Orange Pin 1 ----- Pin 3 White/Green
Orange       Pin 2 ----- Pin 6 Green
White/Green  Pin 3 ----- Pin 1 White/Orange Pin
Blue        Pin 4 ----- Pin 4 Blue
White/Blue  Pin 5 ----- Pin 5 White/Blue
Green       Pin 6 ----- Pin 2 Orange
White/Brown Pin 7 ----- Pin 7 White/Brown
Brown      Pin 8 ----- Pin 8 Brown
    
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Only two pairs of wires in the eight-pin RJ-45 connector are used to carry Ethernet signals. Both 10BASE-T and 100BASE-T use the same pins, a crossover cable made for one will also work with the other.

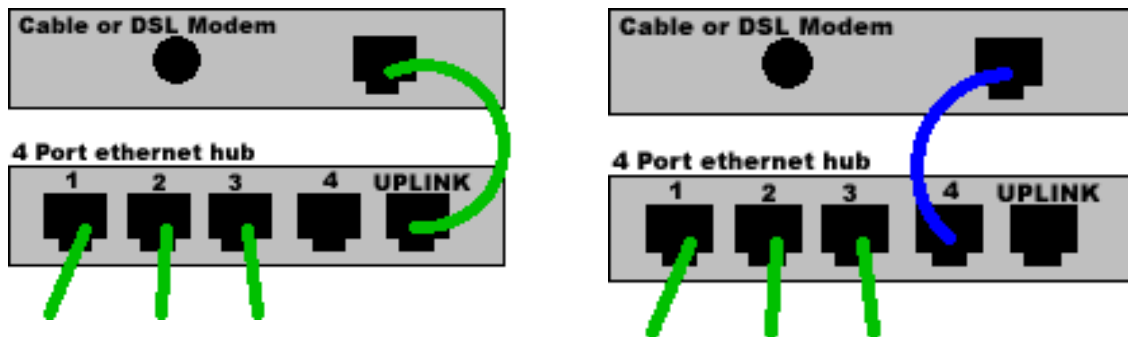
Ethernet crossover cables are most often used in home networks when connecting two ethernet computers without a hub. An Ethernet crossover cable has it's send and receive wires crossed. When using a hub or switch, this is automatically done for you.

Unfortunately some devices like cable and dsl modems have their actual ethernet plugs reversed. This is to allow people to hook up a cable modem to a computer without a special crossover cable. When adding a hub into the mix, the issue can get confusing.

Most modern hubs and switches have what is called an uplink port on them. This is the same kind of 'reversed' port that is on a cable or dsl modem.

This may sound like a confusing issue, but here are some network diagrams that will show when to use a normal ethernet cable and when to use a crossover cable.

GREEN cables represent standard ethernet cables
BLUE cables represent **CROSSOVER** cables



Note: One port on your hub will usually be 'shared' with the uplink port. Either the uplink port OR the standard port can be used, no both.

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Pin number	Wire Color
Pin 1 ==>	Orange/White
Pin 2 ==>	Orange
Pin 3 ==>	Green/White
Pin 4 ==>	Blue
Pin 5 ==>	Blue/White
Pin 6 ==>	Green
Pin 7 ==>	Brown/White
Pin 8 ==>	Brown

Straight-Through		
Wire		Becomes
1	→	1
2	→	2
3	→	3
6	→	6

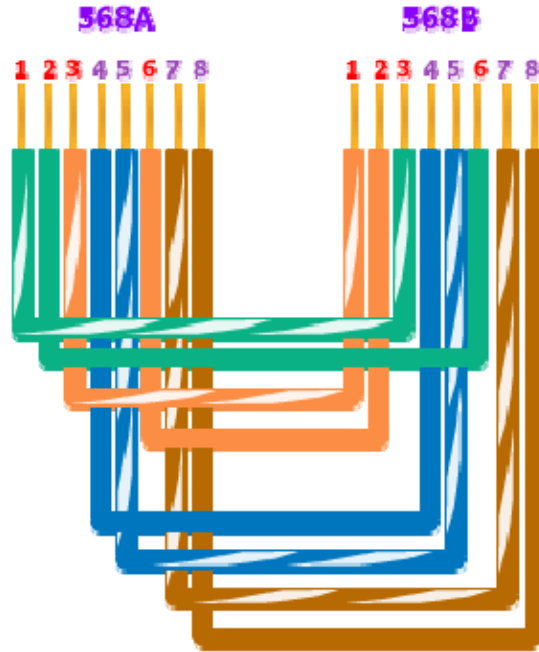


Pin number	Wire Color
Pin 1 ==>	Orange/White
Pin 2 ==>	Orange
Pin 3 ==>	Green/White
Pin 4 ==>	Blue
Pin 5 ==>	Blue/White
Pin 6 ==>	Green
Pin 7 ==>	Brown/White
Pin 8 ==>	Brown

Crossed-Over		
Wire		Becomes
1	→	3
2	→	6
3	→	1
6	→	2

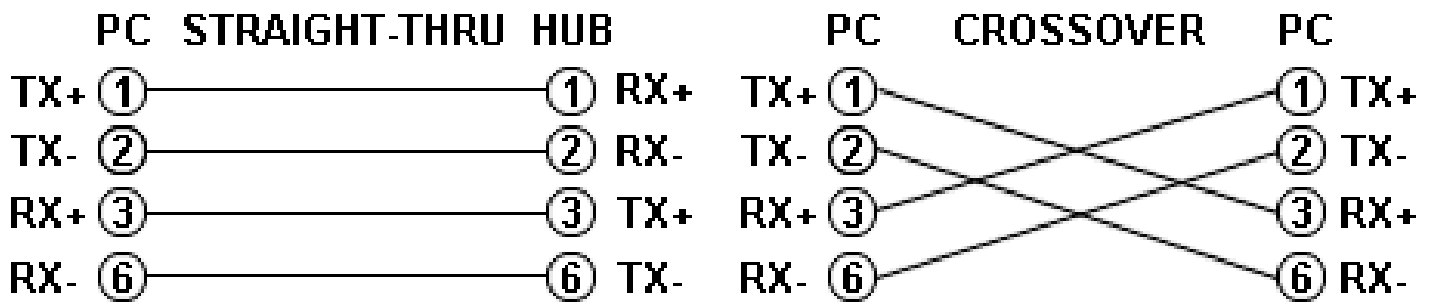
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COLOR-CODE STANDARDS

Let's start with simple pin-out diagrams of the two types of UTP Ethernet cables and watch how committees can make a can of worms out of them. Here are the diagrams:

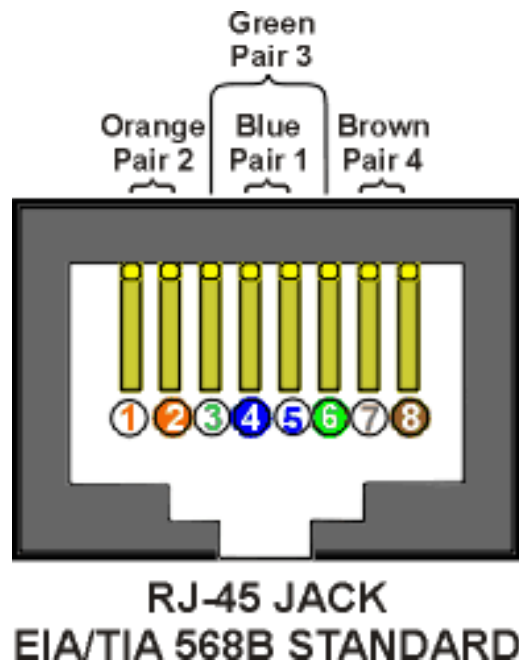
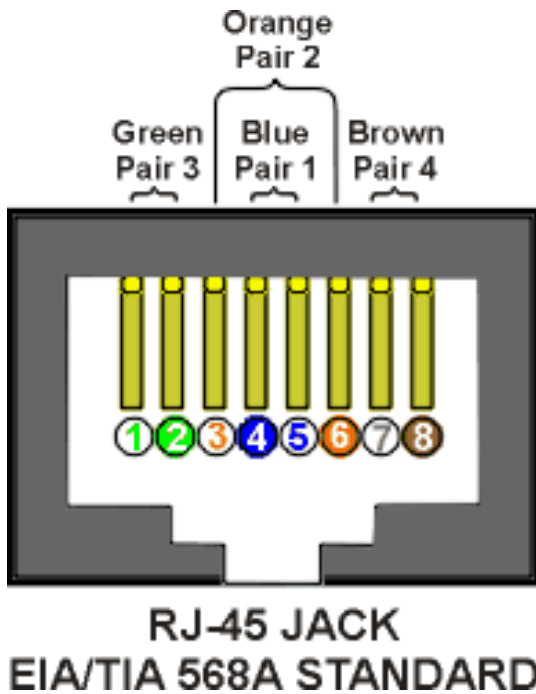


Note that the TX (transmitter) pins are connected to corresponding RX (receiver) pins, plus to plus and minus to minus. And that you must use a crossover cable to connect units with identical interfaces. If you use a straight-through cable, one of the two units must, in effect, perform the crossover function.

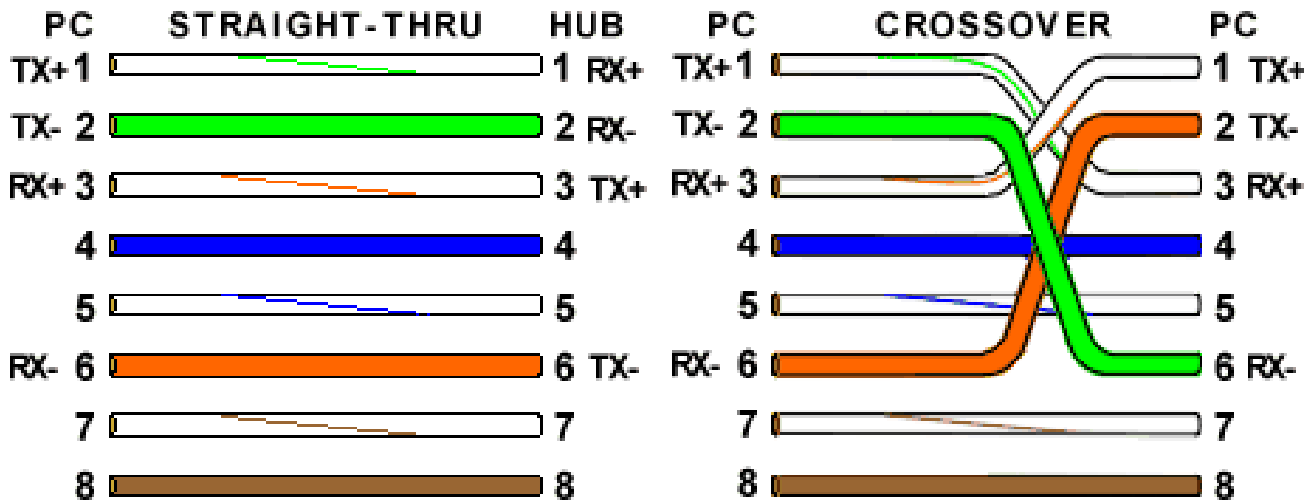
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Two wire color-code standards apply: EIA/TIA 568A and EIA/TIA 568B. The codes are commonly depicted with RJ-45 jacks as follows (the view is from the front of the jacks):



If we apply the 568A color code and show all eight wires, our pin-out looks like this:

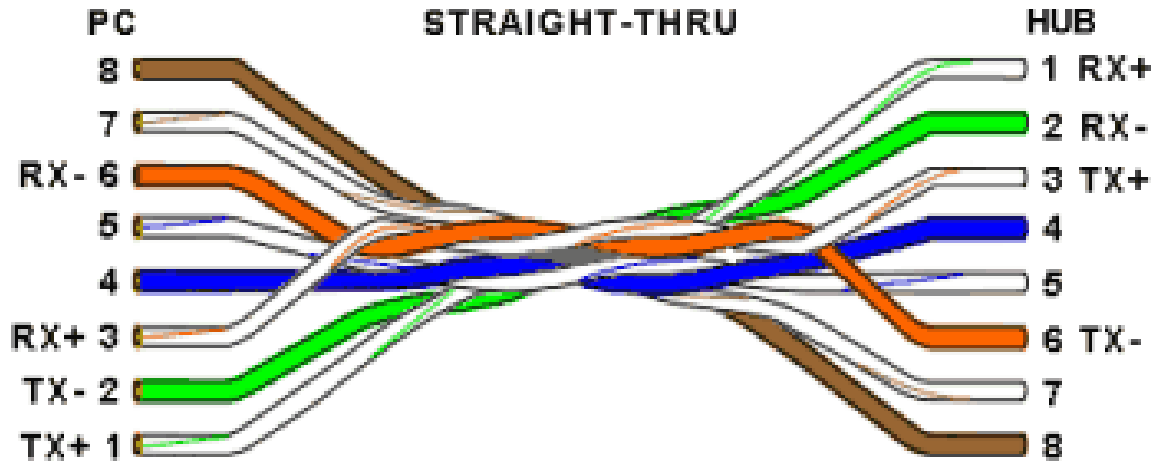


Note that pins 4, 5, 7, and 8 and the blue and brown pairs are not used in either standard. Quite contrary to what you may read elsewhere, these pins and wires are not used or required to implement 100BASE-TX duplexing--they are just plain wasted.

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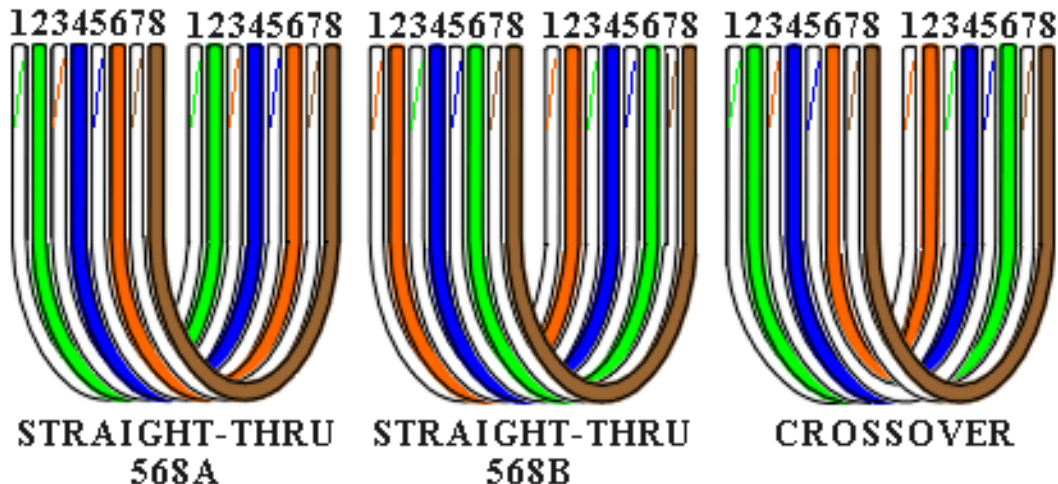
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However, the actual cables are not physically that simple. In the diagrams, the orange pair of wires are not adjacent. The blue pair is upside-down. The right ends match RJ-45 jacks and the left ends do not. If, for example, we invert the left side of the 568A "straight"-thru cable to match a 568A jack--put one 180° twist in the entire cable from end-to-end--and twist together and rearrange the appropriate pairs, we get the following can-of-worms:



This further emphasizes, I hope, the importance of the word "twist" in making network cables which will work. You cannot use a flat-untwisted telephone cable for a network cable. Furthermore, you must use a pair of twisted wires to connect a set of transmitter pins to their corresponding receiver pins. You cannot use a wire from one pair and another wire from a different pair.

Keeping the above principles in mind, we can simplify the diagram for a 568A straight-thru cable by untwisting the wires, except the 180° twist in the entire cable, and bending the ends upward. Likewise, if we exchange the green and orange pairs in the 568A diagram we will get a simplified diagram for a 568B straight-thru cable. If we cross the green and orange pairs in the 568A diagram we will arrive at a simplified diagram for a crossover cable. All three are shown below.



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To make a crossover cable, you will need a length of network cable (**UTP-Cat5**), preferably a factory assembled straight through cable that comfortably reaches each computer. Be careful and measure accurately you would hate to find out that following the baseboard of the wall you end up two feet short. On the other hand you don't want to use a fifty foot cable to connect two computers ten feet apart. Ethernet does not like coiled up excess cable. Consider making the cable with enough slack to allow servicing the computer without needing to unplug the cable.

The hardest part for most people will most likely be finding the **RJ45** cable connectors. Make sure you get at least two, three is better. That way if you mess up you can just cut off the bad end and try again. Cut off the **RJ45** connector from one end of the cable and prepare the end for the new **RJ45** connector. I don't use measurements for stripping the cable end. I start by stripping at least 1 inch of the main cable insulation and then carefully trim the eight internal wires using the factory assembled end as a guide to the proper length. Just make sure that each wire is equal length and that the connector cable lock pinches the main cable insulation.

You don't need any fancy crimping tools to make one cable, just one normal size screw driver and one small screwdriver with a blade the same thickness' of the brass conductors in the **RJ45** connector. You may need a second pair of hands to help hold the cable and **RJ45** connector while you or your helper secures the connector cable lock. It's a little tricky to get all the wires into the proper holes but with a little patience anyone can do it. When it comes time to securing the connector cable lock use the normal size screwdriver that fits into the connector cable lock slot. It doesn't take a lot of pressure to seat the cable lock just tap lightly until the cable is secure.

Note: Make sure ALL wires are pushed completely into the connector before seating the connector cable lock.

Once the connector cable lock is secure it's time to move on to seating the brass wire conductors. This is probably the most tricky part, each wire has a separate brass conductor that needs to be seated to make contact with the wire. Once again you will want a second pair of hands to hold the **RJ45** connector while you or your partner carefully seats each of the brass conductors. Lightly tap each conductor down with the small thin screwdriver to just below the plastic ridge, use the factory assembled end of the cable as a guide for how deep to seat the brass conductors.

Note: A pliers can be used to press down all the brass conductors at one time to the plastic ridges, then use the small thin blade screwdriver to finish seating to the proper recessed level.

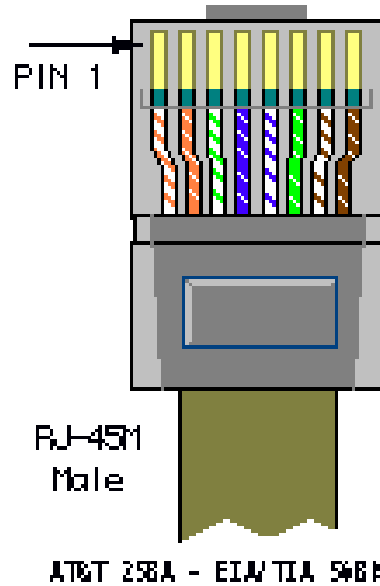
That's it, if everything went well you now have an **Ethernet UTP Category 5 crossover cable**.

Crossover Cable		Straight Through Cable	
RJ-45 PIN	RJ-45 PIN	RJ-45 PIN	RJ-45 PIN
1 Rx+	3 Tx+	1 Tx+	1 Rc+
2 Rc-	6 Tx-	2 Tx-	2 Rc-
3 Tx+	1 Rc+	3 Rc+	3 Tx+
6 Tx-	2 Rc-	6 Rc-	6 Tx-

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Note: The standard connector view shown is color-coded for a straight thru cable



Category 5 wiring standards:

EIA/TIA 568A/568B and **AT&T 258A** define the wiring standards and allow for two different wiring color codes.

Pin #	Signal	EIA/TIA 568A	AT&T 258A, or EIA/TIA 568B	Ethernet 10BASE-T 100BASE-T
1	Transmit+	White/Green	White/Orange	X
2	Transmit-	Green/White or Green	Orange/White or Orange	X
3	Receive+	White/Orange	White/Green	X
4	N/A	Blue/White or Blue	Blue/White or Blue	Not used *
5	N/A	White/Blue	White/Blue	Not used *
6	Receive-	Orange/White or Orange	Green/White or Green	X
7	N/A	White/Brown	White/Brown	Not used *
8	N/A	Brown/White or Brown	Brown/White or Brown	Not used *

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- Pairs may be solid colors and not have the stripe.
- Category 5 cable must use Category 5 rated connectors.

Only two pairs of wires in the eight-pin RJ-45 connector are used to carry Ethernet signals. Both **10BASE-T** and **100BASE-T** use the same pins, a **crossover cable** made for one will also work with the other.

**Note: Even though pins 4,5,7, and 8 are not used, it is mandatory that they be present in the cable.*