Category 5 / 5E & Cat 6 Cabling Tutorial and FAQ's

http://www.lanshack.com/cat5e-tutorial.aspx

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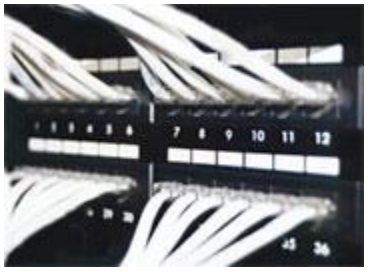
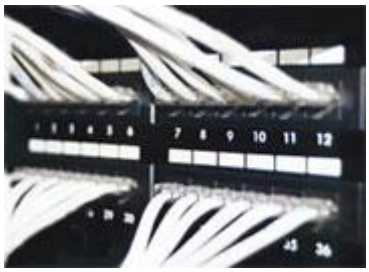


The following information is considered to be "just the right mix" of technical vs. practical knowledge and information on category 5 / 5e cabling, for beginner to intermediate.

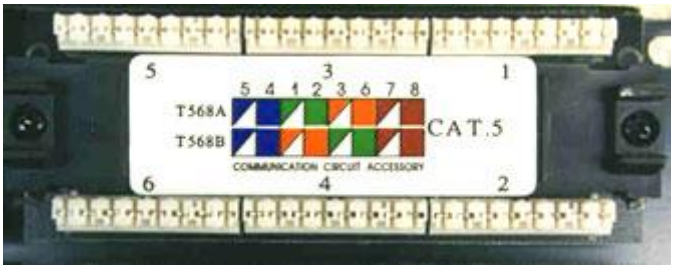
This article does not cover all of the details necessary to do a fully compliant 568A installation (to do that you will need to read the entire standard). It does, however, touch upon what I believe to be the most important things that you will need to know. To insure that you fully understand all of the information, I strongly suggest that you read through the entire article, from beginning to end, including the definitions. Even the intermediate level installer may find new useful facts that they were not aware of. This article is for general information only. Please always check with local code officials, and / or cabling consultants when planning an installation. Please be aware that the terms category 5 and cat 5 mean the same thing and are both used throughout this article. In addition, this article also applies to Category 5E (Cat 5 Enhanced) and Category 6 cables. Basically, when we refer to category 5 cable in this article, we are speaking in general but actually are referring to UTP data cable which encompasses all three types.

Tony Casazza, RCDD

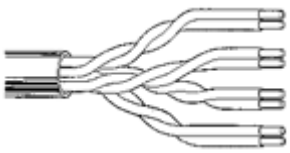
Cable Installation Tools & Accessories



The photo above shows a typical category-5E patch panel with patch cables connecting each network segment to a port on the Hub.



The photo above shows part of the back side of a typical category 5E patch panel. The method of connection is by insulation displacing '110' blocks. Note the connection diagram, showing connection for both 568A and 568B wiring schemes.



Basic Concept of a Twisted Pair Cable

Category 5Cable (UTP) (Unshielded Twisted Pair)	A multipair (usually 4 pair) high performance cable that consists of twisted pair conductors, used mainly for data transmission. Note: The twisting of the pairs gives the cable a certain amount of immunity from the infiltration of unwanted interference. category-5 UTP cabling systems are by far, the most common (compared to SCTP) in the United States. Basic cat 5 cable was designed for characteristics of up to 100 MHz. Category 5 cable is typically used for Ethernet networks running at 10 or 100 Mbps.
Category 5 E Cable (enhanced)	Same as Category 5, except that it is made to somewhat more stringent standards (see comparison chart below). The Category 5 E standard is now officially part of the 568A standard. Category 5 E is recommended for all new installations, and was designed for transmission speeds of up to 1 gigabit per second (Gigabit Ethernet).
Category 6	Same as Category 5 E, except that it is made to a higher standard (see comparison chart below). The Category 6 standard is now officially part of the 568A standard.
Category 7	Same as Category 6, except that it is made to a higher standard (see comparison chart below). The Category 7 standard is still in the works (as of this writing) and is not yet part of the 568A standard. One major difference with category 7's construction (as compared with category 5, 5 E, and 6) is that all 4 pairs are individually shielded, and an overall shield enwraps all four pairs. Category 7 will use an entirely new connector (other than the familiar RJ-45).
Category 5 Cable (SCTP) (Screened Twisted Pair)	Same as above, except that the twisted pairs are given additional protection from unwanted interference by an overall shield. There is some controversy concerning which is the better system (UTP or SCTP). Category 5 SCTP cabling systems require all components to maintain the shield, and are used almost exclusively in European countries.
Category 5E, RJ45 jack (Work Area Outlet)	An 8 conductor, compact, modular, female jack that is used to terminate category-5E cable at the user (or other) location. The jack is specifically engineered to maintain the performance of cat 5E cabling.
Category 5E Patch Panel	A Category 5E Patch Panel is basically just a series of many category-5E jacks, condensed onto a single panel. Common panel configurations are 12, 24, 48, and 96 ports. Patch panels are typically used where all of the horizontal cable sections meet, and are used to connect the segments to the Network Hub.
Category 5E Patch Cable	A Category 5E Patch Cable consists a length of cat 5E cable with an RJ-45 male connector, crimped onto each end. The cable assembly is used to provide connectivity between any two category-5E female outlets (jacks). The two most common are from hub to patch panel, and work area outlet (jack) to the computer.
EIA/TIA 568A Standard	This standard was published in July of 1991. The purpose of EIA/TIA 568A, was to create a multiproduct, multivendor, standard for connectivity. Prior to the adoption of this standard, many "proprietary" cabling systems existed. This was very bad for the consumer. Among other things, the standard set the minimum requirements for category 5E cable and hardware. The 568 "standard" is not to be confused with 568A

	or 568B wiring schemes, which are themselves, part of the "568A standard".
568A and 568B Wiring Schemes	When we refer to a jack or a patch panel's wiring connection, we refer to either the 568A, or 568B wiring scheme, which dictates the pin assignments to the pairs of cat 5E cable. It is very important to note that there is no difference, whatsoever, between the two wiring schemes, in connectivity or performance when connected form one modular device to another (jack to Patch panel, RJ-45 to RJ-45, etc.), so long as they (the two devices) are wired for the same scheme (A or B). The only time when one scheme has an advantage over the other, is when one end of a segment is connected to a modular device, and the other end to a punch block. In which case, the 568A has the advantage of having a more natural progression of pairs at the punch block side. More on 568 A&B later on.
Four Pairs	Pair 1: White / **Blue** Pair 3: White / **Green** Pair 2: White / **Orange** Pair 4: White / **Brown**
Wiremap	This is the most basic test that can be performed on a category-5E segment. Wiremap tests for the basic continuity between the two devices. In 568A or B, all eight pins of each device should be wired straight through (1 to 1, 2 to 2, 3 to 3, etc.). A wiremap (continuity) test, should also test for absence of shorts, grounding, and external voltage.
Crosstalk	Crosstalk is the "bleeding" of signals carried by one pair, onto another pair through the electrical process of induction (wires need not make contact, signals transferred magnetically). This is an unwanted effect, that can cause slow transfer, or completely inhibit the transfer of data signals over the cable segment. The purpose of the wire twists, in category 5E cable is to significantly reduce the crosstalk, and it's effects. Two types are: NEXT (Near End Crosstalk), and FEXT (Far End Crosstalk). Fiber Optic cable is the only medium that is 100% immune to the effects of crosstalk.
Ambient Noise or Electromagnetic Interference (EMI)	Similar to crosstalk, in that it is an unwanted signal that is induced into the cable. The difference is that ambient noise (or EMI) is typically induced from a source that is external to the cable. This could be an electrical cable or device, or even an adjacent category 5E cable.
Attenuation	Attenuation is the loss of signal in a cable segment due to the resistance of the wire plus other electrical factors that cause additional resistance (Impedance and Capacitance for example). A longer cable length, poor connections, bad insulation, a high level of crosstalk, or ambient noise, will all increase the total level of attenuation. The 568A standard, specifies the maximum amount of attenuation that is acceptable in a category-5E cable segment.

Category 5E Installation Do's and Don'ts

Do	Run all cables in a "Star" configuration. That is to say that they all emanate from, and are "homerun" to, one central location, known as the wiring hub. Visualize a wagon wheel, all of the spokes, start from on central point, known as the hub of the wheel.
Do	Keep all cable runs to a maximum of 295 feet (for each run).
Do	Maintain the twists of the pairs all the way to the point of termination, or no more than 0.5" (one half inch) untwisted
Do Not	Skin off more than 1" of jacket when terminating
Do	Make gradual bends of the cable, where necessary. No sharper than a 1" radius. (about the roundness of a half-dollar)
Do Not	Allow the cable to be sharply bent, or kinked, at any time. This can cause permanent damage to the cables' interior.
Do	Dress the cables neatly with cable ties. Use low to moderate pressure.
Do Not	Over tighten cable ties. We recommend Hook and Loop (Velcro) Cable Ties for commercial installations.
Do	Cross-connect cables (where necessary), using cat 5E rated punch blocks and components.
Do Not	Splice or bridge category-5E cable at any point. There should never be multiple appearances of category 5E cable.
Do	Use low to moderate force when pulling cable.
Do Not	Use excessive force when pulling cable.
Do	Use cable pulling lubricant for cable runs that may otherwise require great force to install. (You will be amazed at what a difference the cable lubricant will make)
Do Not	Use oil, or any other lubricant, not specifically designed for cable pulling. Oil, or other lubricants, can infiltrate the cable, causing damage to the insulation.
Do	Keep cat 5E cables as far away from potential sources of EMI (electrical cables, transformers, light fixtures, etc.) as possible.
Do Not	Tie cables to electrical conduits, or lay cables on electrical fixtures.
Do	Install proper cable supports, spaced no more than 5 feet apart.
Do Not	Install cable that is supported by the ceiling tiles (this is unsafe, and is a violation of the building codes).
Do	Always label every termination point. Use a unique number for each cable segment. The idea here, is to make moves, adds, changes, and troubleshooting as simple as possible.
Do	Always test every installed segment with a cable tester. "Toning" alone, is not an acceptable test.
Do	Always install jacks in such a way as to prevent dust and other contaminants from settling on the contacts. The contacts (pins) of the jack should face up on flush mounted plates, or left, right, or down (never up) on surface mount boxes.
Do	Always leave extra slack on the cables, neatly coiled up in the ceiling or nearest concealed place. It is recommended that you leave at least 5 feet at the work outlet side, and 10 feet at the patch panel (wiring hub) side.
Do Not	Never install cables "taught" in the ceiling, or elsewhere. A good installation

	should have the cables loose, but never sagging.
Do	Always use grommets to protect the cable where passing through metal studs or anything that can possibly cause damage to them.
Do	Choose either 568A or 568B wiring standard, before you begin your project. Wire all jacks and patch panels for the same wiring scheme (A or B).
Do Not	Mix 568A and 568B wiring on the same installation.
Do Not **(1 exception)**	Use staples on category-5E cable that crimp the cable tightly. The common T-18 and T-25 cable staples are not recommended for category 5E cable. The T-59 insulated staple gun is ideal for fastening cat5 & 6 and fiber optic cabling as it does not put any excess pressure on the cable.
Do	Always obey all local, and national, fire and building codes. Be sure to "firestop" all cables that penetrate a firewall. Use plenum rated cable where it is mandated.

Notes and Explanations for Do's and Don'ts

Think of a category 5E cable segment as an extension cord to extend a network hub port to a remote location. Since we do not permanently connect it to a live source, and all of the segments are wired "straight through", that is basically what it is (a data extension cord). If all of the computers and devices were located reasonably close to the hub, we would be able to connect them to the hub directly, with patch cables. In most cases, this would not be practical, so we install cable segments to distribute the hub ports to the remote locations in an organized manner.

Ideally, the data extension cord that we install, should smoothly pass the data, from one end to another without altering, the signal (transmitted from device to device) in any way. Consider this fact to be Rule #1, and is perhaps the most important statement that we can make. There are many very technical issues concerning UTP cabling. No matter how technical, these issues all boil down to that one simple fact. You would probably need an Electrical engineering degree to fully understand all of the theories that go into transmitting data over UTP cabling. All that you need to know as an installer is a few simple facts, or do's and don'ts. It is really no more complicated than that. Almost all of the rules (do's and don'ts) above, are designed to adhere to Rule #1. The others are necessary to promote a neat, orderly, safe and professional installation.

I strongly recommend that anyone who installs cabling, takes the rules very seriously. An ill planned, or poorly installed cable plant, can easily become a nightmare in the future. Please also be aware that the faster the data speed, the more important the rules become. Many poorly done installations can run 10 megabits with ease. They may very well, run into trouble, when they upgrade to higher data speeds.

568A & 568B Wiring Schemes

Before we begin, lets eliminate any confusion between 568, the standard, and 568, the wiring scheme. To recap, we'll review the definitions of the two:

568A Standard

This standard was published in July of 1991. The purpose of EIA/TIA 568A, was to create a multiproduct, multivendor, standard for connectivity. Prior to the adoption of this standard, many "proprietary" cabling systems existed. This was very bad for the consumer. Among other things, the standard set the minimum requirements for category-5E cable and hardware.

The 568 "standard" is not to be confused with 568A or 568B wiring schemes, which are themselves, part of the "568A standard".

568A & 568B Wiring Schemes

When we refer to a jack or a patch panel's wiring connection, we refer to either the 568A, or 568B wiring scheme, which dictates the pin assignments to the pairs of cat 5E cable. It is very important to note that there is no difference, whatsoever, between the two wiring schemes, in connectivity or performance when connected form one modular device to another (jack to Patch panel, RJ-45 to RJ-45, etc.), so long as they (the two devices) are wired for the same scheme (A or B). The only time when one scheme has an advantage over the other, is when one end of a segment is connected to a modular device, and the other end to a punch block. In which case, the 568A has the advantage of having a more natural progression of pairs at the punch block side.

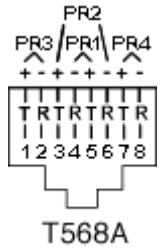
So, when someone refers to 568A, are they talking about the standard, or the wiring scheme? The answer, is that it depends on the context. If they were to say "The entire office fully complies with 568A", obviously, they would be talking about the standard. If they were to say "The jacks and patch panels are all 568A", then they would be referring to the wiring scheme.

The 568 committee, with good intentions, decided to allow both wiring methods (568A & 568B) to exist within the 568A Standard. The reason was that at the time, a great deal of cabling plants had been installed to the B standard (formerly known as WECO or AT&T 258A). Even though they allowed both wiring methods, they stated in their standard that 568A wiring would be the preferred method for all new installations. Time, and popular opinion, went in the other direction. The most popular wiring method today is 568B. Having both A & B methods does nothing but cause errors and confusion. Originally, patch panels and jacks were manufactured either A or B. In most cases, they were not labeled as such. Most suppliers stocked only the B wired products. Luckily, today, almost all jacks and patch panels show diagrams for both A and B. The only difference between the two is the interchanging of the 2nd and 3rd pairs (white/orange and white/green, respectively).

So which method to choose? As we stated earlier; There is no difference, whatsoever, between the two wiring schemes, in connectivity or performance when connected form one modular device to another. The answer, is that it does not matter at all, unless you are terminating one end onto a punch block, in which case, the A method has an advantage. The main thing is that you choose one method, and stick with it. I recommend to all installers that they terminate one segment on both the jack and patch panel sides, and test for proper continuity. It has happened to many professionals, where they terminated the entire installation, and then discovered that the two ends were wired for different methods. Then they had to re-terminate all of the cables on one end completely to correct the situation.

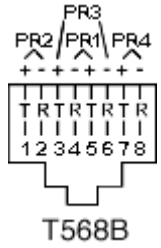
The following charts should be very helpful in illustrating the difference between the A & B methods. For those who are not familiar with telephony, tip (T) refers to the positive (+) side, and ring (R) refers to the negative side of the circuit. The white/blue pair (the first pair in the cable) consists of two wires that are twisted together. They are the white/blue (tip) and the blue/white (ring). The white/blue wire is predominately white with a blue stripe. The blue/white is the inverse, predominately blue with a white stripe.

568A Wiring



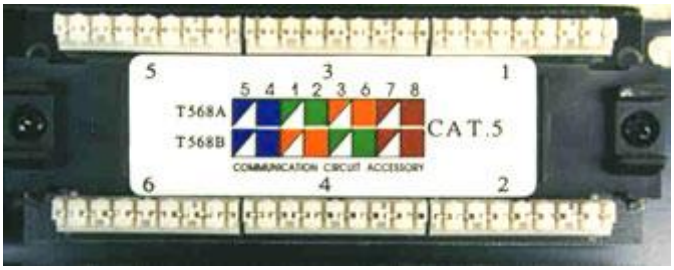
Pair #	Wire	Pin #
1) White/Blue	White/Blue	5
	Blue/White	4
2) White/Orange	White/Orange	3
	Orange White	6
3) White/Green	White/Green	1
	Green/White	2
4) White/Brown	White/Brown	7
	Brown/White	8

568B Wiring



Pair #	Wire	Pin #
1) White/Blue	White/Blue	5
	Blue/White	4
2) White/Orange	White/Orange	1
	Orange White	2
3) White/Green	White/Green	3
	Green/White	6
4) White/Brown	White/Brown	7
	Brown/White	8

As you can see, the wiring diagrams that are imprinted on the jacks and patch panels, both show the A & B wiring methods. Here is a picture of the back of a patch panel:



The upper diagram is for 568A, and the lower diagram is for 568B. Notice that the White/Blue, and the White/Brown pairs are identical for both methods. The White/Orange and the White/Green pairs are interchanged from the A to the B method.

Category 5, 5 E, 6 and 7 Performance Specification Chart

Parameter	**Category 5 and Class D** with additional requirements TSB95 and FDAM 2	**Category 5E** ('568-A-5)	**Category 6 Class E** (Performance at 250 MHz shown in parentheses)	**Proposed Category 7 Class F** (Performance at 600 MHz shown in parentheses)
Specified frequency range	1-100 MHz	1-100 MHz	1-250 MHz	1-600 MHz
Attenuation	24 dB	24 dB	21.7 dB (36 dB)	20.8 dB (54.1 dB)
NEXT	27.1 dB	30.1 dB	39.9 dB (33.1 dB)	62.1 dB (51 dB)
Power-sum NEXT	N/A*	27.1 dB	37.1 dB (30.2 dB)	59.1 dB (48 dB)
ACR	3.1 dB	6.1 dB	18.2 dB (-2.9 dB)	41.3 dB (-3.1 dB)**
Power-sum ACR	N/A	3.1 dB	15.4 dB (-5.8 dB)	38.3 dB (-6.1 dB)**
ELFEXT	17 dB (new requirement)	17.4 dB	23.2 dB (15.3 dB)	ffs***
Power-sum ELFEXT	14.4 dB (new requirement)	14.4 dB	20.2 dB (12.3 dB)	ffs***
Return loss	8 dB* (new requirement)	10 dB	12 dB (8 dB)	14.1 dB (8.7 dB)
Propagation delay	548 nsec	548 nsec	548 nsec (546 nsec)	504 nsec (501 nsec)
Delay skew	50 nsec	50 nsec	50 nsec	20 nsec

Note: Requirements for Category 7 are currently under development.

Frequently Asked Questions

Q: Are the cabling standards backward compatible to lower standards?

A: Yes, you can use a high grade category 6 cable for 10 megabit Ethernet, or voice (phone), for example.

Q: I have standard category 5 cable installed in my office. 1) Will I be able to upgrade to 100 megabits or higher? 2) Will it help to use a higher grade cat 5 patch cable?

A: If it was properly installed, upgrading to 100 megabits should not be a problem. Category 5 cable may be able to run Gigabit Ethernet, but Category 5E is recommended (for gigabit). As for the second part of the question, the answer is that it can only help, and it cannot hurt. The fact is that the weakest part of any category-5 link, are the patch cables used. I suggest that every one who is responsible for a network should use the very best grade of patch cable available. I highly recommend the Custom Category 6 Patch Cables which are "state of the art".

Q: How do they qualify Category 7, when the standard has not been written yet?

A: The various cable manufacturers have determined what the specifications will be, and are working with the standards committees to write the specifications.

Q: What is the difference between megabits, and megahertz?

A: When they refer to network speed, they quantify it in megabits per second. This is the amount (or speed) in which the data is transferred. Megahertz refers to the analog frequency of the **carrier signal** that is used to transmit the data. One hertz, is completed when the carrier signal goes from zero, to it's positive peak, back to zero, to it's negative

peak, and back to zero again. Category 5 cables are tested at 100 megahertz or higher. The higher megahertz frequencies can more easily reveal any defects in the cable or hardware. There is little relationship between the two. In theory, the higher the megahertz, the more megabits per second, you can transmit.

Q: I just bought some category 5E cable and jacks, plus a LAN-PRO-8 Toolkit from you guys, and want to install new cable runs, connecting them to an existing patch panel in our office. The patch panel is not marked 568A or 568B. How can I tell what it actually is?

A: Take a piece of cat 5E cable, about a foot or so. Connect a cat 5E jack on one end. Start with a 568B connection at the jack. Connect the other end to the patch panel in the standard fashion (blue, orange, green, brown). Now, test the cable from jack to patch panel with the LANTEST-PRO Cable Tester cable tester that was part of the toolkit. If it tests good, the patch panel is 568B, if not, reconnect the jack for 568A. Now retest. If it tests ok, it is 568A. Once you determine if it is A or B, you should wire all of the new jacks to that standard.

Q: I am trying to troubleshoot a cat 5 jack that worked fine until recently, suddenly it doesn't seem to work. I disconnected the hub and the computer, and tested out the cat 5 line, and it tests ok. I took the computer to another cat 5 location, and it worked fine. What could be the problem?

A:	**Possible Cause**	**Test**	**Repair**
1	Bad patch cable: Hub side or user side	Test the line with the same patch cables attached.	If in doubt, change both patch cables
2	Bad Hub port	Plug the line, into a different hub port	If you find bad hub port, block it off somehow, and use a different port

If the above remedies do not help. Then I would recommend tracing the line for it's entire length, looking for signs of, and correcting any EMI interference, kinks, poor termination methods, cable ties too tight, etc. Then, change the jack and patch panel port. If all that doesn't work, you could call in a professional to do further testing, but it would probably be quicker and cheaper just to re-install the line.

Q: We have an 100 megabit Ethernet network, that is cabled with category-5 in our office. We need to get a group of computers onto the network that are located on the other side of our warehouse, about 600 feet away. I understand that category-5 cable is limited to a distance of 295 feet. What is the best way to accomplish this?

A: You can run a fiber optic cable and connect it to your existing hub with Media Converter. Measure the exact distance of the cable run. Let us know the distance, and we will make a fiberoptic cable for you, with connectors and a pulling eye, to protect the connections during installation. Now, use a 100 Base TX to FX media converter on each end. On the far end, you could install a new Hub, off of the Media converter, and connect all of the users to the new hub.

Q: What is cat 5 plenum and pvc cable, and why is the plenum cable so much more expensive?

A: Plenum rated cable has a special insulation that has low smoke and low flame characteristics. Plenum cable is mandated to be installed in any "air handling" space. For example, most large office buildings use the ceiling to return air to the AC unit. This qualifies this ceiling as a plenum ceiling, and all cable that goes through that ceiling, must be plenum rated. Please check with your building officials to see if you need plenum cable. The reason why it costs so much more, is because the material required for the

insulation, must meet the standards for plenum cables while meeting the standards for category 5. This material is relatively expensive.

Q: Is the order of the colors really that critical in a patch cable? As long as both ends of a straight through cable match, won't the cable work well regardless of the color order?

A: Of course the signals that travel over those wire pairs are color blind. That is to say that they could care less (if they could think) what color is on their insulation. However, the pairs are grouped inside of the cable and in the RJ-45 connector in a certain fashion. So each pair will react with each other in a unique way. This reaction does have an effect on the performance. The more important factor is the pairing. A circuit of either transmit and receive must travel over a pair that is twisted for maximum shielding from crosstalk.

Q: I am planning a cabling installation in a large building. How can we keep all of the cable runs within the distance limitation of 295 feet?

A: This question is may require an entire article to properly cover. Basically, you should strategically divide the building into sections and pick a hub location (equipment closet) for each section, where all of the cable runs, in that area will fall within the 295 feet. Now choose a main equipment location. You now need to plan to run a "backbone" cable from the main equipment room, to each satellite closet. If the distance of a particular run is within 295 feet, you may run a category 5E backbone to that closet. If the run is over 295 feet, then run a fiber optic backbone cable for that closet. The backbone cable links the satellite hubs to the main network switch. Be sure to use "switch" ports, and not regular ports to link the hubs to the main switch, to assure that that segment will not have to share bandwidth with any other device.

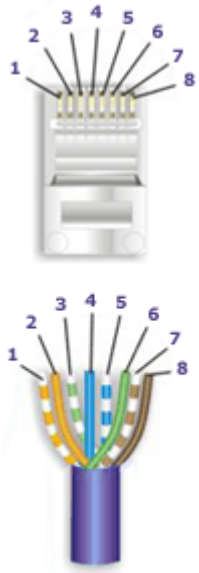
PS: If only a few runs fall over the 295 feet, you may want to consider using media converters.

How to Make a Category 5 / Cat 5E Patch Cable

Due to an overwhelming response to our category 5 & 6 tutorial, and many requests for information and wiring diagrams of "straight through" and "crossover" (cross-pinned) patch cords, I have made this informational page. On this page, we will cover making patch cords, and other technical and non-technical issues relating to category 5 (and beyond) patching and connectivity from device to device. Below, you will find the diagrams for 568A, 568B, and crossover patch cables. I suggest that you read on, past the diagrams for some very useful and important information.

As always, there continues to be Controversies over standards and practices regarding the use and making of patch cords, and UTP cable in general. Please see our section below titled: "Controversies and Caveats : Category 5, 5E, and Cat 6 Patch Cables". I hope that you will find it interesting and informative.

Tony Casazza, RCDD



568-B Wiring

Pair #	Wire	Pin #
1-White/Blue	White/Blue	5
	Blue/White	4
2-Wht./Orange	White/Orange	1
	Orange White	2
3-White/Green	White/Green	3
	Green/White	6
4-White/Brown	White/Brown	7
	Brown/White	8
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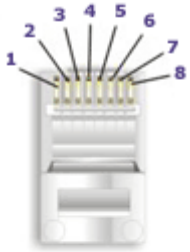
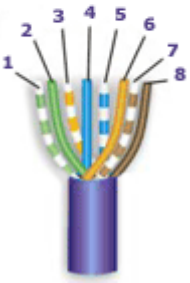


568-A Wiring

Pair #	Wire	Pin #
1-White/Blue	White/Blue	5
	Blue/White	4
2-White/Green	White/Green	1
	Green/White	2
3-White/Orange	White/Orange	3
	Orange/White	6
4-White/Brown	White/Brown	7
	Brown/White	8
< 568-A Diagram		



Notes for wiring diagrams above

1. For patch cables, 568-B wiring is by far, the most common method.
2. There is no difference in connectivity between 568B and 568A cables. Either wiring should work fine on any system*. (*see notes below)
3. For a straight through cable, wire both ends identical.
4. For a crossover cable, wire one end 568A and the other end 568B.
5. Do not confuse pair numbers with pin numbers. A pair number is used for reference only (eg: 10BaseT Ethernet uses pairs 2 & 3). The pin numbers indicate actual physical locations on the plug and jack.

Patch Cable Assembly Instructions

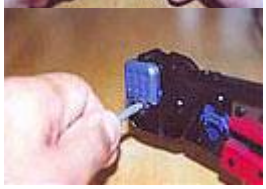
1. Skin off the cable jacket approximately 1" or slightly more.
2. Un-twist each pair, and straighten each wire between the fingers.
3. Place the wires in the order of one of the two diagrams shown above (568B or 568A). Bring all of the wires together, until they touch.
4. At this point, recheck the wiring sequence with the diagram.
5. Optional: Make a mark on the wires at 1/2" from the end of the cable jacket.

6. Hold the grouped (and sorted) wires together tightly, between the thumb, and the forefinger.
7. Cut all of the wires at a perfect 90 degree angle from the cable at 1/2" from the end of the cable jacket. This is a very critical step. If the wires are not cut straight, they may not all make contact. We suggest using a pair of scissors for this purpose.

7B. Conductors should be at a straight 90 degree angle, and be 1/2" long, prior to insertion into the connector.

8. Insert the wires into the connector (pins facing up).

9. Push moderately hard to assure that all of the wires have reached the end of the connector. Be sure that the cable jacket goes into the back of the connector by about 3/16".



10. Place the connector into a crimp tool, and squeeze hard so that the handle reaches it's full swing.

11. Repeat the process on the other end. For a straight through cable, use the same wiring. **For a "crossover" cable, wire one end 568A, and the other end 568B.**
12. Use a cable tester to test for proper continuity.

Notes Regarding Making Category 5 Patch Cable

1. The RJ-45 plugs are normally made for either solid conductors or stranded conductors. It is very important to be sure that the plug that you use matches the conductor type. It is extremely difficult to tell the difference between the two by looking at them. When you buy these plugs, be sure to categorize, and store them carefully. Using the wrong type can cause intermittent problems. The RJ-45, 8 Conductor Plugs that we sell are rated for both Solid and Stranded cable.
2. Ordinarily, it would be taboo to untwist the pairs of any category 5 cable. The one exception to this rule is when crimping on RJ-45 plugs. It would be impossible to insert the wires into the channels without first untwisting and straightening them. Be sure not to extend the un-twisting, past the skin point. If you do it properly, you will wind up with no more than 1/2" of untwisted conductors (up to 1/2" of untwist meets the cat 5 specification).
3. If the completed assembly does not pass continuity, you may have a problem in one, or both ends. First try giving each end another crimp. If that does not work, then carefully examine each end. Are the wires in the proper order? Do all of the wires fully extend to the end of the connector? Are all of the pins pushed down fully. Cut off the suspected bad connector, and re-terminate it. If you still have a problem, then repeat the process, this time giving more scrutiny to the end that was not replaced.
4. It is good to be prepared to make your own patch cables. There may be many instances where you may fall short on supply, and making a cable will surely get you out of a jam. However, there comes a point where the practicality curve will lead you to factory made

cables. Making several cables can be very labor intense. Factory made cables typically have better tolerances, and consequently have better quality than field made cables.

Controversies and Caveats: Category 5, 5E, and Cat 6 Patch Cables

568B vs. 568A

For patch cables, 568-B wiring is by far, the most common wiring method. Virtually all pre-assembled patch cables are wired to the B standard. There is no difference in connectivity between 568B and 568A cables. Therefore, a 568B patch cable should work fine on a 568A cabling system, and visa-versa. To my knowledge, there has never been an issue with networks of up to 100 megabits. However, with the advent of Gigabit over copper cabling, it may very well become a factor at some point. We have conferred with several cable manufacturers, and many other technical resources, on this subject. The consensus is that mixing of the standards on patch cables should not cause a problem. Since Gigabit networks over copper cabling are in their infancy, and no one can say for sure, we would advise our customers to take the safe approach on all future patch cable orders. We now offer our custom cat 5E and category 6 cables in both 568A and 568B wiring schemes for this reason.

Re-use of old cables

We have seen this happen time and time again. Perfectly good patch cables that have been working fine for years, get removed from their installation, and re-installed on the same, or different network. The result can be a nightmare. What happens is that the cable, over time, adapts to the way that it is bent in it's original installation. When these cables are removed and re-installed, they can either completely loose their connection, or develop intermittent problems. This is due to stresses that may be opposite to what they were originally subject to. If the integrity of your network is more valuable than the price of new patch cables, then we strongly suggest that you use brand new cables for all closet cleanups, network moves, etc.

Stranded vs. Solid wire

Almost all patch cables that are made have stranded wire. Stranded wire is normally specified for use in patch cables due to it's superior flexibility. There has been some talk recently, in the technical sector of the structured wiring community, regarding the possible use of solid conductors for patch cables. The reason for the spotlight on solid wire is that it is supposedly more stable, under a variety of conditions. Please note that we now offer custom solid copper category 5E patch cables in Plenum insulation in lengths of up to 295 feet. These cables are suitable for use in air handling (Plenum) ceilings and environments.

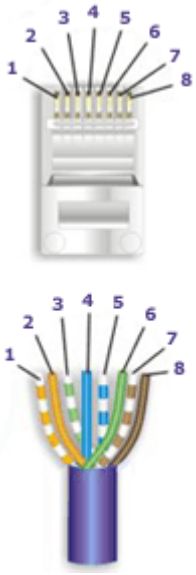
How to Make a Category 6 Patch Cable

It is now not only possible but easy to field terminate category 6 modular plugs thanks to the new Sentinel 111-08080054L34 Category 6 modular plug which contains a new Patented Conductive NEXT Reduction System. The Conductor Loading Bar is molded from a material that substantially reduces the affect of NEXT within the Plug Body. The conductors are isolated by plastic that absorbs the NEXT from between the conductors and channels it away so that the Plug can perform to Category 6 levels. When assembled onto Category 6 compliant patch cable it will pass all TIA/EIA requirements for NEXT and Return Loss. This will help your Category 6 channel maintain increased headroom to assure your network operates at it's best.

Due to an overwhelming response to our category 5E tutorial, and many requests for information and wiring diagrams of "straight through" and "crossover" (cross-pinned) patch cords, I have made this informational page. On this page, we will cover making patch cords, and other technical and non-technical issues relating to category 6 patching and connectivity from device to device. Below, you will find the diagrams for 568A, 568B, and crossover patch cables. I suggest that you read on, past the diagrams for some very useful and important information.

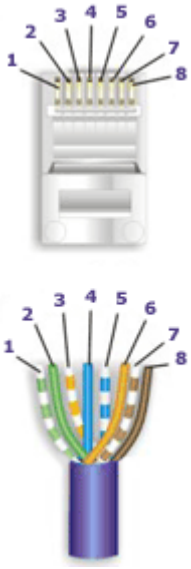
As always, there continues to be Controversies over standards and practices regarding the use and making of patch cords, and UTP cable in general. Please see our section below titled: "Controversies and Caveats : Category 5, 5E, and Cat 6 Patch Cables". I hope that you will find it interesting and informative.

Tony Casazza, RCDD



568-B Wiring

Pair #	Wire	Pin #
1-White/Blue	White/Blue	5
	Blue/White	4
2-Wht./Orange	White/Orange	1
	Orange White	2
3-White/Green	White/Green	3
	Green/White	6
4-White/Brown	White/Brown	7
	Brown/White	8
< 568-B Diagram		



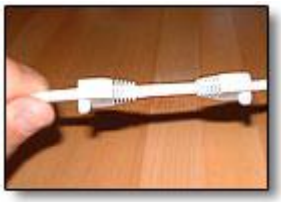
568-A Wiring

Pair #	Wire	Pin #
1-White/Blue	White/Blue	5
	Blue/White	4
2-White/Green	White/Green	1
	Green/White	2
3-White/Orange	White/Orange	3
	Orange/White	6
4-White/Brown	White/Brown	7
	Brown/White	8
< 568-A Diagram		

Notes for wiring diagrams above:

1. For patch cables, 568-B wiring is by far, the most common method.
2. There is no difference in connectivity between 568B and 568A cables. Either wiring should work fine on any system*. (*see notes below)
3. For a straight through cable, wire both ends identical.
4. For a crossover cable, wire one end 568A and the other end 568B.
5. Do not confuse pair numbers with pin numbers. A pair number is used for reference only (eg: 10BaseT Ethernet uses pairs 2 & 3). The pin numbers indicate actual physical locations on the plug and jack.

Steps in Making a Perfect Category 6 Patch Cable

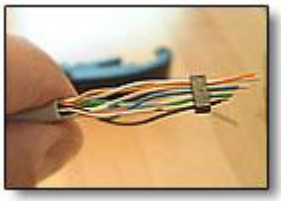


1) If you are planning to use boots than slide them on to the cable as shown. If you prefer not to use boots than start from step 2.

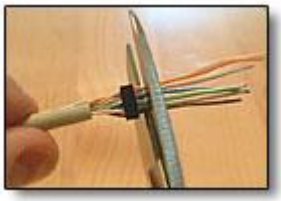
2) Skin off approximately 1.5" of the cable's jacket. For precise and effortless cable skinning we recommend the EZ UTP Cable Stripper

3) Partially untwist the pairs leaving one twist remaining at the bottom being sure not to untwist into the cable's jacket. Straighten and organize the conductors to the diagram above. Note: Choose 568B (most common) or 568A wiring. For crossover see Below

4) (Optional) Cut the end of the conductors on an angle while holding them in proper order. This will make it easier to install the load bar on the next step.

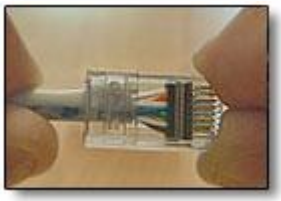


5) Slide the conductors into the load bar in their proper order with the hollow portion of the load bar facing the jacket. The holes in the load bar alternate up and down. For that reason, you may find it easier to insert the conductors one at a time. This would be a good time to re-check the color order.



6) Push the load bar as far down as it will go. Then cut the conductors straight across approximately 0.14" from the front of the load bar. It is very important to get a very straight and even cut. The use of a pair of Electrician's Scissors is highly recommended.

7) Pull the load bar back up near to the cut end of the conductors. Then slide wires and load bar into the connector body holding it with the pins facing you. That is the way the wiring diagrams above are shown so be sure to look at the color order. A very slight amount of jiggling may be helpful to make the wires find their slots in the connector body.



8) Once all of the wires have entered their slots firmly push the connector body toward the cable. You will need to be sure that a) the wires have reached the end of the connector body, and b) that the cable's jacket is about half way into the connector and past the first crimp point (the jacket crimp).

9) Crimp the connector using a high quality crimp tool such as the Ratchet Type RJ-45 and RJ-11/12 that is sold on this website.

10) Install the connector on the other end of the cable. For a straight through (standard) cable use the same wiring. To make a crossover cable, wire one end using the 568A method and the other end using the 568B method.
11) Test the cable for continuity and proper wiring using a high quality cable tester such as the LANTEST-PRO Cable Tester that is sold on this website. Optional: Use a "Scanner" to test for NEXT, and other parameters. Please note that scanners that test for Category 6 cable usually start at around $4000.

Notes Regarding Making Category 6 Patch Cable

1. The RJ-45 plugs are normally made for either solid conductors or stranded conductors. It is very important to be sure that the plug that you use matches the conductor type. It is extremely difficult to tell the difference between the two by looking at them. When you buy these plugs, be sure to categorize, and store them carefully. Using the wrong type can cause intermittent problems. The Cat 6, 8 Conductor Modular Plugs from Sentinel (TM) that we sell are rated for both Solid and Stranded cable.
2. Ordinarily, it would be taboo to untwist the pairs of any category 6 cable. The one exception to this rule is when crimping on RJ-45 plugs. It would be impossible to insert the wires into the channels without first untwisting and straightening them. Be sure not to extend the un-twisting, past the skin point.
3. If the completed assembly does not pass continuity, you may have a problem in one, or both ends. First try giving each end another crimp. If that does not work, then carefully examine each end. Are the wires in the proper order? Do all of the wires fully extend to the end of the connector? Are all of the pins pushed down fully. If the pins are not fully pushed down than it is possible that your crimper may require adjustment or replacement. Cut off the suspected bad connector, and re-terminate it. If you still have a problem, then repeat the process, this time giving more scrutiny to the end that was not replaced.
4. It is good to be prepared to make your own patch cables. There may be many instances where you may fall short on supply, and making a cable will surely get you out of a jam. However, there comes a point where the practicality curve will lead you to factory made cables. Making several cables can be very labor intense. Factory made cables typically have better tolerances, and consequently have better quality than field made cables.

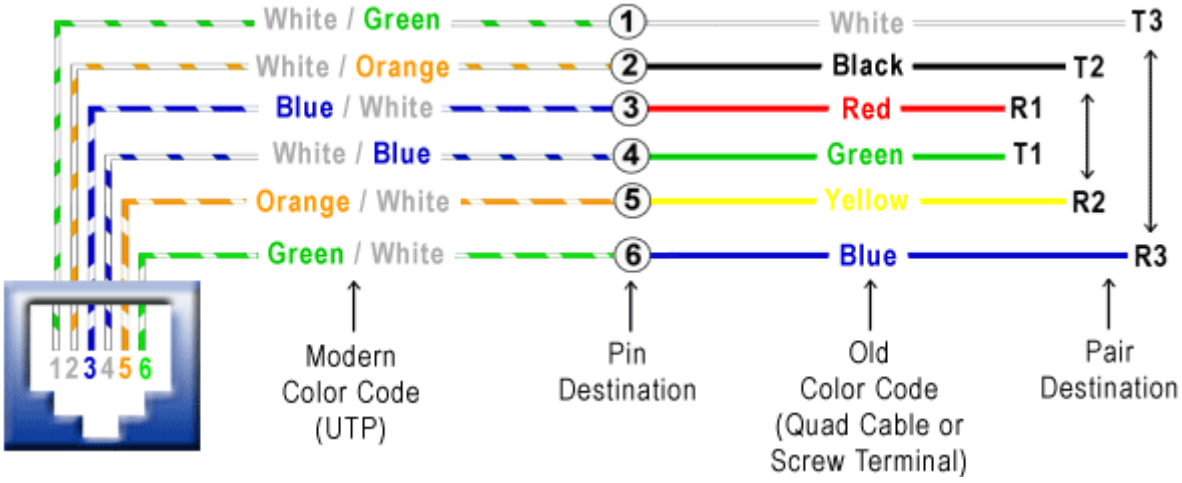
How to Wire a Phone Jack (Voice or Telephone RJ-11 thru RJ-14)

(USOC Wiring Diagram)

Telephone wiring for a phone outlet is typically either 1, 2 or 3 pairs (2, 4, or 6 conductor). Most cable nowadays is UTP (unshielded twisted pair). There may be instances where you may need to connect to or transpose from the old "quad" cable. The diagram below provides the transposition between these standards.

Pair 1 (T1 & R1)

Usually the primary dial tone or talk circuit is wired to the center two pins (pins 3 & 4) and is the white/blue and blue/white pair (AKA: T1 & R1 - tip 1 and ring 1). A standard single line phone draws dial tone from these center pins.



NOTE: The type of wiring shown here is known as USOC (pronounced U-sock). See background below.

Pair 2 (T2 & R2)

The secondary circuit is wired to the two pins (pins 2 & 5) directly to the side of the center pins and is the white/orange and orange/white pair (AKA: T2 & R2 - tip 2 and ring 2). Depending on the application, the secondary circuit can either be the 2nd dial tone line on a two line phone, or the data/control circuit for an electronic key phone.

Pair 3 (T3 & R3)

The third circuit is wired to the two pins (pins 1 & 6) on the outside and is the white/green and green/white pair (AKA: T3 & R3 - tip 3 and ring 3). Depending on the application, the third circuit can either be the 3rd dial tone line on a three line phone or an accessory circuit for an electronic key phone.

Background

Tip & Ring

In telephony the terms that represent the conductors that compromise a circuit are known as "tip and ring". These terms stem from the early days of telephony when operators made telephone connections using 1/4" phono plugs similar to those used today for stereo headphones. The old systems also carried a third wire which was a ground. The "Tip" was the tip of the plug and was the positive (+) side of the circuit. The "Ring" was a conductive ring

right behind the tip of the plug and was the negative (-) side of the circuit. Right behind the ring was the "Sleeve" which was the ground connection.

The ground (sleeve) is no longer used today for individual pairs.

USOC (Universal Service Ordering Codes)

In the old days of telephony, USOC (pronounced U-sock) standards were used to simplify and standardize the various different wiring schemes for modular jacks.

RJ (RJ-11, RJ-45 Etc.)

The USOC standards consisted of many different Registered Jack Configurations which were abbreviated as "RJ" and had designations like RJ-11, RJ-12, etc. Today we still refer to modular jacks in the RJ designations but rarely use them to refer to a wiring standard that they were originally intended for. Even though it is technically incorrect, popular terminology today for the terms RJ-11, 12 or 14 refer to a 6 pin jack and RJ-45 refers to an 8 pin jack.