



PHONE WIRE

Each phone line (i.e. each phone number) is an electrical circuit requiring two wires, just like a hi-fi speaker or a light bulb or bicycle horn.

In some areas, fiber optics or other new technology eliminates the need for a complete **copper path** of wire stretching all the way from the phone company's central office to your phone, but you can assume that almost every phone is connected to between several feet and several miles of low-tech copper wire.

The two wires carrying a phone circuit are generally considered to be a "**pair**," and are usually twisted together and joined with one or more other pairs, inside an outer protective plastic jacket, to make up a multi-pair wire or cable. Multi-pair wires are typically available with two, three, four, six, or twelve pairs. Beyond twelve pairs, as the wire bundle get thicker, it is generally referred to as a **cable**, rather than a wire.

"Cable" sounds more impressive than "wire," but they often mean the same thing. There is no fixed point where wire gets big enough to be called cable. A big boat is a ship, and big wire is cable.

The wire running around inside the walls of most homes and offices has from four to twelve **conductors**, often arranged as two to six pairs, with each pair twisted together.



PHONE JACKS & PHONE PLUGS

The little plastic tips on the ends of phone cords and cables are **modular plugs**. They fit into **modular jacks**. Despite their male name, jacks are **female**. Plugs are **male**. If you don't understand this, the next time you're naked, look in the mirror.

The word "modular" refers to a phone construction format introduced by AT&T in the 1970s, that allowed installers to assemble phones at customer locations by selecting specific components that plugged together, instead of needing **hard wiring**. The modular connector design was also applied to the jacks that phones plugged into, to get dialtone.



Modular plugs are made in three sizes:

- The smallest plug, known as 4-position, 4-wire, is used for handset cords. A **position** is a groove molded into the plastic that *could* contain a little bit of gold-plated wire to make contact with wires inside the jack.
- The middle-size plug is the most common. It has six positions, and either two, four, or six wires. It is used for most line cords that connect phones, modems and other

Until the mid 1980's, 25-pairs was standard for business phone systems; and many apartment houses, particularly in New York City, were **pre-wired** with 25-pair cable going from room-to-room.

If a house or office is being built for you, you can specify any kind of wire you want.

Twisted-pair wire varies in the number of twists per inch. Wire with more twists is better and more expensive. Twisted-pair wire (usually **un-shielded**, and called "UIP") is classified in various **levels** or **categories**. Computer networks generally use **Cat-5 wire**, and phones **Cat-3** or **Cat-5**.

Cat-5 wire is capable of higher data transmission speeds, and must be installed properly to avoid loss of speed and data **glitches**. Special phone jacks and other hardware items are available for use with Cat-5 wire.

In the pair, one wire has positive **electrical polarity**, and is called the **tip** and is traditionally **green** within a **phone jack**. The other is negative, called **ring**, and is **red**. The tip and ring terms come from the parts of an old-fashioned telephone switchboard **plug**.

Multi-pair phone wire uses an industry-standard **color code**, to distinguish one pair from the others. Each wire usually has a base color and a contrasting stripe, and the other wire in the pair is the opposite.

The first pair of wires usually has a white wire with blue stripes, and a blue wire with white stripes. There are codes for 25 different pairs. When cables have more than 25 pairs, each group of 25 pairs is wrapped with colored nylon thread, in a **binder group**.

Wire thickness is indicated by "**gauge**." It is pronounced, and sometimes spelled, "gage." A higher gauge number indicates a thinner wire. Thicker wire allows a signal or voltage to travel a longer distance without noticeable degradation.

The electrical wire in your walls is usually 12 or 14 gauge. A lamp cord is usually 18 gauge.

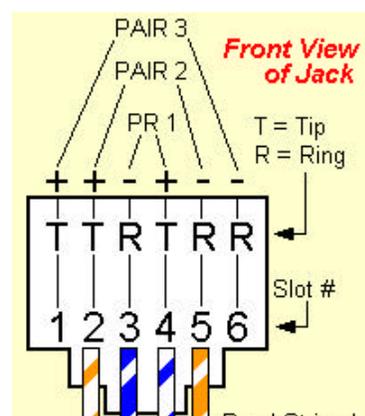
devices to phone jacks.

- The largest plug, with eight positions and eight wires, is usually used for **LANs** (Local Area Networks) and sometimes for four-line phones. It is often called an RJ45, but that designation is inaccurate for LAN connections.

- **! Eight-wire plugs and jacks are also used on some ATT/Lucent phone systems. If you are going to re-use jacks previously installed for a Merlin or other ATT/Lucent/Avaya phone system that uses the "T568B" wiring scheme, you will either have to re-arrange the wires inside the jack, or connect the circuit that would normally go on the white/orange wire pair, to the white/green pair.**

At least 99% of all phone jacks used with one-line phones are really two-line jacks. In the same actual jack, if two wires are connected, it's a one-line jack. If four wires are connected, it's a two-liner.

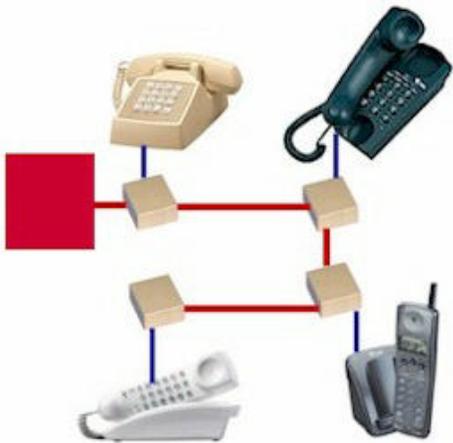
The FCC and phone companies have codes to identify how jacks are wired. A single-line jack designed for mounting a wall phone is an RJ-11W. A single-line jack for a table or desk phone is an RJ-11C. Two-line jacks are RJ-14W and RJ-14C. Three-line jacks are RJ-25. If you know that much, you know more than many phone company employees. Four-line jacks are RJ-61. If you know that, you know more than *all* phone company employees. "RJ" stands for Registered Jack. "W" stands for Wall. Apparently only one person knew what the "C" stood for, and he died without telling anyone.



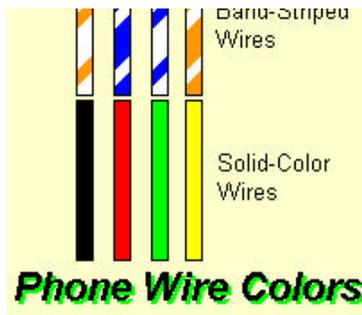
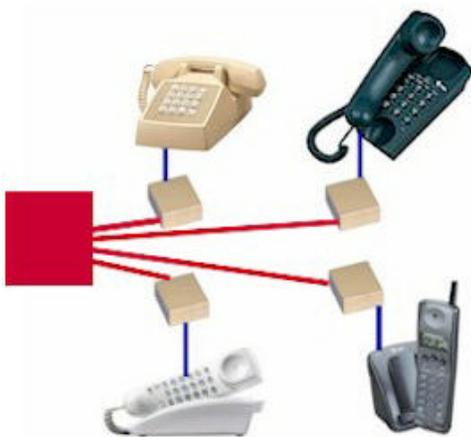
If you look at the springy wires inside a common phone jack, the two inner ones are used for line #1, and the two outer ones are

Phone wiring is usually either 22 or 24 gauge. Unless your home is Buckingham Palace, you don't need 22 gauge. However, the price difference between the two sizes is negligible, and the thicker stuff is a bit stronger and less likely to be broken by amateurs, so there is no reason not to use it. You probably won't find Cat-5 in 22 gauge.

Phone wiring is always **solid**, never stranded like lamp cords or speaker wires. In an emergency, or if you have a special need, you can make a phone work with pretty much any kind of wire (flat TV antenna "twinlead" wire can hide under carpeting), but you'll get the best possible results if you use the proper materials, particularly if you have two lines. It's difficult to connect stranded wire to phone jacks without causing short circuits.



Residential wiring is most often installed in a "**loop-through**" configuration, where wire goes from the phone company's entry point to one room, then another, and another, and another, in a string. The phone jacks are wired electrically in parallel, but physically in series, and a break in the series can knock out phone service in several rooms 'after' the break.



used for line #2. The flat cords that commonly connect phones to phone jacks follow this same arrangement.

Cords used for three-line phones have two additional conductors for the third line, outside the second pair, for a total of six wires (three pairs). If you look at a cross-section of a six-conductor phone cord, the line circuits could be considered to look like this: 321123. If you plug a single-line phone into a two-line jack, it will work on line #1. If you plug a two-line phone into a three-line jack, it will work on lines #1 and line #2.

Four-line cords have two more wires (total of eight wires, in four pairs). Four-line non-system phones can use two two-line cords, or one four-line cord.

! Multi-line phones used in modern **electronic** or **digital** phone systems usually use cords with four or six internal wires, regardless of the number of lines the phone can handle.

Phone jacks are made in three general formats:



The **surface jack**, is a cube, roughly 2 inches by two inches by 3/4 of an inch, and mounts on the surface of the wall. It is usually installed after a wall is constructed, often with wire stapled to the **baseboard**. They are available in a variety of colors, with connections for two, three or four pairs.

If you have the option, it is much better to install **home-run wiring**, where there is a direct path of wire from the phone company's entry point to each phone jack. (Computer guys call it **star topography**.) With home-run wire, a break in one segment will not kill service to other parts of the office or house, and other problems such as short circuits or grounded wires may be more-easily identified and fixed. .

Loop-through is less-expensive and OK for ordinary non-system phones, but not the best choice.

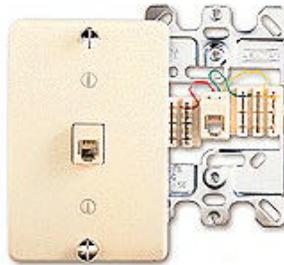
Home-run wiring also makes it easier to install a more elaborate phone system that requires a central control box, commonly called a **Key Service Unit** ("KSU"). Wire is the cheapest part of a phone installation. It is always better to have too much than too little. Spend a few cents extra per-foot and install four-pair wire, which is considered standard today, even if your phones will work on fewer pairs. This will give you some reserve to add an extra phone, or a fax or answerer or modem on another line; or to compensate for wire damaged by a plumber or carpenter.

You can also use an extra pair or two to carry music to a speaker, or as a computer **LAN** (Local Area Network). Macs usually use one pair, IBM usually two pairs. If you *think* you might be using the same wire for both phones and computer, definitely spend a few cents more per foot to buy Cat-5 wire, instead of the Cat-2 or 3 more commonly used for phones alone. If you *know* you'll have a LAN, go first class, with separate wire for phone and data. It's cheaper to prepare now, than to bash or knock down your walls later.

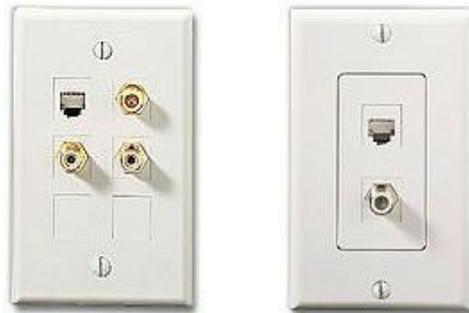
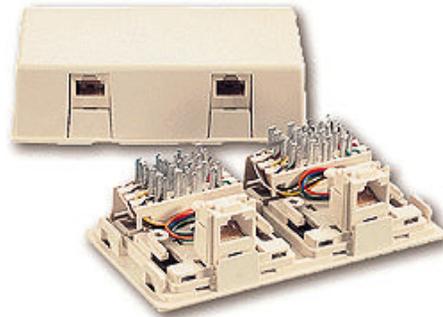
There is an industry-standard color code for identifying the pairs in a multi-pair wire or cable. Each pair consists of one wire with a base color and contrasting stripe, plus another wire with the opposite colors. The



The **flush jack** is flat, like an electrical outlet, and is usually installed in new construction, with wire concealed inside the wall. Flush jacks are available in a variety of colors, for two, three or four pairs of wire, and in both standard and "Decora" styles (at right, above).



The **wall jack**, usually mounted about five feet above the floor, has two metal mounting studs, to support a wall phone. They are available with plastic or stainless steel front plates, with two or three pairs of wire.



first pair, used for line # 1 consists of a white wire with blue stripes, plus a blue wire with white stripes. The second pair, used for line #2, is a white wire with orange stripes, plus an orange wire with white stripes. Line #3 is white with green, and green with white. Line #4 is white with brown, etc. Line #5 is white with gray (which phone pholks call "slate"), etc. Line #6 is red with blue, etc.

As with all industry standards, there are many exceptions. Sometimes you'll find that the first pair consists of a solid white wire and a solid blue wire. And the second pair is solid white and solid orange, etc. And sometimes you'll find that the first pair is a solid blue wire, plus a white wire with blue stripes, and so on. And sometimes you'll find green and red for the first line, black and yellow for the second, and white and blue for the third. And sometimes you'll find orange, brown and slate (gray) wires.

[CLICK for color codes for wire & jacks](#)

For many years, most phone companies installed **4-conductor** wire in homes, and this is what you'll usually find hanging on racks in electronic stores. Instead of having multiple pairs, they have four wires twisted together. This is a bit cheaper to make than twisted-pair, but is more likely to result in "crosstalk," where voices, sounds or signals from one line leak through and are heard on the other line.

Some 4-conductor wire, such as ATT (now probably labeled Lucent or Avaya), is quite good and unlikely to cause crosstalk. Other apparently-identical wire is often sold for alarm installations, but is not twisted properly for phone use, and can cause terrible crosstalk problems. To be safe, go with twisted pairs, and the more pairs, the better.



Both surface and flush jacks are available in **multi-port** versions, with up to six ports in a **single-gang plate** or 12 ports in **double-gang** plate. You can use a mixture of jacks and other connectors, for phone, fax, LAN, modem, answerer, TV, etc. Multi-port assemblies are available in both standard and Decora styles, in a variety of colors.



Special purpose jacks and mounting plates are available for installation in the floor, outdoors, in modular furniture, etc.

