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Receptacles

Definition: A receptacle is a contact device installed at the outlet for the connection of an *attachment plug*, or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device.

Definition: An attachment plug is a device that, by insertion in a receptacle, establishes a connection between the conductors of the *attached flexible cord* and the conductors connected permanently to the receptacle.

20 amp

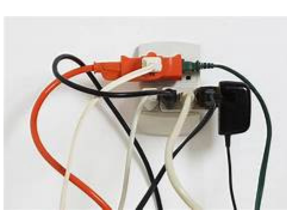
Electrical attachment plugs and cord connectors differ from one another in voltage and current rating, shape, size, and connector type. Different standard systems of plugs and receptacles are used around the world. The most common electrical attachment plugs and cord connectors are 15, 20 and 30 amps.


20 amp

Some multi-standard sockets allow use of several types of plug; improvised or unapproved **adaptors** between incompatible sockets and plugs may not provide the full safety and performance of an approved attachment plug combination.

Multi-receptacle **adaptors** allow the connection of two or more plugs to a single receptacle. They are manufactured in various configurations. This allows connecting more than one electrical consumer item to one single receptacle and is mainly used for low power devices (TV sets, table lamps, computers, etc.). Some people overload them, thus leading to accidents. In some countries these adaptors are banned and are not available in stores, as they may lead to fires due to ***overloading*** them.



The National Electrical Code doesn't limit the number of receptacles you can place on a 20-amp circuit, but you'll overload the breaker if you run appliances that draw more current than the breaker can handle. The NEC does specify that a circuit breaker shouldn't handle more than **80 percent** of the load for which it is rated unless the breaker is labeled otherwise. By this standard, the total current draw on a 20-amp circuit shouldn't exceed 16 amps. A 15-amp circuit should not exceed 12 amps.

15 amp CB
12 amps

20 amp CB
16 amps

210.23(A)(1). Cord-and-Plug-Connected Equipment. Not Fastened in Place. The rating of any *one* **cord-and-plug-connected** utilization equipment not fastened in place **shall not exceed** ***80%*** **of the branch-circuit rating**.

But, how can the 80% be controlled? The electrical designer can design the branch circuit, the electrician can install the branch circuit in compliance with the Code rules.

Then who is going to inform the home owner to stop buying adapters, extensions, etc. to overload the branch circuit?

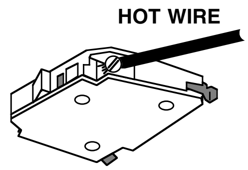
Now they are assuming the circuit breaker should trip thus, protecting the branch circuit wiring.

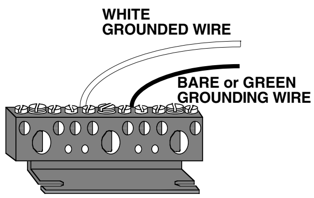
It seems a bit crazy to talk about how using an extension cord breaks the Code rules and should not be done. How many average people know this? I would imagine there isn't a single house in any of our towns where this isn't done regularly. People have no idea what Code safety rules are and since we've all grown up with extension cords with multiple outlets in them, no one would have any idea not to use them as we always have.

According to Electrical Safety Foundation International : Roughly 3,300 home fires originate in extension cords each year, killing 50 people and injuring about 270 more.

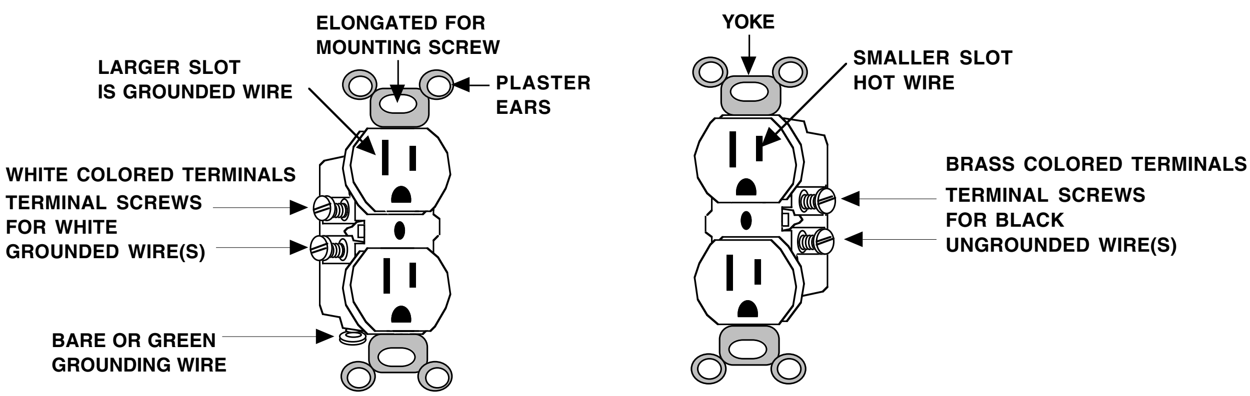
About 4,000 extension cord-related injuries are treated in hospitals each year.

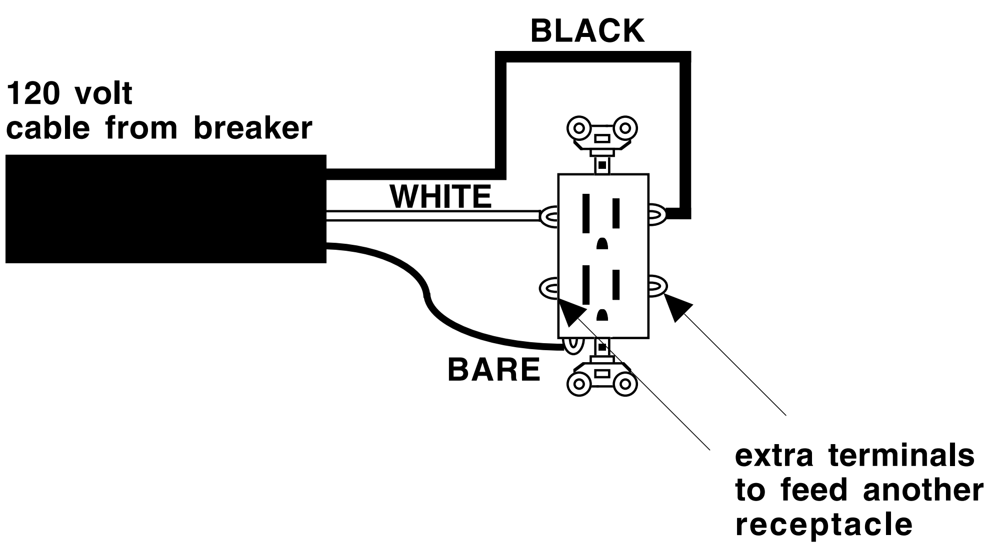
The Duplex Receptacle





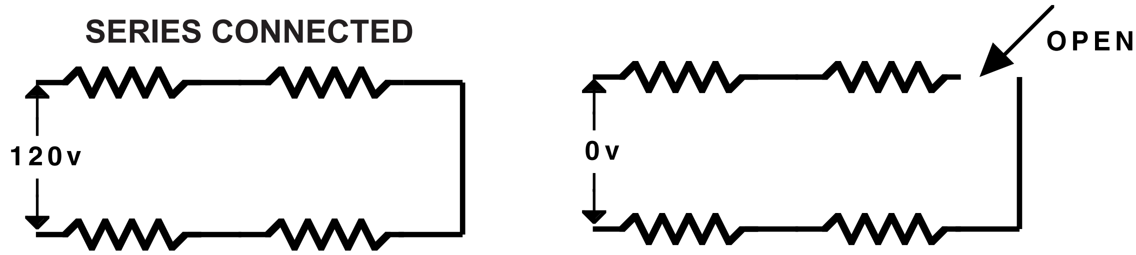
The 120 volt source originates at the panelboard. The ungrounded (hot) wire is connected to the single-pole circuit breaker. The white grounded wire connects to the neutral bus terminal as does the bare or green colored grounding wire. The cable is then run from the panelboard to the first receptacle and the wires connected to supply the receptacle.





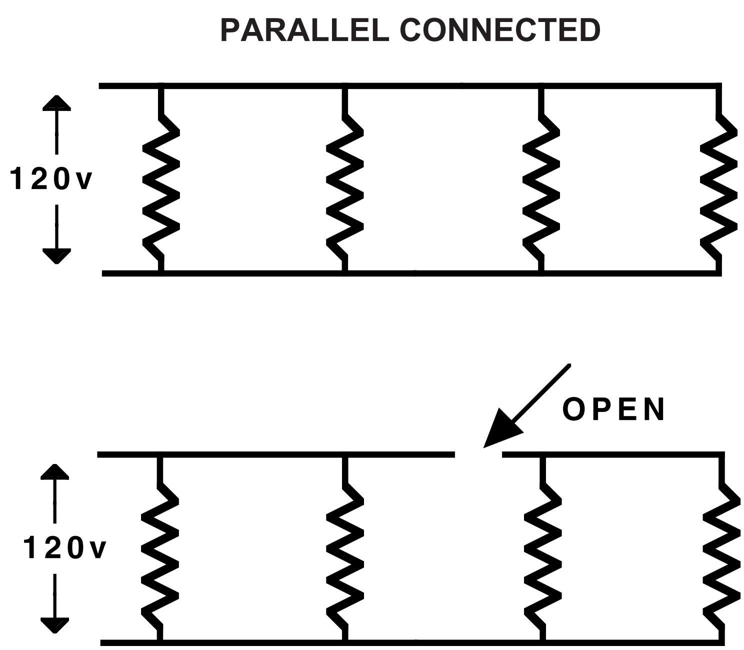
Are receptacles connected in series or parallel?

In your time in the electrical trade you have been taught the series circuit and the parallel circuit. The best way for me to show you the **correct answer** is to put it in a drawing.



With a series connection and open anywhere in the circuit would drop voltage to ALL the loads. So, series is NOT the answer.

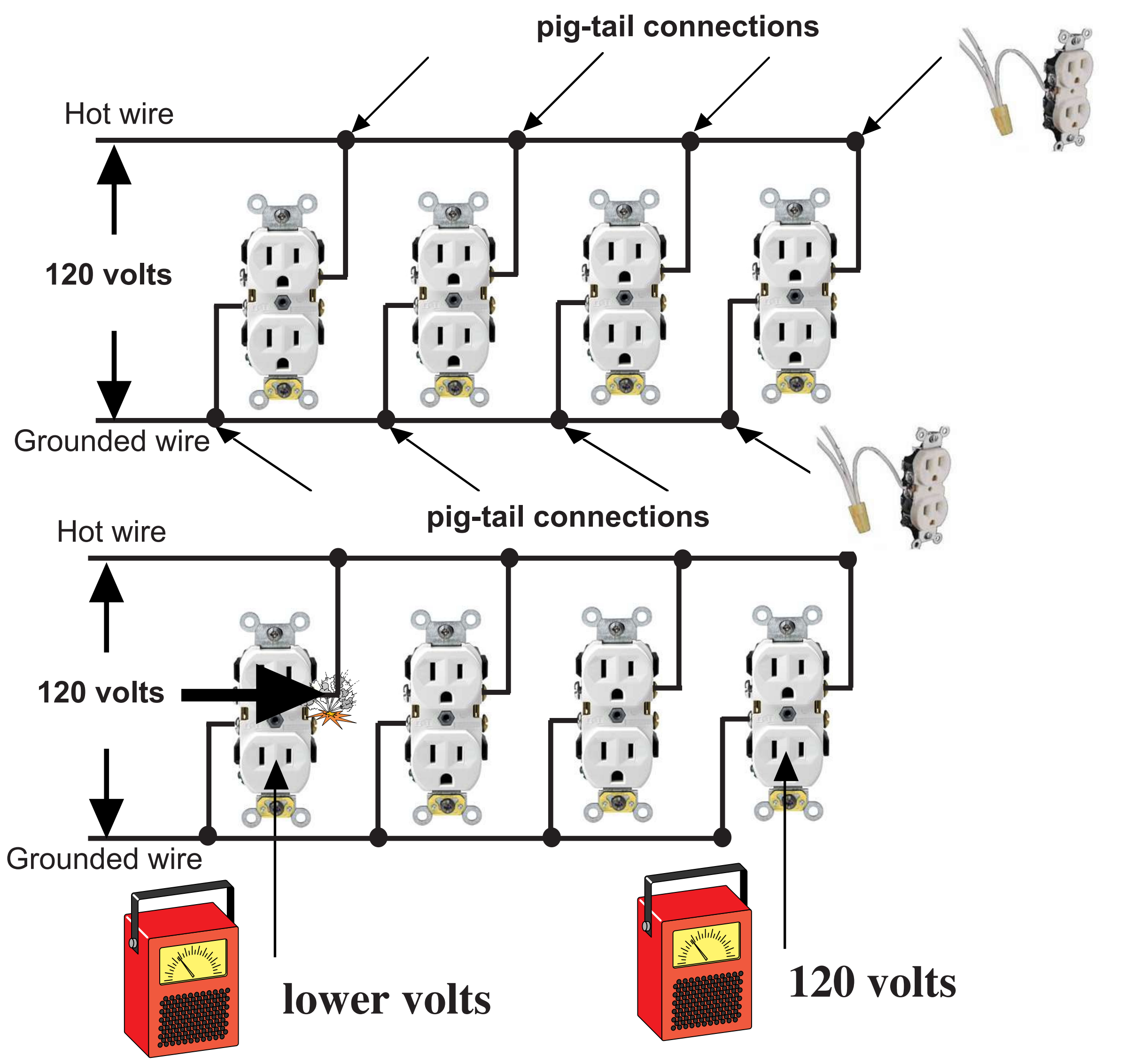
Now, lets check to see if the receptacles are connected in parallel.



(continued next page)

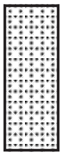
The sketch on the previous page shows an OPEN between the second and third receptacles, but you still have 120 volts at receptacles one and two. So this is not a parallel circuit or you would have power to the other receptacle.

To have a parallel circuit you must "pig tail" the connections as shown below.

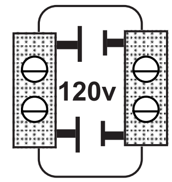


With a **pig-tail** connection to the black and white wires, a loose connection at the terminal would only effect that receptacle as all the other receptacles would receive 120 volts by pig-tailing the connections. You would only have one hot wire terminal connection at each receptacle instead of two hot wire terminal connections as on feed-thru connections.

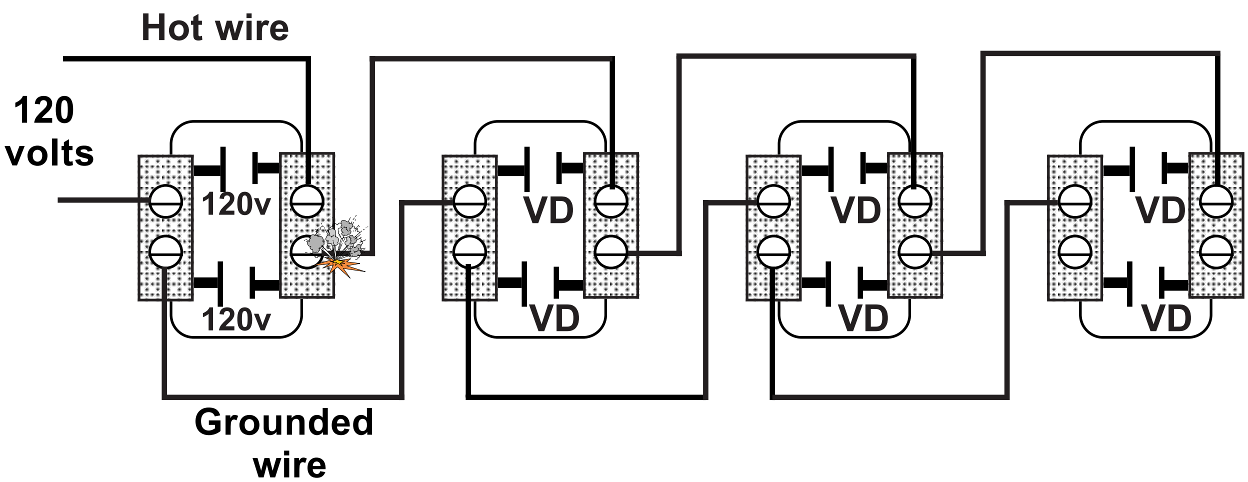
The feed-thru connection is shown below as the hot wire and grounded wire are both connected to the screw terminal on the conductive tab.



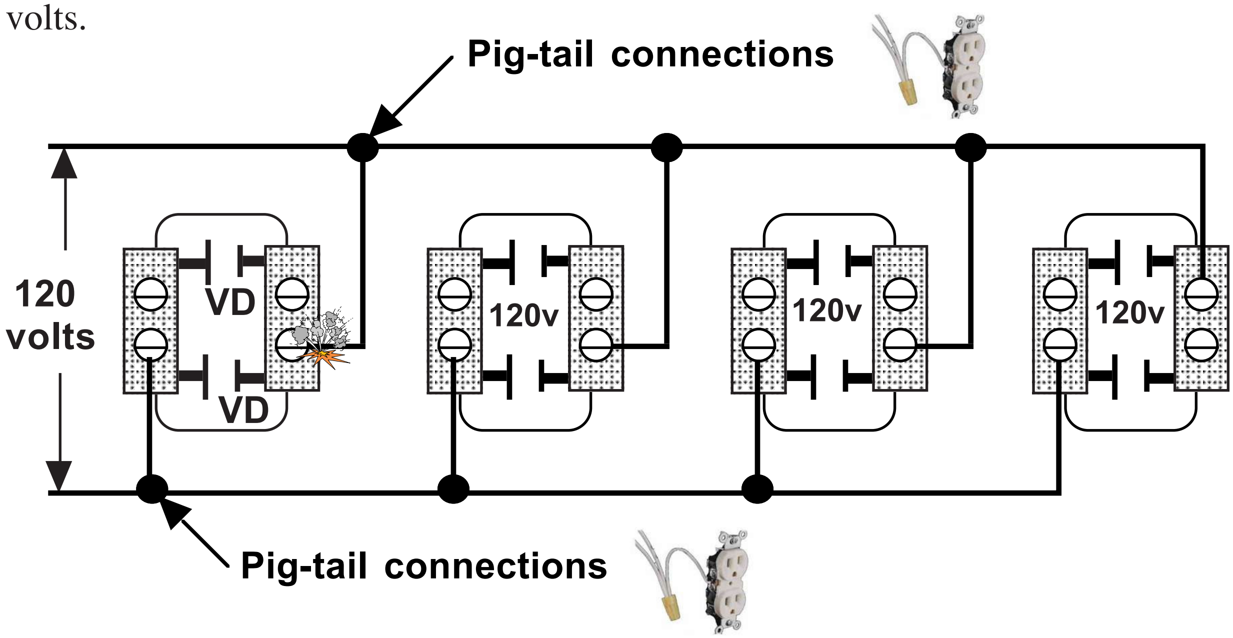
The conductive tab is supplying the applied 120 volts to the blades of the receptacle as there is a **solid direct internal connection**.



The first receptacle has a loose screw at the lower connection on the conductive tab. The tab is applying 120 volts to the lower receptacle. But, the hot wire due to the loose high resistance connection is supplying a voltage drop (**VD)** to the remaining receptacles with the feed-thru connection.



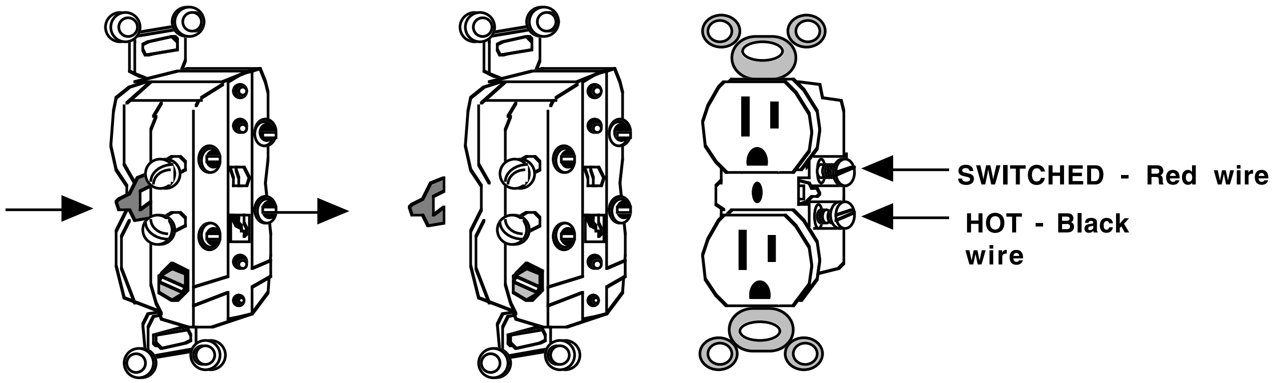
If the circuit had pig-tail connections as shown below, only the first receptacle would have a voltage drop. The remaining receptacles would receive the applied 120 volts.



SPLIT-WIRED RECEPTACLES

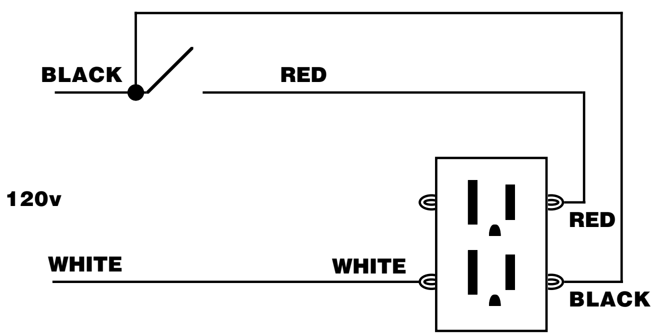
In some cases, instead of having a ceiling light fixture, split-wired duplex receptacles are used to control table or floor lamps by a switch. By *removing the tab on the hot side* (brass colored) of the duplex, you split it into two circuits. One half of the duplex will remain hot from the black wire and the other half will be energized from the red wire which is connected through the single-pole switch. This requires a 3-conductor cable between the receptacles.

REMOVE TAB FOR SPLIT-WIRED DUPLEX RECEPTACLE

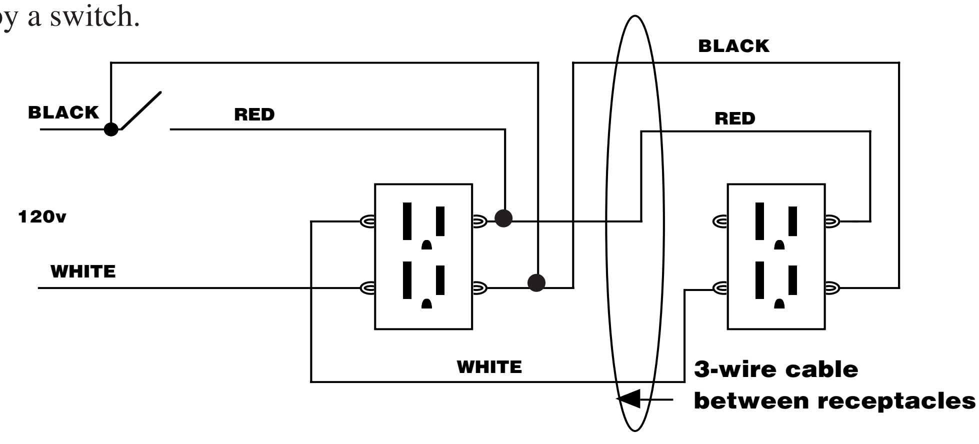


The diagram below shows how the circuit is connected. With the metal tab removed (on the hot side only) the two receptacles become split (separated). When the switch is closed, the top receptacle would become energized. The bottom receptacle is *energized all the time* by the black wire. ***NEVER*** break the tab on the ground "white" side of the receptacle.

A split-circuit is fed from the *same* circuit breaker.



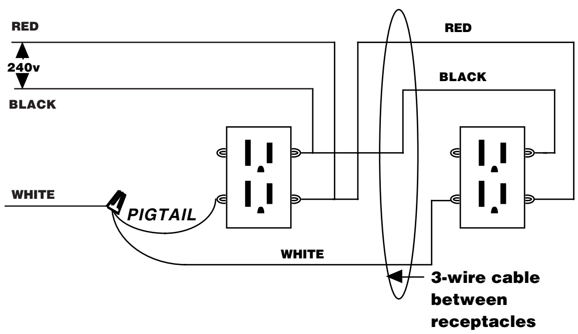
The split receptacle circuit is used so table lamps can be plugged into the top receptacle and controlled by a switch.

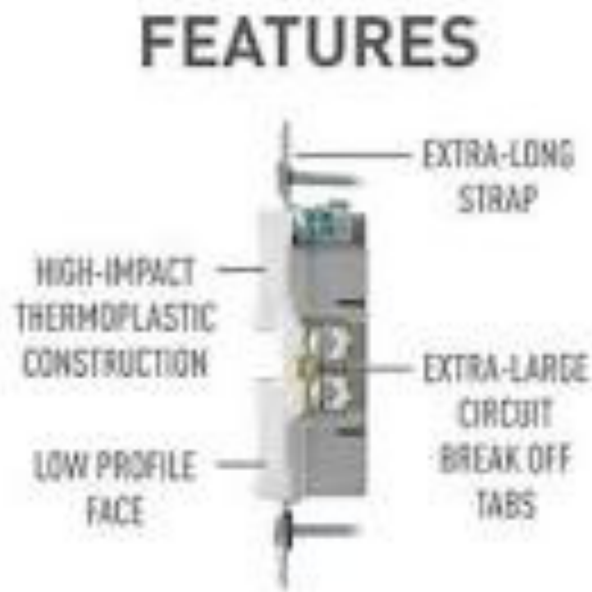


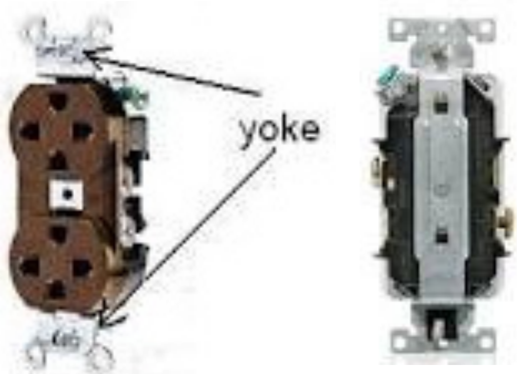
Multi-Wire Circuit

If one circuit was shut off and the receptacle was *unwired and removed,* the other circuit would not have a grounded conductor if the white was connected to the receptacle terminals that was removed. This is WHY a grounded *neutral* wire *must always be pigtailed in a multi-wire circuit.*

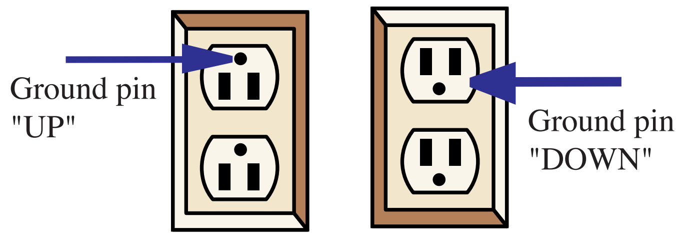
Pigtailing the white wire is NOT required in a split-wired circuit because it is not a neutral wire since there is only one breaker, a multi-wire has *TWO* breakers and the white wire thus becomes a *neutral* wire. The neutral must be pigtailed.







Receptacles UP or DOWN?



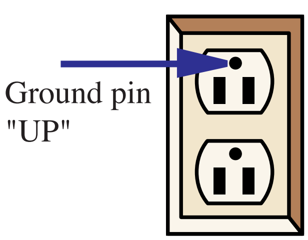
The Code book does NOT state which way, you can install the receptacle either way. Code standards do not require the grounding pin to be in any special orientation.

Some prefer to install the receptacle with the grounding pin "down." They say the receptacle looks as if it's smiling!

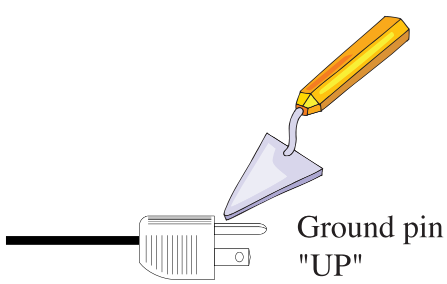
Some feel if the grounding pin is "down" an angle cord cap oriented *incorrectly* will put stress on the cord while in use. With the grounding pin "down," if a cord cap were to work loose in the receptacle, the grounding pin would be the last element to separate from the receptacle.

With the grounding pin installed in the "up" position, some feel there is a measure of protection to the "hot circuit." If conductive material were to fall on the receptacle, it would first come into contact with the grounding pin, if it was installed in the "up" position.

In some cases, specifications on the drawing will state how the receptacles are to be installed. **Hospital** specifications often require for Sensitive Patient areas, the receptacles be installed with the **grounding pin facing in the "UP" position**.



In my own experience, I have witnessed a painter stripping wallpaper with a broad-knife and as the broad-knife hit the receptacle the sparks flew when he made contact with the "hot" pin on the plug on the cord to his fan. If the grounding pin had been installed in the "UP" position the broad-knife would have come into contact with the grounding pin rather than an energized pin.



There is more chance of making contact with the top of a receptacle than the bottom as most receptacles are located 12-16" off the floor. A person stripping wallpaper is bringing the broad-knife in a downward sweep towards the receptacle.

But again, there is no mention of which way to install the receptacle in the NEC. It would have to be written in a *local code* to be enforceable by an inspector.

I think I'd rather keep the "sparks from flying" than have it smiling!

GFCI TEST MONTHLY?

It's marked on the receptacle. The instructions sheet that came with the GFCI states this also. Are we telling the occupants of the dwelling this is to be done?

A GFCI constantly monitors current flowing through a circuit. If the current flowing into the circuit differs by a very small amount (as little as 0.006 amperes) from the returning current, the GFCI interrupts power faster than a blink of an eye to prevent a lethal dose of electricity.

AFCI

AFCIs use electronic detection circuits to discriminate between good and bad arcing conditions. Once an unwanted arcing condition is detected, the control circuitry in the AFCI trips the internal contacts, thus de-energizing the circuit and reducing the potential for a fire to occur.

DID YOU KNOW

Cross-linked polyethylene (PEX), a type of flexible plastic, is currently **replacing traditional copper and galvanized steel** as water supply lines in both new construction and remodeling projects with many beneficial characteristics.

By replacing traditional copper and galvanized steel with plastic (an insulator) you no longer have the required “ground” **G**FCI to the sink water.

After thinking about it, I ran a test and **no** the GFCI did not respond.

Ground fault circuit interrupters (GFCI) can help prevent electrocution inside and outside the home. GFCIs are an effective means of protecting against electrical shock, however, they must be tested regularly -- **UL recommends once a month** -- to verify they are working properly.

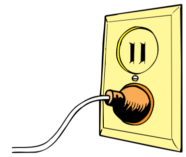
To properly test GFCI receptacles in your home:

- Push the "Reset" button located on the GFCI receptacle, first to assure normal GFCI operation.
- Plug a nightlight (with an "ON/OFF" switch) or other product (such as a lamp) into the GFCI receptacle and turn the product "ON."
- Push the "Test" button located on the GFCI receptacle. The nightlight or other product should go "OFF."
- Push the "Reset" button, again. The light or other product should go "ON" again.

If the light or other product remains "ON" when the "Test" button is pushed, the GFCI is not working properly or has been incorrectly installed (miswired).

RECEPTACLE CONTACT PRESSURE TESTER

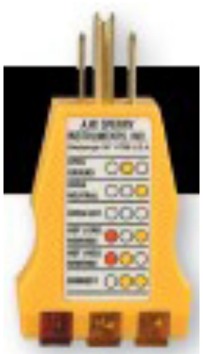
Receptacle performance is only as good as the electrical and **mechanical** contact maintained within the blades of the attachment plug. The first point of wear in a receptacle is usually the tension of the spring contacts.

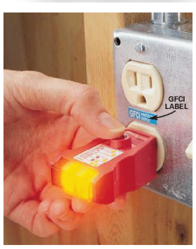


Any reading by this instrument above 4 oz. indicates a serviceable receptacle, that all plugs will fit well.

After 10 years, you will find receptacles that are often used, the contact blade is worn out and the receptacle needs to be replaced. The tester is insulated to be plugged into an energized circuit so it doesn't take long to check all the receptacles.

If the connection of a branch circuit conductor to an appliance or receptacle is loose, severe overheating may occur at the point of connection. Extreme heating can result, damaging the equipment or device and in extreme cases, damaging surrounding materials. Despite extensive heat and progressive deterioration, the current level remains normal, there is *no* "overcurrent," and the circuit breaker is *not* activated. Consequently, the best protection is careful, professional installation, and periodic inspections of susceptible connection points.





I disagree with this use of the word *neutral*.

The definition of a neutral is found in the 2020 Code book in 310.15(E)(1). The neutral conductor that carries only the *unbalanced current*.

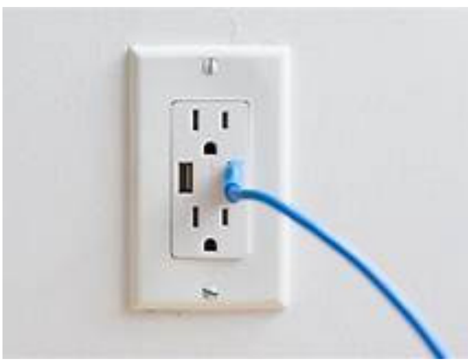
With a circuit to a duplex receptacle connected with a black (ungrounded) conductor, a white (grounded conductor), and a green or bare grounding conductor, there is *no neutral*. It's very simple, to have a neutral you would need two ungrounded (hot) conductors (red & black), then the white conductor becomes a neutral as it would carry the *unbalanced* current. With a black and white wire to a receptacle there is no neutral as the white (grounded) wire is carrying the *same current* as the black wire. The white wire is the *grounded* conductor, it can be a neutral if you have a *three-wire* circuit.

The tester in mention in this article is **incorrect** as the label shows "OPEN NEUTRAL" there is no neutral as I have explained. Also the tester's label marking shows "OPEN GROUND" this should read "OPEN GROUNDING."

Charge faster & enjoy your devices more. USB Wall Outlets / Chargers feature a smart chip that recognizes and optimizes the charging power of your electronic devices for fast and efficient charging of tablets, smartphones, gaming devices, e-readers and a host of other electronic devices.

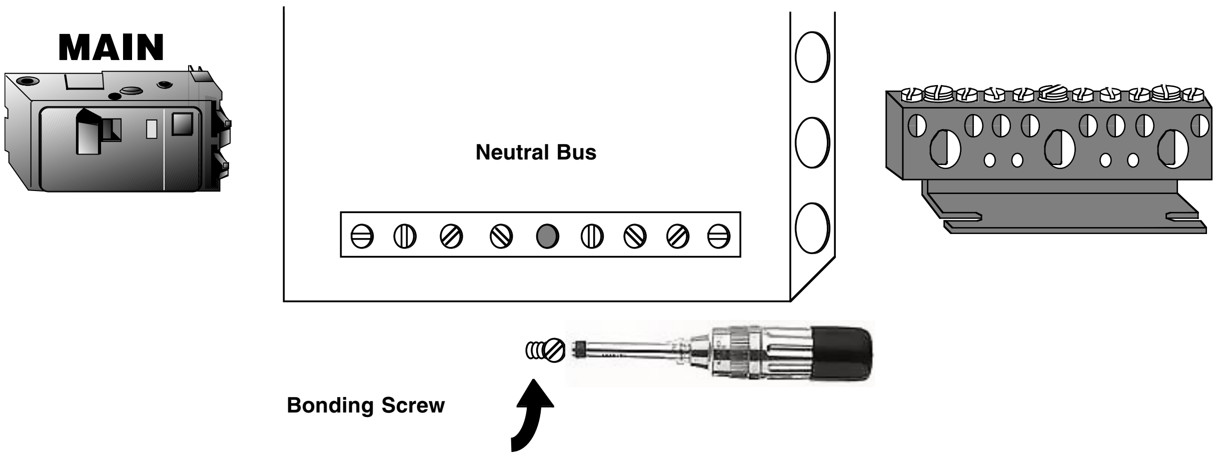
Most phones, tablets, and accessories charge via USB. On a standard wall outlet, charging this way requires a USB power adapter. In contrast, USB wall outlets let you charge your devices directly, using only a USB cable, with the best still giving you two standard outlets.

The USB Charger/Tamper-Resistant Duplex Receptacle offers two high-powered USB Ports with 3.6A of charging power and two 15A or 20A/125V Tamper-Resistant Receptacles.

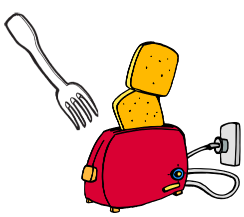


BONDING OF THE NEUTRAL AND GROUNDING

The neutral is only bonded to metal ***at the service***; **NOT** at a sub-panel.This is one of the most violated areas in grounding, mainly because some people simply don't understand the functions of grounding. When incorrectly connecting the neutral to the sub-panel, you would have currents flowing on all the metallic equipment connected to the panelboard.



THE POP-UP TOASTER



The Code requires an equipment grounding conductor to electrical equipment. The Code requires GFCI protection in the kitchen sink area, but yet we have metal appliances in the kitchen with a 2-wire cord and it's deemed okay?

The logic for allowing a 2-wire cord with no equipment grounding conductor is if a piece of toast became lodged in the toaster and a person used a metal fork to retrieve the toast and the metal fork touched the bare heating element when it is energized and the metal edge of the toast slot, if the toaster were grounded with a 3-wire cord, the contact would cause a high level ground fault tripping the overcurrent device.

By using a 2-wire cord and not grounding the metal toaster, *as long as the person is not touching a grounded object* they will be okay to remove the toast that is stuck with the metal fork.

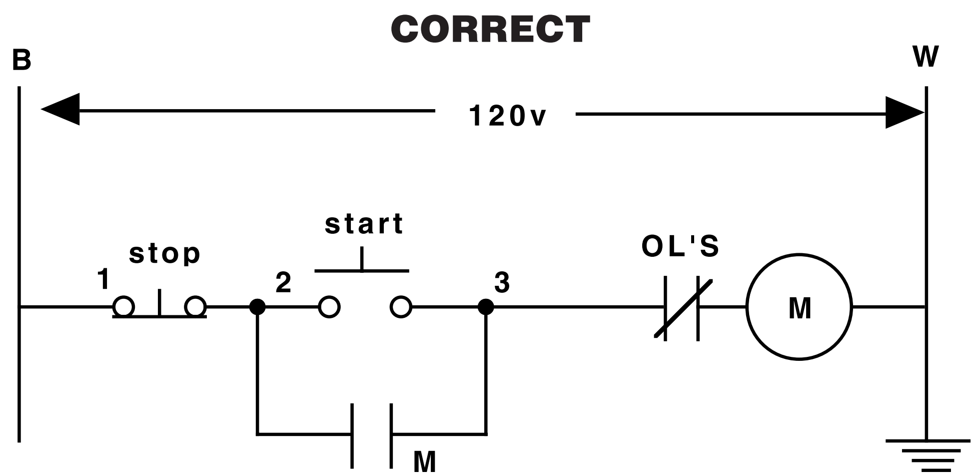
The argument is that grounding the toaster is not a good idea because if a person should touch the energized element with a metal fork and touched the grounded metal frame of the toaster at the same time, they could receive a fatal shock if it was not GFCI protected, which it is not required to be. That is the situation with any piece of equipment that is grounded.

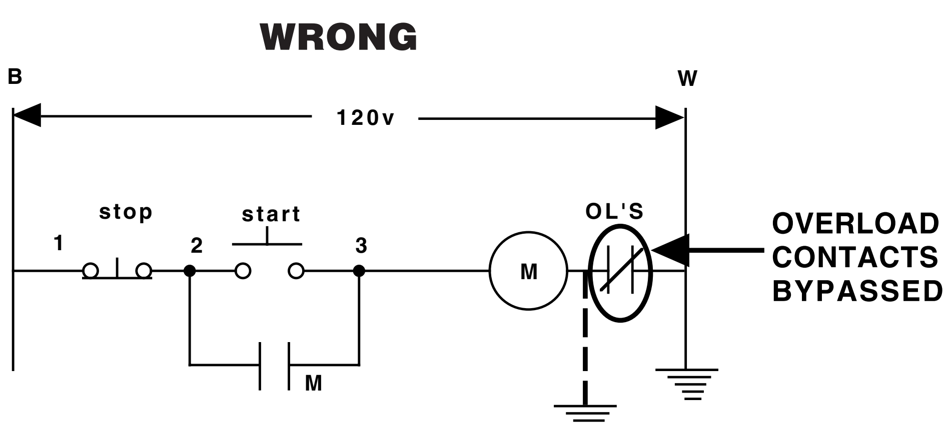
ACCIDENTAL MOTOR STARTING

Code section 430.73 states: Where one side of the motor control circuit is *grounded*, the motor control circuit shall be so arranged that an accidental ground in the control circuit will not start the motor, nor bypass any safety shutdown devices.

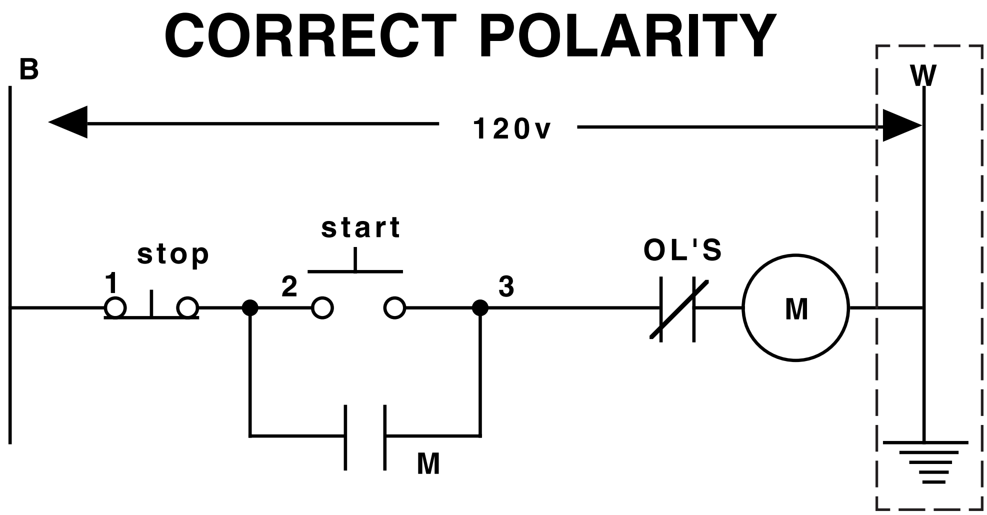
Some motors are 480 volt with 120 volt controls. If the *white wire is grounded,* certain rules must be followed in control wiring to meet the safety requirements.

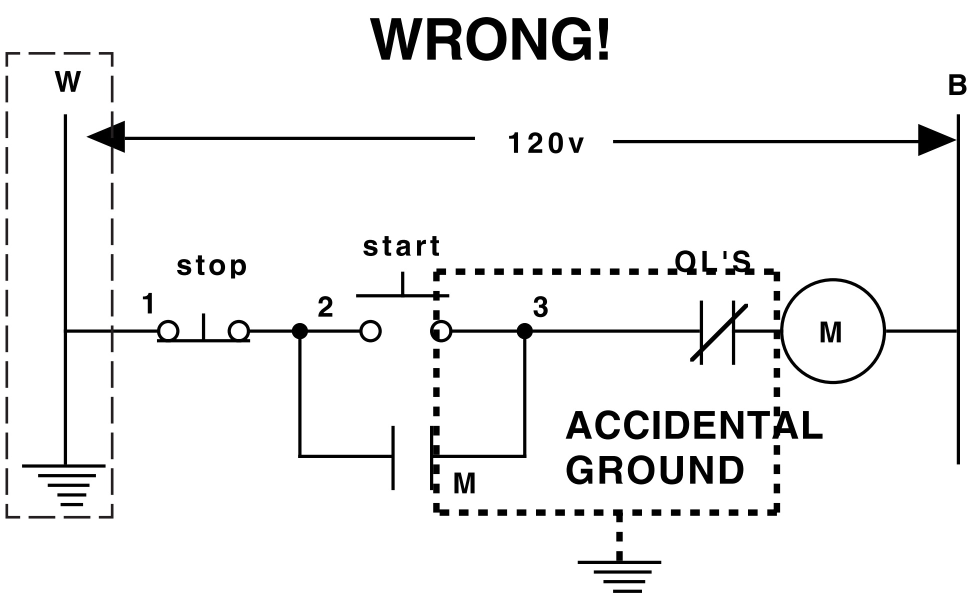
The overload contacts have been wired in series on the other side of the coil, otherwise an accidental ground could bypass the overload contacts.





If the polarity of the black and white is *reversed,* the coil can become energized by an *accidental ground* in the control wiring.





A broaching machine, tool for finishing surfaces by drawing or pushing a cutter called a broach entirely over and past the surface. A broach has a series of cutting teeth arranged in a row or rows, graduated in height from the teeth that cut first to those that cut last.

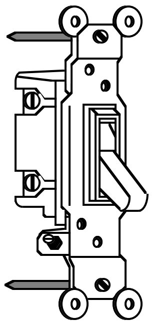

When I worked as a maintenance electrician, I was a witness to this when troubleshooting a machine that had a starting circuit go to ground and accidentally energized an air valve sending the cutters across cutting off the hand of the machine operator.

Vibration in industrial applications can cause terminated relay wires to loosen, resulting in broken or intermittent connections.

The polarity of the black and white was *reversed,* the coil can become energized by an *accidental ground* in the control wiring when the wire came loose and touched the grounded metal relay cabinet.

According to maintenance records, the machine had ran for several months okay and then one day it developed a ground energizing a relay coil with the wrong polarity.

The broach operator can no longer run the broach with the loss of his hand and for the rest of his life he can be a stock handler with the hook.



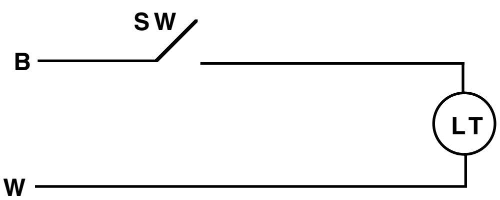
SWITCHES

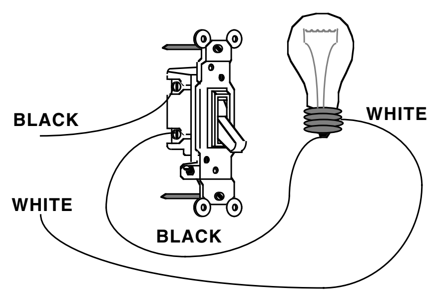
A switch is a device which is used to make and break a connection in a circuit.

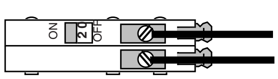
The switches we are learning about are the standard wall switches found in residential wiring. Switches can be connected various ways to change a circuit.

Switch configurations are classified by the number of poles and throws that a switch has. A pole is a make and break contact. A throw is the number of positions a switching arm can have.

The everyday wall switch you use to turn a light on from one place in the room is called a single-pole single-throw switch (SPST). It has one switched contact and one arm that either touches or is separated from the contact. The circuit is shown below in schematic and pictorial forms.

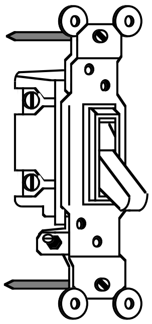






A double-pole single-throw (DPST) would be 240v circuit breaker installed by the electrician in a house. Examples are: a main, range, water heater, clothes dryer, electric heat.

DO *NOT* CONNECT THE WHITE *GROUNDED* WIRE TO A SWITCH. ALWAYS BREAK THE "HOT" WIRE THROUGH THE SWITCH



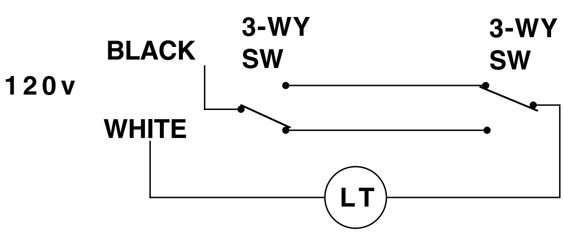
In your work as an electrician, you will hear the single-pole switch also called a *toggle* switch or a *snap* switch.

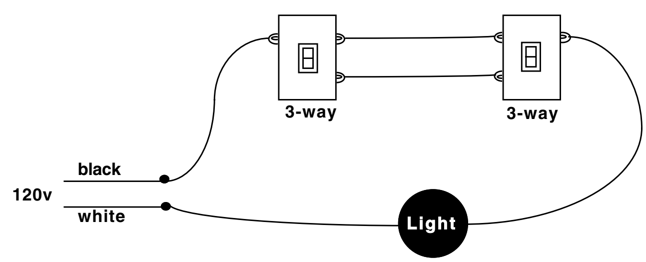
Most standard wall switches have a rating of 10 amperes at 125 volts.

Switches do not generally have a grounding terminal. However, their metal mounting bracket will be connected to ground when the mounting screws are used to secure the switch to a metal box.

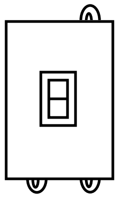
Often a light needs to be controlled by two different switch locations. Example would be a stairway where you can turn the light on or off from the top or bottom of stairway by either switch.

You would use two *3-way* switches. A 3-way switch has three terminals for wires. There is no "on" or "off" marking on a 3-way switch.

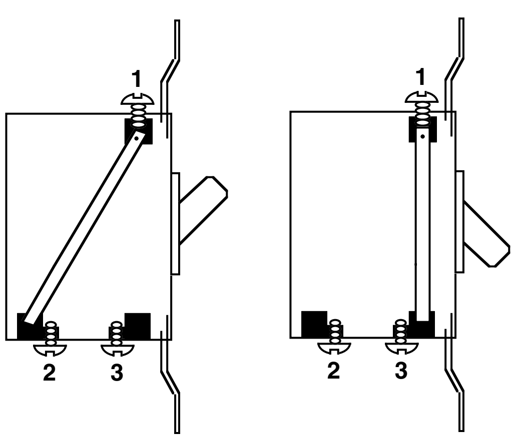




It is easier to understand how the 3-way switches can control the light if you see how the switch is built internally. Shown below is a side view of how the 3-way switch is constructed. The black wire is connected to terminal screw **1**. The view to the left shows when the toggle is turned to the "up" position, there is a *complete* circuit through terminal screws **1** and **2** and an *open* circuit between **1** and **3**. The view to the right shows that when the toggle on the same 3-way switch is turned to the "down" position, there is a *complete* circuit through terminal screws **1** and **3** and an *open* circuit between **1** and **2**.

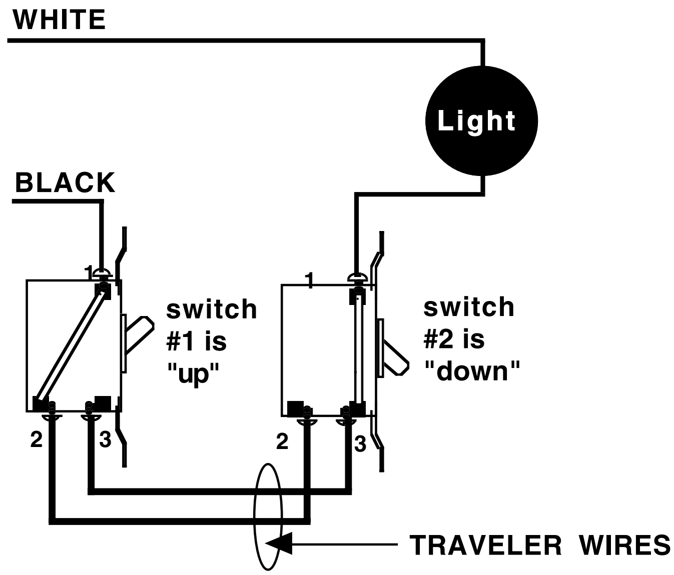


3-way

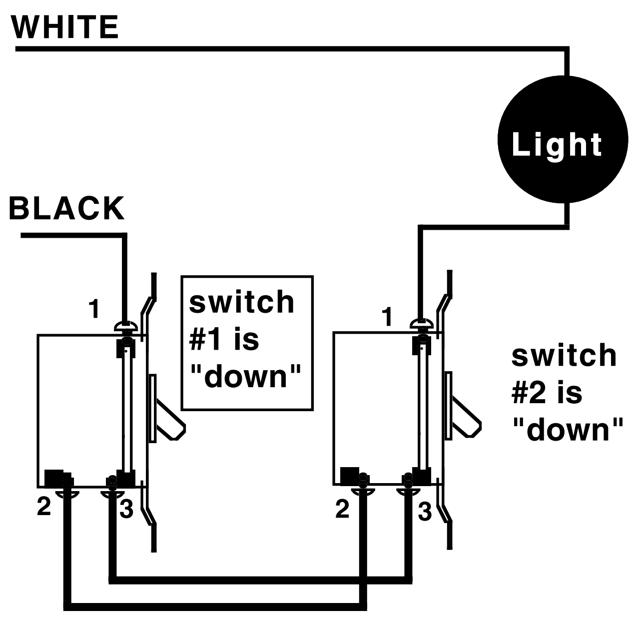


The load would *not* be energized in the circuit shown below. One wire is connected directly from the source to the load. The other wire from the source is controlled through the two 3-way switches.

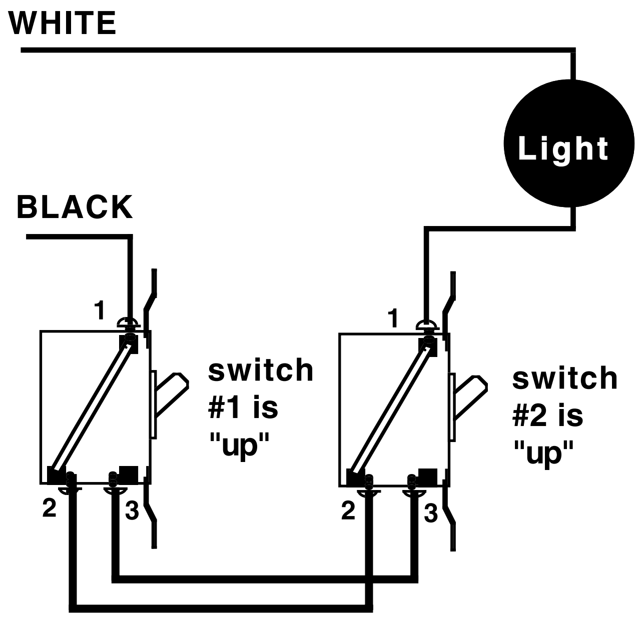
There is voltage from the source through terminal screw **1** and **2** on switch #1. The voltage continues through the wire and stops at terminal screw **2** on switch #2. There is an *open* circuit between terminal **2** and terminal **1** on switch #2. The wires between terminals 2 and 3 are called *traveler* wires.



When switching switch **#1** from "up" to the "*down*" position, the load now becomes *energized* as there is a complete circuit through terminal screws **1** and **3** on switch #1 and through terminals screws **3** and **1** on switch #2 and on to the load. By switching *either* switch #1 or switch #2, the load can be turned off.

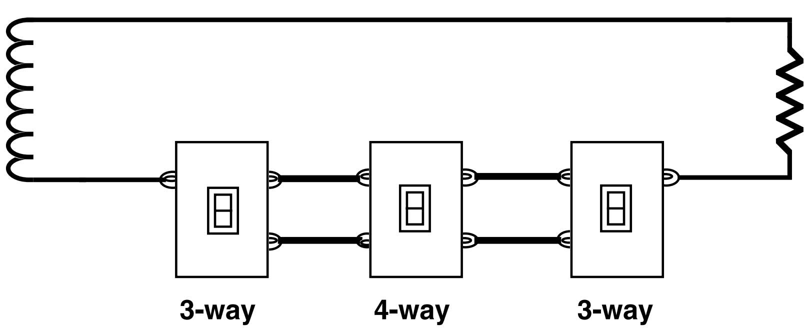


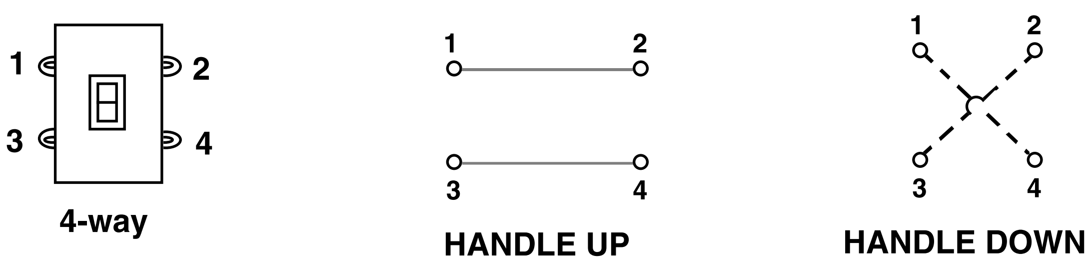
Turning both switches #1 and #2 to the "up" position will also *energize* the load as shown below. And by turning either switch, the load can be shut off.



There are different types of switches. It is important for the student to be able to trace the circuit through these different switches.

When a light is required to be switched from more than two switching points, a 4-way switch must be used in the circuit. 3-way switches are connected to the source and to the light with the 4-way switches connected in between. When connecting a 4-way switch, always wire it between the two 3-way switches. A 4-way switch has four terminals. **There is no "on" or "off" marking on a 4-way switch.**





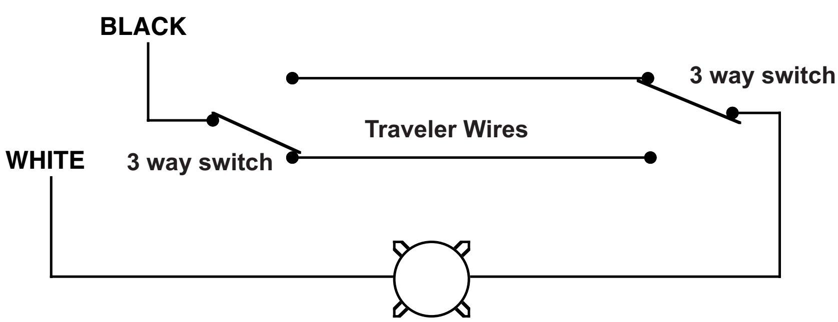
•Three way - Single pole switches, with one switch controlling one light, are marked with an "on" and "off " position. A three-way switch has no marking because there is no consistent on or off position.

A 3-way light switch allows you to control a light source from two separate points such as from both ends of a long hallway.

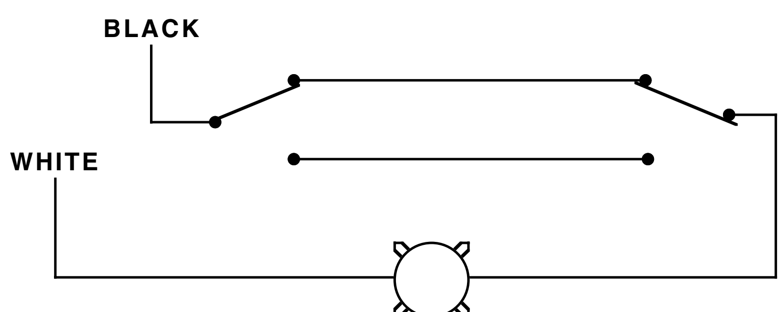
Shown below is a wiring diagram of a light connected through two 3-way switches. The light can be turned on or off from either switch.

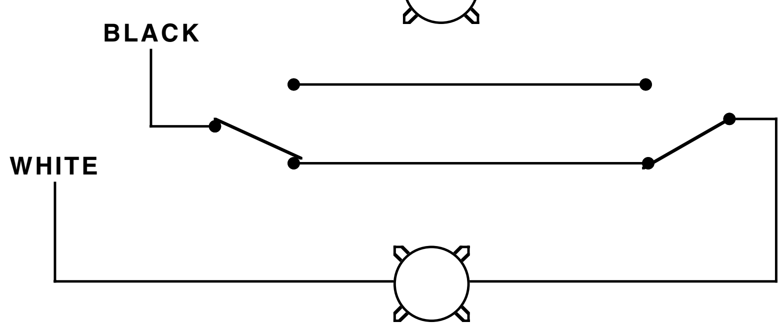
The WHITE wire is connected from the source directly to the light. The BLACK wire is connected through the switches to control the load.

The 3-way switch circuit is shown in **schematic** form. **The light is OFF**.

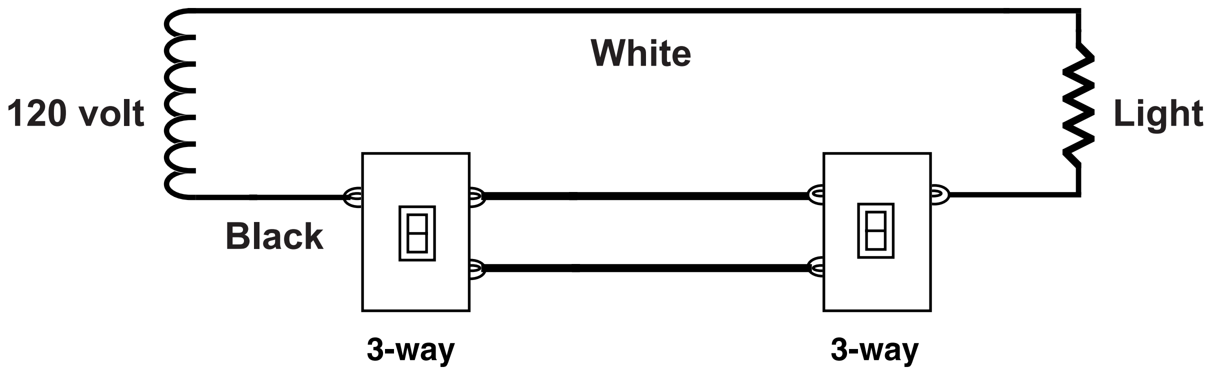


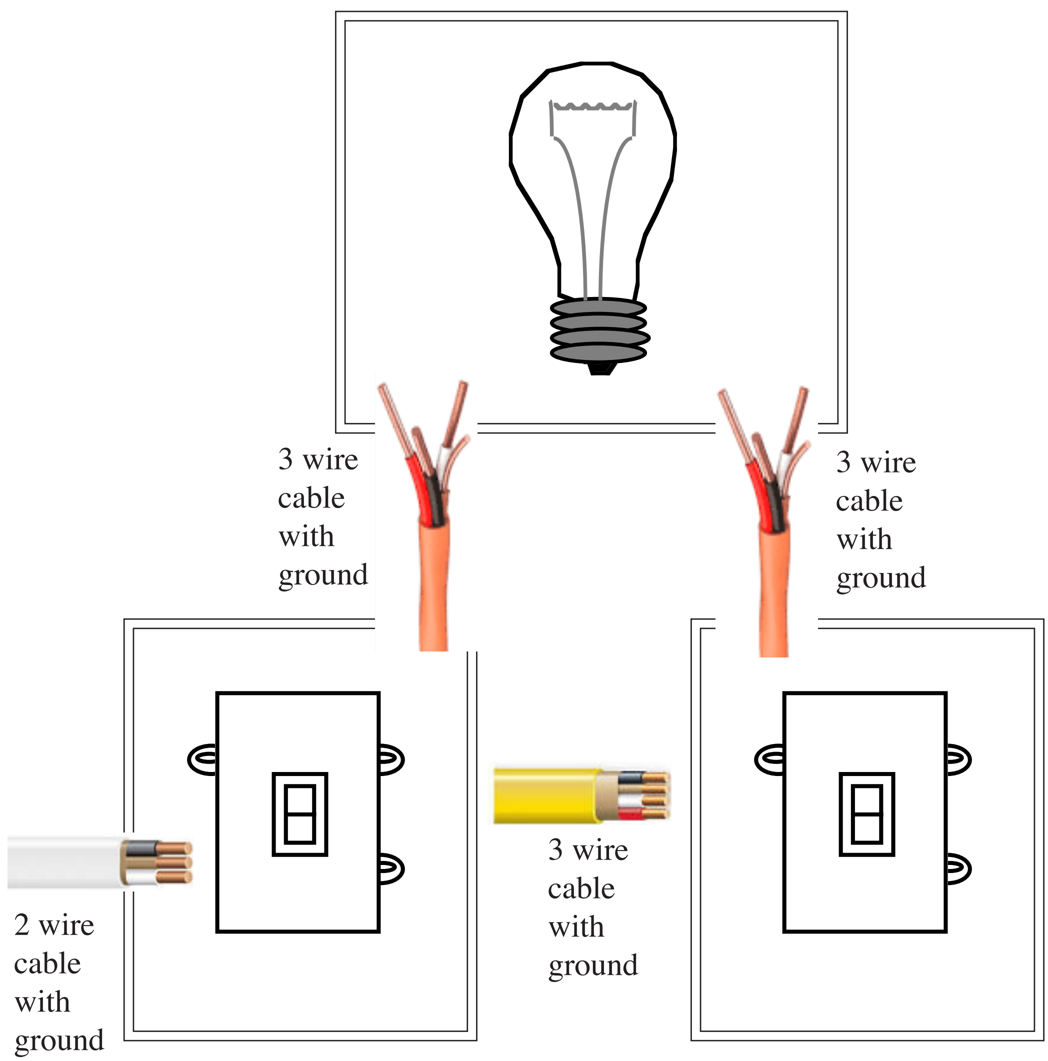
The light can be turned ON or OFF by either 3-way switch.





3-Way switch with one light

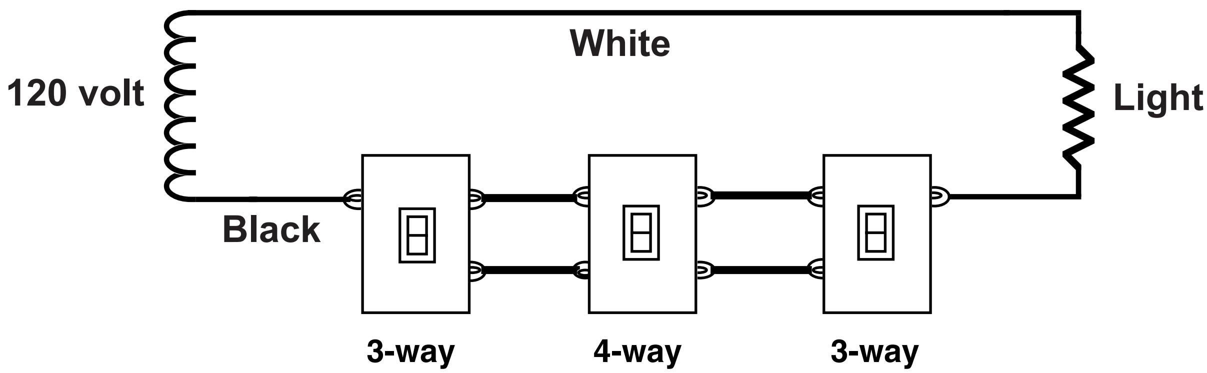




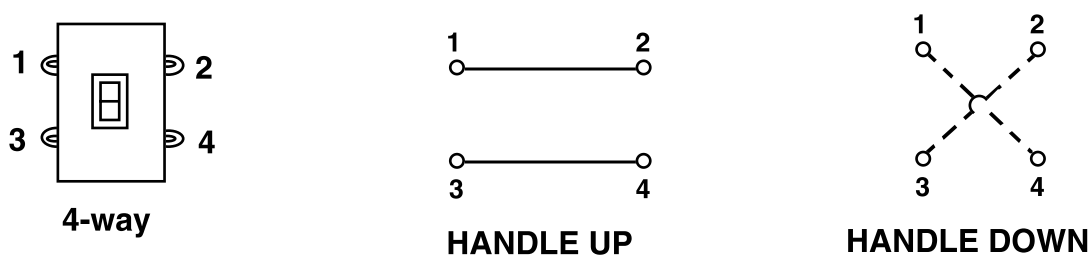
•Four way - A three-way switch has three terminals; a four-way has four. These control a light from two or three switch locations, such as at the top and bottom of a stairwell, at either end of a hallway, or in a large room with multiple entrances.

4-way switches have four terminals on them: two for traveler wires coming in, and two for traveler wires going out. The device will usually indicate which two terminals are for “incoming” and “outgoing” wires.

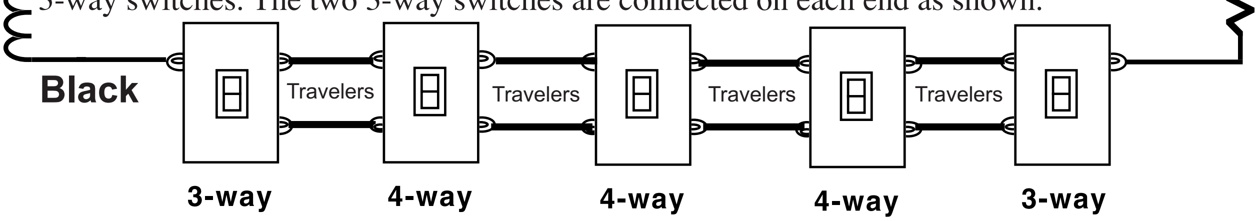
When a load is required to be switched from more than two switching points, a 4-way switch must be used in the circuit. 3-way switches are connected to the source and to the load with the 4-way switches connected in between.



Don't confuse a 4-way switch with a double-pole switch. A double-pole switch will have "on" and "off" marked on the toggle. A 4-way switch has **no** "on" or "off" markings and is constructed so that the switching contacts can alternate their positions as shown below.

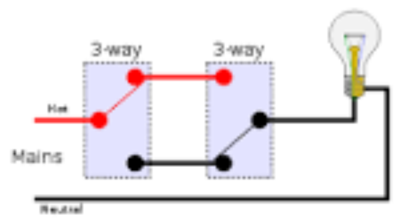


•If you want to control the light from more than 3 switches, shown below is the light controlled from 5 places. Always add the wiring to the extra 4-way switches between the two 3-way switches. The two 3-way switches are connected on each end as shown.

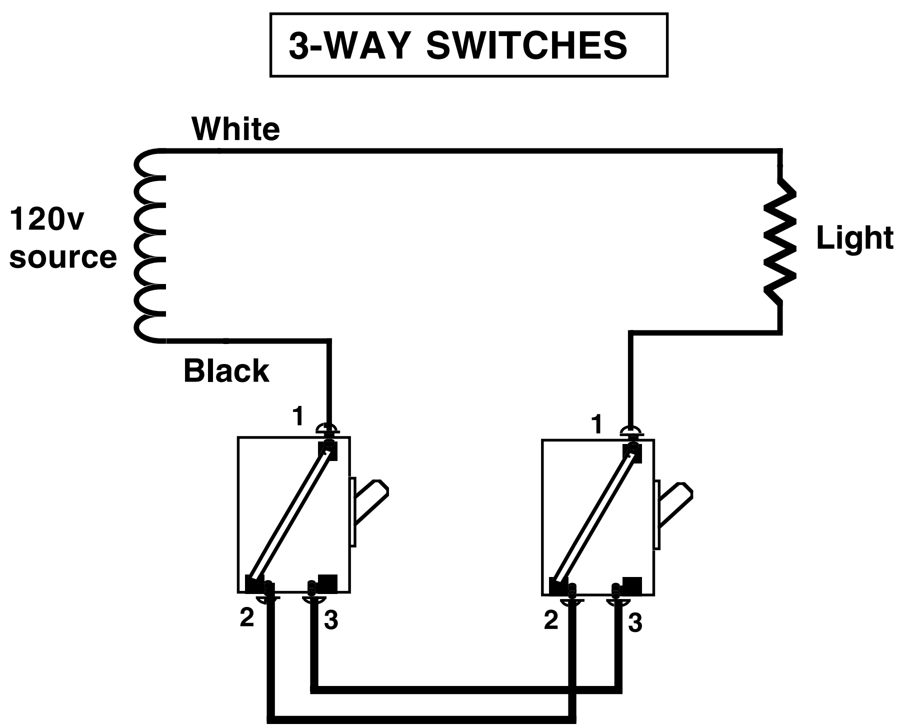


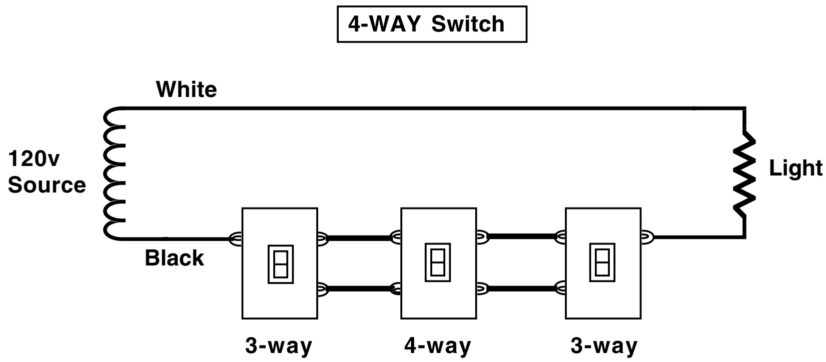
The most common household switch, a single-pole, has two terminals and simply turns power on or off. A three-way switch has three terminals; a four-way has four.

One major difference between the two-way and three-way switch is that there are no grounded wires connected between the three-way switches. While on the other hand there are two grounded white wires connected between two **2-way** switches. (grounding)



A four-way switch is similar to a three-way, except it has four terminals (plus a ground terminal) and controls one fixture from three locations. This type of switch must be combined between two three-way switches to form a circuit. While more uncommon, this is a good option for large rooms with several entrances.





Four-way switches are used to control lighting from three or more locations. Four-way switches are used in combination with 3-way switches. There are four terminals that provide two sets of toggle positions on a 4-way switch.

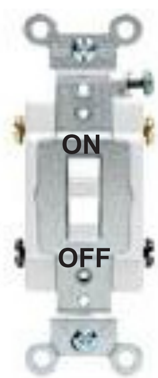
Remember, four-way switches only work if they're installed in the circuit in between two three-way switches. You can have as many intervening four-way switches as you chose.

What Is A Pole?

The pole of a switch refers to the number of separate circuits that the switch can control. Single pole switches control just one circuit whereas a double pole switch can control two circuits. So a double pole switch is almost like having two single pole switches, controlled by the same switch.

A double pole single throw switch controls two circuits (poles) and has 2 states an "on" (closed) state and an "off" (open) state.

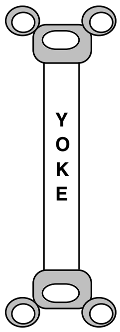
4-WAY



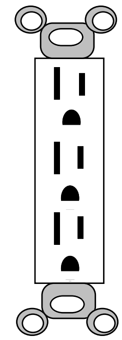
DOUBLE POLE

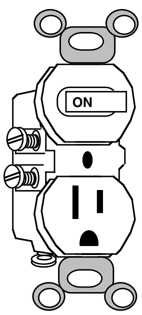
Dimmer Switches

COMBINATION DEVICES

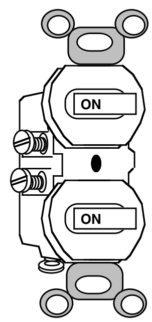


The mounting strap, known as the "yoke" may contain a single-pole switch, a single receptacle, a duplex receptacle, a tri-plex receptacle or *combinations* of a switch and a receptacle.





The switch can be wired to control the receptacle in the same box, or the switch can be used to control a light and the receptacle is wired hot.

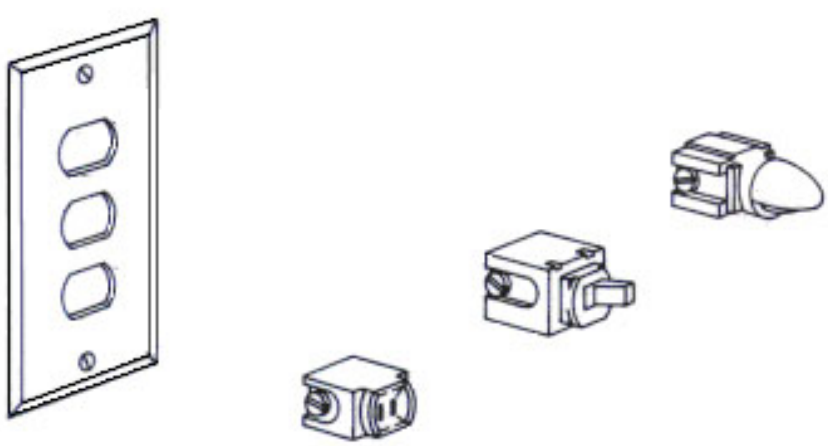


DESPARD DEVICES

A *despard-type* device is small in size as up to *three* may be mounted in a standard device box. They are easily mounted in the same strap, and then the strap is mounted to the device box.

The three devices may include three switches, a switch and two receptacles, a pilot light with a switch and receptacle, etc. The pilot light would be considered a load and not a device.

Despard switches can be purchased in single-pole, three-way or four-way.



DESPARD DEVICES

•Note: When adding despard devices to an existing box for an additional circuit, you may be in violation of box fill cubic inch capacity.

Despard interchangeable electrical connections (most by Pass & Seymour) were used in the mid 1900's – primarily 1930 – 1970. You can still purchase them today but it is hard to find the vintage colors and designs. Since the pieces all go together, you will see both plates and devices mixed together for ease of viewing.