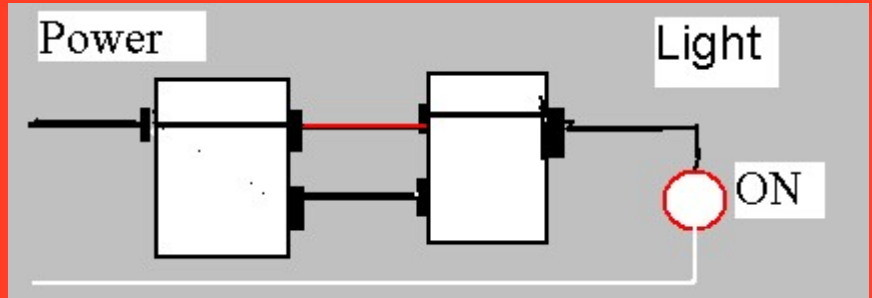


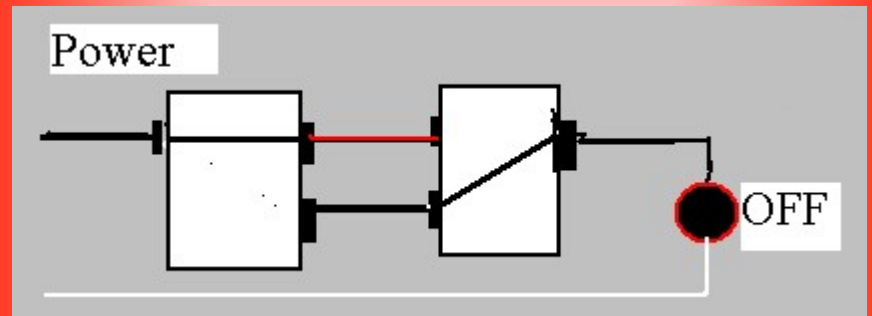
3 WAY SWITCHES ...

"HOW THEY WORK"

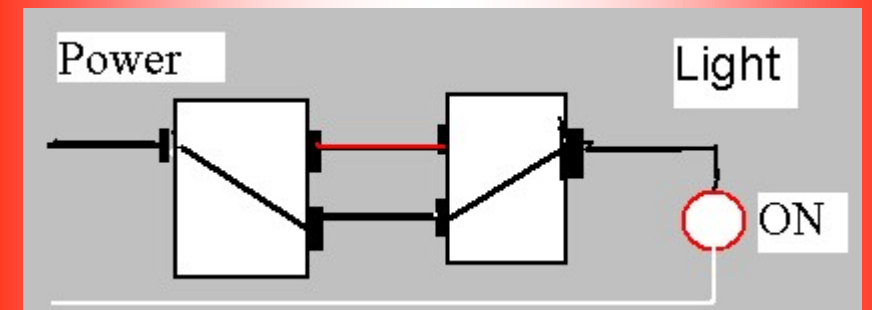
ON ...



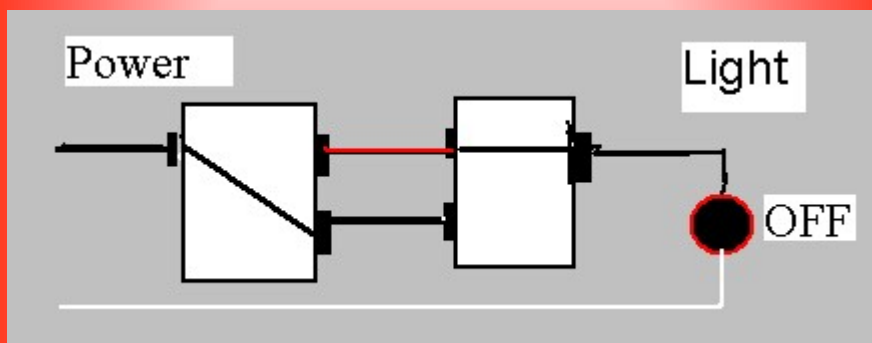
OFF ...



ON ...



OFF ...

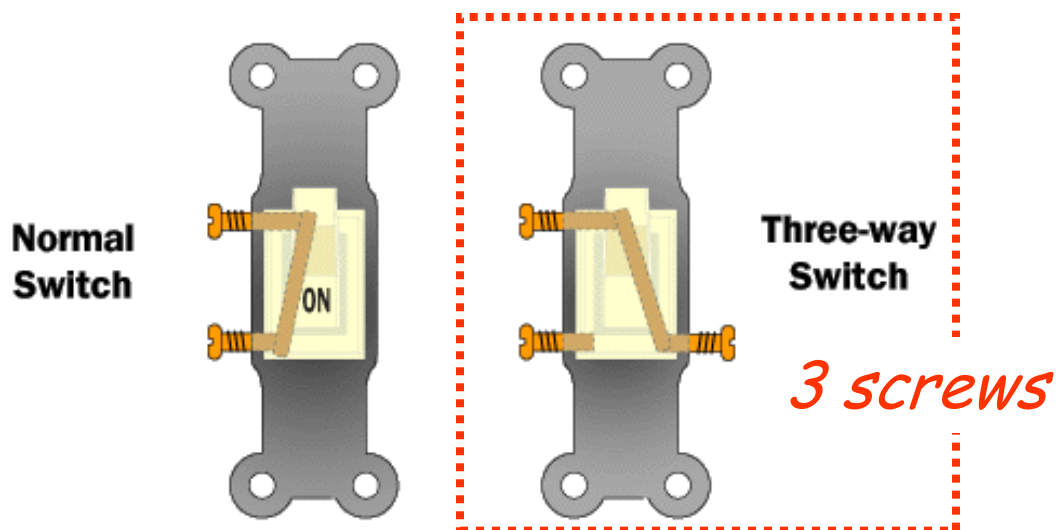


Three-Way Lights

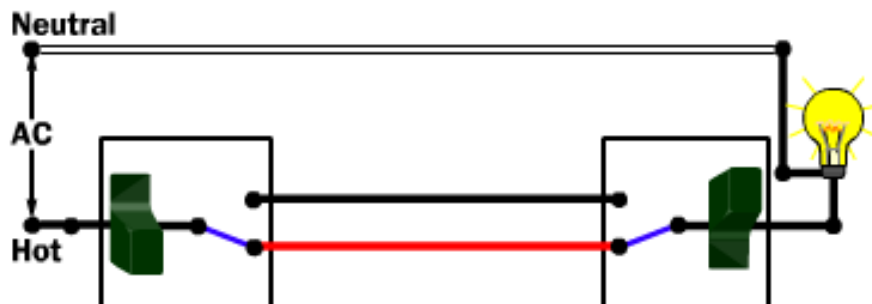
To create lights that operate with two separate switches, the electrician uses two special pieces of equipment in the circuit:

- Special switches known as **three-way switches**
- Special Romex wire that has an extra red insulated wire along with the black and white wires within the sheath

A normal switch has two terminals that are either connected or disconnected. A three-way switch has **three terminals**, and the switch connects the first terminal to either the second or the third terminal, as shown here:



You use two three-way switches to control the light, and wire it up as shown below:



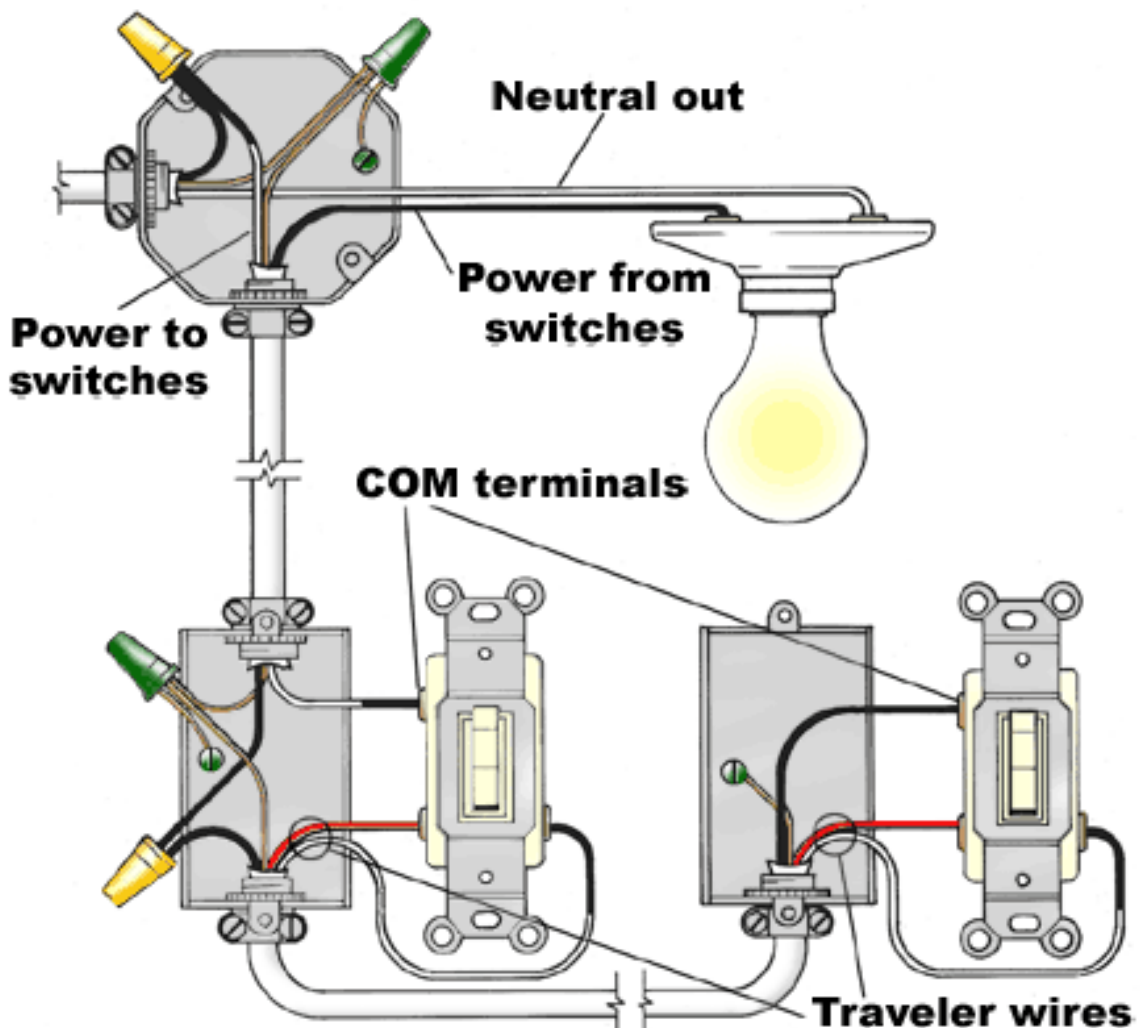
In this diagram, a normal piece of Romex comes from the fuse panel to the first three-way switch. The black "hot" wire enters the switch on the left. Three-way Romex (which includes red, black and white wires) runs from the switch on the left to the switch on the right, with the white wire carrying ground and the red and black wires carrying the output from terminals in the left switch. Normal Romex runs from the right switch to the light.

Three-Way Lights

Miscellaneous

Remember three things:

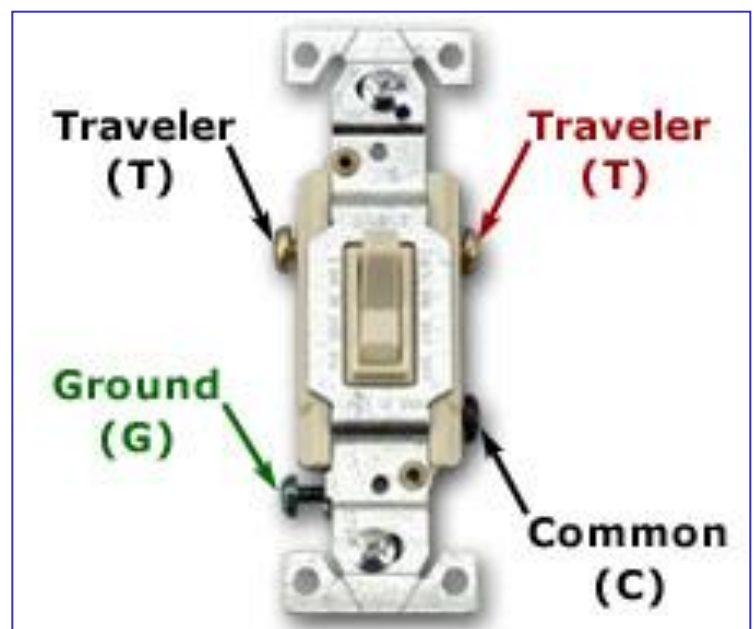
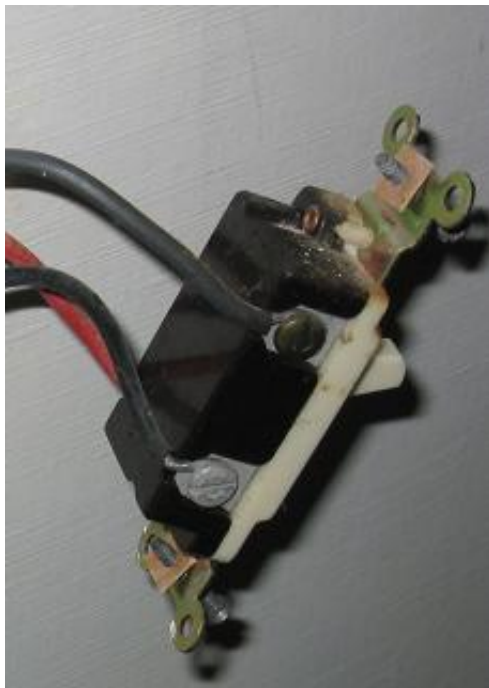
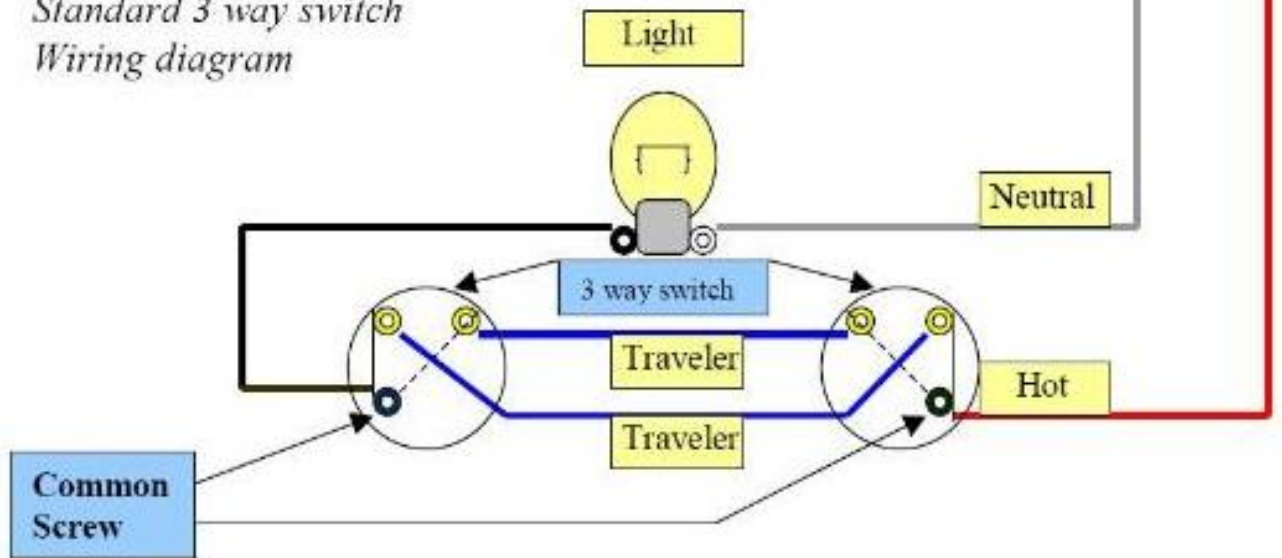
- The two travelers will always be in the same cable with each other.
- The only wire in a 3-and/or/4-way system that is hot all the time when all the wires at the switches are disconnected is the hot (which is to attach to the "common" terminal of a 3-way switch).
- The pair of switch screws that are the same color as each other are for a traveler pair.



The Basics – Understanding how a 3 way switch works.

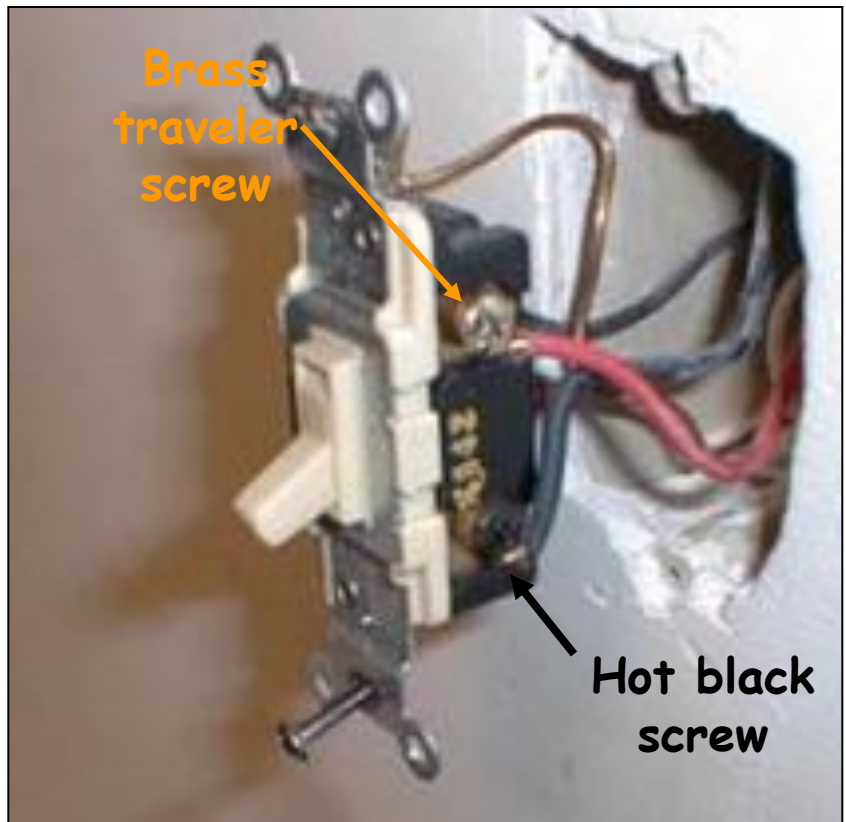
Standard 3 way switch

Wiring diagram



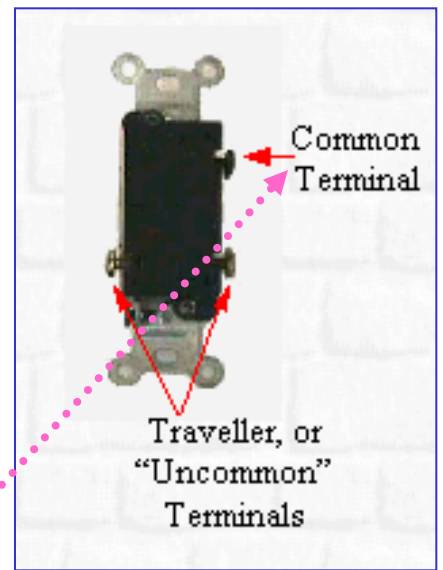
View of a 3-way switch.

Note the different colored screws.

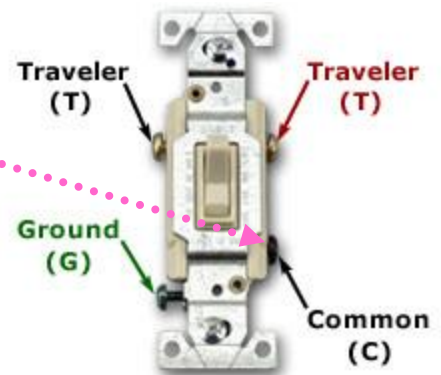


- The top one is brass and the bottom one is black. The other two screws you can't see are brass and green.
- The continuous hot wire and/or the wire that goes to the light connect to the black screw.
- The ground wire connects to the green screw and the travelers connect to the two brass screws.

The heart of a 3-way circuit is the 3-way switch. The 3-way switch has three active terminals (plus a ground in up-to-date installations). Only one is important to identify for the purposes of replacement... the **COMMON TERMINAL**.



Picture shows the **COMMON TERMINAL** in a certain position, it could be any terminal on your individual switch.



The **COMMON TERMINAL** is the "bridge" between the power supply and the load (typically a light fixture) ...the wire that attaches to the common terminal is either (1) a hot wire from the main board or (2) leads to the load (fixture).

TRAVELLERS are two wires connecting the two 3-way switches. Referring to the picture, the two traveler terminals on one 3-way switch are connected to the two traveler terminals on the other 3-way switch by the two traveler wires. **Either traveler wire can be connected to either traveler terminal... it doesn't matter!**

Wire Colors in a 3-way Switch System

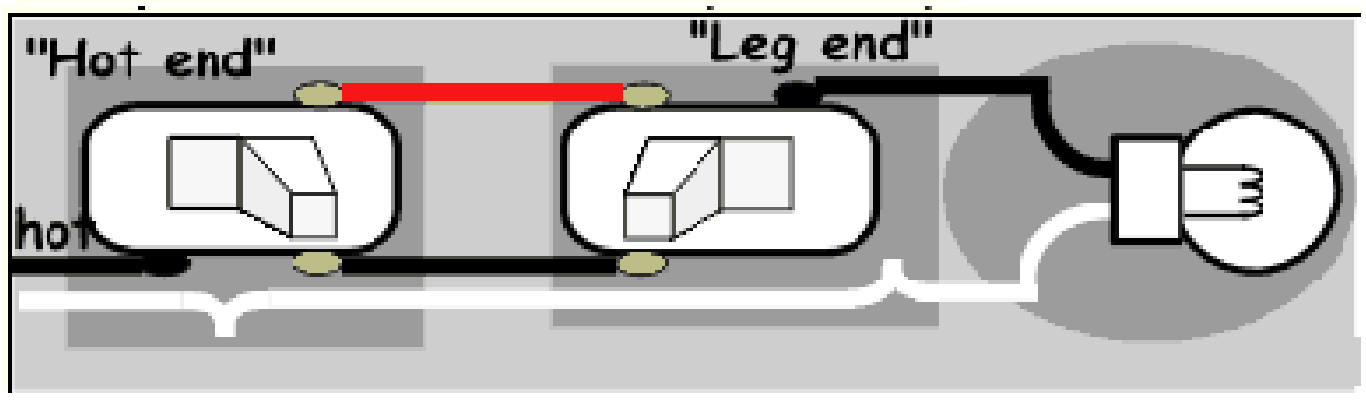
The hot wire at the common terminal at the hot end will be black or (rarely) red or white;

the light-leg wire at the common terminal of the last (leg end) switch will be black or red.

Each traveler pair is contained in one cable, and will be either black and white or black and red, or red and white.

Most other white wires present in these switch location boxes are neutrals that are connected to each other and not to any of the switch terminals.

(Any bare or green wires are grounding wires connected to each other; if the switch has an additional green screw, to meet code a bare piece should be run to it from all the grounds).

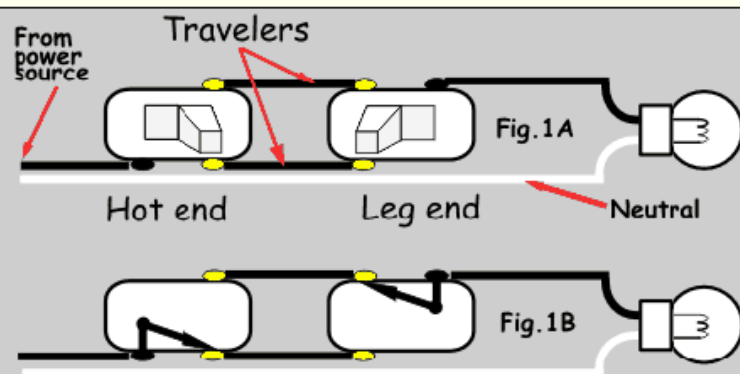


Generic 3-way Diagram

Here you see a diagram of the layout of 3 way switch wiring and of what goes on inside the switches. In your mind, play with pivoting the contacts differently

3-way Switches

Figure 1A shows hot and neutral entering from left. Since a neutral is not switched, switching of the hot will determine whether the circuit to run the light will be completed or not. Fig. 1B shows what is going on inside these same switches. You can see that there is no path for the hot to get through. The switch mechanism can pivot the "arrow" over to the other yellow terminal. Notice that flipping either switch will let hotness through.

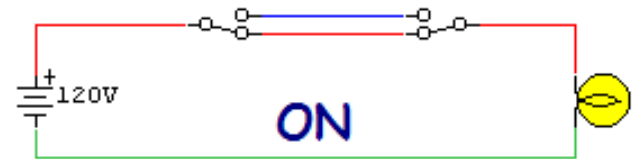
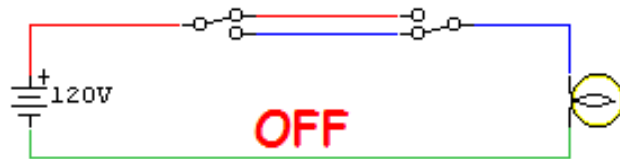
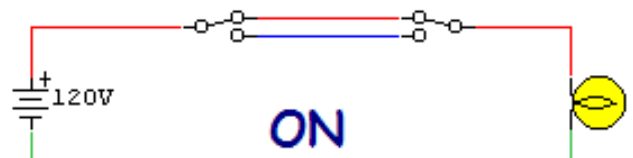
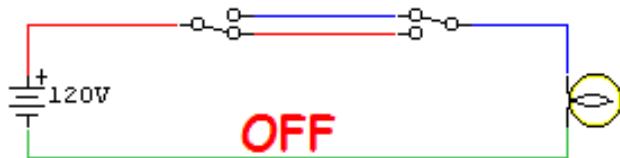


© 2006 Larry Dimock

and notice that either switch is able to override what the other one did last.

How 3-Way Switches Function:

Here is a typical circuit in its
4 possible stages ...



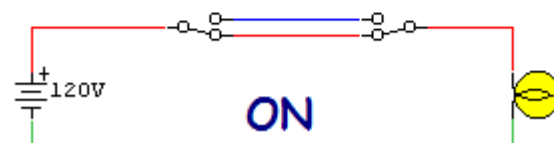
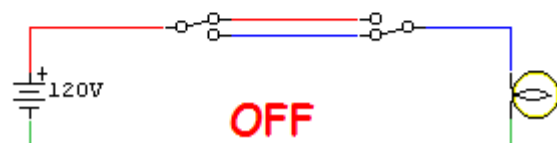
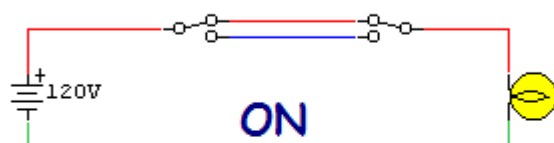
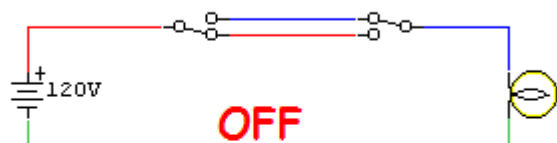
- The switches must create a complete circuit for current to flow and the bulb to light.
- When both switches are up, the circuit is complete (top right).
- When both switches are down, the circuit is complete (bottom right).
- If one switch is up and one is down, the current reaches a dead end, no current flows and the bulb is off (top left and bottom left).

Note that the above color scheme does NOT reflect wire color. It is functional coloring intended to illustrate the voltage state of each wire segment.

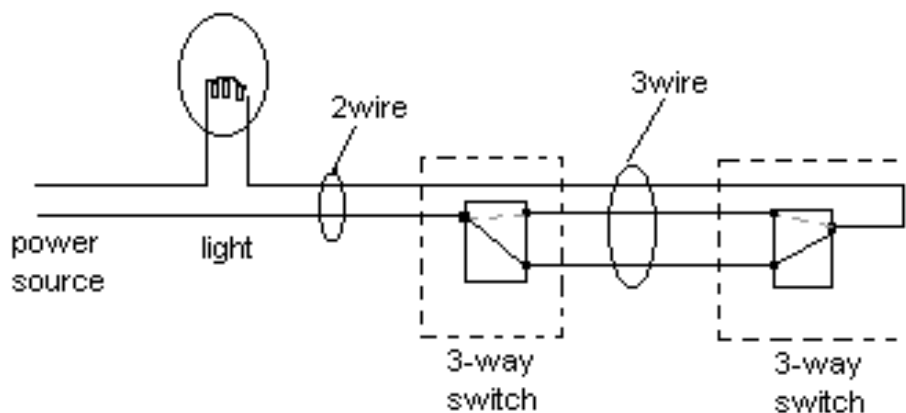
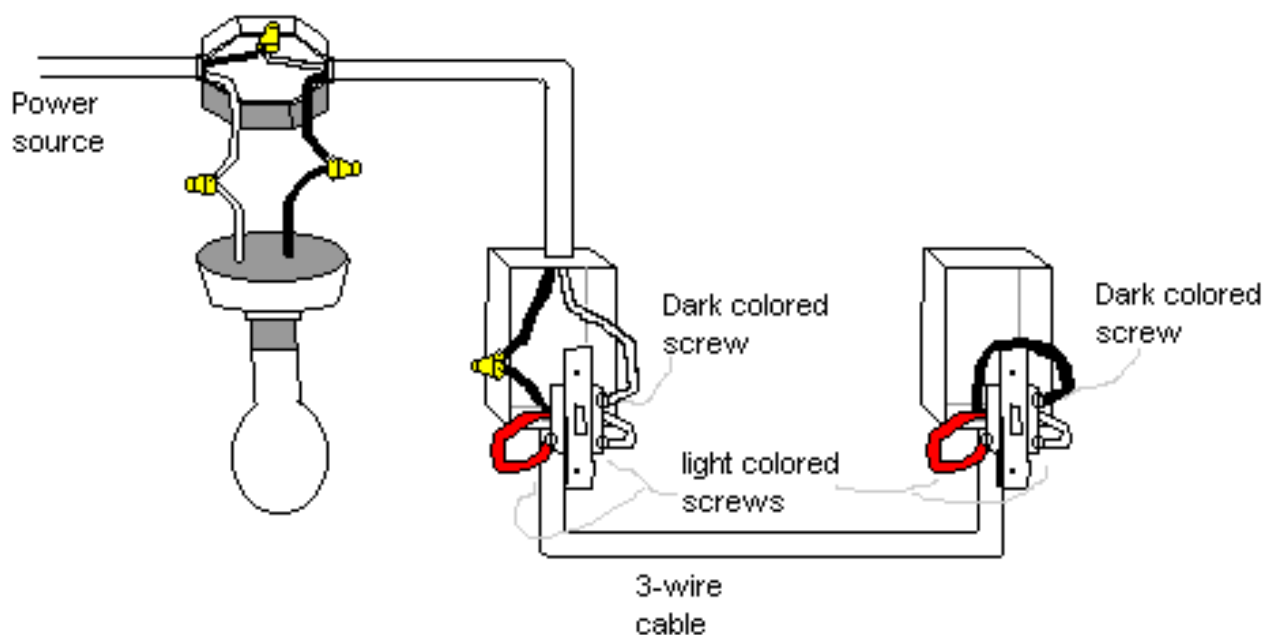
- **Red** indicates a hot wire (120 volts ac).
- **Green** indicates a neutral wire at ground potential.
- **Blue** indicates a wire that is floating. "Floating" here means isolated from hot and neutral by switches and/or light bulbs.

How 3-Way Switches Function:

Here is a typical circuit in its 4 possible stages ...



Typical 3-Way Setup ...

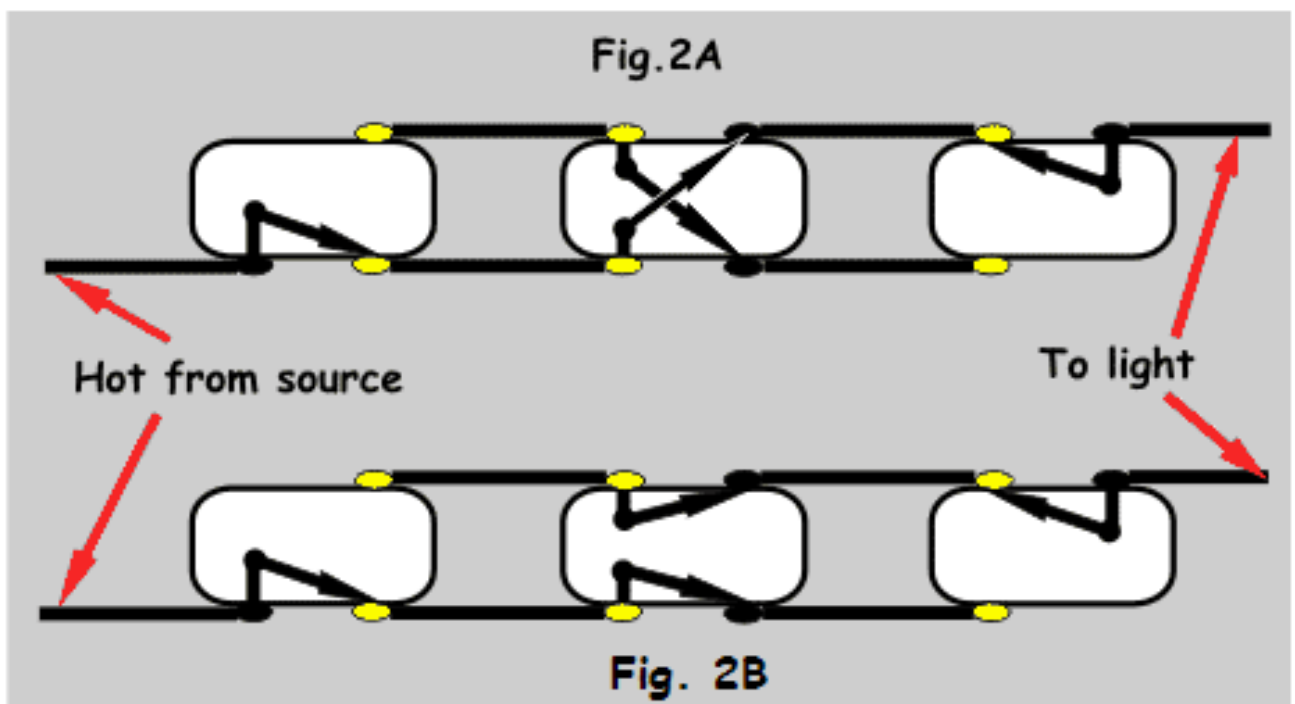


Moving on to

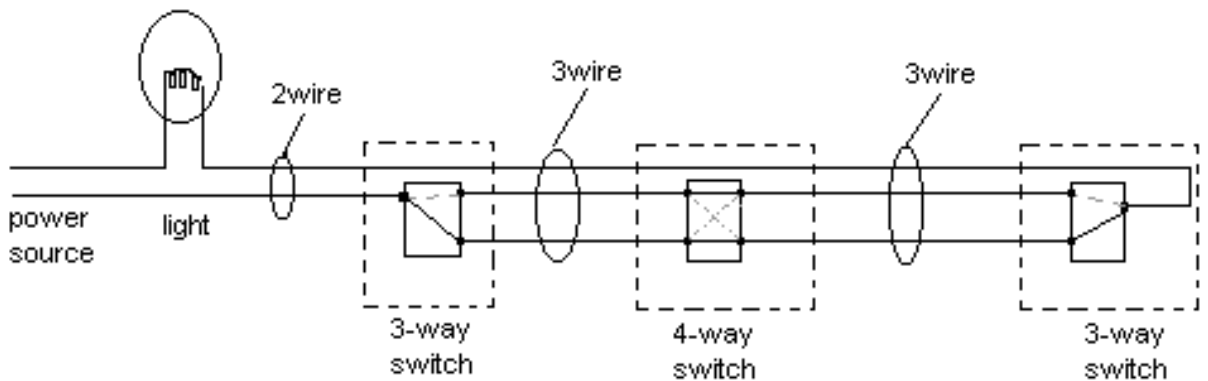
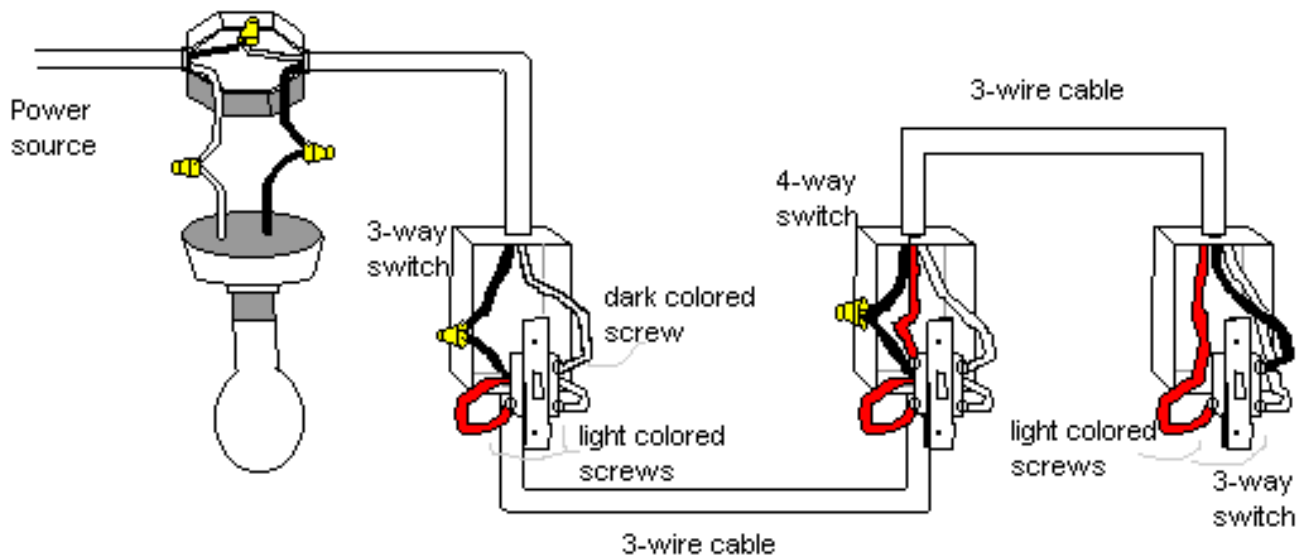
4-Way Switches

When more than two switches control a light, the additional ones must have four terminals, and their mechanism must relate the incoming traveler-pair to the outgoing pair in the two ways shown in Fig. 2A&2B -- crossed or straight through.

Fig. 2A would complete the path through the light, but in Fig. 2B the path would be disrupted.



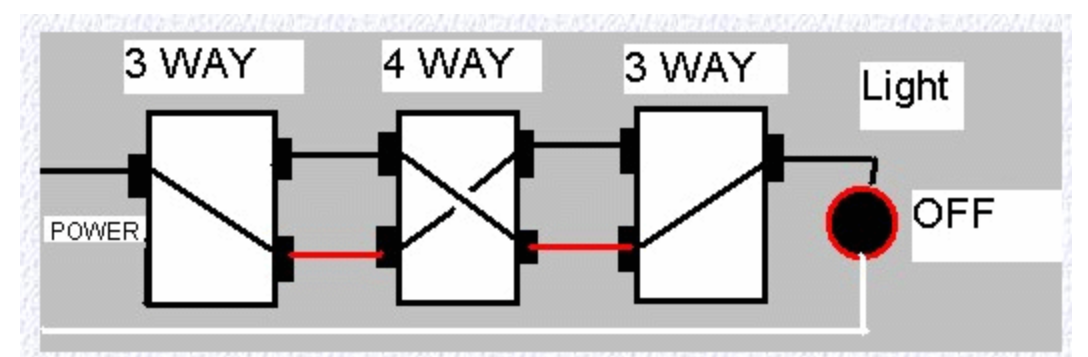
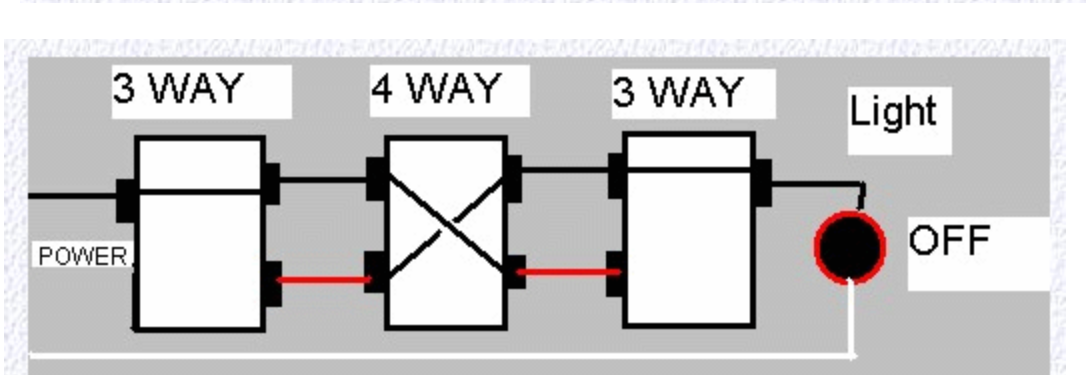
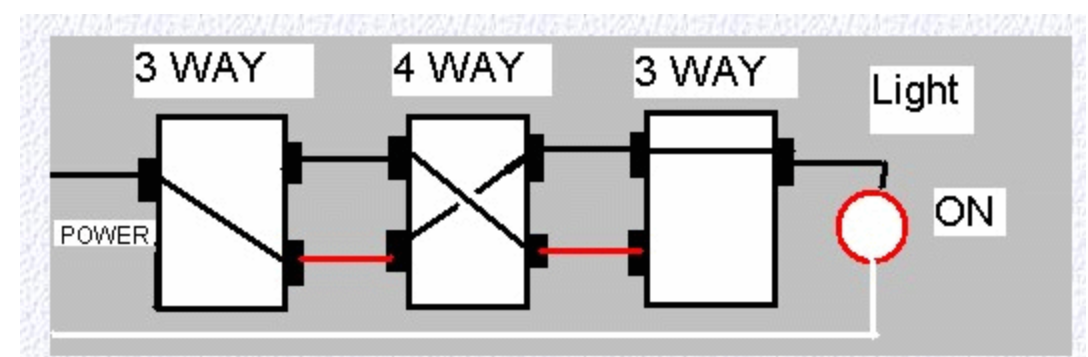
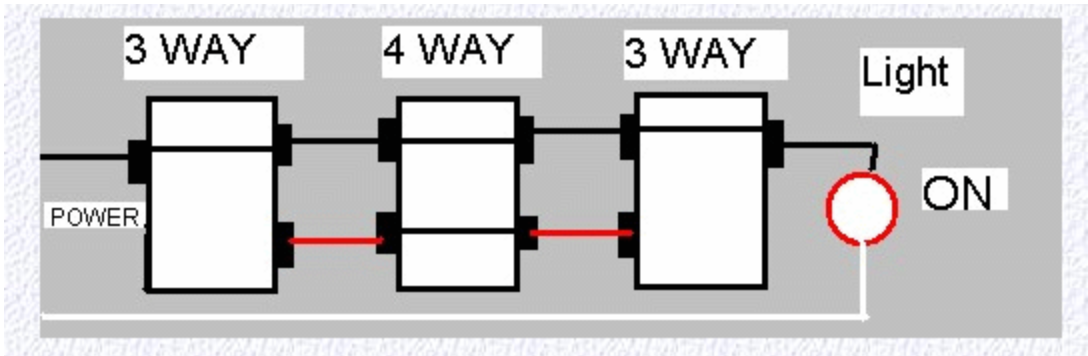
4-Way Switch



4-way switch wiring ... need two 3-way switches (one at each end) and then as many 4-way switches as you want in between. 2 wire cable runs from the light to the first switch, and then 3 wire is run between all the switches.

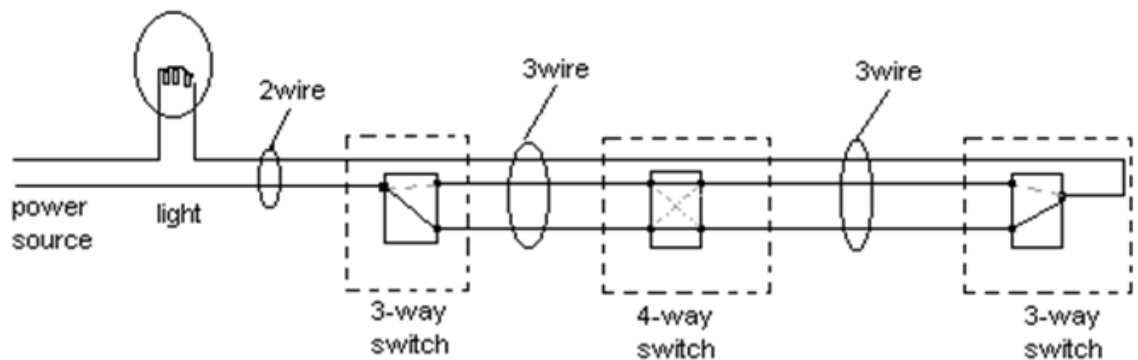
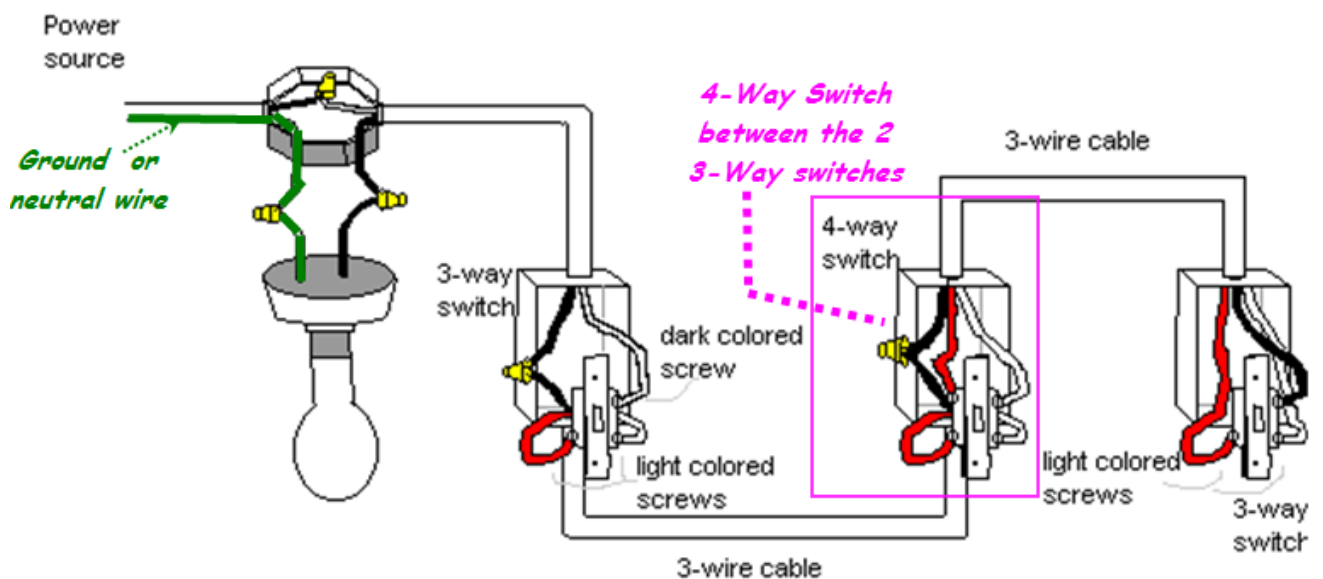
One 4-WAY SWITCH & Two 3-WAY SWITCHES

(Total of 3 switches controlling same fixture)



How 4-Way Switch Function: More

4-Way Switch



Wiring at the 4-Way Switch ...

With any 4 way switch circuit , a 3 way switch must start and end it, you may have as many 4 way switches between 3 way switch (1st) and 3 way switch (last).

One 3 way switch MUST have the circuit power supply ungrounded conductor (aka hot) attached to its common screw, and the at the other end of the switch circuit another 3 way switch must have the switched fixture feed (ungrounded conductor {aka hot}) attached to its common screw.

The common screw of a 3way switch is the odd color screw. If you look at each of the main connection screws on a 3 way switch you should have no problem in determining that one of the screws is distinctly different in color or one screw is darker than the others. That one screw that stands out from the other 2 is the common screw connection.

The correct wire must be connected to the common screw of the 3 way switch, or the switch circuit will not operate properly. Of the remaining 2 wires that connect to a 3 way switch, it doesn't matter which of the remaining 2 wires connect to which of the remaining 2 screws, as long as one goes on each of the remaining screws.

Wiring at the 4-Way Switch ...

Continued

On 4 way switches there is no common screw as such, but there are matching pairs. you will find that of the 4 main connection screws on a 4 way switch, 2 screws will match, and there will be another 2 screws that match, one set will be distinctly different in color or darkness than the other pair.

Now the matching pair could be on one side of the switch and the other pair could be on the other side of the switch, OR it could be that the matching pair be on the top left and right and the other matching pair could be on the bottom left and right.

Now when wiring the traveler wires between switches, make certain that when connecting to the 4 way switch that the 2 wires coming from the previous switch connect to a matching pair of screws on the 4 way switch, and the other matching pair of screws on the 4 way switch connect to the 2 wires leading to the next switch, otherwise the switch circuit will not operate properly.

New wiring tool

HOW TO USE THE SWITCH WIZARD - INSTRUCTIONS -

FIRST TURN OFF THE POWER.... Every 3-way switch circuit will have **two 3-way switches**. If there are more than two switches in the circuit then the others are **4-way switches**. There will be three wires connected to each 3-way switch and four wires connected to each 4-way switch. Depending on the age of your home there may also be a bare or green ground wire connected to a green screw on the switch.

You will not see all black wires connected to your switches as in the below examples and we have done this to illustrate that you can not go by the color of the wire or the physical location of the terminals on 3-way switches. There will be more than one cable also. Don't worry about the color of insulation on the wire right now, we will deal with that later.

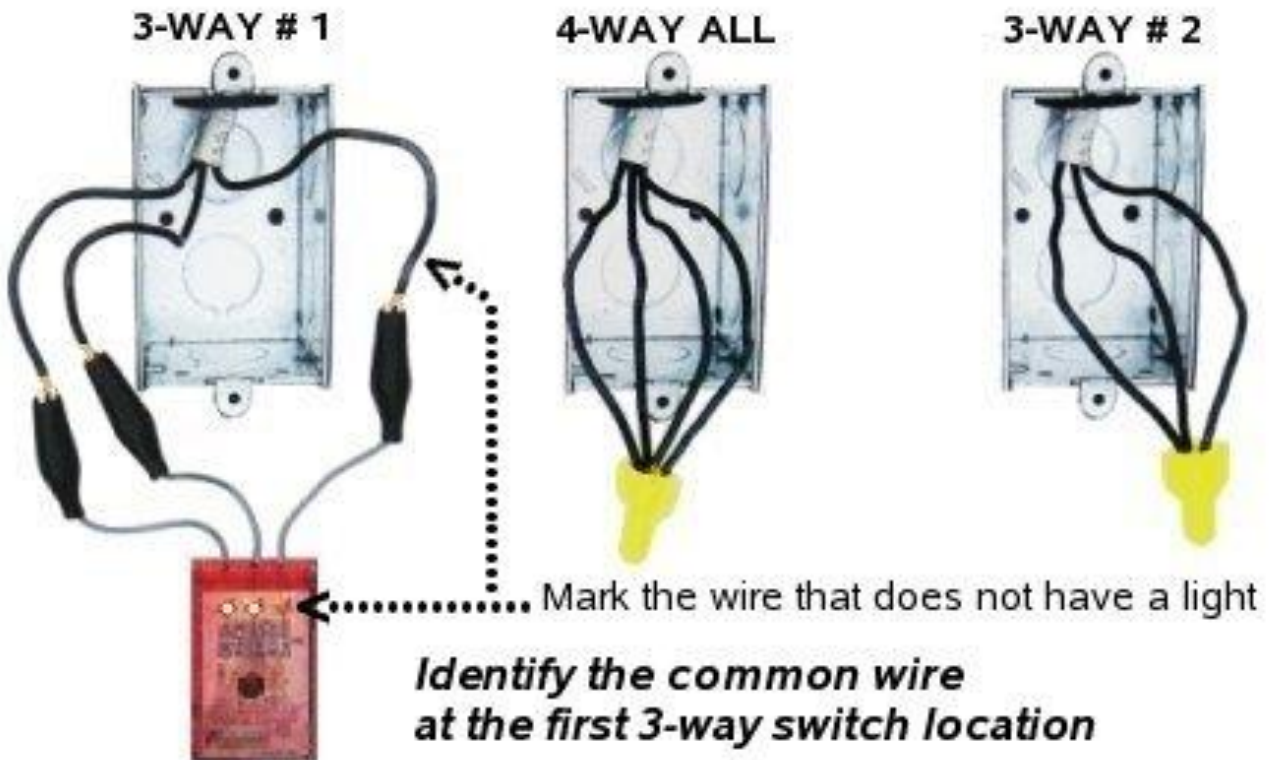
The switch wizard doesn't care, the switches don't care, and right now I don't think you do either, lets just solve your wiring problem.



HOW TO USE THE SWITCH WIZARD - INSTRUCTIONS - continued

STEP 1:

Remove **all** the switches that are for the light that is not working. You don't need to remember which wire was on which terminal. The green or bare ground wire, if there is one, is not used in any of the wiring tests and should not be connected to any of the other wires. It is therefore not shown in the examples.

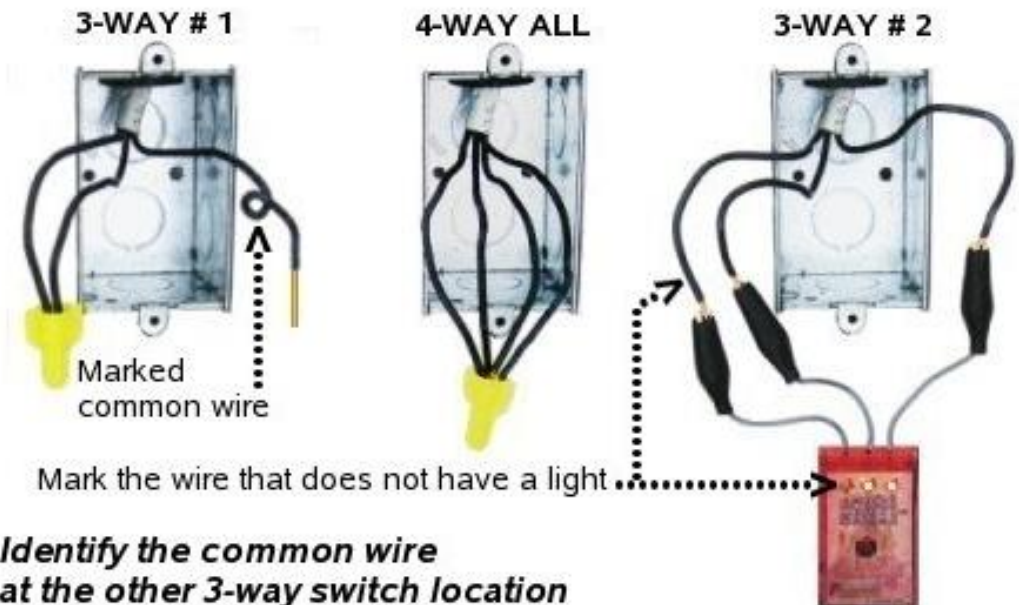


HOW TO USE THE SWITCH WIZARD - INSTRUCTIONS - continued

STEP 2:

At one of the 3-way switch locations connect the three switch wires together, as in (3 way # 2) of previous example. If there are any 4 way switches connect the four wires together at all the 4way switch locations as in (4 way all) example previous. At the other 3-way switch location connect the 3 tester leads to the three switch wires, it does not matter which lead goes to which wire. Press the button on the tester and two LEDs will light. Mark the wire connected to the tester lead that **does not** have a light as in (3 way #1) example previous. Use a piece of tape, bubble gum or whatever, I prefer to just put a loop in it. **Connect the remaining two wires back together** as in (3 way # 1) example below.

* If only the left LED lights then you do not have all the wires at the other switches connected together good.

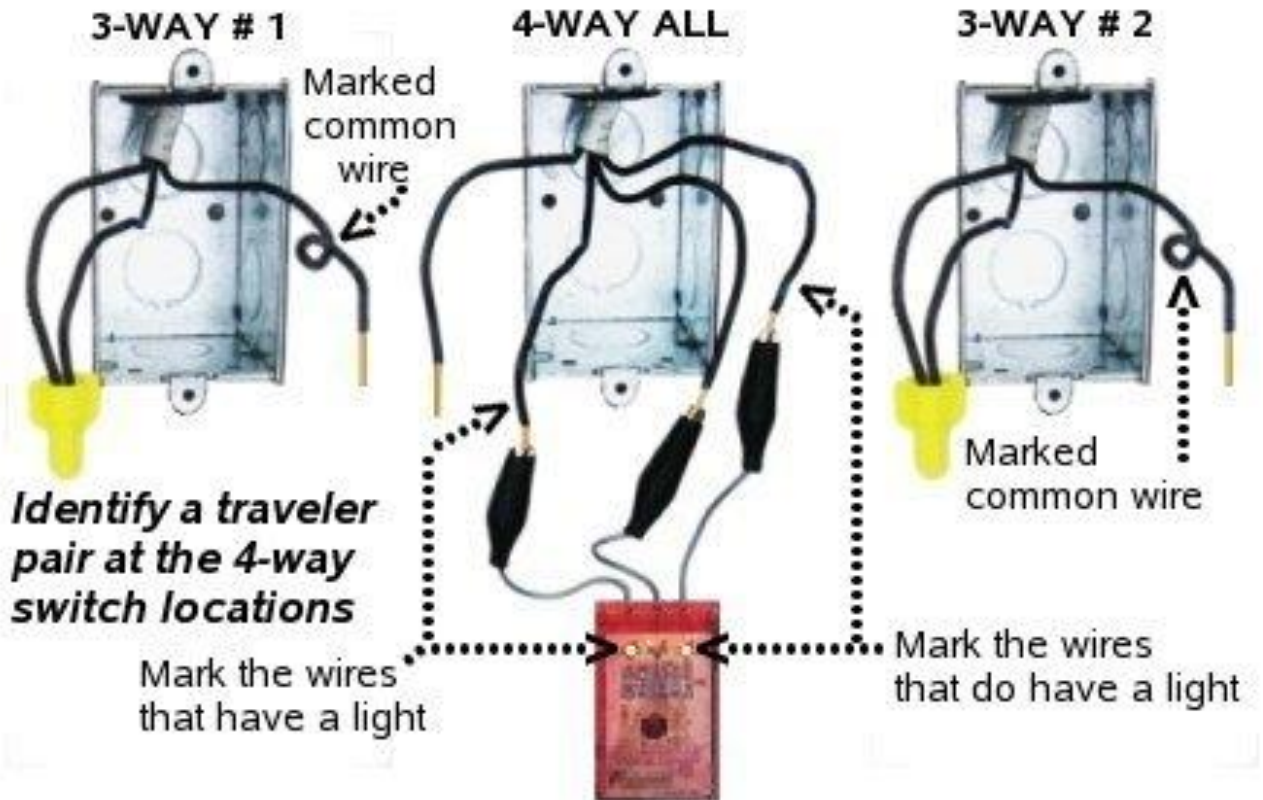


HOW TO USE THE SWITCH WIZARD - INSTRUCTIONS - continued

STEP 3:

Go to the other 3-way switch location and connect the three tester leads to the three switch wires. Push the button on the tester and mark the wire connected to the tester lead that **does not** have a light.

* You must have the two unmarked wires at the other 3-way connected together. If there are not any 4 way switches skip to step 5



HOW TO USE THE SWITCH WIZARD - INSTRUCTIONS - continued

STEP 4:

If any 4 way switches are involved, **Connect the remaining two 3-way switch wires back together** as in (3 way # 2) example above. Go to a 4 way switch location. Connect the three tester leads to any three of the four switch wires as in (4 way all) example above and press the tester button. Mark the two wires that **do have a light**.

* You must have the two unmarked wires at both of the 3-way locations connected together.

Now connect the 4-way switch, the two wires you marked go to the terminals towards one end of the switch, the screws will both be the same color. The remaining two wires go to the screws on the other end. connect the ground wire if there is one to the green screw. If there are more 4 way switch locations repeat this step at the remaining 4-way switch locations, marking two wires at each location and install the 4-way switch.

HOW TO USE THE SWITCH WIZARD - INSTRUCTIONS - continued

STEP 5:

Now connect the 3-way switches. If there is a green or bare wire connect it to the green screw. Then connect the marked wire to the odd colored screw, usually black or copper colored and marked common. Then connect the other two wires, one to each of the remaining two screws, it does not matter which one to which screw.

If there are any white wires connected to the switch terminals the National Electrical Code suggests they should be re identified with black tape or paint to distinguish them from a white neutral wire.

Install the switches into the box being careful the ground wire does not loop up and touch any of the switch terminals. Put the cover plate on, turn on the power and you're done.

Your 3-way switch installation is finished and your hallway switches or stairway switches are now fixed, enjoy.