Understanding, Repairing and Troubleshooting 3-Way Circuits and Switches

Let the Natural Handyman take the mystery out of 3-way circuits... *and get you out of the dark*!

This scene is repeated in hundreds... maybe thousands of homes every evening...

A long day... really tired... and all you want to do is go upstairs to lie down. Oh, how her feet hurt! The upstairs is dark, and as she flips the switch at the bottom of the stairs, she howls... as nothing happens! The dang 3-way switch isn't working. So, to turn the light on, she carefully negotiates the stairs to the top, and flips on the switch. That's just not the way it's supposed to be, is it?

3-way circuits can be a formidable opponent.

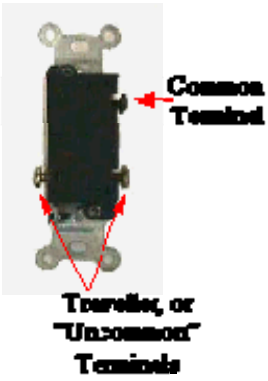
Countless homes across the country are plagued by miswired 3-way circuits causing not only inconvenience but a genuine safety hazard. They are very simple in function, yet ingenious in design. It only takes a few minutes, a little patience, and a healthy respect for electricity to get this job done right!

Right off the bat, I need to tell you that this is not an article on designing 3-way circuits... it's strictly regarding repair. 3-way and four-way circuits can be confusing to design, and even more confusing to install. However, intimate knowledge of circuit design is not really necessary for this repair... as long as the circuit was wired correctly in the first place!

What is a 3-way circuit?

A 3-way circuit is a lighting circuit that allows one light fixture to be controlled by two wall switches in different locations. Stairwells, hallways, and large rooms with multiple access are all candidates for 3-way circuits.

There are also four-way, five-way, and a gazillion-way circuits! These circuits are designed using switches known as 4-way switches between the two 3-way switches. For example, a circuit with 4 switches controlling one fixture... not uncommon in large rooms with multiple access points... there are two 3-way switches and two 4-way switches.



The heart of a 3-way circuit is the 3-way switch. Unlike a common wall switch, the 3-way switch has three active terminals (plus a ground in up-to-date installations). Only one of them is important to identify for the purposes of replacement... the **common TERMINAL**. Though our graphic (left) shows the common terminal in a certain position, the fact is that it could be any terminal on your individual switch.

Sometimes the toughest thing to do is identify it. If there is no labeling on the switch, there may be a different color fastening screw used for the common terminal... usually brass colored.

What is the common terminal?

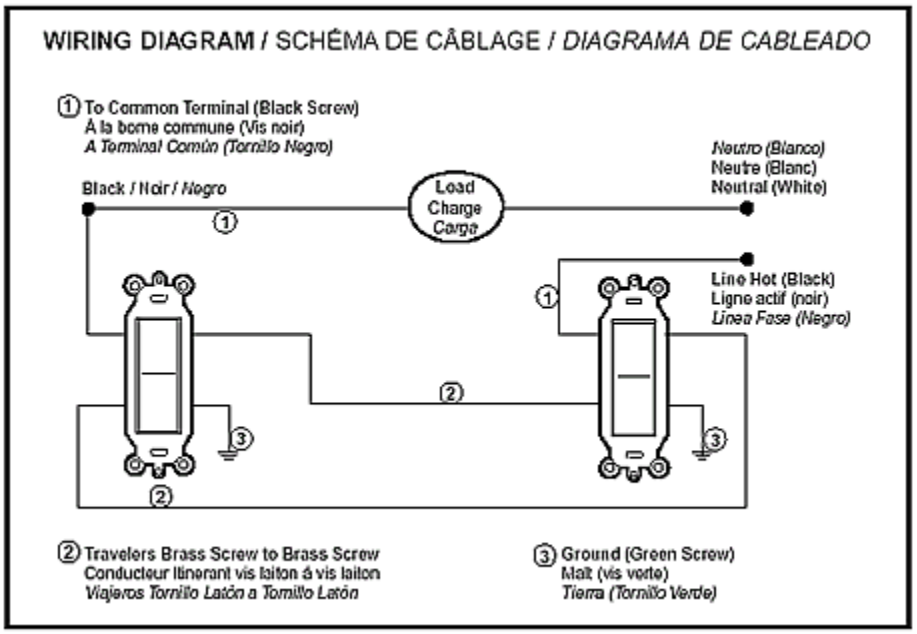
The **common terminal** is one of three electrically active terminals on a 3-way switch (not including the ground terminal that is located on the metal frame of the mounting ears). The common terminal is the "bridge" between the power supply and the load (typically a light fixture). With this in mind, 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).

What are the travellers?

Travellers are two wires connecting the two 3-way switches together. Referring to the graphic (above), 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!**

Confused? Need a picture?

X-Ray View of a typical 3-way circuit...



The above graphic courtesy Leviton Manufacturing Company

NOTE: If your 3-way circuit uses an outlet or outlets instead of light fixtures, you might get confused with the wiring if the outlets are "split"... one of the plugs is always on and the other is controlled by the wall switch.

Replacing a defective 3-way switch...

(The graphic above will help you understand the text below... and visa versa!)

NH's rule for replacing defective 3-way switches is to **ALWAYS REPLACE BOTH SWITCHES AT THE SAME TIME**! There is a common sense reason for this. If one switch has failed, how much longer can the other one last? Besides, it's a chore to determine which of the two switches has become defective. So in the long run it behooves you to spend a few extra dollars now for a reward that will last for years or even decades!

Once you locate the common terminal, replacement of a defective switch is simple:

1) Attach the common wire to the common terminal on the new switch. The remaining two insulated wires are then attached to the remaining traveler terminals. Depending on the wiring in your home, the bare ground wire is attached to the ground terminal on the metal frame of the switch's mounting ears. If you wiring is up to modern codes, the common wire will be black and the travellers will be white

Screw the switches back into their boxes, put the switch plate covers on, and turn the power on to test the switches. Turn the power back on and try it out. Amazing, isn't it! You should now be able to turn your light on and off from either switch.

What... it doesn't work? No luck? Well, you must not have connected the common wire to the common terminal! So now your assignment is to identify the common wire.

Identifying the common wires...

Sometimes, a 3-way circuit doesn't work because someone tried to replace a defective switch and did not properly connect the wires.

Sometimes, one of the switches has become defective.

The following method will address both problems at once. The steps I am going to describe may not be the most time-efficient way to troubleshoot a 3-way circuit. Laid out with y"all handyman-electricians in mind, it allows you to identify the common wires in both switch boxes with no possibility of error! You will need a multimeter to test voltage and continuity in the circuit.

1) Turn off the power to the circuit at the main panel. Disconnect all three wires (or four, if the outlet is grounded) from both switches. Separate the wires so that they are as far away from each other as possible.

2) Turn the power back on. Now, using your multimeter, you are going to determine which of the three colored wires is the ***HOT*** wire. There should be only one ***HOT*** wire in one of the two switch boxes. This is the **common** wire for that box. Set your multimeter to at least 110 volts. Hold one of the probes on a known ground, such as a metal outlet box or a bare ground wire. Touch the other probe to the colored wires, one by one. The wire that registers voltage is the ***HOT*** wire, and the common wire for this box.

NOTE: It is wise to also test the three colored wires in the other box for voltage also, if you haven't already. There should not be any, but with the strange wiring I have seen over the years, it is worth taking a minute to do this. Using a voltage tester, touch one probe to a known ground (metal outlet box or bare ground wire) and the other probe to each wire. You should not get a voltage reading. If you do find voltage, this means that this switch is meant to control another appliance, light, or outlet. **Perhaps you are checking the wrong switch?**

ONLY ONE OF THE ELECTRICAL BOXES IN A THREE WAY CIRCUIT IS CONNECTED DIRECTLY TO *HOT* TERMINAL OF THE MAIN PANEL!!

Once you have finished testing for *HOT* wires, turn the POWER OFF! You will not need power again until the switches are installed.

3) Install the first 3-way switch in the box with the ***HOT*** wire, attaching the ***HOT*** wire to the common terminal of the switch. Attach the other two wires, the travellers, to the other two terminals of the switch. If there is a bare ground wire, attach that to the ground lug of the switch.

4) Go to the other box (without a ***HOT*** wire). Set your multimeter to infinite resistance or to "continuity". Touch one of the probes of the multimeter to a known ground, such as the metal outlet box or bare ground wire. Touch the other probe each of the three wires. Only one of them will register resistance or, if you have a continuity tester, will cause a "beep". You have identified the **common wire** for this box.

5) As with the first box, connect the common wire to the common terminal on the new switch. Connect the other two wires to the TRAVELER terminals, and the ground wire if applicable.

Screw the switches back into their boxes, put the switch plate covers on, and turn the power on to test the switches.

NOTE: If your 3-way circuit uses an outlet or outlets instead of light fixtures, you might get confused with the wiring if the outlets are "split"... one of the plugs is always on and the other is controlled by the wall switch.

YOU CAN TELL IF THE OUTLETS ARE SPLIT BY LOOKING AT THE OUTLET. On the "hot" side, there is a metal strip that connects the two screws. If this strip is broken, then the two plugs are independent of each other. There will be black (hot) wires attached to each screw terminal, though this alone does not indicate that the outlet is split. It may mean that the outlet is connected to another outlet. IF THE METAL STRIP HAS BEEN BROKEN OFF, YOU CAN BE SURE THE OUTLET IS SPLIT. IF NOT, IT ISN'T.

The first two graphics show the metal strip or tab. The third and fourth graphics show how the tab is easily removed with a set of needlenose pliers. Once the tab is removed, the upper and lower outlet plugs are independent so one can be, for example, controlled by a wall switch while the other is always on.

If you have a split outlet, follow the same 3-way switch troubleshooting as with a light fixture EXCEPT you will need to determine which outlet is always on.

After disconnecting all the wires from the switches and from the switched outlet(s), turn the power on and test the wiring at the outlet. The hot wire leading from the 3-way switch circuit will have no power, since all power must travel through the switches.

If one of the black (hot) wires does have power, then that is the wire for the "always on" plug. Turn off the power and mark it so you don't confuse it with the 3-way circuit wires. Enjoy!!