BY GLENN MATHEWSON

Neutral Necessity: Dead-End Switches

There are many different wiring diagrams for switched circuits, including three-way and four-way switching, and these diagrams have guided electricians and others for decades. They've also remained largely unchanged for decades. But with many switch and device arrangements, complicated with jargon such as "travelers" and "switch legs," these installations have been known to go sour after the fixtures and switch trim are installed; for example, when a three-way switch won't respond to the second switch being tripped. With the 2011 National Electric Code, these ubiquitous but often misunderstood wiring arrangements were tweaked, and in 2014 they were revised, rendering many of the old diagrams obsolete—particularly when a switch is placed at the end of a circuit.

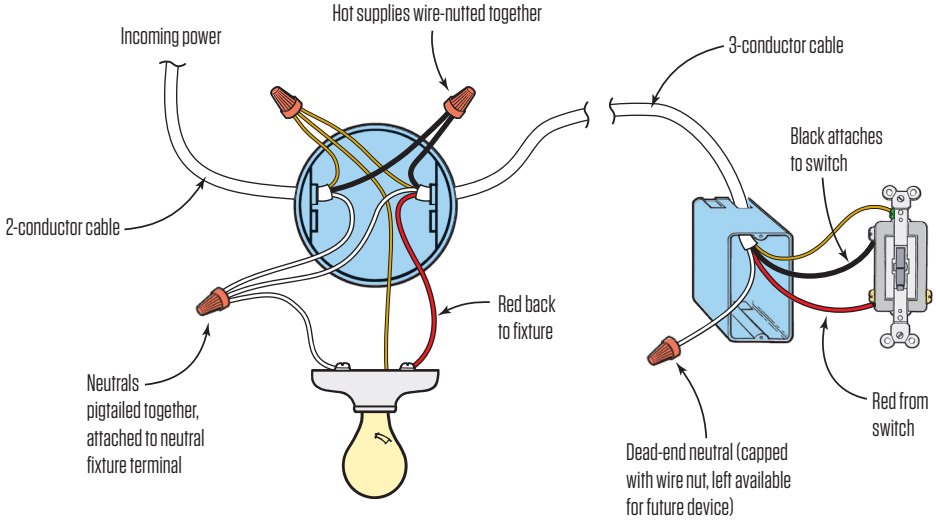
TECHNOLOGY-DRIVEN CHANGES

So why the changes? Codes are regularly updated to stay in step with society's changing expectations of safety, affordability, and convenience. Codes also adapt to changes in technology.

Consider a 1950s home, with just a couple of duplex receptacles typically installed in each bedroom. Back then, a couple of receptacles was plenty to satisfy the needs of an average person. Fast-forward 65 years, my daughter in that same bedroom wants (needs) to power the fish-tank light and filter, her alarm clock, a night light, a phone charger, a tablet charger, plus a desk fan and reading light. (I would vote for her to have a spare outlet for the vacuum cleaner too.) As the laundry list of electrical demands increased, the code began to require that receptacles be spaced more closely together; having more receptacles installed on the walls in turn reduced hazards like overloaded receptacles and extension cords that are located where they could be tripped over.

Similarly, changes in technology have precipitated changes in the wiring of a switch placed at the end of a circuit. Technology and energy-conservation measures, for instance, have prompted a movement toward home automation. Today's complex devices—motion detectors and smart switches that can make your morning coffee—require complex wiring. Instead of acting as

New Dead-End Single-Pole Switches



When a switch is placed after a fixture in a single-pole scenario, the updated code calls for a dedicated neutral conductor in the switch box. A three-conductor cable between the fixture and the switch makes this possible, with the neutral conductor capped off in the switch box for future use.

simple drawbridges to control the current traveling to electrical devices, switches are becoming devices in and of themselves. The bottom line? Every switch box in a habitable room or bathroom must now have a neutral (more accurately referred to as a "grounded conductor"). But many common, more traditional switch arrangements don't allow for this.

HOW IS IT WIRED?

In the past, when a switch was placed after a device (such as a light) in a circuit, the white conductor was re-identified and used as the hot wire. But now, for a single-pole switch, a three-wire cable (with ground) is required between the light and the switch.

In the device box at the light, the black conductors from the supply and the three-wire are connected together so that the power skips the light and heads to the switch. The neutral (white) is pigtailed to the neutral terminal on the light and connected to the white conductor in the three-wire (see Single-Pole Switch, page 25).

At the switch box, the black and red conductors of the three-wire connect to the switch, and the red then sends the switched power back to the device box where it is attached to the other light terminal. The white neutral in the switch box is capped with a wire nut, leaving it available if needed.

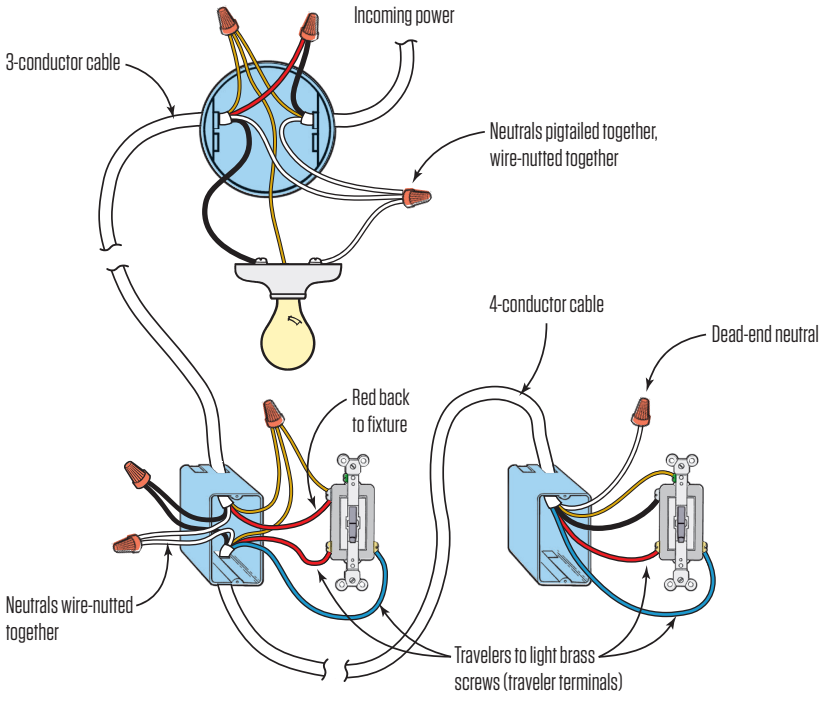
The wiring arrangement for three-way (and four-way) switches is similar (see illustrations, above and on page 27), but you will need a four-wire (or five-wire) cable in these cases to keep the neutral path continuous throughout the entire switching arrangement. Most often, this requirement is primarily "future-proofing" in case a motion detector or some switching device that we can't even conceive of yet is added. When it's not needed, the lonely neutral conductor is terminated with a wire nut and left waiting to be called on in the future. Someday someone will probably be very happy to find it there.

SAFETY FACTORS

Having a neutral in every switch box is not only about paying it forward; it can also be justified from a safety standpoint—protecting us from ourselves. Humans are clever, and when faced with installing a fancy new switch where there is no neutral conductor present, they frequently resort to commandeering the bare equipment-grounding conductor (EGC) and then repurposing it as the neutral conductor back to the previous box—a solution that is not code-compliant.

The outcome of this wiring strategy may be deemed successful when the switch seems to function normally. But it comes with compromised safety if the uninsulated EGC is ever subjected to a build-up of electricity from a switch that should have been connected to a proper neutral conductor.

Three-Way Switches After the Fixture



In this three-way switch layout, both switches come after the fixture. To make a dedicated neutral conductor available in each switch box, a three-conductor cable runs from the fixture to the first switch, and a four-conductor cable runs between switches.

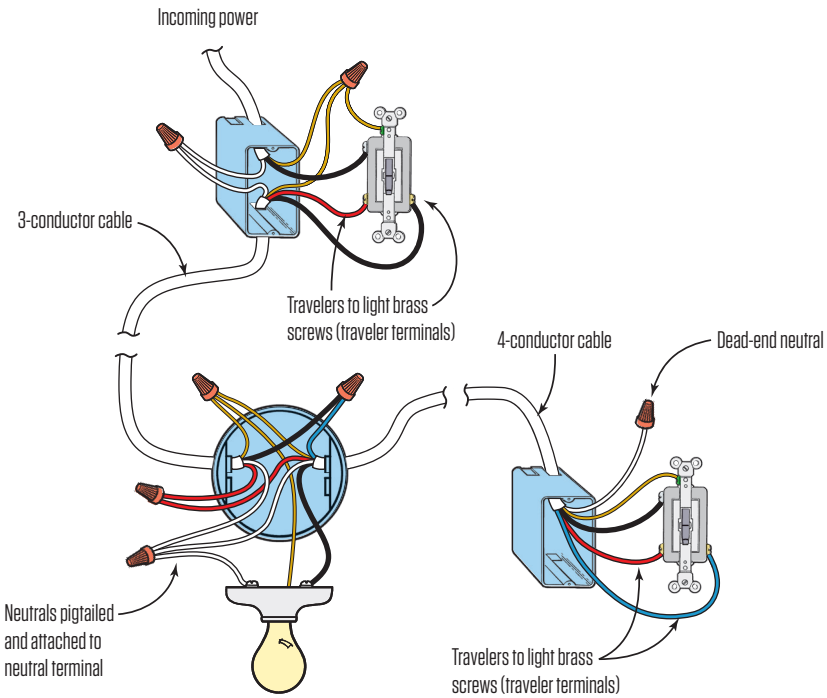
EXCEPTIONS TO THE RULE

As the code's language is crafted, the goal is to describe a level of performance or expectation in a form that's generic enough to make the requirements understandable and effective. However, exceptions are often added to provide flexibility and to apply the code's intent and purpose more accurately, as has been the case with the requirement of providing a neutral in every switch box. Most of the exceptions listed below were added in the 2014 NEC as the first revision to the new rule.

A separate neutral wire is not required in the switch box in the following situations:

- Conductors enter the box through a raceway large enough to fit a neutral in the

Three-Way Switches With the Fixture in Between



In the three-way switch scenario shown above, the fixture is placed between the switches. As before, a three-conductor cable joins the first switch and the fixture, but now a four-conductor cable runs from the fixture to the second switch. The capped off neutral is available in the second switch box should it be needed in the future for a device that demands more complex wiring.

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future. (In other words, there isn't a problem if it will be convenient to add a neutral in the future.)

- The box is accessible for the addition of cables without removing wall finish (for example, when there is an unfinished mechanical room behind the box).
- There are snap switches with integral enclosures permanently mounted to the construction (such as you have with a can light, where you wouldn't be replacing a switch of this type without more serious construction).
- Lighting is controlled by automatic means. (You don't need a neutral if a different type of automatic switch is already in place, such as a motion detector built into the light.)
- The switch controls a receptacle outlet. (A switched outlet usually doesn't control the primary lighting in a room, so it is not likely to be used for an automated switch.)
- Multiple switch locations control the same lights and are visible to the same area of floor. (This exception assumes that you can put a motion detector or smart switch at another switch location that has a neutral.)

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