

# Subpanel Grounding: Answers to Common Questions

by Michael Casey and Barry Stone

There are few subjects in the field of home inspection that raise as many questions, debates, and uncertainties as subpanel grounding. This article will address many of those concerns and provide some clarity on this vital aspect of electrical safety. The points in this article will be expressed, as much as possible, in layman's terminology to enable home inspectors to explain these issues to clients and agents in verbiage that they will understand. So let's start with the basics.

As most inspectors know:

- A properly wired 120/240-volt subpanel includes a 4-conductor feeder;
- Two of these lines are ungrounded conductors, commonly known as "hots;"
- One line is the grounded conductor, commonly known as "the neutral;"
- And one line is the equipment grounding conductor, commonly known as "the ground."

Understanding the rules and relationships that govern these last two lines, the neutral and the ground, is the main subject of this article. Even among electricians, there are those who do not understand the fundamental principles involved.

**Rule #1:** The grounded conductors (neutrals) and the equipment grounds must always be isolated after the main service panel. There are two essential reasons for this rule:

- a) To provide a low-resistance path for current travel to the transformer in the event of a ground fault. This path should not be energized to ensure that it is fully available for the fault current in the event of a malfunction.
- b) To prevent the ground wires from conducting returning neutral current during normal operation. Neutral current in the equipment ground wires can energize the casings and enclosures of appliances and equipment.

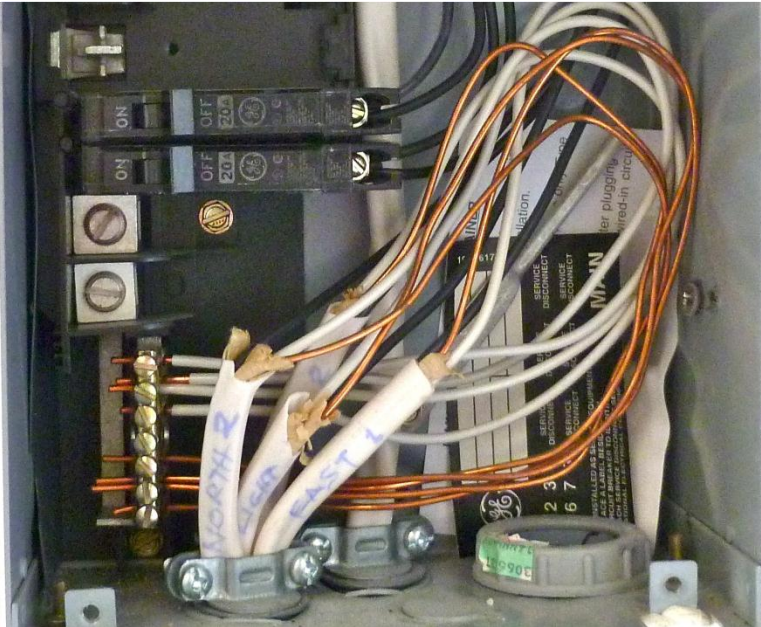
**Rule #2:** In a subpanel, the terminal bar for the grounded conductors (commonly known as the neutral bus) should always be insulated from the enclosure. The reason for this rule is to prevent the enclosure from conducting current.

**Rule #3:** In a subpanel, the terminal bar for the equipment ground (commonly known as a ground bus) should be bonded (electrically connected) to the enclosure. The reason for this rule is to provide a path to the service panel and the transformer in case of a ground fault to the subpanel enclosure.

**Rule #4:** A terminal slot, no matter how large, can be assumed to be approved for one conductor only unless it is labeled otherwise. However, Rule #5 is an exception.

**Rule #5:** The terminal slots in the equipment grounding bus are permitted to have one or two conductors of the same size, per manufacturer's instructions.

**The case of the married grounds and neutrals.** This photo illustrates the most common of all subpanel grounding violations. The grounded conductors and the equipment grounds are connected to the same terminal bar, contrary to Rule #1. In the event of a ground fault, the neutral wires can conduct fault current. During normal operation, the grounding wires can energize equipment enclosures and casings with neutral current (yes, the neutral carries current; the reason the conductors are insulated). A separate terminal bar, bonded to the subpanel, is needed for the equipment grounding conductors. This repair should be performed by a licensed electrical contractor.



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**The case of the bonded neutral bus.**

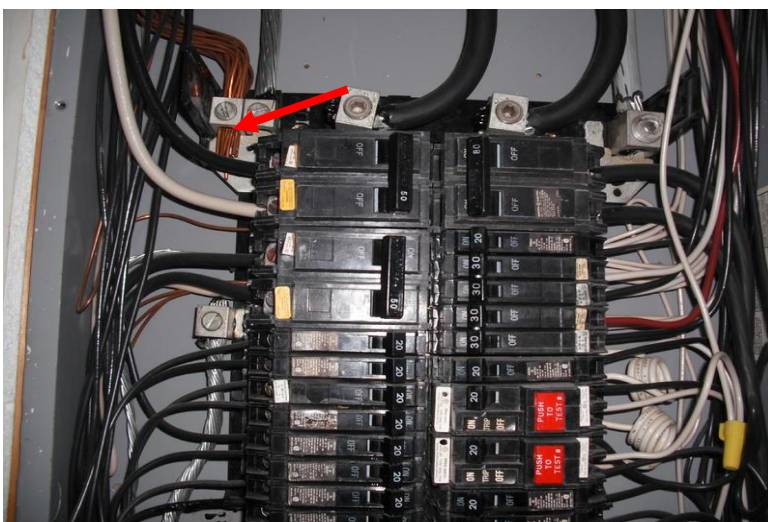
This photo illustrates another common subpanel violation -- bonding the grounded conductor terminal bar (neutral bus) to the subpanel enclosure, contrary to Rule #2. The copper jumper from the terminal bar to the body of the panel enables the neutral wires to energize the panel enclosure or to conduct live current during a ground fault. The bond jumper should be removed by a



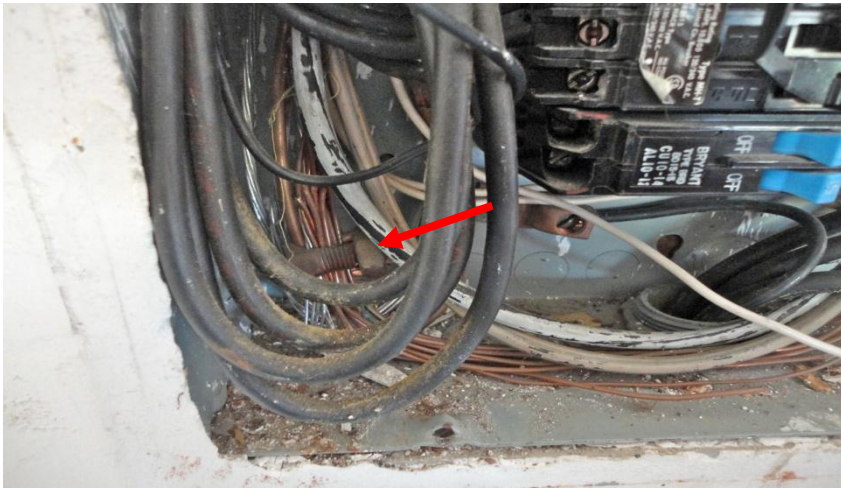
licensed electrical contractor.

**The case of the stuffed terminal lug.**

In this photo we see a subpanel with the proper 4-conductor feeder. However, the installer made an obvious error at the upper left corner. The equipment grounds are bundled together and stuffed into a mechanical connector approved for one conductor only, violating Rule #4. A grounded terminal bar is needed in this panel, with one or two wires to each terminal slot. This panel is a candidate for



further review and correction by a licensed electrical contractor.



**The case of the split bolt connector.** In this photo, the installer used a mechanical connector to bond the equipment grounding conductor to the enclosure – with no provision for branch circuit equipment grounds. The branch circuit equipment grounds were then bundled with a bronze or copper split bolt mechanical connector. There are three issues with this installation.

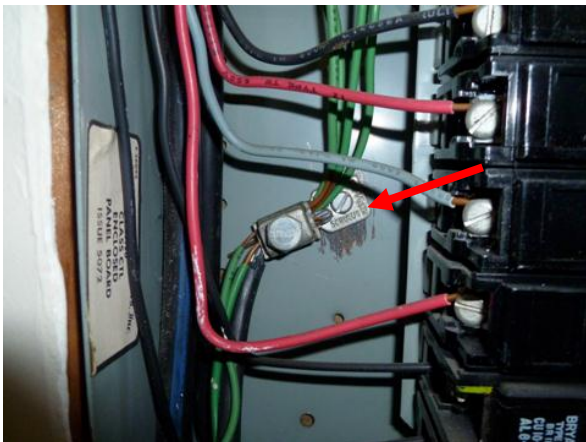
First, the branch circuit equipment grounds are not bonded with the feeder equipment ground. Thus, there is no proper path back to the service equipment and the transformer for ground fault current. Second, split bolt connectors are generally used to tap a main conductor and are approved for a maximum of two conductors only. This one contains a dozen conductors or more. Third, bronze or copper split bolts are approved for copper conductors only. Aluminum conductors are apparent in this bundle. Once again a licensed electrical contractor should be recommended to make corrections.



This split bolt is approved for copper wire only



This split bolt is approved for copper and aluminum wire



**The case of the mechanical terminal lug.** In this photo, the requirement to bond the equipment grounds to the enclosure has been met, and the path back to the service equipment appears to exist, but the mechanical connector is not approved for more than one conductor. An approved terminal bar should be installed, with no more than two wires to a terminal slot. Again, this is a repair for a licensed electrical contractor.

In most of the cases cited in this article, the simple installation of a listed grounding terminal bar would resolve the installation problems. Most of these are readily available for about \$5 each.



**One final grounding issue:** We are often asked if subpanels added at spas and wells can be fed with a three-conductor feeder (two hots and one neutral) and then “grounded” by adding a grounding electrode (grounding rod). There are four reasons why this grounding method is not acceptable:

- 1) The primary purpose of a grounding rod is to provide lightning protection. A rod is required for separate buildings with subpanels, but not as a substitute ground fault path for the system.
- 2) A metal rod driven into the dirt does not provide a low-resistance path back to the service equipment and transformer to clear ground faults. In order to clear a ground fault, the equipment ground must be separate from the neutral and be continuous back to the service equipment, as stated at the beginning of this article.
- 3) Dirt is not a good conductor of electricity, especially when it is dry.
- 4) Four-conductor feeders are required for all subpanels (even in detached buildings and structures) since the 2008 NEC.

Whenever grounding conditions appear questionable, don’t guess and don’t take chances. Recommend a licensed electrical contractor.

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