Electrical Systems: Questions and Answers

By Bruce Barker, ACI

Once again, The Word invites you to travel into the dark realm of subjects that are sometimes misunderstood by home inspectors. The Word hopes you will find this trip informative and maybe a little entertaining.

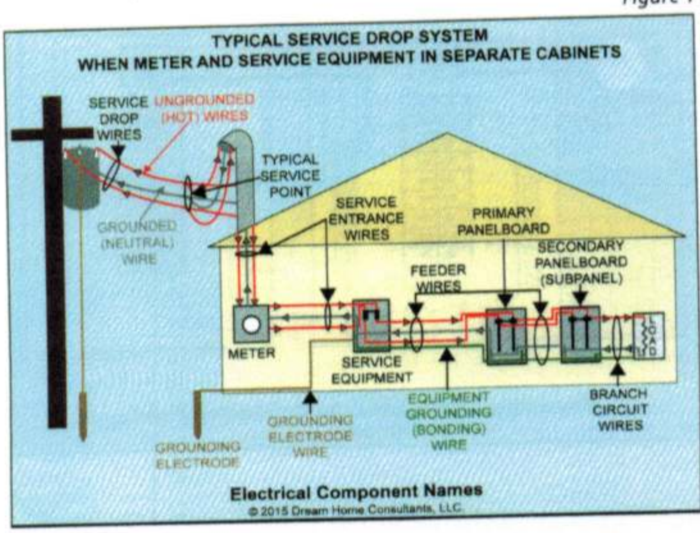
Our subject this month is questions. The Word finds this topic interesting because he has the pleasure and privilege of answering a lot of them. Questions show what topics remain in the dark realm of misunderstanding. Asking questions is a great way to learn. The only better way to learn is to try to answer them. The Word has missed writing these columns in part because he learns so much in the process.

Service Amperage

A common question is about determining electrical service system amperage. Our Standard of Practice (SoP) requires that we report service amperage. This is usually easy for a newer system that has one clearly labeled circuit breaker. Older systems, however, can present a challenge. The first lesson to learn about this requirement is that it is okay if you cannot determine the service amperage. In this case, report your best estimate, be sure to clearly report that it is an estimate, and recommend evaluation if the client wants more information about the service amperage.

Electrical service system amperage is determined by identifying the component with the lowest amperage rating. We should be able to identify each component in this system **(see Figure 1).** An electrical system inspection should include observing each of these components.

Figure 1



The electrical service system begins at the service point. The service point is where the utility's responsibility ends and the homeowner's responsibility begins. In service drop configurations, the service point is usually at the drip loops where the service drop conductors connect to the service entrance conductors. In a service lateral configuration, the service point is usually not visible. It is often at or inside the meter base.

The service entrance conductors may be the lowest rated component. This is especially true of older systems that have been updated without a permit. Some electricians will install a higher rated panelboard and service equipment, but leave the lower rated service entrance conductors. This is a dangerous situation because the new equipment can draw more current through the service entrance conductors than is safe. More current means more heat. More heat can melt the service entrance conductor insulation. Fire and electric shock can occur.

Amperage ratings for service entrance conductors are shown in Table 1. Note that Table 1 does not apply to service entrance conductors installed under the 2014 NEC/2015 IRC. The new maximum ampacities are usually lower than those listed in **Table 1.**

Table 1: Service Entrance Conductor Amperage Ratings

Copper Wire Size (AWG)	Aluminum Wire Size (AWG)	Maximum Ampacity
4	2	100
3	1	110
2	1/0	125
1	2/0	150
1/0	3/0	175
2/0	4/0	200
3/0	250 kcmil or 2 sets of 2/0	225
400 kcmil or 2 sets of 4/0	600 kcmil or 2 sets of 300 kcmil	400

Before we move on, it should be noted that the visible parts of the service drop and service lateral are also within the scope of an inspection, even though they are not part of the house electrical service system. We should inspect these components for general condition, such as damage to the service lateral riser and the service drop conductors being subject to damage from trees. That is about all we can do.

It should also be noted that the conductor amperage ratings in **Table 1** do not apply to the service drop and service lateral conductors. These conductors are the responsibility of the electric utility. The utility determines the ampacity for their conductors. It is not uncommon for these conductors to be smaller than in **Table 1**.

The service entrance conductors run through the meter base and meter. The meter base may be the lowest rated component. The meter base in most systems is the rectangular enclosure in which the meter is set. Newer meter bases are rated at 200 amps or more. The meter base for a very old system may be a small square enclosure, an unusually shaped enclosure or a small circular mounting ring. Sometimes an old enclosure has some type of sheathed cable running to and from it. These older meter bases, especially the very old circular mounting rings, may be rated as low as 60 amps and often are rated at not more than 100 amps. These old meter bases are obsolete. Evaluation by an electrician may be an appropriate recommendation, especially if the downstream components have been upgraded.

The meter may be the lowest rated component. The amperage rating of a modern electric meter is usually printed (in code) on its face, but because there are so many different meters and so many different codes, it is hard for an inspector to determine the meter's amperage rating. Even if you determine a meter's amperage rating, that fact may make no practical difference because many meters can accommodate current beyond their rating. Perhaps the best thing for an inspector to do is ignore the meter and concentrate on other components that make more of a difference.

The service equipment may be the lowest rated component. The service equipment is better known as the main shutoff, main breaker or the service disconnect, as well as other similar terms. The service equipment may be one device or it may be up to six devices. These devices may be in one enclosure or they may be in different enclosures. If there are multiple enclosures, the enclosures should be near each other so that all electricity to the house can be shut off quickly in case of an emergency.

If the amperage rating is marked on a single device, then the service equipment amperage rating is easy to determine. If the amperage rating is not marked, or if there are multiple devices, things are more challenging. One way not to determine the service equipment amperage rating is by adding the amperage of the individual service equipment devices. Individual device amperage ratings have nothing to do with the service amperage.

If the service equipment serves downstream panelboards, it does so through feeder conductors. Feeder conductors may be the lowest rated component. Feeder conductors that run from the service equipment to a primary panelboard are rated the same as service entrance conductors **(as shown in Table 1)**. These feeder conductors are effectively an extension of the service entrance conductors because they serve the entire electrical load of the house.

The panelboard may be the lowest rated component. The panelboard rating should be shown on the label that is usually located on the enclosure door. This label is often absent or faded to the point of being unreadable on older enclosures. If this is the case, there is not much you can do to determine the panelboard rating.

There is a pattern regarding the amperage rating of a component and its location in the system. A higher amperage-rated component downstream from a lower amperage-rated component is usually a bad thing. The higher rated component can allow too much current to flow through upstream components, creating a fire risk. A higher amperage-rated component upstream from a lower amperage–rated component is no problem.

Is This a Subpanel?

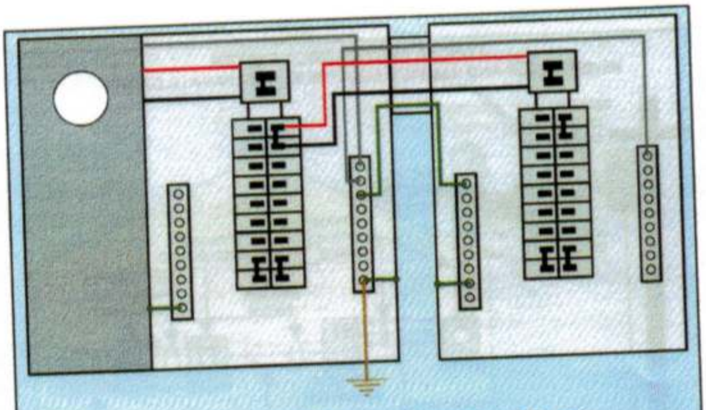
Important disclosure: The discussion in this section is The Word's commonsense approach to a frequently encountered situation. This approach is not sanctioned by the NEC, although it is frequently accepted by code officials. Although this approach causes concern among technical purists, it provides a practical way for inspectors to deal with this situation.

The simple and common definition of a subpanel is any panelboard located downstream from the service equipment. This definition includes situations when the service equipment is in one enclosure and only one panelboard exists downstream. This downstream panelboard might be called the main panel by the uninitiated, but it is still a subpanel **(see Figure 1).** This simple definition works most of the time, but as with many simple definitions, there are exceptions.

One exception occurs when the service equipment is in an enclosure with a panelboard and with the grounding electrode conductor. Another panelboard is located in an adjacent enclosure. Is that adjacent panelboard a subpanel? Should it be wired as such with the neutrals separated from the grounding conductors, often referred to as floating neutrals?

To begin answering this question, let's recall the reason why neutral conductors should not be connected to grounding conductors and should not be bonded to any grounding connection downstream from the service equipment. The reason is that this improper

Figure 2



Physically and Electrically Connected Panels

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connection sets up the potential for multiple paths through which current can return to its source. This current can create a shock hazard under certain conditions. It also can create heat while flowing through these paths. With enough current, enough resistance and enough time, these paths can get hot enough to cause a fire.

One common situation occurs when the panelboards and enclosures are physically and electrically connected **(see Figure 2).** In this situation, the panelboards are effectively the same panelboard but happen to be located in different enclosures. Assuming that the grounding conductor between the panels and the nipple connecting the panels are properly bonded, everything should be at the same potential. The risk posed by unintended return paths is so small as to be appropriately ignored.

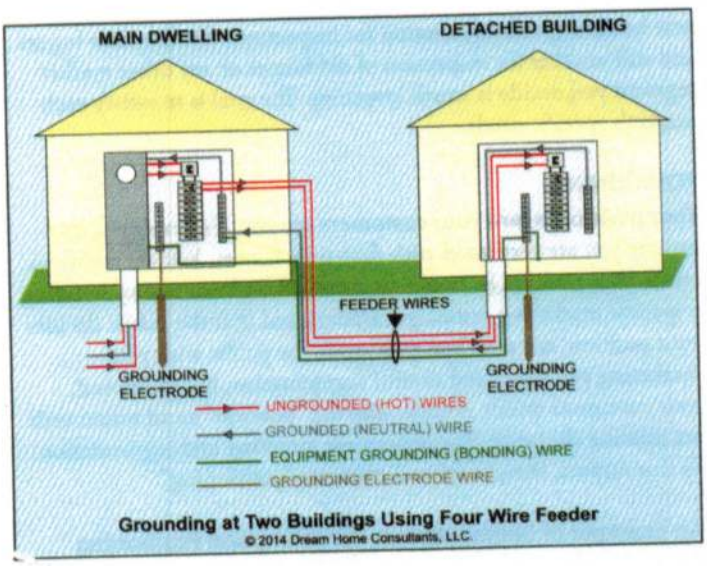
A similar situation occurs when the panelboards and enclosures are very close to each other but are not physically connected. In this situation, the panelboard that does not contain the service equipment is a subpanel. It should be wired as such; however, the risk if it is not wired as a subpanel is very low. The situation should be reported with a recommendation for evaluation and repair; however, the risk is low so there's no need to oversell the hazard.

Subpanel in a Detached Building

A subpanel located in a detached building is a completely different situation. A detached building might be a detached garage, a storage shed, a barn or, for the lucky few, an airplane hanger. How a detached building subpanel is wired depends on how many feeder conductors are installed.

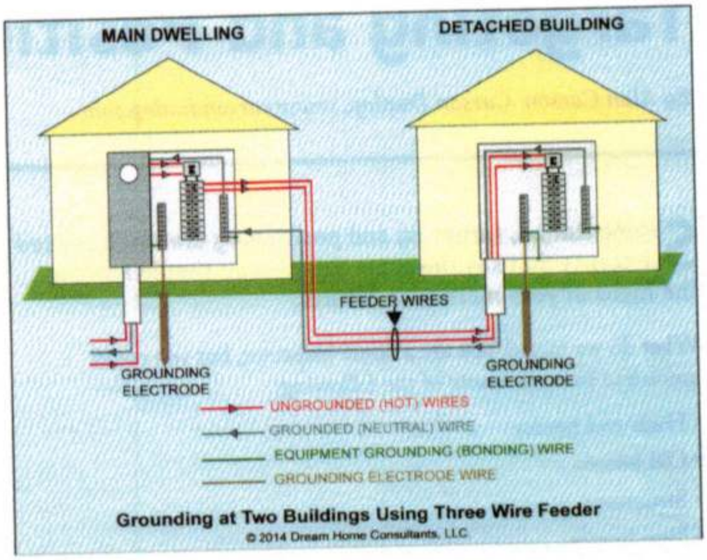
A subpanel installed in a detached building should be supplied with a four-wire feeder, two hot conductors, a neutral and a grounded conductor. This subpanel should be wired as any other subpanel with floating neutrals and grounding conductors bonded to the enclosure **(see Figure 3).**

Figure 3



You may find a subpanel in an older detached building that is supplied with a three-wire feeder, two hot conductors and a neutral. This subpanel should be wired as if it contained service equipment; neutral conductors and grounded conductors may by connected to the same terminal bar **(see Figure 4).** Three-wire feeders have not been allowed since at least the 2008 NEC. Even when three-wire feeders were allowed, metallic pathways between the buildings were prohibited (the old unintended return path problem). These pathways could include metal pipes, fences or even phone or television wires.

Figure 4



The unusual component in both of these situations is the presence of a grounding electrode. A subpanel in a detached building should be connected to a grounding electrode located at the detached building regardless of the number of feeder conductors.

A subpanel is not required in a detached building. One or two 15- or 20-amp, 120-volt branch circuits may be supplied by a three-wire feeder consisting of either #10 copper or #8 aluminum conductors. A single 15-amp, 120-volt branch circuit may be supplied by a three-wire feeder consisting of #14 copper or #12 aluminum conductors.

How Many Conductors in a Terminal?

The general rule is one conductor per terminal or lug. A terminal or lug with more than one conductor is probably wrong, unless it is an exception. It is easier to remember the exceptions.

Square D circuit breakers with the plate under the screw that accommodates two conductors may have two conductors attached. Some Cutler Hammer circuit breakers also allow two conductors, but these are less common. As with many things, just because something is allowed does not necessarily mean it is a good idea to do it. The load of two circuits protected by one circuit breaker could exceed the circuit breaker's capacity and cause it to trip. The inspector may wish to report this circuit breaker overload potential to the client as information because this circuit breaker may trip more often than others. Since the manufacturer allows two circuits to be connected to these circuit breakers, doing so is not a defect and should not be reported as such.

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The ASHI School®
Hands-on Home Inspection Training

The ASHI School: Moving Forward

The ASHI School has had many exciting developments within the last few months that we want to share with you.

Introducing New Locations

We recently opened three new locations:

- Columbus, OH—opened July 2015
- Brentwood, TN—opened September 2015
- Baltimore, MD—opened September 2015

Our new location in Columbus, OH, gives potential students in or near Ohio another place in which to attend The ASHI School. The instructors at our Cincinnati location—John Cordell, Ken Harrington and Tim Buell—will also teach at our Columbus site.

In **Brentwood, TN,** just outside of Nashville, we are offering The ASHI School course as our "Fast Track" to learning. The course in Brentwood is 93 hours, with students starting off doing 40 hours of at-home study, then attending five days of in-class instruction and finishing off day six with field events. Our instructors at the Brentwood location are Scott Patterson and Ray Baird. Both instructors come with many years of experience and home inspecting.

In **Baltimore, MD,** The ASHI School is teaming up with Baltimore City Community College. The college will be offering our 120-hour course as part of their curriculum. In addition, the school's facility offers a full-scale, cut-away house for students to enhance their learning. The instructors are still being reviewed. **If you have interest in becoming an instructor at our new Baltimore location, please e-mail kendra@theashischool.com.**

New Programs for The ASHI School

The school is awaiting approval for a four-point Wind Mitigation class at our Tampa, FL, location. This class will be taught by our lead instructor in Florida, Mike Conley. We look forward to offering this new class.

The Level I Thermography Certification course will be offered as an ancillary course with The ASHI School. We will be posting our upcoming schedule of classes in the near future.

Welcome, New Instructors!

- Scott Johnson—Cumming, GA
- Scott Patterson—Brentwood, TN
- Ray Baird—Brentwood, TN

Upcoming Classes

Lakewood, CO—November 2-13
Leesburg, VA—November 2-13
Des Plaines, IL—November 9-20
St. Louis, MO—November 9-20
Bellevue, WA—November 9-20
Nashville, TN—November 9-14
Cincinnati, OH—November 30-December 11
Tampa, FL—November 30-December 11
Cumming, GA—November 30-December 11

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Two grounding conductors that are the same size may be connected in one lug. Three or more grounding conductors may not be allowed by some manufacturers, and conductors that are different sizes are not allowed.

Code references for these situations are sometimes requested. The general reference for the one conductor per terminal or lug rule is NEC 2014 110(A), which requires that terminals listed for more than one conductor be identified as such. This identification should be on the panelboard label or on the device itself. The NEC 2014 reference for the one neutral conductor per terminal rule is 408.41. This rule has been around for a long time.

The Bottom Line

The wise person is not afraid to ask questions. Nobody knows everything about everything.

When you ask questions, help the person you ask by providing enough information. Information like your city and the age of the house is often essential. Remember, the person answering the question is not on site with you and does not have the perspective that you have.

Memo to Zeus: The Word does not reside on Mt. Olympus (just at its base) and welcomes other viewpoints. Send your lightning bolts or e-mails to Bruce@DreamHomeConsultants.com. The thoughts contained herein are those of The Word; they are not ASHI standards or policies.

Bruce is the founder and president of Dream Home Consultants, and the author of Everybody's Building Code, written to help home inspectors understand the International Residential Code.

Bruce has been building and inspecting homes since 1987. He currently serves on the ASHI Board of Directors. He is a certified Residential Combination Inspector and a licensed contractor in Arizona, Florida and North Carolina.

To read more of Bruce's articles or if you need a presenter at your next chapter event, go to ***www.dreamhomeconsultants.com.***