C

de Check Electrical is a field guide to common code issues in residential
electrical installations. It is based on the 2011 National Electrical Code—
the most widely used electrical code in the United States—and the 2009
International Residential Code. Before beginning any electrical project, check
with your local building department. In addition to a model code, energy codes and
special rules from utility companies could also apply.

Each code line in Code Check Electrical references the two codes named above.
Many building jurisdictions use older versions of the codes. If you are in an area that
still uses the 2008 NEC, look in the “09 IRC” column of code references to see
if the item applies in your area, and use the table on the inside back cover to see
changes that were made in the 2008 NEC, 2009 IRC, and 2011 NEC.

In places where the IRC does not reference a particular rule, the NEC rule might still
apply, even where the IRC code is adopted. The IRC states that items not specifical-
ly mentioned in that code should comply with the NEC. This applies to issues such
as old wiring, outside feeders, and photovoltaics, which are not covered in the IRC.

For information on electrical fundamentals and theory, visit:
http://www.codecheck.com/cc/OhmsLaw.html

HOW TO USE CODE CHECK ELECTRICAL

Each text line ends with two code citations. The code numbers on the left, with
straight brackets, refer to the 2009 IRC. The code numbers on the right, in
braces, refer to the 2011 NEC. For example (from p. 4):

☐ Max 6 disconnects to shut off power________________[3601.7]  [230.71]
This line states that there can be no more than 6 disconnects to shut off power, and
the rule is found in 3601.7 of the IRC and 230.71 of the NEC.

An “n/a” in a code line means the rule is not applicable to that particular code. An
“exc” at the end of a line means that an exception—or exceptions—to the
rule will follow in the next line, for example (from p. 12):

☐ Backfed breakers secured in place EXC___________[3706.5]  [408.36D]
Output circuits from utility interactive PV inverter ______ [n/a]  [705.12D6]
Backfed breakers must be secured in place IRC 3606.5 & NEC 408.36,
except that the NEC has an exception for photovoltaic circuits from an inverter. The
“n/a” in the IRC column tells us this rule does not apply to that code. The list of ab-
Abbreviations (to the right on this page) tells us that PV = photovoltaic.

Significant code changes are highlighted by a different color for their code
citation, and the superscript note after them refers to the list on the inside back
cover, for example (from p. 12): from p. 16):

☐ GFCI devices req’d to be in readily accessible locations ______ [n/a]  [210.8A]*
GFCI devices must be located in an area where they remain readily accessible (see
definition in glossary on page 3). The rule is not in the IRC and in the NEC it is a
change in the 2011 code, summarized as change #19 on the inside back cover T23.

Text lines ending in “or” mean that an alternative rule follows in the next line,
for example (from p. 17):

☐ Separate 20A circuit for bath receptacles only OR____ [3703.4]  [210.11C3]
☐ Dedicated 20A circuit to each bathroom _________[3703.4X]  [210.11C3X]
A separate 20-amp circuit must be supplied for no other purpose than the bathroom
receptacles. Alternatively, each bathroom can be supplied with its own 20-amp circuit,
and then other outlets in that bathroom (such as lights) could be on the circuit.

Abbreviations

A = amp, amperage, amps, such as a 15A breaker
AC = air conditioning
AC = alternating current
AC = armored cable, a.k.a. “BX”
AFCI = arc-fault circuit interrupter
AHJ = Authority Having Jurisdiction
Al = aluminum
AMI = in accordance with manufacturer’s instructions
AwG = American Wire Gauge
CATV = cable television
Co = Carbon Monoxide
Cu = copper
dC = direct current
EGC = equipment grounding conductor
EMT = electrical metallic tubing
ENT = electrical nonmetallic tubing, a.k.a.
“Smurfit tubing”
EV = Electric Vehicle
EXC = exception(s)
FMC = flexible metal conduit (“Greenfield”) ft = foot, feet
GEC = grounding electrode conductor
GES = grounding electrode system
GFCI = ground-fault circuit interrupter
GFPE = ground-fault protection of equipment
hp = horsepower (33,000 lb-ft./minute)
IMC = intermediate metal conduit
In = inch, inches
IRC = International Residential Code
Kcmil = 1,000 circular mil units
(conductor size)
L&L = listed & labeled, listing & labeling
lb = pound, pounds
LFMC = liquidtight flexible metal conduit,
a.k.a. “Sealtight”
LFNMC = liquidtight flexible nonmetallic
conduct
manu = manufacturer
MC = metal-clad cable
max = maximum
min = minimum
Nec = National Electric Code
NFPA = National Fire Protection Associa-
tion
NM = nonmetallic-sheathed cable
OCPP = overcurrent protection device
(breaker or fuse)
PVC = rigid polyvinyl chloride conduit
PV = photovoltaic
SCCR = short circuit rating
SE = service entrance cable
SFP = single-family dwelling
sq = square
temp = temperature
UF = underground feeder cable
USE = underground service entrance cable
v = volt, volts, such as a 120V circuit
VA = volt-amperes, units of apparent power
w/ = with; w/o = without
W = watts, units of true (useful) power
OVERHEAD SERVICE DROP CLEARANCES

Service drop conductors typically have no outer jacket for physical protection and no overload protection at their source. They are protected by isolation and proper clearances. The codes specify minimum clearances, and the serving utility may have different rules that override the code. Check with your local jurisdiction to determine any variations from the standard clearances below.

**Vertical above Roof**

<table>
<thead>
<tr>
<th>Description</th>
<th>09 IRC</th>
<th>11 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4-in-12 slope: min 8ft A EXC</td>
<td>[3604.2.1]</td>
<td>(230.24A)</td>
</tr>
<tr>
<td>≥4-in-12 slope: min 3ft C EXC</td>
<td>[3604.2.1X2]</td>
<td>(230.24AX2)</td>
</tr>
<tr>
<td>18in OK for ≤4ft over eave E</td>
<td>[3604.2.1X3]</td>
<td>(230.24AX3)</td>
</tr>
<tr>
<td>Maintain req’d distance above roof for 3ft past edge EXC</td>
<td>[3604.2.1]</td>
<td>(230.24A)</td>
</tr>
<tr>
<td>Edge clearance above roof is not req’d when attached to side of building</td>
<td>[3604.2.1X4]</td>
<td>(230.24AX4)</td>
</tr>
</tbody>
</table>

**Vertical above Grade**

<table>
<thead>
<tr>
<th>Description</th>
<th>09 IRC</th>
<th>11 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>10ft above final grade to lowest point of drip loop</td>
<td>[3604.2.2]</td>
<td>(230.24B1)</td>
</tr>
<tr>
<td>Area accessible only to pedestrians: 10ft H</td>
<td>[3604.2.2]</td>
<td>(230.24B1)</td>
</tr>
<tr>
<td>General above grade &amp; driveways: 12ft J</td>
<td>[3604.2.2]</td>
<td>(230.24B2)</td>
</tr>
<tr>
<td>Above roads or parking areas subject to truck traffic: 18ft D</td>
<td>[3604.2.2]</td>
<td>(230.24B4)</td>
</tr>
<tr>
<td>Any direction from swimming pool water: 221/2ft</td>
<td>[4103.5]</td>
<td>(680.8A)</td>
</tr>
</tbody>
</table>

**Openings & Communication Wires**

<table>
<thead>
<tr>
<th>Description</th>
<th>09 IRC</th>
<th>11 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical above decks &amp; balconies: 10ft C</td>
<td>[n/a]</td>
<td>(230.9B)</td>
</tr>
<tr>
<td>From side of area above decks &amp; balconies: 3ft D</td>
<td>[3604.1]</td>
<td>(230.9A)</td>
</tr>
<tr>
<td>Below or to sides of openable window: 3ft F</td>
<td>[3604.1]</td>
<td>(230.9A)</td>
</tr>
<tr>
<td>Communications wire ≥12in to parallel power wires</td>
<td>[n/a]</td>
<td>(800.44A4)</td>
</tr>
</tbody>
</table>

The clearances from windows and doors apply to open conductors and not to conductors contained inside a raceway or a cable with an overall outer jacket. The codes do not have a requirement for minimum clearance of open conductors above a window. Check to see if your local utility has a requirement.
EGCs limit the voltage on equipment enclosures and provide a path for fault current. Without EGCs, the conductive frame of an appliance could remain energized if there is a fault from an ungrounded "hot" conductor. Equipment grounding provides a low-impedance path so the overcurrent device will open the circuit. The equipment grounding system has a completely different purpose from the earth grounding system. In fact, earth plays no part in helping to clear faults.

**Equipment Grounding Conductors**

- EGC must provide effective ground-fault current path
- Earth is not an effective ground-fault current path
- Size EGCs per service conductor size
- List the irreversibly compression connectors or exothermic welding OK
- GEC can connect to any electrode of GES
- Buried clamps L&L for direct burial (marked "DB")
- Cu water tubing clamps L&L for Cu tubing
- Ufer clamps L&L for rebar & encasement
- Strap-type clamps suitable only for indoor telecommunications
- Max 1 conductor per clamp unless listed for more
- Connections must be accessible
- Buried or encased connections

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### TABLE 5  GEC SIZING [T3603.1] & (250.66)

<table>
<thead>
<tr>
<th>Cu Service Wire AWG</th>
<th>Al Service Wire AWG</th>
<th>GEC Cu AWG</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤2</td>
<td>≤1/0</td>
<td>8</td>
</tr>
<tr>
<td>1 or 1/0</td>
<td>2/0 or 3/0</td>
<td>6</td>
</tr>
<tr>
<td>2/0 or 3/0</td>
<td>4/0 or 250kcmil</td>
<td>4</td>
</tr>
<tr>
<td>4/0–350kcmil</td>
<td>&gt;250–500kcmil</td>
<td>2</td>
</tr>
<tr>
<td>&gt;350–600kcmil</td>
<td>&gt;500–900kcmil</td>
<td>1/0</td>
</tr>
</tbody>
</table>

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### TABLE 6  EQUIPMENT GROUNDING CONDUCTORS (EGCs)  [T3908.12] & (T250.122)

<table>
<thead>
<tr>
<th>Size in Amps of Breaker or Fuse Protecting Circuit</th>
<th>AWG Size of Cu EGC</th>
<th>AWG Size of Al EGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>30–60</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>70–100</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>110–200</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>400</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

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*Note: Rebar can be brought through the top of a foundation in a protected location, such as the garage, to provide an accessible point for the GEC to attach to the Ufer. The GEC can also be brought into the foundation and connect to the Ufer with L&L clamps or by exothermic welding.*

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*Fig. 7 Bare GEC*  
*Fig. 8 Armor-clad GEC*

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*Fig. 9 GEC in Metal Raceway*  
*Fig. 10 GEC in PVC*
**BONDING**

Bonding ensures electrical continuity to limit voltage potential between conductive components. On the **line side** (ahead of the main disconnect **F15**), it provides a path back to the utility transformer for faults on service conductors and to limit voltage potential to other systems, such as telephones or cable TV. On the **load side** (after the main overcurrent protection **F15**), bonding and equipment grounding provide a path to clear faults and protect against shocks.

### Bonding & Equipment Grounding Methods 09 IRC 11 NEC

- Use listed connectors, terminal bars, exothermic welding, machine screws engaging 2 threads or secured w/ nut, or thread-forming machine screws engaging 2 threads - no sheet metal or drywall screws
  - ![Diagram](image1.png)
  - ![Diagram](image2.png)

- Connections may not depend solely on solder

**Line-Side Bonding F11,12,15 09 IRC 11 NEC**

- Bond all service equipment, raceways, & cable armor
- Bond metal GEC enclosures at each end
- Meyers hub OK for bonding service conduit
- Standard locknuts alone not sufficient on line side of service
- Jumpers req’d around concentric knockouts, or reducing washers
- Service neutral can bond line-side equipment
- Size line-side bonding jumpers per
- Service enclosure main bonding jumper must connect enclosure, service neutral, & equipment grounds

**Load-Side Bonding 09 IRC 11 NEC**

- Bond any metal piping system capable of becoming energized, including hot & cold water & gas
- Size water pipe bonding per
- Size gas pipe bonding per
- Bond metal well casings to EGC of pump motor

**Intersystem Bonding 09 IRC 11 NEC**

- Min 6AWG Cu bond to CATV or phone electrodes
- Bond lightning protection system to GEC
- Intersystem bonding access req’d external to service equipment & separate structure disconnecting means
- Must accept min 3 conductors & be terminal or bonding bar electrically connected to meter or service enclosure
- Existing buildings raceway or GEC OK as bond point
- Bonding device not to interfere w/ enclosure cover

**Fig. 13**

**Bonding Interior Piping**

All interior piping systems capable of becoming energized must be bonded, & connecting them at a gas water heater provides an easy way to check for compliance.

**Fig. 14**

**Intersystem Bonding**

An external terminal bar on the service enclosure is required for connecting GECs of other systems. The bond to the service equipment must be at least a 6AWG conductor.
What is commonly called an "electrical panel" is referred to as a panelboard (NEC 408) inside a cabinet (NEC 312). See p.5 for working space requirements.

## Clearances & Location
- No panels or OCPDs in clothes closet or bathroom [3405.4] (240.24D&F)
- No panels or OCPDs over steps of a stairway [3405.4] (240.24F)
- OCPDs readily accessible & max height 6ft 7in [3705.7] (240.24A)

## Enclosures
- Enclosures weatherproof in wet or damp locations [3907.2] (312.2A)
- Surface-mounted wet or damp location metal enclosures min 1/4in air gap between enclosure & wall [3907.2] (312.2A)
- Equipment rated for dry or damp locations must be protected against damage from weather during construction [3404.4] (110.11)
- Open knockouts & twistouts durably filled EXC [3404.5] (110.12A)
- Manu holes for mounting OK [3404.6&3907.5] (110.12A)
- Protect bus bars & other internal parts from contamination (paint or plaster) during construction [3404.7] (110.12B)
- Max setback in noncombustible wall 1/4in [3907.3] (312.3)
- Flush (no setback) in combustible (wood-frame) wall [3907.3] (312.3)
- Max plater gap at side of flush mount panel 1/8in [3907.4] (312.4)
- Field labeling to distinguish each circuit from all others [3706.2] (408.4)
- Unused (spare) breakers labeled [3706.2] (408.4)

## Grounding & Bonding
- Bond neutral bar to enclosure & EGCs in service [3607.5] (250.24B)
- Isolate neutrals in subpanels [3607.2&3908.6] (250.24A5)
- Grounding terminal bar req’d if wire EGCs present [3607.2] (408.40)
- Continuity of neutral not to depend on enclosures [3406.11] (200.2B)
- Each neutral conductor req’s individual terminal [3706.4] (408.41)

## OCPDs & Wiring
- Panels req OCPD line side of bus [3706.3] (408.36)
- Breakers listed or classified AMI for panel [3403.3] (110.3B)
- Single-pole breakers w/ approved handle ties OK for 240V circuits [3404.16] (240.15B2)
- All multiwire circuits req handle tie or single handle [3701.5.1] (210.4B)
- Handle tie req’d for 2 circuits to receptacles on same yoke [3701.5.1] (210.7B)
- All conductors of multwire circuit must be grouped (wire ties or other means) inside panel EXC [3701.5.1] (210.4D)
- Cable systems where grouping is obvious [3701.5.2] (210.4D)
- Breakfed breakers secured in place EXC [3706.5] (408.36D)
- Output circuits from utility interactive PV inverter [705.12D6]
- Torque all breakers & terminals AMI [3403.3] (110.3B)
- Antioxidant on Al conductors AMI [local] (local)
- Secure each cable entering panel AMI [3907.8] (312.5C)
- Splices & taps in panels OK to 40% fill [3907.1] (312.8)
- Apply warning label to enclosure identifying power source of feed-through conductors [312.8] (408.15B2)

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**FIG. 15**

**FIG. 16**

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**LANE SIDE**

**LOAD SIDE**

Neutral conductor identified (white tape encircling end of conductor)

Do not bond neutral in service enclosure

4-conductor feeder

All multiwire circuits req. handle ties or single-handle 2-pole breaker.

No wire tie needed for multiwire circuit in cable.