Quick guide
Residential Wiring Diagrams, Codes, And Symbols

3-way switch with light in center
- traveler wires
- hot
- connect to light
- second box

3-way switch with light at end
- 2-wire cable
- hot
- 2-wire cable
- traveler wires
- to fixture

4-way switch
- first box
- second box
- third box
- 2-wire cable
- hot
- 2-wire cable
- traveler wires
- to fixture

Outlet symbols
- Duplex receptacle outlet with GFI or GFCI device, wall mounted
- Duplex receptacle outlet, isolated ground, wall mounted
- Duplex receptacle outlet, split wired, wall mounted
- Duplex special purpose outlet
- Emergency outlet, wall mounted
- Garbage disposal outlet, wall mounted
- General outlet, ceiling mounted
- General outlet, wall mounted
- Junction box, ceiling mounted
- Junction box
Electrical circuits
Electrical blueprints
Electrical Wiring Diagrams

Simple outlet circuit

To end of circuit
Pigtail GFCI Outlets
Single switch before light

Single switch after light
3-way switch with light in center

3-way switch with light at end

4-way switch
Dedicated circuits

Oven/range
Service entrance to breaker box
Breaker box
Cable Sizes

- #2 95-Amps
- #4 70-Amps
- #6 55-Amps
- #8 40-Amps
- #10 30-Amps
- #12 20-Amps
- #14 15-Amps
- #16 10-Amps
- #18 7-Amps

- 2-wire cable
- 3-wire cable
- 2-wire armored cable
- 3-wire armored cable
- UF cable
- 10-gauge
- 12-gauge
**Outlet Receptacles**

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Voltage</th>
<th>Wire size</th>
<th>Receptacle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric dryer</td>
<td>120/240V</td>
<td>20 to 30 amps</td>
<td>#10</td>
</tr>
<tr>
<td>Electric water heater</td>
<td>240V</td>
<td>20 to 30 amps</td>
<td>#10</td>
</tr>
<tr>
<td>Electric range</td>
<td>120/240V</td>
<td>Two #6 hot wires</td>
<td>and a #8 neutral wire</td>
</tr>
<tr>
<td>Separate oven and cooktop</td>
<td>120/240V</td>
<td>30 Amps separate separat 30-Amp</td>
<td>50 Amps together circuits use #10 wire</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>120V</td>
<td>20 Amps</td>
<td>#12</td>
</tr>
</tbody>
</table>

**GFCI Residential Location Requirements**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>All bathroom receptacles</td>
<td>3802.1</td>
<td>[210.8A1]</td>
</tr>
<tr>
<td>All garage &amp; accessory building receptacles</td>
<td>3802.2</td>
<td>[210.8A2]</td>
</tr>
<tr>
<td>All receptacles in unfinished basements EXC</td>
<td>3802.5</td>
<td>[210.8A5]</td>
</tr>
<tr>
<td>Permanently installed fire or burglar alarm system</td>
<td>3802.5X3</td>
<td>[210.8A5X]</td>
</tr>
</tbody>
</table>

The 2005 NEC and the 2006 IRC have exceptions for receptacles in garages and unfinished basements that are not readily accessible or that serve appliances not easily moved from one place to another, such as freezers. A receptacle for a single appliance under that exception must be a single receptacle, and for two such appliances a duplex receptacle can be used.

- All outdoor receptacles EXC
- Receptacles for snow melting & deicing equipment on dedicated branch circuit if located so they are not readily accessible
- Equipment plugged into receptacles installed under above exception req's GFPE protection in plug cap
- All receptacles in crawlspace at or below grade level
- All receptacles serving kitchen counters
- Receptacles within 6ft of outside edge of laundry, utility, or wet bar sinks
- Receptacles in boathouses
Residential Electrical Guidelines

GENERAL RESIDENTIAL GUIDELINES

Here are a few typical guidelines that apply to residential work. These are NOT legal interpretations of any one code, so check with your local authority before starting work.

Kitchens

All kitchen, breakfast room, pantry, and dining room outlets must be supplied by at least two 20-amp small appliance circuits.

Outlets above the kitchen counter (used by countertop appliances) normally are fed by both circuits -- they all cannot be wired to just one circuit. The circuits should not supply any lights or other outlets in the house.

Appliances

Separate circuits are needed for built-in appliances (i.e., oven, range, disposer, dishwasher, central air conditioner, furnace).

One 20-amp circuit is needed for the laundry outlet within 6' of the machines. An electric dryer requires an additional 240-volt circuit.

Outlets

One lighting/convenience outlet circuit should be provided for every 575 square feet of floor space in a house.

Any bathroom or garage outlet within 6' of a sink must be Ground-Fault Circuit Interrupter (GFCI) protected. All kitchen outlets for countertop must be GFCI protected. Bedroom outlets should be Arc-Fault Circuit Interrupter (AFCI) protected.

At least one GFCI outlet is required in an unfinished basement, as well as most outdoor outlets. Exceptions include inaccessible outlets like those in a garage ceiling or behind a refrigerator.

Any point along the bottom of a wall (which is 2' or wider) must be within 6' of an outlet. The 6' distance cannot be measured across a doorway or fireplace. And the outlet must be within 5 1/2' of the floor. (This cuts down on extension cord use, especially across doorways, fireplaces and similar openings.)

Switches

Every habitable room, hallway, stairway or garage must have a light switch that controls lighting in that area. In kitchens and bathrooms, the light switch must control a permanently installed light fixture. In other rooms, the switch can control either a light fixture (in the ceiling, for example) or a receptacle into which a lamp may be plugged.

Notching walls and drilling holes

<table>
<thead>
<tr>
<th>Nominal Dimensions</th>
<th>Actual Dimensions</th>
<th>STUDS</th>
<th>DRILLED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25%</td>
<td>40%</td>
</tr>
<tr>
<td>2 x 4</td>
<td>1 1/2 x 3 1/2</td>
<td>7/8&quot;</td>
<td>1.25/64</td>
</tr>
<tr>
<td>2 x 6</td>
<td>1 1/2 x 5 1/2</td>
<td>1 3/8&quot;</td>
<td>2.12/64</td>
</tr>
</tbody>
</table>

STUDS

Load-Bearing Walls

Holes should represent less than 40% of the joist depth (see Drilled / 40% above).

Non-Load-Bearing Walls

Holes should represent less than 60% of the joist depth (see Drilled / 60% above).

JOISTS

Notches must represent less than 1/6th of the depth of the joist.

Notches are not allowed in the middle third of the joist length (only allowed toward the ends).

Drilled holes in joists must not be within 2 inches of an outside edge of the joist.

Drilled holes must represent less than 1/3rd of the overall depth of the joist.
Cable Checklist

Cabling must be installed and supported properly. It also must be protected from physical damage and from electrical damage.

Bends in Romex must not be made too sharply. Bending cable incorrectly can weaken the outer sheathing as well as the insulation on the individual conductors. The radius of the curve of the inner edge of any bend must not be less than five times the diameter of the cable. A correct installation will result in a "jug handle."

Cable must be fastened to the framing every 4-1/2 feet, using staples, cable ties, straps, hangers, or similar fittings.

Flat cables (e.g., 14/2 Romex or 12/2 Romex) must not be stapled on edge.

Flat cables may be installed on top of one another and fastened with one staple, so long as one flat side of one cable is against the framing member and the other flat side is against the flat side of the next cable. (Two cables should not be placed side-by-side and fastened with one staple; this can damage the cable insulation.)

Check that staples or fasteners do not cut through a cable's insulation.

Where cable runs through wood framing members, it must be no closer than 1-1/4 inches to the nearest edge of the framing member. When this clearance cannot be maintained, a nailing plate must be added for protection. A nailing plate is always required.

Where cable runs through metal studs, plastic grommets must be inserted in all holes, whether those holes are manufactured or field-drilled. The plastic grommet must cover all metal edges of the hole, to provide physical protection as the cables are pulled through the metal studs.

Openings around penetrations through walls, floors, and ceilings must be filled with an approved fire-stopping material. (Some locales require fire-stopping measures in both non-fire-rated and fire-rated building components.)

Check for draft-stopping measures where cable penetrates framing members.

Cabling must be secured within 8" of every nonmetallic box that's smaller than 2½ x 4¼.

Cabling must be secured within 12" of every nonmetallic box that's larger than 2½ x 4¼.

Cabling for recessed lights should be fastened to the nearest framing, providing a "jug handle."

All cables that run into metal or plastic boxes must be protected from abrasion. This can be accomplished by using connectors that have smooth openings for the cable to go through or by simply making sure a short section of the cable sheathing extends past the clamping mechanism of a cable clamp.

All cables that run into metal or plastic boxes must be secured to the boxes. Commonly, this is done using internal or external clamps.

Account for the voltage drop that can be caused by long runs of cable. Try to limit drop to less than 3%. (See Voltage Drop table.)

Separate runs of cable/wire are required for bedroom outlets (so they can be provided with Arc-Failure Circuit Interrupter (AFCI) protection. The same is true for any other circuits requiring AFCI or GFCI protection.

Pulling Cable

*Running cable* or "pulling cable" is a bit more involved than it sounds. Getting cable to cooperate can be frustrating and time consuming. So it helps to be patient... and a bit creative.

Double-check your circuit diagrams before running any cable. Also make a note where you can double-up runs anywhere by pulling two cables at once.

When pulling wire through conduit, or even when pulling nonmetallic-sheathed cable through holes in studs, joists, etc., "fish tape" can be fed through holes, hooked to the cable or wire, and pulled back to retrieve it.

A typical way to pull cable is to start at the last fixture in the run, pull cable to each fixture in the circuit, and continue all the way back to the service panel:

- Leave the box/spool of cable at the fixture you are wiring, unwind enough cable to complete the run, and then start pulling it through the holes. On long runs, you may need to return to the box or spool a few times to feed more cable through. Two people can really save time: one feeding cable and one pulling cable.

- Nonmetallic-sheathed cable can tangle or bind. If you feel resistance while pulling, the cable is probably kinked somewhere along the run and should be straightened out.

- Each time you reach a junction box, pull a few extra feet of cable through for making connections later.

- Once the cable reaches the service panel, leave a foot or so of extra length on both the service end and the box/spool end for connecting.

- After the cable is in place, fasten it to framing with staples every 4'-6", at turns, and within 12" of where cable enters a box. At turns, provide a "jug handle."

- Label each cable at the panel end with a felt pen or piece of tape to keep them organized.

Next Steps: Attach the cable to the framing (see diagrams on following pages for maximum distances between fasteners) and securing the cable to junction/device boxes with clamps provided within the boxes.

<table>
<thead>
<tr>
<th>Wire Color</th>
<th>Circuit Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLACK</td>
<td>&quot;Hot&quot; wire. In an outlet, it is always wired to the narrow spade or brass-colored terminal.</td>
</tr>
<tr>
<td>GREEN</td>
<td>&quot;Ground&quot; or &quot;grounding&quot; wire. In an outlet, it is always wired to the green terminal.</td>
</tr>
<tr>
<td>RED</td>
<td>&quot;Second hot&quot; wire in a 3-way outlet. Often called the &quot;traveler.&quot;</td>
</tr>
<tr>
<td>WHITE OR GRAY</td>
<td>&quot;Neutral&quot; wire. In an outlet, it is always wired to the wide spade or silver-colored terminal.</td>
</tr>
</tbody>
</table>
Electrical Switch Symbols

- **S**: Fused switch, wall mounted
- **SP**: Fused safety switch
- **X**: Key controlled switch, wall mounted
- **SV**: Low voltage switch, wall mounted
- **SM**: Low voltage master switch, wall mounted
- **SMO**: Manual motor switch, wall mounted
- **SMO**: Manual motor switch, with thermal overload, wall mounted
- **SNC**: Momentary contact, intermittent switch, wall mounted
- **P**: Motion detector sensor
- **PE/PES**: Photoelectric switch
- **SPO**: Pilot/remote light switch, load off, wall mounted
- **SP**: Pilot/remote light switch, load on, wall mounted
- **SC**: Remote control switch, receiver, wall mounted
- **SCP**: Ceiling pull switch, ceiling mounted
- **SCP**: Chain pull switch
- **SCB**: Circuit breaker switch, wall mounted
- **SCC**: Contractor control switch, wall mounted
- **S3**: Dedicated/specialized switch, letter indicates equipment wall mounted
- **S4**: Dimmer switch, wall mounted
- **SD**: Disconnect safety switch
- **S2**: Door, closet, or jamb switch
- **S2**: Double pole switch, wall mounted
- **SE**: Electric eye, relay
- **SE**: Electric eye, source
- **X**: Enclosed circuit breaker
- **X**: Evaporative cooler switch
- **S**: 3-switches, fan, pump, speed controller, wall mounted
- **S**: Explosion proof switch, wall mounted
- **S**: Fluorescent light dimmer switch, wall mounted
- **S**: Four-way switch, wall mounted
- **S**: Single pole switch, wall mounted
- **S**: Switch with locator lamp, glow, wall mounted
- **S**: Thermal rated motor switch
- **Th**: Thermostat
- **3**: Three-way switch, wall mounted
- **T**: Timer or motor switch, with thermal overload, wall mounted
- **TC**: Time clock switch
- **S**: Variable speed or volume control switch, wall mounted
- **S**: Wall bracket pull switch
- **S**: Weatherproof circuit breaker, wall mounted
- **S**: Weatherproof switch, wall mounted
- **S**: Weatherproof switch, wall mounted
- **S**: Cable tray
- **P**: Conduit turning up
- **P**: Conduit turning down
- **E**: Conduit with capped end
- **E**: Emergency circuit
- **E**: Exposed circuit
- **E**: Home run to panel
- **E**: Letters indicate panel
- **E**: Numbers indicate circuits
- **P**: Plug in or feeder bus
- **P**: Pull box
- **P**: Wire in conduit (solid line indicates conduit in wall or ceiling) #8 phase and neutral size #10
- **P**: Wireway
Fixture Symbols

- Emergency exit light combo, battery powered, wall mount
- Emergency exit light combo, battery powered, ceiling mount
- Emergency exit light remote, battery powered, ceiling mount
- Emergency exit light remote, battery powered, with 3 sealed beams, wall mount
- Emergency lighting on critical power circuit
- Emergency lighting on emergency life safety branch
- Exit light, wall mounted arrow indicates exit
- Exit light, recessed wall mounted
- Exit light, shaded area indicates number of faces shown, arrow indicates exit no arrow when directly over an exit door
- Fluorescent fixture, ceiling mounted
- Fluorescent lighting fixture, wall mounted
- Fluorescent lighting fixture, channel mount, ceiling mounted
- Fluorescent lighting fixture, number of tubes, ceiling mount
- Fluorescent lighting fixture, number of tubes, wall mount
- Fluorescent lighting fixture, mod wired in series wall mount
- Fluorescent lighting fixture, pendant style, ceiling mount
- Same as above, wall mount
- Fluorescent lighting fixture recessed style ceiling mount
- Fluorescent lighting fixture surface mount with outlet box, ceiling mount
- Fluorescent lighting fixture on critical branch circuit
- Fluorescent lighting fixture on emergency circuit
Fixture Symbols

Fluorescent fixtures continuous row

- Illuminated house number, wall mounted
- Incandescent lighting fixture, ceiling mounted
- Incandescent lighting fixture, blank, unused ceiling mounted
- Incandescent lighting fixture, blank unused wall mounted
- Incandescent lighting fixture, chandelier, ceiling mounted
- Incandescent lighting fixture, controlled by low voltage switch relay in box, wall mounted
- Incandescent lighting fixture, letter in triangle is reference to key, ceiling mounted
- Incandescent lighting fixture, mirror lights, wall mounted
- Incandescent lighting fixture, mirror and lights, wall mounted
- Incandescent lighting fixture, multiple flood lights, wall mounted
- Incandescent lighting fixture, recessed, ceiling mounted
- Incandescent lighting fixture, recessed directional light fixture, ceiling mounted

Incandescent lighting fixture, rough in only, ceiling mounted
Incandescent lighting fixture, spot light, ceiling mounted
Incandescent lighting fixture, heat lamp, ceiling mounted
Incandescent lighting fixture, standard upper case = key, number = circuit number, switch control
Incandescent lighting fixture, surface directional light wall mounted
Incandescent lighting fixture, track lighting
Incandescent lighting fixture, underwater recessed, bottom fixture
Incandescent lighting fixture, underwater recessed, wall mounted
Incandescent lighting fixture, underwater up beam bottom mounted
Incandescent lighting fixture, fan ceiling mounted
Wall tan
Incandescent lighting with pull switch, wall mounted
Outlet Symbols

- 220-volt outlet, wall mounted
- 220-volt outlet, clothes dryer wall mounted
- 220-volt outlet, range, wall mounted
- Blanked (unused) duplex outlet, wall mounted
- Blanked (unused) outlet, ceiling mounted
- Blanked (unused) outlet, wall mounted
- Blanked (unused) quad outlet, wall mounted
- Clothes washer outlet, wall mounted
- Combination switch and double outlet, receptacle, wall mounted
- Combination switch and single outlet receptacle, wall mounted
- Dishwasher outlet wall mounted
- Drop cord ceiling mounted
- Duplex receptacle outlet, ceiling mounted
- Duplex receptacle outlet, floor mounted
- Duplex receptacle outlet, wall mounted
Outlet symbols

- **Duplex receptacle outlet with GFI or GFCI device, wall mounted**
- **Duplex receptacle outlet, isolated ground, wall mounted**
- **Duplex receptacle outlet, split wired, wall mounted**
- **Duplex special purpose outlet**
- **Emergency outlet, wall mounted**
- **Garbage disposal outlet, wall mounted**
- **General outlet, ceiling mounted**
- **General outlet, wall mounted**
- **Junction box, ceiling mounted**
- **Junction box, wall mounted**
- **Lamp holder, ceiling mounted**
Outlet Symbols

Lampholder, wall mounted

Lampholder, with pull switch, ceiling mounted

Lampholder, with pull switch, wall mounted

Multi-outlet assembly or power strip

Outlet for exit lamp, ceiling mounted

Outlet for exit lamp, wall mounted

Poke-through with electrical outlets, floor mounted

Poke-through (abandoned)

Polarized plug receptacle outlet, wall mounted

Pull switch, ceiling mounted

Pull switch, wall mounted

Quadruplex (double duplex) receptacle outlet, ceiling mounted

Quadruplex (double duplex) receptacle outlet, floor mounted
Outlet Symbols

- Quadruplex (double duplex) receptacle outlet, ceiling mounted
- Quadruplex (double duplex) receptacle outlet, floor mounted
- Quadruplex (double duplex) receptacle outlet, wall mounted
- Quadruplex (double duplex) receptacle outlet, isolated ground, wall mounted
- Single grounding receptacle outlet, wall mounted
- Single receptacle outlet, ceiling mounted
- Single receptacle outlet, floor mounted
- Single receptacle outlet, wall mounted
- Single special purpose outlet
- Single special purpose outlet, wall mounted
- Special purpose outlet, key indicates purpose, floor mounted
- Special purpose duplex outlet
- Triplex receptacle outlet, wall mounted
- Triplex receptacle outlet, split wired, wall mounted
- Vapor discharge lamp outlet, ceiling mounted
- Vapor discharge lamp outlet, wall mounted
- Water heater outlet, wall mounted
- Waterproof duplex receptacle outlet
Communication Symbols

- Bell
- Bell & buzzer combo
- Buzzer
- Card reader, wall mounted
- Chime
- Clock
- Clock, electrical clock system, wall mounted
- Closed circuit TV camera
- Data/phone outlet
  - Floor mounted
  - Wall mounted
- Computer outlet (general)
- Data outlet, floor mounted
- Data outlet, wall mounted
- Microphone, wall receptacle
- Paging system device, wall mounted
- Poke through, floor mount
- Poke through, with telephone outlets, floor mounted
- Poke through, with various devices, floor mounted
- Poke through, abandoned, floor mounted
- Pole, various devices
- Private telephone devices wall mounted
- Public telephone, wall mount
- Push button switch
- Signal central station device
- Signal system device
- Sound system devices, wall mount
- Special auxiliary outlets letter refers to key
- Telephone public general symbol, letter key
- Telephone public
- Telephone outlet, Private, floor mounted
- Telephone outlet, Public, floor mounted
- Telephone terminal cabinet
- Telephone terminal cabinet, wall mounted
- TV (CATV) outlet
- TV antenna devices wall mounted
- Volume control
- Watchman system devices wall mounted
- Yard bell or chime
Plumbing Symbols

- **Water Meter**
- **Hot Water**
- **Sanitary Waste**
- **Gate Valve**
- **Water Closet**
- **Water Heater**
- **Clothes Washer**
- **Clean Out**
- **Pipe turns Down**
- **Union**
- **Cold Water**
- **Vent Line**
- **Gas Pipe**
- **Water Heater Shut Off**
- **Lavatory**
- **Dishwasher**
- **Floor Drain**
- **Vent Thru Roof**
- **Pipe Turns Up**
- **Tee**
- **Cap**
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTR</td>
<td>Piping, vent through roof</td>
</tr>
<tr>
<td></td>
<td>Valve (designated by key or abbreviations)</td>
</tr>
<tr>
<td></td>
<td>Valve in pit or valve box</td>
</tr>
<tr>
<td></td>
<td>Valve in riser</td>
</tr>
<tr>
<td></td>
<td>Valve in wall box</td>
</tr>
<tr>
<td></td>
<td>Valve, 3-way (shading indicates closed side)</td>
</tr>
<tr>
<td></td>
<td>Valve, 4-way</td>
</tr>
<tr>
<td></td>
<td>Valve, air- or gas-line</td>
</tr>
<tr>
<td></td>
<td>Valve, angled gate type</td>
</tr>
<tr>
<td></td>
<td>Valve, angled globe type</td>
</tr>
<tr>
<td></td>
<td>Valve, ball type</td>
</tr>
<tr>
<td></td>
<td>Valve, butterfly</td>
</tr>
<tr>
<td>HB</td>
<td>Valve, hose bibb</td>
</tr>
<tr>
<td></td>
<td>Valve, hot water balance</td>
</tr>
<tr>
<td></td>
<td>Valve, lift check type</td>
</tr>
<tr>
<td></td>
<td>Valve, listed indicating</td>
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<tr>
<td></td>
<td>Valve, lockable</td>
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<tr>
<td></td>
<td>Valve, needle type</td>
</tr>
<tr>
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<td>Valve, petcock or cock</td>
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<tr>
<td></td>
<td>Valve, pig ball type</td>
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<tr>
<td></td>
<td>Valve, plug type</td>
</tr>
<tr>
<td>PIV</td>
<td>Valve, post-indicator</td>
</tr>
<tr>
<td></td>
<td>Valve, pressure reducing</td>
</tr>
<tr>
<td></td>
<td>Valve, pressure relief</td>
</tr>
<tr>
<td></td>
<td>Valve, rotary plug type</td>
</tr>
<tr>
<td></td>
<td>Valve, safety type</td>
</tr>
</tbody>
</table>
BFP
Valve, check (also called swing check or backflow preventer)
Valve, control, diaphragm actuator
Valve, control, hand actuator
Valve, control, motor operated
Valve, control, rotary actuated
Valve, control, solenoid operated
Valve, diaphragm type
Valve, faucet
Valve, float type
Valve, flush valve

GV
Valve, gate type, normally closed
Valve, gate type, normally opened (abbrev. or letter refers to key)
Valve, globe type

Valve, spring check type
Valve, stop check type
Valve, stop cock plug or cylinder type, 2-way
Valve, stop cock plug or cylinder type, 3-way/2-port
Valve, stop cock plug or cylinder type, 3-way/3-port
Valve, stop cock plug or cylinder type, 4-way/4-port
Valve, triple duty (flow, flow balance, backflow prevention)
Valve, V-ball type
Architectural symbols

Architectural Blueprint Symbols

Single Sink  Double Sink  Dishwasher  Range & Oven  Drop-in Cooktop

Upper Cabinet  Base Cabinet  W  D  O
Refrigerator  Trash Compactor  Washer  Dryer  Wall Oven

Toilet  Shower  Tub  Lavatory/Sink  Wall Light  Ceiling Light

Furnace  Water Heater  Phone  TV Cable  120 Outlet  240 Outlet  Switch
### Electrical boxes

**Boxes** are necessary to safely enclose and protect wiring splices and to support devices and luminaires (fixtures). In raceways, they provide a pull point for the wiring. Boxes must be large enough to contain all the conductors and devices inside them, and sufficient wire must be brought into the box to safely make up connections. Luminaires that are supported from boxes are generally designed so their connections will be made inside the box, rather than inside the fixture canopy. Device boxes with 6/32 threaded holes are designed to mount switches and receptacles and are not generally used to mount luminaires.

#### General

<table>
<thead>
<tr>
<th>Item</th>
<th>06 IRC</th>
<th>08 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal boxes must be grounded</td>
<td>[3805.2]</td>
<td>(314.4)</td>
</tr>
<tr>
<td>Box &amp; conduit body covers must remain accessible</td>
<td>[3805.10]</td>
<td>(314.29)</td>
</tr>
<tr>
<td>Max 3/4in setback from noncombustible surface</td>
<td>[3806.5]</td>
<td>(314.20)</td>
</tr>
<tr>
<td>Box extenders OK to correct excess setback</td>
<td>[3806.6]</td>
<td>(314.20)</td>
</tr>
<tr>
<td>Boxes flush w/ combustible surface</td>
<td>[3806.5]</td>
<td>(314.20)</td>
</tr>
<tr>
<td>Plastic gap max 3/4in for flush cover boxes</td>
<td>[3806.6]</td>
<td>(314.21)</td>
</tr>
<tr>
<td>Min 6in free conductor &amp; 3in past box face</td>
<td>[3306.10.3]</td>
<td>(300.14)</td>
</tr>
<tr>
<td>Ceiling lighting boxes rated min 50lb</td>
<td>[3805.6]</td>
<td>(314.27A)**</td>
</tr>
<tr>
<td>Wall boxes marked w/ max weight if not 50lb EXC [na]</td>
<td>[3806.27A]**</td>
<td></td>
</tr>
<tr>
<td>Wall sconces 0.6lbs OK mounted on device boxes</td>
<td>[3806.6X]</td>
<td>(314.27AX)</td>
</tr>
<tr>
<td>Smoke alarms OK mounted to device boxes [na]</td>
<td>[3806.27EX]</td>
<td>(314.27EX)</td>
</tr>
<tr>
<td>Boxes must be rigidly supported</td>
<td>[3806.8]</td>
<td>(314.23)</td>
</tr>
<tr>
<td>PVC &amp; EMT not OK for box support</td>
<td>[3806.8.5]</td>
<td>(314.23E&amp;F)</td>
</tr>
<tr>
<td>PVC &amp; EMT OK for conduit body support</td>
<td>[3806.8.5]</td>
<td>(314.23E&amp;F)</td>
</tr>
</tbody>
</table>

*Also see NEC sections 352.12B & 336.12.*

<table>
<thead>
<tr>
<th>Item</th>
<th>06 IRC</th>
<th>08 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet location boxes &amp; conduit boxes listed for wet</td>
<td>[3805.11]</td>
<td>(314.15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(314.15)</td>
</tr>
</tbody>
</table>

#### Box Fill

<table>
<thead>
<tr>
<th>Item</th>
<th>06 IRC</th>
<th>08 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size sufficient to provide free space for conductors</td>
<td>[3805.12]</td>
<td>(314.16)</td>
</tr>
<tr>
<td>Standard metal boxes per code tables</td>
<td>[3805.12.1.1]</td>
<td>(314.16A1)</td>
</tr>
<tr>
<td>Include volume of marked mud rings &amp; extensions</td>
<td>[3805.12.1]</td>
<td>(314.16A)</td>
</tr>
<tr>
<td>Plastic boxes have volume marking</td>
<td>[3805.12.1.2]</td>
<td>(314.16A2)</td>
</tr>
<tr>
<td>No splices in pancake boxes EXC P21</td>
<td>[3805.12.2]</td>
<td>(314.16B)</td>
</tr>
</tbody>
</table>

4in (6cu in) pancake OK at end of 14/2 w/ an P21 | [3805.12.2] | (314.16B) |

18cu in box too small for 3 12/2 Romex T8,F20 | [3805.12.2] | (314.16B) |

#### Box Fill Factors T7,T8

<table>
<thead>
<tr>
<th>Item</th>
<th>06 IRC</th>
<th>08 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count each conductor exiting box EXC</td>
<td>[3805.12.2.1]</td>
<td>(314.16B1)</td>
</tr>
<tr>
<td>EGCs from luminaires or up to 4 conductors &lt;14AWG</td>
<td>[3805.12.2.1X]</td>
<td>(314.16B1X)</td>
</tr>
<tr>
<td>from luminaires w/ domed canopies</td>
<td>[3805.12.2.1X]</td>
<td></td>
</tr>
<tr>
<td>Unbroken conductors passing through box count</td>
<td>[3805.12.2.1]</td>
<td>(314.16B1)</td>
</tr>
<tr>
<td>as only 1 conductor EXC</td>
<td>[3805.12.2.1]</td>
<td>(314.16B1)</td>
</tr>
<tr>
<td>Looped unbroken conductors &gt;12in count as 2</td>
<td>[3805.12.2.1]</td>
<td>(314.16B1)</td>
</tr>
<tr>
<td>Do not count pigtailed conductors to devices</td>
<td>[3805.12.2.1]</td>
<td>(314.16B1)</td>
</tr>
<tr>
<td>All internal clamps count as 1, based on largest conductor in box</td>
<td>[3805.12.2.2]</td>
<td>(314.16B2)</td>
</tr>
<tr>
<td>Support fittings count as 1 conductor for each fitting type based on largest conductor in box</td>
<td>[3805.12.2.3]</td>
<td>(314.16B3)</td>
</tr>
<tr>
<td>Count devices as 2 conductors based on the connected wire size</td>
<td>[3805.12.2.4]</td>
<td>(314.16B4)</td>
</tr>
<tr>
<td>All EGCs count as only 1 based on largest conductor</td>
<td>[3805.12.2.5]</td>
<td>(314.16B5)</td>
</tr>
</tbody>
</table>

#### Pancake Boxes

- 4 cu. in.
- 6 cu. in.

#### 2x4 with front nailer

- 2x4 with 16d nails

#### 4x4 with angled nails
Branch circuits and outlets

**Branch Circuits & Outlets – Kitchens**

- **Receptacle Outlets – General Purpose**
  - F27 & 28 06 IRC 08 NEC
  - Walls ≥ 2 ft wide req receptacles (3801.2.2) [210.52A2] (210.52A1)
  - Partitions & bar-type counters count as walls (3801.2.2) [210.52A2] (210.52A1)
  - Doorways & fireplaces not counted as walls (3801.2.2) [210.52A2] (210.52A1)
  - Receptacle req’d within 6 ft horizontally of any point along wall (3801.2.1) [210.52A1] (210.52A2)
  - Receptacle req’d for hallways ≥ 10 ft in length (3801.10) [210.52H]
  - Receptacles that are part of electric baseboard heaters OK as req’d outlets (3801.1) [210.52] (210.52A2)
  - Receptacles > 6 1/2 ft high not OK as req’d outlets (3801.1) [210.52] (210.52A2)
  - Floor receptacles > 18 in from wall not OK as req’d outlets (3801.2.3) [210.52A3] (210.52A2)
  - Switched receptacles installed as req’d lighting do not count as part of req’d receptacle outlets unless “half hot” [n/a] [210.52] (210.52A2)

**Garages & Unfinished Basements**
- F27 & 28 06 IRC 08 NEC
  - Min 1 wall-switched lighting outlet in garage (3803.3) [210.70A2a]
  - Min 1 receptacle not dedicated to fixed equipment (3801.9) [210.52G] (210.52G)

**Bathrooms**
- F27 & 28 06 IRC 08 NEC
  - Receptacle req’d on wall within 3 ft of each basin (3801.6X) [210.52D]
  - May be in cabinet side or face ≤ 12 in below countertop (3801.6X) [210.52D]
  - No face-up outlets on vanity countertop (3801.6) [406.4E]
  - No receptacles within or directly over tub or shower (3801.11) [406.8C]
  - Separate 20A circuit for bath receptacles only OR (3803.4) [210.11C3]
  - Dedicated 20A circuit to each bathroom (3803.4X) [210.11C5X]
  - Max rating of fixed space heater on general lighting circuit (3806.4) [210.23A2]

**Laundry**
- F27 & 28 06 IRC 08 NEC
  - Min 1 20A circuit to laundry receptacles (3803.3) [210.11C2]
  - No other outlets on laundry receptacle circuit (3803.3) [210.11C2]
  - Receptacle within 6 ft of intended appliance location (3001.5) [210.50C]
  - Electric dryer min 30A circuit (10AWG Cu, 8AWG Al) (3804.211) [220.54]
  - Electric dryer req’d 4-conductor branch circuit EXC (3808.7) [250.140]
  - Existing 3-wire circuits allowed to remain in use [n/a] [250.140X]

**Outdoors**
- F27 & 28 06 IRC 08 NEC
  - Receptacle accessible from grade req’d at front & rear of dwelling ≥ 6 1/2 ft above grade (3801.7) [210.52E1] (210.52E2)
  - Receptacle req’d for balconies w/ interior access & ≥ 20 sq ft (n/a) [210.52E3] (210.52E3)
  - Receptacles in damp or wet locations req’d to be listed weather-resistant type [n/a] [406.8A6B]
  - Outdoor damp location receptacle (e.g., protected porch) req’d’s weatherproof cover F29 (3902.8) [406.8A]
  - Wet location 15A & 20A receptacles req in-use covers (3902.9) [406.8B1]

**Outdoor Receptacle Covers**
- Weatherproof cover (n/a) [406.8B1]

**Lighting Outlets (also see p.19)**
- F27 & 28 06 IRC 08 NEC
  - Wall-switch controlled lighting outlets req’d in all habitable rooms & bathrooms (3803.2) [210.70A1]
  - Habitable room lighting outlets may be switched receptacle except in kitchen & bathroom (3803.2X) [210.70A1X]
  - Occupancy-sensor wall switches OK (3803.2X) [210.70A1X2]
  - Wall-switch controlled lighting outlets req’d in hallways, stairways, attached garages, & detached garages w/ power (3803.3) [210.70A2a]
  - Interior stair req’s switch at each entrance if ≥ 2 risers (3803.3) [210.70A2b]
  - Lighting outlet req’d on exterior side grade-level doors (3803.3) [210.70A2b]
  - Lighting outlet not req’d at garage egress doors (3803.3) [210.70A2b]
  - Lighting outlet not req’d at garage vehicle doors (3803.3) [210.70A2b]
KITCHENS

A minimum of two small-appliance branch circuits are required for portable appliances that are used in kitchens and dining areas. These circuits are in addition to those that supply lighting or permanently installed appliances. Portable kitchen appliances have short cords so they are not as likely to be run across cooktops or sinks or to hang down in the reach of children. A receptacle is needed to serve every countertop 1 ft. or more in width.

Branch Circuits

<table>
<thead>
<tr>
<th>06 IRC</th>
<th>08 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Min 2 20A small-appliance circuits req'd</td>
<td>[3603.2]</td>
</tr>
<tr>
<td>☐ Small-appliance circuits must serve refrigerator &amp; all countertop &amp; exposed</td>
<td></td>
</tr>
<tr>
<td>wall receptacles in kitchen, dining room, &amp; pantry EXC</td>
<td>[3603.2]</td>
</tr>
<tr>
<td>Refrigerator OK on individual branch circuit &gt;15A</td>
<td>[3803.2X]</td>
</tr>
<tr>
<td>☐ Switched receptacle for dining room light OK on</td>
<td></td>
</tr>
<tr>
<td>non-small-appliance circuit</td>
<td>[3803.2X]</td>
</tr>
<tr>
<td>☐ No other outlets (including lights) on small appliance</td>
<td></td>
</tr>
<tr>
<td>branch circuits EXC</td>
<td>[3801.3.1]</td>
</tr>
<tr>
<td>☐ Receptacles for clock or gas range ignition OK</td>
<td>[3801.3.1X]</td>
</tr>
<tr>
<td>☐ Dishwasher &amp; disposer req separate circuits if combined rating</td>
<td></td>
</tr>
<tr>
<td>exceeds branch circuit rating</td>
<td>[3800.1]</td>
</tr>
<tr>
<td>☐ Circuits for ranges 28.75kW min 40A 240V</td>
<td>[3802.9.1]</td>
</tr>
</tbody>
</table>

Receptacles for Countertop Spaces

<table>
<thead>
<tr>
<th>06 IRC</th>
<th>08 NEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Receptacles req'd for wall counter spaces &gt;12 in wide</td>
<td>[3801.4.1]</td>
</tr>
<tr>
<td>☐ Countertop spaces separated by sinks or ranges considered</td>
<td></td>
</tr>
<tr>
<td>separate countertop spaces</td>
<td>[3801.4.4]</td>
</tr>
<tr>
<td>☐ Spacing so no point &gt;24 in from receptacle</td>
<td>[3801.4.1]</td>
</tr>
<tr>
<td>☐ Area behind sink or range not considered countertop space</td>
<td></td>
</tr>
<tr>
<td>if &lt;12 in for straight wall</td>
<td>[3801.4.1X]</td>
</tr>
<tr>
<td>☐ Max 20 in above countertop</td>
<td>[3801.4.5]</td>
</tr>
<tr>
<td>☐ Peninsula countertop spaces req receptacle if long dimension &gt;24 in &amp; short dimension &gt;12 in, measured from connecting edge</td>
<td>[3801.4.9]</td>
</tr>
<tr>
<td>☐ Island &amp; peninsula countertop spaces min 1 receptacle per space—no 24 in rule</td>
<td>[3801.4.2&amp;3]</td>
</tr>
<tr>
<td>☐ No feeds up to countertop receptacles</td>
<td>[3801.4.5X]</td>
</tr>
<tr>
<td>☐ No feeds up to countertop receptacles</td>
<td>[3801.4.5]</td>
</tr>
<tr>
<td>☐ GFCI protection for all receptacles serving countertops</td>
<td>[3802.6]</td>
</tr>
</tbody>
</table>

FIG. 30

Kitchen Receptacles

Cord-plug connected rangehood allowed if supplied by individual branch circuit.

FIG. 31

2-ft./4-ft. Rule

Wall countertop receptacles serve the spaces for 2 ft. on each side of the receptacle. Therefore, the maximum spacing between receptacles on the same countertop space is 4 ft.

Max. 12 in. from countertop

Max. 6 in. overhang above receptacle

Island or peninsula countertop spaces req. only 1 receptacle—2-ft./4-ft. rule does not apply.

Receptacle req. when this peninsula dimension is >24 in.

Bar-type counter acts as room divider, so receptacle req. within 6 ft. of end.

This receptacle does not serve the countertop or need GFCI protection.

FIG. 32

Extended Range or Sink

If X ≥ 12 in., countertops not considered separate spaces & the 2-ft./4-ft. rule applies to the entire countertop.

X <12 in.: measure from here

X <12 in.: measure from here

FIG. 33

Corner Range or Sink

If X ≥ 18 in., countertops not considered separate spaces & the 2-ft./4-ft. rule applies to the entire countertop.

X <18 in.: measure from here

X <18 in.: measure from here
SWITCHES

Switch installations must ensure that an equal load is going in and out on each wiring method. Some modern occupancy sensors require a neutral conductor, and old-style switch loops are not sufficient for these sensors.

Switches

- All switching in ungrounded conductors **F34,35** [3901.8&9] (404.2A&B)
- Snap switches & dimmers req grounding EXC [3901.11.1] (404.9B)
- Replacement switches OK w/ GFCI or plastic faceplate [3901.11.1X] (404.9BX)
- Grounding OK by screws to grounded metal box [3901.11.1] (404.9B1)
- Metal faceplates must be grounded to switch [3901.11.1] (404.9B)
- Faceplate must completely cover wall opening [3901.11] (404.9A)
- 3-way switches req'd at stairs w/ 6 or more risers [3803.3] (210.70A2c)
- Dimmers OK for incandescent lights not receptacles [3901.12] (404.14E)
- Current-carrying conductors of circuit grouped **F34** [3306.7] (300.3B)
- Re-identify ungrounded white or gray wires **F34** [3307.3X] (200.7C)
- "CO/ALR" switch req'd if direct Al wire connection [3901.2] (404.14C)

**FIG. 34**

3-Way Switch

3-way switching takes place from a common terminal to one or the other traveler terminals.

![Diagram of 3-Way Switch](image)

**FIG. 35**

4-Way Switch

A 4-way switch is a double-pole, double-throw switch. Any number can be placed between the two 3-ways.

![Diagram of 4-Way Switch](image)

LIGHTING

Lighting outlets and luminaires must be installed with no exposed live parts that could pose a shock hazard. The heating effect of luminaires must be considered, especially around thermal insulation. Lights rated "Type IC" are suitable for insulated ceilings. See p.17 for required locations.

General

- All luminaires & lampholders listed [3903.3] (410.6)
- Exposed metal parts grounded EXC [3903.3] (410.42A)
- Incidental metal parts such as mounting screws [3903.3] (410.42A)
- Metal location luminaries L&L for wet location [3903.8] (410.10A)
- Screw shells for lampholders only-no adapters [3903.4] (410.90)

Recessed Lights

- Non-Type IC min 1/2in from combustibles [3904.8] (410.116A1)
- Non-Type IC min 3in from insulation [3904.9] (410.116B)
- Type IC OK in contact w/ combustible material [3904.8] (410.116A2)
- Type IC OK in contact w/ insulation [3904.9] (410.116B)
- Luminaires that req >60°C wire must be marked [n/a] (410.74)
- Connect proper temp-rated wire to luminaire [n/a] (410.17A)
- Tap conductors to 60°C wire min 18in max 6ft **F36** [n/a] (410.117C)

**FIG. 36**

Recessed Lighting with Old Wiring

![Diagram of Recessed Lighting with Old Wiring](image)

**FIG. 37**

Closet Lights **F37**

- Incandescent bulbs req'd to be fully enclosed [3903.11] (410.16A1)
- Partially enclosed incandescent bulbs prohibited [3903.11] (410.16B)
- Surface mounted only on ceiling or wall above door [3903.11] (410.16C)
- Surface incandescent min 12in from storage [3903.11] (410.16C1)
- Surface fluorescent min 6in from storage [3903.11] (410.16C2)
- Recessed (wall or ceiling) min 6in from storage [3903.11] (410.16C3&4)
- Surface fluorescent or LFD (light-emitting diode) OK in storage area if listed for same [n/a] (410.16C5)

![Diagram of Closet Lights](image)
CABLE SYSTEMS

Cable systems are the most common residential wiring methods. Cables contain all conductors of the circuit inside a protective outer sheath of metal or plastic. Starting with the 2005 edition, the NEC uses a parallel numbering system for rules pertaining to cables and raceways. See the common numbering system table (T23) on the inside back cover.

**Cable Protection Indoors (NM, AC, MC, UF, SE) 06 IRC 08 NEC**
- Bore holes & standoff clamps 1½ in setback F56 [3702.1] (300.4A&D)
- Protect cables w/ ½ in steel plate (or L&L plate)
- if closer than 1½ in to framing surfaces F45 [3702.1] (300.4A&D)
- Provide guard strips within 8 ft of attic scuttle F46 [3702.2.1] (334.23)
- or permanent stairs F46 [3702.2.1] (334.23)

**FIG. 45** Nail-Plate Protection

Protect cable when <1½ in. to face of framing.

<1½ in.

**GLOSsARY OF ELECTRICAL TERMS**

Accessible: Not permanently concealed or enclosed by building construction.

Accessible, as applied to equipment: Capable of being removed or exposed without damaging the building finish or structure. A piece of equipment can be considered accessible even if tools must be used or other equipment must be removed to gain access to it.

accessible, readily: Capable of being reached quickly for operation or inspection without the necessity of using tools to remove covers, resorting to ladders, or removing other obstacles.

Alternating current (AC): Current that flows in one direction and then in the other in regular cycles; referred to as frequency or Hertz.

Apparent power: See power.

Approved: Acceptable to the AHJ. The AHJ will usually approve materials that are listed and labeled.

Arc fault: An electric current propagated through air.

ArcFIC, Arc-Fault Circuit Interrupter: Device intended to provide protection from the effects of arc faults by recognizing certain characteristics unique to arcing and functioning to de-energize the circuit when an arc fault is detected.

AFCI, branch/feeder type: An AFCI meeting the standard for interrupting parallel arcs if 75A of current are available at the device.

AFCI, combination type: An AFCI meeting the standard for interrupting both series and parallel arcs, and requiring <75A available current to facilitate operation.

Authority Having Jurisdiction (AHJ): The building official or person(s) authorized to act on his or her behalf.

Bonded, bonding: Connected to establish continuity and conductivity.

Branch circuit: The circuit conductors between the final OCPD (breaker or fuse) protecting the circuit and the outlet or outlets.

Branch circuit, general purpose: Branch circuit that supplies two or more receptacles or outlets for lighting and appliances.

Branch circuit, individual: Branch circuit supplying only one piece of equipment.

Branch circuit, multiwire, residential: Branch circuit consisting of two hot conductors having a 240V potential between them and a grounded neutral having a 120V difference between it and each hot conductor F17.

Branch circuit, small appliance: Branch circuit supplying portable household appliances in kitchens and related rooms and that has no permanently installed equipment connected to it (see p. 18 for exceptions).

Clothes closet: A non-habitable room or space intended primarily for storage of garments and apparel F37.

Controller: A device to directly open and close power to a load.

Derating: A reduction in the allowable ampacity of conductors because of ambient temperatures >86°F or more than three current-carrying conductors in the same raceway, or cables without spacing between them.

Device: A piece of equipment that carries or controls electrical energy as its primary function, such as a switch, receptacle, or circuit breaker.

Equipment: A general term including materials, fittings, devices, appliances, luminaires (fixtures), apparatus, machinery, and the like used as a part of, or in connection with, an electrical installation.

Equipment Grounding Conductor (EGC): A wire or conductive path that limits voltage on metal surfaces and provides a path for fault currents F16.

Flexibility after installation: Anticipated movement after initial installation, such as that caused by motor vibration or equipment repositioning.

Feeders: Conductors supplying panelboards other than service panels.

Goose neck: A curve at the top of a service entrance cable designed to prevent water from entering the open end of the cable.

Ground: The Earth.

Grounded conductor: A current-carrying conductor that is intentionally connected to earth (a neutral).
Grounding electrode conductor (GEC): A conductor used to connect the service neutral or the equipment to a grounding electrode or to a point on the grounding electrode system F6.

Ground fault: An unintentional connection of a current-carrying conductor to equipment or conductors that are not normally intended to carry current.

GFCI: A device to protect against shock hazards by interrupting current when an imbalance of 6 milliamps or more is detected.

GFPE: A device to protect equipment from ground faults and allowing higher levels of leakage current than a GFCI.

Hertz: A measure of the frequency of AC. In North America, the standard frequency is 60 Hertz.

Individual branch circuit: A circuit supplying only one piece of utilization equipment.

In sight: See within sight.

Load: The electrical demand of a piece of electrical equipment measured in amps or watts.

Lighting outlet: An outlet intended for the direct connection of a lamp or a luminaire.

Location, damp: An area protected from weather, yet subject to moderate degrees of moisture, such as a covered porch.

Location, dry: A location not normally subject to dampness or wetness.

Location, wet: All installations underground or in concrete or masonry in direct contact with the earth and areas subject to direct saturation with water or other liquids.

Luminaire: (formerly lighting fixture) A complete lighting unit, including parts to connect it to the power supply and possibly parts to protect or distribute the light source. A lamp, such as a porcelain socket, is not itself a luminaire.

Neutral conductor: The conductor connected to the neutral point of a system that is intended to carry current under normal conditions F17.

Open conductors: Individual conductors not contained within a raceway or cable sheathing, such as a typical service drop.

Outlet: The point on a wiring system at which current is taken to supply equipment. A receptacle or a box for a lighting fixture is an outlet; a switch is not an outlet.

Overcurrent: Any current in excess of the rating of equipment or conductor insulation. Overcurrents are produced by overloads, ground faults, or short circuits.

Overfusing: A fuse or breaker that has an overload rating greater than allowed for the conductor it is protecting.

Overload: Equipment drawing current in excess of the equipment or conductor rating and in such a manner that damage would occur if it continued for a sufficient length of time. Short circuits and ground faults are not overloads.

Panelboards: The “ guts” of an electrical panel; the assembly of bus bars, terminal bars, etc., designed to be placed in a “ cabinet.” What is commonly called an electrical panel or load center is, by NEC terms, a panelboard mounted in a cabinet F16.

Power: Electrical power is the product of volts times amps and can be expressed as either watts (true power) or VA (apparent power).

Service: The conductors and equipment providing a connection to the utility F2.

Service drop: The overhead conductors supplied by the utility F2.

Service entrance conductors: The conductors on the customer’s premises that convey power to the service equipment.

Service equipment: The equipment at which the power conductors entering the building can be switched off to disconnect the premises’ wiring from the utility power source. A meter can be a part of or separate from the service equipment.

Service lateral: Underground service entrance conductors.

Service point: The connection or splice point at which the service drop and service entrance meet—it is the handoff between the utility and the customer.

Short circuit: A direct connection of current-carrying conductors without the interposition of a load, resulting in high levels of current.

Short circuit rating (SCR): The amount of current that a piece of equipment (such as a breaker or switch) is rated to sustain without damage.

Snap switch: A typical wall switch, including 3-way and 4-way switches.

Ufer: A concrete-encased grounding electrode, named after the developer of the system, Herbert Ufer F6.

Unit switch: A switch that is an integral part of an appliance.

Within sight: (also written as “ in sight”) Visible, unobstructed, and not more than 50 ft. away.
**OHM'S LAW**

The rate of the flow of the current is equal to electromotive force divided by resistance.

- **I** = Intensity of Current = Amperes
- **E** = Electromotive Force = Volts
- **R** = Resistance = Ohms
- **P** = Power = Watts

The three basic Ohm's law formulas are:

- \( I = \frac{E}{R} \)
- \( R = \frac{E}{I} \)
- \( E = I \times R \)

Below is a chart containing the formulas related to Ohm's law. To use the chart, from the center circle, select the value you need to find, I (Amps), R (Ohms), E (Volts) or P (Watts). Then select the formula containing the values you know from the corresponding chart quadrant.

Example:
An electric appliance is rated at 1200 Watts, and is connected to 120 Volts. How much current will it draw?

- \( \text{Amperes} = \frac{\text{Watts}}{\text{Volts}} \)
- \( I = \frac{P}{E} \)
- \( I = \frac{1200}{120} = 10 \text{ A} \)

What is the Resistance of the same appliance?

- \( \text{Ohms} = \frac{\text{Volts}}{\text{Amperes}} \)
- \( R = \frac{E}{I} \)
- \( R = \frac{120}{10} = 12 \Omega \)
**OHM’S LAW**

In the preceding example, we know the following values:

\[ I = \text{amps} = 10 \quad R = \text{ohms} = 12\Omega \]
\[ E = \text{volts} = 120 \quad P = \text{watts} = 1200 \]

We can now see how the twelve formulas in the Ohm’s Law chart can be applied.

\[
\begin{align*}
\text{AMPS} & = \sqrt{\frac{\text{WATTS}}{\text{OHMS}}} \quad I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1200}{12}} = \sqrt{100} = 10\text{A} \\
\text{AMPS} & = \frac{\text{WATTS}}{\text{VOLTS}} \quad I = \frac{P}{E} = \frac{1200}{120} = 10\text{A} \\
\text{AMPS} & = \frac{\text{VOLTS}}{\text{OHMS}} \quad I = \frac{E}{R} = \frac{120}{12} = 10\text{A} \\
\text{WATTS} & = \frac{\text{VOLTS}^2}{\text{OHMS}} \quad P = \frac{E^2}{R} = \frac{120^2}{12} = \frac{14,400}{12} = 1200\text{W} \\
\text{WATTS} & = \text{VOLTS} \times \text{AMPS} \quad P = E \times I = 120 \times 10 = 1200\text{W} \\
\text{WATTS} & = \text{AMPS}^2 \times \text{OHMS} \quad P = I^2 \times R = 100 \times 12 = 1200\text{W} \\
\text{VOLTS} & = \sqrt{\text{WATTS} \times \text{OHMS}} \quad E = \sqrt{P \times R} = \sqrt{1200 \times 12} = \sqrt{14,400} = 120\text{V} \\
\text{VOLTS} & = \text{AMPS} \times \text{OHMS} \quad E = I \times R = 10 \times 12 = 120\text{V} \\
\text{VOLTS} & = \frac{\text{WATTS}}{\text{AMPS}} \quad E = \frac{P}{I} = \frac{1200}{10} = 120\text{V} \\
\text{OHMS} & = \frac{\text{VOLTS}^2}{\text{WATTS}} \quad R = \frac{E^2}{P} = \frac{120^2}{1200} = \frac{14,400}{1200} = 12\Omega \\
\text{OHMS} & = \frac{\text{WATTS}}{\text{AMPS}^2} \quad R = \frac{P}{I^2} = \frac{1200}{100} = 12\Omega \\
\text{OHMS} & = \frac{\text{VOLTS}}{\text{AMPS}} \quad R = \frac{E}{I} = \frac{120}{10} = 12\Omega
\end{align*}
\]}