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Basic Residential Electrical Wiring Rough In and Codes Guide

What are the basic residential wiring circuits? Can you put the hall plug on the same breaker as the dining room? How many switches have to be in the stairwell? What size wire do you use for a dryer? How many amps can 12-2-WG take? All of these questions are answered somewhere in the 700 (more or less) pages of the National Electric Code. Luckily many of the most common residential wiring questions are answered right here on just a couple of pages. This is not intended to replace the NEC or the necessity to become familiar with the NEC. If you spot anything in this that you think is incorrect, please contact me at **info@nojolt.com.**

Required Elements

Inspections

Guidelines

Safety First!

Always Disconnect the Power before beginning work! Failure to follow this rule can result in death or injury.

Breaker and fuse panels remain hot even if the main breaker is turned off or the main fuse is removed. Main panels should only be worked on by qualified persons.

Incorrectly performed electrical work can result in fire, damage to property, and injury or death to people. Furthermore, in some jurisdictions it may be against the law for anyone other than a licensed electrician to perform electrical work, and work which is performed by unqualified people or which has not been inspected and approved **may cause your homeowners insurance policy to be void**.

Are You Qualified?

This article is not intended to be a complete guide on the subject of residential wiring, but only an aid to those who already have some knowledge on the subject. I am not encouraging people with little or no experience to tackle a large wiring project (like wiring an entire house), and if that is your intent, then this is just the beginning of the information that you will need to safely and effectively accomplish such a task. There are many excellent guides available in print if you need more information.

Disclaimer: Incompetent or improper wiring work can result in loss of life limb and property. Wiring which is not properly inspected may void your homeowners insurance. In some areas it is not legal for anyone other than a licensed electrician to do wiring work at all. I am not a codes official. I am also not an expert on electrical wiring. I'm just a guy with some practical experience building and wiring houses. Furthermore, the code changes on a regular basis and is subject to local jurisdictions. If you are going to do electrical wiring, you should become educated about the code as it applies in your area.

Service Equipment

The Service equipment (main panel, entrance conductors, meter base, and associated hardware) must be adequate to safely supply the required load. If you haven't already done so, you can use my **Free Load Calculator** to determine the size that you will need.

The main service equipment panel shall be mounted either outside or inside the dwelling at the point of entrance of the service conductors to the building. All service equipment and electrical panels shall have a clear area 30" wide and 36" deep in front. This clear area must extend from floor to ceiling with no intrusions from other equipment, cabinets, counters, appliances, pipes, etc. Panels are NOT allowed in clothes closets or bathrooms.

According to Article 250 of the NEC, the neutral in the main panel must be bonded to the service enclosure and the grounding electrode system. Also in the main service equipment, the neutral and equipment grounding conductors are bonded together; in sub-panels, the neutral is isolated from ground - this is to maintain a single point ground system and avoid a condition known as a ground loop.

Branch Circuits Guidelines

- Do NOT mix different wire sizes on the same branch circuit.
- Type NM cable must be stapled within 12" of metal boxes, 8" of plastic boxes and every 4½ feet thereafter. Proper connectors must be used where NM cable enters metal cabinets, boxes or panel boards.
- When Type NM cable is installed parallel to framing members, or in bored holes, it shall be located at least 1¼" from the nearest edge of the framing member, where nails or screws may penetrate the cables. If this distance cannot be maintained, the cable shall be protected by a steel plate or sleeve at least 1/16" thick. Section 300.4 (A), NEC.
- Cable or raceway-type wiring methods installed in a groove, to be covered by wallboard, siding, paneling, carpeting, or similar finish, shall be protected by 1/16-inch steel plate, sleeve, or equivalent, or must be recessed in the groove 1 1/4-inch for the full length of the groove in which the cable or raceway is installed. Exception: Raceways as covered in articles 342, 344, 352, and 358. Section 300.4 (E), NEC.

Required Receptacles - Code Summary

- For most areas of a house, receptacles must be no more than 12 feet apart and no more than 6 feet from a door or entryway - IE, every point on almost all walls should be no farther than 6 horizontal feet from a receptacle. The wall spaces formed by fixed room dividers, such as freestanding counters, or railings, are included in the six-foot measurement.

- Receptacles installed in the floor within 18" of the wall may be used in place of wall-mounted receptacles. Receptacles installed in the floor must use a box-receptacle combination designed specifically for that purpose.

- Every hallway over 10 feet long must have at least one receptacle - other than this, hallways are exempt from the 6 foot rule.

- No outlets may be installed over an electric baseboard heater.

- Plugs which are located behind a stationary appliance such as a refrigerator or washing machine do not count when considering plug spacing.

- Any wall space that is 2 feet or more in width must have a receptacle.

- Every basement and garage must have at least one receptacle, and all must be **GFI** protected. At least one receptacle must be installed in the each unfinished portion of a basement. This receptacle is in addition to any receptacles that may be installed for laundry or other specific purposes.

- One 20-amp branch circuit must be provided for the laundry. This circuit is limited to receptacles within the laundry room. No other outlets are permitted on this circuit.

- There must be at least two **GFI** plug on the outside of the house located near the front and back doors, and all exterior plugs must be **GFI** protected. Note: Outdoor outlets installed in wet locations shall have an enclosure that is weatherproof whether or not it is in use.

- An accessible 15 or 20 amp plug must be within 25 feet of all HVAC equipment.

- As a general rule you may have up to 10 receptacles on a single circuit, but this is a gray area which is subject to the discretion of the codes official.
- Dining room plugs must be on a separate circuit,
- At least one 20-amp circuit for bathroom receptacles must be supplied. Each bathroom must have its own **GFI** plug circuit with a plug near the wash basin, and no lights or other plugs or appliances on these circuits. Where a 20-ampere circuit supplies a single bathroom, outlets for other equipment within the same bathroom shall be permitted to be supplied in accordance with 210.23(A). This circuit shall NOT be used to supply a major fixture such as a whirlpool or hot tub!
- At least one 15 or 20 amp, 120 volt GFCI protected receptacle must be installed at an indoor spa or hot tub location - not closer than five feet from the inside wall of the unit and not more than ten feet away from it. Light fixtures, outlets and ceiling fans over spas and hot tubs shall be a minimum of 7'6" above the maximum water level. Note - pump motors and other spa related electrical equipment must remain accessible for service after all finishes are in place. Accessible does not include cutting holes in walls, or removing tile - plan ahead, and use common sense.
- Outdoors spa or hot tubs have the same requirements as a swimming pool. Check in section 680 of the NEC for those requirements.
- Note that all bedrooms outlets must be protected by an arc-fault circuit interrupter listed to provide protection of the entire branch circuit. This includes wiring to the smoke detector outlets.210.12, NEC

Kitchen Receptacles - Code Summary

- In the kitchen and eating areas every counter space wider than 12 inches must have a **GFI** protected plug, in general all kitchen counter top plugs should be **GFI** protected. Countertop receptacles shall be installed so that no point along the wall is more than 24" measured horizontally from a receptacle outlet in that space. Peninsular bars and islands 12" or wider shall have at least one receptacle. Exception: Tennessee Code in dwelling unit's section states, "The installation of receptacles for island counter spaces and peninsular counter spaces below the countertop shall be optional.
- At least two 20-ampere branch circuits are required to feed receptacle outlets for small appliance loads, including refrigeration equipment in the kitchen, pantry, breakfast room, and dining room. These circuits, whether two or more are used, shall NOT supply anything other than receptacles in these areas. Lighting outlets and built-in appliances such as garbage disposals, hood fans, dishwashers, and trash compactors are NOT permitted on these circuits.
- Kitchen counter top receptacles must be supplied by at least two small appliance branch circuits.
- Kitchen appliance and convenience receptacles must be on 20 amp breakers, and wired with 12 gauge wire.

Required Ground Fault Protection

A ground fault circuit interrupter must protect ALL receptacles listed below:

- Bathroom receptacles.
- Outdoor receptacles.
- Garage receptacles.
- Kitchen receptacles that serve counter top surfaces
- Counter top receptacles within 6 feet of a wet bar sink.
- All receptacles in an unfinished basement:
- Sump pumps.
- Crawl spaces at or below grade.
- Spas, Hydro massage, Hot tubs and associated electrical components.
- Pretty much any location where water and electricity might mix.

Required Arc Fault Circuit Interuptor protection - 208 NEC 210.12 (A)"

An arc fault circuit interuper - AFCI is a device (usually if not always a breaker) designed to give protection from arc faults. An AFCI breaker will trip whenver an arc is detected. In all dwellings an arc fault circuit interrupter must protect ALL 120 volt 15 and 20 amp single phase receptacles in family rooms, living rooms, parlors, recreation rooms, dining rooms, libraries, dens, sunrooms, recreation rooms, closets, hallway or similar rooms. In other words pretty much **all receptacles inside of a dwelling except the bathrooms, kitchen, laundry and garage must be AFCI protected.**

Appliance Branch Circuits - Code Summary

- **The following Appliances must be on a separate 20-amp circuit: Dishwasher, Garbage disposal, Washing machine.**
- **As a general rule All 240-volt appliances must be on their own circuit.**
- **Hot tubs, garden tubs, Jacuzzis and the like must be GFI protected and wired as required for the particular model and local codes.**
- **The service areas of all appliances must be accessible after the final finish is complete.**

Required Light Fixtures - Code Summary

- **General Lighting Branch Circuits shall be computed on a three watts per square foot basis. You may wire up to 600 square feet of living area on a 15 ampere branch circuit or up to 800 square feet on a 20-ampere circuit. These branch circuits may supply lighting outlets in all areas of the dwelling and convenience receptacles, other than Small Appliances, Laundry, Bathroom, or HVAC - as outlined above.**
- **"Every room, hallway, stair way, attached garage, and outdoor entrance must have at least one light fixture controlled by a wall switch. However, in most rooms other than kitchens and bathrooms, the wall switch may control one or more plugs into which lamps may be plugged instead of a ceiling or wall mounted fixture."**
- **There must be at least one wall switch controlled light in a utility room, attic, basement or under floor space used for storage or which contains equipment such as heat and air, water heaters, sump pumps, etc. which may ever require service. The switch must be located at the entry point to these areas.**
- **Hallways and stairs with more than six steps require the lights to be controlled by a switch at each end.**
- **In closets, fluorescent fixtures must have at least 6 inches of clearance away from shelves or storables. In a typical two foot deep (approx.) closet, the fixture will be mounted on the wall just over the door.**
- **In summary, put a light in every room or large closet, outside of every exterior door, and under the floor and in the attic if there is electrical equipment in these spaces or if they are suitable for storage.**
- **Switch the room lights at every door entering the room, switch a hall or stairway at both ends, and switch exterior lights at the doors which they service.**
- **As a rule of thumb you can put up to ten average light fixtures on a single circuit, unless this will add up to excessive wattage for the circuit (note, a ceiling fan and light kit qualify as one fixture).**
- **Notable exceptions would be floodlights, which are high wattage fixtures. Four double bulb floodlights would pretty well fill up a circuit by themselves.**
- **The actual rule for this is to not exceed 80% of the calculated wattage capacity of the circuit.**
- **Wattage capacity of the circuit equals the amp rating of the breaker times the voltage (120), so for a typical 15 amp light circuit add up all of the maximum wattage's and make sure that they are less than 80% of 15x120 (1440 watts max).**

Keep in mind that the inspectors may be looking for no more than 10 fixtures (more or less according to local variances) per circuit, your calculations notwithstanding.

Smoke Detectors - Code Summary

- **There must be a 120-volt battery back up smoke detector on the ceiling, or on the wall close to the ceiling in the area outside of every bedroom, and inside of each bedroom. All smoke**

detectors must be tied together so that if one goes off they all do. Smoke detectors must be protected by an arc fault breaker.
When you are roughing in for smoke detectors daisy-chain them with 14-3 WG and the extra (red) wire will interconnect the system.

- **Note that all bedrooms outlets must be protected by an arc-fault circuit interrupter listed to provide protection of the entire branch circuit. This includes wiring to the smoke detector outlets.210.12, NEC**

Ground Conductor Make Up

All equipment grounding conductors must be connected together with solderless pressure connectors such as wire nuts or crimp sleeves, leaving sufficient extra conductor for attachment to the metal box and/or device. When crimp type connectors are used, they must be crimped using the tool recommended by the manufacturer. Please note that ALL metal junction and outlet boxes must be grounded by attaching the equipment grounding conductor out of the NM cable to the metal box using an approved screw or grounding clip. When circuit conductors are made up, six inches of free conductor must be left for use in make-up and for the attachment of devices.

Electric Heat

Electric heat may be installed on 15, 20, or 30 amp branch circuits. Listed below is the maximum wattage that may be installed on each size branch circuit. (All circuits are calculated at 240 v)

- **15A - 2,880 watts maximum**
- **20A - 3,840 watts maximum**
- **30A - 5,760 watts maximum For example, if you are installing baseboard heaters which are rated 250 watts a linear foot, you could install 15 feet on a 20 amp, 240 volt circuit. 250W x 15 = 3,750 watts.**

Wire Size Application Guide

Wire Size and type	Is Suitable for this purpose
14-3 wg	15 amps max, Switch circuits
14-2 wg	15 amps max, Standard 120 volt 15 amp general purpose branch circuits. With all of the electronics equipment that families have (and are likely to have in the future) in the interest of doing a good job it is worth considering to just not use any wire smaller than 12 gauge so that 20 amp breakers can safely be used on all circuits - Even if the local codes would allow 14 gauge wire. Using one less wire size on the job also helps to decrease waste.
12-3 wg	20 amps max, switch circuits and (rarely) 240 volt 20 amp equipment
12-2 wg	20 amps max, branch circuits, kitchen receptacles, and other 120 volt 20 amp small appliance circuits
10-2 wg	30 amps max, Water heaters, AC units, and (rarely) other straight 240 volt 30 amp appliances
10-3 wg	30 amps, Electric clothes dryer, and other 220/110 volt 30 amp combo appliances
8-3 wg	50 amps max, Oven or cook top, and other 220/110 volt 50 amp combo appliances
6-3 wg	65 amps max, Range or oven/cook top combo, other 220/110 volt 60 amp combo appliances

Job procedures

Lay out the locations of all plugs, switches and fixtures. (Electrician, job Supervisor)Lay out all wall boxes on the floor directly under the location where they will go. (Electrician)Install wall boxes using a spacer stick. (Helper)Drill holes for wire runs. (Helper) Drill one hole in the top plate over every single wall box, two holes over every double box, three over every triple box, etc... even if you don't think you will need them all. It's much faster to drill all of your holes at one time instead of one at a time, as you need them. Install ceiling boxes. (Electrician)Install headers for fixture that don't install on a box, such as fluorescent lights, surface mount equipment plugs, thermostats, etc. (helper)Pull the wires to each circuit one circuit at a time starting with the home runs, then the power wires to every location that gets unswitched power, when you have unswitched power to everywhere that gets it, then pull the wires for switches and switched power to multiple lights. While pulling wires strip the cable from at least 6 inches of the ends and install them in the boxes and staple them within 8 inches (of wire) at the boxes, don't tighten box clamps or install intermediate staples at this time. Pull all of the wires in a single circuit before moving on to the next circuit. Following this procedure will make the work efficient, and will help to prevent mistakes. Try to avoid distractions while pulling wires and making up boxes.

If you have a helper, the helper should drill holes, pull home runs, and single fixture circuits like the washing machine, and 240 equipment. If the helper pulls other wires to stay busy, they should be very closely supervised. Don't forget the doorbell, and smoke detectors. (Electrician)After all wires have been pulled and installed in boxes: Install intermediate staples. (Helper)Make up grounds in single gang wall boxes. (Helper, with supervision)Make up fixture and switch boxes. (Electrician)Install electrical panel and install wires into it including the cold water line ground.

If you have time, you may choose to strip the cables and connect the neutrals and grounds inside the panel at this time, but this is not required for a rough in inspection. Usually you do not want to install breakers at this time because of the likelihood that they will be stolen. This completes the rough in procedure.

Inspections

Several inspections (AKA permits) are required for most residential construction projects:

- **Temporary Service Inspection (if a temporary service will be used)**
- **Rough in inspection**
- **Final inspection.**
- **HVAC system electrical inspection**
- **In addition to these, any electrical work done by a subcontractor other than the electrician will have to be inspected (usually both rough in an finals) for example - well pumps, or external wood fired furnaces.**
- **In some cases you may be able to get a service release between rough in and final inspections so that you can more easily run HVAC and other high current services during construction. If so you will usually have to get an inspection for the service release.**

If any inspection is failed then the codes official will usually leave a brief (and often cryptic) note outlining the reasons for the failure, and an additional inspection permit will have to be purchased.

Note that all subcontractors who do wiring work must pull their own permits using their own contractors license. It is not permitted to have work which was done by other subcontractors inspected under any license other than their own. If you are a homeowner who is wiring your own house under a licensing exemption, you are not allowed to pull permits for subcontractors.

Rough in Inspection

At the time you call for your rough in inspection, you should have all wires pulled, stapled properly, installed in ditches, and splices made up and ready to accept devices and fixtures. DO NOT cover any wires with insulation / wall coverings, install any devices / fixtures, or cover any wiring which is to be buried .

Note: Temporary address numbers should be installed prior to the rough in or temporary service inspections.

Final Inspection

All permits must be on site. The electrical installation should be complete at the time of request. All devices and fixtures installed, service equipment complete, and labeled properly. All wiring

shall be free from short circuits, ground faults and open circuits. All light fixtures are required to be grounded along with light switches that are within five feet of a grounded object.

Note: Permanent address numbers should be installed prior to the Final inspection.

Tips and Advice

- **In my experience electrical inspectors are helpful and friendly, but very busy. They usually don't mind answering a quick question or two, but they don't have time to teach everyone how to be an electrician. Try to explore other sources of information before using their valuable time. Other sources of information include the counter help at your local electrical contractor supply house, books, other electricians, the internet, and of course the NEC manual.**
- **If it is at all possible, I would recommend that you try to be on your job site at the time of all inspections. In my experience you are much more likely to pass your inspection if you are there. It will also be much easier to comprehend what the inspector wants you to do in person, and on occasion they will let you take care of minor infractions on the spot thus avoiding a costly delay for another inspection. However, don't follow them around or otherwise annoy the inspector as that is not usually productive.**
- **Ceiling mounted paddle fans weighing 35 pounds or less may be supported by outlet boxes identified for such use. Fans weighing more than 35 pounds must be supported independently of the box (422.18), NEC.**
- **Central heating equipment shall be supplied by an individual branch circuit.**
- **Disconnects are required in sight of the following equipment:**
    - **Electric water heaters**
    - **Well pump controllers**
    - **HVAC equipment**
    - **Spas and hot tubs**
    - **Hydro massage bathtubs**
    - **Appliances**

Disconnects can include the main breaker panel, a sub panel, a cord that can be unplugged, dedicated switches, other disconnect devices. When in doubt refer to the code, or your local inspector.

Boxes and Conductor Fill Capacity

The code requires that all outlet and junction boxes have sufficient space for the use they are put to, and there are charts and formulas for determining those capacities. However, my advice is that whenever possible you just use the large volume boxes. The bigger boxes will cost a few cents more, but they will save time and effort when you are trying to fit your connections neatly inside them. But just in case you must pinch every penny: Based on the following chart each #12 conductor that enters a box needs 2.25 cubic inches with the exception of the grounding conductor which requires one 2.25 cubic inch for all of the grounds. Also, each strap containing one or more devices is counted as the equivalent of two conductors.

VOLUME REQUIRED PER CONDUCTOR

- **#14 - 2 cubic inches**
- **#12 -2.25 cubic inches**
- **#10 -2.5 cubic inches**
- **#8 - 3 cubic inches**
- **#6 - 5 cubic inches**

Just add up all of the values for each conductor, and compare it to the fill capacity stamped on the junction box.

Related articles on Residential Electric Wiring and Codes

- **Understanding 240 volt circuits**
- **How to replace a 2 prong outlet with a 3 prong GFCI outlet**
- **How to Support a Ceiling Fan**
- **Lightning Protection for TV Antennas**
- **Free NEC Load Calculation Program**

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