

GFCI AND AFCI PROTECTION

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Mike Holt is an author, businessman, educator, speaker, publisher and *NEC*[®] expert. He's written hundreds of electrical training books and articles, founded three successful businesses, and has taught thousands of electrical *Code* seminars across the U.S. and internationally.

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Mike's commitment to pushing boundaries and setting high standards extends into his personal life. He's an eight-time Overall National Barefoot Waterski Champion with more than 20 gold medals, many national records, and he has competed in three World Barefoot Tournaments. In 2015, at the tender age of 64, he started a new adventure—competitive mountain bike racing. Every day he continues to find ways to motivate himself, both mentally and physically.

Mike and his wife, Linda, reside in New Mexico and Florida, and are the parents of seven children and six grandchildren. As his life has changed over the years, a few things have remained constant: his commitment to God, his love for his family, and doing what he can to change the lives of others through his products and seminars.

> I dedicate this book to the Lord Jesus Christ, my mentor and teacher. Proverbs 16:3



ARTICLE 210 BRANCH CIRCUITS

Introduction to Article 210—Branch Circuits

This article contains the general requirements for branch circuits which extend from the last point of overcurrent protection to the utilization equipment. Branch circuits account for most circuits run in any electrical installation, so you must be sure you are familiar with these rules. Some topics covered in this material for Article 210 include:

- Identification of branch circuits
- Multi-wire branch circuits
- Voltage limitations
- Required branch circuits
- ▶ GFCI and AFCI requirements
- Branch-circuit ratings
- Permitted loads
- Receptacle and lighting outlet requirements

This article consists of three parts:

- > Part I. General Provisions
- Part II. Branch-Circuit Ratings
- ▶ Part III. Required Outlets

210.8 GFCI Protection

<u>A GFCI</u> device must provide protection as required in 210.8(A) through (F). Figure 210–17 and Figure 210–18

GFCI protective devices must be in a readily accessible location.

According to Article 100, "GFCI" is a device intended to protect people by de-energizing a circuit when ground-fault current exceeds the value established for a "Class" A device. ► Figure 210–19 According to Article 100, "Readily Accessible" means capable of being reached quickly for operation, renewal, or inspection without requiring the use tools (other than keys), climb over or under obstructions, remove obstacles, resort to using portable ladders, and so forth. ▶Figure 210–20 and ▶Figure 210–21







Figure 210-17











Figure 210–20



The GFCI protection required by 210.8(A) and (B) can be provided by using either a circuit breaker with GFCI protection or a receptacle with GFCI protection. For the application of 210.8(A)(8) or (10), 210.8(B)(7), (13), and (15), the distance from the sink or bathtub/ shower is measured as the shortest path the <u>power</u>-supply cord connected to the receptacle will follow without piercing a floor, wall, ceiling, or fixed barrier. Figure 210–22



Figure 210-22

Author's Comment:

- The reference to windows and doors was removed to ensure receptacles within the measured distance as required in 210.8, even if passing through a window or door, are afforded GFCI protection.
- ► The GFCI circuit breaker provides ground-fault protection starting at the breaker, so the entire circuit has groundfault protection. A GFCI receptacle provides ground-fault protection for whatever is plugged into it and has load-side terminals that provide downstream protection for any other receptacle(s) or device(s) on the circuit. Figure 210–23

(A) Dwelling Units. Receptacles installed in the following dwelling unit locations must be GFCl protected. ►Figure 210–24

According to Article 100, "Dwelling Unit" is a single unit that provides independent living facilities with permanent provisions for living, sleeping, cooking, and sanitation. ▶ Figure 210–25



▶ Figure 210-23



Figure 210-24



▶ Figure 210-25

(1) Bathrooms. GFCI protection is required for receptacles in dwelling unit bathroom areas. ► Figure 210–26



▶ Figure 210-26

According to Article 100, "Bathroom Area" is an area that includes a sink (basin) and one or more of the following: toilet, urinal, tub, shower, bidet, or similar plumbing fixture. ►Figure 210–27



[▶] Figure 210-27

(2) Garages and Accessory Buildings. GFCI protection is required for receptacles in dwelling unit garages and dwelling unit accessory buildings. These buildings are not intended as habitable rooms and limited to storage, work, and other areas of similar use. ▶Figure 210–28



Author's Comment:

All receptacles installed for the connection of electric vehicle supply equipment must be GFCI protected. Figure 210–29



Figure 210–29

(3) **Outdoors.** GFCI protection is required for receptacles located outdoors of a dwelling unit. ►Figure 210-30

(4) Crawl Spaces. GFCI protection is required for receptacles in dwelling unit crawl spaces at or below grade. ►Figure 210-31

(5) Basements. GFCI protection is required for receptacles in dwelling unit basements. ► Figure 210–32



▶ Figure 210-30



▶ Figure 210-31



▶ Figure 210-32

(6) Kitchens. GFCI protection is required for receptacles in dwelling unit kitchens. ▶Figure 210–33





According to Article 100, A "Kitchen" is an area with a sink and permanent provisions for food preparation and cooking.

Author's Comment:

Traditionally this requirement only applied to kitchen countertop receptacles, but now any cord-and-plug-connected appliance in the kitchen such as the range receptacle, refrigerator receptacle, disposal receptacle, and microwave receptacle will require GFCI protection.

(7) Food Preparation Areas. GFCI protection is required for receptacles in areas with sinks with permanent provisions for food preparation, beverage preparation, or cooking.

(8) Sinks. GFCl protection is required for receptacles within 6 ft of the top inside edge of the bowl of a dwelling unit sink.

(9) Boathouses. GFCI protection is required for receptacles in a boathouse for a dwelling unit. ▶ Figure 210–34

Author's Comment:

The Code does not require a receptacle to be installed in a boathouse, but if any are, they must be GFCI protected.

(10) Bathtubs or Shower Stalls. GFCI protection is required for receptacles within 6 ft of the outside edge of a bathtub or shower stall not installed within a bathroom. ▶Figure 210–35





(<u>11</u>) Laundry Areas. GFCI protection is required for receptacles installed in the laundry area of a dwelling unit. Figure 210–36





(12) Damp and Wet Locations Indoors. GFCI protection is required for receptacles installed in indoor damp and wet locations.

<u>Ex 1</u>: GFCI protection is not required for a receptacle dedicated to fixed electric snow-melting equipment if the receptacle is not readily accessible and ground-fault protection of equipment (GFPE) is provided as required by 426.28 and 427.22. Figure 210–37

Ex 2: A receptacle supplying only a permanently installed premises security system is permitted to omit GFCI protection.

Ex 4: GFCI protection is not required for receptacles in dwelling unit bathroom exhaust fans, unless specified by the fan instructions. Figure 210–38



Figure 210-36







Figure 210-38

Author's Comment:

- The receptacle for exhaust fans is internal to the exhaust fan. They are not accessible as a convenience cord-andplug receptacle, therefore GFCI protection is not required.
- In accordance with "UL Guide Information GPWX," exhaust fans installed in the area directly above the footprint (width and depth of the equipment) of the bathtub or shower must be GFCI protected.

(B) Other Than Dwellings. GFCI protection is required for 125V through 250V receptacles supplied by single-phase branch circuits 50A (or less) or three-phase branch circuits 100A (or less) installed in the following locations:

(1) Bathrooms. GFCI protection is required for 125V through 250V receptacles in bathroom areas. ►Figure 210–39



▶ Figure 210-39

According to Article 100, "Bathroom" is an area that includes a sink (basin) and one or more of the following: toilet, urinal, tub, shower, bidet, or similar plumbing fixture.

(2) Kitchens. GFCl protection is required for 125V through 250V receptacles in kitchens. ►Figure 210–40

(3) Food Preparation Areas. GFCI protection is required for 125V through 250V receptacles in areas containing sinks with permanent provisions for food preparation, beverage preparation, or cooking.

(4) Buffet Serving Areas. GFCI protection is required for 125V through 250V receptacles in buffet serving areas with permanent provisions for food serving, beverage serving, or cooking.



Figure 210-40

Author's Comment:

This requires GFCI protection for receptacles in the break area of a commercial occupancy.

(5) **Rooftops.** GFCI protection is required for 125V through 250V receptacles on rooftops. ▶ Figure 210–41



(6) **Outdoors.** GFCI protection is required for 125V through 250V receptacles outdoors. ▶ Figure 210–42



Figure 210-42

(7) Sinks. GFCl protection is required for 125V through 250V receptacles and receptacles for cord-and-plug-connected appliances within 6 ft from the top inside edge of the bowl of a sink. Figure 210-43



▶ Figure 210-43

Author's Comment:

A faulted appliance in proximity to sinks presents a shock hazard whether the receptacle is within 6 feet or not.

(8) Indoor Damp or Wet Locations. GFCI protection is required for 125V through 250V receptacles in indoor damp or wet locations.

(9) Locker Rooms. GFCl protection is required for 125V through 250V receptacles in locker rooms with showering facilities. Figure 210-44



▶ Figure 210–44

(10) Garages and Similar Areas. GFCI protection is required for 125V through 250V receptacles in garages, accessory buildings, and similar areas. Figure 210-45



According to Article 100, a "Garage" is a building (or portion of a building) in which one or more self-propelled vehicles can be kept for use, sale, storage, rental, repair, exhibition, or demonstration.

(11) **Crawl Spaces.** GFCI protection is required for 125V through 250V receptacles in crawl spaces at or below grade level.

(12) Unfinished Areas of Basements. GFCI protection is required for 125V through 250V receptacles in unfinished areas of basements.

(13) Aquatic Tanks or Bowls. GFCl protection is required for 125V through 250V receptacles within 6 ft from the top inside edge or rim. It is also required from the conductive support framing of the vessel or container for aquariums, bait wells, and similar open aquatic vessels or containers, such as tanks or bowls. ► Figure 210-46

(14) Laundry Areas. GFCI protection is required for 125V through 250V receptacles in a laundry area. ► Figure 210-47

(15) Bathtubs and Shower Stalls. GFCl protection is required for 125V through 250V receptacles installed within 6 ft of the outside edge of a bathtub or shower stall not installed in a bathroom.

<u>Ex 2</u>: Rooftop GFCI receptacles are only required to be readily accessible from the rooftop itself. ▶Figure 210–48



▶ Figure 210-46



Figure 210-47



Figure 210-48

(C) Crawl Space Lighting Outlets. GFCI protection is required for 120V lighting outlets in crawl spaces.

Author's Comment:

A lighting outlet is not required for a dwelling unit crawl space unless the space is used for storage or has equipment requiring servicing [210.70(C)].

(D) Specific Appliance. GFCI protection is required for the following appliances rated 150V or less to ground, rated 60A or less, single- or three-phase, either cord-and-plug or hardwired connected:

(1) Automotive vacuum machines. Figure 210-49



▶ Figure 210-49

(2) Drinking water coolers and bottle fill stations. Figure 210–50





- (3) High-pressure spray washing machines.
- (4) Tire inflation machines. Figure 210-51



▶ Figure 210-51

- (5) Vending machines. ▶ Figure 210–52
- (6) Sump pumps. Figure 210–53
- (7) Dishwashers Figure 210-54
- (8) Electric ranges. ▶ Figure 210–55
- (9) Wall-mounted electric ovens.
- (10) Counter-mounted electric cooking units.
- (11) Clothes dryers.
- (12) Microwave ovens.



Figure 210–52



Figure 210–53







The appliances in list items 210.8(D)(8) through (12) are commonly installed as hardwired outlets, and the GFCI protection requirements of 210.8(A) and (B) only apply to receptacles. The shock hazards exist whether appliances are hardwired or cord-and-plug connected, and therefore GFCI protection must be provided for the appliance branch circuit or outlet.

(E) Equipment Requiring Servicing.

Air-Conditioning Equipment. GFCI protection is required for the 125V, 15A or 20A service receptacle outlet installed within 25 ft of the air-conditioning equipment as required in 210.63(A). Figure 210–56



Figure 210-56

Indoor Service Equipment. GFCI protection must be provided for the 125V, 15A or 20A service receptacle outlet installed within 25 ft of the indoor service equipment as required by 210.63(B)(1). ▶ Figure 210–57





Indoor Switchboards, Switchgear, Panelboards, and Motor Control Centers. GFCI protection must be provided for 125V, 15A or 20A service receptacle outlets as required by 210.63(B)(2) for indoor switchboards, switchgear, panelboards, and motor control centers.

(F) Outdoor Dwelling Outlets. GFCI protection is required for all outlets rated 50A or less located outside the following dwelling spaces: ▶Figure 210–58



▶ Figure 210–58

(1) Garages

(2) Accessory Buildings

(3) Boathouses

According to Article 100, an "Outlet" is a point on the wiring system at which current is taken to supply utilization equipment. Figure 210–59

If equipment connected to any of the above outlets is replaced, the circuit to the outlet must be GFCI protected.

Ex 2: GFCI protection is not required for listed HVAC equipment, such as motor compressors or heat pumps. **▶Figure 210–60**







Figure 210-60

210.12 Arc-Fault Circuit-Interrupter Protection

AFCI protection is required in accordance with 210.12(B) through (C) and must be in a readily accessible location.

According to Article 100, "Arc-Fault Circuit Interrupter (AFCI)" is a device intended to de-energize the circuit when it detects the current waveform characteristics unique to an arcing fault. Figure 210–71





(B) Dwelling Units. AFCI protection is required for 15A or 20A, 120V branch circuits in the following dwelling unit locations:

- (1) Kitchens
- (2) Family rooms
- (3) Dining rooms
- (4) Living rooms
- (5) Parlors
- (6) Libraries
- (7) Dens
- (8) Bedrooms
- (9) Sunrooms
- (10) Recreation rooms
- (11) Closets
- (12) Hallways
- (13) Laundry areas
- (14) Similar areas ▶ Figure 210–72

Author's Comment:

 AFCI protection is not required for outlets in bathroom areas, garages, or outside.





(C) Dormitory Units. AFCI protection is required for 15A or 20A, 120V branch circuits in the following dormitory unit locations:

- (1) Bedrooms
- (2) Living rooms
- (3) Hallways
- (4) Closets
- (5) Bathrooms
- (6) Similar rooms ► Figure 210-73



▶ Figure 210-73

According to Article 100, "Dormitory Unit" is a space in which sleeping accommodations are provided in one room for more than 16 persons. It can also be a series of closely associated rooms, under joint occupancy and single management, but without individual cooking facilities. ▶Figure 210–74



one room for more than 16 persons; or a series of closely associated rooms, under joint occupancy and single management, but without individual cooking facilities.

Figure 210–74

(D) Other Occupancies. AFCI protection is required for 15A and 20A, 120V branch circuits in the following other occupancy locations:

(<u>1</u>) Guest rooms and guest suites of hotels and motels. ► Figure 210-75



Figure 210–75

According to Article 100, "Guest Room" is an accommodation combining living, sleeping, sanitary, and storage facilities. Figure 210–76



▶ Figure 210–76

According to Article 100, "Guest Suite" is an accommodation with two or more rooms that are connected to each other comprising a compartment (with or without doors between such rooms) that provides living, sleeping, sanitary, and storage facilities. ▶ Figure 210–77



[▶] Figure 210-77

(2) Nursing homes and limited care facilities, areas used exclusively as patient sleeping rooms.

According to Article 100, "Limited Care Facility" is a building (or an area of a building) used for the housing, on a 24-hour basis, of four or more persons who are incapable of self-preservation because of age, physical limitations due to accident or illness, or limitations such as intellectual disability, developmental disability, mental illness, or chemical dependency.

(3) Areas designed for use exclusively as sleeping quarters in fire stations, police stations, ambulance stations, rescue stations, ranger stations, and similar locations. ▶Figure 210-78



[▶] Figure 210-78

(E) Branch-Circuit Wiring Extensions, Modifications, or Replacements. If 15A or 20A, 120V branch-circuit wiring is extended, modified, or replaced in any of the areas specified in 210.12(B), (C), or (D), the wiring must be AFCI protected by one of the following:

- (1) AFCI circuit breaker
- (2) AFCI receptacle installed at the first receptacle outlet of the existing branch circuit

Ex: AFCI protection is not required for extension wiring that is less than 6 ft in length (raceway or cable) if no outlets or devices, other than splicing devices, are added. This measurement does not include the conductors inside an enclosure, cabinet, or junction box.



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