



Mike Holt's Illustrated Guide to

GFCI AND AFCI PROTECTION

Extracted from Understanding the National Electrical Code® Volume 1



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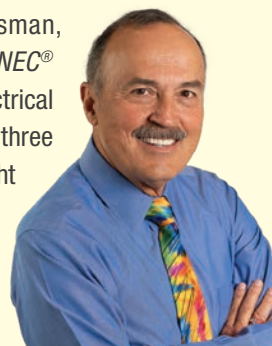
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ABOUT THE AUTHOR

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.



Mike's approach to electrical training is based on his own experience as an electrician, contractor, inspector and teacher. He's always felt a responsibility to his students and to the electrical industry to provide education beyond the scope of just passing an exam. This commitment, coupled with the lessons he learned at the University of Miami's MBA program, have helped him build one of the largest electrical training and publishing companies in the United States. His one-of-a-kind presentation style and his ability to simplify and clarify technical concepts explain his unique position as one of the premier educators and *Code* experts in the country. His passion for the electrical field drives his goal to increase electrical safety and improve lives.

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

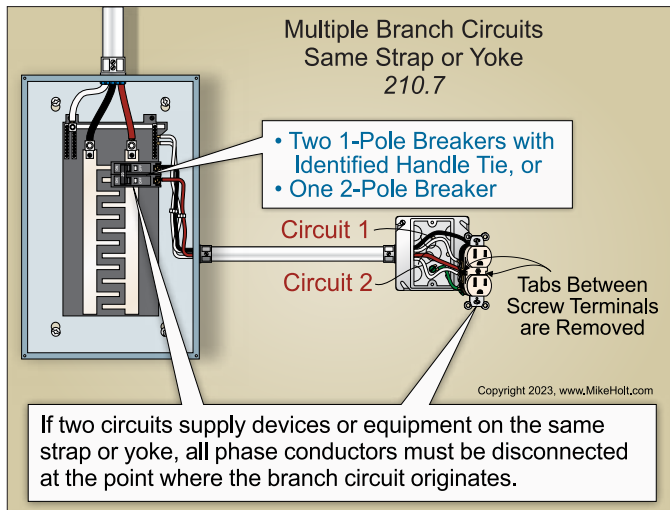
210.8 GFCI Protection

A GFCI device must provide protection as required in 210.8(A) through (F). ▶[Figure 210-17](#) and ▶[Figure 210-18](#)

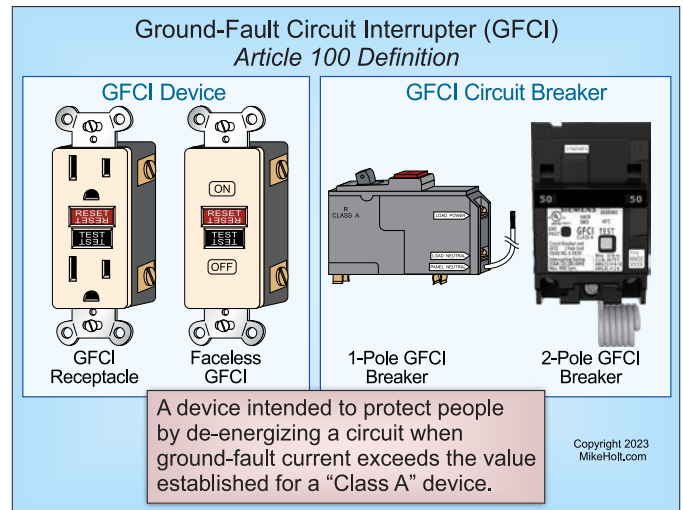
GFCI protective devices must be in a readily accessible location.

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](#)

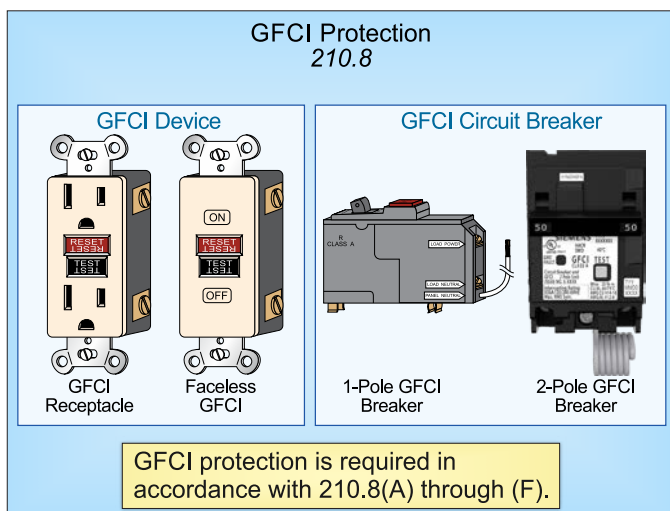
According to Article 100, “Readily Accessible” means capable of being reached quickly for operation, renewal, or inspection without requiring the use tools (other than keys), climb over or under obstructions, remove obstacles, resort to using portable ladders, and so forth. ▶[Figure 210-20](#) and ▶[Figure 210-21](#)



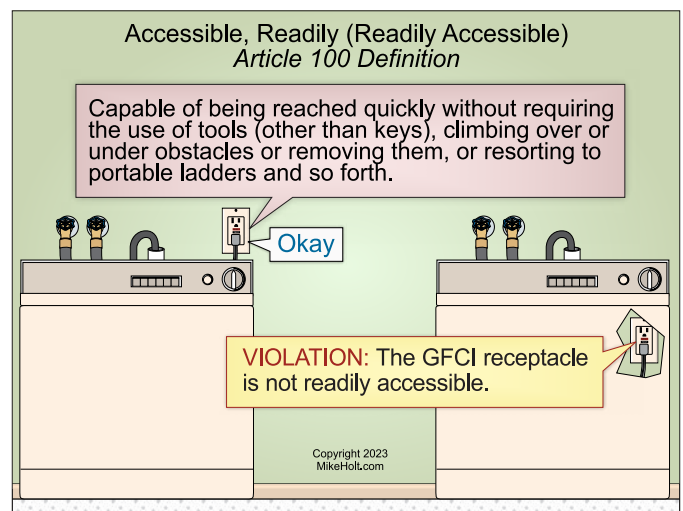
►Figure 210-16



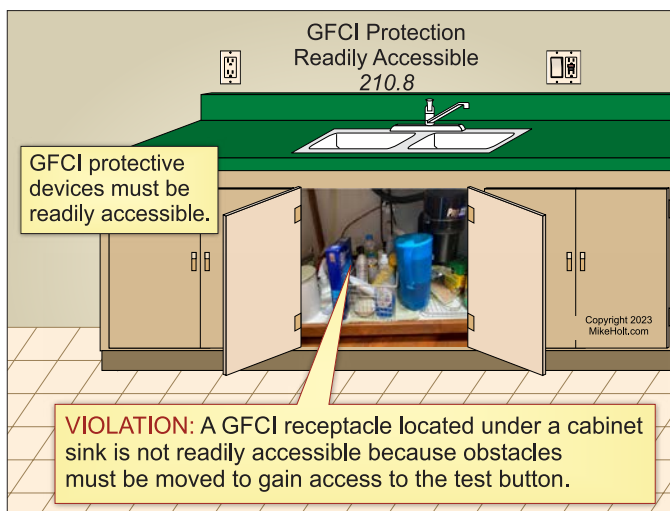
►Figure 210-19



►Figure 210-17



►Figure 210-20



►Figure 210-18



►Figure 210-21

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 power-supply cord connected to the receptacle will follow without piercing a floor, wall, ceiling, or fixed barrier. ▶Figure 210-22



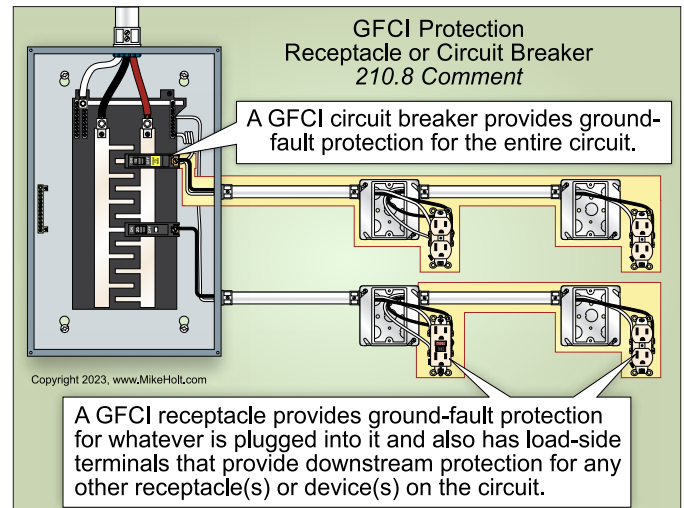
▶Figure 210-22

Author's Comment:

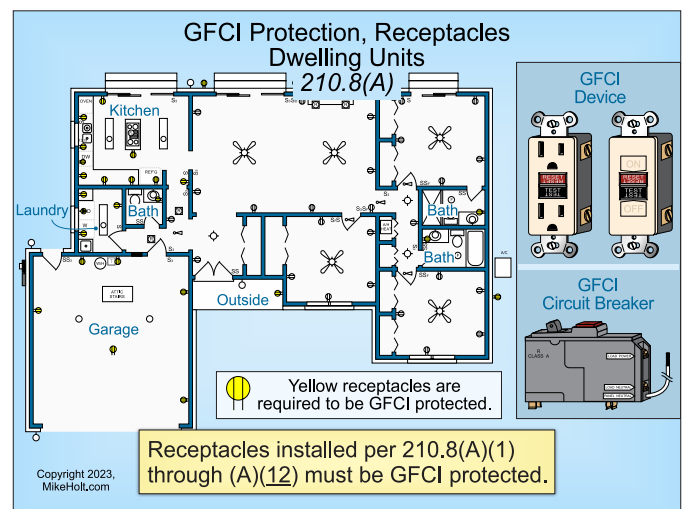
- ▶ The reference to windows and doors was removed to ensure receptacles within the measured distance as required in 210.8, even if passing through a window or door, are afforded GFCI protection.
- ▶ The GFCI circuit breaker provides ground-fault protection starting at the breaker, so the entire circuit has ground-fault 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 GFCI protected. ▶Figure 210-24

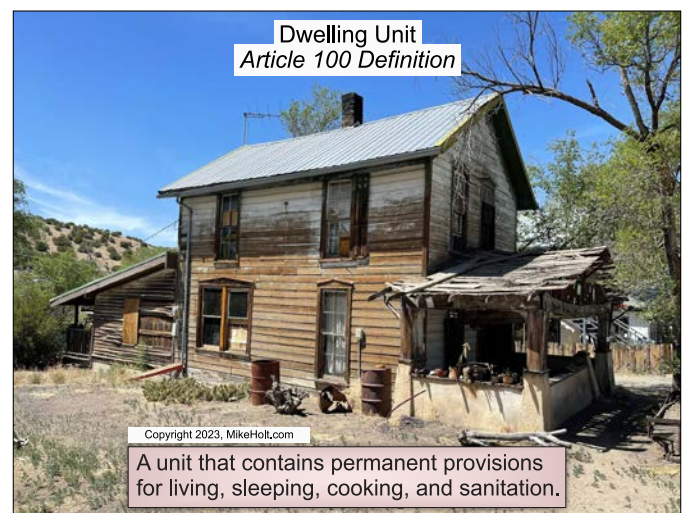
According to Article 100, “Dwelling Unit” is a single unit that provides independent living facilities with permanent provisions for living, sleeping, cooking, and sanitation. ▶Figure 210-25



▶Figure 210-23

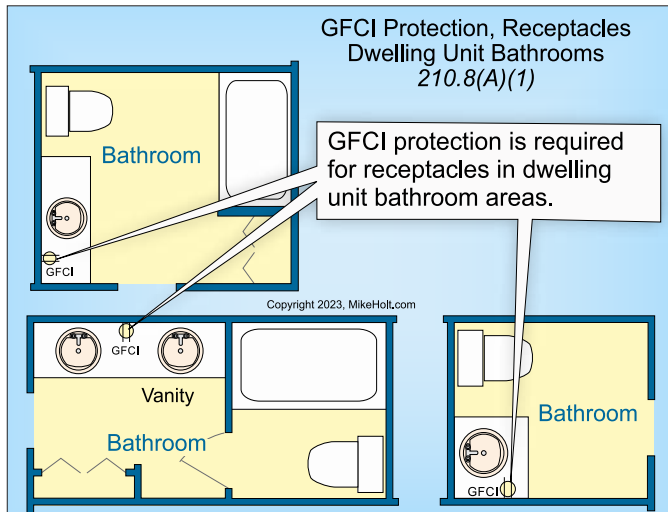


▶Figure 210-24



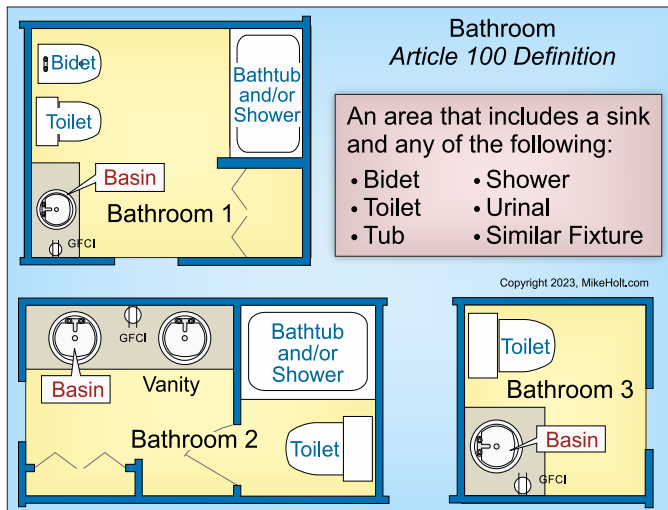
▶Figure 210-25

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



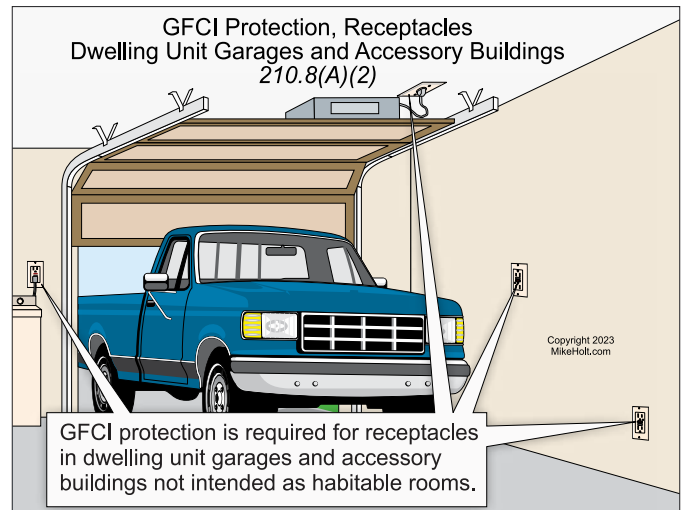
▶Figure 210-26

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



▶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

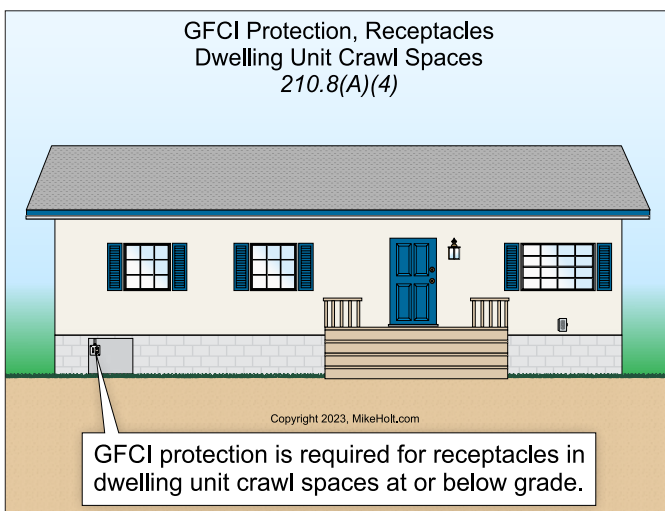
(3) Outdoors. GFCI protection is required for receptacles located outdoors of a dwelling unit. ▶Figure 210-30

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

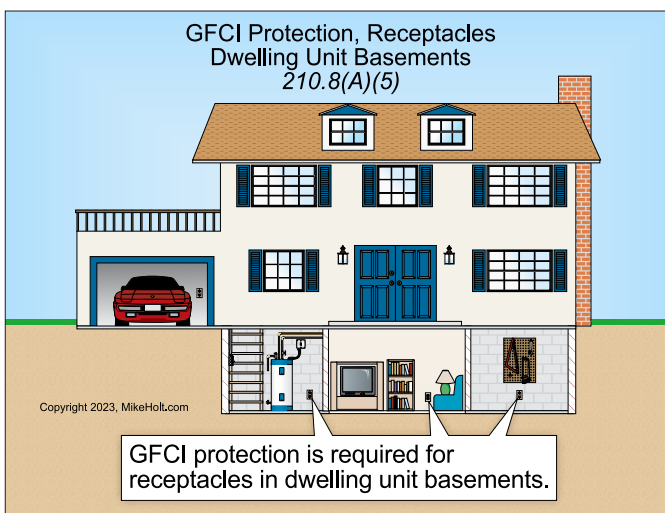
(5) Basements. GFCI protection is required for receptacles in dwelling unit basements. ▶Figure 210-32



►Figure 210-30

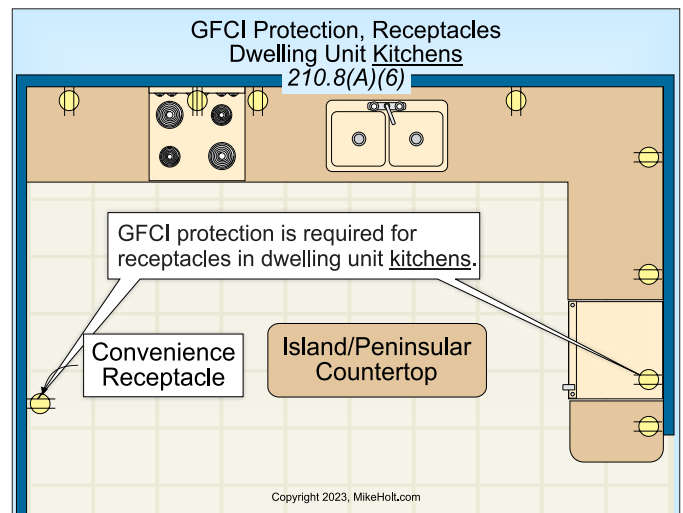


►Figure 210-31



►Figure 210-32

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



►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.

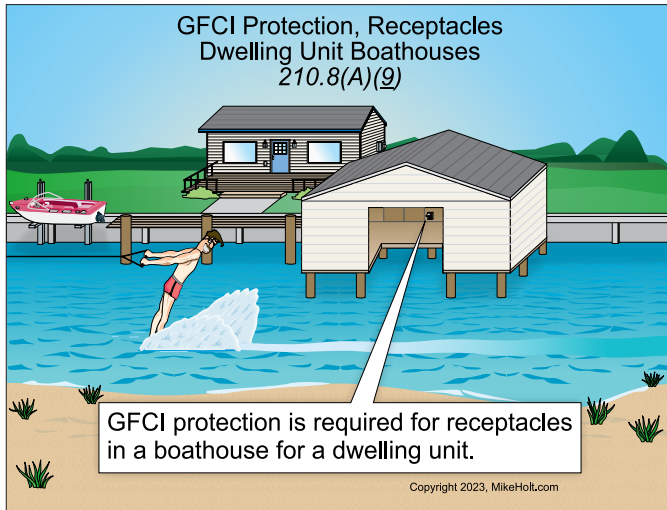
(8) Sinks. GFCI protection is required for receptacles within 6 ft of the top inside edge of the bowl of a dwelling unit sink.

(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

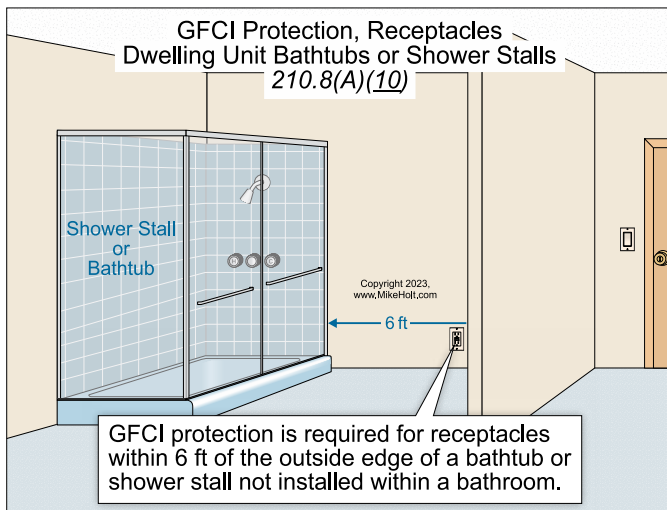


►Figure 210-34



►Figure 210-36

(11) Laundry Areas. GFCI protection is required for receptacles installed in the laundry area of a dwelling unit. ►Figure 210-36



►Figure 210-35

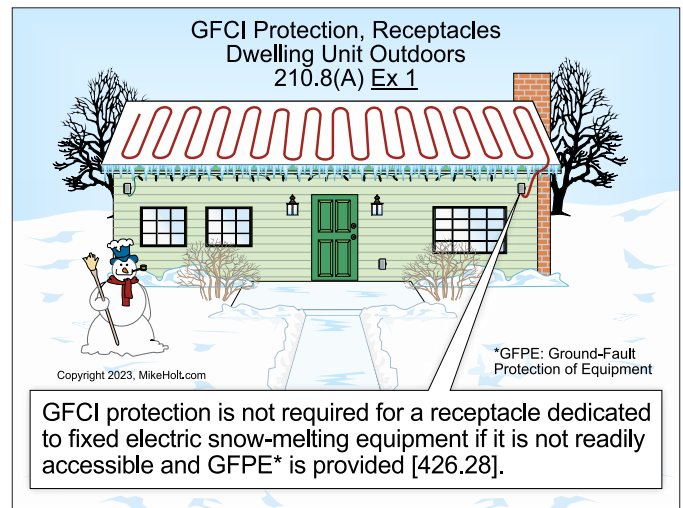
(12) Damp and Wet Locations Indoors. GFCI protection is required for receptacles installed in indoor damp and wet locations.

Ex 1: 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 210-37



►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-and-plug 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



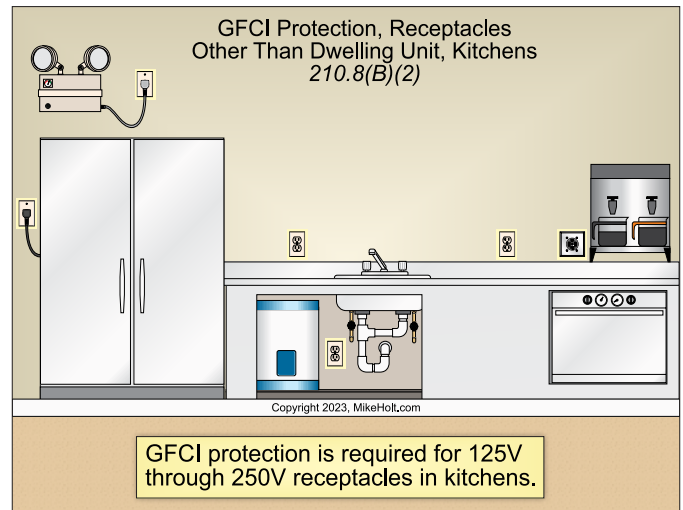
▶Figure 210-39

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. GFCI 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.

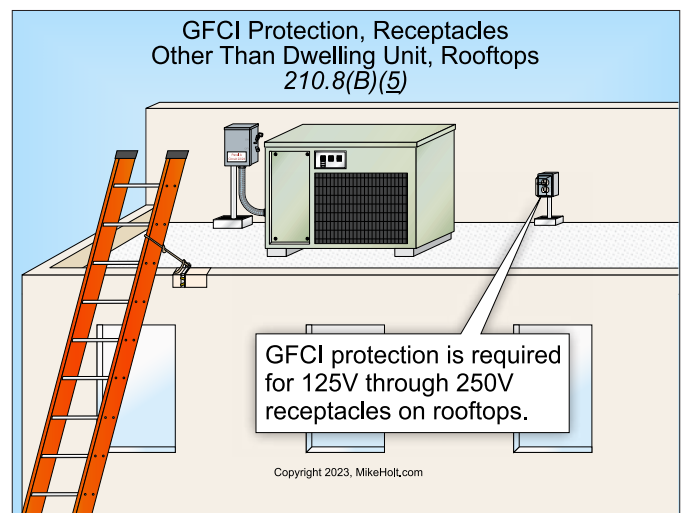


▶Figure 210-40

Author's Comment:

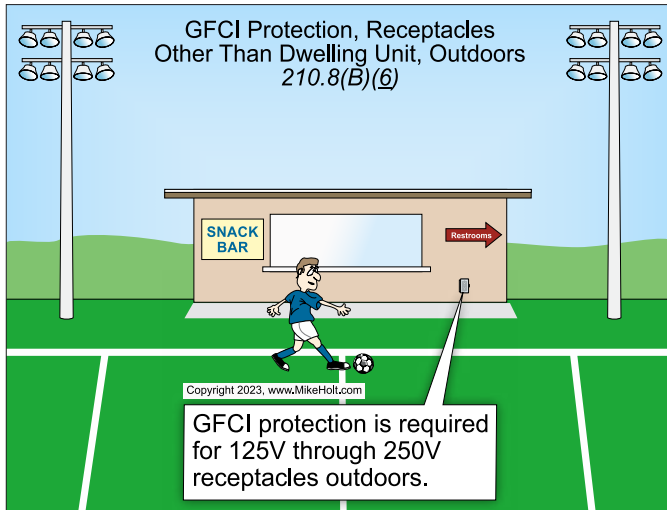
- ▶ This requires GFCI protection for receptacles in the break area of a commercial occupancy.

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



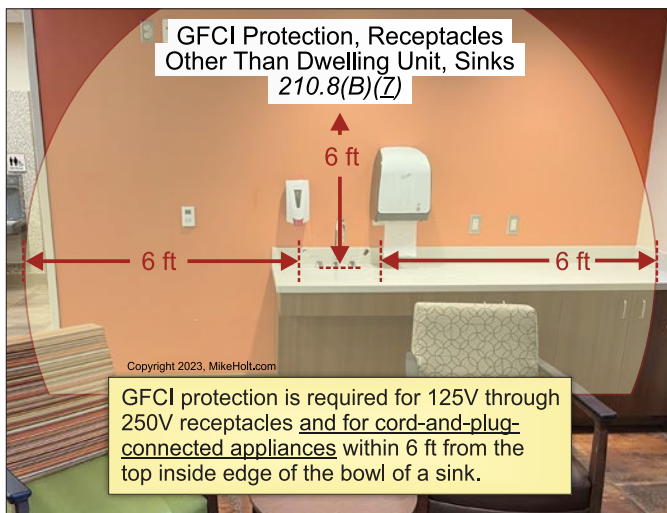
▶Figure 210-41

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



►Figure 210-42

(7) Sinks. GFCI 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.

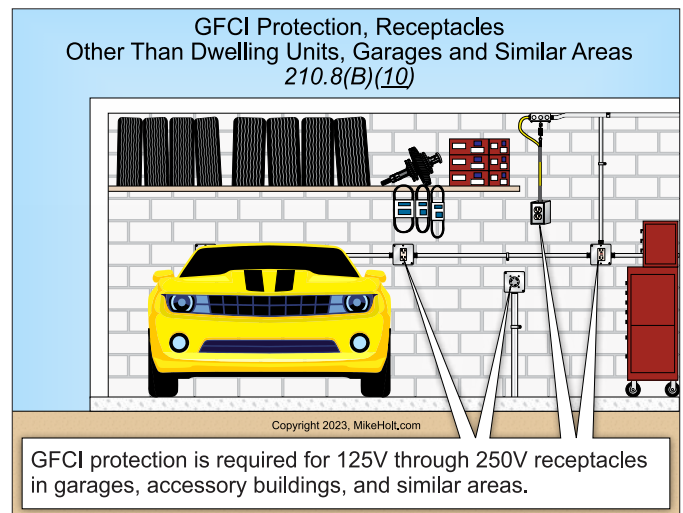
(8) Indoor Damp or Wet Locations. GFCI protection is required for 125V through 250V receptacles in indoor damp or wet locations.

(9) Locker Rooms. GFCI 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



►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. GFCI 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. GFCI 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.

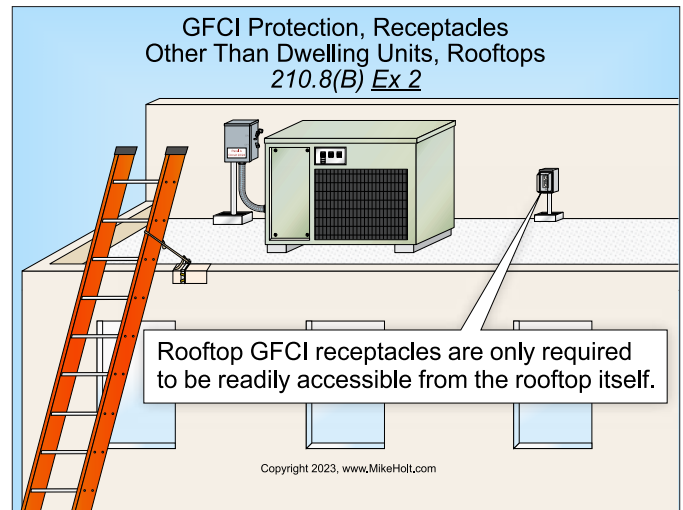
Ex 2: Rooftop GFCI receptacles are only required to be readily accessible from the rooftop itself. ▶Figure 210-48



▶Figure 210-46



▶Figure 210-47



▶Figure 210-48

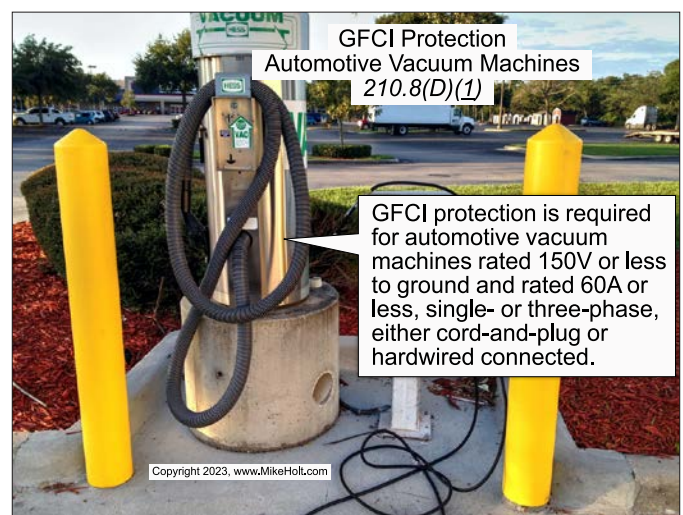
(C) Crawl Space Lighting Outlets. GFCI protection is required for 120V lighting outlets in crawl spaces.

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



►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.

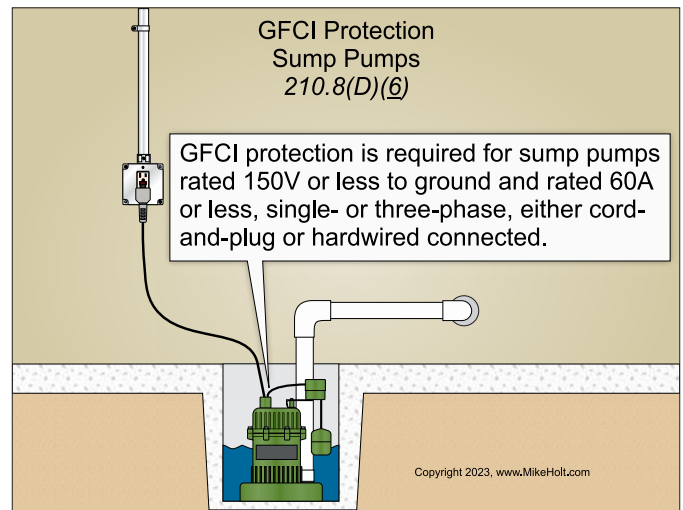
(10) Counter-mounted electric cooking units.

(11) Clothes dryers.

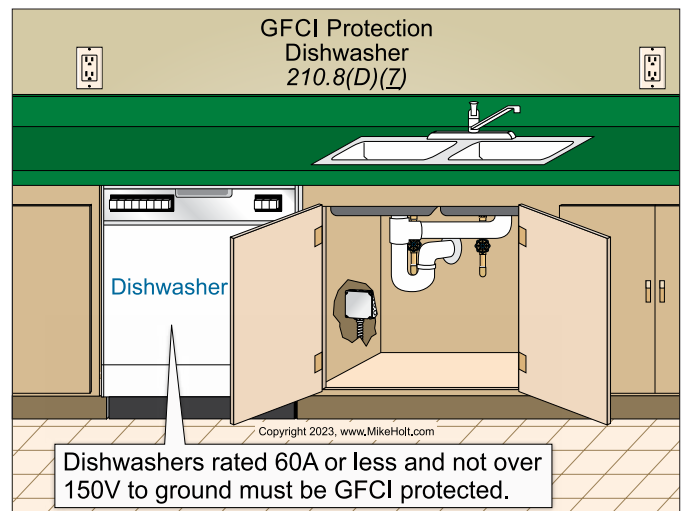
(12) Microwave ovens.



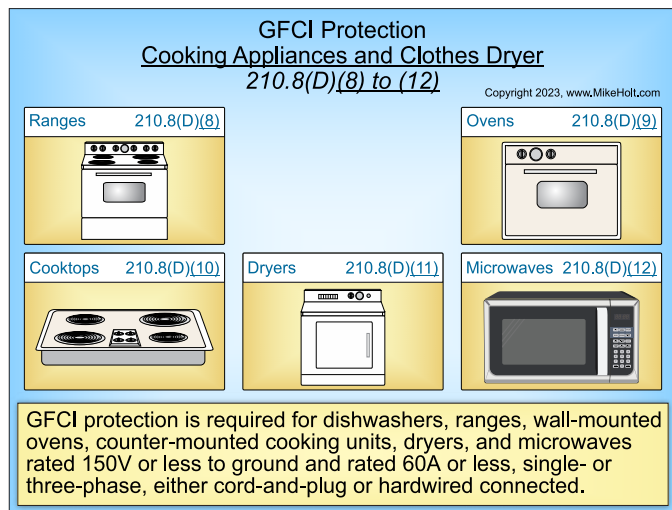
►Figure 210-52



►Figure 210-53



►Figure 210-54



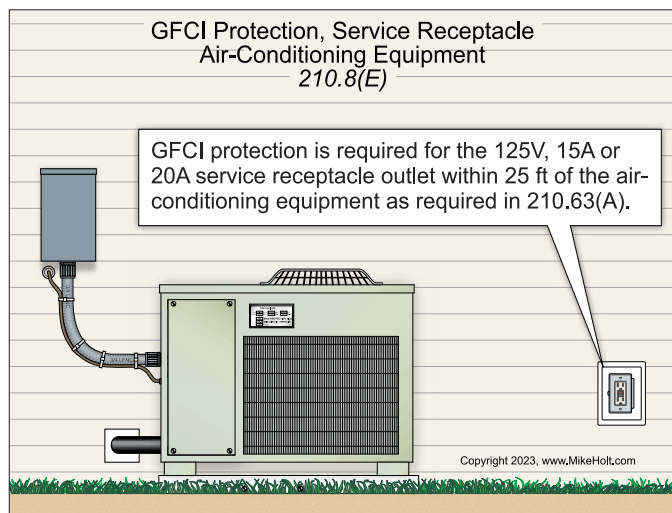
►Figure 210-55

Author's Comment:

- 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.

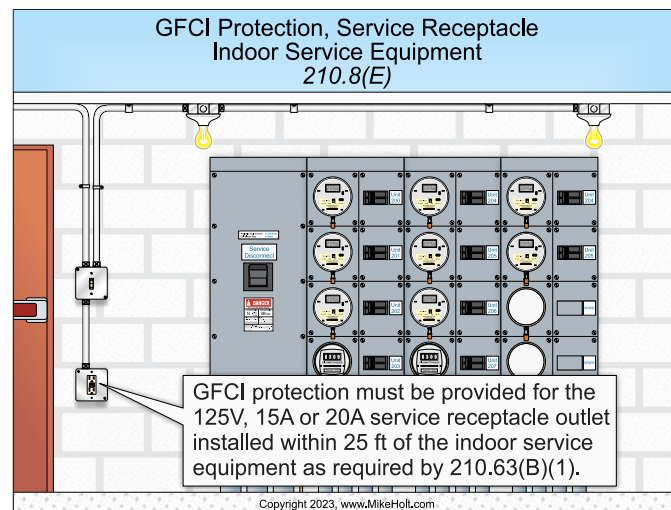
Air-Conditioning Equipment. GFCI protection is required for the 125V, 15A or 20A service receptacle outlet installed within 25 ft of the air-conditioning equipment as required in 210.63(A). ►Figure 210-56



►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).

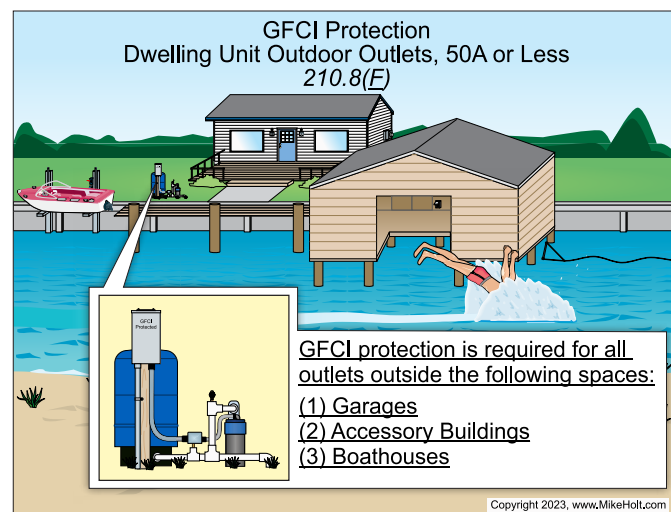
►Figure 210-57



►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



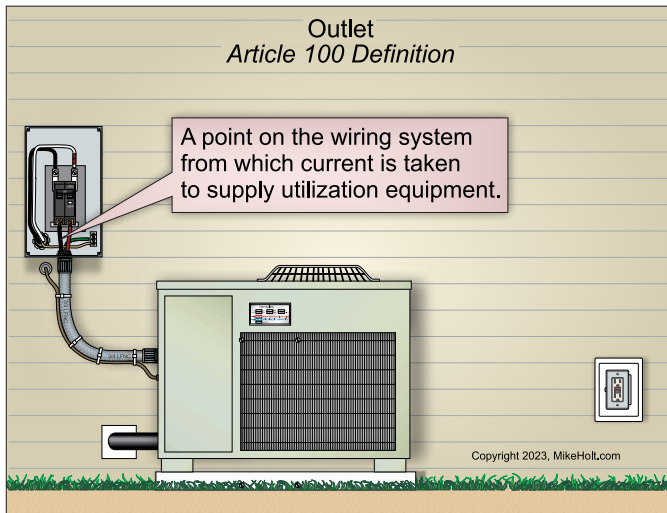
►Figure 210-58

- (1) Garages
- (2) Accessory Buildings
- (3) Boathouses

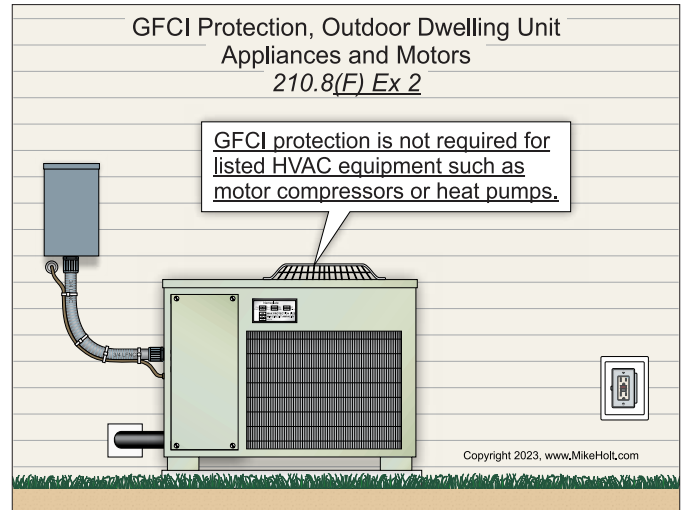
According to Article 100, an “Outlet” is a point on the wiring system at which current is taken to supply utilization equipment. ▶Figure 210–59

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 210–59



▶Figure 210–60

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