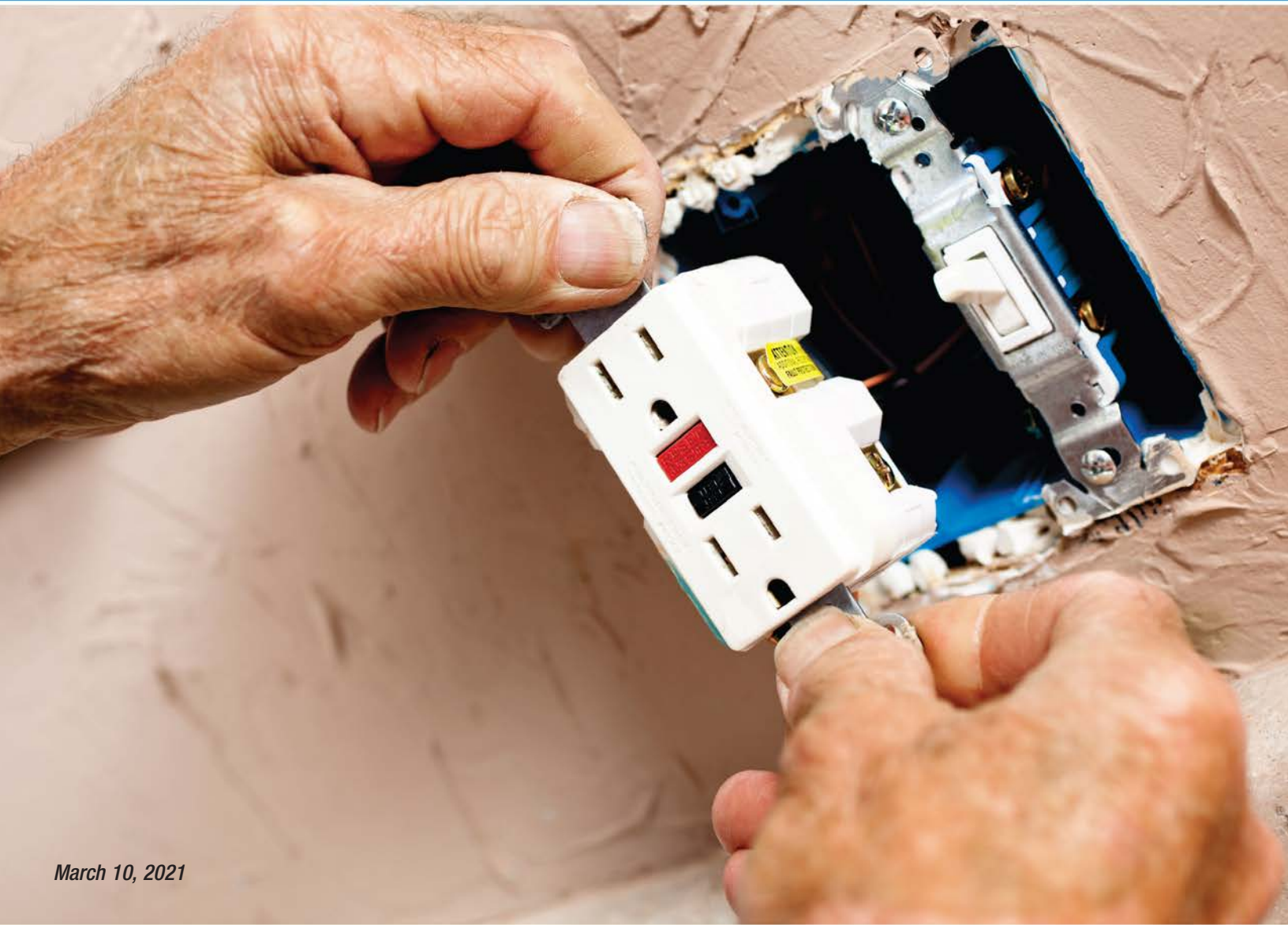




Mike Holt's Illustrated Guide to

GFCI and AFCI Protection

Extracted from Understanding the National Electrical Code® Volume 1



March 10, 2021



Mike Holt Enterprises

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Author: Mike Holt

Technical Illustrator: Mike Culbreath

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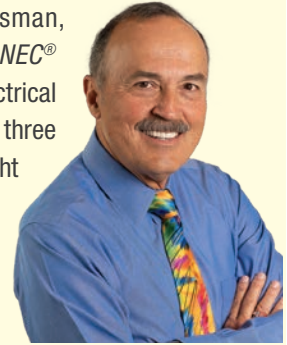
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ABOUT THE AUTHOR

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

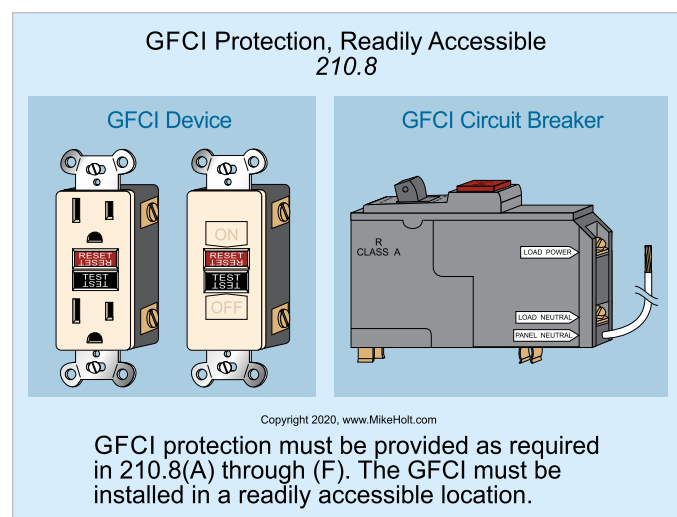
This article contains branch-circuit requirements such as those for conductor sizing and identification, GFCI and AFCI protection, and receptacle and lighting outlet requirements. It consists of three parts:

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

Table 210.3 in this article identifies specific-purpose branch circuits. Its provisions for those that supply the equipment listed amend or supplement the requirements in Article 210 for branch circuits, so it is important to be aware of the contents of this table.

210.8 GFCI Protection

Ground-fault circuit interruption protection, located in a readily accessible location, must be provided in accordance with 210.8(A) through (F). ▶ **Figure 210-17**

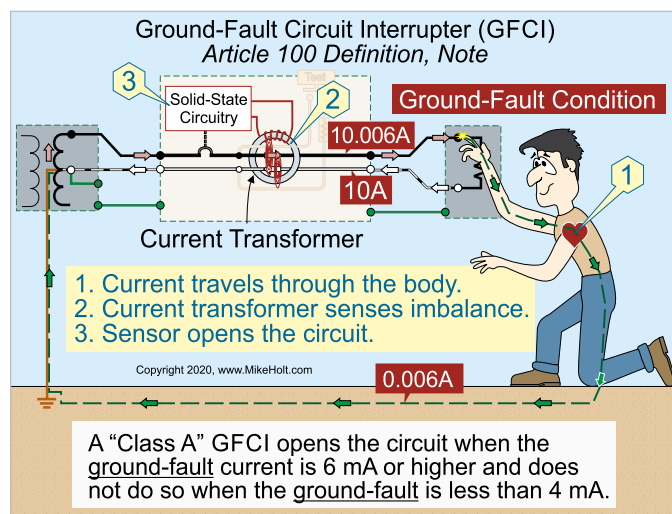


▶ **Figure 210-17**

Author's Comment:

- ▶ According to Article 100, a "Ground-Fault Circuit Interrupter" (GFCI) is a device intended to protect people by de-energizing a circuit when a current imbalance is of 6 mA or higher and does not do so when the current to ground is less than 4 mA.

▶ **Figure 210-18**



▶ **Figure 210-18**

Author's Comment:

- ▶ 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 also has load-side terminals that provide downstream protection for any other receptacle(s) or device(s) on the circuit.
- ▶ According to Article 100, "Readily Accessible" means capable of being reached quickly without having to climb over or remove obstacles, or resort to the use of portable ladders.

Note 2: See 422.5 for GFCI requirements for specific equipment such as automotive vacuum machines, drinking water coolers, high-pressure spray washing machines, tire inflation machines provided for public use, and vending machines.

Note 3: See 555.9 for GFCI requirements for boat hoists.

Note 4: Additional GFCI requirements for specific circuits and equipment are contained in Chapters 4, 5, and 6.

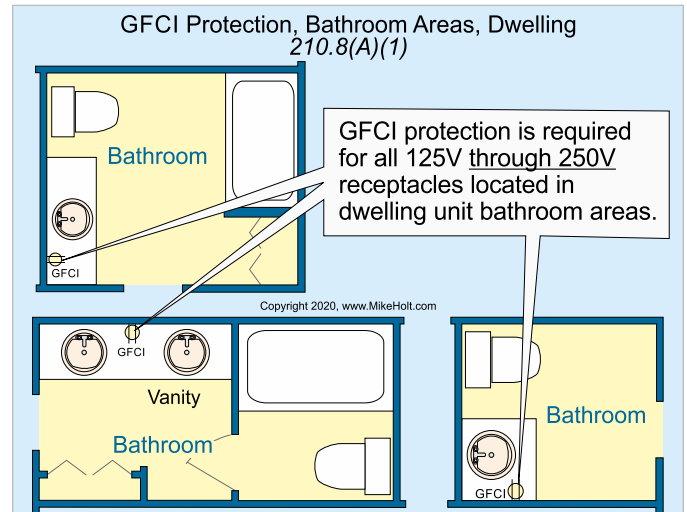
For the application of 210.8(A)(7), 210.8(A)(9), 210.8(B)(5), and 210.8(B)(12), the distance is measured as the shortest path an appliance's supply cord will follow without piercing a floor, wall, ceiling, fixed barrier, or passing through a window. ▶ **Figure 210-19**



▶ **Figure 210-19**

(A) Dwelling Units. 125V through 250V receptacles installed in the following dwelling unit locations must be GFCI protected.

(1) Bathroom Areas. GFCI protection is required for all receptacles located in dwelling unit bathroom areas. ▶ **Figure 210-20**

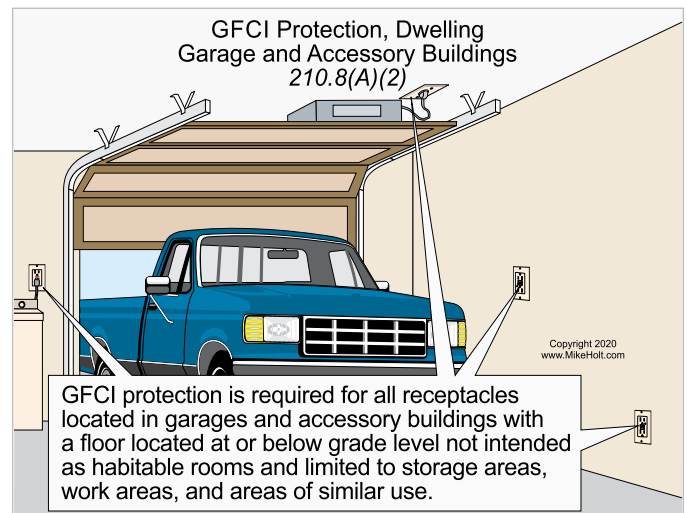


▶ **Figure 210-20**

Author's Comment:

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

(2) Garages and Accessory Buildings. GFCI protection is required for all receptacles located in garages and accessory building that have a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use. ▶ **Figure 210-21**



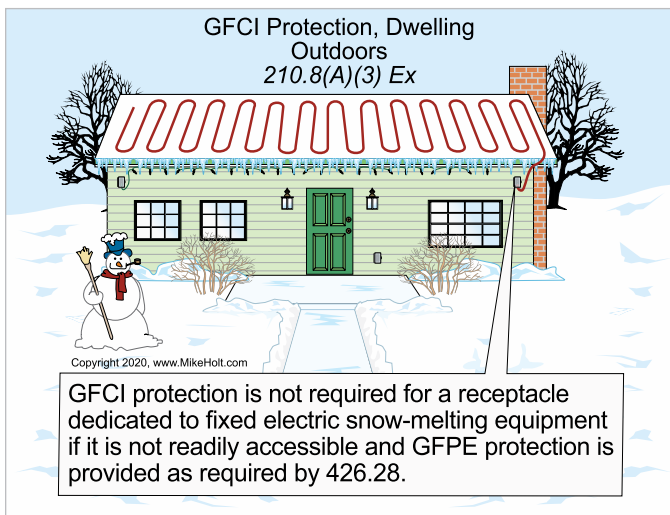
▶ **Figure 210-21**

(3) Outdoors. GFCI protection is required for all receptacles located outdoors of dwelling units including receptacles under the eaves of roofs. ▶ **Figure 210-22**



► Figure 210-22

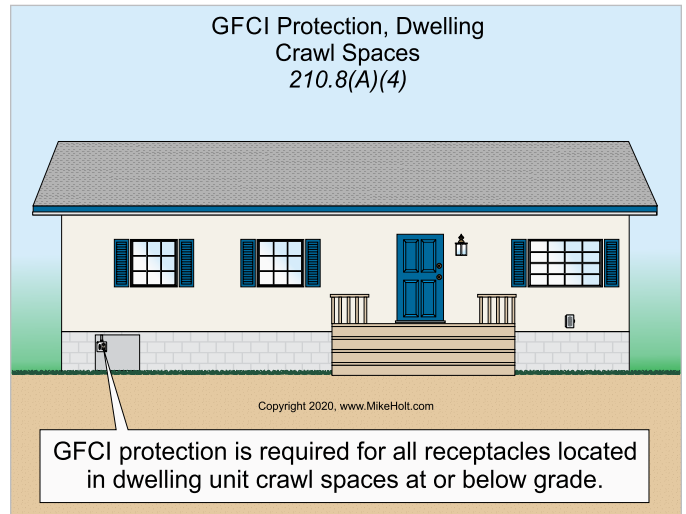
Ex: GFCI protection is not required for a receptacle dedicated to fixed electric snow-melting equipment if the receptacle is not readily accessible and ground-fault protection of equipment is provided as required by 426.28 and 427.22. ► Figure 210-23



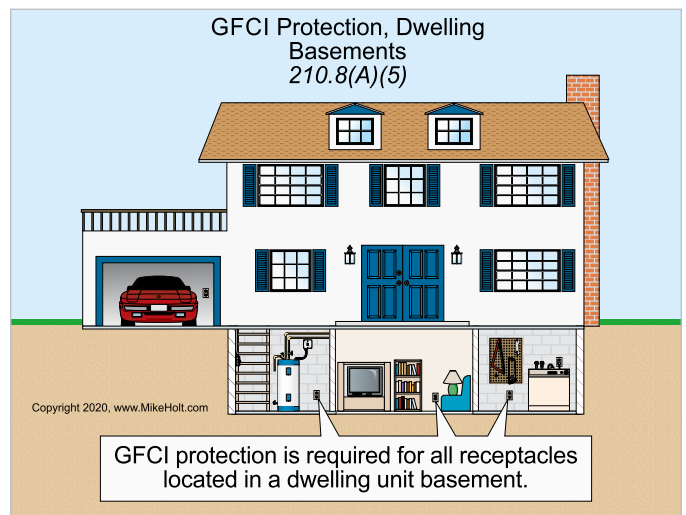
► Figure 210-23

(4) Crawl Spaces. GFCI protection is required for all receptacles located in dwelling unit crawl spaces at or below grade. ► Figure 210-24

(5) Basements. GFCI protection is required for all receptacles located in finished and unfinished areas of dwelling unit basements. ► Figure 210-25



► Figure 210-24



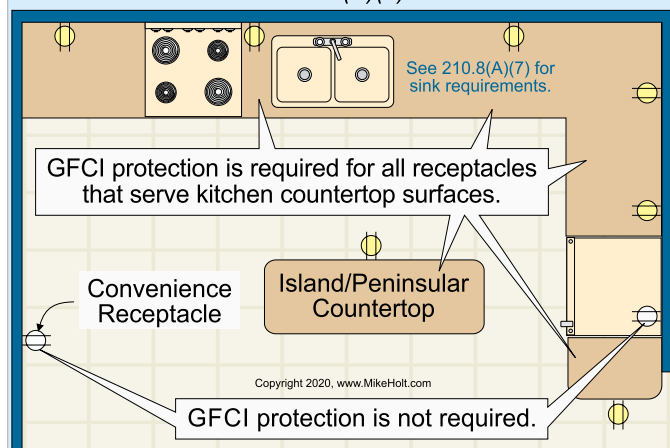
► Figure 210-25

Ex: A receptacle supplying only a permanently installed fire or burglar alarm system is not required to have ground-fault circuit-interrupter protection.

(6) Kitchen Countertops. GFCI protection is required for all receptacles that serve kitchen countertop surfaces. ► Figure 210-26

Author's Comment:

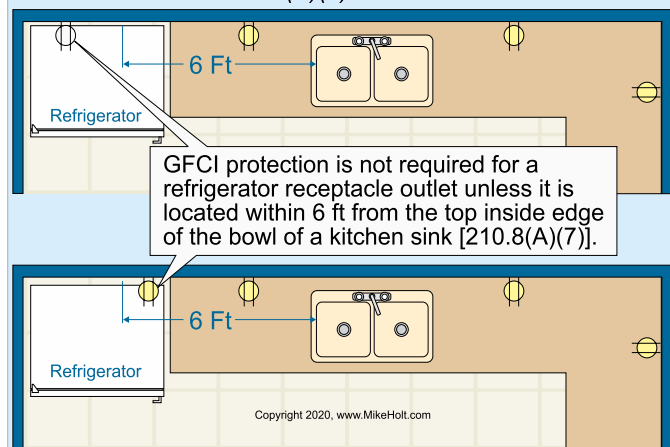
- Receptacles located below a countertop for appliances such as trash compactors or garbage disposals do not require GFCI protection unless they are located 6 ft or less from the top inside edge of the bowl of a sink [210.8(A)(7)].

GFCI Protection, Dwelling, Kitchen Countertops
210.8(A)(6)

▶ Figure 210-26

- ▶ GFCI protection is not required for a refrigerator receptacle outlet unless it is located within 6 ft from the top inside edge of the bowl of a kitchen sink [210.8(A)(7)].

▶ Figure 210-27

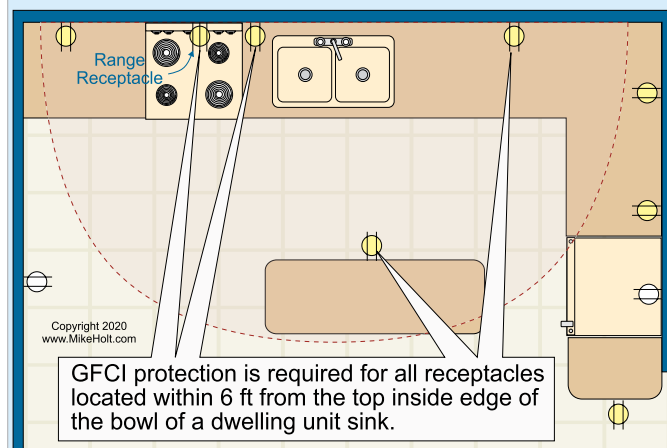
GFCI Protection, Kitchen Countertops, Dwelling
210.8(A)(6) Comment

▶ Figure 210-27

Author's Comment:

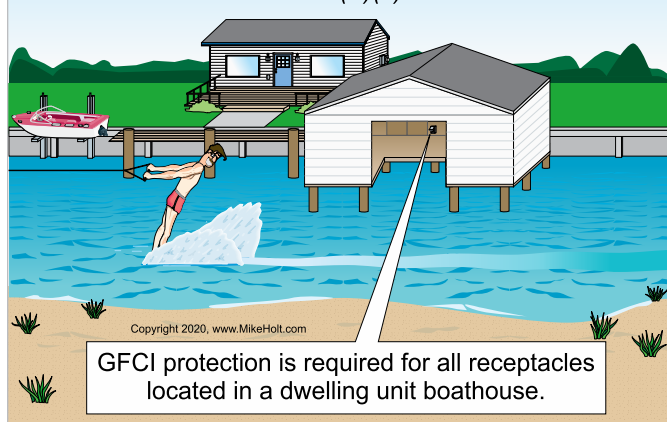
- ▶ Outlets supplying dishwashers require GFCI protection [210.8(D)].

(7) Sinks. GFCI protection is required for all receptacles located within 6 ft of the top inside edge of the bowl of a dwelling unit sink. ▶ Figure 210-28

GFCI Protection, Sinks, Dwelling
210.8(A)(7)

▶ Figure 210-28

(8) Boathouses. GFCI protection is required for all receptacles located in a dwelling unit boathouse. ▶ Figure 210-29

GFCI Protection, Dwelling
Boathouses
210.8(A)(8)

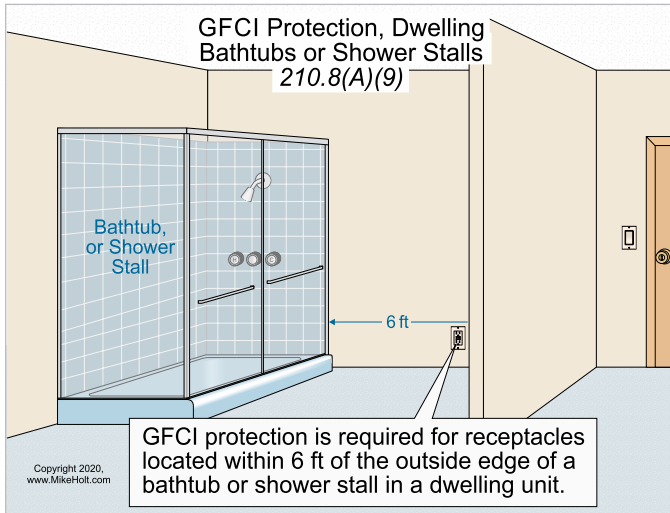
▶ Figure 210-29

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.

(9) Bathtubs or Shower Stalls. GFCI protection is required for receptacles located within 6 ft of the outside edge of a bathtub or shower stall not installed within a bathroom as defined in Article 100. ▶ Figure 210-30

(10) Laundry Areas. GFCI protection is required for all receptacles installed in the laundry area of a dwelling unit. ▶ Figure 210-31



► Figure 210-30



► Figure 210-32



► Figure 210-31

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

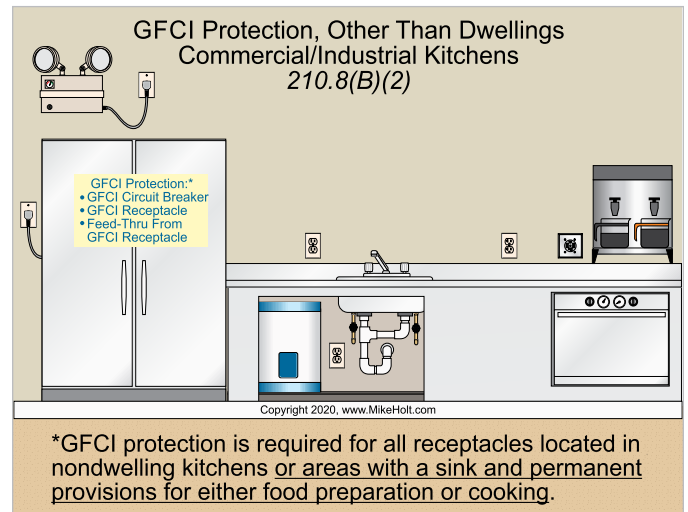
(B) Other Than Dwellings. GFCI protection is required for all 125V through 250V receptacles supplied by single-phase branch circuits rated 150V or less to ground, 50A or less, and all receptacles supplied by three-phase branch circuits rated 150V or less to ground, 100A or less, installed in the following locations.

(1) Bathroom Areas. GFCI protection is required for all receptacles located in bathroom areas. ► Figure 210-32

Author's Comment:

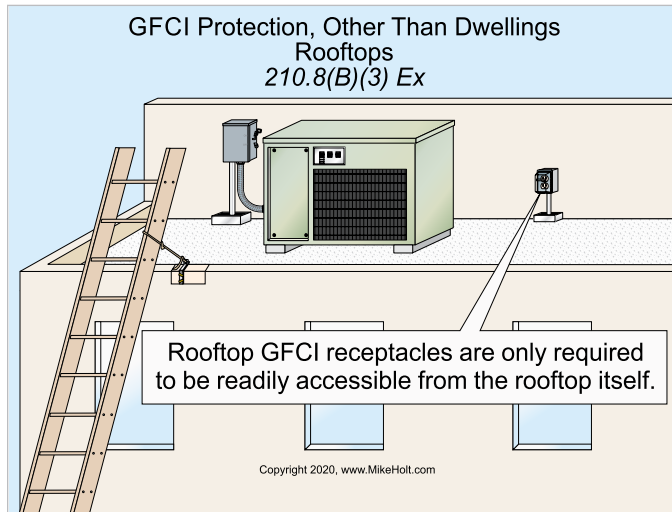
- According to Article 100, a "Bathroom Area" is one that includes a basin and one or more of the following: a toilet, urinal, tub, shower, bidet, or similar plumbing fixture.

(2) Kitchens. GFCI protection is required for all receptacles located in kitchens or areas with a sink and permanent provisions for either food preparation or cooking. ► Figure 210-33



► Figure 210-33

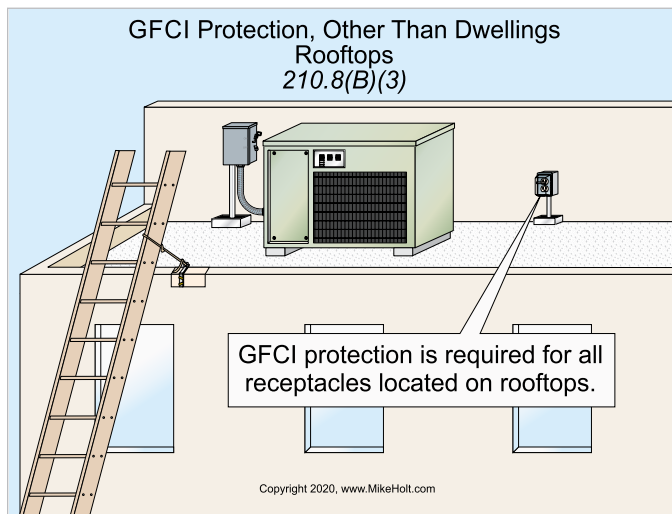
(3) Rooftops. GFCI protection is required for all receptacles located on rooftops. ► Figure 210-34



► Figure 210-34

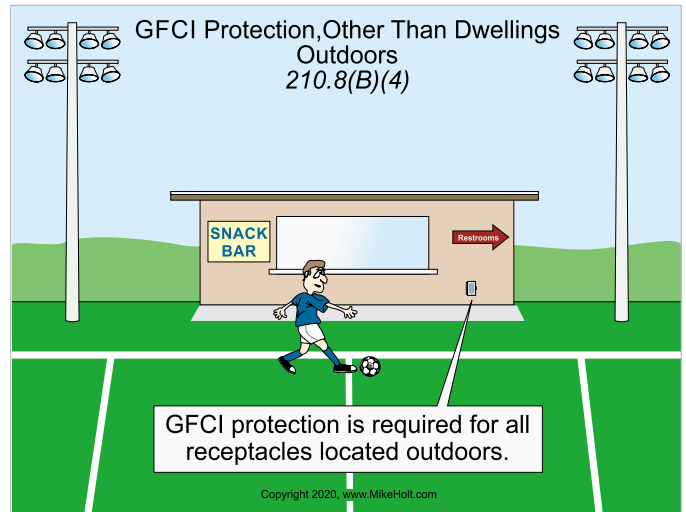
Author's Comment:

- Ex. Rooftop GFCI receptacles are only required to be readily accessible from the rooftop itself. ► **Figure 210-35**

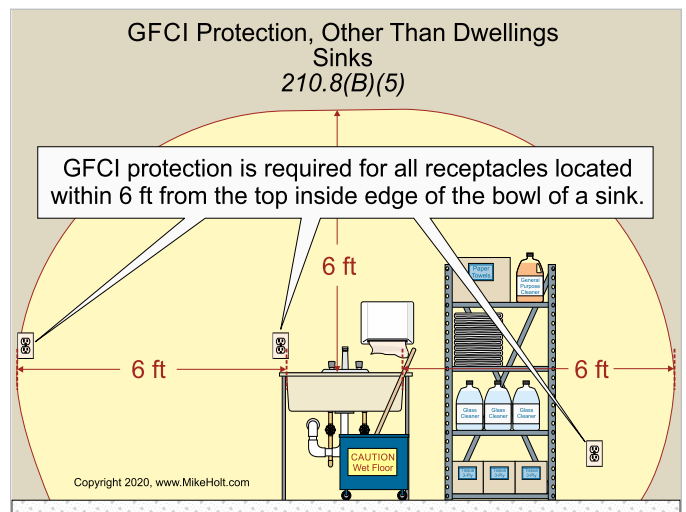


► Figure 210-35

(4) Outdoors. GFCI protection is required for all receptacles located outdoors. ► **Figure 210-36**



► Figure 210-36



► Figure 210-37

(5) Sinks. GFCI protection is required for all receptacles located within 6 ft from the top inside edge of the bowl of a sink. ► **Figure 210-37**

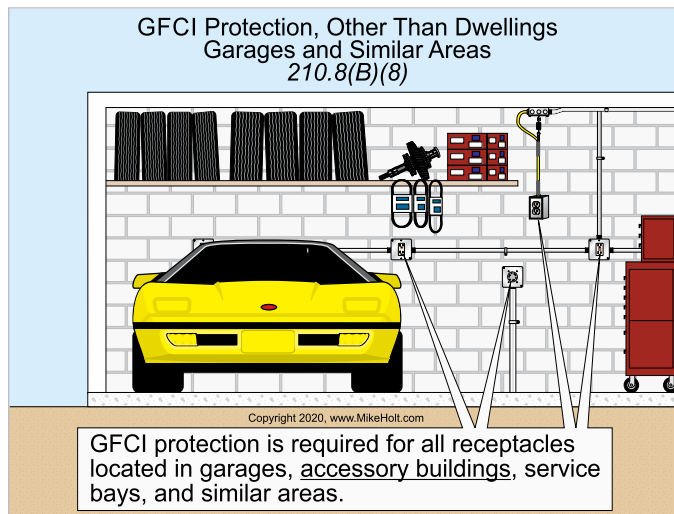
(6) Indoor Damp and Wet Locations. GFCI protection is required for all receptacles located in indoor damp and wet locations.

(7) Locker Rooms. GFCI protection is required for receptacles located in locker rooms with showering facilities. ► **Figure 210-38**



► Figure 210-38

(8) Garages and Similar Areas. GFCI protection is required for all receptacles located in garages, accessory buildings, service bays, and similar areas. ▶ **Figure 210-39**



▶ **Figure 210-39**

(9) Crawl Spaces. GFCI protection is required for all receptacles located in crawl spaces at or below grade level.

Author's Comment:

- ▶ 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.

(10) Unfinished Areas of Basements. GFCI protection is required for all receptacles located in the unfinished areas of basements.

(11) Laundry Areas. GFCI protection is required for all receptacles located in the laundry area.

(12) Bathtubs and Shower Stalls. GFCI protection is required for all receptacles installed within 6 ft of the outside edge of a bathtub or shower stall not installed in a bathroom as defined in Article 100.

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

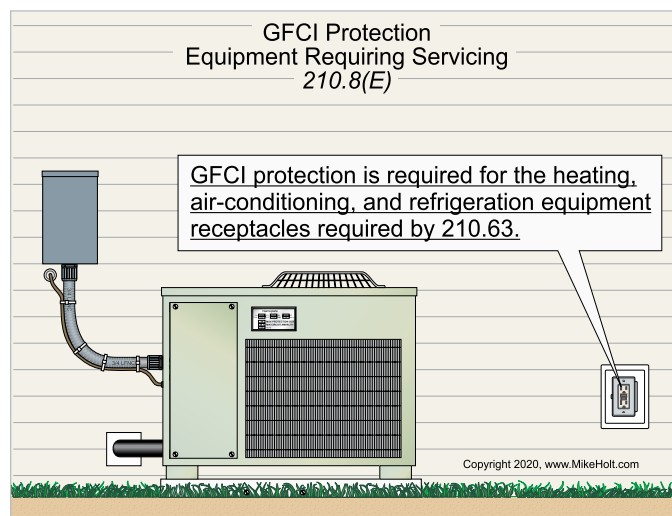
Author's Comment:

- ▶ 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(A)(3)].

(D) Specific Appliances. Unless GFCI protection is provided in accordance with 422.5(B)(3) through (B)(5), the outlets supplying appliances specified in 422.5(A) must have GFCI protection in accordance with 422.5(B)(1) or (B)(2).

Where the appliance is a vending machine as specified in 422.5(A)(5) and GFCI protection is not provided in accordance with 422.5(B)(3) or (B)(4), the branch circuit supplying the vending machines must have GFCI protection in accordance with 422.5(B)(1) or (B)(2).

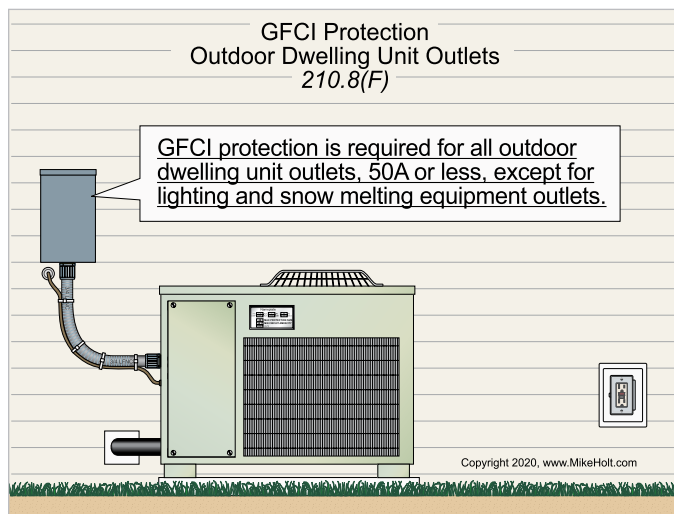
(E) Equipment Requiring Servicing. GFCI protection is required for the heating, air-conditioning, and refrigeration equipment receptacles required by 210.63(A). ▶ **Figure 210-40**



▶ **Figure 210-40**

(F) Outdoor Dwelling Unit Outlets. GFCI protection is required for all outdoor dwelling unit outlets, other than those for snow-melting equipment covered in 210.8(A)(3) Ex. ▶ **Figure 210-41**

Ex: GFCI protection is not required on lighting outlets other than those covered in 210.8(C).

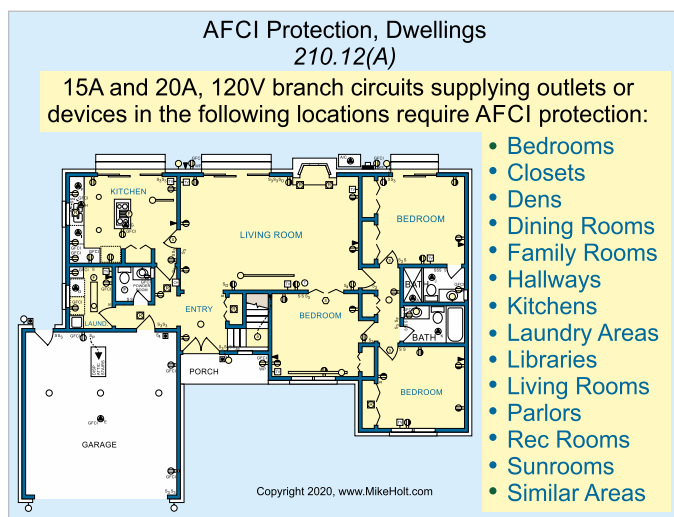


▶ Figure 210-41

210.12 Arc-Fault Circuit-Interrupter Protection

Arc-fault circuit-interrupter protection, located in a readily accessible location, must be provided in accordance with 210.12(A), (B), (C), and (D).

(A) Dwelling Units. AFCI protection is required for all 15A or 20A, 120V branch circuits supplying outlets in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas. ▶Figure 210-51



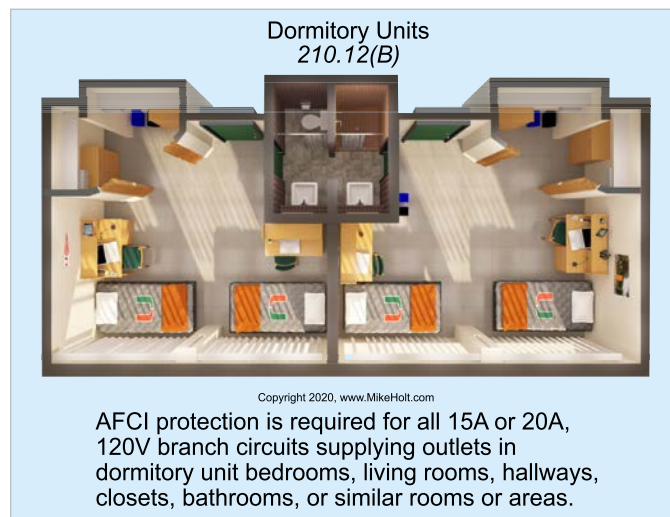
▶ Figure 210-51

Author's Comment:

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

(B) Dormitory Units. AFCI protection is required for all 15A or 20A, 120V branch circuits supplying outlets in dormitory unit bedrooms, living rooms, hallways, closets, bathrooms, or similar rooms or areas.

▶Figure 210-52



▶ Figure 210-52

(C) Guest Rooms and Guest Suites. AFCI protection is required for all 15A and 20A, 120V branch circuits supplying outlets in guest rooms and guest suites of hotels and motels. ▶Figure 210-53



▶ Figure 210-53

(D) Branch Circuit Extensions or Modifications—Dwelling Units, Dormitory Units, Guest Rooms, and Guest Suites. Where 15A or 20A, 120V branch-circuit wiring is modified, replaced, or extended in any of the areas specified in 210.12(A), (B), or (C), the wiring must be AFCI protected.

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.

ARTICLE 422

APPLIANCES

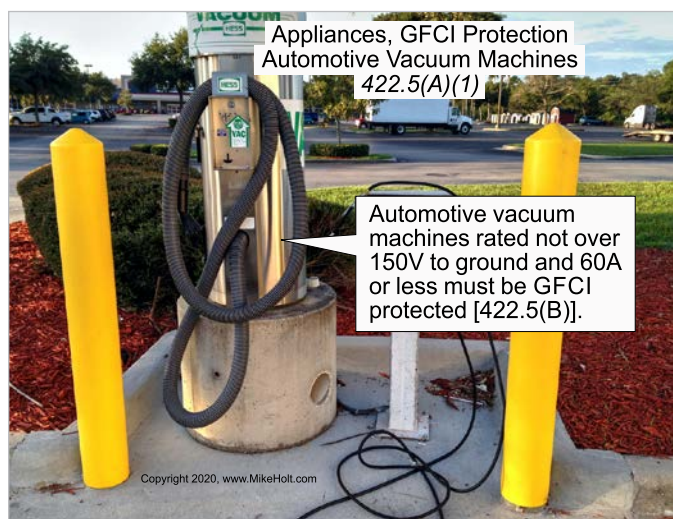
Introduction to Article 422—Appliances

Article 422 covers electric appliances that are fastened in place, permanently connected, or cord-and-plug-connected. The core content of this article is contained in Parts II and III. Parts IV and V are primarily for manufacturers, but you should examine appliances for compliance before installing them.

422.5 GFCI Protection

(A) General. The following appliances rated 60A or less must be GFCI protected by Class “A” protective devices [422.5(B)].

(1) Automotive vacuum machines. ▶Figure 422-2



▶Figure 422-2

(2) Drinking water coolers and bottle fill stations. ▶Figure 422-3

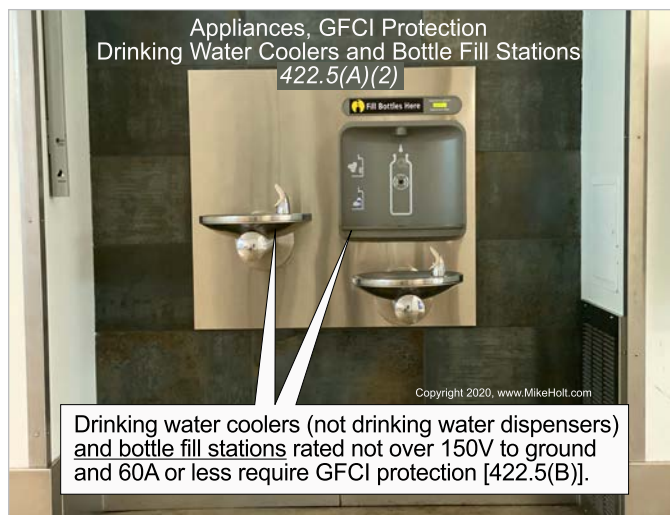
(3) Cord-and-plug-connected high-pressure spray washing machines.

(4) Tire inflation machines. ▶Figure 422-4

(5) Vending machines. ▶Figure 422-5

(6) Sump pumps. ▶Figure 422-6

(7) Dishwashers. ▶Figure 422-7



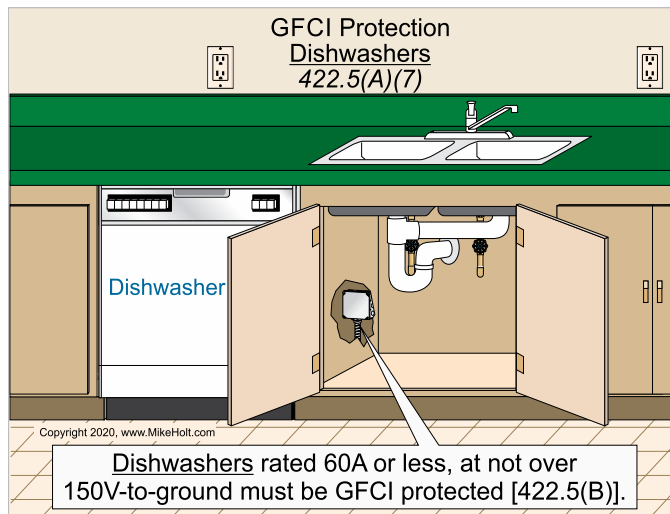
▶Figure 422-3



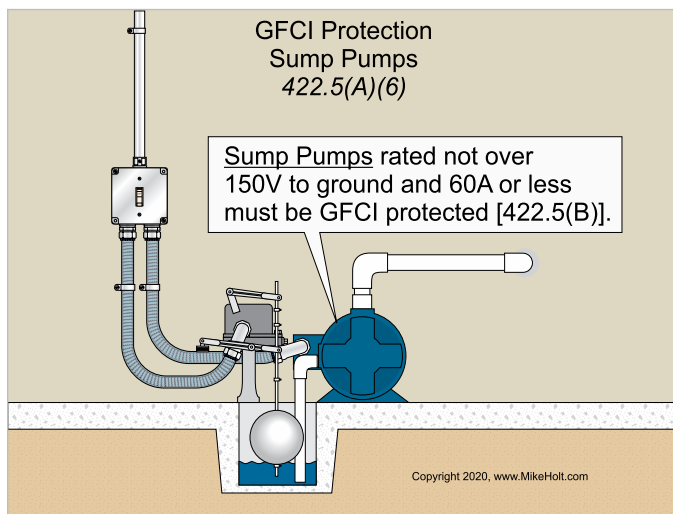
▶Figure 422-4



► Figure 422-5



► Figure 422-7



► Figure 422-6

Note: Section 210.8 specifies requirements for GFCI protection for the receptacle outlets where the location warrants such protection.

(B) Type and Location. The GFCI must be readily accessible and be:

- (1) A GFCI circuit breaker,
- (2) A GFCI device or receptacle,
- (3) A GFCI integral with the attachment plug,
- (4) A GFCI within the supply cord not more than 12 in. from the attachment plug, or
- (5) A factory installed GFCI within the appliance.

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