

# EC&M



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## All you Wanted to know about AFCIs and GFCIs

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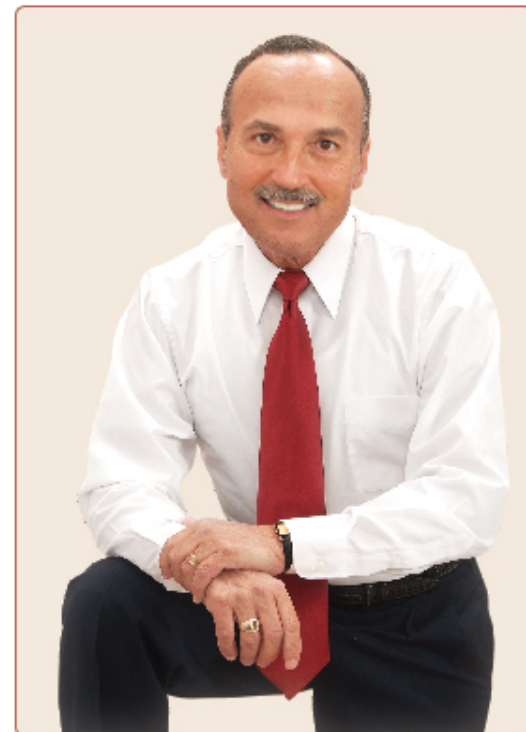
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# *Dedication*

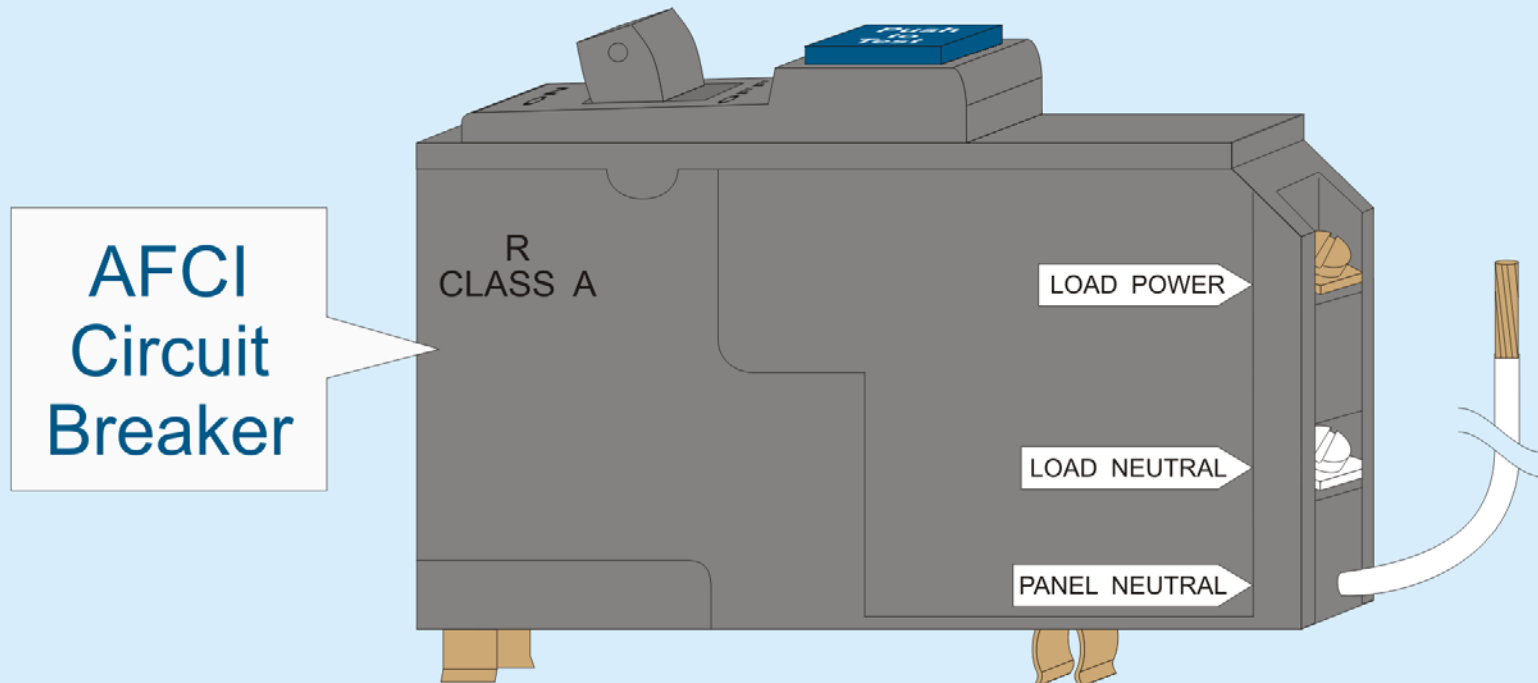
I would like to take this moment to thank God for giving me the opportunity and skill to help others.

# *Article 100 Definitions*

Article 100 contains the definitions of terms used in two or more articles.

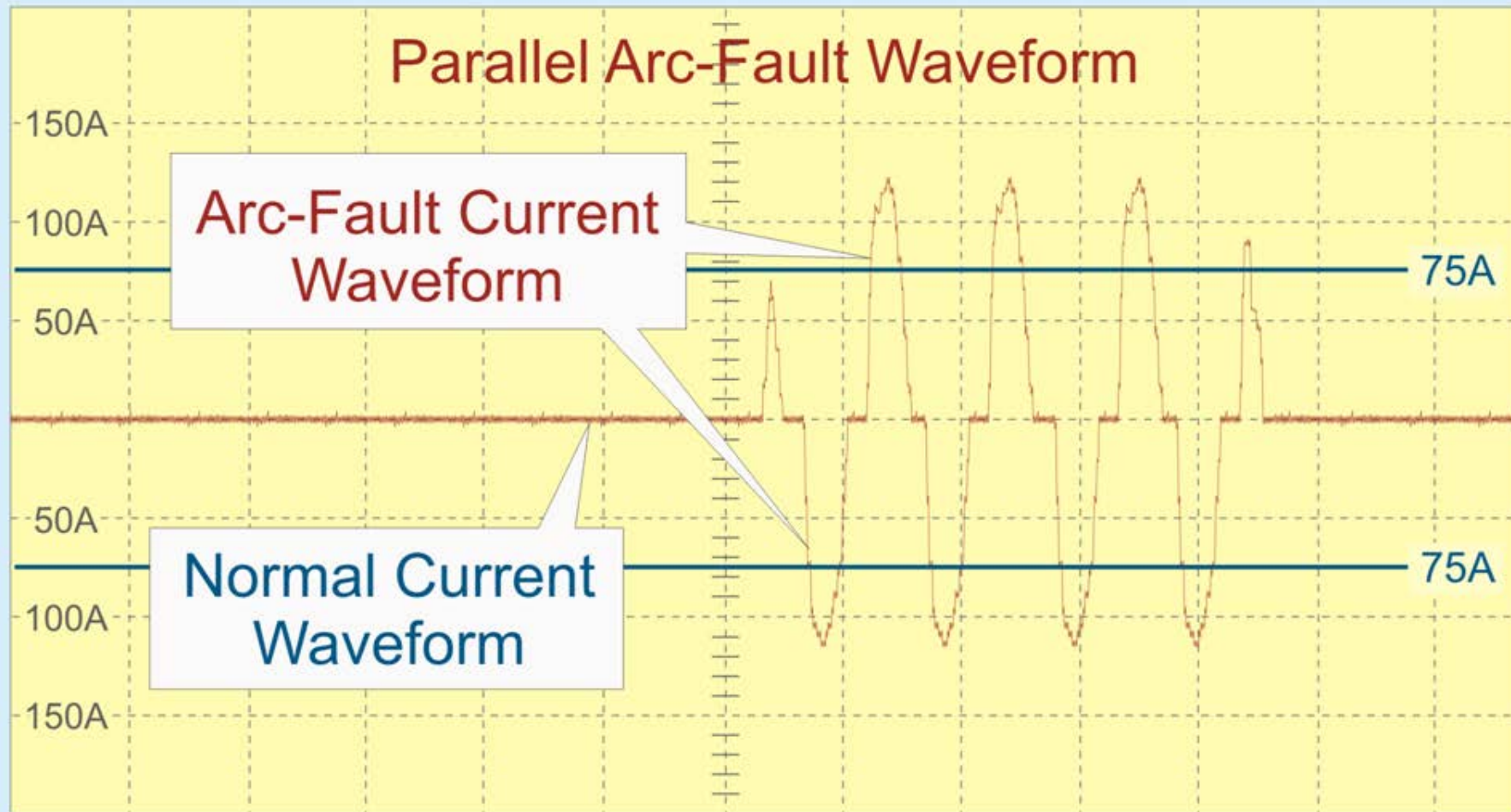
# Arc-Fault Circuit Interrupter (AFCI)

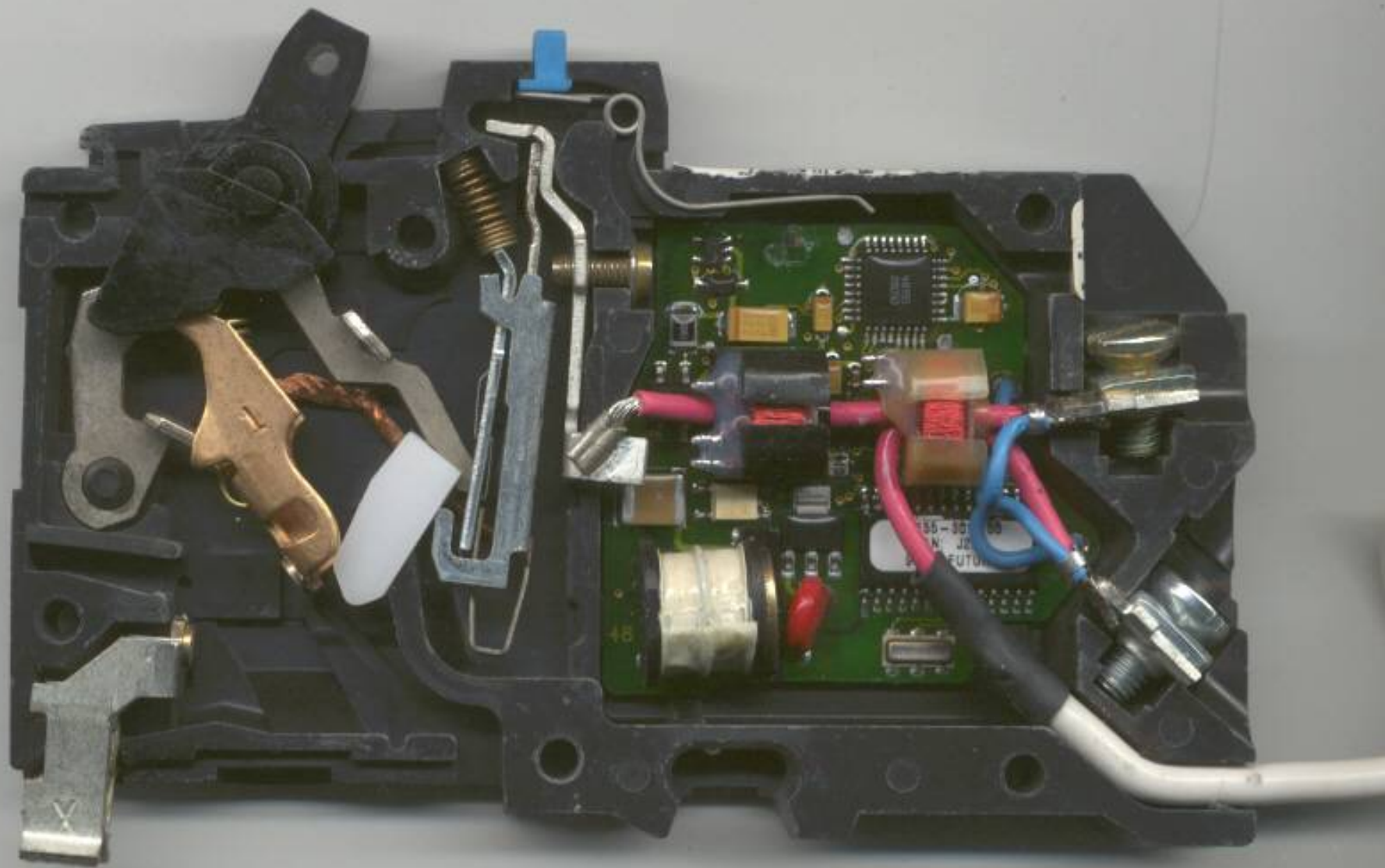
## Article 100 Definition



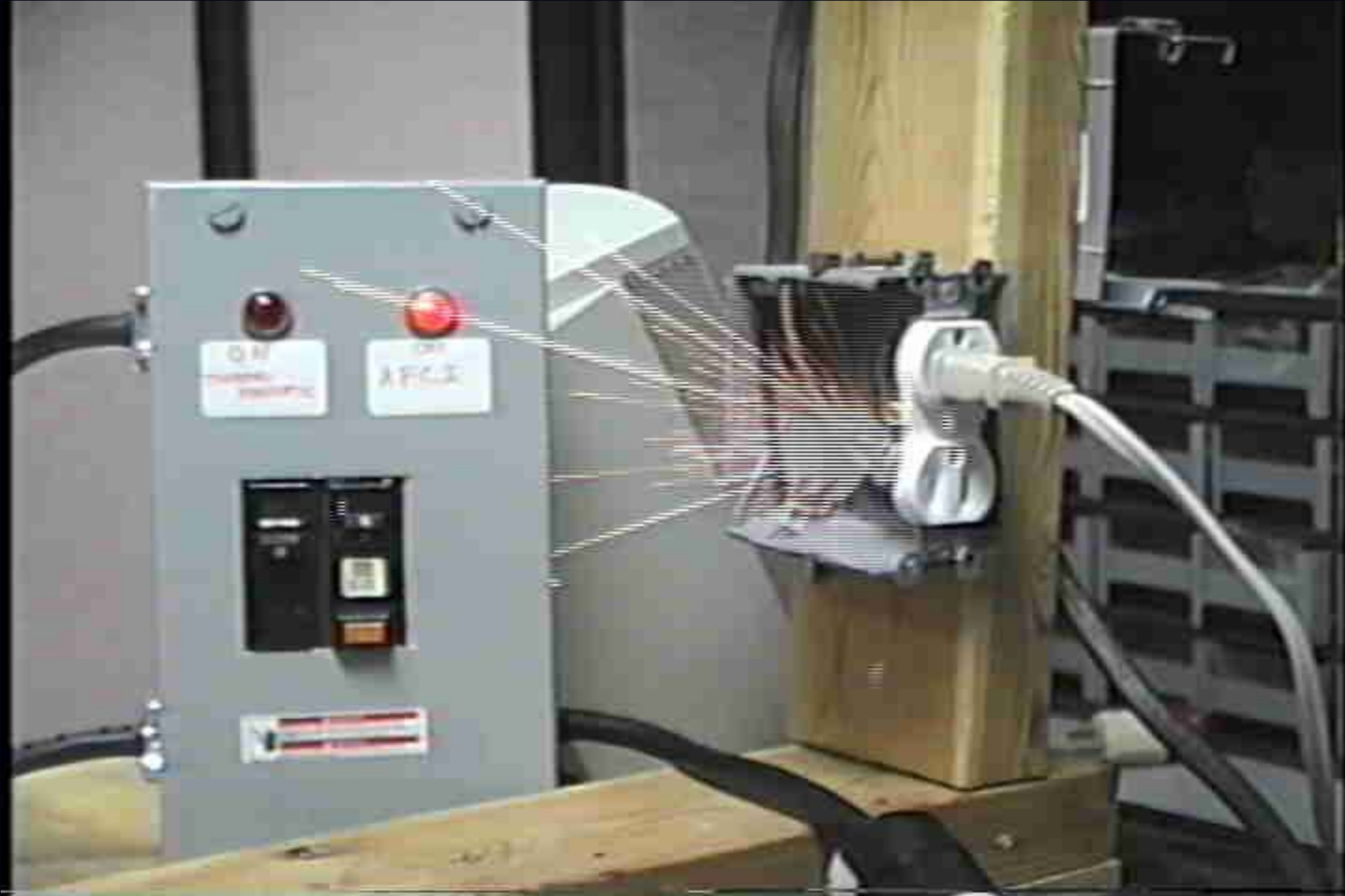
A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.

# Arc-Fault Circuit Interrupter (AFCI) Article 100 Definition









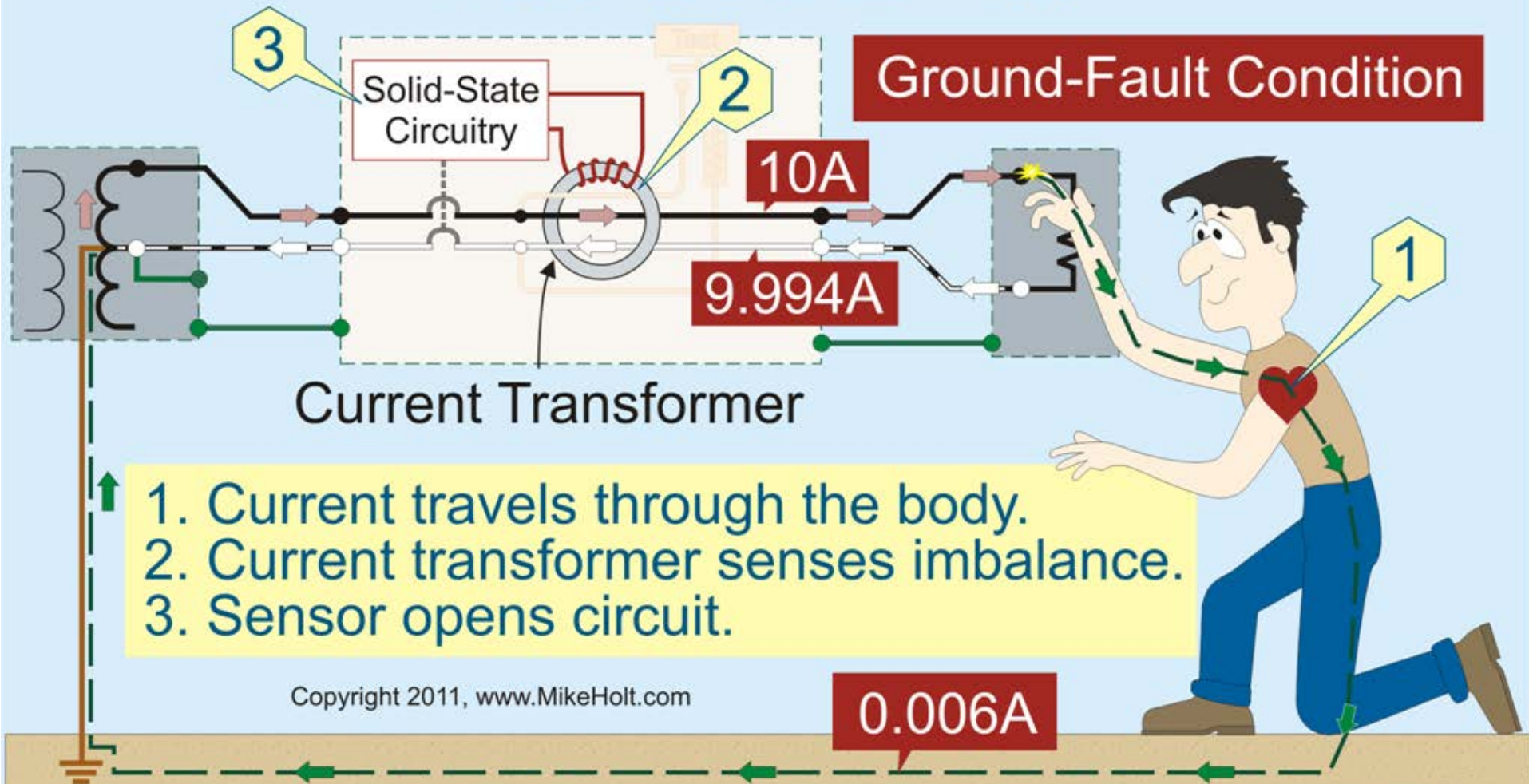


# *Ground-Fault Circuit Interrupter (GFCI)*

A device intended to protect people by de-energizing a circuit when the current to ground exceeds the value established for a "Class A" device.

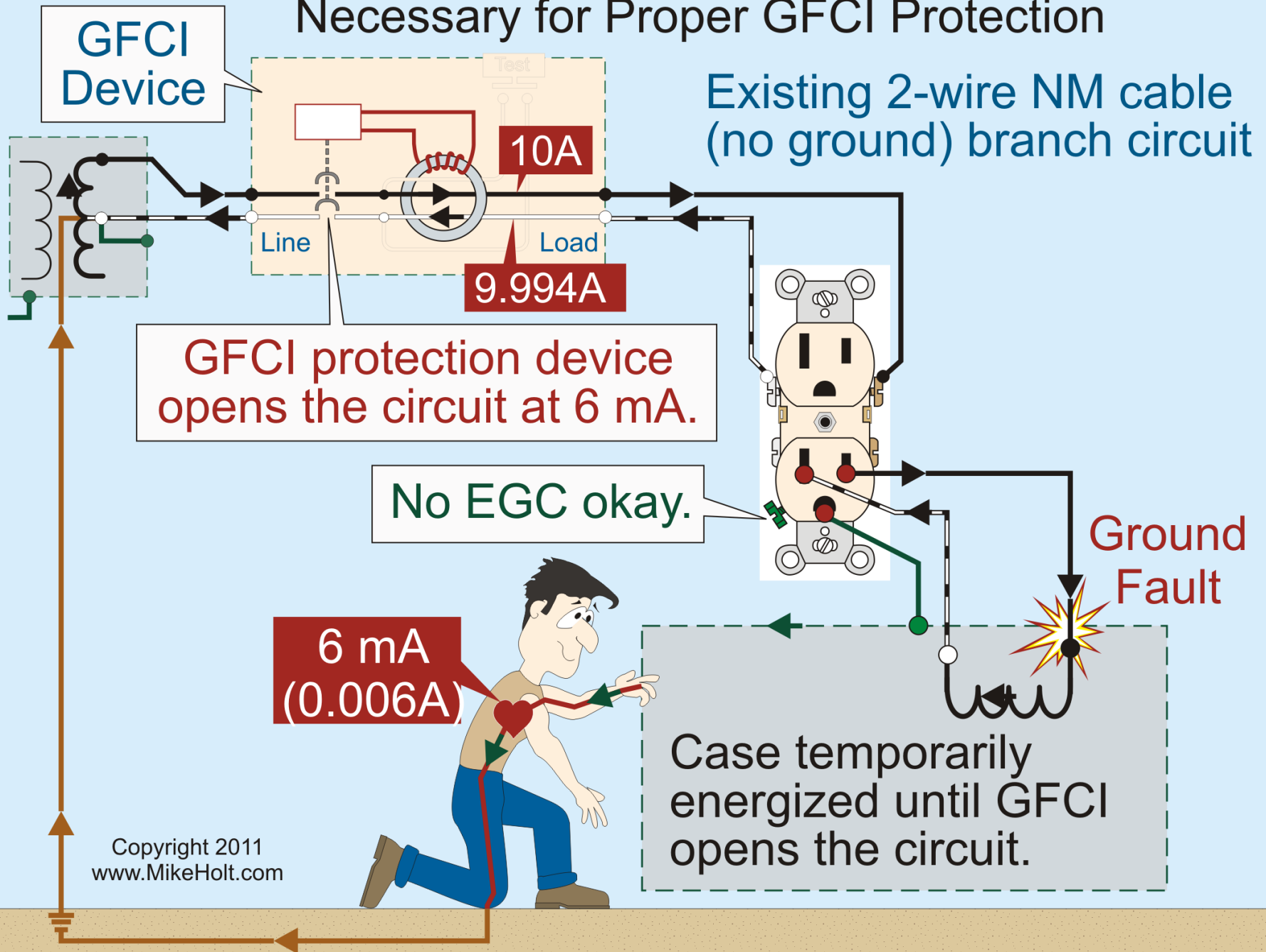
# Ground-Fault Circuit Interrupter (GFCI)

## Article 100 Definition Note

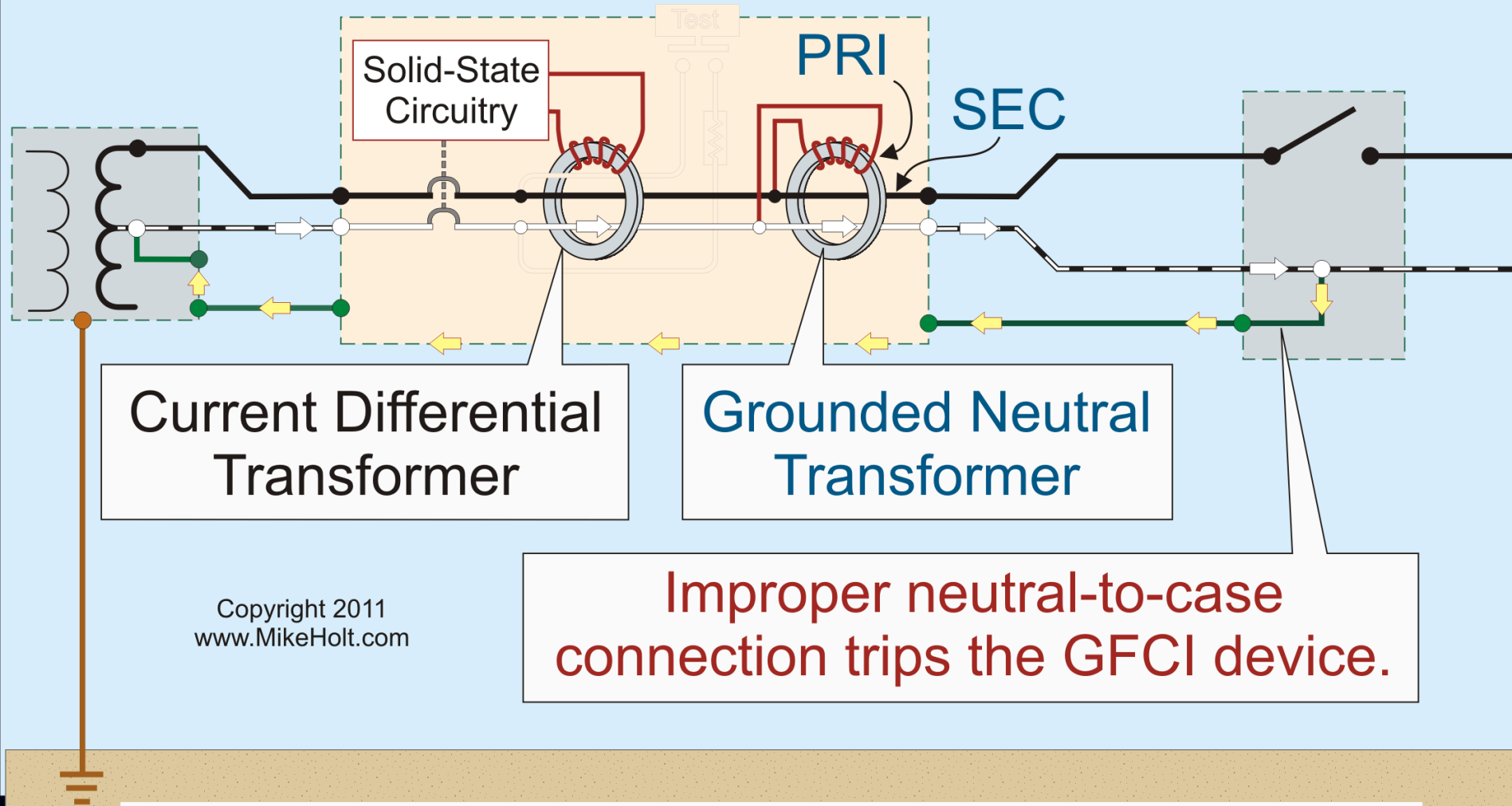


A "Class A" GFCI opens the circuit when the current to ground has a value of 6 mA or higher and doesn't trip when the current to ground is less than 4 mA.

# Equipment Grounding Conductor Not Necessary for Proper GFCI Protection

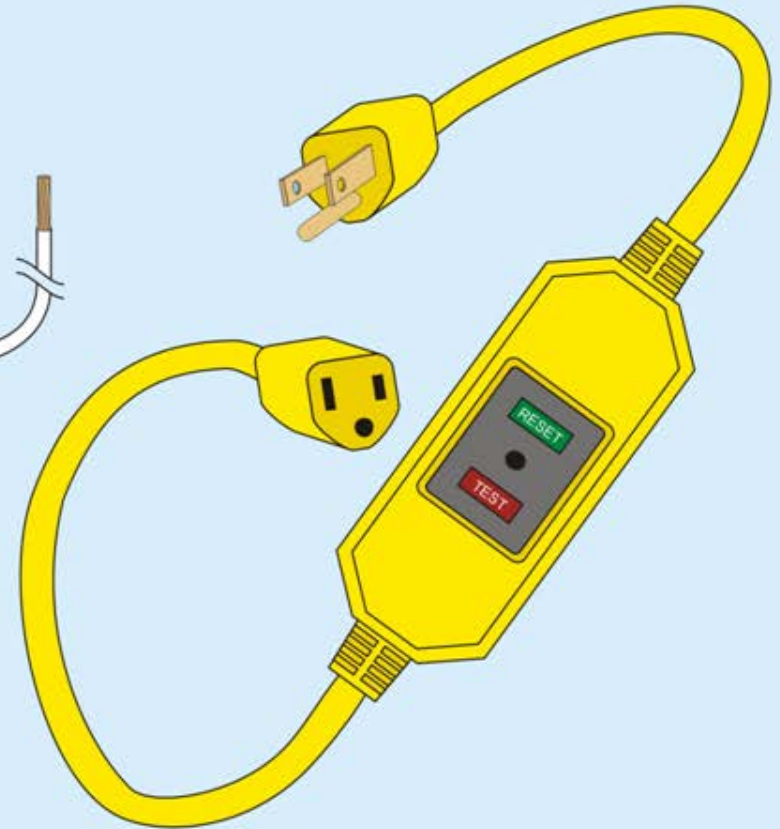
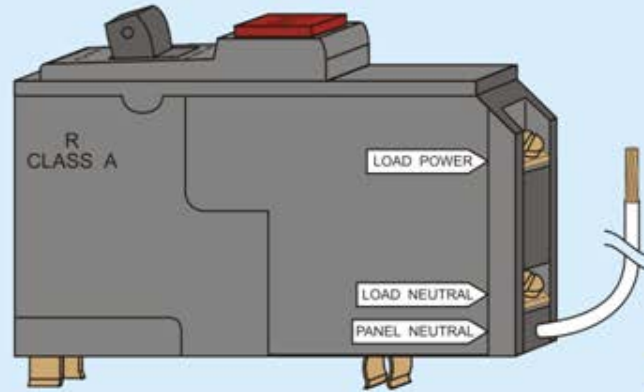


# Ground-Fault Circuit Interrupter (GFCI) Neutral-to-Case Detetection



The grounded neutral transformer continuously monitors for load side neutral-to-case connections.

# GFCI Protection Devices



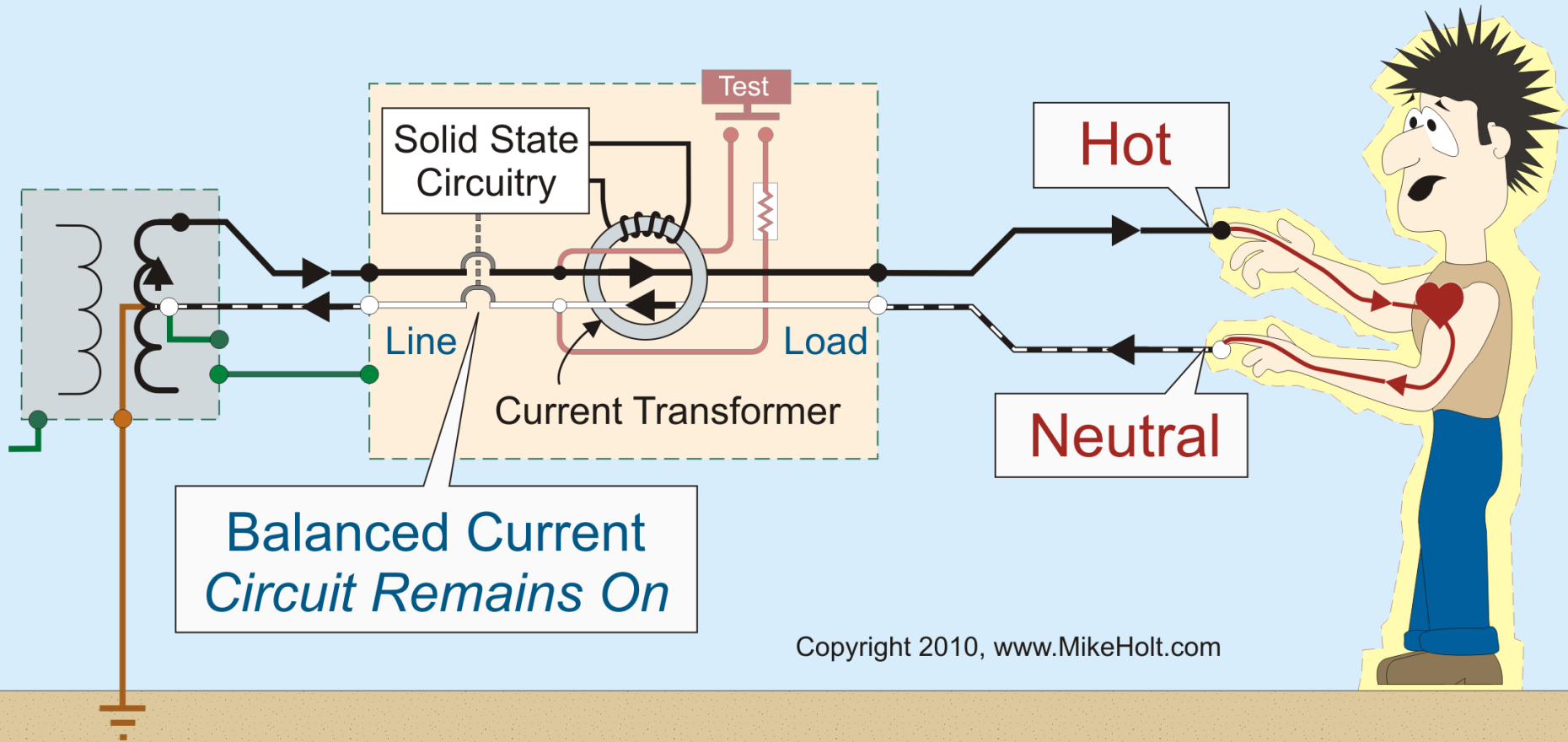
A GFCI is designed to protect persons against electric shock. It operates on the principle of monitoring the unbalanced current between the ungrounded and neutral conductors.

# *Ground-Fault Circuit Interrupter*

DANGER

GFCI protection does not protect against  
line-to-neutral shocks.

# WARNING: GFCI Does Not Protect Against Line-to-Neutral Contact



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Severe shock or death can occur if a person touches a line and neutral wire at the same time, even if GFCI protected!

# *Ground-Fault Circuit Interrupter*

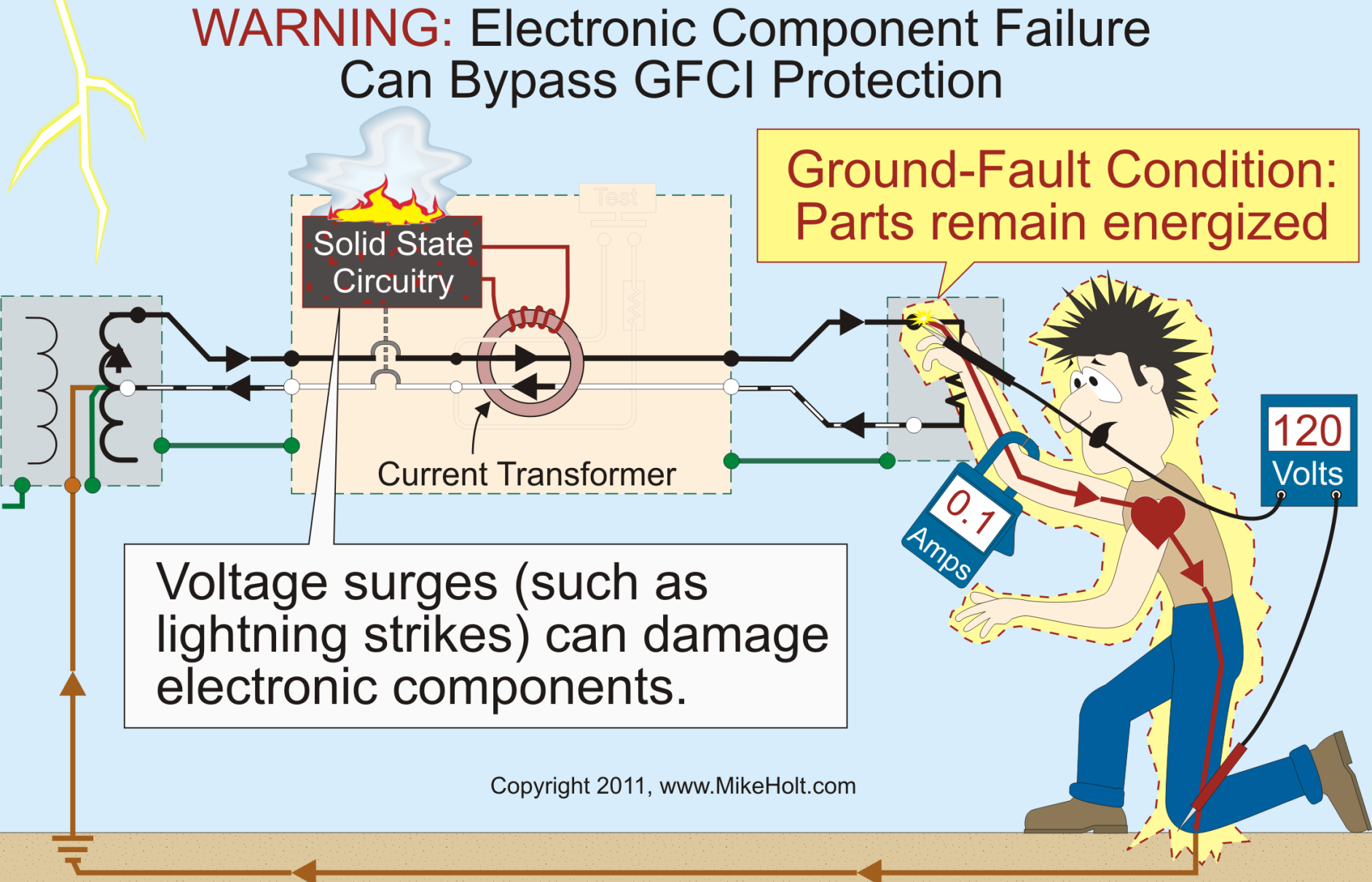
## DANGER

The failure rate of GFCI overcurrent devices averages 12%, with outdoor locations as high as 20% and, in some high-lightning areas, over 50%.



# WARNING: Electronic Component Failure Can Bypass GFCI Protection

Ground-Fault Condition: Parts remain energized

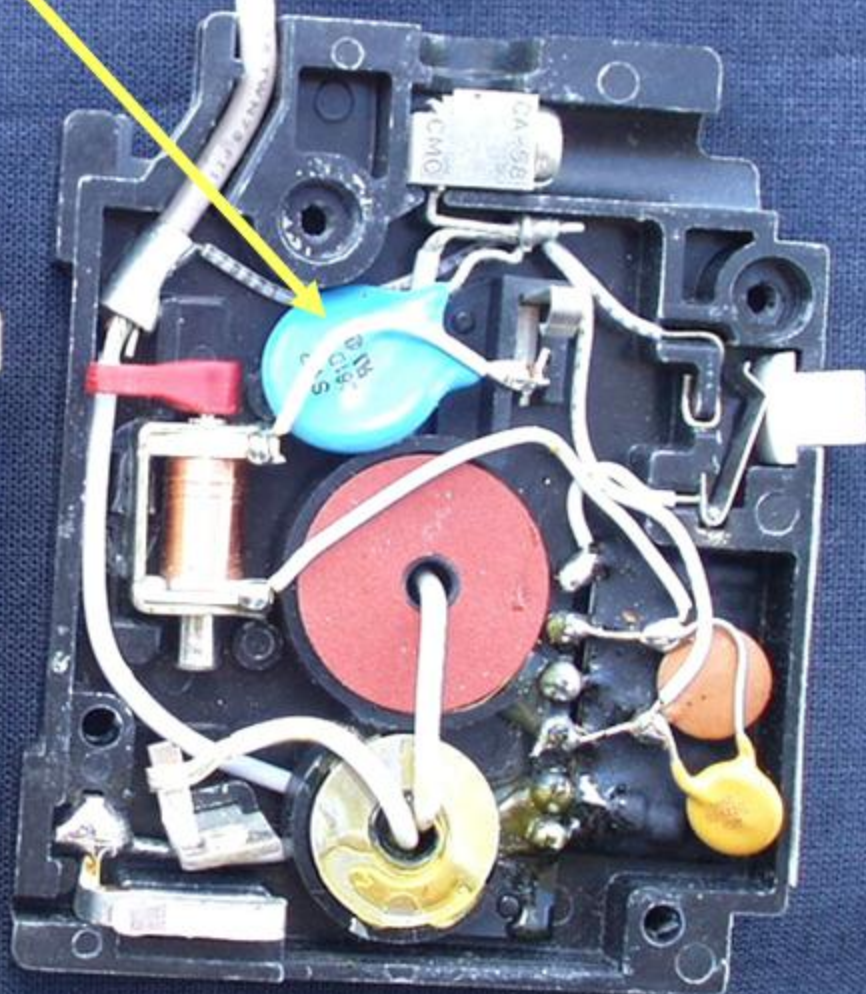


Voltage surges (such as lightning strikes) can damage electronic components.

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Typically, when the GFCI protection fails, the device will continue to provide power without GFCI protection.

MOV

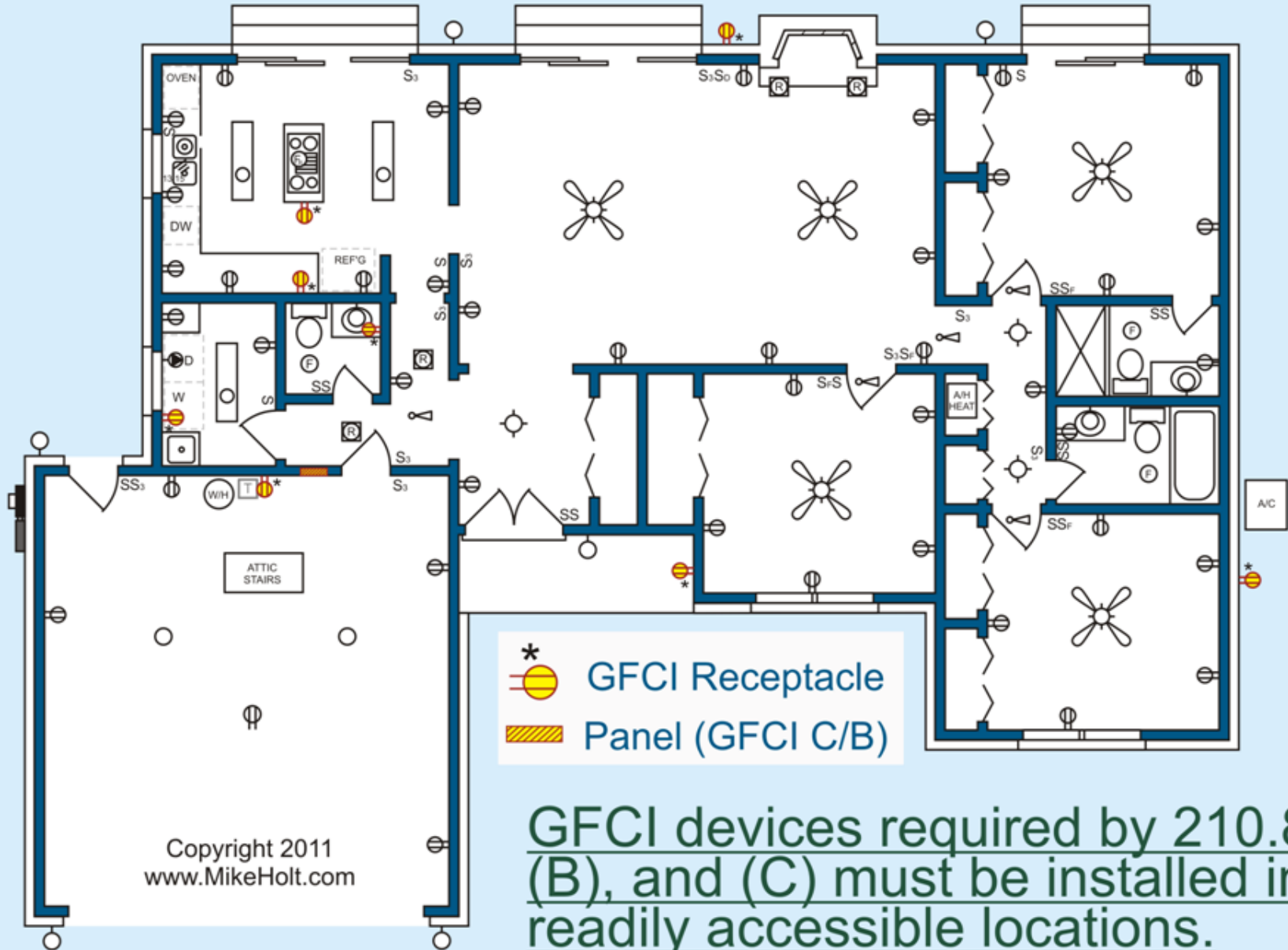


# *210.8 GFCI Protection*

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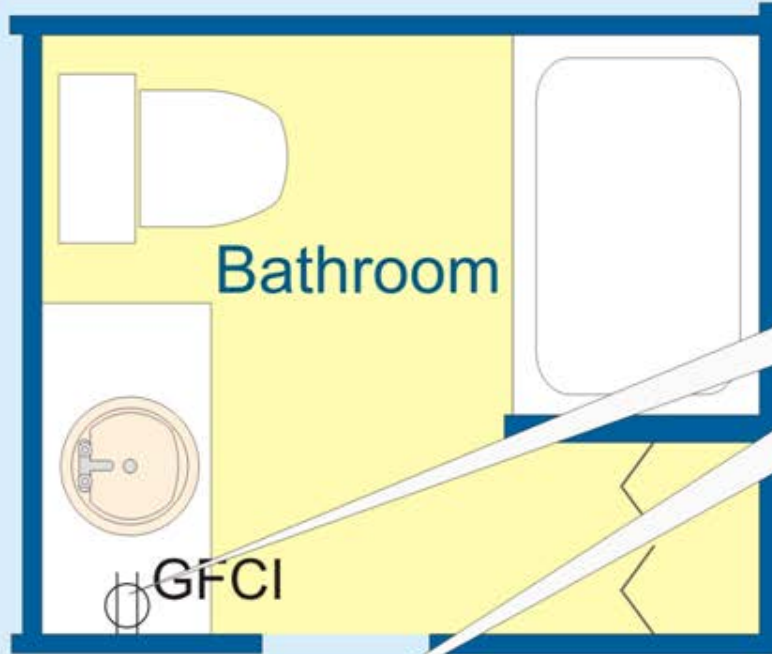
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# GFCI Protection 210.8



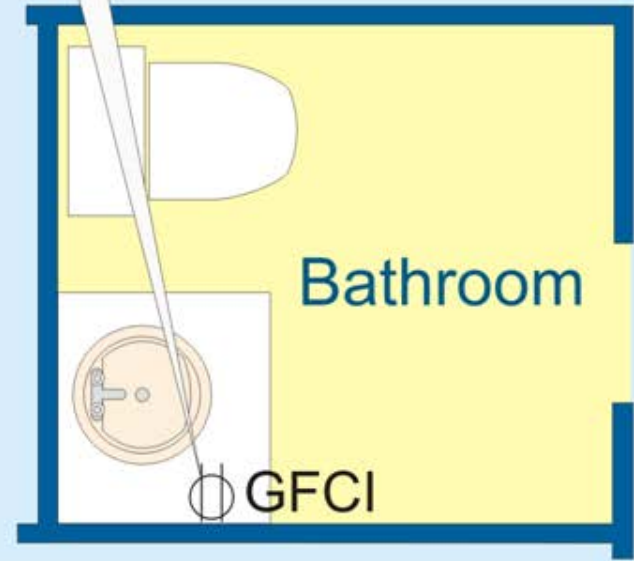
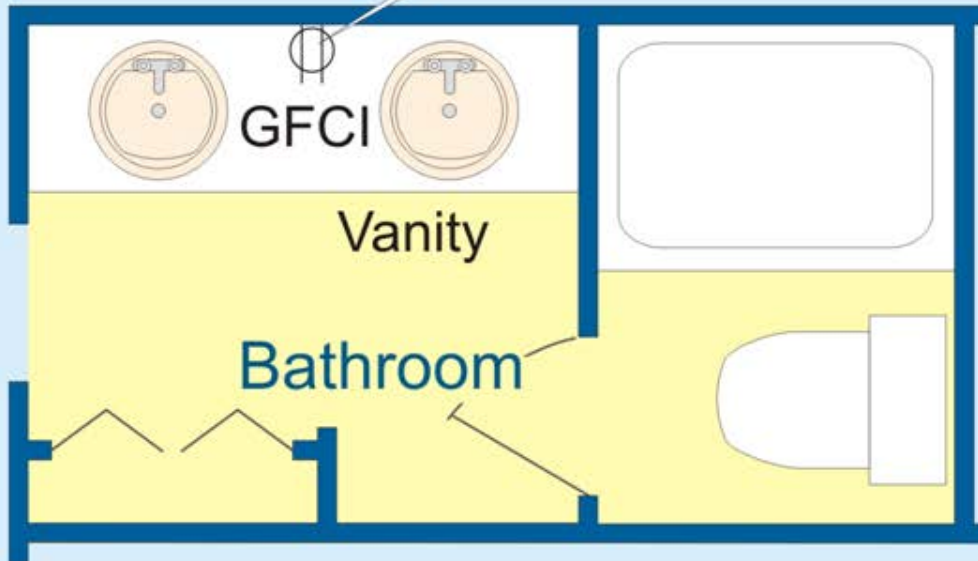
GFCI devices required by 210.8(A), (B), and (C) must be installed in readily accessible locations.

# GFCI Protection - Dwelling Bathroom Receptacles 210.8(A)(1)

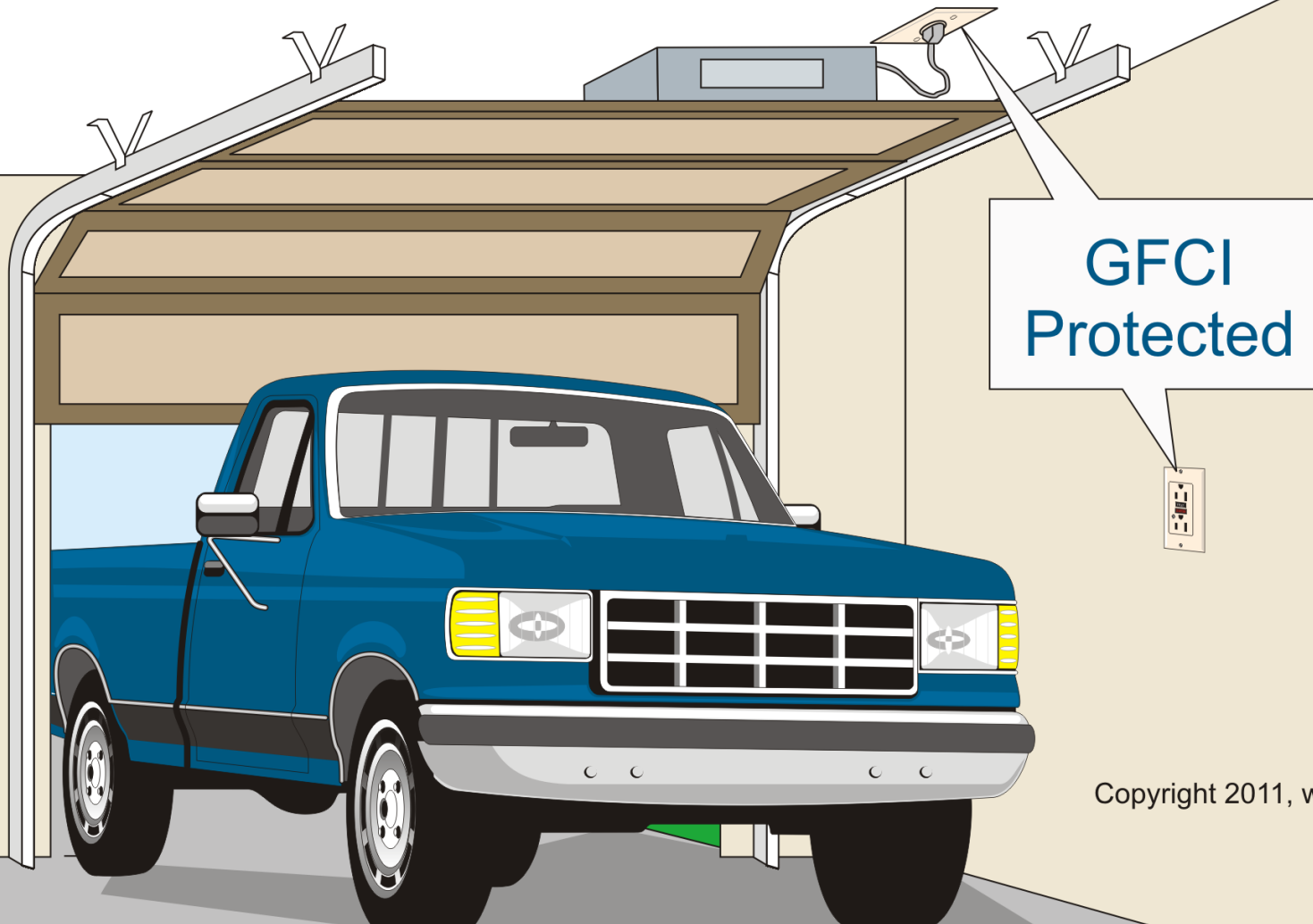


All 15A and 20A, 125V receptacles installed in bathrooms must be GFCI protected.

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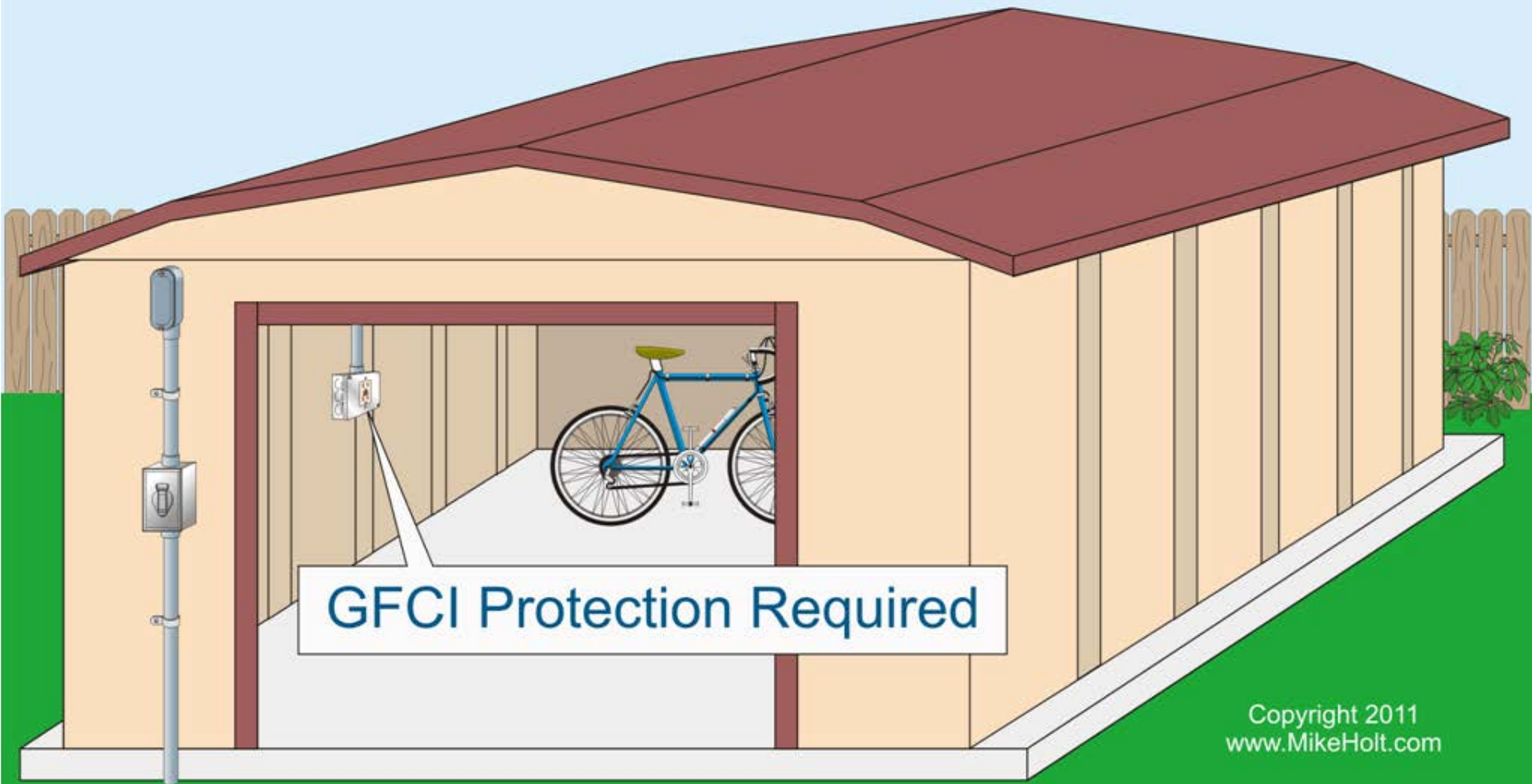
# GFCI Protection - Dwelling Garage Receptacles 210.8(A)(2)



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All 15A and 20A, 125V receptacles installed in a dwelling unit garage must have GFCI protection.

# GFCI Protection - Dwelling Accessory Building Receptacles 210.8(A)(2)



**GFCI Protection Required**

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All 15A and 20A, 125V receptacles in accessory buildings and similar work areas must be GFCI protected.

# GFCI Protection Outdoor Dwelling Receptacles 210.8(A)(3)

A diagram of a single-story house with a beige exterior. On the left is a four-panel door with a silver handle. To the right of the door is a window with a black outdoor light fixture mounted on the wall. Further right is another window. Below the second window, an outdoor electrical receptacle is mounted on the wall. A white callout box with a blue border points to the receptacle. The house has a grey concrete porch. In the background, there is a wooden fence and a green lawn with a small green shrub.

**GFCI  
Protection  
Required**

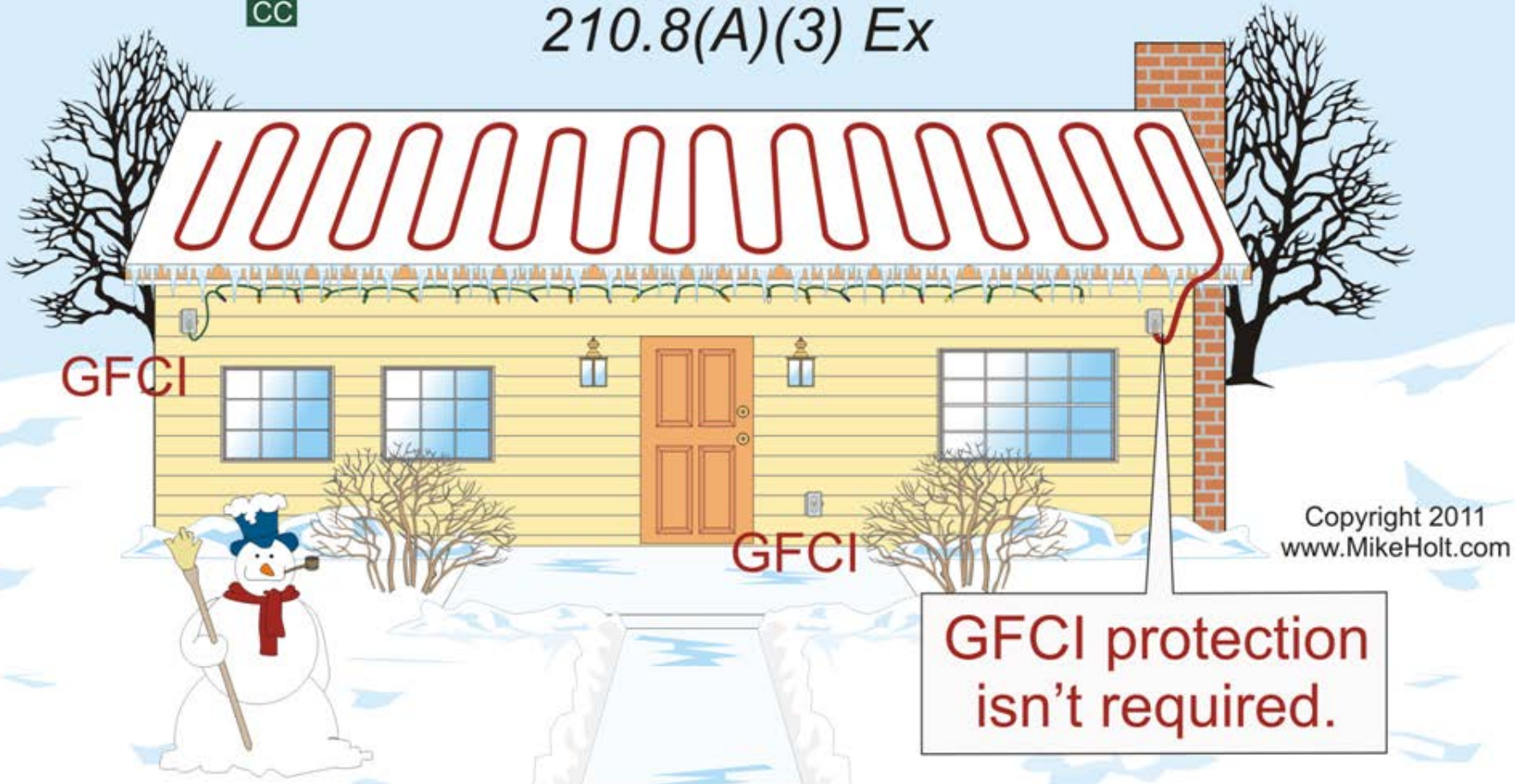
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All 15A and 20A, 125V receptacles installed outside of a dwelling unit require GFCI protection.



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# Outdoor Receptacles - Dwelling 210.8(A)(3) Ex

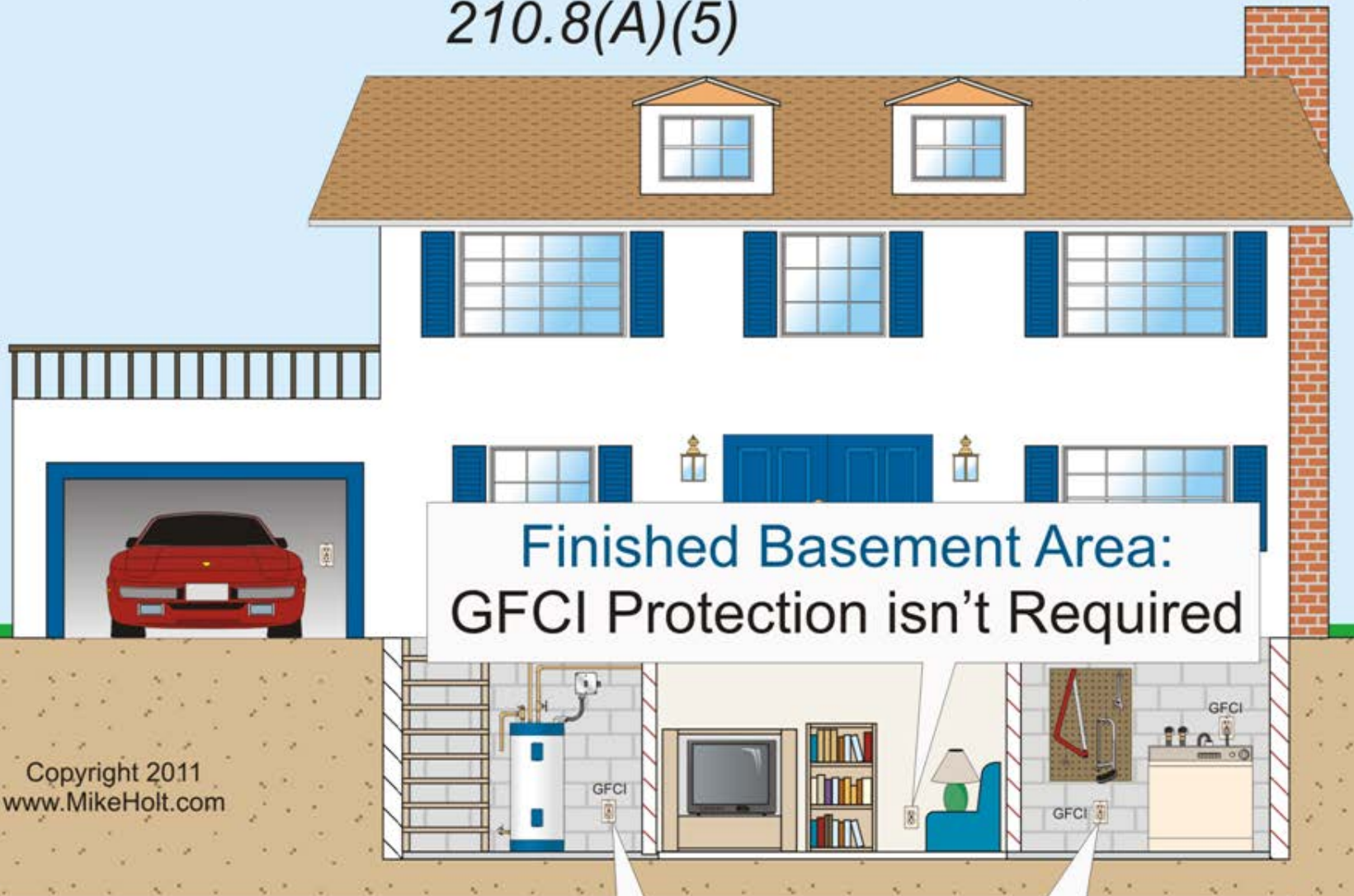


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GFCI protection  
isn't required.

GFCI protection isn't required for a receptacle supplied by a branch circuit dedicated to fixed electric snow-melting or deicing or pipeline and vessel heating equipment, if the receptacle isn't readily accessible and the equipment or receptacle has GFPE [426.28, 427.22].

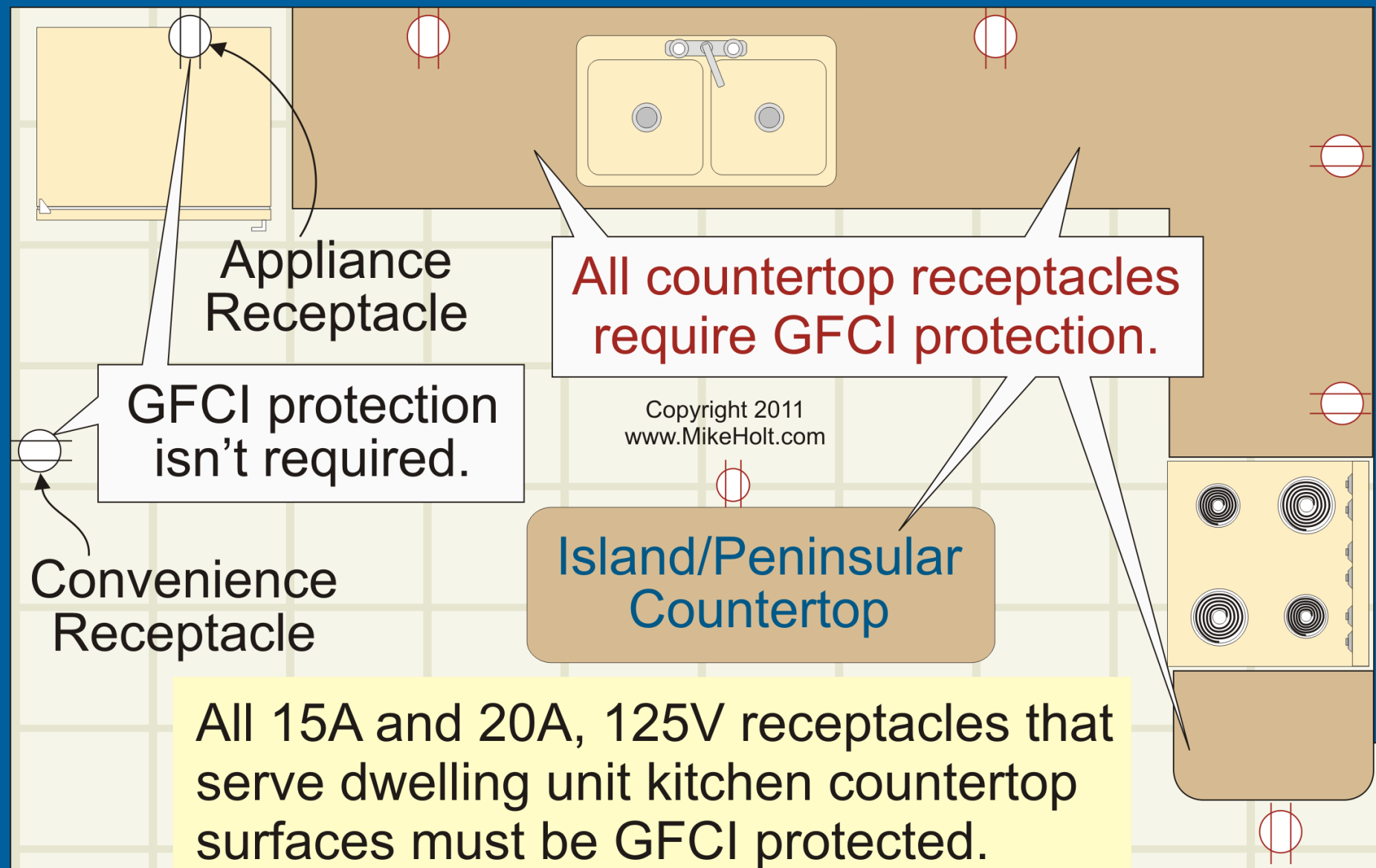
# GFCI Protection - Dwelling Basement Receptacle 210.8(A)(5)



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All 15A and 20A, 125V receptacles in unfinished areas of basements must be GFCI protected.

# GFCI Protection - Kitchen Receptacles - Dwelling 210.8(A)(6)



Appliance Receptacle

GFCI protection isn't required.

Convenience Receptacle

All countertop receptacles require GFCI protection.

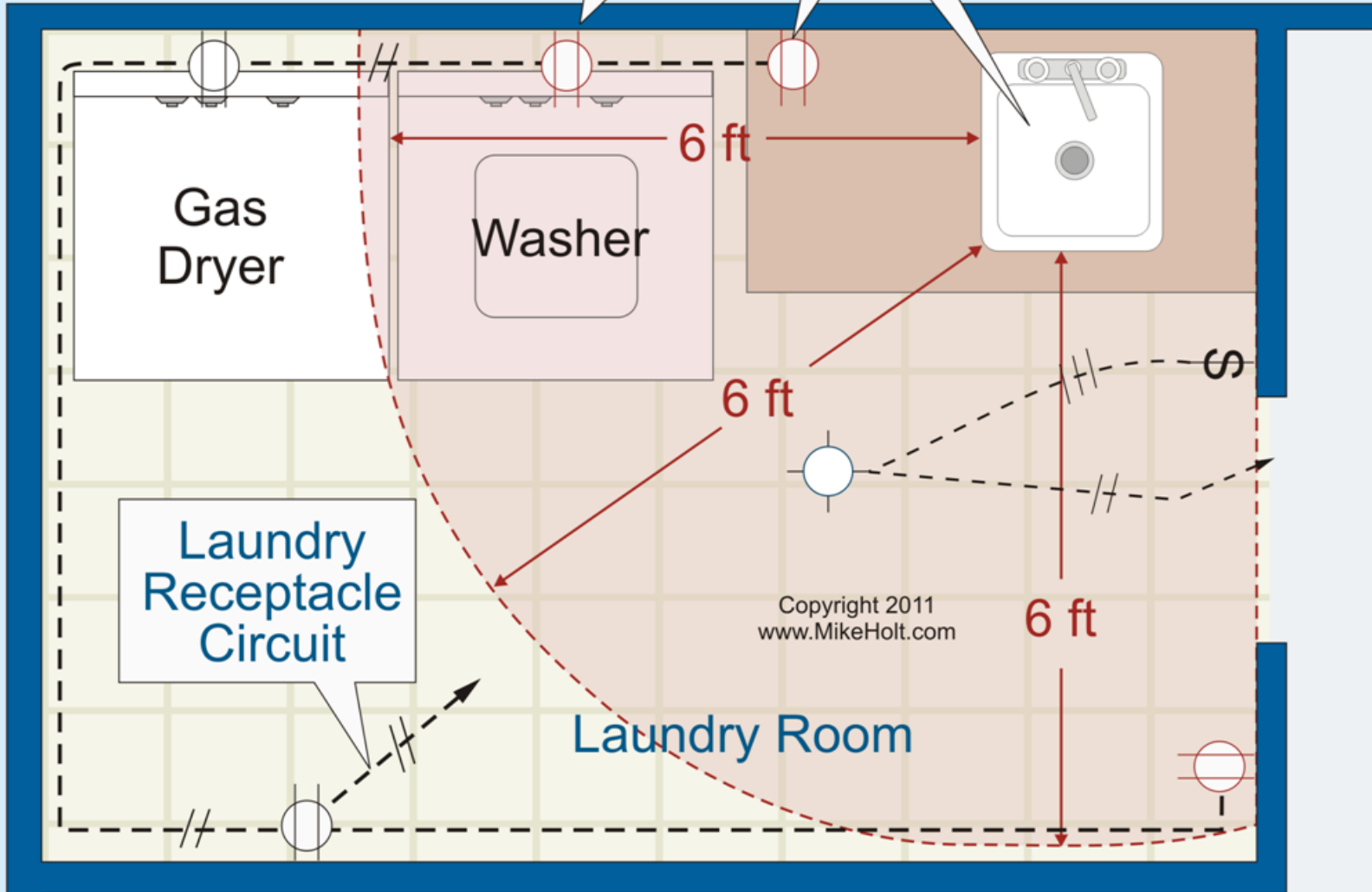
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Island/Peninsular Countertop

All 15A and 20A, 125V receptacles that serve dwelling unit kitchen countertop surfaces must be GFCI protected.

# GFCI Protection - Dwelling Sinks in Other Than Kitchen 210.8(A)(7)

All 15A and 20A, 125V receptacles located within 6 ft of a sink must be GFCI protected.



# GFCI Protection - Boathouse Receptacles 210.8(A)(8)



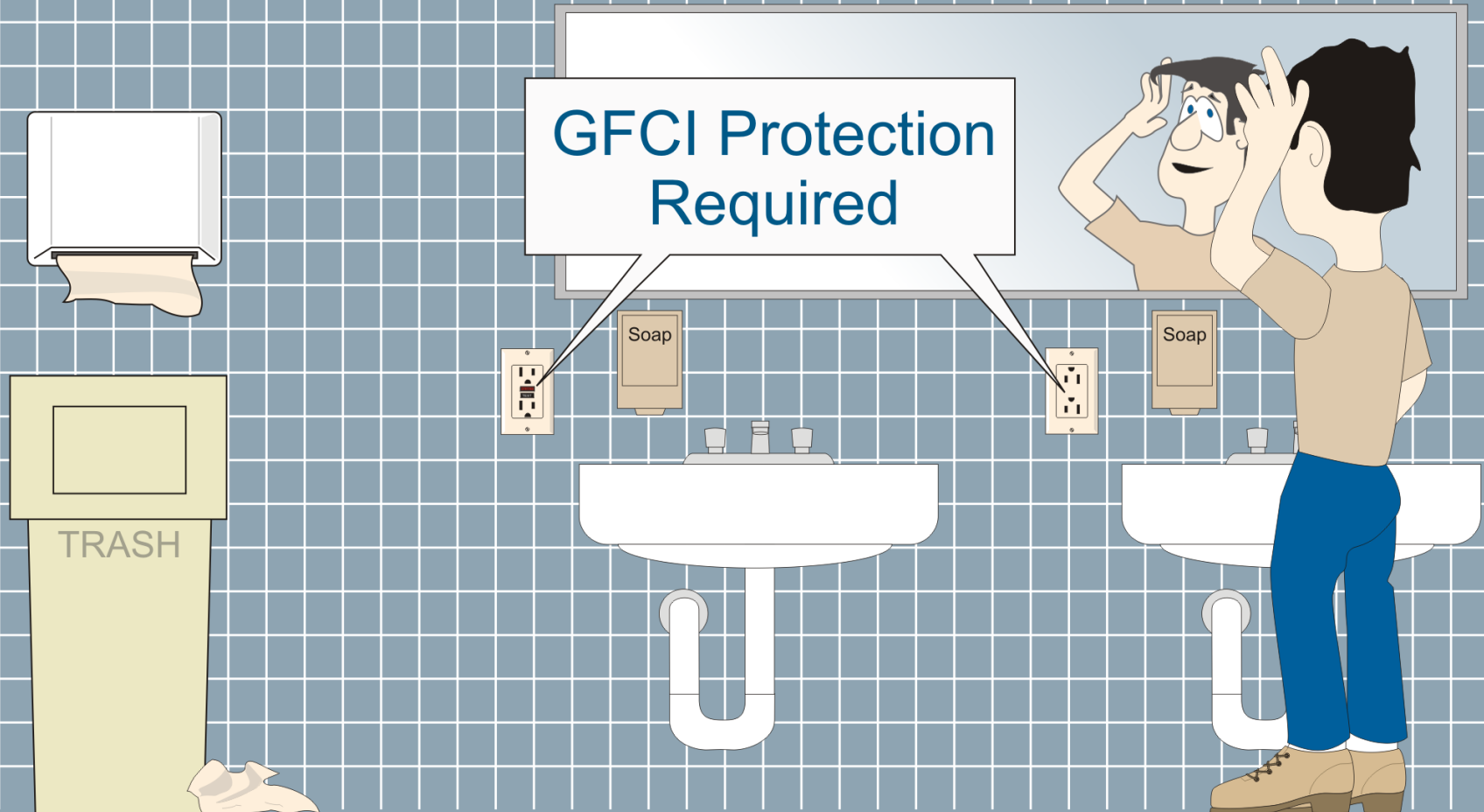
All 15A and 20A, 125V receptacles in boathouses must be GFCI protected.

# *210.8 GFCI Protection*

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(B) Other than Dwelling Units.

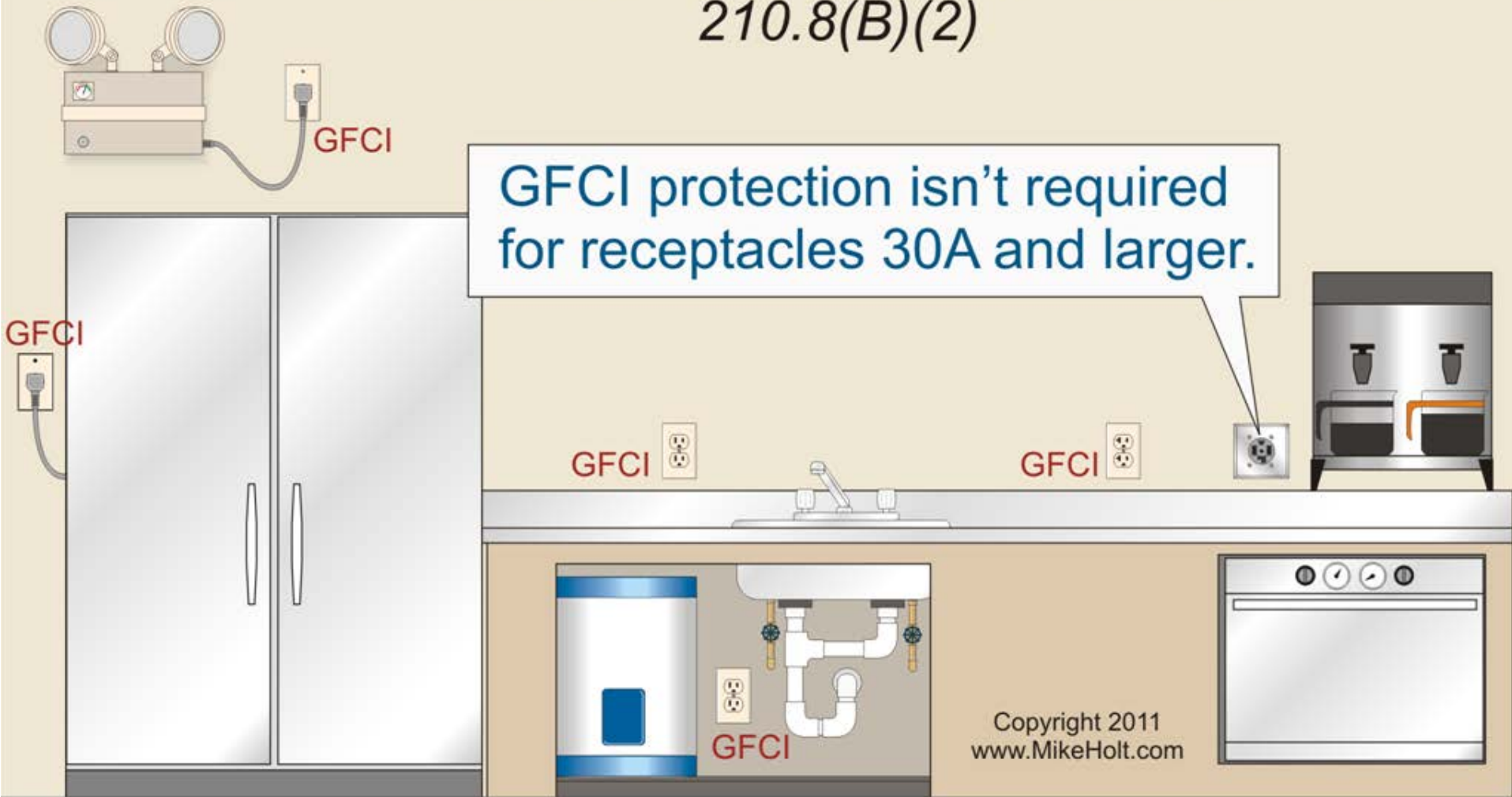
# Bathroom Receptacles - Other Than Dwelling Units 210.8(B)(1)



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All 15A and 20A, 125V receptacles in  
bathrooms must be GFCI protected.

# GFCI-Protected Receptacles Other than Dwelling Unit Kitchens 210.8(B)(2)

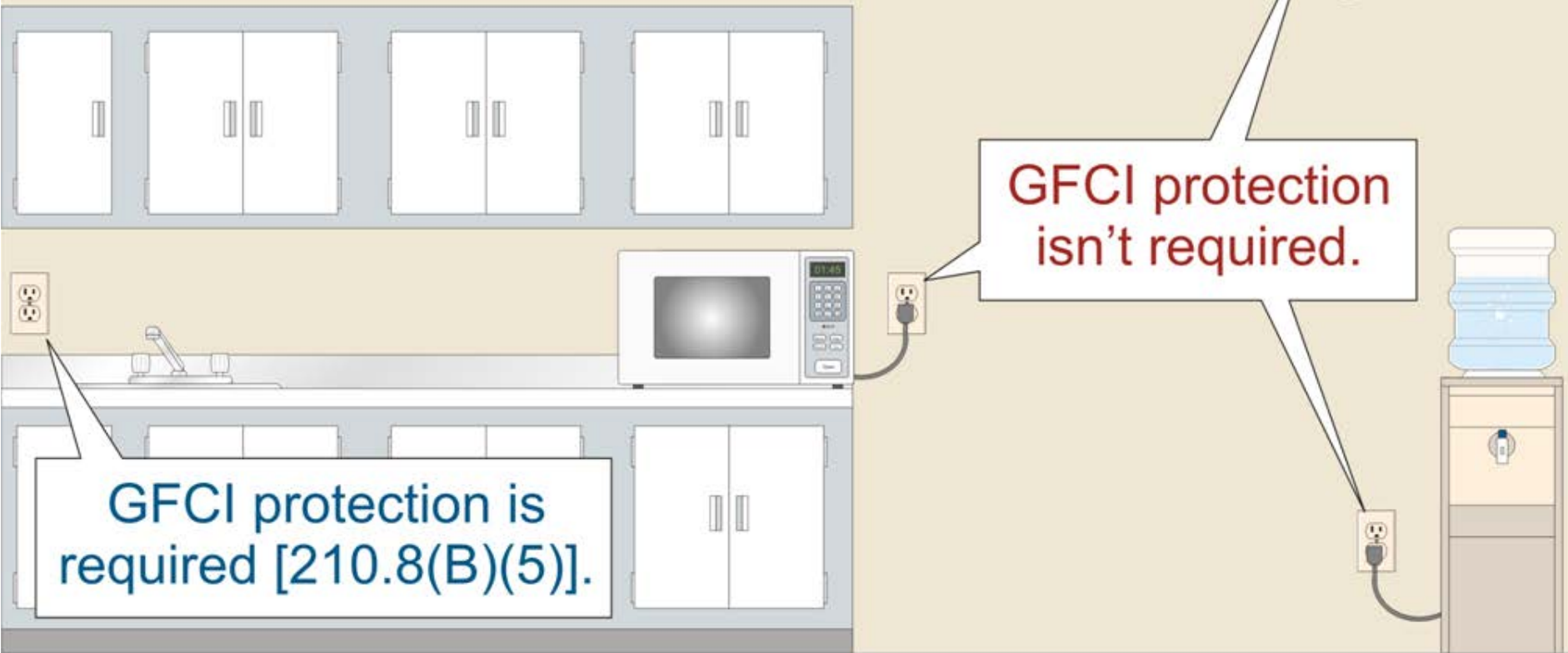


All 15A and 20A, 125V receptacles located in a kitchen must be GFCI protected.





# GFCI-Protected Receptacles Other than Dwelling Unit Kitchens *210.8(B)(2)*



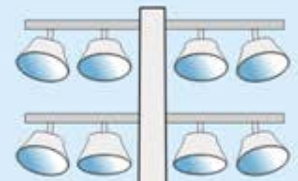
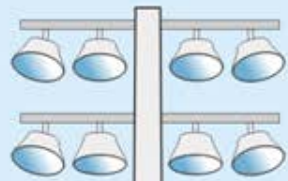
An area such as an employee break room with a sink and cord-and-plug connected cooking appliance such as a microwave oven isn't considered a kitchen.

# GFCI-Protected Receptacles Other Than Dwelling Unit Rooftops 210.8(B)(3)



All 15A and 20A, 125V receptacles installed on rooftops must be GFCI protected.

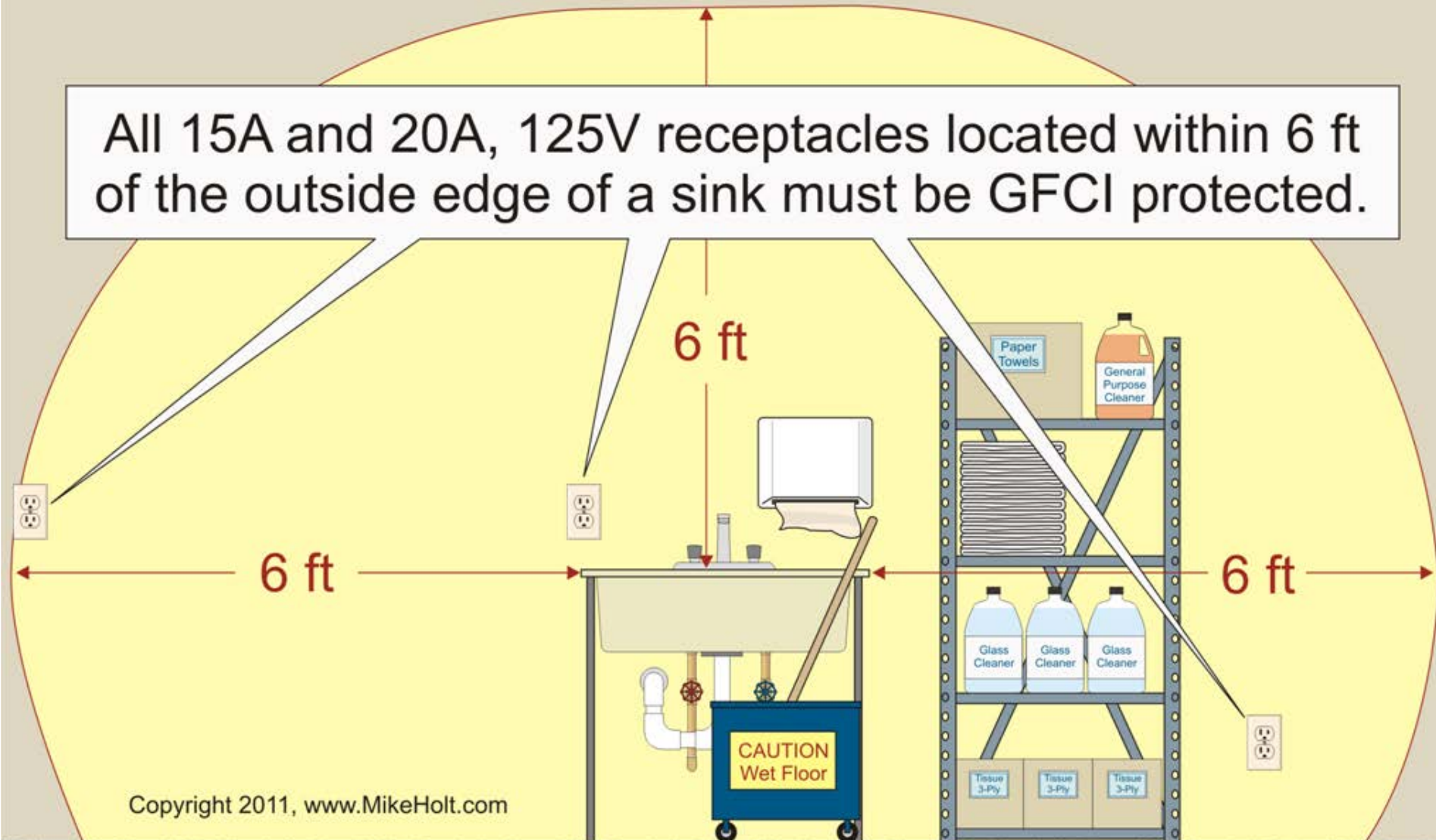
GFCI-Protected Receptacles  
Located Outdoors  
Other Than Dwelling Units  
*210.8(B)(4)*



All 15A and 20A, 125V receptacles installed outdoors must be GFCI protected.

# GFCI-Protected Receptacles Nonresidential Sinks 210.8(B)(5)

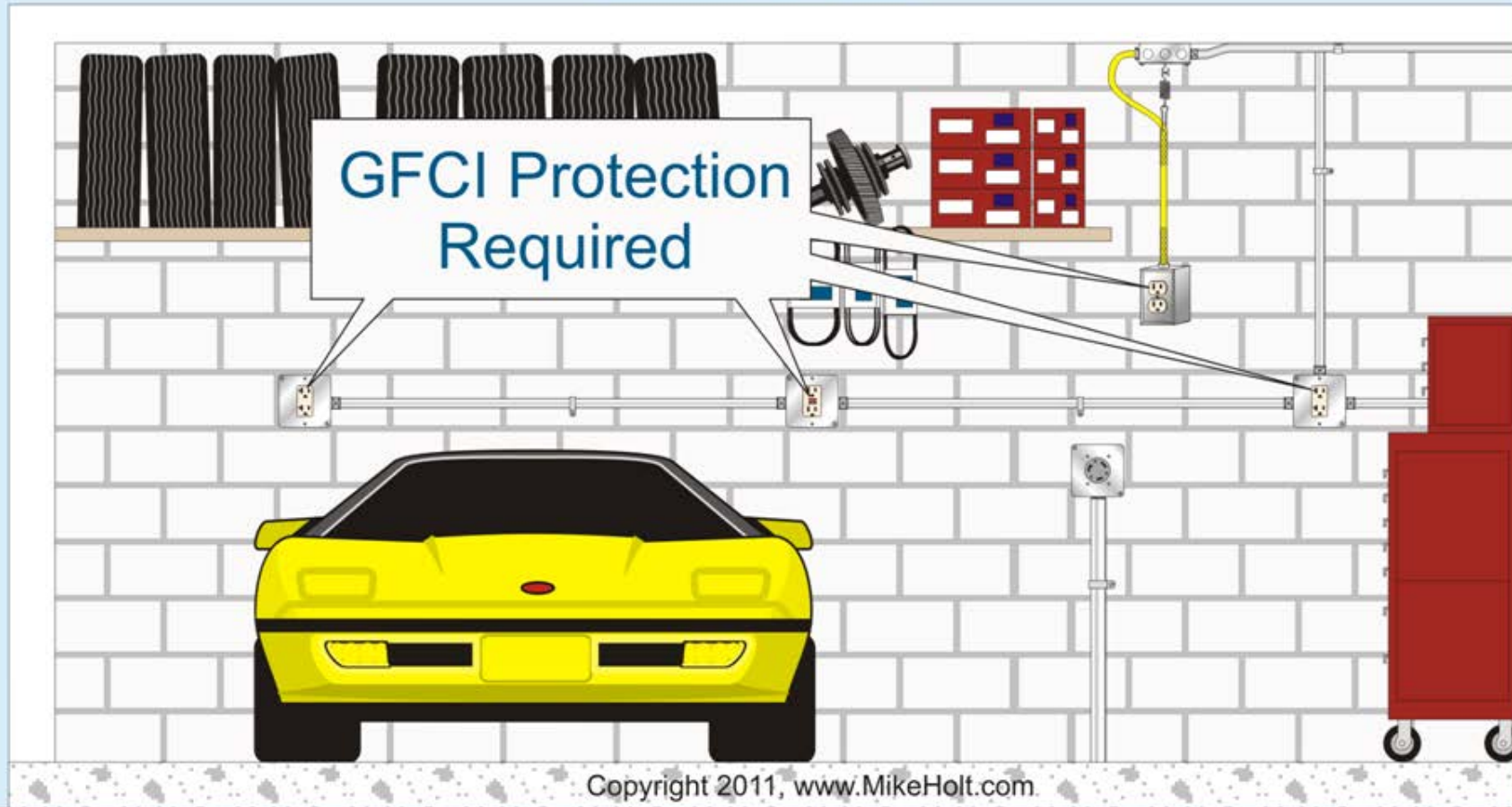
All 15A and 20A, 125V receptacles located within 6 ft of the outside edge of a sink must be GFCI protected.





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# GFCI-Protected Receptacles Garages in Other Than Dwelling Unit 210.8(B)(8)



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15A and 20A, 125V receptacles used in repair or service areas for electrical diagnostic equipment, electric hand tools, or portable lighting must be GFCI protected.

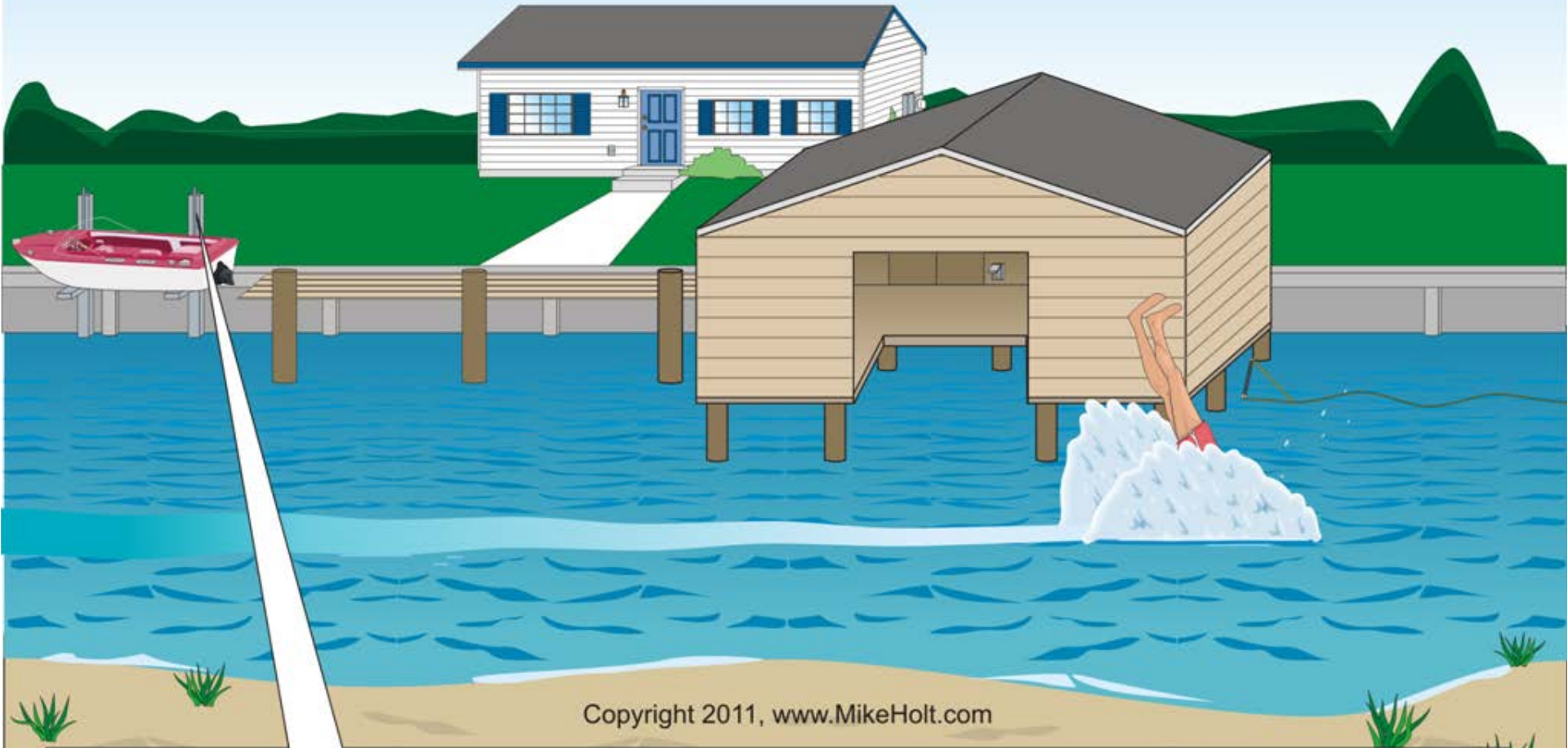
# *210.8 GFCI Protection*

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(C) Boat Hoists.



# GFCI Protection - Boat Hoists 210.8(C)



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GFCI protection is required for outlets not exceeding 240V that supply boat hoists in dwelling unit locations.

# *Chapter 3 and 4*

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## **Chapter 3**

Table 300.5 – Direct Buried Cables

## **Chapter 4**

406.3(D)(3) – Receptacle Replacement

410.44 Ex. 2 – Light Fixtures

422.51 – Vending Machines

# Chapter 5

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511.12 – Commercial Garages

513.12 – Aircraft Hangers

517.17 – Health Care Facilities, also 517.21

518.3 – Assembly Occupancies

525.23 – Carnivals, Circuses, and Fairs

547.5(G) – Agricultural Buildings

550.13(B) – Manufactured Homes

551.41(C) – RV Parks

555.19(B) – Marinas and Boat Yards

590.6 – Temporary Wiring

# Chapter 6

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600.10(C) – Signs

620.85 – Elevators

626.24 – Electrified Truck Parking Space

Article 680 – Pools, Spas, and Hot Tubs

# *210.12 AFCI Protection*

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# AFCI Protection for Dwelling Units - Where Required 210.12(A)

All 15A and 20A, 120V branch circuits supplying outlets in the following locations require AFCI protection:



- Family Rooms
- Dining Rooms
- Living Rooms
- Parlors
- Libraries
- Dens
- Bedrooms
- Sunrooms
- Rec Rooms
- Closets
- Hallways
- Similar Areas

# AFCI Protection - Dwelling Unit Smoke Alarm versus Fire Alarm *210.12(A) Note 3*

CKT  
AFCI-1

Master Bedroom

A single- or multiple station smoke alarm not managed by a fire alarm control panel doesn't qualify as a fire alarm circuit, so AFCI protection is required.

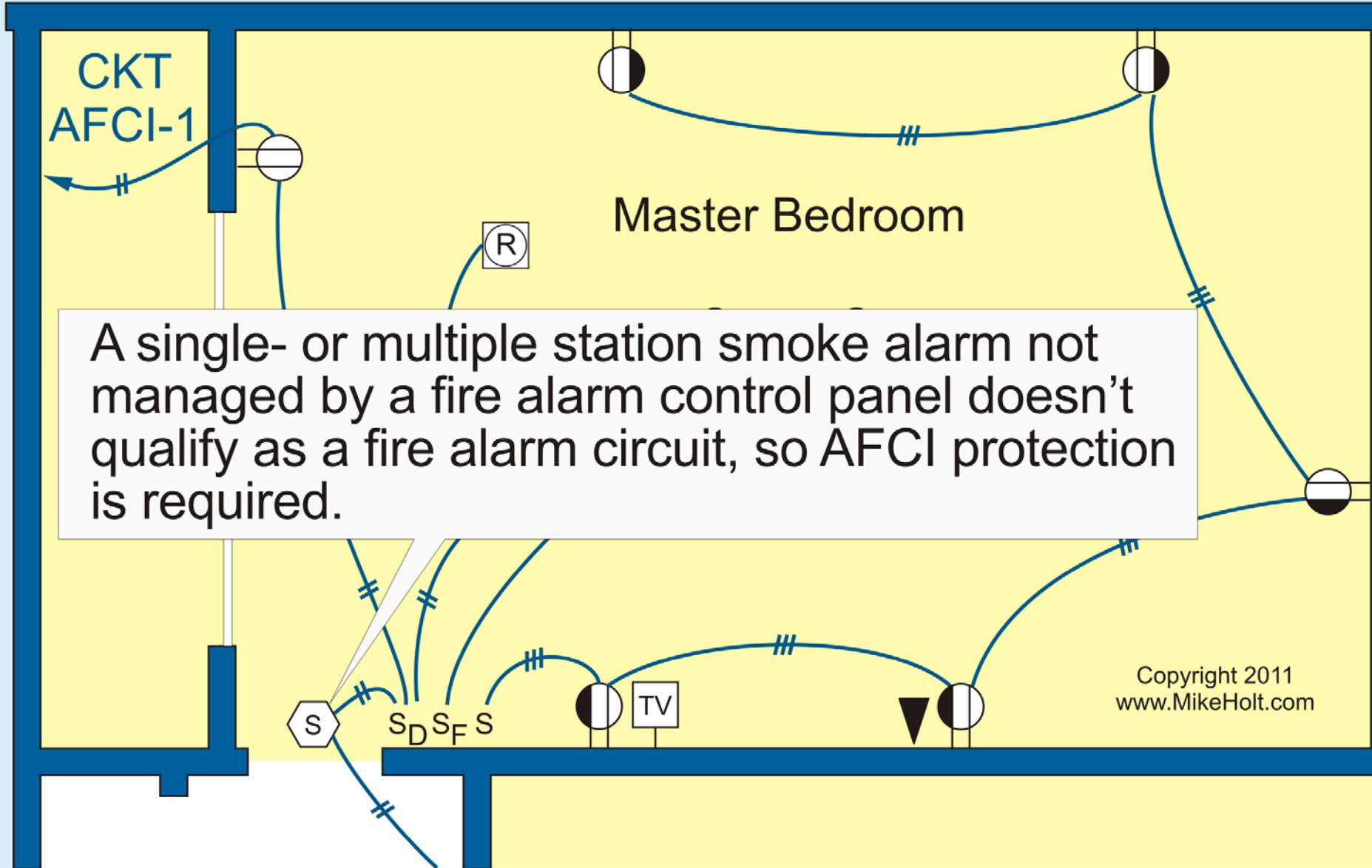
S

S<sub>D</sub>

S<sub>F</sub>

S

TV



20

Combination  
Type AFCl  
Type BRAAF

TEST



**ELCOM**  
Circuit - Plasmacore



LISTED FOR USE WITH AND  
FOR USE WITH THE  
ELCOM PFI



90



Infinium has finished acquiring your waveform!

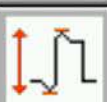
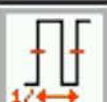
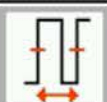
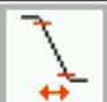
100 kSa/s



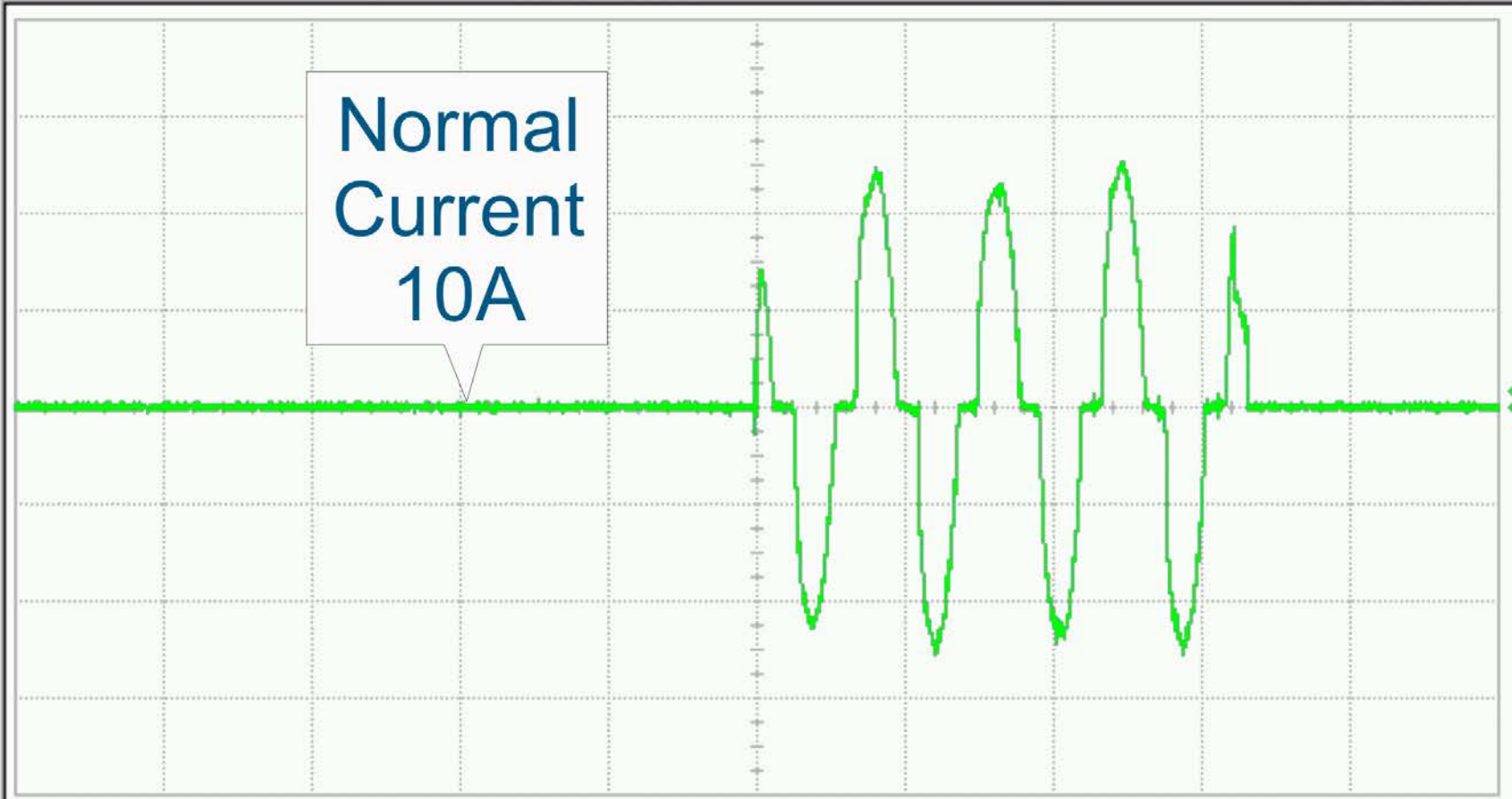
1 On

2 On 10 mV/div

E +/-1.0V



Normal Current 10A



More (1 of 2)



H 20.0 ms/div



0.0 s

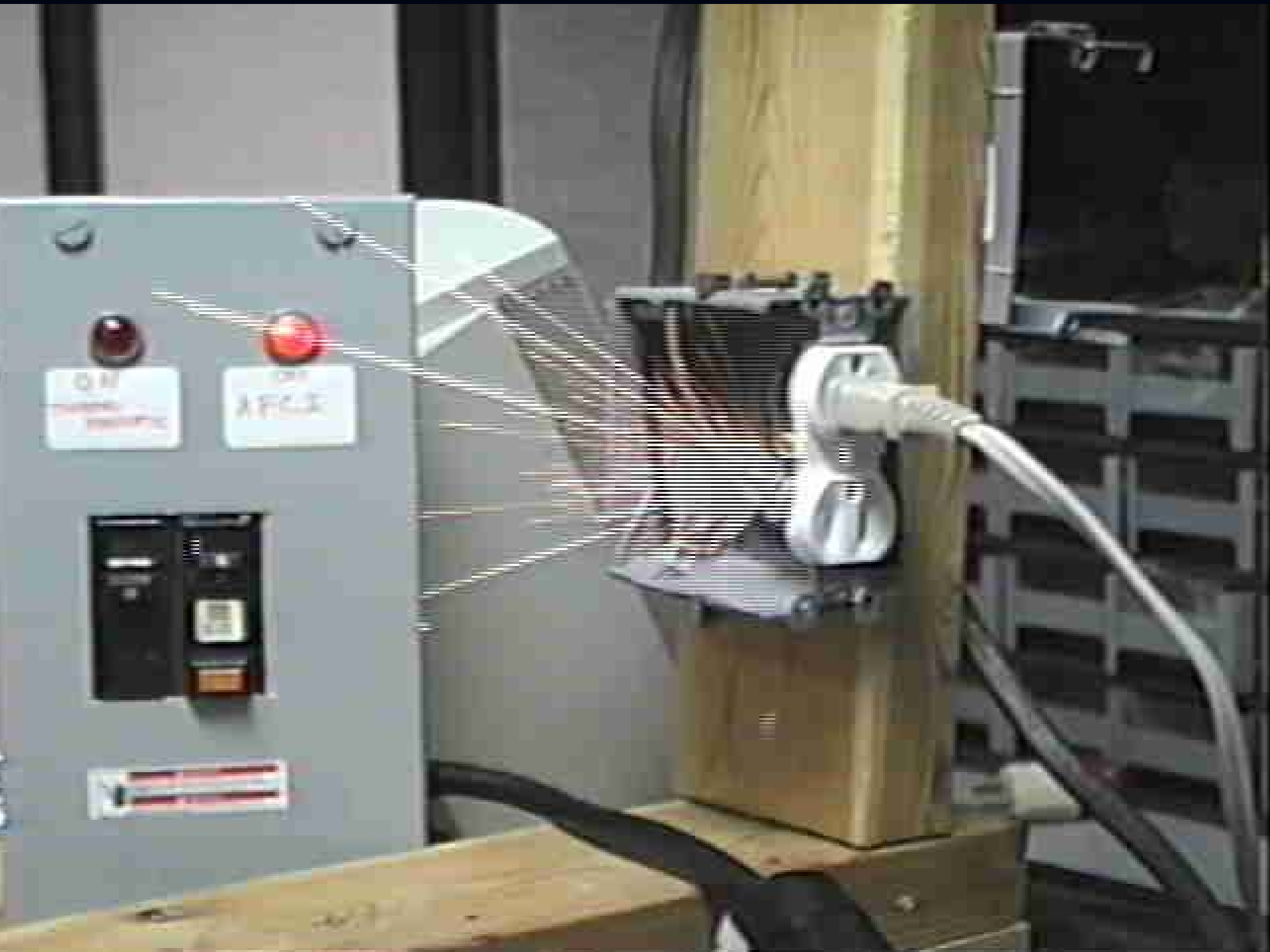
0

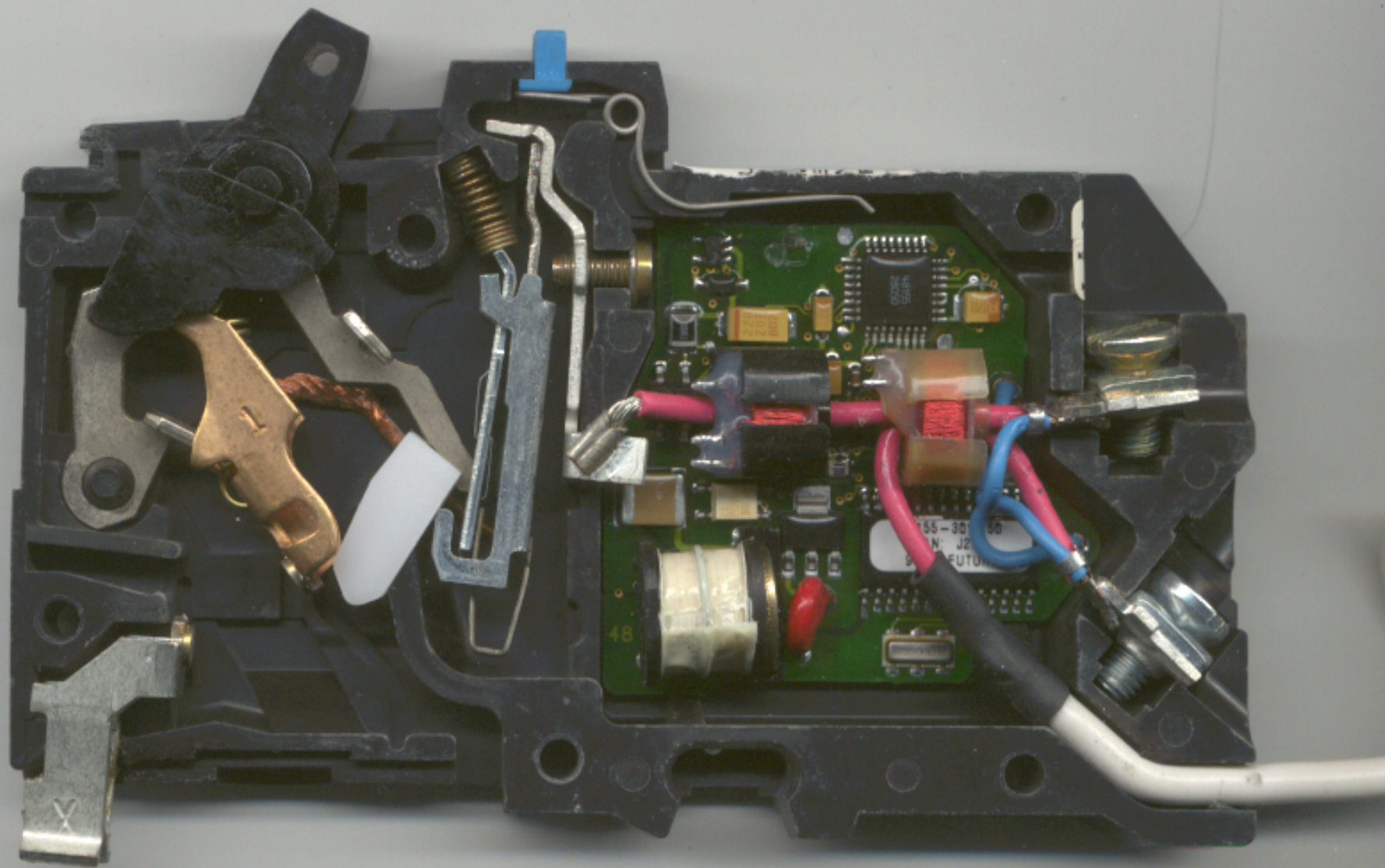
T 1.80 mV

Clear All

V max (2)	current	mean	std dev	min	max
25.4 mV	25.4 mV	25.4 mV	0.0 V	25.4 mV	25.4 mV







# 210.12 AFCI Protection

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*Exception No. 1: If RMC, IMC, EMT, Type MC, or steel armored Type AC cables meeting the requirements of 250.118 and metal outlet and junction boxes are installed for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install an outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.*

## *210.12(B) Branch-Circuit Extensions or Modifications—Dwelling Units.*

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Where branch-circuit wiring is modified, replaced, or extended, the circuit must be AFCI protected by:

- (1) AFCI circuit breaker, or
- (2) AFCI receptacle at first outlet.

# *406.4(D)(4) AFCI Receptacle Replacements*

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Effective January 1, 2014, where a receptacle supplied by a branch circuit requires AFCI protection, the replacement receptacle must be:

- (1) AFCI receptacle.
- (2) Protected by a AFCI receptacle.
- (3) Protected by a AFCI circuit breaker.

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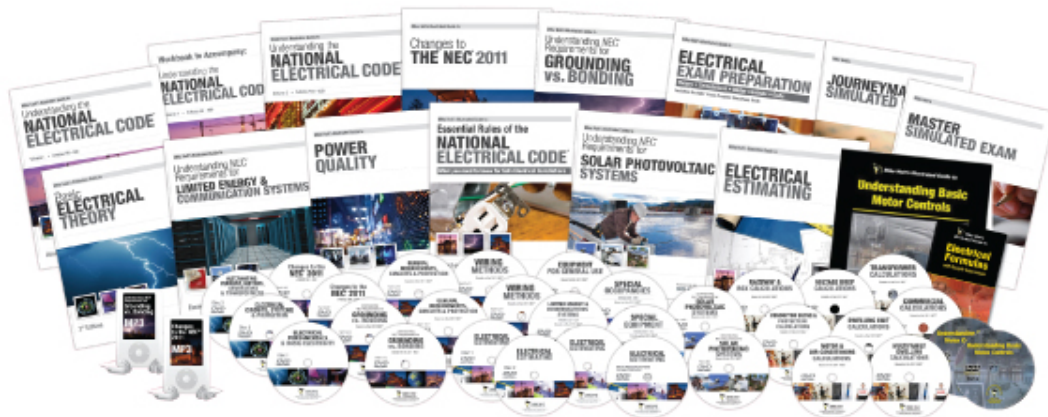
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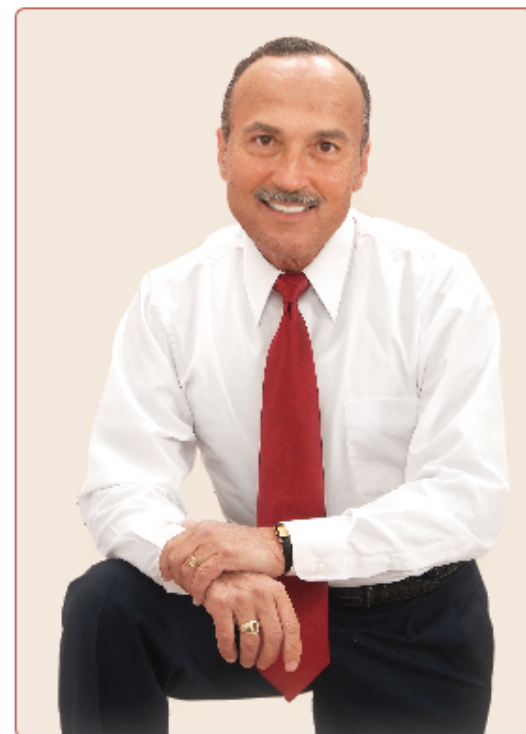
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