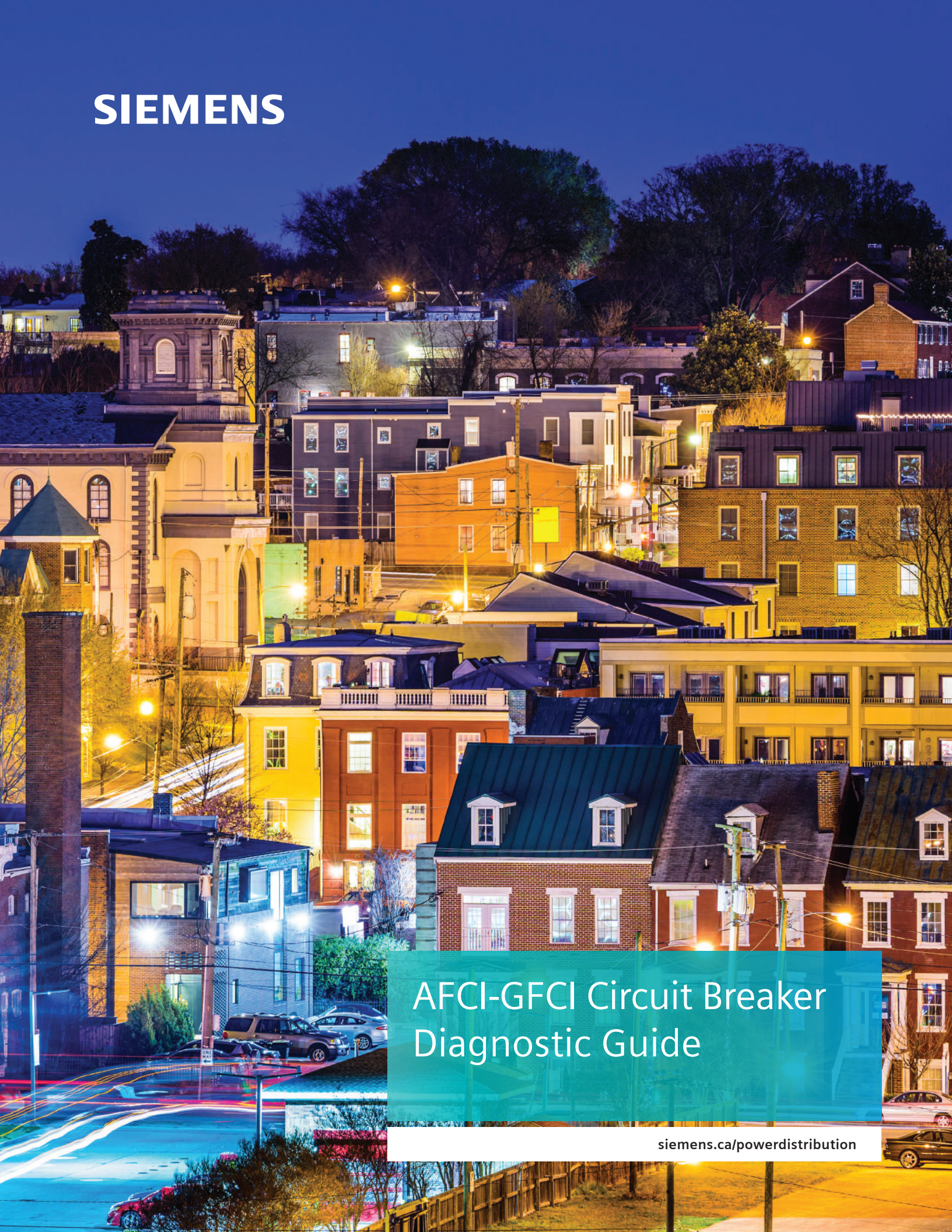
SIEMENS



AFCI-GFCI Circuit Breaker Diagnostic Guide

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Index

1. AFCI/GFCI circuit breaker diagnostic

This document will support to better understand and diagnose circuit breaker trip events with Siemens Arc Fault Circuit Interrupter (AFCI) and Ground Fault Circuit Interrupter (GFCI) circuit breakers.

The questions in this document are applicable to all branch circuits fed by arc fault circuit interrupters (CAFCI or AFCI/GFCI) or ground fault interrupters (GFCI or GFEP). This document is to be used by Siemens application engineering, technical support and sales teams, distributors, electrical contractors and homeowners/end-users to provide application and diagnostic feedback.

This document does not cover the diagnostics of standard circuit breakers.

Qualified person
Circuit breakers should only be operated, inspected, and maintained by qualified personnel. For the purpose of this Guide, a qualified person is one who is familiar with the installation, construction, and operation of the equipment, and the hazards involved. In addition, he/she has the following qualifications:

a) Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
b) Is trained in proper care and use of protective equipment in accordance with established safety practices.
c) Is trained in rendering first aid.

1.1 Facts about arc faults

Every year, residential electrical fires account for hundreds of deaths, thousands of injures, and hundreds of millions of dollars in property damage. A significant number of these electrical fires could have been prevented if the circuits had been protected by arc fault circuit interrupters circuit breakers.

An arc fault is a high-energy discharge created by current flowing through an unwanted path. Generally, arc faults are of short enough duration that they are not detected by standard thermal magnetic circuit breakers. However, arc faults can produce high-intensity heat – exceeding 10,000 degrees Fahrenheit – and can initiate fires. To mitigate fires due to arc faults, AFCIs monitor the branch circuits and mitigate the effects by de-energizing the circuits once an arc-current signature is detected.

1.2. Facts about ground faults

A ground fault circuit interrupter (GFCI or GFI) and a ground fault equipment protection (GFEP) device is a safety device intended to provide protection from unintentional electrical currents between a power source and a grounded surface. An electrical shock, even in the low milliamps, flowing through a body can cause injury or death.

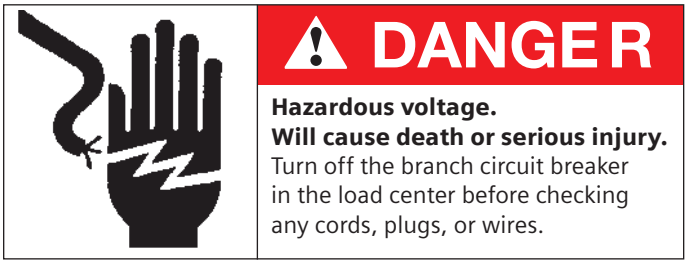
The GFCI and GFEP circuit breakers work by comparing the amount of current going to and returning from a branch circuit. If the current differs by a defined value the GFCI or GFEP circuit breaker will trip, thus shutting off power to the circuit. Siemens offers Class A 5mA GFCI and 30mA GFEP circuit breakers for their residential load centers. While the GFCI circuit breaker provides personal protection from shock the GFEP circuit breakers provides equipment protection from line-to-ground faults that would damage equipment if left uninterrupted.

1.3 What is nuisance tripping?

In some situations, the homeowners/end-users and/or electrical contractors may experience a phenomenon called nuisance tripping. This occurs when the AFCI or GFCI circuit breaker trips and the reason is unknown. The main sources of nuisance tripping are wiring issues and incompatibility with electronic devices. Wiring issues such as damaged wires, loose connections, or incorrectly wired circuits are some examples of conditions that can create nuisance trip events. To resolve nuisance trip events associated with wiring issues the source of the issue will need to be corrected. Incompatibility issues can be created by loads that produce excessive noise that eventually mimics an arc. It is recommended that all installed electronic devices comply with CSA standard to avoid noisy loads from causing
nuisance trips.

2. General diagnostic guide

Should a trip condition occur, homeowners should first note the specific circuit the circuit breaker is protecting, per the load center circuit label (e.g. kitchen, bed room, living room, lighting, etc.), and while the circuit break is in an 'OFF' state, confirm that there are no obvious issues with the loads on that circuit follow these steps:



1. Check for any blackened plugs or outlets. If found, remove all plugs from the outlet and contact an electrical contractor for further investigation.

2. If there are lights on the circuit, check for loose connections between the light bulbs and sockets.

3. Check for any damage or crimps in all electrical cords plugged into an outlet on the circuit. Possible conditions contributing to cord damage:
   a. Cords are pinched in doorways.
   b. An appliance or furniture is pushed against electrical plug or resting on a cord.
   c. Cords deteriorated due to proximity to heat source (e.g: heaters, hot air ducts, sunlight, etc.).

4. Ensure all bulbs are less than or equal to the maximum wattage rating of the fixture. Higher rated bulbs can cause excessive heat and damage.

5. Unplug all equipment on the affected circuit.

6. Reset the circuit breaker by actuating its handle to the 'OFF' and then 'ON' position. If the circuit breaker trips again, a fault still exists on the circuit. Observe and record the trip indicator LED lights. Call an electrical contractor to investigate the issue.

7. If the circuit breaker does not trip after all equipment has been unplugged follow these steps:

   a. Turn on and off each light individually, if lights are on circuit, and observe if circuit breaker trips.

   b. Plug in non-defective equipment one at a time, turn on and off and observe if circuit breaker trips.

Note: If circuit breaker trips during step 7, remove the equipment or light that caused a trip event from the circuit before reenergizing the circuit again and call an electrical contractor.

Helpful tip: Surge protectors are recommended to protect devices from electrical voltage surges. They may also provide the added benefit of filtering unwanted electrical noise sometimes generated by electrical devices. This unfiltered electrical noise could affect the AFCI/GFCI circuit breaker and potentially interfere with or damage other electronics on the circuit. Ensure all electronic devices (e.g: TV, DVR, computer, etc.) are plugged into a surge protector specifically designated with **EMI/RFI** filtering functionality.

Please contact your electrical contractor and provide the following answers to the General diagnostic questions under section 2.3.

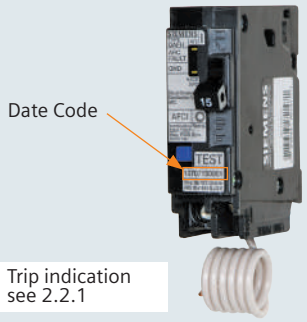
2.1 Identification of circuit breaker types

If no issues are found, please identify the circuit breaker type and manufacturing date codes per the following identification guide. These pictures are intended to be representative samples, and your actual circuit breaker configuration may not be specifically pictured. Plug-on neutral circuit breaker will not have pig-tail leads.

Combination Arc Fault Circuit Interrupter (CAFCI) Dark Blue Test Button

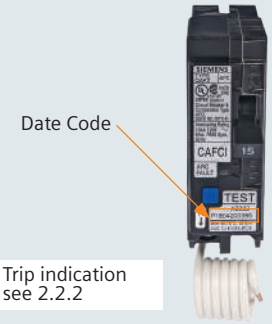
1 Pole

Gen. 1 – 3A



Trip indication see 2.2.1

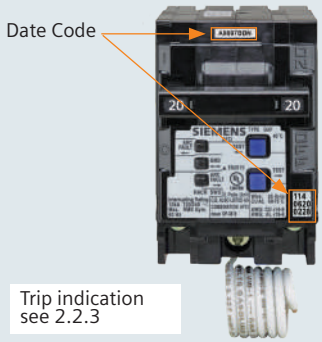
Gen. 3B



Trip indication see 2.2.2

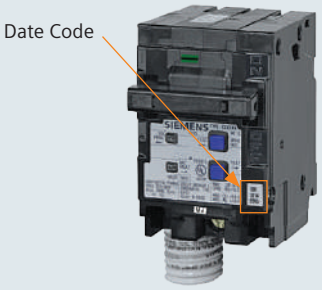
2 Pole

Gen. 1



Trip indication see 2.2.3

Gen. 3B

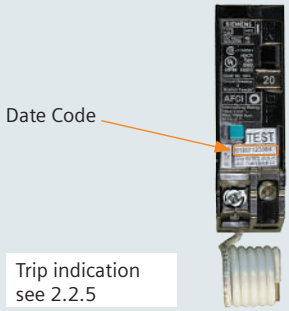


Trip indication see 2.2.4

Branch Feeder Arc Fault Circuit Interrupter (AFCI) Teal Test Button

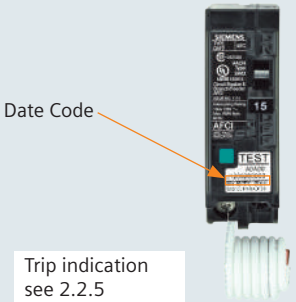
1 Pole

Gen. 1



Trip indication see 2.2.5

Gen. 1B

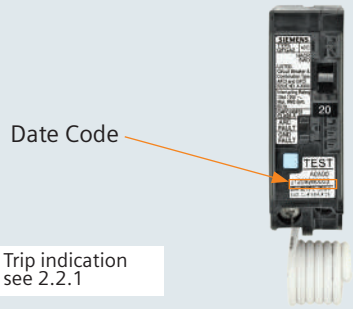


Trip indication see 2.2.5

Dual Function Arc Fault Circuit Interrupter (DF) Light Blue Test Button

1 Pole

Gen. 2

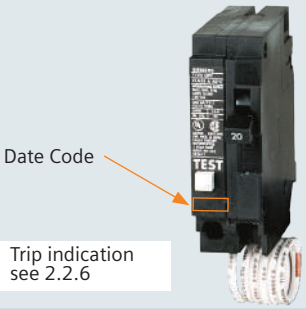


Trip indication see 2.2.1

Ground Fault Circuit Interrupter (GFCI) White Test Button

1 Pole

Gen. 1



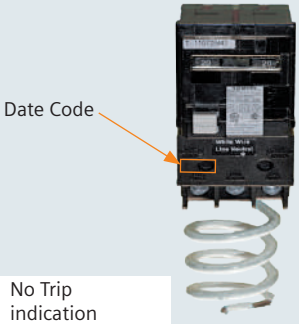
Trip indication see 2.2.6

Gen. 2

Trip indication see 2.2.7

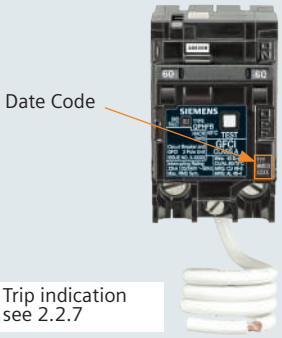
2 Pole

Gen. 1



No Trip indication

Gen. 1B

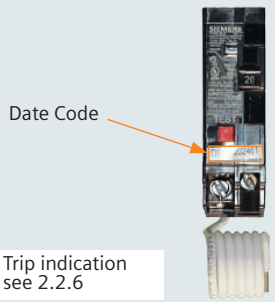


Trip indication see 2.2.7

Ground Fault Equipment Protection (GFEP) Red Test Button

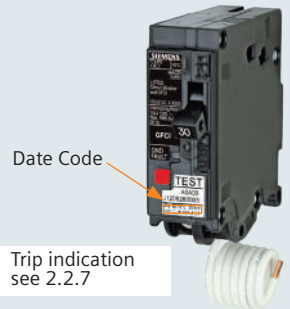
1 Pole

Gen. 1



Trip indication see 2.2.6

Gen. 2



Trip indication see 2.2.7

2 Pole

Gen. 1

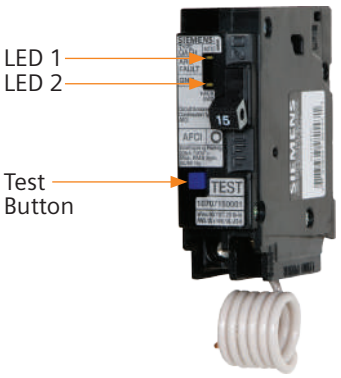
No Trip indication

2.2 General investigation:

2.2.1 1 pole Gen. 1 – 3A CAFCI and Gen. 2 DF circuit breaker trip-indicator LED lights:

LED indicators		Last known trip condition
1	2	
Off	Off	Overcurrent
On	Off	Arc-to-Neutral or Series Arc Fault
On	On	Ground Fault or Arc-to-Ground

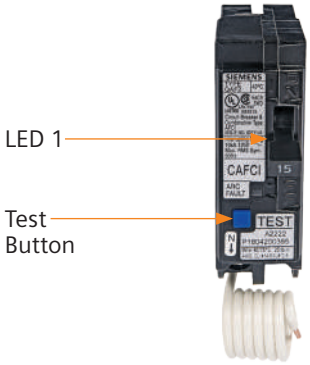
Note: *The trip-indicator LED lights on a Gen.1-3 CAFCI and Gen. 1 DF circuit breaker provide the same fault indications.*



2.2.2 1 pole Gen. 3B CAFCI circuit breaker trip-indicator LED lights:

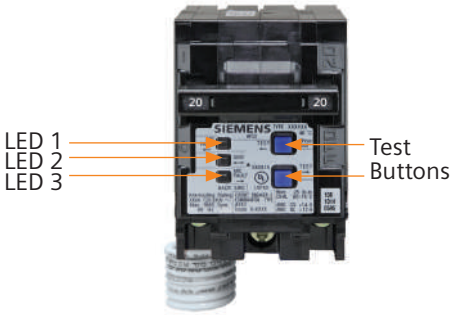
LED indicators	Last known trip condition
1	
Off	Overcurrent
On	Arc-to-Neutral or Arc-to-Ground or Series Arc Fault

Note: *The 1 Pole Gen. 3B CAFCI circuit breaker does not offer ground fault protection.*



2.2.3 2 pole Gen. 1 – 3A CAFCI circuit breaker trip-indicator LED lights:

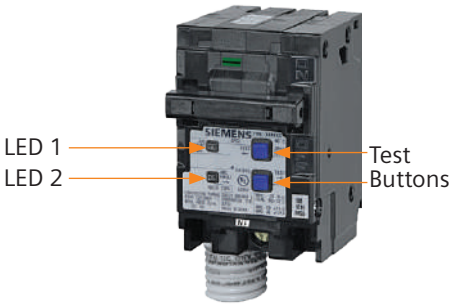
LED indicators			Last known trip condition
1	2	3	
Off	Off	Off	Overcurrent
On	Off	Off	Arc-to-Neutral or Series Arc Fault (leg A)
Off	Off	On	Arc-to-Neutral or Series Arc Fault (leg B)
On	On	On	Ground Fault or Arc-to-Ground



2.2.4 2 pole Gen. 3B CAFCI circuit breaker trip-indicator LED lights:

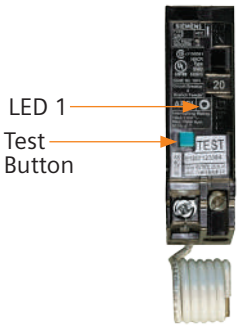
LED indicators		Last known trip condition
1	2	
Off	Off	Overcurrent
On	Off	Arc-to-Neutral, Arc-to-Ground or Series Arc Fault or (leg A)
Off	On	Arc-to-Neutral, Arc-to-Ground or Series Arc Fault or (leg B)

Note: *The 2 P Gen. 3 CAFCI circuit breaker does not offer ground fault protection.*



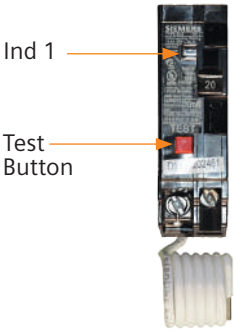
2.2.5 1 pole Gen. 1 – 1B AFCI (branch feeder) circuit breaker trip-indicator:

LED / Window indicator	Last known trip condition
1	
Off / Blank	Overcurrent or Ground Fault
On / Yellow	Arc-to-Neutral, Arc-to-Ground



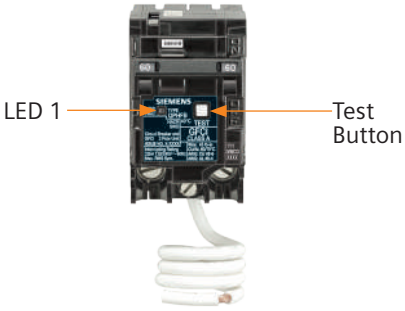
2.2.6 1 pole Gen.1 GFCI and Gen. 1 GFEP circuit breaker trip-indicator:

Window indicator	Last known trip condition
1	
Blank	Overcurrent
Yellow	Ground Fault



2.2.7 1 pole Gen. 2 GFCI, 2 pole Gen. 1B GFCI, and 1 pole Gen. 2 GFEP circuit breaker trip-indicator:

LED indicator	Last known trip condition
1	
Off	Overcurrent or Ground Fault
Blinking	Circuit breaker needs to be replaced



2.3 General diagnostic questions

1. *What type of circuit breaker is tripping? _____
2. *What are the date codes on the circuit breaker? _____
3. *What LEDs are lit on the circuit breaker after it tripped and is reset? _____
4. *What action/event caused the circuit breaker to trip? (For example: Turning on/off an appliance/device) _____

   _____
5. What is the load center circuit number and description? _____
6. Are there combinations of loads that cause the trip condition? _____

   If yes, what are the devices (make and model)? _____

   _____
7. How often does the circuit breaker trip? _____
8. Did the action/event on another circuit coincide with the trip event? _____

   If not, which circuit tripped and on which circuit was the action/event? _____

   _____
9. Please specify property type – single family home/apartment complex/etc. _____

   If other than single family home, how many units? _____

   Please answer questions 1 through 8 per unit or provide common information such as all the kitchen breakers are tripping.

   _____

Note: Answers to these questions will assist the electrical contractor narrow down the source of the trip condition. This will shorten the diagnosing time and reduce the number of visits required to solve the issue. Answers to the questions that are listed with red * are mandatory information needed to understand the issue and escalate to an electrical contractor.

3. Electrical professionals diagnostic guide

Diagnostics of electrical circuits should only be done by a qualified electrical contractor. The first step in diagnosing the root cause of a circuit breaker trip is to eliminate the most common and routine causes. The most common and routine causes of circuit breaker trip events are loose connections, misapplied/damaged appliances, and/or incorrectly wired outlets and circuit breakers.

3.1 Arc fault investigation

Follow the steps below to diagnose the root cause of a trip-condition on a circuit protected by an AFCI circuit breaker:

1. Ensure the previously-mentioned 'General Diagnostics' tips have been reviewed.

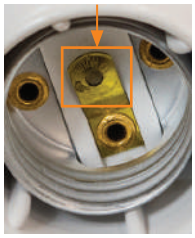
⚠ DANGER

Hazardous voltage.
Will cause death or serious injury.
Turn off and lock out power supplying equipment before working on equipment.

2. Check to make sure the breaker is functioning properly via the 'TEST' button. Move handle to the 'OFF' and then 'ON' position. Reset has been completed, press the 'TEST' button and observe the position of the circuit breaker's handle. If the breaker handle moves between the 'OFF' and 'ON' position, then the circuit breaker is working correctly. If the circuit breaker does not trip, it needs to be replaced by an electrical contractor. Observe and record the trip indicator LED lights.

3. When checking for a loose light bulb, check that the line/hot tab on a light socket makes a good connection to the bulb. If not, with the light fixture disconnected from the circuit, bend the hot tab upward slightly so it will make a good connection to the bulb and retighten the bulb in the socket.

Gently pull up tab indicated in square



4. Check the wiring at the circuit breaker load terminal (line/hot, load neutral, panel neutral/pig tail). Ensure the load neutral conductor is properly connected to the neutral terminal of the circuit breaker and the circuit breaker neutral/pig tail is properly connected to the neutral bar. In case you have a plug-on neutral AFCI or GFCI circuit breaker you will not have a panel neutral/pig tail.

5. Check the wiring to ensure a single pole AFCI circuit breaker is not wired to a multi-wire branch circuit (shared neutral). For multi-wired branch circuits where the neutral is shared between two branch circuits, a two-pole AFCI circuit breaker must be used.

6. Check the load center, switches, receptacles, and hardwired lighting/appliances for loose connections. Siemens highly recommends using screw connections for wire termination on all outlets, switches, etc, instead of using the spring-loaded 'push-in' connections. Ensure all screws and lugs are tightened to specification.

7. Check the installed wiring for damaged insulation that may expose hot wires to neutral or ground wires.

8. Check all devices for cUL and CSA compliance (LED lights, powerline adapters, etc...). If not, check with the supplier/manufacturer to validate its compliance with CSA for residential environments. If not, the device may be producing enough electrical noise to affect all electronics on the circuit (including the AFCI circuit breaker).

9. If the arc-fault trip condition persists after all the wiring has been verified follow these steps:

   a. Disconnect all the loads on the circuit.

   b. Energize each load individually until the AFCI circuit breaker trips.

   c. Move the latest energized load before the trip – where possible – to another circuit to see if the trip condition follows a specific device.

   d. When the circuit breaker trips, the most recently energized load is likely producing the arc-fault signature.

   e. If the circuit breaker still does not trip, then test the loads in different combinations.

   f. If a combination of loads is required to trip the AFCI circuit breaker, isolate each of the loads again and, this time, test the isolated loads in combination with a 5A resistive load such as a portable heater (600W or higher).

   g. If the AFCI circuit breaker trips on an arc fault when the isolated load is tested in combination with the 5A resistive load, the isolated load is most likely producing the arc-fault.

If the source of the trip conditions is still not determined, complete the General diagnostics questions under section 2.3 and Arc fault diagnostic questions under section 3.2 in their entirety, and then contact Siemens Technical Support. Answers to these questions are critical to Siemens understanding of the type of tripping event.

3.2 Arc fault diagnostic questions:

1. Can the trip be traced to a specific light switch or ceiling fan speed control switch? If so, please provide make and model and approximate distance between the switch and load:

   _____

2. For LED or low-voltage lighting fixtures, provide the make and model of the lighting fixture and the switching power supply /electronic transformer:

   _____

3. What is the current draw of the load or the combination of loads that are causing the arc-fault condition?

   _____

4. What type of communication modem is used in the house (WiFi, power line communication (PLC), broadband power line (BPL), etc) and is it related to the trip condition?

   _____

5. What is the make and model of the appliance or device? How many are installed on the circuit?

   _____

For additional AFCI resources, please reference the following links:

Siemens Documentation (including additional diagnosing information): www.usa.siemens.com/afci

AFCI Diagnostic Tool Video: www.usa.siemens.com/intelliarc

Free Online Training: www.afcisafety.org

3.3 Ground fault investigation:

⚠ DANGER

Hazardous voltage.
Will cause death or serious injury.
Turn off and lock out power supplying equipment before working on equipment.

Follow the below steps to diagnose a ground fault trip-condition:

1. Check the wiring to ensure a single pole AFCI, AFCI/GFCI, GFCI, or GFEP circuit breaker is not wired to a multi-wire branch circuit (shared neutral). For multi-wired branch circuits where the neutral is shared between two branch circuits, a two-pole AFCI, GFCI, or GFEP circuit breaker must be used.

2. Check the wiring at the circuit breaker load terminal (line/hot, load neutral, panel neutral/pig tail). Ensure the load neutral conductor is properly connected to the neutral terminal of the circuit breaker and the circuit breaker neutral/pig tail wire is properly connected to the neutral bar. In case you have a plug-on neutral AFCI/GFCI circuit breaker, you will not have a panel neutral/pig tail.

3. Ensure neutral conductors have not inadvertently been connected to a ground conductor at any point in the circuit.

4. Using a leakage current clamp meter on the ground conductor, test loads on the affected branch circuit to confirm if any load creates enough leakage to trip the connected circuit breaker.

5. Check to see if the trip condition is repeatable. If a ground fault exists on the circuit the circuit breaker will immediately trip after a completed reset. An arc-to-ground will not be readily repeatable. If an arc-to-ground is suspected refer to the Arc fault investigation section.

If the source of the trip conditions is still not determined, complete the General diagnostics questions under section 2.3 and Ground fault diagnostic questions under section 3.4 in their entirety, and contact Siemens Technical Support. Answers to these questions are critical to Siemens understanding of the type of tripping event.

3.4 Ground fault diagnostic questions

1. If the ground-fault condition occurs on a pool/spa pump system, please answer the following questions:

a. What is the make and model of the pump system?

_____

b. What is the type of drive installed? (e.g: variable flow, variable frequency, etc.)

_____

c. What accessories are used with the pool pump/filtration system?

_____

Provide bill of material and wiring diagram if possible.

2. If the source of the ground-fault condition is a fan or appliance, please answer the following questions:

a. What is the make and model of the speed control fan or appliance?

_____

b. Does the installation or use and care guide recommend or reject a circuit breaker type?

_____

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