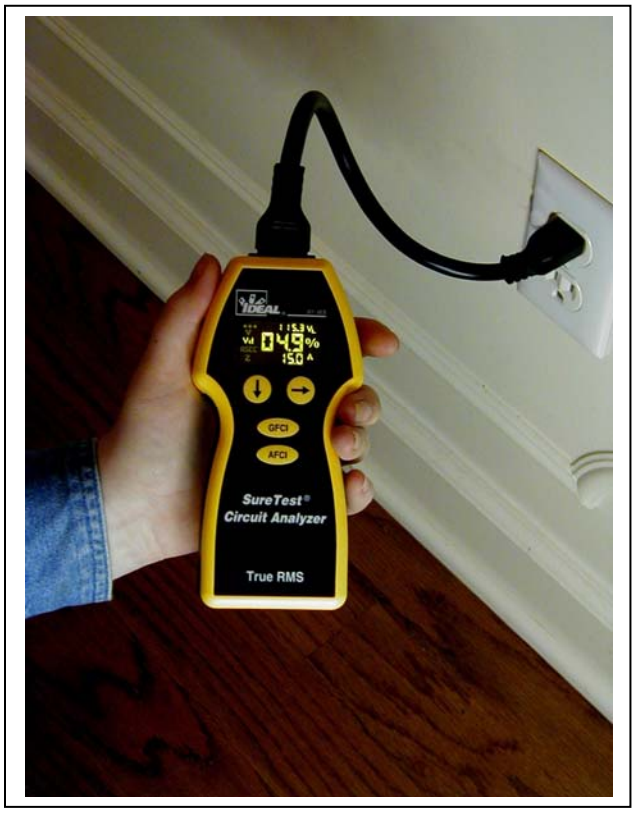
IDEAL INDUSTRIES, INC.

Branch Circuits Protected by AFCI Devices

And the IDEAL SureTest® Circuit Analyzers.

Includes information on testing AFCI devices.



Author: Patrick C Elliott
Field Sales Engineer
IDEAL Industries, Inc

August 2008, Version 3

Distributed by:
TESTERS AND TOOLS.COM
Trust Experience Reliability
sales@testersandtools.com
Tel: 602-795-4033, Fax: 602-795-4624

Branch Circuit Wiring

Branch circuit wiring rules are defined by the National Electrical Code. They are necessary to ensure safe and efficient branch circuits. Hidden problems within a branch circuit can result in fire, equipment failure or even electrocution .

Arc Fault Circuit Interrupters

AFCI requirements began when in 1999 the **N**ational **F**ire **P**rotection **A**gency (NFPA), Code Making Panel (CMP) 2 accepted a proposal that required the installation of **A**rc **F**ault **C**ircuit **I**nterrupt breakers on branch circuits feeding bedroom outlets, with an effective date of January 1, 2002.

An Arc Fault Circuit Interrupt device protects against arcing faults by recognizing the unique characteristics of arcing in a branch circuit. These arcing faults may contribute to residential fires.

UL 1699 defined types of AFCIs for branch circuits:

1. **Branch/Feeder AFCI** is the most common device in used today, this type of AFCI detects parallel arcs on the branch circuit from its origin at the panel.
2. **Outlet Circuit AFCI i**s an outlet that detects both parallel and series faults in devices connected to that outlet only.
3. **Combination AFCI** Is a device that does the job of both the Branch/Feeder AFCI Breaker and the Outlet Circuit AFCI in that it detects both parallel and series arcing faults anywhere on the circuit.

What protection does a Branch/Feeder AFCI provide?

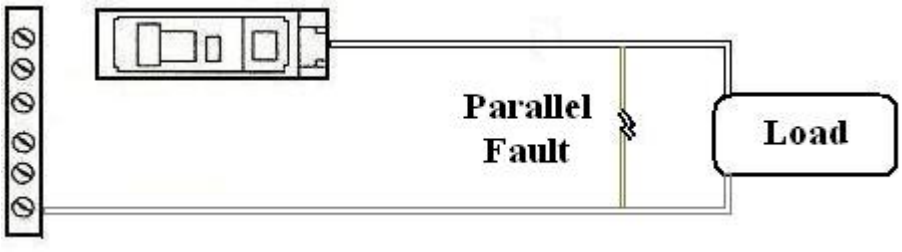
- Over current protection: The breaker will trip when the load current exceeds the current rating of the breaker.
- Parallel arcing: An AFCI will trip when it senses a characteristic arcing between line and neutral greater than 75 amperes.
- Leakage Current: Most AFCI devices will trip between 30mA to 50mA of leakage current.

What protection does a Combination AFCI Breaker provide?

- The Combination AFCI Breaker provides all of the Branch Feeder protection and adds the ability to detect series arcs from a level of 5 amps or greater.

High Resistance Faults: Parallel Arcs, Series Arcs, and Glowing Contacts

Parallel Arcing Faults [3] Parallel arcing faults can be the result of insulation failure between a line to neutral or line to ground. The Parallel arcing fault current is limited by the available short circuit current and the impedance of the fault.



Series Arcing Fault [4] can occur when there is a partial or total failure in one of the conductive paths in series with a load. This failure is characterized by completely opened conductor (which would be infinite resistance) or by resistance alternating between infinite to high resistance and back again. Intermittent connections, loose wire terminals, poor splices, or poor contacts of quick-wired devices can cause high resistance faults.
.

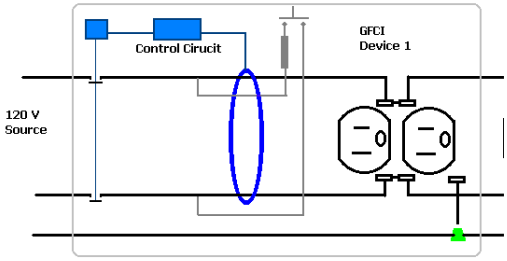
Glowing Contact, or High Resistance Series Arcing Fault [3] is defined as the abnormally high resistance in a wire, wire termination, wire splice of and type of connection, resulting in reduce current flow and excessive heat at the fault.

- These high resistance series faults result from a build-up of copper or aluminum oxide that creates a high resistance "glowing contact."
- This high-resistance point can become extremely hot with temperatures exceeding 600° F causing insulation failures that can result in a damaging high-power parallel arcing fault or ground fault.
- Glowing contacts can develop current carrying conductor. The current in the high resistance fault, like the series arcing fault, is limited to the current being drawn by the load—until the insulation degrades to the point where this type of fault becomes either a parallel arcing fault or it causes fault current to flow.

Loose wire connections create a high resistance point within the electrical system, which can lead to a breakdown in insulation or even a fire.

Ground Fault Circuit Interrupters

Section 210.8 of the 2005 National Electrical Code (NEC) requires the installation of ground fault circuit interrupters (GFCIs) in residential dwellings and guest rooms of hotels to protect person(s) against shock.[7]



A GFCI is a device with a built in circuit to detect leakage current to ground on the load side of the device. When the GFCI detects leakage current to ground, it will interrupt power to the load side of the device, halting a hazardous ground fault condition.

These devices should be tested regularly, because they rely on mechanical parts that can degrade over time. According to a recent study performed by the Leviton Institute, an average 15% of GFCIs were inoperative when tested. "Voltage surges from lightning, utility switching and other sources all take their toll on the devices, which is why Underwriters Laboratories (UL) requires that GFCIs be tested monthly."[8]

Using the SureTest® Circuit Analyzer to test branch circuits.

The IDEAL SureTest® Circuit Analyzer 61-165 has two functions.

1. Test the physical structure of the branch circuit. The SureTest® Circuit Analyzer calculates Voltage Drop and Percent of Voltage drop at 12, 15, and 20 amp loads in a matter of seconds. With its patented technology, it can perform this test even if there are loads on the circuit, without tripping a breaker or interrupting the load. The Available Short Circuit Current, and the resistance of each conductor Hot, Neutral, and Ground are also measured and displayed.

.

Voltage drop at a 12,15, or 20 ampere load can be easily taken by simply plugging the SureTest ® into a receptacle and performing the Voltage drop test.

2. The SureTest® Circuit Analyzer tests the performance of AFCI/GFCI protection from different points on the branch circuit. The Models 61-165 and 61-059 tests the branch circuit performance of the AFCI by simulating an arc fault between hot and neutral. This simulated arc meets the present UL guidelines for AFCI testers. The Model 61-165 can also test GFCI devices at 6mA and 30 mA per the UL guidelines for GFCI testers.

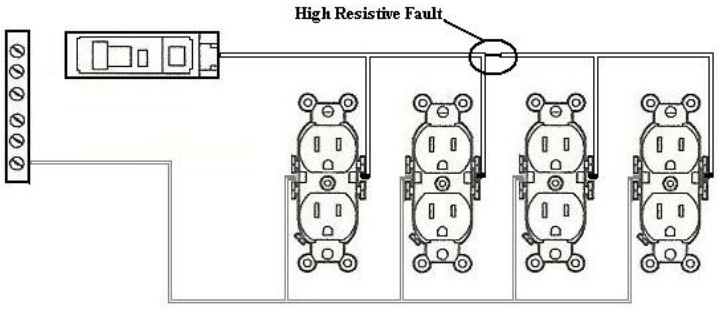
It is important to note that AFCI devices cannot detect a glowing contact, which is a high resistance fault in either the hot or neutral conductor unless it is arcing. You can detect possible glowing contacts and locate series arcing points with the 61-165 SureTest, which has the ability to measure the resistance of the Hot, Neutral and Ground. By measuring and comparing the resistance of the hot and neutral conductors, you will see a resistance fault as a difference between what should be two very similar resistance readings. By measuring at different points in the branch circuit, you can pinpoint the location of the high resistance connection.

Troubleshooting a Standard Circuit.
Measure the voltage drop at the furthest receptacle from the panel on the branch circuit under test. Use 12 amps for a 15 amp circuit, 15 amps for a 20 amp circuit. If the voltage drop is greater than 5%, or the voltage drops below 108 volts, then further investigation is necessary.

Test the receptacles in an organized way, working towards the panel from the furthest point. This will help you pinpoint a high resistance fault, loose connection, or faulty device.

A sudden change in voltage drop from one receptacle to the next indicates a problem somewhere between the two receptacles. Check everywhere wires are joined. The fault may be in a defective device as well.

If the high voltage drop reading steadily decreases as you get closer to the panel with no significant decreases between receptacles, then the wire may be undersized for the length of the branch circuit.



In this example there is a High Resistance Fault between the 2nd and 3rd receptacle. The Voltage drop increased from the 2nd to the 3rd. The high resistance was identified as a poor connection between the two devices.

The IDEAL SureTest® can measure the resistance of the Line, Neutral, and Ground conductors. This can be very helpful when trying to locate a high resistance fault in a branch circuit.

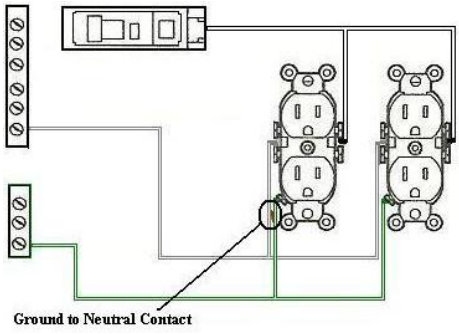
Maintaining a Low Impedance Ground

A good electrical ground must meet NEC requirements, and it must also be low impedance. The IEEE recommends that each conductor be less than 0.25 ohms, or 0.5 ohms for the circuit. It is also important to ensure all bonds are very low resistance, so that all the grounds and bonded parts of interconnected systems are about the same resistance to earth and to each other. Corroded, loose, or missing connections, undersized wiring, and old age cause high resistance grounds and bonds.

False Grounds

The neutral conductor can only be bonded to the ground conductor at the service entrance. Sometimes through error or ignorance, the neutral and the ground conductor are connected or unintentionally touch downstream from the service entrance. This is called a false, or bootleg ground. A 3-bulb receptacle tester will show this circuit as wired normally when in fact this is a hazardous wiring condition. The ground and all bonded metal can become part of the neutral return path. This false ground condition goes undetected in many cases. One consequence of the new AFCI requirement is that false ground conditions cause AFCI devices to trip because of unbalanced return current on the line. This will cause intermittent problems on AFCI protected circuits depending on the load on the circuit. Without the Sure Test, the AFCI breaker would probably be blamed for nuisance tripping.

The SureTest 61-165 will detect a connection between ground and neutral when placed within 15 feet of the connection. That means an outlet that is closer than 15 feet to the service entrance will indicate False Ground.



SureTest® Circuit Analyzer can detect a false ground condition within 15 feet of a receptacle under test or within 15 feet of the panel.

Earth Ground

Grounding Electrodes provide the electrical system reference to earth. The rods and the soil form an effective ground system. The system could be a single ground rod, multiple ground rods, a mat, or a grid system. Section 250-56 states that if the effective resistance of a single ground rod is greater than 25 ohms, then a second ground rod must be added

at least 6 feet from the first.[6] The grounding system can be tested with a three-pole earth resistance tester, or a ground resistance clamp meter.

A ground resistance clamp meter enables electricians to measure the resistance of the ground electrode in a fraction of the time required using the traditional three-point fall of potential test.

While testing the resistance of the ground electrode with a three pole or four pole tester, it is necessary to completely disconnect the ground electrode system from the electrical service. A ground clamp meter can test the ground electrode system while it is still connected to the service.

---

[1] *Fact Sheet on Fire in the US and Canada*, National Fire Protection Agency (NFPA) 1997

[2] *1997 Residential Fire Loss*, Consumer Product Safety Commission, 1997

[3]*Technology for Detecting and Monitoring Conditions that Could Cause Electrical Wiring System Fires. UL Report for CPSC, contract #CPSC-C-94-1112, September 1995.*

[4]*NEC code Articles {210-19(a) FPN No. 4} {215-2(d) FPN No. 2},*

[5] Kinney, Larry "Assessing the Integrity of Electrical Wiring"
Home Energy Sept/Oct 1995: 5,6

[6] *NEC code Article {384-20}*

[7]*NEC code Article {210-8 (a)}*

[8]*Study Identifies potential GFCI weaknesses,*
Electrical Marketing, August 18, 2000

[9] *NEC code Article {285}*

[10] *NEC code Article {250-148}*

[11] *NEC code Article {250-146(d)}*

[12] *NEC code Article {250-146(a) through (d)}*

[13] *NEC code Article {384-20}*

IDEAL 61-051 Receptacle Testers

IDEAL 61-165 SureTest® Circuit Analyzers

IDEAL 61-092 Vol-Con® Elite Digital Voltage Tester

IDEAL 61-310 Resi-Pro Multimeter

IDEAL 61-340 Test-Pro Multimeter

IDEAL 61-920 Clamp-on Ground Resistance Tester

IDEAL 61-796 3-Pole Ground Electrode Tester

IDEAL 61-534 Circuit Breaker Finder

IDEAL 61-956 Circuit Tracer

IDEAL 61-795 Insulation Tester

IDEAL Term-a-Nut® Grounding Products

Distributed by:
TESTERS AND TOOLS.COM
Trust Experience Reliability
sales@testersandtools.com
Tel: 602-795-4033, Fax: 602-795-4624