

TechView: Analog & Power

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Arc-Detecting Circuit Breakers Will See Wider Use

The 2008 National Electrical Code (NEC) will require arc-fault circuit interrupters (AFCIs) throughout new homes in the U.S. So, your new construction should now incorporate ground-fault circuit interrupters (GFCIs) that trip on an unbalance between line and neutral, basic circuit breakers that trip on gross faults, and AFCIs that trip on arcs.

AFCIs are “don’t burn the house down” protection, as opposed to the “don’t electrocute yourself” protection provided by GFCIs. They were developed because regular circuit breakers have relatively slow tripping times that may not catch arcs, which are generally characterized by short bursts of excess current (see the figure).

The trick to designing an AFCI is to enable it to distinguish between legitimate arcs, such as those from motor brushes, and dangerous arcs like those in a conduit that’s been damaged during a renovation or in a worn appliance cord. While AFCIs aren’t new, they’ve been improved, and the expanded code requirements have triggered a public-awareness campaign by the National Electrical Manufacturers Association (NEMA).

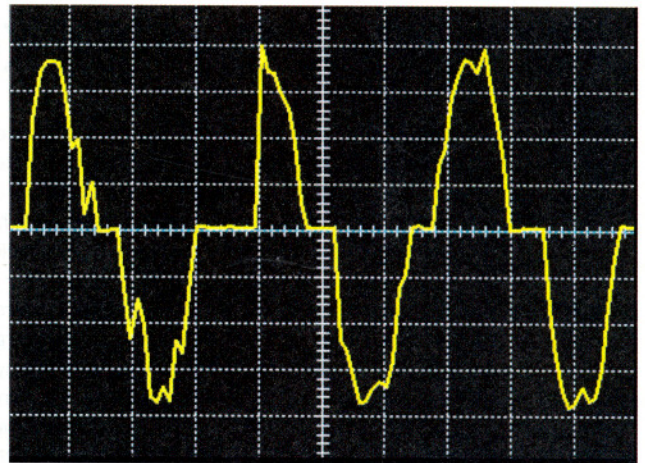
AFCI history starts with the 1999 NEC, which required AFCIs for all branch circuits that supply 125-V, single-phase, 15- and 20-A receptacle outlets in bedrooms starting in 2002. The 2002 NEC extended the AFCI requirement to all bedroom outlets, such as lighting, receptacles, and smoke alarms. The 2005 NEC respecified AFCIs, reducing current levels and requiring the detection of series arcing in a conductor in addition to parallel arcing across conductors.

AFCI manufacturers are cagey about revealing the details of how their products work. At best, you’ll see diagrams with a block labeled “arc signature filter.” Working from that and some of the patents available online, along with the collection of representative waveforms on R&D firm Zlan’s Web site, one can deduce that detection involves an analog-to-digital converter, a lookup table, and a microcontroller or a state machine. Beyond that, the circuit appears to be something of a black box.

The Underwriters Laboratories Standard for AFCIs is UL 1699—Standard for Safety for AFCIs. Specifically AFCIs are tested in several ways for certification. One test, “carbonized path arc ignition,” involves cutting the insulation on one conductor in a cable, resulting in an arc to the uninsulated ground conductor. The test arc current level is 5 A for tripping.

In the “carbonized path arc interruption” test, the insulation is cut on both conductors and ground, creating conductor-to-conductor and conductor-to-ground parallel arcs. The AFCI is supposed to trip if eight half-cycles of arcing occur within a period of 0.5 s. In the “point contact arc” test, the cable is guillotined and the AFCI must trip if, again, eight half-cycles of arcing occur within a period of 0.5 s.

Some AFCI makers also have their own “carbonized path arc clearing time” test. This simulates a broken wire that continues



This is a scope shot of an arc generated by a loose wire. The Web page that contains the image (www.zlan.com) links to downloadable software for frequency- and time-domain analysis of this and other waveforms. Zlan (“Zee-lan”), an R&D firm, licenses many of the patents embodied in AFCIs.

to conduct through an arc, which burns away the cable insulation until there is a direct short or an arc to ground.

THE CONTROVERSY • As part of the public awareness campaign, NEMA’s new AFCI Web site (www.afcisafety.org) reveals that the whole issue of AFCIs is not without controversy. And if you search the Web, you’ll find a number of negative points of view about AFCIs from 2002, when the original AFCI requirements went into effect. These comments focus on the newness of the technology, the things that AFCIs don’t do (e.g., detect glowing hotspots and, until 2005, detect serial arcing), and the number of home fires and deaths that AFCIs might actually prevent.

I couldn’t find any more recent signs of controversy, but NEMA appears to feel that some critics are still using the old arguments. The NEC is published by the National Fire Protection Association (NFPA), but it doesn’t have the force of law unless mandated by state or local law.

While NEMA is focused on AFCIs, the requirements for GFCIs are being expanded in the 2008 NEC. GFCIs will be required in commercial, educational, institutional, and industrial laboratories and kitchens, as well as in the home in basements with laundry sinks that have receptacles within 6 ft of the sink.

National Electrical Contractors Association

www.necanet.org

National Electrical Manufacturers Association

www.nema.org

Underwriters Laboratories

www.ul.com

Zlan Ltd.

www.zlan.com