The Arc Fault Circuit Interrupter

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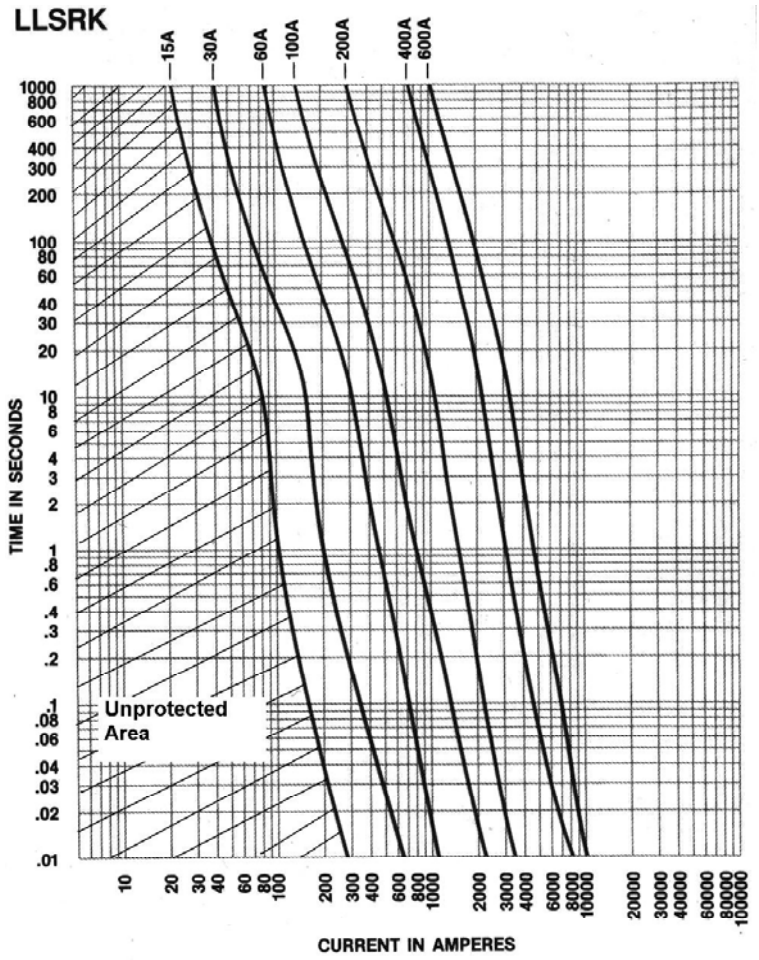
By now you probably have heard of the **A**rc **F**ault **C**ircuit **I**nterrupter (AFCI) but what is it? And as many have asked:

- Does it really work?
- What is the difference between an AFCI and a Ground Fault Circuit Interrupter?
- Where are AFCIs required to be installed?
- Where else should they be installed?
- Is this just one more device someone dreamed up?

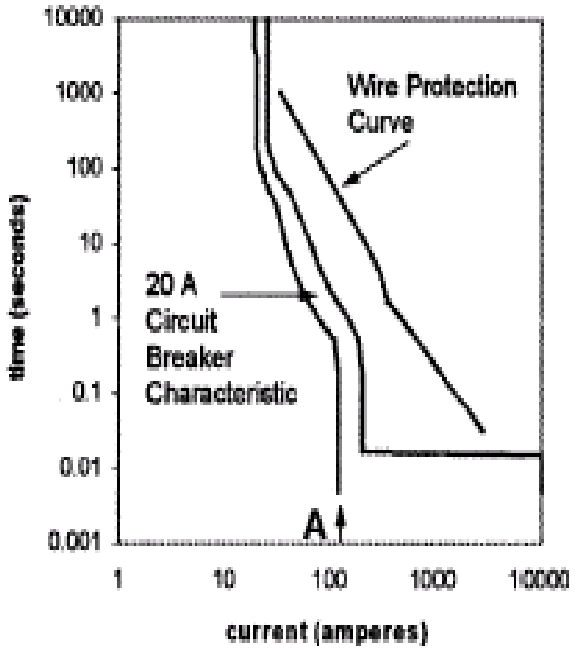
If you have attended one of the seminars on grounding given by John Pfeiffer you would know that circuit breakers and fuses, in may cases, will not protect against fires caused by electrical faults. Please refer to our web site at http://www.pfeiffereng.com , Tech. Ref: "Principles of Electrical Grounding" for a detailed explanation of arcing faults. In the seminar it was shown how a relatively low amount of energy in the form of an arc, can start a fire, yet will not trip a circuit breaker or blow a fuse.

For an over current protective device to function, the short circuit or fault has to be at a sufficient current for enough time to be detected. The following family of curves shows the time-current characteristics of a typical fuse:



For a 15 amp. protective device, more than 15 amps of short circuit current is required. The left-most curve is for a 15-amp fuse. For the fuse to open and clear the fault it requires a 100 amp short for 1 second, an 80 amp short for 10 seconds, or a 20 amp short for over 1000 seconds. An arcing circuit can be producing very hot copper globules flying in all directions for a long time and not open the fuse.

The following curves show the characteristic for a 20A Circuit Breaker. Here the manufacturer has defined the operation within the bounds of the leftmost two curves. Similar to the fuse example above, a lot of unprotected region remains on the left of the breaker characteristic.



The moral of this story is that overcurrent protection primarily protects against overloads and large short circuits. No matter how good an overcurrent protection system is, it will not always work. Most short circuits tend to progress into a phase-to-ground fault. To date, ground fault protection has been the only system that would provide any additional protection.

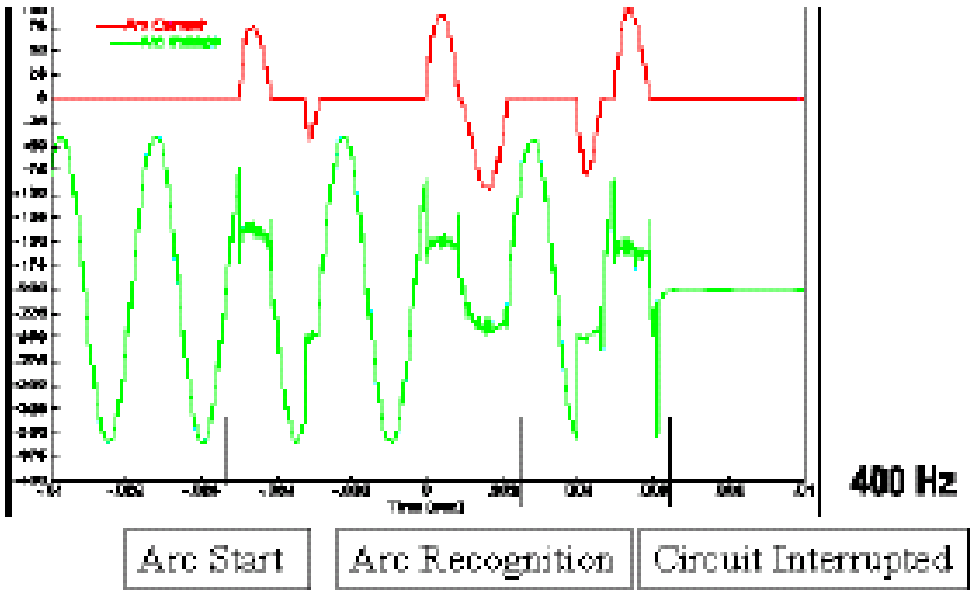
A new device, the AFCI, has recently been introduced and is required for bedroom circuits per the National Electrical Code. If this device proves out to operate as advertised, it will greatly eliminate fires caused by faulty electrical equipment. Initially, for the next few years, the AFCI is only available in a 15 or 20 amp rating.

Arc Fault vs. Ground Fault

The Ground Fault Circuit Interrupter (GFCI) protects people from potentially lethal electric shock when the GFCI detects even minute, but potentially dangerous ground faults or "leaks" of electrical current from a circuit. A GFCI opens the circuit when the leakage to ground exceeds 6mA. And a GFCI is a good detector of phase-to-ground arcing faults, but is unable to detect series or line to neutral arcing faults. An AFCI is designed to detect series faults, line to neutral faults and line to ground faults. The AFCI does not replace the GFCI but instead complements it. Some manufacturers will combine the two in the same unit. The technology in the AFCI is quite different and is substantially more sophisticated than the GFCI.

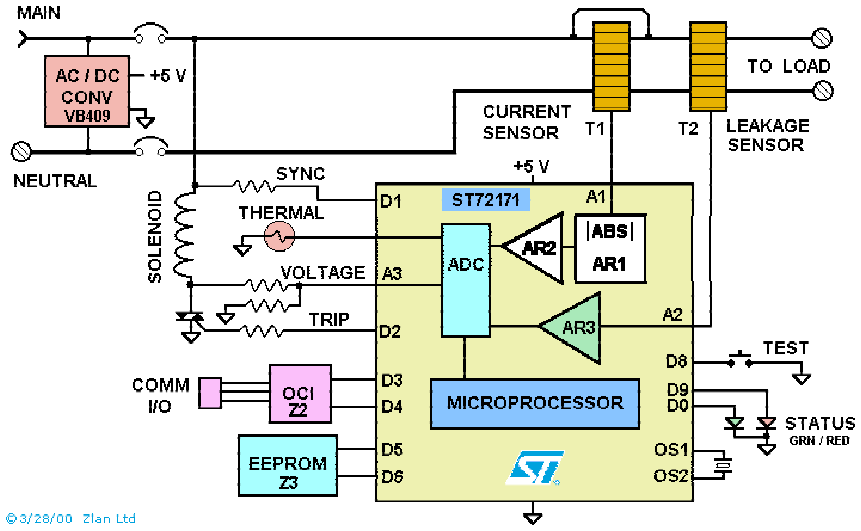
How Do They Work?

Through research on many types of load devices and arc fault conditions a current signature has been developed that distinguishes the difference between arc faults and normal switch transients produced by many common electrical devices. The development of a workable signature was difficult. The following reference shows the effects of a number of types of switching transients produced by common devices; http://www.zlan.com/. Based upon research a signature was developed. The **Green** trace represents the **fault current** and the **Red** trace represents the **detected arc current.**



This characteristic is modeled using a microprocessor that is embedded into the AFCI device. Sensors are used to feedback information about the leakage and current to the microprocessor so that once the ARC conditions are recognized, the circuit can be interrupted. An example circuit is shown below:

Arc Fault Detection Technology



Specifications

	UL Specification	Square D device
Parallel arcing fault – hot to neutral	75 Amps RMS	50 Amps Peak
Hot to ground arcing fault	5 Amps RMS	30 mA RMS

Does It Work?

A lot of people were very skeptical about the device and there was a movement forming to remove the AFCI requirement from the National Electrical Code. After many discussions and many articles published on the Internet the consensus is that the device actually does work. It is not completely fool proof and it will not prevent all electrical fires but it is a giant step forward.

National Electrical Code

The NEC began to require the use of AFCIs with the 1999 edition and expanded the requirements in the 2002 edition. The NEC requires the installation of AFCI devices for all 15 and 20 Amp, (125v or less), bedroom circuits in dwelling units.

Why the bedrooms? Many fire deaths are the result of bedroom fires where the person either never awakens or the fire is already well involved and the person is trapped. Thus, the bedroom is the most hazardous room. In the future, it is expected that AFCIs will be required throughout dwelling units. It is highly recommended that AFCIs are used to replace almost all Circuit Breakers in a house.

References:

IEEE Transactions On Industrial Applications, 9/98 “The Arc-Fault Circuit Interrupter: An Emerging Product.

http://www.cpsc.gov/cpscpub/pubs/afci.html

http://www.cpsc.gov/CPSCPUB/PUBS/afcifac8.pdf

http://www.hq.usace.army.mil/cemp/e/Et/arcfault.pdf

http://www.pyrogen.com/arcfaultsae99.pdf