2-Pole Combination Type AFCIs in residential applications

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Application
Beginning in the 2008 National Electric Code (NEC), installations are required to have Combination Type AFCI protection on "all 120-volt, single phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas..." This has been interpreted by most Authorities Having Jurisdiction (AHJ) to include all living spaces (often defined by areas supplied with heating and air conditioning) that do not require GFCI protection, as defined by NEC Section 210.8. Combination Type AFCI's standards are maintained by Underwriters Laboratories standard 1699.

Multi-wire branch circuits
NEC 210.4 defines multi-wire branch circuits as circuits that "consists of two or more ungrounded conductors that have a voltage between them, and a grounded conductor that has an equal voltage between it and each ungrounded conductor of the circuit, and that is connected to the neutral or grounded conductor of the system." This section of code further requires that the conductors of these circuits must originate from the same panel. These circuits can supply only line-to-neutral loads. Beginning in the 2011 NEC, 200.4 specifically prohibits installation of ungrounded conductors on the same phase (i.e. no voltage between them), to share a neutral.

2-Pole Combination Type AFCI Device details
The Siemens Combination Type 2-Pole AFCI meets or exceeds all requirements of AFCI circuit breakers required by the 2008 NEC. They are UL 1699 listed. The device is designed for two 120V circuits, with common trip. By design, the two phases of a Siemens 2-Pole Combination Type AFCI are on opposite phases, and therefore meet the requirement put forth in NEC 2011, Section 200.4. Like a single pole Combination Type AFCI, the 2-pole Combination Type AFCI comes with a 16" coiled ("pigtail") neutral connection, that is terminated at the neutral bar inside the load center. This wire may be cut to length as needed for a neat installation. The available products are detailed in the table below.

Wire selection
The largest changes for contractors wiring multi-wire branch circuits are in the number of conductors used in the homerun cable, and in making up a home run connection (to be discussed later). In a typical dedicated neutral circuit, installers use two conductor cable, which includes two insulated conductors, color-coded for line and neutral, and a bare ground wire. In a multi-wire branch circuit, installers use three insulated conductor cable, color coded for each phase of line voltage and a neutral, and a bare copper ground wire. In each type of cable, the ground wire is not counted when determining the number of conductors. Typically type NM-B (non-metallic sheathed) cable is used, which is designed for exposed and concealed installations below 90°C. For residential applications, 15A circuits use 14AWG wire, and 20A circuits use 12AWG wire. The type and gauge of wire are specified when selecting wire. For example, when wiring a 15A multi-wire branch circuit, installers should select a 14-3 NM-B cable, indicating 14AWG, three conductor, NM-B rated cable.

Catalog no.	Amperage	Number of poles	Voltage rating
Q215AFC	15 A	2	Two 120 circuits w/ common trip
Q220AFC	20A	2	Two 120 circuits w/ common trip

White Paper

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Wiring practice

In a dedicated neutral AFCI circuit, the line conductor is run from the breaker to the first junction box, where it is connected with the loads on the circuit. The neutral return path from this junction box lands on the neutral connection on the breaker, and the "pig tail" neutral connection is wired to the neutral bar in the load center. This neutral connection can be cut to the required length for a neat installation. The grounding wire from the junction box is run to the ground bar in the load center.

A multi wire branch circuit is very similar except that both line conductors are running in the same cable and they share a neutral connection. Each phase is attached to a phase lug on the breaker, and the neutral conductor to the neutral connection. Again, the neutral "pig tail" connects to the grounding bar, and can be cut to length. In this scenario, the junction box referred to above is where the two branches of the multi-wire circuit split. From this junction, each phase is wired with two conductor cable (A), with the neutral return path of each phase joined together in the junction box described above (B). If the junction box used for this homerun connection is also used for a load (switch, receptacle, etc.), the necessary taps should be left accessible (C) as shown in Figure 1.

Figure 1: Multi-wire branch circuit junction box with load connections accessible

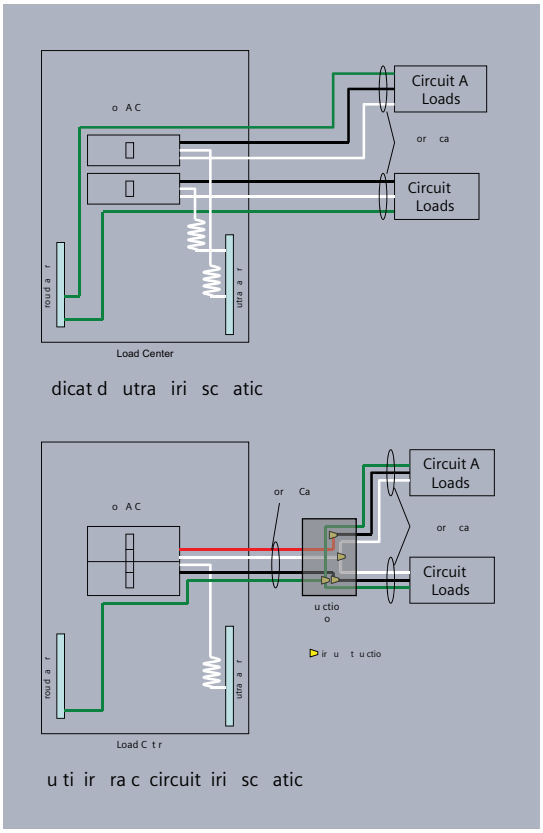

Figure 2: Example wiring schematics for dedicated neutral circuits and multi-wire branch circuits

Troubleshooting
Siemens has published a comprehensive paper on troubleshooting AFCIs. This document is available from the Siemens AFCI website (www.usa.siemens.com/afci)

Savings
The major savings on materials when using multi-wire branch circuits comes from the reduced wire usage. This is best illustrated by an example. Assume that two circuits on the opposite end of a home from the panel each have a 50' homerun. In a dedicated neutral wiring scenario, each of these circuits would require 50' of two conductor cable (12-2 NM-B or 14-2 NM-B, depending on amperage). Comparing this 100' of cable (2 x 50') with one 50' run of three conductor cable, contractors see a noticeable difference in cost.

Using example wire costs, the savings per circuit are demonstrated below. Additional savings can be realized in the breaker itself. A 2-Pole Combination Type AFCI costs slightly less in most areas than 2 single pole AFCIs. This savings is usually around $2.00. Depending on the installation, an additional junction box may be required, but will not be included in this example. Using example wire costs, the savings per circuit are demonstrated below.

Wire type	Cost/1000'	Cost of homerun
14-2 NM-B	$ 250.00	$ 25.00
14-3 NM-B	$ 315.00	$ 15.75
12-2 NM-B	$ 350.00	$ 35.00
12-3 NM-B	$ 455.00	$ 22.75

Savings	15A circuit	20A circuit
Wire	$ 9.25	$ 12.25
Breaker	$ 2.00	$ 2.00
Total	$ 11.25	$ 14.25

These savings are for each pair of circuits combined on a multi-wire branch circuit. In an average home, installers could have several of these installed, resulting in larger total savings. When considered across a large job, such as a condominium or apartment building, or a large development, these savings are multiplied even further, and can easily add up to several thousand dollars over the course of a job.

Depending on wiring practices, installers could see a labor savings as well, because of fewer stud and floor penetrations, and fewer cables to pull. Because wiring practices vary so widely, those savings are not addressed in this document.

Abbreviations
NFPA – Nation Fire Protection Administration
NEC – National Electric Code, published by NFPA
AFCI – Arc Fault Circuit Interrupter
GFCI – Ground Fault Circuit Interrupter
AWG – American Wire Gauge
AHJ – Authority Having Jurisdiction

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