

Applying branch circuit breakers and supplementary protectors in North America



Introduction

Eaton offers three types of miniature circuit breakers for use in North America. The first two versions, FAZ-NA and FAZ-NA-L, fully comply with the molded-case circuit breaker standard UL® 489 and the Canadian equivalent CSA® 22.2 No. 5-02, which states that devices within that range can be applied legitimately as feeder and branch circuit protective devices per the U.S. and Canadian electrical codes.

The third version, FAZ, is recognized per UL 1077 and certified per CSA C22.2 No. 235 as a supplementary protector and can be fully utilized per the National Electrical Code® (NEC®) and the Canadian Electrical Code (CEC) in that capacity. For international purposes, the entire FAZ family is CE marked and in full conformity with the applicable IEC standards for miniature circuit breakers, EN/IEC 60898 and EN/IEC 60947-2.

FAZ, FAZ-NA, and FAZ-NA-L are all offered in various ampere ranges and tripping characteristics. This paper will focus on the main technical aspects of the entire line and should assist in the proper selection and application of all versions.

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Characteristics of IEC-style miniature circuit breakers

Because FAZ miniature circuit breakers are IEC-style devices, it is important to understand their inherent characteristics before examining them in the context of UL/CSA requirements.

- IEC-style miniature circuit breakers are thermal-magnetic, inverse time protective devices, with both a fixed thermal and a fixed magnetic trip setting
- Toggle operated, and like all modern circuit breakers, feature a “trip-free” mechanism, meaning that the tripping action works independently of the handle position for safety purposes
- Mount on a standard 35 mm DIN rail and share a common single-pole width of 17.5 mm
- Most comply with EN/IEC 60898 and EN/IEC 60947-2, which are the relevant international performance and testing standards for low-voltage (<1000 V) circuit breakers in Europe and the rest of the IEC world
- Outside North America, can be used in both residential and industrial applications as feeder and branch circuit protective devices
- In North America, most European miniature circuit breakers are only UL recognized and CSA certified as “supplementary protectors,” meaning they cannot be used as feeder or branch circuit protective devices per the local electrical codes. This commonly restricts their use to applications where “closer” protection is desired than that offered by a branch circuit protection device
- Some variations, like the FAZ-NA and FAZ-NA-L lines have been specially designed to meet UL and CSA requirements for molded-case circuit breakers and are marked accordingly, making them suitable for feeder and branch circuit protection applications in North America

Supplementary protectors

As mentioned, the standard FAZ line fulfills all of the criteria per code of “Supplementary Overcurrent Protective Devices,” or “Supplementary Protectors,” as they are better known.

What is the definition of a supplementary protector per North American standards?

A supplementary protector is a manual reset device designed to open the circuit automatically on a predetermined value of time versus current or voltage within an appliance or other electrical equipment. It may also be provided with manual means for opening or closing the circuit. (Source: UL 1077)

In the U.S. (and similarly in Canada), the NEC further defines supplementary protectors as devices intended to provide limited overcurrent protection for specific applications, such as lighting fixtures and appliances. This limited protection is in addition to the protection provided in the required branch circuit by the branch circuit overcurrent protective device.

Clearly, the underlying message in those definitions is that supplementary protectors are not branch circuit overcurrent protective devices per code, and neither are they tested that way per UL and CSA standards. They cannot replace the primary protective role performed by listed and certified molded-case circuit breakers and fuses.

That explains, in part, their status by UL as “recognized only” devices. Supplementary protectors will never bear a UL listing mark, simply because their suitability as protective devices is dependent on a number of acceptability conditions that can vary from make to make and ultimately define the manner in which they can be properly applied per code. The manufacturer should be consulted in all cases when evaluating the suitability of “recognized only” components such as UL 1077 supplementary protectors.

FAZ protectors are not subject to any specific restrictions in this respect, other than, like all supplementary protectors, they must never be used as a substitute for true listed and certified primary overcurrent protective devices.

Where can supplementary protectors be used effectively per code standards?

Eaton FAZ supplementary protectors can be used in a number of significant areas. To more clearly illustrate potential applications, the following describes the NEC’s definition of a branch circuit:

The circuit conductors between the final overcurrent device protecting the circuit and the outlets. (Source: NEC).

A branch circuit is that portion of the electrical distribution system that extends beyond the final branch circuit overcurrent protective device and is intended to serve lighting, appliance, motors, and/or other individual loads.

Typically, the branch circuit overcurrent protective device (BOPD) will be either a listed molded-case circuit breaker or fuse. Supplementary protectors, such as Eaton FAZ, can therefore be added to any of these branch circuits to “supplement” the branch circuit protection. Examples of applications ideally suited for these devices can include:

- Any type of OEM electrical equipment that is fed from a service panelboard and often requires additional protection for sensitive internal circuitry and components. (Test and medical equipment, copiers and printers, computers, and power supplies etc.)
- The need for manual reset devices with optional accessories such as auxiliary contacts and voltage trips to accomplish fuseless protective circuit designs and enhance operational diagnostics
- Isolation and protection of control cable, coils, contacts, and circuit elements of motor control circuits tapped from the load side of the branch circuit protective device
- Protection of control circuit transformers, especially in the secondary where the manual reset protector can be used to isolate, as well as protect, secondary circuit conductors and loads



“Recognized only” mark from UL

All UL 1077 Supplementary Protectors are recognized only devices. They are subject to Conditions of Acceptability in order to be applied properly per the intent of the Electrical Codes.

Applying branch circuit breakers and supplementary protectors in North America

IEC-based miniature circuit breakers, such as the FAZ, are much more than just conventional supplementary protectors from an internal design point of view and can provide an ideal means to enhance the protective capabilities of any circuit.

The breakers are in full compliance with the pertinent EN/IEC standards (EN/IEC 60898, EN/IEC 60947-2) for miniature circuit breakers and can be applied, outside of North America, as full-fledged standalone overcurrent protective devices in both residential and industrial applications.

As this typical let-through current curve shows, the FAZ circuit breakers are highly current-limiting devices that appreciably limit the amount of let-through current and destructive energy within their ratings to minimize damage levels to downstream loads and circuits.

Circuit breakers that are classified as “current limiting” have the ability to clear damaging short-circuit currents within the first half cycle of the fault, resulting in better overall protection for all circuit components.

Typical let-through curve profile of a current-limiting device

The X axis shows the prospective short-circuit current levels.

The Y axis indicates the actual let-through values (let-through current in the example shown) at those prospective fault ratings for each FAZ device plotted.

As can be interpreted from the bend in the plotted curves, each device acts to limit the damaging let-through energy (and current) at those values of short-circuit current.

By design, all Eaton FAZ supplementary protectors and FAZ-NA and FAZ-NA-L circuit breakers are current-limiting protective devices and come in a variety of tripping characteristics, which is ideal when customizing protection to match specific load requirements. FAZ supplementary protectors offer a total of six different protection tripping characteristics for this purpose: B, C, D, K, S, and Z.

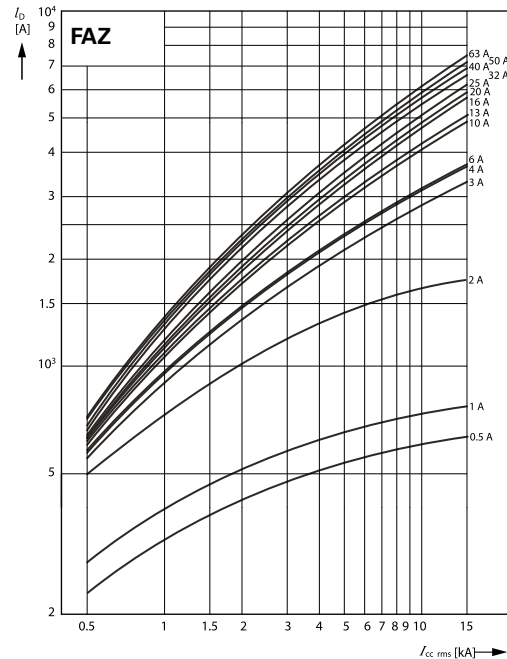
FAZ supplementary protectors feature a number of electrical accessories to enhance the performance and diagnostic capabilities of control panels, as well as a means to facilitate panel mounting and wiring.

Tripping characteristics

Miniature circuit breakers are thermal-magnetic, inverse time tripping devices. From a thermal point of view, all FAZ protectors are calibrated to trip at the same level, which is 135% of the device's fixed current rating for single-pole and 145% for multi-pole at an ambient reference temperature of 40 °C.

Note: Higher ambient temperatures, as well as density of mounting groups, can all be accommodated but may be subject to de-rating factors. Please consult technical data for further information and appropriate curves.

It is the response time of the magnetic trip that differentiates each characteristic and for which an identifying letter is assigned. The IEC 898 standard only specifically covers the B, C, and D characteristics. The rest can vary from brand to brand, but essentially follow a uniform convention.



The following magnetic response times apply to each of the characteristic letters referenced in Eaton FAZ series part numbers:

- B: Instantaneous response between $3\text{--}5 \times I_n$ (I_n = fixed current rating of each unit)—Ideally suited for resistive loads, such as conductors or heaters
- C: Instantaneous response between $5\text{--}10 \times I_n$ —Ideally suited for inductive loads, such as motors and solenoids
- D: Instantaneous response between $10\text{--}20 \times I_n$ —Ideally suited for highly inductive loads, such as lighting and higher efficiency motors
- K: Instantaneous response of $8\text{--}12 \times I_n$ —Ideally suited for highly inductive loads, similar to D but with a narrower range
- S: Instantaneous response of $13\text{--}17 \times I_n$ —Ideally suited for highly inductive loads, especially in control circuits with coils and light filaments
- Z: Instantaneous response of $2\text{--}3 \times I_n$ —very low instantaneous setting to provide tighter protection for loads that are more sensitive to the effects of overcurrents

Typical “inverse time” tripping characteristic of a miniature circuit breaker

- “Inverse time” refers to the device’s tripping characteristic. As the curve shows, the higher the current, the lower the tripping time
- The trip response on the thermal portion is uniform throughout the line
- The instantaneous response differs, depending on the characteristic selected (e.g.; B, C, or D)
- Tripping is very quick (less than a half cycle) in the upper range of overcurrents (bottom right) due to the current-limiting design of the Eaton circuit breakers

FAZ-NA and FAZ-NA-L miniature circuit breakers

Our FAZ line of miniature circuit breakers includes two versions, FAZ-NA and FAZ-NA-L, which are listed and certified as molded-case circuit breakers (UL 489 and CSA No. 5).

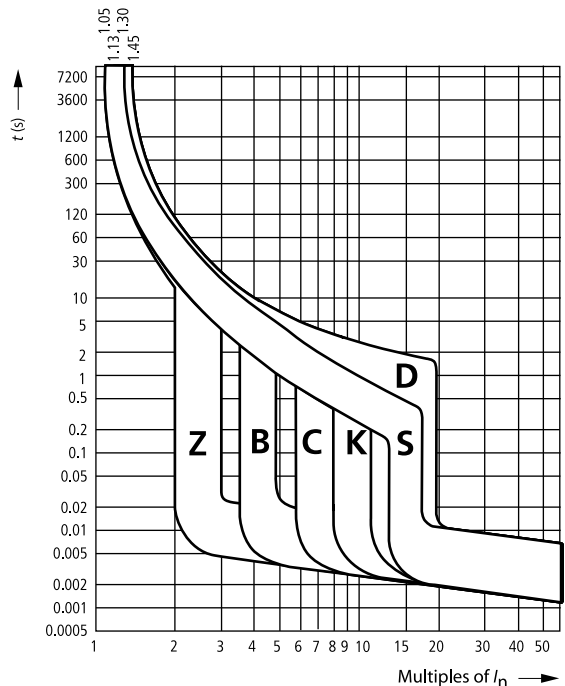
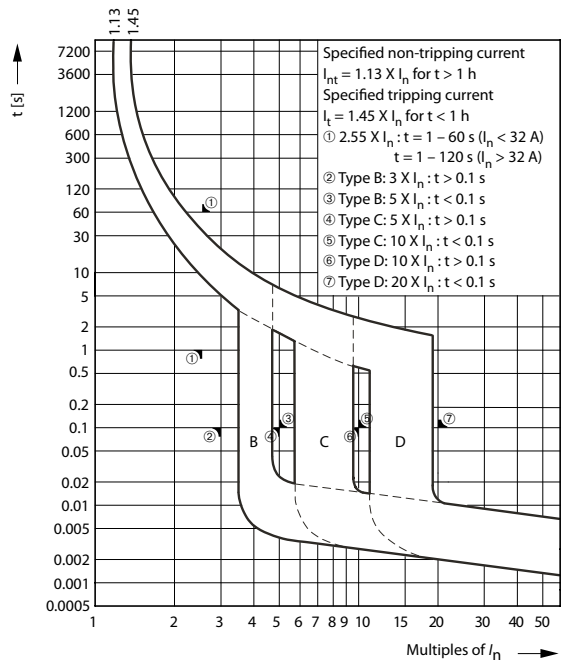
Both FAZ-NA and FAZ-NA-L come in single-, two-, three-, and four-pole versions with instantaneous trip characteristics B, C and D. The distinction between FAZ-NA and FAZ-NA-L is FAZ-NA is rated 277/480 Vac while FAZ-NA-L is rated 240 Vac.

The NEC defines a circuit breaker as follows:

A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

This definition sets circuit breakers apart from any other protective device and establishes their role as primary overcurrent protective switches in all types of electrical circuits. UL listing (and CSA certification) requires additionally that regular testing on circuit breakers be conducted by UL and CSA at the manufacturer’s plant to monitor construction and verify their performance.

Two types of terminals are available for the UL 489 branch circuit breakers: the FAZ-NA and FAZ-NA-L with traditional box terminals for multiple wires, and the FAZ-RT and FAZ-RTL that accommodates ring-tongue terminals.



The advantages of a current-limiting device

As already mentioned, all Eaton series FAZ devices are current limiting by design. In the case of the UL 489 devices, they are also classified by UL/CSA in that manner and are marked on the label.

A circuit breaker that is marked as a current-limiting device is one that does not use a fusible element and, when operating within its current limiting range, limits the let-through energy (I^2t) to less than the energy of a $\frac{1}{2}$ cycle wave of the available symmetrical current.

The label on FAZ-NA devices lists the actual let-through energy ($I^2t = 60$ kA 2 s) and peak let-through current (6.2 kA) at the maximum interrupting rating of 10 kA.

Current-limiting circuit breakers substantially reduce the amount of damage sustained by downstream components in the event of a high short-circuit fault by clearing the fault in the shortest amount of time possible due to the quick separation of its contacts and ensuing extinction of the arc current.

HACR and SWD

FAZ-NA and FAZ-NA-L circuit breakers are also marked “HACR” for use in heating, air conditioning, and refrigeration applications. In addition, the abbreviation “SWD” on the label indicates the devices are suitable for switching fluorescent lighting loads on a regular basis.

Short-circuit markings on FAZ devices

Below is a tabulated summary of short-circuit rating values that apply to the FAZ line of supplementary protectors as well as the FAZ-NA and FAZ-NA-L circuit breakers.

It is important to keep in mind that short-circuit markings on supplementary protectors (UL 1077) and branch circuit breakers (UL 489) must not be interpreted in the same manner.

Supplementary protectors have short-circuit markings in association with upstream primary overcurrent protective devices. Conversely, circuit breakers are primary overcurrent protective devices and their ratings refer to their short-circuit interrupting capability.

Table 1. Product short-circuit rating values chart

FAZ Supplementary protectors (UL 1077)	Trip characteristic	Maximum amperes	Maximum voltage	Short-circuit rating (kA)
Single-pole	B ① and C	0.5–35	277 Vac	10
		40–63	277 Vac	5
		0.5–63	48 Vdc	10
	D	0.5–40	277 Vac	5
			48 Vdc	10
Two-, three-pole	B ① and C	0.5–35	480Y/277 Vac ②	10
		40–63	480Y/277 Vac ②	5
Two-poles in series		6–25	96 Vdc	10
Two-, three-pole	D	0.5–40	480Y/277 Vac ②	5
Two-poles in series			96 Vdc	10
FAZ-NA (RT) branch circuit breakers (UL 489)	Trip characteristic	Maximum amperes	Maximum voltage	Short-circuit interrupting rating (kA)
Single-pole	B ① and C	0.5–32	480Y/277 Vac ②	10
		40–63	240 Vac	10
	D	0.5–32	480Y/277 Vac ②	10
		0.5–40	240 Vac	10
Single-pole	B ① and C	0.5–63	48 Vdc	10
	D	0.5–40	48 Vdc	10
Two-, three-, four-pole	B ① and C	0.5–32	480Y/277 Vac ②	10
		40–63	240 Vac	10
	D	0.5–32	480Y/277 Vac ②	10
		0.5–40	240 Vac	10
Two-pole	B ① and C	0.5–63	96 Vdc	10
	D	0.5–40	96 Vdc	10
FAZ-NA (RT) branch circuit breakers (UL 489)	Trip characteristic	Maximum amperes	Maximum voltage	Short-circuit rating (kA)
Single-pole	B and C	15–25	480Y/277 Vac	14
Two-, three-, four-pole	B and C	15–25	480Y/277 Vac	14
Single-pole	D	13–20	480Y/277 Vac	14
Two-, three-, four-pole	D	13–20	480Y/277 Vac	14
FAZ-NA-DC branch circuit breakers (UL 489)	Trip characteristic	Maximum amperes	Maximum voltage	Short-circuit interrupting rating (kA)
Single-pole	C	2–40	125 Vdc	10
Two-poles in series	C	2–40	250 Vdc	10
FAZ-NA-L (RT-L) branch circuit breakers (UL 489)	Trip characteristic	Maximum amperes	Maximum voltage	Short-circuit rating (kA)
Single-pole	B ① and C	0.5–63	240 Vac	10
	D	0.5–40	240 Vac	10
Two-, three-, four-pole	B ① and C	0.5–63	240 Vac	10
	D	0.5–40	240 Vac	10
Single-pole	B and C	15–25	240 Vac	14
Two-, three-, four-pole	B and C	15–25	240 Vac	14
Single-pole	D	13–20	240 Vac	14
Two-, three-, four-pole	D	13–20	240 Vac	14

① Supplementary protectors and branch circuit breakers with trip characteristic B start at 1 A.

② A circuit breaker with a 480Y/277 Vac rating can be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower value of the circuit breaker’s rating (e.g.: 277 Vac) and the nominal voltage between any two conductors does not exceed its higher value (480 Vac).

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Printed in USA
Publication No. AP01102006E / Z20389
February 2018