Molded-Case Circuit Breakers & Enclosures

Contents

Specifications

See Eaton's *Product Specification Guide*, available on CD or on the Web.

CSI Format:	1995	2010
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Molded-Case Circuit Breakers

Summary of Differences Between Low Voltage Power Circuit Breakers, Insulated-Case Circuit Breakers and Molded-Case Circuit Breakers

There are two main classifications of low voltage circuit breakers—molded-case circuit breakers and low voltage power circuit breakers. All UL®, NEMA® and ANSI standards are for molded-case circuit breakers and low voltage power circuit breakers.

The industry recognizes three types of circuit breakers—molded-case circuit breakers (MCCB), insulated-case circuit breakers (ICCB) and low voltage power circuit breakers LVPCB). Insulated-case circuit breakers are designed to meet the standards for molded-case circuit breakers.

Low voltage power circuit breakers comply with the following standards:

- ANSI Std. C37.16—Preferred Ratings
- ANSI Std. C37.17—Trip Devices for LVPCB
- ANSI Std. C37.50—Test Procedures
- IEEE® Std. C37.13—LVPCB Used in Enclosures
- UL 1066—LVPCB

Molded-case circuit breakers and insulated-case circuit breakers typically comply with the following standards:

- UL 489—MCCB
- UL 489—Molded-Case Switches (MCS)
- NEMA AB1—MCCB and MCS
- NEMA AB3—MCCB Application

Table 27.0-1. Breaker Type Comparison Chart

Description	LVPCB (Type Magnum DS® and Series NRX™)	ICCB (Type Magnum SB and Series NRX)	MCCB (QUICKLAG/Series C®/Series G®)
Select trip short-time rating	Selective trip over full range of fault currents up to interrupting rating (high short-time ratings)	Selective trip over partial range of fault currents within the interrupting rating (medium short-time ratings). Typically up to 35 kA	Selective trip over a smaller range of fault currents within the interrupting rating (low short-time ratings). Typically 10–13 times the frame size
Operator type	Types of operators: mechanically operated and electrically operated two-step stored energy	Types of operators: mechanically operated and electrically operated two-step stored energy	Types of operators: mechanically operated over-center toggle or motor operator
Closing speed	5-cycle closing for electrically operated devices	5-cycle closing for electrically operated devices	Greater than 5-cycle closing for electrically operated devices
Mounting	Available in drawout construction permitting racking to a distinct “test position” and removal for maintenance	Available in drawout construction permitting racking to a distinct “test position” and removal for maintenance	Typically fixed-mounted but large frame sizes may be available in drawout construction
Interrupting rating	Interrupting duty at 635 Vac: 42–100 kA and current limiting with or without fuses up to 200 kA	Interrupting duty at 508 Vac: 35–150 kA	Interrupting duty at 480 Vac: 22–100 kA without fuses and up to 200 kA with integral fuses or for current-limiting type
Current limiting	Special current limiting types available with or without fuses up to 200 kA	Special current limiting types available without fuses up to 150 kA	Current limiting available with and without fuses up to 200 kA
Relative cost	Higher	Medium	Low
Available frame sizes	Small number of frame sizes available. Typical 800–6000 A	Small number of frame sizes available. Typical 800–6000 A	Large number of frame sizes available. Typical 100–2500 A
Maintenance	Extensive maintenance possible on all frame sizes	Limited maintenance possible on larger frame sizes	Very limited maintenance possible on larger frame sizes
Enclosure types	Used in enclosures, MCCs, switchboards and switchgear	Used in enclosures, MCCs and switchboards	Used in enclosures, panelboards, switchboards, MCCs and control panels
Series ratings	Not available in series ratings	Not available in series ratings	Available in series ratings
Enclosed rating	100% continuous current rated in its enclosure	80% continuous-current rated, unless specifically stated to be rated 100% in an enclosure	80% continuous-current rated, unless specifically stated to be rated 100% in an enclosure
Standards	ANSI/IEEE C37 UL 1066	NEMA AB1/AB3 UL 489 or UL 1066	NEMA AB1/AB3 UL 489

Molded-Case Circuit Breakers

Series G

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General Description

General Circuit Breaker Information

Eaton's molded-case circuit breakers are designed to provide circuit protection for low voltage distribution systems. They are described by NEMA as, ". . . a device for closing and interrupting a circuit between separable contacts under both normal and abnormal conditions," and furthermore as, ". . . a breaker assembled as an integral unit in a supporting and enclosing housing of insulating material." The NEC® describes them as, "A device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined overload of current, without injury to itself when properly applied within its rating."

So designed, Eaton circuit breakers protect conductors against overloads and conductors and connected apparatus, such as motors and motor starters, against short circuits.

Circuit Breaker Components and Functions

Being essentially high interrupting capacity switches with repetitive elements, Eaton circuit breakers are comprised of three main functional components. These are:

1. Trip elements (thermal-magnetic or electronic)
2. Operating mechanism
3. Arc extinguishers

1. Trip Elements

The function of the trip element is to trip the operating mechanism in the event of a prolonged overload or short-circuit current. To accomplish this, a thermal-magnetic trip action is provided.

Thermal-Magnetic Breakers

Eaton thermal-magnetic breakers are general purpose devices suitable for the majority of breaker applications and are considered the industry standard. Available from 15–800 A, thermal-magnetic breakers provide accurate reliable overload and short-circuit protection for conductors and connected apparatus.

Thermal trip action is achieved through the use of a bimetal heated by the load current. On a sustained overload, the bimetal will deflect, causing the operating mechanism to trip. Because bimetals are responsive to the heat emitted by the current flow, they allow a long-time delay on light overloads, yet they have a fast response on heavier overloads.

Magnetic trip action is achieved through the use of an electromagnet in series with the load current. This provides an instantaneous tripping action when the current reaches a predetermined value. Front-adjustable magnetic trip elements are supplied as standard on 250 A frame circuit breakers and above (except 100 A and 150 A magnetic only breakers), all other thermal-magnetic breakers have non-adjustable magnetic trip elements.

Electronic RMS Trip Breakers

Eaton electronic trip breakers are generally applied for applications where high levels of system coordination are called for. Available from 20–2500 A, today's electronic trip breakers can provide superior protection and coordination as well as system alarms and diagnostics, monitoring and communications.

Both the overload trip action and the short-circuit trip action of breakers with Digitrip electronic trip units are achieved by the use of current transformers and solid-state circuitry that monitors the current and initiates tripping through a flux shunt trip when an overload or a short circuit is present. All multiple-pole circuit breakers have trip elements in each pole and a common trip bar. An abnormal circuit condition in any one pole will cause all poles to open simultaneously.

Electronic RMS trip breakers can include trip features such as:

- Adjustable long-time pickup
- Adjustable short-time pickup
- Adjustable long delay time
- Adjustable short delay time
- Adjustable instantaneous pickup
- Adjustable ground fault pickup
- Adjustable ground fault delay time
- Zone selective interlocking
- Communications

Trip unit adjustments are made by setting switches on the front of the trip unit or by programming the trip unit electronically.

All electronic RMS trip breakers are equipped with a manual push-to-trip mechanism.

2. Operating Mechanism

The function of the operating mechanism is to provide a means of opening and closing the breaker contacts. All mechanisms are of the quick-make, quick-break type and are "trip free." "Trip free" mechanisms are designed so that the contacts cannot be held closed against an abnormal circuit condition and are sometimes referred to as an "overcenter toggle mechanism." In addition to indicating whether the breaker is "on" or "off," the operating mechanism handle indicates when the breaker is "tripped" by moving to a position midway between the extremes. This distinct trip point is particularly advantageous where breakers are grouped, as in panelboard applications, because it clearly indicates the faulty circuit. The operating mechanism contains a positive on feature. In the normal switching operation, the handle of the circuit breaker will not be capable of being left readily at or near the off position when the main contacts are closed.

3. Arc Extinguishers

The function of the DE-ION® arc extinguisher is to confine, divide and extinguish the arc drawn between opening breaker contacts. It consists of specially shaped steel grids isolated from each other and supported by an insulating housing. When the contacts are opened, the arc drawn induces a magnetic field in the grids, which in turn draws the arc from the contacts and into the grids. The arc is thus split into a series of smaller arcs and the heat generated is quickly dissipated through the metal. These two actions result in a rapid removal of ions from the arc, which hastens dielectric build-up between the contacts and results in rapid extinction of the arc.

Electronic RMS Trip Unit

General

Eaton offers the most comprehensive range of electronic trip units in the industry for molded-case circuit breakers. All electronic trip units are rms sensing and can be applied from 70 A up through 2500 A. Eaton offers electronic trip units as standard for circuit breakers rated above 800 A, and offers electronic trip units as optional for circuit breakers 70 A up through 800 A.

Digitrip electronic trip units are AC devices that employ microprocessor-based technology that provides a true rms current sensing means for proper correlation with thermal characteristics of conductors and equipment. The primary function of the Digitrip electronic trip unit is to provide circuit protection. This is achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker shunt trip when pre-set current levels and time delay settings are exceeded. All Eaton electronic trip units use a high effective sampling rate to maintain measurement accuracy, monitoring, and protection with nonlinear loads having harmonic content up to the 27th order.

Electronic trip units are applied to distribution systems when high standards of protection and coordination are called for. In addition, electronic trip units can provide further enhanced features such as alarming, diagnostics, system monitoring and communications.

Eaton RMS sensing trip units fall into two main categories:

- Front adjustable trip units (Digitrip™ RMS 310, 310+, 510, 610, 810 and 910)
- Programmable trip units (Digitrip OPTIM™ 550 and 1050)

Front-Adjustable Trip Units

Front-adjustable trip units are electronic trip units that have up to nine time-current setting options that are set by switches mounted on the front of the trip unit. The application for front adjustable trip units would be distribution systems that can be coordinated within the range of settings available and that do not require sophisticated coordination strategies to be applied down through the distribution system to small rated breakers.

Programmable Trip Units (OPTIM)

Programmable trip units are electronic trip units that have up to 10 time-current setting options that are programmed electronically by the use of a programming device. The application for programmable trip units would be high integrity distribution systems that require superior levels of system coordination coupled with system alarming, diagnostics and monitoring.

Rating Plugs

Rating plugs provide a means to establish the breaker's continuous current rating. Rating plugs are color-coded and interchangeable to make it easy to match the correct rating plug with the correct trip unit. The same rating plug can be applied to both 50 and 60 Hz distribution systems. Some rating plugs are fixed and some have an adjustable range of amperage values for greater flexibility. Digitrip 310, 510, 610, 810 and 910 trip units can be supplied with either a fixed or adjustable rating plug. Digitrip 310+ trip units are equipped with adjustable rating plugs. OPTIM style trip units are furnished with fixed rating plugs but have a programmable Long Time Pickup rating to allow application over a range of amperage values.

Cause of Trip Indication

All OPTIM and Digitrip 510, 610, 810 and 910 trip units include Cause-of-Trip indication LEDs. Breakers using the RMS 310+ electronic trip unit have the ability to output cause-of-trip information through the test port. The Cause-of-Trip LED module provides trip information via LED indication. The Digiview and Panelmount Digiview can be installed in the RMS 310+ test port to provide both cause-of-trip information and phase current through an LCD display.

Cause-of-Trip LED Module *Digiview*

Table 27.1-1. The Digitrip Family of Low Voltage Electronic Trip Units

RMS 310	RMS 310+	RMS 510	OPTIM 550	RMS 610	RMS 810	RMS 910	OPTIM 1050
							
rms sensing — 5 functions — Front adjustable	rms sensing — 6 functions — Front adjustable — Optional display for diagnostics and load monitoring — Zone selective interlocking — Optional Arcflash Reduction Maintenance System™	rms sensing — 9 functions — Front adjustable — Zone selective interlocking — Diagnostics	rms sensing — 10 functions — Programmable — Load monitoring — Diagnostics — Zone selective interlocking ① — Communications ①	rms sensing — 9 functions — Front adjustable — Zone selective interlocking — Load monitoring — Diagnostics	rms sensing — 9 functions — Front adjustable — Zone selective interlocking — Load monitoring — Diagnostics — Communications — Power and energy monitoring	rms sensing — 9 functions — Front adjustable — Zone selective interlocking — Load monitoring — Diagnostics — Communications — Power and energy monitoring — Harmonics	rms sensing — 10 functions — Programmable — Zone selective interlocking — Load monitoring — Diagnostics — Communications — Power and energy monitoring — Harmonics

① Optional features.

Additional Protection Features

Discriminator/Making Current Release

Eaton's Digitrip RMS electronic trip units are designed and built with safety and reliability in mind, both to protect the user and the equipment, as well as to make sure the trip functions within its design parameters. By providing a discriminator circuit to Digitrip RMS 510, 610, 810 and 910 trip units, as well as to Digitrip OPTIM 550 and 1050 trip units that do not have an instantaneous setting, the user is protected should a faulted circuit exist. The discriminator (or making current releases as it is often called) is set at 11 times the rating plug ampere rating and is enabled for approximately the first 10 cycles of current flow. Should a fault condition exist, the breaker will trip with no intentional time delay on closing, protecting the user from a potentially unsafe condition.

Instantaneous Override

In addition to a discriminator, an instantaneous override is present in all molded-case and insulated-case circuit breakers to provide additional protection for the breaker. The instantaneous override is factory set nominally just below the breaker withstand rating.

Trip Unit Overtemperature

Digitrip electronic trip units can operate reliably in ambient temperatures that range from –20 °C to +85 °C. In the unlikely event that temperatures exceed this ambient, the trip unit has a built-in overtemperature trip to protect the trip unit should the temperature exceed these design parameters.

Thermal Memory

Digitrip RMS and Digitrip OPTIM electronic trip units incorporate powered thermal memory, i.e., the units remember recent overcurrent events that may have initiated the trip timing sequence, and then returned to nominal levels, halting the sequence prior to trip initiation. In the event that the current levels again exceed the pickup set point within a few cycles of the original pickup, the unit's memory recalls the previous near trip and automatically imposes a shorter delay time. In effect, the unit treats multiple time-related events as a single continuous event thereby preventing system damage due to cumulative overheating.

As a further enhancement, the trip units incorporate an unpowered thermal memory feature. In the event that current levels cause the breaker to trip and the breaker is immediately reclosed, the trip unit remembers the previous overcurrent trip and again imposes a shorter delay time should an additional overcurrent occur before a sufficient cooldown period has elapsed.

Thermal memory protects the distribution system from cumulative overheating caused by repeated over-current conditions. OPTIM trip units allow this to be turned ON or OFF.

System Alarms

Digitrip RMS 610, 810 and 910 electronic trip units incorporate a high load alarm capability. Set at 85% of I_r, the alarm will be initiated once the load current exceeds 85% for 40 seconds. Once this occurs, the HILD message will flash in the display window and the power/relay module will operate to send a remote signal.

Digitrip OPTIM electronic trip units also offer a high load alarm capability but with more flexibility. OPTIM trip units have a high load alarm that can be programmed to operate between 50% and 100% of I_r.

Digitrip OPTIM electronic trip units incorporate a ground fault alarm capability. Settings available for ground fault alarm are the same as for ground fault trip. Once a ground fault alarm occurs, both local and remote signal indication is available (OPTIM 550 is remote only).

System Diagnostics

Whenever a circuit breaker trips, it is normally imperative that the cause of trip be determined quickly, the faulty conditions rectified, and the breaker put back into service. Digitrip RMS 510, 610, 810 and 910, and Digitrip OPTIM electronic trip units incorporate a complete package of systems diagnostics to meet this challenge.

Four cause-of-trip LEDs are embedded in the front of the trip unit case, indicating that the cause-of-trip was either a long delay, short delay, instantaneous or ground fault. Remote signal indication for cause of trip as well as magnitude of trip information is also available.

Breakers using the RMS 310+ electronic trip unit have the ability to output cause-of-trip information through the test port. The Cause-of-Trip LED module provides trip information via LED indication. The Digiview and Panelmount Digiview can be installed to provide both cause-of-trip information and phase current through an LCD display.

Systems Monitoring

Digitrip RMS and Digitrip OPTIM electronic trip units offer a complete menu of monitoring capability to include current, power and energy, power factor, power quality harmonics, and other related parameters with a high level of accuracy.

Digital Display

Digitrip RMS 610, 810 and 910 have a large, easy-to-read four-digit alpha-numeric display mounted on the trip unit. The display is supported by LEDs that indicate which parameter is being displayed along with the unit the value is displayed in, e.g., kA and so on.

Current Monitoring

Digitrip RMS 610, 810 and 910 trip units are capable of monitoring currents in individual phases (A, B, C) as well as ground currents. Digitrip OPTIM 550 and 1050 trip units are capable of monitoring currents in individual phases (A, B, C) as well as neutral and ground currents.

Values are displayed in the digital display window in kA. Accuracy of the current monitored values is ±2% of full scale sensor rating.

Breakers using the Digitrip 310+ electronic trip unit have the ability to output phase current monitoring information through the test port. The Digiview or Panelmount Digiview can be installed to provide phase current through an LCD display.

For current and voltage monitoring with 0.5% accuracy of reading that can be used with thermal-magnetic or electronic trip units, refer to the Power Monitoring/Metering Module (PM3) on **Page 27.4-41**.

Power and Energy Monitoring

For the trip unit to calculate true power and energy values, a Potential Transformer Module (PTM) is required. This PTM is mounted internally (R-Frame and larger) or externally (N-Frame or smaller) to the breaker, and provides voltage to the trip unit.

Digitrip RMS 810 and 910 trip units are capable of monitoring peak power demand, present power demand, and reverse power flow in MW. Additionally, both forward and reverse energy consumption in MWh can be monitored. Digitrip OPTIM 1050 trip units can also monitor the same power and energy parameters, but the units are displayed in kW and kWh.

The accuracy of power monitored values is ±4% of full scale sensor/frame rating.

The accuracy of energy monitored values is ±5% of full scale sensor/frame rating.

Both the RMS 910 and OPTIM 1050 report power factor. Digitrip RMS 910 trip units have the additional capability of monitoring line-to-line voltage.

For Real Power and Reactive Power monitoring with ANSI C12.1 revenue class accuracy that can be used with thermal-magnetic or electronic trip units, refer to the Power Monitoring/Metering Module (PM3) on **Page 27.4-41**.

Harmonics Monitoring

Digitrip RMS 910 and Digitrip OPTIM 1050 trip units are capable of monitoring values of current harmonics. Percentage of total harmonic content can be monitored for each level of harmonic content up to the 27th harmonic. Additionally, a total harmonic distortion (THD) value can be calculated and displayed providing the user with total system current harmonic monitoring capability.

Time-Current Curve Shaping

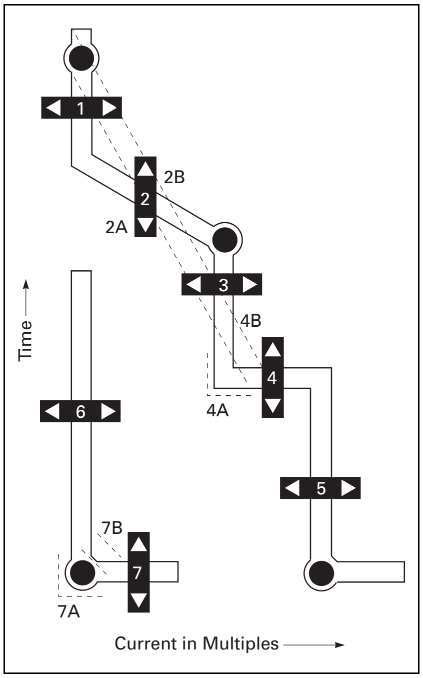


Figure 27.1-1. Time-Current Curve Shaping

Note: See selection guide charts for availability of adjustments.

Long Delay (L)

1. Long Delay Pickup
Determines the continuous ampere rating of the breaker.
2. Long Delay Time
Determines the amount of time the breaker will carry a low level overload before tripping.
   a. I^2t Response
   I^2t in: For coordination with other circuit breakers with electronic trip devices and for coordination with thermal-magnetic circuit breakers.
   b. I^4t Response
   I^4t in: For coordination with fuses and upstream transformer damage curves.

Short Delay (S)

3. Short Delay Pickup
Determines or sets the level of fault current at which the short-time trip delay countdown is actuated.
4. Short Delay
Sets the amount of time the breaker will carry both a low level and high fault currents before tripping.
   a. Flat Response
   I^2t out: For coordination with other circuit breakers with electronic trip devices.
   b. I^2t Response
   I^2t in: For coordination with fuses and thermal-magnetic breakers.

Instantaneous (I)

5. Instantaneous Pickup
Determines the level of fault current that will actuate a trip with no time delay.

Ground Fault (G)

6. Ground Fault Pickup
Determines the level of fault current at which the ground fault trip delay countdown is actuated.
7. Ground Fault Delay
Determines the amount of time the breaker will carry a ground fault before tripping.
   a. Flat Response
   I^2t out: For coordination with other circuit breakers with electronic ground fault settings.
   b. I^2t Response
   I^2t in: For coordination with zero sequence ground fault relays, fuses and thermal-magnetic breakers.

Curve Shaping

Eaton Digitrip RMS 310 trip units are available with up to five phase and ground adjustments on the front of the trip unit. Digitrip RMS 310+ trip units are available with up to six phase and ground adjustments on the front of the trip unit. Selective system coordination with both upstream and downstream devices can be achieved to provide an economic solution for less sophisticated distribution systems.

For more sophisticated selective coordination systems Digitrip RMS 510, 610, 810 and 910 trip units are available with up to nine curve shaping choices via switches on the front of the unit. Curve shaping flexibility is provided by dependent long and short delay adjustments that are based on continuous amperes (I_r) selection.

Digitrip OPTIM 550 and 1050 trip units offer programmable curve shaping via 10 curve shaping choices that are programmed electronically into the trip unit. OPTIM also offers virtual infinite settings to allow the user to optimize coordination for a selectively coordinated distribution system. In addition, time-current set points can be downloaded via a communication system from a central personal computer. Digitrip OPTIM is normally applied to systems where system integrity is very important.

Zone Selective Interlocking

Zone selective interlocking capabilities are available with Digitrip RMS 310+ 510, 610, 810 and 910 trip units as well as Digitrip OPTIM 550 and 1050 trip units.

Note: Optional accessory on the OPTIM 550.

Zone selective interlocking provides increased system protection and can reduce arc flash risk by allowing the breaker closest to the fault to trip without any preset time delays. This is achieved by setting up the distribution system as shown in **Figure 27.1-2**. The hardwired connection between the trip units sends a restraining signal upstream, allowing the breaker closest to the fault to act instantaneously. Zone selective interlocking reduces stress on the distribution system and can reduce arc flash risk by isolating faults without time delays.

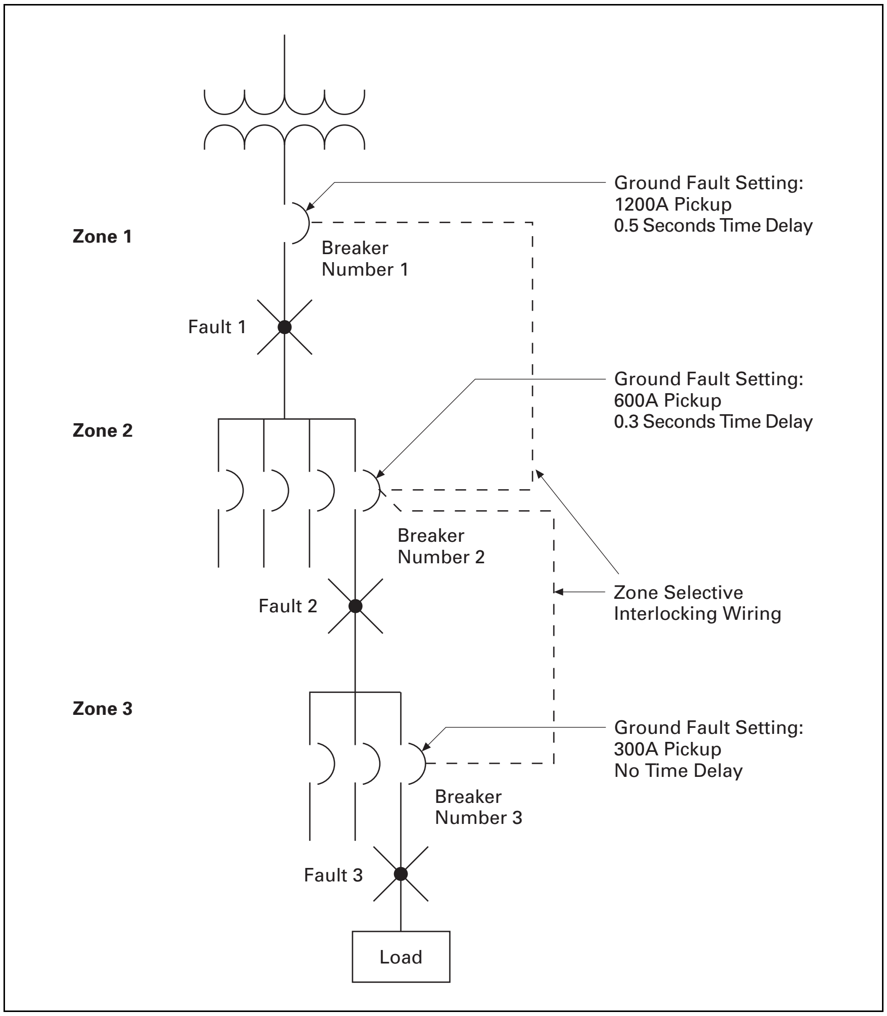


Figure 27.1-2. Zone Selective Interlocking

Fault 1

There are no interlocking signals. The main breaker trip unit will initiate the trip instantaneously.

Fault 2

The feeder breaker trip unit will initiate the trip instantaneously to clear the fault; and Zone 2 will send an interlocking signal to the Zone 1 trip unit. The Zone 1 trip unit will begin to time out, and in the event that the feeder breaker in Zone 2 would not clear the fault, the main breaker in Zone 1 will clear the fault in 0.5 seconds.

Fault 3

The branch breaker trip unit will initiate the trip instantaneously to clear the fault; and Zone 3 will send an interlocking signal to the Zone 2 trip unit; and Zone 2 will send an interlocking signal to Zone 1.

Zone 1 and Zone 2 trip units will begin to time out, and in the event that the branch breaker in Zone 3 would not clear the fault, the feeder breaker in Zone 2 will clear the fault in 0.3 seconds. Similarly, in the event that the feeder breaker in Zone 2 would not clear the fault, the main breaker in Zone 1 will clear the fault in 0.5 seconds.

Internal Accessories

Note: For a complete listing of available external accessories, see Volume 4—Circuit Protection Catalog, CA08100005E, Section 25.

All internal accessories are of the plug-in type and are listed for field installation under UL File E64983. Internal accessories for sealed circuit breakers are listed under UL File E7819 for factory installation only. The available plug-in accessories include the following:

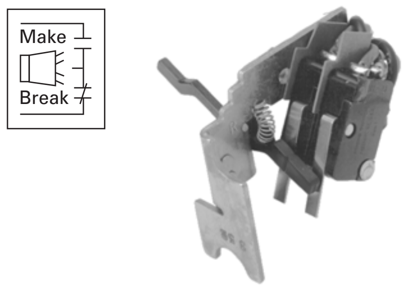
- Alarm (signal)/lockout switch
- Auxiliary switch
- Shunt trip
- Low energy shunt trip
- Undervoltage release mechanism

Typical Internal Plug-in Accessory Installed in K-Frame Circuit Breaker

Different accessory wiring options are available to satisfy most circuit breaker mounting applications. The standard wiring configuration is pigtail leads exiting the rear of the base directly behind the accessory. Optional configurations include a terminal block mounted on the same side of the base as the accessory, leads exiting the side of the base where the accessory is mounted, and leads exiting the rear of the base on the side opposite the accessory. If accessory leads longer than 18.00 inches (457.2 mm) are required, side-mounted terminal blocks should be used.

Alarm (Signal)/Lockout Switch

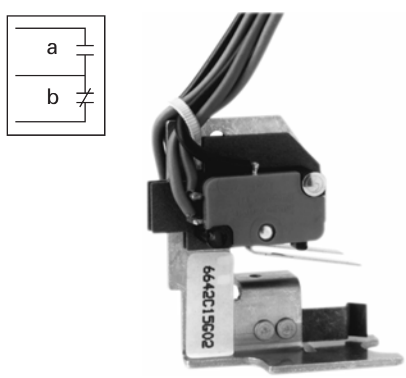
The alarm (signal)/lockout switch monitors circuit breaker trip status and provides remote signaling and interlocking capabilities when the circuit breaker trips. For two-, three- and four-pole circuit breakers, the alarm (signal)/lockout switch consists of one or two SPDT switches assembled to a plug-in module mounted in retaining slots in the top of the trip unit. The SPDT switch contacts are identified as make and break contacts. When the circuit breaker trips, the make contact closes and the break contact opens.



Alarm (Signal)/Lockout Switch

Auxiliary Switch

The auxiliary switch provides circuit breaker contact status information by monitoring the position of the molded crossbar containing the moving contact arms. The auxiliary switch is used for remote signaling and interlocking purposes, and consists of one or two SPDT switches assembled to a plug-in module mounted in retaining slots in the top of the trip unit. Each SPDT switch has one “a” and one “b” contact. When the circuit breaker contacts are open, the ”a“ contact is open and the “b” contact is closed.



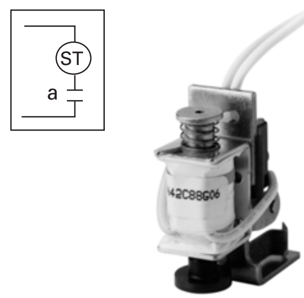
Auxiliary Switch

Shunt Trip

The shunt trip provides remote controlled tripping of the circuit breaker. The shunt trip consists of an intermittent rated solenoid with a tripping plunger and a cutoff switch assembled to a plug-in module. When required for ground fault protection applications, certain AC rated shunt trips are suitable for operation at 55% of rated voltage.

Available in most AC and DC voltages.

Note: Approximate unlatching time—6 milliseconds. Approximate total circuit breaker contact opening time—18 milliseconds. Endurance—4000 electrical operations plus 1000 mechanical operations. Supply voltages suitable for use with Class 1 GFP devices. Marking label included with accessory kits.



Shunt Trip

OPTIM Communications Kit

Eaton’s OPTIM Communications Kit provides the option to field install PowerNet communications into a K-, L- or N-Frame OPTIM 550 breaker. OPTIM 1050 trip units come equipped with communications as standard.

OPTIM Communications Kit

Low Energy Shunt Trip

Low energy shunt trip devices are designed to operate from low energy output signals from dedicated current sensors typically applied in ground fault protection schemes. However, with a proper control voltage source, they may be applied in place of conventional trip devices for special applications. Flux paths surrounding permanent magnets used in the shunt trip assembly hold a charged spring poised in readiness to operate the circuit breaker trip mechanism. When a 100 microfarad capacitor charged to 28 Vdc is discharged through the shunt trip coil, the resultant flux opposes the permanent magnet flux field, which releases the stored energy in the spring to trip the circuit breaker. As the circuit breaker resets, the reset arm is actuated by the circuit breaker handle, resetting the shunt trip. The plug-in module is mounted in retaining slots in the top of the trip unit. Coil is intermittent-rated only. Cutoff provisions required in control circuit.

Low Energy Shunt Trip

Undervoltage Release Mechanism

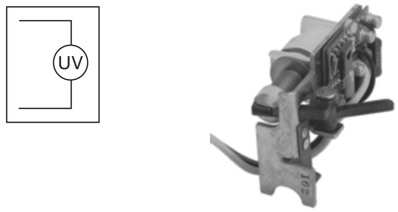
The undervoltage release mechanism monitors a voltage (typically a line voltage) and trips the circuit breaker when the voltage falls to between 70 and 35% of the solenoid coil rating.

Note: Undervoltage release mechanism accessories are not designed for, and should not be used as, circuit interlocks.

The undervoltage release mechanism consists of a continuous rated solenoid with a plunger and tripping lever assembled to a plug-in module.

The tab on the tripping lever resets the undervoltage release mechanism when normal voltage has been restored and the circuit breaker handle is moved to the reset (OFF) position.

With no voltage applied to the undervoltage release mechanism, the circuit breaker contacts will not touch when a closing operation is attempted.



Undervoltage Release Mechanism

External Accessories

Note: For a complete listing of available external accessories, see Volume 4—Circuit Protection Catalog, CA08100005E, Section 25.

Non-Padlockable Handle Block

The nonlockable handle block secures the circuit breaker handle in either the ON or OFF position. (Trip-free operation allows the circuit breaker to trip when the handle block holds the circuit breaker handle in the ON position.) The device is positioned over the circuit breaker handle and secured by a set-screw to deter accidental operation of the circuit breaker handle. (Field installation only.)

Non-Padlockable Handle Block

Padlockable Handle Lock Hasp

The padlockable handle lock hasp allows the handle to be locked in the ON or OFF position. (Trip-free operation allows the circuit breaker to trip when the handle lock holds the circuit breaker handle in the ON position.) The hasp mounts on the circuit breaker cover within the trimline. The cover is predrilled on both sides of the operating handle so that the hasp can be mounted on either side of the handle. The hasp will accommodate up to three padlocks with 1/4-inch (6.4 mm) shackles. One per circuit breaker. (Field installation only.)

Padlockable Handle Lock Hasp

Key Interlock Kit (Lock Not Included)

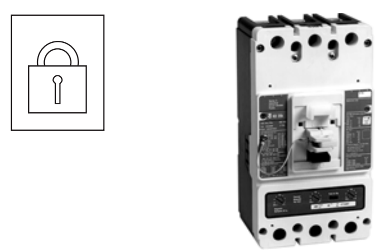
The key interlock is used to externally lock the circuit breaker handle in the OFF position. When the key interlock is locked, an extended deadbolt blocks movement of the circuit breaker handle. Uniquely coded keys are removable only with the deadbolt extended. Each coded key controls a group of circuit breakers for a given specific customer installation.

The key interlock assembly consists of a mounting kit and a purchaser supplied deadbolt lock. The mounting kit comprises a mounting plate, which is secured to the circuit breaker cover in either the left- or right-pole position; key interlock mounting hardware; and a wire seal. Specific mounting kits are required for individual key interlock types. (Field installation only.)

Key Interlock Kit

Padlockable Handle Block

The device is positioned in the cover opening to prevent handle movement. Will accommodate one 5/16-inch (8.0 mm) padlock.



Padlockable Handle Block

Molded-Case Switches

Eaton molded-case switches (MCS) are UL 489 devices that don't have thermal protection, but do have a self-protecting high-magnetic trip setting. Molded-case switches are applied when a compact high-capacity disconnect device is necessary. Accessories that can be installed in molded-case circuit breakers are also available for molded-case switches. The most common application for a molded-case switch would be as a main disconnect for a panelboard or a loadcenter. Available from 100 to 2500 A, molded-case switches provide a compact high-capacity disconnect device along with the added benefits of a molded-case circuit breaker without the thermal protection.

It provides no overcurrent protection, overload or low level fault. The MCS is equipped with a high instantaneous magnetic fixed trip unit. The fixed magnetic trip is factory preset to interrupt high fault currents at or above its preset level. MCS is self protecting within its withstand rating. See **Table 27.2-1**.

Motor Circuit Protectors

Application flexibility of Eaton motor circuit protectors (Type GMCP/HMCP/HMCPE) is enhanced by the higher interrupting ratings and current limiting characteristics designed into the line. These devices are available from 3–1200 A in 63, 100, 150, 250, 400, 600, 800 and 1200 A frame sizes.

The motor circuit protectors are designed for application in individual motor circuits in combination motor starter units. Motor circuit protectors operate on the magnetic principle with a current sensing element in each pole to provide short-circuit protection.

The motor circuit protector design permits the most effective protection possible against low-level faults while offering circuit breaker convenience, quick-make quick-break action, deadfront safety and prevention of single phasing.

The GMCP and HMCPE are 480 V devices rated between 3–100 A. The HMCP is a 600 V device available in five frames and rated between 3–1200 A. The MCP is designed to comply with the applicable requirements of Underwriters Laboratories Standard UL 489, Canadian Standards Association Standard C22.2 No. 5, and International Electrotechnical Commission Recommendations IEC 157-1.

An innovative design of internal components allows higher MCP-starter combination interrupting ratings. The MCP is marked to permit proper electrical application within the assigned equipment ratings.

The MCP is a recognized component (UL File E7819) and complies with the applicable requirements of Underwriters Laboratories Standard UL 489. It is also designed to comply with the applicable requirements of Canadian Standards Association Standard C22.2 No. 5, and International Electrotechnical Commission Recommendations IEC 157-1. The interrupting rating is defined on the assembled equipment nameplate.

Table 27.2-1. Molded-Case Switch Short-Circuit Current Ratings at 60 Hz Only (Maximum Fault Current at Which Device can be Applied in kAIC)

MCS Frame	Ampere Rating	Short-Circuit Current Rating			
		240 V	480 V	600 V	250 Vdc
GD	100	65	22	—	10
EHD	100	18	14	—	10
FD	150	65	35	18	10
HFD	150	100	65	25	22
JD	250	65	35	18	10
HJD	250	100	65	25	22
DK	400	65	—	—	10
KD	400	65	35	25	10
HKD	400	100	65	35	22
LD	600	65	35	25	22
HLD	600	100	65	35	25
MDL	800	65	50	25	22
HMDL	800	100	65	35	25
ND	1200	65	50	25	—
HND	1200	100	65	35	—
RD	2000	125	65	50	—
EGK	125	100	65	—	42
JGK	250	100	65	35	42
LGK	400	100	65	35	42
LGK	600	100	65	35	42
NGK	1200	100	65	35	—
RGK	2000	125	65	50	—

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Motor Protection

In line with 2008 NEC 430.6(A) circuit breaker, HMCP and fuse rating selections are based on full load currents for induction motors running at speeds normal for belted motors and motors with normal torque characteristics using data taken from NEC Table 430.250 (three-phase). Actual motor nameplate ratings will be used for selecting motor running overload protection. Motors built special for low speeds, high torque characteristics, special starting conditions and applications will require other considerations as defined in the application section of the NEC.

These additional considerations may require the use of a higher rated HMCP, or at least one with higher magnetic pickup settings.

Circuit breaker, HMCP and fuse ampere rating selections are in line with maximum rules given in NEC 430.52 and Table 430.250. Based on known characteristics of Eaton type breakers, specific units are recommended. The current ratings are no more than the maximum limits set by the NEC rules for motors with code letters F to V or without code letters. Motors with lower code letters will require further considerations.

In general, these selections were based on:

1. Ambient—Outside enclosure not more than 40 °C (104 °F).
2. Motor starting—Infrequent starting, stopping or reversing.
3. Locked rotor—Maximum 6 times motor FLA.
4. Locked rotor—Maximum 6 times motor FLA.

Type HMCP motor circuit protector may not be set more than 1300% of the motor full-load current to comply with NEC 430.52 (except for NEMA Design B energy efficient motors, which can be set up to 1700%).

Circuit breaker selections are based on types with standard interrupting ratings. Higher interrupting rating types may be required to satisfy specific system application requirements.

For motor full load currents of 208 V and 200 V, increase the corresponding 230 V motor values by 10 and 15% respectively.

Table 27.2-2. Motor Circuit Protector (MCP), Circuit Breaker and Fusible Switch Selection Guide

Horsepower	Full Load Amperes (NEC) FLA	Fuse Size NEC 430.52 Maximum Amperes		Recommended Eaton		
				Circuit Breaker	Motor Circuit Protector Type HMCP	
		Time Delay	Non-Time Delay	Amperes	Amperes	Adj. Range
230 V, Three-Phase						
1	3.6	10	15	15	7	21–70
1-1/2	5.2	10	20	15	15	45–150
2	6.8	15	25	15	15	45–150
3	9.6	20	30	20	30	90–300
5	15.2	30	50	30	30	90–300
7-1/2	22	40	70	50	50	150–500
10	28	50	90	60	50	150–500
15	42	80	150	90	70	210–700
20	54	100	175	100	100	300–1000
25	68	125	225	125	150	450–1500
30	80	150	250	150	150	450–1500
40	104	200	350	150	150	750–2500
50	130	250	400	200	150	750–2500
60	154	300	500	225	250	1250–2500
75	192	350	600	300	400	2000–4000
100	248	450	800	400	400	2000–4000
125	312	600	1000	500	600	1800–6000
150	360	700	1200	600	600	1800–6000
200	480	1000	1600	700	600	1800–6000
460 V, Three-Phase						
1	1.8	6	6	15	7	21–70
1-1/2	2.6	6	10	15	7	21–70
2	3.4	6	15	15	7	21–70
3	4.8	10	15	15	15	45–150
5	7.6	15	25	15	15	45–150
7-1/2	11	20	35	25	30	90–300
10	14	25	45	35	30	90–300
15	21	40	70	45	50	150–500
20	27	50	90	50	50	150–500
25	34	60	110	70	70	210–700
30	40	70	125	70	100	300–1000
40	52	100	175	100	100	300–1000
50	65	125	200	110	150	450–1500
60	77	150	150	125	150	750–2500
75	96	175	300	150	150	750–2500
100	124	225	400	175	150	750–2500
125	156	300	500	225	250	1250–2500
150	180	350	600	250	400	2000–4000
200	240	450	800	350	400	2000–4000
575 V, Three-Phase						
1	1.4	3	6	15	3	9–30
1-1/2	2.1	6	10	15	7	21–70
2	2.7	6	10	15	7	21–70
3	3.9	10	15	15	7	21–70
5	6.1	15	20	15	15	45–150
7-1/2	9	20	30	20	15	45–150
10	11	20	35	25	30	90–300
15	17	30	60	40	30	90–300
20	22	40	70	50	50	150–500
25	27	50	90	60	50	150–500
30	32	60	100	60	50	150–500
40	41	80	125	80	100	300–1000
50	52	100	175	100	100	300–1000
60	62	110	200	125	150	750–2500
75	77	150	250	150	150	750–2500
100	99	175	300	175	150	750–2500
125	125	225	400	200	250	1250–2500
150	144	300	450	225	250	1250–2500
200	192	350	600	300	400	2000–4000

Current Limiting Circuit Breakers

Eaton offers one of the most complete lines of both fusible and non-fused current limiting breakers, and add-on current limiting modules in the industry. The industrial breakers are available in current limiting versions with interrupting capacities up to 200 kA at 480 V without fuses in the same physical size as standard and high interrupting capacity breakers. Eaton also manufactures both fused and non-fused current limiting devices with interrupting capacities up to 200 kA at 600 Vac. See **Section 27.4** for complete selection data for current limiting circuit breakers and add-on current limiting modules.

The current limiting breakers use a reverse loop stationary contact. When current is flowing through the contacts of these breakers, the positions of the reverse loop and moving contact arm induce opposing magnetic fields. The resulting flux lines cause rapid contact blow-apart under these conditions, resulting in very high interrupting capacities and provide current limiting characteristics.

Current limiting breakers are available from 15–2500 A and have an interrupting rating up to 200 kA at 480 V. These breakers are most commonly applied when very high fault levels are available and in series rating applications where the current limiting capability of these breakers are used upstream in series combinations.

Circuit breakers 600 A and below that are current limiting have frame catalog numbers that end with the letter "C." For example, the F-Frame model that is current limiting has a catalog number FDC. In accordance with UL circuit breaker marking requirements, the nameplate on the breaker is also labeled "current limiting."

Current Limit-R Breakers—Non-Fused

FCL Current Limit-R Breaker

The Current Limit-R® molded-case circuit breaker was developed with interrupting ratings up to 200,000 A at 480 Vac to provide complete system protection against faults, including:

1. Overloads, by using inverse time current tripping characteristics.
2. Low-level short-circuits, by using instantaneous and/or short-time delay tripping characteristics.
3. High-level short-circuits, by using ultra high-speed, blow-apart, current limiting contacts.

Current Limit-R circuit breakers can be used in series with Eaton standard molded-case circuit breakers with listed interrupting ratings as low as 10,000 A in systems capable of delivering fault currents as high as 200,000 A. The excellent current limiting properties of Current Limit-R breakers completely protect all Eaton downstream series circuit breakers applied within their voltage ratings.

The high level current-limiting action is achieved by the use of special design, blow-apart contacts. The opening speed of the contacts is amplified by the repulsion force in the slot motor to effectively separate the contacts under high level fault conditions in less than one millisecond. The rapid rise of arc voltage introduces impedance into the system, thus limiting the amount of the otherwise available fault current.

Current Limit-R current limiting circuit breakers incorporate all the advantages and features of conventional molded-case circuit breakers. They are available in two- and three-pole versions in two physical frame sizes and three continuous current frame ratings.

Type FCL has a maximum continuous current frame rating of 100 A. It is equipped with a conventional, non-interchangeable, thermal-magnetic-type trip unit with individual ampere ratings. The Type LCL is available with frames having maximum continuous current ratings of either 250 or 400 A. Overload and low level short-circuit protection is provided by a SELTRONIC™ electronic trip unit that uses the individual rating plug concept for determining the continuous rating of the breaker. Rating plugs are available with either fixed or adjustable ampere ratings.

TRI-PAC Fused Current Limiting Breakers

LA TRI-PAC Breaker

The increase in demand for electrical power in modern commercial and industrial buildings has resulted in electrical services becoming substantially larger. In some low voltage distribution systems, available short-circuit currents can exceed 100,000 symmetrical rms amperes. Fault currents of this intensity may exceed the interrupting ratings of molded-case breakers. As a result, larger expensive circuit interrupting devices that could withstand the thermal and magnetic stresses associated with currents of this value have had to be used. High interrupting capacity current limiting devices have been developed that will restrict short-circuit current. If applied correctly, they may be used in conjunction with molded-case circuit breakers to provide adequate and economical protection.

The TRI-PAC® breaker was developed for this application and so named because it affords TRIple-PACkage protection with (1) time delay thermal trip, (2) instantaneous magnetic trip and (3) current limiting protection, combined and coordinated in a compact and economical device. These protective actions are so coordinated that overcurrents and low magnitude faults are cleared by the thermal action; normal short circuits are cleared by the magnetic action; and abnormal short circuits, above an established value, are cleared by the current limiting device. Thus, unless a severe short-circuit occurs, the current limiter is unaffected and its replacement is held to a minimum.

TRI-PAC breakers are available in ratings from 15–1600 A and have a UL listed interrupting capacity of 200,000 A at up to 600 Vac and also have an interrupting capacity of 100,000 A at up to 250 Vdc.

The TRI-PAC breaker offers all of the advantages of the economical molded-case breaker and the current limiter is retained, while the disadvantages of separately mounted devices are eliminated.

Add-on Current Limiting Modules

Current Limiting Add-On Modules

The current limiting breaker modules use a reverse loop stationary contact arm. When high short-circuit current is flowing through the contacts of these modules, the positions of the reverse loop and moving contact arm induce opposing magnetic fields. The resulting flux lines cause rapid contact blow-apart under fault conditions, resulting in very high interrupting capacities and providing current limiting characteristics. Current limiting breaker modules in combination with select Series C and Series G breakers, are available with interrupting ratings up to 200 kA at 600 Vac.

The combination of the current limiting breaker or HMCP and the current limiter module provides the following system protection:

- Overloads, by using inverse time current tripping characteristics of the molded-case circuit breaker
- Low-level short circuits, by using instantaneous and/or short-time delay tripping characteristics of the molded-case circuit breaker
- High-level short circuits, by using ultra-high-speed, blow-apart contacts of the current limiting module in series with the circuit breaker contacts. The high-level current limiting action is achieved by the use of special design, blow-apart contacts. The opening speed of the contacts is amplified by the repulsion force in the slot motor and reverse loop stationary contact arm to effectively separate the contacts under high-level fault conditions in less than 1 millisecond. The rapid rise of arc voltage introduces impedance into the system, thus limiting the amount of the otherwise available fault current

100% Rated Circuit Breakers

100% rated circuit breakers are tested inside a minimum size enclosure to UL 489 for application at 100% of the breaker's continuous current rating. 100% rated circuit breakers are equipped with electronic trip units and applied with 90 °C cable rated at 75 °C ampacity. To apply 100% rated breakers in switchboards and panelboards, additional tests are required to meet UL 67 and UL 891. Eaton molded-case circuit breaker frames K-, L-, N-, MDL and R-, 70–2000 A, can be applied at 100% of their rated continuous current as long as the breaker is installed in its minimum size enclosure, including ventilation. 100% rated breakers are applied to distribution system to provide installation cost savings. The amount of savings that can be realized is dependent on the application.

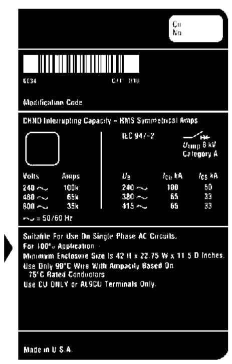


Figure 27.2-1. Breaker Nameplate

A 100% rated breaker receives its UL listing based on tests conducted in a minimum size enclosure with minimum ventilation (if required) and minimum cable sizes, as stated on this nameplate example.

The amount of protection designed into a distribution system is often based on economics. However, each project should be furnished with a reliable distribution system that delivers the most effective protection possible for each investment dollar.

Reliable and economic system design can be usually achieved with Eaton's circuit breakers that are UL listed for application at 100% of their ratings—instead of standard breakers that in actual use are applied at 80% of their frame ratings in an enclosure.

The concept between a system design using standard breakers and that using 100% rated breakers is uncomplicated—but there are no shortcut methods for determining which design (and devices) is the best choice for a given system. Good engineering practice requires a careful system analysis beginning with the lowest feeder and concluding with the main device.

Also included in the system analysis must be all present and future factors that could affect the size and/or quantity of the breakers and associated hardware, such as switchboard bus, busway, cable and conduit. Other factors to consider are loads (continuous and noncontinuous) and system expansions and transformers with provisions for forced air cooling.

The NEC

The rules and intent of the National Electrical Code governing the use of standard or 100% rated breakers must be understood before recommending or applying such devices.

Section 210.20(A) Continuous and Noncontinuous Loads of the National Electrical Code addresses differences between applications of standard rated breakers and 100% rated breakers. (Significant sections are in bold face type.)

"Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than **the noncontinuous load plus 125% of the continuous load**."

The minimum circuit conductor size without the application of any ampacity adjustment or correction factors shall have an allowable ampacity equal to or greater than the noncontinuous load plus 125% of the continuous load.

"Exception: Where the assembly including the overcurrent devices protecting the feeder(s) are listed for operation at 100% of their rating, neither the ampere rating of the overcurrent device nor the ampacity of the feeder conductors shall be less than the **sum of the continuous load plus the noncontinuous load**."

Note: A continuous load as defined by NEC Article 100 is "a load where the maximum current is expected to continue for 3 hours or more."

Figure 27.2-2. NEC Reference

Section 210.20(A) covers standard breakers, and the exception 100% rated breakers. NEC Section 210.20(A) and the Section 210.20(A) exception can be expressed by these formulas:

Standard 80% Rated Design
Noncontinuous Load +
125% of the Continuous Load
= Total Minimum Load

Special 100% Rated Design
Noncontinuous Load +
Continuous Load
= Total Minimum Load

The necessity for these NEC requirements results from circuit breaker testing procedures.

A molded-case circuit breaker is tested in open air to verify its nameplate ampere rating. The nameplate specifies a value of current the circuit breaker is rated to carry continuously without tripping within specific operating temperature guidelines.

In most instances, a breaker is applied in an enclosure and performance could be adversely affected by slow heat dissipation and temperature rise. These factors must be considered regarding the ability of the breaker to comply with its nameplate ampere rating.

Testing Conditions and Operating Conditions

There are distinct differences between these conditions that are addressed in NEC Section 210.20(A) by introducing an overcurrent device and associated hardware sizing factor. The sizing factor ensures reliable equipment performance under realistic conditions. Section 210.20(A) is the key to making the best system design choice.

For feeders, Section 215.2(A) addresses the rating of all overcurrent devices that have been tested in open air but are applied in an enclosure. The thermal response of an overcurrent device applied in an enclosure will usually be faster than in open air, thus dictating the 125% requirement.

The exception allows for properly tested and listed overcurrent devices to be applied at 100% of their nameplate rating.

Application Information—100% Rated Circuit Breakers

There is a Difference Between 100% Rated Breakers and 100% Rated Assemblies

Special attention should be given to the word "assembly" in the NEC Exception. Normally, an assembly is listed for 100% operation only after being successfully tested as an assembly per UL requirements.

For an assembly to receive a 100% rated UL listing, it must be tested separately by UL project engineers. Panelboards are tested to UL 67, switchboards tested to UL 891.

Installing 100% rated breakers in an assembly does not automatically make it acceptable for a 100% rating.

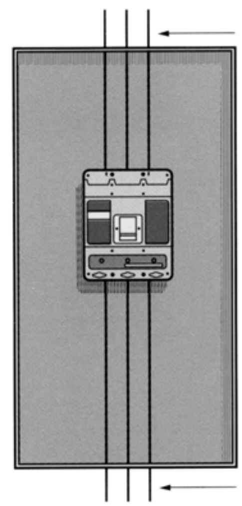


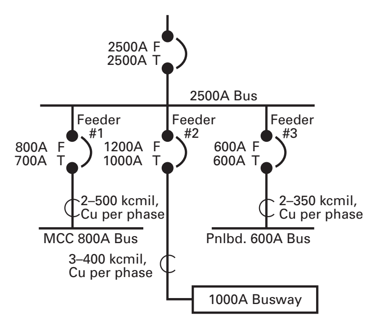
Figure 27.2-3. Conductor Requirements

Table 27.2-3. The Application—These Examples Illustrate the Cost Savings when the 100% Rated Approach is Used ①

A visual comparison of breaker, bus and cable sizes in the Three-Phase Distribution System examples (line diagrams) reveals how a 100% rated system design can provide cost savings.					
Load	**Feeder #1**	**Feeder #2**	**Feeder #3**	**Main**	**Description**
Continuous	400 A	800 A	0	1200 A	Three-phase distribution System line diagrams
Noncontinuous	200 A	0	1000	1200 A	

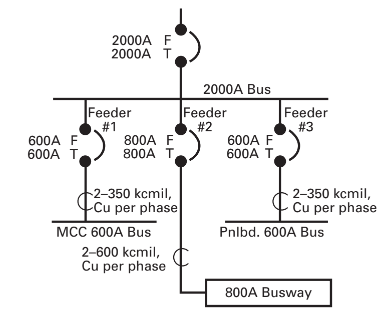
① Selection of either a 100% rated design or standard design must result from a system analysis beginning with the lowest feeder and concluding with the system's main device. For these system examples, assume that all assembly testing has been successfully completed and either the 100% rated design or standard design can be selected. Each system is hypothetical and either approach will meet safety requirements. Loads were arbitrarily selected. The load table includes the calculations for minimum total loads in conformance with NEC Section 210.20(A).

Table 27.2-4. Standard 80% Rated Design

Noncontinuous Load + 125% of the Continuous Load = Total Minimum Load					Line Diagram
Description	**Feeder No. 1**	**Feeder No. 2**	**Feeder No. 3**	**Main**	
Calculation per NEC of minimum total load ②	200 + (1.25) (400) =700 A	0 + (1.25) (800) =1000 A	600 + 0 = 600 A	2250 A ②	
Breaker frame (F) trip (T) rating	(F) (T) 800 A ③/700 A	(F) (T) 1200 A ③/1000 A	(F) (T) 600 A/600 A	(F) (T) 2500 A ③/2500 A	
Bus/cable rating	800 A ③	1000 A	600 A	2500 A ③	

② (Noncontinuous Load) + (125%) (Continuous Load) per NEC Section 210.20(A).
③ Nearest standard size, not less than calculated value.

Table 27.2-5. Standard 100% Rated Design

Noncontinuous Load + Continuous Load = Total Minimum Load					Line Diagram
Description	**Feeder No. 1**	**Feeder No. 2**	**Feeder No. 3**	**Main**	
Calculation per NEC of minimum total load ①	200 + 400 = 600 A	0 + 800 = 800 A	600 + 0 = 600 A	2000 A ②	
Breaker frame (F) trip (T) rating	(F) (T) 600 A/600 A	(F) (T) 800 A/800 A	(F) (T) 600 A/600 A	(F) (T) 2000 A/2000 A	
Bus/cable rating	600 A	800 A	600 A	2000 A	

① (Noncontinuous Load) + (Continuous Load) per NEC Section 210.20(A) Exception.
② Sum of all NEC calculated minimum feeder loads.

Table 27.2-6. The Result—Savings in Both Switchboard and Cable Costs

Design	Minimum Total Load (Amperes)				Potential System Savings
Standard	700	1000	600	2250	100% rated breaker systems can potentially represent significant economic advantages: In lower rated and sized breakers, less cable and significant reductions in equipment floor and wall space. These savings can be realized when the results of a systems analysis favor the 100% rated design approach.
100% rated	600	800	600	2000	
Results	The standard design requires higher rated, more expensive breaker and bus. Although the minimum total load is 700 A, most breakers and hardware are available only in standard sizes requiring even more expensive "nearest standard size" breakers and hardware.	Dramatic economic advantages are achieved by using the 100% rated design. Substantial savings result from using an 800A busway and significant savings are also provided by the smaller breaker frame and cable size.	Calculations indicate either approach results in the same size breaker and hardware. A 100% rated breaker would be more expensive although the final decision could rest on whether or not future load growth is anticipated.	The 100% approach results in the same frame size breaker with a savings in conductor material cost. Additionally, Eaton offers a 2000 A frame 100%-rated breaker, which is less expensive than the 2500 A frame 80%-rated.	

Table 27.2-7. Available 100% Rated Circuit Breakers

Frames	Rating at 480 V	Trip Units
JG-Frame 50/100/250 A Minimum enclosure size 26.00 x 18.00 x 8.00 in (660.4 x 457.2 x 203.2 mm)	JGE-C 25 kA JGS-C 35 kA JGH-C 65 kA JGC-C 100 kA	Thermal-magnetic, Digitrip 310+
K-Frame 125/250/400 A Minimum enclosure size 24.00 x 15.00 x 6.00 in (609.6 x 381.0 x 152.4 mm)	CKD 35 kA CHKD 65 kA	Digitrip 310+ (125 A, 250 A and 400 A)
LG-Frame ③ 250/400/600 A Minimum enclosure size with ventilation 28.00 x 19.00 x 8.00 in (711.2 x 482.6 x 203.2 mm)	LGE-C 35 kA LGS-C 50 kA LGH-C 65 kA	Thermal-magnetic, Digitrip 310+
L-Frame 125/250/400/600 A Minimum enclosure size with ventilation 24.00 x 15.00 x 6.00 in (609.6 x 381.0 x 152.4 mm)	CLD 35 kA CHLD 65 kA CLDC 100 kA	Digitrip 310, Digitrip OPTIM
M-Frame 800 A Minimum enclosure size with ventilation 42.00 x 18.00 x 7.50 in (1066.8 x 457.2 x 190.5 mm)	CMDL 50 kA CHMDL 65 kA	Digitrip 310
N-Frame 800/1200 A Minimum enclosure size with ventilation 42.00 x 22.75 x 11.50 in (1066.8 x 577.9 x 292.1 mm)	CND 50 kA CHND 65 kA CNDC 100 kA	Digitrip 310, Digitrip OPTIM
R-Frame 1600/2000 A Minimum enclosure size with ventilation 21.50 x 18.00 x 13.00 in (546.1 x 457.2 x 330.2 mm) ④	CRD 65 kA CRDC 100 kA	Digitrip 310/510/610/810/910, Digitrip OPTIM

③ Thermal-magnetic LG requires venting 7.00 square inches above and 7.00 square inches below on the front face of enclosure.
④ Use with 9.00-inch (228.6 mm) tee connector.

Series Rated Systems

Series rating is a short-circuit interrupting rating assigned to a combination of two or more overcurrent devices connected in series. The short-circuit interrupting rating of the upstream device must be equal to or greater than the available fault current. Downstream breakers, however, are not fully rated for the system's available fault current. Series combinations must be tested to UL 489. Series ratings are applied to distribution systems where short-circuit coordination is not required. The Eaton listing of available series rating combinations are shown in the applications section of this document.

Under most circumstances, selection of a series rated system will reduce initial cost and size, because downstream breakers are not fully rated for the prospective short-circuit fault current at their point of application. The interrupting rating of the upstream breaker must always be equal to or greater than the available fault current at its line terminals. In addition, downstream breakers must have been tested in combination with the upstream breaker and shown to be protected by the upstream breaker at the assigned series rated interrupting rating. The net result is that the system can be assigned a "series rated" or "integrated" rating higher than the rating of the downstream breaker when it is tested or applied alone. Design of the system and selection of breakers is based on short-circuit interruption test specified and witnessed by UL.

Because of their blow-open design, most molded-case circuit breakers are current limiting to some degree. In a series rated application and in the event of a major fault, both upstream and downstream breakers open, protecting the lower-rated downstream devices by limiting the let-through current.

To develop a series rated protective system, it is suggested that the design engineer, after completing preliminary steps:

- Define available fault current at the line side terminals of the upstream breaker
- Select an upstream breaker with an interrupting rating equal to or greater than the available fault current
- Verify the series tested interrupting ratings of the selected combination of breakers by referring to the tables in this section
- Confirm, during installation, that the correct breakers have been selected by checking the nameplates appearing on the end-use equipment

Evaluating the Protection Systems

Designed properly, series rated and fully rated systems protect electrical equipment with equal effectiveness. But initial cost and continuity of service can vary widely depending on the inherent characteristics of the system, and on the design philosophy adopted.

Fully Rated System

All breakers are rated for full fault current at their point of application in accordance with the National Electrical Code. The continuity of service provided by the system is greater than a series rated system.

Series Rated System

A series rated system is less costly than a fully rated system. The upstream breaker is always fully rated, but the interrupting ratings of downstream breakers are normally lower. Service continuity can be acceptable after initial startup, because the lower-level arcing faults most likely occur after that time can be cleared by the downstream breaker alone. However, under high fault conditions, both the upstream and downstream breakers would open, eliminating service to the affected portion of the system. Therefore, it is not possible to achieve selective coordination for all magnitudes of available fault current with a series rated system.

National Electrical Code Requirements

Requirements of the National Electrical Code for short-circuit ratings may now be met by equipment that is marked with ratings adequate for the available fault current at their point of application in the electrical system. Refer to the current NEC for specific requirements.

General Discussion

Available Short-Circuit Current. Service equipment must be suitable for the short-circuit current available at its supply terminal.

Approval. The conductors and equipment required or permitted by the Code will be acceptable only if approved. See Examination of Equipment for Safety and Examination, Identification, Installation and Use of Equipment. See definitions of "Approved," "Identified," "Labeled" and "Listed."

Examination, Identification, Installation and Use of Equipment

1. Examination: in judging equipment, considerations such as the following should be evaluated.
   a. Suitability for installation and use in conformity with the provisions of this Code. Suitability of equipment use may be identified by a description marked on or provided with a product to identify the suitability of the product for a specific purpose, environment or application. Suitability of equipment may be evidenced by listing or labeling.
   b. Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.
   c. Wire-ending and connection space.
   d. Electrical insulation.
   e. Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service.
   f. Arcing effects.
   g. Classification by type, size, voltage, current capacity and specific use.
   h. Other factors that contribute to the practical safeguarding of persons using or likely to come in contact with the equipment.
2. Installation and use: listed or labeled equipment must be used or installed in accordance with any instructions included in the listing or labeling.

Interrupting Rating

Equipment intended to break current at fault levels must have an interrupting rating sufficient for the system voltage and the current that is available at the terminals of the equipment. Equipment intended to break current at other than fault levels must have an interrupting rating at system voltage sufficient for the current that must be interrupted.

Circuit Impedance and Other Characteristics

The overcurrent protective devices, the total impedance, the component short-circuit withstanding ratings, and other characteristics of the circuit to be protected should be so selected and coordinated as to permit the circuit protective devices used to clear a fault without the occurrence of extensive damage to the electrical components of the circuit. This fault will be assumed to be either two or more of the circuit conductors, or between any circuit conductor and the grounding conductor or enclosing metal raceway.

Motor Contribution

The fault current contribution of motors connected between series rated breakers must be considered. Article 240.86(C) in the 2005 edition of the National Electrical Code states that for series ratings the sum of the motor, full-load currents cannot exceed 1% of the interrupting rating of the lower-rated circuit breaker. The actual fault current contribution from induction motors is about four times their full-load current (impedance value of 25%). For example, if the downstream branch circuit breakers used in a series rated combination have an interrupting rating of 14,000 A rms symmetrical for a 480 V system, the maximum full-load current of motors connected to that panel from the branch circuit breakers is 140 A (1%). For typical induction motors, this is equivalent to a total horsepower at 480 V of approximately 115 horsepower.

Design/Test Considerations for Series Coordinated Circuit Breakers

Test procedures for all Eaton molded-case circuit breakers intended for application in series connected systems are in full compliance with all applicable paragraphs of the latest edition of UL 489.

Note: For further information, see IEEE Standards 141, 242 and 446.

The entire system is tested because such tests are the only way to correctly verify the performance of overcurrent devices under short-circuit conditions.

Calibration, interruption, trip-out and dielectric withstand tests are performed. Breakers in their as-received condition are used for the interrupting and intermediate interrupting capability tests. If agreeable to concerned parties, previously tested samples may be used. The interrupting rating of the line-side circuit breaker is equal to or greater than the maximum available fault current on the distribution system at its point of intended application.

Tests comply also with the intent of the proposed revisions to applicable IEC documents.

Tests are completed in a well-defined sequence:

- Interrupting tests
- Intermediate interrupting tests
- Trip-out tests
- Dielectric voltage-withstand tests

Eaton's Series C circuit breakers intended for application in series rated systems are subjected, in the following sequence, to interrupting ability, intermediate interrupting ability, trip-out, and dielectric voltage-withstand tests.

During testing of the series rated circuit breakers, each breaker is mounted in the smallest enclosure in which it is to be used; openings in the enclosure do not exceed 10% of its total external area, and there are no openings directly opposite a vent in a circuit breaker case. The two enclosures are connected by a 12-inch (304.8 mm) conduit of any diameter. Each lead from test terminals to the line-side breaker is less than 4 feet (1.2m) per breaker, and each load shorting the load-side breaker(s) is sized based on the rating of the load-side breaker. The combined length of the lead from the line-side overcurrent protective device of the load-side breaker and from the load-side breaker to the shorting point, is less than 4 feet (1.2 m) per pole.

Exception: the breakers may be mounted in the end-use equipment that will contain them and is marked for use with the series combination. The load-side breaker is positioned as close as possible to the line-side breaker(s). Line and load leads are less than 4 feet (1.2 m).

A fuse is connected between the enclosure and line terminal of the pole least likely to arc to the enclosure, or the neutral, if the breaker is rated 120/240 or 480Y/277 Vac. The connection to the load-side of the limiting impedance is #10 AWG copper wire less than 6 feet (1.8 m) long. The fuse is a 30 A non-renewable type acceptable for branch circuit protection; its voltage rating is not less than the rating of the device, and its interrupting rating is not less than the available current.

1. Interrupting tests:
   a. The test circuit is closed on the series combination with all breakers fully closed; and
   b. The load-side breaker is closed on the circuit while the line-side breaker is fully closed.

Note: Random closing is used in all three-phase tests. When the circuit is closed on the combination, closing is controlled in single-phase tests so that closing occurs within 10 electrical degrees of the zero-point of the supply voltage wave.

2. *Intermediate interrupting tests* at the specified available current and maximum voltage. Procedures are identical to those described in 1a and 1b (above) but at the maximum current level that causes the load-side breaker to open, but not the line-side breaker. If the line-side breaker is current-limiting, the series combination should be evaluated in the region below its current-limiting threshold. (There is no need for these tests if the current is less than the interrupting rating on the load-side breaker.)
3. *Trip-out tests* of the load-side breaker at 250% of the marked ampere rating.
4. *Dielectric voltage-withstand tests* verify that the breaker can withstand, without breakdown, a 60 (48–62) Hz essentially sinusoidal potential for 1 minute.

Series Connected Ratings: Eaton Circuit Breakers

A wide range of breakers and combinations in the Eaton line is available that has been tested in accordance with UL procedures for series connected ratings: individually enclosed breakers in series with main lug panelboards, main breakers integral with branch breakers in panelboards, in switchboards, and in meter centers. You can rely on the enclosed data for applications with other undefined distribution equipment where series application ratings can be an advantage.

Circuit breaker/circuit breaker series rated combinations are listed by Underwriters Laboratories in their *Component Directory* (Yellow Book) under "Circuit Breakers—Series Connected."

The series combinations shown in the UL Yellow Book are UL recognized component ratings only. Consult the equipment manufacturer for applicable UL recognized assembly combinations.

Specific series ratings tested combinations in assemblies can be found in **Tab 22** for panelboards/switchboards. Both circuit-breaker-to-circuit-breaker and fuse-to-circuit-breaker upstream/downstream series rating tables are provided. The assemblies series ratings tables are also on the Eaton Web site (www.eaton.com). Search for document 1C96944H02 "Panelboard and Switchboards Series Ratings Information Manual."

Circuit Breaker Identification

Marking of all Eaton's circuit breakers is clear for easy identification of type, rating and operating status. Nameplates are color-coded for immediate identification of rating, and a color-coded bar identifies the type and interrupting rating at common application voltages. Operating status is indicated clearly by the position of the handle and color-coded flags. On and off positions are identified by English words and international symbols.

Scientists and engineers at the Eaton Testing Laboratory ensure that Eaton circuit breakers are the most reliable and develop new concepts and improvements in breaker design. Designs and reliability are verified, and products are improved continuously and qualified to meet UL, NEMA and other standards. In addition, engineers from any breaker or panelboard manufacturer can work along-side their peers from Eaton to test their products in the lab.

The consolidated nameplate on all breakers provides complete identification and rating information in a format that is easy to read and understand.

The interrupting rating of the series combination is never permitted to be marked on the downstream breaker. However, the series rating may be marked on panelboards in which the combination has been tested and listed if:

- The upstream breaker is installed in the panelboard as a main breaker
- The panelboard is a main-lug-only type and is specifically marked to indicate the type and rating of the upstream listed series tested breaker that must be applied with the panelboard

Marking of Panelboards

Marking of panelboards conforms to the latest edition of UL 67. Markings are clear and understandable, and include the short-circuit rating in rms amperes; maximum voltage rating for each short-circuit rating; a statement indicating that additional or replacement devices shall be of the same type and of equal or greater interrupting capacity; and, when applicable, the identity of combinations of integral and branch circuit overcurrent devices that are required when applying the marked short-circuit current rating.

Fuses

Fuses can be used instead of circuit breakers in fully rated, selectively coordinated and series connected protection systems. Specific series ratings tested combinations in assemblies can be found in **Tab 22** for panelboards.

Don't apply fuses using the up-over-down method that has been recommended by some fuse manufacturers for sizing a current-limiting fuse that protects a downstream molded-case circuit breaker with a specified rms symmetrical interrupting rating. The method can lead to erroneous and unsafe conclusions, and should not be used.

Example: Assume a specific type of current-limiting fuse rated 2000 A. Then using the following figure:

1. Draw a vertical line from the prospective short-circuit current of 200 kA to intersect the "typical peak let-through curve at "A."
2. Draw a horizontal line left from Point "A" to intersect the "prospective peak" curve at "B."
3. Drop a vertical line from "B" to intersect the horizontal axis and read the recommended rating, 65 kA rms, concluding that a circuit breaker with a 65 kA interrupting capacity will be protected by a specified 2000 A current-limiting fuse.

This conclusion is wrong when the downstream service has a blow-open contact assembly, as does a molded-case circuit breaker or similar device. It may be valid when the current-limiting fuse is sized to protect a passive bus bar system.

The reason: The up-over-down method ignores dynamic impedance (the inherent current-limiting of the downstream molded-case circuit breaker). Such impedance is developed directly by the forces of the let-through current created when the contacts are blown open.

For proper application of current-limiting fuses, always refer to recommendations by the manufacturer of the circuit breaker, which are based on actual test data.

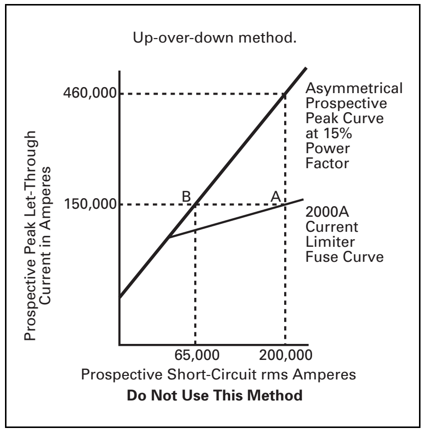


Figure 27.2-4. Up-Over-Down Misapplication

Series Ratings Selected Under Engineering Supervision

The 2005 NEC introduced a new provision allowing a licensed professional engineer to select a series combination of overcurrent devices for existing installations. This represents a major change from the previous requirements that series rated combinations must be proven by actual testing, and witnessed and listed by a third-party certification agency. A calculated evaluation of a series rated system is extremely difficult, if not impossible, to determine because of the dynamic impedance of the downstream breakers as described above. Compatibility of devices could only be determined if it is guaranteed that the downstream device(s) do not even begin to open during the complete interruption time of the upstream device. Another factor is that the let-through current must not exceed the interrupting rating of the downstream device. These are just a couple of the many difficult factors that must be verified to ensure the safe application of an “engineered” series rated combination.

High Instantaneous Breakers for Selective Coordination

High Instantaneous Breaker

Eaton introduces the LHH thermal-magnetic and NHH electronic trip molded-case circuit breakers capable of providing higher current levels of selective coordination. These circuit breakers are based on Eaton industry-leading Series G L-Frame and Series C N-Frame high performance circuit breaker frames. The LHH and NHH circuit breakers are available with trip units having 125–400 A rating.

The LHH and NHH circuit breakers incorporate a higher level of magnetic pickup and electronic instantaneous setting respectively, thus allowing for higher current levels of selective coordination. Standard molded-case circuit breakers typically are furnished with a magnetic pickup or electronic instantaneous adjustment or instantaneous override set at 10 times (10X) the trip rating. Eaton's LHH and NHH molded-case circuit breakers are furnished with a higher level of magnetic pickup (up to 26x) or electronic instantaneous available maximum settings. These higher levels of magnetic pickup (up to 93x) and electronic instantaneous values in turn allow the system designer to obtain selective coordination at fault current levels up to these higher ratings. This allows the line side LHH or NHH circuit breakers to selectively coordinate up to the values for available fault current values determined at the **load** side circuit breaker. When the line side and load side molded-case circuit breaker trip ratings are chosen to coordinate in the overload range, they also can be selectively coordinated in the fault range. For overcurrents protected by circuit breakers on the load side of the LHH or NHH, only the effected load side circuit breaker will open, while the line side LHH and/or NHH circuit breakers remain closed, thus providing continuity of power to the other critical loads supplied by the LHH and NHH circuit breakers. See **Page 27.3-15** for LHH and NHH breaker selection data.

Earth Leakage Circuit Breakers

JG, LG MCCBs Shown with Ground Fault (Earth Leakage) Modules

Eaton earth leakage breakers offer Class 1 ground fault protection and improved ground fault coordination capability. A Class 1 device can open at high levels of fault current, while a Class 2 device prevents opening beyond the contact rating of its interrupting device.

Earth leakage breakers are factory supplied with a single sensor and ground fault relay built-in. The ground fault pick-up setting is adjustable from 0.03 to 30 A in eight steps, and the ground fault time delay setting is adjustable from instantaneous to 2.0 seconds. See **Page 27.4-44** for earth leakage circuit breaker selection data.

AFCI Circuit Breakers

An arc-fault circuit interrupter is a device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.

Eaton offers 120 Vac AFCI single-pole, 15 and 20 A breakers, plug-in and bolt-on, to meet Article 210.12 of the 2008 NEC.

There are currently two types of AFCI circuit breakers on the market today. The types are clearly defined by UL 1699. These are the branch feeder Type AFCI and the Combination Type AFCI. The dual-purpose AFCI is yet another feature available on the market that is achieved by simply adding 5 mA personnel ground fault protection to the existing AFCI.

The AFCI circuit breaker is the most tested residential circuit breaker on the market. In the case of series arc detection, these arcs are detected when equipment is operating thus drawing current. Parallel arcs can occur and are detected even if the load is not operating. When thresholds of monitoring are exceeded, the electronics within this device work to identify safe arcs from hazardous arcs.

There are a few sections in the NEC that in some way reference the AFCI technology. NEC Section 210.12 is the heart of the requirement for the Arc Fault Technology. The introduction of the AFCI product to the National Electrical Code occurred in 1999. The verbiage of this code included a start date of enforcement effective January 1, 2002. The 2002 NEC made a slight change to remove the word "receptacle" to ensure that the AFCI was to be applied on all circuits supplying the bedroom and not just those circuits supplying receptacle outlets. The 2005 NEC introduced some changes that include the introduction of the combination type AFCI.

The combination type AFCI is now set to begin its application as of January 1, 2008. Another change included the location of the combination AFCI that allows it to be within 6 feet of the loadcenter with qualifications.

The 2008 National Electrical Code expanded the application of AFCI outside of the bedroom circuits to include family rooms, closets, parlors, dens, hallways, sunrooms, living rooms and dining rooms. The 6-foot rule was also removed and further clarified the requirements around using a receptacle combination type AFCI were expanded upon.

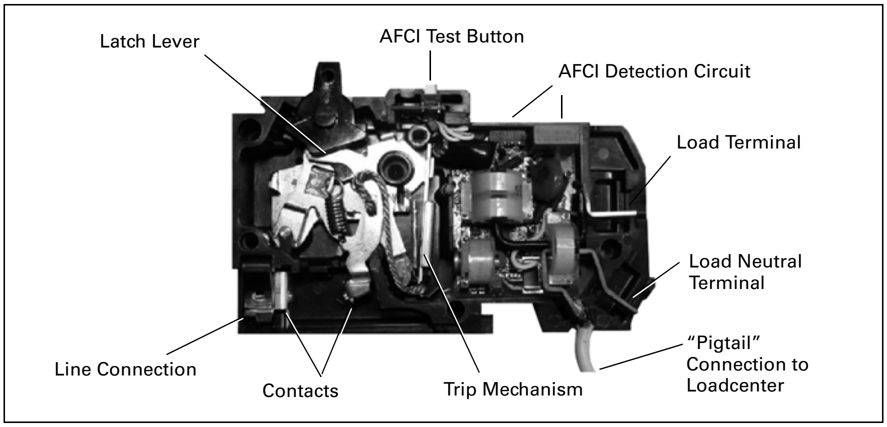


Figure 27.2-5. AFCI Circuit Breaker

Table 27.2-8. NEC Specifications

Article	Description
210.4	Article 210—Branch Circuits "Multiwire Branch Circuits"
210.12	Article 210—Branch Circuits "Arc-Fault Circuit Interrupter (AFCI)"
440.65	Article 440—Air-Conditioning and Refrigerating Equipment "Leakage-Current Detector-Interrupter (LCDI) and Arc-Fault Circuit Interrupter (AFCI)"
550.25	Article 550—Mobile Homes, Manufactured Homes, and Mobile Home Parks "Arc-Fault Interrupter Protection"

DC Rated Breakers

Breakers are available for use with ungrounded applications where all three poles are connected in series, and grounded applications where the load is connected to the grounded terminal, and the series connected poles are on the non-grounded terminal. Rated for up to 750 Vdc, breakers are available from 15 to 2500 A trip ranges with thermal-magnetic trip units. Their compact size and increased interrupting performance give Eaton the most complete range of DC breakers in the industry.

DC Circuit Breakers

UL listed Eaton DC molded-case circuit breakers are for use in general DC circuits, battery supply circuits of UPS systems, PV systems and Level 3 electric vehicle charging circuits. These devices are an excellent alternative to fuses because they are easier to install and require less maintenance.

The various DC voltage ratings are obtained by connecting one, two, three or four poles in series as noted. Connection diagrams are shown on the breaker nameplate. The DC breakers use the same internal and external accessories as the standard breakers for AC application. DC breakers up to 600 Vdc are UL 489 listed and exceed the requirements of UL Supplement SC for molded-case circuit breakers with uninterruptible power supplies.

Molded-case circuit breakers for transportation application requiring 750 Vdc are available 15–150 A with 42 kA interrupting capacity at 750 Vdc. Breakers require four poles in series for high fault current protection in 750 Vdc application. For 750 V applications with low fault current requirements, contact Eaton for three-pole frames and rating details. 750 V is not a UL rating. Dimensions for DC breakers are the same as the standard thermal-magnetic equivalent.

DC molded-case circuit breakers use standard thermal-magnetic trip units, which are calibrated on AC circuits. The use of standard trip units allows for easy interchangeability and inventory management when both AC and DC systems are used. The magnetic trip pickup on DC circuits are, on average, 42% higher than AC. Specific time current curves depicting the values or tolerance band increase for DC breakers are available. Refer to publication TC01215003E for curve information.

Interrupting Capacity Ratings

Table 27.2-9. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Frame	Interrupting Capacity (Symmetrical kA)			
		Volts DC ①②			
		125 ③	250 ④	600 ⑤	750 ⑥
HFDDC	225	42	50	42	42
JGEDC JGSDC JGHDC	250 250 250	35 42 50	35 42 50	35 50 65	— — —
HJDDC HKDDC	250 400	42 42	50 50	42 42	— —
LGEDC LGSDC LGHDC	600 600 600	22 22 42	22 22 42	35 50 65	— — —
HLDDC HLDDC ⑦ HMDLDC	600 1200 800	42 42 42	50 50 50	35 — 35	— — —
NBDC PBDC	1200 2500	42 42	50 65	50 65	— —

① DC ratings apply to substantially non-inductive circuits. Time constant per UL 489.
② Minimum DC application voltage is 48 Vdc.
③ Single-pole in series.
④ Two poles in series.
⑤ Three poles in series.
⑥ Four poles in series. Not a UL listed voltage rating.
⑦ Four-pole frame with two-pole connection in parallel.

Table 27.2-10. DC Breaker Dimensions—Approximate Dimensions in Inches (mm)

Frame	Number of Poles	Width	Height	Depth
HFDDC	1 2 3 4	1.38 (35.1) 2.75 (70.0) 4.13 (105.0) 5.50 (139.7)	6.00 (152.4) 6.00 (152.4) 6.00 (152.4) 6.00 (152.4)	3.38 (86.0) 3.38 (86.0) 3.38 (86.0) 3.38 (86.0)
JGEDC, JGSDC, JGHDC	3	4.13 (105.0)	7.00 (177.8)	3.57 (90.7)
HJDDC HKDDC	2, 3 2, 3	4.13 (105.0) 5.50 (139.7)	10.00 (254.0) 10.13 (257.3)	4.06 (103.1) 4.10 (104.1)
LGEDC, LGSDC, LGHDC	3	5.48 (139.2)	10.13 (257.3)	4.09 (103.9)
HLDDC	2, 3 4	8.25 (209.6) 11.00 (279.4)	10.75 (273.1) 10.75 (273.1)	4.06 (103.1) 4.06 (103.1)
HMDLDC NBDC PBDC	2, 3 3 3	8.25 (209.6) 8.25 (209.6) 12.06 (306.3)	16.00 (406.4) 16.00 (406.4) 22.06 (560.3)	4.06 (103.1) 5.50 (139.7) 9.06 (230.1)

DC Molded-Case Switches

Eaton's DC molded-case switches are used in applications requiring a compact, high-capacity disconnect. They are UL 489 listed and have automatic high instantaneous current protection. These devices do not provide overload protection.

Table 27.2-11. DC Molded-Case Switches

Maximum Continuous Ampere Rating at 40°C	Interrupting Capacity (kA)	Poles in Series	With Line and Load Terminals Catalog Number	Without Line and Load Terminals Catalog Number
600 Vdc Maximum ⑧				
100 150 225	42 42 42	3 3 3	**HFDDC3100KL** **HFDDC3150KL** **HFDDC3225KL**	**HFDDC3100KW** **HFDDC3150KW** **HFDDC3225KW**
250 400 400	42 35 65	3 3 3	**HJDDC3250K** **HKDDC3400K** **LGKDC3400KSG**	**HJDDC3250KW** **HKDDC3400KW** **LGKDC3400KSW**
600 600 800	65 35 35	3 3 3	**LGKDC3630KSG** **HLDDC3600K** **HMDLDC3800K**	**LGKDC3630KSW** **HLDDC3600WK** **HMDLDC3800WK**
250 Vdc Maximum ⑧				
1200	50	⑨	**HLDDC21200K** ⑨	**HLDDC21200WK** ⑨

⑧ Minimum DC application voltage is 48 Vdc.
⑨ Four-pole frame with two-pole connected in parallel.

Table 27.2-12. Typical DC System Applications

Description	250 Vdc Maximum		600 Vdc Maximum		750 Vdc Maximum	
	Grounded	Ungrounded	Grounded	Ungrounded	Grounded	Ungrounded
Switchgear batteries	■					
Telecom	■					
Solar photovoltaic			■	■		
UPS battery systems		■		■		
Traction/transportation systems						■
Electrical vehicle charging			■			
DC motors		■		■		

Wiring Diagrams

Series Connection Diagrams for DC Application ①②"

① Poles in series connection is customer supplied. Use rated cable per NEC.
② For grounded systems, all poles in series must be connected on non-grounded terminal, with load connected to grounded terminal.

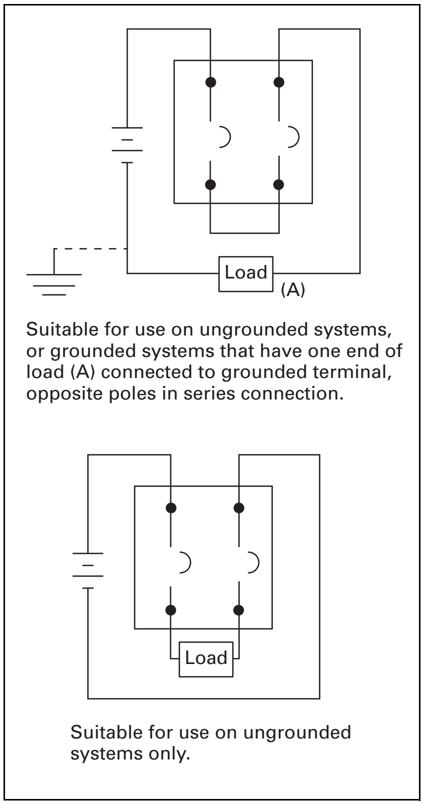


Figure 27.2-6. 250 Vdc Maximum—Two Poles in Series

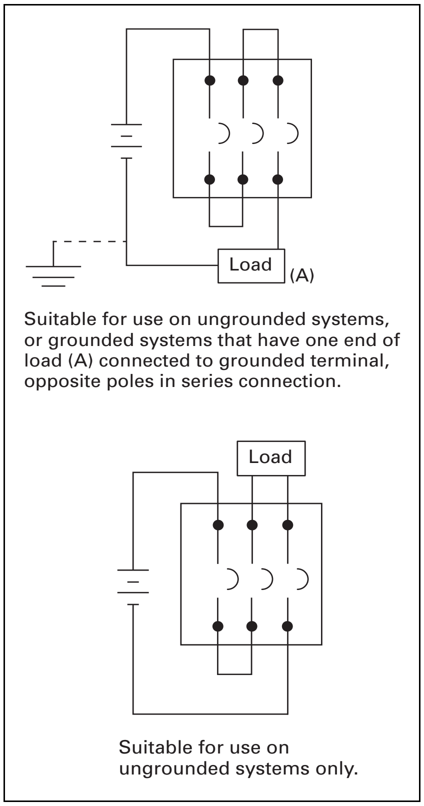


Figure 27.2-7. 600 Vdc Maximum—Three Poles in Series

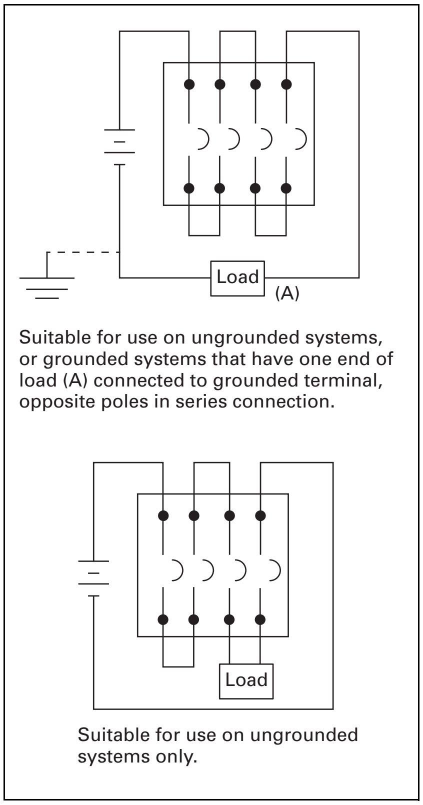


Figure 27.2-8. 750 Vdc Maximum—Four Poles in Series

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Application of Eaton Molded-Case Circuit Breakers to 400–415 Hz Systems

Eaton's molded-case circuit breakers, including breakers with electronic trip units, can be applied for overcurrent protection on 400–415 Hz systems. Commonly used to power computer installations, 400–415 Hz systems are also employed in conjunction with certain aircraft, military and other specialty equipment.

This publication contains guidelines to applying Eaton molded-case circuit breakers on 400–415 Hz systems.

Circuit Breaker Derating Required

Table 27.2-13 lists the maximum continuous current carrying capacity and **Table 27.2-14** lists the interrupting capacities at 400–415 Hz of Eaton molded-case circuit breakers. Due to the increased resistance of the copper sections resulting from the skin effect produced by eddy currents at 400–415 Hz, circuit breakers in many cases require derating.

The thermal derating on these devices is based upon 100%, three-phase application in open air in a maximum of 40 °C (104 °F) with 4 feet (1.2 m) of the specified cable 75 °C (167 °F) of bus at the line and load side. Additional derating of not less than 20% will be required if the circuit breaker is to be used in an enclosure. Further derating may be required if the enclosure contains other heat generating devices or if the ambient temperatures exceed 40 °C.

Table 27.2-13. Continuous Current of 400 Hz Breakers

Breaker Frame Series	Maximum Continuous Amperes at 60 Hz	400–415 Hz Application ①		
		Maximum Continuous Amperes	Cable/ Bus Bar (Per Phase)	Terminals (Fixed Front) Catalog or Style Number
EG ②	15 20 25	15 20 25	1–#12 Cu 1–#12 Cu 1–#12 Cu	**3T125EF** **3T125EF** **3T125EF**
	30 35 40	30 35 40	1–#10 Cu 1–#10 Cu 1–#8 Cu	**3T125EF** **3T125EF** **3T125EF**
	45 50 60	45 50 60	1–#8 Cu 1–#6 Cu 1–#6 Cu	**3T125EF** **3T125EF** **3T125EF**
	80 90 100	70 80 90	1–#4 Cu 1–#2 Cu 1–#1 Cu	**3T125EF** **3T125EF** **3T125EF**
	110 125	100 110	1-1/0 Cu 1-1/0 Cu	**3T125EF** **3T125EF**
EHD, FDB, FD, HFD	15 20 25	15 20 25	1–#12 Cu 1–#12 Cu 1–#12 Cu	**624B100G02** **624B100G02** **624B100G02**
	30 35 40	30 35 40	1–#10 Cu 1–#10 Cu 1–#8 Cu	**624B100G02** **624B100G02** **624B100G02**
	50 70 90	45 65 85	1–#6 Cu 1–#4 Cu 1–#2 Cu	**624B100G02** **624B100G02** **624B100G02**
	100 125 ③ 150 ③	95 115 135	1–#1 Cu 1–1/0 Cu 1–1/0 Cu	**624B100G17** **624B100G17** **624B100G17**
JG ②	70 90 100	60 80 90	1–#4 Cu 1–#2 Cu 1–#1 Cu	**T250FJ** **T250FJ** **T250FJ**
	125 150 175	100 125 150	1–1/0 Cu 1–1/0 Cu 1–2/0 Cu	**T250FJ** **T250FJ** **T250FJ**
	200 200 225 250	160 175 200 200	1–3/0 Cu 1–4/0 Cu 1–4/0 Cu 1–250 kcmil Cu	**T250FJ** **T250FJ** **T250FJ** **T250FJ**
JDB, JD, HJD	70 90 100	60 80 90	1–#4 Cu 1–#2 Cu 1–#1 Cu	**T250KB** **T250KB** **T250KB**
	125 150 175	100 125 150	1–1/0 Cu 1–1/0 Cu 1–2/0 Cu	**T250KB** **T250KB** **T250KB**
	200 225 250	160 200 200	1–3/0 Cu 1–4/0 Cu 1–250 kcmil Cu	**T250KB** **T250KB** **T250KB**

① The calibration of these breakers and the tolerance percentages of the time-current curves are the same as at 60 Hz.
② Thermal-magnetic only.
③ FD and HFD only.

Table 27.2-13. Continuous Current of 400 Hz Breakers (Continued)

Breaker Frame Series	Maximum Continuous Amperes at 60 Hz	400–415 Hz Application ①		
		Maximum Continuous Amperes	Cable/ Bus Bar (Per Phase)	Terminals (Fixed Front) Catalog or Style Number
KDB, KD, HKD	125 150 175	100 125 150	1–1/0 Cu 1–1/0 Cu 1–2/0 Cu	**T300K** **T300K** **T300K**
	200 225 250	160 180 200	1–3/0 Cu 1–4/0 Cu 1–250 kcmil Cu	**T300K** **T300K** **T300K**
	300 350 400	225 275 300	1–350 kcmil Cu 1–500 kcmil Cu 2–3/0 Cu	**T300K** **T350K** **T400K**
LG ②	250 300 350	200 250 275	1–250 kcmil Cu 1–350 kcmil Cu 1–500 kcmil Cu	**TA350LK** **TA350LK** **TA350LK**
	400 500 600	300 400 400	1–500 kcmil Cu 2–500 kcmil Cu 2–500 kcmil Cu	**TA350LK** **3TA632LK** **3TA632LK**
LDB, LD, HLD	250 300 350	210 240 275	1–250 kcmil Cu 1–350 kcmil Cu 1–500 kcmil Cu	**T600LA** **T600LA** **T600LA**
	400 500 600	310 370 425	2–250 kcmil Cu 2–350 kcmil Cu 2–500 kcmil Cu	**T600LA** **T600LA** **T600LA**
LD with Digitrip RMS 310	300 600	300 500	2–250 kcmil Cu 2–350 kcmil Cu	**T401LA** **T401LA**
MDL with Digitrip RMS 310	400 500 600	340 405 470	2–3/0 Cu 2–300 kcmil Cu 2–350 kcmil Cu	**T600MA1** **T600MA1** **T600MA1**
	700 800	355 400	2–4/0 Cu 2–300 kcmil Cu	**T800MA1** **T800MA1**
ND with Digitrip RMS 310	1200	700 750 850	3–300 kcmil Cu 3–350 kcmil Cu 4–350 kcmil Cu	**T1000NBI** **T1000NBI** **T1200NBI**
RD with Digitrip RMS 310	2000	1500	4–1/2 x 4 Cu	Rear connected Cu T-bar

① The calibration of these breakers and the tolerance percentages of the time-current curves are the same as at 60 Hz.
② Thermal-magnetic only.

Cable and Bus Sizing

The cable and bus sizes to be used at 400–415 Hz are not based on standard National Electrical Code tables for 60 Hz application. Larger cross sections are necessary at 400–415 Hz to avoid exceeding component temperature limits. All bus bars specified are based upon mounting the bars in the vertical plane to allow maximum air flow. All bus bars are spaced at a minimum of 1/4-inch (6.35 mm) apart. Mounting of bus bars in the horizontal plane will necessitate additional drafting. Edgewise orientation of the bus may change the maximum ratings indicated. If additional information is required for other connections of cable or bus, contact the Eaton Technical Resource Center.

Interrupting Capacity

400–415 Hz interrupting capacities of the Eaton molded-case circuit breakers are found in **Table 27.2-14**.

Application Recommendations

It is recommended that thermal indicating devices such as "tempi plates" be placed on the line and load terminals or T-connectors of the center pole. These are usually the hottest terminals with a balanced load. A maximum temperature of 90 °C (50 °C over a maximum ambient of 40 °C) would verify the maximum rating for the particular application. Temperature profiles taken on these breakers can be correlated to ensure that the hottest points within the breaker are within the required temperature limits.
A thermal cutoff switch can also be used to actuate a shunt trip to open the breaker if the thermal limits are exceeded. Consult the Eaton Technical Resource Center for further information on special applications.

Application Information—400–415 Hz

Table 27.2-14. Interrupting Capacities of 400 Hz Breakers

Breaker Frame Series	Estimated 400–415 Hz Interrupting Capacities ①② (rms Symmetrical Amperes)		
	240 V	480 V	600 V
Thermal-Magnetic			
EGB	5000	3600	—
EGC	40,000	20,000	7000 ③
EGE	7000	5000	3600 ③
EGH	20,000	13,000	5000 ③
EGS	17,000	7000	4400 ③
EHD	3600	2800	—
FDB	3600	2800	2800
FD, HFD	13,000	5000	3600
JDB, JD	8000	7000	7000
JGC	40,000	20,000	7000
JGE	13,000	5000	3600
JGH	20,000	13,000	5000
JGS	17,000	7000	3600
HJD	14,000	10,000	7000
KDB, KD, HKD	21,000	11,000	8000
LDB, LD	14,000	10,000	7000
LGC	40,000	20,000	10,000
LGE	13,000	7000	3600
LGH	20,000	13,000	7000
LGS	17,000	10,000	5000
HLD	21,000	11,000	8000
MD	14,000	10,000	7000
Electronic Trip Units			
KD, LD, MDL, ND	14,000	10,000	7000
HLD, HMDL	21,000	11,000	8000
HND	21,000	16,000	8000
RD	40,000	33,000	33,000

① The above interrupting ratings are estimates based on the design parameters and operating characteristics of each breaker as well as on the limited amount of test data thus far available for circuit breakers applied to 400–415 Hz systems.
② Not UL listed.
③ Series G E-Frame is 600/347 Vac maximum.

High-Intensity Discharge (HID) Breakers

HID breakers are used to switch 120 V or 277 V fluorescent lighting circuits or high-intensity discharge lighting circuits. Per UL 489 Section 7.14, they must be listed and marked "HID." HID breakers are tested for endurance at 75% power factor. The contacts and the spring of an HID breaker are heavier duty to dissipate the increased heat from greater current flow during the HID ignition period. For listing of available HID rated breakers, see **Table 27.2-15**.

Lighting Control Solenoid Operated Breakers

Eaton manufactures a wide array of solenoid operated breakers for lighting control applications. These are available in both 120 and 277 V single-pole and two-pole configurations. See individual circuit breaker selection data, **Table 27.4-12**, for more information.

For a full discussion of the use of these breakers, see **Tab 23 Lighting Control Systems—Pow-R-Command**.

Switching Duty (SWD) Rated Breakers

SWD breakers are rated 15 or 20 A, 120 and 277 V and intended to switch fluorescent lighting loads on a regular basis and are marked SWD, per UL 489 Section 7.9. SWD breakers are endurance-tested at 100% power factor. Eaton's single-pole 120 Vac QUICKLAG line, as well as the GB, GC and single-pole 277 Vac GHB, GHBS, GHC, EHD Series C and EG Series G breakers are tested, rated and marked SWD. In addition, there are other SWD rated circuit breakers available (see **Table 27.2-16**).

Heating, Air Conditioning and Refrigeration Circuit Breakers (HACR)

Due to changes in the UL 489 standards, all circuit breakers meet the requirements for HACR application. NEMA AB-3 Standard, Molded-Case Circuit Breakers and their Application States, "Section 430.53 of the NEC permits the use of an inverse-time circuit breaker as the branch circuit protective device in multi-motor and combination load installations, commonly involved in heating, air conditioning and refrigeration equipment. Circuit breakers do not need to be marked HACR in order to be used in these applications unless the end use still requires that marking."

Engine Generator Circuit Breakers

Engine generator circuit breakers are designed specifically for application on diesel engine powered standby generator systems where high interrupting circuit breakers are not required. Generator breakers are equipped with a special trip unit that provides standard overload protection with low magnetic short-circuit protection to suit generator applications that call for close short-circuit protection at low interrupting ratings.

Eaton offers a family of engine generator circuit breakers from 15 to 1200 A that conform to UL 489, CSA and IEC 947-2 standards.

Table 27.2-15. HID Rated Molded-Case Circuit Breakers

Frame	Poles	Ampere Rating	120/240 V Maximum	277/480 V Maximum
BAB-D	1, 2	15–60	■	
CH-HID	1, 2	15–30	■	
CHB-HID	1, 2	15–30	■	
GHBS	1, 2	15–30		■
HQP-D	1, 2	15–60	■	
QC	1, 2	15–60	■	
GHQRSP	1, 2	15–30		■
BABRP	1, 2	15–30	■	
BABRSP	1, 2	15–30	■	
BRRP	1, 2	15–30	■	
CLRP	1, 2	15–30	■	

Table 27.2-16. SWD Rated Molded-Case Circuit Breakers

Breaker Family	Frame	Mounting	Poles	Ampere Rating	SWD at 120 Vac	SWD at 277 Vac
QUICKLAG	—	All	1	15 and 20	■	—
Series C	GHB, GHBS, GHC and EHD	All	1	15 and 20	—	■
Series G	EG	All	1, 2	15 and 20	—	■

Table 27.2-17. HACR Rated Molded-Case Circuit Breakers

Breaker Family	Frame	Mounting	Poles	Ampere Rating	Up to 240 Vac	Up to 480 Vac
QUICKLAG	—	Plug-on Bolt-on Cable-cable	1, 2, 3 1, 2, 3 1, 2, 3, 4	15–100 15–100 10–100	■ ■ ■	— — —
Series C Series G	GD thru LD EG thru LG	All All	All All	All All	— —	■ ■

Mining Circuit Breakers

Eaton mining circuit breakers have a tradition of proven dependability and reliability in harsh mine environments, consistently combining strength and reliability with safe, efficient operation. The mining breaker is available from 15–2500 A and is designed for trailing cable applications per MSHA 30 CFR 75. With interrupting ratings up to 25 kA at 1000/577 Vac and rms sensing electronic trip unit, the mining breaker can be applied to all mining circuit breaker applications.

Mining breakers are available with a full line of accessories.

NAVY MIL-SPEC Breakers

NAVY MIL-SPEC molded-case circuit breakers provide both overload protection for conductors and short-circuit protection for all circuit elements, such as conductors, motors and starters. They also serve as manual disconnecting means, as well as circuit protectors.

These breakers range from 5 to 1600 A with interrupting ratings to 100,000 A rms asymmetrical. These breakers are rated 500 Vac class for use in traditional 450 Vac three-phase open delta ungrounded naval distribution systems. Smaller distribution panel breakers are rated 125 Vac. 60 Hz and 400 Hz versions are available as well as 125/250 Vdc ratings.

All Eaton NAVY breakers meet applicable MIL-SPECS including:

- MIL-C-17588/QPL17588 ALB-1 Breakers
- MIL-DTL-17361/QPL17361 AQB Breakers
- MIL-S-901 Shock
- MIL-STD-167-1 Vibration
- MIL-STD-461 EMI
- ASTM D5948 “Special” Molding Compounds

Marine Circuit Breakers

Eaton circuit breakers can be supplied to meet the following marine specifications:

- U.S. Coast Guard CFR
- ABS—American Bureau of Shipping
- IEEE 45
- DNV
- Lloyds
- ABS / NVR

These specifications generally require molded-case circuit breakers to be supplied with 50 °C ambient ratings and plug-in adapter kits. When plug-in adapter kits are used, no terminals need to be supplied (switchboard applications).

Circuit breakers can also be supplied to meet UL 489 Supplement SA (Marine use—for vessels over 65 feet in length) and UL 489 Supplement SB (Naval use).

Molded-Case Breakers for Application on Resistance Welding Circuits

Short-circuit protection for resistance welding devices can be obtained by properly applying instantaneous trip molded-case circuit breakers.

Note: Instantaneous only breakers for welding application are intended for application within the welding equipment not as feeder breakers to welding machines.

These breakers permit normally high welding currents, but trip instantaneously if a short-circuit develops. These breakers include standard molded-case circuit breaker features, such as trip-free operation, deadfront and single-phase protection. Because the breakers are resettable after tripping, replacement costs and downtime are minimized.

Duty Cycle is based on the one minute averaging time of the breaker, and can be determined as follows:

$$\text{Duty Cycle} = \frac{\text{Weld Time} \times 100}{\text{Weld Time} + \text{Off Time}}$$

“During-weld” amperes can be obtained from the welder manufacturer, or as follows:

$$\text{During-weld Amperes} = \frac{\text{During-weld kVA} \times 1000}{\text{Voltage}}$$

Interrupting capacity of the breaker should be within the maximum available at the point of application. Refer to Eaton for additional application details.

Continuous Ampere Rating

Molded-case circuit breakers are rated in rms amperes at a specific ambient. This ampere rating is the continuous current that they will carry in the ambient temperature for which they are calibrated. Eaton thermal-magnetic breakers are calibrated for an ambient temperature 40 °C (104 °F) that is the average temperature within an enclosure; thus, they minimize the need for derating. If the enclosure ambient is known to exceed 40 °C, the breaker used should either be especially calibrated for that ambient, or be derated accordingly.

In accordance with the National Electrical Code, all circuit breakers are derated to 80% for continuous loads except electronic trip unit circuit breakers that have been tested and marked for 100% application.

The selection of a specific ampere rating for a given application is dependent upon the type of load and duty cycle, and is governed by the National Electrical Code. In general, the NEC requires overcurrent protection at the supply and at points where wire sizes are reduced. It further states that the conductors be protected in accordance with their current carrying capacity, but lists exceptions for applications such as motor circuits where a larger rating is often required to override motor inrush currents.

Some test methods used in the field are often poor indicators of the condition of a circuit breaker. These tests are used to minimize test cycle and setup times. Test types range from contact resistance measurements to millivolt drop checks.

Contact resistance should not be considered a reliable measure of a breaker's ability to carry rated current. Contact resistance is usually measured with low currents from a low voltage supply flowing through the contacts, and the resistance value is heavily dependent on transient contact surface conditions. These transient surface conditions can vary with factors, such as the contact material, the gaseous ambient and the current level, and the resistance can markedly decrease with the flow of rated current. Observation of high contact resistance should be considered only as an indicator of the need for further testing whenever circuit breakers are being evaluated.

The millivolt drop procedure outlined in NEMA Standards Publication AB4-1996 Section 5.4 can be used to assess the electrical integrity of connections and contacts within a circuit breaker. The IEEE® paper by John Shea and John Bindas, "Measuring Molded-Case Circuit Breaker Resistance" Vol. CHMT-16, No. 2, March 1993, is available as a guideline for more reliable millivolt drop measurements. Again, the millivolt drop can be affected by contact surface conditions that can change with breaker operation and arcing. Further, the millivolt drop is only one factor in determining the thermal loading of a breaker, and the total system must be considered prior to judging a breaker to be unacceptable.

Proper thermal performance of a well loaded circuit breaker is by far the best indicator of a circuit breaker's current carrying capability, and a millivolt drop test, performed at rated current, can serve to indicate whether further testing is required.

If the resistance and millivolt drop test data raises concerns in regards to breaker integrity, a proper thermal test must be performed.

Circuit Voltage

Molded-case circuit breakers are rated by voltage class and should be applied only to system voltages within their rating. The voltage rating is determined by the maximum voltage that can be applied across its terminals, the type of distribution system and how the breaker is applied in the system.

Circuit breakers listed for use at 120/240 V may be applied on 120/240 V grounded systems. For applications on 240 V ungrounded systems, apply only circuit breakers rated 240 V (with no "slash" rating) or higher.

Circuit breakers rated 277/480 V are suitable for application on 277/480 V grounded wye systems and are not for application on 480 V ungrounded delta systems. Apply circuit breakers rated 480 V (with no "slash" rating) or higher on 480 V ungrounded delta systems.

UL 489 provides standards for testing the individual poles of two- and three-pole molded-case circuit breakers. The test current is generally lower than the interrupting rating of the molded-case circuit breaker. This capability is necessary for breakers applied on corner-grounded delta systems where single line-to-ground faults may be interrupted by only a single pole of a circuit breaker with full line-to-line voltage across that single interrupting pole. Molded-case circuit breakers should not be used on circuits where the available fault current exceeds the level at which individual poles were short-circuit tested at line-to-line voltage.

Note: On all three-phase delta, grounded B Phase applications, refer to Eaton.

Interrupting Ratings

Molded-case circuit breakers are available in various interrupting capacities. Standard interrupting capacity breakers are available in both industrial and replacement circuit breaker lines. These breakers have interrupting capacities up to 35 kA at 480 Vac.

High interrupting capacity breakers are similar to standard interrupting capacity breakers, but the improved performance makes these breakers suited for use in today's network systems where higher fault currents exist. These breakers have interrupting capacities up to 65 kA at 480 Vac.

For applications that call for very high interrupting ratings, current limiting high interrupting capacity breakers are available. These breakers offer true current limiting characteristics in the same physical frame size as the high interrupting capacity version and have interrupting capacities of 100, 150 and 200 kA at 480 Vac.

The maximum amount of fault current supplied by a system can be calculated at any point in that system. One rule must be followed for applying the correct circuit breaker.

The interrupting rating of the breaker must be equal to or greater than the amount of fault current that can be delivered at that point in the system where the breaker is applied.

The interrupting rating of the breaker is the maximum amount of fault current it can safely interrupt without damaging itself. A breaker's interrupting rating always decreases as the voltage increases. Interrupting rating is one of the most critical factors in the breaker selection process.

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Circuit Frequency

The tripping characteristics of most molded-case circuit breakers remain virtually constant when applied to frequencies of 50 and 60 Hz. On higher frequency applications, molded-case circuit breakers must usually be specially calibrated and/or derated. The amount of derating depends upon the frame size and ampere rating, as well as the current frequency. In general, the higher the ampere rating in a given frame size, the greater the derating required.

Thermal-magnetic molded-case circuit breakers applied at frequencies above 60 Hz could require that individual consideration be given to thermal performance, magnetic performance and interrupting capabilities.

Electronic trip units are usually calibrated for 50/60 Hz, although operation at higher frequencies is achievable with the use of special derating factors and specially sized cable or bus.

Avoid making circuit breaker performance assumptions on applications above 60 Hz. Consult Eaton for molded-case circuit breakers above 60 Hz.

Number of Poles

The number of poles in the breaker is determined by the type of distribution system. A pole is required for each hot conductor, but usually not for the neutral conductor, except in certain special applications.

In general, a single-pole breaker may be used on grounded neutral systems for single-phase applications and a three-pole breaker on three-phase applications. There are instances, however, where two-pole breakers are necessary on single-phase systems and four-pole breakers on three-phase systems to interrupt the neutral. Certain DC voltage applications also use special multi-pole configurations.

Ground Fault Protection

Molded-case circuit breakers use internal residual ground fault protection schemes or separate earth leakage modules using zero sequence sensing when optional ground fault protection is required. For more information on how the scheme operates, see **Tab 1, Figure 1.4-7** and the associated explanation.

Code Considerations—Circuit Breaker Sizing

The following paragraphs outline pertinent information from the NEC according to the type of load and duty cycle.

Service

A service includes the conductors and equipment for delivering electrical energy from the supply system to the wiring system of the premises served.

NEC Article 230 contains the many requirements for services of 600 V or less including the sizing, location and overcurrent protection of conductors, disconnect means, permissible number of disconnects, grounding of conductors and ground fault protection requirements of service equipment.

Feeder Circuits

A feeder is composed of the conductors of a wiring system between the service equipment or the generator switchboard of an isolated plant and the branch circuit overcurrent device.

NEC Article 220: Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125% of the continuous load.

Exception: Where the assembly including the overcurrent devices protecting the feeder(s) are listed for operation at 100% of their rating, neither the ampere rating of the overcurrent device nor the ampacity of the feeder conductors shall be less than the sum of the continuous load plus the noncontinuous load.

Only breakers listed for 100% application, and so labeled, can be applied under the exception (for example, type CKD). Breakers without 100% application listing and label are applied under (B) above, or at 80% of rating.

NEC Article 430: Breakers for feeders having mixed loads; i.e., heating (lighting and heat appliances) and motors, should have ratings suitable for carrying the heating loads plus the capacity required by the motor loads.

NEC Article 430: Breakers for motor feeders shall have a rating not greater than the sum of the highest breaker rating of any of its branches and the full load currents of all other motors served by the feeder.

Branch Circuits

A branch circuit is the portion of a wiring system extending beyond the final overcurrent device protecting the circuit.

(1) Lighting Circuits (NEC Article 310)
These are protected in accordance with the conductor ratings as given. High wattage incandescent lamp loads may result in abnormally high inrush currents that must be taken into account to avoid nuisance tripping. The lamp manufacturer should be consulted for data relative to the inrush currents.

(2) Motor Circuits (NEC Article 430)
Breakers are primarily intended for the protection of conductors, motor control apparatus and motors against short circuits and ground fault conditions.

On motor overloads, the motor overcurrent device will open the circuit before the correctly applied breaker. Currents higher than the locked rotor value will be interrupted by the breakers, protecting the circuit from these heavy fault currents. The breaker must not trip on normal starting.

While breakers may be applied for motor running overcurrent protection when the requirements of Article 430 of the NEC are met, these applications are not recommended for Eaton's breakers and, therefore, this discussion is confined to the use of a breaker as a circuit protector.

For many applications, particularly those where starting behavior of the motor is unknown, the NEC maximum rules are followed. Usually, lower rated breakers can be used successfully. This is further discussed under motor circuit application and motor application tables.

Motor circuit application (NEC Article 430): The breaker must have a continuous rating of not less than 115% of the motor full load current. Before applying a breaker, check to determine the effect of any of the following conditions: High ambient temperature, heating within breaker enclosure due to grouping of current consuming devices, frequent motor starting and lengthy motor acceleration period.

Breaker rating or setting (NEC Article 430): The motor branch circuit overcurrent device must be capable of capable of carrying the inrush current of the motor. The required protection should be considered as being obtained when the overcurrent device has a rating or setting not exceeding the values given in **Table 27.3-1**, reference NEC Article 430).

An instantaneous trip circuit breaker (without time delay) should be used only if adjustable and if part of a combination controller having overcurrent protection in each conductor and the combination is especially approved for the purpose. In the event a breaker chosen on this basis still does not allow motor starting, a higher rating is permitted by the code. See Exceptions listed with **Table 27.3-1**.

Due to the infinite number of motor-and-load combinations and because comparable breakers of different manufacture have different tripping characteristics, NEC motor circuit breaker rules are of a general nature and are set up as maximum boundaries. Protection is considered satisfactory if the breaker rating does not exceed the figure allowed by the NEC requirements. Although Eaton breakers rated less than the NEC maximum values may be applied in most cases, many operating engineers select breakers on the basis of the NEC maximum rules simply because consideration of other factors is not usually necessary, or to ensure motor starting when the starting behavior of the motor is not known. **Tables 27.3-1** and **27.3-2** are adapted from Article 430 of NEC.

When a certain motor is standard for a given job, as on a volume-produced machine tool, it is practical (and often more economical) to select a breaker for closer protection than one chosen on the basis of NEC maximum rules.

Circuit Breaker Not Horsepower Rated

Unlike switches, circuit breakers are not horsepower rated because they are able to safely interrupt currents far in excess of the locked rotor value for any motor with which they may be applied. This ability is recognized in the NEC as stated in paragraph 430.109 and is proven by the Underwriters Laboratories tests described in UL bulletin number 489, *Standard for Branch Circuit and Service Circuit Breakers*.

For example, a breaker must pass the UL overload test consisting of breaking a current 600% of its ampere ratings. As motor branch circuit breaker ratings are usually 125 to 250% of motor full-load currents, this test establishes the ability of the breaker to more than interrupt locked rotor currents. Following the overload test and others, the breaker is called upon to successfully clear its rated short-circuit current that is a minimum of 5000 A. This also is many times higher than motor locked rotor current. Because by definition, a circuit breaker is required to “open under abnormal conditions...without injury to itself,” the breaker must still be in operating condition after the test.

Motor Branch Circuits

Table 27.3-1. Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground Fault Protective Devices—NEC Table 430.52

Motor Type	Percent of Full Load Current ①	
	Instantaneous Trip Breaker	Inverse Time Breaker
Single-phase motors	800	250
AC polyphase motors other than wound rotor squirrel cage:		
Other than Design B energy efficient	800	250
Design B energy efficient	1100	250
Synchronous	800	250
Wound rotor	800	150
Direct-current (constant voltage)	250	150

① For certain exceptions to the values specified, see Sections 430.52 through 430.54. The values given in the last column also cover the ratings of nonadjustable inverse time types of circuit breakers that may be modified as in Section 430.52, Exceptions No. 1 and No. 2. Synchronous motors of the low-torque, low-speed type (usually 450 rpm or lower), such as are used to drive reciprocating compressors, pumps and so on, that start unloaded, do not require a fuse rating or circuit breaker setting in excess of 200% of full load current.

Table 27.3-2. Full-Load Current Three-Phase Alternating-Current Motors—NEC Table 430.250 ②

Hp	Induction Type Squirrel Cage and Wound-Rotor Amperes							Synchronous Type Unity Power Factor ③ Amperes			
	115 V	200 V	20 V	230 V	46 V	575 V	2300 V	230 V	460 V	575 V	2300 V
1/2	4.4	2.5	2.4	2.2	1.1	0.9	—	—	—	—	—
3/4	6.4	3.7	3.5	3.2	1.6	1.3	—	—	—	—	—
1	8.4	4.8	4.6	4.2	2.1	1.7	—	—	—	—	—
1-1/2	12.0	6.9	6.6	6.0	3.0	2.4	—	—	—	—	—
2	13.6	7.8	7.5	6.8	3.4	2.7	—	—	—	—	—
3	—	11.0	10.6	9.6	4.8	3.9	—	—	—	—	—
5	—	17.5	16.7	15.2	7.6	6.1	—	—	—	—	—
7-1/2	—	25.3	24.2	22	11	9	—	—	—	—	—
10	—	32.2	30.8	28	14	11	—	—	—	—	—
15	—	48.3	46.2	42	21	17	—	—	—	—	—
20	—	62.1	59.4	54	27	22	—	—	—	—	—
25	—	78.2	74.8	68	34	27	—	53	26	21	—
30	—	92	88	80	40	32	—	63	32	26	—
40	—	120	114	104	52	41	—	83	41	33	—
50	—	150	143	130	65	52	—	104	52	42	—
60	—	177	169	154	77	62	16	123	61	49	12
75	—	221	211	192	96	77	20	155	78	62	15
100	—	285	273	248	124	99	26	202	101	81	20
125	—	359	343	312	156	125	31	253	126	101	25
150	—	414	396	360	180	144	37	302	151	121	30
200	—	552	528	480	240	192	49	400	201	161	40
250	—	—	—	—	302	242	60	—	—	—	—
300	—	—	—	—	361	289	72	—	—	—	—
350	—	—	—	—	414	336	83	—	—	—	—
400	—	—	—	—	477	382	95	—	—	—	—
450	—	—	—	—	515	412	103	—	—	—	—
500	—	—	—	—	590	472	118	—	—	—	—

② The following values of full load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed will be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 V.

③ For 90% and 80% power factor, the above figures should be multiplied by 1.1 and 1.25 respectively.

Motor Protection

In line with 2008 NEC 430.6(A1) circuit breaker, HMCP and fuse rating selections are based on full load currents for induction motors running at speeds normal for belted motors and motors with normal torque characteristics using data taken from NEC Table 430.250 (three-phase). Actual motor nameplate ratings should be used for selecting motor running overload protection. Motors built special for low speeds, high torque characteristics, special starting conditions and applications will require other considerations as defined in the application section of the NEC.

These additional considerations may require the use of a higher rated HMCP, or at least one with higher magnetic pickup settings.

Circuit breaker, HMCP and fuse ampere rating selections are in line with maximum rules given in NEC 430.52 and Table 430.250. Based on known characteristics of Eaton breakers, specific units are recommended. The current ratings are no more than the maximum limits set by the NEC rules for motors with code letters F to V or without code letters. Motors with lower code letters will require further considerations.

In general, these selections were based on:

1. Ambient—outside enclosure not more than 40 °C (104 °F).
2. Motor starting—infrequent starting, stopping or reversing.
3. Locked rotor—maximum 6 times motor FLA.
4. Locked rotor—maximum 6 times motor FLA.

Type HMCP motor circuit protector may not be set more than 1300% of the motor full-load current to comply with NEC 430.52 (except for NEMA Design B energy efficient motors which can be set up to 1700%).

Circuit breaker selections are based on types with standard interrupting ratings. Higher interrupting rating types may be required to satisfy specific system application requirements.

For motor full load currents of 208 V and 200 V, increase the corresponding 230 V motor values by 10% and 15% respectively.

Table 27.3-3. Motor Circuit Protector (MCP), Circuit Breaker and Fusible Switch Selection Guide

Horsepower	Full Load Amperes (NEC) FLA	Fuse Size NEC 430.52 Maximum Amperes		Recommended Eaton		
				Circuit Breaker	Motor Circuit Protector Type HMCP	
		Time Delay	Non-Time Delay	Amperes	Amperes	Adj. Range
230 V, Three-Phase						
1	3.6	10	15	15	7	21–70
1-1/2	5.2	10	20	15	15	45–150
2	6.8	15	25	15	15	45–150
3	9.6	20	30	20	30	90–300
5	15.2	30	50	30	30	90–300
7-1/2	22	40	70	50	50	150–500
10	28	50	90	60	50	150–500
15	42	80	150	90	70	210–700
20	54	100	175	100	100	300–1000
25	68	125	225	125	150	450–1500
30	80	150	250	150	150	450–1500
40	104	200	350	150	150	750–2500
50	130	250	400	200	150	750–2500
60	154	300	500	225	250	1250–2500
75	192	350	600	300	400	2000–4000
100	248	450	800	400	400	2000–4000
125	312	600	1000	500	600	1800–6000
150	360	700	1200	600	600	1800–6000
200	480	1000	1600	700	600	1800–6000
460 V, Three-Phase						
1	1.8	6	6	15	7	21–70
1-1/2	2.6	6	10	15	7	21–70
2	3.4	6	15	15	7	21–70
3	4.8	10	15	15	15	45–150
5	7.6	15	25	15	15	45–150
7-1/2	11	20	35	25	30	90–300
10	14	25	45	35	30	90–300
15	21	40	70	45	50	150–500
20	27	50	90	50	50	150–500
25	34	60	110	70	70	210–700
30	40	70	125	70	100	300–1000
40	52	100	175	100	100	300–1000
50	65	125	200	110	150	450–1500
60	77	150	150	125	150	750–2500
75	96	175	300	150	150	750–2500
100	124	225	400	175	150	750–2500
125	156	300	500	225	250	1250–2500
150	180	350	600	250	400	2000–4000
200	240	450	800	350	400	2000–4000
575 V, Three-Phase						
1	1.4	3	6	15	3	9–30
1-1/2	2.1	6	10	15	7	21–70
2	2.7	6	10	15	7	21–70
3	3.9	10	15	15	7	21–70
5	6.1	15	20	15	15	45–150
7-1/2	9	20	30	20	15	45–150
10	11	20	35	25	30	90–300
15	17	30	60	40	30	90–300
20	22	40	70	50	50	150–500
25	27	50	90	60	50	150–500
30	32	60	100	60	50	150–500
40	41	80	125	80	100	300–1000
50	52	100	175	100	100	300–1000
60	62	110	200	125	150	750–2500
75	77	150	250	150	150	750–2500
100	99	175	300	175	150	750–2500
125	125	225	400	200	250	1250–2500
150	144	300	450	225	250	1250–2500
200	192	350	600	300	400	2000–4000

Capacitor Protection (NEC Article 460)

In normal applications, breakers rated about 150% of capacitor rated currents are recommended. This factor allows for switching surges, and possible overcurrent due to overvoltage and harmonic currents. Such selection fully meets the NEC requirements in 460.8 for a conductor and disconnect to be rated not less than 135% capacitor rating. Where the operating currents exceed 135% of rated current due to harmonic components, service conditions may require the selection of a breaker with a higher current rating.

For application in ambients higher than the rated ambient of the breaker, the breaker derating table should be checked to determine the rating of the breaker required to meet the minimum of 135% capacitor rating.

Circuit breakers and switches for use with capacitor must have a current rating in excess of rated capacitor current to provide for overcurrent from overvoltages at fundamental frequency and harmonic currents. The following percent of the capacitor-rated current should be used:

Fused and unfused switches . . . 165%

Enclosed molded-case circuit breaker (includes additional de-rating for enclosures) 150%

Air circuit breakers 135%

Contactors:

Open type 135%

Enclosed type 150%

Refer to Tab 35 for specific sizing of protective devices by kVAR rating.

Transformer Protection (NEC Article 450) Primary

Each transformer 600 V or less shall be protected by an individual overcurrent device on the primary side. Rated or set at not more than 125% of the rated primary current of the transformer.

Exception No. 1: Where the rated primary currents of a transformer are 9 A or more and 125% of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher standard rating described in Section 240 will be permitted. Where the rated primary current is less than 9 A, an overcurrent device rated or set at not more than 167% of the primary current shall be permitted.

Where the rated primary current is less than 2 A, an overcurrent device rated or set at not more than 300% will be permitted.

Exception No. 2: An individual overcurrent device will not be required where the primary circuit overcurrent device provides the protection specified in this Section.

Exception No. 3: As provided in (2) below.

(2) Primary and Secondary

A transformer 600 V or less having an overcurrent device on the secondary side rated or set at not more than 125% of the rated secondary current on the transformer shall not be required to have an individual overcurrent device on the primary side if the primary feeder overcurrent device is rated or set at a current value not more than 250% of the rated primary current of the transformer.

A transformer 600 V or less, equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current, will not be required to have an individual overcurrent device on the primary side if the primary feeder overcurrent device is rated or set at a current value not more than six times the rated current of the transformer for transformers having more than 6% impedance and not more than four times the rated current of the transformer for transformers having more than six but not more than 10% impedance.

Exception 4: Where the rated secondary current of a transformer is 9A or more and 125% of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher standard rating described in Section 240 will be permitted.

Where the rated secondary current is less than 9 A, an overcurrent device rated or set at not more than 167% of the rated secondary current shall be permitted. Closer protection can be provided by breakers having shunt trips actuated by a temperature sensing device imbedded in transformer windings.

Table 27.3-4. Single-Phase Transformer Primary Protection When Secondary Protection Provided

kVA	208 V		240 V		277 V		480 V		600 V	
	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip
2	10	20	8	20	7	15	5	10	4	—
3	14	30	13	30	11	20	6	15	5	10
5	24	50	21	50	18	40	10	20	8	20
7.5	36	70	31	60	27	50	16	30	13	30
10	48	100	42	80	36	70	21	40	17	40
15	72	150	63	125	54	100	31	60	25	50
25	120	225	104	200	90	175	52	100	42	100
37.5	180	350	156	300	135	250	78	150	63	150
50	240	450	208	400	181	350	104	200	83	150
75	361	700	313	600	271	500	156	300	125	250
100	481	1000	417	800	361	700	208	400	167	350
167	803	1600	696	1200	603	1200	348	700	278	600
250	1202	2000	1042	1600	903	1600	521	800	417	800
333	1601	3000	1388	2000	1202	2000	694	1200	555	800
500	2404	3200	2083	3000	1805	2500	1042	1600	833	1200

Table 27.3-5. Single-Phase Transformer Secondary Protection When Primary Protection Provided

kVA	208 V		240 V		277 V		480 V	
	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip
2	10	15	8	15	—	—	—	—
3	14	20	13	20	11	15	—	—
5	24	30	21	30	18	25	10	15
7.5	36	45	31	40	27	35	16	20
10	48	60	42	60	36	50	21	30
15	72	90	63	80	54	70	31	40
25	120	150	104	150	90	150	52	70
37.5	180	225	156	200	135	175	78	100
50	240	300	208	300	181	225	104	150
75	361	450	313	400	271	350	156	200
100	481	600	417	600	361	450	208	300
167	803	1000	696	900	603	800	348	450
250	1202	1600	1042	1400	903	1200	521	700
333	1601	2000	1388	1800	1202	1600	694	900
500	2404	3000	2083	3000	1805	2500	1042	1400

Table 27.3-6. Three-Phase Transformer Primary Protection When Secondary Protection Provided

kVA	240 V		480 V		600 V	
	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip
3	7	15	—	—	—	—
6	14	30	7	15	6	15
9	22	40	11	25	9	20
15	36	70	18	40	14	30
30	72	150	36	70	29	60
37.5	90	200	45	90	36	70
45	108	200	54	110	43	90
50	120	225	60	125	48	100
75	180	350	90	200	72	150
112.5	271	500	135	250	108	200
150	361	700	180	350	144	300
225	541	1000	271	500	217	400
300	722	1000	361	600	289	500
500	1203	2000	601	800	481	700
750	1804	2500	902	1200	722	1000
1000	2406	4000	1203	2000	962	1600

Table 27.3-7. Three-Phase Transformer Secondary Protection When Primary Protection Provided

kVA	208 V		240 V		480 V		600 V	
	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip	FLA	Breaker Trip
3	8	10	7	10	—	—	—	—
6	17	20	14	20	7	10	—	—
9	25	35	22	30	11	15	9	10
15	42	60	36	45	18	25	14	20
30	83	110	72	100	36	45	29	40
37.5	104	150	90	125	45	60	36	50
45	125	175	108	150	54	70	43	60
50	139	175	120	175	60	80	48	60
75	208	300	180	225	90	125	72	90
112.5	312	400	271	350	135	175	108	150
150	416	600	361	500	180	225	144	200
225	652	800	541	700	271	350	217	300
300	833	1200	722	900	361	500	289	400
500	1388	1800	1203	1500	601	800	481	600
750	2082	3000	1804	2500	902	1200	722	900
1000	2776	3500	2406	3000	1203	1600	962	1200

Slash Ratings from 2008 NEC Article 240.85 Applications

A circuit breaker with a straight voltage rating, such as 240 or 480 V, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker's voltage rating. A two-pole circuit breaker shall not be used for protecting a three-phase, corner-grounded delta circuit unless the circuit breaker is marked 1ø–3ø to indicate such suitability.

A circuit breaker with a slash rating, such as 120/240 V or 480Y/277 V, shall be permitted to be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker's voltage rating.

FPN: Proper application of molded-case circuit breakers on three-phase systems, other than solidly grounded wye, particularly on corner-grounded delta systems, considers the circuit breakers' individual pole-interrupting capability."

For corner-grounded delta systems refer to Eaton for reduced interrupting ratings of selected type two- and three-pole breakers.

For center tapped delta applications where there is a tap between "A" and "C" (high "B" being the leg), the following applies:

1. The voltage from the tapped winding center point that is grounded is 0.867 x line to line voltage.
2. Any single-pole breaker connected to "B" phase must have a voltage rating equal to 0.867 x line to line voltage.
3. Any two-pole breaker should have a full voltage rating equal to or above line to line voltage (slash rating is not acceptable).

Cable Sizing/Selection

There is often much confusion about the size and insulation ratings of cables that are used with circuit breakers and other types of electrical equipment assemblies. Much of the confusion is caused by not taking into consideration the rating of the terminations of the electrical equipment. When sizing and selecting a cable, the designer must consider the temperature rating of the termination it will be landed on so that the proper size and insulation rating can be chosen.

- Per UL 489, circuit breakers rated 125 A or less shall be marked as being suitable for 60 °C (140 °F) only, 75 °C (167 °F) only or 60 °C/ 75 °C (140 °F/167 °F) wire. All Eaton listed breakers rated 125 A and less are marked 60 °C/75 °C
- Per UL 489, circuit breakers rated over 125 A shall be marked as being suitable for 75 °C (167 °F). All Eaton listed breakers rated over 125 A are marked 75 °C

It is important to note that the termination rating of electrical equipment is based on the entire equipment assembly and not just the rating of the lug termination itself.

The designer must review the equipment labeling or installation guidelines to determine the proper cable size and insulation required, regardless of the markings on the actual lugs. For example, panelboards, switchboards, motor control centers and so on. often contain lugs that are marked 90 °C on the lug itself, however, the assembly is only rated for a 75 °C cable termination. Therefore, only cables with a minimum of 75 °C insulation and rated/derated per its 75 °C ampacity rating can be used.

Note: All listed electrical distribution equipment rated 600 Vac and less has a maximum cable termination rating of 75 °C (167 °F).

There are many different types of conductors and Table 310.13(A) of NEC 2008 can help provide an understanding of conductors to use for various field-wired applications. This table shows that insulation type is a key aspect of a conductor that impacts not only where it can be installed but also the conductor's rated ampacity. Together with Tables 310.16 through 310.21, the cable ampacities of various conductors with various insulation types are presented to the designer who must choose the appropriate conductor for the application.

When a designer is sizing cables for termination on electrical distribution equipment, they must ensure not to exceed:

1. The temperature rating of the equipment termination.
2. The insulation rating of the cable at the full load ampacity of the equipment.

The following are a couple simple sizing examples to illustrate some of the considerations for selecting and sizing cables.

It should also be noted that many terminals are suitable for use only with copper wire. Where aluminum or copper-clad aluminum wire is used, the terminals must be marked appropriately. The marking is usually abbreviated as "AL" for aluminum, "CU" for copper and "AL-CU" for a terminal that can handle both.

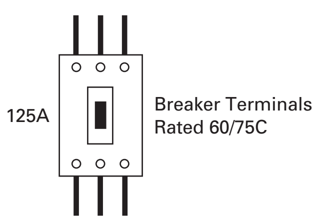


Table 27.3-8. Sizing Example 1

Allowable Ampacity	Properly Sized	Explanation
#1/0 Cu Type TW (60 °C Insulation)		
60 °C 125 A	Yes	Meets the ampere requirement of the equipment without exceeding the equipment terminal ratings
#1 Cu Type THHN (90 °C Insulation)		
60 °C 110 A	No	The 60 °C rating of #1 Cu is not sufficient for the 125 A equipment
75 °C 130 A	Yes	Meets the ampere requirement of the equipment without exceeding the equipment terminal ratings
90 °C 150 A	No	Cannot use 90°C rating—exceeds the equipment terminal ratings

Figure 27.3-1. Sizing Example 1

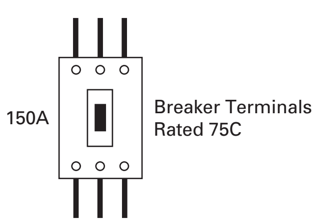


Table 27.3-9. Sizing Example 2

Allowable Ampacity	Properly Sized	Explanation
##3/0 Cu Type TW (60 °C Insulation)		
60°C 164 A	No	Meets the ampere requirement of the equipment, but equipment terminal temperature rating exceeds cable insulation temperature rating
#1 Cu Type THHN (90°C Insulation)		
60 °C 110 A	No	The 60 °C rating of #1 Cu is not sufficient for the 150 A equipment
75 °C 130 A	No	The 75°C rating of #1 Cu is not sufficient for the 150 A equipment
90 °C 150 A	No	Cannot use 90 °C rating—exceeds the equipment terminal ratings
1/0 Cu Type THHN (90 °C Insulation)		
60 °C 125 A	No	The 60 °C rating of 1/0 Cu is not sufficient for the 150 A equipment
75 C 150 A	Yes	The 75 °C rating of 1/0 Cu is sufficient for the 150 A equipment and does not exceed equipment terminal ratings
90 °C 170 A	No	Cannot use 90 °C rating—exceeds the equipment terminal ratings

Figure 27.3-2. Sizing Example 2

Time-Current Trip Curve Characteristics

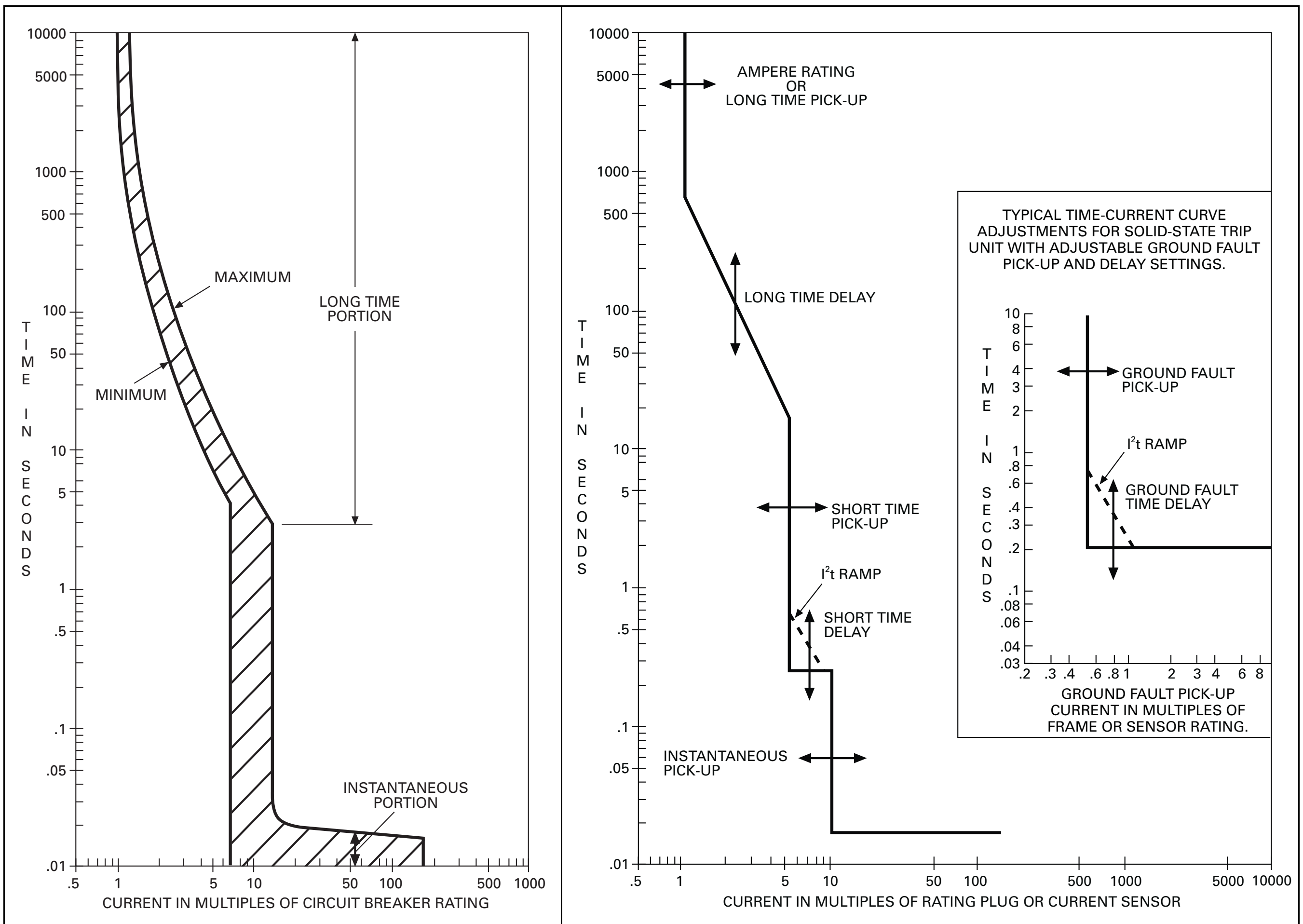
Time-current trip curve characteristics are available on the Eaton Web site.

The band curves shown for each breaker type represent current tripping limits for the breaker and are within limits established by Underwriters Laboratories. For a given current, at rated ambient, a breaker will clear the circuit automatically at some total time within the two extreme values defined by “maximum” and “minimum” curves. For example, a single-pole, 15 A QUICKLAG would trip in no less than 10 seconds and in no more than 150 seconds on a 30 A current. Because of this allowed spread, users should not specify exact tripping times.

The upper left portions of these curves show the inverse time delay tripping of the breakers due to thermal action. The lower right segments for these curves portray the magnetic tripping action of the breakers. In the case of the front-adjustable thermal-magnetic breakers, the magnetic tripping elements may be adjusted to trip at values within a specific current range. This adjustment is shown in the respective characteristic tripping curve. When these breakers leave the factory, their magnetic trip elements are set at the high side of their tripping range. Adjustment downward may be made to fit the requirements of the installation. Currents equal to or greater than these magnetic settings will cause instant tripping.

Curves can be family curves and are suitable for most applications; for more accurate applications, a detailed curve of the particular type and ampere rating of the breaker should be requested.

The total time taken by a breaker to clear a fault consists of the mechanical operating time plus the time of actual current interruption. Characteristic time/current curves show total clearing times. Magnetic only breakers have no time delay in tripping. The tripping characteristics of these breakers are similar to the right-hand portion of the standard breakers, except with the vertical lines extended to the top of the curve.



Non-Adjustable Thermal-Magnetic Molded-Case Circuit Breakers

Electronic Trip Unit with Adjustable Phase and Ground Current Settings

Figure 27.3-3. Typical Time-Current Curves

Selective Coordination Design Issues

In the design of Elevator feeders, Emergency systems, Legally Required Standby systems and new Critical Operations Power Systems (COPS), today's engineer faces greater difficulty in meeting the NEC selective coordination requirements. Whether using breakers or fuses, the engineer has to understand the nature of the devices being selected, and properly apply them, such that only the protective device nearest to the fault will open to clear an overload/fault condition.

Design Considerations

In order to properly design a selectively coordinated system, the design professional engineer must recognize how the various low voltage (600 V and below) overcurrent protective devices, such as molded-case circuit breakers (MCCBs) and low voltage power circuit breakers (LVPCBs) operate. Following is a brief discussion of these devices in relationship to selective coordination. Each MCCB and LVPCB must have a voltage rating and interrupting capacity equal to or greater than the system voltage and available fault current at its point of application in the electrical distribution system.

For MCCBs and LVPCBs in the low level overload or low level fault current range (typically below 10 times the device rating) it is only necessary to ensure that the minimum time band of the upstream device does not overlap the maximum time band of the downstream device. This information can be typically determined from the published time-current curves of the devices.

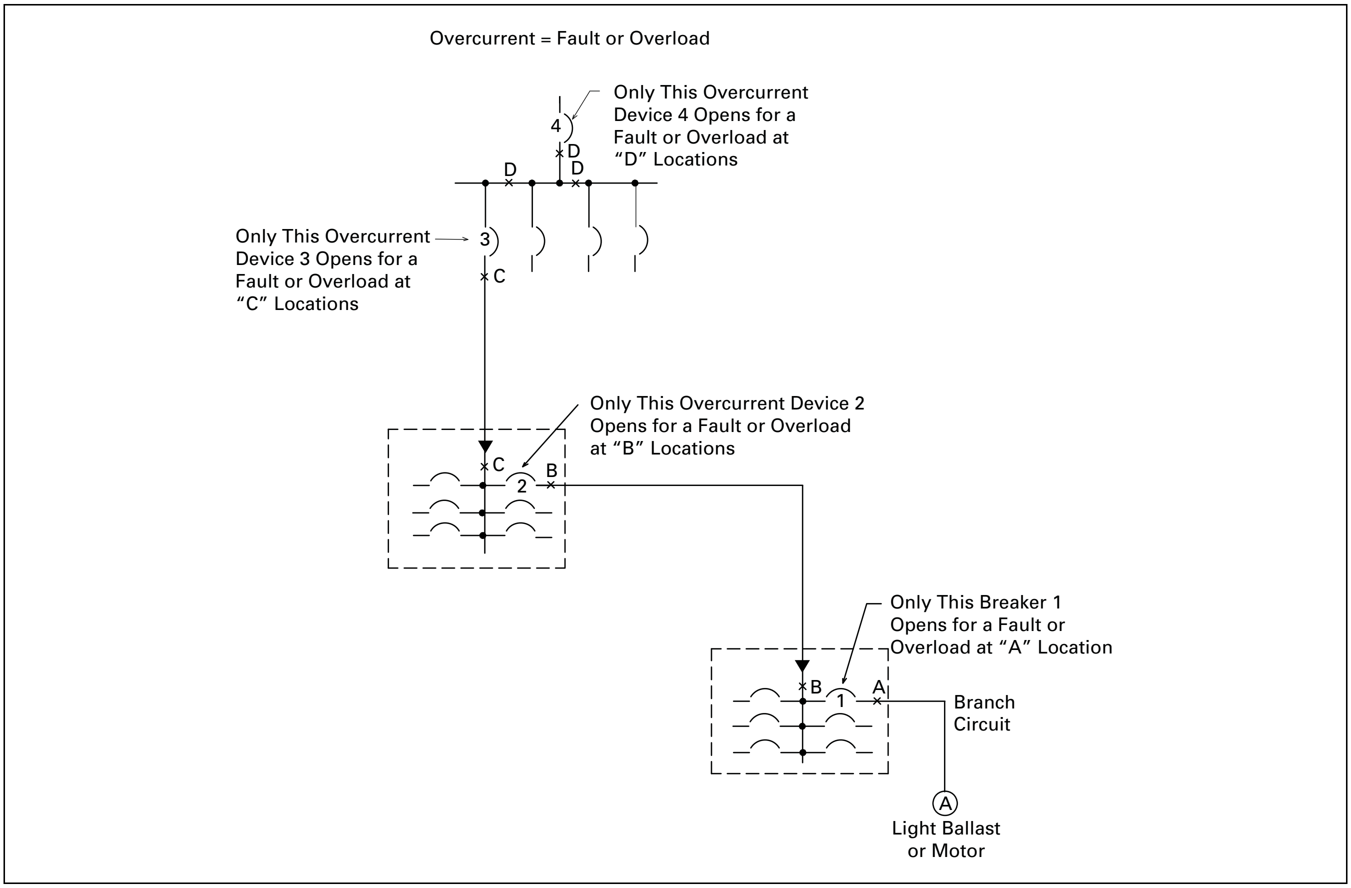


Figure 27.3-4. Example of 100% Selective Coordination of Molded-Case Circuit Breakers

Low Voltage Circuit Breaker Interrupting and Short-Time Rating

IEEE Standard 1015 defines the interrupting rating of the breaker as "The highest current at rated voltage that a device is intended to interrupt under standard test conditions." On the other hand, IEEE Standard 1015 refers to the short-time rating of the low voltage circuit breaker as "A rating applied to a circuit breaker that, for reason of system coordination, causes tripping of the circuit breaker to be delayed beyond the time when tripping would be caused by an instantaneous element." In other words, the device's ability to stay closed and NOT open the circuit immediately under fault conditions. The short-time rating of the breaker will be broken down into two facets for ease of discussion:

1. **Short-time current** rating—The current carried by the circuit breaker for a specified interval, or the maximum current magnitude under a fault condition for which the circuit breaker can stay closed.
2. **Short-time delay** rating—An intentional time delay in the tripping of a circuit breaker between the overload and the instantaneous pickup setting. The maximum short-time delay is the maximum amount of time the breaker can keep its contacts closed under the fault condition. If two breakers are in series, to obtain selective coordination, the upstream breaker must have a short-time **current** rating above the actual fault current on the load side of any downstream breaker. In addition, the upstream breaker has to have short-time delay capability long enough to allow the downstream breaker to open and clear the fault condition.

It should be recognized that as the short-time current rating and/or short-time delay rating of the upstream devices is increased, should a fault occur on the line side of downstream circuit breaker "1" and the load side of upstream circuit breaker "2" the amount of the arc flash energy allowed to the fault condition generally will be increased significantly. This increased arc flash energy reduces the safety of operating and/or maintenance personnel if they are present at the time of the fault. The higher level of arc flash energy also increases the potential for major equipment damage, resulting in fires and extended downtime.

Molded-Case Circuit Breakers

Molded-case circuit breakers are manufactured and tested to the UL 489 standard. Molded-case circuit breakers have over-center toggle mechanisms and either a thermal-magnetic or electronic trip unit. The thermal-magnetic trip unit is such that the magnetic pickup maximum setting is approximately 10 times the trip rating. The electronic trip unit is typically furnished with a fixed instantaneous override of approximately 10 to 15 times the breaker frame rating, or trip unit rating. Thus, for molded-case circuit breakers with electronic trip units, for any load side fault above these levels, the breaker will open. The exact magnitude of current that will cause the molded-case circuit breaker to open instantaneously will vary by 1) circuit breaker manufacturer, 2) circuit breaker frame rating, 3) type of trip unit, 4) type/vintage of molded-case circuit breaker, 5) manufacturer's curve tolerances. It will be assumed that the current magnitude needed to open molded-case circuit breakers with electronic trips instantaneously is 13 times the frame rating—its maximum fixed instantaneous override. The manufacturer's actual data should be used to determine this value. Typically for molded-case circuit breakers, once the magnetic pickup or fixed instantaneous override is exceeded, the opening time is 1 cycle or less.

Although short-time "ratings" for molded-case circuit breakers are not covered in the IEEE Standard 1015 for molded-case circuit breakers, some molded-case circuit breakers are equipped with electronic trip units that have adjustable "short delay" functions. However, they typically also have either an adjustable instantaneous trip (typically with a maximum setting of 10 times trip ampere) or a fixed instantaneous override (of 13 times the frame ampere rating). When the electronic trip is in the short-time pickup range (below 13 times frame size), they can typically be adjusted up to a maximum short-time delay setting of approximately 18 cycles (300 ms).

Current Limiting

Per UL 489-1991, current limiting circuit breakers have characteristics that, when operating within their current-limiting range, limit the let-through I^2t to a value less than the I^2t of a 1/2-cycle wave of the symmetrical prospective current. Current limiting circuit breakers achieve this by opening their contacts very rapidly, such that their I peak let-through current is reduced to a value much lower than the I peak current available from the system at the molded-case circuit breakers point of application.

Insulated-Case Circuit Breakers

Insulated-case circuit breakers are also manufactured and tested to the UL 489 standard, however, they usually have a two-step stored energy mechanism and increased short-time ratings. These breakers are typically available in 800, 1600, 2000, 2500, 3000, 4000 and 5000 A frame sizes. Although they may have high interrupting ratings, the typical instantaneous override values for insulated-case circuit breakers are 25 kA to 35 kA for the smaller frames and up to 85 kA for the larger frames. Maximum short-time delay capability is generally up to 30 cycles (0.5s).

Low Voltage Power Circuit Breakers

Low voltage power circuit breakers are manufactured and tested to the UL 1066 Standard and ANSI C37 standards and have a two-step stored energy mechanism. Low voltage power circuit breakers are typically available in 800, 1600, 2000, 2500, 3000, 4000 and 5000 A frame sizes. However, even the smaller 800 A frame size is available with very high short-time current ratings of approximately 85 kA to 100 kA. Low voltage power circuit breakers are capable of keeping their contacts closed for up to 30 cycles of fault current, at levels up to their maximum short-time current rating. Thus, low voltage power circuit breakers can normally provide selective coordination with relative ease when in series with each other, or when supplying downstream molded-case circuit breakers or low voltage power circuit breakers.

Methods to Obtain 100% Selective Coordination

There are various methods to obtain selective coordination between overcurrent protective devices, but the end goal is to have all the line side overcurrent protective devices in series to wait until the overcurrent protective device directly protecting the circuit having the overcurrent opens. This means that typically as the devices progress upstream toward the source, each device on the line side of a downstream series device must have a longer waiting time. The only two exceptions to this general rule would be:

1. Two protective devices of the same trip or fuse rating directly in series.
2. A transformer primary feeder breaker and transformer secondary main breaker.

For both of these exceptions, it would not matter which overcurrent device would open or if they both opened, because the protected circuit would be disconnected in either case.

Circuit Breaker Selection

1. Select Specific Molded-Case Circuit Breakers

Selective coordination between upstream molded-case circuit breakers and downstream molded-case circuit breakers requires special consideration. There are various ways to obtain selective coordination, some applicable basic methods are as follows:

- For molded-case circuit breakers with thermal-magnetic trip units, select a line-side breaker with a magnetic trip (instantaneous element) setting above the calculated available fault current level at the load side downstream breaker
- For molded-case circuit breakers with electronic trip units, select a line side breaker that has an adjustable instantaneous element or fixed instantaneous override greater than the calculated available fault current level at the load side downstream breakers. In addition, the line side breaker short-time delay setting must be selected to allow the load side breaker adequate time to open and clear the fault

2. Select Larger Line Side Molded-Case Circuit Breaker

Select a line side breaker with a larger frame size than would normally be required when just considering the load current requirements. Typically, the larger the molded-case circuit breaker frame size, the higher the magnetic trip adjustment or fixed instantaneous override value.

General rule: The magnetic trip setting or fixed instantaneous override value must be higher than the calculated available fault current at load side circuit breaker. However, the larger the molded-case circuit breaker frame size, typically the higher the associated cost and arc flash energy on a fault condition.

3. Select a Line Side Low Voltage Power Circuit Breaker

Use the combination of upstream low voltage power circuit breakers and downstream molded-case circuit breakers. The required combinations will vary depending on the available fault current. Most manufacturers have low voltage power circuit breakers available in two types.

Type 1: Low voltage power circuit breakers with short-time current ratings available up to 100 kA and with interrupting ratings up to 100 kA.

Type 2: For fault currents above 100 kA, low voltage power circuit breakers are available either as combination low voltage power circuit breakers with current limiters, or as true current limiting versions without current limiters. Both types have interrupting ratings up to 200 kA, but typically have reduced short-time current ratings.

4. Select Both Line and Load Low Voltage Power Circuit Breakers

When usinng low voltage power circuit breakers, because of the high short-time current ratings available in all frame sizes, and their maximum 30-cycle short-time delay rating, there is generally no problem obtaining selective coordination between line and load side low voltage power circuit breakers. However, the higher the short delay setting, the higher the level of available arc flash energy should a fault occur directly on the load side of a given low voltage power circuit breaker.

Use Manufacturer's Test Information

Circuit breaker manufacturers, such as Eaton Corporation, provide selective coordination tables between specific line side circuit breakers and load side circuit breakers, for various maximum values of fault current. (See **Table 27.3-10** for 100% Selective Breaker Combinations.) These tables are based on circuit breaker test data. It should be noted that in many cases, the allowable fault current levels to achieve selective coordination is significantly higher when using the manufacturer's specific test information. This is attributed to the high-speed performance of modern molded-case circuit breakers that in some cases are marked as being current limiting: "In addition, although some molded-case circuit breakers may not be formally marked as current limiting, they still begin to open before the first 1/2-cycle peak, inserting arc impedance into the circuit, and thus still reduce the peak let-through current (I_{PI}) with resulting lower I^2t values. This current reduction by the downstream breaker reduces the current to a level below the instantaneous override of the upstream breaker, thus providing selective coordination for higher fault current levels.

It should be noted that the test circuit used by manufacturers to confirm selective coordination must be known and reasonable. Eaton's test circuit is similar to the test circuit used by UL 489. This test circuit allows for 4 feet of wire for the combination of wire from the load side of the upstream breaker through the downstream breaker to the point of the fault.

0.1 Second Selective Coordination

Some applications and jurisdictions only mandate breaker selectivity for time periods longer than 0.1 seconds. This allows the designer greater flexibility to balance the affects of arc flash risk, downtime risk, risk of equipment damage and so on. with selectivity. (See **Table 27.3-11** for 0.1 Second Breaker Selectivity Combinations.)

Molded-Case Circuit Breaker Selective Coordination Combinations—100% Selective Coordination

For 100% Selective Coordination Applications—Table 27.3-10

The left side columns list the amperages of the **downstream** breaker grouped by the available breaker frames. The next columns on the right of the amperages indicate the type of Pow-R-Line® panelboards and/or switchboard that the given downstream breaker is available in and whether the breaker may be used in that assembly as a main, feeder or sub-feed breaker.

The top rows of the table list the amperages of the **upstream** breaker grouped by the available breaker frames. The next row below indicates the type of trip unit needed:

T/M = Thermal-Magnetic

ETU = Electronic Trip Unit

For ETUs, the next rows indicate the specific type of Digitrip RMS trip unit and/or OPTIM trip unit available.

The **minimum trip/maximum trip** rows indicate the amperage range for which the indicated selectivity is valid.

The next rows below the minimum/maximum trip indicate the type of Pow-R-Line panelboards and/or switchboard that the given upstream breaker is available in and whether the breaker may be used in that assembly as a main, feeder or sub-feed breaker.

The values at the intersection of a row and column represent the maximum fault current at which selective coordination can be achieved between the chosen downstream and upstream circuit breakers.

Steps in Determining Selective Coordination Between Line and Load Side Circuit Breakers

1. Determine the maximum available fault current from all sources, at both the upstream and downstream breakers, by means of a short-circuit study, appropriate charts and/or formulas. Where both upstream and downstream breakers are connected to the same bus, this will be the same value.

2. Starting on the left at the top and moving downward, select the downstream Eaton breaker that has adequate Interrupting Capacity (IC), voltage rating and continuous amperage rating for the downstream breaker application. If the required interrupting rating, voltage rating or amperage rating is not shown in the table, continue downward to the row for the next larger breaker frame.

3. Move horizontally from the selected downstream breaker trip rating to the first value of symmetrical rms fault current that meets or exceeds the value of rms fault current at the upstream breaker as determined from Step 1.

4. Proceed upward to read the possible upstream breaker frame. Check the minimum and maximum trip range indicated to ensure it meets the required upstream breaker trip rating. If the trip rating meets the requirements, this will be one of the possible upstream breakers that will selectively coordinate with the downstream breaker. If the indicated trip rating or trip range does not meet the requirements for the line side breaker, repeat Step 3 and Step 4.

5. Once an upstream family of circuit breakers is determined that selectively coordinates, you can find the specific breaker within that family that meets the required interrupting capacity by checking the breaker product overview tables on **Pages 27.4-4** through **27.4-6**.

6. Optional—Once the selective combination of breakers is determined, you can determine the type of Pow-R-Line panelboard or switchboard assembly that can be used.

Note: If both the upstream and downstream breakers are to be in the same assembly, ensure that both devices are available in the same type Pow-R-Line assembly.

Repeat the above steps for each pair of breakers in the system to quickly and easily select devices that will 100% selectively coordinate.

Table 27.3-10. Molded-Case Circuit Breaker (MCCB) 100% Selective Coordination Combinations

			Upstream Breaker										
			Breaker Family	**EG**	**F**	**F**	**F**	**F**	**F**	**F**	**J**	**J**	**J**
			Type Trip Unit	**T/M**	**T/M**	**T/M**	**T/M**	**ETU**	**ETU**	**ETU**	**T/M**	**T/M**	**T/M**
			Digitrip RMS Trip Unit	**—**	**—**	**—**	**—**	**310+**	**310+**	**310+**	**—**	**—**	**—**
			OPTIM Trip Unit	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
			Minimum Trip (Plug/Trip)	**125 A**	**100 A**	**150 A**	**225 A**	**15 A**	**60 A**	**100 A**	**70 A**	**150 A**	**250 A**
			Maximum Trip (Frame)	**125 A**	**100 A**	**200 A**	**225 A**	**80 A**	**160 A**	**225 A**	**125 A**	**225 A**	**250 A**
			Pow-R-Line: Main	**3E**	**1a, 2a, 3a, 3E**						**3a**		
			Pow-R-Line: Branch	**3E**	**3a, 4, Swbd**						**4, Swbd**		
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**—**	**1a, 2a, 3E**						**3a**		
	Pow-R-Line Panelboard/Switchboard												
	Main	**Branch**	**Sub-Feed**										
BR, BAB, HQP and QC (10 kA at 240 Vac) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.6	1.2	2.3	1.0	2.1	4.0
20	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.6	1.2	2.3	1.0	2.1	3.4
30	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.6	1.2	2.3	0.7	2.1	3.4
40	—	1a, 3a, 4, Swbd	—	0.8	1.0	1.5	2.2	0.6	1.2	2.3	—	1.5	3.4
50	—	1a, 3a, 4, Swbd	—	0.8	—	1.5	2.2	—	1.2	2.3	—	1.5	2.5
60	1a	1a, 3a, 4, Swbd	—	0.8	—	1.5	2.2	—	1.2	2.3	—	1.5	2.5
70	1a	1a, 3a, 4, Swbd	—	—	—	1.5	2.2	—	1.2	2.3	—	1.5	2.5
80	1a	1a, 3a, 4, Swbd	—	—	—	—	2.2	—	—	2.3	—	—	2.5
90	1a	1a, 3a, 4, Swbd	—	—	—	—	2.2	—	—	2.3	—	—	2.3
100	1a	1a, 3a, 4, Swbd	—	—	—	—	1.8	—	—	2.3	—	—	2.3
BRH, QPHW, QBHW and QCHW (22 kA at 240 Vac) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.6	1.2	2.3	1.0	2.1	4.0
20	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.6	1.2	2.3	1.0	2.1	3.4
30	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.6	1.2	2.3	0.7	2.1	3.4
40	—	1a, 3a, 4, Swbd	—	0.8	1.0	1.5	2.2	0.6	1.2	2.3	—	1.5	3.4
50	—	1a, 3a, 4, Swbd	—	0.8	—	1.5	2.2	—	1.2	2.3	—	1.5	2.5
60	1a	1a, 3a, 4, Swbd	—	0.8	—	1.5	2.2	—	1.2	2.3	—	1.5	2.5
70	1a	1a, 3a, 4, Swbd	—	—	—	1.5	2.2	—	1.2	2.3	—	1.5	2.5
80	1a	1a, 3a, 4, Swbd	—	—	—	—	2.2	—	—	2.3	—	—	2.5
90	1a	1a, 3a, 4, Swbd	—	—	—	—	2.2	—	—	2.3	—	—	2.3
100	1a	1a, 3a, 4, Swbd	—	—	—	—	1.8	—	—	2.3	—	—	2.3
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)													
20	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.8	1.6	2.8	0.7	1.5	2.5
30	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	0.8	1.6	2.8	0.7	1.5	2.5
50	—	1a, 3a, 4, Swbd	—	1.2	1.0	1.5	2.2	—	1.6	2.3	—	1.5	2.3
70	2a	1a, 3a, 4, Swbd	—	—	—	—	2.2	—	—	2.3	—	—	2.3
100	2a	1a, 3a, 4, Swbd	—	—	—	—	1.8	—	—	1.8	—	—	2.3
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)													
100	—	Swbd	—	—	—	—	1.8	—	1.6	1.8	—	—	2.3
EG Family (EGB, EGE, EGS, EGH)													
15	—	3E	—	1.3	1.0	1.5	2.2	0.8	1.6	2.8	1.0	1.5	2.5
30	—	3E	—	1.3	1.0	1.5	2.2	0.8	1.6	2.8	0.7	1.5	2.5
50	—	3E	—	1.3	1.0	1.5	1.8	0.8	1.6	2.3	—	1.5	2.3
60	3E	3E	—	1.3	—	1.5	1.8	—	1.6	2.3	—	1.5	2.3
100	3E	3E	—	—	—	—	1.8	—	1.2	1.8	—	—	2.3
125	3E	3E	—	—	—	—	1.8	—	1.2	1.8	—	—	2.3
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB (150 A), EHD (100 A), FDE, HFDE, FDCE)													
15	—	3a, 4, Swbd	—	—	1.0	1.5	1.8	0.8	1.2	2.8	1.0	1.5	2.5
40	—	3a, 4, Swbd	—	—	1.0	1.5	1.8	0.8	1.2	2.3	0.7	1.5	2.5
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	1.8	—	1.2	1.8	—	—	2.3
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—

Table 27.3-10. MCCB 100% Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	EG	F	F	F	F	F	F	J	J	J
			Type Trip Unit	T/M	T/M	T/M	T/M	ETU	ETU	ETU	T/M	T/M	T/M
			Digitrip RMS Trip Unit	—	—	—	—	310+	310+	310+	—	—	—
			OPTIM Trip Unit	—	—	—	—	—	—	—	—	—	—
			Minimum Trip (Plug/Trip)	125 A	100 A	150 A	225 A	15 A	60 A	100 A	70 A	150 A	250 A
			Maximum Trip (Frame)	125 A	100 A	200 A	225 A	80 A	160 A	225 A	125 A	225 A	250 A
			Pow-R-Line: Main	3E	1a, 2a, 3a, 3E						3a		
			Pow-R-Line: Branch	3E	3a, 4, Swbd						4, Swbd		
Downstream Breaker			Pow-R-Line: Sub-Feed	—	1a, 2a, 3E						3a		
	Pow-R-Line Panelboard/Switchboard												
	Main	Branch	Sub-Feed										
J Family (JDB, JD, HJD, JDC)													
70	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
125	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
250	2a, 3a, 4	4, Swbd	1a, 2a, 3a	—	—	—	—	—	—	—	—	—	—
LCL 250 Family Current Limiting													
125	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
200	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
250	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LCL 400 Family Current Limiting													
200	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
300	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
K Family (KDB, KD, CKD, HKD, CHKD, KDC)													
100	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
200	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)													
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)													
250	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LG Current Limiting Family													
400	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LHH Family													
150	1a, 2a, 3a, 3E, 4	4, S	—	—	—	—	—	—	—	—	—	—	—
200	1a, 2a, 3a, 3E, 4	4, S	—	—	—	—	—	—	—	—	—	—	—
400	1a, 2a, 3a, 3E, 4	4, S	—	—	—	—	—	—	—	—	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)													
400	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
NHH Family													
350	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—

Table 27.3-10. MCCB 100% Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	K	K	K	K	K	K	LD	LD	LD	LD
			Type Trip Unit	T/M	T/M	T/M	ETU	ETU	ETU	T/M	T/M	T/M	ETU
			Digitrip RMS Trip Unit	—	—	—	310	310	310	—	—	—	310
			OPTIM Trip Unit	—	—	—	550, 1050	550, 1050	550, 1050	—	—	—	550, 1050
			Minimum Trip (Plug/Trip)	100 A	200 A	400 A	70 A	125 A	200 A	300 A	400 A	600 A	200 A (OPTIM) 300 A (Digi)
			Maximum Trip (Frame)	175 A	350 A	400 A	125 A	250 A	400 A	350 A	500 A	600 A	600 A
			Pow-R-Line: Main	1a, 2a, 3a, 3E, 4						3a,4,Swbd			
			Pow-R-Line: Branch	4, Swbd						4, Swbd			
Downstream Breaker			Pow-R-Line: Sub-Feed	1a, 2a, 3a, 3E						—	—	—	—
	Pow-R-Line Panelboard/Switchboard												
	Main	Branch	Sub-Feed										
BR, BAB, HQP and QC (10 kA at 240 Vac) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	2.5	5.0	10	3.0	6.0	10	10	10	10	10
20	—	1a, 3a, 4, Swbd	—	2.0	4.0	8.0	2.5	5.0	8.0	9.0	10	10	10
30	—	1a, 3a, 4, Swbd	—	2.0	4.0	8.0	2.5	5.0	8.0	9.0	10	10	10
40	—	1a, 3a, 4, Swbd	—	1.2	3.0	6.0	1.5	4.0	6.0	7.5	10	10	10
50	—	1a, 3a, 4, Swbd	—	1.2	3.0	6.0	1.5	4.0	6.0	7.5	10	10	10
60	1a	1a, 3a, 4, Swbd	—	—	3.0	6.0	1.5	4.0	6.0	7.5	10	10	10
70	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	10	10
80	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	10	10
90	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	10	10
100	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	10	10
BRH, QPHW, QBHW and QCHW (22 kA at 240 Vac) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	2.5	5.0	10	3.0	6.0	10	10	10	22	22
20	—	1a, 3a, 4, Swbd	—	2.0	4.0	8.0	2.5	5.0	8.0	9.0	10	22	22
30	—	1a, 3a, 4, Swbd	—	2.0	4.0	8.0	2.5	5.0	8.0	9.0	10	22	22
40	—	1a, 3a, 4, Swbd	—	1.2	3.0	6.0	1.5	4.0	6.0	7.5	10	22	22
50	—	1a, 3a, 4, Swbd	—	1.2	3.0	6.0	1.5	4.0	6.0	7.5	10	22	22
60	1a	1a, 3a, 4, Swbd	—	—	3.0	6.0	1.5	4.0	6.0	7.5	10	22	22
70	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	22	22
80	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	22	22
90	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	22	22
100	1a	1a, 3a, 4, Swbd	—	—	2.5	5.0	—	3.0	5.0	7.5	10	22	22
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)													
20	—	1a, 3a, 4, Swbd	—	2.0	2.7	4.5	2.7	4.0	4.5	10	10	15	10
30	—	1a, 3a, 4, Swbd	—	2.0	2.7	4.5	2.7	4.0	4.5	10	10	15	10
50	—	1a, 3a, 4, Swbd	—	1.6	2.7	4.2	2.7	3.6	4.2	10	10	12	10
70	2a	1a, 3a, 4, Swbd	—	—	2.5	4.2	—	3.6	4.2	7.4	7.4	12	7.4
100	2a	1a, 3a, 4, Swbd	—	—	2.5	4.2	—	3.6	4.2	10	7.4	12	7.4
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)													
100	—	Swbd	—	—	2.8	5.0	—	6.0	6.5	10	10	10	10
EG Family (EGB, EGE, EGS, EGH)													
15	—	3E	—	2.0	2.5	5.6	2.5	4.6	5.6	20	20	35	35
30	—	3E	—	2.0	2.5	5.6	2.5	4.6	5.6	15	15	35	35
50	—	3E	—	1.6	2.5	5.2	2.5	4.0	5.2	10	10	18	18
60	3E	3E	—	—	2.5	5.2	2.5	4.0	5.2	10	10	18	18
100	3E	3E	—	—	2.5	5.2	—	4.0	5.2	10	10	18	18
125	3E	3E	—	—	—	5.2	—	4.0	5.2	10	10	18	18
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB (150 A), EHD (100 A), FDE, HFDE, FDCE)													
15	—	3a, 4, Swbd	—	2.0	2.5	5.0	2.5	4.0	5.0	10	10	12	12
40	—	3a, 4, Swbd	—	1.6	2.5	5.0	2.5	3.2	4.2	8.3	8.3	12	12
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	2.3	3.2	—	3.2	4.0	7.0	7.0	12	12
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	3.2	—	—	4.0	—	7.0	12	12

Table 27.3-10. MCCB 100% Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	**K**	**K**	**K**	**K**	**K**	**K**	**LD**	**LD**	**LD**	**LD**
			Type Trip Unit	**T/M**	**T/M**	**T/M**	**ETU**	**ETU**	**ETU**	**T/M**	**T/M**	**T/M**	**ETU**
			Digitrip RMS Trip Unit	**—**	**—**	**—**	**310**	**310**	**310**	**—**	**—**	**—**	**310**
			OPTIM Trip Unit	**—**	**—**	**—**	**550, 1050**	**550, 1050**	**550, 1050**	**—**	**—**	**—**	**550, 1050**
			Minimum Trip (Plug/Trip)	**100 A**	**200 A**	**400 A**	**70 A**	**125 A**	**200 A**	**300 A**	**400 A**	**600 A**	**200 A (OPTIM) 300 A (Digi)**
			Maximum Trip (Frame)	**175 A**	**350 A**	**400 A**	**125 A**	**250 A**	**400 A**	**350 A**	**500 A**	**600 A**	**600 A**
			Pow-R-Line: Main	**1a, 2a, 3a, 3E, 4**						**3a,4,Swbd**			
			Pow-R-Line: Branch	**4, Swbd**						**4, Swbd**			
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**1a, 2a, 3a, 3E**						**—**	**—**	**—**	**—**
	Pow-R-Line Panelboard/Switchboard												
	Main	**Branch**	**Sub-Feed**										
J Family (JDB, JD, HJD, JDC)													
70	—	4, Swbd	—	—	2.0	3.2	—	2.5	4.0	6.0	8.0	12	12
125	—	4, Swbd	—	—	—	3.2	—	2.5	3.7	6.0	7.0	12	12
250	2a, 3a, 4	4, Swbd	1a, 2a, 3a	—	—	3.2	—	—	3.5	—	7.0	10	10
LCL 250 Family Current Limiting													
125	—	4, Swbd	—	—	—	3.7	—	2.5	4.2	4.2	4.2	17	17
200	—	4, Swbd	—	—	—	3.2	—	—	3.7	—	3.2	17	17
250	—	4, Swbd	—	—	—	—	—	—	—	—	—	17	17
LCL 400 Family Current Limiting													
200	—	4, Swbd	—	—	—	3.2	—	—	3.2	—	3.2	17	17
300	—	4, Swbd	—	—	—	—	—	—	—	—	—	17	17
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	17	17
K Family (KDB, KD, CKD, HKD, CHKD, KDC)													
100	—	4, Swbd	—	—	2.0	3.5	—	2.5	4.2	4.2	4.2	10	10
200	—	4, Swbd	—	—	—	3.2	—	—	3.7	—	3.7	10	10
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	10	10
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)													
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	6.0	6.0
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	6.0	6.0
600	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)													
250	—	4, Swbd	—	—	—	—	—	—	—	—	—	6.0	6.0
400	—	4, Swbd	—	—	—	—	—	—	—	—	—	6.0	6.0
600	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LG Current Limiting Family													
400	—	4, Swbd	—	—	—	—	—	—	—	—	—	6.0	6.0
600	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LHH Family													
150	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	6.0	6.0
200	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	6.0	6.0
400	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)													
400	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	—	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
NHH Family													
350	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—

Application Information—100% Selective Coordination

Table 27.3-10. MCCB 100% Selective Coordination Combinations (Continued)

			Upstream Breaker								
			Breaker Family	LHH	LHH	LHH	LG	LG	LG	LG	NHH
			Type Trip Unit	T/M	T/M	T/M	ETU	ETU	ETU	T/M	ETU
			Digitrip RMS Trip Unit	—	—	—	310+	310+	310+	—	310
			OPTIM Trip Unit	—	—	—	—	—	—	—	—
			Minimum Trip (Plug/Trip)	125 A	175 A	225 A	100 A	160 A	250 A	600 A	150 A
			Maximum Trip (Frame)	150 A	200 A	400	250 A	400 A	600 A	600 A	350 A
			Pow-R-Line: Main	1a, 2a, 3a, 3E, 4			—	—	4, Swbd	4, Swbd	4
			Pow-R-Line: Branch	4, Swbd			4, Swbd				4, Swbd
Downstream Breaker			Pow-R-Line: Sub-Feed	—	—	—	—	—	—	—	—
	Pow-R-Line Panelboard/Switchboard										
	Main	Branch	Sub-Feed								
BR, BAB, HQP and QC (10 kA at 240 Vac) Single-, Two- and Three-Pole											
15	—	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10
20	—	1a, 3a, 4, Swbd	—	7.5	10	10	9.0	10	10	10	10
30	—	1a, 3a, 4, Swbd	—	7.5	10	10	9.0	10	10	10	10
40	—	1a, 3a, 4, Swbd	—	5.3	10	10	7.5	10	10	10	10
50	—	1a, 3a, 4, Swbd	—	5.3	10	10	7.5	10	10	10	10
60	1a	1a, 3a, 4, Swbd	—	5.3	10	10	7.5	10	10	10	10
70	1a	1a, 3a, 4, Swbd	—	4.3	10	10	7.5	10	10	10	10
80	1a	1a, 3a, 4, Swbd	—	—	10	10	7.5	10	10	10	—
90	1a	1a, 3a, 4, Swbd	—	—	10	10	7.5	10	10	10	—
100	1a	1a, 3a, 4, Swbd	—	—	10	10	7.5	10	10	10	—
BRH, QPHW, QBHW and QCHW (22 kA at 240 Vac) Single-, Two- and Three-Pole											
15	—	1a, 3a, 4, Swbd	—	10	22	22	10	14.4	22	22	22
20	—	1a, 3a, 4, Swbd	—	7.5	22	22	9.0	14.4	22	22	22
30	—	1a, 3a, 4, Swbd	—	7.5	22	22	9.0	14.4	22	22	22
40	—	1a, 3a, 4, Swbd	—	5.3	22	22	7.5	14.4	22	22	22
50	—	1a, 3a, 4, Swbd	—	5.3	22	22	7.5	14.4	22	22	22
60	1a	1a, 3a, 4, Swbd	—	5.3	22	22	7.5	12	18	22	22
70	1a	1a, 3a, 4, Swbd	—	4.3	22	22	7.5	12	18	22	22
80	1a	1a, 3a, 4, Swbd	—	—	22	22	7.5	12	18	22	—
90	1a	1a, 3a, 4, Swbd	—	—	22	22	7.5	12	18	22	—
100	1a	1a, 3a, 4, Swbd	—	—	22	22	7.5	12	18	22	—
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)											
20	—	1a, 3a, 4, Swbd	—	3.2	7.6	14	4.0	7.4	10	12.7	14
30	—	1a, 3a, 4, Swbd	—	3.2	7.6	14	4.0	7.4	10	12.7	14
50	—	1a, 3a, 4, Swbd	—	3.2	7.6	14	3.6	7.4	10	10	14
70	2a	1a, 3a, 4, Swbd	—	3.2	7.6	12.7	3.6	7.4	10	10	—
100	2a	1a, 3a, 4, Swbd	—	—	7.6	12.7	3.6	7.4	10	10	—
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)											
100	—	Swbd	—	—	10	30	6.0	10	10	—	—
EG Family (EGB, EGE, EGS, EGH)											
15	—	3E	—	10	27	65	4.6	20	35	—	65
30	—	3E	—	7.5	14	35	4.6	15	35	—	65
50	—	3E	—	3.2	10	18	4.0	10	18	—	65
60	3E	3E	—	3.2	10	18	4.0	10	18	—	65
100	3E	3E	—	—	10	18	4.0	10	18	—	—
125	3E	3E	—	—	10	18	4.0	10	18	10	—
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB(150 A), EHD(100 A), FDE, HFDE, FDCE)											
15	—	3a, 4, Swbd	—	7.5	14	22	4.0	10	12	—	65
40	—	3a, 4, Swbd	—	3.2	10	16	3.2	8.3	12	—	65
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	10	14	3.2	7.0	12	—	—
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	12	—	7.0	12	10	—

Table 27.3-10. MCCB 100% Selective Coordination Combinations (Continued)

			Upstream Breaker								
			Breaker Family	**LHH**	**LHH**	**LHH**	**LG**	**LG**	**LG**	**LG**	**NHH**
			Type Trip Unit	**T/M**	**T/M**	**T/M**	**ETU**	**ETU**	**ETU**	**T/M**	**ETU**
			Digitrip RMS Trip Unit	**—**	**—**	**—**	**310+**	**310+**	**310+**	**—**	**310**
			OPTIM Trip Unit	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
			Minimum Trip (Plug/Trip)	**125 A**	**175 A**	**225 A**	**100 A**	**160 A**	**250 A**	**600 A**	**150 A**
			Maximum Trip (Frame)	**150 A**	**200 A**	**400 A**	**250 A**	**400 A**	**600 A**	**600 A**	**350 A**
			Pow-R-Line: Main	**1a, 2a, 3a, 3E, 4**			**—**	**—**	**4, Swbd**	**4, Swbd**	**4**
			Pow-R-Line: Branch	**4, Swbd**			**4, Swbd**				**4, Swbd**
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
	Pow-R-Line Panelboard/Switchboard										
	Main	**Branch**	**Sub-Feed**								
J Family (JDB, JD, HJD, JDC)											
70	—	4, Swbd	—	3.2	7.6	12.7	2.8	8.0	12	10	—
125	—	4, Swbd	—	—	7.6	10	2.8	7.0	12	—	—
250	2a, 3a, 4	4, Swbd	1a, 2a, 3a	—	—	10	—	7.0	10	—	—
LCL 250 Family Current Limiting											
125	—	4, Swbd	—	—	—	12.7	2.8	4.2	17	—	—
200	—	4, Swbd	—	—	—	10	—	3.2	17	—	—
250	—	4, Swbd	—	—	—	—	—	—	17	—	—
LCL 400 Family Current Limiting											
200	—	4, Swbd	—	—	—	10	—	3.2	15	—	—
300	—	4, Swbd	—	—	—	—	—	—	15	—	—
400	3q, 4	4, Swbd	—	—	—	—	—	—	15	—	—
K Family (KDB, KD, CKD, HKD, CHKD, KDC)											
100	—	4, Swbd	—	—	5.0	10	3.5	4.2	10	—	—
200	—	4, Swbd	—	—	—	10	—	3.7	10	—	—
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	10	—	—
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)											
300	3a, 4	4, Swbd	—	—	—	—	—	—	6.0	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	6.0	—	—
600	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)											
250	—	4, Swbd	—	—	—	—	—	—	6.0	—	—
400	—	4, Swbd	—	—	—	—	—	—	6.0	—	—
600	4	4, Swbd	—	—	—	—	—	—	—	—	—
LG Current Limiting Family											
400	—	4, Swbd	—	—	—	—	—	—	6.0	—	—
600	4	4, Swbd	—	—	—	—	—	—	—	—	—
LHH Family											
150	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	6.0	—
200	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	6.0	—
400	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)											
400	—	4, Swbd	—	—	—	—	—	—	—	—	—
600	—	4, Swbd	—	—	—	—	—	—	—	—	—
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—
NHH Family											
350	4	4, Swbd	—	—	—	—	—	—	—	—	—

Table 27.3-10. MCCB 100% Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	N	N	N	N	R	R	R	R	R	R
			Type Trip Unit	ETU	ETU	ETU	ETU	ETU	ETU	ETU	ETU	ETU	ETU
			Digitrip RMS Trip Unit	310	310	310	310	310	310	310	310	310	310
			OPTIM Trip Unit	550, 1050	550, 1050	550, 1050	550, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050
			Minimum Trip (Plug/Trip)	400 A	400 A	400 A	600 A	800 A	800 A	800 A	800 A	1000 A	1200 A
			Maximum Trip (Frame)	400 A	600 A	800 A	1200 A	800 A	1000 A	1200 A	1600 A	2000 A	250 A
			Pow-R-Line: Main	—	—	4, Swbd	4, Swbd	4, Swbd					
			Pow-R-Line: Branch	4, Swbd				4, Swbd					
Downstream Breaker			Pow-R-Line: Sub-Feed	—	—	—	—	—	—	—	—	—	—
	Pow-R-Line Panelboard/Switchboard												
	Main	Branch	Sub-Feed										
BR, BAB, HQP and QC (10 kA at 240 Vac) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
20	—	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
30	—	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
40	—	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
50	—	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
60	1a	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
70	1a	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
80	1a	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
90	1a	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
100	1a	1a, 3a, 4, Swbd	—	10	10	10	10	10	10	10	10	10	10
BRH, QPHW, QBHW and QCHW (22 kA at 240 Vac) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
20	—	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
30	—	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
40	—	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
50	—	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
60	1a	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
70	1a	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
80	1a	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
90	1a	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
100	1a	1a, 3a, 4, Swbd	—	22	22	22	22	22	22	22	22	22	22
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)													
20	—	1a, 3a, 4, Swbd	—	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14
30	—	1a, 3a, 4, Swbd	—	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14
50	—	1a, 3a, 4, Swbd	—	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14
70	2a	1a, 3a, 4, Swbd	—	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14
100	2a	1a, 3a, 4, Swbd	—	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14	65/14
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)													
100	—	Swbd	—	200/65	200/65	200/65	200/65	200/65	200/65	200/65	200/65	200/65	200/65
EG Family (EGB, EGE, EGS, EGH)													
15	—	3E	—	65	65	65	65	65	65	65	65	65	65
30	—	3E	—	65	65	65	65	65	65	65	65	65	65
50	—	3E	—	42	42	42	42	65	65	65	65	65	65
60	3E	3E	—	42	42	42	42	65	65	65	65	65	65
100	3E	3E	—	35	35	35	35	65	65	65	65	65	65
125	3E	3E	—	35	35	35	35	65	65	65	65	65	65
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB [150 A], EHD [100 A], FDE, HFDE, FDCE)													
15	—	3a,4, Swbd	—	50	50	50	50	65	65	65	65	65	65
40	—	3a, 4, Swbd	—	42	42	42	42	65	65	65	65	65	65
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	35	35	35	35	65	65	65	65	65	65
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	30	30	30	30	65	65	65	65	65	65

Table 27.3-10. MCCB 100% Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	**N**	**N**	**N**	**N**	**R**	**R**	**R**	**R**	**R**	**R**
			Type Trip Unit	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**
			Digitrip RMS Trip Unit	**310**	**310**	**310**	**310**	**310**	**310**	**310**	**310**	**310**	**310**
			OPTIM Trip Unit	**550, 1050**	**550, 1050**	**550, 1050**	**550, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**
			Minimum Trip (Plug/Trip)	**400 A**	**400 A**	**400 A**	**600 A**	**800 A**	**800 A**	**800 A**	**800 A**	**1000 A**	**1200 A**
			Maximum Trip (Frame)	**400 A**	**600 A**	**800 A**	**1200 A**	**800 A**	**1000 A**	**1200 A**	**1600 A**	**2000 A**	**2500 A**
			Pow-R-Line: Main	**—**	**—**	**4, Swbd**	**4, Swbd**	**4, Swbd**					
			Pow-R-Line: Branch	**4, Swbd**				**4, Swbd**					
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
	Pow-R-Line Panelboard/Switchboard												
	Main	**Branch**	**Sub-Feed**										
J Family (JDB, JD, HJD, JDC)													
70	—	4, Swbd	—	35	35	35	35	35	35	65	65	65	65
125	—	4, Swbd	—	30	30	30	30	30	30	65	65	65	65
250	2a, 3a, 4	4, Swbd	1a, 2a, 3a	30	30	30	30	30	30	50	65	65	65
LCL 250 Family Current Limiting													
125	—	4, Swbd	—	65	65	65	65	65	65	65	65	65	65
200	—	4, Swbd	—	65	65	65	65	65	65	65	65	65	65
250	—	4, Swbd	—	65	65	65	65	65	65	65	65	65	65
LCL 400 Family Current Limiting													
200	—	4, Swbd	—	30	30	30	30	65	65	65	65	65	65
300	—	4, Swbd	—	30	30	30	30	65	65	65	65	65	65
400	3q, 4	4, Swbd	—	—	30	30	30	65	65	65	65	65	65
K Family (KDB, KD, CKD, HKD, CHKD, KDC)													
100	—	4, Swbd	—	22	22	22	22	42	42	42	42	65	65
200	—	4, Swbd	—	18	18	18	18	40		40	40	65	65
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	18	18	35	35	35	35	50	50
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)													
300	3a, 4	4, Swbd	—	—	18	18	18	25	25	25	25	42	42
400	3a, 4	4, Swbd	—	—	—	18	18	22	22	22	22	35	35
600	3a, 4	4, Swbd	—	—	—	—	18	20	20	20	20	30	30
LG Family (LGE, LGS, LGH, LGC)													
250	—	4, Swbd	—	10	18	18	18	25	25	25	25	50	50
400	—	4, Swbd	—	—	—	18	18	22	22	22	22	35	35
600	4	4, Swbd	—	—	—	—	18	20	20	20	20	30	30
LG Current Limiting Family													
400	—	4, Swbd	—	—	—	25	25	35	35	35	50	50	50
600	4	4, Swbd	—	—	—	—	25	30	30	30	42	42	42
LHH Family													
150	1a, 2a, 3a, 3E, 4	4, Swbd	—	10	18	18	18	25	25	25	25	50	50
200	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	18	18	22	22	22	22	35	35
400	1a, 2a, 3a, 3E, 4	4, Swbd	—	—	—	—	18	20	20	20	20	30	30
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)													
400	—	4, Swbd	—	—	—	—	12	16	16	16	16	22	25
600	—	4, Swbd	—	—	—	—	12	—	—	16	16	22	25
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	16	22	25
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	18	18
NHH Family													
350	4	4, Swbd	—	—	—	—	12	16	16	16	16	22	25

Molded-Case Circuit Breaker Selective Coordination Combinations—0.1 Second Selective Coordination

For 0.1 Second Selective Coordination Applications—Table 27.3-11

The left side columns list the amperages of the **downstream** breaker grouped by the available breaker frames. The next columns on the right of the amperages indicate the type of Pow-R-Line panelboards and/or switchboard that the given down-stream breaker is available in and whether the breaker may be used in that assembly as a main, feeder or sub-feed breaker.

The top rows of the table list the amperages of the **upstream** breaker grouped by the available breaker frames. The next row below indicates the type of trip unit needed:

T/M = Thermal-Magnetic

ETU = Electronic Trip Unit

For ETUs, the next rows indicate the specific type of Digitrip RMS trip unit and/or OPTIM trip unit available.

The **minimum trip/maximum trip** rows indicate the amperage range for which the indicated selectivity is valid.

The next rows below the minimum/ maximum trip indicate the type of Pow-R-Line panelboards and/or switchboard that the given upstream breaker is available in and whether the breaker may be used in that assembly as a main, feeder or sub-feed breaker.

The letter "T" at the intersection of a row and column indicates that 0.1 second selective coordination can be achieve between the chosen downstream and upstream circuit breakers up to the maximum interrupting rating of the downstream breaker.

Steps in Determining 0.1 Second Selective Coordination Between Line and Load Side Circuit Breakers

1. Determine the maximum available fault current from all sources, at both the upstream and down-stream breakers, by means of a short-circuit study, appropriate charts and/or formulas. Where both line and load breakers are connected to the same bus, this will be the same value.
2. Starting on the left at the top and moving downward, select the downstream Eaton breaker that has adequate Interrupting Capacity (IC), voltage rating and continuous amperage rating for the downstream breaker application. If the required interrupting rating, voltage rating, or amperage rating is not shown in the table, continue downward to the row for the next larger breaker frame.
3. Move horizontally from the selected downstream breaker trip rating to the first column that indicates "T." ("T" indicates that 0.1 second selective coordination can be achieved between the chosen downstream and upstream circuit breakers up to the maximum interrupting rating of the downstream breaker.)
4. Proceed upward to read the possible upstream breaker frame. Check the minimum and maximum trip range indicated to ensure it meets the required upstream breaker trip rating. If the trip rating meets the requirements, this will be one of the possible upstream breakers that will selectively coordinate with the downstream breaker. If the indicated trip rating or trip range does not meet the require-ments for the line side breaker, repeat Step 3 and Step 4.
5. Once an upstream family of circuit breakers is determined that selectively coordinates, you can find the specific breaker within that family that meets the required interrupting capacity by checking the breaker product overview tables on **Pages 27.4-4** through **27.4-6**.
6. Optional—Once the selective combination of breakers is determined, you can determine the type of Pow-R-Line panelboard or switchboard assembly that can be used.

Note: If both the upstream and downstream breakers are to be in the same assembly, ensure that both devices are available in the same type Pow-R-Line assembly.

Repeat the above steps for each pair of breakers in the system to quickly and easily select devices that will selectively coordinate to 0.1 seconds.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations

			Upstream Breaker										
			Breaker Family	**EG**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**
			Type Trip Unit	**T/M**	**T/M**	**T/M**	**T/M**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**
			Digitrip RMS Trip Unit	**—**	**—**	**—**	**—**	**310+**	**310+**	**310+**	**310+**	**310+**	**310+**
			OPTIM Trip Unit	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
			Minimum Trip (Plug/Trip)	**125 A**	**100 A**	**150 A**	**175 A**	**50 A**	**80 A**	**100 A**	**150 A**	**200 A**	**225 A**
			Maximum Trip (Frame)	**125 A**	**100 A**	**150 A**	**225 A**	**—**	**—**	**—**	**160 A**	**—**	**225 A**
			Pow-R-Line: Main	**3E**	**1a, 2a, 3a, 3E**								
			Pow-R-Line: Branch	**3E**	**3a, 4, Swbd**								
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**—**	**1a, 2a, 3a, 3E**								
	Pow-R-Line Panelboard/Switchboard												
	Main	**Branch**	**Sub-Feed**										
BR, BAB, HQP and QC (240 Vac, 10 kA) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	—	T	T	—	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	—	—	T	T	—	T	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	—	—	—	T	—	—	T	—	T	T
80	1a	1a, 3a, 4, Swbd	—	—	—	—	T	—	—	T	—	T	T
90	1a	1a, 3a, 4, Swbd	—	—	—	—	T	—	—	T	—	T	T
100	1a	1a, 3a, 4, Swbd	—	—	—	—	—	—	—	T	—	T	T
BRH, QPHW, QBHW and QCHW (240 Vac, 22 kA) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	—	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	—	T	T	—	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	—	—	T	T	—	—	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	—	—	—	T	—	T	T	—	T	T
80	1a	1a, 3a, 4, Swbd	—	—	—	—	T	—	—	T	—	T	T
90	1a	1a, 3a, 4, Swbd	—	—	—	—	T	—	—	T	—	T	T
100	1a	1a, 3a, 4, Swbd	—	—	—	—	—	—	—	T	—	T	T
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)													
20	—	2a, 3a, 4, Swbd	—	—	—	—	T	—	T	T	T	T	T
30	—	2a, 3a, 4, Swbd	—	—	—	—	T	—	—	T	T	T	T
60	—	2a, 3a, 4, Swbd	—	—	—	—	T	—	—	T	T	T	T
70	2a	2a, 3a, 4, Swbd	—	—	—	—	T	—	—	—	T	T	T
100	2a	2a, 3a, 4, Swbd	—	—	—	—	T	—	—	—	T	T	T
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)													
15	—	4, Swbd	—	—	—	—	T	—	—	—	T	T	T
40	1a, 2a, 3a	4, Swbd	—	—	—	—	T	—	—	—	T	T	T
50	1a, 2a, 3a	4, Swbd	—	—	—	—	T	—	—	—	T	T	T
100	1a, 2a, 3a	4, Swbd	—	—	—	—	T	—	—	—	T	T	T
EG Family (EGB, EGE, EGS, EGH)													
15	—	3E	—	T	—	T	T	—	T	—	T	T	T
20	—	3E	—	T	—	T	T	—	T	—	T	T	T
50	3E	3E	—	—	—	T	T	—	T	—	T	T	T
60	3E	3E	—	—	—	—	T	—	—	—	T	T	T
90	3E	3E	—	—	—	—	T	—	—	—	T	T	T
100	3E	3E	—	—	—	—	—	—	—	—	T	T	T
125	3E	3E	—	—	—	—	—	—	—	—	—	—	—

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	EG	F	F	F	F	F	F	F	F	F
			Type Trip Unit	T/M	T/M	T/M	T/M	ETU	ETU	ETU	ETU	ETU	ETU
			Digitrip RMS Trip Unit	—	—	—	—	310+	310+	310+	310+	310+	310+
			OPTIM Trip Unit	—	—	—	—	—	—	—	—	—	—
			Minimum Trip (Plug/Trip)	125 A	100 A	150 A	175 A	50 A	80 A	100 A	150 A	200 A	225 A
			Maximum Trip (Frame)	125 A	100 A	150 A	225 A	—	—	—	160 A	—	225 A
			Pow-R-Line: Main	3E	1a, 2a, 3a, 3E								
			Pow-R-Line: Branch	3E	3a, 4, Swbd								
Downstream Breaker			Pow-R-Line: Sub-Feed	—	1a, 2a, 3a, 3E								
	Pow-R-Line Panelboard/Switchboard												
	Main	Branch	Sub-Feed										
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB(150 A), EHD(100A), FDE, HFDE, FDCE)													
15	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	—	—	T	—	—	T	T	T	T
40	—	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	T	—	—	T	T	T	T
70	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	T	—	—	—	T	T	T
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	T	—	—	—	T	T	T
125	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	T	T
150	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
J Family (JDB, JD, HJD, JDC)													
70	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
100	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
125	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
175	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
225	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
250	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LCL 250 Family Current Limiting													
150	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
200	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
225	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
250	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LCL 400 Family Current Limiting													
225	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
275	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
K Family (KDB, KD, CKD, HKD, CHKD, KDC)													
100	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
150	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
200	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
250	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
300	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)													
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
350	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
500	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)													
300	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
350	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
500	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)													
400	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	J	J	J	K	K	K	K	K	K	K
			Type Trip Unit	T/M	T/M	T/M	T/M	T/M	T/M	ETU	ETU	ETU	ETU
			Digitrip RMS Trip Unit	—	—	—	—	—	—	310	310	310	310
			OPTIM Trip Unit	—	—	—	—	—	—	550, 1050	550, 1050	550, 1050	550, 1050
			Minimum Trip (Plug/Trip)	70 A	150 A	250 A	100 A	200 A	400 A	70 A	100 A	125 A	150 A
			Maximum Trip (Frame)	—	—	—	—	—	—	—	—	—	—
			Pow-R-Line: Main	3a			1a, 2a, 3a, 3E, 4						
			Pow-R-Line: Branch	4, Swbd			4, Swbd						
Downstream Breaker			Pow-R-Line: Sub-Feed	3a			1a, 2a, 3a, 3E						
	Pow-R-Line Panelboard/Switchboard												
	Main	Branch	Sub-Feed										
BR, BAB, HQP and QC (240 Vac, 10 kA) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	—	T	T	T	T	T	—	T	T	T
60	1a	1a, 3a, 4, Swbd	—	—	T	T	T	T	T	—	T	T	T
70	1a	1a, 3a, 4, Swbd	—	—	—	T	T	T	T	—	—	—	—
80	1a	1a, 3a, 4, Swbd	—	—	—	T	—	T	T	—	—	—	—
90	1a	1a, 3a, 4, Swbd	—	—	—	T	—	T	T	—	—	—	—
100	1a	1a, 3a, 4, Swbd	—	—	—	T	—	—	T	—	—	—	—
BRH, QPHW, QBHW and QCHW (240 Vac, 22 kA) Single-, Two- and Three-Pole													
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	—	T	T	T	T	T	—	T	T	T
60	1a	1a, 3a, 4, Swbd	—	—	T	T	T	T	T	—	T	T	T
70	1a	1a, 3a, 4, Swbd	—	—	—	T	T	T	T	—	—	—	—
80	1a	1a, 3a, 4, Swbd	—	—	—	T	—	T	T	—	—	—	—
90	1a	1a, 3a, 4, Swbd	—	—	—	T	—	T	T	—	—	—	—
100	1a	1a, 3a, 4, Swbd	—	—	—	T	—	—	T	—	—	—	—
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)													
20	—	2a, 3a, 4, Swbd	—	T	T	T	—	T	T	—	T	T	T
30	—	2a, 3a, 4, Swbd	—	T	—	T	—	T	T	—	—	—	T
60	—	2a, 3a, 4, Swbd	—	T	—	T	—	T	T	—	—	—	—
70	2a	2a, 3a, 4, Swbd	—	—	—	T	—	T	T	—	—	—	—
100	2a	2a, 3a, 4, Swbd	—	—	—	T	—	T	T	—	—	—	—
GD Family (65 kA at 240 Vac, 22 kA at 80 Vac)													
15	—	—	—	T	T	T	T	T	T	—	T	T	T
40	—	—	—	T	—	T	T	T	T	—	T	T	T
50	—	—	—	T	—	T	T	T	T	—	T	T	T
60	—	—	—	—	—	T	T	T	T	—	T	T	T
40	—	—	—	—	—	T	—	T	T	—	—	—	T
100	—	—	—	—	—	T	—	T	T	—	—	—	T
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)													
15	—	4, Swbd	—	—	T	T	—	T	T	—	—	T	T
40	1a, 2a, 3a	4, Swbd	—	—	T	T	—	T	T	—	—	—	T
50	1a, 2a, 3a	4, Swbd	—	—	T	T	—	T	T	—	—	—	—
100	1a, 2a, 3a	4, Swbd	—	—	T	T	—	T	T	—	—	—	—
EG Family (EGB, EGE, EGS, EGH)													
15	—	3E	—	—	T	T	T	T	T	—	—	T	T
20	—	3E	—	—	T	T	T	T	T	—	—	T	T
50	3E	3E	—	—	T	T	T	T	T	—	—	T	T
60	3E	3E	—	—	T	T	—	T	T	—	—	T	T
90	3E	3E	—	—	T	T	—	T	T	—	—	—	—
100	3E	3E	—	—	—	T	—	T	T	—	—	—	—
125	3E	3E	—	—	—	T	—	—	T	—	—	—	—

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Application Information—0.1 Sec Selective Coordination

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker										
			Breaker Family	**J**	**J**	**J**	**K**	**K**	**K**	**K**	**K**	**K**	**K**
			Type Trip Unit	**T/M**	**T/M**	**T/M**	**T/M**	**T/M**	**T/M**	**ETU**	**ETU**	**ETU**	**ETU**
			Digitrip RMS Trip Unit	—	—	—	—	—	—	**310**	**310**	**310**	**310**
			OPTIM Trip Unit	—	—	—	—	—	—	**550, 1050**	**550, 1050**	**550, 1050**	**550, 1050**
			Minimum Trip (Plug/Trip)	**70 A**	**150 A**	**250 A**	**100 A**	**200 A**	**400 A**	**70 A**	**100 A**	**125 A**	**150 A**
			Maximum Trip (Frame)	—	—	—	—	—	—	—	—	—	—
			Pow-R-Line: Main	**3a**			**1a, 2a, 3a, 3E, 4**						
			Pow-R-Line: Branch	**4, Swbd**			**4, Swbd**						
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**3a**			**1a, 2a, 3a, 3E**						
	Pow-R-Line Panelboard/Switchboard												
	Main	**Branch**	**Sub-Feed**										
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB (150 A), EHD (100 A), FDE, HFDE, FDCE)													
15	—	3a, 4, Swbd	1a, 2a, 3a, 3E	—	T	T	T	T	T	—	T	T	T
40	—	3a, 4, Swbd	1a, 2a, 3a, 3E	—	T	T	—	T	T	—	—	—	T
70	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	T	T	—	T	T	—	—	—	—
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	T	—	T	T	—	—	—	—
125	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	T	—	T	T	—	—	—	—
150	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	T	—	T	T	—	—	—	—
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	T	—	—	—	—
J Family													
70	3a, 4	4, Swbd	—	—	—	—	—	T	T	—	—	—	—
100	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
125	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
175	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
225	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
250	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LCL 250 Family Current Limiting													
150	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
200	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
225	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
250	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
LCL 400 Family Current Limiting													
225	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
275	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
300	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	T	—	—	—	—
K Family (KDB, KD, CKD, HKD, CHKD, KDC)													
100	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	T	T	—	—	—	—
150	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	T	—	—	—	—
200	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	T	—	—	—	—
250	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	T	—	—	—	—
300	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—	—
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)													
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
350	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
500	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)													
300	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
350	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
400	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
500	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)													
400	4	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
600	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—	—

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker								
			Breaker Family	**K**	**K**	**K**	**K**	**K**	**L**	**L**	**L**
			Type Trip Unit	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**T/M**	**T/M**	**T/M**
			Digitrip RMS Trip Unit	**310**	**310**	**310**	**310**	**310**	**—**	**—**	**—**
			OPTIM Trip Unit	**550, 1050**	**550, 1050**	**550, 1050**	**550, 1050**	**550, 1050**	**—**	**—**	**—**
			Minimum Trip (Plug/Trip)	**200 A**	**225 A**	**250 A**	**300 A**	**400 A**	**300 A**	**400 A**	**600 A**
			Maximum Trip (Frame)	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
			Pow-R-Line: Main	**1a, 2a, 3a, 3E, 4**					**3a, 4, Swbd**		
			Pow-R-Line: Branch	**4, Swbd**					**4, Swbd**		
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**1a, 2a, 3a, 3E**					**—**	**—**	**—**
	Pow-R-Line Panelboard/Switchboard										
	Main	**Branch**	**Sub-Feed**								
BR, BAB, HQP and QC (240 Vac, 10 kA) Single-, Two- and Three-Pole											
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
BRH, QPHW, QBHW and QCHW (240 Vac, 22 kA) Single-, Two- and Three-Pole											
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)											
20	—	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
30	—	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
60	—	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
70	2a	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
100	2a	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T
GD Family (65 kA at 240 Vac, 22 kA at 80 Vac)											
15	—	—	—	T	T	T	T	T	T	T	T
40	—	—	—	T	T	T	T	T	T	T	T
50	—	—	—	T	T	T	T	T	T	T	T
60	—	—	—	T	T	T	T	T	T	T	T
40	—	—	—	T	T	T	T	T	T	T	T
100	—	—	—	T	T	T	T	T	T	T	T
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)											
15	—	4, Swbd	—	T	T	T	T	T	T	T	T
40	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T	T	T	T
50	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T	T	T	T
100	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T	T	T	T
EG Family (EGB, EGE, EGS, EGH)											
15	—	3E	—	T	T	T	T	T	T	T	T
20	—	3E	—	T	T	T	T	T	T	T	T
50	3E	3E	—	T	T	T	T	T	T	T	T
60	3E	3E	—	T	T	T	T	T	T	T	T
90	3E	3E	—	T	T	T	T	T	T	T	T
100	3E	3E	—	T	T	T	T	T	T	T	T
125	3E	3E	—	—	—	T	T	T	T	T	T

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker								
			Breaker Family	**K**	**K**	**K**	**K**	**K**	**L**	**L**	**L**
			Type Trip Unit	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**T/M**	**T/M**	**T/M**
			Digitrip RMS Trip Unit	**310**	**310**	**310**	**310**	**310**	**—**	**—**	**—**
			OPTIM Trip Unit	**550, 1050**	**550, 1050**	**550, 1050**	**550, 1050**	**550, 1050**	**—**	**—**	**—**
			Minimum Trip (Plug/Trip)	**200 A**	**225 A**	**250 A**	**300 A**	**400 A**	**300 A**	**400 A**	**600 A**
			Maximum Trip (Frame)	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
			Pow-R-Line: Main	**1a, 2a, 3a, 3E, 4**					**3a, 4, Swbd**		
			Pow-R-Line: Branch	**4, Swbd**					**4, Swbd**		
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**1a, 2a, 3a, 3E**					**—**	**—**	**—**
	Pow-R-Line Panelboard/Switchboard										
	Main	**Branch**	**Sub-Feed**								
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB (150 A), EHD (100 A), FDE, HFDE, FDCE)											
15	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T
40	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T
70	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T
125	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	T	T	T	T	T	T	T
150	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	T	T	T	T	T
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	T	T
J Family											
70	3a, 4	4, Swbd	—	T	T	T	T	T	T	T	T
100	3a, 4	4, Swbd	—	—	T	T	T	T	T	T	T
125	3a, 4	4, Swbd	—	—	—	—	T	T	T	T	T
175	3a, 4	4, Swbd	—	—	—	—	—	T	T	T	T
225	3a, 4	4, Swbd	—	—	—	—	—	—	—	T	T
250	3a, 4	4, Swbd	—	—	—	—	—	—	—	T	T
LCL 250 Family Current Limiting											
150	3a, 4	4, Swbd	—	T	T	T	T	T	T	T	T
200	3a, 4	4, Swbd	—	—	—	—	T	T	T	T	T
225	3a, 4	4, Swbd	—	—	—	—	—	T	T	T	T
250	3a, 4	4, Swbd	—	—	—	—	—	T	T	T	T
LCL 400 Family Current Limiting											
225	3a, 4	4, Swbd	—	—	—	—	—	T	—	T	T
275	3a, 4	4, Swbd	—	—	—	—	—	T	—	T	T
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	T	T
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	T
K Family (KDB, KD, CKD, HKD, CHKD, KDC)											
100	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	T	T	T	T	T	T
150	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	T	T	T	T
200	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	T	T
250	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	T
300	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	T
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)											
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	T
350	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	T
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—
500	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—
600	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)											
300	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	T
350	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	T
400	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	T
500	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—
600	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)											
400	4	4, Swbd	—	—	—	—	—	—	—	—	—
600	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker									
			Breaker Family	**L**	**L**	**L**	**LG**	**LG**	**LG**	**LG**	**N**	**N**
			Type Trip Unit	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**
			Digitrip RMS Trip Unit	**310**	**310**	**310**	**310+**	**310+**	**310+**	**310+**	**310(+)**	**310(+)**
			OPTIM Trip Unit	**550, 1050**	**550, 1050**	**550, 1050**	**—**	**—**	**—**	**—**	**550, 1050**	**550, 1050**
			Minimum Trip (Plug/Trip)	**300 A**	**400 A**	**600**	**250 A**	**300 A**	**400 A**	**500 A**	**400 A**	**600 A**
			Maximum Trip (Frame)	**—**	**—**	**—**	**—**	**—**	**—**	**600 A**	**—**	**—**
			Pow-R-Line: Main	**1a, 2a, 3a, 3E, 4**			**3a, 3E, 4, Swbd**				**PRL4, Swbd**	
			Pow-R-Line: Branch	**4, Swbd**			**4, Swbd**				**PRL4, Swbd**	
Downstream Breaker			**Pow-R-Line: Sub-Feed**	—	—	—	—	—	—	—	—	—
	Pow-R-Line Panelboard/Switchboard											
	Main	**Branch**	**Sub-Feed**									
BR, BAB, HQP and QC (240 Vac, 10 kA) Single-, Two- and Three-Pole												
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
BRH, QPHW, QBHW and QCHW (240 Vac, 22 kA) Single-, Two- and Three-Pole												
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)												
20	—	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
30	—	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
60	—	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
70	2a	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
100	2a	2a, 3a, 4, Swbd	—	T	T	T	T	T	T	T	T	T
GD Family (65 kA at 240 Vac, 22 kA at 80 Vac)												
15	—	—	—	T	T	T	T	T	T	T	T	T
40	—	—	—	T	T	T	T	T	T	T	T	T
50	—	—	—	T	T	T	T	T	T	T	T	T
60	—	—	—	T	T	T	T	T	T	T	T	T
40	—	—	—	T	T	T	T	T	T	T	T	T
100	—	—	—	T	T	T	T	T	T	T	T	T
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)												
15	—	4, Swbd	—	T	T	T	T	T	T	T	T	T
40	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T	T	T	T	T
50	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T	T	T	T	T
100	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T	T	T	T	T
EG Family (EGB, EGE, EGS, EGH)												
15	—	3E	—	T	T	T	T	T	T	T	T	T
20	—	3E	—	T	T	T	T	T	T	T	T	T
50	3E	3E	—	T	T	T	T	T	T	T	T	T
60	3E	3E	—	T	T	T	T	T	T	T	T	T
90	3E	3E	—	T	T	T	T	T	T	T	T	T
100	3E	3E	—	T	T	T	T	T	T	T	T	T
125	3E	3E	—	T	T	T	T	T	T	T	T	T

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Application Information—0.1 Sec Selective Coordination

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker									
			Breaker Family	L	L	L	LG	LG	LG	LG	N	N
			Type Trip Unit	ETU	ETU	ETU	ETU	ETU	ETU	ETU	ETU	ETU
			Digitrip RMS Trip Unit	310	310	310	310+	310+	310+	310+	310(+)	310(+)
			OPTIM Trip Unit	550, 1050	550, 1050	550, 1050	—	—	—	—	550, 1050	550, 1050
			Minimum Trip (Plug/Trip)	300 A	400 A	600 A	250 A	300 A	400 A	500 A	400 A	600 A
			Maximum Trip (Frame)	—	—	—	—	—	—	600 A	—	—
			Pow-R-Line: Main	1a, 2a, 3a, 3E, 4			3a, 3E, 4, Swbd				PRL4, Swbd	
			Pow-R-Line: Branch	4, Swbd			4, Swbd				PRL4, Swbd	
Downstream Breaker			Pow-R-Line: Sub-Feed	—	—	—	—	—	—	—	—	—
	Pow-R-Line Panelboard/Switchboard											
	Main	Branch	Sub-Feed									
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB (150 A), EHD (100 A), FDE, HFDE, FDCE)												
15	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T	T
40	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T	T
70	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T	T
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T	T
125	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T	T
150	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T	T	T	T	T
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	—	—	T	—	—	T	T	—	T
J Family												
70	3a, 4	4, Swbd	—	T	T	T	T	T	T	T	T	T
100	3a, 4	4, Swbd	—	T	T	T	T	T	T	T	T	T
125	3a, 4	4, Swbd	—	T	T	T	T	T	T	T	T	T
175	3a, 4	4, Swbd	—	T	T	T	T	—	T	T	T	T
225	3a, 4	4, Swbd	—	—	—	T	—	—	T	T	—	T
250	3a, 4	4, Swbd	—	—	—	T	—	—	—	—	—	T
LCL 250 Family Current Limiting												
150	3a, 4	4, Swbd	—	T	T	T	T	T	T	T	T	T
200	3a, 4	4, Swbd	—	T	T	T	T	T	T	T	T	T
225	3a, 4	4, Swbd	—	—	T	T	T	T	T	T	T	T
250	3a, 4	4, Swbd	—	—	T	—	T	T	T	T	T	T
LCL 400 Family Current Limiting												
225	3a, 4	4, Swbd	—	—	T	T	T	T	T	T	T	T
275	3a, 4	4, Swbd	—	—	—	T	—	—	T	T	T	T
300	3a, 4	4, Swbd	—	—	—	T	—	—	T	T	—	T
400	3a, 4	4, Swbd	—	—	—	T	—	—	—	—	—	T
K Family (KDB, KD, CKD, HKD, CHKD, KDC)												
100	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T	—	T	T	T	T	T
150	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	T	T	—	T	T	T	T	T
200	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	T	—	—	T	T	—	T
250	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	T	—	—	—	T	—	T
300	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	—	—	—	—	—	—	—	—
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)												
300	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
350	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
400	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
500	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
600	3a, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)												
300	3a, 3E, 4	4, Swbd	—	—	—	T	—	—	—	—	—	T
350	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
400	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
500	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
600	3a, 3E, 4	4, Swbd	—	—	—	—	—	—	—	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)												
400	4	4, Swbd	—	—	—	—	—	—	—	—	—	—
600	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—
800	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—
1200	4, Swbd	4, Swbd	—	—	—	—	—	—	—	—	—	—

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker					
			Breaker Family	**N**	**N**	**R**	**R**	**R**
			Type Trip Unit	**ETU**	**ETU**	**ETU**	**ETU**	**ETU**
			Digitrip RMS Trip Unit	**310(+)**	**310(+)**	**310**	**310**	**310**
			OPTIM Trip Unit	**550, 1050**	**550, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**
			Minimum Trip (Plug/Trip)	**800 A**	**1000 A**	**800 A**	**1000 A**	**1200 A**
			Maximum Trip (Frame)	**—**	**1200 A**	**—**	**—**	**—**
			Pow-R-Line: Main	**PRL4, Swbd**		**Swbd**		
			Pow-R-Line: Branch	**PRL4, Swbd**		**Swbd**		
Downstream Breaker			**Pow-R-Line: Sub-Feed**	**—**	**—**	**—**	**—**	**—**
	Pow-R-Line Panelboard/Switchboard							
	Main	**Branch**	**Sub-Feed**					
BR, BAB, HQP and QC (240 Vac, 10 kA) Single-, Two- and Three-Pole								
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
BRH, QPHW, QBHW and QCHW (240 Vac, 22 kA) Single-, Two- and Three-Pole								
15	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T	T	T
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)								
20	—	2a, 3a, 4, Swbd	—	T	T	T	T	T
30	—	2a, 3a, 4, Swbd	—	T	T	T	T	T
60	—	2a, 3a, 4, Swbd	—	T	T	T	T	T
70	2a	2a, 3a, 4, Swbd	—	T	T	T	T	T
100	2a	2a, 3a, 4, Swbd	—	T	T	T	T	T
GD Family (65 kA at 240 Vac, 22 kA at 80 Vac)								
15	—	—	—	T	T	T	T	T
40	—	—	—	T	T	T	T	T
50	—	—	—	T	T	T	T	T
60	—	—	—	T	T	T	T	T
40	—	—	—	T	T	T	T	T
100	—	—	—	T	T	T	T	T
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)								
15	—	4, Swbd	—	T	T	T	T	T
40	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T
50	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T
100	1a, 2a, 3a	4, Swbd	—	T	T	T	T	T
EG Family (EGB, EGE, EGS, EGH)								
15	—	3E	—	T	T	T	T	T
20	—	3E	—	T	T	T	T	T
50	3E	3E	—	T	T	T	T	T
60	3E	3E	—	T	T	T	T	T
90	3E	3E	—	T	T	T	T	T
100	3E	3E	—	T	T	T	T	T
125	3E	3E	—	T	T	T	T	T

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker					
			Breaker Family	N	N	R	R	R
			Type Trip Unit	ETU	ETU	ETU	ETU	ETU
			Digitrip RMS Trip Unit	310(+)	310(+)	310	310	310
			OPTIM Trip Unit	550, 1050	550, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050
			Minimum Trip (Plug/Trip)	800 A	1000 A	800 A	1000 A	1200 A
			Maximum Trip (Frame)	—	1200 A	—	—	—
			Pow-R-Line: Main	PRL4, Swbd		Swbd		
			Pow-R-Line: Branch	PRL4, Swbd		Swbd		
Downstream Breaker			Pow-R-Line: Sub-Feed	—	—	—	—	—
	Pow-R-Line Panelboard/Switchboard							
	Main	Branch	Sub-Feed					
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB (150 A), EHD (100 A), FDE, HFDE, FDCE)								
15	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
40	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
70	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
125	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
150	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
J Family								
70	3a, 4	4, Swbd	—	T	T	T	T	T
100	3a, 4	4, Swbd	—	T	T	T	T	T
125	3a, 4	4, Swbd	—	T	T	T	T	T
175	3a, 4	4, Swbd	—	T	T	T	T	T
225	3a, 4	4, Swbd	—	T	T	T	T	T
250	3a, 4	4, Swbd	—	T	T	T	T	T
LCL 250 Family Current Limiting								
150	3a, 4	4, Swbd	—	T	T	T	T	T
200	3a, 4	4, Swbd	—	T	T	T	T	T
225	3a, 4	4, Swbd	—	T	T	T	T	T
250	3a, 4	4, Swbd	—	T	T	T	T	T
LCL 400 Family Current Limiting								
225	3a, 4	4, Swbd	—	T	T	T	T	T
275	3a, 4	4, Swbd	—	T	T	T	T	T
300	3a, 4	4, Swbd	—	T	T	T	T	T
400	3a, 4	4, Swbd	—	T	T	T	T	T
K Family (KDB, KD, CKD, HKD, CHKD, KDC)								
100	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
150	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
200	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
250	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
300	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T	T	T
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	—	T	—	T	T
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)								
300	3a, 4	4, Swbd	—	T	T	T	T	T
350	3a, 4	4, Swbd	—	—	T	—	T	T
400	3a, 4	4, Swbd	—	—	T	—	T	T
500	3a, 4	4, Swbd	—	—	T	—	—	T
600	3a, 4	4, Swbd	—	—	—	—	—	—
LG Family (LGE, LGS, LGH, LGC)								
300	3a, 3E, 4	4, Swbd	—	T	T	T	T	T
350	3a, 3E, 4	4, Swbd	—	T	T	T	T	T
400	3a, 3E, 4	4, Swbd	—	T	T	—	T	T
500	3a, 3E, 4	4, Swbd	—	—	T	—	T	T
600	3a, 3E, 4	4, Swbd	—	—	T	—	—	—
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)								
400	4	4, Swbd	—	—	T	T	T	T
600	4, Swbd	4, Swbd	—	—	T	T	T	T
800	4, Swbd	4, Swbd	—	—	T	—	T	T
1200	4, Swbd	4, Swbd	—	—	—	—	—	—

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker			
			Breaker Family	R	R	R
			Type Trip Unit	ETU	ETU	ETU
			Digitrip RMS Trip Unit	310	310	310
			OPTIM Trip Unit	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050	510, 610, 810, 910, 1050
			Minimum Trip (Plug/Trip)	1600 A	2000 A	2500 A
			Maximum Trip (Frame)	—	—	—
			Pow-R-Line: Main	Swbd		
			Pow-R-Line: Branch	Swbd		
Downstream Breaker			Pow-R-Line: Sub-Feed	—	—	—
	Pow-R-Line Panelboard/Switchboard					
	Main	Branch	Sub-Feed			
BR, BAB, HQP and QC (240 Vac, 10 kA) Single-, Two- and Three-Pole						
15	—	1a, 3a, 4, Swbd	—	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T
BRH, QPHW, QBHW and QCHW (240 Vac, 22 kA) Single-, Two- and Three-Pole						
15	—	1a, 3a, 4, Swbd	—	T	T	T
20	—	1a, 3a, 4, Swbd	—	T	T	T
30	—	1a, 3a, 4, Swbd	—	T	T	T
40	—	1a, 3a, 4, Swbd	—	T	T	T
50	—	1a, 3a, 4, Swbd	—	T	T	T
60	1a	1a, 3a, 4, Swbd	—	T	T	T
70	1a	1a, 3a, 4, Swbd	—	T	T	T
80	1a	1a, 3a, 4, Swbd	—	T	T	T
90	1a	1a, 3a, 4, Swbd	—	T	T	T
100	1a	1a, 3a, 4, Swbd	—	T	T	T
GHB Family (65 kA at 240 Vac, 14 kA at 480Y/277 Vac)						
20	—	2a, 3a, 4, Swbd	—	T	T	T
30	—	2a, 3a, 4, Swbd	—	T	T	T
60	—	2a, 3a, 4, Swbd	—	T	T	T
70	2a	2a, 3a, 4, Swbd	—	T	T	T
100	2a	2a, 3a, 4, Swbd	—	T	T	T
GD Family (65 kA at 240 Vac, 22 kA at 80 Vac)						
15	—	—	—	T	T	T
40	—	—	—	T	T	T
50	—	—	—	T	T	T
60	—	—	—	T	T	T
40	—	—	—	T	T	T
100	—	—	—	T	T	T
FCL Family Current Limiting (200 kA at 240 Vac, 150 kA at 480 Vac)						
15	—	4, Swbd	—	T	T	T
40	1a, 2a, 3a	4, Swbd	—	T	T	T
50	1a, 2a, 3a	4, Swbd	—	T	T	T
100	1a, 2a, 3a	4, Swbd	—	T	T	T
EG Family (EGB, EGE, EGS, EGH)						
15	—	3E	—	T	T	T
20	—	3E	—	T	T	T
50	3E	3E	—	T	T	T
60	3E	3E	—	T	T	T
90	3E	3E	—	T	T	T
100	3E	3E	—	T	T	T
125	3E	3E	—	T	T	T

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Application Information—0.1 Sec Selective Coordination

Table 27.3-11. MCCB 0.1 Second Selective Coordination Combinations (Continued)

			Upstream Breaker			
			Breaker Family	**R**	**R**	**R**
			Type Trip Unit	**ETU**	**ETU**	**ETU**
			Digitrip RMS Trip Unit	**310**	**310**	**310**
			OPTIM Trip Unit	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**	**510, 610, 810, 910, 1050**
			Minimum Trip (Plug/Trip)	**1600 A**	**2000 A**	**2500 A**
			Maximum Trip (Frame)	—	—	—
			Pow-R-Line: Main		**Swbd**	
			Pow-R-Line: Branch		**Swbd**	
Downstream Breaker			**Pow-R-Line: Sub-Feed**	—	—	—
	Pow-R-Line Panelboard/Switchboard					
	Main	**Branch**	**Sub-Feed**			
F Family (ED, EDB, EDS, EDH, EDC, FD, HFD, FDC, FDB (150 A), EHD (100 A), FDE, HFDE, FDCE)						
15	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T
40	—	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T
70	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T
100	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T
125	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T
150	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T
225	1a, 2a, 3a, 3E	3a, 4, Swbd	1a, 2a, 3a, 3E	T	T	T
J Family						
70	3a, 4	4, Swbd	—	T	T	T
100	3a, 4	4, Swbd	—	T	T	T
125	3a, 4	4, Swbd	—	T	T	T
175	3a, 4	4, Swbd	—	T	T	T
225	3a, 4	4, Swbd	—	T	T	T
250	3a, 4	4, Swbd	—	T	T	T
LCL 250 Family Current Limiting						
150	3a, 4	4, Swbd	—	T	T	T
200	3a, 4	4, Swbd	—	T	T	T
225	3a, 4	4, Swbd	—	T	T	T
250	3a, 4	4, Swbd	—	T	T	T
LCL 400 Family Current Limiting						
225	3a, 4	4, Swbd	—	T	T	T
275	3a, 4	4, Swbd	—	T	T	T
300	3a, 4	4, Swbd	—	T	T	T
400	3a, 4	4, Swbd	—	T	T	T
K Family (KDB, KD, CKD, HKD, CHKD, KDC)						
100	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T
150	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T
200	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T
250	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T
300	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T
400	1a, 2a, 3a, 3E, 4	4, Swbd	1a, 2a, 3a, 3E	T	T	T
L Family (LDB, LD, CLD, HLD, CHLD, LDC, CLDC)						
300	3a, 4	4, Swbd	—	T	T	T
350	3a, 4	4, Swbd	—	T	T	T
400	3a, 4	4, Swbd	—	T	T	T
500	3a, 4	4, Swbd	—	T	T	T
600	3a, 4	4, Swbd	—	T	T	T
LG Family (LGE, LGS, LGH, LGC)						
300	3a, 3E, 4	4, Swbd	—	T	T	T
350	3a, 3E, 4	4, Swbd	—	T	T	T
400	3a, 3E, 4	4, Swbd	—	T	T	T
500	3a, 3E, 4	4, Swbd	—	T	T	T
600	3a, 3E, 4	4, Swbd	—	T	T	T
N Family (ND, CND, HND, CHND, NDC, CNDC, NGS, NGH, NGC)						
400	4	4, Swbd	—	T	T	T
600	4, Swbd	4, Swbd	—	T	T	T
800	4, Swbd	4, Swbd	—	T	T	T
1200	4, Swbd	4, Swbd	—	T	T	T

Note: T = Selectivity to 0.1 seconds is achieved with available fault current values up to the full AIC rating of the breaker.

Electric Arc Flash Hazards

There have been several recent codes and standards regulations that relate to the fundamental dangers of arc flash energy. The following provides a brief overview.

The *NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces* presents numerous requirements for a wide range of topics such as electrical equipment, Personal Protective Equipment (PPE), lockout/tagout practices and safety training. Where it has been determined that work will be performed within the flash protection boundary, NFPA 70E requires an analysis to determine and document the flash hazard incident energy exposure of a worker. This document also contains some of the initial methods developed in order to quantify the incident energy.

The Occupational Safety and Health Administration (OSHA) is the governmental enforcement agency whose mission is to save lives, prevent injuries and protect the health of America's workers. They refer to their standard *Code of Federal Regulations, CFR 1910.333, Selection and Use of Work Practices*, which states "Safety-related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts, when work is performed near or on equipment or circuits which are or may be energized." This general statement provides the basis for OSHA's citing and insisting upon compliance with the arc flash requirements contained in NFPA 70E.

The 2002 edition of the *National Electrical Code (NEC), NFPA 70*, contained the first arc flash hazard references by adding the following new requirement as Article 110.16.

"Flash Protection. Switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing or maintenance while energized, shall be field marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination adjustment, servicing, or maintenance of the equipment.

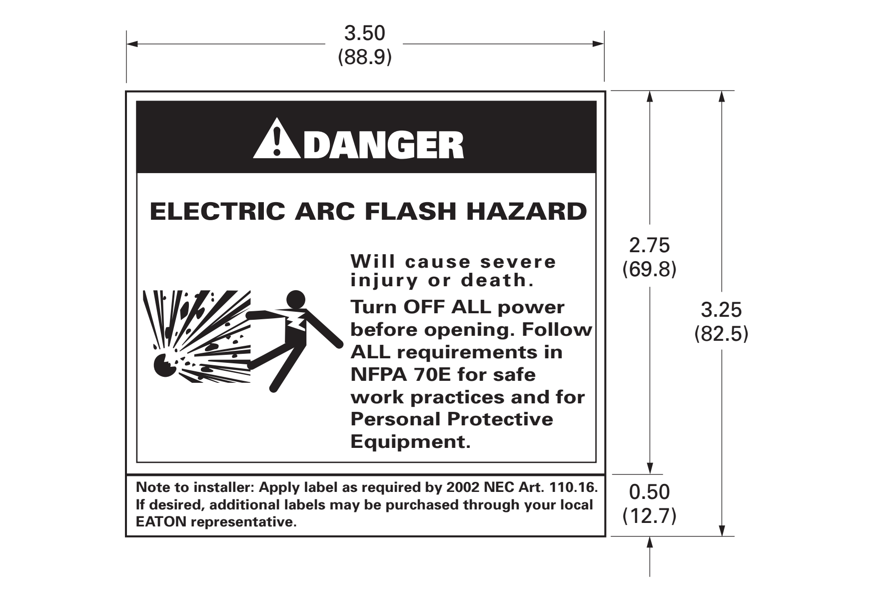


Figure 27.3-5. Electric Arc Flash Hazard

FPN No. 1: NFPA 70E-2000, Electrical Safety Requirements for Employee Workplaces, provides assistance in determining severity of potential exposure, planing safe work practices, and selecting personal protective equipment.

FPN No. 2: ANSI Z535.4-1998, Product Safety Signs and Labels, provides guidelines for the design of safety signs and labels for application to products."

There were numerous proposals for the 2005 NEC that would expand this requirement to "indicate the incident energy in calories per square centimeter for a worker at a distance of 18 in." Adoption of this requirement would indicate the need for a standardized method for determining incident energy.

The *IEEE 1584-2002, Guide for Performing Arc Flash Calculations*, provides a method for the calculation of incident energy and arc flash protection boundaries. It presents formulas for numerically quantifying these values. The IEEE 1584 Guide also includes an Excel spreadsheet "Arc Flash Hazard Calculator" that performs the actual calculations using the formulas stated in the Guide.

The hazard analysis cited in NFPA 70E requires calculations of the **incident energy** available at a given location. This energy is calculated in cal/cm^2 and, based on amount of energy available, a risk category is assigned, and based on that risk category, certain levels of PPE are required. These risk categories are designed to limit worker injuries to second degree burns that occur at energy levels of 1.2 cal/cm^2.

The calculations have two components: 1) magnitude fault current and 2) duration of the fault. The specifics of the formulas are beyond the scope of this discussion, but several factors included in the calculations need understanding. Faster clearing times significantly reduce the incident arc flash energy.

The third factor affecting arc flash incident energy exposure to personnel is the distance the person is from the arc flash location.

Arcflash Reduction Maintenance System

Selected models of Eaton's molded-case circuit breakers are available with an Arcflash Reduction Maintenance System to provide reduced levels of incident arc flash energy when put in the Maintenance Mode.

The Arcflash Reduction Maintenance System is available on Magnum power circuit breakers, NRX power circuit breakers and select Series G molded-case circuit breakers. In Series G molded-case breakers, the trip unit combines Eaton's Arcflash Reduction Maintenance System with the Digitrip 310+ electronic trip unit, allowing for the ability to place the trip unit in Maintenance Mode to reduce potential arc flash energy. This is done by a dedicated instantaneous sensing circuit with settings of 2.5 and 4.0 times the current rating of the trip unit. This dedicated analog sensing circuit delivers **breaker clearing times that are faster than instantaneous** by eliminating microprocessor processing latencies. This provides superior arc flash reduction to competitor's systems that simply lower the standard instantaneous pickup set point.

When the Eaton Arcflash Reduction Maintenance System is enabled, the resulting reduced arc flash energy allows for reduced PPE, which improves worker comfort and mobility. With the Arcflash Reduction Maintenance System set at 2.5X or 4.0X, it reduces incident energy levels to allow PPE Category 0 for currents of 2.5X or 4.0X the breaker ampere rating or greater. The initial setting of each Arcflash Reduction Maintenance System trip unit is determined by completing a power system analysis, to assess available fault current at the circuit breaker. Based on that analysis, the Maintenance Mode protection settings are defined, achieving a reduced level of arc flash energy. The Maintenance Mode is then activated by adjusting the trip units instantaneous setting to desired Maintenance Mode levels determined by the power analysis.

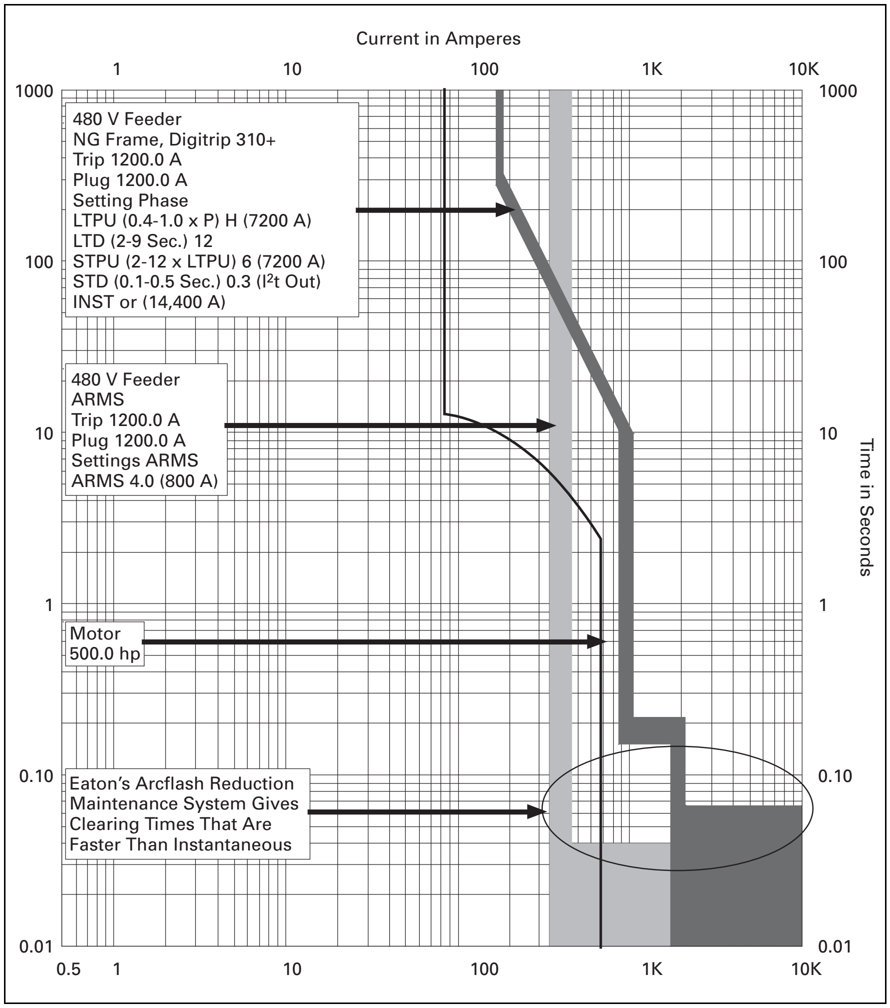


Figure 27.3-6. Time Current Curve

Close-Up of LG Trip Unit

Series G MCCB Features

- Available with ALSI and ALSIG electronic trip unit
- Dedicated analog trip circuit for "faster than instantaneous" tripping
- Superior arc flash reduction over systems that simply lower the standard instantaneous pickup set point
- Adjustable pickup settings (2.5x, 4.0x)
- Local or remote initiation
- Maintenance Mode LED

Unusual Environmental Conditions

Trip Unit Temperatures

Eaton's thermal-magnetic circuit breakers are temperature sensitive. At ambient temperatures below 40 °C (104 °F), circuit breakers carry more current than their continuous current rating. Nuisance tripping is not a problem under these lower temperature conditions, although consideration should be given to closer protection coordination to compensate for the additional current carrying capability. In addition, the actual mechanical operation of the breaker could be affected if the ambient temperature is significantly below the 40 °C standard.

For ambient temperatures above 40 °C, breakers will carry less current than their continuous current rating. This condition promotes nuisance tripping and can create unacceptable temperature conditions at the terminals. Under this condition, the circuit breaker should be recalibrated for the higher ambient temperature.

Electronic trip units are insensitive to ambient temperatures within a certain temperature range. The temperature range for most Eaton electronic trip units is –20 °C to +55 °C (–4 °F to 131 °F). However, at very low ambient temperatures, the mechanical parts of the breaker could require special treatment, such as the use of special lubricants. If the ambient temperature exceeds 40 °C significantly, damage to the electronic circuitry and other components could result. Eaton includes temperature protective circuits in its designs to initiate a tripping operation and provide self-protection, should the internal temperature rise to an unsafe level.

Circuit Breaker Temperatures

The temperature of the air surrounding a circuit breaker is the ambient temperature. In the mid-1960s, industry standards were changed to make all standard breakers calibrated to a 40 °C ambient temperature. For any ambient temperature application above or below 40 °C, it is recommended that the breaker manufacturer be consulted as to any possible re-rating, recalibration or special procedures, before the circuit breaker is selected and applied.

Table 27.3-12. Derating for Non-Compensated Thermal-Magnetic Breakers Calibrated for 40°C

Breaker Ampere Rating at 40°C	Ampere Rating		
	25 °C (77 °F)	50 °C (122 °F)	60 °C (140 °F)
F-Frame/EG-Frame			
15	17	13	11
20	22	18	16
25	32	21	18
30	33	27	24
35	41	32	27
40	45	34	29
50	55	46	42
60	66	56	52
70	77	65	60
90	99	84	78
100	110	94	87
125	137	116	105
150	165	138	125
GD-Frame			
15	—	14	13
20	—	19	18
25	—	24	22
30	—	28	27
35	—	33	31
40	—	38	36
45	—	43	40
50	—	48	45
60	—	57	54
70	—	67	63
80	—	76	72
90	—	86	81
100	—	96	91
J-Frame/JG-Frame			
70	79	63	55
90	102	81	71
100	115	89	76
125	140	114	102
150	171	134	116
175	200	156	134
200	230	178	153
225	252	205	183
250	281	227	201
K-Frame			
100	121	90	79
125	145	116	106
150	188	132	111
175	210	159	141
200	243	180	157
225	255	212	198
250	294	230	208
300	364	270	236
350	412	322	291
400	471	368	333
L-Frame/LG-Frame			
300	330	276	252
350	385	325	301
400	440	372	340
500	550	468	435
600	660	564	525
M-Frame			
300	332	277	252
350	388	322	292
400	444	368	334
450	495	418	383
500	550	468	435
600	660	564	525
700	770	658	613
800	880	754	704

Humidity/Moisture—Corrosion

Molded-case circuit breakers are suited for operation in 0 to 95% non-condensing humidity environments. As is the case with all electrical equipment, application in a condition or environment above this humidity level should be avoided. The ability of molded-case circuit breakers to perform their protective function is negatively affected by exposure to condensation or water, as well as the minerals, particles and contaminants that may be present in them. Prolonged humidity exposure and/or the presence of corrosive elements can result in damage to key operating components and/or severely compromise the breaker's operational integrity. It may adversely impact breaker contact condition and reduce the insulation and dielectric properties of the circuit breaker. In electronic trip circuit breakers, functionality may be similarly compromised by these conditions. To prevent these effects, the breaker should be protected by the proper NEMA rated enclosure for its installation environment, and kept dry through the use of space heaters in the enclosure. If such operating conditions cannot be met, special treatment of the circuit breaker should be considered to minimize the possibility of operational problems.

Most Eaton molded-case circuit breaker cases are molded from glass polyester that does not support the growth of fungus. In addition, a special moisture- and fungus-resisting treatment is recommended for any parts that are susceptible to the growth of fungus.

Altitude

Low voltage circuit breakers must be progressively derated for voltage, current carrying and interrupting rating at altitudes above 6000 ft (1829 m). The thinner air at higher altitudes reduces cooling and dielectric characteristics compared to the denser air found at lower altitudes. Refer to Eaton for additional application details.

Shock/Vibration

Where high shock is an anticipated condition, hi-shock Navy MIL-SPEC type breakers are recommended. Molded-case circuit breakers can be supplied to meet the following marine specifications, several of which require vibration testing: U.S. Coast Guard CFR 46, ABS–American Bureau of Shipping, IEEE 45, UL 489 Supplement SA Marine, UL 489 Supplemental SB Naval, ABS/NVR, Lloyds of London and DNV. See **Page 27.2-20** for additional information on Navy MIL-SPEC and marine circuit breakers.

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Reverse-Feed Application of Circuit Breakers

Circuit breakers may be applied in panelboard, switchboard or motor control center installations where there may occasionally be multiple sources of power, as shown in **Figure 27.3-7**. For example, these may be applications that require high "uptime" and high reliability requirements. For these requirements, permanent, fixed mount or portable electrical generator systems, with an appropriate automatic transfer switching system, are made available to supplement the normal utility power supply source. In other instances, the second power source may be from a so-called "alternate energy source," such as that derived from solar photovoltaic or from wind power electric systems. Similarly, these alternate energy sources are also typically connected as a supplement to the normal utility power sources. As electrical load demand conditions change, the user may switch between using power from the normal utility source to the alternate power source, and vice versa. Whenever this switch in power source occurs, the terminals of the circuit breaker that the power is connected to will have been reversed. This reversal in the way that power is connected to a circuit breaker is called "reverse-feed." Reverse-feed (or "back feed") refers to a way that the conductors supplying current are connected to a circuit breaker.

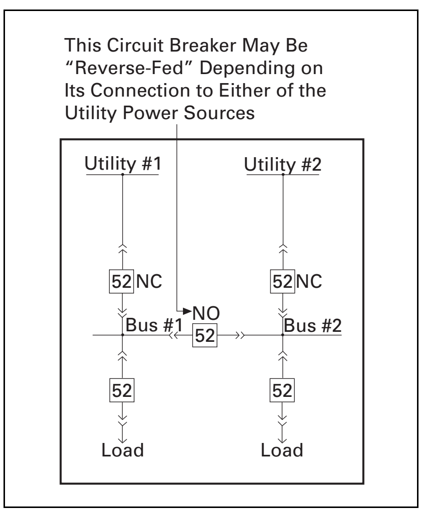

Figure 27.3-7. Circuit Breaker Fed from Multiple Power Supply Sources

In other applications where there is a single power source, circuit breakers may be mounted in an electrical enclosure where the cables from the power source are fed to the bottom of the enclosure. In this case, it may be a matter of convenience for the installation to simply connect the power source conductors to the terminals at the bottom of the circuit breaker that are closest to the incoming power supply conductors. This connection of the power supply source to the circuit breaker's "bottom" terminals will also result in power being applied in a reverse-feed manner.

There are different classifications and types of circuit breakers that exist, and they should be carefully considered when used in reverse-feed applications described above. Depending on the type of circuit breaker, as listed below, reverse-feeding of that circuit breaker may or may not be suitable for that application.

Circuit Breaker Classifications

Low voltage circuit breakers fall into two basic classifications of design.

1. Molded-Case Circuit Breakers (MCCBs) per UL 489 Standard
2. Low Voltage Power Circuit Breakers (LVPCBs) per UL 1066 Standard

Standards Requirements

UL 489—Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures

Per UL 489, there are clear test performance and marking requirements for circuit breakers and molded-case switches that are UL listed as being suitable for reverse-feed applications. UL 489 requires reverse-feed circuit breakers to meet certain construction requirements, and to be tested and marked accordingly, as follows:

1. Tested per UL 489, Paragraph 7.1.1.18
2. Markings per UL 489, Paragraph 9.1.1.13

Testing Requirements

Per UL 489, Paragraph 7.1.1.18: Except for single-pole circuit breakers tested singly, if a circuit breaker is not marked "Line" and "Load," one sample of each set tested, or one additional sample, shall be connected with the line and load connections reversed during the overload, endurance and interrupting tests.

This UL test requirement specifies that for circuit breakers and molded-case switches to be UL Listed for reverse-feed applications, samples shall be tested with the line and load terminals reverse-fed, as shown in **Figure 27.3-8**, and that the test results shall be the same as those of "normally" fed circuit breakers.

Depending on the design configuration and construction, the circuit breaker may or may not be affected by the application of power in a reverse-feed connection during these tests.

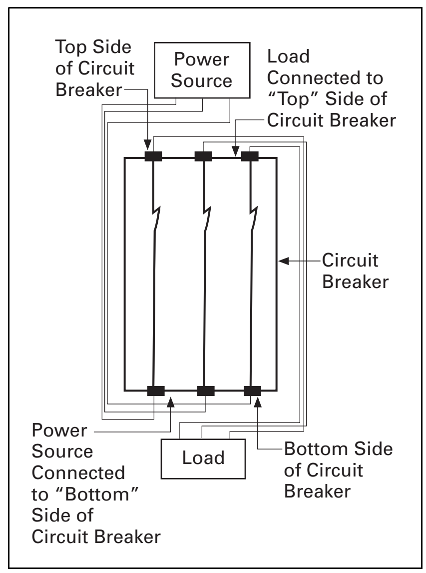

Figure 27.3-8. Circuit Breaker Connections for "Reverse-Feed" Testing per UL 489

Marking Requirements

Per UL 489 Paragraph 9.1.1.13: Circuit breakers shall be marked "Line" and "Load" unless the construction and test results are acceptable with the line and load connections reversed.

This marking requirement specifies that UL listed circuit breakers and molded-case switches shall be marked with the word "Line" on one end of the circuit breaker and the word "Load" on the other end, as shown in **Figure 27.3-9**, if they are unable to successfully meet the reverse-feed test requirements per Paragraph 7.1.1.18 of UL 489. Conversely, a UL listed circuit breaker does not have to be marked with "Line" and "Load" if it successfully meets the reverified test requirements.

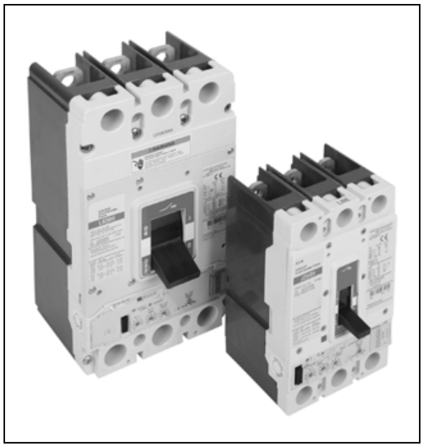

Figure 27.3-9. Circuit Breakers Showing "Line" and "Load" Markings, per UL 489

MCCB General Rule

- Cannot be reverse-fed:
  When a UL listed molded-case circuit breaker and a molded-case switch (not shown) are marked showing "Line" and "Load," the power supply conductors must be connected to the end marked "Line." These devices cannot be reverse-fed
- Can be reverse-fed:
  If "Line" and "Load" are not marked on the UL listed molded-case circuit breaker, the power supply conductors may be connected to either end. These devices are suitable for reverse-feed applications

UL 1066—Low Voltage AC and DC Power Circuit Breakers Used in Enclosures

As part of the standard test programs required by UL 1066 (referenced to ANSI/IEEE C37.50-1989) for low voltage power circuit breakers, tests are conducted that, when successfully completed, demonstrate that the circuit breaker may be applied in a reverse-feed configuration.

These are mandatory tests that are done as part of the short-circuit current tests per Table 3 in Sequence II (Power-Operated Circuit Breaker with Dual Trip Device) of ANSI/IEEE C37.50-1989. As part of this sequence, tests are "to be performed with opposite terminals energized."

During these specified sequences of tests, the circuit breaker is energized in a reverse-feed configuration, and the satisfactory completion of these tests demonstrates their ability to be used in reverse-feed applications. Therefore, all low voltage power circuit breakers that are listed per UL 1066 may be reverse-fed.

PCB General Rule

- Can be reverse-fed:
  Low voltage power circuit breakers that are listed per UL 1066 may be reverse-fed

Special Application Considerations

Circuit Breakers With Integral Ground-Fault Protection

Many of Eaton's UL listed molded-case and low voltage power circuit breakers have design options and schemes that allow for the detection and interruption of unwanted ground-fault currents. In these ground-fault protection schemes, the means for ground-fault detection are either integral to the circuit breaker or externally mounted.

The ground-fault detection means commonly consist of current sensors and control logic circuitry that may be connected in various configurations as follows:

1. Separate current sensors that monitor each phase circuit and the neutral circuit conductors, as shown in **Figure 27.3-10**
2. One current sensor that monitors all phases and the neutral circuit conductors together (not shown)
3. One current sensor that monitors the ground circuit conductor (not shown)

The interruption of ground-fault currents is done by the circuit breaker opening all three-phase conductor circuits at the same time, in response to a trip signal from the ground-fault detection means.

Therefore, whenever an unwanted ground-fault condition exists, a UL listed circuit breaker with ground-fault protection will detect and interrupt the ground-fault current flow.

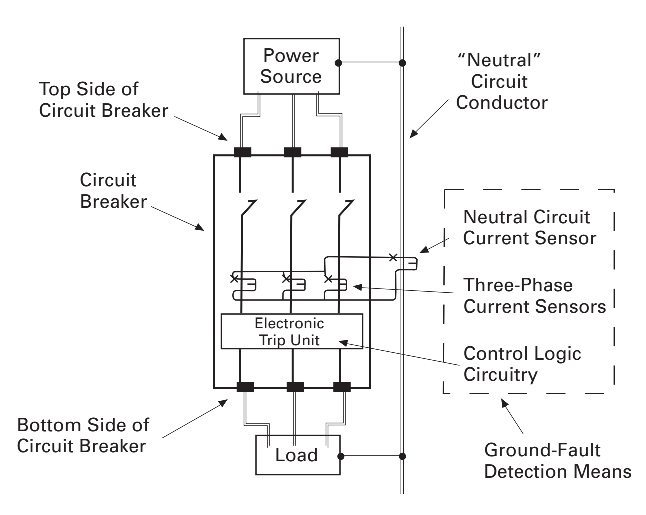

Figure 27.3-10. Circuit Breaker with Integral Ground-Fault Protection

In reverse-feed applications, while the primary phase currents and the ground currents have been interrupted with the opening of the circuit breaker, voltage at the circuit breaker's terminals may or may not cause damage to the components of the ground-fault protection system. If components in the detection means or control logic circuitry of the ground-fault (or the phase current) protection system may be damaged by reverse-feed connections, then the circuit breaker must be marked accordingly. In this case, where the circuit breaker with ground-fault protection is not suitable for reverse-feed applications, the circuit breaker's terminals are marked with "Line" and "Load" to indicate the required terminal connection points for the power supply source ("Line") and the load ("Load").

Conversely, there are Eaton circuit breaker design configurations where the components in the ground-fault (or phase current) protection system are unaffected by reverse-feed connections, and are suitable for those applications. These circuit breakers are not marked with "Line" and "Load," to indicate that they are suitable for reverse-feed connections—the power supply source may be connected to the terminals at either end of the circuit breaker.

A circuit breaker with integral ground-fault protection may be reverse fed if it is not marked with "Line" and "Load." The UL listed mark that is applied on this circuit breaker with integral ground-fault protection indicates that it has successfully met the UL test requirements for reverse-feed applications.

General Rule

- Cannot be reverse-fed:
  When a UL listed circuit breaker is marked showing "Line" and "Load," the power supply conductors must be connected to the end marked "Line." These devices cannot be reverse-fed
- Can be reverse-fed:
  If "Line" and "Load" are not marked on the UL listed circuit breaker, the power supply conductors may be connected to either end. These devices are suitable for reverse-feed applications

Molded-Case Circuit Breakers with External Ground-Fault/ Earth Leakage Accessories

There are ground-fault current detection schemes that require sensitivity down to relatively low current levels, typically as low as 30 mA. These products are called ground-fault/earth leakage modules.

Figure 27.3-11. Molded-Case Circuit Breakers with Earth Leakage Modules

Eaton's molded-case circuit breakers are available with UL listed ground-fault (earth leakage) modules that are typically mounted external to the "bottom" end of the circuit breaker, as shown in **Figure 27.3-11**. These modules are self-contained with a current sensor and logic control circuitry all located inside the product. Depending on the design configuration and construction of these earth leakage modules, some of these products may or may not be suitable for reverse-feed applications. Each product is marked with a label containing text that describes their suitability for reverse-feed applications, as shown in **Figure 27.3-12** and **Figure 27.3-13**.

General Rule

- Cannot be reverse-fed:
  When either a UL listed circuit breaker is marked showing "Line" and "Load," or the earth leakage module is marked as unsuitable for reverse-feed, the power supply conductors MUST be connected to the "Line" end of the circuit breaker. These devices cannot be reverse-fed
- Can be reverse-fed:
  If "Line" and "Load" are not marked on the UL listed circuit breaker, and the earth leakage module is marked as suitable for reverse-feed, the power supply conductors may be connected to either end. These devices are suitable for reverse-feed applications

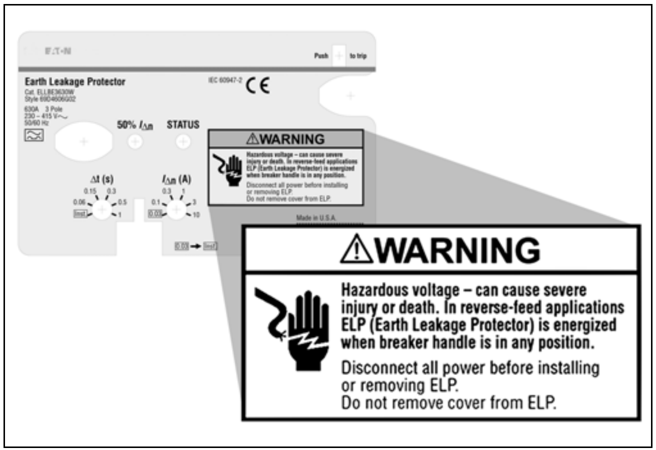

Figure 27.3-12. Earth Leakage Module Suitable for Reverse-Feed Applications

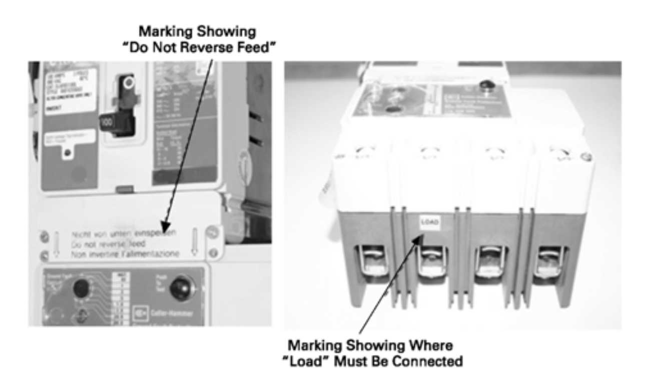

Figure 27.3-13. Earth Leakage Modules Not Suitable for Reverse-Feed Applications

Note: The only acceptable combination of circuit breakers and earth leakage modules that should be used in reverse-feed applications is where BOTH 1) the circuit breaker is not marked "Line" and "Load," and 2) the earth leakage module is not marked "Line" and "Load," and not marked "Do not reverse-feed."

Miniature Circuit Breakers with Integral Ground-Fault and Arcing-Fault Protection

Eaton's molded-case circuit breakers are available with UL listed ground-fault current protection levels that are able to detect and trip on ground-fault currents as low as 5 mA for personnel protection, and at 30 mA for sensitive electrical equipment. Eaton also has circuit breakers that provide low-level 30 mA arcing-fault protection in residential applications. The constructions of these circuit breakers are typically in a single-pole or two-pole configuration, and with continuous ampere ratings of 15–100 A. Due to their relative small size and low continuous ampere ratings, these types of molded-case circuit breakers are commonly called "miniature circuit breakers."

- The 5 mA designs for personnel protection are known as ground-fault circuit interrupters (GFCI)
- The 30 mA designs for equipment protection are known as ground-fault equipment protectors (GFEP)
- The circuit breaker designs for arcing-fault protection are known as arc-fault circuit interrupters (AFCI)

While the overall performance of the circuit breaker is governed by UL 489 for molded-case circuit breakers, the specific 5 mA personnel protection performance is per UL 943 ground-fault circuit interrupters, and the specific 30 mA performance for sensitive electrical equipment is per UL 1053, ground-fault sensing and relaying equipment. The AFCI performance requirements are governed by UL 1699.

For these AFCI, GFCI and GFEP ground-fault protection designs, when the circuit breaker is closed, the control power for the groundfault control logic circuitry is typically connected to the "Load" side of the circuit breaker. Whenever a ground-fault condition occurs, the detection means and control logic circuit will operate and cause the circuit breaker's main current-carrying contacts to open without any intentional delay, and will interrupt the flow of the fault current. This instantaneous trip minimizes electrical shock hazards to personnel in GFCIs, and minimizes the flow of potentially damaging currents to sensitive electrical equipment in GFEP applications. In addition to the interruption of the ground-fault current, the detection means and control logic circuitry also rely on the main current-carrying contacts to open and disconnect the currents that flow though the detection and trip system.

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If power is applied to the "Line" terminals, and the load is connected to the "Load" terminals in a "normal" feed configuration, whenever the circuit breaker trips and the main current-carrying contacts open, the ground-fault current is interrupted and control power is also disconnected from the detection means and control logic circuitry of the ground-fault system, as shown in **Figure 27.3-14**.

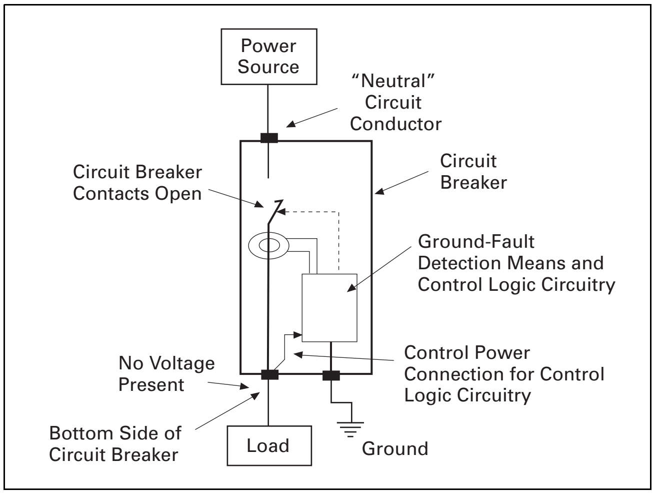

Figure 27.3-14. Miniature AFCI, GFCI and GFEP Circuit Breaker Connected in "Normal" Feed Configuration

When the circuit breaker trips and control power is disconnected from the control logic circuitry, no further current flows through the control logic circuitry to ground.

On the other hand, if power is applied to the "Load" terminals, whenever the AFCI, GFCI, and GFEP circuit breaker trips and the main current-carrying contacts open, the ground-fault current is interrupted, but control power continues to be applied to the ground-fault detection and control logic circuit of the ground-fault system, as shown in **Figure 27.3-15**. The presence of the control power will cause current to continually flow through the control logic circuitry. The effect of this continuous current may or may not degrade the performance of the control logic circuitry over time.

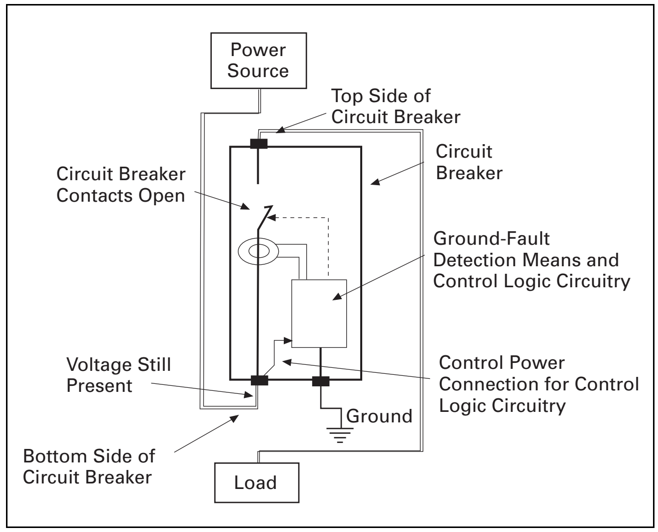

Figure 27.3-15. Miniature AFCI, GFCI and GFEP Circuit Breaker Connected in "Reverse-Feed" Configuration

Depending on the design configuration, the ground-fault detection means and control logic circuit of AFCI, GFCI, and GFEP miniature circuit breakers may be affected by this reverse-feed application. If the AFCI, GFCI and GFEP circuit breaker is not able to be connected and applied in a reverse-feed configuration, the terminals will be marked "Line" and "Load."

General Rule

- Cannot be reverse-fed:
  When a UL listed circuit breaker is marked showing "Line" and "Load," the power supply conductors MUST be connected to the end marked "Line." These devices cannot be reverse-fed
- Can be reverse-fed:
  If "Line" and "Load" are not marked on the UL listed circuit breaker, the power supply conductors may be connected to either end. These devices are suitable to be reverse-feed applications

Summary

Molded-case circuit breakers, UL listed per UL 489, have specific test and marking requirements to demonstrate that the circuit breaker is suitable for reverse-feed applications. The capabilities of UL 1066 listed low voltage power circuit breakers for reverse-feed applications are verified as part of standard circuit breaker test sequences.

- If a circuit breaker and molded-case switch are marked "Line" and "Load," it is not suitable for reverse-feed applications
- Only circuit breakers and molded-case switches without "Line" and "Load" markings are suitable for reverse-feed applications

Note: Warning—for all types of Eaton's circuit breakers, do not connect the power source to circuit breaker terminals marked "Load."

Application Information—Reverse-Feed Applications

Table 27.3-13. Reverse-Feed Applications—Eaton's Circuit Breakers

Circuit Breaker Types Suitable for Reverse Feed	Circuit Breaker Types Not Suitable for Reverse Feed
Thermal-Magnetic QUICKLAG and Residential Breakers	GFCI, GFEP
BW, BWH, BWHH, CSR, CSH	AFCI
CA, CAH, CC, CCH, CHH	BABRP, BABSP, BRRP, CLRP
EB, EHB	GHBS, GBHS, GHQRSP
FB, HFB, FB TRI-PAC	KA, HKA
JA	KB, HKB
JB	LA, HLA
LBB, DA	LB, HLB
LAB	MA, HMA, MD
LC, HLC, etc.	NB, HNB
MC, HMC, etc.; MDS	PB
NC, HNC, etc.	LA, NB, PB TRI-PAC's
PC, PCC, PCCG, PCF, PCCF, etc.	JD, HJD, JDC,
SPB	KD, HKD, KDC, CKD, CHKD
FCL, LCL	LD, HLD, LDC
SPCB	MDL, HMDL
GB, GHB, GC, GHC, GD, GD-K	JGE, JGS, JGH, JGC, JGU, JGX frames with interchangeable trip unit
EDB, EDS, ED, EDH, EDC	LGE, LGS, LGH, LGC, LGU with interchangeable trip unit
EHD, EHD-K, FDB, FD, HFD, FDC, FD-K	GMCP
FDE, HFDE, FDCE	HMCP, HMCPE
JD, HJD, JDC sealed breakers	ELFD, ELHFD, ELFDC
JDB, HJDB, JDCB, JDB-K, HJDB-K	ELKD, ELHKD, ELKDC
DK, DK-K	ELJD, ELHJD, ELJDC
KD, HKD, KDC, CKD, CHKD sealed breakers	GHBGFEP, GHCGFEP
KDB, HKDB, KDCB, CKDB, CHKDB	
KDB-K, HKDB-K	
LD, HLD, LDC sealed breakers	
LDB, HLDB, LDCB, CLDB, CHLDB, CLDCB	
LDB-K, HLDB-K	
MDL, HMDL sealed breakers	
MDLB, HMDLB, CMDLB, CHMDLB	
MDLB-K, HMDLB-K	
ND, HND, NDC, NDU, CND, CHND, CNDC	
ND-K, HND-K, NGS, NGH, NGC, NGU, NGK	
RD, RDC, CRD, CRDC, RD-K, RD-N, RGH, RGC, RGK	
E125, EGB, EGE, EGS, EGH, EGC	
E125K, EGK switches	
J250, JGE, JGS, JGH, JGC, JGU, JGX sealed breakers	
J250K, JGK switches	
L630, LGE, LGS, LGH, LGC, LGU, LGX sealed breakers	
L630K, LGK switches	
Magnum DS, Magnum SB, DS, DSII	
Series NRX	

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QUICKLAG Industrial Circuit Breakers ①

Miniature Circuit Breakers and Supplementary Protectors

Table 27.4-1. Eaton's QUICKLAG Industrial Circuit Breakers ① Plug-In, Bolt-On, Cable-In/Cable-Out

Circuit Breaker Type	Circuit Breaker Type Code	Continuous Ampere Rating at 40 °C	Number of Poles	Vac	Vdc	Federal Spec. W-C-375b	Interrupting Ratings rms Symmetrical Amperes					
							Vac Ratings			Vdc Ratings ②		
							120	120/240	240	24–48	62.5	80
HQP	P	10–70	1	120/240	24, 48, 62.5	10a, 11a, 12a	—	10,000	—	5000	③	—
HQP	P	10–125	2	120/240	24, 48, 80	10a, 12a	—	10,000	—	5000	5000	5000
HQP	P	10–100	2, 3	240	—	10b, 11b, 12b	—	—	10,000	—	—	—
QPHW	P	15–70	1	120/240	24, 48, 62.5	14a	—	22,000	—	5000	③	—
QPHW	P	15–125	2	120/240	24, 48, 80	14a	—	22,000	—	5000	5000	5000
QPHW	P	15–100	2, 3	240	—	14b	—	—	22,000	—	—	—
QHPX	P	15–70	1	120/240	24, 48, 62.5	—	—	42,000	—	5000	③	—
QHPX	P	15–100	2	120/240	24, 48, 80	—	—	42,000	—	5000	5000	5000
QHPX	P	15–100	3	240	—	—	—	—	42,000	—	—	—
QHPW	P	15–30	1	120/240	24, 48, 62.5	15a	—	65,000	—	5000	③	—
QHPW	P	15–30	2	120/240	24, 48, 80	15a	—	65,000	—	5000	5000	5000
QHPW	P	15–20	3	240	—	15b	—	—	65,000	—	—	—
QPGF	P, GF	15–40	1	120	—	10a, 11a, 12a	10,000	—	—	—	—	—
QPGF	P, GF	15–50	2	120/240	—	10a, 11a, 12a	—	10,000	—	—	—	—
QPHGF	P, GF	15–30	1	120	—	10a, 11a, 12a	22,000	—	—	—	—	—
QPHGF	P, GF	15–50	2	120/240	—	10a, 11a, 12a	—	22,000	—	—	—	—
QPGFEP	P, GFEP	15–40	1	120	—	—	10,000	—	—	—	—	—
QPGFEP	P, GFEP	15–50	2	120/240	—	—	—	10,000	—	—	—	—
QPHGFEP	P, GFEP	15–30	1	120	—	—	22,000	—	—	—	—	—
BABRSP	B	15–30	1	120	—	—	10,000	—	—	—	—	—
BABRSP	B	15–30	2	120/240	—	—	—	10,000	—	—	—	—
BRRP	P	15–30	1	120	—	—	10,000	—	—	—	—	—
BRRP	P	15–30	2	120/240	—	—	—	10,000	—	—	—	—
CLRP	P	15–30	1	120	—	—	10,000	—	—	—	—	—
CLRP	P	15–30	2	120/240	—	—	—	10,000	—	—	—	—
BAB	B	10–70	1	120/240	24, 48, 62.5	10a, 11a, 12a	—	10,000	—	5000	③	—
BAB	B	10–125	2	120/240	24, 48, 80	10a, 12a	—	10,000	—	5000	5000	5000
BAB	B	10–100	2, 3	240	—	10b, 11b, 12b	—	—	10,000	—	—	—
BABRP	B	15–30	1	120	—	—	10,000	—	—	—	—	—
BABRP	B	15–30	2	120/240	—	—	—	10,000	—	—	—	—
QBAF	B, AF	15–20	1, 2	120/240	—	—	—	10,000	—	—	—	—
QBCAF	B, AF, GF	15–20	1, 2	120/240	—	—	—	10,000	—	—	—	—
QBHW	B	15–70	1	120/240	24, 48, 62.5	14a	—	22,000	—	5000	③	—
QBHW	B	15–125	2	120/240	24, 48, 80	14a	—	22,000	—	5000	5000	5000
QBHW	B	15–100	2, 3	240	—	14b	—	—	22,000	—	—	—
QBHAF	B, AF	15–20	1, 2	120/240	—	—	—	22,000	—	—	—	—
QBHCAF	B, AF	15–20	1, 2	120/240	—	—	—	22,000	—	—	—	—
HBAX	B	15–70	1	120/240	24, 48, 62.5	—	—	42,000	—	5000	③	—
HBAX	B	15–100	2	120/240	24, 48, 80	—	—	42,000	—	5000	5000	5000
HBAX	B	15–100	3	240	24, 48, 62.5	—	—	—	42,000	—	—	—
HBAW	B	15–30	1	120/240	—	15a	—	65,000	—	5000	③	—
HBAW	B	15–30	2	120/240	24, 48, 80	15a	—	65,000	—	5000	5000	5000
HBAW	B	15–20	3	240	—	15b	—	—	65,000	—	—	—
QBGF	B, GF	15–40	1	120	—	10a, 11a, 12a	10,000	—	—	—	—	—
QBGF	B, GF	15–50	2	120/240	—	10a, 11a, 12a	—	10,000	—	—	—	—
QBHGF	B, GF	15–30	1	120	—	10a, 11a, 12a	22,000	—	—	—	—	—
QBHGF	B, GF	15–30	1	120/240	—	10a, 11a, 12a	—	22,000	—	—	—	—

① QUICKLAG circuit breakers are suitable for application in relative humidity 0–95% noncondensing.
② Two-pole DC interrupting ratings based on two poles connected in series. Not UL listed.
③ 62.5 Vdc interrupting rating is 3800 AIC 10–50 A and 2500 AIC 55–100 A continuous.

Note: Circuit Breaker Type Codes: **AF** Arc Fault; **P** Plug-In; **B** Bolt-On; **C** Cable-In/Cable-Out; **GF** Ground Fault, 5 mA; **GFEP** Ground Fault, 30 mA.

QUICKLAG Industrial Circuit Breaker Overview Tables

Table 27.4-1. Eaton's QUICKLAG Industrial Circuit Breakers ① Plug-In, Bolt-On, Cable-In/Cable-Out (Continued)

Circuit Breaker Type	Circuit Breaker Type Code	Continuous Ampere Rating at 40 °C	Number of Poles	Vac	Vdc	Federal Spec. W-C-375b	Interrupting Ratings rms Symmetrical Amperes					
							Vac Ratings			Vdc Ratings ②		
							120	120/240	240	24–48	62.5	80
QBGFEP	B, GFEP	15–40	1	120	—	—	10,000	—	—	—	—	—
QBGFEP	B, GFEP	15–50	2	120/240	—	—	—	10,000	—	—	—	—
QBHGFEP	B, GFEP	15–30	1	120	—	—	22,000	—	—	—	—	—
QBHGFEP	B, GFEP	15–30	2	120/240	—	—	22,000	22,000	—	—	—	—
QC	C	10–70	1	120/240	24, 48, 62.5	10a, 11a, 12a	—	10,000	—	5000	③	—
QC	C	10–100	2	120/240	24, 48, 80	10a, 12a	—	10,000	—	5000	5000	5000
QC	C	10–100	2, 3, 4	240	—	10b, 11b, 12b	—	—	10,000	—	—	—
QCD	C	10–60	1, 2	120/240	24, 48, 62.5	—	10,000	10,000	—	3000	3000	—
QCD	C	10–100	2, 3	240	24, 48, 62.5	—	—	10,000	—	3000	3000	—
QCF	C	10–60	1, 2	120/240	24, 48, 62.5	—	10,000	10,000	—	3000	3000	—
QCF	C	15–20	1, 2	120/240	24, 48, 62.5	—	22,000	—	—	3000	3000	—
QCF	C	15–30	2, 3	240	24, 48, 62.5	—	—	10,000	—	3000	3000	—
QCR	C	10–60	1, 2	120/240	24, 48, 62.5	—	10,000	10,000	—	3000	3000	—
QCR	C	15–20	1, 2	120/240	24, 48, 62.5	—	22,000	—	—	3000	3000	—
QCR	C	15–30	2, 3	240	24, 48, 62.5	—	—	10,000	—	3000	3000	—
QCHW	C	15–70	1	120/240	24, 48, 62.5	14a	—	22,000	—	5000	③	—
QCHW	C	15–100	2	120/240	24, 48, 80	14a	—	22,000	—	5000	5000	5000
QCHW	C	15–100	2, 3	240	—	14b	—	—	22,000	—	—	—
QHCX	C	15–70	1	120/240	24, 48, 62.5	—	—	42,000	—	5000	③	—
QHCX	C	15–100	2	120/240	24, 48, 80	—	—	42,000	—	5000	5000	5000
QHCX	C	15–100	3	240	—	—	—	—	42,000	—	—	—
QHCW	C	15–30	1	120/240	24, 48, 62.5	15a	—	65,000	—	5000	③	—
QHCW	C	15–30	2	120/240	24, 48, 80	15a	—	65,000	—	5000	5000	5000
QHCW	C	15–20	3	240	—	15b	—	—	65,000	—	—	—
QCGF	C, GF	15–40	1	120	—	—	10,000	—	—	—	—	—
QCGF	C, GF	15–50	2	120/240	—	—	—	10,000	—	—	—	—
QCHGF	C, GF	15–30	1	120	—	—	22,000	—	—	—	—	—
QCHGF	C, GF	15–30	2	120/240	—	—	—	22,000	—	—	—	—
QCGFEP	C, GFEP	15–40	1	120	—	—	10,000	—	—	—	—	—
QCGFEP	C, GFEP	15–50	2	120/240	—	—	—	10,000	—	—	—	—
QCHGFEP	C, GFEP	15–30	1	120	—	—	22,000	—	—	—	—	—
QCHGFEP	C, GFEP	15–30	2	120/240	—	—	—	22,000	—	—	—	—

① QUICKLAG circuit breakers are suitable for application in relative humidity 0–95% noncondensing.
② Two-pole DC interrupting ratings based on two poles connected in series. Not UL listed.
③ 62.5 Vdc interrupting rating is 3800 AIC 10–50 A and 2500 AIC 55–100 A continuous.

Note: Circuit Breaker Type Codes: **AF** Arc Fault; **P** Plug-In; **B** Bolt-On; **C** Cable-In/Cable-Out; **GF** Ground Fault, 5 mA; **GFEP** Ground Fault, 30 mA.

QUICKLAG Industrial Circuit Breaker Overview Tables

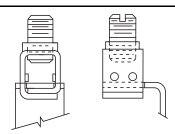
Table 27.4-2. Factory Modifications ①

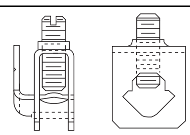
Modification Type	Breaker Type	Catalog Suffix
Shunt trip (requires one extra pole space on right side) 120, 208, 240 Vac 12, 24, 48 Vac/Vdc Draws 2.6 A at 120 V Draws 11 A at 24 Vdc	 QUICKLAG Types P, B and C QUICKLAG Types P, B and C	 **S** **S1**
Special calibration (50 °C) Shock testing Freeze testing	QUICKLAG Types P, B and C QUICKLAG Types P, B and C QUICKLAG Types P, B and C	**V** **L** **Y**
Moisture-fungus treatment Marine duty Naval duty 400 Hz calibration Specific DC ratings (breaker marked with a maximum Vdc rating)	QUICKLAG Types P, B, C and Ground Fault QUICKLAG Types P, B, C QUICKLAG Types P, B, C QUICKLAG Types P, B, C QUICKLAG Types P, B, C	**F** **H08** **H09** **G** **Q thru Q9**

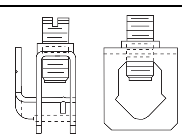
① Contact the Eaton factory for modifications available for QCR and QCF breakers.

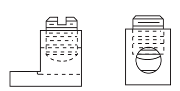
Table 27. 4-3. Factory-Installed Breaker Terminals

Breaker Type	Continuous Ampere Rating	Standard Line Terminal			Standard Load Terminal			Optional Terminals	
		Terminal Type	Wire Type	Wire Range (AWG)	Terminal Type	Wire Type	Wire Range (AWG)	Line	Load
QUICKLAG Type P HQP, QPHW, QHPX, QHPW	10–30 35–50 55–125	Plug-on female clips that mate with the bus stabs			1 2 3	Cu/Al Cu/Al Cu/Al	14–4 14–4 8–1/0	N/A	3 3 —
QUICKLAG Ground Fault QPGF, QPHGF, QPGFEP, QPHGFEP	10–30 40	Plug-on female clips that mate with the bus stabs			1 (single-pole) 4 (two-pole) 4	Cu/Al Cu/Al Cu	14–4 14–8 14–8	N/A	3 3 —
QUICKLAG Type B BAB, QBHW, HBAX, HBAW	10–30 35–50 55–125	Extended tangs that bolt directly to the bus			1 (single- and two-pole) 2 (three-pole) 3	Cu/Al Cu/Al Cu/Al	14–4 14–4 8–1/0	N/A	3 3 —
QUICKLAG Ground Fault/Arc Fault QBGF, QBAF, QBCAF, QBHGF, QBHAF, QBHCAF, QBGFEP, QBHGFEP	10–30 40	Extended tangs that bolt directly to the bus			1 (single-pole) 4 (two-pole) 4	Cu/Al Cu/Al Cu	14–4 14–8 14–8	N/A	N/A
QUICKLAG Type C QC, QCHW, QHCX, QHCW	10–20 25–60 70–100	5 6 7	Cu/Al Cu/Al Cu/Al	TBD TBD TBD	5 2 3	Cu/Al Cu/Al Cu/Al	14–10 14–4 8–1/0	6, 7 5, 7 5	6, 7, 8 5, 6, 7, 8 5, 7, 8
QUICKLAG QCR, QCF	10–55 60	1 1	Cu/Al Cu	TBD TBD	1 1	Cu/Al Cu	14–4 14–4	N/A	N/A
QUICKLAG Ground Fault QCGF, QCHGF, QCGFEP, QCHGFEP	10–20 25–50	5 6	Cu/Al Cu/Al	TBD TBD	1 1	Cu/Al Cu/Al	14–4 14–4	6, 7 5, 7	5 5
QUICKLAG QCD	10–60 70–100	9 10	Cu/Al Cu	14–4 4–1/0	9 10	Cu/Al Cu	14–4 4–1/0	See accessories	

1

Steel Box Lug

2

Steel Box Lug

3

Steel Box Lug

4

Aluminum Box Lug

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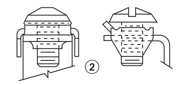

Steel Ring Type

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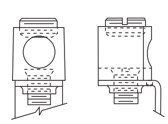
Aluminum Box Lug

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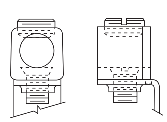
Aluminum Box Lug

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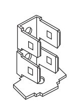
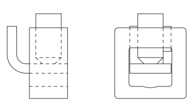

4-Prong Quick Connect Catalog Suffix P

9

QCD Terminal Assembly 10–60 Amperes

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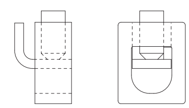
QCD Terminal Assembly 70–100 Amperes

② Clamp on line side only.

Series G Industrial Breakers Overview Table

Table 27.4-4. Industrial Circuit Breakers—Series G

Circuit Breaker Type	Continuous Ampere Rating at 40 °C	No. of Poles	Volts		Trip Type ①	Federal Specification W-C-375b	UL Listed Interrupting Ratings (rms Symmetrical Amperes)								
			AC	DC			AC Ratings Volts						DC ②		
							120	120/240	240	277	480	600	125	250	125/250
E-Frame															
EGB	15–125	1	347	250	N.I.T.	—	35,000	—	25,000	18,000	—	—	10,000	—	—
		2, 3, 4	600Y/347			—	—	—	25,000	—	18,000	—	—	10,000	—
EGE	15–125	2, 3, 4	600Y/347	250	N.I.T.	—	—	—	35,000	—	25,000	18,000	10,000	10,000	—
EGS	15–125	1	347	250	N.I.T.	—	100,000	—	85,000	35,000	—	—	35,000	—	—
		2, 3, 4	600Y/347		N.I.T.	—	—	—	85,000	—	35,000	22,000	—	35,000	—
EGH	15–125	1	347	250	N.I.T.	—	200,000	—	100,000	65,000	—	—	42,000	—	—
		2, 3, 4	600Y/347			—	—	—	100,000	—	65,000	25,000	—	42,000	—
EGC ③	15–125	3	600Y/347	250	N.I.T.	—	—	—	200,000	—	100,000	35,000	—	42,000	—
J-Frame ④															
JGE	63–250	2, 3, 4	600	250	I.T.	—	—	—	65,000	—	25,000	18,000	—	10,000	—
JGS	63–250	2, 3, 4	600	250	I.T.	—	—	—	85,000	—	35,000	18,000	—	22,000	—
JGH	63–250	2, 3, 4	600	250	I.T.	—	—	—	100,000	—	65,000	25,000	—	22,000	—
JGC ③	63–250	2, 3, 4	600	250	I.T.	—	—	—	200,000	—	100,000	35,000	—	42,000	—
JGU ③	63–250	3, 4	600	250	I.T.	—	—	—	200,000	—	150,000	50,000	—	50,000	—
JGX ③	63–250	3, 4	600	250	I.T.	—	—	—	200,000	—	200,000	50,000	—	50,000	—
L-Frame															
LGE	100–600	3, 4	600	250	I.T.	23a	—	—	65,000	—	35,000	18,000	—	22,000	—
LGS	100–600	3, 4	600	250	I.T.	23a	—	—	85,000	—	50,000	25,000	—	22,000	—
LGH	100–600	3, 4	600	250	I.T.	23a	—	—	100,000	—	65,000	35,000	—	42,000	—
LGC ③	100–600	3, 4	600	250	I.T.	23a	—	—	200,000	—	100,000	100,000	—	42,000	—
LGU ③	100–600	3, 4	600	250	I.T.	—	—	—	200,000	—	150,000	65,000	—	50,000	—
LGX ③	100–600	3, 4	600	250	I.T.	—	—	—	200,000	—	200,000	65,000	—	50,000	—
LHH ⑤	125–400	3	600	250	N.I.T.	—	—	—	100,000	—	65,000	35,000	—	22,000	—
N-Frame															
NGS 800, 1200	600–1200	2, 3, 4	600	—	N.I.T.	—	—	—	85,000	—	50,000	25,000	—	—	—
NGH 800, 1200	600–1200	2, 3, 4	600	—	N.I.T.	—	—	—	100,000	—	65,000	35,000	—	—	—
NGC 800, 1200	600–1200	2, 3, 4	600	—	N.I.T.	—	—	—	200,000	—	100,000	45,000	—	—	—
NGU 800	600–1200	3	600	—	N.I.T.	—	—	—	300,000	—	150,000	75,000	—	—	—
NGS ⑥	1600	3	600	—	N.I.T.	—	—	—	—	—	—	—	—	—	—
NHH ⑤	150–350	3	600	250	N.I.T.	—	—	—	100,000	—	65,000	35,000	—	—	—
R-Frame															
RGH	800–1600	3, 4	600	—	N.I.T.	—	—	—	125,000	—	65,000	50,000	—	—	—
RGC	800–1600	3, 4	600	—	N.I.T.	—	—	—	200,000	—	100,000	65,000	—	—	—

① N.I.T. is non-interchangeable trip unit and I.T. is interchangeable trip unit.
② Two-pole circuit breaker, or two poles of three-pole circuit breaker at 250 Vdc.
③ Current limiting.
④ Not presently available for panelboard or switchboard mounting.
⑤ High instantaneous circuit breaker for selective coordination.
⑥ Not UL or CSA listed.

Series C Industrial Breakers Overview Table

Table 27.4-5. Industrial Circuit Breakers—Series C

Circuit Breaker Type	Continuous Ampere Rating at 40 °C	No. of Poles	Volts		Trip Type ①	Federal Specification W-C-375b	UL Listed Interrupting Ratings (rms Symmetrical Amperes)								
			AC	DC			AC Ratings Volts						DC ②		
							120	120/240	240	277	480	600	125	250	125/250
G-Frame															
GHB	15–100	1	120	125	N.I.T.	11a	65,000	—	—	—	—	—	14,000	—	—
GHB	15–100	2, 3	240	125/250	N.I.T.	10b, 11b,	—	—	65,000	—	—	—	—	—	14,000
GHB	15–100	1	277	125	N.I.T.	12b, 14b,	—	—	—	14,000	—	—	14,000	—	—
GHB	15–100	2, 3	277/480	125/250	N.I.T.	15b	—	—	—	14,000	14,000	—	—	—	14,000
HGHB	15–30	1	277	125	N.I.T.	12c, 13a, 13b	65,000	—	—	25,000	—	—	14,000	—	—
GHQ	15–20	1	277	—	N.I.T.	12c, 13a, 13b	65,000	—	—	14,000	—	—	—	—	—
GHQRSP	15–20	1	277	—	N.I.T.	12c, 13a, 13b	65,000	—	—	14,000	—	—	—	—	—
GHBS	15–30	1, 2	277/480	—	—	—	65,000	65,000	—	14,000	—	—	—	—	—
GBHS	15–20	1, 2	347/600	—	N.I.T.	—	—	—	—	—	—	10,000	—	—	—
GD	15–50	2	480	125/250	N.I.T.	13b	—	—	65,000	—	14,000	—	—	—	10,000
GD	15–100	3	480	250	N.I.T.	13b	—	—	65,000	—	22,000	—	—	10,000	—
GHC	15–100	1	120	125	N.I.T.	12c, 13a	65,000	—	—	—	—	—	14,000	—	—
GHC	15–100	2, 3	240	125/250	N.I.T.	13b	—	—	65,000	—	—	—	—	—	14,000
GHC	15–100	1	277	125	N.I.T.	12c, 13a	—	—	—	14,000	—	—	14,000	—	—
GHC	15–100	2, 3	277/480	125/250	N.I.T.	13b	—	—	—	14,000	14,000	—	—	—	14,000
HGHC	15–30	1	277	125	N.I.T.		65,000	—	—	25,000	—	—	14,000	—	—
F-Frame															
EDB	100–225	2, 3	240	125	N.I.T.	12b	—	—	22,000	—	—	—	10,000	—	—
EDS	100–225	2, 3	240	125	N.I.T.	12b	—	—	42,000	—	—	—	10,000	—	—
ED	100–225	2, 3	240	125	N.I.T.	12b	—	—	65,000	—	—	—	10,000	—	—
EDH	100–225	2, 3	240	125	—	14b	—	—	100,000	—	—	—	10,000	—	—
EDC ④	100–225	2, 3	240	125	—	1	—	—	200,000	—	—	—	10,000	—	—
EHD	15–100	1	277	125	N.I.T.	13a	—	—	—	14,000	—	—	10,000	—	—
EHD	15–100	2, 3	480	250	—	13b	—	—	18,000	—	14,000	—	—	10,000	—
FDB	15–150	2, 3	600	250	N.I.T.	18a	—	—	18,000	—	14,000	14,000	—	10,000	—
FDB	15–150	4	600	250	—	⑤	—	—	18,000	—	14,000	14,000	—	10,000	—
FD	15–225	1	277	125	N.I.T.	13a	—	—	—	35,000	—	—	10,000	—	—
FD	15–225	2, 3	600	250	—	22a	—	—	65,000	—	35,000	18,000	—	10,000	—
FD	15–225	4	600	250	—	⑤	—	—	65,000	—	35,000	18,000	—	10,000	—
FDE	15–225	3	600	—	N.I.T.	—	—	—	65,000	—	35,000	18,000	—	—	—
HFD	15–225	1	277	125	N.I.T.	13a	—	—	—	65,000	—	—	10,000	—	—
HFD	15–225	2,3	600	250	—	22a	—	—	100,000	—	65,000	25,000	—	22,000	—
HFD	15–225	4	600	250	—	⑤	—	—	100,000	—	65,000	25,000	—	22,000	—
HFDE	15–225	3	600	—	N.I.T.	—	—	—	100,000	—	65,000	25,000	—	—	—
FDC ④	15–225	2, 3	600	250	N.I.T.	24a	—	—	200,000	—	100,000	35,000	—	22,000	—
FDC ④	15–225	4	600	250	—	⑤	—	—	200,000	—	100,000	35,000	—	22,000	—
FDCE	15–225	3	600	—	N.I.T.	—	—	—	200,000	—	100,000	25,000	—	—	—
J-Frame															
JDB	70–250	2, 3	600	250	N.I.T.	22a	—	—	65,000	—	35,000	18,000	—	10,000	—
JD	70–250	2, 3, 4	600	250	I.T.	22a	—	—	65,000	—	35,000	18,000	—	10,000	—
HJD	70–250	2, 3, 4	600	250	I.T.	22a	—	—	100,000	—	65,000	25,000	—	22,000	—
JDC ④	70–250	2, 3, 4	600	250	I.T.	22a	—	—	200,000	—	100,000	35,000	—	22,000	—
K-Frame															
DK	250–400	2, 3	240	250	N.I.T.	14b	—	—	65,000	—	—	—	—	10,000	—
KDB	100–400	2, 3	600	250	N.I.T.	23a	—	—	65,000	—	35,000	25,000	—	10,000	—
KD	100–400	2, 3, 4	600	250	I.T.	23a	—	—	65,000	—	35,000	25,000	—	10,000	—
CKD ③	100–400	2, 3, 4	600	250	I.T.	23a	—	—	65,000	—	35,000	25,000	—	—	—
HKD	100–400	2, 3, 4	600	250	I.T.	23a	—	—	100,000	—	65,000	35,000	—	22,000	—
CHKD ③	100–400	2, 3, 4	600	250	I.T.	23a	—	—	100,000	—	65,000	35,000	—	—	—
KDC ④	100–400	2, 3, 4	600	250	I.T.	23a	—	—	200,000	—	100,000	65,000	—	22,000	—

① N.I.T. is non-interchangeable trip unit and I.T. is interchangeable trip unit.
② Two-pole circuit breaker, or two poles of three-pole circuit breaker at 250 Vdc.
③ 100% rated.
④ Current limiting.
⑤ Not defined in W-C-375b.

Series C Industrial Breakers Overview Table

Table 27.4-5. Industrial Circuit Breakers—Series C (Continued)

Circuit Breaker Type	Continuous Ampere Rating at 40 °C	No. of Poles	Volts		Trip Type ①	Federal Specification W-C-375b	UL Listed Interrupting Ratings (rms Symmetrical Amperes)								
			AC	DC			AC Ratings Volts						DC ②		
							120	120/240	240	277	480	600	125	250	125/250
L-Frame															
LDB	300–600	2, 3	600	250	N.I.T.	23a	—	—	65,000	—	35,000	25,000	—	22,000	—
LD	300–600	2, 3, 4	600	250	I.T.	23a	—	—	65,000	—	35,000	25,000	—	22,000	—
CLD ③	300–600	2, 3, 4	600	250	I.T.	23a	—	—	65,000	—	35,000	25,000	—	—	—
HLD	300–600	2, 3, 4	600	250	I.T.	23a	—	—	100,000	—	65,000	35,000	—	25,000	—
CHLD ③	300–600	2, 3, 4	600	250	I.T.	23a	—	—	100,000	—	65,000	35,000	—	—	—
LDC ④	300–600	2, 3, 4	600	250	I.T.	23a	—	—	200,000	—	100,000	50,000	—	25,000	—
CLDC ③④	300–600	2, 3, 4	600	250	I.T.	23a	—	—	—	—	100,000	50,000	—	—	—
M-Frame															
MDL	300–800	2, 3	600	250	I.T.	23a	—	—	65,000	—	50,000	25,000	—	22,000	—
CMDL ③	300–800	2, 3	600	250	I.T.	23a	—	—	65,000	—	50,000	25,000	—	—	—
HMDL	300–800	2, 3	600	250	I.T.	23a	—	—	100,000	—	65,000	35,000	—	25,000	—
CHMDL ③	300–800	2, 3	600	250	I.T.	23a	—	—	100,000	—	65,000	35,000	—	—	—
N-Frame															
ND	600–1200	3, 4	600	—	N.I.T.	23A	—	—	65,000	—	50,000	25,000	—	—	—
CND ③	600–1200	3, 4	600	—	N.I.T.	23A	—	—	65,000	—	50,000	25,000	—	—	—
HND	600–1200	3, 4	600	—	N.I.T.	23A	—	—	100,000	—	65,000	35,000	—	—	—
CHND ③	600–1200	3, 4	600	—	N.I.T.	23A	—	—	100,000	—	65,000	35,000	—	—	—
NDC	600–1200	3, 4	600	—	N.I.T.	23A	—	—	200,000	—	100,000	65,000	—	—	—
HNDC ③	600–1200	3, 4	600	—	N.I.T.	23A	—	—	200,000	—	100,000	65,000	—	—	—
NDU	600–1200	3	600	—	N.I.T.	—	—	—	300,000	—	150,000	75,000	—	—	—
R-Frame															
RD 1600	800–1600	3, 4	600	—	N.I.T.	24a	—	—	125,000	—	65,000	50,000	—	—	—
CRD 1600 ③	800–1600	3, 4	600	—	N.I.T.	24a	—	—	125,000	—	65,000	50,000	—	—	—
RD 2000	1000–2000	3, 4	600	—	N.I.T.	24a	—	—	125,000	—	65,000	50,000	—	—	—
RD 2500	1000–2500	3, 4	600	—	N.I.T.	24a	—	—	125,000	—	65,000	50,000	—	—	—
CRD 2000 ③	1000–2000	3, 4	600	—	N.I.T.	24a	—	—	125,000	—	65,000	50,000	—	—	—
RDC 1600	800–1600	3, 4	600	—	N.I.T.	25a	—	—	200,000	—	100,000	65,000	—	—	—
CRDC 1600 ③	800–1600	3, 4	600	—	N.I.T.	25a	—	—	200,000	—	100,000	65,000	—	—	—
RDC 2000	1000–2000	3, 4	600	—	N.I.T.	25a	—	—	200,000	—	100,000	65,000	—	—	—
RDC 2500	1000–2500	3, 4	600	—	N.I.T.	25a	—	—	200,000	—	100,000	65,000	—	—	—
CRDC 2000 ③	1000–2000	—	—	—	—	25a	—	—	200,000	—	100,000	65,000	—	—	—

① N.I.T. is non-interchangeable trip unit and I.T. is interchangeable trip unit.
② Two-pole circuit breaker, or two poles of three-pole circuit breaker at 250 Vdc.
③ 100% rated.
④ Current limiting.

Table 27.4-6. Current Limit-R Current Limiting Circuit Breakers—Non-Fused Type

Circuit Breaker Type	Continuous Ampere Rating at 40 °C	No. of Poles	Volts		Trip Type ⑤	Federal Specification W-C-375b	UL Listed Interrupting Ratings (rms Symmetrical Amperes)								
			AC	DC			AC Ratings Volts						DC ⑥		
							120	120/240	240	277	480	600	125	250	125/250
FCL	15–100	2, 3	480	—	N.I.T.	—	—	—	200,000	—	150,000	—	—	—	—
LCL	125–400	2, 3	600	—	N.I.T.	—	—	—	200,000	—	200,000	100,000	—	—	—

⑤ N.I.T. is non-interchangeable trip unit and I.T. is interchangeable trip unit.
⑥ Two-pole circuit breaker, or two poles of three-pole circuit breaker at 250 Vdc.

Table 27.4-7. TRI-PAC Current Limiting Circuit Breakers—Fused Type

Circuit Breaker Type	Continuous Ampere Rating at 40 °C	No. of Poles	Volts		Trip Type ⑦	Federal Specification W-C-375b	UL Listed Interrupting Ratings (rms Symmetrical Amperes)								
			AC	DC			AC Ratings Volts						DC ⑧		
							120	120/240	240	277	480	600	125	250	125/250
FB	15–100	2, 3	600	—	N.I.T.	—	—	—	200,000	—	200,000	200,000	—	100,000	—
LA	70–400	2, 3	600	—	N.I.T.	—	—	—	200,000	—	200,000	200,000	—	100,000	—
NB	300–800	2, 3	600	250	N.I.T.	—	—	—	200,000	—	200,000	200,000	—	100,000	—
PB	600–1600	2, 3	600	250	N.I.T.	—	—	—	200,000	—	200,000	200,000	—	100,000	—

⑦ N.I.T. is non-interchangeable trip unit and I.T. is interchangeable trip unit.
⑧ Two-pole circuit breaker, or two poles of three-pole circuit breaker at 250 Vdc.

Table 27.4-8. Eaton Molded-Case Circuit Breakers in Assemblies

Frame	Ampere Range	Panelboards						Switchboards		Motor Control Centers		Enclosed Control	Bus Plugs	Enclosed Breaker
		1A	2A	3A	3E	4	5P	PRL-C	IFS	Freedom	FlashGard			
QUICKLAG ①														
BAB	15–100	■	■	■		■		■	■					
QB	15–100	■	■	■		■		■	■					
QBH	15–100	■	■	■		■		■	■					
Series G														
EG	15–125				■					■	■	■		■
JG	20–250													■
LG	100–600					■		■	■					■
NG	400–1200					■		■	■	■	■			■
RG	800–2500									■	■			
Series C														
FD/ED	15–225	■	■	■	■	■	■	■	■	■	■	■	■	■
JD	70–250	■	■	■	■	■	■	■	■	■	■	■	■	■
KD	70–400	■	■	■	■	■	■	■	■	■	■	■	■	■
LD	400–600					■	■	■	■	■	■	■	■	■
MDL	300–800					■	■	■	■	■	■	■	■	■
ND	400–1200					■	■	■	■	■	■	■	■	■
RD	800–2500						■	■	■	■	■			
Current Limiting Breakers														
FCL	15–100					■		■	■					
LCL	125–400					■		■	■					
FB	15–100					■		■	■					
LA	70–400					■		■	■					
NB	300–800					■		■	■					
PB	600–1600							■	■					

① Including ground fault, arc fault and solenoid operated versions of each frame.

Electronic Trip Units

Circuit Breakers with Microprocessor Trip Units

Table 27.4-9. Digitrip RMS Circuit Breaker Trip Unit Selection (See Table 27.4-10 for details)

Description		Digitrip 310	Digitrip 310+	Digitrip 510	OPTIM 550	Digitrip 610	Digitrip 810	Digitrip 910	OPTIM 1050
Circuit Breaker Type									
Molded-case F-Frame 225 A			■						
Molded-case JG250-Frame 250 A			■						
Molded-case K-Frame 400 A			■		■				■
Molded-case L-Frame 600 A	LD	■			■				■
	LG		■						
Molded-case M-Frame 800 A		■							
Molded-case N-Frame 1200 A	ND	■			■				■
	NG		■						
Molded-case R-Frame 2500 A	RD	■		■		■	■	■	■
	RG		■						
Features									
Curve shaping functions		5	6	9	10	9	9	9	10
Front adjustable		■	■	■		■	■	■	
Programmable					■				■
Zone selective interlocking			■	■	■ ①	■	■	■	■
Load monitoring			Option ②		■	■	■	■	■
Diagnostics (cause-of-trip)			Option ③	■	■	■	■	■	■
Power/energy monitoring			Option ④				■	■	■
Harmonics								■	■
Waveform capture								■	■
Communications			Option ④		■ ①		■	■	■
Arcflash Reduction Maintenance System (local and remote)			■ ⑤						
Ground fault alarm		■ ⑥	Option		■ ①⑥	■	■	■	■

① Optional feature.
② Requires ammeter/cause-of-trip display.
③ Requires cause-of-trip LED module or ammeter/cause-of-trip display.
④ Requires Power Metering and Monitoring Module (PM3). See **Page 27.4-41** for product details.
⑤ Only available in LG, NG and RG breakers.
⑥ Requires auxiliary alarm module below R-Frames.

Note: For time current curves for the trip units, see www.eaton.com.

Table 27.4-10. Molded-Case Digitrip Selection Guide

Trip Unit Type	Digitrip RMS 310+		Digitrip RMS 310		Digitrip RMS 510	Digitrip RMS 610	Digitrip RMS 810	Digitrip RMS 910	Digitrip OPTIM 550	Digitrip OPTIM 1050
rms sensing	Yes		Yes		Yes	Yes	Yes	Yes	Yes	Yes
Breaker Type										
Frame	**FDE, JG, K , LG, NG, RG** ①		**L, M**		**R**	**R**	**R**	**R**	**K, L, N**	**K, L, N, R**
Ampere range	15–2500 A		300–800 A		800–5000 A	800–5000 A	800–5000 A	800–5000 A	70–1200 A	70–5000 A
Interrupting rating at 48 V	35, 65, 100, 150 (kA)		35, 65, 100 (kA)		65, 100 (kA)	65, 100 (kA)	65, 100 (kA)	65, 100 (kA)	35, 65, 100 (kA)	35, 65, 100 (kA)
Protection										
Ordering options	LS LSG	LSI LSIG	LS LSG	LSI LSIG	LI, LS, LSI, LIG, LSG, LSIG	LI, LS, LSI, LIG, LSG, LSIG	LI, LS, LSI, LIG, LSG, LSIG	LI, LS, LSI, LIG, LSG, LSIG	LSI, LSI (A), LSIG	LSI (A), LISG
Arcflash Reduction Maintenance System	No	ALSI ALSIG ②	No	No	No	No	No	No	No	No
Fixed rated plug (I_n) Overtemperature trip	No Yes		Yes Yes		Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
Long Delay Protection (L)										
Adjustable rating plug (I_n) Long delay pickup Long delay time I^2t	No 40–100% frame 2–24 seconds		Yes 0.5–1.0 x (I_n) ③ 10 seconds		No 0.5–1.0 x (I_n) 2–24 seconds	No 0.5–1.0 x (I_n) 2–24 seconds	No 0.5–1.0 x (I_n) 2–24 seconds	No 0.5–1.0 x (I_n) 2–24 seconds	No 0.4–1.0 x (I_n) 2–24 seconds	No 0.4–1.0 x (I_n) 2–24 seconds
Long delay time I^4t Long delay thermal memory High load alarm	No Yes Yes		No Yes No		No Yes No	No Yes 0.85 x I_r	No Yes 0.85 x I_r	No Yes 0.85 x I_r	1–5 seconds Yes 0.5–1.0 x I_r	1–5 seconds Yes 0.5-1.0 x I_r
Short Delay Protection (S)										
Short delay pickup	Varies by frame ④		200–800% x (I_n)		200–600% S1 and S2 x (I_r)	200–600% S1 and S2 x (I_r)	200–600% S1 and S2 x (I_r)	200–600% S1 and S2 x (I_r)	150–800% x (I_r)	150–800% x (I_r)
Short delay time I^2t Short delay time flat	Yes No	No Inst–300 ms	100 ms No	No Inst–300 ms	100–500 ms 100–500 ms	100–500 ms 100–500 ms	100–500 ms 100–500 ms	100–500 ms 100–500 ms	100–500 ms 100–500 ms	100–500 ms 100–500 ms
Short delay time Z.S.I.	Yes		No		Yes	Yes	Yes	Yes	Optional	Yes
Instantaneous Protection (I)										
Instantaneous pickup	No	Varies by frame ④	No	200–800% x (I_n)	200–600% M1 and M2 x (I_n)	200–600% M1 and M2 x (I_n)	200–600% M1 and M2 x (I_n)	200–600% M1 and M2 x (I_n)	200–800% x (I_n)	200–800% x (I_n)
Discriminator Instantaneous override	No Yes		No Yes		Yes ⑤ Yes	Yes ⑤ Yes	Yes ⑤ Yes	Yes ⑤ Yes	Yes Yes	Yes Yes
Ground Fault Protection (G)										
Ground fault alarm Ground fault pickup Ground fault delay I^2t	Yes 20–100% frame ⑥ No		Yes Var/frame ⑥ No		No 25–100% x I_n ⑥ 100–500 ms	No 25–100% x I_n ⑥ 100–500 ms	No 25–100% x I_n ⑥ 100–500 ms	No 25–100% x I_n ⑥ 100–500 ms	20/25–100% ⑥ 20/25–100% ⑥ 100–500 ms	20/25–100% ⑦⑧ 20/25–100% ⑦⑧ 100–500 ms
Ground fault delay flat Ground fault Z.S.I. Ground fault thermal memory	Inst–300 ms Yes Yes		Inst–500 ms No Yes		100–500 ms Yes Yes	100–500 ms Yes Yes	100–500 ms Yes Yes	100–500 ms Yes Yes	100–500 ms Optional Yes	100–500 ms Yes Yes
System Diagnostics										
Cause of trip LEDs Magnitude of trip information Remote signal contacts	No No No		No No No		Yes No No	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes No	Yes Yes Yes
System Monitoring										
Digital display Current Voltage	No No No		No No No		No No No	Yes Yes No	Yes Yes No	Yes Yes Yes	Yes ⑧ Yes No	Yes ⑧ Yes No
Power and energy Power quality-harmonics Power factor	No ⑨ No No		No ⑩ No No		No No No	No No No	Yes No Yes (over PowerNet only)	Yes Yes Yes	No No No	Yes Yes Yes
Communications										
PowerNet	No		No		No	No	Yes	Yes	Optional	Yes
Testing										
Testing method	Test kit		Test set		Integral	Integral	Integral	Integral	OPTIMizer, BIM, PowerNet (optional)	OPTIMizer, BIM, PowerNet

① No rating plugs necessary.
② Only available on LG, NG and RG breaker.
③ Adjust by rating plug.
④ FDE and JG 200–1200% x I_n
LG 200–1200% x I_n
NG 200–900% x I_n
RG 200–800% x I_n
⑤ LS/LSG only.
⑥ Not to exceed 1200 A.
⑦ L- and N-Frames *20–100% x I_s.
R-Frame *25–100% x I_n.
⑧ By OPTIMizer/BIM.
⑨ Yes, with addition of power monitoring/metering module (PM3).
⑩ Yes, with addition of Energy Sentinel.

BIM = Breaker Interface Module
I_s = Sensor Rating
I_n = Rating Plug
I_r = LDPU Setting x I_n

Digitrip OPTIM

Circuit Breaker Trip Units and Accessories

General Description

Digitrip OPTIM is a programmable communicating microprocessor-based electronic trip unit system for Eaton's molded-case circuit breakers. Digitrip OPTIM trip units are available in two models: Digitrip OPTIM 550 and 1050, for the K-, L-, N- and R-Frames (70–2500 A).

Digitrip OPTIM trip units are fully programmable and can be applied as a standalone breaker with a hand-held Digitrip OPTIMizer programmer for configuring the trip unit, displaying information and testing. In addition, OPTIM can be applied as a low voltage assembly with a panel-mounted Breaker Interface Module (BIM) to configure, display and test. Alternatively, OPTIM can be applied as part of a fully integrated IMPACC/PowerNet/Power Xpert® system. (See **Tab 2**.)

Features

- Fully programmable, rms sensing trip unit
- Available in K, L, N and R Series C breakers
- Available in 80% and 100% rated breakers
- Available in LSI, LSIG or LSIA configurations

Note: Ground fault alarm only.

- Available in two models: OPTIM 550 and OPTIM 1050
- 10 function time-current curve shaping options, including a new I^4t long delay time or slope
- Short delay and ground delay Zone Selective Interlocking (Optional on 550)
- Additional programmable protection features including thermal memory and discriminator functions
- Advanced warning systems including high load alarm, ground fault alarm
- Full system diagnostics capability
- System monitoring features including:
  - Phase currents (amps)
  - Power (kW)
  - Peak demand (kW)
  - Forward energy (kWh)
  - Reverse energy (kWh)
  - Total energy (kWh)
  - Power factor
  - Total harmonic distortion (%THD)
  - Magnitude of trip information (amps)
- Power Xpert communications saves individual wiring of breakers

Hand-Held Programmer

The Digitrip OPTIMizer hand-held programmer accesses, displays and configures information from OPTIM trip units. The OPTIMizer plugs into the front of the trip unit and is powered by a nine-volt battery, or an auxiliary power module.

An operator can use the OPTIMizer to:

- Complete initial system setup:
  - Select breaker address
  - Select system frequency (50/60 Hz)
  - Set system baud rate
  - Set system password
- Configure the system:
  - Change time-current set points
  - Select protection options
  - Select alarm levels
- Display information:
  - Breaker information
  - Time-current set points
  - Metered values
  - Trip event information
- Test trip unit performance:
  - Phase and ground
  - Trip/no trip

Panel-Mounted User Interface

The breaker interface module can be mounted directly on the assembly or at a remote location and can be used to access, configure and display information from OPTIM trip units.

An operator can use the breaker interface module to:

- Complete initial system setup:
  - Select system frequency (50/60 Hz)
  - Set system password
- Configure the system:
  - Change time-current set points
  - Select protection options
  - Select alarm levels
- Display information:
  - Breaker information
  - Time-current set points
  - Metered values
  - Trip event information
- Test trip unit performance:
  - Phase and ground
  - Trip/no trip
- Expanded energy monitoring:
  - Set addresses for group energy monitoring
  - Group energy readings
- Common alarm contacts:
  - Three Form C contacts
  - Saves wiring to each breaker
- Local and remote indication:
  - Remote indication/alarming
  - Breaker status LED indication
- Expanded communications:
  - Communicate with:
    - OPTIM trip units
    - Digitrip RMS 810 and 910 trip units
    - IQ Energy Sentinel™ and Universal Sentinels
    - IQ Power Sentinels
    - A total of 50 devices

QUICKLAG Industrial Circuit Breakers

HQP, QPHW, QHPX

QPHW

QPGF, QPHGF, QPGFEP, QPHGFEP

BAB, QBHW, HBAX

HBAW

Table 27.4-11. QUICKLAG Industrial Circuit Breakers

Type of Breaker Mounting/Electrical Connections				
Plug-On			**Bolt-On**	
Thermal-Magnetic HQP, QPHW, QHPX	**Thermal-Magnetic QHPW**	**Thermal-Magnetic QPGF, QPHGF, QPGFEP, QPHGFEP**	**Thermal-Magnetic BAB, QBHW, HBAX**	**Thermal-Magnetic HBAW**

Circuit Breaker Ratings—Continuous Current Rating at 40 °C and 0–95% Humidity (Noncondensing)

Amperes	Poles	Volts	Amperes	Poles	Volts	Amperes	Poles	Volts	Amperes	Poles	Volts	Amperes	Poles	Volts
HQP			QHPW			QPGF			BAB			HBAW		
5–70 10–150 10–100	1 2 2-3	120/240 120/240 240	15–30 15–20	1-2 3	120/240 240	15–40 15–50	1 2	120 120/240	5–70 10–150 10–100	1 2 2-3	120/240 120/240 240	15–30 15–20	1-2 3	120/240 240
QPHW						QPHGF			QBHW					
15–70 15–125 15–100	1 2 2-3	120/240 120/240 240				15–30 15–30	1 2	120 120/240	15–70 15–125 15–100	1 2 2-3	120/240 120/240 240			
QHPX						QPGFEP			HBAX					
15–70 15–100 15–100	1 2 2-3	120/240 120/240 240				15–40 15–50	1 2	120 120/240	15–70 15–100 15–100	1 2 3	120/240 120/240 240			
						QPHGFEP								
						15–30 15–30	1 2	120 120/240						

Dimensions in Inches (mm) Per Single-Pole Breaker

W	H	D	W	H	D	W	H	D	W	H	D	W	H	D
1.00 (25.4)	2.94 (74.6)	2.38 (60.3)	1.00 (25.4)	2.94 (74.6)	2.38 (60.3)	1.00 (25.4)	3.19 (81.0)	2.38 (60.3)	1.00 (25.4)	2.94 (74.6)	2.38 (60.3)	1.00 (25.4)	2.94 (74.6)	2.38 (60.3)

AC Interrupting Ratings—UL Listed Interrupting Ratings Shown (rms Symmetrical Amperes)

Volts	Amps I.R.	Volts	Amps I.R.	Volts	Amps I.R.	Volts	Amps I.R.	Volts	Amps I.R.
HQP		QHPW		QPGF, QPGFEP		BAB		HBAW	
120/240, 240	10,000	120/240, 240	65,000	120, 120/240	10,000	120/240, 240	10,000	120/240, 240	65,000
QPHW				QPHGF, QPHGFEP		QBHW			
120/240, 240	22,000			120, 120/240	22,000	120/240, 240	22,000		
QHPX						HBAX			
120/240, 240	42,000					120/240, 240	42,000		

DC Interrupting Ratings ①

Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.
48 62.5 80	1-2 1 2	5000 2500 5000	48 62.5 80	1-2 1 2	5000 2500 5000	— — —	— — —	— — —	48 62.5 80	1-2 1 2	5000 2500 5000	48 62.5 80	1-2 1 2	5000 2500 5000

Accessories and Modifications—See MCCB CD-ROM for Description and UL Installation Status

Moisture-fungus treatment Handle lock devices Shunt trip Special calibration Shock tested Dummy breaker Optional terminals	Moisture-fungus treatment Handle lock devices Shunt trip Special calibration Shock tested Dummy breaker Optional terminals	Moisture-fungus treatment Bell alarm contacts Auxiliary switch contacts	Moisture-fungus treatment Handle lock devices Shunt trip Special calibration Shock tested Panelboard accessories Dummy breaker Optional terminals	Moisture-fungus treatment Handle lock devices Shunt trip Special calibration Shock tested Panelboard accessories Optional terminals

① Two-pole interrupting ratings based on two poles connected in series. Not UL listed.

QUICKLAG Industrial Circuit Breakers

QBGF, QBHGF, QBGFEP, QBHGFEP

QCR,QCF

QC, QCHW, QHCX, QCD

QHCW

QCGF, QCHGF, QCGFEP, QCHGFEP

Table 27.4-12. QUICKLAG Industrial Circuit Breakers

Type of Breaker Mounting/Electrical Connections														
Bolt-On			**Cable-In/Cable-Out**											
Thermal-Magnetic QBAF, QBGF, QBHGF, QBGFEP, QBHGFEP			**Thermal-Magnetic QCR, QCF**			**Thermal-Magnetic QC, QCHW, QHCX**			**Thermal-Magnetic QCD**			**Thermal-Magnetic QCGF, QCHGF, QCGFEP, QCHGFEP**		
Circuit Breaker Ratings—Continuous Current Rating at 40 °C and 0–95% Humidity (Noncondensing)														
Amperes	Poles	Volts	Amperes	Poles	Volts	Amperes	Poles	Volts	Amperes	Poles	Volts	Amperes	Poles	Volts
QBAF (Arc Fault)			QCR, QCF			QC			QCD			QCGF		
10–20 10–20	1 2	120 120/240	10–60 10–60 15–30	1 2 2-3	120 120/240 240	5–70 10–125 10–100	1 2 2-3	120/240 120/240 240	10–100 10–100	1-2 3	120/240 240	15–40 15–50 —	1 2 —	120 120/240 —
QBGF						QCHW						QCHGF		
15–40 15–50 —	1 2 —	120 120/240 —				15–70 15–100 15–100	1 2 2-3	120/240 120/240 240				15–30 15–50 —	1 2 —	120 120/240 —
QBHGF						QHCX						QCGFEP		
15–30 15–30 —	1 2 —	120 120/240 —				15–70 15–100 15–100	1 2 2-3	120/240 120/240 240				15–30 15–50 —	1 2 —	120 120/240 —
QBGFEP						QHCW						QCHGFEP		
15–40 15–50 —	1 2 —	120 120/240 —				15–30 15–20	1–2 3	120/240 240				15–50 15–30	1 2	120 120/240
QBHGFEP														
15–30 15–30	1 2	120 120/240												
Dimensions in Inches (mm) Per Single-Pole Breaker														
W	H	D	W	H	D	W	H	D	W	H	D	W	H	D
1.00 (25.4)	3.19 (81.0)	2.38 (60.3)	.50 (12.7)	3.94 (74.6)	2.63 (66.7)	1.00 (25.4)	3.75 (95.3)	2.44 (61.9)	1.00 (25.4)	3.75 (95.3)	2.63 (66.7)	1.00 (25.4)	3.75 (95.3)	2.44 (61.9)
AC Interrupting Ratings—UL Listed Interrupting Ratings Shown (rms Symmetrical Amperes)														
Volts		Amps I.R.	Volts		Amps I.R.	Volts		Amps I.R.	Volts		Amps I.R.	Volts		Amps I.R.
QBAF, QBGF, QBGFEP			QCR, QCF			QC			QCD			QCGF, QCGFEP		
120, 120/240		10,000	120/240		10,000	120/240, 240		10,000	120/240, 240		10,000	120/240		10,000
QBHGF, QBHGFEP						QCHW						QCHGF, QCHGFEP		
120, 120/240		22,000				120/240, 240		22,000				120		22,000
						QHCX								
						120/240, 240		42,000						
						QHCW								
						120/240, 240		65,000						
DC Interrupting Ratings ①														
Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.	Volts	Poles	Amps I.R.
— — —	— — —	— — —	62.5 125 —	1 2 —	3000 3000 —	48 62.5 80	1-2 1 2	5000 2500 5000	48 62.5 80	1-2 1 2	5000 2500 5000	— — —	— — —	— — —
Accessories and Modifications—See MCCB CD-ROM for Description and UL Installation Status														
Moisture-fungus treatment Handle lock devices Bell alarm contacts Auxiliary switch contacts Ring terminals			Moisture-fungus treatment Handle lock devices QCR mounting clips Ring terminals Quick connect Terminals Shunt trip Shock tested DIN rail mounting clip			Moisture-fungus treatment Handle lock devices Shunt trip Special calibration Shock tested Face mounting plate Base mounting hardware Optional terminals Dummy breaker DIN rail mounting clip			Moisture-fungus treatment Handle lock devices Shunt trip Special calibration Shock tested Face mounting plate Base mounting hardware Optional terminals Dummy breaker DIN rail mounting clip			Moisture-fungus treatment Handle lock devices Bell alarm contacts Auxiliary switch contacts DIN rail mounting clip		

① Two-pole DC interrupting ratings based on two poles connected in series. Not UL listed.

Solenoid-Operated, Remote-Controlled Latching Types BABRP, BABRSP, BRRP and CLRP

BABRP and BABRSP Breakers—Single- and Two-Pole

General Description

The BABRP and BABRSP are bolt-on branch circuit breakers designed for use in panelboards. The BRRP is a plug-on branch circuit breaker designed for use in loadcenters not manufactured with breakers with a 1.00-inch wide format and are listed on the "Compatibility list for Classified Applications"—Pub. 26271. In addition to providing conventional branch circuit protection, they include a unique solenoid-operated mechanism that provides for efficient breaker pulse-on and pulse-off operation when used with a suitable controller like Eaton's Pow-R-Command™ lighting control system. These breakers can also be controlled by pushbutton or a PLC unit.

Application Description

Eaton's BABRP, BABRSP, BRRP and CLRP breakers are remotely operated molded-case circuit breakers ideally suited for lighting control applications or energy management applications.

Features, Benefits and Functions

- Bolt-on line-side terminal (BABRP, BABRSP—Type BA)
- Plug-on line-side terminal (BRRP—Type BR, CLRP—Type CL)
- Cable connected load-side terminal
- Four-position control terminal
- Bi-metal assembly for thermal overload protection
- Fast-acting short-circuit protection
- Arc-chute assembly for fast-acting arc extinction
- Three-position handle: OFF, TRIP (Center), ON
- Handle permits manual switching when control power is lost
- Mechanical trip indicator
- 15 and 20 A breakers SWD (switching duty) rated
- HID ratings for HID (high intensity discharge) lighting
- All models HACR rated
- Status feedback of control circuit (BABRSP)
- Series rated (BABRP, BABRSP only)
  - BRRP series rated same as BR breakers
  - BABRP, BABRSP same as BA breakers

Product Selection

Table 27.4-13. BABRP UL 489 and CSA 22.2 Interrupting Ratings

Number of Poles	Interrupting Capacity (Symmetrical Amperes)				
	Ampere Rating ①	Vac (50/60 Hz) 120	120/240	277/480	Catalog Number
1	15	10,000	—	—	**BABRP1015**
	20	10,000	—	—	**BABRP1020**
	25	10,000	—	—	**BABRP1025**
	30	10,000	—	—	**BABRP1030**
2	15	—	10,000	—	**BABRP2015**
	20	—	10,000	—	**BABRP2020**
	25	—	10,000	—	**BABRP2025**
	30	—	10,000	—	**BABRP2030**

① Continuous current rating at 40°C.

Table 27.4-14. BABRP and BABRSP Wire Harness

Description	Catalog Number
This 60-inch (1524.0 mm) wire pigtail provides a connection from a single BABRP's control plug to a customer's pushbutton, relay or PLC. Each box contains 12 pigtails. Wires are 22 AWG, 600 V. Order in multiples of 12.	**SLBKRPTL1**

Table 27.4-15. BABRSP UL 489 and CSA 22.2 Interrupting Ratings

Number of Poles	Interrupting Capacity (Symmetrical Amperes)				
	Ampere Rating ②	Vac (50/60 Hz) 120	120/240	277/480	Catalog Number
1	15	10,000	—	—	**BABRSP1015**
	20	10,000	—	—	**BABRSP1020**
	25	10,000	—	—	**BABRSP1025**
	30	10,000	—	—	**BABRSP1030**
2	15	—	10,000	—	**BABRSP2015**
	20	—	10,000	—	**BABRSP2020**
	25	—	10,000	—	**BABRSP2025**
	30	—	10,000	—	**BABRSP2030**

② Continuous current rating at 40 °C.

Table 27.4-16. BRRP UL 489 and CSA 22.2 Interrupting Ratings

Number of Poles	Interrupting Capacity (Symmetrical Amperes)			
	Ampere Rating	Vac (50/60 Hz) 120	120/240	Catalog Number
1	15	10,000	—	**BRRP115**
	20	10,000	—	**BRRP120**
	25	10,000	—	**BRRP125**
	30	10,000	—	**BRRP130**
2	15	—	10,000	**BRRP215**
	20	—	10,000	**BRRP220**
	25	—	10,000	**BRRP225**
	30	—	10,000	**BRRP230**

Table 27.4-17. CLRP UL 489 and CSA 22.2 Interrupting Ratings

Number of Poles	Interrupting Capacity (Symmetrical Amperes)			
	Ampere Rating	Vac (50/60 Hz)		Catalog Number
		120	120/240	
1	15	10,000	—	**CLRP115**
	20	10,000	—	**CLRP120**
	25	10,000	—	**CLRP125**
	30	10,000	—	**CLRP130**
2	15	—	10,000	**CLRP215**
	20	—	10,000	**CLRP220**
	25	—	10,000	**CLRP225**
	30	—	10,000	**CLRP230**

Technical Data and Specifications

Solenoid Operating Data

- Power requirements: 24 Vac/Vdc (20.4 V minimum–30 V maximum)
  - Controlled signal: +AC/DC 8 ms minimum with zero cross, 300 ms maximum
  - AC: 1.3 cycles minimum, 18 cycles or 300 ms maximum
  - DC: 8 ms minimum, 300 ms maximum
  - Maximum duty cycle of 6 OPEN/CLOSE cycles per minute
- Current draw: open 1 A, close 3/4 A
- Blue wire: power input (see power requirements)
- Black wire: remote opening
- Red wire: remote closing
- Yellow wire: feedback status from power input, maximum 0.50 A draw (BABRSP only)

Operation

- Tripping system—the BABRP, BABRSP, BRRP and CLRP circuit breakers have a permanent trip unit that contains a factory preset thermal (overload) trip element in each pole
- Operating mechanism—the BABRP, BABRSP, BRRP and CLRP circuit breakers have an over-center toggle mechanism that provides quick-make, quick-break operation. The operating mechanism is trip free. An internal cross-bar provides a common tripping of all multi-pole circuit breakers

Operating/Application Data

- Ambient temperature: 0 to 40 °C
- Nominal pulse magnitude: 24 Vac/Vdc
- Frequency: 50/60 Hz
- Maximum breaker cycling: 6 operations per minute
- Tolerance: +10% to –15% of nominal voltage
- Humidity: 0 to 95% noncondensing

Wiring Diagrams

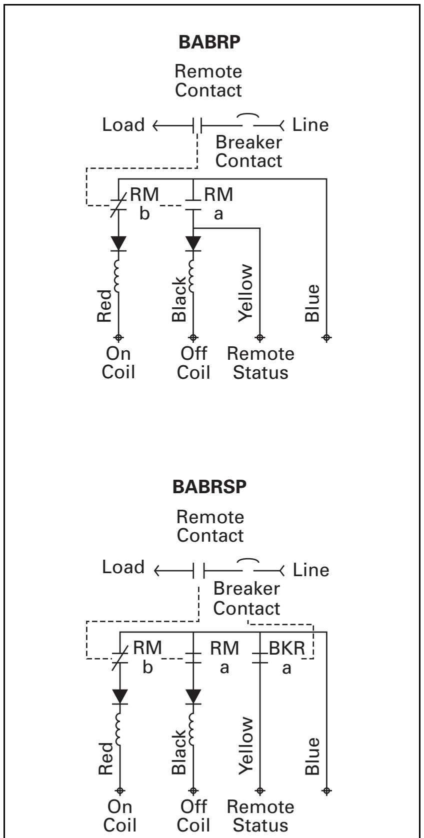

Figure 27.4-1. Control Circuit for the BABRP and BABRSP

Solenoid Operated—Remote-Controlled Latching for Type GHBS, GBHS and GHQRSP Breakers

GHBS and GHQRSP

General Description

Eaton's GHBS, GBHS and GHQRSP circuit breakers are bolt-on branch circuit breakers designed for use in 277/480 Vac panelboards. In addition to providing conventional branch circuit protection, they include a unique solenoid-operated mechanism that provides for efficient breaker pulse-on and pulse-off operation when used with a suitable controller like Eaton's Pow-R-Command lighting control system.

Features, Benefits and Functions

- Bolt-on line-side terminal
- Cable-connected load-side terminal
- Status switch—remote status and breaker status available from internal auxiliary switches
- Bi-metal assembly for thermal overload protection
- Fast-acting short-circuit protection
- Arc-runner and arc-chute assembly for fast-acting arc extinction
- Three-position breaker handle: OFF, TRIP (Center), ON
- Visual indication of the remotely operated contact's position (open, closed or trip)
- Remote override handle permits manual switching when control power is lost
- 15 and 20 A breakers SWD (switching duty) rated
- 15 and 20 A breakers HID rated for HID (High intensity discharge) lighting
- All models HACR rated
- Series rated with various Eaton main circuit breakers

Product Selection

Table 27.4-18. GHBS UL 489 Interrupting Ratings

Number of Poles	Interrupting Capacity (Symmetrical Amperes)				
	Ampere Rating ①	Vac (50/60 Hz)			Catalog Number
		120	240	277/480	
1	15 20 30	65,000 65,000 65,000	— — —	14,000 14,000 14,000	**GHBS1015D** **GHBS1020D** **GHBS1030D**
2	15 20 30	— — —	65,000 65,000 65,000	14,000 14,000 14,000	**GHBS2015D** **GHBS2020D** **GHBS2030D**

① Continuous current rating at 40 °C.

Table 27.4-19. GBHS CSA 22.2 Interrupting Ratings (Not UL Listed)

Number of Poles	Interrupting Capacity (Symmetrical Amperes)		
	Ampere Rating ②	Vac (50/60 Hz)	Catalog Number
		347/600	
1	15 20	10,000 10,000	**GBHS1015D** **GBHS1020D**
2	15 20	10,000 10,000	**GBHS2015D** **GBHS2020D**

② Continuous current rating at 40 °C.

Table 27.4-20. GHQRSP UL 489 and CSA 22.2 Interrupting Ratings

Number of Poles	Interrupting Capacity (Symmetrical Amperes)					
	Ampere Rating ③	Vac (50/60 Hz)				Catalog Number ④
		120	120/240	277	480Y/277	
1	15 20 30	65,000 65,000 65,000	65,000 65,000 65,000	14,000 14,000 14,000	14,000 14,000 14,000	**GHQRSP1015** **GHQRSP1020** **GHQRSP1030**
2	15 20 30	65,000 65,000 65,000	65,000 65,000 65,000	14,000 14,000 14,000	14,000 14,000 14,000	**GHQRSP2015** **GHQRSP2020** **GHQRSP2030**

③ Continuous current rating at 40 °C.
④ All UL listed circuit breakers are HID (high intensity discharge) rated.

Technical Data and Specifications

Solenoid Operating Data

- Power requirements: 24 Vac/Vdc (20.4 V minimum–30 V maximum)
  - Controlled signal: +AC/DC 8 ms minimum with zero cross, 300 ms maximum
  - AC: 1.3 cycles minimum, 18 cycles or 300 ms maximum
  - DC: 8 ms minimum, 300 ms maximum
  - Maximum duty cycle of 6 OPEN/CLOSE cycles per minute
- Current draw: open 1 A, close 3/4 A
- Blue wire: power input (see power requirements)
- Black wire: remote opening
- Red wire: remote closing
- Yellow wire: feedback status from power input, maximum 0.50 A draw

Operation

Mechanism manually operated by external handle allowing ON, OFF and RESET operation. Handle assumes a center TRIP position after performing protective response.

Operating/Application Data

- Ambient temperature: 0–40 °C
- Frequency: 48–62 Hz
- Humidity: 0–95% noncondensing

Table 27.4-21. Terminal Type

Circuit Breaker Type	Circuit Breaker Amperes	Screw Head Type	Terminal Type	Terminal Range
GHQRSP	15–20	Slotted	Clamp	#14–#4 AWG

Wiring Diagrams

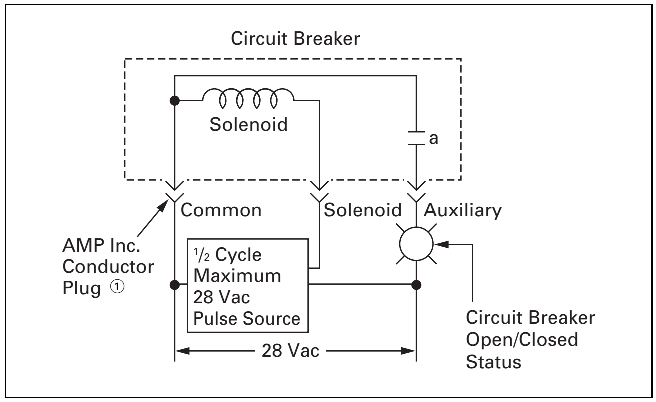

Figure 27.4-2. Typical Single-Pole Circuit Breaker Schematic Diagram for GHBS and GBHS Breakers

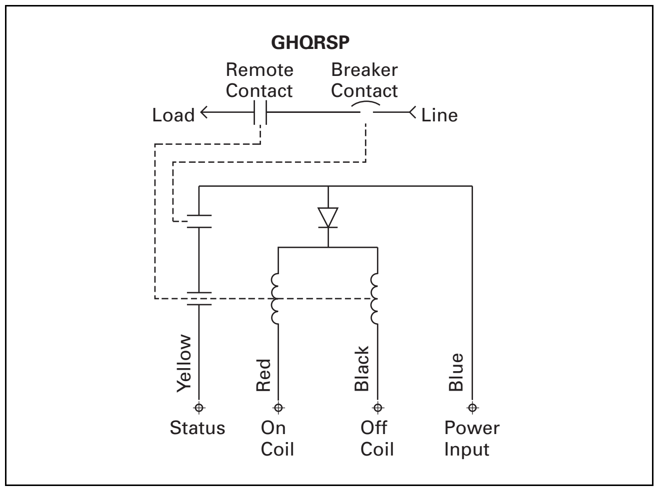

Figure 27.4-3. Typical Single-Pole Circuit Breaker Schematic Diagram for GHQRSP Breakers

Dimensions

Approximate dimensions in inches (mm).

Table 27.4-22. Dimensions Per Pole

Circuit Breaker Type	Width	Height ②	Length ③
GHQRSP	1.00 (25.4)	4.63 (117.6)	2.81 (71.4)

① Purchase separate AMP Inc. conductor plug #640426-3.
② Excluding line terminal.
③ Excluding handle.

Solenoid Operated—Remote Controlled Emergency Circuit Breaker

Solenoid Operated—Remote Controlled Emergency Circuit Breaker

General Description

The GHQRSPEL circuit breaker contains both a solenoid operated remote switching circuit and a manually operated thermal-magnetic circuit breaker. This Emergency Lighting Circuit Breaker complies with the 2008 National Electrical Code; Section 700.12(F) for Sources of Power used in emergency lighting applications.

Features, Benefits and Functions

- Left pole: Integral solenoid controlled contacts in series with thermal-magnetic circuit breaker pole
- Right pole: Standard thermal-magnetic circuit breaker pole
- Both poles tied to same phase
- Bolt-on line-side terminal
- Cable-connected load-side terminal
- Status switch—remote status and breaker status available from internal auxiliary switches
- Bi-metal assembly for thermal overload protection
- Fast-acting short-circuit protection
- Arc-runner and arc-chute assembly for fast-acting arc extinction
- Three-position breaker handle: OFF, TRIP (Center), ON
- Visual indication of the remotely operated contact's position (open, closed or trip)
- Remote override handle permits manual switching when control power is lost
- 15 and 20 A breakers SWD, and HID rated

Product Selection

Table 27.4-23. Solenoid Operated—Remote Controlled Emergency Circuit Breaker

Amperes	Catalog Number
15	**GHQRSPEL2015**
20	**GHQRSPEL2020**

Technical Data and Specifications

Operating Data

Mechanism manually operated by external handle allowing ON, OFF and RESET operation. Handle assumes a center TRIP position after performing protective response.

Solenoid

- Power requirements: 24 Vac/Vdc (20.4 V minimum to 30 V maximum)
- Controlled signal: +AC/DC 12 ms minimum with zero cross, 300 ms maximum
- AC: 1.3 cycles minimum, 18 cycles or 300 ms maximum
- DC: 12 ms minimum, 300 ms maximum
- Maximum duty cycle of 6 OPEN/CLOSE cycles per minute
- Current draw: open 1 A, close 3/4 A
- Blue wire: power input
- Black wire: remote opening
- Red wire: remote closing
- Yellow wire: feedback status from power input, maximum 0.50 A draw

Application

- Ambient temperature: 0–40 °C
- Frequency: 48–62 Hz
- Humidity: 0–95% noncondensing

Product Specifications

GHQRSPEL circuit breakers incorporate many of the same robust features as other GHQRSP breakers including:

- Handle rating: 20 A (both switched and unswitched circuits)
- Maximum voltage rating: 277 Vac
- Interrupting ratings: 65 kA at 240 Vac, 14 kA at 277 Vac
- Maximum series connected ratings: 200 kA at 240 Vac and 100 kA at 277 V
- Overcurrent protection—UL listed 489
- UL listed switch duty rated (SWD) and high intensity discharge (HID) ratings
- Lug wire size: (1) #12–8 Al, #14–8 Cu per circuit, 75 °C conductors

Solenoid Operated—Remote Controlled Emergency Circuit Breaker

Wiring Diagrams

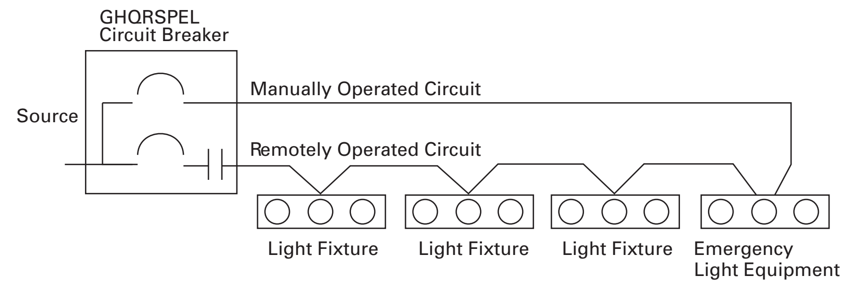

Figure 27.4-4. The Need for Relay is Eliminated with Extra Box, Wiring and Selecting a Properly Rated Component

Note: Circuit breaker mounts into panelboard. Switched and unswitched conductors are connected directly to the breaker load side lug.

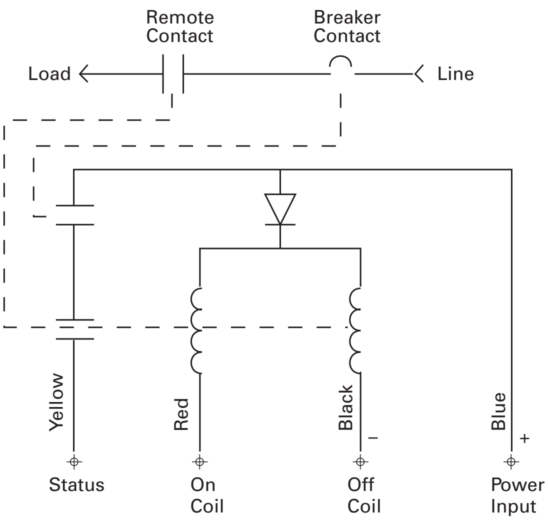

Figure 27.4-5. Typical Circuit Breaker Schematic for GHQRSP

Series G, E-Frame Thermal-Magnetic 15–125 A

E125-Frame Breaker

Table 27.4-24. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
1 2	1.00 (25.4) 2.00 (50.8)	5.50 (139.7) 5.50 (139.7)	2.99 (75.9) 2.99 (75.9)
3 4	3.00 (76.2) 4.00 (101.6)	5.50 (139.7) 5.50 (139.7)	2.99 (75.9) 2.99 (75.9)

Table 27.4-25. Thermal-Magnetic Trip Ratings

Frame	Ratings
EG	15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125
EG ①	16, 32, 63

① Not UL listed.

Note: EG breaker is HACR rated.

Table 27.4-26. UL 489/IEC 60947-2 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Interrupting Capacity (Symmetrical Amperes) (kA)														
		Volts AC (50/60 Hz)											Volts DC ②			
		120	220–240		277	347	380–415		480	600Y/347	690 ③		125		250 ④⑤	
			I_{cu}	I_{cs}			I_{cu}	I_{cs}			I_{cu}	I_{cs}	I_{cu}	I_{cs}	I_{cu}	I_{cs}
EGB125	1 2, 3, 4	35 —	25 25	25 25	18 —	— —	— 18	— 18	— 18	— —	— —	— —	10 —	10 —	— 10	— 10
EGE125	2, 3, 4	—	35	35	—	—	25	25	25	18	—	—	—	—	10	10
EGS125	1 2, 3, 4	100 —	85 85	43 43	35 —	22 —	— 40	— 30	— 35	— 22	— —	— —	35 —	35 —	— 35	— 35
EGH125	1 2, 3, 4	200 —	100 100	50 50	65 —	30 —	— 70	— 35	— 65	— 25	— —	— —	42 —	42 —	— 42	— 42
EGC125	3, 4	—	200	200	—	—	100	100	100	35	—	—	—	—	42	42

② DC ratings apply to substantially non-inductive circuits.
③ IEC only.
④ Two-pole circuit breaker, or two poles of three-pole circuit breaker.
⑤ Time constant is 3 milliseconds minimum at 10 kA and 8 milliseconds minimum at 42 kA.

Series G, F-Frame 15–225 A Electronic RMS 15–225 A

F-Frame Breaker

Table 27.4-27. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
3	4.13 (104.8)	6.00 (152.4)	3.38 (85.7)

Table 27.4-28. Digitrip 310+ Electronic Trip Units

Types	Frame	Ratings
FDE, HFDE, FDCE	225	100, 110, 125, 150, 160, 175, 200, 225
	160	60, 70, 80, 90, 100, 125, 150, 160
	80	15, 20, 30, 40, 50, 60, 70, 80

Table 27.4-29. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type ①	Interrupting Capacity (Symmetrical Amperes)					
			Volts AC (50/60 Hz)				Volts DC	
			240	277	480	600	125	250
FDE ②	3	N.I.T.	65,000	—	35,000	18,000	—	10,000
HFDE ②	3	N.I.T.	100,000	—	65,000	25,000	—	22,000
FDCE ②③	2, 3, 4	N.I.T.	200,000	—	100,000	25,000	—	—

① N.I.T. is non-interchangeable trip unit.
② Current limiting.
③ Electronics available on thee-pole only.

Table 27.4-30. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ④	Wire Type	AWG Wire Range	Metric Wire Range (mm^2)	Catalog Number Package of 3 Terminals
Standard Pressure Type Terminals					
100	Steel	Cu/Al	(1) #14–1/0	2.5–50	**3T100FB**
150	Aluminum	Cu/Al	(1) #4–4/0	25–95	**3TA150FB**
225	Aluminum	Cu/Al	(1) #4–4/0	25–95	**3TA225FD**
Optional Pressure Terminals					
50	Aluminum	Cu/Al	(1) #14–#4	2.5–16	**3TA50FB**
100	Aluminum	Cu/Al	(1) #14–1/0	2.5–50	**3TA100FD**
150	Stainless steel	Cu	(1) #4–4/0	25–95	**3T150FB**
225	Aluminum	Cu/Al	(1) #6–300 kcmil	16–150	**3TA225FDK**

④ UL listed for use with copper or aluminum conductors as noted.

Series G Selection Data—JG-Frame

Series G, J-Frame Electronic RMS, 20–250 A Thermal-Magnetic, 63–250 A

J-Frame Breaker

Table 27.4-31. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
2, 3	4.13 (104.9)	7.00 (177.8)	3.57 (90.7)
4	5.34 (135.6)	7.00 (177.8)	3.57 (90.7)

Table 27.4-32. Thermal-Magnetic Trip Ratings

Frame	Ratings
JG	70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250
JG ①	160

① Not UL listed.

Table 27.4-33. Digitrip 310+ Electronic Trip Units

Frame	Ratings
JG250	100, 125, 150, 160, 175, 200, 225, 250
JG160 ②	63, 80, 90, 100, 110, 125, 150, 160
JG100	40, 45, 50, 63, 70, 80, 90, 100
JG50	20, 25, 30, 32, 40, 45, 50

② Not UL listed.

Note: JG breaker is HACR rated.

Table 27.4-34. UL 489/IEC 60947-2 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Interrupting Capacity (kA Symmetrical Amperes)								
		Volts AC (50/60 Hz)								Volts DC ③
		220–240		380–415		480	600	690		250 ④⑤
		I_{cu}	I_{cs}	I_{cu}	I_{cs}			I_{cu}	I_{cs}	
JGE250	2, 3, 4	65	65	25	25	25	18	12	6	10
JGS250	2, 3, 4	85	85	40	40	35	18	12	6	22
JGH250	2, 3, 4	100	100	70	70	65	25	14	7	22
JGC250	3, 4	200	200	100	100	100	35	16	12	42
JGU250	3, 4	200	200	150	150	150	50	18	14	50
JGX250	3, 4	200	200	200	200	200	50	18	14	50

③ DC ratings apply to substantially non-inductive circuits.
④ Two-pole circuit breaker, or two poles of three-pole circuit breaker.
⑤ Time constant is 3 milliseconds minimum at 10 kA and 8 milliseconds minimum at 22 kA.

JG-Frame circuit breakers include Cu/Al terminals T250FJ as standard. When optional copper only terminals are required, order by catalog number.

Table 27.4-35. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material	Wire Type	Metric Wire Range mm^2	AWG Wire Range/Number of Conductors	Catalog Number
Standard Pressure Type Terminals					
250	Stainless steel	Cu	25–185	#4–350 (1)	**T250FJ** ⑥⑦
250	Aluminum	Cu/Al	25–185	#4–350 (1)	**TA250FJ** ⑥
Optional Copper and Cu/Al Pressure Type Terminals					
250	Copper	Cu/Al	25–185	#4–350 (1)	**TC250FJ** ⑥⑧

⑥ Single terminals individually packed.
⑦ Standard line and load terminals.
⑧ Contact factory for availability.

Series G, L-Frame Electronic RMS, 100–630 A* Thermal-Magnetic, 250–630 A* *UL Maximum is 600 A

L-Frame Breaker

Table 27.4-36. Dimensions in Inches (mm), Weight in Lbs (kg)

Number of Poles	Width	Height	Depth	Weight
3	5.48 (140)	10.13 (258)	4.09 (104)	16 (7.3)
4	7.22 (183)	10.13 (258)	4.09 (104)	20 (9.1)

Table 27.4-37. Thermal-Magnetic Trip Rating

Frame	Ratings
LG	250, 300, 350, 400, 500, 600
LG ①	320, 630

① Not UL listed.

Table 27.4-38. Digitrip 310+ Electronic Trip Units

Frame	Ratings
LG_630	250, 300, 315, 350, 400, 500, 600, 630
LG_600	250, 300, 315, 350, 400, 450, 500, 600
LG_400	160, 200, 225, 250, 300, 315, 350, 400
LG_250	100, 125, 150, 160, 175, 200, 225, 250

Note: 160, 315 and 630 are IEC ratings only. LG breaker is HACR rated.

Table 27.4-39. UL 489/IEC 60947-2 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Interrupting Capacity (kA rms Symmetrical Amperes) (kA)									
		Volts AC (50/60 Hz)								Volts DC ②	
		240–240		380–415		480	600	690		250 ③	
		I_{cu}	I_{cs}	I_{cu}	I_{cs}			I_{cu}	I_{cs}	I_{cu}	I_{cs}
LGE630	3, 4	65	65	35	35	35	18	12	6	22	22
LGS630	3, 4	85	85	50	50	50	25	20	10	22	22
LGH630	3, 4	100	100	70	70	65	35	25	13	42	42
LGC630	3, 4	200	200	100	100	100	50	30	15	42	42
LGU630	3, 4	200	200	150	150	150	65	35	18	50	50
LGX630	3, 4	200 ④	200	200	200	200	65	35	18	50	50

② DC rating applies to substantially non-inductive circuits.
③ Two-pole circuit breaker, or two poles of three-pole circuits.
④ IEC rating is 300 kA at 240 Vac.

Table 27.4-40. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material	Wire Type	AWG Wire Range/Number of Conductors	Metric Wire Range mm^2	Number of Terminals Included	Catalog Number
400	Aluminum	Cu/Al	500–750 (1)	240–380 (1)	3	**3TA631LK** ⑤
400	Aluminum	Cu/Al	500–750 (1)	240–380 (1)	4	**4TA631LK** ⑤
400	Copper	Cu	500–750 (1)	240–380 (1)	3	**3T631LK** ⑤
400	Copper	Cu	500–750 (1)	240–380 (1)	4	**4T631LK** ⑤
630	Aluminum	Cu/Al	2–500 (2)	35–240 (2)	3	**3TA632LK** ⑤⑥
630	Aluminum	Cu/Al	2–500 (2)	35–240 (2)	4	**4TA632LK** ⑤⑥
630	Copper	Cu	2–500 (2)	35–240 (2)	3	**3T632LK** ⑤
630	Copper	Cu	2–500 (2)	35–240 (2)	4	**4T632LK** ⑤
400	Aluminum	Cu/Al	2–500 (1)	35–240 (1)	1	**TA350LK** ⑥
400	Copper	Cu	2–500 (1)	35–240 (1)	1	**T350LK**

⑤ Includes LTS3K (three-pole) or LTS4K (four-pole) terminal covers.
⑥ Standard terminal included with complete breaker.

Series G, N-Frame Electronic RMS, 400–1200 A

N-Frame Breaker

Table 27.4-41. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
3	8.25 (209.6)	16.00 (406.4)	5.50 (139.7)

Table 27.4-42. Digitrip 310+ Electronic Trip Units

Frame	Ratings
800	320, 400, 450, 500, 600, 630, 700, 800
1200	500, 600, 630, 700, 800, 900, 1000, 1200

Table 27.4-43. Series G Molded-Case Circuit Breaker Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type	Interrupting Capacity (kA Symmetrical Amperes)—Volts AC (50/60 Hz)								
			UL 489			IEC 60947-2					
			240	480	600	220–240		380–415		660–690	
						I_{cu}	I_{cs}	I_{cu}	I_{cs}	I_{cu}	I_{cs}
800, 1200 A											
NGS	3	N.I.T.	65	50	25	85	85	50	50	20	10
NGH	3	N.I.T.	100	65	35	100	100	70	50	25	13
NGC	3	N.I.T.	200	100	50	200	100	100	50	35	18
800 A											
NGU	3	N.I.T.	300	150	75	—	—	—	—	—	—

Table 27.4-44. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ①	Wire Type	AWG/kcmil Wire Range/Number of Conductors	Metric Wire Range (mm^2)	Catalog Number
Standard Cu/Al Pressure Terminals					
700	Aluminum	Cu/Al	(2) 1–500 kcmil	50–300	**TA700NB1**
1000	Aluminum	Cu/Al	(3) 3/0–400 kcmil	95–185	**TA1000NB1**
1200	Aluminum	Cu/Al	(4) 4/0–500 kcmil	120–300	**TA1200NB1**
1200	Aluminum	Cu/Al	(3) 500–750 kcmil	300–400	**TA1201NB1**
Optional Copper and Cu/Al Pressure Type Terminals					
700	Copper	Cu	(2) 2/0–500 kcmil	70–300	**T700NB1**
1000	Copper	Cu	(3) 3/0–500 kcmil	95–300	**T1000NB1**
1200	Copper	Cu	(4) /0–400 kcmil	95–185	**T1200NB3**

① UL listed for use with copper or aluminum conductors as noted.

Series G, R-Frame Electronic RMS, 800–2500 A

R-Frame Breaker

Table 27.4-45. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
3	15.50 (393.7)	16.00 (406.4)	9.75 (247.7)
4	20.00 (508.0)	16.00 (406.4)	9.75 (247.7)

Table 27.4-46. Digitrip 310 Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
1600	800, 1000, 1200, 1250, 1400, 1500, 1600 ①
2000	1000, 1200, 1250, 1400, 1600, 2000 ①
2500	1200, 1250, 1600, 2000, 2500 ①

① Adjustable rating plug available.

Table 27.4-47. Digitrip 510/610/810/910 and Digitrip OPTIM Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
1600	800, 1000, 1200, 1600
2000	1000, 1200, 1600, 2000
2500	1600, 2000, 2500

Table 27.4-48. Series G Molded-Case Circuit Breaker Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type	Interrupting Capacity (kA Symmetrical Amperes)—Volts AC (50/60 Hz)								
			UL 489			IEC 60947-2					
			240	480	600	220–240		380–415		660–690	
						I_{cu}	I_{cs}	I_{cu}	I_{cs}	I_{cu}	I_{cs}
RGH	3, 4	N.I.T.	125	65	50	135	100	70	50	25	13
RGC	3, 4	N.I.T.	200	100	65	200	100	100	50	35	18

Table 27.4-49. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ②	Wire Type	Hardware	AWG/kcmil Wire Range/Number of Conductors	Metric Wire Range (mm^2)	Catalog Number
Wire Terminal						
1600	Aluminum	Cu/Al	English	(4) 500–1000 kcmil	300–500	**TA1600RD**
1600	Copper	Cu	English	(4) 1–600 kcmil	50–300	**T1600RD**
2000	Aluminum	Cu/Al	English	(6) 2–600 kcmil	35–300	**TA2000RD**

② UL listed for use with copper or aluminum conductors as noted.

Series C, G-Frame Thermal-Magnetic, 15–100 A

GHB Breaker and G-Frame

Table 27.4-50. G-Frame—Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
1P G-Frame 2P G-Frame 3P G-Frame	1.00 (25.4) 2.00 (50.8) 3.00 (76.2)	4.00 (101.6) 4.00 (101.6) 4.00 (101.6)	2.81 (71.4) 2.81 (71.4) 2.81 (71.4)
GHCGFEP GHBGFEP	2.00 (50.8) 2.00 (50.8)	4.88 (124.0) 4.00 (101.6)	2.81 (71.4) 2.81 (71.4)

Table 27.4-51. Thermal-Magnetic Trip Ratings

Frame	Ratings
GHB, GHC GHCGFEP, GHBGFEP	15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100 15, 20, 30, 40, 50, 60
GHQ HGHB	15, 20 15, 20, 25, 30

Table 27.4-52. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Interrupting Capacity (kA Symmetrical Amperes)						
		Volts AC (50/60 Hz)					Volts DC	
		120	240	277	480	480Y/277	125	250 ①②
GDB	2, 3	—	—	—	14	—	—	10
GD	2	—	65	—	14	—	—	10
GD	3	—	65	—	22	—	—	10
GHQ	1	65	—	14	—	—	—	—
GHB	1	65	—	14	—	—	14 ③	—
GHB	2, 3	—	65	—	—	14	14	—
HGHB	1	65	—	25	—	—	14	—
GHC	1	65	—	14	—	—	14 ③	—
GHC	2, 3	—	65	—	—	14	14	—
HGHC	1	65	—	25	—	—	14	—

① Time constant is 8 milliseconds minimum.
② Two poles of three-pole circuit breaker.
③ 15–70 A breakers only.

Table 27.4-53. Terminal Types

Circuit Breaker Amperes	Terminal Body Material ④	Wire Type	AWG Wire Range
15–20 25–100	Clamp (plated steel) Pressure (aluminum body)	Cu/Al Cu/Al	(1) #14–10 (1) #10–1/0
15–20 25–60	Clamp Pressure	Cu/Al Cu/Al	(1) #14–#10 AWG (1) #10–1/0 AWG

④ UL listed for use with copper or aluminum conductors as noted.

GHCGFEP, GHBGFEP—277 V 30 mA GF Breaker

Application Notes

- Type GHB are bolt-on panelboard breakers while type GHC is a cable-in and cable-out breaker for stand-alone mounting typically in a control panel or separate enclosure
- GHCGFEP and GHBGFEP are earth leakage breakers, rated for 30 mA ground fault protection
- On all three-phase delta (240 V) grounded B phase applications, refer to Eaton
- 480Y/277 V, circuit breakers (Type GHB) not suitable for three-phase delta (480 V) grounded B phase applications
- All two- and three-pole circuit breakers are of the common trip type
- Single-pole circuit breakers, 15 and 20 A. Switching duty rated (SWD) for fluorescent lighting applications
- Suitable for reverse-feed applications
- HACR rated

Terminals

Line side (on GHC) and load side (on GHC and GHB) terminals are UL listed as suitable for wire type and size listed below. When used with aluminum conductors, use joint compound.

Table 27.4-54. Terminals

Breaker Amperes	Terminal Type	Wire Type	Wire Range
15–20 25–60	Clamp Pressure	Cu/Al Cu/Al	#14–#10 AWG #10 –1/0 AWG

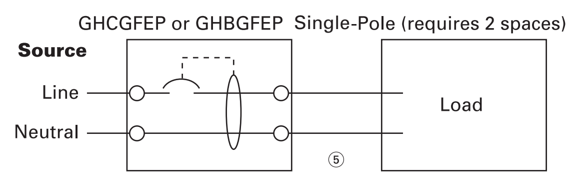

Figure 27.4-6. Electrical Schematic

⑤ Do not ground neutral anywhere on load side of breaker.

Series C Selection Data—F-Frame

Series C, F-Frame Thermal-Magnetic 10–225 A Electronic RMS 15–225 A

F-Frame Breaker

Table 27.4-55. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
1 2	1.38 (34.8) 2.75 (69.9)	6.00 (152.4) 6.00 (152.4)	3.38 (85.7) 3.38 (85.7)
3 4	4.13 (104.8) 5.50 (139.7)	6.00 (152.4) 6.00 (152.4)	3.38 (85.7) 3.38 (85.7)

Table 27.4-56. Thermal-Magnetic Trip Ratings

Frame	Ratings
ED, EDH, EDC	100, 125, 150, 175, 200, 225
EHD, FDB, FD, HFD, FDC, HFDDC	10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150
FD, HFD, FDC	175, 200, 225

Table 27.4-57. Digitrip 310+ Electronic Trip Units

Types	Frame	Ratings
FDE, HFDE, FDCE	225	100, 110, 125, 150, 160, 175, 200, 225
	160	60, 70, 80, 90, 100, 125, 150, 160
	80	15, 20, 30, 40, 50, 60, 70, 80

Table 27.4-58. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type ①	Interrupting Capacity (Symmetrical Amperes)					
			Volts AC (50/60 Hz)				Volts DC	
			240	277	480	600	125	250 ②③
EDB EDS	2, 3 2, 3	N.I.T.	22,000 42,000	— —	— —	— —	10,000 10,000	— —
ED EDH EDC ④	2, 3 2, 3 2, 3	N.I.T.	65,000 100,000 200,000	— — —	— — —	— — —	10,000 10,000 10,000	— — —
EHD	1 2, 3	N.I.T.	— 18,000	14,000 —	— 14,000	— —	10,000 —	— 10,000
FDB	2, 3, 4	N.I.T.	18,000	—	14,000	14,000	—	10,000
FD FD FDE ⑤	1 2, 3, 4 2, 3, 4	N.I.T.	— 65,000 65,000	35,000 — —	— 35,000 35,000	— — 18,000	10,000 — —	— 10,000 —
HFD HFD HFDE ⑤	1 2, 3, 4 2, 3, 4	N.I.T.	— 100,000 100,000	65,000 — —	— 65,000 65,000	— — 25,000	10,000 — —	— 22,000 —
FDC ④ FDCE ⑤	2, 3, 4	N.I.T.	200,000	—	100,000	35,000 25,000	—	22,000
HFDDC ⑥	3	N.I.T.	—	—	—	—	—	42,000 ⑦

① N.I.T. is non-interchangeable trip unit.
② Two-pole circuit breaker, or two poles of three-pole circuit breaker.
③ Time constant is 3 milliseconds minimum at 10 kA and 8 milliseconds minimum at 22 kA.
④ Current limiting.
⑤ Electronics available on three-pole only.
⑥ HFDDC is UL only and is not tested to other standards.
⑦ Interrupting rating is 35,000 A at 600 Vdc with three poles in series, for ungrounded systems only.

Table 27.4-59. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ⑧	Wire Type	AWG Wire Range	Metric Wire Range (mm^2)	Catalog Number
					Package of 3 Terminals
Standard Pressure Type Terminals					
20 (EHD)	Steel	Cu/Al	(1) #14–#10	2.5–4	**3T20FB** ⑨
100	Steel	Cu/Al	(1) #14–1/0	2.5–50	**3T100FB**
150	Aluminum	Cu/Al	(1) #4–4/0	25–95	**3TA150FB**
225	Aluminum	Cu/Al	(1) #4–4/0	25–95	**3TA225FD**
Optional Pressure Terminals					
50	Aluminum	Cu/Al	(1) #14–#4	2.5–16	**3TA50FB** ⑨
100	Aluminum	Cu/Al	(1) #14–1/0	2.5–50	**3TA100FD**
150	Stainless Steel	Cu	(1) #4–4/0	25–95	**3T150FB**
225	Aluminum	Cu/Al	(1) #6–300 kcmil	16–150	**3TA225FDK**

⑧ UL listed for use with copper or aluminum conductors as noted.
⑨ Not for use with ED, EDH, EDC breakers.

Series C, J-Frame Thermal-Magnetic, 70–250 A

J-Frame Breaker

Table 27.4-60. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
2, 3	4.13 (104.8)	10.00 (254.0)	4.06 (103.2)
4	5.50 (139.7)	10.00 (254.0)	4.06 (103.2)

Table 27.4-61. Thermal-Magnetic Trip Ratings

Frame	Ratings
JDB, JD, HJD JDC, HJDDC	70, 90, 100, 125, 150, 175, 200, 225, 250

Table 27.4-62. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type ①	Interrupting Capacity (Symmetrical Amperes)				
			Volts AC (50/60 Hz)			Volts DC	
			240	480	600	250 ②③	600 ④
JDB	2, 3	N.I.T.	65,000	35,000	18,000	10,000	—
JD	2, 3, 4	I.T.	65,000	35,000	18,000	10,000	—
HJD	2, 3, 4	I.T.	100,000	65,000	25,000	22,000	—
JDC ⑤	2, 3, 4	I.T.	200,000	100,000	35,000	22,000	—
HJDDC	3 ⑥	I.T.	—	—	—	42,000 ⑦	35,000 ⑥

① N.I.T. is non-interchangeable trip; I.T. is interchangeable trip.
② Two-pole circuit breaker or two outside poles of three-pole circuit breaker.
③ Time constant is 3 milliseconds minimum at 10 kA and 8 milliseconds minimum at 22 kA.
④ 8 milliseconds time constant.
⑤ Current limiting.
⑥ Three poles in series.
⑦ Two poles in series.

Table 27.4-63. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ⑧	Wire Type	AWG Wire Range	Metric Wire Range (mm^2)	Catalog Number
Standard Cu/Al Pressure Terminals					
250	Aluminum	Cu/Al	(1) #4–350 kcmil	25–185	**TA250KB**
250	Stainless steel	Cu	(1) #4–350 kcmil	25–185	**T250KB**

⑧ UL listed for use with copper or aluminum conductors as noted.

Series C Selection Data—K-Frame

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Series C, K-Frame Electronic RMS, 70–400 A Thermal-Magnetic, 100–400 A

K-Frame Breaker

Table 27.4-64. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
2, 3	5.50 (139.7)	10.13 (257.2)	4.06 (103.2)
4	7.22 (183.4)	10.13 (257.2)	4.06 (103.2)

Table 27.4-65. Thermal-Magnetic Trip Ratings

Frame	Ratings
DK, KDB, KD, HKD, KDC, HKDDC,	100, 125, 150, 175, 200, 225, 250, 300, 350, 400

Table 27.4-66. Digitrip 310+ Electronic Trip Units

Frame	Ratings
KD, CKD, HKD, CHKD, KDC	55, 60, 70, 90, 100, 110, 125, 150, 160, 175, 200, 225, 250, 300, 315, 350, 400

Table 27.4-67. Digitrip OPTIM Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
KD, CKD, HKD, CHKD, KDC	70, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400

Table 27.4-68. NEMA/UL 489/CSA Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type ①	Interrupting Capacity (Symmetrical Amperes)				
			Volts AC (50/60 Hz)			Volts DC	
			240	480	600	250 ②③	600 ④
DK	2, 3	N.I.T.	65,000	—	—	10,000	—
KDB	2, 3, 4	N.I.T.	65,000	35,000	25,000	10,000	—
KD	2, 3, 4	I.T.	65,000	35,000	25,000	10,000	—
HKD	2, 3, 4	I.T.	100,000	65,000	35,000	22,000	—
KDC ⑤	2, 3, 4	I.T.	200,000	100,000	65,000	22,000	—
HKDDC	3	I.T.	—	—	—	42,000 ⑦	35,000 ⑧
CKD ⑥	3	I.T.	65,000	35,000	25,000	—	—
CHKD ⑥	3	I.T.	100,000	65,000	35,000	—	—

① N.I.T. is non-interchangeable trip; I.T. is interchangeable trip.
② Two-pole circuit breaker or two outside poles of three-pole circuit breaker.
③ Time constant is 3 milliseconds minimum at 10 kA and 8 milliseconds minimum at 22 kA.
④ 8 milliseconds time constant.
⑤ Current limiting.
⑥ 100% rated.
⑦ Two poles in series.
⑧ Three poles in series.

Table 27.4-69. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material	Wire Type	AWG/Wire Range/Number Conductors	Metric Wire Range (mm^2)	Catalog Number
Standard Cu/Al Pressure Terminals					
225	Aluminum	Cu/Al	3–350 (1)	35–185	**TA300K** ⑨
350	Aluminum	Cu/Al	250–500 (1)	120–240	**TA350K** ⑨
400	Aluminum	Cu/Al	3/0–250 (2)	95–120	**2TA400K** ⑩⑪ **3TA400K** ⑩⑫ **4TA400K** ⑬⑭
Optional Copper and Cu/Al Pressure Type Terminals					
225	Copper	Cu	3–350 (1)	35–185	**T300K** ⑨
350	Copper	Cu	50–500 (1)	120–240	**T350K** ⑨
400	Copper	Cu	3/0–250 (2)	95–120	**2T400K** ⑪ **3T400K** ⑫ **4T400K** ⑬
400	Aluminum	Cu/Al	2/0–250 (2) or 2/0–500 (1)	70–120 70–240 70–240	**2TA401K** ⑩⑪ **3TA401K** ⑩⑫ **4TA401K** ⑬⑭
400	Aluminum	Cu/Al	500–750 (1)	300–400	**2TA402K** ⑩⑪ **3TA402K** ⑩⑫ **4TA402K** ⑬⑭
400	Copper	Cu/Al	500–750 (1)	—	**2T402K** ⑩⑪ **3T402K** ⑩⑫ **4T402K** ⑬⑭

⑨ Individually packed.
⑩ Terminal kits contain one terminal for each pole and one terminal cover.
⑪ Two-pole kit.
⑫ Three-pole kit.
⑬ Four-pole kit.
⑭ Terminal kits contain one terminal for each pole and three interphase barriers.

Series C, L-Frame Electronic RMS, 70–600 A Thermal-Magnetic, 300–600 A

L-Frame Breaker

Table 27.4-70. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
2, 3	8.25 (209.6)	10.75 (273.1)	4.06 (103.2)
4	11.00 (279.4)	10.75 (273.1)	4.06 (103.2)

Table 27.4-71. Thermal-Magnetic Trip Ratings

Frame	Ratings
LDB, LD, CLD, HLD, CHLD, LDC, CLDC, HLDDC	300, 350, 400, 450, 500, 600

Table 27.4-72. Digitrip 310 Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
LDB, LD, CLD, HLD, CHLD, LDC, CLDC	300, 350, 400, 450, 500, 600 300/600 adjustable

Table 27.4-73. Digitrip OPTIM Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
LD, CLD, HLD, CHLD, LDC, CLDC	70, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 500, 600

Table 27.4-74. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type ①	Interrupting Capacity (rms Symmetrical Amperes)				
			Volts AC (50/60 Hz)			Volts DC	
			240	480	600	250 ②③	600
LDB	2, 3	N.I.T.	65,000	35,000	25,000	22,000	—
LD, CLD ④	2, 3, 4	I.T.	65,000	35,000	25,000	22,000	—
HLD	2, 3, 4	I.T.	100,000	65,000	35,000	25,000	—
CHLD ④	2, 3, 4	I.T.	100,000	65,000	35,000	—	—
LDC ⑤	2, 3, 4	I.T.	200,000	100,000	50,000	30,000	—
CLDC ④⑤	2, 3, 4	I.T.	200,000	100,000	50,000	—	—
HLDDC	3	I.T.	—	—	—	42,000 ⑥	35,000 ⑦

① N.I.T. is non-interchangeable trip; I.T. is interchangeable trip.
② L/R = 8 milliseconds minimum.
③ Two-pole circuit breaker or two poles of three-pole circuit breaker. Incorporating T/M trip unit only.
④ 100% rated.
⑤ Current limiting.
⑥ Two poles in series.
⑦ Three poles in series.

Table 27.4-75. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ⑧	Wire Type	AWG/kcmil Wire Range/ Number of Conductors	Metric Wire Range (mm^2)	Catalog Number
Standard Cu/Al Pressure Terminals					
400	Aluminum	Cu/Al	(1) 4/0–600 kcmil	120–300	**2TA401LDK** (two-pole kit) ⑨ **3TA401LDK** (three-pole kit) ⑨ **4TA401LDK** (four-pole kit) ⑨
500 600	Aluminum Aluminum	Cu/Al Cu/Al	(2) 250–350 kcmil (2) 400–500 kcmil	120–150 185–240	**TA602LD** **2TA603LDK** (two-pole kit) ⑨ **3TA603LDK** (three-pole kit) ⑨ **4TA603LDK** (four-pole kit) ⑨
Optional Copper Pressure Type Terminals					
600	Copper	Cu	(2) 250–350 kcmil	120–150	**T602LD**

⑧ UL listed for use with copper or aluminum conductors as noted.
⑨ Terminal kits contain one terminal for each pole and one terminal cover.

Series C, M-Frame Electronic RMS, 400–800 A Thermal-Magnetic, 300–800 A

M-Frame Breaker

Table 27.4-76. Dimensions in Inches (mm)

Width	Height	Depth
8.25 (209.6)	16.00 (406.4)	4.06 (103.2)

Table 27.4-77. Thermal-Magnetic Trip Ratings

Frame	Ratings
MDL	300, 400, 450, 500, 600, 700, 800

Table 27.4-78. Digitrip 310 Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
MDL	400, 500, 600, 700, 800, 400/800 adjustable

Table 27.4-79. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type ①	Interrupting Capacity (rms Symmetrical Amperes)			
			Volts AC (50/60 Hz)			Volts DC ②③
			240	480	600	250
MDL, CMDL ④ HMDL, CHMDL ④	2, 3 2, 3	N.I.T. N.I.T.	65,000 100,000	50,000 65,000	25,000 35,000	22,000 25,000

① N.I.T. is non-interchangeable trip unit.
② Two poles or two poles of three-pole circuit breaker. Thermal-magnetic trip units only, MDL, HMDL breakers with electronic trip unit are not DC rated.
③ Time constant is 3 milliseconds minimum at 10 kA and 8 milliseconds minimum at 22 kA.
④ 100% rated. Not for use on DC.

Table 27.4-80. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ⑤	Wire Type	AWG/kcmil Wire Range/Number of Conductors	Catalog Number
Standard Cu/Al Pressure Terminals				
600 800 800	Aluminum Aluminum Aluminum	Cu/Al Cu/Al Cu/Al	(2) #1–500 kcmil (3) 3/0–400 kcmil (2) 500–750 kcmil	**TA700MA1** **TA800MA2** **TA801MA**
Optional Copper and Cu/Al Pressure Type Terminals				
600 800	Copper Copper	Cu Cu	(2) 2/0–500 kcmil (3) 3/0–300 kcmil	**T600MA1** **T800MA1**

⑤ UL listed for use with copper or aluminum conductors as noted.

Series C, N-Frame Electronic RMS, 400–1200 A

N-Frame Breaker

Table 27.4-81. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
2, 3	8.25 (209.6)	16.00 (406.4)	5.50 (139.7)
4	11.13 (282.6)	16.00 (406.4)	5.50 (139.7)

Table 27.4-82. Digitrip 310 Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
800	400, 450, 500, 600, 700, 800 ①
1200	600, 700, 800, 900, 1000, 1100,1200 ①

① Adjustable rating plug available.

Table 27.4-83. Digitrip OPTIM Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
800	400, 450, 500, 550, 600, 700, 800
1200	600, 700, 800, 1000, 1200

Table 27.4-84. UL 489 Interrupting Capacity Ratings

Circuit Breaker Type	Number of Poles	Trip Type ②	Interrupting Capacity (Symmetrical Amperes) Volts AC (50/60 Hz) 240	277	480	600
ND, CND ③	2, 3, 4	N.I.T.	65,000	—	50,000	25,000
HND	2, 3, 4	N.I.T.	100,000	—	65,000	35,000
CHND ③	2, 3, 4	N.I.T.	100,000	—	65,000	35,000
NDC	2, 3, 4	N.I.T.	200,000	—	100,000	65,000
CNDC ③	2, 3, 4	N.I.T.	200,000	—	100,000	65,000
NDU ⑤	3	N.I.T.	300,000 ⑥	—	150,000	75,000 ④

② N.I.T. is non-interchangeable trip unit.
③ 100% rated.
④ 800 A maximum rating.
⑤ Successfully tested at 300 kAIC, although UL recognizes maximum of 200 kAIC at 240 Vac.
⑥ Successfully tested at 75 kAIC, although UL recognizes maximum of 65 kAIC at 600 Vac.

Table 27.4-85. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ⑦	Wire Type	AWG/kcmil Wire Range/Number of Conductors	Metric Wire Range (mm^2)	Catalog Number
Standard Cu/Al Pressure Terminals					
700	Aluminum	Cu/Al	(2) 1–500 kcmil	50–300	**TA700NB1**
1000	Aluminum	Cu/Al	(3) 3/0–400 kcmil	95–185	**TA1000NB1**
1200	Aluminum	Cu/Al	(4) 4/0–500 kcmil	120–300	**TA1200NB1**
1200	Aluminum	Cu/Al	(3) 500–750 kcmil	300–400	**TA1201NB1**
Optional Copper and Cu/Al Pressure Type Terminals					
700	Copper	Cu	(2) 2/0–500 kcmil	70–300	**T700NB1**
1000	Copper	Cu	(3) 3/0–500 kcmil	95–300	**T1000NB1**
1200	Copper	Cu	(4) 3/0–400 kcmil	95–185	**T1200NB3**

⑦ UL listed for use with copper or aluminum conductors as noted.

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Series C, R-Frame Electronic RMS, 800–2500 A

R-Frame Breaker

Table 27.4-86. Dimensions in Inches (mm)

Number of Poles	Width	Height	Depth
3	15.50 (393.7)	16.00 (406.4)	9.75 (247.7)
4	20.00 (508.0)	16.00 (406.4)	9.75 (247.7)

Table 27.4-87. Digitrip 310 Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
1600	800, 1000, 1200, 1250, 1400, 1500, 1600 ①
2000	1000, 1200, 1250, 1400, 1600, 2000 ①
2500	1200, 1250, 1600, 2000, 2500 ①

① Adjustable rating plug available.

Table 27.4-88. Digitrip 510/610/810/910 and Digitrip OPTIM Electronic Trip Unit Rating Plugs

Frame	Rating Plugs
1600	800, 1000, 1200, 1600
2000	1000, 1200, 1600, 2000
2500	1600, 2000, 2500

Table 27.4-89. UL 489 Interrupting Capacity Ratings

Circuit Breaker Frame	Number of Poles	Trip Type ②	Interrupting Capacity (Symmetrical Amperes)			
			Volts AC (50/60 Hz)			
			240	277	480	600
RD	3, 4	N.I.T.	125	—	65	50
CRD ③	3, 4	N.I.T.	125	—	65	50
RDC	3, 4	N.I.T.	200	—	100	65
CRDC ③	3, 4	N.I.T.	200	—	100	65

② N.I.T. is non-interchangeable trip unit.
③ 100% rated versions.

Table 27.4-90. Line and Load Terminals

Maximum Breaker Amperes	Terminal Body Material ②	Wire Type	Hardware	AWG/kcmil Wire Range/Number of Conductors	Metric Wire Range (mm^2)	Catalog Number
Wire Terminal						
1600	Aluminum	Cu/Al	English	(4) 500–1000 kcmil	300–500	**TA1600RD**
1600	Copper	Cu	English	(4) 1–600 kcmil	50–300	**T1600RD**
2000	Aluminum	Cu/Al	English	(6) 2–600 kcmil	35–300	**TA2000RD**

④ UL listed for use with copper or aluminum conductors as noted.

Series G Accessories and Modifications

Table 27.4-91. Series G Breaker Accessories and Modifications

Breaker Frame	E	J	L	N	R
Internal Accessories ①					
Alarm lockout (make/break)	■	■	■	■	■
Auxiliary switch (1A, 1B)	■	■	■	■	■
Auxiliary switch (2A, 2B)	■	■	■	■	■
Auxiliary switch and alarm switch combination	■	■	■	■	■
Shunt trip	■	■	■	■	■
Undervoltage release mechanism	■	■	■	■	■
External Accessories					
Control wire kit	■	■			
Multi-wire kit	■	■			
End cap kit	■	■	■		
Base mounting hardware	■	■	■	■	■
Terminal cover	■		■		
Terminal shields	■				
Terminal end covers	■				
Interphase barriers	■	■		■	
Handle mechanisms	■	■	■	■	■
Handle extension			■	■	■
Non-padlockable handle block	■			■	
Padlockable handle block		■	■		
Padlockable handle lock hasp	■		■	■	■
Key interlock kit		■	■	■	■
Sliding bar/walking beam interlock	■	■	■	■	
Electrical operator	■	■	■	■	■
Rear connecting studs			■	■	
Plug-in adapters	■	■	■	■	
Drawout cassette		■	■	■	■
Earth leakage/ground fault protector		■	■		
Power monitoring and metering module		■	■		
Cause-of-Trip LED module		■	■	■	■
Ammeter/Cause-of-Trip display		■	■	■	■
DIgitrip 310+ test kit		■	■	■	■
Modifications ②					
Moisture fungus treatment	■	■	■	■	■
Freeze-tested circuit breakers	■	■	■	■	■
Marine/naval application, UL 489 Supplement SA and SB	■	■	■	■	■

① Only one per pole.
② Refer to the Eaton.

Series C Breaker Accessories and Modifications

Table 27.4-92. Series C Breaker Accessories and Modifications

Breaker Frame	G	F	J	K	L	M	N	R
Termination Accessories								
Line and load terminals	■	■	■	■	■	■	■	■
Plug nut		■	■					
Control wire terminal kit		■	■	■				
Base mounting hardware	■	■	■	■	■	■	■	■
Terminal shields		■	■	■	■	■		
Interphase barriers		■	■	■	■		■	
Multiwire connectors		■	■	■	■	■		
Internal Accessories								
Alarm lockout (1 make/1 break)	■	■ ①	■	■	■	■	■	■
Alarm lockout (2 make/2 break)		■		■	■		■	■
Auxiliary switch (1A, 1B)	■	■	■	■	■	■	■	
Auxiliary switch (2A, 2B)	■	■	■	■	■	■	■	■
Auxiliary switch (3A, 3B)			■	■	■		■	
Auxiliary switch (4A, 4B)								■
Auxiliary switch (1A, 1B)/alarm lockout	■	■	■	■	■	■	■	
Auxiliary switch (2A, 2B)/alarm lockout					■		■	
Auxiliary switch (3A, 3B)/alarm lockout					■			
Standard shunt trip	■	■	■	■	■	■	■	■
Low energy shunt trip		■	■	■	■		■	■
Undervoltage release mechanism	■	■	■	■	■	■	■	■
External Accessories								
Non-padlockable handle block	■	■	■	■	■	■	■	
Padlockable handle block		■	■	■	■	■	■	
Padlockable handle lock hasp	■	■	■	■				■
Cylinder lock		■	■	■				
Key interlock kit		■	■	■	■	■	■	■
Sliding bar interlock ②		■	■	■	■	■	■	
Walking beam interlock ②		■		■	■	■	■	
Electrical (solenoid) operator		■	■	■	■	■	■	
Electrical (motor) operator								■
IQ Energy Sentinel		■	■	■				
LFD current limiter		■						
Plug-in adapters		■	■	■	■	■	■	
Drawout cassette								■
Rear connecting studs		■	■	■	■	■	■	
Panelboard connecting straps		■	■	■	■	■	■	
Handle mechanisms	■	■	■	■	■	■	■	■
Door hardware/accessories		■	■	■	■	■		
Solid-state (electronic) test kit		■		■	■	■	■	■
Handle extension			■	■	■	■	■	■
Ammeter/Cause-of-Trip display		■						
Cause-of-Trip LED module		■						
Power monitoring and metering module (PM3)		■		■				
Digitrip 310+ test kit		■						
Modifications ③								
Special calibration		■	■	■	■	■	■	■
Moisture fungus treatment		■	■	■	■	■	■	■
Freeze-tested circuit breakers		■	■	■	■	■	■	■
Marine application		■	■	■	■	■	■	■

① Make only (one pole).
② Requires two breakers.
③ Refer to the Eaton.

High Instantaneous Circuit Breaker for Selective Coordination

High Instantaneous Circuit Breaker

General Description

Eaton's Electrical Sector introduces new high-magnetic withstand molded-case circuit breakers, specifically designed for critical operations and selective coordination requirements. The high-magnetic withstand LHH and NHH frames continue the legacy of circuit breaker innovation for which Eaton is recognized throughout the world. The LHH and NHH breakers are equipped with 125 to 400 A trip units with high-magnetic capability. This design enables the breakers to withstand up to 90 times rated current before opening under short-circuit conditions.

The LHH and NHH circuit breakers incorporate a higher level of instantaneous pickup, thus allowing for higher current levels of selective coordination. Standard molded-case circuit breakers typically are furnished with a magnetic pickup or electronic instantaneous adjustment or instantaneous override set at 10 times (10x) the continuous trip rating.

Features, Benefits and Functions

Eaton's LHH and NHH molded-case circuit breakers are furnished with a higher level of magnetic pickup or electronic instantaneous settings as indicated in **Table 27.4-95**. These higher levels of magnetic pickup and electronic instantaneous values in turn allow the system designer to obtain selective coordination at fault current levels up to these higher ratings. Greater values of selective coordination are available based on manufacturer tested combinations using the LHH and NHH as line-side breakers and standard breakers as load-side devices. Refer to IA01200002E to determine the maximum fault values that selective coordination achieves. When the line-side and load-side molded-case circuit breaker trip ratings are chosen to coordinate in the overload range, they also can be selectively coordinated in the fault range up to the values listed in **Table 27.4-95** or IA01200002E. For overcurrents protected by circuit breakers on the load-side of the LHH or NHH, only the effected load-side circuit breaker will open, while the line-side LHH and/or NHH circuit breakers remain closed, thus providing continuity of power to the other critical loads supplied by the LHH or NHH circuit breakers.

Benefits of Using the LHH and NHH Molded-Case Circuit Breakers

Customer expectations and codes are driving product development to protect customers' critical operations. NEC® 2005 and 2008 requires circuits with elevators, emergency systems, legally required standby systems, health care essential systems and critical operation power systems to be selectively coordinated. Simply stated, only the closest protective device directly protecting the circuit having an overcurrent (overload or fault) condition should open.

All other overcurrent protective devices within these systems shall remain closed. Similarly, backup power system designs of a critical nature that are not code mandated may also require overcurrent protective devices to be selectively coordinated as much as practicable to provide a higher level of uptime.

Proven Technology and Performance

The LHH is based on the Series G L-Frame circuit breaker, sharing the same small footprint and field-fit accessories as the L-Frame breaker. The NHH is based on the Series G N-Frame circuit breaker and shares the same footprint and accessories as the N-Frame breaker. NHH accessories must be factory installed.

The LHH incorporates a thermal-magnetic trip unit with fixed thermal and fixed magnetic settings. The NHH has an OPTIM™ electronic trip unit with LSI adjustment capabilities. The instantaneous setting is adjustable from 1000 to 4000 A or may be turned off to default to the frame override of 14,000 A. A hand-held OPTIMizer must be used with the NHH to adjust short-time delay and instantaneous; however, the long delay pickup is fixed and cannot be adjusted.

The LHH and NHH breakers are available in Eaton's panelboards and switchboards.

Standards and Certifications

- UL
- CSA

Product Selection

Table 27.4-93. LHH and NHH Catalog Numbers

Ampere Rating	Thermal-Magnetic Trip Unit	LSI Electronic Trip Unit
	LHH Frame	NHH Frame
125	LHH3125FFG	—
150	LHH3150FFG	NHH3150T52X15
175	LHH3175FFG	NHH3175T52X15
200	LHH3200FFG	NHH3200T52X15
225	LHH3225FFG	NHH3225T52X15
250	LHH3250FFG	NHH3250T52X15
300	LHH3300FFG	NHH3300T52X15
350	LHH3350FFG	NHH3350T52X15
400	LHH3400FFG	—

Technical Data and Specifications

- Three-pole
- 65 kAIC at 480 Vac
- 125–400 A LHH
- 150–350 A NHH
- Trip units:
  - LHH—thermal-magnetic
  - NHH—LSI electronic trip unit
- No rating plugs required
- Factory-sealed breakers
- LHH uses same internal and external accessories as standard Series G L-Frame circuit breaker
- NHH uses same internal and external accessories as standard Series G N-Frame circuit breaker

LHH and NHH Electrical Characteristics

Table 27.4-94. Short-Circuit Current Ratings (kA rms) AC 50–60 Hz

Description	Breaker Type	
	LHH	NHH
Max. rated current (amperes)	400	350
NEMA UL 489		
240 Vac 480 Vac 600 Vac 250 Vac	100 65 35 42	100 65 35 —
IEC 60947-2		
220 Vac 415 Vac 690 Vac 125/250 Vdc	100 70 25 22	100 70 25 —
Number of poles Ampere range	3 125–400	3 150–350

Table 27.4-95. Continuous Current Ratings

Continuous Current Rating Amperes	LHH		NHH		
	Magnetic Trip Point Amperes	Continuous Current Multiplier	Instantaneous Trip Point Amperes	Continuous Current Multiplier	Short Delay Pickup Amperes
125	2500	20x	—	—	—
150	2500	16x	14,000	93x	225–1200
175	4000	22x	14,000	80x	260–1400
200	4000	20x	14,000	70x	300–1600
225	6000	26x	14,000	62x	338–1800
250	6000	24x	14,000	56x	375–2000
300	6000	20x	14,000	47x	450–2400
350	6000	17x	14,000	40x	525–2800
400	6000	15x	—	—	—

High Instantaneous Breakers

Dimensions—Approximate Dimensions in Inches (mm)

Table 27.4-96. Dimensions

Description	Height	Width	Depth	Weight in Lb (kg)
LHH NHH	10.13 (257.3) 16.00 (406.4)	5.48 (139.2) 8.25 (209.5)	4.09 (103.9) 5.50 (139.7)	12.36 (5.6) 46.80 (21.2)

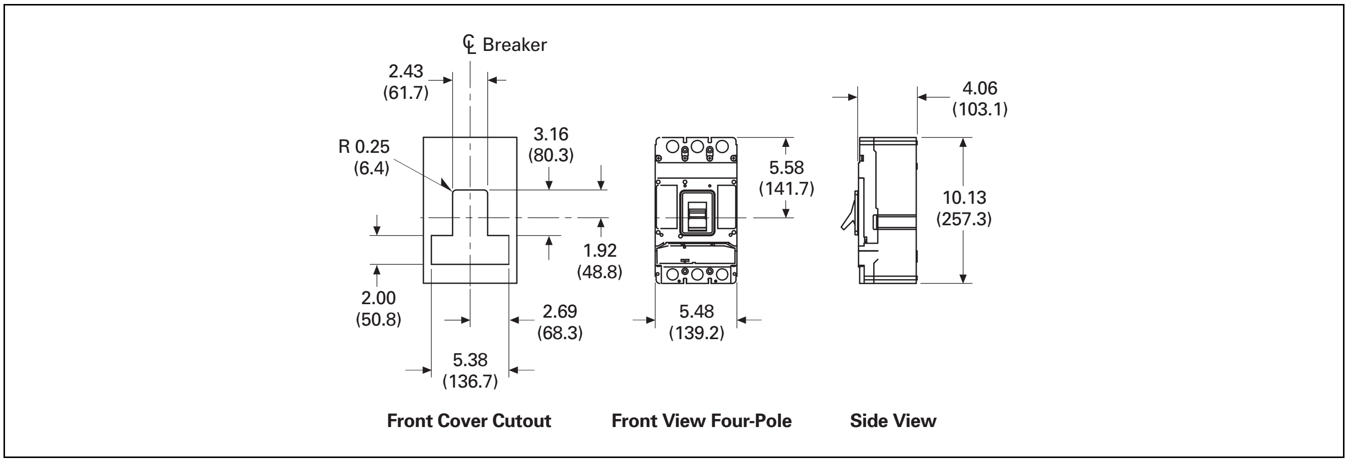


Figure 27.4-7. L-Frame

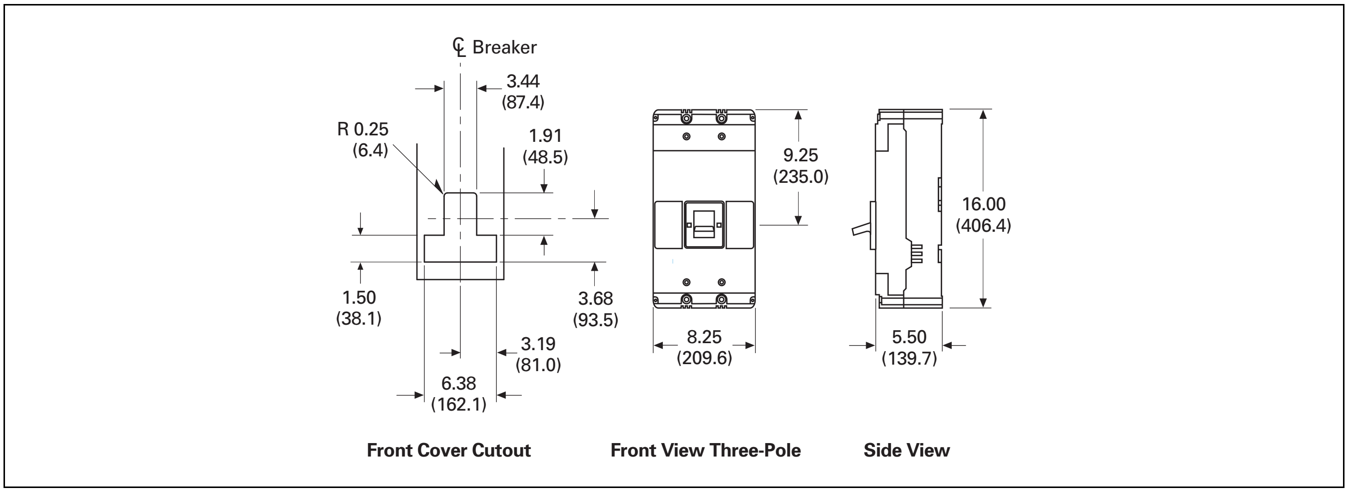


Figure 27.4-8. N-Frame

Motor Circuit Protectors, 3–1200 A

Motor Circuit Protectors 3–1200 A

Catalog Numbering System

Note: This information is presented only as an aid to understanding catalog numbers. It is not to be used to build catalog numbers for circuit breakers or trip units.

Table 27.4-97. HMCP

HMCP 003 A0 C

Motor Circuit Protector Type

HMCP = 3-pole
HM2P = 2-pole ①
HMCPS = 3-pole

Continuous Ampere Rating

003 = 3
007 = 7
015 = 15
025 = 25
030 = 30
050 = 50
070 = 70
100 = 100
150 = 150
250 = 250
400 = 400
600 = 600
800 = 800
12 = 1200

Magnetic Trip Range/ NEMA Starter Size

A0 = 9–30/0	**D5** = 500–1000/5
C0 = 21–70/0	**F5** = 625–1250/5
E0 = 45–150/0	**G5** = 750–1500/5
D0 = 40–60/0	**J5** = 875–1750/5
H1 = 90–300/1	**K5** = 1000–2000/5
G2 = 80–120/2	**L5** = 1125–2250/5
K2 = 150–500/2	**W5** = 1250–2500/5
J2 = 115–170/2	**N5** = 1500–3000/5
M2 = 210–700/2	**R5** = 1750–3500/5
L3 = 160–240/3	**X5** = 2000–4000/5
R3 = 300–1000/3	**L6** = 1800–6000/6
T4 = 450–1500/4	**X6** = 500–2500
U4 = 750–2500/4	**Y6** = 1000–4000
A5 = 350–700/5	**X7** = 1600–6400
C5 = 450–900/5	**Y8** = 2400–9600

Suffix

C = Non-aluminum terminals
W = W/O terminals
X = Load terminals only
Y = Line terminals only
S = Stainless steel terms (150 A frame only)
No Suffix = Standard terminals on line and load (electronic)

① On J- and K-Frame HMCPs only.

Table 27.4-98. GMCP/HMCPE

GMCP/HMCPE 003 A0 C

Motor Circuit Protector Type

GMCP = 3-pole
HMCPE = 3-pole

Continuous Ampere Rating

003 = 3
007 = 7
015 = 15
030 = 30
050 = 50
060 = 60
063 = 63
070 = 70
100 = 100

Magnetic Trip Range

GMCP	HMCPE
A0 = 15–30	**A0** = 9–33
C0 = 35–70	**C0** = 21–77
E0 = 75–150	**E0** = 45–165
H1 = 150–300	**H1** = 90–330
K2 = 250–500	**K2** = 150–550
J2 = 300–600	**M2** = 210–770
M2 = 320–630	**R3** = 300–1100
	T3 = 500–1500

Suffix

C = Non-aluminum terminals

Table 27.4-99. 600 Vac Maximum, 250 Vdc Minimum

Continuous Amperes	MCP Trip Range (Amperes)	MCP Catalog Number
JG-Frame ②		
250	500–1000	**HMCPJ250D5L**
	625–1250	**HMCPJ250F5L**
	750–1500	**HMCPJ250G5L**
	875–1750	**HMCPJ250J5L**
	1000–2000	**HMCPJ250K5L**
	1125–2250	**HMCPJ250L5L**
	1250–2500	**HMCPJ250W5L**
LG-Frame ②③		
600	1125–2250	**HMCPL600L6G**
	1500–3000	**HMCPL600N6G**
	1750–3500	**HMCPL600R6G**
	2000–4000	**HMCPL600X6G**
	2250–4500	**HMCPL600Y6G**
	2500–5000	**HMCPL600P6G**
	3000–6000	**HMCPL600M6G**

② UL listed for use with Eaton motor starters.
③ Equipped with an electronic trip device.

Motor Circuit Protector Catalog Numbers and Ranges

Tables are available to provide specific catalog numbers and application ranges for the G-Frame (GMCP), E-Frame (HMCPE), J-Frame (HMCP) and K-Frame (HMCP) motor circuit protectors. Motor circuit protector models are available with earth leakage ground fault protection. Models are also available for motor starters provided with electronic overload relays rather than thermal overload relays, such as the Eaton's Advantage™ motor starter.

Similar tables for the selection of the settings are available with motor control products that use motor circuit protectors. As required by the NEC, the HMCP setting is selected by using the actual full load ampere data from the motor nameplate. The corresponding trip settings provided are within 13 times the minimum full load amperes of the motor as required by the NEC. The NEC allows a higher setting for Design B energy efficient motors.

See Volume 4—Circuit Protection Catalog, CA08100005E, (Molded-Case Circuit Breakers, Tab 2) for detailed tables.

Accessories

Termination Accessories

- Line and load terminals
- Keeper nut/plug nut
- Control wire terminal kit
- Base mounting hardware
- Terminal shields
- Terminal end covers
- Interphase barriers
- ELC current limiter
- Multiwire connector

Internal Accessories

- Only one internal accessory per pole maximum
- Alarm lockout (make/break)
- Alarm lockout (2 make/2 break)
- Auxiliary switch (1A, 1B)
- Auxiliary switch (2A, 2B)
- Auxiliary switch/alarm lockout
- Shunt trip—standard
- Shunt trip—low energy
- Undervoltage release mechanism

External Accessories

- Non-padlockable handle block
- Padlockable handle block
- Padlockable handle lock hasp
- Key interlock kit
- Sliding bar interlock—requires two breakers
- Electrical (solenoid) operator
- Handle mechanism
- Door hardware/accessories
- DIN rail adapter (GMCP only)

Modifications

- Moisture fungus treatment
- Freeze test

Series G Motor Protector Circuit Breaker (MPCB)

Series G Motor Protector Circuit Breaker (MPCB)

General Description

Eliminates need for separate overload relay.

Application Description

- Can be used with contactor to eliminate need for overload relay and still create manual motor control
- Meets requirement for motor branch protection, including:
  - Disconnecting means
  - Branch circuit short-circuit protection
  - Overload protection

Features

- Phase unbalance protection
- Phase loss protection
- Hot trip/cold trip
- High load alarm
- Pre-detection trip relay option
- Class 10, 15, 20, 30 protection

Standards and Certifications

- IEC 60947-2
- UL 489 rating
- CSA C22.2

Product Selection

Table 27.4-100. JGMP Catalog Numbers

Continuous Amperes	35 kAIC	65 kAIC
	Catalog Number	Catalog Number
50	JGMPS050G	JGMPH050G
100	JGMPS100G	JGMPH100G
160	JGMPS160G	JGMPH160G
250	JGMPS250G	JGMPH250G

Table 27.4-101. LGMP Catalog Numbers

Continuous Amperes	50 kAIC	65 kAIC
	Catalog Number	Catalog Number
250	LGMPS250G	LGMPH250G
400	LGMPS400G	LGMPH400G
600	LGMPS600G	LGMPH600G
630 ①	LGMPS630G	LGMPH630G

① 630 A is not a UL listed rating. 600 A is the maximum UL or CSA for LG breaker.

Note: For pre-trip alarm option, order style number 5721B31G02.

Technical Data

Table 27.4-102. JGMPS and JGMPH Rating and Ampere Range

Maximum Rated Current (Amperes)			250	
Breaker Type			**JGMPS**	**JGMPH**
Breaker Capacity (kA rms) AC 50–60 Hz				
IEC 60947-2	220–240 Vac	I cu	85	100
		I cs	85	100
	380–415 Vac	I cu	40	70
		I cs	40	70
	660–690 Vac	I cu	12	14
		I cs	6	7
NEMA UL 489	240 Vac		85	100
	480 Vac		35	65
	600 Vac		25	35
Number of poles			3	3
Ampere range			50–250	50–250

Table 27.4-103. LGMPS and LGMPH Rating and Ampere Range

Maximum Rated Current (Amperes)			630 ①	
Breaker Type			**LGMPS**	**LGMPH**
Breaker Capacity (kA rms) AC 50–60 Hz				
IEC 60947-2	220–240 Vac	I cu	85	100
		I cs	85	100
	380–415 Vac	I cu	50	70
		I cs	50	70
	660–690 Vac	I cu	20	25
		I cs	10	13
NEMA UL 489	240 Vac		85	100
	480 Vac		50	65
	600 Vac		25	35
Number of poles			3	3
Ampere range			250–630 ②	250–630 ②

② 630 A is not a UL listed rating. 600 A is the maximum UL or CSA for LG breaker.

Molded-Case Circuit Breaker Power Monitoring and Metering Module (PM3)

Power Monitoring/Metering Module (PM3)

General Description

The Power Monitoring and Metering Module (PM3) is a UL-listed add-on communications module that mounts directly to the load side of three-pole molded-case circuit breakers, similar to an earth leakage module. The PM3 adds revenue accurate power metering and breaker status monitoring to new and/or existing Series C and Series G breakers. Regardless of the type of trip unit (thermal-magnetic or electronic), the PM3 can be applied in applications where power metering, circuit breaker monitoring and/or communications is essential. The PM3 is extremely flexible and can be used in main breaker or feeder breaker applications. The automatic voltage sensing means that the same PM3 module can be used on 208, 240 or 480 Vac applications. It can also be installed in reverse-feed and reverse-phasing (CBA) applications.

Features and Functions

The PM3 provides the following metering, monitoring and communications functions:

Metering

- Phase currents (Ia, Ib, Ic, Iavg)
- Phase-to-phase voltages (Vab, Vbc, Vca, Vavg)
- Phase-to-neutral voltages (Van, Vbn, Vcn, Vavg)
- Real power (kW)—total and per phase
- Reactive power (kVAR)—total and per phase
- Apparent power (kVA)—total and per phase
- Power factor—total and per phase
- Real energy (WHr)—forward, reverse and net
- Reactive Energy (VARHr)—forward, reverse and net
- Apparent energy (VAHr)—forward, reverse and net

Accuracy

- Voltage and amperage: 0.5% of reading
- Watts, VARs, VA: 1% of reading
- Energy: 1% per ANSI C12.1
- Revenue Grade Accuracy: ANSI C12.1

Monitoring

- Breaker status ①
  - Open/close status—thru breaker auxiliary contact
  - Tripped status—thru breaker bell alarm contact
- Unit health—flashing status LED when module is powered

① Breaker must include auxiliary contact and bell alarm contact accessory.

Communications

- INCOM and Modbus RTU communications
  - Shielded-twisted pair communications
  - Daisy-chaining of multiple units
  - Web-based communications available through a Power Xpert Gateway
  - TX and RX communication diagnostic LEDs

Metering Module

Control Power

The PM3 is powered directly from the circuit breaker voltage for applications 480 Vac and below. External control power is not required for these applications. However, an auxiliary 24 Vdc external power input is included for applications requiring communications capability even when the breaker circuit is de-energized.

Note: For 600 V applications, external 24 Vdc auxiliary power is required.

Product Selection

Table 27.4-104. PM3 Product Selection

PM3 Modules Frame	Catalog Number	
	480 V	600 V
Modbus		
FD	—	**PM3FM**
JG	—	**PM3JM**
KD and LG	—	**PM3LM**
INCOM		
FD	**PM3FI480**	**PM3FI600**
JG	**PM3JI480**	**PM3JI600**
KD and LG	**PM3LI480**	**PM3LI600**

Technical Data and Specifications

Metered parameters

- Ia, Ib, Ic
- Vab, Vbc, Vca, Van, Vbn, Vcn
- Apparent Energy, Forward Real Energy, Reverse Real Energy, Net Real Energy, Lagging Reactive Energy, Leading Reactive Energy, Net Reactive Energy
- Apparent Power A, B, C; Apparent Power Total; Reactive Power A, B, C; Reactive Power Total; Real Power A, B, C; Real Power Total
- Frequency, Apparent Power Factor, Apparent PFA, Apparent PFB, Apparent PFC

Table 27.4-105. PM3 Power Monitoring and Communications Module Technical Specifications for Modbus RTU

Description	Specification	
Current Inputs		
Pickup current	0.3A rms	
Maximum reported current	FD/JG 250 A rms KD/LD 630 A rms	
Accuracy 0.5%	0.5% of reading	
Voltage Inputs		
Range	Line-to-neutral 30–366 Vac Line-to-line 52–635 Vac	
Supported systems	Three-element wye, three-element wye + neutral Two-element delta, four-wire delta systems	
Input impedance	996 kiloohm/phase	
Burden per phase	0.36 VA/phase max. at 600 V; 0.014 VA at 120 V	
Phase voltage connections	Internal via screw terminal to busbar. For wye system, a neutral is required to be connected to the PM3 on the right Phoenix connector.	
Neutral connection	If neutral is not available, the meter will calculate a virtual neutral based on the phase-to-phase rms voltage. The system voltage must be balanced for this to be accurate.	
Frequency		
Frequency	50/60 Hz	
Accuracy	± 0.1 Hz	
Resolution	0.1 Hz	
Power and Energy		
Accuracy	1% of reading (ANSI C12.1)	
Isolation		
All inputs and outputs are galvanically isolated to 2500 V.		
Environmental Ratings		
Operating temperature	–20 °C to +50 °C	
Storage temperature	–20 °C to +50 °C	
Operating humidity	5 to 95% RH noncondensing	
Sensing Method		
Voltage, current	True rms	
Sampling rate	13.02K samples per second	
Update Rate		
Watts, VAR and VA	1.03 sec at 60 Hz	
All other parameters	1.07 sec at 60 Hz	
Power Supply (External)		
DC voltage	18–30 Vdc	
Maximum current	30 mA at 24 Vdc	
Burden	0.72W	
Standard Communication Format		
Connection type	Three-wire RS-485 (A, B, Common)	
Com port baud rate	9600 or 19,200 bauds	Default: 19,200 bauds
Modbus address range	01–247	
Data format	Selectable (8, N, 1 | 8, N, 2 | 8, Even, 1 | 8, Odd, 1)	Default: 8, N, 2
Protocols	Modbus RTU	
Internal termination resistor selectable ON or OFF	Via DIP switch	Default: Enabled

Dimensions and Weights

Approximate Dimensions in Inches (mm)

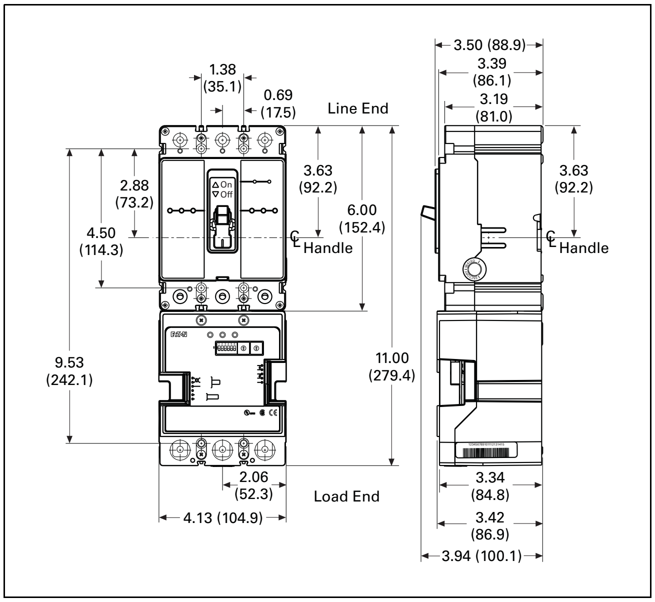


Figure 27.4-9. FD Three-Pole with PM3 Modbus

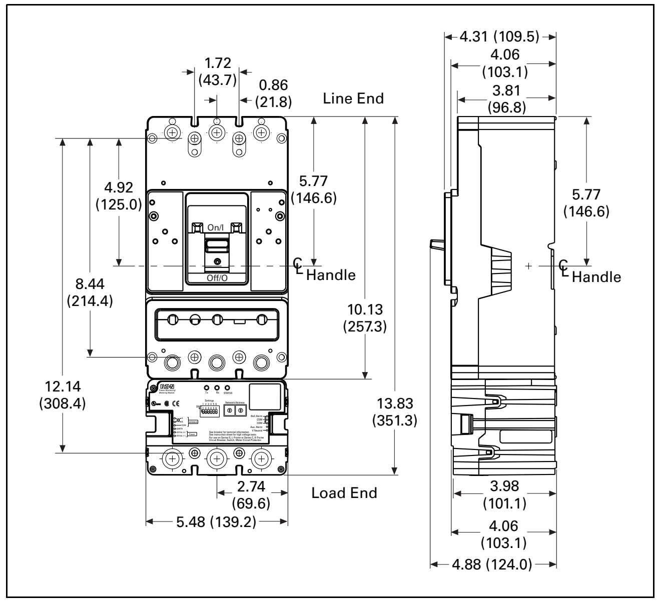


Figure 27.4-11. KD Three-Pole with PM3 Modbus

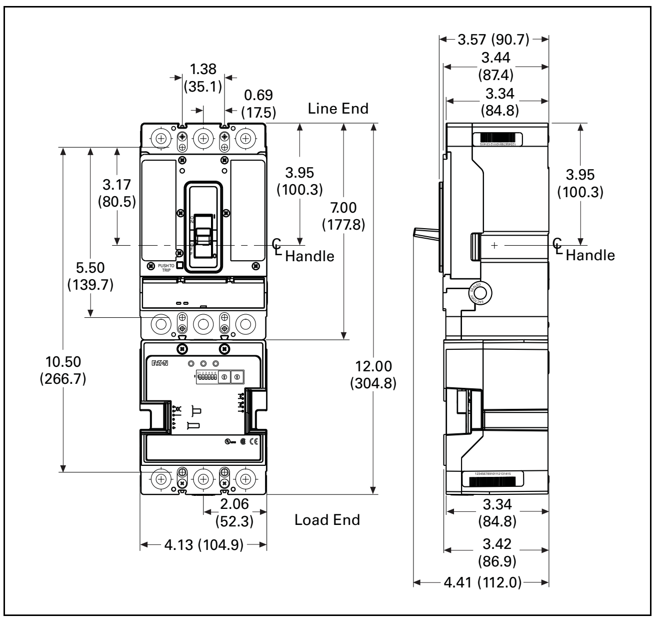


Figure 27.4-10. JG Three-Pole with PM3 Modbus

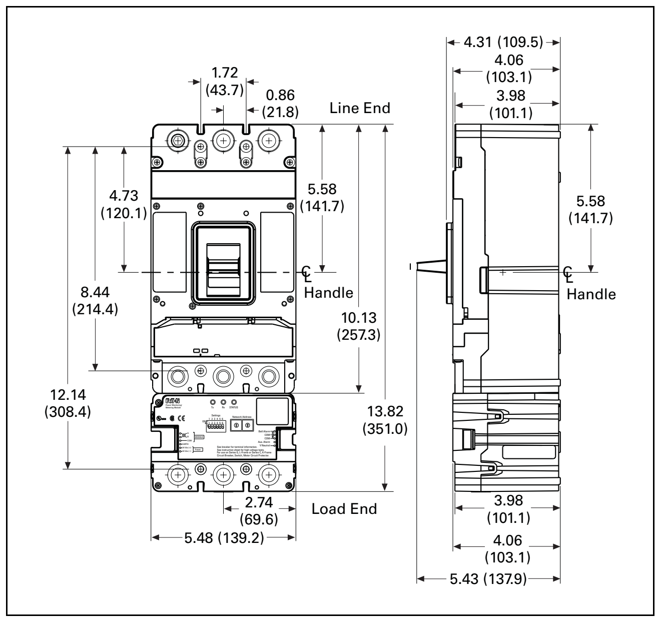


Figure 27.4-12. LG Three-Pole with PM3 Modbus

Table 27.4-106. PM3 Dimensions and Shipping Weights

Description	Frame	Dimensions and Weights
Weight in lb (kg)	FD	1.26 (0.57)
	JG	1.60 (0.73)
	KD/LG	2.25 (1.02)
Basic unit in inches (mm)	FD	4.13 W x 5.00 L x 3.39 H (104.9 x 127.0 x 86.1)
	JG	4.13 W x 5.00 L x 3.39 H (104.9 x 127.0 x 86.1)
	KD/LG	5.48 W x 3.70 L x 4.06 H (139.2 x 94.0 x 103.2)
Shipping container dimensions in inches (mm)	FD/JG	8.00 x 5.13 x 5.50 (203.2 x 130.3 x 139.7)
	KD/LG	6.25 x 8.25 x 7.00 (158.7 x 209.5 x 177.8)

27

30 mA Ground Fault (Earth Leakage) Modules

Clockwise from Left: JG, LG MCCBs Shown with Ground Fault (Earth Leakage) Modules

General Description

Eaton offers a three- and four-pole 30 mA ground fault (earth leakage) protection module for JG and LG breakers. The module does not restrict the use of other breaker accessories. UL-listed modules are available for JG and LG MCCBs. The JG and LG modules are both bottom mounted for circuits up to 160 and 250 A (JG), or 400 and 630 A for the LG.

The module is completely self-contained because the current sensor, relay and power supply are located inside the product. Current pickup settings are selectable from 0.03 to 10 A for all IEC-rated modules and JG UL-listed module, and 0.03–30 A for the LG UL-listed modules. Time delays are also selectable from instantaneous to 1.0 second for 0.10 A settings and above. A current pickup setting of 0.03 A defaults to an instantaneous time setting regardless of the time dial's position. Two alarm contacts come as standard: a 50% pretrip and a 100% after trip, both based only on earth leakage current levels.

Product Selection

Table 27.4-107. EG-Frame Ground Fault Modules, UL-Rated (Bottom Mounted, 120–480 Vac, 50/60 Hz)

Amperes	Poles	Catalog Number
125	3	**ELEBN3125G**
125	4	**ELEBN4125G**

Table 27.4-108. EG-Frame Earth Leakage Modules, IEC-Rated (Bottom Mounted, 230–415 Vac, 50/60 Hz)

Amperes	Poles	Catalog Number
125	3	**ELEBE3125G**
125	4	**ELEBE4125G**

Table 27.4-109. JG-Frame Ground Fault Modules, UL-Rated (Bottom Mounted, 120–480 Vac, 50/60 Hz)

Amperes	Poles	Catalog Number
150	3	**ELJBN3150W**
150	4	**ELJBN4150W**
250	3	**ELJBN3250W**
250	4	**ELJBN4250W**

Table 27.4-110. JG-Frame Earth Leakage Modules, IEC (Bottom Mounted, 230–415 Vac, 50/60 Hz)

Amperes	Poles	Catalog Number
160	3	**ELJBE3160W**
160	4	**ELJBE4160W**
250	3	**ELJBE3250W**
250	4	**ELJBE4250W**

Table 27.4-111. LG-Frame Ground Fault Modules, UL-Rated (Bottom Mounted, 120–480 Vac, 50/60 Hz)

Amperes	Poles	Catalog Number
400	3	**ELLBN3400W**
400	4	**ELLBN4400W**
600	3	**ELLBN3600W**
600	4	**ELLBN4600W**

Table 27.4-112. LG-Frame Earth Leakage Modules, IEC (Bottom Mounted, 230–415 Vac, 50/60 Hz)

Amperes	Poles	Catalog Number
400	3	**ELLBE3400W**
400	4	**ELLBE4400W**
630	3	**ELLBE3630W**
630	4	**ELLBE4630W**

Table 27.4-113. Dimensions for Assembled Breaker and Earth Leakage Module

Frame	Height	Width	Depth
Three-Pole			
EG	10.25 (260.3)	3.00 (76.2)	2.98 (75.8)
JG	11.25 (285.8)	4.13 (104.9)	3.57 (90.7)
LG	15.38 (390.7)	5.48 (139.2)	4.06 (103.1)
Four-Pole			
EG	10.25 (260.3)	4.00 (101.6)	2.98 (75.8)
JG	11.25 (285.8)	5.50 (139.7)	3.57 (90.7)
LG	15.38 (390.7)	7.23 (183.6)	4.06 (103.1)

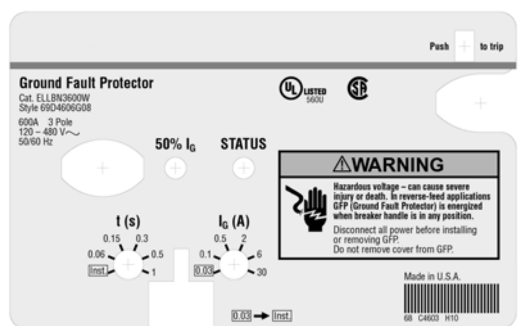


Figure 27.4-13. UL-Rated LG-Frame Earth Leakage Module Faceplate

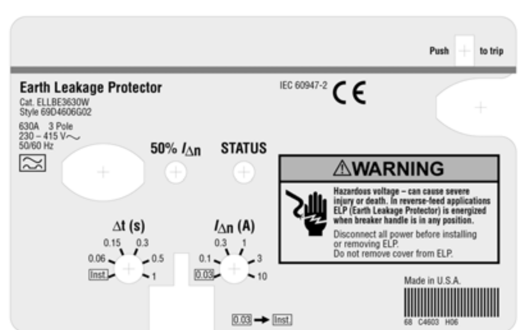


Figure 27.4-14. IEC-Rated LG-Frame Earth Leakage Module Faceplate

Current Limiting Circuit Breaker Modules

Current Limiting Circuit Breaker Modules

General Overview

Power demand continues to grow in new and existing facilities. To meet increased demand, larger utility supplies, spot networks and large facility transformers are installed. The increased capacity of the electrical source provides increased fault currents. In the past, 65 and 100 kA overcurrent protective devices may have suited the job. The new systems require in excess of 100 kA short-circuit protection. Eaton manufactures non-fused current limiting modules with interrupting capacities up to 150 kA at 480 Vac. Unlike fused current limiters with a one-time use, the current limiter module provides automatic reset of the module after interruption. Reset the molded-case circuit breaker to restore power to the system without worry of finding the correct replacement fuse.

General Description

The current limiting breaker modules use a reverse loop stationary contact arm. When high short-circuit current is flowing through the contacts of these modules, the positions of the reverse loop and moving contact arm induce opposing magnetic fields. The resulting flux lines cause rapid contact blow-apart under fault conditions, resulting in very high interrupting capacities and providing current limiting characteristics. Current limiting breaker modules, in combination with Series G E-Frame breakers, are available from 15 to 100 A and have an interrupting rating up to 100 kA at 600 Vac.

Application Description

These breakers are most commonly applied when very high fault levels are available and with applications where the current limiting capability is used upstream of the final load to limit current to the load. Typical loads include lighting and power distribution, and motor controller applications.

Features and Benefits

The combination of the Series G E-Frame current limiting breaker or HMCP and the current limiter module provides the following system protection:

- Overloads, by using inverse time current tripping characteristics of the molded-case circuit breaker
- Low-level short circuits, by using instantaneous and/or short-time delay tripping characteristics of the molded-case circuit breaker
- High-level short circuits, by using ultra-high-speed, blow-apart contacts of the current limiting module in series with the circuit breaker contacts. The high-level current limiting action is achieved by the use of special design, blow-apart contacts. The opening speed of the contacts is amplified by the repulsion force in the slot motor and reverse loop stationary contact arm to effectively separate the contacts under high-level fault conditions in less than one millisecond. The rapid rise of arc voltage introduces impedance into the system, thus limiting the amount of the otherwise available fault current

Product Selection

Table 27.4-114. EG

UL Listed (NEMA/IEC Rated) Base Molded-Case Circuit Breaker	Breaker with Line Side Mounted Current Limiter	Breaker with Load Side Mounted Current Limiter	Line and Load Terminations Included ①	Interphase Barrier Included for Limiter
EGC3015FFG	EGC3015FFGQ01	EGC3015FFGQ02	T125EF	EIPBSK
EGC3016FFG	EGC3016FFGQ01	EGC3016FFGQ02	T125EF	EIPBSK
EGC3020FFG	EGC3020FFGQ01	EGC3020FFGQ02	T125EF	EIPBSK
EGC3025FFG	EGC3025FFGQ01	EGC3025FFGQ02	T125EF	EIPBSK
EGC3030FFG	EGC3030FFGQ01	EGC3030FFGQ02	T125EF	EIPBSK
EGC3032FFG	EGC3032FFGQ01	EGC3032FFGQ02	T125EF	EIPBSK
EGC3035FFG	EGC3035FFGQ01	EGC3035FFGQ02	T125EF	EIPBSK
EGC3040FFG	EGC3040FFGQ01	EGC3040FFGQ02	T125EF	EIPBSK
EGC3045FFG	EGC3045FFGQ01	EGC3045FFGQ02	T125EF	EIPBSK
EGC3050FFG	EGC3050FFGQ01	EGC3050FFGQ02	T125EF	EIPBSK
EGC3060FFG	EGC3060FFGQ01	EGC3060FFGQ02	T125EF	EIPBSK
EGC3063FFG	EGC3063FFGQ01	EGC3063FFGQ02	T125EF	EIPBSK
EGC3070FFG	EGC3070FFGQ01	EGC3070FFGQ02	T125EF	EIPBSK
EGC3080FFG	EGC3080FFGQ01	EGC3080FFGQ02	T125EF	EIPBSK
EGC3090FFG	EGC3090FFGQ01	EGC3090FFGQ02	T125EF	EIPBSK
EGC3100FFG	EGC3100FFGQ01	EGC3100FFGQ02	T125EF	EIPBSK

① Two interphase barriers required on line end mounted limiter; (2) line end of limiter. Four interphase barriers required on load end mounted limiter; (2) line end of breaker (2) load end of limiter.

Table 27.4-115. HMCP

Motor Circuit Protector	Breaker with Line Side Mounted Current Limiter	Breaker with Load Side Mounted Current Limiter	Line and Load Terminations Included ②	Interphase Barrier Included for Limiter
HMCPE003A0C	HMCPE003A0CQ01	HMCPE003A0CQ02	T125EF	EIPBSK
HMCPE007C0C	HMCPE007C0CQ01	HMCPE007C0CQ02	T125EF	EIPBSK
HMCPE015E0C	HMCPE015E0CQ01	HMCPE015E0CQ02	T125EF	EIPBSK
HMCPE030H1C	HMCPE030H1CQ01	HMCPE030H1CQ02	T125EF	EIPBSK
HMCPE050K2C	HMCPE050K2CQ01	HMCPE050K2CQ02	T125EF	EIPBSK
HMCPE070M2C	HMCPE070M2CQ01	HMCPE070M2CQ02	T125EF	EIPBSK
HMCPE100R3C	HMCPE100R3CQ01	HMCPE100R3CQ02	T125EF	EIPBSK
HMCPE100T3C	HMCPE100T3CQ01	HMCPE100T3CQ02	T125EF	EIPBSK

② Two interphase barriers required on line end mounted limiter; (2) line end of limiter. Four interphase barriers required on load end mounted limiter; (2) line end of breaker (2) load end of limiter.

Dimensions—Approximate Dimensions in Inches (mm)

Table 27.4-116. Assembled Breaker and Current Limiting Module

Frame	Height	Width	Depth
EG	9.66 (245.7)	3.00 (76.2)	2.98 (75.8)
HMCP	9.66 (245.7)	3.00 (76.2)	2.98 (75.8)

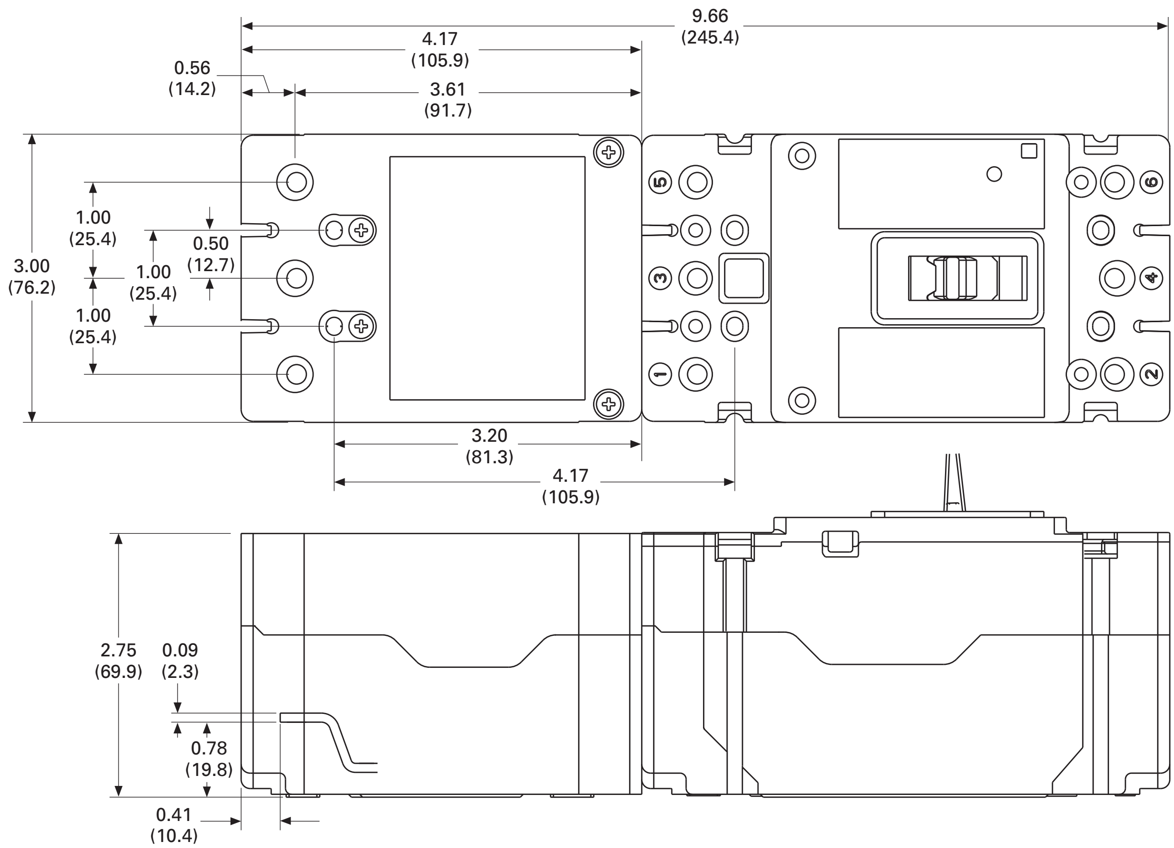


Figure 27.4-15. EG-Frame with Current Limiter Module

Current Limiting—Non-Fused Type FCL-Frame 15–100 A, LCL-Frame 125–400 A

FCL-Frame

FCL-Frame Breaker

Interrupting Capacity Ratings

Table 27.4-117. FCL Interrupting Capacity Ratings

Volts AC (50/60 Hz)	Trip Type ①	Interrupting Capacity (Symmetrical Amperes)
240 480	N.I.T. N.I.T.	200,000 150,000

① N.I.T. is non-interchangeable trip unit.

Note: On all three-phase delta, grounded B phase applications, refer to Eaton.

Terminals

Breakers listed include line and load terminals. Terminals are Underwriters Laboratories listed for wire sizes and types listed below. When used with aluminum cable, use joint compound. To order optional aluminum terminals, add suffix "Z" to breaker catalog number listed.

Table 27.4-118. FCL Terminals

Maximum Breaker Amperes	Wire Type	AWG Wire Range
Standard Pressure Terminals		
100	Al/Cu	#14–1/0
Optional Al/Cu Pressure Terminals		
50 100	Al/Cu Al/Cu	#14–#4 #4–4/0

Table 27.4-119. Dimensions in Inches (mm)

Frame	Number of Poles	Width	Height	Depth
FCL	2, 3	4.13 (104.8)	8.75 (222.3)	3.50 (88.9)
LCL, LCLG ②	2, 3	8.25 (209.6)	16.00 (406.4)	4.00 (101.6)

② Breaker with built-in ground fault protection.

Table 27.4-120. Thermal-Magnetic Trip Ratings

Frame	Ratings
FCL	15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100

Table 27.4-121. SELTRONIC Electronic Trip Unit Rating Plug

Frame	Ratings
LCL, LCLG ③	125, 150, 175, 200, 225, 250, 275, 300, 350, 400

③ Breaker with built-in ground fault protection.

LCL-Frame

LCL-Frame Breaker

Listed with Underwriters Laboratories Except as Noted

Type LCL breakers are not defined in Federal Specifications W-C-375-b.

Interrupting Capacity Ratings

Table 27.4-122. LCL Interrupting Capacity Ratings

Volts AC (50/60 Hz)	Trip Type ④	Interrupting Capacity (Symmetrical Amperes)
240 480 600	N.I.T. N.I.T. N.I.T.	200,000 200,000 100,000

④ N.I.T. is non-interchangeable trip unit.

Note: On all three-phase delta, grounded B phase applications, refer to Eaton.

Terminals

Two terminals are required per pole. Terminals are Underwriters Laboratories listed for wire type and range listed below. When used with aluminum cable, use joint compound.

Table 27.4-123. LCL Terminals

Maximum Breaker Amperes	AWG/kcmil Wire Range/Number of Conductors	Terminal Catalog Number
Standard Copper Pressure Terminals		
225 400	(1) #6–350 kcmil Cu (1) #4–250 kcmil Cu, plus (1) 3/0–600 kcmil Cu	**T225LA** **T401LA**
Optional Al/Cu Pressure Terminals		
225	(1) #6–350 kcmil Cu, or (1) #4–350 kcmil Al	**TA225LA1**
400	(1) #4–250 kcmil Al/Cu, plus (1) 3/0–600 kcmil Al/Cu	**TA400LA1**

Current Limiting—Fused Type FB TRIPAC 15–100 A, LA TRI-PAC 70–400 A

FB TRI-PAC

FB TRI-PAC Breaker

Listed with Underwriters Laboratories Except as Noted

FB TRI-PAC breakers meet the requirements for Class 16a, 16b, 17a and 26a circuit breakers as defined in Federal Specification W-C-375b.

Interrupting Capacity Ratings

Underwriters Laboratories Listed

600 Vac maximum: 200,000 A symmetrical.

Based on NEMA Test Procedures

250 Vdc maximum: 100,000 A.

Note: On all three-phase delta, grounded B phase applications, refer to Eaton.

Terminals

Breakers listed include line and load terminals. Terminals are Underwriters Laboratories listed for wire sizes and types listed below. When used with aluminum cable, use joint compound. To order optional aluminum terminals, add suffix "Z" to breaker catalog number listed.

Table 27.4-124. FB TRI-PAC Terminals

Maximum Breaker Amperes	Wire Type	AWG Wire Range
Standard Pressure Terminals		
100	Al/Cu	(1) #14–1/0
Optional Al/Cu Pressure Terminals		
50 100	Al/Cu Al/Cu	(1) #14–#4 (1) #4–4/0

Table 27.4-125. Dimensions in Inches (mm)

Frame	Number of Poles	Width	Height	Depth
FB	2, 3	4.13 (104.8)	8.75 (222.3)	3.50 (88.9)
LA	2, 3	8.13 (206.4)	16.00 (406.4)	7.75 (196.9)

Table 27.4-126. Thermal-Magnetic Trip Ratings

Frame	Ratings
FB TRI-PAC	15, 20, 30, 40, 50, 60, 70, 90, 100
LA TRI-PAC	70, 90, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400

LA TRI-PAC

LA TRI-PAC Breaker

Listed with Underwriters Laboratories Except as Noted

LA TRI-PAC breakers meet the requirements for Class 16a, 16b, 17a and 26a circuit breakers as defined in Federal Specification W-C-375b.

Interrupting Capacity Ratings

Underwriters Laboratories Listed

600 Vac maximum: 200,000 A symmetrical.

Based on NEMA Test Procedures

250 Vdc maximum: 100,000 A.

Note: On all three-phase delta, grounded B phase applications, refer to Eaton.

Terminals

Two terminals are required per pole. Terminals are Underwriters Laboratories listed for wire size and type listed below. When used with aluminum conductors, use joint compound. To order optional aluminum terminals, add suffix "Z" to complete breaker catalog number.

Table 27.4-127. LA TRI-PAC Terminals

Maximum Breaker Amperes	AWG/kcmil Wire Range/Number of Conductors	Terminal Catalog Number
Standard Copper Pressure Terminals		
225 225	(1) #6–350 kcmil Cu (1) #6–250 kcmil Cu	**T225LA** **T225LBF**
400	(1) #4–250 kcmil Cu, plus (1) 3/0–600 kcmil Cu	**T401LA**
Optional Al/Cu Pressure Terminals		
225	(1) #6–350 kcmil Cu, or (1) #4–350 kcmil Al/Cu	**TA225LA1**
400	(1) #4–250 kcmil Al/Cu, plus (1) 3/0–600 kcmil Al/Cu	**TA400LA1**

Current Limiting—Fused Type NB TRI-PAC 300–800 A, PB TRI-PAC 600–1600 A

NB TRI-PAC

NB TRI-PAC Breaker

Listed with Underwriters Laboratories Except as Noted

NB TRI-PAC breakers meet the requirements for Class 16b, 17a and 26a circuit breakers as defined in Federal Specification W-C-375b.

Interrupting Capacity Ratings

Underwriters Laboratories Listed

600 Vac maximum: 200,000 A symmetrical.

Based on NEMA Test Procedures

250 Vdc maximum: 100,000 A.

Note: On all three-phase delta, grounded B phase applications, refer to Eaton.

Terminals

Two terminals are required per pole. Terminals are UL listed for wire size and type listed below. When used with aluminum conductors, use joint compound. To order optional aluminum terminals, add suffix "Z" to complete breaker catalog number.

Table 27.4-128. NB TRI-PAC Terminals

Maximum Ampere Rating	AWG/kcmil Wire Range/Number of Conductors	Terminal Catalog Number
Standard Copper Pressure Terminals		
350	1 #1–600 kcmil Cu	**T350NB**
700	2 2/0–500 kcmil Cu	**T700NB1**
800	3 3/0–500 kcmil Cu	**T1000NB1**
Optional Al/Cu Pressure Terminals		
700	2 #1–500 kcmil Al/Cu	**TA700NB1**
800	3 3/0–400 kcmil Al/Cu	**TA1000NB1**
800	3 500–750 kcmil Al/Cu	**TA1201NB1**

Table 27.4-129. Dimensions in Inches (mm)

Frame	Number of Poles	Width	Height	Depth
NB	2, 3	8.25 (209.6)	22.00 (558.8)	5.50 (139.7)
PB	2, 3	12.06 (306.4)	22.13 (562.0)	9.06 (230.2)

Table 27.4-130. Thermal-Magnetic Trip Ratings

Frame	Ratings
NB TRI-PAC	300, 350, 400, 500, 600, 700, 800
PB TRI-PAC	600, 700, 800, 900, 1000, 1200, 1400, 1600

PB TRI-PAC

PB TRI-PAC Breaker

Listed with Underwriters Laboratories Except as Noted

PB TRI-PAC breakers meet the requirements for Class 17a and 26a circuit breakers as defined in Federal Specification W-C-375b.

Interrupting Capacity Ratings

UL Listed

600 Vac maximum: 200,000 A symmetrical.

Based on NEMA Test Procedures

250 Vdc maximum: 100,000 A.

Note: On all three-phase delta, grounded B phase applications, refer to Eaton.

Bus Bar Connectors

"T" Connector for Cu/Al Bus

Two required per pole. For rear bus connection. Accepts up to four bus bolts. May be rotated 90°.

"T" Connector for Cu/Al Bus

Cable Connector (Optional)

For "T" Connector. Accepts four 600 kcmil copper cables.

Optional Cable Connector

NEMA 1 General Purpose

Surface or Flush Mounting
15–1200 A, 600 Vac, 500 Vdc

NEMA 1

Eaton’s NEMA 1 enclosed breakers are designed for indoor use in commercial buildings, apartment buildings and other areas where a general purpose enclosure is applicable. The breaker is front operable and is capable of being padlocked in the OFF position. (Padlocking not available on enclosures for QUICKLAG breakers.) Ratings through 1200 A are UL listed as suitable for service entrance application. Both surface and flush mounted enclosures are available.

UL File Number E7819
CSA File Number LR84319

NEMA 3R Rainproof Surface Mounting

Interchangeable Hubs (through 400 A)
15–1200 A, 600 Vac, 500 Vdc

NEMA 3R

This general purpose outdoor service center employs a circuit breaker inside a weatherproof sheet steel enclosure to serve as a main disconnect and protective device for feeder circuits. The operating handle can be padlocked in the OFF position, and is interlocked to prevent the door from opening when the breaker is ON. Ratings through 1200 A are UL listed as suitable for service entrance application.

UL File Number E7819
CSA File Number LR84319

NEMA 4/4X, 5 Water and Dustproof

Stainless Steel—Type 304, Surface Mounting
15–1200 A, 600 Vac, 500 Vdc

NEMA 4/4X, 5

This enclosure meets NEMA 4/4X and 5 requirements for water and dustproof applications and has no knockouts or other openings. It is particularly well suited for use in dairies, borax mines, breweries, paper mills and other process industries. The operating handle can be padlocked in the OFF position, and is interlocked to prevent the door from opening when the breaker is ON. Ratings through 1200 A are UL listed as suitable for service entrance application.

UL File Number E7819
CSA File Number LR84319

NEMA 12 Dustproof Surface Mounting

No Knockouts or Other Openings
15–1200 A, 600 Vac, 500 Vdc

NEMA 12 Dustproof

The Eaton Type 12 enclosure is designed in line with specifications for special industry application where unusually severe conditions involving oil, coolant, dust and other foreign materials exist in the operating atmosphere. The handle padlocks in the OFF position and the cover is interlocked with the handle mechanism to prevent opening the cover with the circuit breaker in the ON position.

Ratings through 1200 A are UL listed as suitable for service entrance application. A NEMA 12 semi-dust-tight design that includes knockouts is available. These units are rated 15–400 A, 600 Vac, 500 Vdc.

UL File Number E7819
CSA File Number LR84319

NEMA 7/9 Hazardous Location

Cast Aluminum, Explosion-Proof Surface Mounting
15–1200 A, 600 Vac, 250 Vdc

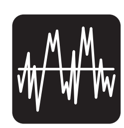
NEMA 7/9 Hazardous Location

Hazardous location, Class I, Groups B, C, D, Divisions 1, 2; Class II, Groups E, F, G, Divisions 1, 2. This special service cast aluminum enclosure is supplied with a wide, machined flanged cover to prevent igniting outside atmospheres by arcing from inside the enclosure. Front operable, the handle padlocks in the OFF position. Enclosures rated 600 A and above have lift-off hinges for ease of assembly.

Note: XFDN050 is not Group B compliant.

UL File Number E84577 Enclosed Circuit Breakers

Seismic Qualification



Refer to **Tab 1** for information on seismic qualification for this and other Eaton products.

Selection Data—Circuit Breaker Enclosures

To determine enclosed circuit breaker dimensions, first select the desired frame size along with the desired NEMA class of enclosure (from **Tables 27.4-131** and **27.4-132**). This will determine the enclosure catalog number.

Then, use **Tables 27.4-136** through **27.4-142** to determine appropriate dimensions for that selected catalog number.

Table 27.4-131. Enclosure Only Catalog Numbers Selection Guide

Breaker Frame	Breaker Ampere Range	Enclosure NEMA Class	Enclosure Catalog Number
Series C Breakers			
GHC, GD two- and three-pole only GHCGFEP single-pole only	15–100	1 surface 3R 12 4/4X, 5 st. steel	**SGDN100** ① **RGDN100** **JGDN100** **WGDN100**
EDB, EDS, ED, EDH, EHD, FDB, FD, HFD, HFDE, FDC, HFDDC ②, FDE	15–100	1 surface 1 flush 3R 12 4/4X, 5 st. steel	**SFDN100** **FFDN100** **RFDN100** **JFDN100** **WFDN100**
EHD, FD, FDB, HFD, FDC	15–50 60–225 ③	7/9 cast alum. 7/9 cast alum.	**XFDN050B** **XFDN225B**
ED, EDB, EDS, EDH, EDC, FD, FDB, FDE, HFD, HFDE, FDC, FDCE, HFDDC ②	125–225	1 surface 1 flush 3R 12 4/4X, 5 st. steel	**SFDN225** **FFDN225** **RFDN225** **JFDN225** **WFDN225**
JD, JDB, HJD, JDC	125–250	1 surface 1 flush 3R 12 4/4X, 5 st. steel 7/9 cast alum.	**SJDN250** **FJDN250** **RJDN250** **JJDN250** **WJDN250** **XJDN250B**
DK, KD, KDB, CKD, KDC, HKD, HKDB ④, CHKD, HKDDC ②, KDB	125–400	1 surface 1 flush 3R 12 4/4X, 5 st. steel 7/9 cast alum.	**SKDN400** **FKDN400** **RKDN400** **JKDN400** **WKDN400** **XKDN400B**
LD, LDB, HLD, ⑤ HLDB, LDCB	300–600	1 surface 3R 12 4/4X, 5 st. steel 7/9 cast alum.	**SLDN600** **RLDN600** **JLDN600** **WLDN600** **XLDN600B**
LD, LDB, HLD, MDL, HMDL	300–600 400–800	7/9 cast alum.	**XMCN800B**
MDL, HMDL, ND, HND, ⑤ MPS, MPH, HMDL, MDLB, HMDLDC ②, HMDLB, MDLPV Molded Case Switches (w/ WK suffix) MDL, MDLB, HMDL, HLDLC, ND, HND, HMDLDC ② Molded Case Switches (w/ K suffix) MPS Molded Case Switches (w/ SE suffix) NGK	400–1200	1 surface 3R 12 4/4X, 5 st. steel	**SNDN1200** **RNDN1200** **JNDN1200** **WNDN1200**
ND, HND	400–1200	7/9 cast alum.	**XNDN1200B**

① Suitable for use with single-pole breaker base mounting plate kit. QCCBP required.
② Limited to 500 Vdc maximum.
③ Maximum wire size: 4/0.
④ Not applicable for XKDN400B.
⑤ Short circuit ratings are limited for high interrupting rated breakers.

Table 27.4-131. Enclosure Only Catalog Numbers Selection Guide (Continued)

Breaker Frame	Breaker Ampere Range	Enclosure NEMA Class	Enclosure Catalog Number
Series G Breakers			
LGE, LGS, LGH	250–600	1 surface 3R 12 4/4X, 5 st. steel	**SLG630** ⑥ **RLG630** ⑥ **JLG630** ⑥ **WLG630** ⑥
NG, NGS, NGH	320–1200	1 surface 3R 12 4/4X, 5 st. steel	**SNDN1200** **RNDN1200** **JNDN1200** ⑦ **WNDN1200**
Earth Leakage Breakers			
LGE, LGS, LGH used with ELLBN	250–600	1 surface 3R 12 4/4X, 5 st. steel	**SLG630E** **RLG630** **JLG630** **WLG630**

⑥ Three- or four-pole.
⑦ Can be field convertible to NEMA Type 3R.

Table 27.4-132. Enclosure Only Catalog Numbers for 100% Rated Circuit Breakers

Breaker Frame ⑧	Breaker Ampere Range	Enclosure NEMA Class	Enclosure Catalog Number
CKD, CHKD	125–400	1 surface 1 flush 3R 12 4/4X, 5 st. steel 7/9 cast alum.	**SKDN400** **FKDN400** **RKDN400** **JKDN400** **WKDN400** **XKDN400B**
LGE...C ⑨ LGS...C ⑨ LGH...C ⑨	250–600	1 surface 3R 12 4/4X, 5 st. steel	**SLG630** **RLG630** **JLG630** **WLG630**
CMDL, CHMDL	400–800	1 surface 3R	**SCNDN1200** **RCNDN1200**
CND ⑩, CHND ⑩, CNDC ⑩⑪, NGH...C ⑩⑪	1200	1 surface 3R	**SCNDN1200** **RCNDN1200**

⑧ Breaker frames include both thermal magnetic and electronic trip versions.
⑨ Cu conductors only.
⑩ Cu conductors only, 90 °C wire sized at 75 °C ampacity. Conductor extensions and barriers required.
⑪ Maximum interruption ratings as follows, 100 kAIC at 240 Vac, 65 kAIC at 480 Vac, 35 kAIC at 600 Vac, 30 kAIC at 250 Vdc, 30 kAIC at 500 Vdc.

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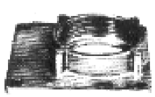
Selection Data—Circuit Breaker Enclosures

Table 27.4-133. Neutral Kits, Insulated and Groundable

Maximum Enclosure Rating (Amperes)	Neutral Wire Range Cu/Al	Ground Wire Range Cu/Al	Catalog Number
100	2 lugs with range (1) 14–1/0	2 lugs with range (1) 14–2	**DH100NK** ①
100 (all others)	2 lugs with range (1) 14–1/0	1 lug with range (1) 14–1/0	**INK100**
250	2 lugs with range 4–350 kcmil	1 lug with range (1) 4–300 kcmil	**INK250**
400	(1) 4–600 kcmil or (2) 1/0–250 kcmil	1 lug with range ((1) 4–300 kcmil	**INK400**
600	2 lugs with range (2) 250–500 kcmil	1 lug with range 4–300 kcmil	**INK600**
1200	2 lugs with range (4) 1/0–750 kcmil	3 lugs with range (1) #6–250 kcmil	**DS800NK** ②

① For use with RFDN100 and SFDN100 enclosures with breakers 100 A and less.
② For use with 800 A and 1200 A M and N frame, and 100% rated.

Table 27.4-134. Raintight Hubs—Dimensions in Inches (mm)



All rainproof enclosures 30–400 A are shipped with plate over cutout. Hubs are not supplied with screws on 30–400 A enclosures. Use screws from plate.

Hub Diameter		Catalog Number
Small Hubs		
For use with RGDN and RFDN	0.75 (19.1) 1.00 (25.4) 1.25 (31.8) 1.50 (38.1) 2.00 (50.8)	**DS075H1** **DS100H1** **DS125H1** **DS150H1** **DS200H1**
Large Hubs		
For use with RJDN. RKDN has two cutouts	2.00 (50.8) 2.50 (63.5) 3.00 (76.2)	**DS200H2** **DS250H2** **DS300H2**
Required if using Type DS hubs on RJDN and RKDN enclosures		**DS900AP**

Table 27.4-135. Breather and Drain, Hazardous Enclosures—Dimensions in Inches (mm)

Description	Compliance	Conduit Opening	Catalog Number
A universal breather/drain fitting is installed in the top of an enclosure to provide ventilation to minimize condensation and in the bottom to allow drainage of accumulated condensation while maintaining explosion-proof integrity.	Type BD: NEMA 7–Class I, Groups C, D; Class I, Zone 1, Group IIB NEMA 9–Class II, Groups F, G	0.50 (12.7)	**XPBD2**
	Type DBB: NEMA 7–Class I, Groups B, C, D; Class I, Zone 1, Group IIB + Hydrogen NEMA 9–Class II, Groups E, F, G	0.50 (12.7)	**XPDBB50**

Technical Data and Specifications

NEMA 1, 12, 3R

Note: Not to be used for construction purposes unless approved.

Table 27.4-136. NEMA 1 Surface Mounted (See Figure 27.4-16)

Catalog Number	Maximum Amperes	Dimensions in Inches (mm)						Approximate Weight in Lb (kg)
		A	B	C	D	E	F	
SGDN100	100	17.50 (444.5)	8.56 (217.4)	6.28 (159.5)	13.03 (331.0)	1.20 (30.5)	17.19 (436.6)	12 (5)
SFDN100	100	19.13 (485.9)	9.13 (231.9) ②	5.20 (132.1)	17.00 (431.8)	N/A ③	18.81 (477.8)	13 (6)
SFDN225	225 ①	23.25 (590.6)	8.56 (217.4)	6.28 (159.5)	18.75 (476.3)	1.20 (30.5)	22.94 (582.7)	15 (7)
SJDN250	250	34.70 (881.4)	10.92 (277.4)	7.20 (182.9)	30.00 (762.0)	1.88 (47.8)	34.39 (873.5)	31 (14)
SKDN400	400 ④	38.81 (985.8)	11.06 (280.9)	10.94 (277.9)	34.00 (863.6)	1.25 (31.8)	38.50 (977.9)	53 (24)
SLG630	600	51.06 (1296.9)	21.87 (555.5)	9.96 (253.0)	51.63 (1311.5)	1.94 (49.3)	50.13 (1273.3)	90 (41)
SLG630E ⑤	600	51.06 (1296.9)	21.87 (555.5)	9.96 (253.0)	51.63 (1311.5)	1.94 (49.3)	50.13 (1273.3)	90 (41)
SLDN600	600	45.88 (1165.4)	14.31 (363.5)	12.38 (314.5)	46.56 (1182.6)	1.91 (48.5)	45.56 (1157.2)	81 (37)
SNDN1200	1200	61.22 (1555.0)	21.44 (544.6)	15.41 (391.4)	61.84 (1570.7)	1.97 (50.0)	60.91 (1547.1)	178 (81)
SCNDN1200 ⑥	1200	67.82 (1722.6)	21.41 (543.8)	15.53 (394.5)	69.32 (1760.7)	1.97 (50.0)	68.69 (1744.7)	128 (58)

① Maximum wire size: 4/0.
② Total width, including door clip is 9.95 inches (252.7 mm).
③ Single centered mounting hole provided.
④ Maximum wire size: 500 kcmil.
⑤ For earth leakage applications. Includes an opening so that the settings are accessible without removing the cover.
⑥ 100% rated breaker.

Table 27.4-137. NEMA 1 Flush Mounted (See Figure 27.4-17)

Catalog Number	Maximum Amperes	Dimensions in Inches (mm)						Approximate Weight in Lb (kg)
		A	B	C	D	E	F	
FFDN100	100	18.81 (477.8)	9.72 (246.9)	6.28 (159.5)	13.03 (331.0)	1.86 (47.2)	18.50 (469.9)	12 (5)
FFDN225	225 ⑦	24.56 (623.8)	9.72 (246.9)	6.28 (159.5)	18.75 (476.3)	1.86 (47.2)	24.25 (616.0)	15 (7)
FJDN250	250	36.02 (914.9)	12.23 (310.6)	7.20 (182.9)	30.00 (762.0)	1.88 (47.8)	35.70 (906.8)	32 (15)
FKDN400	400 ⑧	40.13 (1019.3)	12.38 (314.5)	10.94 (277.9)	34.00 (863.6)	2.94 (74.7)	39.81 (1011.2)	53 (24)

⑦ Maximum wire size: 4/0.
⑧ Maximum wire size: 500 kcmil.

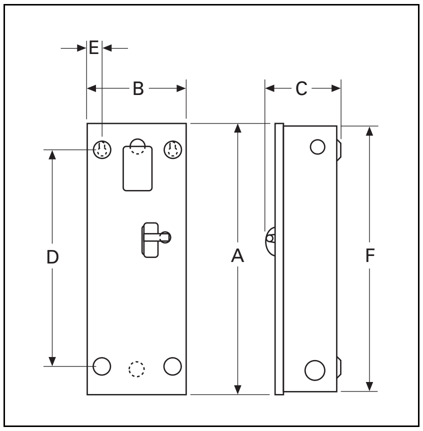


Figure 27.4-16. NEMA 1 Surface Mounted

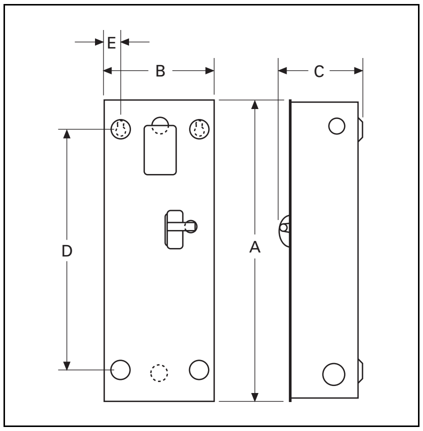


Figure 27.4-17. NEMA 1 Flush Mounted

27

Selection Data—Circuit Breaker Enclosures

Table 27.4-138. NEMA 12 Dustproof (See Figure 27.4-18)

Catalog Number	Maximum Amperes	Dimensions in Inches (mm)					Approximate Weight in Lb (kg) ①
		A	B	C	D	E	
JGDN100	100	19.91 (505.7)	9.16 (232.7)	9.31 (236.5)	18.53 (470.7)	1.70 (43.2)	16 (7)
JFDN100	100	19.91 (505.7)	9.16 (232.7)	9.31 (236.5)	18.53 (470.7)	1.70 (43.2)	16 (7)
JFDN225	225 ②	25.66 (651.8)	9.16 (232.7)	9.31 (236.5)	24.28 (616.7)	1.70 (43.2)	19 (9)
JJDN250	250	37.53 (953.3)	11.88 (301.8)	10.22 (259.6)	35.77 (908.6)	1.94 (49.3)	37 (17)
JKDN400	400 ③	41.69 (1058.9)	12.31 (312.7)	14.06 (357.1)	39.94 (1014.5)	1.97 (50.0)	58 (26)
JLG630 ④	600	53.37 (1355.6)	23.06 (585.7)	14.10 (358.1)	51.63 (1311.4)	1.94 (49.3)	94 (43)
JLDN600	600	48.31 (1227.1)	15.56 (395.2)	15.50 (393.7)	46.56 (1182.6)	1.92 (48.8)	84 (38)
JNDPN800	800	63.59 (1615.2)	22.63 (574.8)	17.63 (447.8)	—	—	110 (50)
JNDN1200	1200	63.59 (1615.2)	22.63 (574.8)	17.63 (447.8)	61.84 (1570.7)	1.97 (50.0)	175 (80)

① Weight values are for the enclosure only. See **Table 27.4-143** for breaker weights.
② Maximum wire size: 4/0.
③ Maximum wire size: 500 kcmil.
④ Also for earth leakage applications.

Table 27.4-139. NEMA 3R Rainproof (See Figure 27.4-19)

Catalog Number	Maximum Amperes	Dimensions in Inches (mm)					Approximate Weight in Lb (kg) ⑤
		A	B	C	D	E	
RGDN100	100	19.91 (505.7)	9.16 (232.7)	9.31 (236.5)	18.53 (470.7)	1.70 (43.2) ⑦	16 (7)
RFDN100	100	19.91 (505.7)	9.16 (232.7)	9.31 (236.5)	18.53 (470.7)	1.70 (43.2)	16 (7)
RFDN225	225 ⑥	25.66 (651.8)	9.16 (232.7)	9.31 (236.5)	24.28 (616.7)	1.70 (43.2)	19 (9)
RJDN250	250	37.50 (952.5)	11.88 (301.8)	10.22 (259.6)	35.77 (908.6)	1.94 (49.3)	37 (17)
RKDN400	400 ⑧	41.69 (1058.9)	12.31 (312.7)	14.06 (357.1)	39.94 (1014.5)	1.97 (50.0)	58 (26)
RLG630 ⑨	600	53.37 (1355.6)	23.06 (585.7)	14.10 (358.1)	51.63 (1311.4)	1.94 (49.3)	94 (43)
RLDN600	600	48.31 (1227.1)	15.56 (395.2)	15.50 (393.7)	46.56 (1182.6)	1.92 (48.8)	84 (38)
RNDN1200	1200	63.59 (1615.2)	22.63 (574.8)	17.63 (447.8)	61.84 (1570.7)	1.97 (50.0)	175 (80)
RCNDN1200	1200	71.06 (1804.9)	32.40 (823.0)	17.65 (448.3)	69.32 (1760.7)	8.04 (204.2)	214 (97)

⑤ Weight values are for the enclosure only. See **Table 27.4-143** for breaker weights.
⑥ Maximum wire size: 4/0.
⑦ Single centered mounting hole provided on RFDN100, Series "B."
⑧ Maximum wire size: 500 kcmil.
⑨ Also for earth leakage applications.

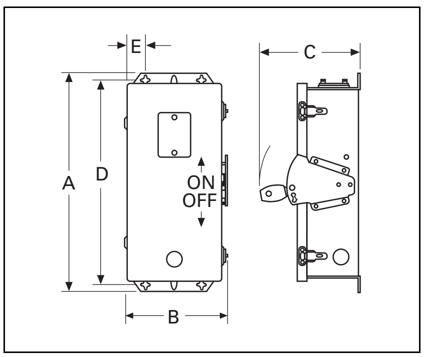


Figure 27.4-18. NEMA 12 Dustproof

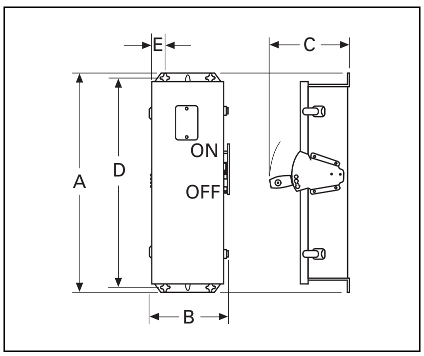


Figure 27.4-19. NEMA 3R Rainproof

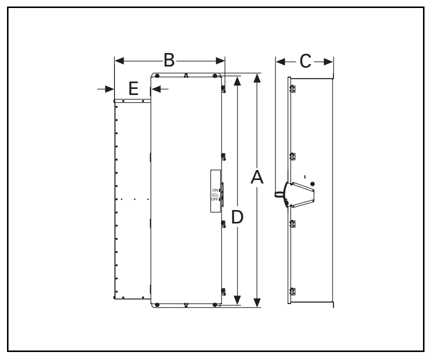


Figure 27.4-20. Catalog Number RCNDN1200

Selection Data—Circuit Breaker Enclosures

Table 27.4-140. NEMA 4/4X, 5 Stainless Steel—Dimensions in Inches (mm)

Catalog Number	Approximate Weight Lbs (kg) ①	Maximum Amperes	Dimensions A	B	C	D	E
WGDN100	16 (7)	100	19.91 (505.6)	8.84 (224.6)	9.31 (236.6)	18.53 (470.7)	1.70 (43.3)
WFDN100	16 (7)	100	19.91 (505.6)	8.84 (224.6)	9.31 (236.6)	18.53 (470.7)	1.70 (43.3)
WFDN225	20 (9)	225	25.66 (651.7)	8.84 (224.6)	9.31 (236.6)	24.28 (616.7)	1.70 (43.3)
WJDN250	39 (18)	250	37.50 (952.5)	11.56 (293.7)	10.22 (259.6)	35.77 (908.5)	1.94 (49.2)
WKDN400	60 (27)	400	41.69 (1058.9)	11.75 (298.4)	14.06 (357.2)	39.94 (1014.4)	1.97 (50.0)
WLDN600	88 (40)	600	48.31 (1227.2)	14.91 (378.6)	15.50 (393.7)	46.56 (1182.7)	1.92 (48.8)
WLG630 ②	96 (44)	600	53.38 (1355.9)	23.06 (585.7)	14.11 (358.4)	51.64 (1311.7)	1.94 (49.3)
WNDN1200	185 (84)	1200	63.59 (1615.3)	22.00 (558.8)	17.63 (447.7)	61.84 (1570.8)	1.97 (50.0)

① Weight values are for the enclosure only. See **Table 27.4-142** for breaker weights.
② Also for earth leakage applications.

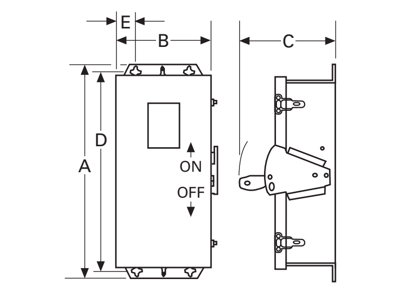


Figure 27.4-21. NEMA 4/4X, 5 Stainless Steel

Table 27.4-141. NEMA 7/9 Cast Aluminum with Weather Resistant Seals—15–250 A—Dimensions in Inches (mm)

Catalog Number	Breaker Size Amperes	Number of Outlets	Dimensions Mounting A	Mounting B	Mounting J	Inside C	Inside D	Inside E	Outside F	Outside G	Outside H	K Dim	Standard Conduit Size	Approximate Weight in Lb (kg) ④
XFDN050B	15–50	4	5.50 (139.7)	13.13 (333.5)	14.13 (358.9)	6.13 (155.7)	10.75 (273.1)	5.25 (133.4)	10.63 (270.0)	15.25 (387.4)	8.88 (225.6)	2.00 (50.8)	1.50 (38.1)	38 (17.3)
XFDN100B ③	60–100	4	6.00 (152.4)	18.00 (457.2)	19.00 (482.6)	6.50 (165.1)	16.00 (406.4)	5.50 (139.7)	11.00 (279.4)	20.50 (520.7)	9.00 (228.6)	2.31 (58.7)	2.00 (50.8)	57 (25.9)
XFDN225B ③	125–225	4	10.25 (260.4)	22.63 (574.8)	—	11.38 (289.1)	20.00 (508.0)	6.38 (162.1)	16.38 (416.1)	25.13 (638.3)	9.63 (244.6)	3.50 (88.9)	2.50 (63.5)	104 (47.2)
XJDN225B	70–225	4	8.50 (215.9)	27.13 (689.1)	—	11.25 (285.8)	29.88 (759.0)	7.38 (187.5)	16.00 (406.4)	29.50 (749.3)	12.31 (312.7)	4.00 (101.6)	3.00 (76.2)	145 (65.8)
XJDN250B	250	4	9.50 (241.3)	27.25 (692.2)	—	11.25 (285.8)	29.88 (759.0)	8.06 (204.7)	16.38 (416.1)	35.00 (889.0)	12.38 (314.5)	4.19 (106.4)	4.00 (101.6)	170 (77.2)

③ Weight values are for the enclosure only. See **Table 27.4-143** for breaker weights.
④ Maximum wire size: 4/0.

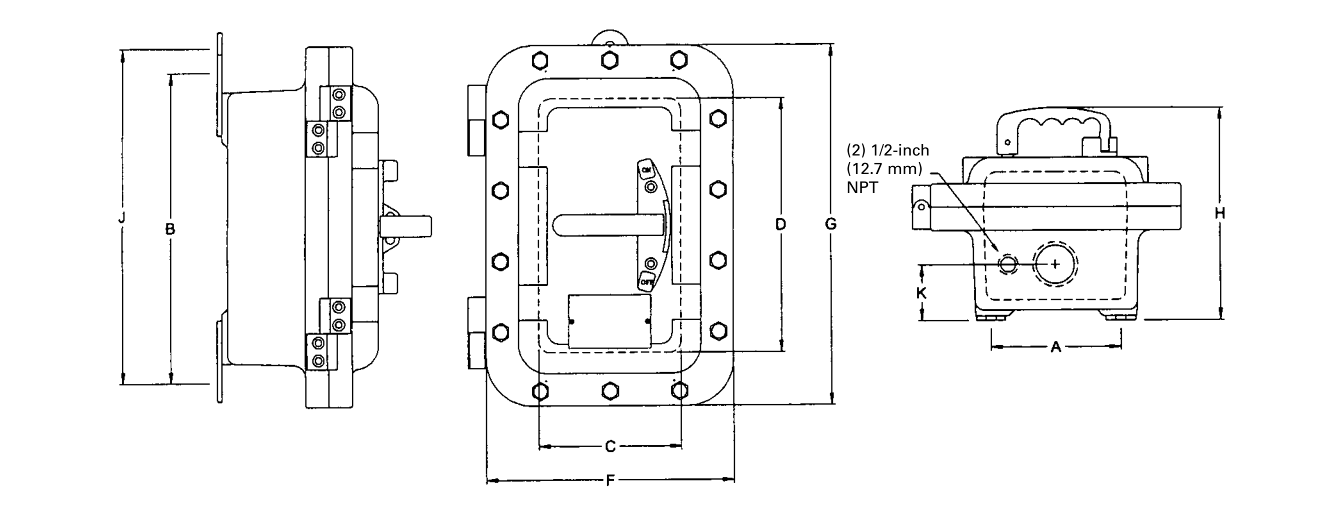


Figure 27.4-22. NEMA 7/9 Cast Aluminum with Weather-Resistant Seals—Dual 3 and 4 Point Mounting Available as Standard on F-Frame 100 A and Below

Selection Data—Circuit Breaker Enclosures

Table 27.4-142. NEMA 7/9 Cast Aluminum with Weather-Resistant Seals—400–1200 A—Dimensions in Inches (mm)

Catalog Number	Breaker Size Amperes	Dimensions in Inches (mm)											Weight in Lb (kg) ①
		Overall Enclosure				Enclosure Mounting		Conduit		Hinged Cover	Standard Conduit		
		A	B	C	D	E	F	H	I	J	Size	Location	
XKDN400B ②	400	35.00 (889.0)	16.38 (416.1)	12.63 (320.8)	7.13 (181.1)	9.50 (241.3)	27.25 (692.2)	3.00 (76.2)	4.19 (106.4)	5.50 (139.7)	4.00 (101.6)	1, 3 and 6, 8	170 (77)
XLDN600B	600	37.88 (962.2)	23.88 (606.6)	14.25 (362.0)	8.25 (209.6)	16.00 (406.4)	45.38 (1152.7)	4.00 (101.6)	5.00 (127.0)	6.00 (152.4)	4.00 (101.6)	1, 3 and 6, 8	419 (191)
XKCN800B	800	47.88 (1216.2)	13.63 (346.2)	12.81 (325.4)	6.81 (173.0)	16.13 (409.7)	40.75 (1035.1)	4.00 (101.6)	4.00 (101.6)	6.00 (152.4)	4.00 (101.6)	1, 3 and 6, 8	228 (104)
XNDN1200B ③	1200	64.00 (1625.6)	26.00 (660.4)	21.38 (543.1)	14.38 (365.3)	27.56 (700.0)	38.63 (981.2)	6.50 (165.1)	4.38 (111.3)	7.00 (177.8)	4.00 (101.6)	1, 3 and 6, 8	567 (257)

① Weight values are for the enclosure only. See **Table 27.4-143** for breaker weights.
② Maximum wire size: 500 kcmil.
③ Power cables must enter and leave from opposite ends (through-feed).

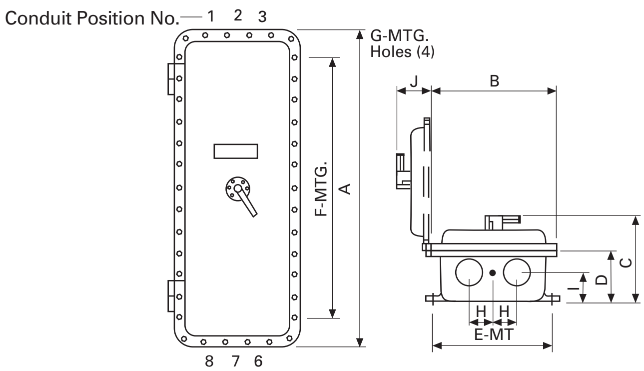


Figure 27.4-23. NEMA 7/9 Cast Aluminum with Weather-Resistant Seals

Table 27.4-143. Typical Breaker Weights

Frame	Lb	kg
G	2	0.9
E	3	1.4
F	5	2.3
J	12	5.4
K	13	5.9
L	20	9.1
M	30	13.6
N	45	20.4

Table 27.4-144. Circuit Breaker Enclosure Interpretation Data

1st Field Enclosure Type			2nd Field Breaker Family	3rd Field Maximum Ampacity
NEMA 1	Flush	F	G-Frame	50
	Surface	S	F-Frame	100
NEMA 3R		R	J-Frame	150
NEMA 12		J	K-Frame	225
NEMA 4/4X, 5	Stainless	W	M-Frame	400
NEMA 7/9	Cast Al.	X	N-Frame	600
				1200

1st Field — 2nd Field — 3rd Field

R FD N④ 150

R: NEMA Enclosure; FD: Breaker Frame; 150: Maximum Ampacity

NEMA Enclosure Type	Definitions NEMA Standard
1	Type 1 enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment.
3R	Type 3R enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain, sleet and external ice formation.
12	Type 12 enclosures are intended for indoor use primarily to provide a degree of protection against dust, falling dirt and dripping noncorrosive liquids.
4/4X	Type 4 enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose-directed water, and corrosion; and will be undamaged by the external formation of ice on the enclosure.
5	Type 5 enclosures are used for indoor use primarily to provide a degree of protection against dust and falling dirt.
7	Type 7 enclosures are for use indoors in locations classified as Class I, Groups B, C or D as defined in the National Electrical Code. ⑤
9	Type 9 enclosures are for use in indoor locations classified as Class II, Groups E, F or G as defined in the National Electrical Code.

④ "N" in this position indicates enclosure complies with NEC gutter space requirement.
⑤ XFDN050 is not Group B compliant.

Enclosed Circuit Breaker (ECB) with Arcflash Reduction Maintenance System

Enclosed Circuit Breaker (ECB) with Arcflash Reduction Maintenance System

General Description

The enclosed circuit breaker (ECB) with Arcflash Reduction Maintenance System™ is an extension of the arc flash risk reducing solutions currently offered by Eaton. The assembly provides an enclosed circuit breaker with functionality that allows the operator to place the breaker into a maintenance mode, thus reducing the amount of available arc flash incident energy downstream. This is the market's first UL listed, enclosed circuit breaker design with arc flash mitigation technology. It's a fully industrialized, packaged solution that uses Eaton's Digitrip™ 310+ technology with Arcflash Reduction Maintenance System. The new ECB with Arcflash Reduction Maintenance System is a welcome addition to the product line not only for applications affected by 2014 updates to NEC Article 240.87, but for any application where a reduction of the amount of available arc flash incident energy is desired.

Product Description

Selected models of Eaton's molded case circuit breakers are available with an Arcflash Reduction Maintenance System to provide reduced levels of incident arc flash energy when put in the maintenance mode. The Arcflash Reduction Maintenance System is available within an enclosed circuit breaker assembly, including KD, HKD, LGE, LGH, NGS, and NGH frame circuit breakers using the Digitrip 310+ electronic trip unit. These trip units have maintenance mode settings of 2.5 and 4.0 times the current rating. This dedicated Arcflash Reduction Maintenance System analog sensing circuit delivers breaker clearing times that are faster than the standard instantaneous function by eliminating microprocessor processing latencies. This faster clearing time provides superior arc flash energy reduction as compared to competitors' systems that simply lower the pickup set point of the standard instantaneous function. When the Eaton Arcflash Reduction Maintenance System is enabled, the resulting reduced arc flash energy allows for reduced PPE, which improves worker dexterity and mobility. The pickup setting of each Arcflash Reduction Maintenance System trip unit is determined by completing a power system analysis to assess the arcing fault current levels at the circuit breaker. Based on that analysis of the arcing fault current, the Arcflash Reduction Maintenance System maintenance mode pickup settings are defined, achieving a reduced level of arc flash energy.
The maintenance mode is activated by switching the lockable selector switch on the front of the enclosure, allowing this to be integrated into standard lock-out/tag-out procedures. Positive indication that the Arcflash Reduction Maintenance System maintenance mode is active is shown with a blue LED indicating light on the front of the enclosure. An additional control relay is also included to allow users to enable the Arcflash Reduction Maintenance System via a remote input signal.

Features

Standard Features

- Digitrip 310+ trip unit with ALSI protection
- Full range, 55 A to 1200 A
- NEMA Type 1, 3R, 12, 4X
- 600 Vac maximum
- 65 kAIC maximum at 480 Vac
- Additional control relay included to allow users to enable the Arcflash Reduction Maintenance System maintenance mode via a remote input signal
- 48 W power supply
- 100 VA CPT
- Cover controls, including padlock-able selector switch for Arcflash Reduction Maintenance System maintenance mode activation and blue LED indication light
- Padlockable in the OFF position ①
- Padlockable enclosure
- Three-position handle (ON/Tripped/OFF)
- Assembly is fully factory wired and ready to go out of the box
- Can be applied on three-phase and single-phase systems ②

① From the factory, the handle can only be locked in the OFF position and can accommodate a maximum of three padlocks. Field modification to drill the shroud can allow locking in the ON position. Check with your local AHJ for requirements. The breaker will trip as usual, even with the handle locked ON.
② For single-phase applications, the customer must wire using the breaker's two outside poles.

Optional Features

- Standard molded case breaker accessories available
- For ground fault applications, ALSIG protection is available
- Modifications available such as custom paint, 316-stainless enclosures, lock-on provisions, and more. Call the Flex Center at 888-329-9272 for more information.

Standards and Certifications

- UL 489 (File Number E309241)
- cUL® 489 (File Number E309241)
- NEC 240.87 Compliant

Enclosed Circuit Breaker with Arcflash Reduction Maintenance System

Product Selection

Table 27.5-1. Short-Circuit Ratings

Breaker Frame	kAIC Ratings			Catalog Numbers
	240 V	480 V	600 V	
KD HKD LGE	65 100 65	35 65 35	25 35 18	**AR1S, AR2S, AR3S** **AR1H, AR2H, AR3H** **AR4S**
LGH NGS NGH	100 85 100	65 50 65	35 25 35	**AR4H** **AR5S, AR6S** **AR5H, AR6H**

Table 27.5-2. Neutral Field Kits

Ampere Rating/ Breaker Frame	Catalog Number Prefix	Trip Unit	Neutral Assembly	Neutral Wire Range
125 A KD-frame	AR1	ALSI ALSIG	**DS400NK** **AR1NGFCT** ①	2 lugs with range (1) 750 kcmil–1/0 or (2) 300 kcmil–1/0 3 lugs with range (1) 250 kcmil–#6
250 A KD-frame	AR2	ALSI ALSIG	**DS400NK** **AR2NGFCT** ①	2 lugs with range (1) 750 kcmil–1/0 or (2) 300 kcmil—1/0 3 lugs with range (1) 250 kcmil–#6
400 A KD-frame	AR3	ALSI ALSIG	**DS400NK** **AR3NGFCT** ①	2 lugs with range (1) 750 kcmil–1/0 or (2) 300 kcmil–1/0 3 lugs with range (1) 250 kcmil–#6
600 A LG-frame	AR4	ALSI ALSIG	**DS600NK** **AR4NGFCT** ①	2 lugs with range (1) 750 kcmil–1/0 and (1) 600 kcmil–#2 3 lugs with range (1) 250 kcmil–#6
800 A NG-frame	AR5	ALSI ALSIG	**DS800NK** **AR5NGFCT** ①	2 lugs with range (4) 750 kcmil–1/0 3 lugs with range (1) 250 kcmil–#6
1200 A NG-frame	AR6	ALSI ALSIG	**DS800NK** **AR5NGFCT** ①	2 lugs with range (4) 750 kcmil–1/0 3 lugs with range (1) 250 kcmil–#6

① Includes neutral and ground fault neutral sensor.

Catalog Number Selection

Table 27.5-3. Catalog Numbering System

AR 3 S A 1 N L2 R - A1SI

Enclosed Circuit Breaker (ECB) with Arcflash Reduction Maintenance System
- **AR**

Ampere Rating/Frame
- **1** = 125 A, KD frame
- **2** = 250 A, KD frame
- **3** = 400 A, KD frame
- **4** = 600 A, LG frame
- **5** = 800 A, NG frame
- **6** = 1200 A, NG frame

kAIC Performance at 480 V
- **S** = Standard (35/50) ②
- **H** = High (65)

Trip Unit
- **A** = ALSI
- **B** = ALSIG ③

CPT Voltage
- **1** = 480 V
- **2** = 208 V
- **3** = 240 V
- **4** = 600 V

Neutral
- **N** = With neutral
- **D** = No neutral

Terminals
- **L1** = (1) 3–350, K frame
- **L2** = (2) 2/0–250 or (1) 2/0–500, K frame
- **L3** = (1) 500–750, K frame
- **L4** = (2) 2–500, L frame
- **L5** = (3) 3/0–400 800 A, N frame
- **L6** = (4) 4/0–500 800 A / 1200 A, N frame
- **L7** = (3) 500–750 800 A / 1200 A, N frame

NEMA Enclosure
- **G** = NEMA 1
- **R** = NEMA 3R
- **D** = NEMA 12
- **P** = NEMA 4 painted
- **W** = NEMA 4X stainless
- **H** = NEMA 1 100% rated
- **S** = NEMA 3R 100% rated
- **E** = NEMA 12 100% rated
- **Q** = NEMA 4 painted 100% rated
- **X** = NEMA 4X stainless 100% rated

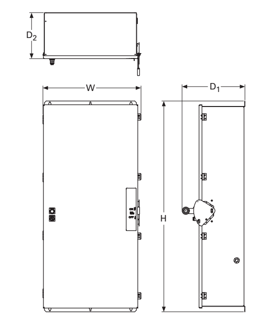
Options/Modifications ④⑤
- **00A1** = 1NO/1NC auxiliary
- **00A2** = 2NO/2NC auxiliary
- **00S1** = 120 V shunt
- **00S2** = 24 V shunt
- **A1S1** = 1NO/1NC auxiliary, 120 V shunt
- **0316** = 316 stainless steel
- **WHIT** = Painted white
- **ORNG** = Painted orange
- **0B20** = High load alarm relay
- **00ZG** = Zone selective interlocking
- **0B21** = GF alarm relay, breaker trips
- **0B22** = GF alarm relay, breaker no trip
- **316W** = 316 stainless steel painted white
- **00LO** = Lock on

② Standard = 35 kAIC for KD and LG, 50 kAIC for NG.
③ Neutral CTs are included for ground fault protected breakers (ALSIG option).
④ More combinations and options are available.
⑤ Breaker accessories (shunt, UVR, etc.) can be field installed. See molded case breaker catalog section for information regarding accessories and proper installation.

Dimensions

Approximate Dimensions in Inches (mm)

Table 27.5-4. Dimensions



Breaker Frame	Maximum Amperage	Height (H)	Width (W)	Depth (D1)	Depth (D2)
K	400	53.63 (1362.2)	26.48 (672.6)	12.69 (322.3)	7.54 (191.5)
LG	600	53.63 (1362.2)	26.48 (672.6)	12.69 (322.3)	7.54 (191.5)
NG	1200	63.54 (1614.0)	29.63 (752.6)	18.99 (482.3)	13.87 (352.3)
K 100% rated	400	53.63 (1362.2)	26.48 (672.6)	12.69 (322.3)	7.54 (191.5)
LG 100% rated	600	53.63 (1362.2)	26.48 (672.6)	12.69 (322.3)	7.54 (191.5)
NG 100% rated	1200	①	①	①	①

① Contact the Switching Device Flex Center at 1-888-329-9272 or FlexSwitches@eaton.com for availability of this product.

Wiring Diagram

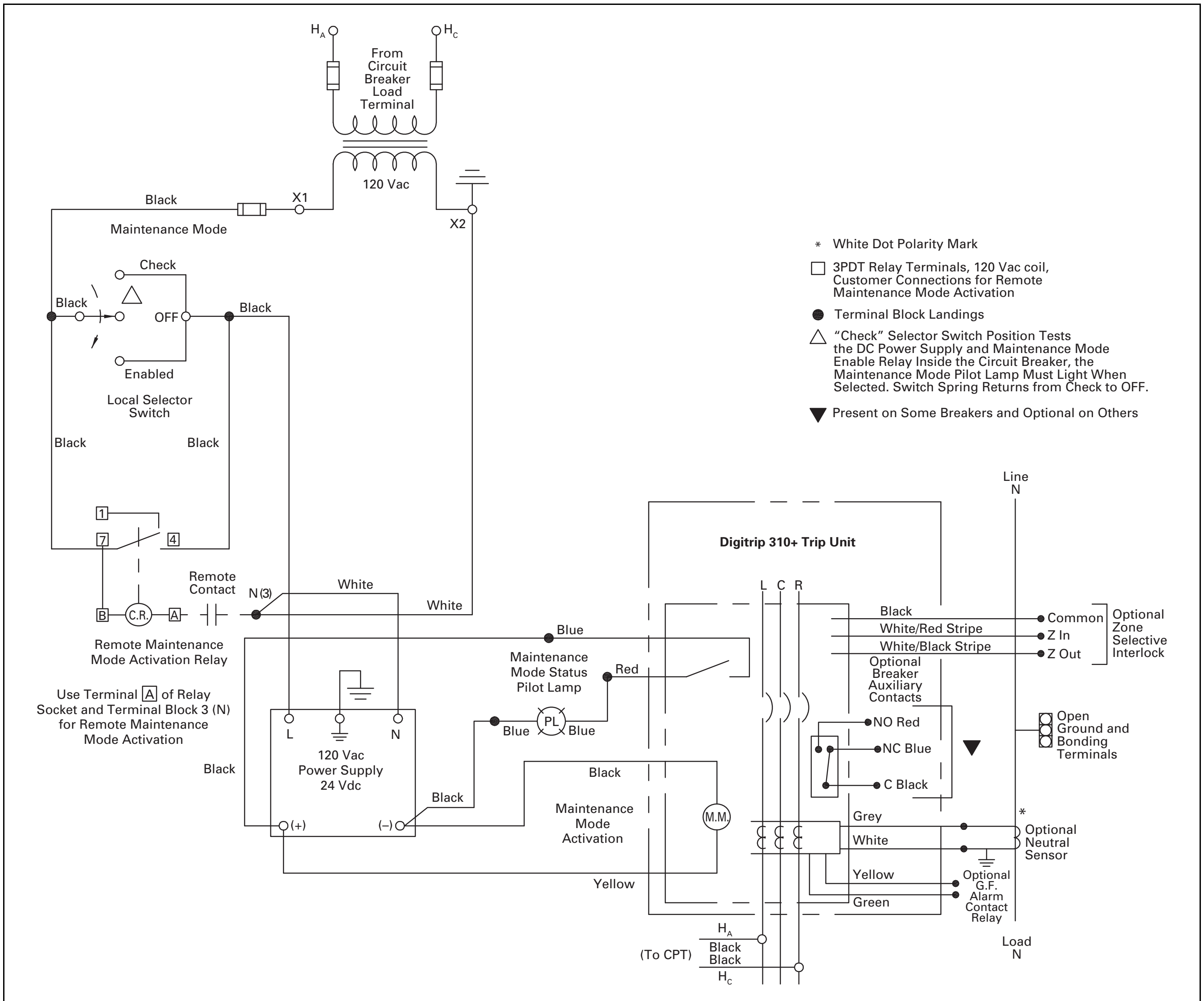


Figure 27.5-1. ECB with Arcflash Reduction Maintenance System Wiring

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