Circuit Protection

HOW TO SELECT THE RIGHT ONE

Circuit breakers are everywhere. If a technology, product, or piece of equipment runs on electricity, chances are it contains at least one circuit breaker to keep users and internal components safe.

A circuit breaker is any device that automatically opens a circuit to stop current flow when a predetermined overload current is detected. It does this without damage to itself so that it can be reset once current returns to normal.

Overload current can occur for many reasons, but it is potentially dangerous to personnel and equipment. This is true for electrical applications in marine settings, vehicles, military programs, telecom and datacom equipment, industrial automation, household appliances, HVAC, and renewable energy, to name a few.

Circuit-Breaker Types

With such a wide variety of applications for circuit breakers, it's no surprise that there are a wide variety of designs and capabilities tailored to any need. Engineers selecting circuit breakers must consider the agency approvals required by their industry, the current and voltage ratings needed, the type of electrical input the breaker will see, the desired interrupt capacity, and any time delays or high inrush protections needed.

These needs will dictate the overall circuit-breaker technology to use, as well as details of the breaker's capabilities. There are three main circuit-breaker categories: hydraulic-magnetic , thermal, and equipment leakage and ground fault.

Hydraulic-Magnetic

Hydraulic-magnetic circuit breakers consist of a current-sensing coil in series with a set of contacts. The coil surrounds a non-magnetic delay tube. The tube, in turn, contains a mobile iron core biased with a spring.

The coil assembly forms an electromagnet. When the contacts are closed, current flows through the coil and creates a magnetic field. The magnetic field acts on the core within the delay tube according to the right-hand rule, drawing it into the center of the coil. Increased current strengthens the magnetic field and, consequently, the force with which the core is drawn into the coil.

As more of the core enters the coil, the increased volume of magnetic metal intensifies the magnetic field, boosting the electromagnetic force.

In an overcurrent situation, the core is ever more forcefully drawn to into the core and toward the pole piece. Once the core is fully in the coil, the armature is magnetically attracted to the pole piece. The armature moves, unlatching the trip mechanism and opening the contacts to break the circuit.

The "hydraulic" portion of this breaker technology refers to the fluid in the non-magnetic cylinder that contains the magnetic core. The viscosity of this fluid determines whether the breaker experiences a short, medium, or long time delay in reacting to currents over the trip point. This is often used when current may fluctuate, but not to an extent that would damage equipment,

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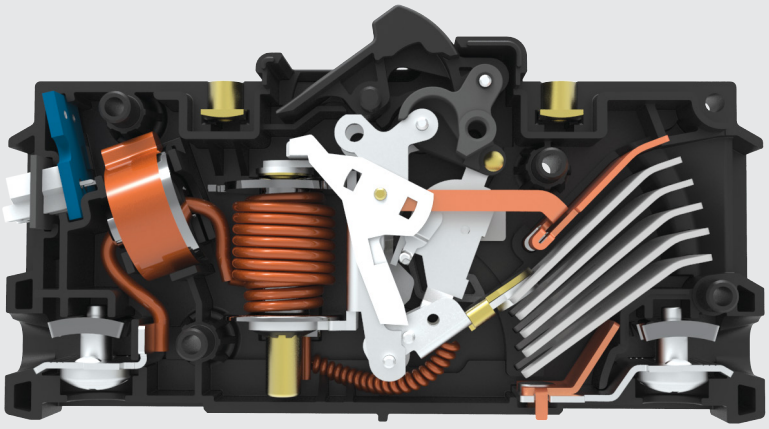


Low profile circuit breaker with sliding terminal barriers. Features a current transformer that allows for remote outlet metering and monitoring of power usage.

or, more commonly, on equipment that requires high inrush, like an electric motor. Short circuits create an instantaneous overcurrent condition, an immediate magnetic field buildup, and an instantaneous trip regardless of the delay type.

Hydraulic-magnetic circuit breakers have the advantage of being largely insensitive to ambient temperature changes. The current-sensing coil has no temperature sensitivity; the hydraulic fluid viscosity will vary with temperature, so the delay curve can change slightly as temperatures rise or fall. Additionally, these breakers don't need to warm up to achieve the desired delay curve. They can also be reset immediately after an overload condition is corrected.

This type of breaker is commonly used in datacenter and telecom applications, high-voltage applications like renewable energy installations and electric vehicles, and in extreme temperature environments.

Thermal

Thermal circuit breakers use a bimetallic strip electrically in series with the circuit. As current increases, the strip gets hotter, but one metal deforms more in response to the temperature change than the other. This uneven deformation causes the whole strip to bend, breaking the circuit and tripping the breaker. This simple breaker design can easily be reset after tripping. It can also function as the main on/off switch for the circuit.

Its main drawback, however, is that its operation is affected by ambient temperatures. When the surrounding environment is warm, the breaker experiences nuisance trips at currents lower than its desired set point. Likewise, the breaker may fail to trip at the desired current threshold if the ambient temperature is too low. These simple circuit breakers are often found as part of a circuit-breaker assembly, which may also include a magnetic circuit breaker to react to short-circuit conditions and an actuator for manually engaging or disengaging the circuit.

Rugged miniature circuit breaker for off-highway, military and harsh environment applications need robust casings, seals to keep dirt and water out, and high shock resistance. The unit shown meets IP68 for rugged COTS products.

Equipment leakage and ground-fault

Equipment leakage and ground-fault circuit breakers combine the function of a ground-fault circuit interruption (GFCI) breaker with the adjustable overcurrent protection of a hydraulic-magnetic breaker.

GFCIs compare the current returning to the power supply (neutral) to that leaving the supply (phase). Since the polarity of the phase winding and neutral winding are opposite, an equal current in each, indicating normal operation, would produce positive and negative electromotive forces (EMFs) that exactly cancel. If any current is leaking to ground, a non-zero resultant EMF is detected by the circuit-breaker electronics and results in a trip that stops the current flow.

This current-sensing scheme is extremely sensitive, permitting breakers to place equipment in a safe open-circuit mode when there's a ground fault that would not normally trip a standard breaker. The electronics also illuminate an LED upon trip to show users that the trip resulted from ground leakage instead of an overcurrent condition. Being able to quickly diagnose the cause of a trip can prevent serious equipment damage and reduce fire risk.

These breakers are commonly used in marine applications for ac-branch ground-fault protection. They can also be used with portable generators and ac main circuits.

Advanced Circuit-Breaker Applications

Each circuit-breaker technology fills a specific niche when it comes to protecting circuits and equipment. Today, circuit breakers are needed more than ever as devices become increasingly dependent on smart electronics and connected to the Internet of Things. Growing and emerging applications rely on circuit breakers, especially those in the hydraulic-magnetic category, to protect sensitive electronics and keep power safely flowing to their applications. Data centers, solar energy installations, harsh environments, and emerging technologies are just a few of the areas where smart circuit breakers are making a difference.

Data-Center Power Distribution Units

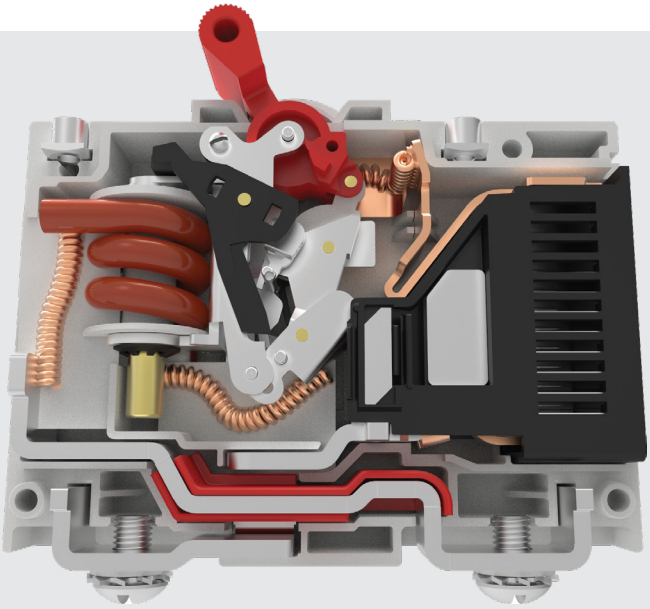
Telecom and data centers need to fit a lot of equipment into a small space, including power distribution units (PDUs) that send power to servers. PDUs, in turn, need circuit breakers to protect sensitive electronics from short circuits and overcurrent conditions. In these confined spaces, the risk of fires and overheating are real concerns. Engineers building data centers look for compact, low profile circuit breakers with one or two poles that operate normally at between 1 and 30 Amps. Due to the amount of power used in these centers, breakers for PDUs need to be able to interrupt up to 10,000 Amps in the event of a short circuit.

Data centers also have to conform to industry requirements, like UL 489 in North America and IEC EN60947-2 in Europe. For example, UL 489 requires terminal barriers, and a minimum spacing between components.

In some data centers, engineers can save space with a circuit breaker that also serves as a current transformer that can monitor current with 99% accuracy and remotely report the power consumed by each device connected to the PDU. Such transformers also maximize power distribution efficiency and facilitate load adjustments.

Solar Energy Installations

Solar energy installations collect electricity created by an array of photovoltaic cells and funnel it to a central point. The combiner boxes that collect streams from different panels see high dc voltages and currents. The circuitry in these boxes, as well as in emergency shutoff switches, needs circuit breakers to protect it from overcurrent conditions that can pose the risk of fire that can damage expensive equipment and spread quickly in unmanned installations. For these arrays, engineers look for hydraulic-magnetic circuit breakers that perform with little variation at both the high and low temperatures the installation sees due to exposure to the elements. Some designs function seamlessly between -40°C and 85°C. Compact breakers help keep electronic enclosures' size down.



High voltage circuit breaker. Unit shown features an enhanced arc chamber for quick arc extinction.

The breakers must also handle currents between 1 and 125 Amps and voltages of 600VDC or higher At these high operating levels, the arc generated when current is interrupted can create significant heat if not properly controlled. Some designs use a terminal configuration that boosts magnetic flux. The resulting strong magnetic field motivates the arc into the circuit breaker's arc chamber. Arc-splitting plates with integrated pressurizing walls quickly transfer heat away from the arc, preventing overheating and promoting full arc extinction.

Circuit breakers in these environments must meet industry standards like UL489, UL489B, and TUV EN60947-2.

Harsh Environments

Equipment that must operate in a marine environment, outdoors, or off-highway needs electronics that can handle harsh conditions. Many military applications also require equipment that can withstand harsh environments so that parts will be ready for anything. Regardless of what exists in the harsh environment—sprays of water, salt water, dust, or humidity—these applications need electronics that are sealed from ingress.

Engineers specifying a circuit breaker for such applications often look for units that have seals on both the panel and the toggle. Such units are sufficiently sealed to garner IP68 ingress protection ratings. The "6" indicates the part is completely sealed against ingress of solid particles, while the "8" indicates it can be submerged to a depth of up to 1.5m for up to 30 minutes without damage. For military applications, a parallel specification is MIL-PRF-39019F.

Circuit breakers that meet the requirements of military applications using commercial-off-the-shelf (COTS) parts also comply with MIL-PRF-55629 and MIL STD 202 that also test for vibration and shock resistance. That compliance ensures they can withstand 0.060-in. excursions from 10 to 55Hz vibrations and 10 g, 55 to 500 Hz vibrations as well as 100g, 6ms

shocks, both at the rated current.

Harsh environments also include wide temperature ranges from -40˚C to 85˚C and thermal shocks like sudden increases from -55˚C to +25˚C or decreases from +85˚C to +25˚C. Hydraulic-magnetic circuit breakers excel in this area due to their insensitivity to temperature swings.

Due to the wide variety of applications that need to operate in harsh environments, circuit breaker manufacturers make rugged, sealed units with up to three poles and designed to handle between 0.2 and 30 Amps with a variety of voltage options.

Emerging Industries

The world of electronics is evolving faster than ever. Once-futuristic products like gas-electric hybrid vehicles are now commonplace , and purely electric vehicles and smart building components are becoming ubiquitous. While these applications are diverse, they do have some commonalities.

Engineers in both the EV and smart-building arenas look for products that are compact, lightweight, and low-maintenance. The ability to transmit current usage data and other feedback is helpful in these applications as well.

Some circuit breakers meet these needs by providing DIN-rail mounting provisions with terminal bus connectors and optional auxiliary contacts. These auxiliary contacts can power indicator lights to remotely signal the status of the breaker.

These units come with wiping contacts for longer service life. They also meet UL 489 and UL 1077 standards as well as relevant cUL, TUV, CSA, and CCC codes. Such breakers can be specified with one to four poles and operating currents from 0.1 to 63 Amps. They can be specified for dc voltages of 80 or 125 or ac voltages up to 480V.

For higher current applications, like charging electric vehicles, engineers look for breakers that can be specified for higher voltages up to 600 VAC and currents ranging from 0.1 to 100 Amps.

Choosing the Right Circuit Breaker ›

The array of circuit breakers available is almost as varied as the applications in which they are used. Some are insensitive to temperature while others rely on temperature change to sense overcurrent conditions. Some safely deal with huge currents while others detect tiny changes in low-current applications. Some are designed ruggedly for extreme environments while others are streamlined to be as compact as possible.

When specifying a circuit breaker for a given application, the engineer must consider many factors beyond the rated amperage and voltage. They include reaction time, reset time, and the ability to design in a delay; ability to withstand shock and exclude particles and water; temperature capabilities; and form factor. So, although the circuit breaker may play a supporting role in an engineer's design, choosing the right one is not a straightforward task.

Circuit-breaker companies have engineers and application experts available to help guide engineers through the process of choosing the best circuit breaker for the job.

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HYDRAULIC-MAGNETIC CIRCUIT BREAKER

QUICKLY FIND THE BEST SUITED SERIES

VISUAL SELECTOR GUIDE

OVERVIEW

Carling Technologies has a wide range of hydraulic-magnetic circuit breakers that consist of advanced features and cutting-edge design to meet today's leading application requirements.

Well known for their performance and reliability, you can now utilize this selector guide to quickly narrow down the product series options that best fit the application.

Note that this guide is optimized by online use and it features hyperlinks to help navigate the various options. The table of contents page numbers are interactive and each product series links to the product web-page for additional details.

If additional assistance is needed to select the appropriate product series, please don't hesitate in contacting team2@carlingtech.com.

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PRODUCT DECISION BY AMPERAGE

This selection groups circuit breakers into amperage capabilities. If a product is classified at a higher amperage group, it also qualifies for preceding amperage groups. Some exceptions apply where noted.

UP TO 20A *F-Series doesn't apply*

J-Series

TB-Series

UP TO 30A *F-Series doesn't apply*

MS-Series

N-Series

UP TO 32A *F-Series doesn't apply*

L-Series

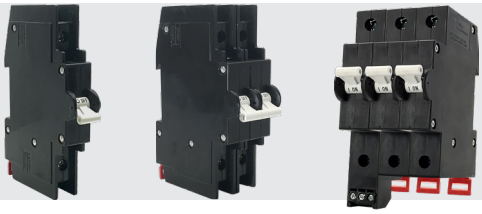
UP TO 35A *F-Series doesn't apply*

H-Series

UP TO 50A

M-Series *A-Series* *B-Series* *D-Series*

UP TO 80A



G-Series

UP TO 115A

CX-Series

UP TO 120A

E-Series

UP TO 250A

C-Series: Parallel Pole configuration only goes to 250A

50 TO 700A *F-Series Only*

F-Series

PRODUCT DECISION BY VOLTAGE

This selection groups circuit breakers into DC and AC voltage capabilities. Most product series are grouped in multiple categories.

DIRECT CURRENT:

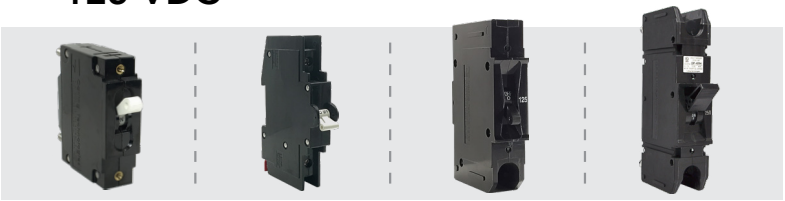
0 TO 65 VDC

MS-Series *M-Series* *H-Series* *A-Series* *B-Series* *C-Series* *D-Series* *G-Series*

80 VDC

M-Series *H-Series* *A-Series* *B-Series* *C-Series* *G-Series* *E-Series*

125 VDC



C-Series *G-Series* *E-Series* *F-Series*

GREATER THAN 125 VDC

CX-Series *E-Series*

ALTERNATING CURRENT:

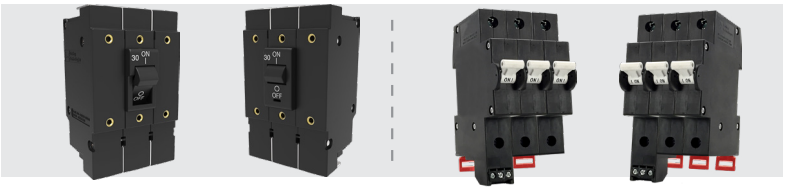
0 TO 250 VAC

MS-Series *M-Series* *H-Series* *A-Series* *B-Series* *J-Series* *C-Series* *L-Series* *N-Series* *G-Series* *TB-Series* *E-Series* *F-Series*

251 TO 277 VAC

A-Series *B-Series* *C-Series* *D-Series* *N-Series* *E-Series* *F-Series*

278 TO 480 VAC



L-Series *G-Series*

GREATER THAN 480 VAC

E-Series

PRODUCT DECISION BY AGENCY APPROVAL

This selection groups circuit breakers by agency approvals. Most product series are grouped in multiple categories.

UL 1077 *Recognized*

MS-Series *M-Series* *H-Series* *A-Series* *B-Series* *C-Series* *CX-Series* *D-Series* *G-Series* *E-Series*

UL 489 *Listed*

B-Series *J-Series* *C-Series* *CX-Series* *L-Series* *N-Series* *G-Series* *TB-Series* *E-Series* *F-Series*

UL 489A

M-Series *A-Series* *B-Series* *C-Series* *F-Series*

UL 1500

A-Series *B-Series* *C-Series* *E-Series*

TUV *Certified*

MS-Series *M-Series* *H-Series* *A-Series* *B-Series* *J-Series* *C-Series* *CX-Series* *L-Series* *N-Series* *G-Series* *TB-Series* *F-Series*

VDE *Certified*

M-Series *A-Series* *B-Series* *C-Series* *D-Series* *E-Series*

CSA

M-Series *H-Series* *A-Series* *B-Series* *C-Series* *D-Series* *E-Series*

cUL

MS-Series *L-Series* *G-Series* *TB-Series* *F-Series*

cULus

J-Series

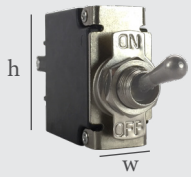
CCC

H-Series *G-Series*

PRODUCT DECISION BY SIZE

This selection groups circuit breakers by size from smallest to largest. Dimensions are shown in inches [mm] and width is for 1 pole only. Depth dimensions not shown due to terminal size variations.

MS-SERIES



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M-SERIES

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H-SERIES

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A-SERIES

h: 2.00 [50.80] w: 0.75 [19.18]

B-SERIES

h: 2.15 [54.76] w: 0.75 [19.18]

J-SERIES

h: 2.25 [57.15] w: 0.75 [19.18]

C-SERIES

h: 2.50 [63.50] w: 0.75 [19.18]

ROCB-SERIES

h: 2.50 [63.50] w: 0.75 [19.18]

CX-SERIES

h: 3.09 [78.59] w: 0.75 [19.18]

D-SERIES

h: 3.61 [91.75] w: 0.75 [19.18]

L-SERIES

h: 3.64 [92.58] w: 0.75 [19.18]

N-SERIES

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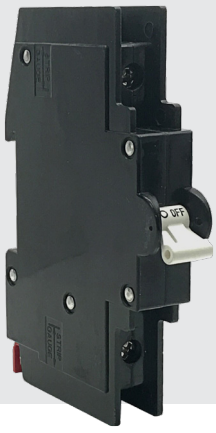
G-SERIES



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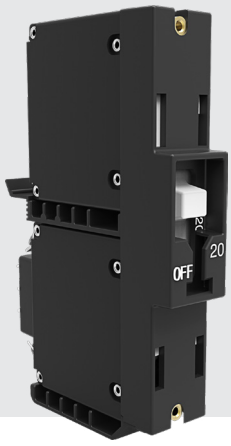
TB-SERIES



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E-SERIES

h: 5.12 [130.18] w: 1.02 [26.06]

F-SERIES

h: 7.12 [180.98] w: 1.50 [38.10]