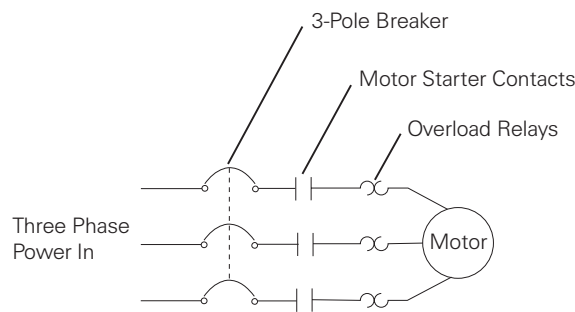


Types of Circuit Breakers

Instantaneous Magnetic-Trip-Only Circuit Breakers

Instantaneous magnetic-trip-only circuit breakers do not provide overload protection and are used on motor circuits where overload protection is provided by a motor starter. The current level at which an instantaneous trip circuit breaker trips is adjustable. The name comes from the electromagnet used to sense short circuit current. The purpose of overload protection is to prevent the motor from operating beyond its full-load capability. In the schematic illustrated below, a motor is supplied through a 3-pole circuit breaker, motor starter contacts and separately supplied overload contacts. Heat generated from excessive current will cause the overload contacts to open, removing power from the motor.

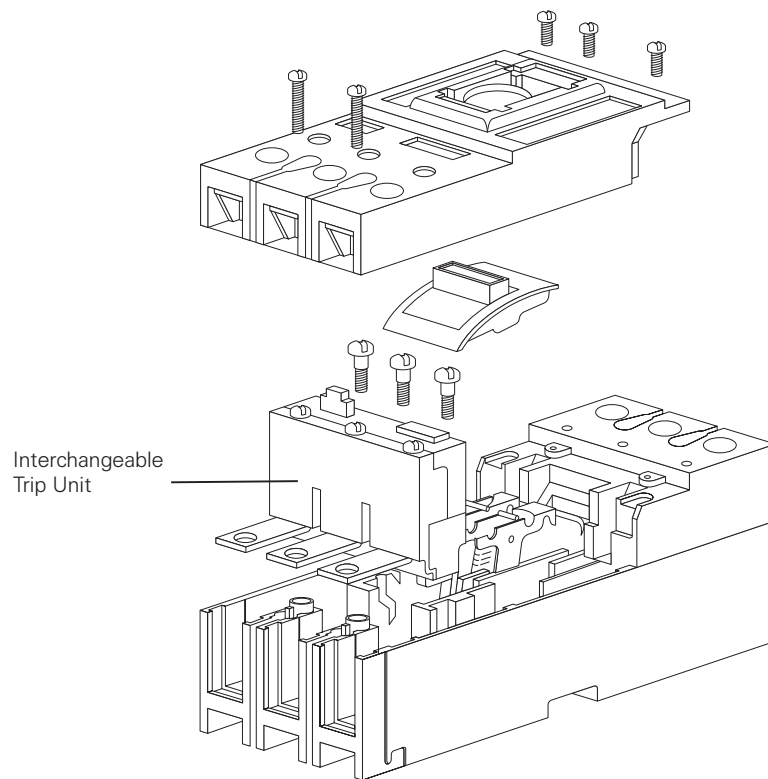


Thermal-Magnetic Circuit Breakers

Thermal-magnetic circuit breakers have both overload and instantaneous trip features. When an overload condition exists, the excess current will generate heat, which is detected in the circuit breaker. After a short period of time, dependent on the rating of the breaker and amount of overload, the breaker will trip, disconnecting the load from the voltage source. If a short circuit occurs, the breaker responds instantaneously to the fault current and disconnects the circuit.

Interchangeable Trip Circuit Breakers

The user does not have access to the trip unit on some circuit breakers. This means the trip unit cannot be changed with another. Interchangeable trip is a design feature that is available on some thermal-magnetic and solid state breakers. The advantage of a breaker with an interchangeable trip unit is that the user can change the continuous current rating of the breaker without replacing the breaker. This is done by replacing the trip unit with one of a different rating.



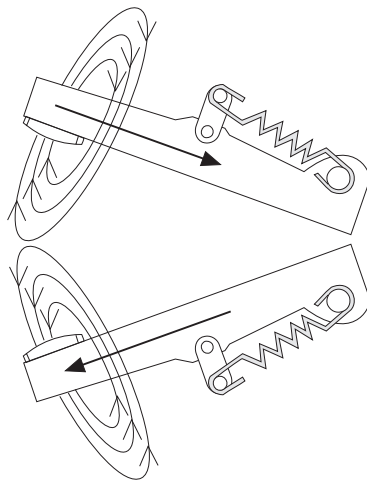
Note: Care must be exercised when considering interchangeable trip circuit breakers. A circuit breaker may be UL (Underwriters Laboratories, Inc. ®) Listed for a specific interchangeable trip unit only. Circuit breaker frames are usually designed to prevent the installation of an improper trip unit size or type.

Molded Case Switch

Siemens molded case circuit breakers are available as a molded case switch. Molded case switches employ the same operating mechanism as the thermal magnetic and magnetic only units. A preset instantaneous function is factory installed to allow the switch to trip and protect itself at a high fault current, but the switch provides no thermal overload protection.

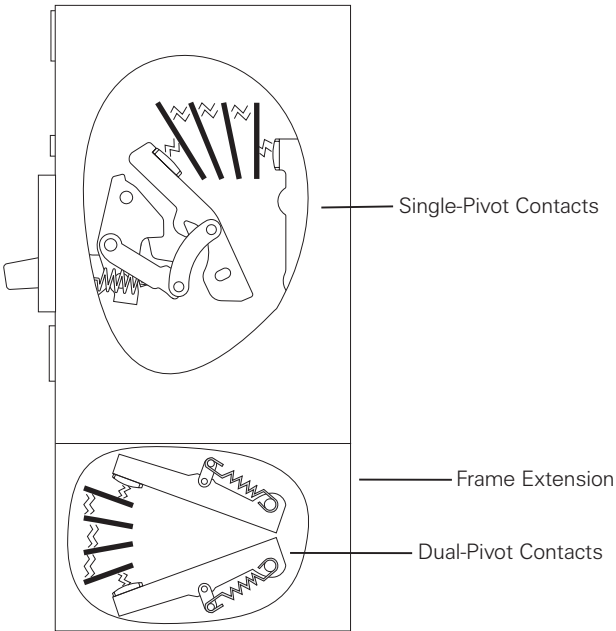
Current Limiting Circuit Breakers

Many electrical distribution systems can deliver large short circuit currents to electrical equipment. This high current can cause extensive damage. Current limiting circuit breakers will reduce the current flowing in the faulted circuit to substantially less magnitude. This helps protect expensive equipment. One way to accomplish current limiting is with an additional set of contacts that feature two moveable arms. These are referred to as dual-pivot contacts, which separate even more quickly than the single-pivot contacts. The dual-pivot contacts are connected in series with the single-pivot contacts. As with the single-pivot design, current flows in opposite directions through the contact arms, creating a magnetic repulsion. As current increases, the magnetic repulsion force increases.



In an overload condition where current may only be one to six times normal current, the contacts remain closed until the breaker trips. In a short circuit condition fault current is extremely high, both sets of contact arms may open simultaneously, generating high impedance arcs. The contact gap of the dual-pivot contacts increases more rapidly, therefore generating arc impedance more rapidly. Once the arcs are extinguished, the dual-pivot contacts close on their own due to spring tension. The single-pivot contacts are held open by the breaker mechanism, which will have tripped during the fault and must be manually reset.

The frame on current limiting circuit breakers of this design is extended to allow room for the dual-pivot set of contacts. Siemens current limiting breakers are easily identified by a red label and can handle fault currents of up to 200,000 amps.

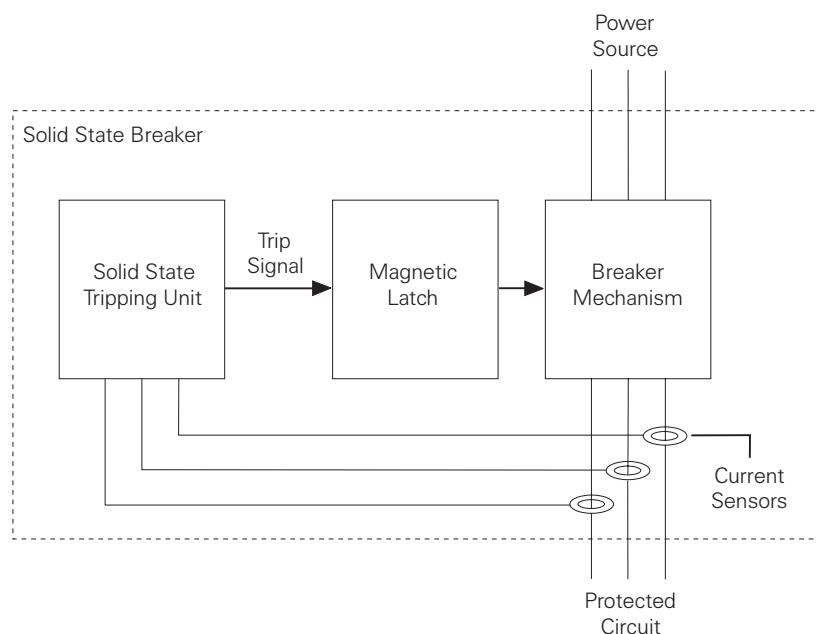


Solid State Circuit Breakers

Solid state circuit breakers function similarly to thermal-magnetic breakers. The basic breaker mechanism is still mechanical. The tripping unit is solid state. Siemens Sentron™ Series solid state breakers are referred to as Sensitrip® circuit breakers. As with the thermal-magnetic tripping unit, the Sensitrip circuit breaker tripping unit performs the following three functions:

- Senses magnitude of current flow
- Determines when current becomes excessive
- Determines when to send a trip signal to the breaker mechanism

Sensitrip circuit breakers use a microprocessor to execute numerous functions programmed in the unit. These units have a greater degree of accuracy and repeatability. Adjustments on the trip unit allow the user to select numerical values the microprocessor will use in performing protective functions. Current sensors mounted in the trip unit monitor the value of load current. The value of current is reduced to a low level and converted to a digital voltage, which is used by the microprocessor. The microprocessor continuously compares the line current with the value set by the user. When current exceeds a preset value for the selected time, the trip unit sends a signal to a magnetic latch. The magnetic latch opens the breaker's contacts, disconnecting the protected circuit from the power source.



Circuit Breaker Ratings

Ampere Rating

Every circuit breaker has a specific ampere rating. The ampere rating is the maximum continuous current a circuit breaker can carry without exceeding its rating. The main purpose of circuit breakers is to protect the conductor and equipment. As mentioned earlier, conductors are rated by how much current they can carry on a continuous basis, known as ampacity. As a general rule, the circuit breaker ampere rating should match the conductor ampacity. For example, if the conductor is rated for 20 amps, the circuit breaker should be rated for 20 amps. Siemens I-T-E[®] breakers are rated on the basis of using 60° C or 75° C conductors. This means that even if a conductor with a higher temperature rating were used, the ampacity of the conductor must be figured on its 60° C or 75° C rating.

There are some specific circumstances when the ampere rating is permitted to be greater than the current carrying capacity of the circuit. For example, motor and welder circuits can exceed conductor ampacity to allow for inrush currents and duty cycles within limits established by *NEC*[®].

Generally the ampere rating of a circuit breaker is selected at 125% of the continuous load current. This usually corresponds to the conductor ampacity which is also selected at 125% of continuous load current. For example, a 125 amp circuit breaker would be selected for a load of 100 amps.

Voltage Rating

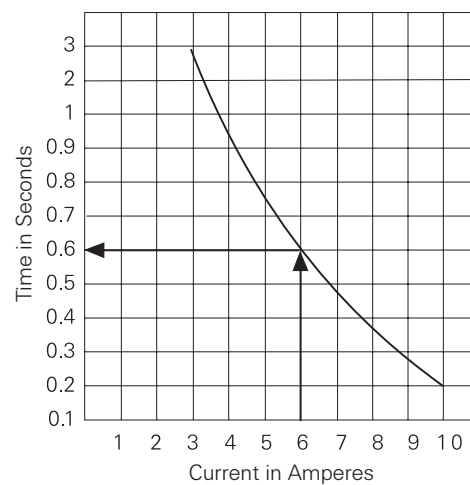
Circuit breakers are also rated according to the maximum voltage they can handle. The voltage rating of the circuit breaker must be at least equal to the circuit voltage. The voltage rating of a circuit breaker can be higher than the circuit voltage, but never lower. For example, a 480 VAC circuit breaker could be used on a 240 VAC circuit. A 240 VAC circuit breaker could not be used on a 480 VAC circuit. The voltage rating is a function of the circuit breakers ability to suppress the internal arc that occurs when the circuit breaker's contacts open.

Circuit Interrupting Ratings

Circuit breakers are also rated according to the level of fault current they can interrupt. When applying a circuit breaker, one must be selected which can sustain the largest potential short circuit current which can occur in the selected application. Siemens circuit breakers have interrupting ratings from 10,000 to 200,000 amps. To find the interrupting rating of a specific circuit breaker refer to the Speedfax catalog.

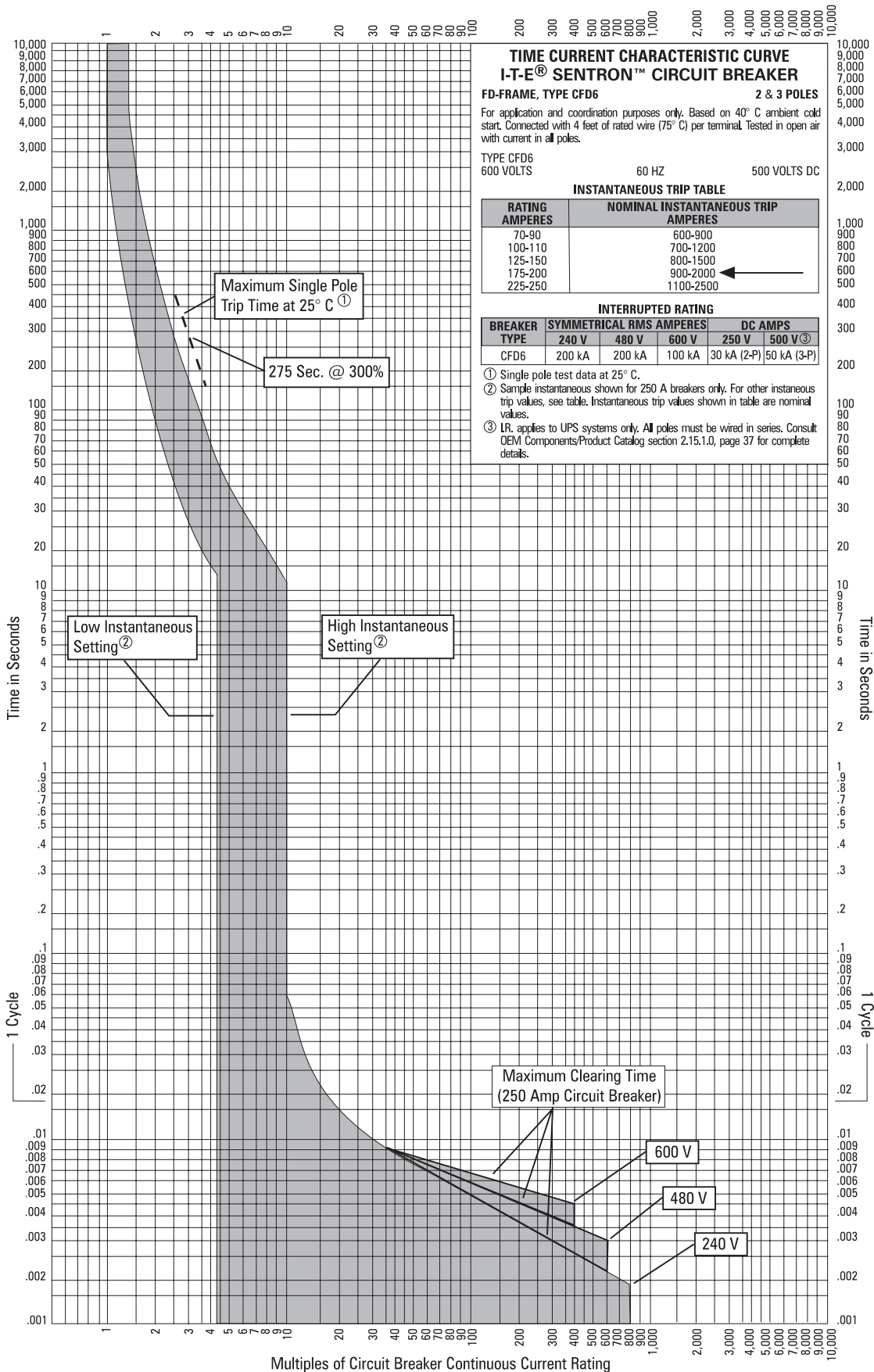
Time-Current Curves

Time-current curves, similar to the one shown on the following page, are used to show how fast a breaker will trip at any magnitude of current. The following illustration shows how a time-current curve works. The figures along the bottom (horizontal axis) represent current in amperes. The figures along the left side (vertical axis) represent time in seconds.



To determine how long a breaker will take to trip at a given current, find the level of current on the bottom of the graph. Draw a vertical line to the point where it intersects the curve. Then draw a horizontal line to the left side of the graph and find the time to trip. For example, in this illustration a circuit breaker will trip when current remains at 6 amps for .6 seconds. Note that the higher the current, the shorter the time the circuit breaker will remain closed. Time-current curves are usually drawn on log-log paper, and the horizontal line is in multiples of the breaker's continuous current rating.

From the information box in the upper right hand corner, note that the time-current curve illustrated on the following page defines the operation of a CFD6 circuit breaker. For this example, operation with a 200 ampere trip unit is shown.

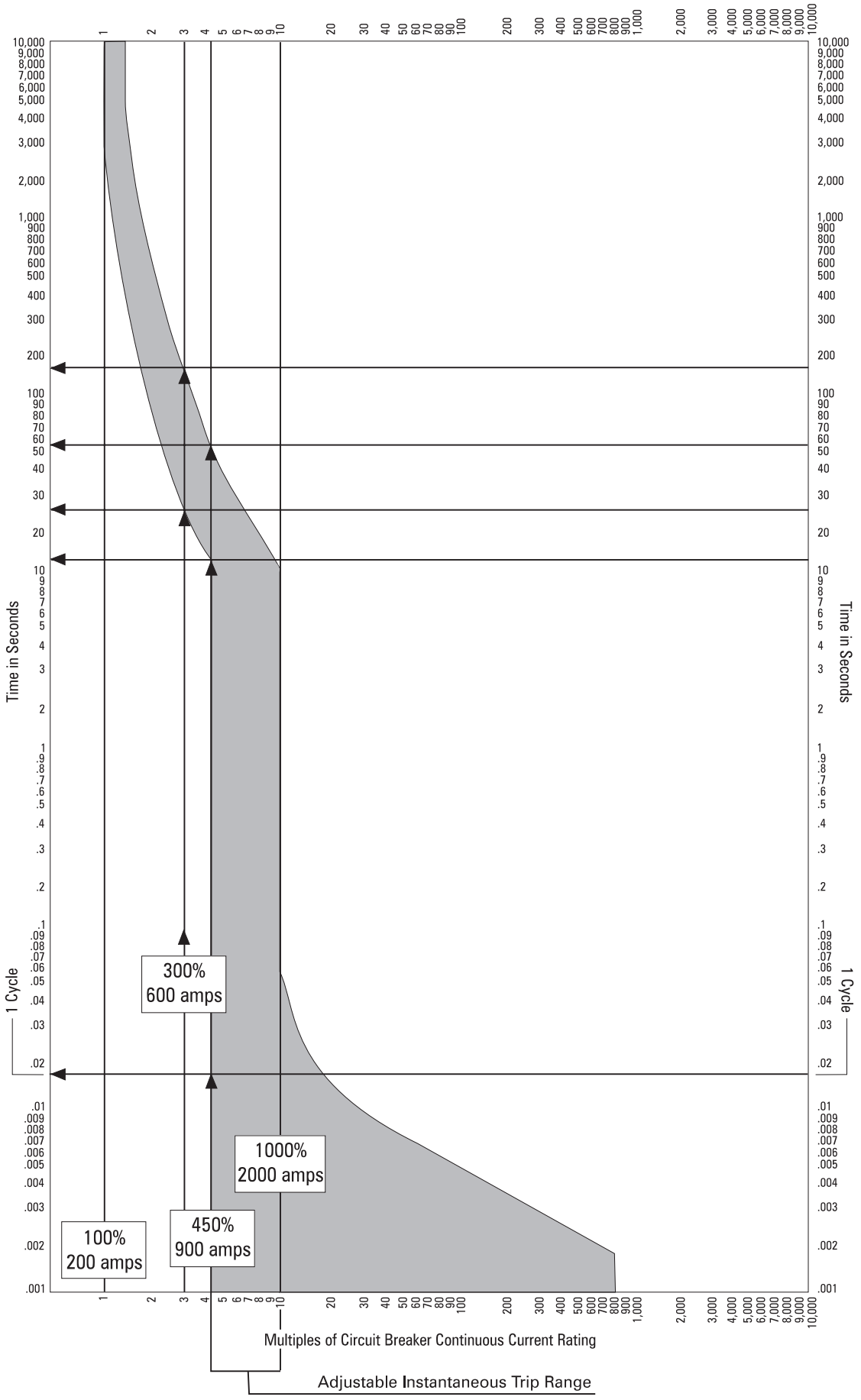


Overload Protection Component

The top part of the time-current curve shows the performance of the overload trip component of the circuit breaker. Time-current curves are shown as bands, and the actual performance of any one breaker can fall anywhere within the band. Using the example CFD6 breaker and 200 ampere trip unit, the time the breaker will trip for any given overload can easily be determined using the same procedure as previously discussed. For example, the breaker will trip between 25 seconds and 175 seconds at 600 amps with a 40°C ambient temperature, which is 3 times the trip unit rating. This is illustrated by the time-current curve on the following page.

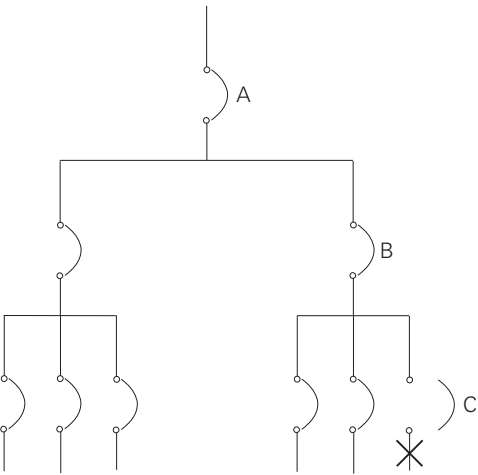
Instantaneous Trip Component

The bottom part of the time-current curve shows the performance of the instantaneous trip component (short circuit) of the circuit breaker. The maximum clearing time (time it takes for breakers to completely open) decreases as current increases. This is because of the blow-apart contact design which utilizes the magnetic field built-up around the contacts. As current increases the magnetic field strength increases, which aids in opening the contacts. This circuit breaker has an adjustable instantaneous trip point from 900 A to 2000 A, which is 4.5 to 10 times the 200 A trip unit rating. If the trip point adjustment is set to minimum (900 A), and a fault current of 900 amps or greater occurs, the breaker will trip within 1 cycle (16.8 ms). If the trip point setting is set to maximum (2000 A), and a fault current of 900 amps occurs, the breaker will trip between approximately 12 and 55 seconds. A greater fault current will cause the breaker to trip faster.



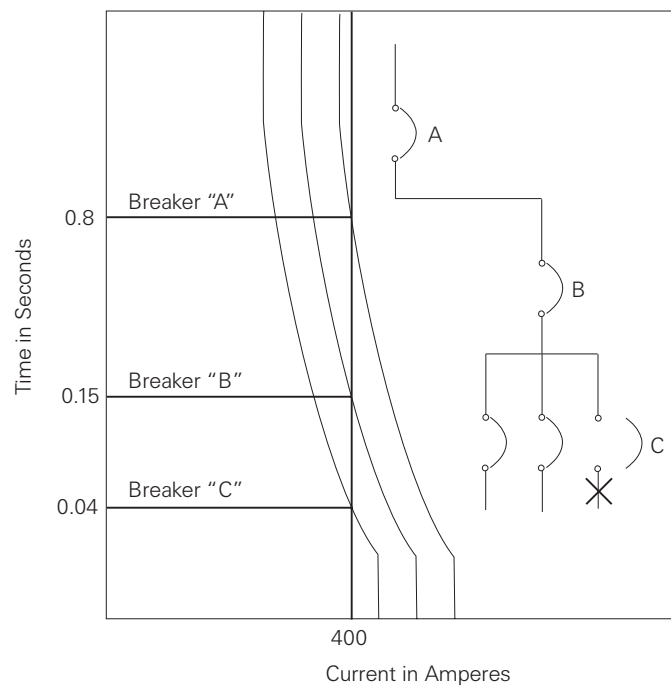
Selective Coordination

Selective coordination is the application of circuit protective devices in series such that under overload or fault conditions, only the upstream device nearest the fault will open. The rest of the devices remain closed, leaving other circuits unaffected. In the following example a short circuit has occurred in the circuit fed by branch circuit breaker "C." Power is interrupted to equipment supplied by circuit breaker "C" only. All other circuits remain unaffected.



Circuit Breaker Coordination

Time current curves are useful for coordinating circuit breakers. If the trip curves of main breaker "A," feeder breaker "B," and branch breaker "C" are placed on the same graph, there should be no overlapping, indicating the breakers are coordinated. The three circuit breakers in the following example have been coordinated so that for any given fault value, the tripping time of each breaker is greater than the downstream breakers. In the following illustration circuit breaker "C" is set to trip if a 400 amp fault current remains for .04 seconds. Circuit breaker "B" will trip if the fault remains for .15 seconds, and circuit breaker "A" if the fault remains for .8 seconds. If a 400 amp fault occurs downstream from circuit breaker "C," it will trip first and clear the fault. Circuit breakers "A" and "B" will not trip.



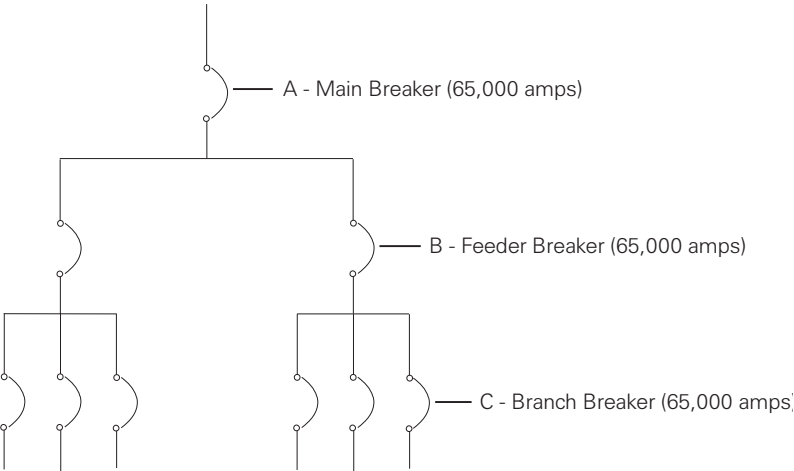
Series-Connected Systems

When selecting circuit breakers it is extremely important to know both the maximum continuous amperes and available fault current. This is true for any circuit breaker that is selected for any application. *NEC*[®] article 110.9 states:

Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current which is available at the line terminals of the equipment.

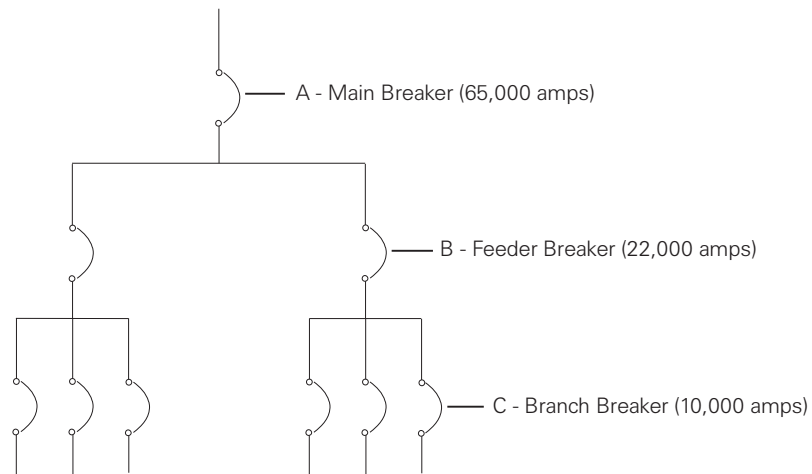
Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

There are two ways to meet this requirement. The first method is to select circuit breakers with individual ratings equal to or greater than the available fault current. This means that, in the case of a building with 65,000 amperes of fault current available at the service entrance, every circuit breaker must be rated at 65,000 amperes interrupting capacity (AIC).



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The second method is to select circuit breakers with a series combination rating equal to or greater than the available fault current at the service entrance. The series-rated concept is that the main upstream breaker must have an interrupting rating equal to or greater than the available fault current of the system, but subsequent downstream breakers connected in series can be rated at lower values. For example, a building with 65,000 amperes of available fault current might only need the breaker at the service entrance to be rated at 65,000 AIC. Additional downstream breakers can be rated at lower values. The series combination must be tested and listed by UL.



Siemens series-rated breakers are listed under "Integrated Equipment Short Circuit Ratings" in the Siemens Speedfax[®] catalog, and in the UL "Recognized Components Directory" (yellow books) Volume 1. Your Siemens sales engineer can provide more information on Siemens series-rated circuit breakers.

Review 3

1. _____ magnetic-trip-only circuit breakers protect against short circuits, but provide no overload protection.
2. _____ magnetic circuit breakers have both overload and instantaneous trip features.
3. Siemens current limiting circuit breakers can interrupt up to _____ amps.
4. The maximum continuous current a circuit breaker can carry is known as its _____ rating.
5. The upper part of a time-current curve represents the _____ component, while the lower part of a time-current curve represents the instantaneous trip component.
6. Circuit breaker _____ will allow the circuit breaker supplying a circuit that faults to trip, but all upstream circuit breakers will remain unaffected.

Catalog Numbers

To help identify each type of circuit breaker, a catalog number is assigned. The catalog number provides a description of the circuit breaker. There are five parts to the standard I-T-E[®] molded case circuit breaker catalog number. The following figure illustrates a typical catalog number.

	Part 1	Part 2	Part 3	Part 4	Part 5
ED43B125A =	ED4	3	B	125	A

Part 1

Part 1 signifies the circuit breaker's frame type. There are four basic frame types available: normal duty, heavy duty, extra heavy duty, and fuseless current limiting. Most normal duty breakers are rated up to 240 VAC and have a maximum interrupting capacity of 10,000 or 22,000 amps. Heavy duty breakers have a stronger case. They are rated up to 600 VAC and have interrupting capacities up to 65,000 amps. This is the Sentron™ Series. There are eight basic Sentron Series frames: ED, FD, JD, LD, MD, ND, PD and RD. Extra heavy duty frames are rated up to 600 VAC and have interrupting capacities up to 100,000 amps.

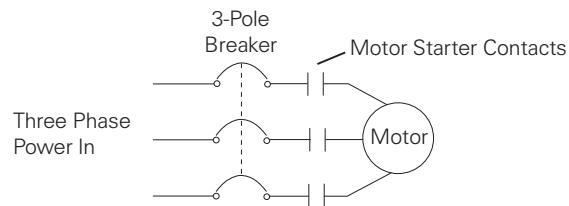
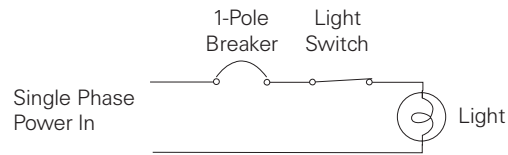
An extra heavy duty circuit breaker will have an "H" in the frame type designation. For example, one type of normal duty circuit breaker is identified as QP. The same circuit breaker in an extra heavy duty frame is identified as HQP.

This is also true for the Sentron Series. For example, one type of heavy duty Sentron circuit breaker might be identified as FD6. The same Sentron circuit breaker in an extra heavy duty frame is identified as HFD6.

A similar method is used to identify current limiting frames. For example, a CED6 circuit breaker is a current limiting circuit breaker and an ED6 frame breaker is not.

Part 2

Part 2 indicates the number of poles on the circuit breaker. Sentron Series circuit breakers can be provided with 1, 2, or 3 poles. The number of poles reflects the number of ungrounded phases that are connected. For example, a 1-pole breaker might be used on a simple lighting circuit, and a 3-pole breaker might be used on a 3-phase AC motor.



Part 3

Part 3 identifies the style of breaker.

- B = 40° C calibrated complete breaker
- M = 50° C calibrated complete breaker
- F = Breaker frame only
- T = Trip unit calibrated for 40° C
- W = Trip unit calibrated for 50° C
- S = Molded case switch

Part 4

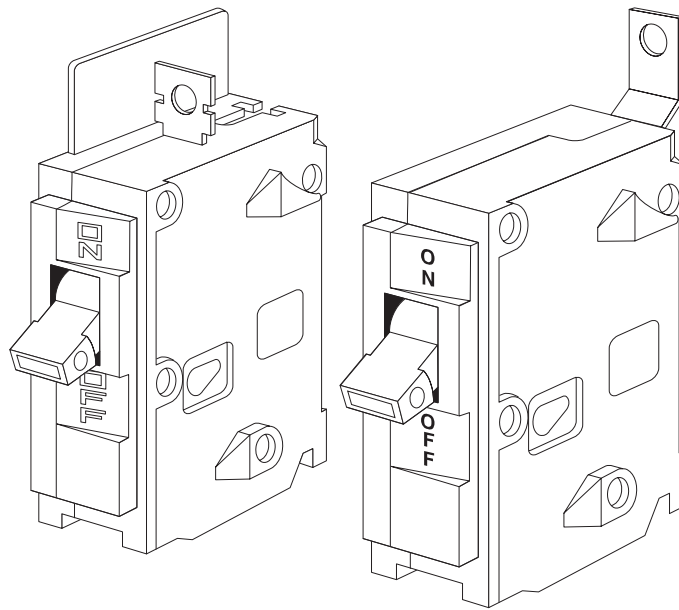
Part 4 shows the circuit breaker's continuous current rating. In the example shown on the previous page it is 125 amps.

Part 5

Part 5 is used to identify a special circuit breaker types, such as automatic switches.

Residential and Commercial Circuit Breakers

Siemens has several circuit breakers that are used in residential, commercial and light industrial applications. These circuit breakers are normally plug-in or bolt-on types that mount in load centers or panelboards. Other types are also available, for example, circuit breakers that mount on a DIN rail. There are several variations of circuit breakers, and this section will attempt to explain the most popular of them. The specific ratings for each circuit breaker can be found in the Speedfax[®] catalog.



EQ Frame Circuit Breakers

EQ[®] frame circuit breakers, which includes QP, BL, and BQ type circuit breakers, are UL Listed for use with EQ load centers.

QP Circuit Breakers

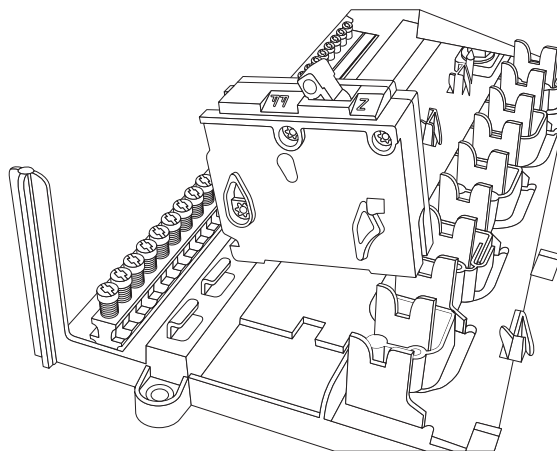
One type of circuit breaker that belongs to the EQ family is the QP plug-in breaker. Depending on the specific QP type circuit breaker, the following ratings are available:

Interrupting rating	10,000, 22,000, or 65,000 amps
Continuous ampere rating	15-125 amps
Volts	120/240 VAC or 240 VAC
Number of poles	1, 2, or 3

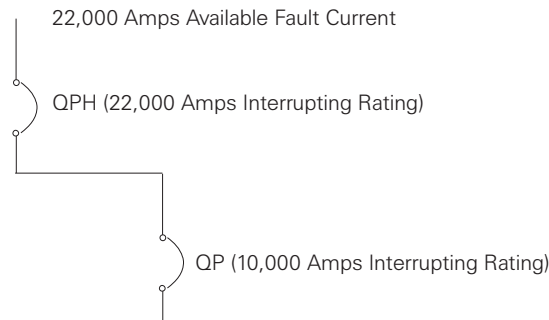
For example, referring to the circuit breaker section of the Speedfax catalog, note that a 1-pole, 15 amp QP breaker, rated for an interrupting capacity of 10,000 amps at 120/240 VAC is a Q115. A 20 amp breaker is a Q120.

EQ 125A Frame - QP Plug-in (10,000A IR)				
NON-INTERCHANGEABLE TRIP				
Continuous Current Rating @40°C	1-Pole		2-Pole	
	120/240 VAC		120/240 VAC Common Trip	
	Catalog Number	List Price	Catalog Number	List Price
15	Q115		Q215	
20	Q120		Q220	

The following illustration shows a QP 1-pole breaker installed and an interior from an EQ load center.

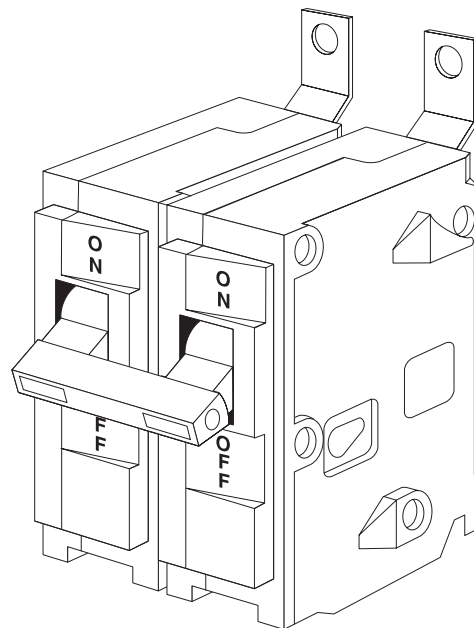


QP breakers can be used in single family homes where the available fault current does not normally exceed 10,000 amps. In some instances where fault current exceeds 10,000 amps, a QPH might be selected. In apartments, condominiums, and commercial buildings the available fault current is normally greater than 10,000 amps. Series-rated circuit breakers can be used. For example, a QPH feeder disconnect, with an interrupting capacity of 22,000 amps might be placed in front of a QP branch with an interrupting capacity of 10,000 amps. There are restrictions when using series-rated breakers. Refer to the Speedfax catalog for acceptable series-rated combinations.



BL and BQ Breakers

BL and BQ bolt-on breakers also belong to the EQ family. These breakers bolt directly to the power bus on panelboards in commercial and industrial applications, or the tab on the BQ can also be used to accept wire connectors.



BL 2-Pole

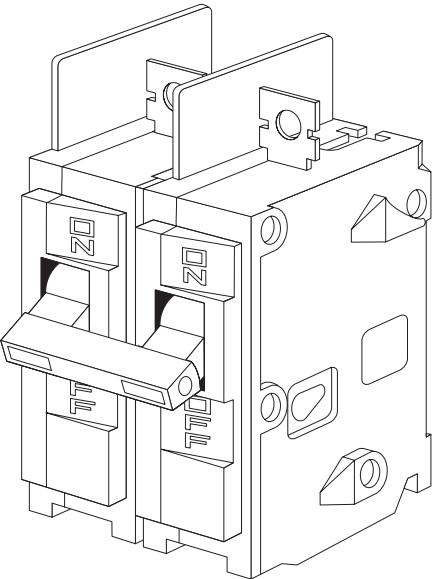
Depending on the specific BL type circuit breaker, the following ratings are available:

Interrupting rating 10,000, 22,000, or 65,000 amps
 Continuous ampere rating 15-125 amps
 Volts 120/240 VAC or 240 VAC
 Number of poles 1, 2, or 3

For example, referring to the circuit breaker section of the Speedfax catalog, it can be seen that a 1-pole, 15 amp BLH breaker, rated for an interrupting capacity of 22,000 amps at 120/240 VAC is a B115H. A 20 amp breaker is a B120H.

EQ 125A Frame - BLH Low Tab Bolt-on (22,000A IR)				
NON-INTERCHANGEABLE TRIP				
Continuous Current Rating @40°C	1-Pole		2-Pole	
	120/240 VAC		120/240 VAC Common Trip	
	Catalog Number	List Price	Catalog Number	List Price
15	B115H		B215H	
20	B120H		B220H	

Another bolt-on circuit breaker belonging to the EQ family is the BQ breaker. A BQ 2-pole breaker is illustrated below.



BQ 2-Pole

Depending on the specific BQ type circuit breaker, the following ratings are available:

Interrupting rating 10,000, 22,000, or 65,000 amps
 Continuous ampere rating 15-125 amps
 Volts 120/240 VAC or 240 VAC
 Number of poles 1, 2, or 3

For example, referring to the circuit breaker section of the Speedfax catalog, note that a 2-pole, 20 amp BQ breaker, rated for an interrupting capacity of 10,000 amps at 120/240 VAC is a BQ2B020.

EQ 125A Frame - BQ Bolt-on (10,000A IR)				
NON-INTERCHANGEABLE TRIP				
Continuous Current Rating @40°C	1-Pole		2-Pole	
	120/240 VAC		120/240 VAC Common Trip	
	Catalog Number	List Price	Catalog Number	List Price
15	BQ1B015		BQ2B015	
20	BQ1B020		BQ2B020	

BQD Type Circuit Breakers

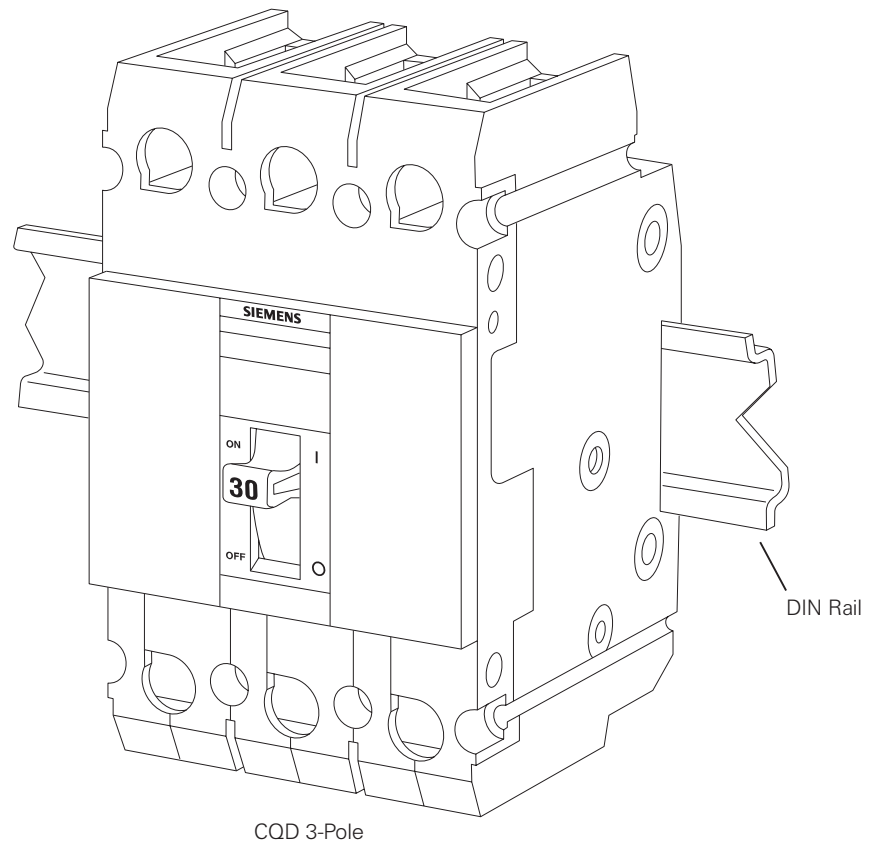
BQD type circuit breakers (not shown) are panel-mount-only breakers for light industrial loads or 277 VAC lighting. Depending on the specific BQD type circuit breaker, the following ratings are available:

Interrupting rating 14,000 or 65,000 amps
 Continuous ampere rating 15-100 amps
 Volts 277 or 277/480 VAC
 Number of poles 1, 2, or 3

CQD Circuit Breaker

The CQD type circuit breaker is similar to the BQD, but mounts on a DIN rail. The one and two pole devices have a high intensity discharge (HID) rating for high pressure lighting. Depending on the specific CQD type circuit breaker, the following ratings are available:

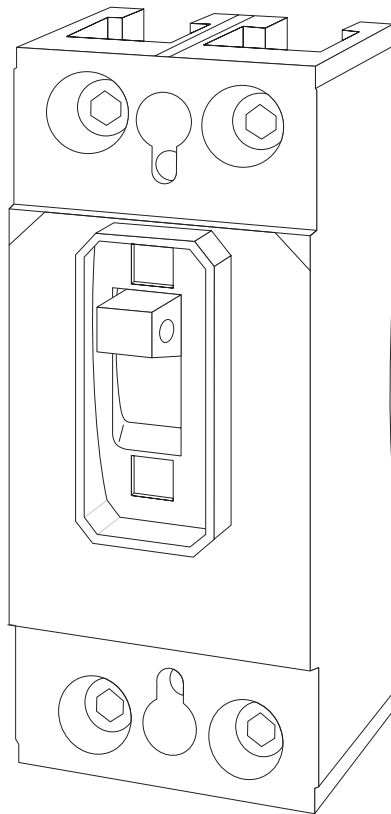
Interrupting rating	14,000 or 65,000 amps
Continuous ampere rating	15-100 amps
Volts	120, 240, 277 or 277/480 VAC
Number of poles	1, 2, or 3



QJ Circuit Breakers

QJ type circuit breakers can be used as main circuit breakers in EQ 3-phase load centers. They are also used as branch circuit breakers in commercial panelboards and switchboards. Depending on the specific QJ type circuit breaker, the following ratings are available:

Interrupting rating	10,000, 22,000, or 42,000 amps
Continuous ampere rating	60-225 amps
Volts	240 VAC
Number of poles	2 or 3

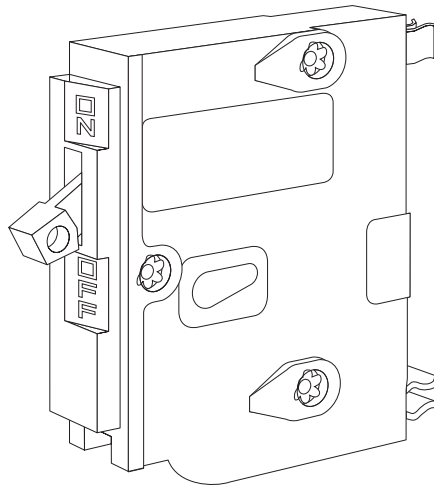


QJ 2-Pole

QD Circuit Breakers

QD type circuit breakers are UL Classified for certain Square D Company load centers in place of Square D QO® circuit breakers. A panelboard compatibility list is packaged with each Siemens QD circuit breaker. Siemens QD circuit breakers are to be used only in those Square D panelboards shown on the compatibility list. Depending on the specific QD type circuit breaker, the following ratings are available:

Interrupting rating	10,000 amps
Continuous ampere rating	15-60 amps
Volts	120/240 VAC
Number of poles	1 or 2



QD 1-Pole

Review 4

1. Part one (1) of the catalog number identifies the circuit breaker's _____ type.
2. An extra heavy duty FD6 type circuit breaker will be identified as _____ .
3. The continuous ampere range of the QP type circuit breakers is from _____ to _____ amps.
4. The Siemens type _____ circuit breaker can be used as a replacement for a Square D QO circuit breaker in certain Square D load centers.
5. The _____ type circuit breaker mounts on a DIN rail.