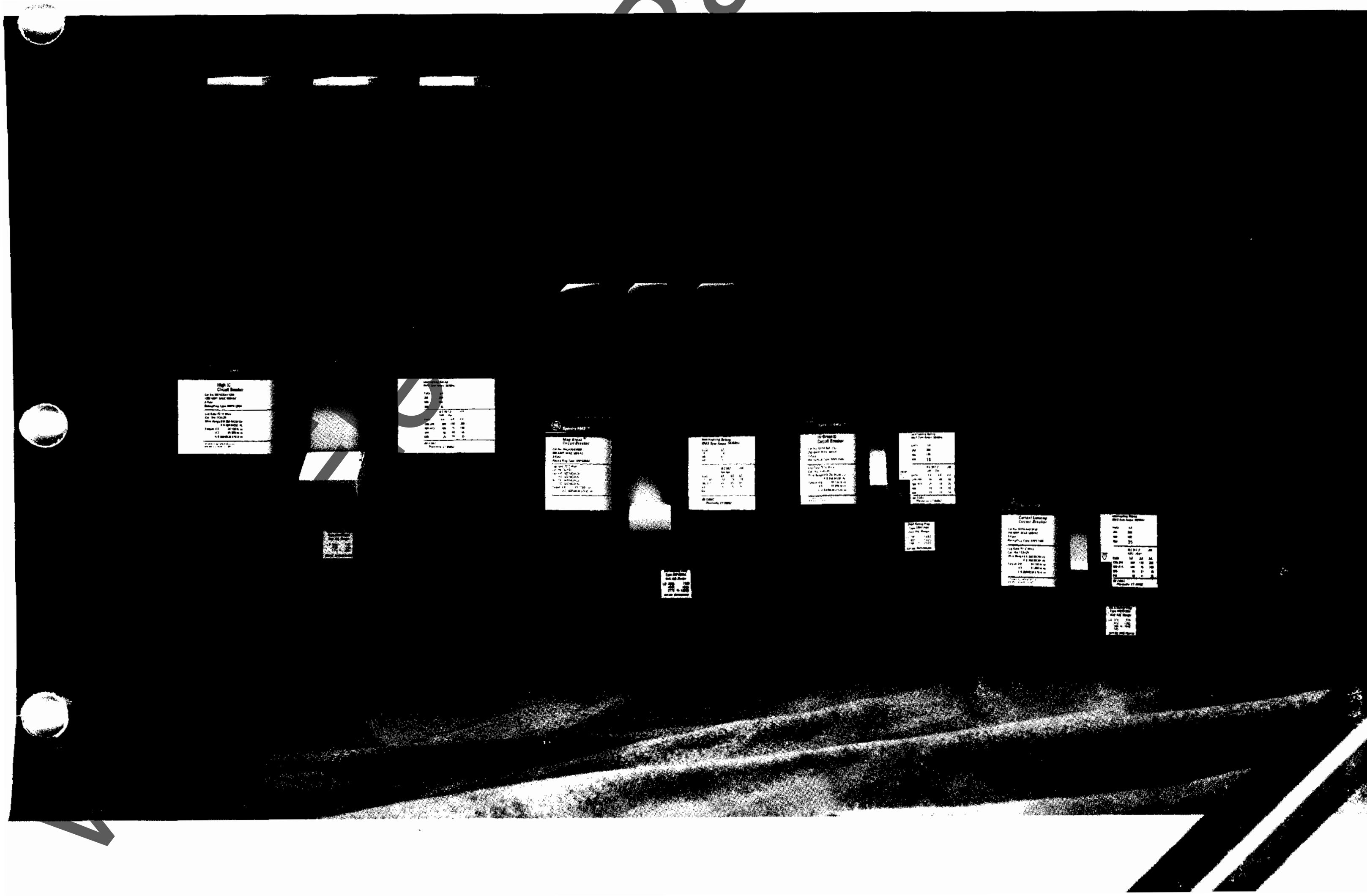
Spectra RMS™ Molded Case Circuit Breakers

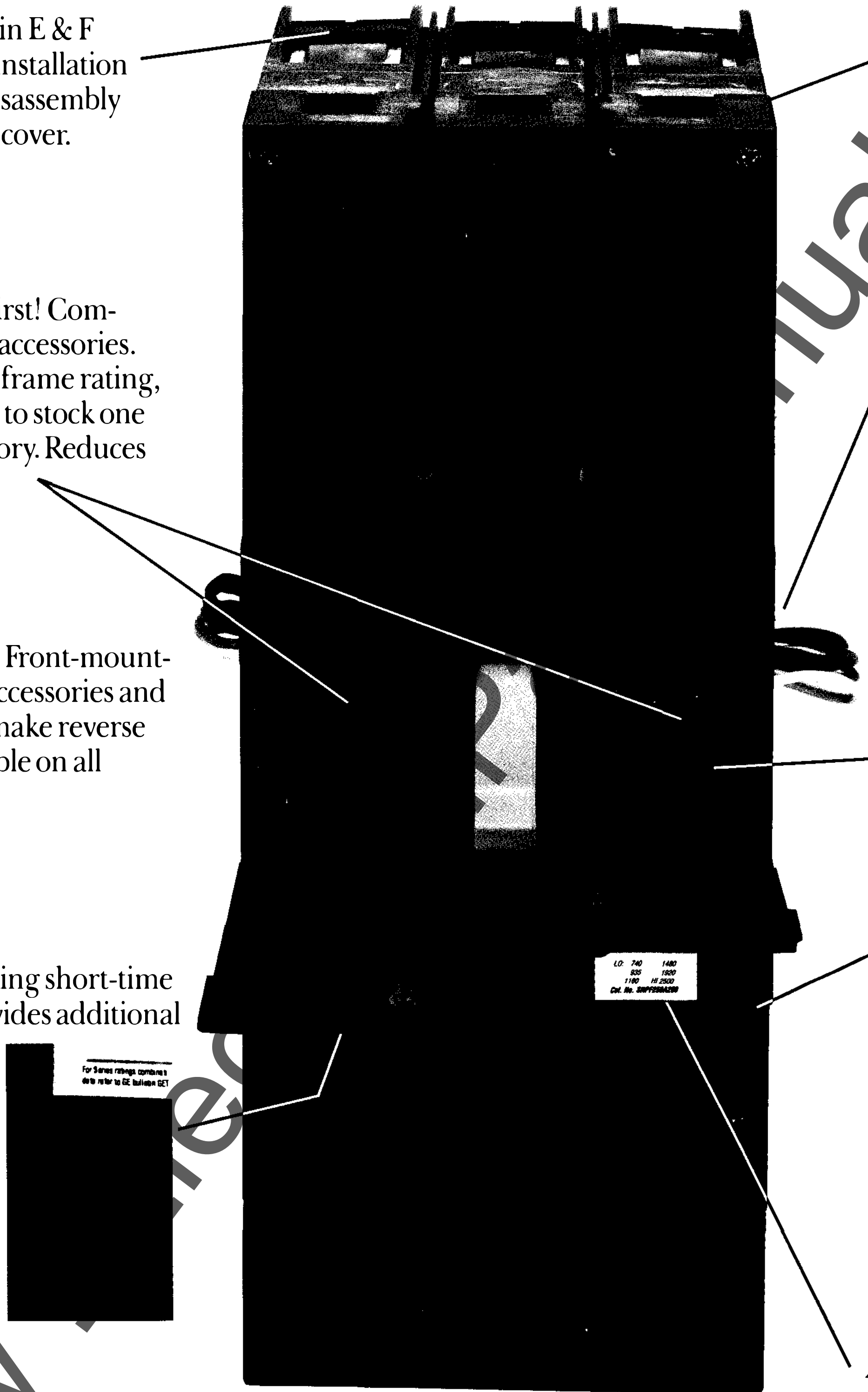
Application and Selection



INTRODUCING THE FIRST BREAKER LINE WITH UNIVERSAL ACCESSORIES. GE'S NEW SPECTRA RMS.™

Table of Contents	Pages

The Features You've Asked For.



Snap-in lugs (in E & F frames). Lug installation requires no disassembly or removal of cover.

An industry first! Common internal accessories. Regardless of frame rating, you only have to stock one type of accessory. Reduces SKUs.

Reverse Feed. Front-mounting internal accessories and rating plugs make reverse feeding possible on all frames.

Unique, tracking short-time function provides additional protection for motors and transformers. A new solution in a lower-priced breaker!

Current limiting by design. E150, F250, and G400/600 provide exceptional equipment protection and less system stressing.

Addition of internal accessories does not add to breaker width.

Accessory leads, which fit into troughs, can be either right or left feed. And, thanks to the side and rear troughs, no added space is required for lead exit.

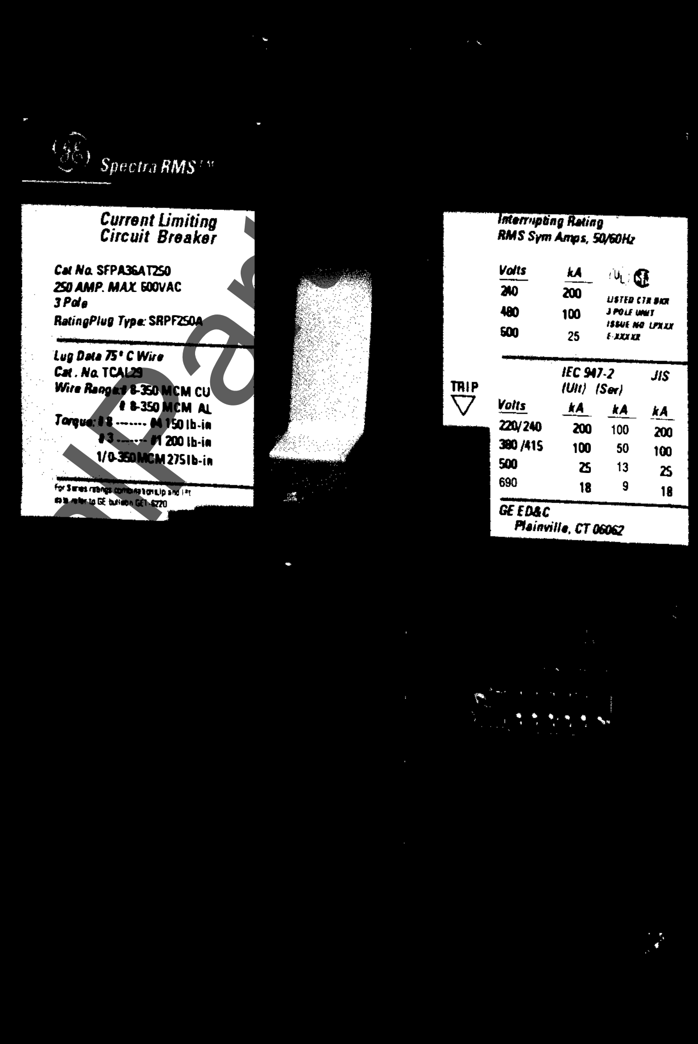
Higher IC ratings. Ratings to 100kA @480V without fuses – and without changing from traditional GE breaker sizes.

Entire line provides true RMS sensing. Breakers accurately react to non-sinusoidal currents produced by SCR drives, welders, arc furnaces, computer power supplies, and discharge-type lighting.

A GE exclusive! Full line of interchangeable rating plugs. Amp rating changed by plugs – a marketing advantage. Reduced stock keeping – your advantage.

New frame size/current ratings. Better packaging density. More amps per cubic inch. F-frame now offers 250-amp protection. 5 1/2″-wide 400- and 600-amp G-frame replaces 8 1/4″-wide J-frame.

TURN THE FLAP, AND SEE HOW EASY IT IS TO INSTALL BREAKER RATING PLUGS AND ACCESSORIES.



Standard and Current Limiting Circuit Breakers

INTERCHANGEABLE RATING PLUGS

Each Spectra RMS™ circuit breaker has an array of interchangeable rating plugs, as shown in Figure 4.1, to change a current rating up to the maximum rating of the frame. Instant modification with a minimum number of different components is a reality.

FIELD-INSTALLED BREAKER ACCESSORIES

Each Spectra RMS™ circuit breaker accepts a full range of internal accessories without breaker disassembly while maintaining the UL Listing. The shunt trip, undervoltage release, bell alarm and auxiliary switch devices, shown in Figure 4.2, can be used with any circuit breaker in the Spectra RMS™ product line.

Fig. 4.1 Typical range of rating plugs SF-Frame, 60-amp shown

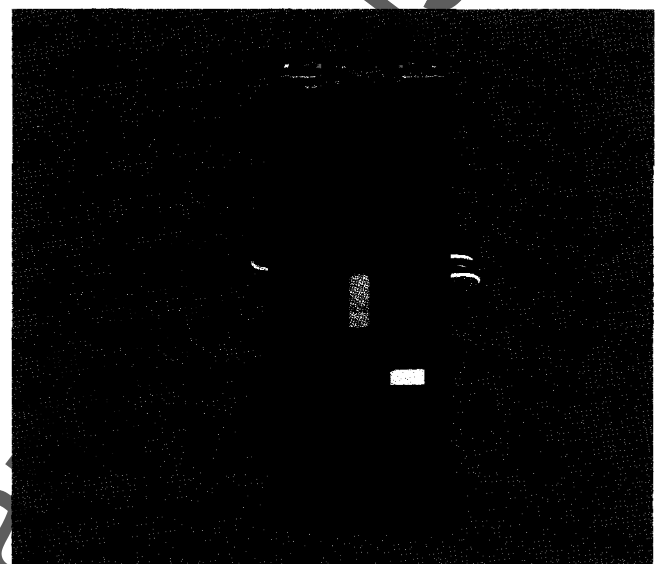
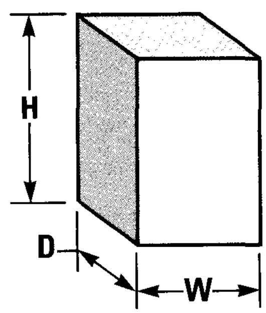


Fig. 4.2 View of SF-Frame breaker with accessory pouches open, and accessories displayed



Frame	Maximum Ampere	Dimensions (in.)		
		H	W	D
SE	7, 30, 60 100 & 150	6.51	4.12	3.38
SF	250	10.12	4.12	4.06
SG	400 & 600	13.62	5.50	4.06
SK	800 & 1260	15.50	8.25	5.50

Fig. 4.3 Envelopes and ratings of Spectra RMS™ circuit breakers

Important space savings are built into each Spectra RMS™ circuit breaker. Envelope geometry and the rating matrix are illustrated in Figure 4.3. Accessory leads can be routed (see Figure 5.1) to either the right- or left-side channel within the overall dimensions of the breaker envelope – avoiding additional space requirements for leads. A rear channel is also provided (see Figure 5.2), allowing accessory leads to be routed behind a panel-mounted unit without the need for stand-off hardware.

APPLICATION FOCUSED TIME-CURRENT CHARACTERISTICS

The new short-time function provided by Spectra RMS™ circuit breakers is shown in Figure 5.3. Long-time and instantaneous-trip points establish the primary full load and severe overcurrent trip characteristics of the breaker's protection. In feeder circuit applications, the new short-time function backs up downstream devices such as fuses or starter overloads with time for them to clear before the breaker opens. For branch circuit applications, the Spectra RMS™ breaker provides added, tighter protection not available in any other standard 150-amp frame breaker.

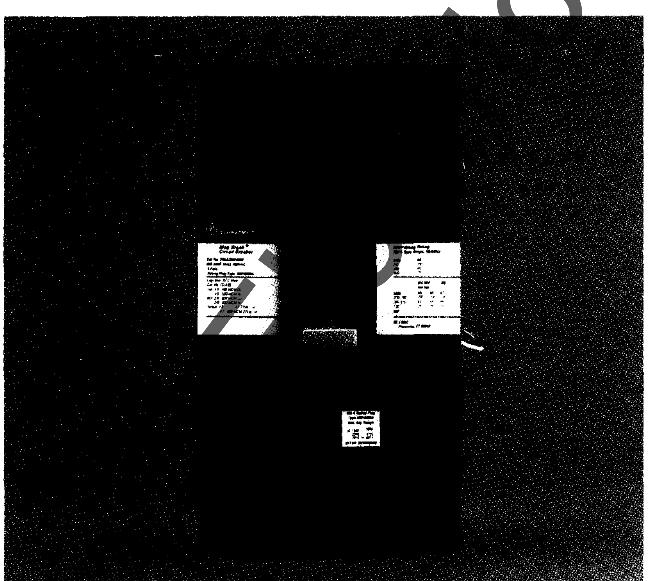


Fig. 5.1 View of typical breakers with shunt trip leads brought out on left and right sides

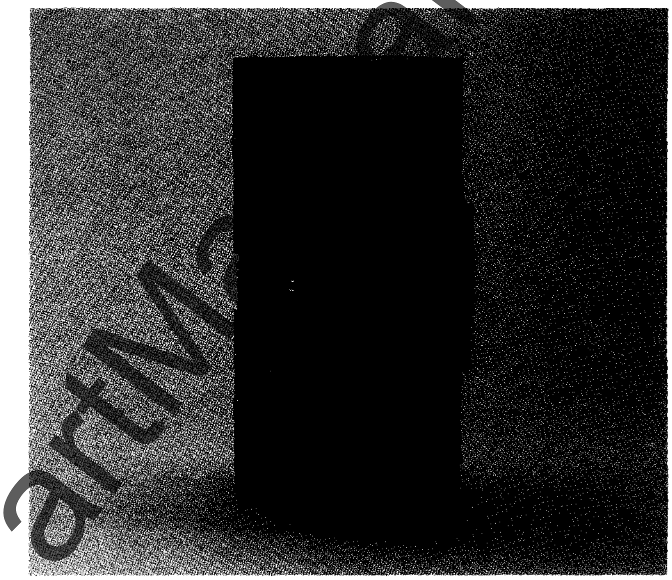


Fig. 5.2 Shunt trip leads run behind back of panel-mounted breaker

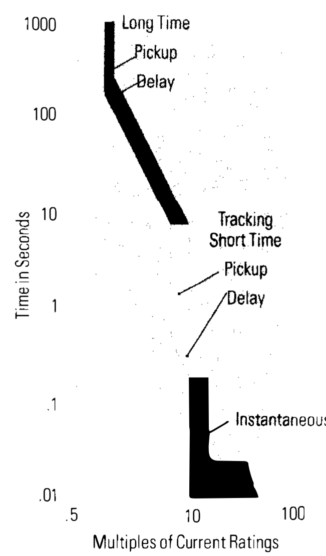


Fig. 5.3 Spectra RMS™ typical time-current curve

HIGHER INTERRUPTING CAPACITIES

Modern power distribution systems require higher IC (Interrupting Capacity) protective devices. Each Spectra RMS™ circuit breaker is available in three IC ranges: 25 kA (25,000 amps), 65 kA and 100 kA, rms, symmetrical, at 480 Vac. The new SE-Frame is also available with an IC of 14 kA, rms, symmetrical.

Interrupting capacity ratings are detailed in Tables 43.1 & 44.1, pages 43 & 44.

SPECTRA RMS™ MAG-BREAK® PRODUCT LINE

The new Spectra RMS™ Mag-Break® motor circuit protector offers the precision and ambient insensitivity of GE's solid-state tripping system in a highly cost-effective motor circuit protective device. Interchangeable rating plugs define both the maximum continuous full-load current and the instantaneous setting ranges of each unit. The instantaneous-trip point and tracking short-time characteristic is adjustable over approximately a 5-to-1 range. Figure 6.1 illustrates time-current curve features of the typical Mag-Break® unit shown in Figure 6.2.

SPECTRA RMS™ MOLDED-CASE SWITCH PRODUCT LINE

The new Spectra RMS™ circuit breaker family also has a full line of compact, economical circuit disconnect devices. Spectra RMS™ molded case switches have seven current ratings from 100 amps to 1200 amps. In the event of misapplication or severe overcurrent, the contacts of these devices will open on a non-adjustable, high-set, instantaneous basis preventing damage to the molded case switch. Down stream conductor and load protection must be provided by other devices with adequate interrupting capacity.

Molded case switches, by definition, do not provide any overcurrent protection. The withstand ratings are listed in Table 44.2, page 44.

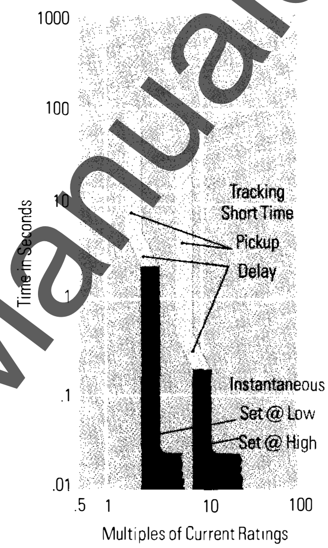


Fig. 6.1 Typical time curve of a Spectra RMS™ Mag-Break® motor circuit protector

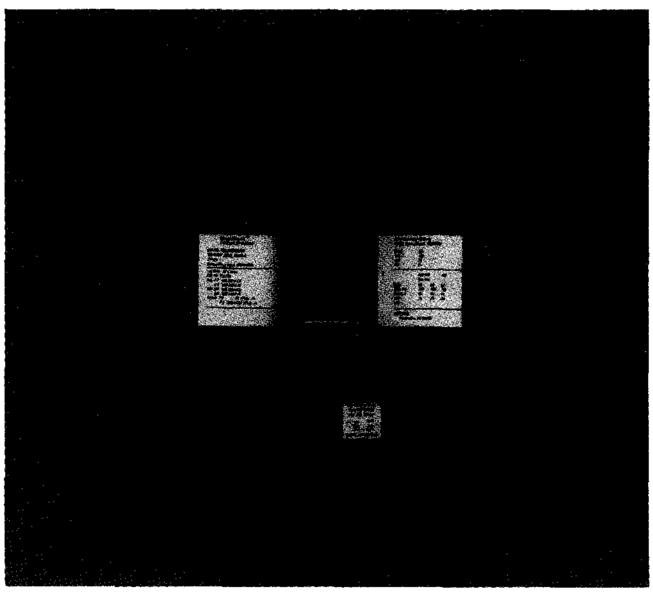


Fig. 6.2 SG-Frame Mag-Break® motor circuit protector

OVERVIEW OF THE SPECTRA RMS™ CIRCUIT BREAKER, MAG-BREAK® AND MOLDED CASE SWITCH PRODUCT FAMILY

Table 7.1 Circuit Breakers, Changeable Long-Time/Adjustable Instantaneous/Short-Time

Feature	SE-Frame	SF-Frame	SG-Frame	SK-Frame
Poles	2 & 3	2 & 3	2 & 3	2 & 3
Maximum Frame Amps	30 60 100 150	250 – – –	400 600 – –	800 1200 – –

Table 7.2 Mag-Break®, Adjustable Instantaneous/Short-Time

Feature	SE-Frame	SF-Frame	SG-Frame	SK-Frame
Poles	3	3	3	3
Maximum Frame Amps	7 30 60 100 150	250 – – – –	400 600 – – –	800 1200 – – –

Table 7.3 Molded Case Switches, Non-Adjustable (Fixed, High-Set Instantaneous Override)

Feature	SE-Frame	SF-Frame	SG-Frame	SK-Frame
Poles	3	3	3	3
Maximum Frame Amps	100 150	250 –	400 600	800 1200

THE SPECTRA RMS™ RATING PLUG CONCEPT

All Spectra RMS™ circuit breakers use a UL Listed interchangeable rating plug to establish the long-time trip point of the circuit breaker. The adjusting knob at the front of the circuit breaker enables the user to change the instantaneous-trip setting and the short-time portion of the breaker's time-current curve. The rating plug operates as a ratioing circuit for the breaker's internal current sensors.

The key advantage of the Spectra RMS™ rating-plug concept is the flexibility of interchangeable rating plugs across the permissible current ratings of a given circuit breaker frame. Since the installed rating plug establishes the amp rating of the breaker, the installer must verify the adequacy of the connected cable and/or bus bar ampacity. The National Electrical Code allows cable size to be matched to the amp rating established by the rating plug.

INSERTION AND REMOVAL

Figures 8.1 and 8.2 illustrate the ease of rating plug insertion and removal. Insertion requires little force, and the lug has snap-in locking provisions. The plug cavity and body is constructed to accept only those plugs compatible with the breaker's frame and ratings. Removal uses a simple, readily available extraction tool (GE Cat. No. TRPT or other commercially available equivalent).

RATING POLARITY

The rating plug has a built-in accept/reject feature to assure that only plugs of the proper rating are inserted in specific circuit breakers. Spectra RMS™ rating plugs utilize a mechanically fit or mechanically reject feature to perform this function. For example, SE-Frame Spectra RMS™ circuit breakers are offered in four frame ratings: 30, 60, 100 and 150 amps. The 60-amp frame has three rating plugs (40-, 50- and 60-amp). Rating plugs for the 60-amp SE-Frame circuit breaker can only be used on that family of units. Conversely, rating plugs for other frames or current ratings are not accepted by the 60-amp SE-Frame cavity.

This plurality of ratings enables the user wide flexibility while still assuring continuity of load protection.

Fig. 8.1 Insertion of Rating Plug

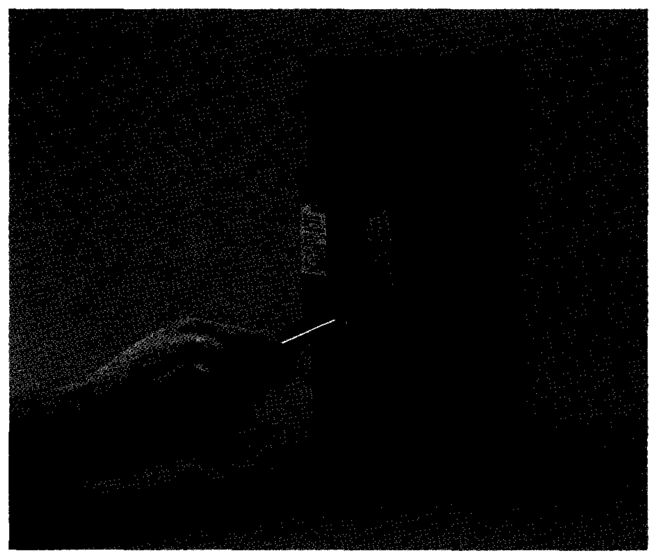


Fig. 8.2 Removal of Rating Plug

TRIP UNIT CHARACTERISTICS

Spectra RMS™ circuit breakers offer the application flexibility and accurate measurement of current waveforms with harmonic content pioneered by GE. In addition, SE-, SF- and SG-Frame (400-amp) circuit breakers incorporate true current limiting construction. All Spectra RMS™ circuit breakers offer IC (Interrupting Capacity) ratings up to, and including, 100,000 amps, rms, symmetrical, at 480 Vac and up to 200 kA at 240 Vac.

APPLICATION FLEXIBILITY

Application flexibility is provided by adding tailored short-time and instantaneous-trip characteristics to the long-time, time-current curve of the solid-state trip system.

LONG TIME

The long-time trip characteristics of Spectra RMS™ circuit breakers is determined by the rating plug. The circuit breaker trip circuit is designed to carry 100% of its plug rating, continuously, in open air without exceeding a 50°C rise at the breaker terminals. At 105% to 130% of the plug rating (the long-time pickup tolerances of the trip circuit), the circuit breaker will trip in the event of a long-term overload downstream from the circuit breaker.

SHORT TIME

The inverse-time, short-time delay trip characteristic of Spectra RMS™ circuit breakers provides an increase in protection by providing closer tracking of load operating conditions. The short-time pickup function tracks the instantaneous pickup by a factor of 0.5 to 0.8, depending upon specific frame and rating plug.

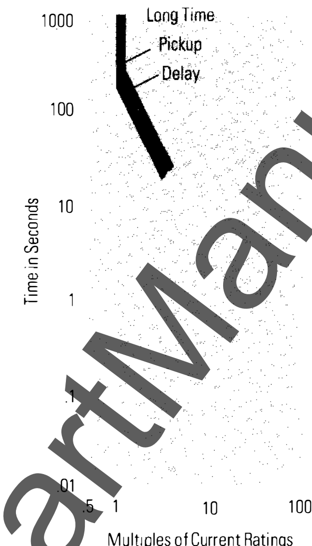


Fig. 9.2 Typical Long-Time Trip Characteristic

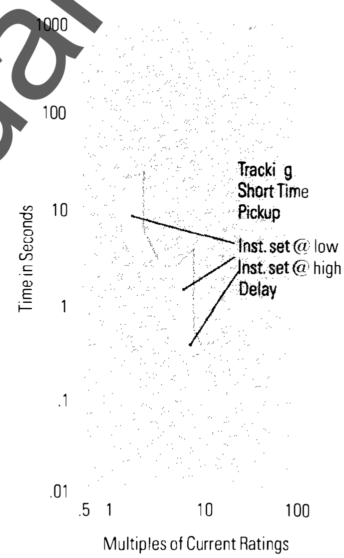


Fig. 9.4 Typical Tracking Short-Time Trip Characteristic

Fig. 9.1 Rating Plug Label

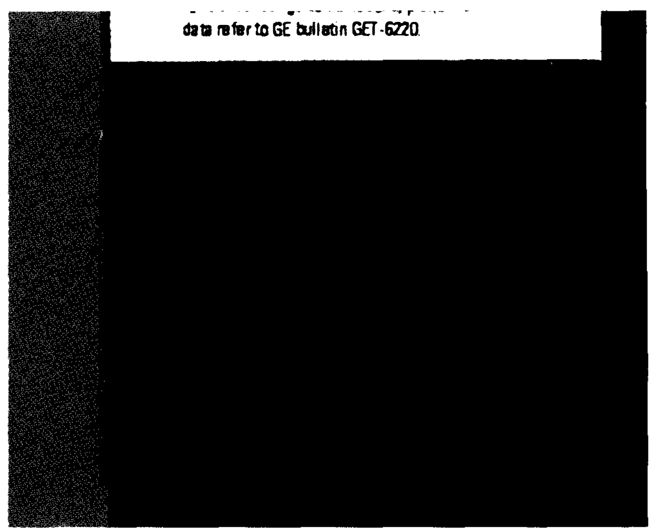


Fig. 9.3 Short-Time/Instantaneous Adjustment Knob

Standard and Current Limiting Circuit Breakers

INSTANTANEOUS

The trip setting adjustment knob of Spectra RMS™ circuit breakers controls the settings of both short-time and instantaneous-trip characteristics. When the adustment knob is set in its "High" position, the breaker will trip on instantaneously at between 10 times to 13 times (depending upon breaker frame) its long-time trip rating (i.e., rating plug amp rating). This provides sufficient margin to override load inrush (e.g., motor, transformer, etc.) current.

The nominal instantaneous pickup values, in amps, are listed on each rating plug, as shown in Figure 9.1.

Figure 10.1 shows the typical adjustability of instantaneous settings.

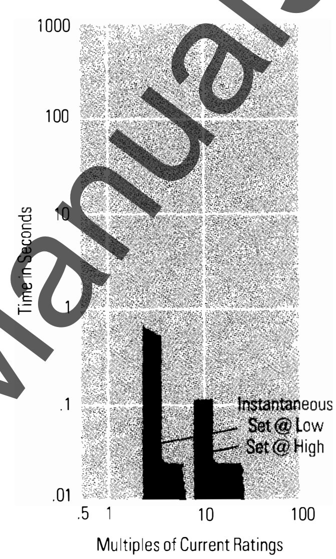


Fig. 10.1 Typical Instantaneous Adjustment

SPECTRA RMS™ CURRENT LIMITING CONSTRUCTION

Spectra RMS™ circuit breakers continue the GE standard of rugged construction and the use of heavy silver-alloy contacts. The low physical mass of the circuit contact arms in SE-, SF- and SG-Frame Spectra RMS™ circuit breakers, coupled with a reverse current loop, provide a true current limiting function without compromising breaker life or performance.

When short-circuit current flows through the lower and upper contact arms of the circuit breaker, a strong magnetic field is produced by the fault current. Since the fields are opposing, forces proportional to the square of the current act to force the two contact arms apart. The higher the fault current, the higher the contact separation forces. During maximum fault conditions, contact separation typically occurs within a quarter of one cycle, and the arc is fully quenched within eight milliseconds.

Peak let-through current, illustrated in Figure 10.2, is held to less than 45% of the maximum available peak fault current, resulting in tremendous reduction in the energy a short-circuit delivers to both conductors and connected loads.

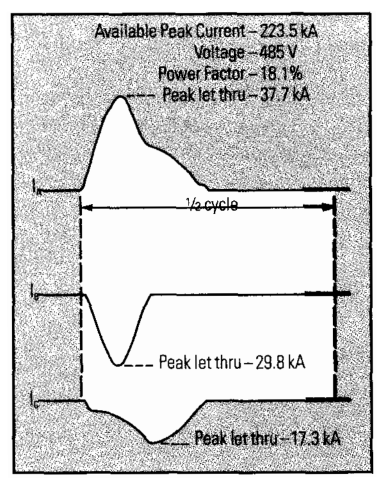


Fig. 10.2 Typical Current Limiting Performance

SPECTRA RMS™ CIRCUIT BREAKER RATINGS

Table 11.1 lists the rating plugs available for each circuit breaker frame size.

Spectra RMS™ circuit breakers are designed to meet applicable European, Japanese and Australian standards for molded case circuit breakers. Instantaneous settings are listed under electrical data on page 33 and interrupting ratings are on pages 43 and 44.

Table 11.1 Spectra RMS™ Circuit Breaker and Rating Plug Current Ratings

Circuit Breaker Frame	Maximum Frame Amperes	Available Rating Plugs, Amperes
SE-Frame	30	15, 20, 25 & 30
	60	40, 50 & 60
	100	70, 80, 90 & 100
	150	110, 125 & 150
SF-Frame	250	70, 90, 100, 110, 125, 150, 175, 200, 225 & 250
SG-Frame	400	125, 150, 175, 200, 225, 250, 300, 350 & 400
	600	250, 300, 350, 400, 450, 500 & 600
SK-Frame	800	300, 400, 500, 600, 700 & 800
	1,200	600, 700, 800, 1,000 & 1,200

Mag-Break® Motor Circuit Protectors

SPECTRA RMS™ MAG-BREAK® MOTOR CIRCUIT PROTECTORS

Interchangeable Rating Plug. Spectra RMS™ Mag-Break® motor circuit protectors use the same snap-in rating plugs as fully configured (long-time trip function) Spectra RMS™ circuit breakers. Each rating plug defines the range of instantaneous-trip settings available to the circuit breaker through its trip setting adjustment.

Trip Setting Adjustment. The solid-state instantaneous-trip circuitry of the Spectra RMS™ Mag-Break® motor circuit protectors has a single, multi-position adjustment at the front of each breaker. Changes in settings vary the instantaneous-trip and tracking short-time characteristics. The Mag-Break® motor circuit protectors differ from a fully configured circuit breaker by providing only an instantaneous and tracking short-time trip function.

Accessory Pockets. Spectra RMS™ Mag-Break® motor circuit protectors have the same accessory pockets and use the same internal accessories as fully configured Spectra RMS™ circuit breakers. This important capability allows field modification of Mag-Break® units with shunt trip, undervoltage release, bell alarm or auxiliary switch accessories, in any combination, without affecting UL Listing status.

Fig. 12.1 SE150 Spectra RMS™ Mag-Break® Motor Circuit Protector

SPECTRA RMS™ RATING PLUGS

Use of the same UL Listed interchangeable rating plugs for both Mag-Break® and fully configured Spectra RMS™ circuit breakers expands the flexibility of the entire Spectra RMS™ family of products. The advantages of interchangeable rating plugs with Spectra RMS™ circuit breakers are inherent to Spectra RMS™ Mag-Break® units, which permit wider ranges of motor ratings to be protected by a given breaker frame size.

SPECTRA RMS™ MAG-BREAK® TRIP UNIT CHARACTERISTICS

Spectra RMS™ Mag-Break® motor circuit protectors provide positive, reliable and cost-effective instantaneous, with short-time tracking, overcurrent protection to those circuits where long-time overload protection is supplied by thermal or solid-state overload devices.

MOTOR CIRCUIT SHORT-CIRCUIT PROTECTION

When a squirrel-cage induction motor is first energized, a high value of magnetizing inrush current flows for the first few cycles, followed by a substantially reduced current flow while the motor accelerates to its rated speed. Typically, the magnetizing inrush current may be 10 times rated full-load current for normal efficiency motors and as high as 14 times rated full-load current for high-efficiency motors prior to the first five to eight cycles. Magnetizing inrush current is followed by a "locked-rotor" line current of 5 to 6 times rated full-load current during the 0.1- to 10-second acceleration phase – with line current rapidly declining to normal load current values as the motor nears rated speed.

Optimum instantaneous protection would have a two-tiered tripping characteristic. A high value of current would be tolerated for a few cycles, followed by a lower, sustained trip setting.

That is exactly what is found in the Mag-Break® tripping characteristic.

Use of this two-tiered time-current curve prevents nuisance tripping due to magnetizing inrush current, without compromising superior short-circuit protection during motor acceleration as indicated in Figure 13.1.

Figure 13.1 illustrates the most popular application of Mag-Break® motor circuit protectors. The time-current curve shows a plot of motor-line current versus time (Curve C) for a three-phase squirrel cage induction motor. The shaded portion of the time-current curve (above Curve A) indicates a region of operation that could produce permanent damage to either the motor, its feeded conductors, or both. The trip characteristics of the motor starter's overload relay is shown as Curve B. The overload relay provides both long-term overload and stall protection. However, the overload relay does not protect the system from short circuits in either the motor or its feeder conductors.

Curve C is a plot of motor-line current during a worst-case start (e.g., low line voltage, highest anticipated required load torque, etc.). Curve D is a plot of the Spectra RMS™ Mag-Break® motor circuit protectors' tripping characteristic.

With the addition of the Mag-Break® motor circuit protectors, the motor circuit now has protection against short circuits. Stall and long-term overload protection is provided, in this example, by the motor starter's overload relay.

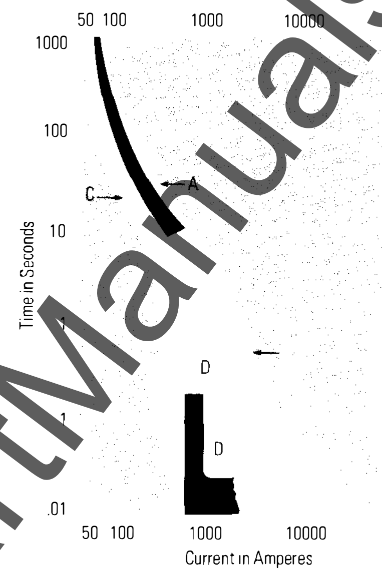


Fig. 13.1 Motor Circuit Protection Using Mag-Break® Motor Circuit Protectors

SPECTRA RMS™ MAG-BREAK® MOTOR CIRCUIT PROTECTOR RATINGS

Table 13.1 lists rating plugs available for each Mag-Break® motor circuit protector frame size. Instantaneous settings are listed under electrical data on page 33 and interrupting ratings are on pages 43 and 44.

Table 13.1 Spectra RMS™ Mag-Break® Motor Circuit Protector and Rating Plug Current Ratings

Circuit Breaker Frame	Maximum Frame Amperes	Available Rating Plugs, Amperes
SE-Frame	7	3 & 7
	30	15, 20, 25 & 30
	60	40, 50 & 60
	100	70, 80, 90 & 100
	150	110, 125 & 150
SF-Frame	250	70, 90, 100, 110, 125 150, 175, 200, 225 & 250
SG-Frame	400	125, 150, 175, 200, 225, 250, 300, 350 & 400
	600	250, 300, 350, 400, 450, 500 & 600
SK-Frame	800	300, 400, 500, 600, 700 & 800
	1,200	600, 700, 800, 1,000 & 1,200

Molded Case Switches

MOLDED CASE SWITCH

Construction. The family traditions of ruggedness and dependability are continued in the Spectra RMS™ molded case switch line. These units provide a circuit disconnect function using the compactness of molded-case circuit breaker construction. The operating handle actuates all three poles of the switch using the same common trip bar of Spectra RMS™ circuit breakers and Mag-Break® units.
Termination Lugs. Snap-in termination lugs used with SE- and SF-Frame Spectra RMS™ circuit breakers are used interchangeably in Spectra RMS™ molded case switches. SG- and SK-Frame molded case switches use the same bolt-on termination lugs used with Spectra RMS™ circuit breakers.
External Accessories. The full range of external circuit breaker accessories offered for use with Spectra RMS™ circuit breakers, both fully configured and Mag-Break,® are available for molded case switches. Figure 14.1 shows the Spectra RMS™ molded case switch with a plug-in base assembly. In addition, plug-in bases, motor-operated mechanisms, mechanical interlocks, and the full complement of external handle operators (TDA, TDR and TDM) are available for use with Spectra RMS™ molded case switches.

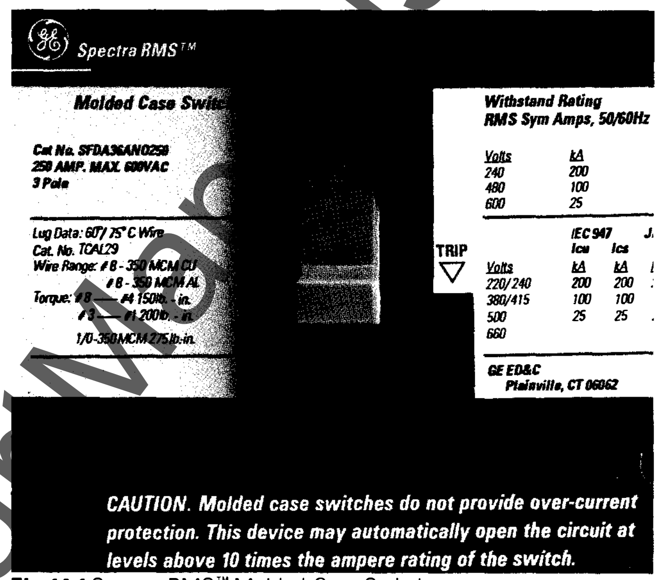


Fig.14.1 Spectra RMS™ Molded Case Switch

SPECTRA RMS™ MOLDED CASE SWITCH APPLICATIONS

Molded case switches are inherently horsepower-rated. By virtue of the UL489 six-times-rated current overload test, they can be used as motor circuit disconnects where overload and short-circuit protection are provided by other protective devices.

A common application of Spectra RMS™ molded case switches is illustrated in Figure 15.1. Figure 15.1 shows a system containing three branch circuits.

Branch Circuit 1 uses a Spectra RMS™ Mag-Break® motor circuit protector, in conjunction with the overload devices of the motor starter, to protect the motor and the conductors of that branch circuit. Branch Circuits 2 and 3 use fully configured Spectra RMS™ circuit breakers to provide instantaneous, short-time and long-time protection for both branch-circuit conductors and loads.

Protection of the short bus and feeder between the Spectra RMS™ molded case switch and the bus in this figure is provided by a properly rated breaker.

Spectra RMS™ molded case switches are excellent circuit disconnect devices for those applications where both the advantages of molded case switch construction are desired, and where the available short-circuit current is less than the switch withstand rating as defined in Table 44.2 under electrical data page 44.

All Spectra RMS™ molded case switches are UL Listed and tested per UL Standard 1087 for molded case switches. The short-circuit withstand ratings are based upon three cycle tests. Thus the UL Listed upstream overcurrent protective devices (i.e., low-voltage power circuit breakers equipped with instantaneous-trip functions, insulated-case circuit breakers, molded case circuit breakers or fuses) can be used in conjunction with molded case switches.

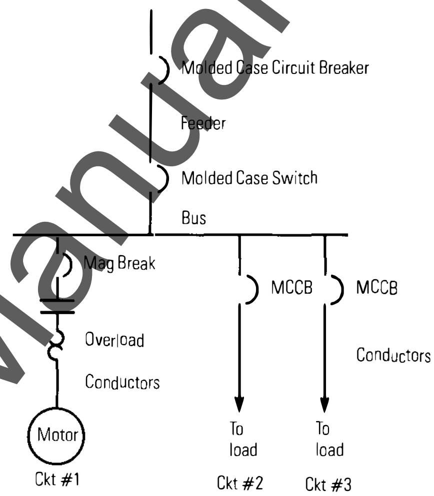


Fig. 15.1 Spectra RMS™ Molded Case Switch Application

SPECTRA RMS™ MOLDED CASE SWITCH CURRENT RATINGS

Table: 15.1 Spectra RMS™ Molded Case Switch Current Ratings

Molded Case Switch Frame	Maximum Frame Amperes
SE-Frame	100 & 150
SF-Frame	250
SG-Frame	400 & 600
SK-Frame	800 & 1,200

Accessories

Table: 16.1 Internal and external accessories available for the Spectra RMS™ product line

	Product		Circuit Breakers	Mag-Break CBs	Molded Case Switches
Internal Accessories	Shunt Trip		Yes	Yes	Yes
	UV Release		Yes	Yes	Yes
	Bell Alarm Switch		Yes	Yes	Yes
	Aux Switch		Yes	Yes	Yes
External Accessories	Line & Load Lugs		Yes	Yes	Yes
	Back-Connected Studs		Yes	Yes	Yes
	Plug-in Bases		Yes	Yes	Yes
	Motor-Operated Mechanism		Yes	Yes	Yes
	Mechanical Interlock		Yes	Yes	Yes
	External Handles	Type TDA	Yes	Yes	Yes
		Type TDR	Yes	Yes	Yes
		Type TDM	Yes	Yes	Yes
	Handle Blocking Device		Yes	Yes	Yes
	Padlock Device		Yes	Yes	Yes

Internal Accessories

Four types of internal accessories are available for Spectra RMS™ Circuit Breaker products: Shunt Trips, Undervoltage Releases, Bell Alarms, and Auxiliary Switches. Spectra RMS™ internal accessories are common to all products in the Spectra RMS™ product family, including circuit breakers, Mag-Break® Motor Circuit Protectors, and molded case switches. They are interchangeable between frame sizes, i.e., the 24 VDC Shunt Trip – SAST3 – can be installed in any of the four basic frames from the type SE150 to the type SK1200. In addition, Spectra RMS™ internal accessories are designed to be installed in pockets accessible from the front of the circuit breaker.

NO DISASSEMBLY OF THE CIRCUIT BREAKER CASE IS REQUIRED.

These unique characteristics: interchangeability, commonality, and installation without violation of case integrity, provide the user with the optimum combination of reliability, standardization and parts reduction. ALL SPECTRA RMS™ ACCESSORIES ARE UL LISTED FOR FIELD INSTALLATION.

Figure 17.1 shows an SF-Frame Spectra RMS™ Circuit Breaker with open accessory pockets. The left-hand pocket accepts either a shunt trip or an undervoltage release, plus a bell alarm. The right-hand pocket is used for auxiliary switches. All accessories are supplied with 36-inch long, #18AWG, 125C insulated leads. Side and rear wire channels allow accessory leads to be led to the left, right, or back of the breaker within the dimensions of the breaker envelope.

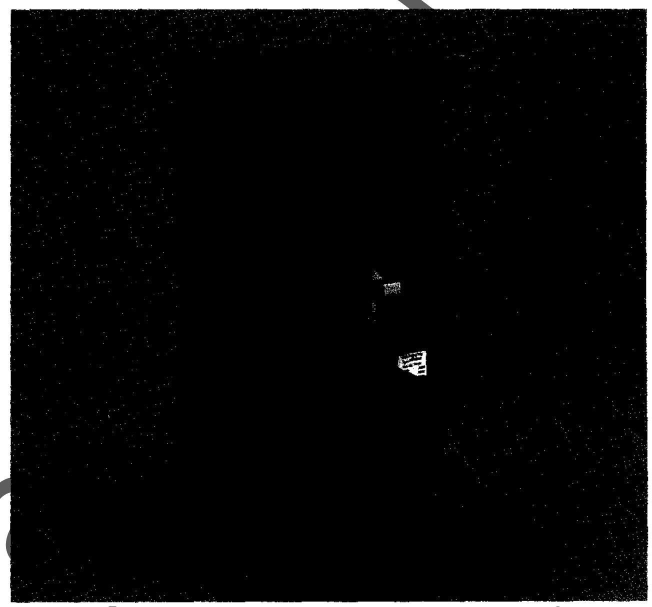


Fig. 17.1 SF-Frame Circuit Breaker with Accessory Pockets Open

Internal Accessories

SHUNT TRIP

The shunt trip is used to trip (open) the circuit breaker by remote control. Spectra RMS™ shunt trips are UL Listed for field installation, meeting UL requirements for operation at 55% of rated ac voltage and 75% of rated dc voltage for use on ground fault systems.

Spectra RMS™ Shunt Trips are common to all circuit breakers and switches in the Spectra RMS™ product family.

For remote tripping of breaker, use with momentary close contact. Not recommended for use with latching relay contact since electronics in Shunt Trip will pulse power to the coil if continuously energized, and breaker tripping upon reclosure will be delayed 1-2 seconds at rated control voltage.

If maintained (latching relay) contact must be used and delayed shunt tripping is not acceptable, use bell alarm in series with control power for SE150 and SF250 frames and auxiliary switch for SG600 and SK1200 breakers.

Fig. 18.1 Shunt Trip

ELECTRICAL DATA

Table 18.1 Shunt Trip Device Electrical Characteristics

	Rated Nominal Voltage		Current, mA	
Catalog Number	**Ac**	**Dc**	**Inrush**	**Cont.**
SAST1	120	125	500	6.0
SAST2	240	250	400	5.0
SAST3	–	24	300	10.0
SAST4		48	300	10.0

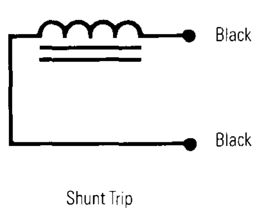


Fig. 18.1 Wiring Diagram, Shunt Trip

UNDERVOLTAGE RELEASE

The undervoltage release trips the circuit breaker when control voltage drops to less than 35% to 70% of rating. Optional time delay units from 100 to 1,000 milliseconds allow the user to minimize nuisance tripping. The time delay may be switched off to provide an instantaneous undervoltage trip. In the event an attempt is made to reclose the circuit breaker while the undervoltage condition is still present, the undervoltage release device will prevent breaker contact closure.

Spectra RMS™ Undervoltage Releases are common to all circuit breakers and switches in the Spectra RMS™ product family. All Spectra RMS™ accessories are UL Listed for field installation.

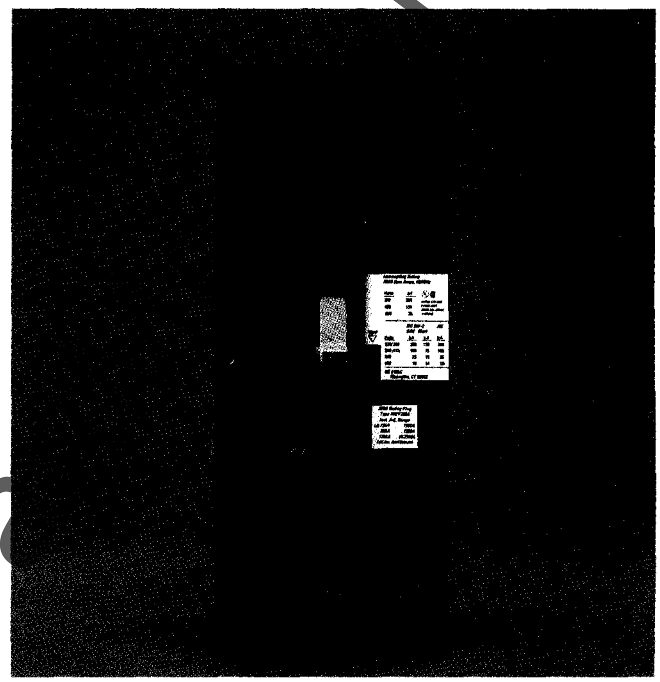


Fig. 19.1 Undervoltage Release

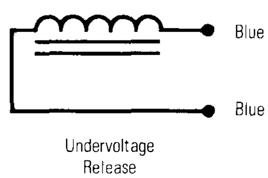


Fig. 19.2 Wiring Diagram, Undervoltage Release

ELECTRICAL DATA

Table 19.1 Undervoltage Release Electrical Characteristics

Catalog Number	Peak Current, mA	Rated Nominal Voltage	
		Ac	Dc
SAUV1	200	120	125
SAUV2	200	240	250
SAUV3	100	–	24
SAUV4	100	–	48

Internal Accessories

BELL ALARM SWITCH

The bell alarm switch is applied to signal breaker trip status to other accessories (e.g., external alarm devices, indicating lights, relays, or logic circuits) for remote indication and interlocking functions. The switch operates when the breaker is tripped as a result of its protective functions, or as the result of the operation of a shunt trip or undervoltage release. The switch is *not* actuated as a result of normal breaker "On-Off" operation, including operation of the slide-to-trip or push-to-trip VERIFIER mechanism.

The bell alarm switch is available with one single-pole double-throw (SPDT) element in either of two ratings: with control power duty contacts suitable for 120-240 Vac and 48-125 Vdc application, or low-impedance contacts for signal-level circuits such as dc pilot circuits and programmable logic controllers. Signal-level contacts are gold-plated and are suitable for 5-30 Vac or Vdc.

Spectra RMS™ Bell Alarm Switches are common to all circuit breakers and switches in the Spectra RMS™ product family. All Spectra RMS™ accessories are UL Listed for field installation.

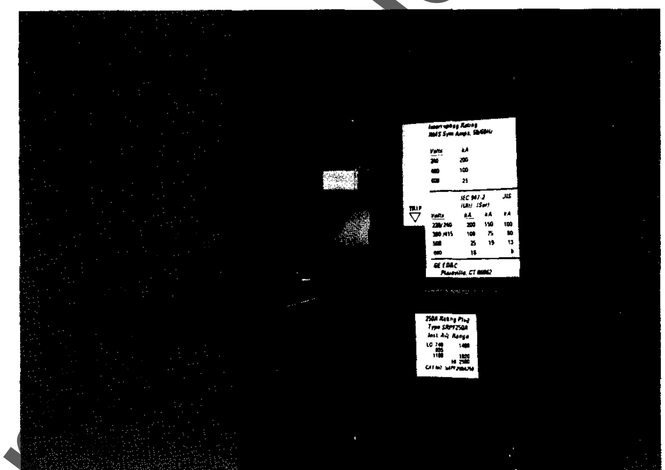


Fig. 20.1 Bell Alarm Switch

ELECTRICAL DATA

Table 20.1 Alarm Switch Electrical Characteristics

Catalog Number	Contact Configuration	Contact Ratings				
		Ac		Dc		
		Volts	Amps	Volts	Amps -Res.	Amps -Ind.
SABAP1	1 AB Element	120-240	5	48-125	0.50	0.25
SABAG1	1 AB Element, gold-plated	5-30	1	30	1.0	0.50

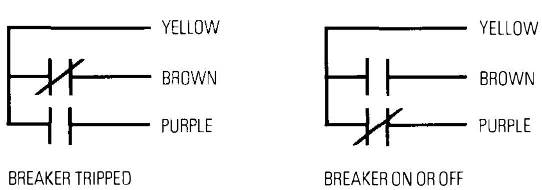


Fig. 20.2 Wiring Diagram, External Alarm Switch

AUXILIARY SWITCH

The auxiliary switch signals primary contact position (open or closed) to other accessories (e.g., indicating lights, relays, or logic circuits) for remote indication, interlocking, and control applications. Switch operation is independent of the method used to open or close the breaker. Auxiliary switches do not distinguish between a trip or open condition.

The auxiliary switch is available with either one or two single-pole double-throw (SPDT) elements in either of two contact ratings: control power duty contacts suitable for 120-240 Vac and 48-125 Vdc application, or low-impedance contacts for signal-level circuits such as dc pilot circuits and programmable logic controllers. Signal-level contacts are gold-plated and are suitable for 5-30 Vac or Vdc.

Spectra RMS™ Auxiliary Switches are common to all circuit breakers and switches in the Spectra RMS™ product family. All Spectra RMS™ accessories are UL Listed for field installation.

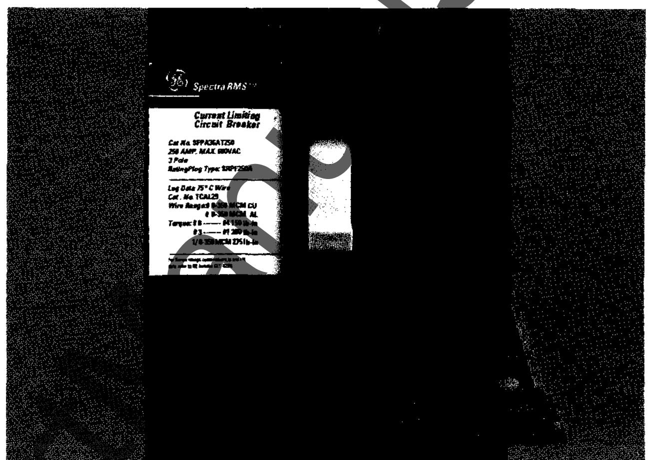


Fig. 21.1 Auxiliary Switch

ELECTRICAL DATA

Table 21.1 Auxiliary Switch Electrical Characteristics

Catalog Number	Contact Configuration	Contact Ratings				
		Ac		Dc		
		Volts	Amps	Volts	Amps-Res.	Amps-Ind.
SAUXPAB1	1 AB Element	120-240	5	48-125	0.50	0.25
SAUXPAB2	2 AB Elements	120-240	5	48-125	0.50	0.25
SAUXGAB1	1 AB Element, gold-plated	5-30	1	5-30	1.0	0.5
SAUXGAB2	2 AB Elements, gold-plated	5-30	1	5-30	1.0	0.5

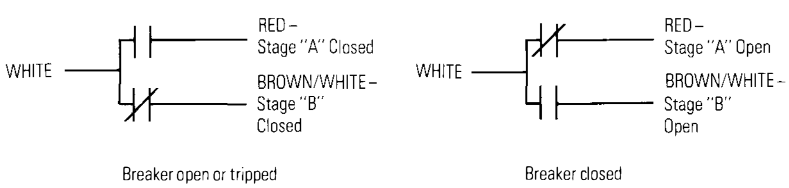


Fig. 21.2 Wiring Diagram, Auxiliary Switch One AB Element

TERMINATION LUGS

Termination lugs permit easy front connection of either copper- or aluminum-insulated conductors to the terminals of Spectra RMS™ circuit breakers and molded case switches.

Figure 22.1 illustrates the snap-in lugs that are installed without tools in SE- and SF-Frame Spectra RMS™ circuit breakers and molded case switches.

Sizes and Ratings. Termination lugs are designed and tested for use with specific conductor sizes and number of conductors per phase. These characteristics are dictated by UL and represent sound engineering practice. Table 22.1 lists the maximum-size conductor range for tin-plated extruded-aluminum lugs.

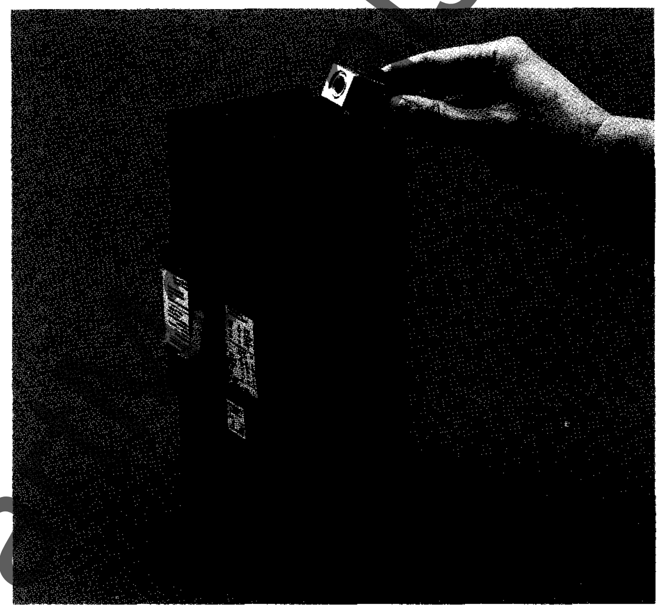


Fig. 22.1 Typical Snap-In Line Side Lug

Table 22.1 Lug Sizes and Ratings for Circuit Breakers (Including Mag-Break®) and Molded Case Switches

Device		Line/Lug Catalog No.	Maximum 75C Insulated Conductor	
Frame	Frame Amps		Copper Conductor	Aluminum & Copper Clad
SE	7			
	30			
	60	TCAL18	#14 AWG – 3/0	#12 AWG – 3/0
	100			
	150			
SF	250	TCAL29	#6 AWG – 350 MCM	#4 AWG-350 MCM
SG	400	TCLK65		
	600			
SK	800	TCAL81 (upper) TCAL91 (lower)	(3) 3/0 – 500 MCM	(3) 3/0 – 5 – MCM
	1,200	TCAL121 (upper) TCAL131 (lower)	(3) 3/0 – 500 MCM (4) 250 – 500 MCM	(4) 250 – 500 MCM

BACK-CONNECTED STUDS

Back-connected studs are used when panel mounting (of the protective device), quick removal, and cabling or bussing behind the panel is required. A mounting sub-base is provided that mates with the Spectra RMS™ circuit breaker or molded case switch and the studs. Each stud is of sufficient length to accommodate panel thicknesses from 0.25 inches (6mm) to one inch (25mm).

Sizes and Ratings. Table 23.1 lists the back-connected studs available for the complete line of Spectra RMS™ circuit breakers, including Mag-Break® devices and molded case switches. These studs are field-installed.

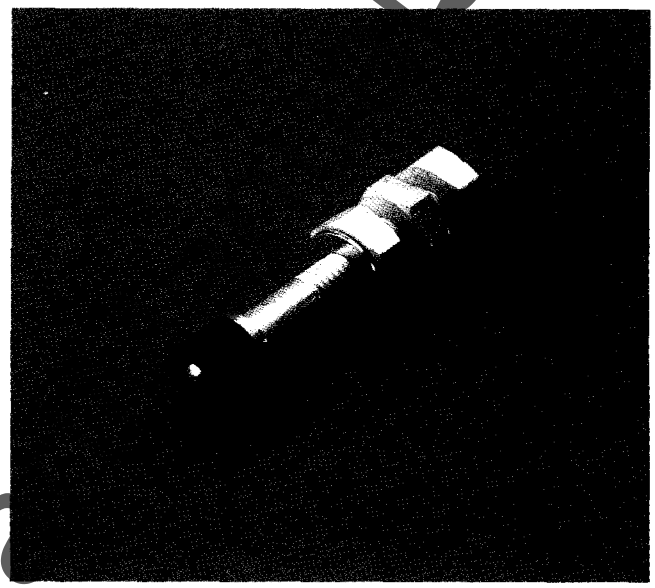


Fig. 23.1 Back-Connected Stud

Table 23.1 Back-Connected Line and Load Studs

Frame	Frame Amps	Length, Back of Device		Short/Long	Catalog Number
		Inches	Millimeters		
SE	15-50	$2\frac{25}{32}$	70.6	Short	TEF1
		$4\frac{13}{32}$	112.0	Long	TEF2
	60-150	$3\frac{13}{32}$	86.5	Short	TEF3
		$5\frac{25}{32}$	147.0	Long	TEF4
SF	70-250	$2\frac{23}{32}$	69.0	Short	TFK1
		$5\frac{31}{32}$	151.5	Long	TFK2
SG	125-400	$5\frac{17}{32}$	140.5		SGBCS
	250-600	$5\frac{17}{32}$	140.5		SGPCS
SK	◆ 300-800	$5\frac{1}{2}$	139.7		TKM11
	800-1,200	8	203.0		TKM12

PLUG-IN MOUNTING BASES

Plug-in mounting bases provide the user with another option for quick changeout of breaker and switch assemblies without disturbing power connections. Two plug-in bases (one for each terminal end) are required for each protective device. When a pair of bases are ordered, the optional mounting plate (shown in Figure 24.1) is supplied at no additional charge and provides three important functions. The plate locates and supports the line and load base assemblies, provides a convenient means to mount the entire assembly to a metal structure, and serves as a deadfront barrier.

Each plug-in base assembly contains all of the mounting hardware necessary to mount the base to either end of the circuit breaker or molded case switch. Electrical spacing between adjacent terminals is provided by alternate long-short-long (LSL) or short-long-short (SLS) terminal assemblies. Fully configured Spectra RMS™ circuit breakers are available in two-pole configurations – with the center pole missing. Consequently, base assemblies for two-pole breakers are either short-open-short (SOS) or long-open-long (LOL). SE-, SF- and SK-Frames use horizontal studs (suffix PD1 or PD2), while SG-Frames use vertical studs (suffix PC1 or PC2).

When breakers or switches are mounted side by side, it is important to plan for adjacent outside poles of the two devices to have a long-short or short-long configuration, so that adequate electrical spacing is provided between adjacent devices.

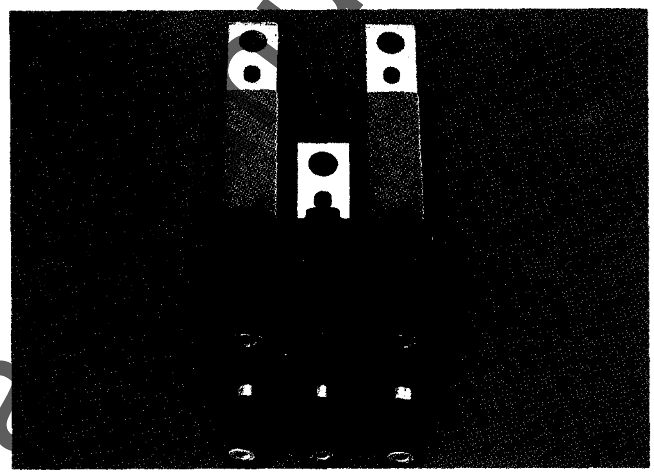


Fig. 24.1 Plug-In Mounting Base

Sizes and Ratings. Table 24.1 lists sizes and ratings of the plug-in base assemblies. There are two basic stud configurations, PD1 and PD2. PD1 always has two short outside stud terminals (either short-long-short (SLS), or short-open-short (SOS)). PD2 always has two long outside terminals (either long-short-long (LSL), or long-open-long (LOL)).

Table 24.1 Plug-In Mounting Base

Plug-In Mounting Bases, 2 Required per Breaker						Optional Mounting Plate
Amp Rating	Breaker Type	No. of Poles	Stud Configurations PD1	Stud Configurations PD2	Catalog Number	Catalog Number
150	SE150	3	SLS	LSL	TE13PD1,2	TMP1
250	SF250	2 3	SOS SLS	LOL LSL	TF22PD1,2 TF23PD1,2	TMP2
600	SG400 SG600	3 3	SLS SLS	LSL LSL	TGPC1,2 TGPC1,2	SMP3
800	SK1200	3	SLS	LSL	TK83PD1A,2A	TMP4
1,200	SK1200	3	SLS	LSL	TK123PD1A,2A	TMP4

MOTOR-OPERATED MECHANISMS (MOM)

The MOM function uses an ac or dc motor-driven mechanism to produce rapid closing or opening. No physical modification of the breaker or switch is needed to add the MOM. The MOM operator slips over the operating handle of the circuit breaker or molded case switch. The MOM cover can be lifted to manually open or close the breaker or switch. Visual indication of the "On-Off" status appears on the mechanism cover.

Figure 25.1 shows an SF-Frame motor operator.

MECHANICAL INTERLOCKS

Mechanical interlocks are available for all SG- and SK-Frame Spectra RMS™ circuit breakers and molded case switches. The function of the mechanical interlock is to positively assure that two adjacent devices in an assembly cannot both be in their "On" (i.e., closed) position at the same time. However, both devices can be "Off" (i.e., open or tripped) at the same time. The interlocking function is performed mechanically by a walking beam mechanism and does not require any control power.

These interlocks are useful whenever control or safety requirements dictate an either-or energized condition downstream of the two protective devices.

Sizes and Ratings. Spectra RMS™ circuit breakers and molded case switches used with mechanical interlocks require special factory drilling. Note that each mechanical interlock must be ordered with two circuit breakers or molded case switches, along with instructions for drilling the bases of the two protective devices.

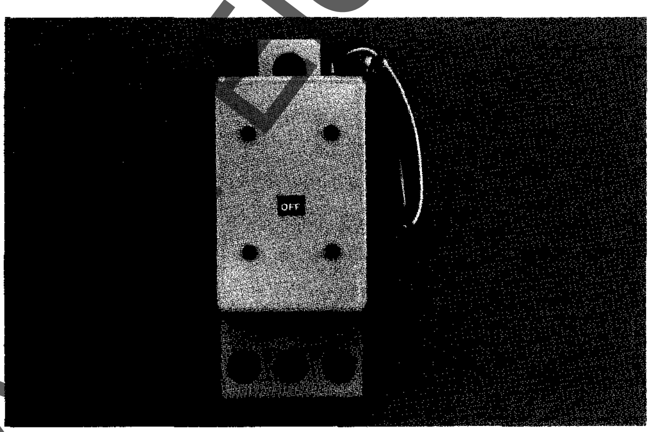


Fig. 25.1 Motor-Operated Mechanism for an SF-Frame Spectra RMS™ Circuit Breaker

Table 25.1 Motor-Operated Mechanisms, Ratings and Electrical Data

Device Frame	Catalog Number	Control Power ① Voltage	Control Power Amps Inrush	Control Power Amps Running	Operating Time Seconds Closing	Operating Time Seconds Opening Reset	Recommended Fuse
SE	SEMOM1	120 Vac 125 Vdc	10 11		0.3	0.3	
	SEMOM2	240 Vac	6		0.3	0.3	
	SEMOM6	24 Vdc	25		0.3	0.3	
	SEMOM9	48 Vdc	15		0.3	0.3	
SF	SFMOM1	120 ac 125 dc	10 11		0.3 0.3	0.3 0.3	
	SFMOM2	240 ac	6		0.3	0.3	
	SFMOM8	24 ac	25		0.3	0.3	
	SFMOM9	48 dc	15		0.3	0.3	
SG	SGMOM1	120 Vac 125 Vdc	12 13		0.3	0.3	
	SGMOM2	240 Vac 250 Vdc	7 8		0.3	0.3	
	SGMOM8	24 Vdc	30		0.3	0.3	
	SGMOM9	48 Vdc	24		0.3	0.3	
SK	SKMOM1	120 Vac 125 Vdc	14 15		0.3	0.3	
	SKMOM2	240 Vac 250 Vdc	8 9		0.3	0.3	
	SKMOM8	24 Vdc	35		0.3	0.3	
	SKMOM9	48 Vdc	25		0.3	0.3	

① All ac control power may be either 50 Hz or 60 Hz.

Table 25.2 Mechanical Interlocks

Device Frame	Panel Thickness Maximum Inches	Panel Thickness Maximum Millimeters	Panel Thickness Minimum Inches	Panel Thickness Minimum Millimeters	Catalog Number
SG	CONSULT FACTORY FOR AVAILABILITY.				
SK					

HANDLE OPERATORS

Three different operating handles are available for use with Spectra RMS™ circuit breaker and molded case switches: TDA, TDM, and TDR. Each provides its own unique function. Types TDA and TDM are adjustable-depth operating handles. Type TDR operating handles are rotary handles that connect directly to the protective device, and the operating handle projects directly through the enclosure door.

TYPE TDA ENCLOSE FLANGED MOUNTED HANDLES, VARIABLE DEPTH OPERATING MECHANISMS AND ACCESSORIES

Type TDA handles are designed to meet automotive-duty specifications. They are NEMA 12 and NEMA 13 UL recognized components. These handles can be located on either the right-hand or left-hand flange of an enclosure, and they are field-convertible for either position. Handle mounting dimensions fit standard flanged enclosures with depths from eight inches to 24 inches (203mm to 609mm).

Two different handle lengths are provided. Type TDA1 handles have a nominal length of six inches (152mm), and Type TDA2 handles have a length of 10 inches (254mm). Both flange handles are interchangeable and are satisfactory for use with all operator mechanisms. The advantage to using the longer Type TDA2 handle is the reduction in the operating forces provided by the longer lever arm. Both handles permit use of up to three-sixteenths of an inch to five-sixteenths of an inch (4.75mm to 7.94mm) diameter padlocks. Both handles are equipped with O-ring seals for oil-tight/dust-tight duty.

Variable Depth Operating Mechanisms. The operating mechanism consists of two primary components: a combination mounting plate and yoke, and a drive rod that connects the handle to the yoke mechanism.

The protective device is mounted on the plate, and the device's operating handle slips into a slot at the front of the yoke. The mounting plates have toggle spring-assist to assure positive "On-Off" operation. Yoke stops are included to prevent excessive wear of the operating handle of the circuit breaker or molded case switch.

The standard drive rod is three-eighths of an inch (9.5mm) in diameter for SE- and SF- and one-half inch for SG- and SK-Frames. For all frames, it is 16 inches (406mm) long, and may be cut to a shorter desired length during installation.

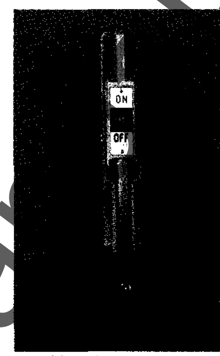


Fig. 26.1 Type TDA1 Flange Handle

Type TDA Handle Accessories. Four Type TDA handle accessories are available. They are auxiliary contacts, a flange stiffener (and an extended drive rod), an extended drive stud, and special NEMA 12 vault-type sealing and interlocking door hardware for left-hinge enclosure doors.

Auxiliary Contacts. Auxiliary single-pole, double-throw (SPDT) and double-pole, double-throw (DPDT) auxiliary contact kits are available for either left-flange or right-flange mounting. These contacts are actuated by the operating mechanism yoke.

Flange Stiffener and Extended Drive Rod. When either the enclosure needs stiffening begind the operating handle, or a drive rod longer than 16 inches is required, a special flange stiffener kit is available. The kit contains a $^3/_8$-inch (9.5mm) drive rod 22 inches (559mm) long. The drive rod is threaded and may be cut to any convenient length.

Extended Drive Stud. Extended drive stud provides additional room inside the enclosure by allowing a $1^5/_{16}$-inch (33mm) displacement of the operating mechanism with respect to the handle. Specifically, when the handle is mounted on the right-hand side of the enclosure, the operating mechanism is displaced <u>to the left</u> by $1^5/_{16}$ inches with the extended drive stud installed. Conversely, when the handle is installed on the left-hand side, the operating mechanism is displaced $1^5/_{16}$ inches to the right. (Note: Not suitable with SK-Frame operating mechanism.)

Vault-Type Interlocking Door Hardware. For left-hinged enclosure doors. A type TDA hardware kit is available to permit interlocking a left-hinged door by the Type TDA handle. The kit is designed for doors having a nominal depth of three-quarters of an inch (19mm). The interlocking function requires use of a screwdriver to release interlocking and permit door opening. Normally, the flange handle and operating mechanism cannot be placed in the "On" (energized) position unless the enclosure door and door hardware is closed.

When enclosure doors are 40 inches (1,016mm) long or longer, a third point latch is recommended and available.

TYPE TDM DOOR-MOUNTED HANDLES AND VARIABLE DEPTH OPERATING MECHANISMS

Type TDM handles and mechanisms are designed for door-mounting of a rotary operating handle. Shafts of various lengths connect directly to a sliding plate assembly that fits over the "On-Off" handle of the Spectra RMS™ circuit breaker or molded case switch. Rotation of the handle causes up and down (or right and left, for horizontally mounted protective devices) motion of the device toggle handle, which closes or opens the device.

Handles. TDM door-mounted handles accommodate up to three padlocks. There are two basic handle styles. Both TH1 and TH2 handles are designed for NEMA 1, 3R and 12 enclosures. TH2 handles are longer than TH1 to provide more torque for SG- and SK-Frame devices. When NEMA 4 or 5 enclosures are required, handle Cat. No. THCH45 is available (for all size devices).

Operating Mechanisms, Including Shafts. The Type TDM operating mechanism attaches to the face of the Spectra RMS™ circuit breaker or molded case switch with screws provided in the handle assembly kit. As mentioned earlier, the protective device may be mounted either vertically or horizontally. Shafts are cut by the user to the length required for the specific application.

Replacement Handle Gaskets. There are two sets of replacement neoprene gaskets for NEMA 3R, 12 and 12K enclosures. One set is for Cat. No. TH1 handles (SE- and SF-Frame devices), and the other for Cat. No. TH2 handles (SG- and SK-Frame devices).

TYPE TDR INTEGRAL HANDLE MECHANISM

Type TDR handles are designed for direct mounting to the Spectra RMS™ circuit breaker or molded case switch operating handle. A door ring on the handle projects through a mating hole on the front of the enclosure door. Type TDR handles are suitable for use with shallow depth NEMA 1, NEMA 12 or NEMA 12K enclosures. Rotary motion of the handle opens or closes the protective device.

Figure 27.1 shows a Type TDR handle mounted to an SE-Frame Spectra RMS™ circuit breaker, mounted vertically. Different handles are used for vertical and horizontal mounting of the protective device. An interlock kit is available to mate with the door ring of the type TDR handle, and provide an interlock function between protective device and enclosure door. A gasket kit is also available to limit the intrusion of dust and dirt into the enclosure through the space between the door ring on the protective device and the hole in the enclosure door. This gasket kit is required for NEMA 12 and NEMA 12K applications.

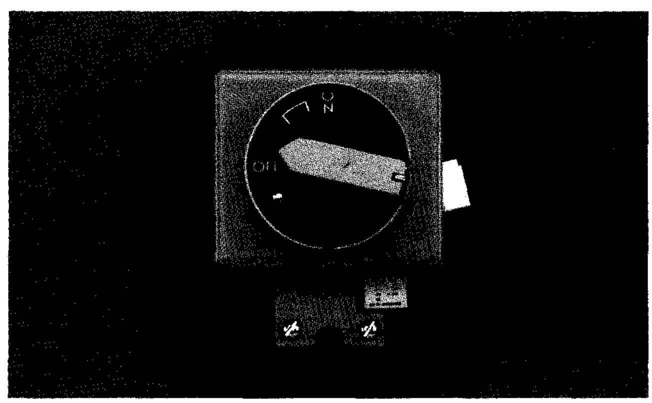


Fig. 27.1 Type TDR Integral Handle Mechanism

Cataloging Definition

This section contains catloging definition for Spectra RMS™ circuit breakers, molded case switches and their rating plugs.

THE SPECTRA RMS™ CATALOG NUMBERS – CIRCUIT BREAKERS AND SWITCHES

Table 28.1 Circuit Breaker Catalog Numbering System

S	E	L	A	3	4	AT	0100

Prefix
Spectra RMS™ Product Line

Frame Size
E = SE-Frame
F = SF-Frame
G = SG-Frame
K = SK-Frame

Interrupting Capacity
Varies with frame size. Refer to rating tables.

Standard Rated per NEC

Number of Poles
1 = 1 pole
2 = 2 poles
3 = 3 poles

Voltage
2 = 240 Vac
4 = 480 Vac
6 = 600 Vac

Product Function
AT = Fixed Long Time, Adjustable Instantaneous with Tracking Short Time Circuit Breaker.
AI = Mag-Break® Adjustable Instantaneous only with Tracking Short Time Circuit Breaker.
AN = Non-Automatic with Fixed Instantaneous Molded Case Switch

0100 Cont.

Maximum Frame Current – Amperes
0007 = 7 Amps
0030 = 30 Amps
0060 = 60 Amps
0100 = 100 Amps
0150 = 150 Amps
0250 = 250 Amps
0400 = 400 Amps
0600 = 600 Amps
0800 = 800 Amps
1200 = 1,200 Amps

EXAMPLE:

The catalog number SELA36AT0100 describes a Spectra RMS™ SE-Frame, current limiting, 65 kA (symmetrical) IC, 3-poles, 480-Vac, fully configured circuit breaker; i.e., fixed long-time (determined by rating plug), adjustable instantaneous with tracking short-time function and a maximum frame current of 100 amps.

SPECTRA RMS™ CATALOG NUMBERS– RATING PLUGS

Table 29.1 Rating Plug Catalog Numbering System

SRP	E60A	40
Prefix	Frame Size Rejection Code	Plug Rating
Same for All Rating Plugs	Device Frame E = SE-Frame G = SG-Frame F = SF-Frame K = SK-Frame	In Amperes

EXAMPLE:

A rating plug with a catalog number SRPG400A350 is:

SRP=Rating plug.

G400A=Rejection Code (see explanation below.) Rating plug may be used with any 400-amp frame SG-Frame fully configured circuit breaker or Mag-Break® motor circuit protector.

350=Current rating of plug is 350 amps.

Rejection Codes. The term "rejection code" describes the results of the mechanical accept/reject arrangement allowing only properly rated rating plugs to be inserted into a circuit breaker. For example, both SE-Frame and SF-Frame circuit breakers have 100-amp rating plugs. However, a 100-amp frame SE-Frame circuit breaker is designed to accept only SE-Frame rating plugs from 70 amps to 100 amps, and reject all other rating plugs. The SF-Frame circuit breaker family accepts 10 rating plugs, ranging from 70 amps to 250 amps, and will reject all other rating plugs for different frame-size breakers.

ACCESSORIES

Both internal and external accessories utilize a sequential catalog numbering system consisting of a set of alpha characters (e.g., SAUX for an internal auxiliary switch, "S" for Spectra RMS™ and "AUX" for auxiliary switch) and numbers. The numbers have no significance as to the voltage or current rating of the accessories. External accessory catalog numbers use different mixtures of alpha characters and numbers.

Table 29.2 Spectra RMS™ Interchangeable Rating Plugs

Frame	Type	Plug Rating Amps	Catalog Number
SE	E7A①	3	SRPE7A3
		7	SRPE7A7
	E30A	15	SRPE30A15
		20	SRPE30A20
		25	SRPE30A25
		30	SRPE30A30
	E60A	40	SRPE60A40
		50	SRPE60A50
		60	SRPE60A60
	E100A	70	SRPE100A70
		80	SRPE100A80
		90	SRPE100A90
		100	SRPE100A100
	E150A	110	SRPE150A110
		125	SRPE150A125
		150	SRPE150A150
SF	F250A	70	SRPF250A70
		90	SRPF250A90
		100	SRPF250A100
		110	SRPF250A110
		125	SRPF250A125
		150	SRPF250A150
		175	SRPF250A175
		200	SRPF250A200
		225	SRPF250A225
		250	SRPF250A250
SG	G400A	125	SRPG400A125
		150	SRPG400A150
		175	SRPG400A175
		200	SRPG400A200
		225	SRPG400A225
		250	SRPG400A250
		300	SRPG400A300
		350	SRPG400A350
		400	SRPG400A400
	G600A	250	SRPG600A250
		300	SRPG600A300
		350	SRPG600A350
		400	SRPG600A400
		450	SRPG600A450
		500	SRPG600A500
		600	SRPG600A600
SK	K800A	300	SRPK800A300
		400	SRPK800A400
		500	SRPK800A500
		600	SRPK800A600
		700	SRPK800A700
		800	SRPK800A800
	K1200A	600	SRPK1200A600
		700	SRPK1200A700
		800	SRPK1200A800
		1,000	SRPK1200A1000
		1,200	SRPK1200A1200

Note: ① Mag-Break® only.

Electrical Data

INTRODUCTION

The Electrical Data section of this manual is intended to assist those responsible for the selection and application of circuit-protective devices in making the proper choices of Spectra RMS™ circuit breakers and molded case switches. Because Spectra RMS™ devices are true international products, attention is given to the selection procedures associated with American, Canadian and IEC Standards.

Electrical Data is presented in a sequence that follows the steps necessary to make the selection of the protective device that matches system and equipment requirements.

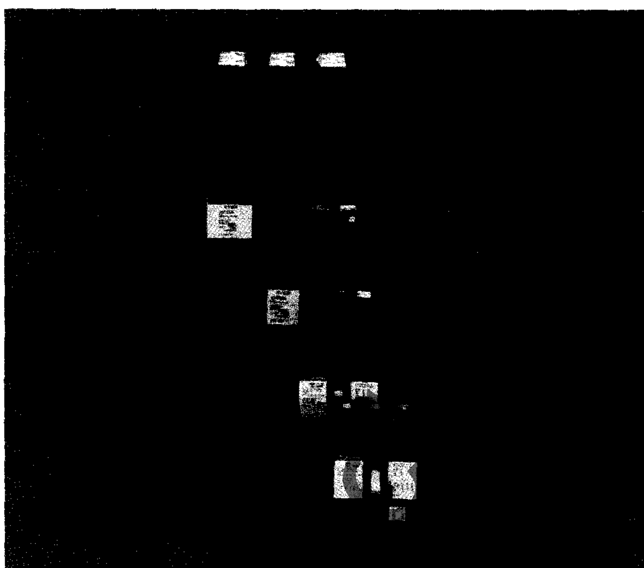


Fig.30.1 The Spectra RMS™ Circuit Breaker Family

General

MOLDED CASE CIRCUIT BREAKERS

Molded case circuit breakers are circuit-protective devices that perform two primary functions: 1) manual switching to open and close a circuit by means of a toggle handle; and 2) automatic opening of the circuit under short-circuit and/or sustained overload conditions.

Functions A circuit breaker inherently protects circuits during short-circuit and overload conditions by automatically opening its protected electrical circuit without the use of fuses. When the circuit breaker opens to clear a short-circuit or a sustained overload condition, its "toggle" handle moves to the "Tripped" position (midway between "On" and "Off" positions), indicating the circuit breaker has automatically opened. Once the overload or short circuit has been corrected, the circuit breaker can be closed by simply moving the toggle handle first into the "Reset" (fully "Off") position, and then into the "On" position.

Circuit Breaker Advantages There are several advantages to using circuit breakers as protective devices. One key advantage to circuit breakers over fusible elements is that an overcurrent on one pole of a multipole device actuates a common trip bar that trips all poles simultaneously. Consequently, "single phasing" a three-phase load is not possible when a circuit breaker opens, while it is possible with fusible devices. Molded case circuit breakers utilize "trip-free" construction. A trip-free device is one that cannot be forced into the closed or "On" position when a tripping action is present as the result of an abnormal condition. If an attempt is made to manually close a circuit breaker's toggle handle while an overcurrent condition exists in the protected circuitry, the circuit breaker will open, even if the toggle handle is held in the "On" position.

Protective Function – Circuit breakers Spectra RMS™ circuit breakers are not intended to replace running overload, unbalanced voltage or special-purpose protection provided by other motor-protective equipment such as overload relays and motor-temperature sensing devices. However, Spectra RMS™ circuit breakers can be used to provide motor overload and overcurrent protection for branch circuits containing infrequently started induction or synchronous motors.

Spectra RMS™ molded case circuit breakers meet UL Standard 489 covering "Branch Circuit and Service Circuit Breakers"; NEMA Standard AB-1 – Molded Case Circuit Breakers; IEC Standard 947-2, Circuit Breakers (Low-Voltage Switchgear and Controlgear) and applicable Canadian and Japanese Standards.

UL Standard-Rated Circuit Breakers Spectra RMS™ circuit breakers are classified as "standard-rated" devices. UL Standard 489 makes provisions for two categories of circuit breakers, "UL Standard-rated" and "UL 100 percent-rated." The basis for UL Standard-rated circuit breakers is as follows:

Mounted in Free Air. Circuit breakers are tested to carry 100 percent of nameplate current rating, continuously, when mounted in free air at 25°C (77°F) and cable per Table 35.1, Page 35. However, they are not applied in this manner.

Mounted in an Enclosure. Spectra RMS™ enclosed circuit breakers are rated to carry 100 percent of nameplate current rating, intermittently (three hours, maximum), and 80 percent, continuously, with the enclosure in a 25°C ambient, and cabled per Table 35.1, Page 35.

Group-Mounted. Group-mounted circuit breakers may require derating of the circuit breakers and cable in room ambients other than 25°C and with cable other than listed in Table 35.1, Page 35.

IEC Equivalent to UL Standard-Rated Circuit Breakers IEC Standard 947-2 lists three current ratings: "conventional free air thermal current, (I_{th})"; "conventional enclosed thermal current (I_{the})"; and "rated current (I_n)." IEC procedures call for an eight-hour test. Consequently, when a standard-rated circuit breaker is mounted in free air at 25°C and with the cabling of Table 35.1, Page 35, the breaker's conventional free air thermal current may be considered to be 100 percent of nameplate current. Enclosed circuit breakers cabled per Table 35.1 and mounted in 25°C room ambient may be considered to have a conventional enclosed thermal current of 80 percent of nameplate current. Group-mounted circuit breakers may require additional derating to reflect actual room ambient and cabling.

Rated current (I_n) is equal to the free air thermal current (I_{th}), and is the same as the rated current for circuit breakers described in the technical data of this publication. Specifically, rated current per UL489 and rated current per IEC947-2 are equivalent terms.

MOLDED CASE SWITCHES

Molded case switches are used as circuit-disconnect devices where overload and short-circuit protection for the relevant circuit is provided by other devices. Because these switches are tested to meet a six-times rated current overload requirement, they are useful as disconnects in motor circuits and are horsepower rated.

Spectra RMS™ molded case switches are designed to meet and are tested in accordance with UL Standard 1087, specifically covering molded case switches.

STANDARDS AND REFERENCES

Underwriters' Laboratories

UL Standard 489, Branch Circuit and Service Circuit Breakers; and UL Standard 1087, Molded Case Switches. Order from UL Publications Stock, 333 Pfingston Road, Northbrook, IL 60062.

National Electrical Manufacturers Association (NEMA)

NEMA Standard AB-1, Molded Case Circuit Breakers. Order from NEMA Publications, 155 East 44th Street, New York, NY 10017.

Institute of Electrical and Electronics Engineers (IEEE)

IEEE Standard No. 45, Recommended Practices for Electrical Installation on Shipboard. Order from IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

National Electrical Code (NEC)

1990 issue scheduled availability in fall, 1989 to replace 1987 issue. Order from National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

International Electrotechnical Commission (IEC)

IEC Standard 947-2, Low-Voltage Switchgear and Controlgear, Part 2, Circuit Breakers. Order from Bureau Central de la Commission Electrotechnique Internationale, 3 ruede Varemble, Geneva, Switzerland.

Canadian Standards Association (CSA)

CSA Standard 22.2 No. 5, Service Entrance and Branch Circuit Breakers. Order from CSA, 178 Rexdale Blvd., Rexdale (Toronto), Ontario, Canada M9W1R3.

Japanese Industries Standard (JISC)

JISC Standard 8370, Low-Voltage Switchgear and Controlgear, Circuit Breakers.

Verband Deutscher Electrotechniker (VDE)

(Association of German Electrical Engineers) VDE Specification 0660, Low-Voltage Switchgear and Control Gear, Circuit Breakers.

CURRENT RATINGS OF CIRCUIT BREAKERS AND MAG-BREAK® MOTOR CIRCUIT PROTECTORS

Table 32.1 Spectra RMS™ Circuit Breaker Current Ratings SE- and SF-Frame Circuit Breakers

Frame	Max. Frame Amps	Rating Plug Amps	Instantaneous Trip Settings, Nominal RMS Sym, Amperes — Trip Setting Adjustment Position: Lo	2	3	4	5	6	Hi
SE	7[1]	3	11	13	16	19	24	31	39
		7	22	27	35	43	56	71	90
	30	15	43	55	69	86	111	143	182
		20	58	74	93	116	151	196	254
		25	73	93	117	147	193	253	332
		30	87	112	142	179	237	314	415
	60	40	118	150	188	237	308	394	501
		50	148	187	236	296	386	498	637
		60	178	224	284	355	464	604	777
	100	70	206	261	329	411	534	684	863
		80	236	299	377	472	614	787	999
		90	267	338	426	532	694	892	1,138
		100	297	376	475	593	775	998	1,280
	150	110	328	415	524	654	857	1,105	1,426
		125	374	474	598	745	979	1,265	1,640
		150	450	570	720	897	1,181	1,528	1,991

Frame	Max. Frame Amps	Rating Plug Amps	Lo	2	3	4	5	Hi
SF	250	70	205	260	330	410	535	700
		90	265	335	425	530	690	900
		100	295	375	470	590	765	1,000
		110	325	410	520	650	845	1,100
		125	370	465	570	740	960	1,250
		150	440	560	705	885	1,150	1,500
		175	515	655	825	1,035	1,345	1,750
		200	590	750	940	1,180	1,535	2,000
		225	665	840	1,050	1,330	1,730	2,250
		250	740	935	1,180	1,480	1,920	2,500

Note: [1] The 7-amp frame and the 3A and 7A rating plugs are used only with the Spectra RMS™ Mag-Break® motor circuit protector.

[redacted]

Table 33.1 Spectra RMS™ Circuit Breaker Current Ratings SG- and SK-Frame Circuit Breakers

Frame	Max. Frame Amps	Rating Plug Amps	Instantaneous Trip Settings, Nominal RMS Sym, Amperes — Trip Setting Adjustment Position: Lo	2	3	4	5	Hi
SG	400	125	380	480	620	765	990	1,275
		150	455	575	740	920	1,185	1,530
		175	530	670	865	1,070	1,385	1,785
		200	605	765	990	1,225	1,580	2,040
		225	680	860	1,115	1,375	1,780	2,295
		250	755	955	1,235	1,530	1,975	2,550
		300	905	1,145	1,480	1,835	2,370	3,060
		350	1,060	1,340	1,730	2,140	2,765	3,570
		400	1,210	1,530	1,980	2,445	3,160	4,080
	600	250	765	965	1,215	1,500	1,960	2,530
		300	915	1,155	1,455	1,800	2,355	3,035
		350	1,070	1,350	1,700	2,100	2,745	3,545
		400	1,220	1,540	1,940	2,400	3,135	4,050
		450	1,375	1,735	2,185	2,695	3,530	4,555
		500	1,525	1,925	2,425	2,995	3,920	5,060
		600	1,830	2,310	2,910	3,595	4,705	6,075
SK	800	300	940	1,150	1,445	1,795	2,375	3,015
		400	1,255	1,535	1,930	2,395	3,165	4,015
		500	1,570	1,915	2,410	2,990	3,955	5,020
		600	1,875	2,290	2,895	3,610	4,740	6,195
		700	2,155	2,665	3,375	4,240	5,525	7,420
		800	2,440	3,035	3,860	4,875	6,305	8,705
	1,200	600	1,825	2,310	2,905	3,685	4,730	6,110
		700	2,125	2,690	3,385	4,315	5,655	7,400
		800	2,425	3,065	3,865	4,955	6,620	8,775
		1,000①	3,015	3,810	4,820	6,240	8,675	11,755
		1,200①	3,605	4,550	5,775	7,550	10,885	15,050

Note: ① Values are preliminary.

Electrical Data

Table 34.1 Spectra RMS™ Molded Case Switch Current Ratings Three-Pole, 600-Vac

Switch Frame	Type	Maximum Frame Ampere
SE	SEDA	100 and 150
SF	SFDA	250
SG	SGDA	400 and 600
SK	SKDA	800 and 1,200

FACTORS AFFECTING CURRENT RATINGS OF INSTALLED DEVICES

There are seven application factors that need to be considered in the selection of the current ratings of molded case circuit breakers and switches. These are: 1) the size of the cable used in the line and load connections, 2) the actual installed ambient temperature, 3) the system operating frequency, 4) the altitude of the installation, 5) the type of loading of the protected circuit, 6) the design safety factor, and 7) derating for continuous loading, if applicable.

The following simple relationship combines these seven application factors into one equation:

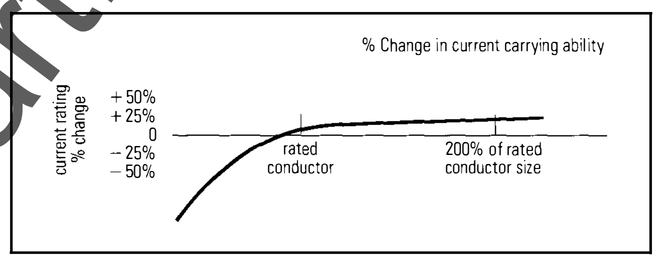
$$I_p = I_a \times A \times B \times C \times D \times E \times F \times G$$

Where: I_p = Circuit breaker amp rating
I_a = Actual load current in amps
A = Cable size factor
B = Ambient temperature rating factor
C = Frequency rating factor
D = Altitude rating factor
E = Load class rating factor
F = Safety factor
G = Intermittent/continuous duty rating factor

Examples of how these selection factors are used are shown on Pages 40 and 41.

CABLE SIZE

The thermal design of a circuit breaker takes into account the ability of line and load cables to act as heat sinks. UL Standard 489 has assigned specific cable sizes for each current rating. Generally, these assignments are coordinated with specific conductor temperature ratings. Increasing a conductor's temperature rating decreases both the cross sectional area of the conductor and its ability to conduct heat. Figure 34.1 illustrates the effect of changing cable size upon the current-carrying ability of the circuit breaker or molded case switch.



Breaker current rating and conductor size are a matched pair; any insulation type may be used but the cross section must remain constant.

Fig. 34.1 Effects of Changing Load and Line Conductor Sizes

Table 35.1 Cable Size by Circuit Breaker or Switch Amp Rating

Device Ampere Rating	Copper Conductor		Aluminum or Copper-Clad Aluminum Conductor	
	Paralleled	Size	Paralleled	Size
15 or less	–	14 AWG	–	12 AWG
20	–	12 AWG	–	10 AWG
25	–	10 AWG	–	10 AWG
30	–	10 AWG	–	8 AWG
35	–	8 AWG	–	6 AWG
40	–	8 AWG	–	6 AWG
45	–	6 AWG	–	4 AWG
50	–	6 AWG	–	4 AWG
60	–	4 AWG	–	3 AWG
70	–	4 AWG	–	2 AWG
80	–	3 AWG	–	1 AWG
90	–	2 AWG	–	1/0 AWG[1]
100	–	1 AWG	–	1/0 AWG[1]
110	–	1 AWG	–	1/0 AWG
125	–	1/0 AWG[2]	–	2/0 AWG
150	–	1/0 AWG	–	3/0 AWG
175	–	2/0 AWG	–	4/0 AWG
200	–	3/0 AWG	–	250 kcm
225	–	4/0 AWG	–	300 kcm
250	–	250 kcm	–	350 kcm
275	–	300 kcm	–	500 kcm
300	–	350 kcm	–	500 kcm
325	–	400 kcm	Two	4/0 AWG
350	–	500 kcm	Two	4/0 AWG
400	Two	3/0 AWG	Two	250 kcm
450	Two	4/0 AWG	Two	300 kcm
500	Two	250 kcm	Two	350 kcm
550	Two	300 kcm	Two	500 kcm
600	Two	350 kcm	Two	500 kcm
700	Two	500 kcm	Three	350 kcm
800	Three	300 kcm	Three	400 kcm
1,000	Three	400 kcm	Either Four	350 kcm
			Or Three	600 kcm
1,200	Either Four	350 kcm	Four	600 kcm
	Or Three	600 kcm		

Notes: [1] No. 1 AWG Type RH, RHH, RHW, THW, THWN or XHHW aluminum conductor may be used if device is marked to permit its use.
[2] No. 1 AWG Type RH, RHW, RUH, THW, THWN or XHHW copper conductor may be used if device is marked to permit its use.

Table 35.2 Approximate Correlation, Standard Cross Sections of Round Copper Conductors AWG and KCM versus ISO Metric Cable Sizes

AWG or MCM		
Size	**Equivalent Cross-Section (mm)2**	**ISO Metric Cable Size (mm)2**
18	0.82	0.75
–	–	1
16	1.3	1.5
14	2.1	2.5
12	3.3	4
10	5.3	6
8	8.4	10
6	13.3	16
4	21.2	25
2	33.6	35
1/0	53.5	50
2/0	67.4	70
3/0	85	95
4/0	107.2	–
250	127	120
300	152	150
350	177	185
500	253	240
600	304	300

Table 36.1 Properties of Conductors Rated for Use with Molded Case Circuit Breakers

Size AWG, kcm	Area Cir. Mils	Concentric Lay Stranded Cond.		Bare Conductors		Dc Resistance, Ohms per 1000 ft. @ 25C (77F)		
						Copper		
		No. of Wires	Dia. Ea. Wire Inches	Dia. In Inches	Area[1] In Sq. In.	Bare Conductor	Tinned Conductor	Aluminum
18	1,620	Solid	0.0403	0.0403	0.0013	6.51	6.79	10.7
16	2,580	Solid	0.0508	0.0508	0.0020	4.10	4.26	6.72
14	4,110	Solid	0.0641	0.0641	0.0032	2.57	2.68	4.22
12	6,530	Solid	0.0808	0.0808	0.0051	1.62	1.68	2.66
10	10,380	Solid	0.1019	0.1019	0.0081	1.018	1.06	1.67
8	16,510	Solid	0.1285	0.1285	0.0130	0.6404	0.659	1.05
6	26,240	7	0.0612	0.184	0.027	0.410	0.427	0.674
4	41,740	7	0.0772	0.232	0.042	0.259	0.269	0.424
3	52,620	7	0.0867	0.260	0.053	0.205	0.213	0.336
2	66,360	7	0.0974	0.292	0.067	0.162	0.169	0.266
1	83,690	19	0.0664	0.332	0.087	0.129	0.134	0.211
1/0	105,600	19	0.0745	0.372	0.109	0.102	0.106	0.168
2/0	133,100	19	0.0837	0.418	0.137	0.0811	0.0843	0.133
3/0	167,800	19	0.0940	0.470	0.173	0.0642	0.0668	0.105
4/0	211,600	19	0.1055	0.528	0.219	0.0509	0.0525	0.0836
250	250,000	37	0.0822	0.575	0.260	0.0431	0.0449	0.0708
300	300,000	37	0.0900	0.630	0.312	0.0360	0.0374	0.0590
350	350,000	37	0.0973	0.681	0.364	0.0308	0.0320	0.0505
400	400,000	37	0.1040	0.728	0.416	0.0270	0.0278	0.0442
500	500,000	37	0.1162	0.813	0.519	0.0216	0.0222	0.0354
600	600,000	61	0.0992	0.893	0.626	0.0180	0.0187	0.0295
700	700,000	61	0.1071	0.964	0.730	0.0154	0.0159	0.0253
750	750,000	61	0.1109	0.998	0.782	0.0144	0.0148	0.0236

Note: [1] Area shown is that of a circle having a diameter equal to the diameter of the stranded conductor.

Cable Size Selection Factor A Determine any difference between the cross-sectional area of the cable size assigned to the breaker or switch current rating shown in Table 35.1, and the cross-sectional area of the cable actually used in the installation. Then select the cable size selection factor (Item "A" in the equation on Page 34) from Table 37.1.

Table 37.1 Cable Size Selection Factor A

Applied Cable Cross-Section Area as a Percent of Rated Cable Size Cross-Sectional Area	Percent								
	50	60	70	80	90	100	125	150	200
Cable Size Selection Factor A	1.4	1.25	1.15	1.07	1.03	1.00	0.99	0.97	0.97

AMBIENT TEMPERATURE

Ambient temperatures have a wider effect on the rating of the circuit breaker/cable system than making an exact match of actual versus rated cable sizes. While the accuracy of the internal sensing and tripping circuitry within Spectra RMS™ circuit breakers are ambient-insensitive, high ambient may cause internal temperatures to exceed insulation temperature limits. Low temperatures substantially increase current-carrying capability of the circuit breaker/cable system until other limiting factors occur (e.g., lubrication problems or mechanical binding due to differential contraction of internal parts).

Cable with temperature ratings above 75°C may be used, providing it is sized to 75°C ampacity per the NEC, or other applicable electrical code.

The term "ambient" temperature *always* refers to the temperature of the air immediately surrounding the protective device itself, and *never* the temperature of the air outside the device's enclosure. Room or outside air temperature only establishes the thermal floor to which all other heating is added.

To convert breaker ambient temperature to room ambient, it is necessary to know the temperature rise within the equipment housing the circuit breaker (or switch). This temperature rise is a function of several variables, including heating caused by other equipment, ventilation, solar heating, factors relating to group mounting and free surface area of the breaker's enclosure.

Ambient Temperature Selection Factor B Once the device ambient temperature is determined, select the ambient temperature selection factor from Table 37.2 (Factor "B" in the equation on Page 34). In the event the ambient temperature exceeds 60°C (140°F), or if the ambient and cable combination appears to allow selection factors lower than 1.00, contact the factory for application assistance.

Table 37.2 Ambient Temperature Selection Factor B

	Circuit Breaker or Switch Ambient Temperature ①							
	25C (77F)		40C (104F)		50C (122F)		60C (140F)	
Frame Size	**Selection Factor B**	**Minimum Cable Rating Deg. C**	**Selection Factor B**	**Minimum Cable Rating Deg. C**	**Selection Factor B**	**Minimum Cable Rating Deg. C**	**Selection Factor B**	**Minimum Cable Rating Deg. C**
SE	1.0	60	1.0	90	1.0	105	1.1	105
SF	1.0	75	1.0	90	1.0	105	1.1	105
SG	1.0	75	1.0	90	1.0	105	1.1	105
SK	1.0	75	1.0	105	1.0	105	1.1	105

Note: ① For ambient temperatures in excess of 60°C, refer application to the factory. Note 60°C selection factors are preliminary.

OPERATING FREQUENCY

All Spectra RMS™ circuit breakers and molded case switches may be applied at their published ratings on 50-Hz and 60-Hz systems. Operation at other system frequencies such as 380 Hz, 400 Hz and 415 Hz should only be undertaken with the specific concurrence of the factory. Spectra RMS™ circuit breakers and molded case switches are not suitable for direct current applications.

System-operating frequencies above 60 Hz may change the performance and rating of molded case circuit breakers by increasing heating of metallic parts and significantly reducing interrupting capacity. System-operating frequencies below 50 Hz may saturate the current sensors and adversely affect their accuracy.

Operating Frequency Selection Factor C Determine the system-operating frequency. The operating frequency selection factor (Factor "C" in the equation on Page 34) for both 50-Hz and 60-Hz systems is 1.0. If the operating frequency is either lower than 50 Hz or higher than 60 Hz, refer the application to the factory.

ALTITUDE

Spectra RMS™ circuit breakers and molded case switches are designed for operation at altitudes from sea level to 6,000 feet (1,800 meters). Reduced air density at altitudes above 6,000 feet affects the ability of a circuit breaker to both transfer heat and interrupt short circuits.

Altitude Selection Factor D Determine the altitude of the installation. The altitude selection factor (Factor "D" in the equation on Page 34) is given in Table 34.1 for altitudes up to and including 10,000 feet (or 3,000 meters). For altitudes above 10,000 feet, refer the application to the factory.

Table 38.1 Altitude Selection Factor D

Installation Altitude		Selection Factor D
Feet	Meters	
From -100 To 6,000	From -30 To 1,800	1.00
From 6,001 To 10,000	From 1,801 To 3,000	1.04
Above 10,000	Above 3,000	Refer to Factory

LOAD TYPE AND DUTY CYCLES

Both the type of loading and its duty cycle must be considered in the application of a molded case circuit breaker. For example, both capacitors and electromagnets require a significant continuous current derating if a circuit breaker is used to switch the load. Group-mounted devices may require additional derating due to the lack of free air circulation around the devices.

The minimum continuous current rating for resistance welder loads is 125 percent of the welder's 100 percent duty-cycle rating.

IEC 947-2 Considerations IEC uses a number of different terms to quantify rated duties of circuit breakers. These include:

Eight-hour duty: The circuit breaker carries a steady, continuous current (conventional thermal current, I_{th} and I_{the}), for eight hours.

Uninterrupted duty: The circuit breaker carries a steady, continuous current for periods in excess of eight hours – essentially no time limit.

Intermittent periodic duty and intermittent duty: A relationship involving the value of current flow, the ratio of "On Time"-to-total time within the defined time period, and a "class" definition of the number of load cycles per hour. For example, an intermittent duty consisting of a current flow of 100A for two minutes in every five minutes would be stated as "100A, class 12, 40 percent."

As a general rule, refer all eight-hour and intermittent duty applications using IEC rules to the factory for assistance and concurrence with rating selection.

Load Class Selection Factor E Table 39.1 lists six different load class factors. A specific load may involve more than one of these factors. For example, a group-mounted circuit breaker may be responsible for the branch circuit protection of a single-motor (with normal duty). In this type of application, the load class selection factors in Table 39.1 would be multiplied (i.e., group-mount factor x single-motor (normal duty) factor = 1.1 x 1.5, or 1.65). The total load class selection factor is Factor E in the equation on Page 34.

It is important to emphasize here that molded case circuit breakers are intended to act as protection for insulated cable. When a circuit breaker will be applied to protect equipment, prudent engineering practices call for obtaining factory review and concurrence with the selection of the specific protective device.

Table 39.1 Total Load Class Selection Factor E ①

Group-Mounted (12 or more breakers)	Switching Capacitors	Switching Electro-magnets	Single-Motor Branch Circuit Protection (Normal Duty)	Single-Motor Branch Circuit Protection (Heavy Duty)②	All Other (Normal) Loads
1.1	1.5	1.5	1.5	1.75	1.0

Notes: ① The total load class Factor E is the *product* of all the load class factors that apply to the circuit under consideration.
② Use this load factor for any plugging duty, or cycling loads with over 25 starts per hour where the rms current cannot be reliably calculated.

SAFETY FACTOR

A safety factor is used to provide a design margin between the rating limit of a circuit breaker and the derived operating current calculated using all of the selection factors described in the equation on Page 34.

A safety factor of 10 percent is recommended to prevent nuisance tripping.

Safety Factor F A safety factor of 10 percent is equivalent to a current rating multiplier of 1.10.

INTERMITTENT/CONTINUOUS DUTY RATING FACTOR

In those applications governed by UL rules and the National Electrical Code (NEC), an additional rating factor is necessary for standard-rated circuit breakers. This factor differentiates between continuous and intermittent duty.

When a circuit breaker is installed in an intermittent duty application, the duty rating factor is 1.00. Intermittent duty is defined as operation under rated load for a period of not more than three hours, followed by a period of no-load operation, followed by a period of rest. The time periods of no load and rest are undefined by the NEC. Some authorities suggest the use of a three-hour period of no-load operation after the three-hour, full-load operation meets the intent of the term "intermittent."

Continuous duty generally means operation without any time limit whatsoever. However, for purposes of rated molded-case circuit breakers, operation at rated loads for periods of time in excess of three hours is considered continuous duty. The duty rating factor for Spectra RMS ™ circuit breakers, as standard-rated devices, in continuous duty applications, is 1.25.

Duty Rating Factor G Table 39.2 lists the duty rating factor (Factor G in the equation on Page 34).

Table 39.2 Duty Rating Factor

	Continuous Duty (Operation at constant load for more than three hours)	Intermittent Duty (Operation at constant load for three hours, or less)
Selection Factor G	1.25	1.00

SELECTION OF CIRCUIT BREAKER CURRENT RATING

There are basically two different situations present in making the selection of circuit breaker current rating. The first is where the circuit breaker is assigned to protect insulated cable that has been selected by a competent authority. The second is where a number of factors, such as altitude, motor loads, high-ambient temperatures, etc., are involved.

Wire and Cable Protection One of the primary functions of molded case circuit breakers is to protect insulated wire and cable from sustained overloads and short circuits. The National Electrical Code (NEC) requires that conductors be protected in accordance with their ampacities. A series of tables found in Article 310 defines ampacities for a number of different conditions. Exceptions are listed in Article 310 for specific applications, including protection of motor-circuit conductors.

When the size and type of conductors are specified by a competent authority (e.g., an electrical consulting engineer), it is only necessary to select a standard rating matching the ampacity of the conductor; the NEC permits the use of the next higher standard rating – with some specific exceptions.

Equipment Protection and Other Special Conditions When only load current is known, or where one or more special conditions exist (e.g., use of smaller-than-assigned cable, group mounting, high-ambient temperatures, special-duty cycles, equipment protection, etc.), use of the equation on Page 34 is required to determine the current rating of the suitable circuit breaker. This equation is repeated here for ease of use.

$$I_p = I_a \times A \times B \times C \times D \times E \times F \times G$$

Where: I_p = Circuit breaker current rating in amps
I_a = Actual load current in amps
A = Cable size factor
B = Ambient temperature rating factor
C = Frequency rating factor
D = Altitude rating factor
E = Load class rating factor
F = Safety factor
G = Duty rating factor

Example: Step 1. Determine Actual Load Current
Determine the actual current of the circuit by adding the continuous load current for each load component of the total circuit to be protected by the circuit breaker.

When an intermittent load is involved, a derived rms load current is used as the actual load current. The time period to be used in calculating rms current is a function of circuit breaker frame amps. The assigned time period is equal to one-tenth of the breaker frame ampere rating, in minutes. For example, an SE100 breaker would have a time period of 10 minutes, and an SF250 breaker would have a time period of 25 minutes.

Example Data: An air-conditioning compressor cycles on and off at a maximum rate of four times per hour and has the following load characteristics:

1. Full load current	62A
2. Locked rotor (starting) current	248A
3. Acceleration (starting) time	6 sec (0.1 min)
4. Off time between starts	5 min
5. Duty cycle	0.1 min start, 9.9 min run, 5 min off, cycle repeats

Using an SE100 breaker, calculate rms current during worst 10-minute period. This would be one Start and Run period of this example.

$$I_{rms} = \sqrt{\frac{(I_{start})^2 (T_{start}) + (I_{run})^2 (T_{run})}{T_{total}}}$$

$$I_{rms} = \sqrt{\frac{(248)^2 (0.1) + (62)^2 (9.9)}{10}}$$

$$I_{rms} = 66.5A$$

Using an SF250 breaker, calculate rms current during a 25-minute period. This consists of two starts, one 5-minute off period and two 9.9-minute run periods.

$$I_{rms} = \sqrt{\frac{\{2[(248)^2(0.1)]\} + \{2[(62.2)^2(9.9)]\}}{25}}$$

$$I_{rms} = 59.6 \text{ amps}$$

Step 2. Estimate Breaker Frame Size. Using either the actual current or the calculated rms current, whichever is greater, estimate the frame size required for the application. Record the estimate for use in completing Step 3.

Step 3. Determine Breaker Selection Factors A through F. Determine the selection factors described on Pages 34 through 39, and substitute in the formula for determination of I_p, circuit breaker current rating. For those applications under the jurisdiction of the NEC, the product of Factors B through F must be equal to or greater than 1.25 for standard-rated devices (such as Spectra RMS™ circuit breakers).

Step 4. Select Circuit Breaker. Compute circuit breaker amp rating for the application by multiplying actual current by each of the factors determined in Step 3. Select circuit breaker.

Second Example:

Example data:

1. Circuit voltage	480-Vac, 3-phase, 60-Hz
2. Loading (computer power supply)	50-amp, rms, continuous
3. Available short-circuit current	10kA, or less, rms symmetrical
4. Mounting	Group-mounted, panelboard, 30 circuits total
5. Conductor equal to device rating	
6. Ambient inside box	40°C, or less
7. No appreciable harmonics	
8. Altitude	7,200 ft

Calculation:

$I_p = I_a \times A \times B \times C \times D \times E \times F \times G$

$= 50 \text{ amps} \times 1.0 \times 1.0 \times 1.0 \times 1.04 \times 1.1 \times 1.1 \times 1.25$

$= 78.65 \text{ amps}$

Calculated rating = 78.65 amps.

Next standard rating is 80 amps.

Selection: Select an SE-Frame Spectra RMS™ circuit breaker with 100-amp frame amp rating. Select an E80 amp rating plug. Catalog number of circuit breaker is: SEDA36AT0100.

INTERRUPTING RATINGS

In addition to full load considerations, fully configured circuit breakers (not Mag-Break® motor circuit protectors or molded case switches) must automatically trip – or open – the protected circuit under overload conditions. Further, the device must have either sufficient interrupting capacity (circuit breakers) or withstand capability (molded case switches) to either interrupt or withstand the maximum short-circuit current that can flow under worst-case conditions.

The following pages describe the interrupting ratings of Spectra RMS™ circuit breakers and withstand ratings of Spectra RMS™ molded case switches.

BASIS OF INTERRUPTING RATINGS

Short-Circuit Current Interrupting ratings depend upon knowing the magnitude of the short-circuit current that may flow through the circuit breaker or molded case switch. Devices rated in accordance with UL Standard 489 list their interrupting capacity of withstand capability in terms of rms symmetrical amps. Devices rated in accordance with the IEC Standard 947-2 list both a "rated ultimate short-circuit breaking capacity (I_{cu})" and a "rated service short-circuit breaking capacity (I_{cs})" both in terms of rms symmetrical amps.

Differences between the IEC 947-2 values of I_{cu} (ultimate) and I_{cs} (service) breaking capacities are based upon specific ratios of I_{cs}-to-I_{cu}, depending upon a number of factors, including whether the protective device is intentionally designed to incorporate time delay to provide selectivity to the protection system.

The procedures for calculating short-circuit current and the X/R ratios are described in detail in GE Publication GET3550.

Generally, electrical power system engineers calculate the X/R ratios rather than the power factors of protected circuits during their short-circuit studies. The magnitude of the momentary peak current to be interrupted – or withstood – is a function of the maximum peak current displacement from the zero current axis. That displacement is a function of the X/R ratio (or power factor) of the faulted circuit. The higher the X/R ratio, the lower the power factor, and the greater the magnitude of peak current displacement.

Listed interrupting ratings are subject to derating where circuit power factors are below listed values. A table of rating factors versus X/R ratios and power factors allows the user to compensate the interrupting rating of a Spectra RMS™ circuit breaker for circuit power factor, where necessary.

Frequency Frequency has an effect upon the interrupting capability of a molded case circuit breaker. Exhaustive testing has been conducted at the two worldwide standard frequencies, 50 Hz and 60 Hz. Less testing has been conducted on industrial circuit breakers at 25 Hz and 400 Hz. Table 45.2, Page 45 lists suggested application guidelines for Spectra RMS™ circuit breakers in 400 Hz circuits.

The data shown takes into account the lack of world test facilities to verify 400 Hz performance, but does represent the existing best engineering judgment of General Electric.

Power Factor, or X/R Ratio Interrupting ratings of molded case circuit breakers are based upon a specific ratio of reactance-to-resistance, or a specific power factor. Since practical ac circuits contain some reactance, there is some displacement between current and voltage waveforms. Because a short-circuit can literally occur during any point of the voltage wave, an actual trace of short-circuit current may display considerable initial displacement from the zero axis.

Figure 42.1 shows a symmetrical ac current waveform that would occur if a purely resistive circuit was short-circuited (or even a circuit containing reactance if the short circuit occurred at precisely the right point in the voltage waveform – which is unlikely).

Figure 43.1 shows the current trace of a short circuited ac circuit where displacement about the zero axis exists as a consequence of when the short circuit is applied and the amount of reactance in the short-circuited circuit, compared to its resistance.

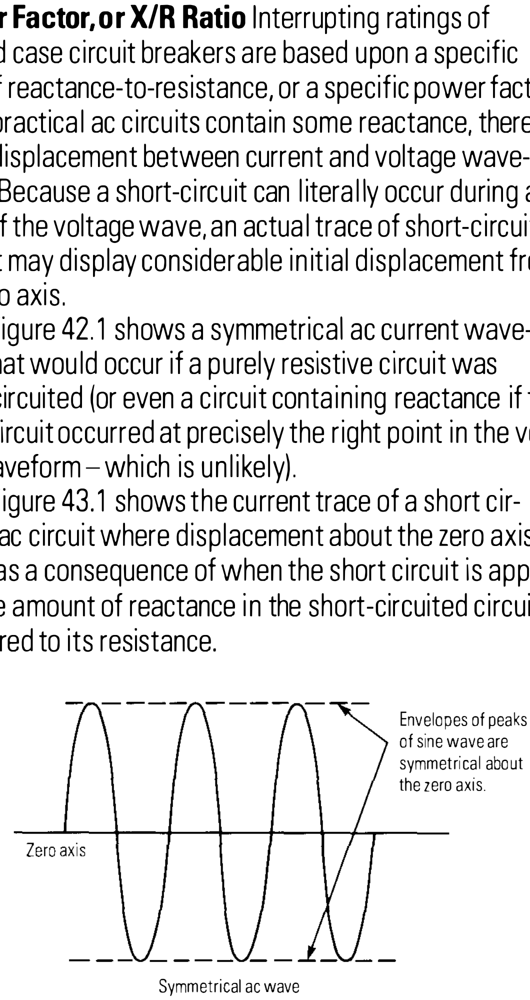


Fig. 42.1. Symmetrical Ac Waveform

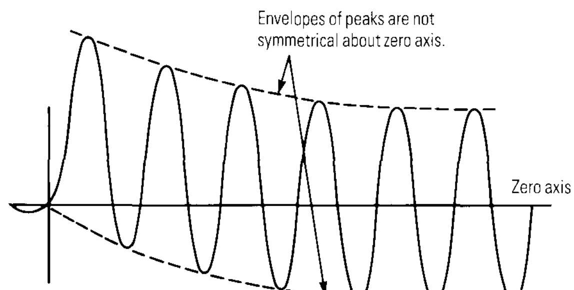


Fig. 43.1. Asymmetrical Ac Waveform

INTERRUPTING RATINGS

There is a simple relationship between the power factor of a short-circuited circuit and its X/R ratio. It is:

$$\text{Power Factor (in Percent)} = \frac{R}{Z} \times 100$$

and:

$$Z = \sqrt{(R)^2 + (X)^2}$$

$$\text{therefore: PF} = \frac{R}{\sqrt{(R)^2 + (X)^2}} \times (100)$$

Table 43.1. Spectra RMS™ Circuit Breaker Interrupting Ratings, UL489 and CSA C22.2 Rms Symmetrical Amps (in thousands), 50/60 Hz

Frame	Type	Max. Rating Amperes	Ac Voltage					
			208Y/120	240	480Y/277	480	600Y/346①	600①
			Multi-Pole	Single-Pole②	Multi-Pole	Single-Pole	Multi-Pole	Single-Pole
SE③	SEDA	150	18	8.7	14	8.7	14	8.7
	SEHA	150	25	8.7	25	8.7	18	8.7
	SELA	150	100	8.7	65	8.7	25	8.7
	SEPA	150	200	8.7	100	8.7	35	8.7
SF	SFHA	250	65	8.7	25	8.7	18	8.7
	SFLA	250	100	8.7	65	8.7	25	8.7
	SFPA	250	200	8.7	100	8.7	25	8.7
SG③	SGDA	600	65	8.7	–	–	–	–
	SGHA	600	65	8.7	25	8.7	18	8.7
	SGLA	600	100	8.7	65	8.7	25	8.7
	SGPA	600	200	8.7	100	8.7	50	8.7
SK	SKHA	1,200	65	12.1	50	12.1	25	12.1
	SKLA	1,200	100	12.1	65	12.1	42	12.1
	SKPA	1,200	200	12.1	100	12.1	65	12.1

Notes: ① For two-pole SE- and SF-Frame rated 480Y/277 volts.
② The single-pole interrupting ratings shown are the UL Listed ratings for three-pole circuit breakers applied to ungrounded and resistance-grounded circuits. These single-pole ratings are not necessarily the maximum capability of the specific devices.
③ Some interrupting ratings are subject to final test verification.

Electrical Data

INTERRUPTING RATINGS

Table 44.1. Spectra RMS™ Circuit Breaker Interrupting Ratings, IEC 947-2 Rms Symmetrical Amps (in thousands) 50/60 Hertz

Frame	Type	Max. Rating Amperes	Ac Voltage U_e① 220-240 I_{cu}③	Ac Voltage U_e① 220-240 I_{cs}④	U_e 380-415 I_{cu}	U_e 380-415 I_{cs}	U_e 500② I_{cu}	U_e 500② I_{cs}	U_e 690② I_{cu}	U_e 690② I_{cs}
SE⑤	SEDA	160	18	9	14	7	14	7	10	5
	SEHA	160	65	33	25	13	18	9	10	5
	SELA	160	100	50	65	33	25	13	10	5
	SEPA	160	200	100	100	50	65	33	10	5
SF	SFHA	250	65	33	25	13	18	9	10	5
	SFLA	250	100	50	65	33	25	13	14	7
	SFPA	250	200	100	100	50	65	33	18	9
SG⑤	SGDA	630	65	33	–	–	–	–	–	–
	SGHA	630	65	33	25	13	18	9	14	7
	SGLA	630	100	50	65	33	35	18	22	11
	SGPA	630	200	100	100	50	65	33	35	18
SK	SKHA	1,250	65	33	50	25	25	13	20	10
	SKLA	1,250	100	50	65	33	42	21	25	13
	SKPA	1,250	200	100	100	50	65	33	50	25

Notes: ① IEC defines "rated operational voltage, U_e" as the voltage between phases for systems where a phase-to-ground fault will not cause a line-to-line voltage across one breaker pole.
② Two-pole SE- and SF-Frame rated 500 volts maximum.
③ I_{cu} = rated ultimate short-circuit breaking capacity.
④ I_{cs} = rated service short-circuit breaking capacity.
⑤ Some interrupting ratings are subject to final test verification.

Table 44.2. Spectra RMS™ Molded Case Switch Withstand Ratings, UL 1087

Molded Case Switch Frame	Molded Case Switch Type	Molded Case Switch Rated Amperes	Protective Device Fuse Type	Protective Device Fuse Max. Rating Amperes	Protective Device Circuit Breaker ① Type	Protective Device Circuit Breaker Max. Rating Amperes	Withstand Rating RMS Symmetrical Amps. (in thousands) Ac Voltage 208Y/120	Withstand Rating Ac Voltage 480Y/277	Withstand Rating Ac Voltage 600Y/346
SE	SEDA	100	RK5, J, T, or L	100	MCCB, ICCB, or LVPCB	100	200	100	65
	SEDA	150		150		150			
SF	SFDA	250		250		250			
SG	SGDA	400		400		400			
	SGDA	600		600		600			
SK	SKDA	800		800		800			
	SKDA	1,200		1,200		1,200			

Notes: ① Abbreviations are as follows: MCCB = molded case circuit breaker, ICCB = insulated-base circuit breaker and LVPCB = low-voltage power circuit breaker.
② Two-pole SE- and SF-frame rated 480Y/277 volt maximum.
③ Published withstand ratings are based upon the use of the proper protective device located on the *Line* side of the molded case switch.
④ Some withstand ratings are subject to final test verification.

Table 45.1
Interrupting Rating Multiplying Factors For Power Factors Lower Than (Or X/R Ratios Higher Than) Test Values

Power Factor (Percent)	X/R Ratio	Rated Maximum Interrupting Rating		
		1 to 10 kA[1]	11 to 20 kA	21 kA and Higher
		Multiplier	Multiplier	Multiplier
4	24.980	0.636	0.743	0.820
5	19.974	0.645	0.754	0.832
6	16.637	0.654	0.764	0.843
7	14.251	0.663	0.775	0.855
8	12.460	0.672	0.785	0.867
9	11.066	0.681	0.796	0.867
10	9.950	0.690	0.806	0.889
11	9.036	0.699	0.816	0.901
12	8.273	0.708	0.826	0.909
13	7.627	0.716	0.837	0.923
14	7.072	0.725	0.847	0.935
15	6.591	0.734	0.857	0.945
16	6.169	0.742	0.867	0.957
17	5.797	0.751	0.877	0.968
18	5.465	0.759	0.887	0.978
19	5.167	0.767	0.896	0.989
20	4.899	0.776	0.906	1.000
21	4.656	0.784	0.916	1.000
22	4.434	0.792	0.925	1.000
23	4.231	0.803	0.937	1.000
24	4.045	0.808	0.944	1.000
25	3.873	0.817	0.953	1.000
26	3.714	0.824	0.963	1.000
27	3.566	0.833	0.973	1.000
28	3.429	0.841	0.981	1.000
29	3.300	0.849	0.991	1.000
30	3.180	0.856	1.000	1.000
31	3.067	0.864	1.000	1.000
32	2.961	0.872	1.000	1.000
33	2.861	0.880	1.000	1.000
34	2.766	0.887	1.000	1.000
35	2.676	0.894	1.000	1.000
36	2.592	0.902	1.000	1.000
37	2.511	0.909	1.000	1.000
38	2.434	0.917	1.000	1.000
39	2.361	0.924	1.000	1.000
40	2.291	0.931	1.000	1.000
41	2.225	0.938	1.000	1.000
42	2.161	0.946	1.000	1.000
43	2.100	0.952	1.000	1.000
44	2.041	0.960	1.000	1.000
45	1.984	0.966	1.000	1.000
46	1.930	0.974	1.000	1.000
47	1.878	0.980	1.000	1.000
48	1.828	0.987	1.000	1.000
49	1.779	0.994	1.000	1.000
50	1.732	1.000	1.000	1.000

Note: [1] kA = Kiloamps (1 kA is 1,000 amps) rms, symmetrical.

Example: An SE-Frame Spectra RMS™ type SEHA circuit breaker has a 208Y/120-Vac short-circuit interrupting rating of 25,000 rms symmetrical amps when used in a circuit whose X/R ratio at the point of breaker application is 4.899, or higher (or the equivalent circuit power factor is 20 percent, or higher).

Assume the calculated system X/R ratio at the point of breaker application is 6.591. Using Table 45.1, the adjusted interrupting rating for the SEHA circuit breaker for this circuit at 208Y/120-Vac is (25,000) 0.945 or 23,625 rms symmetrical amps.

Table 45.2 Estimated 380-Hz to 450-Hz Interrupting Ratings of Spectra RMS™ Circuit Breakers Amps, Rms, Symmetrical – Not UL Listed

Frame	Type	Rating Amperes	Ac Voltage		
			208Y/120	480Y/277	[1] 600Y/346
			Multi-pole	Multi-pole	Multi-pole
SE	SEDA	150	1,800	1,400	1,400
	SEHA	150	2,500	2,500	1,800
	SELA	150	2,500	2,500	1,800
	SEPA	150	2,500	2,500	1,800
SF	SFHA	250	6,500	2,500	1,800
	SFLA	250	6,500	2,500	1,800
	SFPA	250	6,500	2,500	1,800
SG	SGDA	600	6,500	–	–
	SGHA	600	6,500	2,500	1,800
	SGLA	600	6,500	2,500	1,800
	SGPA	600	6,500	2,500	1,800
SK	SKHA	1,200	6,500	5,000	2,500
	SKLA	1,200	6,500	5,000	2,500
	SKPA	1,200	6,500	5,000	2,500

Note: [1] For SE- and SF-Frame three-pole units only for 600-Vac applications.

Electrical Data

Humidity and Fungus Spectra RMS™ circuit breakers and molded case switches contain no fungus nutrients on any of their functional parts. Consequently, all Spectra RMS™ circuit breakers and molded case switches are considered inherently fungus-proof.

Spectra RMS™ circuit breakers and molded case switches may be applied in applications with relative humidities up to 95 percent, non-condensing.

Electrical Formulas The formulas shown in Table 46.1 provide the basis for calculating current and other critical circuit values.

Table 46.1 Electrical Formulas

To Find	Alternating Current ② Single Phase	Alternating Current ② Three Phase	Direct Current
Power, Kilowatts (kW)	$\frac{E \times I \times PF}{1{,}000}$	$\frac{1.73 \times E \times I \times PF}{1{,}000}$	$\frac{I \times E}{1{,}000}$
kVA	$\frac{E \times I}{1{,}000}$	$\frac{1.73 \times E \times I}{1{,}000}$	$\frac{I \times E}{1{,}000}$
Power, Horsepower (hp)①	$\frac{E \times I \times n \times PF}{746}$	$\frac{1.73 \times E \times I \times n \times PF}{746}$	$\frac{I \times E \times n}{746}$
Power, Kilowatts (kW)	$\frac{1.34 \times hp}{n}$	$\frac{1.34 \times hp}{n}$	$\frac{1.34 \times hp}{n}$
Current from kVA (A)	$\frac{kVA \times 1{,}000}{E}$	$\frac{kVA \times 1{,}000}{1.73 \times E}$	$\frac{kVA \times 1{,}000}{E}$
Current from kW (A)	$\frac{kW \times 1{,}000}{E \times PF}$	$\frac{kW \times 1{,}000}{1.73 \times E \times PF}$	$\frac{kW \times 1{,}000}{E}$
Current from Horsepower (A)	$\frac{hp \times 746}{E \times n \times PF}$	$\frac{hp \times 746}{1.73 \times E \times n \times PF}$	$\frac{hp \times 746}{E \times n}$

Note: ① Horsepower ratings used in Table 46.1 are always the *Output* power rating of a machine, usually an electric motor. The objective of the equations using horsepower units is to determine electrical *Input* characteristics based on output ratings.
② Equation units in Table 46.1 are:
E = Voltage in volts (V) I = Current in Amps (A) PF = Power factor as a decimal fraction (e.g., 80% PF = 0.80) kW = Input power in kilowatts (kW) kVA = Input kilovolt-amps (kVA) hp = Output power in horsepower (hp) n = Efficiency as a decimal fraction

Time-Current Tripping Characteristics

SOLID-STATE SENSING

The advent of cost-effective microprocessors has enabled manufacturers of molded case circuit breakers to offer products containing solid-state trip units. There are a number of advantages to using solid-state circuitry in the trip circuitry of a circuit breaker. These advantages include:

- Higher levels of accuracy in establishing specific tripping points
- Ability to shape instantaneous, short-time and long-tripping current versus time curves to obtain better protection, better selectivity, or both
- Ability to provide better user adjustment of tripping points
- Ability to provide sensing and tripping circuitry that is ambient-insensitive

These advantages are essentially generic to any well-engineered molded case circuit breaker with a solid-state tripping system. They apply to all Spectra RMS™ circuit breakers. Figure 47.1 shows the typical time-current curves for a circuit breaker with a thermal-magnetic trip system. Figure 47.2 shows the time-current curves for a 150-amp, SE-Frame Spectra RMS™ circuit breaker. Differences in flexibility and accuracy are visible and obvious.

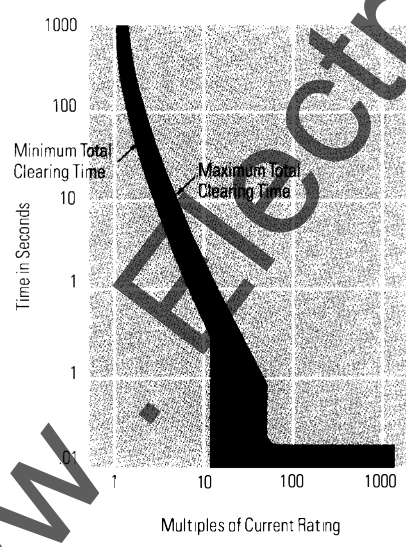


Fig. 47.1 Time-Current Curve Typical Thermal-Magnetic Trip

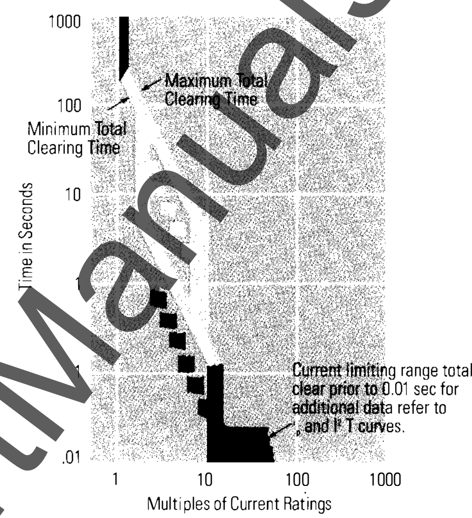


Fig. 47.2 Time-Current Curve Spectra RMS™ 150-Amp, SE-Frame Circuit Breaker

TRUE RMS SENSING VERSUS PEAK SENSING

Many modern electrical loads use static power conversion units that produce a high level of harmonics that cause the steady state current to become non-sinusoidal. Peak or rms-sensing solid-state trip systems can provide accurate overload and overcurrent protection for sinusoidal currents. However, peak-sensing units will overprotect or underprotect as the steady state current becomes increasingly non-sinusoidal, since they measure peak current and then compute rms.

Figure 47.3 shows a distorted current waveform with about 10 percent fifth harmonic.

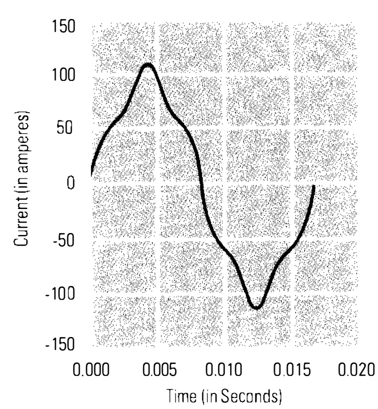


Fig. 47.3 Distorted Current Waveform With 10% Fifth Harmonic

In Figure 47.3, peak current is 110 amps, and the true rms current is 71.1 amps. However, a peak-sensing circuit, calibrated to produce rms equivalent outputs, would measure 77.8 amps. If, for example, the peak-sensing breaker were set to trip at 72 amps, the breaker would "over-protect" its loads and produce a nuisance trip.

Conversely, "underprotection" occurs when a peak-sensing circuit calculates a rms current lower than actual. Figure 48.1 shows a current waveform with 20 percent third harmonic. Peak current is 85 amps, which the rms calculator will output as 60.1 amps. The true rms current is 71.1 amps, a difference of more than 15 percent.

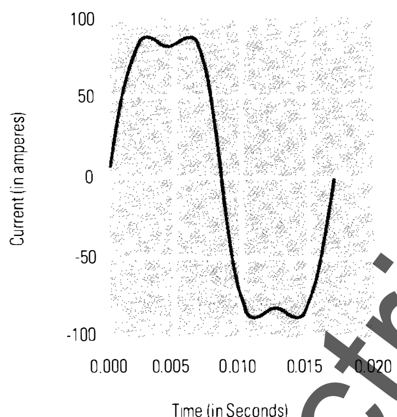


Fig. 48.1 Distorted Current Waveform With 20% Third Harmonic

Other current waveform measuring techniques involve either measuring average current, or sub-cyclical measurements of the current wave for several cycles within a longer sampling period. Both methods introduce significant errors when the loads involve solid-state controllable output power conversion equipment.

SPECTRA RMS™ TRUE RMS-SENSING CIRCUITRY

The magnitude of any harmonic is inversely related to its harmonic order. Consequently, harmonics above the 13th will not cause significant distortion of the current waveform. Sampling theory indicates if the current is measured at least 27 times during each cycle (1,620 measurements per second), rms current can be computed with a resulting error of one percent, or less, between calculated and true rms. For multiple-phase systems this sampling must be done for each phase.

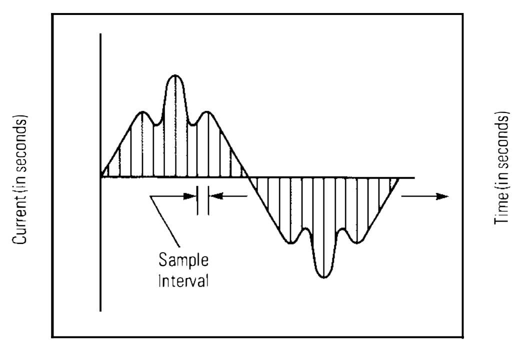


Fig. 48.2 Frequent Sampling of Current Waveform

The use of accurate current sensors, fast analog to digital converters and microprocessors, enables GE to produce a rugged and cost-efficient trip circuit to meet the requirements of a true rms current measuring system. GE continuously samples each phase throughout every cycle at a sampling frequency greatly exceeding 1620 Hz, which provides superior accuracy in determining true rms current. The Spectra RMS™ true rms-sensing circuit is an ideal design solution for protective devices used in modern power distribution systems. Literature describing GE's true rms-sensing circuitry is documented in an IEEE paper presented at the 35th Petroleum and Chemical Industry Conference, Dallas, Texas, and recorded in the conference record dated September 12-14, 1988, pages 157-163. Copies are available as well as additional literature from the company upon request.

ELECTRICAL TIME-CURRENT TRIPPING CHARACTERISTICS

Molded case circuit breaker time-current curves are the engineering documents that define technical performance characteristics of the devices. The test parameters for the generation of these curves are as follows:

A. Circuit breaker connected with a minimum of four feet of rated conductor per terminal.

B. Circuit breaker in open air at ambient temperature indicated.

C. All tests initiated from the no-current condition (cold start).

Information provided on the time-current curve includes the following:

1. Product family type
2. Specific device type
3. Amp ratings covered on curve
4. Overcurrent characteristics – long-time, short-time, instantaneous, etc.
5. Maximum total clearing time
6. Maximum and minimum temperature limits
7. Frequency ratings
8. Voltage ratings
9. Specific trip unit ratings
10. Trip unit adjustment ranges
11. Tolerances

Current in multiples of rating plug are shown on the top and bottom horizontal axis, with time in seconds on the vertical axis. Approximate minimum and maximum clearing time is readily determined from the characteristics curves. For example, an SFLA, 3-phase, 480-volt breaker equipped with a 100-amp rating plug and instantaneous set at high (reference curve K215-173) under a sustained overload of 200 amps (2 times trip rating) reading up to curve from the horizontal axis, will clear within 50 seconds to 120 seconds. Curve also shows that this breaker will trip instantaneously, when set at "HI," at current values within band ranging from 8 times to 12 times breaker rating plug rating. This instantaneous clearing time with no intentionally introduced time delay, ranges up to 0.025 seconds as shown on curve.

Tripping characteristics meet National Electrical Manufacturers Association (NEMA AB-1) Underwriters' Laboratories, Inc. standards (489), CSA, IEC and JIS.

Time-Current Tripping Characteristics

TIME-CURRENT CURVE INDEX

Table 50.1

Breaker			Time-current Curve Number	
Type	**Frame**	**Rating Plug**	**Circuit Breaker**	**Mag-Break®**
SE	7	3, 7		K215-181
SE	30	15, 20	K215-165	K215-182
SE	30	25, 30	K215-166	K215-183
SE	60	40, 50	K215-167	K215-184
SE	60	60	K215-168	K215-185
SE	100	70, 80	K215-169	K215-186
SE	100	90, 100	K215-170	K215-187
SE	150	110, 125	K215-171	K215-188
SE	150	150	K215-172	K215-189
SF	250	70, 90, 100, 110 125, 150, 175 200, 225, 250	K215-173	K215-190
SG	400	125, 150, 175 200, 225, 250 300, 350, 400	K215-174	K215-191
SG	600	250, 300, 350 400, 450, 500, 600	K215-175	K215-192
SK	800	300, 400, 500, 600	K215-176	K215-193
SK	800	700, 800	K215-177	K215-194
SK	1200	600, 700 800, 1000 1200	K215-178	K215-195

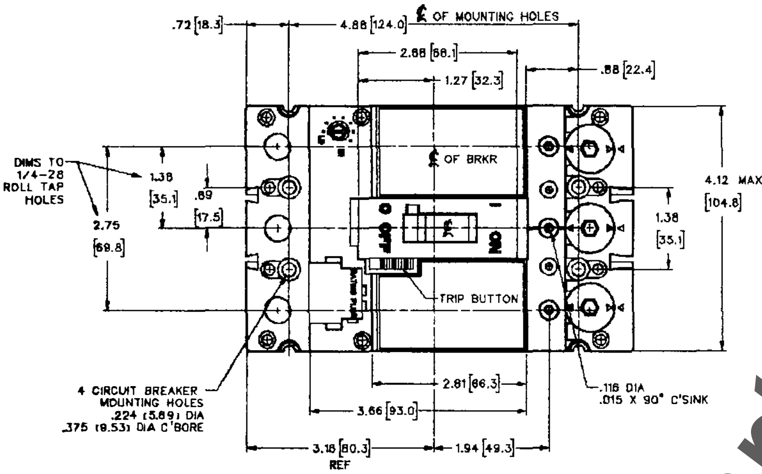
OUTLINE DRAWINGS

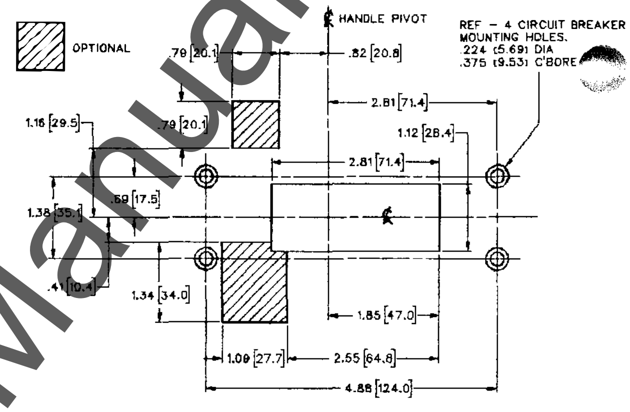
Other Reference Publications

GEA – 11884	Spectra RMS™ Circuit Breakers
GEP – 1100G	Buy Log Catalog
GET – 3550E	Short-Circuit Calculations

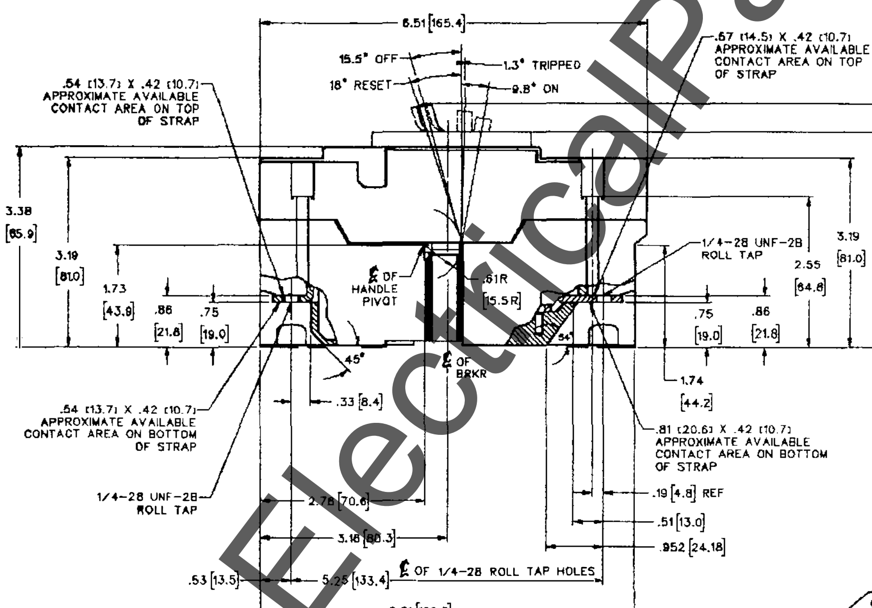
Installation Instructions

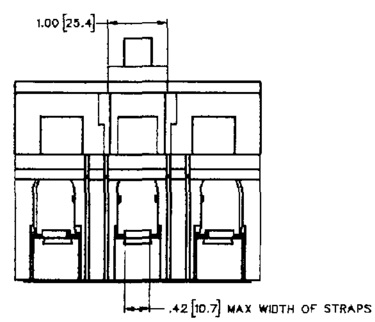
GEH – 5591	Spectra RMS™ Circuit Breakers – SE- and SF-Frame
GEH – 5592	Spectra RMS™ Circuit Breakers – SG- and SK-Frame
GEH – 5551	Internal Accessories – Shunt Trip & UVR
GEH – 5593	Internal Accessories – Aux. Sw & Bell Alarm
GEJ – 3045	External Accessory – SF-Frame Lug
GEJ – 3051	External Accessory – SE-Frame Lug





DOOR CUT-OUT

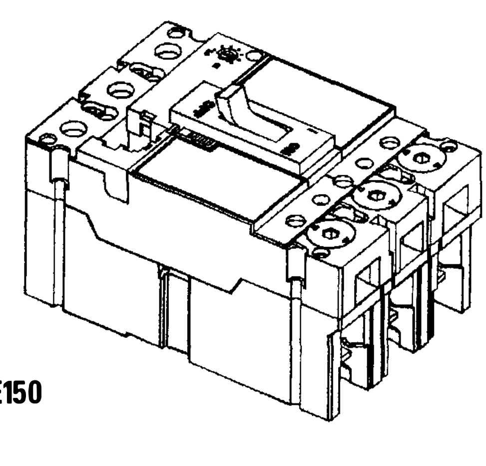




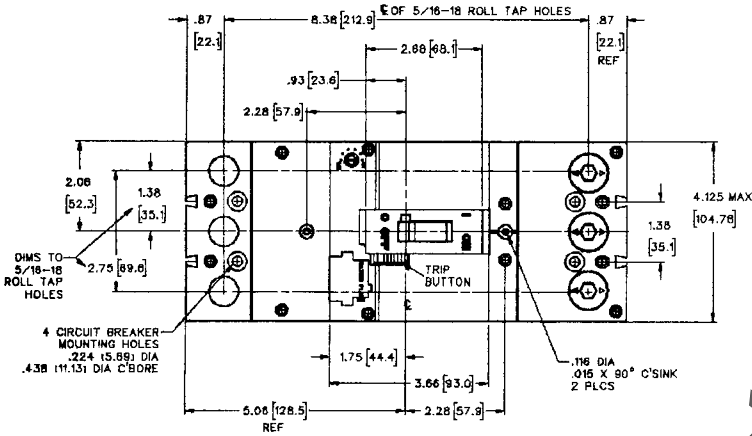
NOTE:

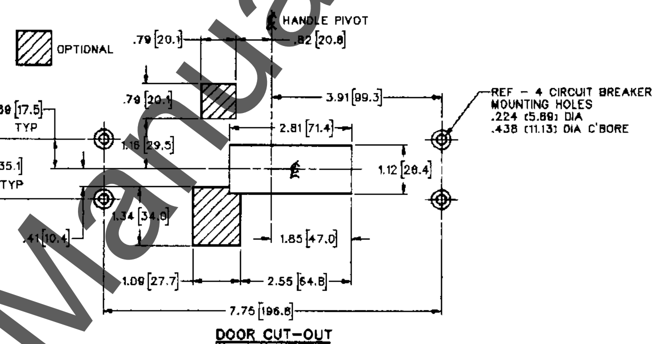
1. DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.

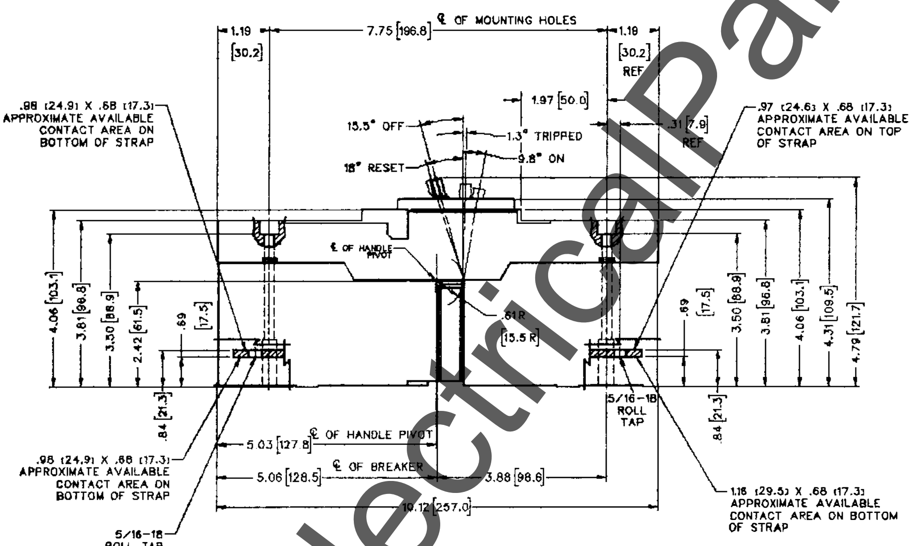
OPERATING FORCES	
TRIPPED TO MAX RESET	28 LB (12.7 Kg)
OFF TO ON	13 LB (5.9 Kg)
ON TO OFF	14 LB (6.4 Kg)

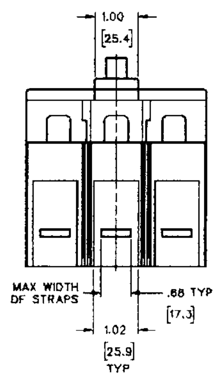


SE150



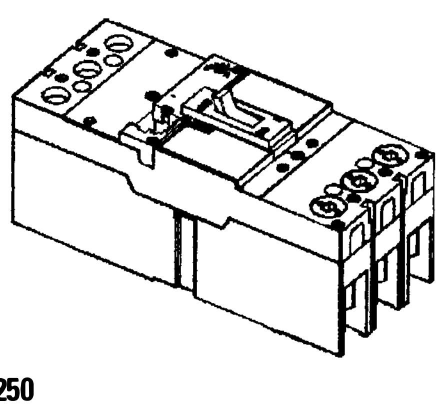






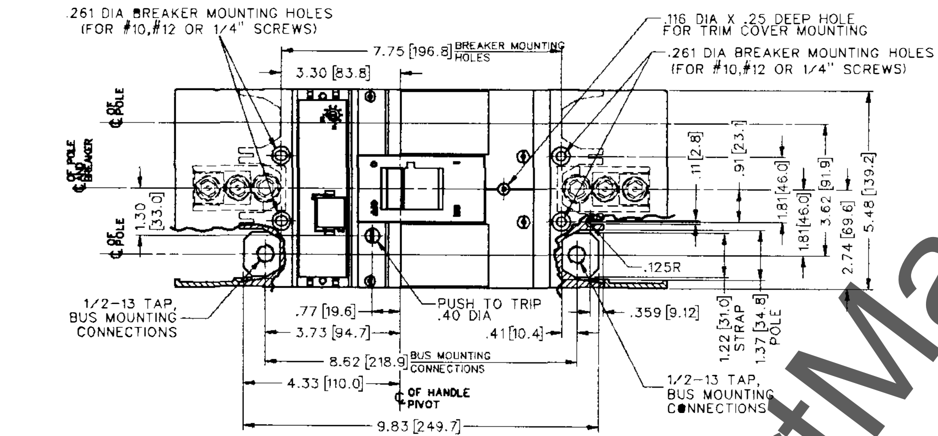
NOTE:

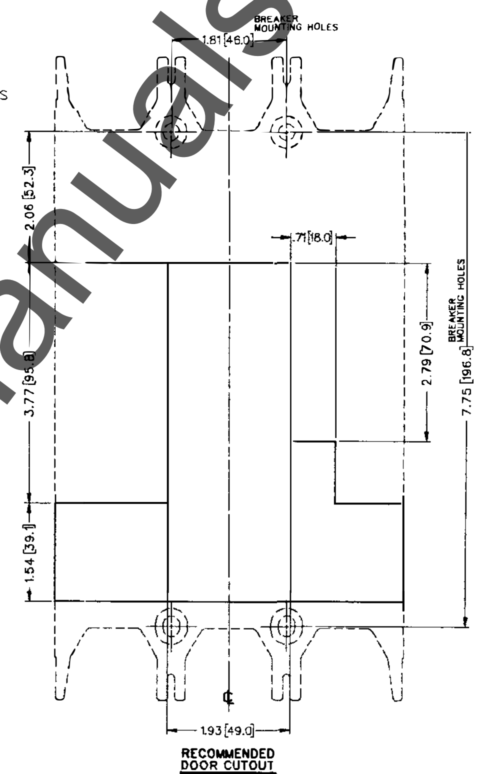
1. DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.

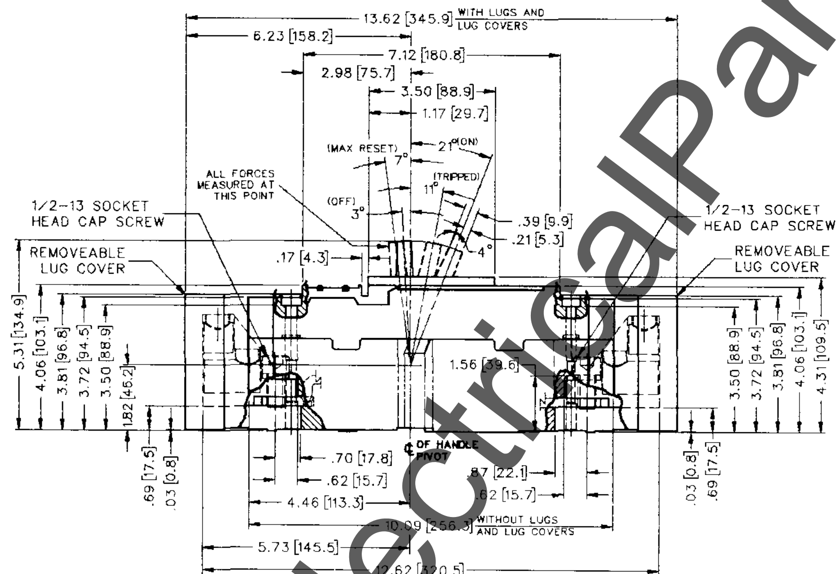


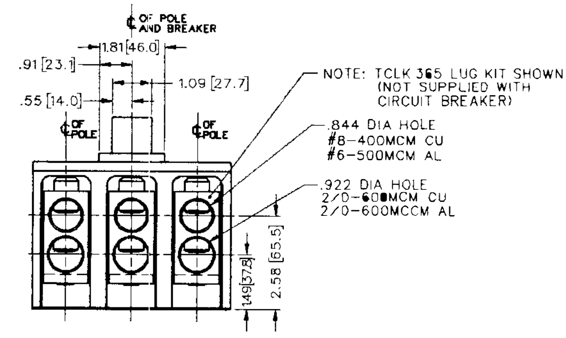
OPERATING FORCES	
TRIPPED TO MAX RESET	28 LB (12.7 Kg)
OFF TO ON	13 LB (5.9 Kg)
ON TO OFF	14 LB (6.4 Kg)

SF250



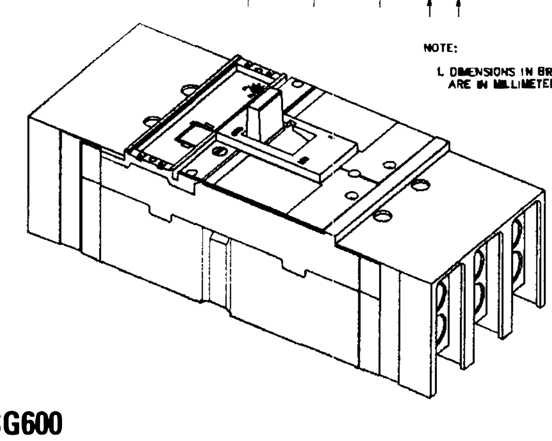






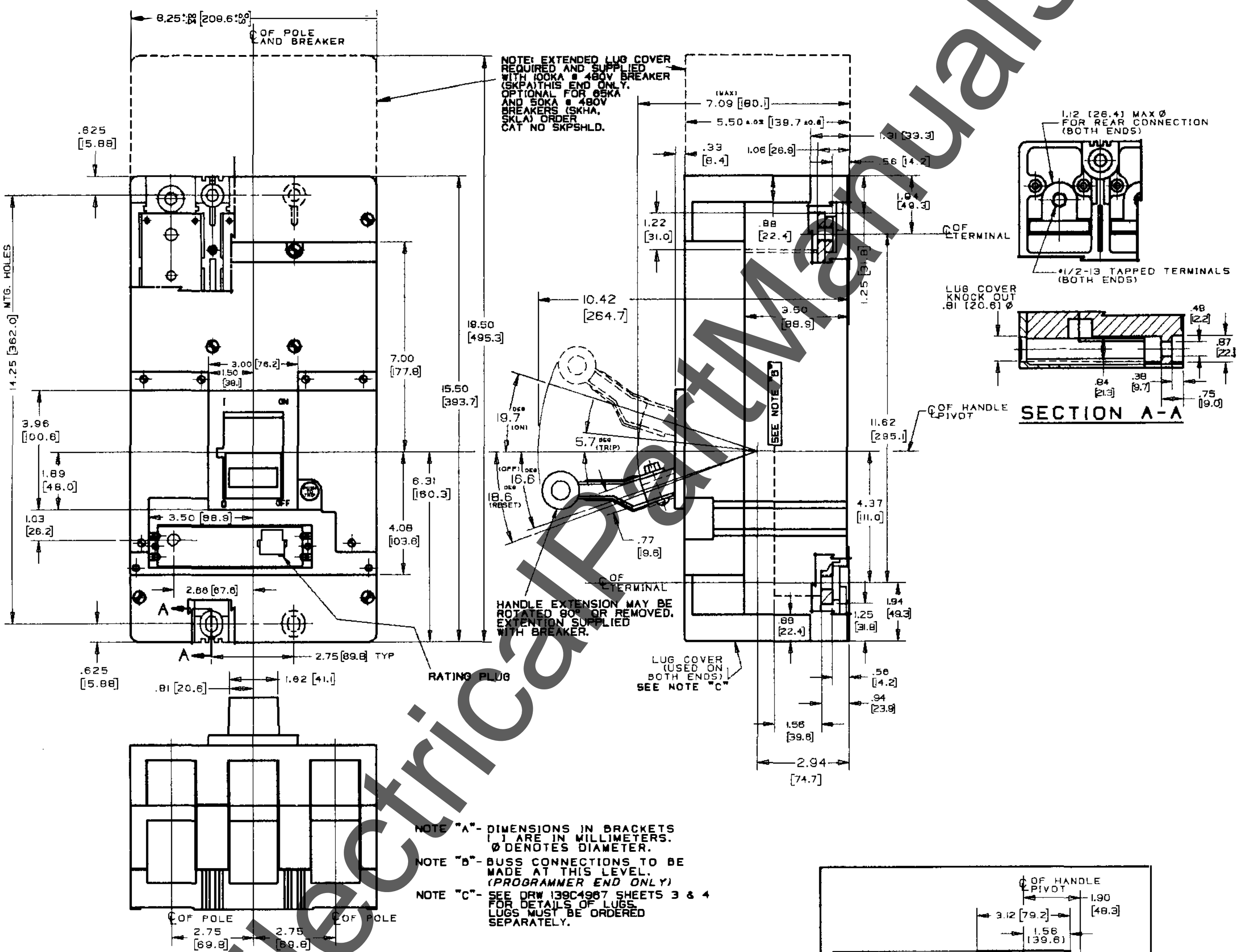
NOTE:

1. DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.

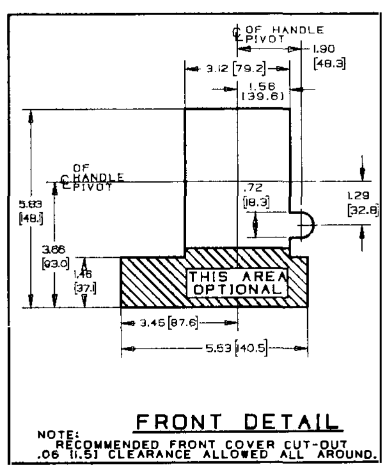


OPERATING FORCES	
TRIPPED TO MAX RESET	40 lb [18.1 kg]
OFF TO ON	40 lb [18.1 kg]
ON TO OFF	30 lb [13.6 kg]
PUSH-TO-TRIP BUTTON	3 lb [1.4 kg]

SG600
(PRELIMINARY)



NOMINAL HANDLE OPERATING FORCES (LBS)	WITHOUT EXTENSION	WITH EXTENSION
ON TO OFF	46	23
TRIP TO RESET	64	32
OFF TO ON	78	39



SK1200

Guide Form Specifications

SPECTRA RMS™ CIRCUIT BREAKERS GUIDE FORM SPECIFICATIONS

All molded case circuit breakers shall have an over-center, toggle handle-operated, trip-free mechanism with quick-make, quick-break action independent of the speed of the toggle handle operation. The designs shall provide common tripping of all poles. The escutcheon area of the breaker cover shall have molded-in "ON" and "OFF" markings and corresponding "I" and "O" (for "ON" and "OFF" respectively) international markings.

All molded case circuit breakers shall be GE Spectra RMS™ or equal with digital solid state, ambient insensitive tripping. All frames from 30A to 1200A shall use field-installed, UL Listed rating plugs to establish (or change) the ampere rating and shall be suitable for reverse feed (i.e., no line/load markings). The digital microprocessor trip system shall be applicable for 50 hertz through 400 hertz systems. It shall accurately sense sinusoidal and non-sinusoidal current waveforms (fundamental through the thirteenth harmonic order on a 60 hertz base) by continuously sampling each phase throughout every cycle.

All breaker frame sizes (SE150, SF250, SG600 and SK1200) shall have a single, customer-adjustable, instantaneous pickup knob to set the instantaneous response for all poles. In addition, there shall be a short time pickup with I^2t slope delay that tracks the instantaneous pickup setting at approximately 50 to 80 percent of the instantaneous pickup.

(Where) (If) required, instantaneous-only breakers shall be Spectra RMS™ Mag-Break® motor circuit protectors or equal employing the same features as the molded case breakers, except with the long-time (thermal) response omitted. The tracking short-time function and common rating plugs shall be provided on the instantaneous-only breakers.

Molded case switches (where) (if) required, shall have a fixed, high-set instantaneous pickup set below the popping level of the contacts. The short circuit withstand ratings shall be 100kA @ 480 Vac and 25kA (minimum) @ 600 Vac when protected by any UL Listed circuit breaker or fuse of equal or lesser ampere rating.

Circuit breakers and instantaneous-only breakers shall have frame sizes as follows: 30A, 60A, 100A, 150A, 250A, 400A, 600A, 800A and 1200A. In addition a 7A instantaneous-only frame shall be available. Rating plugs shall cover all standard ampere ratings from one frame's maximum ampere rating down to the next lower frame ampere rating. A frame shall reject a rating plug not intended for use in it. Mag-Break® or equal breakers shall use the same rating plugs for 15A through 1200A ratings as the Spectra RMS™ circuit breakers and shall additionally have 3A and 7A plugs for the 7A frame.

The circuit breaker frames shall employ high-strength, molded-polyester, glass-reinforced cases and covers. The breaker frame shall have legible, tamper-proof nameplates containing catalog number; maximum frame ampere rating; maximum voltage ratings and interrupting ratings in accordance with UL Standard 489, International Electrotechnical Commission (IEC) Standard 947.2 and Japanese Industrial Standard (JIS) No. C8370; terminal lug catalog number, torque requirements and cable insulation rating and wire ranges; the rating plug type; and Underwriters' Laboratories, Inc. Listing mark (or Component Recognition symbol in the case of Mag-Break® instantaneous-only breakers). The IEC short-circuit ratings shall contain both service (Ics) and ultimate (Icu) values.

All breaker frame sizes shall have a Verifier™ or equal to provide an external means for manually tripping the breaker and exercising the mechanism and trip latch member.

Internal accessories shall be UL Listed for field installation and shall not require circuit breaker cover removal. All internal accessories shall be common to SE150, SF250, SG600 and SK1200 frame sizes. Shunt trips, undervoltage releases, auxiliary switches and bell alarms shall be available and shall install from the front of the circuit breaker, instantaneous-only breaker or molded case switch.

External accessories, such as motor-operated mechanisms, various handle operators, plug-in base assemblies, back-connected studs, shall be UL Listed for field installation on circuit breakers (including instantaneous-only circuit breakers) and molded case switches.

GE Electrical Distribution & Control

General Electric Company
41 Woodford Ave.
Plainville, CT 06062

GET-7002 0989 MHJ