Industrial Solutions

TECHNICAL APPLICATION GUIDE

Evolution series E9000

Motor control center

by ABB

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Evolution series E9000 Motor control center

Safety and flexibility are standard
Evolution Series E9000 motor control centers (MCC) provide safe and flexible centralizing of motor starters and related control equipment. It combines motor control units, feeder units, distribution transformers, lighting panels, relays, remote and local control, sophisticated communications, metering and other miscellaneous devices to be contained in a single floor-mounted structural assembly fed from a common enclosed main bus.

Rugged and reliable
Motor control centers are constructed of standardized heavy gauge vertical sections housing vertical and horizontal buses, wiring channels and compartmented control units. Shipping splits are bolted together to form a single line-up assembly. Units are mounted and wired in accordance with the wiring class specified. The motor control center may be powered by incoming line connection at a single point protected by an upstream disconnect or provided with a main protective device within the equipment. Where possible, motor control centers bear UL section and unit labels.

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Figure 1:
E9000 MCC

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Figure 2:
E9000 MCC with Arc Flash Mitigation Units

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Figure 1

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Figure 2

E9000 with AFM: Even more protection
E9000 MCC with arc flash mitigation (AFM) units is an offering for customers and specific applications where additional protection of personnel is essential. The AFM units were designed around lowering the potential for electrical shock hazards in motor control centers. The AFM unit design includes optional IP20 devices and incidental contact safety barriers in an effort to prevent accidental contact with energized parts during maintenance.

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Figure 3:
E9000 arc-resistant construction

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Figure 3

New level of arc flash mitigation
The E9000 AFM units are designed to reduce the likelihood of exposure to electrical shock and the potential of internal arcing faults from occuring during maintenance.

The retractable stab mechanism allows for closed-door racking of the unit, providing added protection to the electrical personnel from the dangers of an arc flash occurrence.

The introduction of a compact NEMA contactor in these AFM units will allow a minimum of IP10 protection with optional IP20 terminal protection for starters using this contactor. Other IP20 protection options are available in starter units including IP20 control power transformer fuses and pilot devices.

Arc-resistant construction
E9000 AR offers a heavy-duty enclosure which is tested per applicable sections of IEEE/ANSI C37.20.7 with Type 2 accessibility. Reinforced doors, latches, and pilot device brackets provide strength and an optional plenum allows flexibility for installation.

Overview

Product design and features

Design flexibility, performance, personnel and equipment pro tection, ease of maintenance and installation are all contained in the Evolution Series E9000. Evolution Series E9000 features, such as separate wiring troughs, split-type terminal boards, isolated bus, drawout starter units, operating mechanisms, and provisions for starter interchangeability, are designed for a high level of reliability, safety and convenience.
The new Arc Flash Mitigation (AFM) units were added in order to provide additional safety features and flexibility for customers.

Enclosure features
These steel-enclosed control centers can be joined together to centralize, protect and control the most complex systems of industrial auxiliary drives, or the simplest of loads such as fan or pump controls. As the need arises, additional sections can be added to an existing lineup in the field, often times without the need for a transition section.

A paint finish is applied to all un-plated steel parts. The powder coating process passes 1000 Hr. ASTM117B salt spray tests and provides lasting protection.

All case side wireways are roll-formed to provide a 1/2" lip for cross wiring to rest on, thus preventing skinned insulation.

Easily removable plastic knock-outs are provided in the vertical wireway ladder assembly to allow routing of field wiring into units.

An incoming-line terminal compartment can be located at the top or bottom of a vertical section to allow cable termination with minimum bending. The standard 600-ampere incoming line terminal compartment shown is furnished with mechanical type lugs. Other incoming line terminal compartments are available for main bus ampacities up to 2500 amperes.

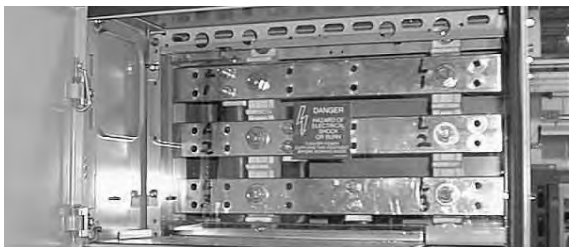
An optional snap-in steel barrier in the wireway provides added isolation for low voltage signal wiring between units.

Bus features

Splicing

E9000 MCC can be spliced onto existing 7700 Line, 8000 Line and Spectra MCC for 1200A (supplied with 2" bars) and below without a transition section. Horizontal bus location in E9000 matches the existing bus location. Main bus amperage 1200A and greater with 4" bus bars can be spliced together but requires a transition section.

Main bus barrier



Clear Lexan barriers located in front of the main horizontal bus isolate the bus from the top horizontal wireway. Maintenance personnel can easily gain entrance to the top horizontal wireway of the control center without danger of contact with a live bus.

Infrared scanning

Windows on the main bus are available when required. Please contact the factory for further information.

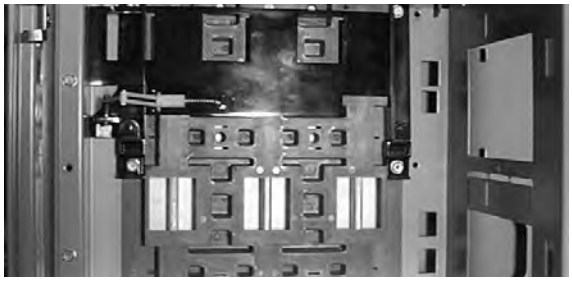
Vertical ground bus and unit ground stab

(Optional) Vertical copper ground bus allows direct grounding of unit saddles to the equipment ground bus. A unit ground bus stab engages the vertical ground bus before the unit power stabs engage the vertical bus. A load ground lug is available for customer cable grounding. Termination points are located at the rear of the bucket, next to starter.

Insulated and isolated vertical bus

A polyester-reinforced “sandwich” insulates and isolates the vertical bus and helps prevent the spread of faults from starter and feeder units to vertical or horizontal bus. Small stab openings provide access to vertical bus and maintains effective isolation. 65kA short circuit bracing is standard for Evolution Series E9000 MCC.

Vertical bus shutters



(Optional) For standard E9000 MCC's, a vertical bus shutter mechanism can be supplied which covers the vertical bus stab area when a plug-in starter or feeder is withdrawn. Cap plugs are standard to close unused stab openings.

(Standard for AFM) For E9000 AFM, a vertical bus shutter mechanism is supplied as standard. The shutter will be mechanically closed when the stabs are retracted, isolating the bus and preventing contact. When the stab is extended and engaged with the bus, the shutter will reverse the operation.

The vertical bus shutter for AFM design is different than the standard E9000 vertical bus shutter option. The AFM shutter and shutter guide are shown above.

Unit features

Doors

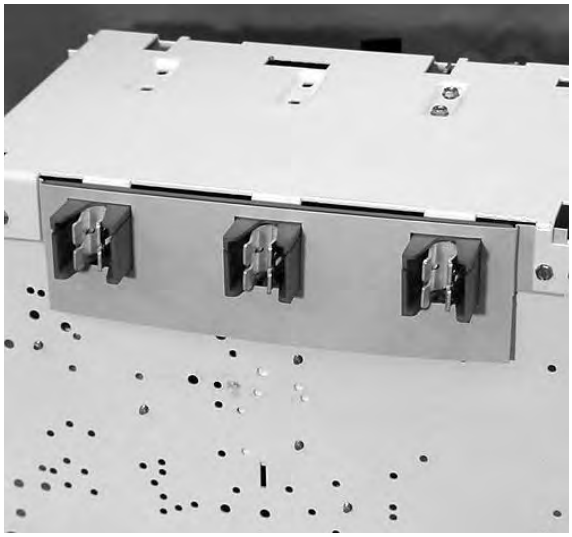
New doors mounted on the case feature a removable hinge pin providing easy door removal and accurate alignment.

AFM doors have a visual stab and shutter indicator feature as well as a remote racking provision.

New oversized laser-engraved unit nameplates on 12" units and larger feature 1 to 9 lines of up to 20 characters 0.18" high or 4 lines of up to 10 characters 0.30" high. Nameplates use Microsoft® Windows® Arial font. Custom non-English characters are an option.

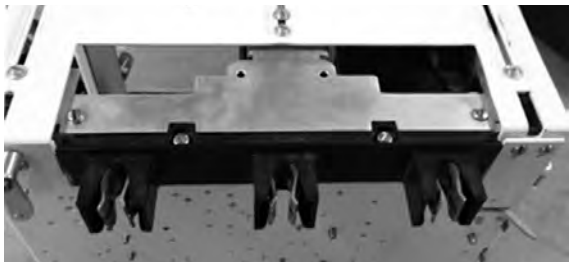
Device bracket mounts 30mm for compact pilot devices and bracket swings open to allow easy access to unit components, wiring and terminal blocks. Fully insulated – does not require grounding.

Stationery stabs



Combination starter and feeder units of plug-in construction utilize a positive guidance system. Plug-in stabs are rated 250A and 600A. The 250A stab connections shown are made with copper unit power stabs which are under double spring pressure and engage the vertical bus to provide positive contact.

Retractable stabs



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Extended stabs

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Retracted stabs

AFM unit stabs are retractable while maintaining a closed-door unit. They move in a horizontal motion to engage and disengage from the bus when retracted (below) or extended (above).

The 600A stab shown uses a two-step engagement with vertical bus for low insertion/withdrawal force. Line side cables crimped directly into spring reinforced tin-plated copper stabs. No hidden line side cable in rear of units. Tapered glass polyester stab mounting base gives positive plug-in alignment with vertical bus.

Safety interlocks

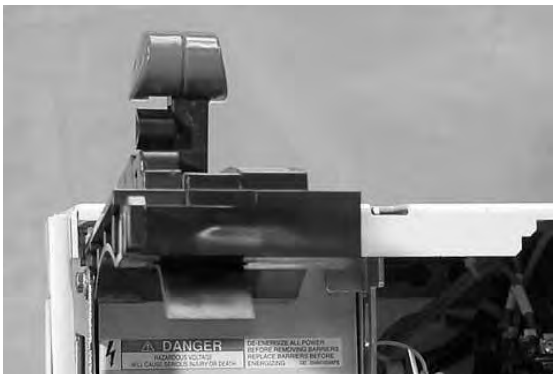
An interlock release system is provided so that – if it becomes necessary for maintenance purposes – the disconnect may be closed with the door open. A by-pass is provided to allow opening the door with the disconnect closed.

Note: Only qualified personnel familiar with the equipment should use the interlock release and by-pass features.

An interlock release system is provided so that – if it becomes necessary for maintenance purposes – the disconnect may be closed with the door open. A by-pass is provided to allow opening the door with the disconnect closed.

Padlocks

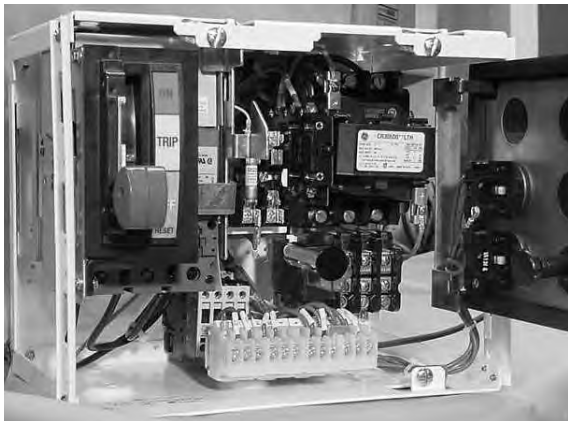
Units can be withdrawn to a disconnected position and padlocked for maintenance. The vertically mounted integral handle can be locked in the OFF position. A drilling pattern is furnished, allowing the handle to be modified for locking in the ON position with a single padlock. This modification should only be made afterthe user determines it is desirable to lock the disconnect in the ON position. Padlock to have maximum 3/8" shackle.



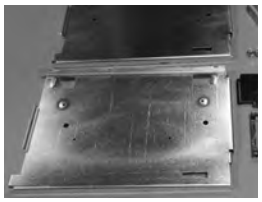
Lift up handle design to allow full access to fuses and CB rating plug. Position indication ON-TRIP-OFF.

Horizontal handles are standard on 6" 150A and 12" 250A feeder breakers to optimize space. Optional vertical handles are available, but will increase the unit height. Horizontal handles are not available with AFM units.

Interchangeable units



For flexibility, many units can be interchanged. This design allows quick, easy field changes when modifications are desired after installation. Front accessible quarter-turn latches provide for ease of securing and withdrawal of all plug-in units.



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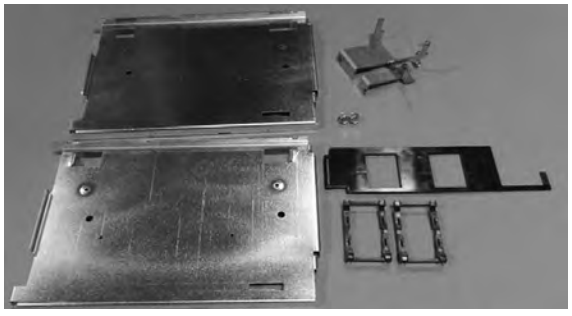
AFM retrofit kit unit shelves

With the AFM unit, a different unit shelf is required to support the movement of the unit while it is being racked in or racked out. When retrofitting an existing E9000 MCC, a Retrofit Kit will need to be ordered with the AFM Retrofit bucket. The Retrofit Kit will include this AFM shelf.



AFM units can be ordered to retrofit existing E9000 MCC by ordering the AFM Retrofit Kit along with the unit.

High density two-piece, pull-apart control terminal boards feature up to 18 points in 12” high units. External and internal unit connections are made on opposite sides, allowing the unit to be withdrawn without disconnecting control wiring. Accommodates up to (2) #12 AWG wires with ring, fork or bare terminations. Rated 30 Amps, 600 Vac. Meets NEC Article 430.74.

The E9000 AFM unit is equipped with the C2000 contactor as standard configuration. The CR305 contactor is available for most configurations. Please contact factory if the CR305 contactor is required in an AFM unit.

IP20 and incidental contact barrier features

(Optional) Motor power terminal blocks can be supplied in Size 1 and 2 to allow disconnecting motor wires when removing a unit. NEMA Type BT wiring.

(Optional) IP20 rated fuses are available. Please contact factory.

The E9000 MCC unit is equipped with the CR305 contactor as standard configuration. The C2000 contactor is available for many configurations to obtain a compact footprint.

(Optional) CR104P Lights and Push butons are available with optional IP20 accessory. Please contact factory.

(Optional) C2000 Contactor is available with optional IP20 accessory. Please contact factory.

(Optional) Clear Lexan incidental contact barriers are available for CR305 contactor.

Wire and cable

Standard control and power wire includes flame-retardant, (VW-1) moisture-heat-and oil-resistant thermoplastic insulation rated 600 volts, with stranded copper conductors, types MTW and THW. Standard colors[1] are:

- Red – AC Control
- Blue – DC Control
- Black – AC/DC Power and CPT primary
- Green – Ground
- White – Neutral

Optional wiring available includes SIS heat-resistant synthetic rubber-covered switchboard wire and XHHW flame-retardant cross-linked synthetic polymer, both rated 600 volts with stranded copper conductors, and a VW-1 flame rating (no PVC).

Wire is rated 90 degrees Celsius and terminalsare rated 75 degrees Celsius.

Note: Not all colors are available with optional wiring.

Nameplates

Unit service designation nameplates are furnished when specified. Nameplates can be supplied as blanks suitable for field engraving, or engraved at the factory. The standard unit service designation nameplate is of 2-ply thermoplastic material, black face with white core, 2 5/32" x 3 1/2", or 1" x 3" depending on the unit configuration, fastened with non-corrosive nylon clips. Stainless steel screws are available as an option. Nameplates are engraved with white letters on a black background.

NEMA class of diagrams and wiring
Motor control centers are classified by NEMA as follows:

NEMA class I definition[1]
Class I motor control centers consist essentially of a mechanical grouping of combination motor control units, feeder tap units and/or other units arranged in a convenient assembly and connect to the horizontal and vertical common power bus to the units.

This class does not include interwiring or interlocking between units or to remotely mounted devices, nor does it include control system engineering. Diagrams of the individual units only are supplied.

NEMA class II dDefinition[1]
Class II motor control centers consist of a grouping of combination motor control units, feeder tap units and/or other units designed to form a complete control system. They include the necessary electrical interlocking and interwiring between units and interlocking provisions to remotely mounted devices in addition to the connections from the horizontal and vertical common power bus to the units.

The control manufacturer shall provide a suitable diagram to illustrate operation of the control associated with the motor control center.

NEMA class IS and IIS definition[1]
Class IS and IIS motor control centers shall be the same as Class I and II motor control centers except custom drawings shall be provided in lieu of standard drawings.

Examples of custom drawings are:
• Special identifications for electrical devices
• Special terminal numbering designations
• Special sizes of drawings

1. From NEMA standard 18-2001.

The drawings supplied by the manufacturer shall convey the same information as drawings provided with Class I and II motor control centers, additionally modified as specified by the user.

When to specify class I
Specify NEMA Class I control centers for independently operated motors requiring no interlocking or other interconnection between units.

When to specify class II
When factory interconnections are desired to provide such functions as sequencing and other interlocking or interconnection, the control centers required are NEMA Class II.

When to specify class IS and IIS
When custom drawings are desired to show special device identification, special terminal numbering, or special diagram size, etc. the control centers required are Class IS or IIS.

Wiring type
The NEMA classes are sub-divided into A, B and C depending on the type wiring furnished, with type B further having type B-D for customer load wiring direct to the device and B-T for customer wiring to a load TB (size 1 and 2 starters).

Note: For feeders and large starters, customer must wire direct to unit device terminals.

Note: In addition to NEMA prescribed wiring types, ABB offers a NEMA 1A Modified MCC. This type of MCC will be supplied without wiring and without control diagrams. ABB can mount low voltage control devices on the pilot device bracket and supply terminal boards. This would be considered on OEM product device terminals.

Wiring features by NEMA classification

Type of power or control termination furnished	Class I			Class IS			Class II		Class IIS	
	A	B	C	A	B	C	B	C	B	C
Pull-apart and numbered control terminal boards on unit starter–Sizes 1, 2, 3 and 4	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Stationery and numbered control terminal boards on unit starter – Sizes 5, 6 and 7	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Pull-apart and numbered power terminal oards on unit starter –Sizes 1 and 2. (On Type A wiring: Same type of numbered terminals on starter itself for Sizes 1, 2, 3and 4)	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Numbered terminals on starter itself for power connection with no power terminal boards – Sizes, 5, 6 and 7	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stationery master terminal boards (Top, bottom or rear of section) For control – Sizes 1 thru 5 / For power – izes 1 thru 3 (E9000 Sizes 1 and 2 only)	No	No	Yes	No	No	Yes	No	Yes	No	Yes
Unit terminal boards for feeder tap units and distribution panels	No	No	No	No	No	No	No	No	No	No
Starter-unit-mounted pilot devices internally wired to starter – Sizes 1 thru 7	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Terminal board points for remote devices (Excluding extra tie points)	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Master terminal-board wiring connections	No	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
Factory-wired interconnections between units in the same motor control center	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Type of drawings furnished										
Outline and summary sheet (Schedule of units)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Unit elementary wiring diagrams showing numbered terminal points (Terminal boards not furnished on Type A)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Unit elementary wiring diagrams showing numbered terminal points and interconnections to other units and/or to the first level of remote devices	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Schedule of wires to master terminal blocks	No	No	Yes	No	No	Yes	No	Yes	No	Yes
Custom drawings as specified by user	No	No	No	Yes	Yes	Yes	No	No	Yes	Yes

A computerized manufacturing process necessitates that the E9000 Line motor control center standard unit numbering system be followed to identify the section and location of each unit. This is explained in detail in application data (Section J). It greatly simplifies wire tracing of interconnection wires, and is beneficial to the application of programmable control. The Outline and Summary drawing furnished with the equipment cross references the unit numbers and customer unit designations when specified.

Codes and Standards
Motor control centers are manufactured to NEMA standard ICS 18 and are eligible to receive the Underwriters Laboratories listing mark under standard UL 845. Vertical sections and units which have been listed with UL will bear the UL/cUL listing mark (see right for examples). Since vertical sections and units are listed independently, it is possible to have combinations of listed and non-listed sections and units within the same control center. Sections and units which will be shipped with the UL listing mark are identified in the appropriate sections of this publication.

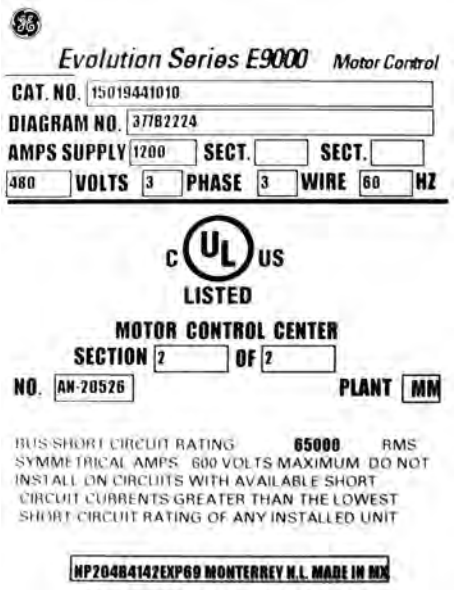
The National electrical code (NEC) covers installation of electric conductors and equipment for installations identified in the NEC Article 90. The NEC is not intended as a design specification and acceptance of an installed motor control center by a local code authority relies on factors independent of the equipment as shipped from the factory. In general, equipment which bears the UL listing mark can be installed to meet the NEC. Compliance to NEC is the responsibility of the installer. Where 100 percent UL listed equipment is mandatory or there are other special code requirements refer to the factory for verification.

The NEC defines several types of control circuits and the over-current protection required for each type. The following paragraphs provide a general reference to the NEC Article applicable for the more common control circuits.

NEC Articles 430.72(a) and (b) cover motor control circuits tapped from the load side of a motor branch-circuit short-circuit protective device (unit disconnect). Control circuit conductors from such a tapped control circuit shall be protected in accordance with NEC Table 430.72(b), which lists the maximum fuse or circuit breaker rating vs. conductor size.

Motor control circuits other than such tapped control circuits (common control transformers or external power source) shall be protected against overcurrent in accordance with section 725.12 or 725.35, as applicable. This section of NEC also indicates the type power source and field wiring conductor sizes. Where a motor control circuit transformer is provided, the transformer should be protected in accordance with NEC Article 430.72(c). Transformers other than motor control circuit transformers should be protected in accordance with NEC Article 450.3(b).

Section label



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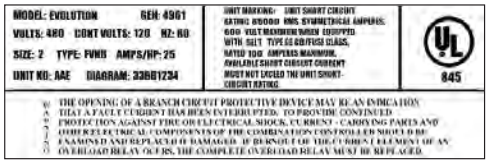
UL #E33752, Vol. 1, Sec. 5.

Unit label



Short circuit considerations
All ratings in this publication are RMS symmetrical amperes.

Short-circuit current ratings
The NEMA Motor Control Center Standard ICS 18-2001 defines the short-circuit rating of a motor control center as follows:
"The motor control center short-circuit rating shall be the maximum available rms symmetrical current in amperes permissible at its line terminals. It shall be computed as the sum of the short-circuit current contributions of the motors connected to the motor control center and the maximum available current, including all other short-circuit current contributions of the supply system at the point of connection to the motor control center."

Motor control center bus

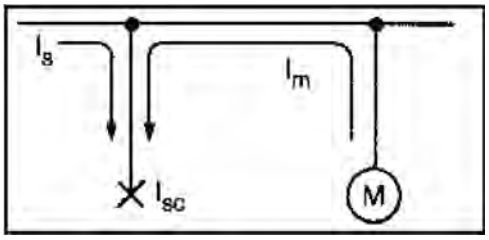


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Figure 1.

Figure 1 illustrates simply the basis of determining the available short-circuit current. The individual short-circuit current ratings of the main bus extensions, combination-controller units and feeder-tap units must equal or exceed available short-circuit current.

I_s is the short-circuit current available from the system at the point where the motor control center is connected. Im is the short-circuit current contribution of the motors connected to the motor control center. If exact information is lacking, the motor contribution can be estimated at four times (4X) the continuous-current rating of the main horizontal bus. I_{sc} is the available short-circuit current to be used as the basis for selection.
Thus: $I_{sc} = I_s + I_{m.}$

High available short-circuit currents of modern distribution systems require special consideration so that equipment may be operated within its rating. The cost and operational acceptability of the following should be carefully considered:

1. Use load-center distribution systems with smaller transformers which limit the available short-circuit current.
2. Use a current-limiting busway, reactors or higher-impedance transformers to reduce the available short-circuit current.
3. Use current-limiting fuses, current-limiting breakers, or breakers with limiters, in all combination starters and feeders in the control centers.

Main protective devices
A motor control center requires adequate overcurrent and short-circuit protection. This is the function of the main protective device. It may be located in or remote from the control center and sized per NEC A or 240 for horizontal bus protection. Wherever located, it must have an interrupting rating equal to or greater than the available short-circuit current at the point of its connection to the system. If located at the control center, this value would be the system available short-circuit current, I_s (Figure 1).

A motor control center should be protected for all types of faults from low-level arcing ground faults to bolted threephase faults which can develop the full available short-circuit current. Line-to-line and line-to-ground arcing faults (ofte produced by contaminated atmospheres, foreign materials, etc.) can be appreciably lower in magnitude than the available short-circuit current and must be assumed not to be selfextinguishing.

Even low-level arching faults are capable of releasing tremendous energy at the point of fault and can be highly destructive.

A Spectra (molded case switch) or a non-automatic insulated case circuit breaker must be properly coordinated with up stream protective devices.

For full protection against all levels of arcing faults on grounded systems, a ground-fault relay is recommended. The ground-fault system is a protective means that responds to phase-to-ground current, but is not affected by phase-tophase current. It is used to protect motor control centers from extensive damage, which can be caused by phase-toground arcing faults.

Fuses are single-pole interrupters. An arcing fault may not necessarily be cleared by a single-pole interruption, as the fault can be back-fed from the other energized phases. This reduces the fault current, increasing the blowing time of the energized fuses. Because of this delay, severe equipment damage may occur. Single-phasing is eliminated with fastacting three-pole fused interrupter switches which open when a single fuse blows.

An electrically operated HPC switch with single-phase detector will meet the three-phase disconnection (single-phase protection) recommendations for a main protective device.

When switches without a three-phase trip are used, an ITI BGFL ground-fault protection scheme is particularly recommended since damaging arcing faults almost always involve ground. It should operate the trip device on the closest line-side three-phase disconnect.

Main horizontal bus and vertical bus extensions
The standard bus short-circuit withstand rating is 65 kAIC symmetrical amperes. Also available as an option is 100kAIC. The bus rating must equal or exceed the available shortcircuit current. Refer to "Structure" section for ratings.

Combination motor control units
The short-circuit rating of a combination controller is based on tests with rated short-circuit current available at the line terminal of the control center and at rated voltage. The short-circuit rating must equal or exceed the available short-circuit current. Refer to "Starters" section for ratings.

Feeder tap units
All feeder tap units must have a short-circuit rating which equals or exceeds the available short-circuit current. Refer to Feeders" section" for ratings.

Fuse classification

UL classifications are the most definitive method of determining fuse characteristics, and are used in this publication. Use UL fuse “Class” when specifying type of fuse.

UL classifications used in motor control centers are:

A. Class R – current-limiting type fuses with reject mounting features. Class R fuses are sub-divided into Classes RK-1 and RK-5, depending on maximum peak let-through currents. RK fuses are rated 600 amperes maximum and 250 volts or 600 volts.
B. Class J-TD – are more current limiting than RKs and due to their unique dimensions have an inherent rejection feature. Ratings are 600 amperes maximum, 600 volts. (Time delay Class J-TD fuse may limit component damage under fault.)
C. Class L – are current limiting and due to their unique mounting dimensions have an inherent rejection feature. Ratings are 601 amperes minimum, 600 volts.

Fuses marked with “Time-Delay,” “Dual-Element” or similar designations are time-delay type fuses and will generally carry 500 percent rated amperes for 10 seconds, thus allowing a smaller rated fuse to be used in most starter applications.

Fuses that are mechanically interchangeable may not be electrically equivalent. Refer to the fuse manufacturer for interrupting rating and current-limiting characteristics.

	UL standard		
Characteristic[1]	**Class J-TD**	**Class R**	**Class L**
Ampere Range	0-600	0-600	601-6000
		250	
Voltage Ratings	600	600	600
Interrupting Rating RMS Symmetrical Amperes	200 K	200 K	200 K
Current-Limiting	Yes	Yes	Yes
Rejection Type	Yes	Yes	Yes

1. Check fuse manufacturers for specific fuse characteristics.

Environmental considerations
The standard E9000 motor control center is designed for operation in a clean, indoor environment having a 40°C maximum ambient temperature.

The nominal minimum temperature for storage is -40°C and for operation, -20°C. Motor control center space heaters are recommended whenever temperature conditions below 0°C will exist. Where extreme cold temperatures are to be encountered for long periods of time. It is recommended that the motor control center be installed in heated rooms or enclosures.

For ambient temperatures above 40°C, special consideration must be given to the need for ventilation, ambient-compensated breakers and overload relays, special wire insulation and oversized control transformers. Ambient compensated overloads provide essentially constant trip setting as the control ambient varies.

For indoor environments subject to falling liquids, NEMA 2 dripproof enclosures are recommended. If water spray and splashing are to be encountered, NEMA 2 construction should also be used. Space heaters may be desirable to prevent condensation on internal parts.

For outdoor installations, NEMA 3R non-walk-in weatherproof enclosures are required. Thermostatically controlled space heaters and ambient-compensated breakers and overload relays should be considered for these applications. Provisions for heating and cooling the entire outdoor enclosure are also available.

Standard NEMA 3R construction is suitable for wind velocities up to 75 mph. Beyond this, up to 130 mph, specially reinforced enclosures are available through Strategic Equipment Packaging Services. This special design is also necessary if the NEMA 3R enclosure has to withstand seismic conditions, including seismic Zone 4 applications.

E9000 motor control center is available for earthquake conditions. It is IBC rated.
Please see DET-463.

For dusty atmospheres, see "Structure " section.

The altitude limit for the standard electro-mechanical motor control center design is 6000 feet. Applications above this should be referred to the Company for recommendations. Some solid-state components are only rated to 3300 feet and may reduce the altitude limit of the motor control center.

Fungus-proofing of organic materials is inherent. Keeping equipment dry and above the dew-point is the best way of avoiding fungus-growth, and the use of space heaters is recommended for this purpose. Heaters should be energized if the motor control center is to be stored for any length of time. Where export crating is involved, provisions must be made on the outside of the crate for access to space heaters.

Structure

Enclosure types
Motor control centers are made up of standardized vertical sections housing vertical and horizontal bus, wiring channels and compartmented control units. Sections may be bolted together to form a single panel assembly powered by line connection at a single point. Normal shipping split is three sections maximum.

NEMA type 1 – Gasketed – semi dust-tight, indoor
Intended to cushion doors and mitigate vibration. Standard finish is light-gray ANSI 61 over a phosphate rust inhibitor. All unpainted parts are zinc-chromate electroplated or galvanized. Enclosures are furnished with bolt-on rear covers. Hinged rear doors are available as an option. Pan-type doors utilize quarter-turn fasteners. Gasketed doors, cover plates, and operating handles are available as an option. Two heavy-duty 3" by 1-1/2", 12-gauge floor sills and 1/4" structural lifting lugs are included. Open bottom is standard.

NEMA type 2 – Drip-proof, indoor
Intended for use indoors to protect the enclosed equipment against falling noncorrosive liquids and falling dirt. Dripshields on top of the motor control center and neoprene closed-cell gasketing afford protection from falling and splashing liquids. They are not water-tight. Similar to NEMA 12 gasketed construction except with catch pan-type dripshield on top and with open bottom.

Dripshield extends four inches beyond front of motor control center. Standard finish: light gray ANSI 61. Furnished with removable conduit cover plates unless otherwise specified.

NEMA type 3R – Rain-proof, outdoor
Intended for use outdoors to protect the enclosed equipment against rain. They are not dust-proof, snow-proof nor sleet proof (ice-proof). Optional lights and receptacles available.

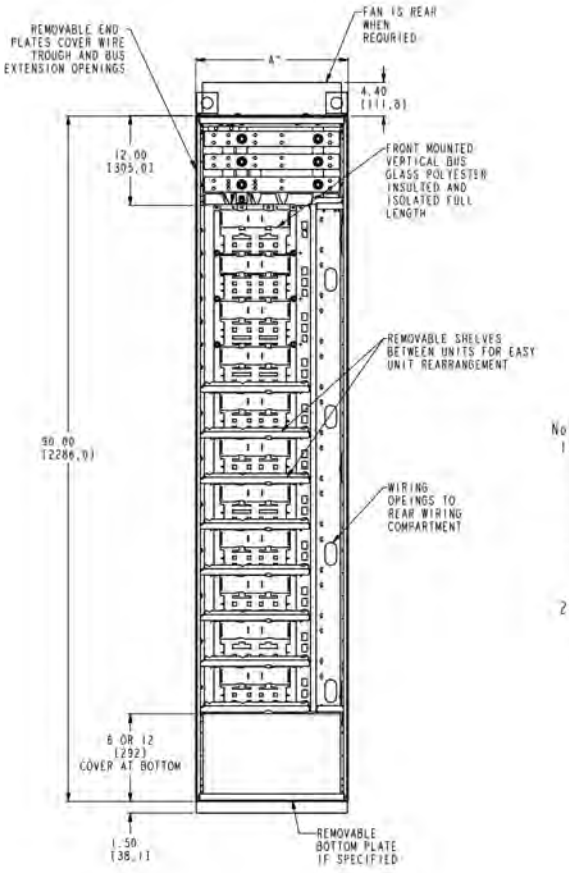
Type 12 – Industrial use – Dust-tight and drip-tight, indoor
Intended for use indoors to protect the enclosed equipment against fibers, flyings, lint, dust and dirt, light splashing, seepage, dripping and external condensation of noncorrosive liquids.

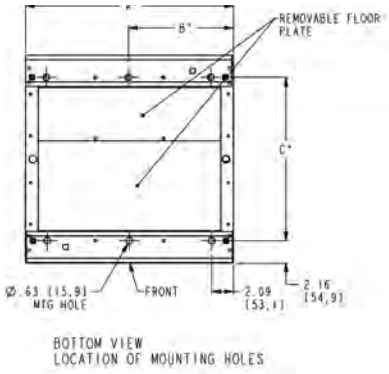
1HG
Similar to NEMA 1 gasketed construction except that bottom plates are furnished and all removable plates are gasketed.

Construction type	Enclosure type	Description	Voltage (V)		Short circuit (kA)		Main bus rating							
			480	600	65	100	600	800	1200	1600	2000	2500	3000	3200
Standard	NEMA Type 1	Semi Dust-tight, Indoor	•	•	•	•	•	•	•	•	•	•	•	•
	NEMA Type 1HG	Heavy Gasketed	•	•	•	•	•	•	•	•	•	•	•	•
	NEMA Type 2	Drip-proof, Indoor	•	•	•	•	•	•	•	•	•	•	•	•
	NEMA Type 3R	Rain-proof, Outdoor	•	•	•	•	•	•	•	•	•	•	•	•
	Type 12	Dust-tight, Drip-tight, Indoor	•	•	•	•	•	•	•	•	•	•		
Arc-resistant	NEMA Type 1	Semi Dust-tight, Indoor	•	•	•		•	•	•	•	•			
	Type 12	Dust-tight, Drip-tight, Indoor	•	•	•		•	•	•	•	•			

Indoor enclosures

Front elevation and mounting locations (13", 20", 22" and 25" Deep sections)



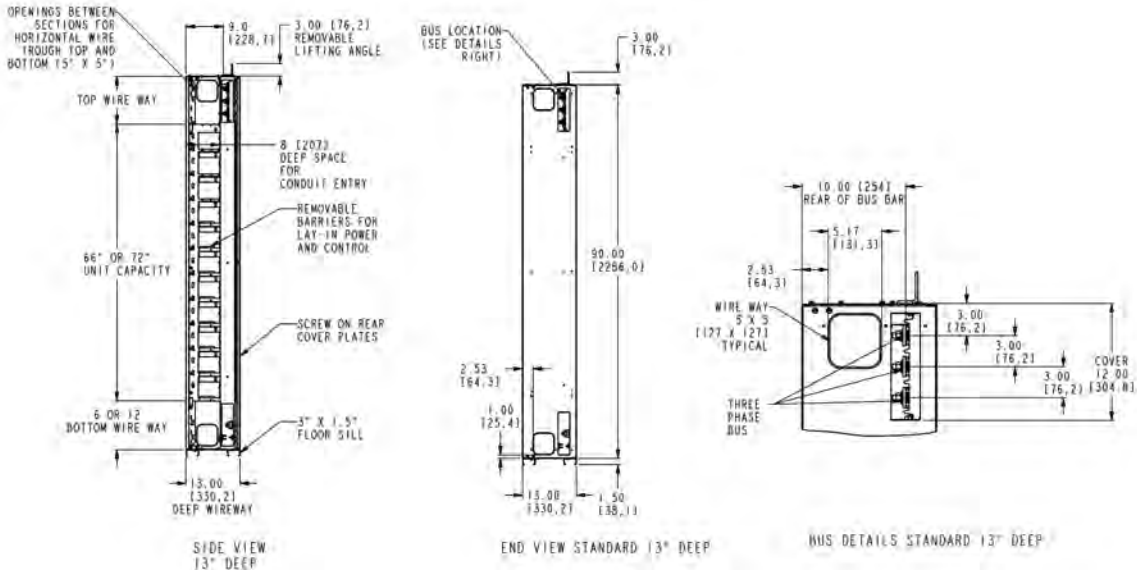


Note: If anchor bolts are to be inbedded in the foundation, they must be located according to the drawing furnished by ABB for the specific equipment. Locate one in the center front and one in the center back. Anchor bolts should be 1/2 inch diameter, of Grade 2 steel (minimum) in non-Seismic Zone 4 Locations. Bolts must extend a minimum of 2 11/32 inch above grade to 3/4 inch above the channel sill. If 13 (330.2mm) deep verical sections are used, anchor bolts or some form of external bracing is required.

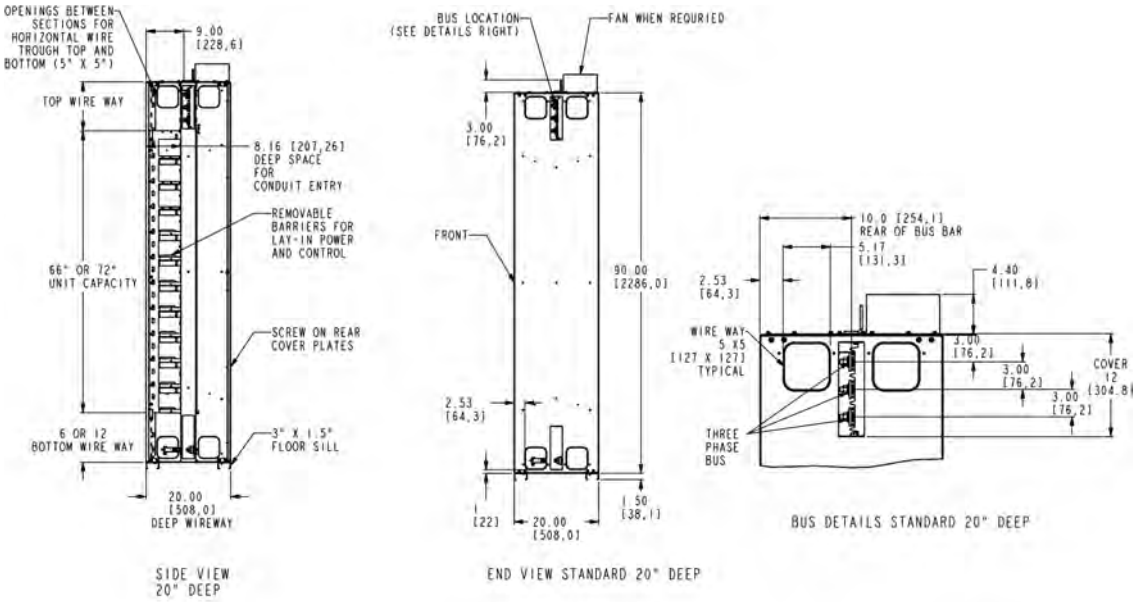
Note: Seismic IBC testing was performed use 1/2' - 13 Grade 5 bolts, torqued to 50 foot-pounds, located in each of the four corners in each section.

Ref. Dim.	Section depth							
	13" Deep		20" Deep		22" Deep		25" Deep	
Width "A"	B	C	B	C	B	C	B	C
20"	10.00"	8.73"	10.00"	15.73"	10.00°	17.73"	10.00"	20.68"
508.8 mm	254.4 mm	221.7 mm	254.4 mm	399.5 mm	254.4 mm	450.3 mm	254.4 mm	525.3 mm
24"	12.00"	8.73"	12.00"	15.73"	12.00°	17.73"	12.00"	20.68"
609.6 mm	304.8 mm	221.7 mm	304.8 mm	399.5 mm	304.8 mm	450.3 mm	304.8 mm	525.3 mm
30"	15.00"	8.73"	15.00"	15.73"	15.00°	17.73"	15.00"	20.68"
762.0 mm	381.0 mm	221.7 mm	381.0 mm	399.5 mm	381.0 mm	450.3 mm	381.0 mm	525.3 mm

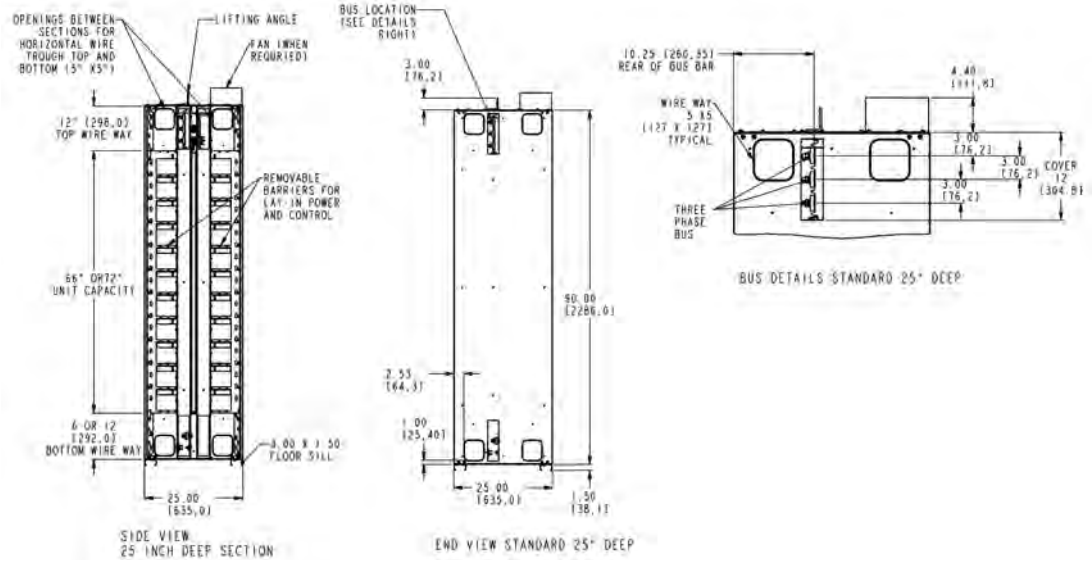
Side elevations 13" deep section
600A to 1200A main bus



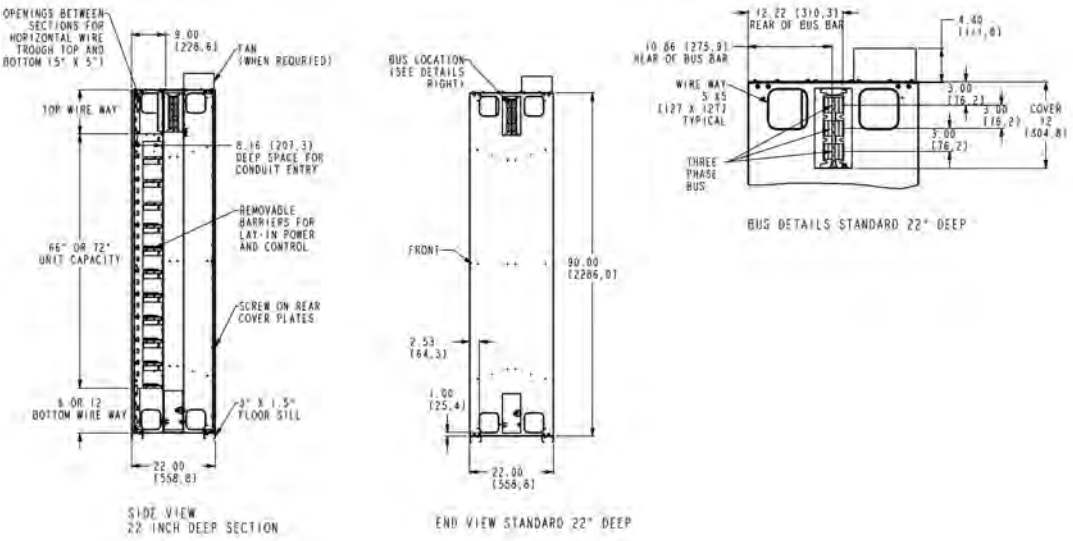
Side elevations 20" deep section
600A to 1200A main bus



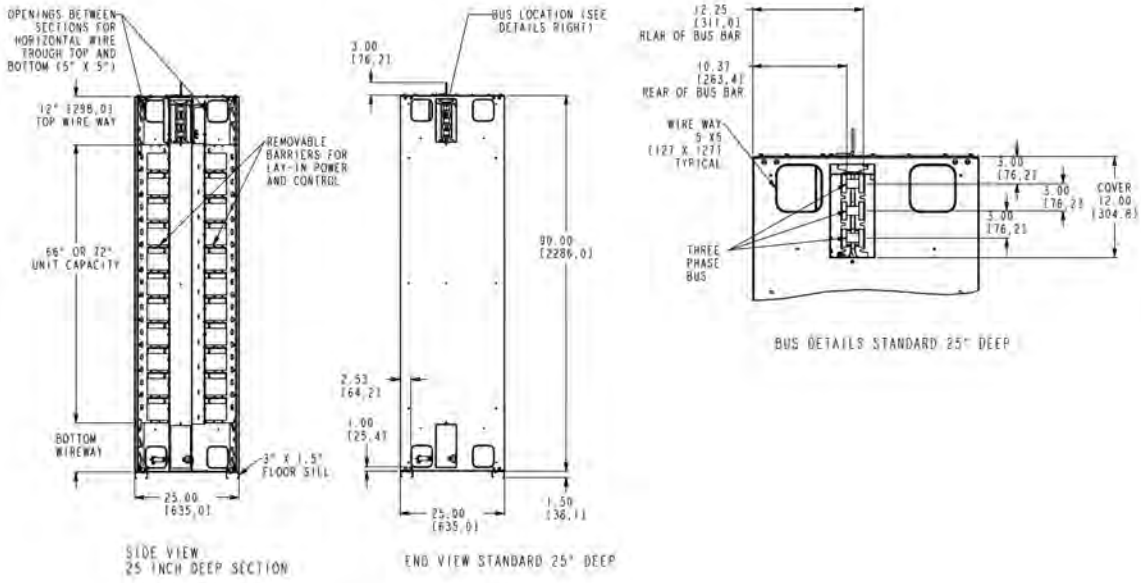
Side elevations 25" deep
back-to-back section 1200A main bus



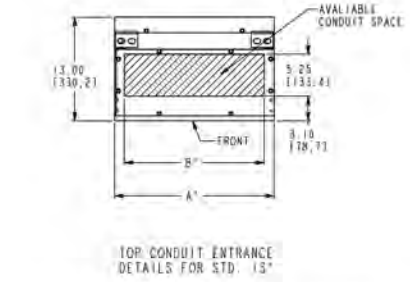
Side elevations 22" deep section
1600A to 2500A main bus

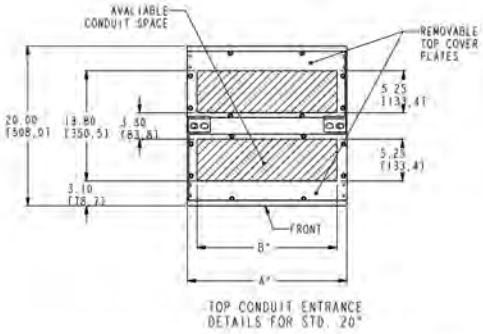


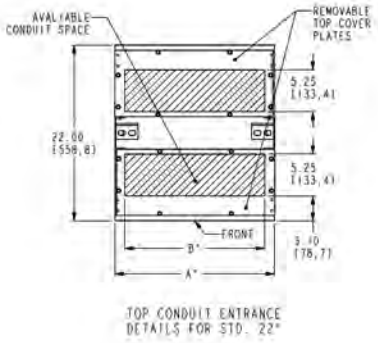
Side elevations 25" deep back-to-back section 1600A to 2500A main bus

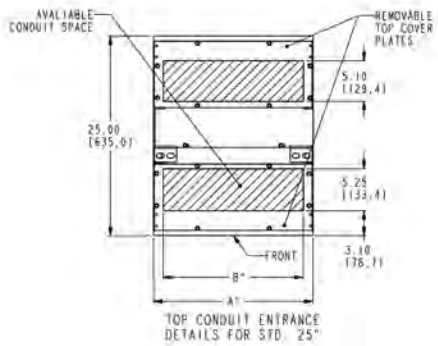


Top conduit entry (13", 20", 22" and 25" deep sections)

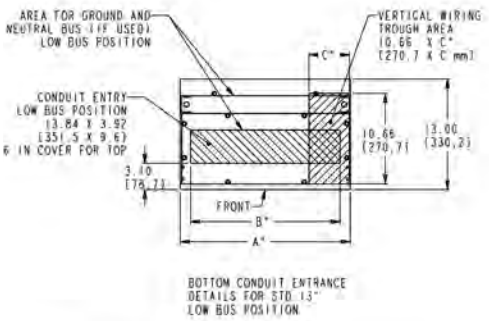




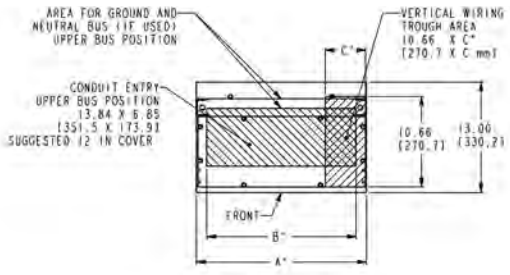




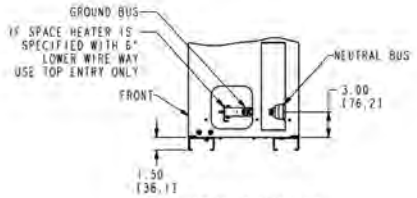
Bottom conduit entry 13" deep section



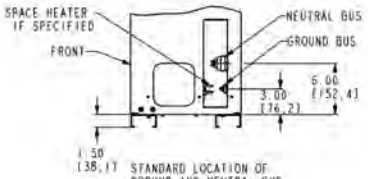
BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 13" LOW BUS POSITION



BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 13" BUS UPPER POSITION

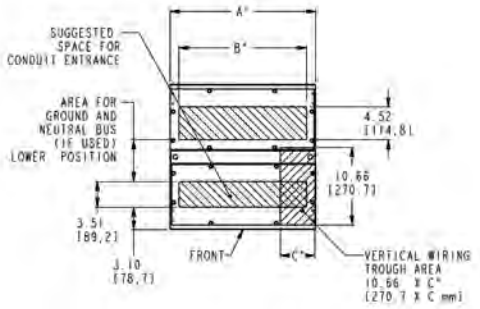


LOW BUS POSITION OF GROUND AND NEUTRAL BUS (MINIMUM AVALIABLE SPACE FOR CONDUIT ENTRY) 6 IN [152.4] COVER

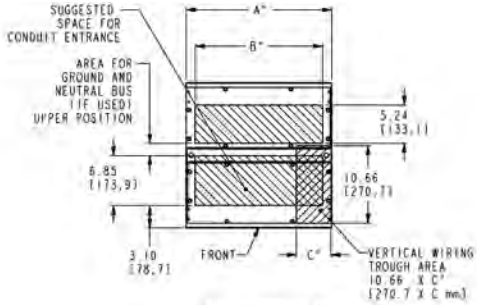


STANDARD LOCATION OF GROUND AND NEUTRAL BUS WITH 12IN [304.8] COVER COMPARTMENT AT THE BOTTOM OF MCC

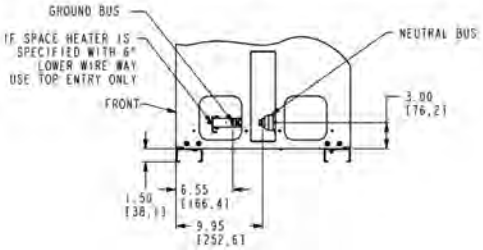
Bottom conduit entry 20" deep section



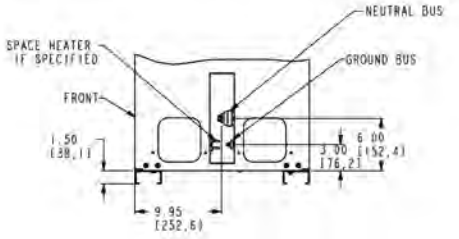
BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 20" X 20" LOW BUS POSITION, 6" BOTTOM COVER



BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 20" BUS UPPER POSITION



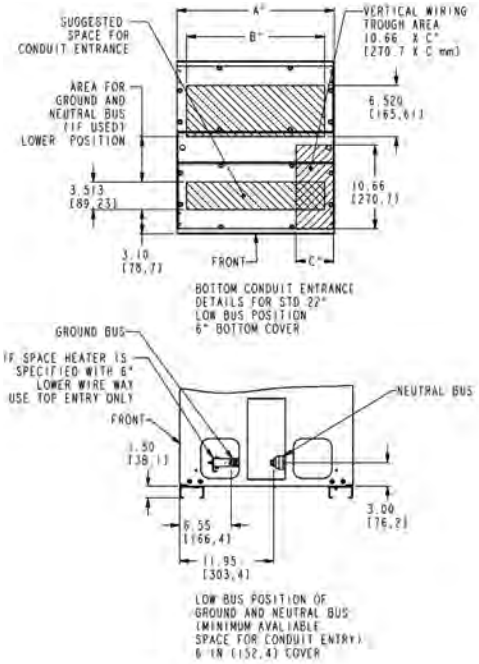
LOW BUS POSITION OF GROUND AND NEUTRAL BUS (MINIMUM AVALIABLE SPACE FOR CONDUIT ENTRY) 6 IN [152.4] COVER

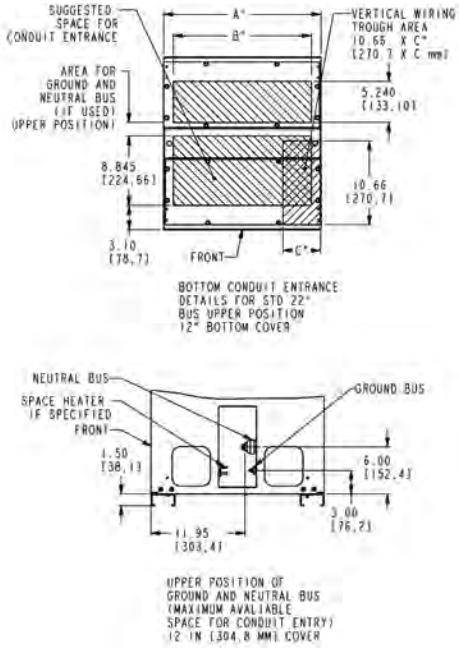


UPPER POSITION OF GROUND AND NEUTRAL BUS (MAXIMUM AVALIABLE SPACE FOR CONDUIT ENTRY) 12 IN [304.8 MM] COVER

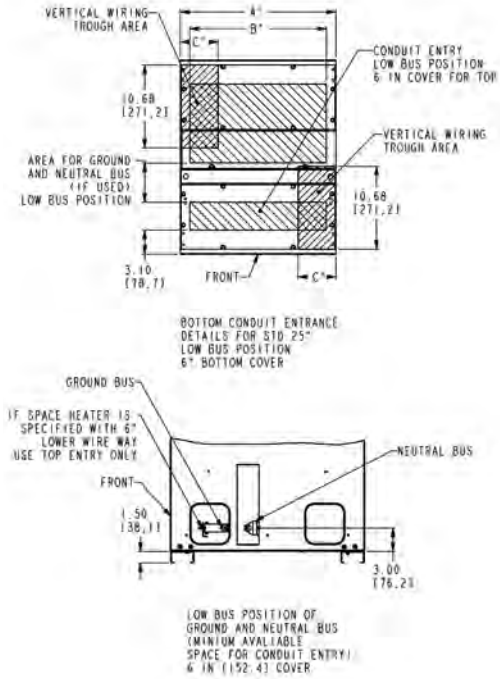
Ref. dim.	20" wide enclosure	24" wide enclosure	30" wide enclosure
A"	20"	24"	30"
	508.8 mm	609.6 mm	762.0 mm
B"	17.56"	21.56"	27.56"
	446.0 mm	547.6 mm	700.0 mm
C"	4.85"	8.85"	14.85"
	123.2 mm	174.2 mm	377.2 mm

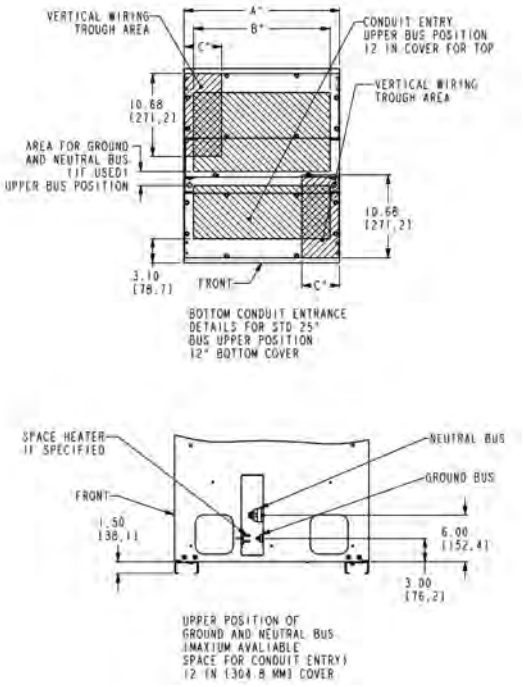
Bottom conduit entry 22" deep section





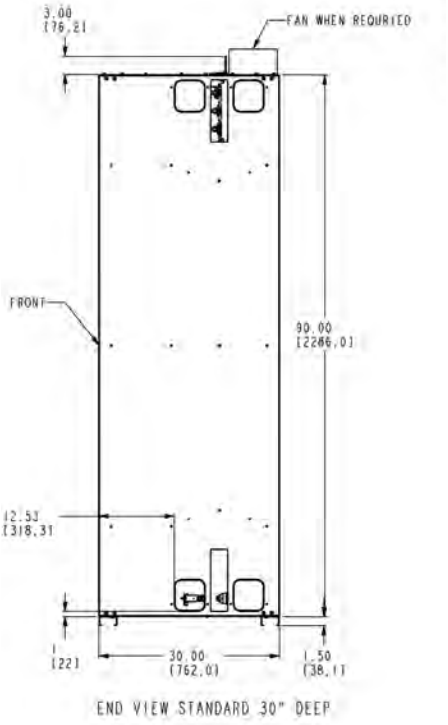
Bottom conduit entry 25" deep section

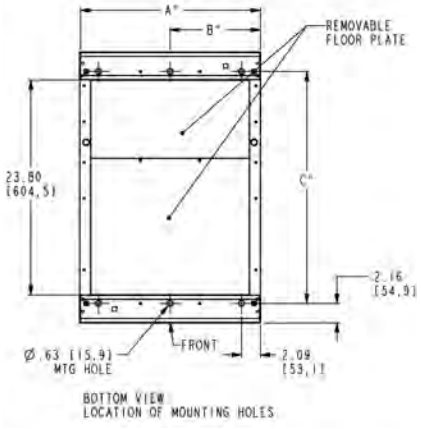




Ref. dim.	W	24" wide enclosure	30" wide enclosure
A"	20"	24"	30"
	508.8 mm	609.6 mm	762.0 mm
B"	17.56"	21.56"	27.56"
	446.0 mm	547.6 mm	700.0 mm
C"	4.85"	8.85"	14.85"
	123.2 mm	174.2 mm	377.2 mm

Elevation and mounting 30" deep section 600A to 1200A main bus



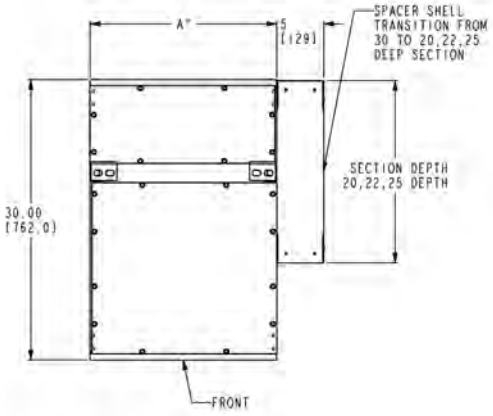


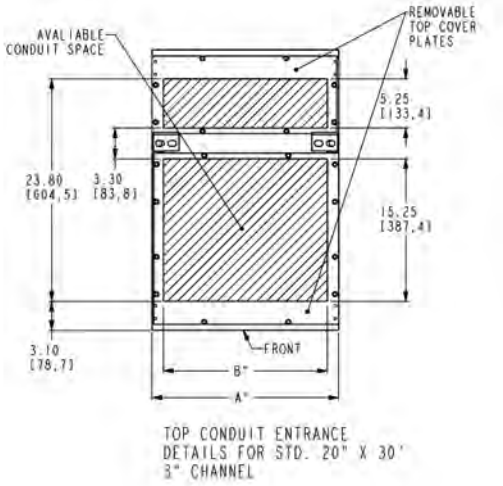
Note: If anchor bolts are to be inbedded in the foundation, they must be located according to the drawing furnished by ABB for the specific equipment. Locate one in the center front and one in the center back. Anchor bolts should be 1/2 inch diameter, of Grade 2 steel (minimum) in non-Seismic Zone 4 Locations. Bolts must extend a minimum of 2 11/32 inch above grade to 3/4 inch above the channel sill. If 13 (330.2mm) deep verical sections are used, anchor bolts or some form of external bracing is required.

Note: Seismic IBC testing was performed use 1/2' - 13 Grade 5 bolts, torqued to 50 foot-pounds, located in each of the four corners in each section.

Ref. Dim.	Section depth									
	13" Deep		20" Deep		22" Deep		25" Deep		30" Deep	
Width "A"	B	C	B	C	B	C	B	C	B	C
20"	10.00"	8.73"	10.00"	15.73"	10.00"	17.73"	10.00"	20.68"	10.00"	25.69"
508.8 mm	254.4 mm	221.7 mm	254.4 mm	399.5 mm	254.4 mm	450.3 mm	254.4 mm	525.3 mm	254.4 mm	653.5 mm
24"	12.00"	8.73"	12.00"	15.73"	12.00"	17.73"	12.00"	20.68"	12.00"	25.69"
609.6 mm	304.8 mm	221.7 mm	304.8 mm	399.5 mm	304.8 mm	450.3 mm	304.8 mm	525.3 mm	304.8 mm	653.5 mm
30"	15.00"	8.73"	15.00"	15.73"	15.00"	17.73"	15.00"	20.68"	15.00"	25.69"
762.0 mm	381.0 mm	221.7 mm	381.0 mm	399.5 mm	381.0 mm	450.3 mm	381.0 mm	525.3 mm	381.0 mm	653.5 mm

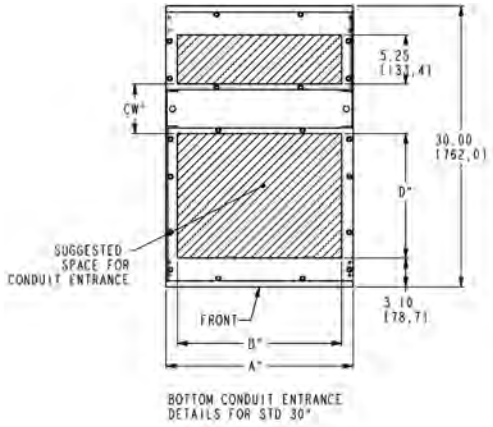
Top conduit entry 30" deep section





Note: Spacer shell allows unit doors, in spliced section on the right, to open fully.

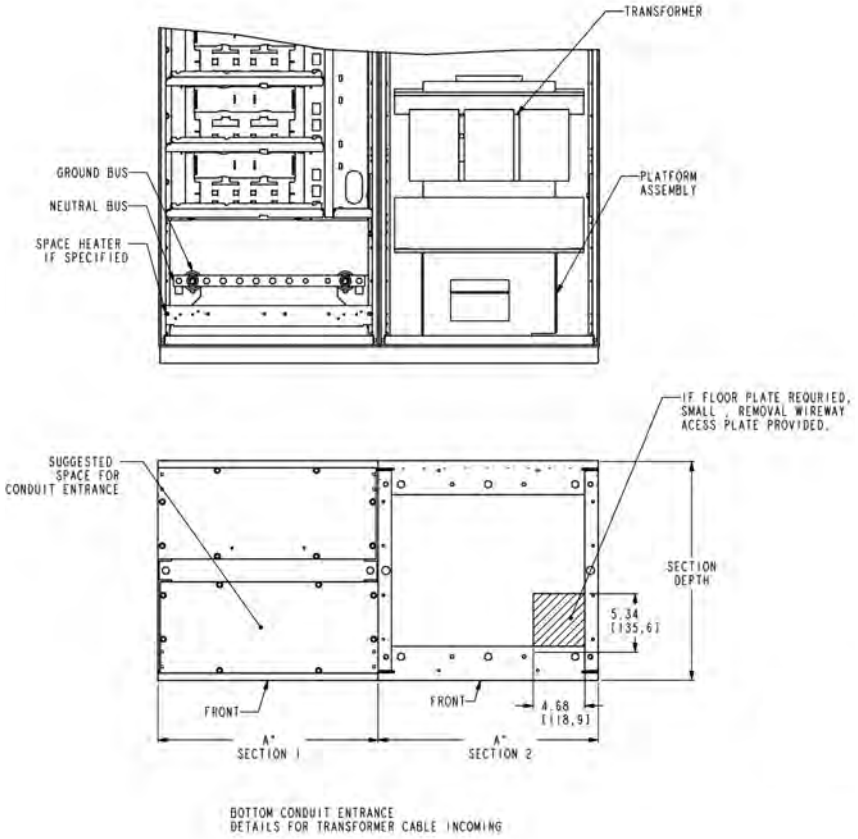
Bottom conduit entry 30" deep section



	Ref. dim.	30" deep section		
	A"	20.00"	24.00"	30.00"
	B"	17.56"	21.56"	27.56"
D	CW" - 3" 600A - 1200A	13.25"	13.25"	13.25"
	CW" - 5" 1600A - 2500A	15.25"	15.25"	15.25"

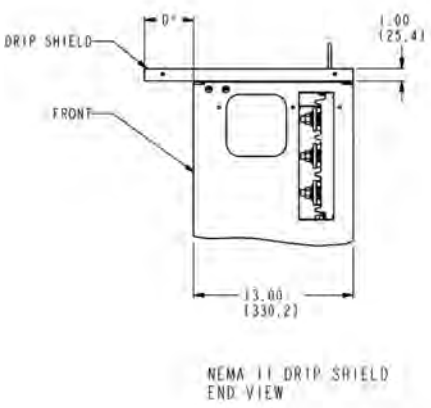
—
CW - Channel width

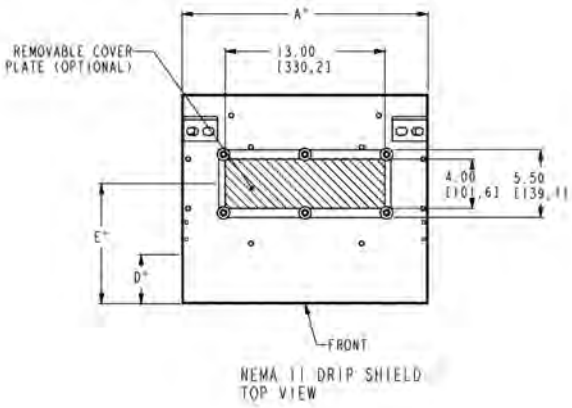
Details for auto transformer

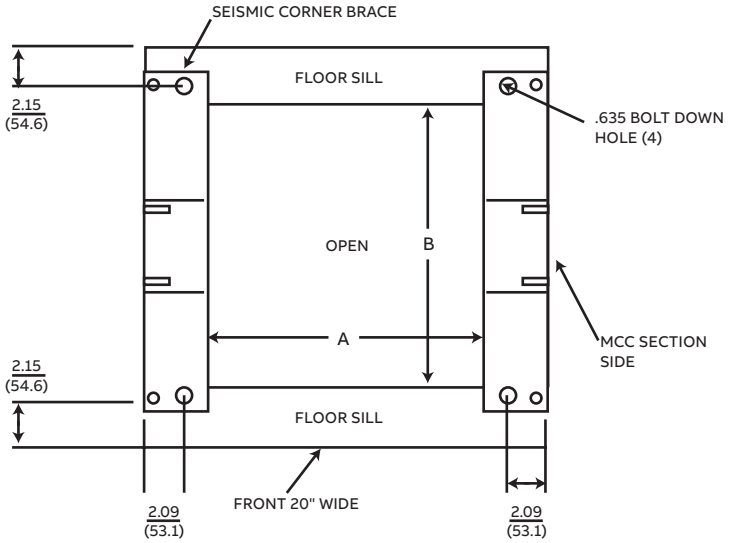


Note: Transformer platform is 6" from floor recommend that cable entry come from adjoining section.

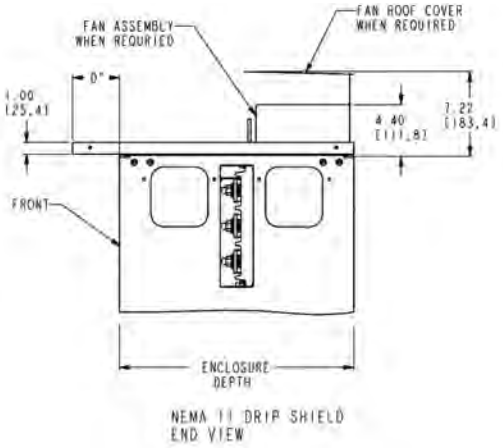
Drip pan — NEMA II 13" deep section



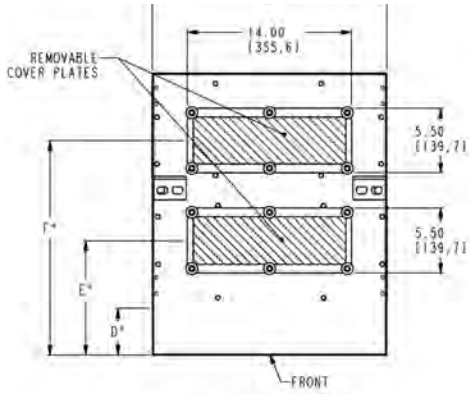




Drip pan — NEMA II 20", 22", 30" deep sections

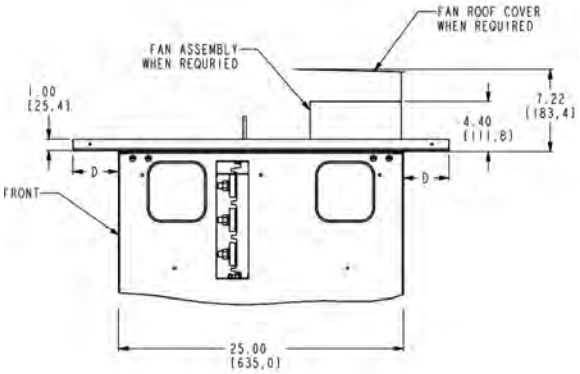


NEMA II DRIP SHIELD
END VIEW

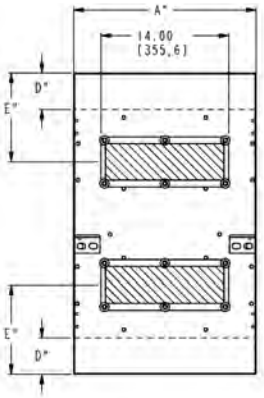


NEMA II DRIP SHIELD
TOP VIEW

Drip pan — NEMA II 25" deep section back-to-back



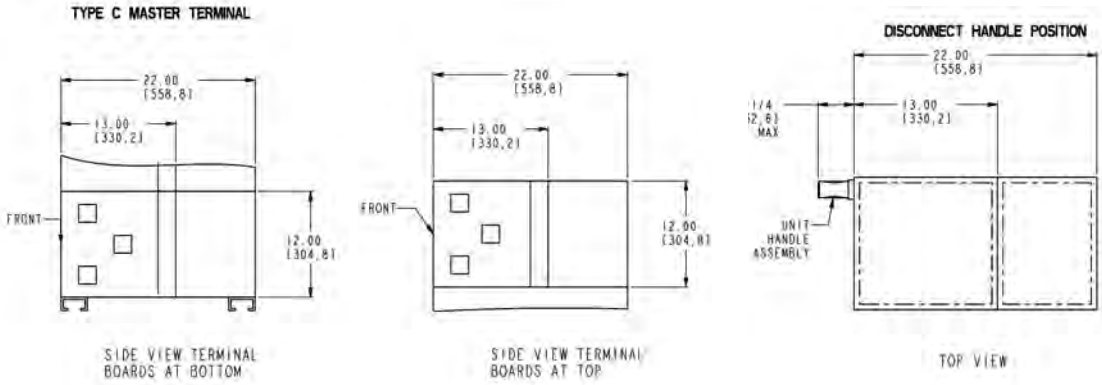
NEMA II DRIP SHIELD
END VIEW



NEMA II DRIP SHIELD
TOP VIEW

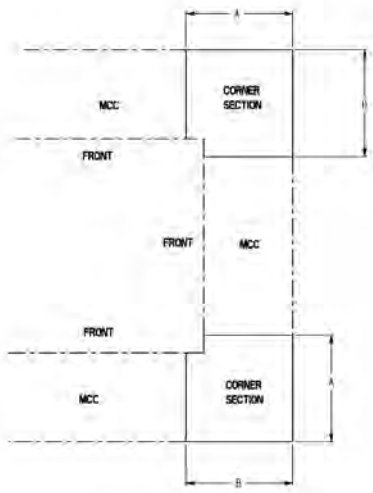
Ref. dim.	13" Deep	20" Deep	22" Deep	25" Deep	30" Deep
A"	20.00"	20.00"	20.00"	20.00"	20.00"
D"	4.00"	4.00"	4.00"	4.00"	4.00"
E"	9.75"	9.75"	9.75"	9.76"	9.75"
F"	NA	18.25"	20.25"	NA	28.25"

Type C master terminal



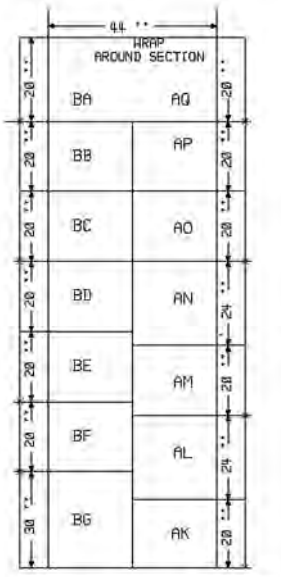
Note: Maxium handle is 6'7", measure from bottom of sill to top of handle

Used for L and U shaped motor control center arrangements



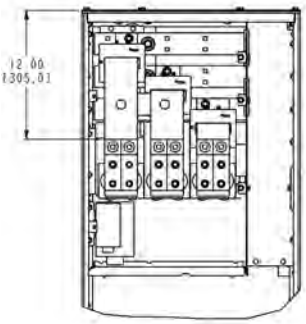
Dimensions (in inches)		
MCC depth	A	B
13	20	17
20	24	24
22	24	26

Back-to-back configuration with wrap-around corner section

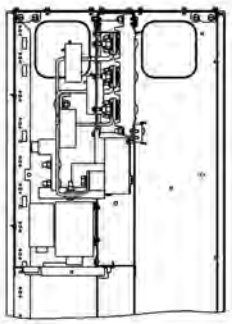


The wrap-around corner section is standard sections which accommodate plug-in units, therefore no space is lost in the transition.

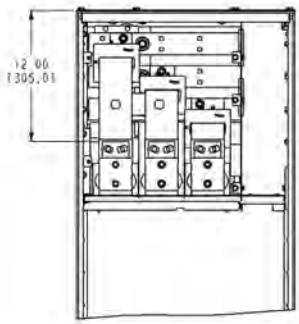
Incoming line terminations



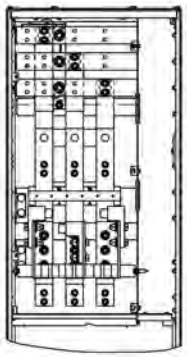
Front Elevation
600 Ampere (Top)
20" W, NEMA Lug
Shown with Lightening Arrestor and
Surge Suppressor for 24" H



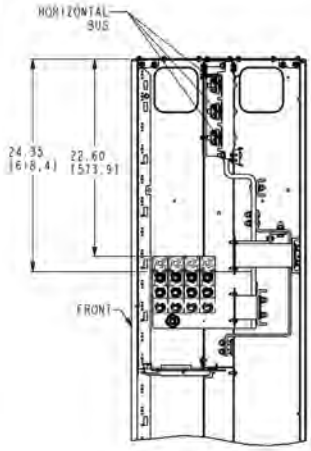
Side View
600 Ampere (Top)
20" W



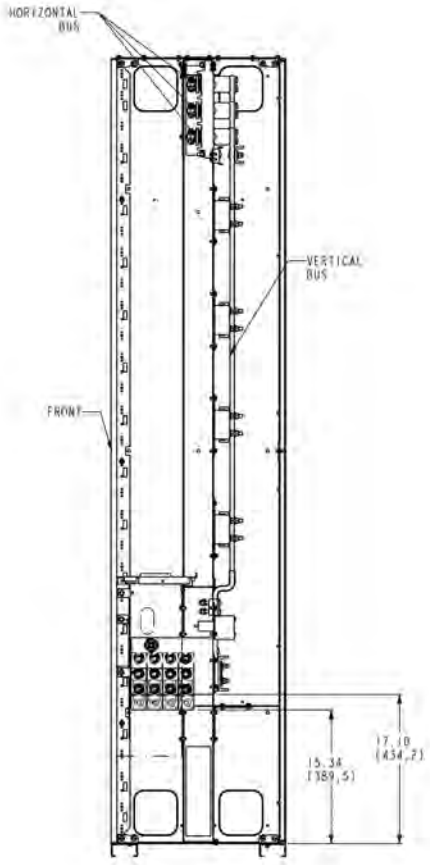
Front Elevation
600 Ampere (Top)
20" W, STD. Lug



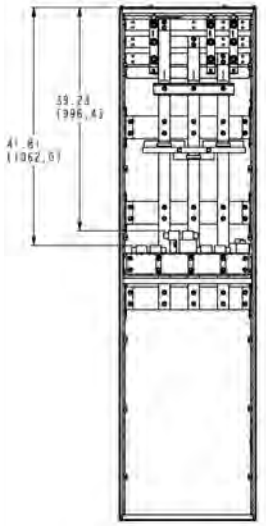
Front Elevation
800/1200 Ampere (Top)
20" W, NEMA Lug



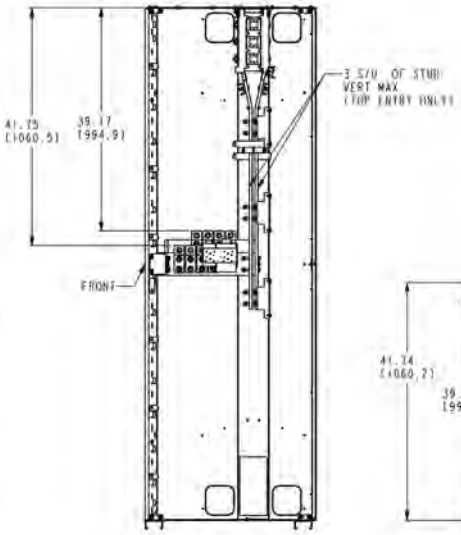
Side View
800 /1200 Ampere (Top)
20" W, NEMA Lug



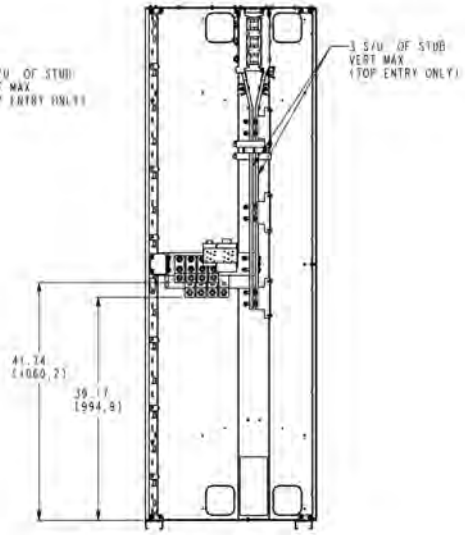
End View
800 /1200 Ampere (Bottom)
20" W, NEMA Lug



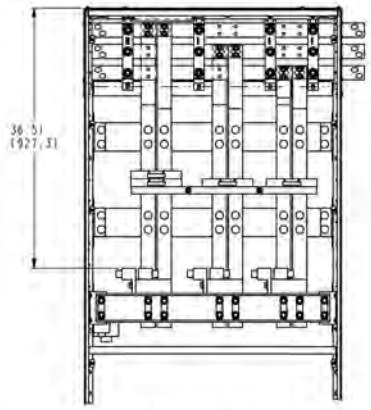
Front Elevation
1600/2000 Ampere (Top/Bottom)
24" W X 30" D



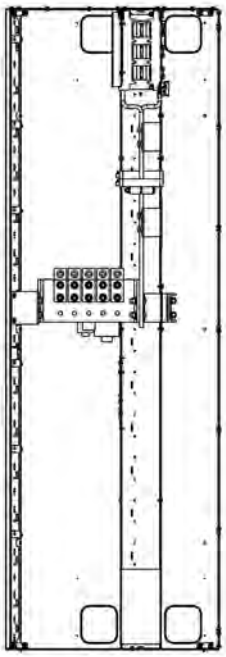
Side View
1600/2000 Ampere (Top)
24" W X 30" D



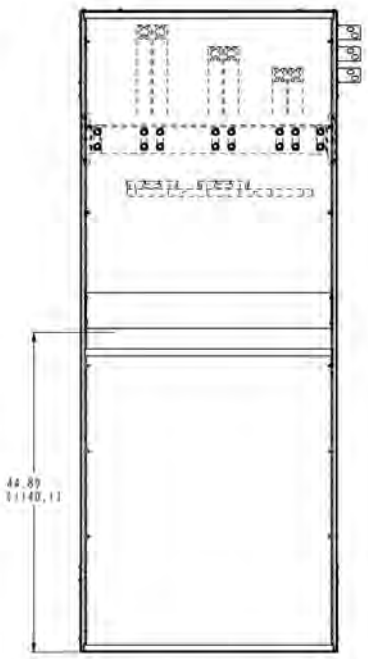
Side View
1600/2000 Ampere (Bottom)
24" W X 30" D



Front Elevation
2500 Ampere (Top)
36" W X 30" D, NEMA Lug



Side View
2500 Ampere (Top)
36" W X 30"D Nema Lug



Front Elevation
2500 Ampere (Bottom)
36" W X 30" D, NEMA Lug

Outdoor enclosures

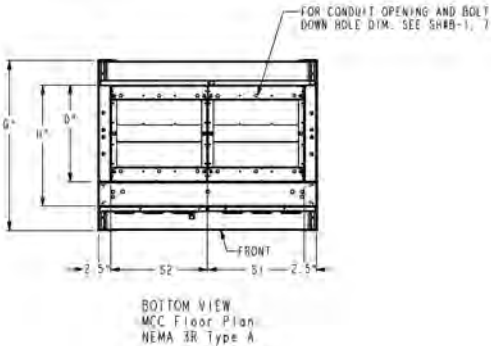
UL listed type 3R non-walk-inenclosure (standard)
The standard NEMA 3R enclosure consists of a specially constructed MCC section with a mating framework which supports the roof and extended front. The basic design is similar to switchboard construction. The smaller footprint will permit a broader usage than the optional NEMA 3R construction. Meets Seismic Zone 4.

The standard NEMA 3R enclosure consists of a specially constructed MCC section with a mating framework which supports the roof and extended front, designed for bottom entry and exit.

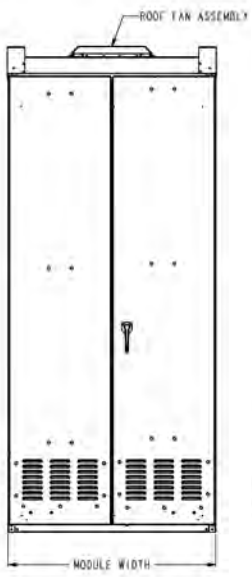
- Three-point door latch;
- 90° door with wind stop;
- Reinforced roof;
- Crane lifting;
- 2° roof pitch;
- Shipped via flatbed truck;
- 3" floor sills.

MCC Depth (D)	Front extension (F)	Top cover (G)	(H)
20"	5	35	25
22"	5	37	27
30"	5	45	35

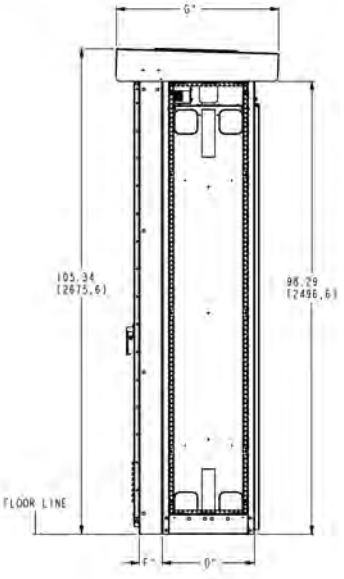
Note:
1. Doors shown are double door or single door module width less than 45".
2. Nema 3R module may contain 1, 2 or 3 MCC sections, 3 section shipping split limited to (3) 20" wide MCC sections only.
3. When 30" deep sections is used, 20" and 22" deep section enclosure are extended so that they are flush front and rear with the 30" deep enclosure.
4. All dimensions are in inches.



BOTTOM VIEW
MCC Floor Plan
NEMA 3R Type A



ELEVATION
NEMA 3R TYPE A



SIDE VIEW
NEMA 3R TYPE A

Enclosure options

Space heaters
Space heaters are used to prevent moisture condensation on the inside of the motor control center. One heater (62.5 watts at 120 volts AC) is installed in the bottom of each vertical section. UL requires space heaters be controlled by a thermostat. One thermostat can control up to 23 heaters and is located in the top horizontal wireway.

A terminal board for connecting an external 120-volt power source is standard. The terminal board is located in the top horizontal wireway adjacent to the thermostat(s).

This is recommended since it permits the space heaters to be energized even when the motor control center itself is deenergized. If export crating is involved, the space heater circuit can be wired to an external plug for energizing the heaters during shipment and storage.

When specified, space heater power can be provided from within the motor control center. Include the required distribution transformer with primary and secondary protection in the motor control center.

An enclosed foreignvoltage disconnect switch is available as an option.

Bottom plates
Plates bolt on to the bottom of each motor control center section. They may be removed to facilitate installing conduit.

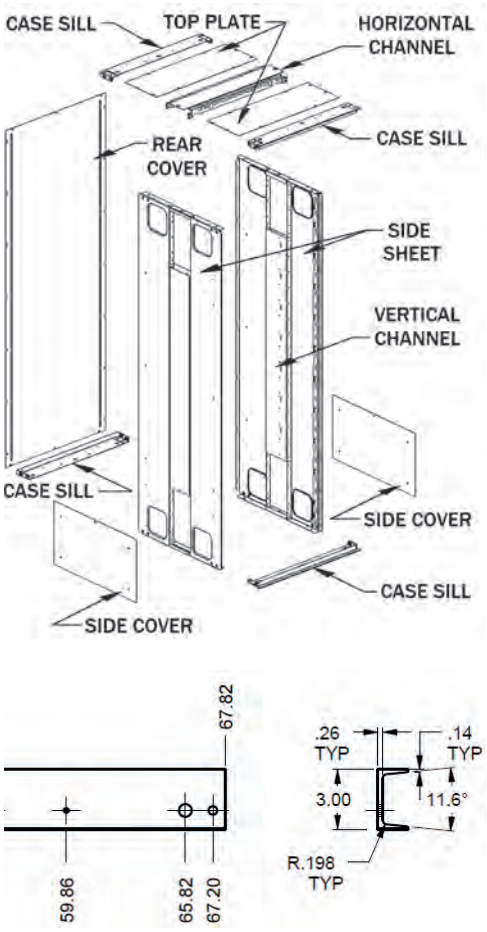
Extended height pull box (top hat)
A pull box can be mounted on top of a vertical section when specified. The standard height is 12 inches; 6-, 18-, and 24" heights are also available. Top, front, and end covers are removable for access.

Special transitions to 8000 line and low-voltage switchboards are available upon request. Please consult factory.

Rodent barriers
Metal plates bolted to the bottom of each end section to close the opening between the front and rear floor sills. Not required if the floor sills will be removed or imbedded in concrete.

Extra width vertical wireway
24" wide sections can be furnished with 8" wide vertical wireway and door.

Motor control center construction	
Major structural components side sheets,L-H and R-H	0.075"
Vertical Bus Mounting Channels	0.090"
Case Sills, Front/Rear, Top/Bottom, Top Horizontal Channel	(13 gauge)
Lifting channel (top)	0.187"
Floor sills (optional structural type) see below	0.105" (12 gauge)
Enclosing covers/panels	
Rear covers, 13" and 30" deep	0.075" (14 gauge)
Rear covers, 20" and 22" deep	0.060" (16 gauge)
Endplates	0.060" (16 gauge)
Top conduit covers	0.060"
Bottomplates	0.060"
Vertical wiretrough door	0.060"
Other steel	
Unit barrier shelves	0.063"
Unit cover doors	0.075"
Unit saddles	0.090"

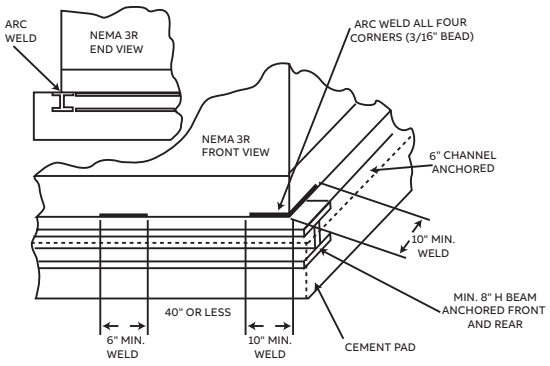


Material: 3" × 5#/FT CHANNEL B4A10
Finish: F31-HC2

—
Optional structural type floor sills

Note that bolt down locations for sections with seismic bracing change from center of structure (left to right), to four corners with .635 clearance holes for 1/2" bolts

Mounting requirements for seismic NEMA 3R with optional heavy base



Note: Arc weld down length of NEMA 3R every 40" or less for 130 mph winds and 2.25G shock (length and depth per outline)

Note: For all installations, including Seismic Zone 4, testing was performed using 1/2"-13 Grade 5 bolts, torqued to 50 foot-pounds, located in each of the four corners in each section.

Center of gravity

For a uniformly loaded 90" high x 20" deep lineup, center of gravity is:

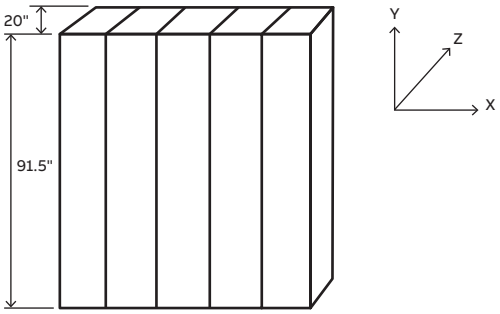
- X = center of lineup
- Y = 46 1/2" above bottom of floor sill
- Z = 8" in from front (front-mounted devices 20" deep)

OR: 10" in from front (back-to-back construction)

- Z = 5" in from front (13" deep)
- Z = 8 1/2" in from front (22" deep)
- Z = 11" in from front (25" NEMA 3R)

Typical variations due to uneven loads:

- X = ± 5"
- Y = ± 1"
- Z = ± .5"



—
CW - Channel width

Sections	Lbs	Kg
90"H × 20"W indoor type 1 and 12	500	272
90"H × 20"W indoor back-to-back type 1 and 13	700	318
90"H × 20"W outdoor type 3R	725	329

Bus selection
All continuous-current rating selections or recommendations are based on the motor control center being located in a maximum 40°C (104°F) ambient. Refer to "Overview" section for other environmental considerations.

Main horizontal bus
The size of motor control center main bus and cables feeding the main bus is based on the current-carrying capacity required for motors plus other connected loads.

The capacity required for motors can be taken as 125 percent of the full-load rating of the largest motor plus 100 percent of the full-load rating of all other motors to be operated at the same time. Modified requirements resulting from duty-cycle or demand factor can be taken into account.

The current-carrying capacity required for other connected loads should be computed on the basis of 100 percent of the sum of individual loads except where a demand factor can properly be applied to reduce this total. Consideration should be given to future requirements.

Vertical bus extensions
Vertical bus is available in 30" wide enclosures maximum. The maximum vertical bus loading is calculated as follows: 80 percent of the feeder trip or fuse clip rating, plus 100 percent of the starter full load amps, plus 25 percent of the largest motor full load amps.

This total cannot exceed the vertical bus rating. Tin plated copper vertical bus is standard, with silver plating as an option.

Neutral bus
Neutral lugs will be provided as applicable. Neutral bus is normally sized at 50 percent of the main bus ampacity.

Ground bus
NEC requires a ground bus in multisection motor control centers. 300 ampere Cu ground bus will meet minimum size requirements for main busses rated through 2000 amperes. A clearance hole for 3/8" hardware is provided in each section. The default for incoming ground termination is (3) #2-1/0 for 300A ground bus and (3) 1/0-500 kcmil for 600A ground bus. Ground bar comes with 6 predrilled holes for ground connectors.

Options
The following UL listed options are available:
- Shutter mechanism for vertical bus stab openings.
- Fully-insulated main horizontal bus.
- Silver plated horizontal and vertical bus.
- Silver plated ground bus.

Bus systems/selection[6]

MCC Bus	Continuous current	Material	Short-circuit rating in RMS symmetrical amperes – (kA)		UL	Notes
	Rating amperes	Cu	65	100		
Main Horizontal	600	•	•		•	1/4" x 2"
	800	•	•		•	3/8" x 2"
	1200	•		•	•	1/2" x 2"
	1600	•		•	•	(2) 1/2" x 2"
	2000	•		•	•	(2) 1/2" x 2"
	2500	•		•	•	(2) 1/2" x 2"
	2500/3000/3200	•		•	•	(6) 3/8" x 1.5"
Vertical	300	•	•		•	3/8" x 3/4"
	600/700*/850	•		•	•	3/8" x 1 1/2"
Neutral	800	•			•	
	1200	•			•	
	1250	•			•	
	1600	•			•	(2) 0.5" x 2"
Horizontal ground	300	•			•	1/4" x 1"
	600	•			•	1/4" x 2"
	800	•			•	3/8" x 2"
Vertical grounds	150	•			•	1/8" x 1"

All values shown based on 1200A/sq.in. density rating. Alternate density ratings are available; if required, consult factory.

1. When a size 6 or 7 starter is in the motor control center lineup, use a 1200 ampere microEntelliguard Trip Unit circuit breaker as a main.
2. Requires special section 90" high, 24" wide, 20" deep.
3. Requires special section 90" high, 30" wide, 30" deep.
4. Main breaker must be mounted at top of the section and requires full 20" depth of enclosure.
5. Requires special section 90" high, 30" wide, 30" deep. When section is on the left, allow for a 5" spacer to permit unit doors on the right to open.
6. For UL or service entrance labels provide main breaker in switchboard construction.
7. Consult factory for availability.
8. 2500 Type 12, 3000, 3200 require section 90"H, 36"W, 30"D; Spacer shell (5");
9. 3000/3200 require elevated roof cover (5")
10. 3000A EntelliGuard G will be UL489, 3200A EntelliGuard G will be UL1066. Solidly grounded Wye 3 phase, 4 wire.

Data subject to change without notice.

Mains, feeders, incoming lines

Mains

General

Main units consist of an externally operable circuit disconnect, either a fusible switch or a circuit breaker. Sizes by ampere rating, short-circuit rating, type construction and Space units required are given in the accompanying lists. Normally, thermal magnetic circuit breakers or fuses are necessary for main protection. The short-circuit interrupting rating depends on the type disconnect furnished. Select a main unit for which the interrupting rating equals or exceeds the maximum available fault current. For reverse-fed circuit breakers, refer to factory for details.

Refer to specific breaker publications for time-current characteristics and programmable options for the various types of circuit breakers. A list of these publications is given in "Application data" section.

Service entrance

UL listed main units containing only circuit breakers or fused switches may be UL classified as suitable for service entrance.

If a single disconnect is furnished as a disconnect for all load circuits the unit will be marked “Main”. In order for the units to be classified as suitable for service entrance, the incoming phase conductors must connect directly to the disconnect device line terminals or to a UL listed main line terminal assembly.

A grounding electrode conductor terminal connector sized in accordance with the circuit ampacity is furnished in one section. Three-phase, four-wire systems include a neutral bonding jumper for grounding the neutral conductor during installation. Ground fault protection is required for disconnects 1000A and above for solidly grounded wye services, where phase-to-ground is more than 150 volts (NEC 230.95).

Main metering/lugs

Current transformers (CTs) can be provided in the main compartment for use with a metering unit. This option may increase space requirement. If crimp type lugs are required, a bus assembly is fabricated to provide a landing pad for these terminals. This extends the space required for the main and must be factory installed. Size will be the same as NEMA lug option.

Ul listed fused switch mains

Amperes	Interrupting rating RMS amps (in thousands)[1]			Construction		Space units	Notes
	Volts						
	240	480	600	Stab-in	Bolt-in		
Fusible switches							
200	100	100	100	•		2	
400 MCS	100	100	100		•	4	[4]
600 MCS	100	100	100		•	4	[4]
High pressure contact (HPC) switch							
800	100	100	100		•	6	[2]
1200	100	100	100		•	6	[2]
1600	100	100	100		•	6	[3]
2500	100	100	100		•	6	[3]

1 With Class J, R and L fuses.
2 Requires a 24" wide by 20" deep section. Full depth of enclosure is required.
3 Requires 30" wide by 30" deep section. Must be NEMA 1 Construction, 80% rated only.
4 Class J fuse is 3X.

Mains, feeders, incoming lines

Amperes	CB Type	IC (kA)			Stab-in	Bolt-in	Space units	UL (X) listed	Notes	Entry top/ bottom	
		240V	480V	600V							
Spectra thermal magnetic molded case circuit breaker											
150	SEL/SEP	65/100	65/100	25	•		1	•		T/B	
250	SFL/SFP	65/100	65/100	25	•		1.5	•		T/B	
600	SGL/SGP	65/100	65/100	65	•		2	•		T/B	
1200	SKL	65	65	42		•	3.5	•	(1)(4)	T/B	
PowerBreak II insulated-case circuit breaker with EntelliGuard G trip unit											
800	SSF/SHF	65	65	42		•	6 (24W)	•	(2)	T/B	
1200	SSF/SHF	65	65	42		•	6 (24W)	•	(2)	T/B	
1600	SSF/SHF	65/100	65/100	42/65		•	6 (30W)	•	(3)	T/B	
2000	SSF/SHF	65/100	65/100	42/65		•	6 (30W)	•	(3)(5)	T/B	
2500	SSF/SHF	65/100	65/100	42/65		•	6 (36W)	•	(3)(5)	T/B	
800	SSD	65	65	42	•		6 (30W)		(5)(6)(7)	T/B	
1600	SSD	65	65	42	•		6 (30W)		(3)(5)(6)(7)	T/B	
2000	SSD	65	65	42	•		6 (30W)		(3)(5)(6)(7)	T/B	
EntelliGuard G air circuit breaker with EntelliGuard G trip unit											
800	GB		65/100	65/100		•	5.5(24Wx30D)	•	(6)(8)	T/B	
1200	GB		65/100	65/100		•	5.5(24Wx30D)	•	(6)(8)	T/B	
1600	GB		65/100	65/100		•	5.5(24Wx30D)	•	(6)(8)	T/B	
2000	GB		65/100	65/100		•	5.5(24Wx30D)	•	(6)(8)	T/B	
2500	GA/GB	100	100	100		•	6 (36W)	•	(6)(8)	T/B	Design without fan cooling.
3000	GA/GB	100	100	100		•	6 (36W)	•	(6)(8)(9)(10)	T/B	Requires 3" rear clearance from wall
3200	GA/GB	100	100	100		•	6 (36W)	•	(6)(8)(9)(10)	T/B	Requires 3" rear clearance from wall
800	GB		65/100	65/100	•		5.5(24Wx30D)	•	(6)(8)	T/B	
1200	GB		65/100	65/100	•		5.5(24Wx30D)	•	(6)(8)	T/B	
1600	GB		65/100	65/100	•		5.5(24Wx30D)	•	(6)(8)	T/B	
2000	GB		65/100	65/100	•		5.5(24Wx30D)	•	(6)(8)	T/B	
2500	GA/GB	100	100	100	•		6 (36W)	•	(6)(8)	T/B	Design without fan cooling.
3000	GA/GB	100	100	100	•		6 (36W)	•	(6)(8)(9)(10)	T/B	Requires 3" rear clearance from wall
3200	GA/GB	100	100	100	•		6 (36W)	•	(6)(8)(9)(10)	T/B	Requires 3" rear clearance from wall

1. When a size 6 or 7 starter is in the motor control center lineup, use a 1200 ampere microEntelliguard Trip Unit circuit breaker as a main.
2. Requires special section 90" high, 24" wide, 20" deep.
3. Requires special section 90" high, 30" wide, 30" deep.
4. Main breaker must be mounted at top of the section and requires full 20" depth of enclosure.
5. Requires special section 90" high, 30" wide, 30" deep. When section is on the left, allow for a 5" spacer to permit unit doors on the right to open.
6. For UL or service entrance labels provide main breaker in switchboard construction.
7. Consult factory for availability.
8. 2500 Type 12, 3000, 3200 require section 90"H, 36"W, 30"D; Spacer shell (5");
9. 3000/3200 require elevated roof cover (5")
10. 3000A EntelliGuard G will be UL489, 3200A EntelliGuard G will be UL1066

Data subject to change without notice

Ground-fault protection of equipment per NEC
Each main or feeder disconnect rated 1000 amperes or more and installed on a solidly grounded wye electrical system of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase, will be provided with ground-fault protection of equipment.
Exception No 1: The above is not required if the disconnect is for a continuous industrial process where a non-orderly shutdown will introduce additional or increased hazards.
Exception No 2: The above is not required for fire pumps.
Exception No 3: The above is not required if ground-fault protection is provided ahead of the equipment.

Note: The above is paraphrased from NEC section 215.10, 215.95 and 240.13.

Arc flash mitigation (AFM) main and feeder units
The E9000 AFM units are designed to reduce the likelihood of exposure to electrical shock and the potential of internal arcing faults from occurring during maintenance. The retractable stab mechanism allows for closed-door racking of the unit, providing added protection to the electrical personnel from the dangers of an arc flash occurrence. The introduction of a compact NEMA contactor in these AFM units will allow a minimum of IP10 protection with optional IP20 terminal protection for starters using this contactor. The 300-Line Legacy NEMA contactor is remain available with this new design. Other IP20 protection options are available in all starter units including IP20 control power transformer fuses and pilot devices. For more information see page D2 and GE Publication DEA-593.

AFM circuit breaker mains — standard selection

Amperes (up to)	Circuit breaker type	Interrupting rating RMS Amps (in thousands)		Construction		Space units
		Volts		Retractable		
		480	600	Stab-in	Bolt-in	
Spectra Thermal Magnetic						
150	SEL/SEP	100	65	•		1
150	SELT-L/SEPT-L		65	•		1
250	SFL/SFP	100	65	•		1.5
600	SGL/SGP	100	65		•	2

Feeders

Feeder units consist of an externally operable circuit disconnect, either a fusible switch or a circuit breaker. Thermal magnetic circuit breakers are required unless the feeder supplies a critical circuit, such as a fire pump controller.

Select the fuse or circuit breaker trip rating based on the feeder circuit continuous current rating in accordance with the NEC. Feeder unit short-circuit interruption ratings must equal or exceed the available short-circuit currents.

Fused switch feeders

Amperes	Interrupting rating RMS Amps (in thousands) Volts			Construction		Space units[1]	UL (X) listed	Notes
	240	480	600	Stab-in	Bolt-in			
Fusible switches								
30	100	100	100	•		1	•	
30/30	100	100	100	•		1	•	[2]
60	100	100	100	•		1	•	
60/60	100	100	100	•		1	•	[2]
100	100	100	100	•		1	•	
100/30	100	100	100	•		1	•	
100/60	100	100	100	•		1	•	
100/100	100	100	100	•		1	•	
200	100	100	100	•		2	•	
400 MCS	100	100	100	•		3	•	
600 MCS	100	100	100	•		3	•	
High pressure contact (HPC) switch								
800	100	100	100		•		•	[3]
1200	100	100	100		•		•	[3]
1600[4]	100	100	100		•			[3]

1. Top/bottom entry.
2. Dual or twin feeder units.
3. Requires a 24" wide by 20" deep section. Full depth of enclosure is required.
4. Requires a 30" wide by 20" deep section. Full depth of enclosure is required.

AFM fused switch feeders – standard selection

Amperes	Interrupting rating(in thousands)	Construction Retractable Stab-in	Space units
Fusible switches			
30	100	•	1
60	100	•	1
100	100	•	1
200	100	•	2

Feeders

Circuit breaker feeders – standard selection

Amperes	Circuit breaker type	IC (kA) 240V	480V	600V	Stab-in	Bolt-on	Space units	UL (X) listed	Notes	Entry top/ bottom
Spectra thermal magnetic molded case circuit breaker										
100	SEL/SEP	65/100	65/100	25/25	•		½	•		T/B
100/100	SEL/SEP	65/100	65/100	25/25	•		1	•		T/B
150	SEL/SEP	65/100	65/100	25/25	•		½	•		T/B
150/150	SEL/SEP	65/100	65/100	25/25	•		1 ½	•		T/B
250	SFL/SFP	65/100	65/100	25/25	•		1	•	(2)	T/B
250/250	SFL/SFP	65/100	65/100	25/25	•		2	•	(2)	T/B
600	SGL/SGP	65/100	65/100	65/65	•		2	•		T/B
1200	SKL	65	65	42		•	3.5	•	(3) (4)	T
PowerBreak II insulated-case circuit breaker with EntelliGuard G trip unit										
800	SSF/SHF	65	65	42		•	6 (24W)	•		T/B
1200	SSF/SHF	65	65	42		•	6 (24W)	•		T/B
1600	SSF/SHF	65/100	65/100	42/65		•	6 (30W)	•		T/B
2000	SSF/SHF	65/100	65/100	42/65		•	6 (30W)	•		T/B
2500	SSF/SHF	65/100	65/100	42/65		•	6 (36W)	•		T/B
800	SSD	65	65	42	•		6 (30W)			T/B
1600	SSD	65	65	42	•		6 (30W)			T/B
2000	SSD	65	65	42	•		6 (30W)			T/B
EntelliGuard G air circuit breaker with EntelliGuard G trip unit										
800	GB		65/100		•		5.5(24Wx30D)	•		T/B
1200	GB		65/100		•		5.5(24Wx30D)	•		T/B
1600	GB		65/100		•		5.5(24Wx30D)	•		T/B
2000	GB		85/100		•		5.5(30Wx30D)	•		T/B
2500	GA/GB	100	100		•		5.5(30Wx30D)	•	(5)	T/B
800	GB		65/100	•			5.5(24Wx30D)	•		T/B
1200	GB		65/100	•			5.5(24Wx30D)	•		T/B
1600	GB		65/100	•			5.5(24Wx30D)	•		T/B
2000	GB		85/100	•			5.5(24Wx30D)	•		T/B
2500	GA/GB	100	100	•			5.5(30Wx30D)	•	(5)	T/B

1. When feeder unit accessories are required such as shunt trip, Aux switch, UV release, etc., unit height must be a minimum of 1 space.
2. 1X units are available with horizontal handle.
3. Requires full depth of enclosure; (20" deep minimum).
4. Feeder units 1000A and over should have ground fault sensing on three-phase, four-wire systems where line to ground voltage is more than 150V.
5. If used with 3000A or 3200A main bus, an elevated roof (5").

AFM circuit breaker feeders – standard selection

Amperes (up to)	Circuit breaker type	Interrupting rating RMS Amps (in thousands) 480	Volts 600	Construction Retractable Stab-in	Space units
Spectra thermal magnetic					
150	SEL/SEP	100	25/65	•	1
150	SELT-L/SEPT-L		65	•	1
250	SFL/SFP	100	65	•	1.5
600	SGL/SGP	100	65	•	2

Accessories

Accessories for mains and feeders

Circuit breaker	Accessories				
	Bell alarm	Auxiliary switch	Shunt trip	Undervoltage release	RELT
Spectra	•	Up to 2[4]	•[4]	•	X[2]
Power Break II	•[1]	Up to 12[1]	•	•	X
HPC	•	Up to 12[1]	•	•	X

1. 600VAC not UL Listed.
2. G and K Frame only.
3. Shunt trip requires aux switch (G and K) or bell alarm (EandF) for continuous operation.
4. Aux switch available @ 240V max only.

Options for mains and feeders

Terminals for field wiring mains and feeders

Terminal size		Will accept wire[2]	
		AWG/kcmil[1]	Material
Switches			
30A QMW		14-8	Cu-Al
60A QMW		14-2	Cu
		12-2	Al
100A QMW		14-1/0	Cu
		12-1/0	Al
200A QMW		(1) 6-250	Cu-Al
400A MCS (molded case switch))		(1) 2-350[3]	Cu-Al
		(1) 8-600	Cu-Al
600A MCS (molded case switch)		(1) 8-600	Cu-Al
		(1) 4-500[3]	Cu-Al
		(2) 6-500	Cu-Al
HPC Switch — 800-1600A		300-750	Cu
		300-800	Al
Circuit breakers			
SE150 15-150A	1 lug	12-3/0	Cu-Al
SF250 70-225A	1 lug	8-350	Cu-Al
SG600	1 lug	6-600	Cu-Al
125-600A	2 lugs	2/0-500	Cu-Al
SK1200	3 lugs (800A)	3/0-500	Cu-Al
	3 lugs	300-750	Cu-Al
300-1200A	4 lugs	250-400	Cu-Al

1. Conductor #1 and smaller may be noted 60/75°C. Conductors #0 and larger must be rated 75°C.
2. Conductor sizes based on 1/Ph unless otherwise indicated.
3. Feeders

Accessories for fused switches

Fused switches can be ordered with up to two auxiliary contacts which are available in the following UL listed configurations: 1 normally open, 1 normally closed, 1 normally open/1 normally closed, or 2 normally open.

Accessories for high pressure contact (HPC) switches

- Motor operator mechanism
- Remote close
- Undervoltage release
- Shunt trip with lockout
- Bell alarm–alarm only
- Bell alarm with lockout
- Auxiliary switch module
- Mechanical counter
- Key interlock mounting provision
- Push button cover
- Door interlock
- Blown fuse protector

Key interlocking

Provisions for key interlocking can be provided on all circuit breakers over 250A and fusible switches over 100A. The standard key lock is by Superior Lock Corporation. However, coordination with Kirk key locking will be supplied if necessary. The following information is required when lock coordination is to be provided with other up-stream or down-stream devices remote from the motor control center:

PURCHASED BY _____
ULTIMATE USER _____
DESTINATION _____
LOCK MANUFACTURER _____
LOCK NUMBER_____
PURCHASE ORDER NUMBER _____

Note: Minimum 24" high units are required for key interlocking. UL listed option.

Ground fault protection

Two types of UL listed ground fault protection can be provided as an option with feeder and main circuit breakers. A shunt trip device is required in the circuit breaker to trip the breaker if a ground fault should occur. ITI BGFL ground break protective relaying is recommended for main breaker application. Model #252 ground fault relaying is recommended for most feeder applications. See "Components" section for description of both ground fault relay types. A minimum of 12" additional space height is required in addition to the standard space height shown for each main feeder unit. A separate 120-volt source for the shunt trip circuit will decrease the additional space required. Refer to page 179 for application help.

Incoming line terminations

The following cable terminal compartments are commonly specified for use in motor control center construction where the main AC power disconnect is located upstream of the motor control center. For other custom cable termination arrangements contact an ABB sales representative. The number of cables indicated must not be exceeded to maintain the short-circuit rating.

Incoming line cable assemblies	MLO space in inches / vertical space available		Cables/ lug[3]	Cables/ phase	Cable range per NEMA Bending[7]	Minimum width and depth	Top feed conduit space top bottom (Figure 1)
	Top	Bottom					
600A Std. Lug[4][5]	18/66		2	2	#2-350 kcmil	20"x13"	5"x13.7" A-B
	18/66		3	3	#6-300 kcmil	20"x13"	5"x13.7" A-B
		24/54	2	2	#2-600 kcmil	20"x13"	5"x13.7" A-B
		24/54	3	3	#2-500 kcmil	20"x13"	5"x13.7" A-B
		30/48	1	2	#2-600 kcmil	20"x13"	5"x13.7" A-B
600A NEMA Lug[2]	18/66		1	2	#2-350 kcmil	20"x13"	5"x13.7" A-B
		30/48	1	2	#2-600 kcmil	20"x13"	5"x13.7" A-B
800A/1200A Std. Lug [1][4]	24/60	24/54	4	4	#2-500 kcmil	20"x13"	5"x13.7" A-B
	24/60	24/54	3	3	#2-600 kcmil	20"x13"	5"x13.7" A-B
	30/54	24/54	4	4	#2-600 kcmil	20"x13"	5"x13.7" A-B
800A/1200A NEMA Lug		30/48[6]	1	4	500-750kcmil	24"x13"	5"x13.7" A-B
	36/58	36/42	1	4	500-1000kcmil	24"x13"	5"x13.7" A-B
1600A NEMA Lug	72/0	72/0	1	8	500-1000kcmil	30"x30"	13"x17.7" A-C
2000A NEMA Lug[2][4]	72/0	72/0	1	8	500-1000kcmil	30"x30"	13"x17.7" A-C
2500A NEMA Lug[2][4]	72/0	72/0	1	10	500-1000kcmil	36"x30"	13"x17.7" A-C
2500A Without Fans	72/0	72/0	1	12	500-1000kcmil	36"x30"	13"x27.6" A-C
3000A	72/0	72/0	1	12	500-1000kcmil	36"x30"	13"x27.6" A-C
3200A	72/0	72/0	1	12	500-1000kcmil	36"x30"	13"x27.6" A-C

1. Space shown above is for 20" deep design 800A to 1200A MLO.
2. Burndy type YA crimp lugs is available as an option. Crimp Lugs require NEMA drilling and NEMA Lug spacing.
3. Mechanical compression Cu/Al Lugs furnished for 75°C cable.
4. Cu/Al standard. Copper only lugs are available as an option. These may affect number of cables per lug.
5. NEMA wire bending rules reduce cable size if entry is from the side.
6. 13" deep requires full section no vertical bus.
7. Lug cable range may be larger than the NEMA bending allows above.

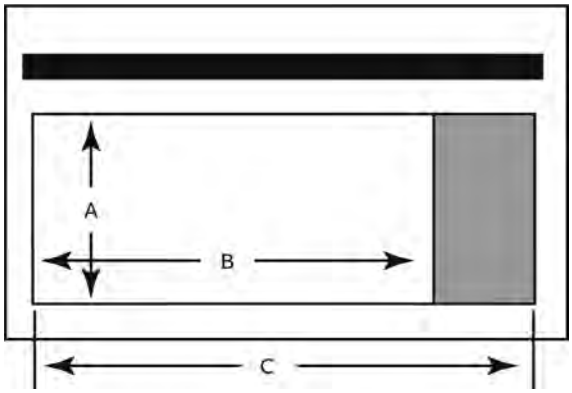


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Figure 1

Busway entrances
Motor control centers include provisions for connecting a busway. Busway must be braced for maximum available short circuit current. Minimum enclosure sizes for busway are shown in the adjacent table. Refer to the factory for other type busway. Include busway requisition number when ordering motor control center.

Spectra series busway

Entry	Pull box	Enclosure size	Max. busway Ampacity			
			Cu		Al	
			Std	1000A/ IN²	Std	750A/ IN²
Top	12"	30"W x 22"D	1600	1500	1350	1000
Bottom		30"W x 22"D	1600	1500	1350	1000
Top	12"	30"W x 22"D	2000	2000	2000	2000
Bottom		30"W x 22"D	2000	2000	2000	2000
Top	12"	36"W x 22"D	2500	2500	2500	2500
Bottom		36"W x 22"D	2500	2500	2500	2500

Note: Bus bars must be phased front-to-rear in 24" width enclosure. Bottom entry requires full section. For busway, refer to factory.

Automatic Transfer Switches
Motor control centers may be furnished with Zenith transfer switches. The switch is mounted in a separate unit and cable-connected to the motor control center bus. Manual control, pushbuttons, pilot lights and switches may be door-or bracket-mounted within the unit. Up-stream overcurrent protection must be provided for each power source. The unit can be UL listed if all components are listed for use in motor control center equipment.

The following features apply to ZTSD open-type switches which are UL listed through 480 volts and CSA listed through 600VAC. For specific ratings and additional optional features refer to Zenith.

Zenith ZTSD Utility to Generator time delay MX 250 Module Standard Features:

6P	Microprocessor activated test switch (momentary)
A3	Aux Contact - closed in emergency (Source 2) Additional available up to 10, must be specified
A4	Aux Contact - closed in normal (Source 1) Additional available up to 10, must be specified
CDT	Exerciser no load timer
DS	Disconnect Switch for source voltage to transfer power panel, 600A to 1200A only
DT	Time Delay from Neutral Switch position to Source 1 on retransfer
DW	Time Delay from Neutral Switch position to Source 2 on retransfer
E	Engine Start Relay
EL/P	Event Log of last 16 events
K/P	Frequency Indication on the controller
LNP	Center-off position LCD-Indicator
L1,2,3,4	LED lights, Source 1and2 position, Source 1and2 available
P1	Engine Start Timer (adj. To 6 sec.)
R50	In Phase monitor between Normal (Source 1) and Emergency (Source 2) to allow transfer
S13P	Microprocessor activated commit/no commit on transferring to Emergency (Source 2) (with enable/ disable settings)
T	Retransfer to Normal (Source1) adjustable time delay
U	Engine stop / cool down timer
V1	Voltage imbalance between phases (3 phase only)
W	Adjustable time delay on transfer to Emergency (Source2)
YEN	Bypass transfer timers function (soft key switch in microprocessor)

Withstand current ratings (WCR) for automatic transfer switches[1]

Minimum MCC Space units[2]	MCC enclosure widths (in inches)	Switch rating (Amps)[3]	Available RMS symmetrical Amperes at 480 Volts AC			
			When used with class J or L current-limiting fuses		When used with class RK-5 fuses or molded-case circuit breakers	
			WCR	Max. fuse size (Amps)	WCR	Max. breaker size (Amps)
3	24	40	100,000	50	22,000	150
3	24	80	200,000	100	22,000	150
3	24	100	200,000	125	22,000	150
3	24	150	200,000	200	42,000	400
3	24	260	200,000	350	42,000	400
3	24	400	200,000	600	50,000	400
3	24	600	200,000	750	65,000	800
6	30	800	200,000	1200	65,000	1200
6	30	1000	200,000	1200	65,000	1200
6	30	1200	200,000	1200	65,000	1200

1. 3-pole vs. 4-pole transfer switches: Typically, most MCCs do not have the neutral pulled, so a 3-pole switch will suffice. If the generator neutral is bonded to the frame of the generator and pulled to the MCC to provide a single-phase connection, a 4-pole transfer switch is required to facilitate transferring the neutral from the Utility to the Generator connection.
2. Does not include space for protection; switches must be mounted at bottom of section in order to install vertical bus above switch.
3. Larger sizes require special over-size enclosures. Refer to factory.

Transitions

Transitions for connecting control centers to transformers, low-voltage switchgear or switchboards are available and generally the same depth as the equipment to which they are to be connected. Appropriate overcurrent protection for the control center must be provided.

Starters

General
Combination motor control starter units consist of an externally operable circuit disconnect, either a fusible switch or circuit breaker, and a magnetic starter with an overload relay in the motor lines.

Unit NEMA sizes listed are based on continuous horsepower ratings. The maximum horsepower rating of each NEMA size controller is reduced for long accelerating times and for jogging or plugging duty. Jogging duty is defined as 5 or more contactor openings or closings per minute or over 10 in a 10-minute period. Plugging is rapidly stopping or reversing the motor by reversing the phase sequence of the power supplied to the motor. Refer to the factory anytime accelerating times exceed 10 seconds or jogging or plugging duty is required. Refer to the factory when `Design E' motors are used, not to be confused with Energy Policy Act (EPAC) motors.

The short-circuit interrupting rating depends on the type disconnect furnished. Select a starter combination for which the interrupting rating equals or exceeds the maximum available fault current.

Basic combination motor starter units consist of:
1. Externally operable circuit disconnect.
2. Magnetic starter with a thermal-magnetic, or electronic overload relay.
3. External overload reset operator.
4. Tapped line voltage, 120-volt CPT control power or external control power.
5. Pull-apart control terminal boards through NEMA size 5.
6. Pull-apart power terminal boards through NEMA size 2 (when BT specified).
7. Extra CPT capacity for operating auxiliary relays and pilot devices (when specified).
8. Plug-in construction through NEMA size 5 (FVNR) starters. Bolt-in construction may require vertical bus modifications.

Basic starter units are provided in tables in this section. Starters are listed by starter function, line voltage, HP, NEMA size, and combination short-circuit rating. Tables in this section also list control power options and other options including any additional space requirements for these options. Typical starter circuits are shown in "Drawings/ tests" section. Starters can also be used for lighting or resistive heat loads ("Application data" section).

Arc flash mitigation (AFM) main and starter units
E9000 AFM units are a new offering for customers and specific applications where additional protection of personnel is essential. The AFM units were designed around lowering the electrical shock hazards for motor control centers. The AFM unit design includes optional IP20 devices and incidental contact safety barriers in an effort to prevent accidental contact with energized parts during maintenance.

The E9000 AFM units are designed to reduce the likelihood of exposure to electrical shock and the potential of internal arcing faults from occurring during maintenance. The retractable stab mechanism allows for closed-door racking of the unit, providing added protection to the electrical personnel from the dangers of an arc flash occurrence. The introduction of a compact NEMA contactor in these AFM units will allow a minimum of IP10 protection with optional IP20 terminal protection for starters using this contactor.

The 300-Line Legacy NEMA contactor remains available with this new design. Other IP20 protection options are available in all starter units including IP20 control power transformer fuses and pilot devices.

A safety interlock prevents customers from opening the unit door and racking out the stab when the unit is energized. The visual indicators on the front of the units provide personnel with a clear view of the status of the stab and vertical bus isolation shutter.

AFM Features:

- Two-position closed-door retractable unit stabs
- Automatic operation vertical bus isolation shutter
- Stab and Shutter position indicators on unit doors
- Padlock for racking screw and stab-breaker interlock
- Optional IP20 safety features and incidental contact barriers
- Stab and Door Interlock: prevents opening the unit door when stab is energized.
- Stab and Unit Interlock: prevents user from taking the unit out when stab is energized, or inserting the unit into the bus when stab is extended.
- Racking Screw and Disconnect Interlock: prevents the user from racking the stab in/out of the unit with the disconnect in the “ON” position.

For information, please see publication DEA-593.

Selection tables

Circuit breaker type

FVNR AFM

NEMA size	Circuit breaker type	C2000 standard space units	300-line standard space units
1	SEL/SEP	1	1.5
2	SEL/SEP	1	1.5
3	SEL/SEP	1.5	2
4	SFL/SFP	2	2.5
5	SGL/SGP		4

FVR AFM

NEMA size	Circuit breaker type	C2000 standard space units	300-Line standard space units
1	SEL/SEP	1.5	2
2	SEL/SEP	2	2.5
3	SEL/SEP	3	3.5
4	SFL/SFP	3	3.5

Selection Tables

Fused Switch Type

FVNR AFM

NEMA size	Class RK-1, RK-5, J-TD		C2000 standard Space units	300-line standard Space units
	Switch Amps	Clip Amps		
1	30	30	1	1.5
2	60	60	1	1.5
3	100	60	2	2.5
3	100	100	3	3.5
3	200	200	3.5	4
4	200	200	3.5	4

FVR AFM

NEMA size	Class RK-1, RK-5, J-TD		C2000 standard space units	300-line standard space units
	Switch Amps	Clip Amps		
1	30	30	1.5	2
2	60	60	2	2.5
3	100	60	4	4.5

Selection tables

Circuit breaker type

208 Volts, 60 Hertz – combination motor starters

FVNR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
1	7.5	65/100	SEL/SEP	1	(2)
2	10	65/100	SEL/SEP	1	
3	25	65/100	SEL/SEP	1.5	
4	40	65/100	SFL/SFP	2	
5	75	100	SGL	3	
6	150	65	SKL	4	

Part winding

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units
1	10	65/100	SEL/SEP	2
2	20	65/100	SEL/SEP	2
3	40	65/100	SFL/SEP	4.5
4	75	100	SGL	5
5				

FVR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
5	75	100	SGL	3	
6	150	65	SKL	3.5	
1	7.5	65/100	SEL/SEP	2	
2	10	65/100	SEL/SEP	2	
3	25	65/100	SEL/SEP	3.5	
4	40	65/100	SFL/SFP	4	
5	75	100	SGL	5.5	
6	150	65	SKL	8.5	(1)

Y-Delta

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
2	20	65/100	SEL/SEP	4	
3	40	65/100	SEL/SEP	5	
4	60	100	TGL	5.5	
5	150	100	TGL	5.5	(3)
6	300	100	TGL	5.5	

2S1W, 2S2W

NEMA size	Max. Hp		IC (kA)	Circuit breaker type	Space units	Notes	Rev space units
	Constant variable torque	Constant HP					
4	40	30	25	SFL	4.5		7.5
5	75	60	30	SGL	5		10
6	150	100	65	SGL/SKL	8.5	(3)	
1	7.5	5	65/100	SEL/SEP	2		2.5
2	10	7.5	65/100	SEL/SEP	2		3
3	25	20	65/100	SEL/SEP	4		4.5
4	40	30	65/100	SFL/SFP	4.5		5.5
5	75	60	100	SGL	5.5		10

RVAT

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units		Notes
				13" Deep	20" Deep	
4	40	25	SFL	5	4	
5	75	100	SGL		5	
6	150	65	SKL	N/A	12	(1)
2	10	65/100	SEL/SEP	4	4	
3	25	65/100	SEL/SEP	5	4	
4	40	65/100	SEL/SFP	5.5	4.5	
5	75	100	SGL		5	(2)
6	100	65	SKL	N/A	12	(1)

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

1. Size 6 FVR, RVAT, 2S2W require (2) adjacent 24" wide sections, 20" deep (2S1W).
2. A 1/2X compact starter is available.
3. Refer to factory.

Selection tables

Circuit breaker type

230 Volts, 60 Hertz – combination motor starters

FVNR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
6	200	65	SKL	5.5	
1	7.5	65/100	SEL/SEP	1	(4)
2	15	65/100	SEL/SEP	1	
3	30	65/100	SEL/SEP	2	
4	50	65/100	SFL/SFP	2.5	
5	100	100	SGL	3	
6	200	65	SKL	6	(1)

Part winding

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
4					
5					(3)
1	10	65/100	SEL/SEP	2	
2	25	65/100	SEL/SEP	2	
3	50	65/100	SEL/SEP	4.5	
4	75	100	SGL	5	
5					(3)

FVR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
5	100	100	SGL	5.5	(1)
6	200	65	SKL	8.5	(2)
1	7.5	65/100	SEL/SEP	2	
2	15	65/100	SEL/SEP	2	
3	30	65/100	SEL/SEP	3	
4	50	65/100	SFL/SFP	3	
5	100	100	SGL	5.5	(1)
6	200	65	SKL	8.5	(2)

Y-Delta

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
4	75	100	SGL	5.5	(1)
5					(3)
2	25	65/100	SEL/SEP	4	
3	50	65/100	SEL/SEP	5	(1)
4	75	100	SGL	5.5	(1)
5	150	100	SGL	5.5	(3)

2S1W, 2S2W

NEMA size	Max. Hp		IC (kA)	Circuit breaker type	Space units	Notes	Rev Space units
	Constant variable torque	Constant HP					
4	50	40	25	SFL	4.5		5.5
5	100	75	30	SGL	5.5	(2)	10
6	200	150	65	SKL	8.5	(2)	
1	7.5	7.5	65/100	SEL/SEP	2		2.5
2	15	20	65/100	SEL/SEP	2		3
3	30	40	65/100	SEL/SEP	4		4.5
4	50	75	65/100	SFL/SFP	4.5		7.5
5	100	150	100	SGL	5.5	(2)	10

RVAT

NEMA aize	Max. Hp	IC (kA)	Circuit breaker type	Space units		Notes
				13" Deep	20" Deep	
5	100	100	SGL	N/A	5	
6	200	65	SKL	N/A	12	(2)
2	15	65/100	SEL/SEP	4	4	
3	30	65/100	SEL/SEP	5	4	
4	50	65/100	SFL/SFP	6	4.5	
5	100	100	SGL	N/A	5	

1. Requires 24" wide section.
2. Size 6 FVR, RVNR, 2S2W require (2) adjacent 24" wide sections, 20" deep (2S2W).
3. Refer to factory.
4. A 1/2X compact starter is available.

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

Selection tables

Circuit breaker type

460 Volts, 60 Hertz – combination motor starters

FVNR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
5	200	100	SGL	3	
6	400	65	SKL	5.5	
1	10	65/100	SEL/SEP	1	(5)
2	25	65/100	SEL/SEP	1	
3	50	65/100	SEL/SEP	1.5	
4	100	65/100	SFL/SFP	2	
5	200	100	SGL	3.0	
6	400	65	SKL	5.5	

Part winding

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
4	150	10	SGL	4.5	
5					(4)
1	15	65/100	SEL/SEP	2	
2	40	65/100	SEL/SEP	2	
3	75	65/100	SEL/SEP	4.5	
4	150	100	SGL	5	
5					(4)

FVR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
4	100	25	SFL	3	
5	200	100	SGL	6	(1)
6	400	65	SKL	12	(2)
1	10	65/100	SEL/SEP	2	
2	25	65/100	SEL/SEP	2	
3	50	65/100	SEL/SEP	3	
4	100	65/100	SFL/SFP	4	
5	200	100	SGL	5.5	(1)
6	400	65	SKL	8.5	(2)

Y-Delta, OT

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
2	40	25/65	SE	3	
3	75	25/65	SGL	3.5	(1)
4	150	65	SGL	4.5	(1)
5	300	65	SGL	5	

2S1W, 2S2W

NEMA size	Max. Hp		IC (kA)	Circuit breaker type	Space units	Notes	Rev space units
	Constant variable torque	Constant HP					
4	100	75	25	SFL	4.5		5.5
5	200	150	30	TJC	6	(1)(2)	10
6	400	300	65	SKL	12	(2)	
1	10	7.5	65/100	SEL/SEP	1.5		2.5
2	25	20	65/100	SEL/SEP	2		3
3	50	40	65/100	SEL/SEP	4		4.5
4	100	75	65/100	SFL/SFP	4.5		7.5
5	200	150	100	SGL	6	(1)(2)	10

RVAT

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units		Notes
				13" Deep	20" Deep	
5	200	100	SGL		5	(3)
6	400	65	SKL	N/A	12	(2)
2	25	65/100	SEL/SEP	4	4	
3	50	65/100	SEL/SEP	5	4	
4	100	65/100	SEL/SEP	6	4.5	
5	200	100	SGL	N/A	5	(3)

1. Requires 24" wide section.
2. Size 6 FVR, RVAT, 2S2W require (2) adjacent 24" wide sections, 20" deep (2S1W not available).
3. Size 5 RVAT cannot be mounted in 13" deep enclosure.
4. Refer to factory.
5. A 1/2X compact starter is available.

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

Selection tables

Circuit breaker type

575 Volts, 60 Hertz – combination motor starters

FVNR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
1	10	25	SEL	1	
2	25	25	SEL	1	
3	50	25	SEL	1.5	
4	100	25	SFL	2	
5	200	65	SGL	3	
6	400	42	SKL	6	(1)
4	100	42	SGL	2	
5	200	65	SGL	3.5	
6	400	42	SKL	6	

FVR

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
1	10	25	SEL	2	
2	25	25	SEL	2	
3	50	25	SEL	3	
4	100	25	SFL	3	
5	200	65	SGL	5.5	(1)
6	400	42	SKL	8.5	(2)
4	100	42	SGL	3	
5	200	100	SGL	5.5	(1)
6	400	42	SKL	8.5	(1)

Part winding

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
1	15	25	SEL	2	
2	40	25	SEL	2	
3	75	25	SEL	4.5	
4	150	10	SGL	5	
5					(3)
4	150	42	SGL	5	
5					(3)

Y-Delta, OT

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units	Notes
2	40	25	SEL	3	
3	75	25	SEL	3.5	(1)
4	100	25	SEL	4.5	(1)
4	150	100	SGL	5	(1)
5					(3)
4	150	42	SGL	5	(1)

2S1W, 2S2W

NEMA size	Max. Hp		IC (kA)	Circuit breaker type	Space units	Notes	Rev Space units
	Constant Variable Torque	Constant HP					
1	10	7.5	25	SEL	2		2.5
2	25	20	25	SEL	2		3
3	50	40	25	SEL	4		4.5
4	100	75	25	SFL	5		7.5
5	200	150	22	SGL	5.5	(1)(2)	10
6	400	300	42	SKL	8.5	(2)	

RVAT

NEMA size	Max. Hp	IC (kA)	Circuit breaker type	Space units		Notes
				13" Deep	20" Deep	
2	25	25	SEL	4	4	
3	50	25	SEL	5	4	
4	100	25	SFL	6	4.5	
5	200	65	SGL	5	4.5	
6	400	42	SKL	N/A	12	(2)
5	200	100	SGL	N/A	5	
6	400	42	SKL	N/A	11	(2)

1. Requires 24" wide section.
2. Size 6 FVR, RVAT, 2S2W require (2) adjacent 20 and 24" wide sections, 20" deep (2S1W).
3. Refer to factory.

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

Selection tables

Fused switch type

208 Volts, 60 Hertz – combination motor starters[5][7]

FVNR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units
			Switch Amps	Clip Amps	
1	7.5	100	30	30	1
2	10	100	60	60	1
3	15	65	100	60	2
3	25	65	100	100	2.5
3	25	100	200	200	2.5
4	40	100	200	200	3.5
5	75	100	400	400	5
6	150		600	600	

FVR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	7.5	100	30	30	1.5	
2	10	100	60	60	2	
3	15	65	100	60	3	[5]
3	25	65	100	100	3.5	[5]
4	40	100	200	200	5	
5	75	100	400	400	9.5	
6						[3][6]

RVAT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units		Notes
			Switch Amps	Clip Amps	13" Deep	20" Deep	
2	10	100	60	60	4	4	
3	15	65	100	60	5	4	[5]
3	25	65	100	100	5	4	[5]
4	40	100	200	200	6	5	
5	75	100	400	400	—	6	[3]
6							

Part winding

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	7.5	100	30	30	2	
2	15	100	100	60	2	
3	20	65	100	100	4	[5]
3	30	100	200	200	5	
4	60	100	400	400	5.5	

Y-Delta, OT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
2	7.5	100	60	30	3	[2]
2	10	100	60	30	3	
2	15	100	100	60	3	
3	20	65	100	100	4	[1]
3	30	100	200	200	5	[1]
4	40	100	200	200	5	[1]
4	60	100	400	400	6	[4]

2S1W, 2S2W

NEMA size	Max. Hp		IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
	CT VT	Constant HP		Switch Amps	Clip Amps		
1	7.5	5	100	30	30	2	
2		7.5	100	60	30	2	
2	10		100	60	60	2	
3	15	15	65	100	60	3.5	[5]
3	25	20	65	100	100	3.5	[5]
4	40		100	200	200	5.5	
5	75		100	400	400	8.5	[3]
1	7.5	5	100	30	30	2	
2		7.5	100	60	30	2	
2	10		100	60	60	2	
3	15	15	65	100	60	3.5	[5]
3	25	20	65	100	100	3.5	[5]
4	40		100	200	200	5.5	
5	75		100	400	400	8.5	[3]
6	100			600	600	8.5	[3]

1. Requires 24" wide section.
2. Size 1 not available. Use Size 2.
3. Size 5 FVR, 2S1W, 2S2W with fused switch requires [2] adjacent sections; left hand section is 24" wide 6X, right hand section is 20" wide with top 31/2X used for disconnect.
4. Size 4 Wye-Delta with fused switch requires a 24" wide section when main horizontal bus is rated 1000 ampere UL or less. A 30" wide section is required with 1200 ampere UL or higher rated main horizontal bus.
5. Use size 4 spacing for 100k ratings.
6. Requires 12" bottom wireway cover to UL Label.
7. All 400/600A units are MCS (molded case switches).

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

Selection tables

Fused switch type

230 Volts, 60 Hertz – Combination Motor Starters[5][7]

FVNR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	7.5	100	30	30	1	
2	15	100	60	60	1	
3	30	65	100	100	2	[6]
3	30	100	200	200	2.5	
4	50	100	200	200	3.5	
5	100	100	400	400	5	
6	200	100	600	600	5.5	[1]

FVR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	7.5	100	30	30	1.5	
2	15	100	60	60	2	
3	30	65	100	100	3	[6]
4	50	100	200	200	5	
5	100	100	400	400	8.5	[3][6]
6	200	100	600	600	8.5	[2]

RVAT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units		Notes
			Switch Amps	Clip Amps	13" Deep	20" Deep	
2	15	100	60	60	4	4	
3	30	65	100	100	5	4	[6]
4	50	100	200	200	6	5	
5	100	100	400	400		6	
6	200	100	600	600	N/A	12	[2]

Part winding

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	7.5	100	30	30	2	
2	15	100	60	60	2	
2	20	100	100	100	2	
3	30	65	100	100	4	[6]
4	60	100	400	400	5.5	

Y-Delta, OT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
2	7.5	100	60	30	4	
2	10	100	60	30	4	
2	15	100	60	60	4	
2	20	100	100	100	4	
3	30	65	100	100	4.5	[1][6]
4	60	100	400	400	6	[4]

2S1W, 2S2W

NEMA size	Max. Hp		IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
	CT VT	Constant HP		Switch Amps	Clip Amps		
1	7.5	5	100	30	30	2	
2		7.5	100	60	30	2	
2	15	10	100	60	60	2	
3	30	25	65	100	100	4	[6]
4		30	100	200	100	5.5	
4	50	40	100	200	200	5.5	
5	100	75	100	400	400	8.5	[3]
1	7.5	5	100	30	30	2	
2		7.5	100	60	30	2	
2	15	10	100	60	60	2	
3	30	25	65	100	100	4	[6]
4		30	100	200	100	5.5	
4	50	40	100	200	200	5.5	
5	100	75	100	400	400	8.5	[3]
6	200	150	100	600	600	8.5	[2]

1. Requires 24" wide section.
2. Size 6 FVR, RVNR, 2S1W, 2S2W require (2) adjacent 24" wide sections, 20" deep.
3. Size 5 FVR, 2S1W, 2S2W with fused switch requires (2) adjacent sections; left hand section is 24" wide 6X, right hand section is 20" wide with top 31/2 X used for disconnect.
4. Size 4 Wye-Delta with fused switch requires a 24" wide section when main horizontal bus is rated 1000 ampere UL or less. A 30" wide section is required with 1200 ampere UL or higher rated main horizontal bus.
5. Use time-delay fuse, maximum rating same as switch amps.
6. Use size 4 spacing for 100k ratings.
7. All 400/600A units are MCS (molded case switches).

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

Selection tables

Fused switch type

460 Volts, 60 Hertz – Combination Motor Starters[6]

FVNR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	10	100	30	30	1	
2	15	100	60	30	1	
2	25	100	60	60	1	
3	30	65	100	60	2	
3	50	65	100	100	2.5	
4	100	100	200	200	3.5	
5	125	100	400	200	5	
5	200	100	400	400	5	
6	250	100	600	400	6	[1]
6	400	100	600	600	6	[1]

FVR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	10	100	30	30	1.5	
2	15	100	60	30	2	
2	25	100	60	60	2	
3	30	65	100	60	3	
3	50	65	100	100	3.5	
4	100	100	200	200	5	
5	125	100	400	200	8.5	[4]
5	200	100	400	400	8.5	[4]
6	250	100	600	400	8.5	[2]

RVAT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units		Notes
			Switch Amps	Clip Amps	13" Deep	20" Deep	
2	15	100	60	30	4	4	
2	25	100	60	60	4	4	
3	30	65	100	60	5	4	
3	50	65	100	100	5	4	
4	100	100	200	200	6	5	
5	125	100	400	200	—	6	
5	200	100	400	400	—	6	
6	250	100	600	400	N/A	12	[2]
6	400	100	600	600	N/A	12	[2]

Part winding

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units
			Switch Amps	Clip Amps	
1	10	100	30	30	2
1	15	100	60	30	2
2	25	100	60	60	2
2	30	100	100	60	2
3	60	100	200	200	5
4	150	100	400	200	5.5

Y-Delta, OT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
2	10	100	60	30	3	[3]
2	15	100	60	30	3	
2	25	100	60	60	3	
2	30	100	100	60	3	
3	50	65	100	100	4	[1]
3	60	100	200	200	5	[1]
4	100	100	200	200	6	[1]
4	125	100	400	200	6	[5]

1. Requires 30" wide section.
2. Size 6 FVR, RVNR, 2S1W, 2S2W require (2) adjacent 24" wide sections, 20" deep with 12" bottom wireway cover.
3. Size 1 not available. Use Size 2.
4. Size 5 FVR, 2S1W, 2S2W with fused switch requires (2) adjacent sections; left hand section is 24" wide 6X, right hand section is 20" wide with top 3 1/2 X used for disconnect.
5. Size 4 Wye-Delta with fused switch requires a 24" wide section when main horizontal bus is rated 1000 ampere UL or less. A 30" wide section is required with 1200 ampere UL or higher rated main horizontal bus.
6. All 400/600A units are MCS (molded case switches).

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

2S1W

NEMA size	Max. Hp		IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
	CT VT	Constant HP		Switch Amps	Clip Amps		
1	10	7.5	100	30	30	2	
2	15	15	100	60	30	2	
2	25	20	100	60	60	2	
3	30	30	65	100	60	4	
3	50	40	65	100	100	4	
4	100	75	100	200	200	5.5	
5	125	100	100	400	200	8.5	(4)
5	200	150	100	400	400	8.5	(4)
6	250	250	100	600	400	8.5	(2)
6	400	300	100	600	600	8.5	(2)

2S2W

NEMA size	Max. Hp		IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
	CT VT	Constant HP		Switch Amps	Clip Amps		
1	10	7.5	100	30	30	2	
2	15	15	100	60	30	2	
2	25	20	100	60	60	2	
3	30	30	65	100	60	4	
3	50	40	65	100	100	4	
4	100	75	100	200	200	5.5	
5	125	100	100	400	200	8.5	(4)
5	200	150	100	400	400	8.5	(4)
6	250	250	100	600	400	8.5	(2)
6	400	300	100	600	600	8.5	(2)

Selection tables

Fused switch type

575 Volts, 60 Hertz – combination motor starters[5][6]

FVNR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units
			Switch Amps	Clip Amps	
1	10	100	30	30	1
2	25	100	60	60	1
3	40	100	100	60	2
3	50	100	100	100	2.5
4	100	100	200	200	3.5
5	200	100	400	400	5
6	400	100	600	600	6

FVR

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
1	10	100	30	30	1.5	
2	25	100	60	60	2	
3	40	100	100	60	3	
3	50	100	200	100	5	
4	100	100	200	200	5	
5	200	100	400	400	8.5	[4]
6	400	100	600	600	8.5	[2]

RVAT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units		Notes
			Switch Amps	Clip Amps	13" Deep	20" Deep	
2	25	100	60	60	4	4	
3	40	100	200	60	6	5	
3	50	100	200	100	6	5	
4	100	100	200	200	6	5	
5	200	100	400	400		6	
6	400	100	600	600	N/A	12	[2]

Part winding

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units
			Switch Amps	Clip Amps	
1	10	100	30	30	2
1	15	100	60	30	2
2	25	100	60	60	2
3	50	100	200	100	5
3	75	100	200	200	5
4	100	100	200	200	5
4	150	100	400	400	6

Y-Delta, OT

NEMA size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
			Switch Amps	Clip Amps		
2	10	100	60	30	3	[3]
2	15	100	60	30	3	
2	20	100	60	60	3	
2	25	100	60	60	3	
3	50	100	200	100	4	[1]
3	75	100	200	200	4	[1]
4	100	100	200	200	6	[1]
4	150	100	400	400	6	[5]
5						[6]

2S1W, 2S2W

NEMA size	Max. Hp		IC (kA)	Class RK-1, RK-5, J-TD		Space units	Notes
	CT VT	Constant HP		Switch Amps	Clip Amps		
1	10	7.5	100	30	30	2	
2	25		100	60	60	2	
3	40	40	100	200	60	5.5	
3	50		100	200	100	5.5	
4	100		100	200	200	5.5	
5	200		100	400	400	8.5	[4]
6	400		100	600	600	8.5	[2]
1	10	7.5	100	30	30	2	
2	25		100	60	60	2	
3	40	40	100	200	60	5.5	
3	50		100	200	100	5.5	
4	100		100	200	200	5.5	
5	200		100	400	400	8.5	[4]
6	400		100	600	600	8.5	[2]

1. Requires 24" wide section.
2. Size 6 FVR, RVNR, 2S1W, 2S2W require (2) adjacent 24" wide sections, 20" deep with 12" bottom wireway cover.
3. Size 1 not available. Use Size 2.
4. Size 5 FVR, 2S1W, 2S2W with fused switch requires (2) adjacent sections; left hand section is 24" wide 6X, right hand section is 20" wide with top 3 1/2 X used for disconnect.
5. Size 4 Wye-Delta with fused switch requires a 24" wide section when main horizontal bus is rated 1000 ampere UL or less. A 30" wide section is required with 1200 ampere UL or higher rated main horizontal bus.
6. Refer to factory.
7. All 400/600A units are MCS (molded case switches).

Note: The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to factory. One space unit or X unit equals 12 inches of vertical height.

Starter options

Option	Function	Additional space required
Control transformer	Provides control power. See “Control Transformer” for details	—
CPT primary fuses	Class CC fuse wired in each ungrounded transformer primary conductor.	
CPT secondary fuse	One midget fuse (typical Gould Ferraz type TRM) wired in ungrounded Control Power Conductor	—
Control power fuse	One Class CC fuse wired in each ungrounded control power conductor. Use when control power source is remote from unit.	
Starter overload protection	For more information see "Application data" section.	—
Pilot lights	CR104P type.	
Full voltage	Red–ON FAST, FWD, UP Amber–DOWN, REV, SLOW Green–STOPPED, READY	—
Transformer	CR104P with 6V lamp (See full voltage lights for lens colors)	—
LED	CR104P Type transformer type with 6V LED Lamp	—
Push-to-test	CR104P, Full-voltage transformer type, or LED (See full-voltage lights for lens colors)	—
Push buttons Start-stop	CR104P momentary type-use with FVNR starters with 3-wire control.	—
Stop	CR104P momentary type-provides stop function at MCC with 3-wire control.	—
Stop	CR104P maintained type–provides stop function at MCC with 2/3 wire control. Can be furnished with mushroom head and provision for locking open.	—
Fwd, Rev, Stop	CR104P momentary type-use with FVR starters.	—
Fast, Slow, Stop	CR104P momentary type-use with 2-speed starters.	—

Option	Function	Additional space required
Selector switches on-off	CR104P maintained type–use as permissive start with 2 or 3 wire control.	—
Hand-off-auto	CR104P maintained type–use to select auto or manual start with 2-wire control.	—
Fast-slow-off-auto	CR104P maintained type–use with 2-speed starters.	—
Fixed control TB	Stationery control terminal boards in place of split type terminal boards.	—
Power TB	Stationery motor lead terminal boards Size 3 and 4	Yes
Power TB	Split ype terminal blocks on NEMA size 1 and 2	—
Control disconnect	High density pull-apart TB will provide foreign voltage isolation without disengaging the unit vertical bus stabs.	—
Control relay	C2000 Type (standard) Rated 600V, with 10A contacts. Relays are available with normally open and normally closed non-convertible contacts. Up to four additional contact blocks can be added to basic 4 pole relay. Size 1 and Size 2 FVNR starters require an additional half-space unit for three to four relays. Two relays can be added with no increase in Space units.	Yes
Timing relays pneumatic	C2000 (standard) .3 to 3 seconds or 10 to 180 seconds timing range. 10A contacts. 4 INST and 2 TD interlocks (NO and NC).	Yes
Timing relays electronic	Time-delay on energization/ de-energization double pole, double throw contacts rated 600V, 10A. Timing ranges 1-10 or 10-300 seconds.	

Starter options

Option	Function	Additional space required
Motor driven	Used for long timing periods. Specify timing range.	1/2X
Accelerating relay	C2000 (standard) timing relay for multi-speed motors to provide definite accelerating time for each speed above first speed. Time interval is adjustable .3 to 30 seconds. Alternate Electronic Timer.	
Decelerating relay	C2000 (standard) timing relay allows time for motor to coast stop before permitting restart or coast to a lower speed on multi-speed motors before initiating slow speed operation (2-speed motors). Time interval is adjustable .3 to 30 seconds. Alternate Electronic Timer.	
Compelling relays	On multi-speed starters, requires the controller to progress in sequence from low to high speed. One relay is required for each speed over one. Requires same space as C-2000 timing relay. Alternate Electronic Timer.	
Latch relay	Once relay closes, mechanical latch holds relay closed until electrically reset.	
Fused switch auxiliary interlock	2-10A auxiliary interlocks operated by disconnect operator Max. (2NO, or 1NO and 1NC)	—
CB options (spectra only) aux. Interlock	SPDT auxiliary interlocks mounted in CB. Refer to factory if more than 2 required.	—
Bell alarm	Internal CB alarm switch.	—
Shunt trip	Electric remote trip.	—
Key interlock above 250A	Added to disconnect operating handle to require a predetermined system operating sequence. Specify operating sequence.	—
Ground fault	Zero sequence sensing Ground Fault Relay for equipment protection for NEMA size 2-6 starters.	Yes
Current transformer	Donut type CT located in one motor phase conductor for purchasers use. (Also used for door mounted Ammeter.)	Yes
Amp transducer ammeter	Integrated CT/Current transducer with 4-20 MA output. (Requires 120V Power). AC panel-type, single current transformer operated five-ampere movement. Scale selected based on 125% motor full-load amperes.	Yes
Elapsed time meter	Mounts on pushbutton bracket. Meter Visible from front of MCC.	
Phase loss/ unbalance voltage sensing	APVR used primarily to sense phase loss, unbalance, or reversal, has time delay under-voltage.	—
Motor winding heater	The motor winding heater is designed for use with 3-phase ac motors to guard against damage caused by condensation buildup on motor windings which can occur in high humidity environments during motor idle periods. Refer to application data in "Components" section (1X-size 5).	1/2X
Coil suppressor 120V	Surge suppressors reduce undesirable transients in control circuits by absorbing voltage transients generated by operating coils.	
Door diagram	Circuit diagram mounted on back of unit door.	—
Wire markers	Permanent wire number identification on each control wire. Tube type standard, heat shrink optional.	—
Provision for PFC capacitor	Terminals located between contactor and OL relay.	

Product information

Undervoltage protection

Standard starters drop out when line voltage drops below approximately 65 percent rated volts and can be reclosed when voltage returns to 85 percent rated volts. Where momentary contact devices are used in standard three-wire control circuits, the starter will not reclose on momentary loss of voltage until the START button is pushed, thus inherently providing undervoltage protection.

If a maintained contact device, such as a float switch, is used to start the motor, the starter will close automatically upon restoration of control voltage. In some cases, this may not be desirable for safety reasons, and a reset pushbutton and auxiliary relay should be specified to provide undervoltage protection.

Overload relays

Standard relays are three-leg block bimetallic type with adjustment from 90 to 110 percent of the heater rating. A single calibration adjusts all three legs. A single reset button mounted on the starter door permits external reset. Ambient-compensated relays are available for ambients from –30°C to +80°C and have adjustment from 90 to 110 percent of normal rating. Improved protection is provided when the motor is in a relatively constant ambient but control is subject to varying ambient. Relays are interchangeable with standard type.

Optional electronic overload relay and Motor managment relays

Electronic overload relays and electronic overload relays with basic communication functions are available (see page H-12). Advanced motor management relays from Multilin are also available (see page H-5 for MM200 and MM300).

Control circuit protection

Motor control circuits tapped from the load side of the starter unit disconnect, such as line-to-line control and line-to-neutral control are protected by listed, branch circuit rated fuses in each ungrounded conductor. UL requires rejection type fuses for equipment rated above 10kA short-circuit rating. 6 ampere, 600 volt Class CC fuses are furnished as standard. Motor control circuit transformers are protected with a fuse in each ungrounded secondary conductor. Secondary fuses are UL Recognized supplementary fuses size per Article 450 of the NEC (20 amperes maximum).

UL required primary transformer protection in accordance with NEC Article 430.72(c) and Article 450 fuses are furnished in each ungrounded primary conductor. Motor control circuit power, other than power tapped from the load side of the starter unit disconnect, should be protected against overcurrent. The protective device may be located at the source or by the optional fuse(s) located in each unit. Normally, one (Class CC) fuse in the ungrounded conductor will provide the needed protection. Where wiring external to the motor control center is indicated, No. 14 AWG copper will be assumed as the minimum conductor size unlessotherwise specified.

Long control circuits

On exceedingly long control circuits two problems may occur – (1) starter will not close due to line voltage drop and (2) starter may not open due to capacitive coupling. Table below gives the one-way distances (in feet) from the starter to the pushbutton along the route of the control cable. This table is for 120 volt coils and allows for a maximum voltage variation of 10 percent. The distances are given for #14 and #12 AWG control wire.

NEMA size	Distance in feet with #14 wire	Distance in feet with #12 wire
1	1300	2070
2	460	730
3	320	510
4	250	395
1-6[1]	5000	6000

1. Distance based on using an interposing relay, type C2000

Separate source control circuits

A separate control bus is available as an option. This bus can be fed from a separate external source, or from within the motor control center by a separate distribution transformer or distribution panel. A normally open auxiliary contact should be specified on each unit disconnect to open the control bus circuit when the unit disconnect is opened. Unit control circuit fusing should also be added.

In lieu of the auxiliary disconnect contact, pull-apart terminal boards may be specified to provide control voltage isolation for individual starters.

Pilot devices

Pushbuttons, selector switches, pilot lights, etc., are single-unit, heavy-duty oil-tight type mounted on the starter unit door.

Auxiliary contact ratings

NEMA size 1-6

AC Volts	Amperes		
	Continuous	Make	Break
115	10	60	6.0
230	10	30	3.0
460	10	15	1.5
575	10	12	1.2
DC Volts			
125	10	—	1.1
250	10	—	0.5

Starter auxiliary contacts (option)

Auxiliary contacts rated 10 amperes, 600 volts are available, either normally open or closed (non-convertible). Quantities of contacts shown are maximum available and include starter requirements for cross-electrical interlocking and holding circuits. If more contacts are required than shown, a relay must be added.

Starter type	Total control contacts available (includes contacts required in basic control circuit for seal-in,cross interlocking, etc.)					
	NEMA size Starter					
	1	2	3	4	5	6
Full-voltage, nonreversing (FVNR)	5	6[2]	6	6	6	6
Full voltage, reversing (FVR)						
Forward contactor	4	4	4	4	4	4
Reverse contactor	4	4	4	4	4	4
Two-speed, one winding (251W)[1]						
Low-speed contactor	4	4	4	4	4	5
High-speed contactor	3	4	4	4	4	5
Two-speed, two winding (252W)						
Low-speed contactor	4	4	4	4	4	5
High-speed contactor	4	4	4	4	4	5
Part winding						
Run contactor	5	6	6	6	6	6
Autotransformer, reduced-voltage						
Run contactor		6	6	6	6	6

Control terminals

The table below lists the maximum number of high density control terminals available on standard heights units. See standard diagrams in "Typical circuits" section for number of control terminals required for standard starters. Note total number of control points are in addition to T1, T2 and T3 power terminal points.

Starter function	Size 1 CB/FS	Size 2 CB/FS	Size 3 CB/FS	Size 4	
				CB	FS
FVNR	18	18	18	18	48
FVR	30	42	48	48	48
2S1W	24	36	48	48	48
2S2W	24	36	48	48	48

—
CB = Circuit breaker; FS = Fused Switch.

Control transformers

Power is tapped from the load side of the starter unit disconnect and the transformer provides 120 volt power. Two 600 volt primary fuses, plus one 250 volt secondary fuse in the ungrounded conductor is standard.

Standard control power transformer ratings are adequate to handle the starter-coil current and three pilot lights. If additional burdens are expected, larger transformers should be specified.

Starter Size and type[3]	CPT Std. VA		CPT Max. VA[5]		UL (X) Listed	Notes
	60 Hz	50 Hz	60 Hz	50 Hz		
All Size 1	60	150	300	250	•	[6]
All Size 2	150	150	300	250	•	
All Size 3	300	250	300	250	•	
All Size 4	300	250	300	250	•	
All Size 5 and 6	100	100	300	250	•	[4]

Coil characteristics

Size and Type	Inrush Volt–Amp	Sealed Volt–Amp
Size 1, FVNR, FVR	151*	23*
Size 2, FVNR, FVR	528	60
Size 3, FVNR, FVR	1152	83
Size 4, FVNR, FVR	1248	87
Size 5, FVNR	2580	191
Size 6, FVNR	3360	255
Size 2, 2S1W	576	75
Size 3, 2S1W	1248	87
Size 4, 2S1W	1336	95
Relay for RVAT size 3 and 4	55	9
Relay for FVNR size 5 and 6	55	9

—
* Compact starter inrush 88VA, sealed 9VA

300 line standard coil data

Size	Coil	Amps 120V	Amps 480V	VA	Watts	Vars	PF	% Volts		Millisec	
								P/U	D/O	P/U	D/O
1	Inrush	1.26	.33	151	69.5	134	.46	85	63	15 to 30	7 to 15
	Holding	.2	.55	24	6	23	.25				
2	Inrush	4.4	1.2	528	169	500	.32	85	68	20 to 40	7 to 15
	Holding	.5	.14	60	12.9	57.9	.26				
3	Inrush	9.6	2.6	1152	230	1129	.20	85	65	20 to 45	7 to 15
	Holding	.69	.18	83	18.4	81.5	.19				
4	Inrush	10.4	2.8	1248	262	1220	.21	85	65	20 to 45	7 to 15
	Holding	.73	.2	87	18.8	84.8	.22				
5	Inrush	21.5	5.7	2580	464	2538	.18	85	65	30 to 50	15 to 25
	Holding	1.6	.42	191	38.8	185	.25				
6	Inrush	28.1	7.6	3360	608	3325	.18	85	65	30 to 50	15 to 25
	Holding	2.1	.58	255	44	246	.25				

1. For constant- or variable-torque motors.
2. Limit 4 with APVR relay.
3. Refer to Company for part-winding and Y-delta starters.
4. Starter coils operated at line voltage. Starters operated by control relay in 120 volt control circuit.Class CC fuses are provided for starter coil circuit.
5. Without increasing standard unit space requirements for size 1 to 4, over size CPT in size 5 will add 6".
6. 1/2X FVNR uses a 100VA CPT.

Thermal magnetic circuit breaker substitution

Substituting a thermal-magnetic circuit breaker in place of a Mag-Break® circuit breaker may require increasing the circuit breaker trip rating to avoid tripping on starting. See "Appendix" section for recommended thermal-magnetic circuit breaker trip ratings.

NEMA size starter	Standard circuit breaker	Substitute	Short-circuit rating		
			230V	460V	575V
1,2,3	SELI	SELT	25	25	22
			100	100	25
		SELL	100	100	65
4	SEL	SFLT	65	65	25
	SFLI	SFLT	100	100	25
			100	100	100
5	SGLI	SGLT	100	100	65

Terminals for field wiring

Description	Will accept wire[1]	
	AWG/MCM	Material
Starter Load Terminals		
Size 1 Starter	14-8	Cu
Size 2 Starter	14-4	Cu
Size 3 Starter	8-1/0	Cu
Size 4 Starter	4-3/0	Cu
Size 5 Starter	(2) 2/0-400	Cu
Size 6 Contactor	(2) 2/0-500	Cu-Al
Control Terminal Boards		
Hi Density Pull-Apart	(2) 12 Max.	Cu
Power Terminal Boards		
50 Amp Size 1 and 2 Type C Wiring	14-6[2]	Cu

1. Conductors #1 and smaller may be rated 60/75°C. Conductors #1/0 and larger must be rated 75°C. Conductors wired directly to OL device terminals must be rated 75°C Cu.
2. #6 only with ring terminal.

Miscellaneous units

Operator and metering panels
Unit spaces can be used to provide metering and/or operator's panels in the motor control center itself. Arrangement and dimensions will vary depending on the quantity and type of the devices required. Normally, fuse blocks, terminal blocks (T.B.s), current and potential transformers, etc., can be mounted on a base within the unit space. Meters, pilot lights, pushbuttons, switches, etc., can be mounted on the door. Suitable locations and adequate space should be provided so that wiring is simplified and there is no interference between door and base mounted components. The following devices are often specified:

- Pushbuttons, selector switches, pilot lights;
- Ammeters, voltmeters and other instruments (switchboard type);
- Instrument and transfer switches;
- Electronic power meter;
- Control relays;
- Timing relays (pneumatic, motor-operated or electronic);
- Protection relays;
- Alternator relays.

These panels will be UL labeled providing all the components are UL listed for use in motor control centers.

Relay panels
Relay panels can be furnished from 1 space unit to 6 Space units with full width doors. The amount of vertical space required is generally determined by the number of terminal board points required or relay type used; when in doubt allow for a double vertical row of terminal boards.

These panels will be UL labeled providing all the components are UL listed for use in motor control centers.

Alternator relay panels
Consists of two motor alternator circuit using two control relays and a latching relay. Requires minimum 1 space unit height.

Space units	Single vertical row of T.B.s			Double vertical row of T.B.s		
	Maximum no. of T.B. points	Horizontal width for component mounting	Maximum no. of std. 4-pole relays	Maximum no. of T.B. points	Horizontal width for component mounting	Maximum no. of std. 4-pole relays
		Section width 20"W				Section width 20"W
1	12	11 1/2"	6	24	6"	3
1 1/2	24	11 1/2"	12	48	6"	6
2	30	11 1/2"	18	60	6"	9
2 1/2	42	11 1/2"	24	84	6"	12
3	48	11 1/2"	36	96	6"	18
3 1/2	60	11 1/2"	42	120	6"	21
4	72	11 1/2"	48	144	6"	24
4 1/2	78	11 1/2"	54	156	6"	27
5	90	11 1/2"	60	180	6"	30
5 1/2	96	11 1/2"	66	192	6"	33
6	108	11 1/2"	72	216	6"	36

—
T.B.s or relays for size estimating only.

Mounting plates

Blank plates are available for customer use when field mounting a PLC and/or relays. All plates come with mounting screws and door. Full height dished plates come with top horizontal bus barrier.

Description	Min. enclosure depth (inches)	Mounting plate dimensions (inches)		Part number
		Width	Height	
Over vertical bus, 9.5" from door	13	15	12	110C1040MDG1
			18	110C1040MDG2
			24	110C1040MDG3
			30	110C1040MDG4
			36	110C1040MDG5
			42	110C1040MDG6
			48	110C1040MDG7
		20	12	110C1040MDG8
			18	110C1040MDG9
			24	110C1040MDG10
			30	110C1040MDG11
			36	110C1040MDG12
			42	110C1040MDG13
			48	110C1040MDG14
			54	110C1040MDG15
			60	110C1040MDG16
			66	110C1040MDG17
			72	110C1040MDG18
		24	12	110C1040MDG19
			18	110C1040MDG20
			24	110C1040MDG21
			30	110C1040MDG22
			36	110C1040MDG23
			42	110C1040MDG24
			48	110C1040MDG25
			54	110C1040MDG26
			60	110C1040MDG27
			66	110C1040MDG28
			72	110C1040MDG29
		30	12	110C1040MDG30
			18	110C1040MDG31
			24	110C1040MDG32
			30	110C1040MDG33
			36	110C1040MDG34
			42	110C1040MDG35
			48	110C1040MDG36
			54	110C1040MDG37
			60	110C1040MDG38
			66	110C1040MDG39
			72	110C1040MDG40

Description	Min. enclosure depth (inches)	Mounting plate dimensions (inches)		Part number
		Width	Height	
Dished mounting plate, No bus, 13.5" from door	20	20	12	110C1040MDG41
			18	110C1040MDG42
			24	110C1040MDG43
			30	110C1040MDG44
			36	110C1040MDG45
			42	110C1040MDG46
			48	110C1040MDG47
			54	110C1040MDG48
			60	110C1040MDG49
			66	110C1040MDG50
			72	110C1040MDG51

Description	Min. enclosure depth (inches)	Mounting plate dimensions (inches)		Part number
		Width	Height	
Dished mounting plate, no bus, 13.5" from door	20	24	12	110C1040MDG52
			18	110C1040MDG53
			24	110C1040MDG54
			30	110C1040MDG55
			36	110C1040MDG56
			42	110C1040MDG57
			48	110C1040MDG58
			54	110C1040MDG59
			60	110C1040MDG60
			66	110C1040MDG61
			72	110C1040MDG62
		30	12	110C1040MDG63
			18	110C1040MDG64
			24	110C1040MDG65
			30	110C1040MDG66
			36	110C1040MDG67
			42	110C1040MDG68
			48	110C1040MDG69
			54	110C1040MDG70
			60	110C1040MDG71
			66	110C1040MDG72
			72	110C1040MDG73
Dished Mounting Plate, no Bus, 15.5" from door	20	20	12	110C1040MDG74
			18	110C1040MDG75
			24	110C1040MDG76
			30	110C1040MDG77
			36	110C1040MDG78
			42	110C1040MDG79
			48	110C1040MDG80
			54	110C1040MDG81
			60	110C1040MDG82
			66	110C1040MDG83
			72	110C1040MDG84
		24	12	110C1040MDG85
			18	110C1040MDG86
			24	110C1040MDG87
			30	110C1040MDG88
			36	110C1040MDG89
			42	110C1040MDG90
			48	110C1040MDG91
			54	110C1040MDG92
			60	110C1040MDG93
			66	110C1040MDG94
			72	110C1040MDG95

Description	Min. enclosure depth (inches)	Mounting plate dimensions (inches)		Partnumber
		Width	Height	
Dished mounting plate, no bus, 15.5" from door	20	30	12	110C1040MDG96
			18	110C1040MDG97
			24	110C1040MDG98
			30	110C1040MDG99
			36	110C1040MDG100
			42	110C1040MDG101
			48	110C1040MDG102
			54	110C1040MDG103
			60	110C1040MDG104
			66	110C1040MDG105
			72	110C1040MDG106
Dished mounting plate, no bus, 17.5" from door	20	20	12	110C1040MDG107
			18	110C1040MDG108
			24	110C1040MDG109
			30	110C1040MDG110
			36	110C1040MDG111
			42	110C1040MDG112
			48	110C1040MDG113
			54	110C1040MDG114
			60	110C1040MDG115
			66	110C1040MDG116
			72	110C1040MDG117
		24	12	110C1040MDG118
			18	110C1040MDG119
			24	110C1040MDG120
			30	110C1040MDG121
			36	110C1040MDG122
			42	110C1040MDG123
			48	110C1040MDG124
			54	110C1040MDG125
			60	110C1040MDG126
			66	110C1040MDG127
			72	110C1040MDG128
		30	12	110C1040MDG129
			18	110C1040MDG130
			24	110C1040MDG131
			30	110C1040MDG132
			36	110C1040MDG133
			42	110C1040MDG134
			48	110C1040MDG135
			54	110C1040MDG136
			60	110C1040MDG137
			66	110C1040MDG138
			72	110C1040MDG139
Dished mounting plate, no bus, 18.5" from door	20	20	12	110C1040MDG173
			18	110C1040MDG174
			24	110C1040MDG175
			30	110C1040MDG176
			36	110C1040MDG177
			42	110C1040MDG178
			48	110C1040MDG179
			54	110C1040MDG180
			60	110C1040MDG181
			66	110C1040MDG182
			72	110C1040MDG183

Description	Min. enclosure depth (inches)	Mounting plate dimensions (inches)		Part number
		Width	Height	
Dished mounting plate, no bus, 18.5" from door	20	24	12	110C1040MDG184
			18	110C1040MDG185
			24	110C1040MDG186
			30	110C1040MDG187
			36	110C1040MDG188
			42	110C1040MDG189
			48	110C1040MDG190
			54	110C1040MDG191
			60	110C1040MDG192
			66	110C1040MDG193
			72	110C1040MDG194
		30	12	110C1040MDG195
			18	110C1040MDG196
			24	110C1040MDG197
			30	110C1040MDG198
			36	110C1040MDG199
			42	110C1040MDG200
			48	110C1040MDG201
			54	110C1040MDG202
			60	110C1040MDG203
			66	110C1040MDG204
			72	110C1040MDG205
Dished mounting plate, no bus, 21" from door	22	20	12	110C1040MDG140
			18	110C1040MDG141
			24	110C1040MDG142
			30	110C1040MDG143
			36	110C1040MDG144
			42	110C1040MDG145
			48	110C1040MDG146
			54	110C1040MDG147
			60	110C1040MDG148
			66	110C1040MDG149
			72	110C1040MDG150
		24	12	110C1040MDG151
			18	110C1040MDG152
			24	110C1040MDG153
			30	110C1040MDG154
			36	110C1040MDG155
			42	110C1040MDG156
			48	110C1040MDG157
			54	110C1040MDG158
			60	110C1040MDG159
			66	110C1040MDG160
			72	110C1040MDG161
		30	12	110C1040MDG162
			18	110C1040MDG163
			24	110C1040MDG164
			30	110C1040MDG165
			36	110C1040MDG166
			42	110C1040MDG167
			48	110C1040MDG168
			54	110C1040MDG169
			60	110C1040MDG170
			66	110C1040MDG171
			72	110C1040MDG172

Lighting and distribution panelboards
The following panelboards are available for mounting in motor control centers. Type AL and AQ Panelboards with main circuit breakers are normally provided. Type AE and AD panels require a feeder unit for the main circuit breaker, which then feeds the M.L.O. panel.

Panel type	System voltage (max.)	Branch			Interrupting rating rms symmetrical Amps (in thousands)
		Type	Poles (1)	Poles Ampere Rating	
A Series Type AL	120/240 Vac	THQL	1	15-70	10
		THQL	2	15-100	10
		THHQL	1	15-70	22
		THHQL	2	15-125	22
		TXQL	1.2	15-30	65
	240 Vac	THQL	2.3	15-100	10
		THHQL	2.3	15-100	22
		THQL	3	15-30	65
A Series Type AQ	120/240 Vac	THQB-GF	1.2	15-30	10
		THQB	1	15-70	10
		THQB	2	15-100	10
		THHQB-GF	1	15-30	22
		THHQB	1	15-70	22
		THHQB	2	15-100	22
		TXQB	1.2	15-30	65
	240 Vac	THQB	1.2	15-100	10
		THHQB	2.3	15-100	22
		TXQB	3	15-30	65
A Series Type AE 4 wire	120 Vac	TEY	1	15-100	65
	240 Vac	TEY	2.3	15-100	65
	277 Vac	TEY	1	15-100	14
	480/277 Vac Max.	TEY	2.3	15-100	14
A Series Type AD 3 wire	277 Vac	TED	1	15-100	14
		TED4	1	15-50	14
		THED	1	15-30	65
	480 Vac	TED4	2	15-100	14
		TED4,6	3	15-150	14
		THED4	2	15-100	25
		THED4	3	110-150	25
		THED6	3	15-150	25
	600 Vac	TED6	3	15-150	14
		THED6	3	15-150	18

1. Two-pole THED breakers require a 3-pole space.
2. Equipment rating is equal to the lowest interrupting rating of any circuit breaker installed.
3. One space unit (X) equals 12" vertical height. M.L.O. panel does not include feeder space requirements. (see pg. C4)

Notes:
- Branch devices are plug-in for Type AL and bolt-on for AQ, AE and AD panelboards. Maximum of 42 circuits per panel.
- Ground fault CB not available in AL panels.
- Lighting panel main bus is rated 1000 amps per square inch, alternate 800 amps per square inch is available.
-

Notes:
- 65 kAIC rating for panels is obtained through series rating.
- For all panels fed from MCC bus, add feeder unit to feed panel.

MCC Space units

Number of Circuits	Panel Main Bus Rating (Amps)	Space units(3) AL, AQ	SpaceUnits(3) AE
12	100	2	2
12	225	2 1/2	2
18	100	2 1/2	2 1/2
18	225	2 1/2	2 1/2
24	225	2 1/2	2 1/2
24	400	4 1/2	3 1/2
30	225	3	3
30	400	4 1/2	3 1/2
36	225	3 1/2	3
36	400	5	4
42	225	3 1/2	3 1/2
42	400	5	4

AD

Number of Circuits	Panel Main Bus Rating (Amps)	Space units(3)
12	100	2 ½
12	225	3
18	100	3
18	225	3 ½
24	100	3
24	225	3 ½
30	100	3 ½
30	225	4
36	100	4
36	225	4 ½
42	100	4
42	400	½

The unit rating is the same as the lighting panel rating when:

A. The lighting panel is mounted as a separate motor control center unit but not connected to any power source within the motor control center. This does not reduce or affect motor control center short-circuit rating. The lighting/ distribution panel must have a main breaker.
B. The lighting panel is mounted as a separate motor control center unit and factory connected directly (with no intermediate transformer) to motor control center bus through a feeder. The panel series rating must equal or exceed motor control center short-circuit rating.
C. The lighting panel is mounted as a separate motor control center unit and factory connected to a transformer unit in the motor control center. This does not reduce or affect motor control center short-circuit rating.

Distribution transformers

General

Open, dry-type transformers with primary thermal-magnetic circuit breaker or fusible switch with NEMA Class R (dual element) fuses are available in motor control center construction. The accompanying tables give both single- and three-phase transformers normally mounted in motor control centers for use in supplying separate-source control circuits, panelboards and power external to the motor control center.

Space units shown include space necessary for the primary disconnect. One space unit equals 12 inches of vertical height. If transformers with taps are required, refer to the factory. Primary disconnects stab into the vertical bus.

Primary protection only

Primary Current	Primary protection rating
9 amps or more	125% or next higher standard rating per NEC Sect. 240-6
2 amps to 9 amps	167% maximum
Less than 2 amps	300% maximum

Primary and secondary protection

Secondary current	Primary protection rating	Secondary protection rating
9 amps or more	250% maximum	125% or next higher standard rating
Less than 9 amps	250% maximum	167% maximum

Transformer secondary conductors are wired to a terminal board in the unit. One leg of 120 volt secondaries, the center point of 120/240 volt secondaries, and the Y-point of 3-phase secondaries are grounded unless otherwise specified. NEC Article 450-3 covers transformer protection, other than motor control circuit transformers or special applications.

The general requirements are:

- The degree of protection required depends on the specific application.
- Select a transformer protective device which provides the required protection.
- Secondary protection in each ungrounded conductor can be provided if specified.

Three-phase transformers (Delta-Y, no Taps[6])

Fused switch-100kAIC						Circuit breaker					
KVA	Switch size	Fuse Amps[4]	Space unit	UL listed (X)	Notes	IC rating (kA) 65	IC rating (kA) 100	CB Trip	Space unit[5]	UL listed (X)	Notes
380-120/208 Volts, 50 Hertz											
3	30	7	2.5	•			QMW		2.5		
9	30	17.5	3	•		SEL	SEP	30	3		
30	60	60	6	•	(1)(3)	SEL	SEP	70	4	•	(1)(7)
45	200	90	6	•	(3)	SEL	SEP	150	4.5	•	(3)
480-120/208 Volts, 60 Hertz											
3	30	5.6	2.5	•			QMW		2.5		
9	30	15	3	•		SEL	SEP	20	3	•	
15	30	25	4	•		SEL	SEP	30	3.5	•	
30	60	45	4	•	(1)(7)	SEL	SEP	70	3.5	•	(1)(7)
45	100	70	4	•	(3)	SEL	SEP	125	3.5	•	(1)(7)
600-120/208 Volts, 60 Hertz											
3	30	4.5	2.5	•			QMW		2.5		
9	30	12	3	•			SELL	20	3.5	•	
30	60	40	4	•	(1)(7)		SELL	70	3.5	•	(1)(7)

1. Requires full depth of motor control center.
2. Requires 24" wide enclosure.
3. Requires 20" deep enclosure 24" wide.
4. Sized for primary protection only. (Dual element fuses)
5. Sized for primary and secondary protection.
6. Add 6" for Taps.
7. Requires 30" wide enclosure.

Notes:

- 15-45KVA transformers are TP-1 rated per NEMA Standard TP-1-1996.
- Low temperature rise and/or copper windings are available. Refer to factory.

Distribution transformers

Single-phase transformers

KVA	Fused switch-100kAIC					Circuit breaker					
	Switch size	Fuse Amps[4]	Space unit	UL listed (X)	Notes	IC rating (kA) 65	IC rating (kA) 100	CB trip [5]	Space unit	UL listed (X)	Notes
240-120/240 Volts, 60 Hertz											
0.5	30	3.2	1	•			QMW		1		
1	30	7	1	•			QMW		1		
3	30	15	1.5	•		SEL	SEP	30	1.5	•	
5	30	30	2	•		SEL		40	2	•	
10	60	60	2	•	(1)	SEL		70	2	•	(1)
15	200	80	4	•	(1)(6)	SEL	SEP	150	3.5	•	(1)(6)
25	200	150	4	•	(1)(6)	SEL	SEP	225	3	•	(1)(6)
37.5	200	200	6	•	(1)(7)	SEL	SEP	225	4	•	(1)(7)
380-120/240 Volts, 50 Hertz											
0.50	30	3.5	1	•			QMW		1		
1	30	4	1	•			QMW		1		
3	30	12	1.5	•		SEL		15	1.5	•	
10	60	35	2	•	(1)	SEL		50	2	•	(1)
15	60	50	3	•	(1)(6)	SEL		90	2.5	•	(1)(6)
25	100	90	3	•	(3)	SEL	SEP	150	2.5	•	(3)
37.5	200	125	4	•	(6)(7)	SEL	SEP	125	4	•	(6)(7)
480-120/240 Volts, 60 Hertz											
0.50	30	2.8	1	•		SEL			1		
1	30	3.5	1	•		SEL			1		
3	30	10	1.5	•		SEL		15	1.5	•	
5	30	12	2	•		SEL		20	2	•	
10	30	25	2	•	(1)	SEL		40	2	•	(1)
15	60	40	3	•	(1)(6)	SEL		50	2.5	•	(1)(6)
25	100	70	3	•	(3)	SEL	SEP	125	2.5	•	(3)
37.5	100	100	4	•	(6)(7)	SEL	SEP	125	3.5	•	(6)(7)
600-120/240 Volts, 60 Hertz											
0.50	30	2.5	1	•			QMW		1		
1	30	4	1	•			QMW		1		
3	30	8	1.5	•			QMW		1.5		
10	30	20	2	•	(1)		SELL	40	2	•	(1)
15	60	35	3	•	(1)(6)			50	2.5	•	(1)(6)
25	60	60	3	•	(3)			100	2.5	•	(3)
37.5	100	80	4	•	(6)(7)			90	3.5	•	(6)(7)

1. Requires full depth of motor control center.
2. Requires 24" wide enclosure.
3. Requires 20" deep enclosure 24" wide.
4. Sized for primary protection only. (Dual element fuses)
5. Sized for primary and secondary protection.
6. Add 6" for Taps.
7. Requires 30" wide enclosure.

Notes:

- 15-45KVA transformers are TP-1 rated per NEMA Standard TP-1-1996.
- Low temperature rise and/or copper windings are available. Refer to factory.

Power factor correction capacitors

Description

Motors and other inductive loads require two kinds of electrical current: Current which performs the actual work and reactive current which produces the magnetic fields necessary for the operation of inductive devices such as motors. Both types of currents produce system I2R losses. Capacitors installed near inductive loads can be used to reduce the reactive currents which flow through much of the system, thereby reducing I2R losses.

Low-voltage capacitors are generally three-phase units, delta-connected, and are protected by current limiting fuses. The fuses disconnect the capacitor in the event of an electrical short, providing service continuity for the system and reducing the possibility of rupturing the capacitor case.

Capacitors switched with the motor

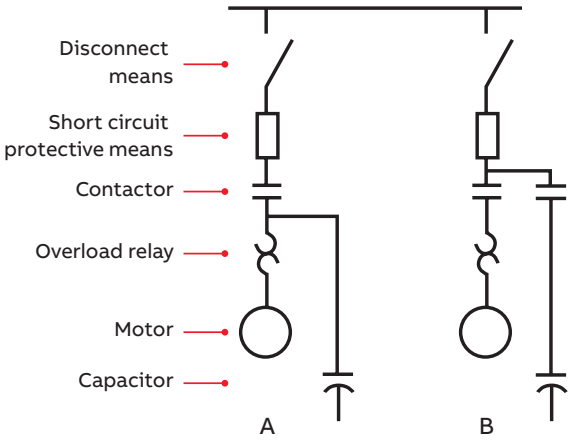
Capacitors used for power factor correction should be selected using the motor manufacturer's application data.

When the capacitor is connected ahead of the overload relay (sketch A and B), the overload current elements should be selected using the full-load motor current and service factor values specified on the nameplate of the motor. Capacitors must not exceed the maximum KVAR recommended by the motor manufacturer for switching with the specific motor selected.

Power factor correction capacitors should be switched by a separate contactor (sketch B) under any of the following conditions:

- High inertia load;
- Open circuit transition reduced voltage starting;
- Wye-delta motor;
- Reversing or frequently jogged motor;
- Multispeed motor (2S1W, 2S2W, etc.).

Power factor correction capacitors should not be connected to the load side of solid state starters and drives*. It should be noted that two-speed motor starters and soft starters require separate contactors to switch in capacitors after a time-delay in order to avoid possible motor damage while the capacitors discharge. For the same reason, Wye-Delta starters have the capacitors applied after the delta connection has been made.



*Care should be taken when connecting power factor correction to the line side of power conversion equipment, such as drives, to avoid component damage.

Power factor correction capacitors

Selection of power factor correction capacitors

The following table is provided as a guide. Consult motor manufacturer for actual capacitor KVAR values.

Typical capacitor ratings[1]

HP	Nameplate Volts	Full load RPM	Maximum KVAR
3	230/460	1750	1.4
5	230/460	1740	1.9
7	230/460	1760	3.1
10	230/460	1750	3.6
15	230/460	1760	4.5
20	230/460	1750	5.1
25	230/460	1760	7.2
30	230/460	1760	9.1
40	230/460	1770	14.9
50	230/460	1765	19.1
60	230/460	1775	24.9
75	230/460	1775	27
100	230/460	1780	29.1
125	460	1780	32.3
150	460	1785	38.7
200	460	1785	50.5
300	460	1785	77.2

1. For use with 1800 rpm, 3-phase. 60Hz classification B motors Type KE to raise full-load power factor to approximately 95 percent.
2. See J1 for full load amps.

MCC Space Units Required	Maximum KVAR			UL Listed (X)
	240V	480V	600V	
1X	22 1/2	50	45	X

One space unit X equals 12 inches of vertical height. Space required is for capacitor only. Add space for switching device as needed.

In front-mounted configurations utilizing the 20" deep enclosure, capacitors may be mounted in the rear 10 inches of space behind the vertical bus. Rear access to the motor control center is required for servicing the capacitors.

Optional 240 and 480 volt blown fuse indicating lights are available. The indicating lights are mounted on the unit door.

All capacitor units are Dry Type.

Bus connected power factor capacitors may be paralleled to increase kvar ratings. Refer to factory.

Power factor correction capacitors should be switched by a separate contactor (sketch B) under any of the following conditions:
- High inertia load;
- Open circuit transition reduced voltage starting;
- Wye-delta motor;
- Reversing or frequently jogged motor;
- Multispeed motor (2S1W, 2S2W, etc.).

Power factor correction capacitors should not be connected to the load side of solid state starters and drives*. It should be noted that two-speed motor starters and soft starters require separate contactors to switch in capacitors after a time-delay in order to avoid possible motor damage while the capacitors discharge. For the same reason, Wye-Delta starters have the capacitors applied after the delta connection has been made.

Recommended switching device

KVAR	Switch with class J (in Amperes)	Molded case circuit breaker (in Amperes)
240 Volts, 60 Hertz		
2 1/2	10	15
5	20	20
7 1/2	30	30
10	40	40
15	60	60
20	80	80
27 1/2	125	100
30	125	110
37 1/2	175	150
480 Volts, 60 Hertz		
5	10	15
7 1/2	15	15
10	20	20
15	30	30
20	40	40
25	50	50
27 1/2	60	50
30	60	60
37 1/2	80	70

—
For PFCC other than 240V or 480V, 60 Hz, refer to factory for sizing.

Intelligent MCC

Intelligent E9000 MCC
The Intelligent low-voltage motor control center (MCC) is an extension of the Evolution E9000 MCC product which utilizes network devices to communicate the status of the system, to enable control of the system devices, or to facilitate advanced diagnostics.

A motor control center is responsible for controlling multiple motor loads throughout your facility. With the intelligent MCC offering, you can remotely monitor and control your system, helping to increase productivity and personnel safety.

Standard network devices
ABB offers a wide variety of network devices to build a customized MCC to meet your needs. Overload and motor management relays, intelligent trip units, variable frequency drives (VFD's), soft starters, and main metering are all available with communication capabilities. This section will highlight the intelligent solutions ABB can offer by leveraging these network devices.

To learn more about these devices, please see "Components" section and "Solid-state drives and starters" section (for VFD's and Soft Starters).

—
Multilin's MM200 motor management relay

—
EntelliGuard trip unit (TU)

—
FC 102 & FC 302 VFD's

—
ASTAT XT soft starters

—
Multilin's MM300 motor management relay

—
microEntelliGuard TU

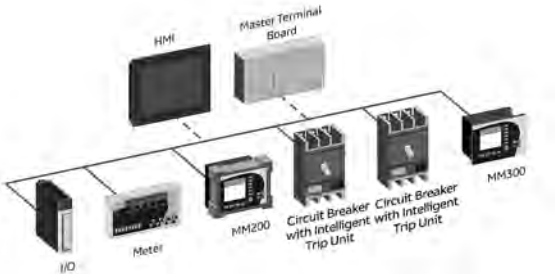
—
ASTAT BP soft starters

—
Multlin's main metering: PQMII and EPM series

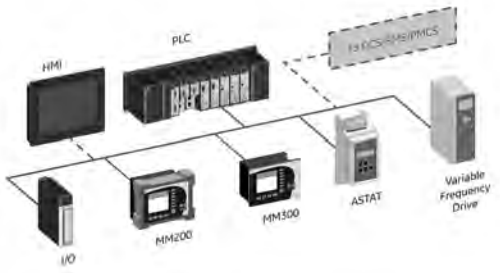
Intelligent solutions
ABB offers multi-level solutions to help meet the needs of your motor control center application. Intelligent E9000 MCC configurations can provide local monitoring at or near the equipment, remote control of the network devices, dual protocol solutions, and complete system integration with existing equipment.

The following examples demonstrate some of the different intelligent MCC configurations ABB can provide using programmable logic controllers, programmable automation controllers, I/O systems, human machine interfaces, and envisage* Energy Management software to help transform network devices into an intelligent MCC solution.

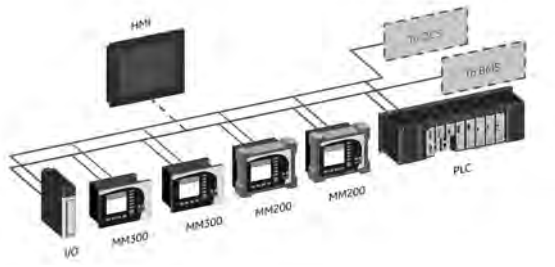
Monitoring



Monitoring and control



Dual communication bus



VersaMax Nano and Micro controllers

Pick the palm-sized PLC that's light on your budget
For tight spaces, the VersaMax Nano PLC is the perfect solution. Thanks to its all-in-one construction, installation is a breeze. All you have to do is snap it onto a DIN-rail or screw it into a panel. With the VersaMax Nano, you save on initial as well as life-cycle costs.

Select the big-featured PLC in a compact package
The small footprint VersaMax Micro PLC offers the flexibility of modular design and a variety of built-in features, including up to 64 I/O points (expandable to 176 I/O points), fast cycle times, a robust instruction set and extensive memory that multiplies your programming options.

Tap the perfect solution for low-end motion applications

Both the VersaMax Nano and Micro can be used with either a PWM or a pulse train device. In addition, both controllers come with built-in high-speed counters that can be used in either Type A or Type B configurations. The new Micro 20, Micro 40 and Micro 64 support four 100Khz high-speed counters and four 65Khz PWM or pulse train outputs for high speed motion applications.

The new MicroMotion expansion module (2 axis of Servo or Stepper @ 500Khz pulses/second with encoder inputs) is ideal for either Micro integrated motion control or standalone motion control (over serial or Ethernet networking). The MicroMotion expansion module is loaded with features and supports 2 axis of stepper and servo control. The module supports a powerful function set, Home, Jog, Registration Input, S-Curve acceleration, Feedrate Override and more. Up to 256 move profiles are stored on the module and backed up with the Portable Memory device (removable Flash device) for easy program storage of the motion moves. The Micro 20, Micro 40, and Micro 64 support up to 2 Micro-Motion expansion modules for a total of 4 axis high performance motion control.

Take advantage of a host of communications options

Both the VersaMax Nano and Micro have an RS-232 port that can be used for SNP slave, Modbus RTU or serial I/O commands. The Micro 23 and Micro 28 also have an RS-485 port that adds SNP master and Modbus master commands. With serial I/O commands, you can interface with such devices as pagers, intelligent scales, bar code readers and printers. The new Micro 20, Micro 40 and Micro 64 have a second option port that supports either RS-232, RS-485 or USB communications module. The VersaMax Nano and Micro can easily be networked to Ethernet utilizing the powerful VersaMax SE (Serial to Ethernet module).

Program your controllers in record time

With Proficy Machine Edition software, programming your VersaMax Nano and Micro PLCs is a simple and intuitive process. Mix Relay Ladder Diagram and Instruction List programming within an application. Develop and save custom view tables. View PLC and I/O system fault tables on demand. Machine Edition is an automation software breakthrough deploying HMI, motion, and multi-target control in an integrated development environment. This environment provides a common user interface, drag-and-drop editing, and a rich set of development tools. The Micro 20, Micro 40 and Micro 64 support a portable program FLASH Memory Module that provides a simple cost effective way of upgrading field controllers.

VersaMax Nano and Micro controllers

Typical Micro 20, Micro 40 and Micro 64 applications

—
Material handling, packaging and assembly machines

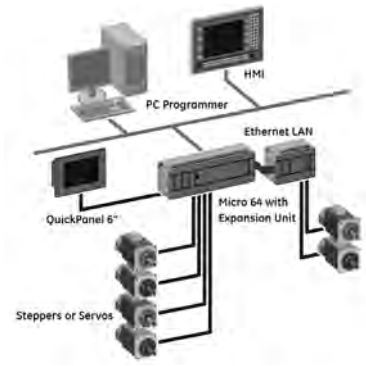
—
SCADA

Micro 20, Micro 40, Micro 64 Advantages
Flexible motion control to improve machine throughput is built into controller
- Up to 4 axes of stepper or servo control (32bit, 65Khz Pulse Train)
- Up to 4 high speed counters at 100Khz (32bit)

Powerful networking to improve data gathering
- Plug in 10/100M bit Ethernet available
- Two built-in communication ports

Simple control for complex applications
- 48K bytes of user program memory and 32Kwords of data storage
- Advanced programming instruction set. Ramping, Jog, Find Home, Go Home, Blended Move (up to 4 continuous moves)
- Portable program storage device

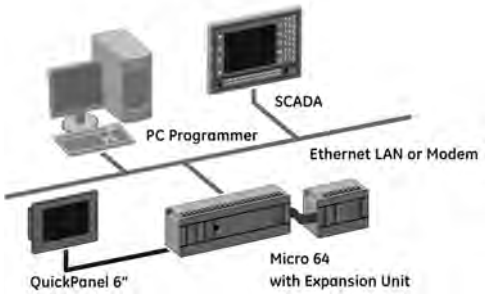
MicroMotion expansion
- 2 axis of Servo or Stepper @ 500Khz pulses/second with encoder inputs
- Supports Home, Jog, Registration Input, S-Curve acceleration, Feedrate Override and more
- Interfaces with Micro 20, Micro 40, Micro 64 or standalone mode using Serial or Ethernet
- Stores up to 256 motion profiles on module



Micro advantages
Flexible Communications from Serial to Ethernet
- Modbus master, Modbus slave and Report by exception
- Modem and Ethernet SRTP or Modbus TCP (Server) option

Abundance of data storage capability
- Up to 32Kwords of data storage

Powerful instruction set
- Floating point math and PID for process control
- Write and Read data to internal FLASH



VersaMax Nano and Micro controllers

The newest additions to the Micro family – the Micro 20, Micro 40 and Micro 64 PLCs – feature expansion to 132, 152 and 176 I/O points respectively, to fast cycle times, robust instruction sets, and generous memory to allow more flexible programming. These new Micros each feature an optional second port that provides you with an additional RS-232 port, RS-485, USB, or Ethernet. The serial expansion ports come with two analog input channels. A user-friendly memory module is available to easily download changes to the controller without the need of a PC.

And it's all packaged in a sturdy modular design for easy access and long-term durability. These all-in-one PLCs give you everything you need to control a wide variety of applications.

VersaMax Nano and Micro controllers selection guide

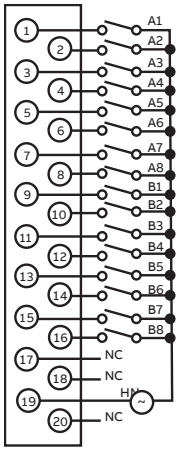
Features	Nano 10	Micro 14	Micro 23	Micro 28	Micro 20	Micro 40	Micro 64
Built-in Discrete I/O	6 in/4out	8 in/6 out	13 in/10 out	16 in/12 out	12 in/8 out	24 in/16 out	40 in/24 out
Built-in Analog I/O	1 on some models	none	2 in/1 out	none	none	none	none
I/O Expansion Units	none	Up to 4 units	Up to 4 units	Up to 4 units	Up to 4 units	Up to 4 units	Up to 4 units
Logic Memory (Words)	2K	9K	9K	9K	24K	24K	24K
Data Storage (Words)	256	256	2K	2K	32K	32K	32K
Scan Time (msec/K)	1.3 msec	1.1 msec	1.1 msec	1.1 msec	1.1 msec	1.1 msec	1.1 msec
Battery Backed RAM	Super Cap only	Super Cap only	Yes and Super Cap	Yes and Super Cap	Yes and Super Cap	Yes and Super Cap	Yes and Super Cap
Real Time Clock	none	none	Yes, Included	Yes, Included	Yes, Included	Yes, Included	Yes, Included
Ports Available	1 RS-232	1 RS-232	1 RS-232 and 1 RS-485	1 RS-232 and 1 RS-485	1 RS-232 and second port optional RS-232, RS-485, USB or Ethernet	1 RS-232 and second port optional RS-232, RS-485, USB or Ethernet	1 RS-232 and second port optional RS-232, RS-485, USB or Ethernet
Ethernet Option	Yes, VersaMax SE	Yes, VersaMax SE	Yes, VersaMax SE	Yes, VersaMax SE	Yes on second port	Yes on second port	Yes on second port
High Speed Counter	Up to 4 at 10Khz (16 bit)	Up to 4 at 10Khz (16 bit)	Up to 4 at 10Khz (16 bit)	Up to 4 at 10Khz (16 bit)	Up to 4 at 100Khz (32 bit)	Up to 4 at 100Khz (32 bit)	Up to 4 at 100Khz (32 bit)
Pulse Train/ PWM	Up to 4 at 5Khz (16 bit)	Up to 4 at 5Khz (16 bit)	Up to 4 at 5Khz (16 bit)	Up to 4 at 5Khz (16 bit)	Up to 4 at 65Khz (32 bit)	Up to 4 at 65Khz (32 bit)	Up to 4 at 65Khz (32 bit)
Motion Commands	N/A	N/A	N/A	N/A	Find Home, Go Home, Jog, Ramp, Blended Move (4 Consecutive Moves)	Find Home, Go Home, Jog, Ramp, Blended Move (4 Consecutive Moves)	Find Home, Go Home, Jog, Ramp, Blended Move (4 Consecutive Moves)
Write Register Values to Internal Flush	No	Yes	Yes	Yes	Yes	Yes	Yes

VersaMax Nano and Micro controllers – general

I/O Circuits

Standard input circuit – 120 Volt AC input module (VersaMax IC200MDL240)

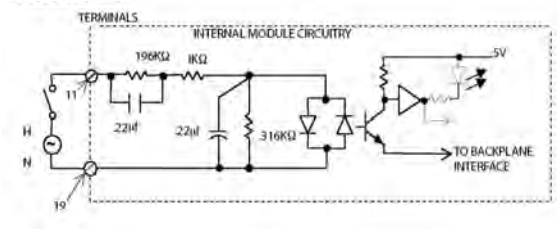
Terminals **Field Wiring**



Rated Voltage	120 Volts AC
Indicators	One Lcd per point
Inputs per Module	16 (1 group with a single common)
Isolation	1500 volts RMS between field side an logic side
Current Draw	50 mA (typical) at rated voltage from backplane

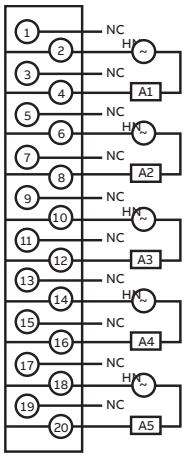
Input Characteristics:

Max. On-state	70 volts to 132 volts
Min. Off-state	0 to 20 volts
Min. On-state	6 mA maximum
Max. Off-state	1.5 mA maximum
On response time	1 cycle
Off response time	2 cycle



Standard input circuit – 120/240 Volt isolated AC output module (VersaMax IC200MDL331)

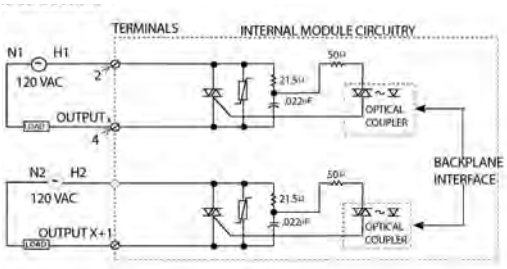
Terminals **Field Wiring**



Rated Voltage	120/240 Vac
Output Voltage Range	85 to 264 Vac
Outputs per Module	8 (each output isolated)
Isolation	1500 volts RMS between fieldside and logic side 500 volts RMS between each output
Output Current (Max.)	2 amps per point, 5 amps per module

Output Characteristics:

Inrush Current	25 amps maximum for one cycle
Min. Load Current	100 mA
Output Voltage Drop	1.5 volts maximum
Output Leakage Current	3 mA maximum at 120 Vac 6 mA maximum at 240 Vac
On response time	1 ms maximum
Off response time	9 ms maximum (1/2 cycle)



I/O Configurations

Standard I/O for motor control center consists of grouped input cards and isolated output cards (note that the isolated outputs can control NEMA size 1 to 6 starters).

Programmable automation controllers

Expanding on traditional PLCs
Intelligent Platforms created the concept of the Programmable Automation Controller with the introduction of the PACSystems family of automation controllers. Expanding on traditional PLCs, PAC controllers provide a highly reliable, high-performance advanced control platform for discrete logic control, motion control, and process control. While ABB offers and supports a wide variety of communications protocols to support our customers needs, we have standardized our control systems on the market-leading industrial network, PROFINET, to provide an extremely high performance, highly reliable, yet simple to configure and install distributed IO network.

PACSystems RXi controller
High Performance Distributed IO Controller Platform

Intelligent Platforms has leveraged its rich experience in embedded computing and control technology in the design of the innovative PACSystems RXi controller platform. The RXi Controller incorporates leading-edge CPU technology, the market leading industrial Ethernet network technology, and a unique user interface for maintaining the controller to deliver a control system unique in the industry.

The PACSystems RXi controller is PROFINET enabled, delivering a small footprint solution with highly flexible distributed I/O capabilities to equipment builders and end users. Its unique Intelligent Display Module provides configuration and maintenance functions at the controller without software. As a PACSystems controller, the RXi is fully compatible with applications written for any other PACsystems platform. The result is a high performance solution designed for distributed IO applications.

Higher performance
The RXi Controller is designed for high performance distributed IO applications. With a high performance dual core CPU and Gigabit PROFINET (with built in MRP redundancy) and Ethernet ports, every aspect of the RXI has been designed for performance. For even more power, the RXi controller can be combined with the RXi Modular IPC to deliver a unique control and computing platform for the factory floor. Integrated highspeed connectors allow instant data handling. Operator usability can be enhanced by pairing the RXi Modular IPC with new RXi panel displays with new multitouch technology.

The unique combination of high performance control, integrated PROFINET, intelligent display module, and compact format truly distinguishes the RXi Controller from other offerings.

Greater uptime
Systems with distributed architectures are easier to configure and maintain. In addition, RXi components are industrial temperature grade, which combined with patented thermal monitoring technology and sophisticated passive cooling techniques delivers reliable control in rugged environments.

Lower total cost of ownership
RXi's compact control and computing platform allows users to simplify panel design and reduce the overall size of the panel while benefiting from the performance, maintainability, and upgradeability of the PACSystems platform. The optional Intelligent Display Module provides a maintenance touchscreen display right on the controller, providing faster interaction with the controller and simpler start-up.

PACSystems RXi controller

Feature	Benefit
COMExpress CPU technology	Dual core processor for high performance in rugged applications
	Rugged technology with wider temperature ranges, higher shock and vibration designs, suitable for industrial applications
	Carrier and enclosure designs last across multiple CPU lifespans to provide faster performance enhancements
Integrated redundant PROFINET I/O Interface	Provides a Gigabit Ethernet I/O network connection with built-in cable redundancy (MRP) delivering IO cabling redundancy with no external switches
High-speed interconnect bus	Enables truly unique combinations of control and Proficy (or other Microsoft® Windows® or Linux applications)
Built-in data storage	Internal industrial grade SSD drive provides local long-term data retention
USB and SD interfaces	Interfaces enable program loading, serial communications and data storage via standard devices

Specifications

Storage
- 10 MB user memory

Data Retention
- RXi specific Energy Pak provides power during power failure while data is written to NV RAM

Ethernet
- 2 Port (shared MAC) GB PROFINET – with MRP
- 1 Ethernet (10, 100, 1000 Mbit) port
- 1 Ethernet (1000 Mbit) – internal

USB Interface
- 2 USB 2.0 Standard Size

Others
- SD Card (on Intelligent Display Module or Intelligence Faceplate)

Power
- Input: 24V DC (±25%) with protection

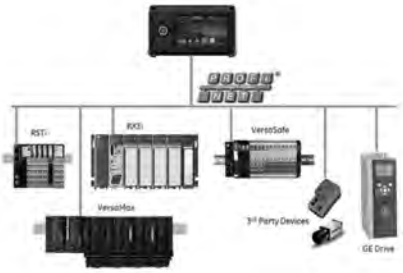
Environmental
- Operating: -25°C to +55° C (standard)
- Storage: -40°C to +125° C
- Operating humidity: 10% to 90%

Mounting
- Panel Mount
- Dinrail Mount with Optional DIN Mount Plate

Safety
- UL, CE
- Class 1, Div 2 (pending)

↑ Controller information and diagnostics screens built into IDM

→ Customize your solution by stacking together RXi Controller, IDM, Panel Displays and IPCs



← Connect to the I/O or your choice in line, star, or ring topologies

PACSystems RXi controller
The PACSystems RX3i controller is an incredibly powerful Programmable Automation Controller (PAC) in the innovative PACSystems family.
The RX3i features a single control engine and a universal programming environment to provide application portability across multiple hardware platforms and deliver a true convergence of control. With integrated critical control platforms, logic, motion, HMI, process control and high availability based on our Reflective Memory technology, the RX3i provides the performance and flexibility to give you an advantage. No matter the challenges your applications bring, PACSystems RX3i lets you take control.

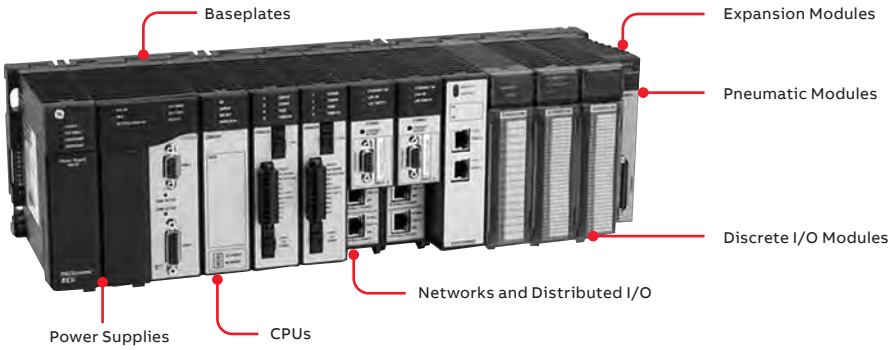
Benefits
The innovative technology of the PACSystems RX3i enables users to:
- Address major engineering and business issues, such as higher productivity and tighter cost control
- Boost the overall performance of their automation systems
- Reduce engineering and commissioning costs
- Easily integrate new technology into installed base systems
- Significantly decrease concerns regarding short- and longterm migration and platform longevity

Features
- High-speed processor and patented technology for faster throughput without information bottlenecks
- Dual backplane bus support per module slot:
  - High-speed, PCI-based for fast through put of new advanced I/O
  - Serial backplane for easy migration of existing Series 90-30 I/O
- Multiple CPU offerings meeting various performance criteria up to and including an Intel® 1 GHz CPU for advanced programming and performance with 64 Mbytes memory
- Memory for ladder logic documentation and machine documentation (Word, Excel, PDF, CAD and other files) in the controller to reduce downtime and improve troubleshooting
- Open communications support including Ethernet, GENIUS, PROFIBUS™, HART, DeviceNet™ and serial
- Supports high density discrete I/O, universal analog (TC, RTD, Strain Gauge, Voltage and Current configurable per channel), isolated analog, high-density analog, high-speed counter, and motion modules
- Expanded I/O offering with extended features for faster processing, advanced diagnostics and a variety of configurable interrupts
- Hot insertion for both new and migrated modules

High performance control on one platform
The PACSystems RX3i provides logic, motion, HMI, and process control with open communications protocols.
- PACMotion modules can control up to 40 high speed axes in one rack
- PACSystems High Availability solution offers true dual redundancy data synchronization and bumpless transfer
- The Control Memory Xchange offers amazing data transfer at a rate of 2.12 Gbaud

Universal development environment
The common software platform across all controllers, award-winning Proficy Machine Edition software provides the universal engineering development environment for programming, configuration and diagnostics for the entire PACSystems family.
- Programming tools such as tag-based programming, a library of reusable code and a test edit mode for improved online troubleshooting
- User-friendly environment that can increase design flexibility and improve engineering efficiency and productivity

PACSystems RXi Controller



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Motion modules

CPUs
The CMU310 is a High Availability redundant CPU that is configured using the MaxON software. The CMU310 has the same functionality as the CPU310. Synchronization of the CMU310s is via an Ethernet link.

Baseplates
The RX3i Universal baseplates support hot swap capability to reduce downtime. Expansion bases are available in 5 and 10 slot versions to maximize flexibility.

Universal bases power supplies
The RX3i power supply modules simply snap in just like I/O, and they work with any model CPU. Each version provides auto-ranging so there is no need to set jumpers for different incoming power levels, and they are current limiting so a direct short will shut the power supply down to avoid damage to the hardware.at a rate of 2.12 Gbaud.

Discrete I/O modules
Input modules provide the interface between the PLC and external input devices such as proximity sensors, push buttons, switches, and BCD thumbwheels. Output modules provide the interface between the PLC and external output devices such as contactors, interposing relays, BCD displays and indicator lamps.

Analog I/O modules
ABB offers easy-to-use analog modules and HART analog modules for control processes such as flow, temperature and pressure.

Specialty modules
The RX3i features a wide range of Specialty Modules to address specific application requirements.
These modules include:
- Millivolt and Strain Gage I/O
- RTD I/O
- Temperature Control
- Thermocouple I/O
- Resistive I/O
- Power Transducer

Networks and distributed I/O systems
The RX3i features a variety of communications options for distributed control and/or I/O. Choose from Ethernet EGD, PROFIBUS-DP, Genius and DeviceNet. These communication modules are easy to install and quick to configure.

RX3i pneumatic module
This output module provides 11 pneumatic outputs and five 24 VDC sourcing outputs. For each pneumatic output, the module contains an internal 3-way solenoid-actuated valve and an associated output fitting. Solenoid power is supplied from an external 24 VDC source to the“DC Outputs” connector on the front panel.

Expansion modules for local and remote I/O
The RX3i supports various expansion options for local and remote I/O to optimize configurations. The RX3i can be expanded up to 8 expansion bases using local remote expansion module. The RX3i also supports Ethernet remote I/O using the RX3i Ethernet Network Interface module (IC695NKT001) Series 90-30 Ethernet Network Interface module (IC693NIU004) for more distributed I/O.

Motion control
The PACMotion controller is a versatile 4-axis servo motion controller that provides the scalability and flexibility to cover a full range of motion applications from small material handling applications to complex multi-axis machines and electronic line shaft applications. PACMotion provides real-time synchronization of all axes in an RX3i rack. A separate RX3i fast logic scan enables fast deterministic event response and synchronization, and the demand driven data exchange model between the RX3i CPU and PACMotion module many significantly reduce scan time impact. The 4-axis servo motion controller is built on a high performance hardware platform, with a new enhanced motion engine, operating system, and open standard integrated programming paradigm.

Example PLC connections

PLC controlled starters
A combination motor starter will require a minimum of one Input and one Output per starter. As shown in Figure 5, the Output is connected between the starter coil and the fused, ungrounded leg of the control voltage source (terminals 3, 1). The Input connection is made between the starter “Seal contact” and the grounded leg of the control voltage source (Terminals 2, X2). The Input monitors the status of the seal circuit to independently verify that the starter has closed.

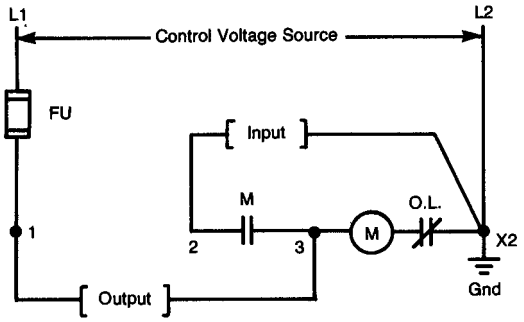

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Figure 5. Input and output Connection

When an H-O-A switch is used with PLC I/O, the configuration will appear as shown in Figure 6. Note: as mentioned previously, the INPUT monitors the status of the starter’s seal circuit in the manual mode as well as the PLC (automatic) mode.

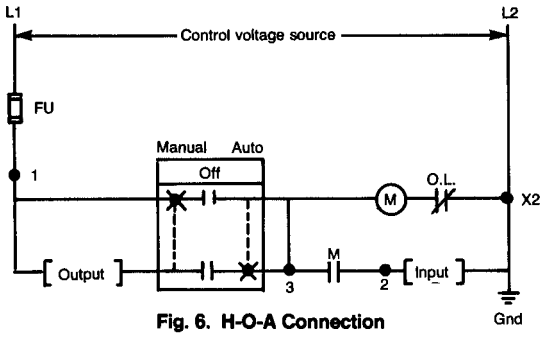

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Figure 6. H-O-A Connection

Starter units with individual control transformers
For starters having individual control power transformers all Outputs must be isolated type. This requirement is necessary due to the separate voltage sources provided by the individual control transformers. Inputs may be either isolated or non-isolated types. Where non-isolated Inputs are used all X2 terminals must be wired together.

Surge suppressors
In cases where excessive noise is present on the control line or hard interlocks which will operate often (in series with PLC Output), surge suppressors are recommended.

Optional inputs/diagnostic
Additional Input connections can be made to monitor the specific status of combination starters and feeders to provide further diagnostic information to the process operator and maintenance personnel.

1. The status of the overload relay can be monitored. An electricallyisolated, normally-open auxiliary contact can be ordered with the 300-Line overload relay and an additional PLC Input can be wired in series with it.
2. A PLC Input can be connected between terminals 1 and X2 to monitor the availability of control power to the starter unit.

Starter units with separate-source control voltage
Input and Output connections are shown below (see Figure 7) for units arranged for separate-source control.

Input
A common (non-isolated) Input can be used if all X2 terminals are wired together.

Output
As required by NEC Article 430-74, if a disconnect auxiliary contact and/or control circuit fuse (FU) is included with each starter, then the Output must be the isolated type. However, if the auxiliary contact and fuse are omitted, a common Output module can be used. With common output modules, interposing relays are required with NEMA size 3 and 4 starters. Note: NEC article 430-74 can be met with standard split-type control terminal boards on all draw-out units, or with pull-apart terminal boards.

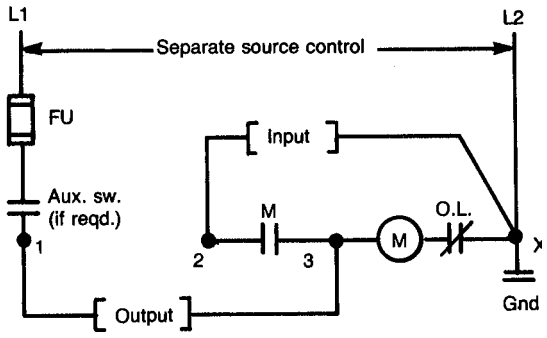


Figure 7. Input and Output Connections for Separate-Source Control

Isolated versus non-isolated outputs

Isolated outputs
Isolated outputs can be used for direct control of NEMA size 1 through 4 combination starters without the use of an interposing relay. The contactors of standard NEMA size 5 and larger starters are operated at line voltage with interposing relays operated from the secondary of the control transformer.

Non-isolated outputs
NEMA size 1-2 starters may be operated directly from common PLC output cards. The continuous current rating of ABB's non-isolated output module requires an interposing relay for NEMA size 3 and larger starters. Check the module ratings for inrush and continuous values.

Distributed I/O and Remote I/O
Intelligent Platforms provides high performance distributed I/O for demanding control applications. Our I/O and Controllers are connected by PROFINET – the market leading industrial network. Using this common interface allows users to mix and match their preferred controller with the I/O that best meets the needs of each part of the applica-tion. Our I/O portfolio has a wide range of packaging options covering the full spectrum of needs from simple discrete to high speed analog control, and from factory automation to process industries with harsh environments. We deliver best in class flexibility, performance, reliability and connectivity.

VersaMax I/O and control
Maximum versatility is the guiding principle behind VersaMax from Intelligent Platforms. This compact, extremely affordable control solution can be used as a PLC, as I/O, and as distributed control. With its modular and scalable architecture, intuitive features and ease of use, this innovative control family can save machine builders and end users considerable time and money.

Offering big PLC power in a small package
VersaMax CPUs supply a number of features usually found only in PLCs with larger footprints, including up to 64k of memory for application programs, floating point math, realtime clock, subroutines, PID control, flash memory, and bumpless program store. The serial ports support serial read/write and Modbus master/slave communications.

An abundance of useful I/O options
ABB offers a broad range of discrete, analog, mixed, and specialty I/O modules. These modules can be freely combined to create stand-alone I/O stations with up to 256 I/O points and expanded I/O systems with up to 4,096 I/O points.

The perfect match for today's open systems
VersaMax gives you the freedom to connect to a wide variety of host controllers, including PLC, DCS and PC-based control systems by way of Genius, DeviceNet™, PROFIBUS-DP™ and Ethernet networks. VersaMax also fully supports the power and open architecture of PC Control solutions.

The ultimate in cost-effective control and I/O
With intuitive diagnostics, hot insertion of modules and quick connect wiring, VersaMax extends uptime, reduces engineering and training needs, and dramatically reduces project life-cycle costs.

A design that maximizes ease of use
Every aspect of VersaMax has been carefully refined to accommodate the user. Snap-together I/O carriers mean that no tools are required for module installation or extraction. A convenient rotary switch can be used for setting bus and reducing programming time. With VersaMax, you can even address I/O automatically.

PACSystems RSTi
Ethernet based I/O delivers high performance and system flexibility.

To succeed in an outcome-driven world, businesses must operate faster and leaner and be increasingly connected. At Intelligent Platforms, we understand today's connected business environment, and are committed to simplifying it. That's why we've designed an automation architecture that helps you design better machines and plants, operate them smarter, and redefine the interaction with your equipment.

A pivotal point in this architecture is the I/O. Intelligent Platforms leverages industry standards and our experience in embedded technology and high-performance automation to deliver I/O that simplifies system design while reducing costs.

With Ethernet-based RSTi I/O, communications are enhanced through PROFINET, a high-speed, open protocol that facilitates the massive amounts of data that devices generate. The RSTI I/O unlocks the potential of continuity, connectivity, and collaboration for your control systems.

Simplifying system design without sacrificing performance
Equipment builders are continuously looking to improve the performance of their equipment while augmenting usability and reducing size and complexity. These requirements extend to the I/O control system. With PACSystems automation portfolio, ABB provides high-performance control solutions with best-in-class integration of distributed (networked) I/O ideally suited for demanding applications.

The RSTi line of I/O extendds the capabilities of PROFINET enabled solutions with a comprehensive line of granular slice I/O that simplifies panel design and reduces the overall size of the control panel while offering the performance, maintainability and upgradability of the PACSystems platform.

Decentralized I/O reduces cost
The RSTi decentralized I/O addresses the challenges of high installation overhead cost and lack of granularity of a centralized I/O system. The RSTi provides a high performance distributed I/O network that reduces the cost of field wiring. The distributed nature of the RSTI enables a machine builder to design in sections with distributed I/O drops closer to the field devices.

Decentralized I/O systems are easily disassembled and reassembled with a standard, off-the-shelf Ethernet cable versus hundreds of wires coming back to a centralized control cabinet.

The compact RSTi I/O line allows the user to "right size" the application, minimizing cost and panel space. I/O expansion is simple with the slide and lock design.

Feature	Benefit
PROFINET Connectivity	High-speed I/O throughout that connects to hundreds of third-party devices
System Diagnostics	Increased uptime by isolating system failures quickly
Powerful Integration Tools	Reduced development time with Proficy Machine Edition tools
"Build as You Go"	Granular design enables "right sizing" the application, resulting in minimum installation cost and panel space
Rugged Design	Rugged "slide and lock" design provides an easy, secure installation
Network Independence	Eight global standard network interfaces supported by the RSTi enables the user to standardize on one I/O system regardless of the bus requirements

PACSystems RSTi
Distributed I/O delivers high performance and system flexibility

Powerful solution
The RSTi innovative design enables module power, communications and field power to be passed from one module to the next. Power Distribution, Power Booster and Field Power Isolation modules are available to simplify installation wiring. The RSTI compact design (99 mm high x 70 mm deep x 12mm wide for I/O) reduces panel space.

Global standards
- CE, UL, CUL approved
- UL Class 1 Div 2 and ATEX Zone 2
- Temperature range -20°C to 60°C
- UL temperature range -20°C to 60°C

Flexible network interfaces
- PROFINET RT
- Modbus TCP/IP
- DeviceNet
- CC-Link
- PROFIBUS DP/V1
- Modbus Serial
- CANOpen

Over 80 module types available
- AC and DC I/O
- Relay Outputs
- Analog I/O
- RTD
- Thermocouple
- 2, 4, 8 and 16 point density

User friendly design
- Rugged, removable terminal block
- Tool-less spring clamp wiring
- DIN Rail “slide and lock” design
- Color coded identification
- Easy to read LED status
- Diagnostic test points

Specialty modules
- Serial communications
- High-speed counters
- SSI interface
- PWM and pulse output

SVDC module power and communications
- Passed from one module to the next

Field power
- Passed from one module to the next

The high-performance PACSystems RSTi PROFINET enabled family of I/O modules are part of the Intelligent Platforms High Performance Platform strategy. The platform leverages industry standards plus the combination of experience in embedded technology and automation to deliver long-life and higher performance solutions that are easy to configure, manage and upgrade. Contact your local representative for more information about solutions for your I/O requirements.

Human machine interfaces (HMIs)

The QuickPanel view family
The QuickPanel View bundled visualization solution provides the tools required for today's application needs with a combination of bright touch screen displays, multiple communications options, and Proficy View – Machine Edition software.

Information delivery
Acting as the bridge between the enterprise system and the plant floor, QuickPanel View provides information, not just data, that the operators need to run the machines, and that managment needs to run their business.

The QuickPanel View is a critical link to a well-integrated manufacturing operation.
- Built on Microsoft Windows CE operating system
- Built-in web server access data and panel using any standard browser

Scalable
As your information requirements grow, so will your hardware needs. QuickPanel View products are exceedingly scalable to grow with your needs.
- Broad range of display sizes from 6" to 15"
- Choice of Monochrome, Color-STN, or Color-TFT display
- Expandable memory and communications options
- Easy configuration allows you to run the same program on different size models

Seamless connectivity
As your need to monitor and collect data grows, you may need to connect to a wide variety of devices. Unless your operator interface has seamless connectivity, you may face delays and headaches. That is why QuickPanel View comes standard with a large number of built-in drivers to connect with the the world of automation devices, making it easy to connect to anything.
- Communication drivers over serial and Ethernet
- Communication over fieldbus and vendor specific networks through the addition of a communication expansion card

Other advantages
We invite you to explore the advantages of QuickPanel View.
- Cost-effective replacement for push buttons and pilot lights
- Data collection, trending, system security and other functions
- Multi-language support
- Migration of applications developed with QuickDesigner
- Adherence to global standards UL, ATEX, and CE

envisage
Energy management system

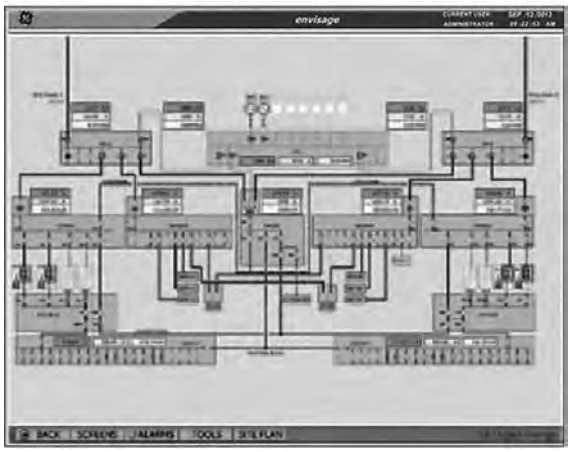
envisage monitoring
The envisage Monitoring module displays real-time power and demand data from remote intelligent energy devices as well as facility-wide infrastructure systems.

A birds-eye graphical site diagram provides a model representation of the complete facility and leads quickly to more detail in dynamic one-line schematics for the site location and even individual installed devices and monitored values.

It keeps you completely and accurately informed of the system's status in real-time – both locally and remotely – through customized views that aggregate and scale the information you need. Energy monitoring includes trend data from meters, relays, and breaker trip units in order to analyze the power system. It allows you to highlight and acknowledge unusual activity and alarm conditions with the real-time and historical alarm viewers to ensure that problems do not go unnoticed.

Typical monitored values
- RMS current
- Current demand
- Peak current
- RMS voltage
- KW and KWh
- Peak KW demand
- Apparent power (KVA) and apparent energry (KVAh)
- Reactive power (KVA) and reactive energry (KVARh)
- Power factor
- Frequency
- Event records
- Additional system parameters — water, air, gas, electric, steam, HVAC, backup power, security
- Switch position and breaker status

Typical connected devices
- Meters
- Trip units
- UPS
- Solar chargers
- CRAC units
- ATS
- PSG
- PDU
- Generators
- VFD
- PLC
- Proactive relays
- "Smart" power strips



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Overview of entire network

Solid-state drives and starters

Adjustable frequency AC drives

General application notes
As a vehicle for controlling multiple motor functions, the Motor Control Center has become the logical place to mount variable speed drives. However, the application of these drives is not a simple selection process, and the following is an explanation of some of the variables involved.

A drive must have ventilation. The basic power switching components are transistors, which are mounted on finned heat sinks. Although the drive may be operating at 95% or greater efficiency, the 5% (±) normal heat loss cannot be enclosed in the MCC without exceeding the safe operating temperature (50°C). Standard mounting is ventilated **(NEMA 1 or 1A only)**.

A drive is electronically controlled. The new generation of PWM drives are all microprocessor based. Although well shielded from stray noise, they require careful wire routing, and in some cases shielded wire runs to avoid “nuisance” problems. Control wires should be run separate from power leads. If they must cross, try to keep them at right angles to minimize the induced electric fields (noise).

A drive creates noise on the power system. Although we use line reactors to minimize system disturbances, a drive will create harmonics on the power/system (both at the motor and at the transformer). If sensitive computer systems are to be utilized, they should be isolated from the drive’s source, or EMI/RFI filters added. Likewise, the harmonics created at the motor may cause the motor to run hotter than expected. Standard motors should be derated 10% when used with a drive. We recommend high efficiency motors for drive applications as a minimum. See motor application data, SH, page G3.

A drive must have short circuit protection. Since a drive is subjected to higher available short circuit currents in an MCC, (vs. a wall mounted unit) additional components such as current limiting fuses and reactors are utilized. See typical one line sketch.

A drive can provide significant energy savings. When a fan or pump is utilized on a system with variable flow rates, whether measured in gallons per minute or cubic feet of cooling air per minute, a variable speed drive is the most efficient means of control. Since a variable torque load requires significantly less energy when operated at lower speed, the energy savings can be in the 25 to 50% range when compared to a full voltage motor using dampers or valving to reduce its output. (The amount of savings depends, of course, on the amount of time the motor can be used at the reduced speed.) It will also lower demand charges due to reduced motor starting current.

Line reactors
The available power source connected to the Drive is not to exceed 500kVA. If the AC power source is greater than 500kVA and the Drives rating (HP) is less than 10% of the power source's kVA; AC line reactors will have to be installed in L1, L2, and L3 power leads of the Drive. We provide 3% Line reactors as standard but they can be deleted as an option. The drive internally has a DC reactor, which will protect the drive components.

Load filters
IGBT drives create voltage spikes at the motor. Motor insulation rating must be higher than these peaks. Motor should meet NEMA MGI part 31. If not, load filters may be required. Refer to page G4.

Adjustable speed drives
FC 102 and FC 302 Series

Adjustable frequency drive
The FC 102 VFD is an AC packaged drive that provides the functionality required for variable torque loads such as fans, pumps and compressors. Forward/Reverse and Simple commands from the local or remote keypad or from the facility management system, along with pre-loaded motor parameters and factory defaults, allow for quick and readyto- go installation.

The E9000 offers expanded horsepower ratings in 230Vac (1/4 to 50Hp), 460Vac (1/2 to 500Hp) and 575Vac (1-500Hp) for even greater range of application. The FC 302 Adjustable Frequency Drive with flux vector and dynamic torque-vector control using optimized control of voltage and current vectors provides the enhanced performance that you are looking for in your application. The FC 302 process control systems will make any task simple and profitable. In addition, by adding an optional (encoder) speed feedback device, this drive can be configured to operate in a flux vector control mode. The FC 302 provides flexibility across a wide range of constant torque applications.

The FC 102 and FC 302 series have an array of functions that provides significant benefits. Standard features include: auto-tuning without having to rotate the motor, built in PID control, rotating motor pick up control (catch spinning motor), Standard RS485 (Modbus RTU), Metasys or Apogee FLN P1 Communications, automatic energy-saving operation (which minimizes drive and motor loss at light load) and other functions to combine performance and energy savings.

The new generation IGBT means reduced electrical noise and less voltage spiking. On-line-tuning provides a continuous check for variation of motor characteristics during running of high-precision speed control. All drives conform with the following safety standards: UL, cUL, CE and C-Tick.

—
FC 102 & FC 302 VFD's

Adjustable speed drives

Standard specifications FC 102 and FC 302 (continued)

Process PID differential time	0.0 - 10 s
Process PID differential gain	1.0-50.00
On reference bandwidth	0-200%
Operation Operation method	Keypad operation: Hand, Off, Auto Digital Input: Programmable for Start/Stop, Forward/Reverse, Jog Timer operation: Stop after predetermined time frame. USB Port for programming drive with optional PC Software
Frequency reference signal	Left or Right Arrow buttons on keypad in Manual Mode Speed Potentiometer: 0 to +10 Vdc, 10 to 0 Vdc, 0- 10Vdc analog input 0/4-20ma analog input
References	Up to 3 Input References can be selected from Analog Input #1 or #2, Frequency Input #1 or #2, Network, or Potentiometer
Input signals	Signals 6 - Digital Inputs, 24 Vdc PNP or NPN, 1 - Safe Stop Digital Input suitable for category 3 installations to meet EN-954-1, 2 - Pulse Inputs rated to 110kHz or 1 - Pulse Input and 1 - Encoder Input 24 Vdc rated to 4096 PPR 2 - Analog Inputs -10 to +10V scalable or 0/4 to 20 mA scalable. Digital Input Settings: No Operation, Reset after drive trip or alarm, Drive at stop with no holding current, Quick Stop according to Quick Stop Decel Time 1, Stop on input going low, Start, Maintained Start after signal applied for Minimum of 2ms, Reversing, Start Reverse, Enable Start Forward only, Enable Start Reverse only, Jog, Multi-Step Frequency selection (1 to 8 Steps), Hold Drive Frequency, Hold Reference, Speed Up; activated by Hold Drive Frequency, or Hold Reference, Slow Down; activated by Hold Drive Frequency or Hold Reference, Drive Parameter Setup Select 1-4 Precise Start or Stop; Activated when drive parameter, precise start or stop function is selected, Catch Up or Slow Down; Activated by signal to add to or subtract from input reference to control speed,Pulse Input selectable from 100 - 110000Hz, Accel / Decel Time select. Set Input to Accel / Decel Times 1 to 4, Digital Potentiometer Input Increase or Decrease, Mechanical Brake Feedback.
Output signals	2 - Digital Outputs 24 Vdc (Digital Outputs are used in place of 2 of the Digital Inputs), 2 - Form C Relays rated to 2A at 240 Vac, 1 - Analog Output 0/4 to 20mA, Relay Output Settings : No Operation, Control Ready, Drive Ready, Drive Ready in Remote, Standby No Drive Warnings, Drive Running, Drive Running No Drive Warnings, Drive Running on Remote, Alarm, Alarm or Warning, At Torque Limit, Out of Current Range, Below Current, Above Current, Out of Speed Range, Below Speed, Above Speed, Out of Feedback Range, Below Feedback, Above Feedback, Thermal Overload Warning, Reverse, Bus OK, Torque Limit and Stopped, Brake and no Warning, Brake Ready and No Faults, Brake Chopper Fault, External Interlock, Out of External Reference Range, Below External Reference, Above External Reference, Fieldbus Controlling Drive, No Alarm, Running in Reverse, Local Mode Active, Remote Mode Active, Start Command Active, Hand Mode Active, Auto Mode Active
Protective functions	Line Phase Loss, DC Overvoltage, DC Undervoltage, Drive Overload, Motor Overtemperature, Motor Thermistor Overtemperature, Torque Limit, Overcurrent, Ground Fault, Short Circuit, Control Word Timeout, Brake Resistor Short-Circuited, Brake Chopper Short-Circuited, Brake Check, DC Link Voltage High, DC Link Voltage Low, Internal Fan Fault, External Fan Fault, Power Board Overtemperature, Missing U Phase, Missing V Phase, Missing W Phase, Internal Fault, Control Voltage Fault, Auto Tune Check - Wrong Motor Parameters, Auto Tune Low Inom - Motor current is too low, Current Limit, Mechanical Brake Low, Drive Initialized to Default Value, Keypad Error, No Motor, Soft Charge Fault, Auto Tuning Fault, Serial Comms Bus Fault, Hardware Mismatch, Speed Limit.
Keypad Keypad features	LCD Display with 6 Alpha-numeric lines. Multi-Language Support, Hot Pluggable, Remote Mount Option, and CopyCat Feature, IP65 rating when remote mounted on enclosure, LED's - Green - drive is on, Yellow - indicates a warning, Red - indicates an alarm, Amber - Indicates active Menu keys and H-O-A keys
Keypad keys	Status - shows status of drive, Quick Menu - Enters Quick Start, Parameter Data Check or Trending Modes, Main Menu - Used for programming all drive parameters, Alarm Log - Used to display Alarm list, Back - Reverts to previous step or layer in parameter,structure, Cancel - Used to cancel last change or command, Info - Displays information about a command arameter, or function in any display. Hand/Off/Auto - Used to control drive locally or put drive in remote mode, Reset - Used to reset Warnings or Alarms.
Password	2 Level Password Protection
Alternate motor parameters	Up to 4 Separate complete parameter set-ups are available
Graphical trending	Trend Speed, Power, Frequency or any value programmed in status display
RS485 modbus RTU serial communications Physical Level	EIA/RS485
Transmission distance	1640 ft (500m)
Node address	32
Transmission speed	2400, 4800, 9600, 19200, 38400,or 115200 (bits/s)
Transmission mode	Half Duplex
Transmission protocol	Modbus RTU
Character code	Binary
Character length	8 Bits
Error check	CRC
Special AF650 FP modes	
Fire override mode	Overrides drive's protective features and keeps motor running
Pump cascade controller	Distributes running hours evenly over up to 4 pumps.
Sleep mode	Drive detects low or no flow conditions and adjusts output
Dry pump detection	Detects pump operation and can set off alarm, shuts off, or other programmed actions
Belt monitoring	Drive can detect relationship between current and speed to recognize a broken belt

FC 102 and FC 302 Standard options

Line reactor	3% Reactor is standard with the drive
DC link reactors	Standard with drive
Class AFII RFI	Standard with drive
Speed control	The unit comes with a Keypad that can be used for Speed adjustment.
Outputs relays	Drive come standard with two relays form C rated to 2A at 240 VAC.
Outputs analog	Drive comes standard with 1 Analog output 0/4-20mA
Outputs digital	Drive comes standard with 2 Digital outputs at 24 VDC (Digital Outputs are used in place of the 2 Digital inputs.
Communications	Drive RS-485, Modbus RTU, Metasys N2, or Apogee FLN P1

FC 102 and FC 302 Additional options

Line reactor	5% Reactor must be requested and priced
Speed control	Door mounted potentiometer must be requested and priced.
Communication module Profibus	Profibus DP internal mounted module **for use on FC 102 and FC 302.** Supports Profibus DP V1 communications networks.
DeviceNet	DeviceNet internal mounted module **for use on FC 302 and FC 102.** ODVA certified device.
Ethernet IP	Ethernet IP internal mounted module **for use on FC 302 and FC 102.** ODVA certified device. Features 2-Port built-in switch. Also includes webserver and email notification. 1Requires I/O and network slots and cannot be used with any other network or I/O modules
Modbus TCP	Modbus TCP internal mounted module **for use on FC 302 and FC 102.**
ProfiNet RT	ProfiNet RT internal mounted module **for use on FC 302 and FC 102.**
LonWorks	LonWorks internal mounted module **for use on FC 102 drives only.** Supports LonWorks building automation communications networks
BacNet	BacNet internal mounted module **for use on FC 102 drives only.** Supports BacNet MSTP building automation communications networks.
Relay output	Relay Output internal mounted module **for use on the FC 302 and FC 102.** Module adds (3) Form C relay outputs to the drive. Relays are rated at 2A at 240V resistive load.
Analog I/O	Analog I/O internal mounted module **for use on the FC 102 drive only.** Module Includes: 3 - Analog Inputs 0-10V, 0/4-20mA and 3 - Analog Outputs 0-10V,Battery Back-Up power for FC 102's internal Real Time Clock
24V DC external supply	24V DC External Supply internal mounted module **for use on the FC 302 and FC 102 drives.** This module accepts an external 24V DC supply which is used to keep the control board of the drive and other option modules powered in the event of a Line side power outage. Can be used with Communications and I/O Modules.
General purpose I/O	General Purpose I/O internal mounted module **for use on FC 302 and FC 102 drives.** Module includes: 3 - 24V Digital Inputs, 2 - PNP/NPN Digital Outputs, 2 - 0-10V Analog Inputs and 1 - 0/4-20mA Analog Output
Encoder	Encoder internal mounted module for **use on the FC 302.** Module supports all 5V incremental encoders. Also supports Hyperface SinCos encoders.
Resolver	Resolver internal mounted module **for use on the FC 302 drive.** Module supports 4-8Vrms, 2.5kHz - 15kHz, 50mA resolvers. Resolution is 10bit at 4Vrms.
Safe PLC I/O	Safe PLC I/O internal drive mounted module **for use on the FC 302 drive.** This module provides a safety input based on a single pole 24V DC input.

Adjustable speed drives

Space height and assembly

FC 102 and FC 302 space height, 42 kAIC

Function	Plug-Ini	Max HP GP/FP CT/VT @					Disconnect	Section 1		Section 2	
		208V	230/240V	380/415V	440/480V	575/600V		Width	X height	Width	X height
Basic ,LR, bypass and isolation	•	5/5	5/5	3/3	5/5		SELI, SELT	15	2.5		
	•			5/7.5	10/10		SELI, SELT	15	3		
	•	10/15	10/15	15/15	20/25		SELI, SELT	15	4		
		25/40	25/40	40/60	60/60		SELI, SELT	24	4		
					/75		SELI, SELT	24	5.5		
		40/	40/				SELI, SELT	30	5.5		
		50/60	50/60				SFLI, SFLT	30	5.5		
				75/	75/		SELI, SELT	24	5.5	15	1.5
				/75	100/125		SFLI, SFLT	24	5.5	15	1.5
				100/125	150/200		SGLI. SGLT	30	5.5	24	1.5
				200/250	300/		SGLI. SGLT	30	5.5	30	4.5

1. Section 2 will always be on the left and bottom mounted. All Space height is based on all main bus sizes.
2. When line reactors are not required consult factory for dimensions.
3. Pilot devices may impact the X height on certain plug-in HPs

Minimum UL short-circuit rating 42KAIC@ 480V

FC 102 and FC 302 space height, 65 kAIC

Function	Plug-in	Max HP GP/FP CT/VT @					Disconnect	Section 1		Section 2	
		208V	230/240V	380/415V	440/480V	575/600V		Width	X height [3]	Width	X height [1]
Basic and LR	•	3/3	3/3	3/3	5/5		SELI, SELT	15	2		
	•					10/10	SELI, SELT, TECL	15	2		
	•	10/15	10/15	15/15	20/25		SELI, SELT	15	3		
	•					20/25	SELI, SELT, TECL	15	3		
	•	15/20	15/20	30/30	40/50		SELI, SELT	15	4		
	•					40/50	SELI, SELT, TECL	15	4		
		25/40	24/40	40/60	60/75		SELI, SELT	24	4		
						60/75	SELI, SELT, TECL	24	4		
		40/	40/	75/			SELI, SELT	24	4.5		
				/75	100/125		SFLI, SFLT	24	4.5		
						75/100	SELI, SELT, TECL	24	4.5		
				100/	150/		SFLI, SFLT	30	5.5		
				200/250	300/350		SGLI, SGLT	30	5.5	20	3
				350/350	500/500		SKLI, SKLT	30	6	24	6
						500/500	SGLI, SGLT	30	6	24	3.5

1. Section 2 will always be on the left and bottom mounted. All Space height is based on all main bus sizes.
2. When line reactors are not required consult factory for dimensions.
3. Pilot devices may impact the X height on certain plug-in HPs

Minimum UL short-circuit rating 65KAIC@ 480V
Minimum UL short-circuit rating 65KAIC @ 600V for all buckets rated 575/600 V

Adjustable speed drives

Space height and assembly

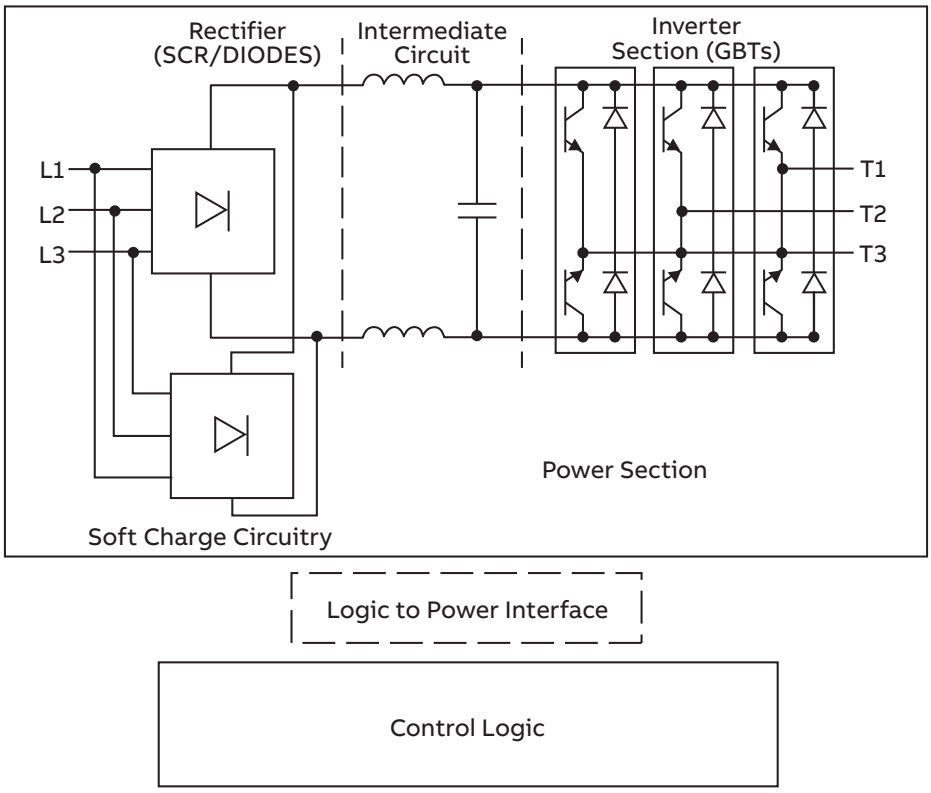
FC 102 and FC 302 space height, 100 kAIC

Function	Plug-In	Max HP GP/FP CT/VT @				Disconnect	Section 1		Section 2	
		208V	230/240V	380/415V	440/480V		Width	X Height[3]	Width	X Height[1]
Basic, LR, Bypass with J-Fuse (2)	X	5/5	5/5	3/3	5/5	SEPI, SEPT	15	2.5		
	X			5/7.5	10/10	SEPI, SEPT	15	3		
	X	15/20	15/20	30/30	40/50	SEPI, SEPT	15	4		
		40/	40/			SEPI, SEPT	30	5.5		
		50/60	50/60			SFPI, SFPT	30	5.5		
				75/	75/	SEPI, SEPT	24	5.5	15	1.5
					100/125	SFPI, SFPT	24	5.5	15	1.5
				100/125	150/200	SGPI, SGPT	36	4.5	15	3
				200/250	300/350	SGPI, SGPT	36	5.5	30	4.5

1. Section 2 will always be on the left and bottom mounted. All Space height is based on all main bus sizes.
2. When line reactors are not required consult factory for dimensions.
3. Pilot devices may impact the X height on certain plug-in HPs

Minimum UL short-circuit rating 100KAIC@ 480V

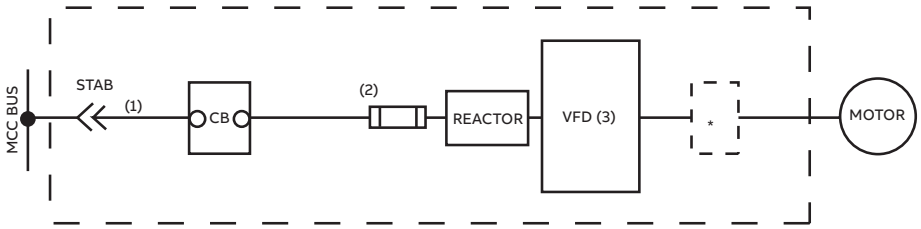
Six pulse VFD generic block diagram



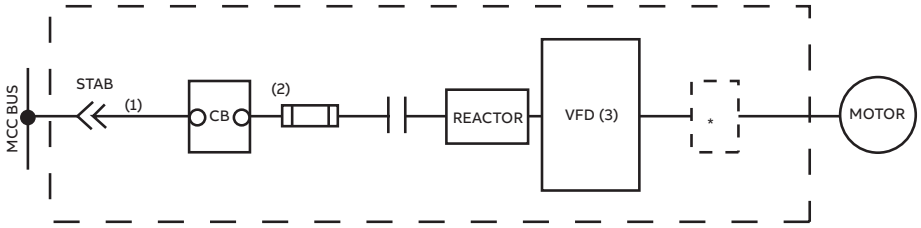
Adjustable speed drives

Drive configuration in motor control center construction
circuit breaker or fusible switch required for disconnect

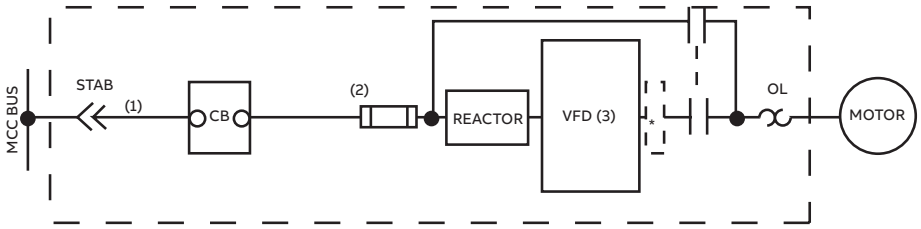
STANDARD VFD



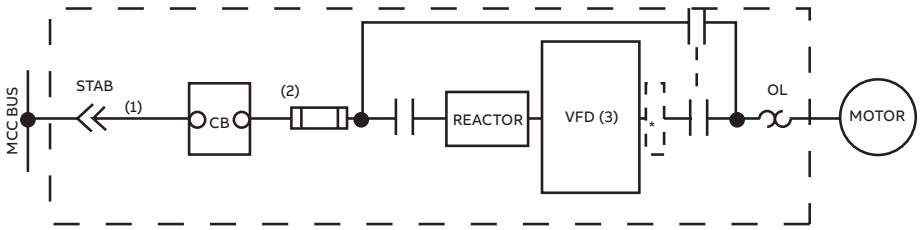
VFD WITH
LINE ISOLATION



VFD WITH
BYPASS FEATURE



VFD WITH
LINE ISOLATION
PLUS BYPASS FEATURE



1. Drawout breaker through 600A
2. J Fuse as required
3. DC link reactor (choke) included in drive

* Load filter option

Adjustable speed drives
Harmonic filters

ABB offers two basic filter types in MCC construction: Matrix and Dynamic Current Injection. Consult factory for sizing.

Matrix Harmonic Filters provide broadband reduction of harmonics. They not only offer better performance over other broadband filtering and 12- and 18-pulse harmonic reduction techniques, they also are suitable for a wider range of applications. Matrix Harmonic Filters can be installed in either variable or constant torque drive applications and can be applied on either a six pulse or half-controlled rectifier. For applications other than variable torque, contact the factory for filter selection.

Matrix Harmonic Filters enable most AC drive systems to comply with the voltage and current distortion limits outlined in IEEE 519. A complete harmonic analysis and product selection tool is available at **www.gedigitalenergy.com**.
Select Digital Energy > HV/MV Equipment > Capacitors > LV Power Factor Correction > Matrix Harmonic Filter or simply use this “link”.

Matrix Harmonic Filters are multi-stage low pass filters specially configured to avoid the attraction of harmonics from other sources on a shared power system. They will not cause power system resonance. However, the configuration of the filter requires that only drives or equivalent loads be loaded on the output. One filter can be used with multiple drives, but if there is a drive bypass circuit, there must be one filter per drive and the filter and drive combination must
be bypassed.

GEMActive Dynamic Current Injection Filters for harmonic cancellation and power factor correction:
- Reduce harmonics for IEEE 519 (1992) standard compliance
- Decrease harmonic related overheating of cables, switchgear and transformers
- Reduce downtime caused by nuisance thermal tripping of protective devices
- Increase electrical network reliability and reduce operating costs
- Compensate each phase independently
- Are UL approved
- Offer parallel connection for easy retrofit and installation of multiple units for large networks
- Filter to the 50th order harmonic
- Filter entire network or specific loads depending on installation point
- Respond to load fluctuations in 40 microseconds with 8 milliseconds for full response to step load changes
- Feature IGBT based power electronic technology
- Come in 50, and 100A models for 208-480V, 50/60 Hz, three phase networks that can be paralleled to match load requirements

GEMActive reduces problematic harmonic levels and provides instantaneous power factor correction. Cost savings result from reduced downtime and maintenance. In addition, over-sizing of distribution equipment to provide for harmonics and poor power factor can be avoided.

GEMActive dynamically corrects power quality by providing: Active Harmonic Filtration, Resonance Prevention, Power Factor Correction and Dynamic VAR Compensation

Adjustable speed drives

Motor application data

Harmonic derating

AC motors have traditionally been applied as constant speed motors, so there is little published information on reduced speed efficiencies, especially when operated with a non-sinusoidal supply such as an inverter. The harmonics present in the PWM inverter output increase motor losses and thus motor heating. Energy Saver motors, designed for high efficiency and improved thermal characteristics, may be applied at nameplate rating for variable torque duty, such as centrifugal fans and pumps, for 4 and 6 pole ratings. Standard AC motors designed for 60 Hertz operation should be derated 10% for variable torque duty. For constant torque applications, Energy Saver and standard design motors should be applied per Figure 7.
For other applications refer to the Company.

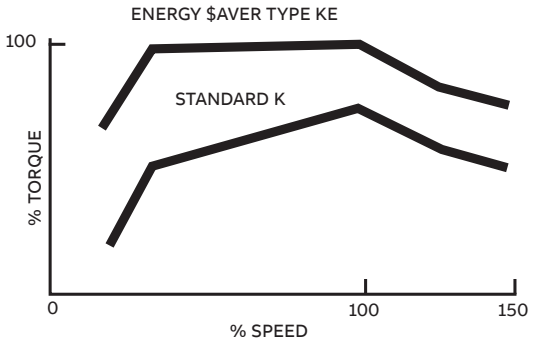
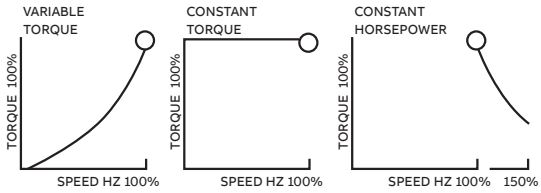


Figure 7

How to select drives

1. Types of load

In selecting inverters, load patterns of machines should be known in advance. Generally, loads can be categorized into the three types shown below. Estimate or obtain the point marked 0 as indicated. This defines maximum torque and the maximum or minimum speed requirement of the driven equipment. Calculate the required motor HP by substituting the maximum torque and rated motor base speed in equation (1).



$$(1) HP = \frac{TXN}{5250}$$

HP = Required HP
T = Torque in lb./ft.
N = Speed in RPM

Select the proper motor using the data from motor application brochures, identify the motor full load current and select the inverter which meets or exceeds the motor full load current requirements.

2. Motor speed range

Motor synchronous speed is determined by the following equation:

$$\text{Sync. Motor Speed} = \frac{120 \times \text{Applied Frequency}}{\text{Number of Motor Poles}}$$

Induction motors operate at a somewhat slower speed than synchronous speed due to slip, which is generally 2-3 percent of synchronous speed.

If the application requirements call for higher or lower speeds than can be obtained by using standard motors following these application guidelines, gear increasers or reducers should be considered.

3. Multi motor drives

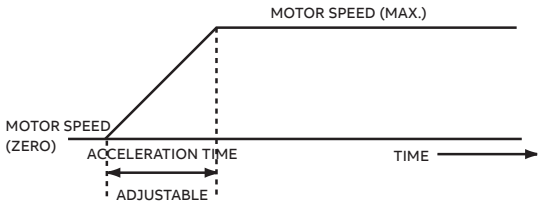
Multiple motors can be driven simultaneously by one drive unit. In order to select the proper inverter, total the individual motor full load currents and multiply the sum by a factor of 1.1. Select the inverter than can deliver the total current calculated. Each motor will require individual overload relays, when switched independently RTF.

4. Acceleration time
Acceleration time is programmable. If the programmed setting calls for a faster acceleration than the drive system is capable of, the unit may trip due to an overcurrent condition. Therefore, the actual time to accelerate the driven load should be calculated using the following equation and the acceleration time setting should be adjusted accordingly.

$$TA = \frac{(Wk^2 \times \Delta N)}{308\ (T \times 1.2)}$$

Where:
TA = Time to accelerate the driven load (in seconds).
ΔN = Change in speed (in RPM)
WK2 = The total system inertia reflected to the motor shaft. Includes motor, machine gears (in ft./lbs.2)
T = Motor full load torque (lb./ft.)

When using a drive in a conventional constant speed machine application where a full voltage starter has been used, the acceleration time should be set longer than the original machine. This is because the maximum allowable current that the FC 302 drive can deliver is 150 percent of rated current, while full voltage starters deliver 600-800 percent. This means that the drive delivers a “soft start” and thus reduces starting torque over that of a full voltage starter, which naturally yields a longer acceleration time.



Adjustable speed drives

How to select drives (cont.)
5. Deceleration Time
Deceleration time is programmable. If the programmed setting calls for faster deceleration than the drive system is capable of, the unit may trip due to an overvoltage or overcurrent condition. Therefore, the actual time required to decelerate the driven load should be calculated using the following equation and the deceleration time setting should be adjusted accordingly.

$$TD = \frac{(Wk^2 \times \Delta N)}{308\ (T \times .2)}$$

Where:
TD = Time to decelerate the driven load (in seconds).
ΔN = Change in speed (in RPM)
Wk2 = The total system inertia reflected to the motor Shaft. Includes motor, machine gears (in ft./lbs.2)
T = Motor full load torque (lb./ft.)

If faster deceleration is required, refer to the Company.

Cable and motor considerations for drives
A primary concern in recent years has been for wiring between adjustable speed drives and motors. This is because voltage spiking, seen at the motor terminals at the switching frequency can cause damage to the motor insulation. This spiking depends on several factors such as drive input voltage level, drive output wave-form dv/dt, length of the cabling from the drive to the motor and characteristics of the cabling used, etc. In addition, there are secondary effects related to drive/motor wiring that impact performance such as parasitic capacitance.

Drive input voltage, motor insulation and cable length are beyond the scope of the drive design. The following guidelines were compiled for your convenience.

System filtering
The use of a properly sized filter can reduce the voltage peaks and rise times seen at the motor. The filter must be properly sized and located. If the filtering is done with reactors it must be placed close to the motor terminals. If the filtering is with LRC (Inductance, Resistance and Capacitance) it must be placed at the output terminals of the drive.

Application consideration for drives:

Max. cable lengths between drive and motor without filters

Motor insulation level	1000V	1300V	1600V
FC 302 and FC 102 460V Input	49 ft. (15M)	984 ft. (300M)	984 ft. (300M)
FC 302 and FC 102 230V Input	984 ft. (300M)	984 ft. (300M)	984 ft. (300M)

- PWM IGBT drives are not typically recommended with 1000Vac insulation Motors
- Load filters are recommended from 984 ft. when motor insulation level is 1300V or above
- Custom motors are available for applications not listed
- Contact motor manufacturer or your ABB sales representative

Peak voltage insulation rating (horizontal, 60 Hzonly)

Frame	ODP-KE	TEFC-KE	XSD-KS	XSD-IEEE841-KS	ASD-KAF
140	1000V P-P	1000V P-P	1300V P-P	1600V P-P	1600V P-P
180	1000V P-P	1000V P-P	1300V P-P	1600V P-P	1600V P-P
210	1000V P-P	1000V P-P	1300V P-P	1600V P-P	1600V P-P
250	1000V P-P	1000V P-P	1300V P-P	1600V P-P	1600V P-P
280	1000V P-P	1000V P-P	1300V P-P	1600V P-P	1600V P-P
320	1300V P-P	1000V P-P	1300V P-P	1600V P-P	1600V P-P
360	1300V P-P	1000V P-P	1300V P-P	1600V P-P	1600V P-P
400	1300V P-P	1300V P-P	1300V P-P	1600V P-P	1600V P-P
440	1300V P-P	1300V P-P	1300V P-P	1600V P-P	1600V P-P
500	1300V P-P	1300V P-P	N/A	1600V P-P	1600V P-P

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ODP = Open-Dripproof, TEFC = Totally Enclosed Fan-Cooled, XSD = Extra Saver Duty, ASD = Adjustable Speed Drive

Caution: If existing motors are used, condition of insulation must be checked and manufacturers insulation rating as well. Load filters may be required.

ASTAT XT

Digital soft starters for 3ph standard induction motors

ASTAT XT solid state soft starter features microprocessor control digital technology. Setup and adjustment is performed through a six-button keypad and parameters or messages are displayed out trough a friendly LCD multilanguage interface with two rows, sixteen alphanumeric characters each. The design includes isolated I/O and high level of protection in their circuits to minimize the disturbance effects while working in the hardest industrial environment.

ASTAT XT soft starter offers reliable performance and smooth acceleration for a variety of standard AC motors up to 1400A and up to 690V, reducing mechanical shock to the driving system, resulting in extended component and motor life.

ASTAT XT offers many traditional features such a motor overload function, adjustable ramps, current limit, kick start, but also other high end features like Inside-Delta operation, Torque control, Pump control and a reliable motor and unit set of protections.

Key features

- Ratings up to 1400Amps and up to 690VAC;
- Friendly multilanguage interface with two rows, sixteen characters each;
- Built-in with three extra power terminals for external bypass;
- In-Line or Inside-Delta operation modes;
- Torque control and pump control advanced features;
- Motor protection according IEC 10, 20 and NEMA 10, 20, 30, even if ASTAT XT is in bypass;
- Built-in communications RS485 port, and ModBus protocol as standard;
- ProfibusDP and DeviceNet optional interfaces for communications.

For units up to 820A. “U” type.

—
ASTAT XT

—
ASTAT XT Control Panel

ASTAT XT

Technical data

Ratings	
Main voltage 3ph AC supply	230 to 500Vac +10%, -15% for QT1xxx units 460 to 600Vac +10%, -15% for QT2xxx units 690Vac +10%, -15% for QT3xxx units
Starter current rating 3ph AC motors	From 8A up to 1400A
Motor current rating 3ph Induction motors	Motor rated current from 50% to 100% of starter current
Control voltage 1ph AC supply	230VAC, +10, -15%, 50/60Hz or 110VAC, +10, -15%, 50/60Hz (optional)
Frequency range 50/60Hz systems	Wide from 45Hz to 65Hz. Auto-tracking frequency range
Digital inputs voltage	90-230Vac, +10 -15%, 50/60Hz or 24Vdc, +10%, -15% (optional)
Control specifications	
Control system	Digital control with microcontroller. Starting ramp, with progressive increase in voltage and current limitation.
Operation mode	In-Line (three wires) or Inside-Delta (six wires) of the motor
Run operation	Soft Start and Soft stop by multiple choices, including torque control both at start or Stop phases
Operator interface	By LCD display, keypad and Indication LEDs Display: LCD with two rows, 16 characters each Type: Multilanguage, dip-switch selectable for English, Italian, Spanish and German Keys: Six keys, Mode, reset, Set, Select and Up / Down LEDs: ON, Start, Run, Soft Stop, Stop, Save / Slow Speed, Dual Set / Reverse and Fault
Initial voltage	10-50% Un. Up to 80% with expanded settings function
Starting current	100-400% In. Can be extended up to 500%, by using extended settings
Acceleration ramp time	1-30 sec. Can be extended up to 90 sec, by using extended settings
Deceleration ramp time	1-30 sec. Can be extended up to 90 sec, by using extended settings
Current limitation	100-400% of motor rated current. Can be extended up to 500% by using extended settings
Bypass	By external contactor while motor is full protected by ASTAT XT
Monitoring	Motor current, line voltage, motor thermistor resistance, test and maintenance and statistics
Environmental conditions	
Operating temperature	-10°C up to 60ºC, with current derating by 2.5% per °C, from 50ºC
Storage temperature	-20ºC up to 70ºC
Maximum altitude	Up to 1000 mts. Ask your dealed for installation at higher altitude
Humidity	95% at 50ºC or 98% at 45ºC
Protection degree	IP20 for units up to 72A, IP00 for units from 85A up to 1400A
Pollution degree	Class 3
Standards	
Global standards	CE for the full trange. UL, cUL for specifi ed units up to 820A
EMC emissions	EN 61000-6-4 CISPR 11 Class A
Immunity	EN 61000-6-2 ESD 8KV air, IEC 801-2; Electric RF fi eld 10 V/m, 20-1000Mhz, IEC 801-3; Fast transients 2KV, IEC 801-4
Safety	EN 600947-1 Related to safety requirements; UL508C

ASTAT XT
Functions

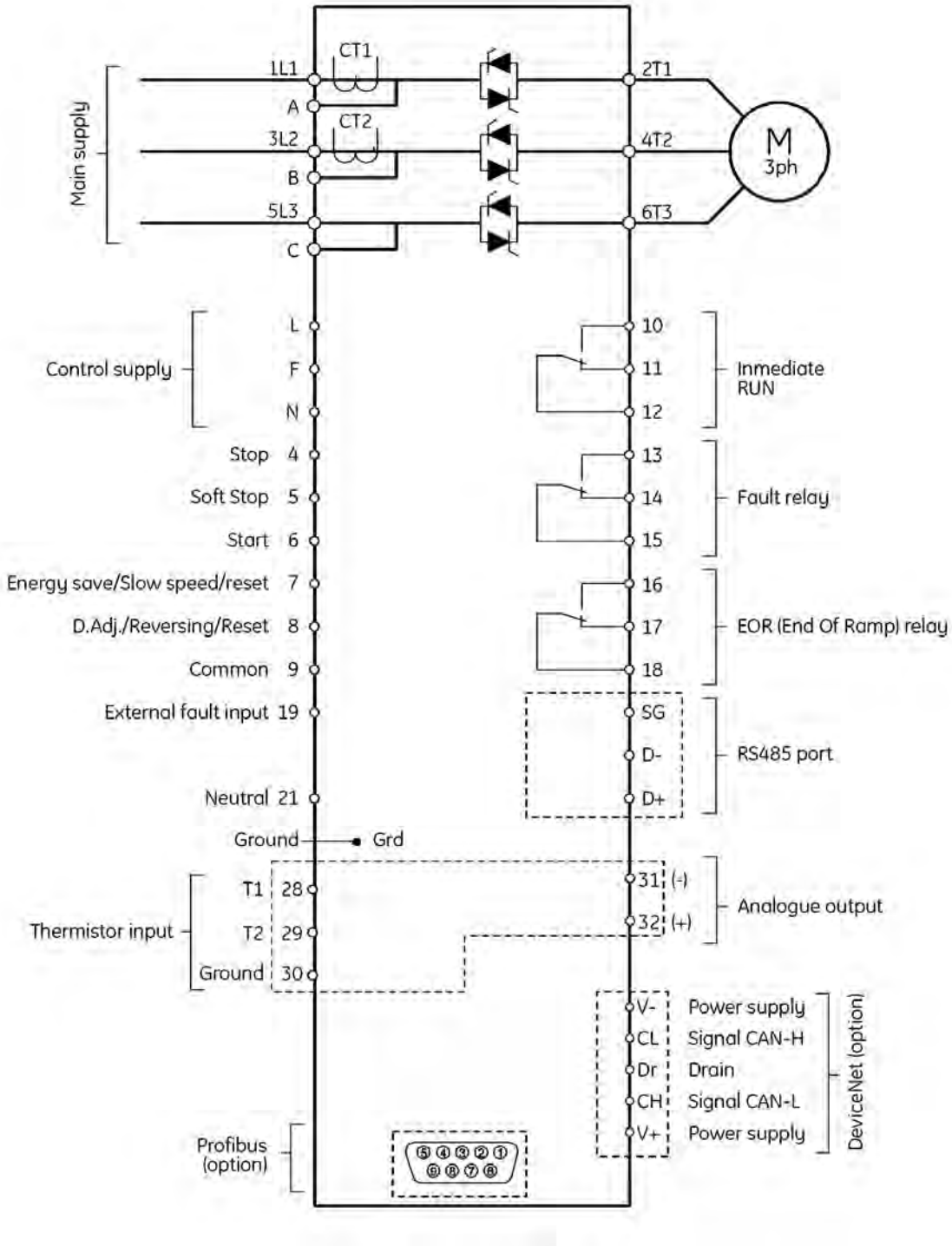
Available Standard Functions	
Soft Start and Soft Stop	ASTAT XT is provided with a soft start and soft stop features, including fi ve independent acceleration and decelertaion curve models. The factory default curve is used for general purpose, other three are used for pump control and the last one for torque control.
Pump Control	Specific function for pump control, that avoids overpressure in the system at the end of acceleration phase and suppresses the hammering at stopping phase.
Torque Control	Provides a smoth time controlled torque ramp acceleration and deceleration, with linear deceleration of the torque resulting in a close to linear speed deceleration, thus eliminating stall conditions.
In Line / Inside Delta	ASTAT XT allows either traditional Line operation or Inside Delta operation. When the ASTAT XT is installed to operate Inside Delta, the individual phases of the starter are connected in series with the individual motor windings (six wiring connections like the Start-Delta starters), thus reducing the current x1.73, and allowing the use of a much smaller starter (x1.5 less than motor rated current).
Bypass	ASTAT XT allows bypass operation using an external contactor, controlled ON/OFF by starter function EOR (End Of Ramp).The starter is provided with three dedicated power terminals to facilitate wirings to the bypass contactor. ASTAT XT protections to motor are enabled, even in bypass.
Kick Start	This function allows to start high friction loads that require high starting torque for a short period of time. When this function is enabled, a pulse of 80% Un during an adjustable time from 0 to 1 sec. is given to the motor. After this pulse the output voltage is ramping down to starting voltage setting, before ramping up again to full voltage.
End of Ramp	Detects end of acceleration and outputs a signal by a dry relay contact. This signal can be delayed by an adjustable timer from 0-120 sec.
Lock-out	Allows to control the number of startings into a period of time, then protecting both motor and ASTAT.
Dual Settings	By this function, ASTAT XT is able to control a secondary motor dual setting of starting voltage, starting current, durrent limit, ramp up, ramp down and motor current parameters can be selected by using one of the programmable ASTAT XT inputs.
Energy Saving	Activated when the motor has a light load for extended periods of time, then reducing the output voltage level and decreasing the reactive current and motor copper/iron losses. This function can be enabled or disabled by dedicated parameters in ASTAT XT.
Slow Speed	Function that allows the motor to run at 1/6 constant rated speed, for a short period of time of maximum 30 sec. This function supports forward and reverse operation.
Auto Reset	This function allows the ASTAT XT automatic recover after a fault caused by undervoltage, undercurrent or phase lost. Auto-reset can be programed up to maximum 10 attempts.
Cooling Fan Control	Allows three methods of control for the ASTAT´s built-in cooling fans: — Continuous operation — Controlled by an external input — Automatically OFF controlled, after five minutes ASTAT XT is stopped
Generator Supply	This is a specific function useful when the starter is powered from a diesel generator rather than from commercial power supply. The function is enabled by an internal dip switch, and helps to minimize the negative effects caused by the generator´s voltage fluctuations during starting.
Keypad Lock	This function is enabled by means of starter´s internal dip switch, then locking the keypad. This is usefull to prevent undesired parameter modifications.
Built-in Communications	ASTAT XT includes a ModBus RTU communications protocol. Communications are carried out through a half duplex RS485 port, with maximum baud rate of 9600, supporting up to 247 stations.
Statistic Data	ASTAT XT records useful data for maintenance and start up: — Last 10 trip events. — Statistical data like number of starts, number of trip events and elapsed RUN time. — Last trip data information of motor current, starting current and acceleration time.

ASTAT XT (continued)

Functions

Motor and Starter Protection	
Overload	Digital control with microcontroller. Starting ramp with progressive increase in voltage and current limitation.
Motor Thermistor	In-Line (three wires) or Inside-Delta (six wires) of the motor.
Too Many Starts	Soft start and soft stop by multiple choices, including torque control both at start or stop phases.
Long Start Time	Trips if output voltage does not reach rated voltage at the preset maximum start time.
O/C JAM Fault	Trips under the following conditions: — Instantaneously when current exceeds 8.5 x ASTAT XT current — During starting when current exceeds 8.5 x motor current — During running when current exceeds 200-850% of motor current, O/C JAM has a programmable triping delay of 0-5 sec.
Undercurrent	Trips when line current drops below the preset level for the preset time.
Undervoltage	Trips when line voltage drops below the preset level for the preset time.
Overvoltage	Trips when line voltage increases above a preset level for a preset time.
Phase loss	Trips if 1 or 2 phases are lost.
Frequency loss	Trips if frequency is not in the range of 40-66.6 Hz.
Phase sequence	Trips if line phase sequence is wrong.
Slow speed time	Trips when operating at slow speed for extended periods.
Wrong connection	Trips the ASTAT XT when one or more motor phases is not properly connected to ASTAT XT's load terminals or if there is an internal disconnection in the motor winding.
Shorted SCR	Trips and prevents starting if any SCR is short-circuited or when motor windings are shorted.
Over temperature	Heat-sink over-temperature. Trips the ASTAT XT when the heat-sink temperature rises above 85°C.
External fault	Trips the ASTAT XT when a NO contact between terminals 19-21 closes for over two seconds.
Wrong parameters	Parameters not transferred from RAM to EEPROM or vice versa.
OC or wrong CON	Trips when the ASTAT XT is connected Inside Delta and wrong connection or overcurrent is detected.

ASTAT XT
I/O Wiring, Basic Scheme

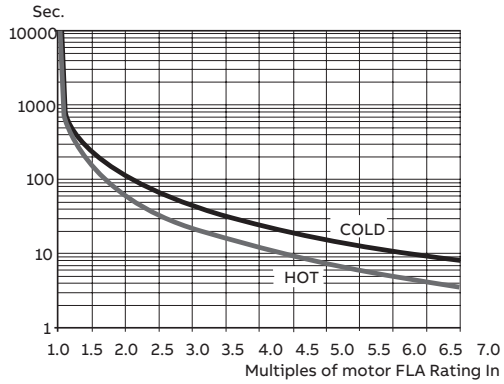


Note: Profibus or DeviceNet options cannot be ordered separately. For those communication networks, please order the ASTAT XT with the required option built-in.

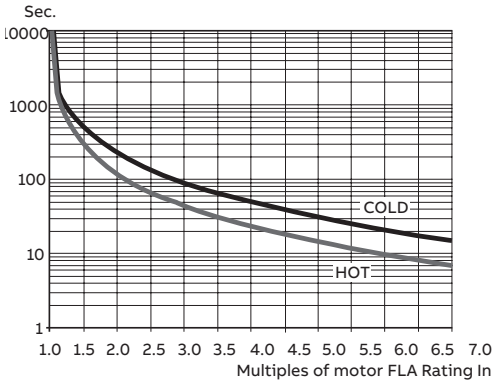
Overload protections
Thermal characteristics

The ASTAT XT allows motor protection according IEC Class 10 or Class 20 and NEMA 10, 20 or 30. User free selectable by ASTAT internal dedicated parameter.

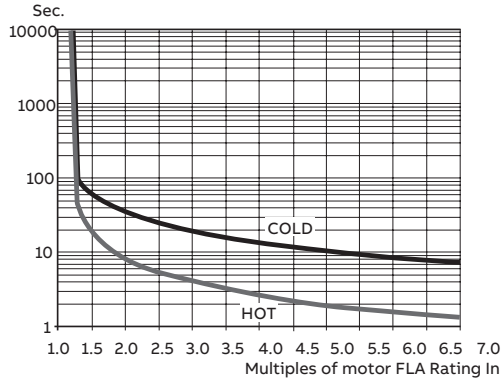
IEC Class 10



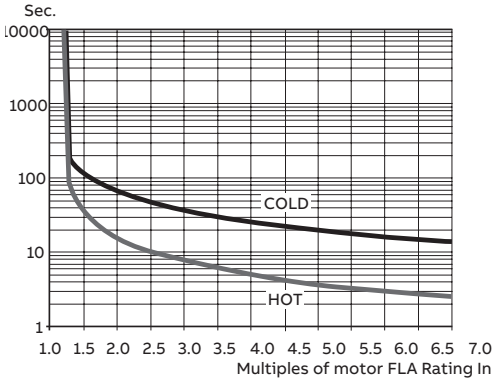
C Class 20



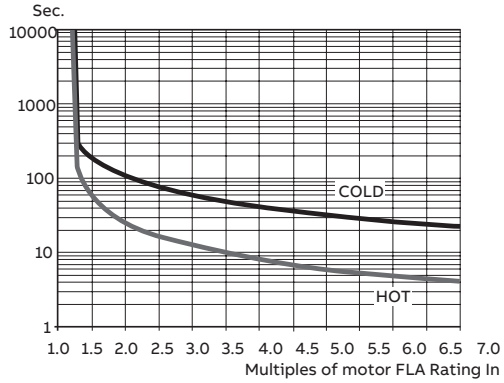
NEMA 10 Light Duty



EMA 20



NEMA 30



Maximum Number Starting/Hour

Starting Current I/In[1]	Ramp Time		
	10s	20s	30s
2	24	12	8
3	16	8	5
4	12	6	4

1. In= rated current of ASTAT XT in the specified class IEC/NEMA

ASTAT BP

Digital soft starters for 3ph AC induction motors
The ASTAT BP soft starter delivers reliable performance and smooth acceleration and deceleration on 3 phase AC induction motors from 8A-1100A at 208V-400V or 460V-600V. It reduces mechanical wear and tear on motors and also can reduce peak energy demands by limiting the current to motors at startup.

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ASTAT BP

Features
- Offers current and torque control
- Has multiple soft start and stop curves to meet a variety of applications
- Comes with built in NEMA Class 10, 20, 30 or IEC Class 10 or 20 overload
- Features full text programming

Ratings
- Current ratings
  - 8A, 17A, 31A, 44A, 58A, 72A, 85A, 105A, 145A, 170A, 210A, 240A, 310A, 360A, 414A, 477A, 515A, 590A, 720A, 840A, 960A, 1100A
- Line voltage
  - 3ph, 208V to 440V, 50/60Hz (QB1x)
    3ph, 460V to 600V, 50/60Hz (QB2x)
- Frequency range
  - 45Hz-65Hz, auto-tracking frequency range
- Control voltage
  - 120V or 240V, +10% / -15%
  (specified at through catalog number)

Environmental conditions
- Networks
  - Modbus RTU as standard
- Standards
  - UL and cUL
- Ambient Temperature
  - -10ºC to 50ºC
- Altitude
  - 3300ft or 1000m (consult factory)
- Protection degree
  - Open Chassis / IP20 to 44A,
    Open Chassis / IP00 58A and above

ASTAT BP

Technical data

General information	
Supply voltage	Line to line 208-600V (to be specified) + 10%-15%
Frequency	45 – 65 Hz (fixed or variable frequency source)
Control supply	Either 110VAC or 230VAC (to be specified) +10% - 15%
Control inputs	Either 90-230VAC - Must be the same as Control Supply
Load	Three phases, three/six wires, squirrel cage induction motor
Connection type	Standard 3 wire U, V, W connection, or 6 wire Inside Delta (programmable)
Rated insulation voltage	1,000V
Rated impulse voltage	4kV
Form designation	Form 1 (Bypassed Controller)
Start-stop parameters	
Starter current	ASTAT-BP's rated current according to its nameplate
Motor current	Motor Full Load Ampere of Starter Current
Start/stop curve 0 (standard)	2 standard starting and stopping curves
Pump control curves (1!, 2!, 3!)	6 field selectable curves preventing over-pressure during start and water hammer during stop
Torque control curve (4)	2 selectable curves preventing over-pressure during start and water hammer during stop. In addition, these curves may be used for torque control starting of constant torque applications
Kick start duration	A pulse of 80% Un, for an adj. time 0.1-1 Sec, for starting high friction loads
Starting voltage	10-50% Un (5-80%)
Initial current	100-400% In. A single current control starting curve. It appears when Starting Voltage is displayed, the up arrow is pressed and Starting Voltage has reached its max.
Current limit	100-700% of Motor Current
Ramp UP time	1-30 Sec (1-90 sec)
Ramp DOWN time	1-30 Sec (1-90 sec)
DUAL settings parameters	Secondary start stop characteristic for: Starting Voltage, Starting Current, Current Limit, Ramp UP, Ramp DOWN and Motor Current
Slow speed torque	Torque while motor is at 1/6 nominal speed
Motor protection	
Too many starts	Maximum number of starts, range: Off or 1-10, during a time period 1-60 min.
Starts inhibit	Time period 1-60 min, when starting is prevented, after too many starts fault
Long start time (stall protection)	Maximum allowable starting time 1-30 sec. (1-250 sec)
Over current (JAM Fault)	Three trip functions: 1. At all time If I > 850% of Starter Current (Ir) it trips the ASTAT-BP within 1 cycle (overrides the value of the O/C – JAM Delay setting). 2. At starting process If I > 850% of Motor Current it trips the ASTAT-BP after O/C JAM Delay (see here after) 3. At run time If I > O/C – JAM Fault setting of Im it trips the ASTAT-BP after O/C JAM Delay
Electronic overload	Can be set as IEC Class 10, 20 or NEMA Class 10, 20 or 30. Can be set to operate at all times, disabled or operate during Run only.
Under current	Trips when current drops below 20-90% of Motor Current, time delay 1-40 sec. Optional auto reset after time delay
Under voltage	Trips when main voltage drops below 50-90% of Line Voltage, time delay 1-10 sec. Optional Auto Reset.
Over voltage	4Trips when main voltage increase above 110-125% of Line Voltage, time delay 1-10 sec.
Phase loss, Under/over frequency	Trips when one or two phases are missing, or frequency is < 40Hz or > 65Hz. Optional auto reset.
Phase sequence	Trips when phase sequence is wrong
Long slow speed time	Trips if operating at slow speed TRQ for more than 1-30 sec (1-250 sec)
Wrong connection	Prevents starting, trips if motor is not connected / incorrectly connected to the ASTAT-BP (not active in D.Set: Generator Parameters)
Shorted SCR	Trips if one or more SCRs have been shorted (not active in D.Set: Generator Parameters)
Heat sink over temperature	Trips when heat-sink temperature rises above 85°C
External fault	Trips when an external contact closes for 2 sec.
Motor thermistor	Trip level setting 1-10K, trips when resistance decreases below the level set

ASTAT BP

Technical data (continued)

Control	
Displays	LCD in 4 – Field selectable languages and 8 LEDs
Keypad	6 keys for easy setting
Aux contact – programmable	1 NO, 8A, 250VAC, 2000VA
Fault contact	1 NO, 8A, 250VAC, 2000VA
Communication	RS 485 with Modbus protocol for full control and supervision
Communication (optional)	Profibus DPV1 for full control and supervision DeviceNett for full control and supervision
Temperatures operating	-10° to 60°C; For ambient temperature between 50°C and 60°C, derate the current by 2.5% for each °C that is above 50°C
Storage	-20° to 70°C
Standards	
Dielectric test	2500VAC
Degree of protection	IP 20 for QBx0008 - QBx0044 ; IP 00 for QBx0058 – QTx1100
Pollution degree	3
EMC emissions	EN 61000-6-4 CISPR 11 Class A
Immunity	EN 61000-6-2 ESD 8KV air, IEC 801-2; Electric RF field 10 V/m, 20-1000Mhz, IEC 801-3 Fast transients 2KV, IEC 801-4
Safety	UL508C
Rated operational current	AC:53a:3.5-30: 50-4
Normal service conditions	
Altitude	Up to 1000m
Humidity	95% at 50°C or 98% at 45°C
Fan and control consumption ratings	
QBx0008 to QBx0170 — No fan	Total approximate consumption: 35VA
QBx0210 to QBx0477 — Fans 50 VA	Total approximate consumption: 85VA
QBx0515 to QBx0840 — Fan 50 VA	Total approximate consumption: 100VA
QBx0960 to QBx1100 — Fans 110 VA	Total approximate consumption: 160VA

ASTAT XT

Starter type and feature		Power unit size /current rating	Circuit breaker frame	Horsepower[1]				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT XT with no features	Stab	0008	SELT	2	2	5	5	65	15"	2
		0017	SELT	3	5	10	15	65	15"	2
		0031	SELT	7.5	10	20	25	65	15"	2
		0044	SELT	10	15	30	40	65	15"	2.5
		0058	SELT	15	20	40	50	65	15"	2.5
		0072	SELT	20	25	50	60	65	15"	2.5
		0085	SELT	25	30	60	75	65	20"	3
		0105	SELT	30	40	75	100	65	20"	3
	Stationery	0145	SFLT	40	50	100	150	65	20"	3
		0210	SFLT	50	60	125	150	65	20"	3
		0310	SFLT	60	75	150	200	65	20"	3
		0390	SGLT	100	100	250	300	65	20"	3
		0460	SGLT	125	150	300	400	65	20"	3
		0580	SGLT	150	150	350	400	65	30"	4.5
		0650	SGLT	200	200	400	400	65	30"	4.5
		0820	SKLT	200	250	500	500	65	20" + 30"	4.5 + 3
ASTAT XT with no features and J fuses	Stab	0008	SELT	2	2	5	5	100	15"	2
		0017	SELT	3	5	10	15	100	15"	2
		0031	SELT	7.5	10	20	25	100	15"	2
		0044	SELT	10	15	30	40	100	15"	2.5
		0058	SELT	15	20	40	50	100	15"	2.5
		0072	SELT	20	25	50	60	100	15"	2.5
		0085	SELT	25	30	60	75	100	20"	3.5
		0105	SELT	30	40	75	100	100	20"	3.5
	Stationery	0145	SFLT	40	50	100	150	100	20"	4
		0210	SFLT	50	60	125	150	100	20"	4
		0310	SFLT	60	75	150	200	100	20"	4
		0390	SGLT	100	100	250	300	100	20"	4
		0460	SGLT	125	150	300	400	100	20"	4
		0580	SGLT	150	150	350	400	100	30"	5.5
		0650	SGLT	200	200	400	400	100	30"	5.5
		0820	SKLT and L Fuses	200	250	500	500	100	20" + 30"	4.5 + 4.5

1. All ratings are based on a selection of Normal Duty or Class 20 overloads. See operators guide for more rating options.

ASTAT XT – Type 1

Starter type and feature		Power unit size/current rating	Circuit breaker frame	Horsepower[1]				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT XT with no features	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2
		0017	SEL*/SEP*		5	10	15	65	15"	2
		0031	SEL*/SEP*		10	20	25	65	15"	2
		0044	SEL*/SEP*		15	30	40	65	15"	3
		0058	SEL*/SEP*		20	40	50	65	15"	3
		0072	SEL*/SEP*		25	50	60	65	15"	3
	Stationery	0085	SEL*/SEP*		30	60	75	65	20"	3
		0105	SEL*/SEP*		40	75	100	65	20"	3
		0145	SFL*/SFP*		50	100	150	65	20"	3
		0170	SFL*/SFP*		60	125	150	65	20"	3
		0210	SFL*/SFP*		75	150	200	65	20"	4
		0310	SFL*/SFP*		100	250	300	65	20"	4
		0390	SGL*/SGP*		150	300	400	65	20"	4
		0460	SGL*/SGP*		150	350	400	65	30"	4.5
		0580	SKL*/SKP*		200	400	400	65	30"+20"	4.5+3
		0820	SKL*/SKP*		250	500	500	65	30"+20"	4.5+3
ASTAT XT with bypass feature	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2.5
		0017	SEL*/SEP*		5	10	15	65	15"	2.5
		0031	SEL*/SEP*		10	20	25	65	15"	2.5
	Stationery	0044	SEL*/SEP*		15	30	40	65	20"	2.5
		0058	SEL*/SEP*		20	40	50	65	20"	2.5
		0072	SEL*/SEP*		25	50	60	65	20"	2.5
		0085	SEL*/SEP*		30	60	75	65	20"	3.5
		0105	SEL*/SEP*		40	75	100	65	20"	3.5
		0145	SFL*/SFP*		50	100	150	65	20"	3.5
		0170	SFL*/SFP*		60	125	150	65	20"	3.5
		0210	SFL*/SFP*		75	150	200	65	20"	5.5
		0310	SFL*/SFP*		100	250	300	65	20"	5.5
		0390	SGL*/SGP*		150	300	400	65	20"	5.5
		0460	SGL*/SGP*		150	350	400	65	30"+20"	6+2
		0580	SKL*/SKP*		200	400	400	65	30"+20"	6+4
		0820	SKL*/SKP*		250	500	500	65	30"+20"	6+4
ASTAT XT with bypass and J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2.5
		0017	SEMCS		5	10	15	100	15"	2.5
		0031	SEMCS		10	20	25	100	15"	2.5
		0044	SEMCS		15	30	40	100	15"	2.5
		0058	SEMCS		20	40	50	100	15"	2.5
		0072	SEMCS		25	50	60	100	15"	2.5
	Stationery	0085	SEMCS		30	60	75	100	20"	4
		0105	SEMCS		40	75	100	100	20"	4
		0145	SFMCS		50	100	150	100	20"	4
		0170	SFMCS		60	125	150	100	20"	4
		0210	SFMCS		75	150	200	100	20"	6
		0310	SFMCS		100	250	300	100	20"	6
		0390	SGMCS		150	300	400	100	20"	6
		0460	SGMCS		150	350	400	100	30"+20"	6+3
		0580	SKMCS		200	400	400	65	30"+20"	6+5.5
		0820	SKMCS		250	500	500	65	30"+20"	6+5.5

1. All ratings are based on a selection of Normal Duty or Class 20 overloads. See operators guide for more rating options.

ASTAT XT – Type 1 (continued)

Starter type and feature		Power unit size/current rating	Circuit breaker frame	Horsepower[1]				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT XT with ISO and bypass feature	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2.5
		0017	SEL*/SEP*		5	10	15	65	15"	2.5
		0031	SEL*/SEP*		10	20	25	65	15"	2.5
		0044	SEL*/SEP*		15	30	40	65	15"	2.5
		0058	SEL*/SEP*		20	40	50	65	15"	2.5
		0072	SEL*/SEP*		25	50	60	65	15"	2.5
	Stationery	0085	SEL*/SEP*		30	60	75	65	20"	3.5
		0105	SEL*/SEP*		40	75	100	65	20"	3.5
		0145	SFL*/SFP*		50	100	150	65	20"	3.5
		0170	SFL*/SFP*		60	125	150	65	20"	3.5
		0210	SFL*/SFP*		75	150	200	65	20"	5.5
		0310	SFL*/SFP*		100	250	300	65	20"	5.5
		0390	SGL*/SGP*		150	300	400	65	20"	5.5
		0460	SGL*/SGP*		150	350	400	65	30"+20"	6+2
		0580	SKL*/SKP*		200	400	400	65	30"+20"	6+4
		0820	SKL*/SKP*		250	500	500	65	30"+20"	6+4
ASTAT XT with ISO, bypass and J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2.5
		0017	SEMCS		5	10	15	100	15"	2.5
		0031	SEMCS		10	20	25	100	15"	2.5
		0044	SEMCS		15	30	40	100	15"	3
		0058	SEMCS		20	40	50	100	15"	3
		0072	SEMCS		25	50	60	100	15"	3
	Stationery	0085	SEMCS		30	60	75	100	20"	4
		0105	SEMCS		40	75	100	100	20"	4
		0145	SFMCS		50	100	150	100	20"	4
		0170	SFMCS		60	125	150	100	20"	4
		0210	SFMCS		75	150	200	100	20"	6
		0310	SFMCS		100	250	300	100	20"	6
		0390	SGMCS		150	300	400	100	20"	6
		0460	SGMCS		150	350	400	100	30"+20"	6+3
		0580	SKMCS		200	400	400	65	30"+20"	6+5.5
		0820	SKMCS		250	500	500	65	30"+20"	6+5.5
ASTAT XT with ISO feature	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2
		0017	SEL*/SEP*		5	10	15	65	15"	2
		0031	SEL*/SEP*		10	20	25	65	15"	2
		0044	SEL*/SEP*		15	30	40	65	15"	2.5
		0058	SEL*/SEP*		20	40	50	65	15"	2.5
		0072	SEL*/SEP*		25	50	60	65	15"	2.5
	Stationery	0085	SEL*/SEP*		30	60	75	65	20"	3
		0105	SEL*/SEP*		40	75	100	65	20"	3
		0145	SFL*/SFP*		50	100	150	65	20"	3
		0170	SFL*/SFP*		60	125	150	65	20"	3
		0210	SFL*/SFP*		75	150	200	65	20"	5.5
		0310	SFL*/SFP*		100	250	300	65	20"	5.5
		0390	SGL*/SGP*		150	300	400	65	20"	5.5
		0460	SGL*/SGP*		150	350	400	65	30"	5.5
		0580	SKL*/SKP*		200	400	400	65	30"+20"	6+3
		0820	SKL*/SKP*		250	500	500	65	30"+20"	6+3

1. All ratings are based on a selection of Normal Duty or Class 20 overloads. See operators guide for more rating options.

ASTAT XT – Type 1 (continued)

Starter type and feature		Power unit size/current rating	Circuit breaker frame	Horsepower[1]				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT XT with ISO and J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2
		0017	SEMCS		5	10	15	100	15"	2
		0031	SEMCS		10	20	25	100	15"	2
		0044	SEMCS		15	30	40	100	15"	2.5
		0058	SEMCS		20	40	50	100	15"	2.5
		0072	SEMCS		25	50	60	100	15"	2.5
	Stationery	0085	SEMCS		30	60	75	100	20"	3.5
		0105	SEMCS		40	75	100	100	20"	3.5
		0145	SFMCS		50	100	150	100	20"	3.5
		0170	SFMCS		60	125	150	100	20"	3.5
		0210	SFMCS		75	150	200	100	20"	6
		0310	SFMCS		100	250	300	100	20"	6
		0390	SGMCS		150	300	400	100	20"	6
		0460	SGMCS		150	350	400	100	30"+20"	5+2.5
		0580	SKMCS		200	400	400	65	30"+20"	5+4.5
		0820	SKMCS		250	500	500	65	30"+20"	5+4.5
ASTAT XT with J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2
		0017	SEMCS		5	10	15	100	15"	2
		0031	SEMCS		10	20	25	100	15"	2
		0044	SEMCS		15	30	40	100	15"	2.5
		0058	SEMCS		20	40	50	100	15"	2.5
		0072	SEMCS		25	50	60	100	15"	2.5
	Stationery	0085	SEMCS		30	60	75	100	20"	3.5
		0105	SEMCS		40	75	100	100	20"	3.5
		0145	SFMCS		50	100	150	100	20"	3.5
		0170	SFMCS		60	125	150	100	20"	3.5
		0210	SFMCS		75	150	200	100	20"	4
		0310	SFMCS		100	250	300	100	20"	4
		0390	SGMCS		150	300	400	100	20"	4
		0460	SGMCS		150	350	400	100	30"	5.5
		0580	SKMCS		200	400	400	65	30"+20"	4.5+4.5
		0820	SKMCS		250	500	500	65	30"+20"	4.5+4.5

1. All ratings are based on a selection of Normal Duty or Class 20 overloads. See operators guide for more rating options.

ASTAT XT – Type 12

Starter type and feature		Power unit size/current rating	Circuit breaker frame	Horsepower[1]				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT XT with no fFeatures	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2
		0017	SEL*/SEP*		5	10	15	65	15"	2
		0031	SEL*/SEP*		10	20	25	65	15"	2
		0044	SEL*/SEP*		15	30	40	65	15"	3
		0058	SEL*/SEP*		20	40	50	65	15"	3
		0072	SEL*/SEP*		25	50	60	65	15"	3
	Stationery	0085	SEL*/SEP*		30	60	75	65	20"	4
		0105	SEL*/SEP*		40	75	100	65	20"	4
		0145	SFL*/SFP*		50	100	150	65	20"	4
		0170	SFL*/SFP*		60	125	150	65	20"	4
		0210	SFL*/SFP*		75	150	200	65	20"	5.5
		0310	SFL*/SFP*		100	250	300	65	20"	5.5
		0390	SGL*/SGP*		150	300	400	65	20"	5.5
		0460	SGL*/SGP*		150	350	400	65	30"	7.5
		0580	SKL*/SKP*		200	400	400	65	30"	7.5
		0820	SKL*/SKP*		250	500	500	65	30"	7.5
ASTAT XT with bypass feature	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2.5
		0017	SEL*/SEP*		5	10	15	65	15"	2.5
		0031	SEL*/SEP*		10	20	25	65	15"	2.5
		0044	SEL*/SEP*		15	30	40	65	20"	3
		0058	SEL*/SEP*		20	40	50	65	20"	3
		0072	SEL*/SEP*		25	50	60	65	20"	3
	Stationery	0085	SEL*/SEP*		30	60	75	65	20"	3.5
		0105	SEL*/SEP*		40	75	100	65	20"	3.5
		0145	SFL*/SFP*		50	100	150	65	20"	3.5
		0170	SFL*/SFP*		60	125	150	65	20"	3.5
		0210	SFL*/SFP*		75	150	200	65	20"	5.5
		0310	SFL*/SFP*		100	250	300	65	20"	5.5
		0390	SGL*/SGP*		150	300	400	65	20"	5.5
		0460	SGL*/SGP*		150	350	400	65	30"+20"	6+2
		0580	SKL*/SKP*		200	400	400	65	30"+20"	6+4
		0820	SKL*/SKP*		250	500	500	65	30"+20"	6+4
ASTAT XT with bypass and J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2.5
		0017	SEMCS		5	10	15	100	15"	2.5
		0031	SEMCS		10	20	25	100	15"	2.5
		0044	SEMCS		15	30	40	100	15"	2.5
		0058	SEMCS		20	40	50	100	15"	2.5
		0072	SEMCS		25	50	60	100	15"	2.5
	Stationery	0085	SEMCS		30	60	75	100	20"	4
		0105	SEMCS		40	75	100	100	20"	4
		0145	SFMCS		50	100	150	100	20"	4
		0170	SFMCS		60	125	150	100	20"	4
		0210	SFMCS		75	150	200	100	20"	6
		0310	SFMCS		100	250	300	100	20"	6
		0390	SGMCS		150	300	400	100	20"	6
		0460	SGMCS		150	350	400	100	30"+20"	6+3
		0580	SKMCS		200	400	400	65	30"+20"	6+5.5
		0820	SKMCS		250	500	500	65	30"+20"	6+5.5

1. All ratings are based on a selection of Normal Duty or Class 20 overloads. See operators guide for more rating options.

ASTAT XT – Type 12 (continued)

Starter type and feature		Power unit size/current rating	Circuit breaker frame	Horsepower[1]				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT XT with ISO and bypass feature	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2.5
		0017	SEL*/SEP*		5	10	15	65	15"	2.5
		0031	SEL*/SEP*		10	20	25	65	15"	2.5
		0044	SEL*/SEP*		15	30	40	65	15"	2.5
		0058	SEL*/SEP*		20	40	50	65	15"	2.5
		0072	SEL*/SEP*		25	50	60	65	15"	2.5
	Stationery	0085	SEL*/SEP*		30	60	75	65	20"	3.5
		0105	SEL*/SEP*		40	75	100	65	20"	3.5
		0145	SFL*/SFP*		50	100	150	65	20"	3.5
		0170	SFL*/SFP*		60	125	150	65	20"	3.5
		0210	SFL*/SFP*		75	150	200	65	20"	5.5
		0310	SFL*/SFP*		100	250	300	65	20"	5.5
		0390	SGL*/SGP*		150	300	400	65	20"	5.5
		0460	SGL*/SGP*		150	350	400	65	30"+20"	6+2
		0580	SKL*/SKP*		200	400	400	65	30"+20"	6+4
		0820	SKL*/SKP*		250	500	500	65	30"+20"	6+4
ASTAT XT with ISO, bypass and J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2.5
		0017	SEMCS		5	10	15	100	15"	2.5
		0031	SEMCS		10	20	25	100	15"	2.5
		0044	SEMCS		15	30	40	100	15"	3
		0058	SEMCS		20	40	50	100	15"	3
		0072	SEMCS		25	50	60	100	15"	3
	Stationery	0085	SEMCS		30	60	75	100	20"	4
		0105	SEMCS		40	75	100	100	20"	4
		0145	SFMCS		50	100	150	100	20"	4
		0170	SFMCS		60	125	150	100	20"	4
		0210	SFMCS		75	150	200	100	20"	6
		0310	SFMCS		100	250	300	100	20"	6
		0390	SGMCS		150	300	400	100	20"	6
		0460	SGMCS		150	350	400	100	30"+20"	6+3
		0580	SKMCS		200	400	400	65	30"+20"	6+5.5
		0820	SKMCS		250	500	500	65	30"+20"	6+5.5
ASTAT XT with ISO feature	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2
		0017	SEL*/SEP*		5	10	15	65	15"	2
		0031	SEL*/SEP*		10	20	25	65	15"	2
		0044	SEL*/SEP*		15	30	40	65	15"	3
		0058	SEL*/SEP*		20	40	50	65	15"	3
		0072	SEL*/SEP*		25	50	60	65	15"	3
	Stationery	0085	SEL*/SEP*		30	60	75	65	20"	4
		0105	SEL*/SEP*		40	75	100	65	20"	4
		0145	SFL*/SFP*		50	100	150	65	20"	4
		0170	SFL*/SFP*		60	125	150	65	20"	4
		0210	SFL*/SFP*		75	150	200	65	20"	5.5
		0310	SFL*/SFP*		100	250	300	65	20"	5.5
		0390	SGL*/SGP*		150	300	400	65	20"	5.5
		0460	SGL*/SGP*		150	350	400	65	30"+20"	7.5+2.5
		0580	SKL*/SKP*		200	400	400	65	30"+20"	7.5+3
		0820	SKL*/SKP*		250	500	500	65	30"+20"	7.5+3

1. All ratings are based on a selection of Normal Duty or Class 20 overloads. See operators guide for more rating options.

ASTAT XT – Type 12 (continued)

Starter type and feature		Power unit size/current rating	Circuit breaker Frame	Horsepower[1]				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT XT with ISO and J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2
		0017	SEMCS		5	10	15	100	15"	2
		0031	SEMCS		10	20	25	100	15"	2
		0044	SEMCS		15	30	40	100	15"	3
		0058	SEMCS		20	40	50	100	15"	3
		0072	SEMCS		25	50	60	100	15"	3
	Stationery	0085	SEMCS		30	60	75	100	20"	4
		0105	SEMCS		40	75	100	100	20"	4
		0145	SFMCS		50	100	150	100	20"	4
		0170	SFMCS		60	125	150	100	20"	4
		0210	SFMCS		75	150	200	100	20"	5.5
		0310	SFMCS		100	250	300	100	20"	5.5
		0390	SGMCS		150	300	400	100	20"	5.5
		0460	SGMCS		150	350	400	100	30"+20"	7.5+2.5
		0580	SKMCS		200	400	400	65	30"+20"	7.5+4.5
		0820	SKMCS		250	500	500	65	30"+20"	7.5+4.5
ASTAT XT with J or L fuse feature	Stab	0008	SEMCS		2	5	5	100	15"	2
		0017	SEMCS		5	10	15	100	15"	2
		0031	SEMCS		10	20	25	100	15"	2
		0044	SEMCS		15	30	40	100	15"	3
		0058	SEMCS		20	40	50	100	15"	3
		0072	SEMCS		25	50	60	100	15"	3
	Stationery	0085	SEMCS		30	60	75	100	20"	4
		0105	SEMCS		40	75	100	100	20"	4
		0145	SFMCS		50	100	150	100	20"	4
		0170	SFMCS		60	125	150	100	20"	4
		0210	SFMCS		75	150	200	100	20"	5.5
		0310	SFMCS		100	250	300	100	20"	5.5
		0390	SGMCS		150	300	400	100	20"	5.5
		0460	SGMCS		150	350	400	100	30"+20"	7.5+2.5
		0580	SKMCS		200	400	400	65	30"+20"	7.5+4.5
		0820	SKMCS		250	500	500	65	30"+20"	7.5+4.5

1. All ratings are based on a selection of Normal Duty or Class 20 overloads. See operators guide for more rating options.

ASTAT BP

Starter type and feature		Power unit size/current rating	Circuit breaker frame	Horsepower				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT BP with no features	Stab	0008	SEL*/SEP*		2	5	5	65	15"	1.5
		0017	SEL*/SEP*		5	10	15	65	15"	1.5
		0031	SEL*/SEP*		10	20	25	65	15"	1.5
		0044	SEL*/SEP*		15	30	40	65	15"	1.5
		0058	SEL*/SEP*		20	40	50	65	15"	2
		0072	SEL*/SEP*		25	50	60	65	15"	2
		0085	SEL*/SEP*		30	60	75	65	15"	2.5
		0105	SEL*/SEP*		40	75	100	65	15"	2.5
		0145	SFL*/SFP*		50	100	125	65	15"	2.5
		0170	SFL*/SFP*		60	125	150	65	15"	2.5
	Stationery	0210	SGL*/SGP*		75	150	200	65	20"	3.5
		0240	SGL*/SGP*		100	200	250	65	20"	3.5
		0310	SGL*/SGP*		—	250	300	65	20"	3.5
		0360	SGL*/SGP*		125	300	350	65	24"	4
		0414	SGL*/SGP*		150	350	400	65	24"	4
		0477	SGL*/SGP*		—	400	450	65	24"	4
		0515	SKL*/SKP*		200	450	500	65	24"	6
		0590	SKL*/SKP*		—	500	600	65	24"	6
ASTAT BP with ISO features	Stab	0008	SEL*/SEP*		2	5	5	65	15"	2
		0017	SEL*/SEP*		5	10	15	65	15"	2
		0031	SEL*/SEP*		10	20	25	65	15"	2
		0044	SEL*/SEP*		15	30	40	65	15"	2
		0058	SEL*/SEP*		20	40	50	65	15"	2
		0072	SEL*/SEP*		25	50	60	65	15"	2
		0085	SEL*/SEP*		30	60	75	65	15"	2.5
		0105	SEL*/SEP*		40	75	100	65	15"	2.5
		0145	SFL*/SFP*		50	100	125	65	15"	3
		0170	SFL*/SFP*		60	125	150	65	15"	3
	Stationery	0210	SGL*/SGP*		75	150	200	65	20"	5
		0240	SGL*/SGP*		100	200	250	65	20"	5
		0310	SGL*/SGP*		—	250	300	65	20"	5
		0360	SGL*/SGP*		125	300	350	65	24"	5
		0414	SGL*/SGP*		150	350	400	65	24"	5
		0477	SGL*/SGP*		—	400	450	65	24"	5
		0515	SKL*/SKP*		200	450	500	65	24"+20"	5.5+2
		0590	SKL*/SKP*		—	500	600	65	24"+20"	5.5+2
ASTAT BP with ISO and J or L fuse features	Stab	0008	SEMCS		2	5	5	100	15"	2
		0017	SEMCS		5	10	15	100	15"	2
		0031	SEMCS		10	20	25	100	15"	2
		0044	SEMCS		15	30	40	100	15"	2
		0058	SEMCS		20	40	50	100	15"	2
		0072	SEMCS		25	50	60	100	15"	2
		0085	SEMCS		30	60	75	100	15"	2.5
		0105	SEMCS		40	75	100	100	15"	2.5
		0145	SFMCS		50	100	125	100	15"	3.5
		0170	SFMCS		60	125	150	100	15"	3.5
	Stationery	0210	SGMCS		75	150	200	100	20"	6
		0240	SGMCS		100	200	250	100	20"	6
		0310	SGMCS		—	250	300	100	24"	6
		0360	SGMCS		125	300	350	100	24"	6
		0414	SGMCS		150	350	400	100	24"	5.5
		0477	SGMCS		—	400	450	100	24"	5.5
		0515	SKMCS		200	450	500	65	24"+20"	5.5+4.5
		0590	SKMCS		—	500	600	65	24"+20"	5.5+4.5

ASTAT BP (continued)

Starter type and feature		Power unit size/current rating	Circuit breaker frame	Horsepower				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT BP with J or L fuse fFeatures	Stab	0008	SEMCS		2	5	5	100	15"	2
		0017	SEMCS		5	10	15	100	15"	2
		0031	SEMCS		10	20	25	100	15"	2
		0044	SEMCS		15	30	40	100	15"	2
		0058	SEMCS		20	40	50	100	15"	2
		0072	SEMCS		25	50	60	100	15"	2
		0085	SEMCS		30	60	75	100	15"	2.5
		0105	SEMCS		40	75	100	100	15"	2.5
		0145	SFMCS		50	100	125	100	15"	3
		0170	SFMCS		60	125	150	100	15"	3
	Stationery	0210	SGMCS		75	150	200	100	20"	5
		0240	SGMCS		100	200	250	100	20"	5
		0310	SGMCS		—	250	300	100	20"	5
		0360	SGMCS		125	300	350	100	24"	5
		0414	SGMCS		150	350	400	100	24"	5
		0477	SGMCS		—	400	450	100	24"	5
		0515	SKMCS		200	450	500	65	24"+20"	5.5+4.5
		0590	SKMCS		—	500	600	65	24"+20"	5.5+4.5

Solid-state starters

Standard reduced-voltage, nonreversing with primary disconnect

ASTAT-BP integrated by-pass space requirement

Starter type and feature		Power unit size / current rating	Circuit breaker frame	Horsepower				IC (kA) @ 460V	Section width	X-height
				200V	230V	460V	575V			
ASTAT-BP	Stab	0058	SELT	15	20	40	50	42	20"	3
		0072	SELT	20	25	50[1]	60	42	20"	3
		0085	SELT	25	25	60[1]	75	42	20"	3
		0105	SELT	30	30	75	75	65	20"	3
	Stationery	0145	SFLT	40	50	100	125	65	20"	4
		0170	SGLT	50	60	125	150	65	20"	5
		0210	SGLT	60	75	150	200	65	24"	5
		0240	SGLT	75	100	200[2]	300	65	24"+ 20"	4 + 2.5
		0310	SGLT	100	100	250[3]	300	65	24"+ 20"	4 + 2.5
		0360	SGLT	125	150	300[3]	350	65	24"+ 20"	4 + 2.5
ASTAT-BP with J fuses	Stab	0058	SELT	15	20	40	50	100	20"	3.5
		0072	SELT	20	25	50[1]	60	100	20"	3.5
		0085	SELT	25	25	60[1]	75	100	20"	3.5
		0105	SELT	30	30	75	75	100	20"	3.5
	Stationery	0145	SFLT	40	50	100	125	100	20"	4
		0170	SGLT	50	60	125	150	100	20"	5
		0210	SGLT	60	75	150	200	100	24"	5.5
		0240	SGLT	75	100	200[2]	300	100	24"+ 20"	5 + 2.5
		0310	SGLT	100	100	250[3]	300	100	24"+ 20"	5 + 2.5
		0360	SGLT	125	150	300[3]	350	100	24"+ 20"	5 + 2.5
ASTAT-BP with isolation and J fuse	Stab	0058	SELT	15	20	40	50	100	20"	3.5
		0072	SELT	20	25	50[1]	60	100	20"	3.5
		0085	SELT	25	25	60[1]	75	100	20"	3.5
		0105	SELT	30	30	75	75	100	20"	3.5
	Stationery	0145	SFLT	40	50	100	125	100	20"	4.5
		0170	SGLT	50	60	125	150	100	20"	5
		0210	SGLT	60	75	150	200	100	24"	5 + 2.5
		0240	SGLT	75	100	200[2]	300	100	24"+ 20"	5 + 2.5
		0310	SGLT	100	100	250[3]	300	100	24"+ 20"	5 + 2.5
		0360	SGLT	125	150	300[3]	350	100	24"+ 20"	5 + 2.5

1. Use M power unit for 450% for 30 sec. Heavy Duty rating.
2. Use S power unit for 450% for 30 sec. Heavy Duty rating.
3. Standard Duty only

Run C-2000 Contactor

The ASTAT-BP is supplied with a bypass contactor across the entire product line. Refer to factory if NEMA contactors are required.

Solid-state starters

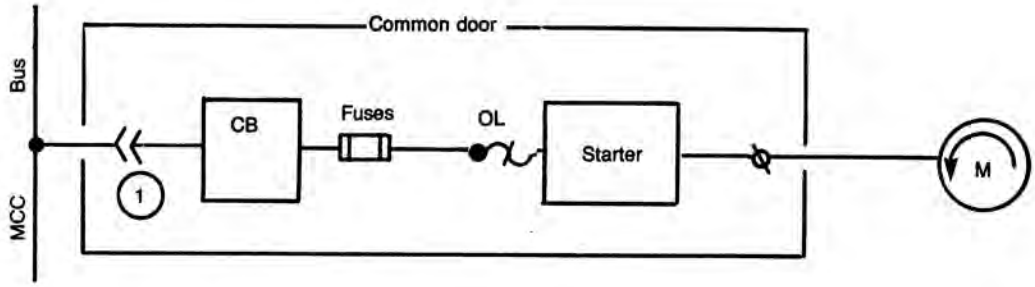
Reduced-voltage, 300/450%

ASTAT SS starters standard duty (300/450% selectable)

Function	NEMA size[1]	HP @ 200/208	HP @ 230/240	HP @ 380/50HZ	HP @ 460/480	SSS Cat# FLA @1.15 SF	Disconnect		IC (kA)[2]	Section 1 width	Section 2 width	X-height
SSS BASIC	1	.1-3	.1-3	.1-7.5	.1-10	QC2GDP 13.9 A	SELT	Stab In	25	20”		2X
		5-7.5	5-7.5	10		QC2IDP 27.8 A						
	2			15	15-20							
		10	10-15	20-25	25	QC2KDP 54.8 A			100	20”		2.5X
	3	15	20	30	30-40							
		20-25	25-30	40-50	50	QC2MDP 91.3 A						
	4	30		60	75							
		40	40-50	75	100	QC2QDP 187.0 A	SFLT			20”		4X
	5	50-60	60-75	100-125	150		SGT			24”		5X
		75	100	150	200	QC2SDP 321.7A				30”	20”	3X 5.5X
	6	100	125	200-250	300					30”	20”	3X 5.5X
		125-150	150	300	350	QC2TDP 413.0A			65	30”		5.5X
					400					36”	20”	3X 5.5X
	7		200		500	QC2UDP 547.8A	SKT			36”	20”	5.5X 5.5X
SSS with isolation	1	.1-3	.1-3	.1-7.5	.1-10	QC2GDP 13.9 A	SELT	Stab In	42	20”		2.5X
		5-7.5	5-7.5	10		QC2IDP 27.8 A						
	2			15	15-20							
		10	10-15	20-25	25	QC2KDP 54.8 A				20”		3X
	3	15	20	30	30-40							
		20-25	25-30	40-50	50	QC2MDP 91.3 A						
	4	30		60	75							
		40	40-50	75	100	QC2QDP 187.0 A			65	24”		5X
	5	50-60	60-75	100-125	150		SFLT			30”		5X
		75	100	150	200	QC2SDP 321.7A	SGT					
	6	100	125	200-250	300					30”	20”	5X 3.5X
		125-150	150	300	350	QC2TDP 413.0A				36”	20”	5X 3.5X
			200		400		SKT					
		200-250[1]	250-300[1]	400-500[1]	500	QC2UDP 547.8A						
SSS with bypass isolation	1	.1-3	.1-3	.1-7.5	.1-10	QC2GDP 13.9 A	SELT	Stab In	42	20”		2.5X
		5-7.5	5-7.5	10		QC2IDP 27.8 A						
	2			15	15-20							
		10	10-15	20-25	25	QC2KDP 54.8 A				20”		3.5X
	3	15	20	30	30-40							
		20-25	25-30	40-50	50	QC2MDP 91.3 A						
	4	30		60	75							
		40	40-50	75	100	QC2QDP 187.0 A	SFLT			24”		5X
	5	50-60	60-75	100-125	150		SGT			30”		5X
		75	100	150	200	QC2SDP 321.7A				30”	20”	5X 3.5X
	6	100	125	200-250	300				65			
		125-150	150	300	350	QC2TDP 413.0A				36”	20”	5X 3.5X
			200		400		SKT					
		200-250[1]	250-300[1]	400-500[1]	500	QC2UDP 547.8A						

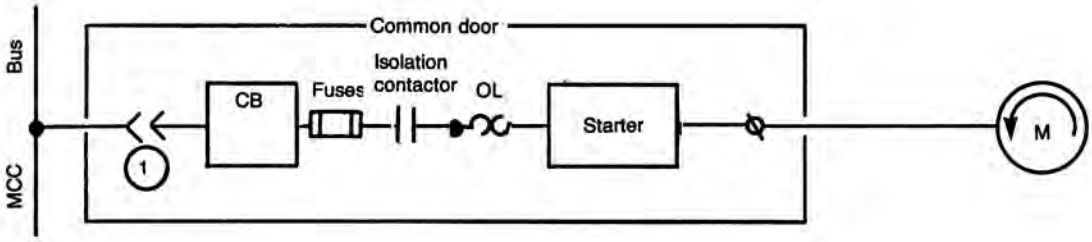
1. Application rated C2000 contactors. NEMA size is used as a reference to horsepower only.
2. 65/85KAIC rating is with fuses.

Solid-state starters
Standard reduced-voltage, nonreversing
with primary disconnect

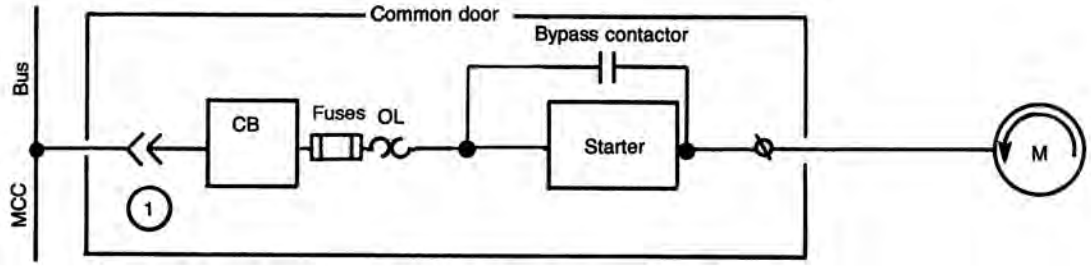


Options

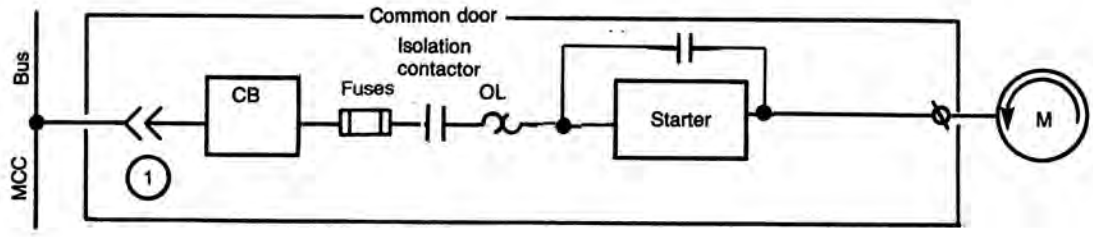
1. Solid-state starter with isolation contactor



2. Solid-state starter with bypass contactor



3. Solid-state starter, isolation and bypass



Solid state drives and starters

Arc flash mitigation (AFM)

The E9000 AFM units are designed to reduce the likelihood of exposure to electrical shock and the potential of internal arcing faults from occurring during maintenance. The retractable stab mechanism allows for closed-door racking of the unit, providing added protection to the electrical personnel from the dangers of an arc flash occurrence.

For more information see page D2 and Publication DEA-593.

AFM Solid State Drives and Starters

Unit Type	Rating @ 480V (hp)	Standard Bucket Height (inches)	AFM Bucket Height w/ C2000 (inches)
ASTAT-BP (Internal Bypass)	5-30	18	24
	40-50	24	30
	60-100	30	36
ASTAT-XT (External Bypass)	5-20	24	30
	25-50	30	36
VFD-GP (Constant Torque)	0.25-5	24	30
	5-10	24	36
	10.1-20	36	48
	20.1-40	48	60
VFD-FP (Variable Torque)	0.25-5	24	30
	5-10	24	36
	10.1-25	36	48
	25.1-50	48	60

Components

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, multiposition 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 only providing 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 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 the UL Listing status.

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-Bbreak 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 provid positive, reliable and cost-effective instantaneous, with tracking short-time overcurrent protection to those circuits where long-time overload protection is supplied by thermal or solid-state overload devices.

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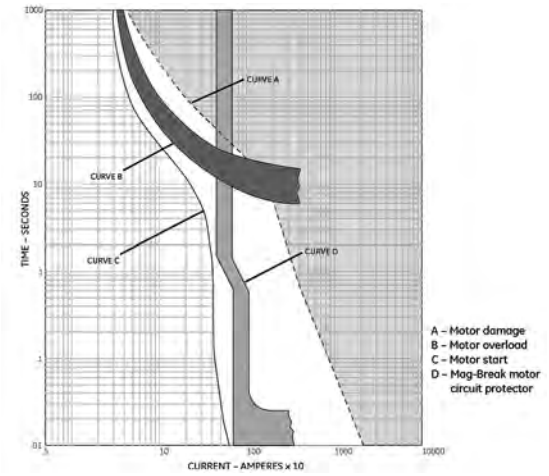
SE150 Spectra RMS Mag-break motor circuit protector

Motor circuit short circuit protection
When a squirrel-cage induction motor is energized, a high value of magnetizing inrush current flows for the first few cycles, followed by a substantial reduction in current flow while the motor accelerates to its rated speed. When plotted on a time current curve, the motor current has three distinct regions – for the first five to eight cycles, typical magnetizing inrush currents are approximately ten times the full-load motor current (but can be much greater for high efficiency motors). Between 0.10 and 10 seconds, the magnetizing inrush current drops to approximately five to six time the full-load motor current. After approximately 10 seconds, the motor reaches its full speed and the current quickly decreases to the full-load current of the motor.

Optimum motor protection for the first two regions of the motor time current plot would involve a two-tiered protection scheme with a high value of current tolerated for a few cycles, followed by a lower,sustained trip setting.

This is exactly the protection that is offered by the Mag-Break motor circuit protector. This two tiered protection scheme prevents nuisance tripping due to magnetizing inrush current, without compromising superior short circuit protection during motor acceleration. Protection for the third region of the motor time current plot is accomplished via the motor starter's overload relay.

The time current curve below illustrates this motor protection scheme. Curve A and the shaded area directly above it represents the region of operation that will produce permanent damage to either the motor, its feeder conductors or both. Curve B represents the trip characteristics of the motor starter's overload relay, which provides both long-term overload and stall protection but does not protect the system from short circuits in either the motor or its feeder conductors. Curve C is a plot of the motor current during a worst-case start (e.g., low line voltage, highest load torque, etc.). Curve D represents the trip characteristics of the Mag-Break motor circuit protector — with this addition, the motor and its feeder conductors are now fully protected against short circuits.



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Motor Circuit Protection Using Mag-Break Motor Circuit Protectors

Spectra RMS Mag-break motor circuit protector ratings
The table below lists rating plugs available for each Mag-Break motor circuit protector frame size. Instantaneous trip settings are listed under electrical data on page 21 and UL interrupting ratings are shown on page 28 (per UL 489, motor circuit protectors are not marked with interrupt ratings). Except for 3 amp and 7 amp plugs, all other rating plugs are used in both circuit breaker and Mag-break motor circuit protectors .

Spectra RMS mag-break motor circuit protector and rating plug current ratings

Frame	Maximum Amperes	Available rating Plugs, Amperes
SE-frame	7[1]	3 and 7
	30	15, 20, 25 and 30
	60	40, 50 and 60
	100	70, 80, 90 and 100
	150	110, 125 and 150
SF-frame	250	70, 90, 100, 110, 125, 150, 175, 200, 225 and 250
SG-frame	400	125, 150, 175, 200, 225, 250, 300, 350 and 400
	600	250, 300, 350, 400, 450, 500 and 600
SK-frame	800	300, 400, 500, 600, 700 and 800
	1200	600, 700, 800, 900, 1000 and 1200

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

Spectra RMS molded case switches
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 SEand 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 and Mag-Break motor circuit protectors, are available for molded case switches. In addition, plug-in bases, motoroperated mechanisms, mechanical interlocks, and the full complement of external handle operators (STDA, TDR and TDM) are available for use with Spectra RMS molded case switches.

Fixed-Trip Setting. The Spectra RMS molded case switches are equipped with a fixed Hi-set instantaneous trip setting whose values are shown in the table below.

Spectra RMS molded-case switch fixed-trip setting

Molded case switch frame	Maximum ampere rating	Fixed-Trip setting RMS Amperes nominal ±20%
SE-frame	100	2100
	150	
SF-frame	250	2450
SG-frame	400	5600
	600	6000
SK-frame	800	12.600
	1200	12.700

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.

Spectra RMS molded case switches are most commonly used as a disconnect in main, feeder, or starter applications in combination with fuses.

All Spectra RMS molded case switches are UL Listed and tested per UL Standard 1087 for molded case switches.

Heavy duty fusible disconnects

QMW fusible switch

QMW fusible switch (30-200 Amps)
The QMW Fusible Switch is a premium heavy-duty disconnect switch. It was developed to meet the most rigorous industrial requirements. It meets or exceeds all industry standards for withstand capability and interrupting ratings, and it is UL listed for use in Evolution MCC.

Spectra molded case switch (MCS)
400 and 600 Amp
A growing number of industrial applications with high available short-circuit current has made switch fuse coordination increasingly important. In addition, there has been a growing number of requirements for 400 amp and above applications, including Ground Fault, Annunciation and Remote Tripping. The Evolution E9000 MCC supports these requirements by incorporating Spectra Molded Case Switches with separate fuse blocks for all 400A and 600A applications. The same accessories used in the Spectra Circuit Breaker can be used in the MCS. In addition to ease of accessorizing, the MCS saves space.

Withstand capability – Safety and reliability depend on the interrupting capacity of both the switch and the switch-fuse combination. While switch-fuse interrupting ability is limited by the maximum current the fuse will interrupt, it is also determined by the maximum let-through energy the switch will withstand as the fuse clears a short circuit.

The switch must remain operable after the fuse has cleared. Switch withstand capability rating is determined by the maximum energy the switch can withstand (and remain operable), stated as ampere-squared seconds, I^2t.

Interrupting Capacity – In addition, the switch may have to interrupt a wide range of currents without assistance from the fuse, including normal switching-duty currents (up to fullload rating), overload and motor “jogging” currents (up to 10 times motor full load) or intermediate fault currents (usually arcing faults–from overload to near full-system available).

Previously, basic switch design criteria has been primarily concerned with interrupting normal switching and motor starting currents. New applications require a switch capable of interrupting intermediate fault currents without assistance from a fuse. For maximum protection, a switch should be able to interrupt any current on which it can be closed and reopened before the fuse blows. This is commonly called “fuse racing.”

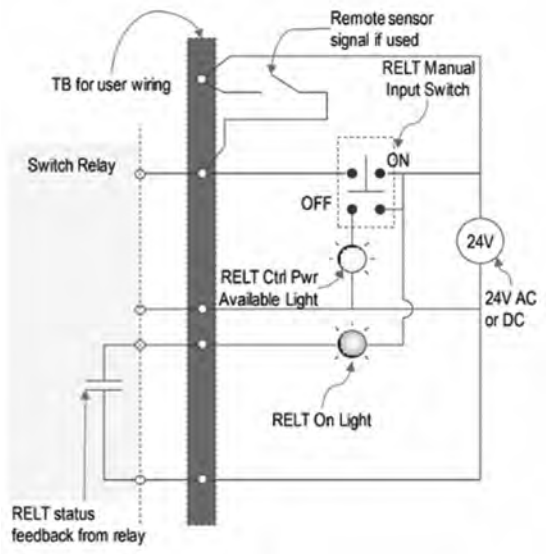
High pressure contact (HPC) switches
The new generation HPC switch is based on the time-proven platform of the Power Break II circuit breaker. Now, it's ArcWatch-enabled to provide a better Arc Flash hazard mitigation solution. The new generation HPC builds on the abilities of the original HPC by utilizing the features of the Power Break II (PBII) circuit breaker. In addition, HPC utilizes the EntelliGuard control unit which incorporates many of the features of the EntelliGuard Trip Unit for circuit breakers.

The HPC switch is available in frame ratings of 800, 1200, 1600, 2000 and 2500, both top and bottom feed, with IC ratings to 200kA with the appropriate UL Class L fuses. The new generation HPC switch is available for new installations and for retrofit, to replace the older HPC. By retrofitting with the new generation HPC switch, remote operation of the switch through the motor operators, shunt trips with lockouts, RELT and the Adjustable IOC for continuous reduced incident energy can be added in the same footprint as that of the older existing switch.

Features and benefits
- Top or Bottom Feed
  - 800-4000 Amperes 600 Volts ac Max
- High Durability–Safety of Operation
  - High-dielectric strength, glass reinforced insulating case
- High Interrupting Capability
  - Arc chute of unique construction suppresses arcs and cools gases rapidly, providing quick arc interruption and extended switch life
- High Transient Voltage Withstand Capability
  - Interphase partitions mesh with switch cover to completely isolate each pole
- Extended Switch Life
  - Preloaded constant pressure pivot eliminates braid whip and fraying on high short-circuit currents and repeated operations
- Positive "ON-OFF" Indication
  - Green (OFF), Red (ON), eliminates any question about the position of the switch contacts
- Easy Operation Quick Make
- Emergency Open–Quick Break
  - Finger-tip "OFF" button instantly opens the switch contacts
- Fuse Mounting Bolts with Captive Washers for Ease of Mounting Fuses
- Padlocking Provisions Standard

In addition, the HPC utilizes the EntelliGuard control unit which incorporates many of the features of the EntelliGuard Trip Unit for circuit breakers:
- Built-in metering, waveform capture and Modbus communications
- Ground fault protection or alarm, optional GF disable
- WFR Adjustable Selective Instantaneous protection
- RELT Alternate Adjustable fast instantaneous setting, remote operable and with positive status feedback
- Zone-Selective operation for GF that works with all circuit breaker trip platforms and includes four different GF curve shapes
- Instantaneous Zone-Selective operation that works with upstream EntelliGuard Trip Units and EntelliGuard control units

RELT Control Schematic



Power Break II insulated case circuit breakers

General Description

Power Break II insulated case circuit breakers offer the rugged, reliable type of system protection critical for heavy-duty applications. In Evolution Series E9000 MCC, Power Break II circuit breakers are rated up to 100,000 amperes RMS symmetrical interrupting capacity without fuses or current limiters. In Evolution E9000 MCC, the Power Break II design consists of 800, 1600A*, 2000A*, and 2500A* Amp frame sizes.

Power Break II is a versatile breaker, designed for a wide variety of applications with features such as temperature insensitive trip units, push-to-open and -close buttons, standard padlocking provision, maximum three-cycle closing time, field installable rating plugs to change ampere ratings, UL listing, plug in field installable accessories, and easy-to-operate two stage pumphandle, stored-energy operating mechanism capable of change after close.

EntelliGuard TU trip unit

EntelliGuard TU is the trip unit with the built-in flexibility required to match your system's needs, whether for optimum safety, optimum system reliability or both at the same time. The EntelliGuard TU trip unit provides the industry's most advanced instantaneous protection without compromising system selectivity.

Standard features for exceptional flexibility

- Highly flexible time current settings
  - up to 22 Long Time Delays
  - up to 22 (fuse shaped) Long Time
  - up to 14 Short Time Delay bands
  - 3 Short Time slopes (I2T)
- Selective Instantaneous algorithm (WFR)
- Ammeter
- Large backlit LCD screen
- Breaker status indication
- Universal rating plugs – less plug inventory
- Status and event log (10 Events)
- Date and time event stamping
- LED health status indicator
- Free set-up software
- Discrete I/O
- Thermal memory, battery back-up
- Common interface across all versions
- Mechanism self-timing

Optional full-function metering

- Current (Amps, kAmps)
- Voltage (Ph-Ph, Ph-N)
- Energy (kWh, MWh, GWh)
- Real power (kW, MW)
- Total power (kVA, MVA)
- Frequency (Hz)
- Demand (avg. kW, MW) and peak demand

Options

- Internal/external ground fault trip or alarm with 4 curves to select from (I2T, I4T, special selective GF curve, and definite time slope)
- Switchable ground fault trip / alarm (now password protected and UL Listed)
- Modbus RTU communications (Profibus also available for EntelliGuard G)
- Waveform capture for harmonic analysis
- Full-function metering
- Protective relaying (see list of functions below)
- Zone-Selective-Interlocking for GF, ST, Instantaneous (I-ZSI)
- Threshold Zone-Selective-Interlocking for ST and Instantaneous (T-ZSI)
- Built-in Zone-Selective-Interlocking test capability
- RELT – Reduce Energy Let Through
- RELT and ground fault alarm harness kits
- Test Set GTUTK20
- Digital Test Kit Software, available December 2013

Optional protective relaying functions
- Undervoltage
- Overvoltage
- Voltage unbalance
- Current unbalance
- Power reversal
- Power direction setup

1. Some options require 24VDC additional hardware to enable Metering, Relaying, RELT, ZSI, Modbus to be added to the breaker, equipment cubicle and equipment sections.

* 1600A, 2000A, 2500A PowerBreak II circuit breakers are 100% rated in the LV MCC construction. 800A PowerBreak II circuit breakers are 80% rated

Spectra RMS circuit breakers -features

Spectra RMS
SE150, SF250, SG600 and SK1200 circuit breaker frames have a digital, solid state, RMS sensing trip system with field installable, front-mounted rating plugs to establish or change the breaker ampere rating. Adjustable instantaneous with tracking short-time is standard on all frames. The trip unit uses digital sampling to determine the RMS value of sinusoidal and non-sinusoidal currents. See more at: http://www.geindustrial.com/products/circuit-breakers/spectra-rms-electronic-trip#sthash.fmoX8l9f.dpuf.

A complete circuit breaker consists of a UL Listed circuit breaker frame and a rating plug (UL Listed interchangeable trip breaker unit). Terminal lugs for cable connection are available if required.

- All frames use the same UL listed, field installable internal accessories (auxiliary switch, shunt trip, undervoltage release and bell alarm).
- All frame sizes have maximum UL listed interrupting ratings of 100 kA @ 480 volts AC with 600 volts AC ratings to 65 kA depending on frame size. UL listed current limiting versions are provided through the SG600 frame for the 65 kA @480 volts AC and the 100 kA @ 480 volts AC models, with no increase in physical frame size.
- Spectra RMS Mag-Break instantaneous-only motor circuit protectors also use the same digital, solid state trip unit and rating plugs as the circuit breakers. The interchangeable rating plug establishes the instantaneous pickup range (with tracking short-time) but does not change the frame ampere rating.
- Spectra RMS molded case switches have a fixed, high-set instantaneous trip (without tracking short-time function) and have short circuit withstand ratings equal to their equiva- lent breaker frame size interrupting rating in most cases.
- RMS breakers are ambient insensitive. Trip times will not vary over the range 10-50° breaker ambient .
- Spectra RMS breakers contain no parts that would support fungus growth and are, therefore, inherently fungusproof.
-

Other MCCB features
- Broad product line to meet virtually any application need.
- Reduced downtime. A tripped breaker is easily spotted and can be immediately reset after the fault has been corrected.
- Eliminates single phasing. A common trip bar disconnects all poles simultaneously on both overloads and short circuits.
- Offers application flexibility through the use of a wide variety of accessory devices and special attachments.
- Repetitive operation — no fuses to replace.
- Breakers can be repetitively tested. Fuses must be destroyed to confirm calibration accuracy.

Reference – GET-7002 for further application information.

The add-on limiter coordinates with the Spectra thermal magnetic trip to allow normal tripping functions at standard ratings with backup limiting at high short-circuit levels for 150A frame Spectra circuit breakers

Spectra RMS Circuit Breakers - Features

microEntelliGuard Trip Unit

The microEntelliGuard trip unit is the newest and most advanced trip unit available in the Spectra line of molded case circuit breakers. Based on the EntelliGuard TU trip platform, the new microEntelliGuard trip unit allows you to select the enhanced system protection, coordination, metering and communications options required for the application. New features include enhanced time-current adjustability, Ground Fault Alarm, Neutral Protection, Zone Selective Interlock (ST/GF/INST), and direct Modbus communications. Other features that enhance system protection and diagnostics include long-time thermal memory, waveform capture, programmable output contacts, and an LED “Health” status indicator.

Standard features

- Adjustable Long-Time pickup and delay bands with three curve shapes (MVT I2t, CB and Fuse I4t) for optimal system coordination (includes thermal memory for enhanced system protection)
- Adjustable Short-Time pickup with multiple delay bands, curve slopes, I2t IN/OUT, and OFF setting
- Adjustable Instantaneous pickup
- 3-Phase ammeter
- Backlit LCD display with five-button tactile keypad and sealable, clear LEXAN cover for tamper resistant settings
- LED Status Indicator to show “health” of trip unit
- Trip Target indication and local pickup warning signal
- Interchangeable/universal rating plugs
- Test set jack for GTUTK20 test kit
- True RMS sensing for accurate response to high harmonic content waveforms
- EMI immunity per ANSI C37.90

Optional features

- Ground Fault (Trip or Alarm) pickup and delay bands with multiple slopes, I2t IN/OUT for optimal system coordination
- Neutral Protection provides overload protection on the system neutral
- Zone Selective Interlocking (ZSI) capability on Short Time, Ground Fault and Instantaneous settings for optimal system coordination and selectivity
- Reduced Energy Let-Through (RELT) setting for enhanced equipment and personnel protection
- Advanced metering option includes the ability to monitor current, voltage, energy, frequency, power factor, power (real/reactive/apparent) and peak power demand
- Modbus communications system with user selectable address assignment for communicationdirectly with EnerVista Viewpoint power system monitoring software
- Waveform capture for enhanced system diagnostics
- Protective Relays for enhanced system protection
  - Voltage Unbalance
  - Current Unbalance
  - Under Voltage
  - Over Voltage
  - Power Reversal
  - Load Alarm
- Input relay for RELT signal or remote tripping of the breaker
- Two programmable output relays for enhanced signaling and diagnostics
- Control Power option provides connection capability for +24Vdc control power via the distributioncable system

Other features

- UL Listed for reverse feed and HACR type (standard)
- UL Listed Current Limiting (optional on SG Frame)
- Internal Accessories (Shunt Trip, Undervoltage Release, Auxiliary Contacts, Bell Alarm) – UL Listed for field installation and common across the entire line of Spectra RMS breakers

Note: Spectra molded case circuit breakers are 80% rated (continuously) in LV MCC construction as tested by UL845.

Ground fault current detection systems
Model BGFL (Relay)
Trip Currents 5-60, 30-360, or 100-1200A

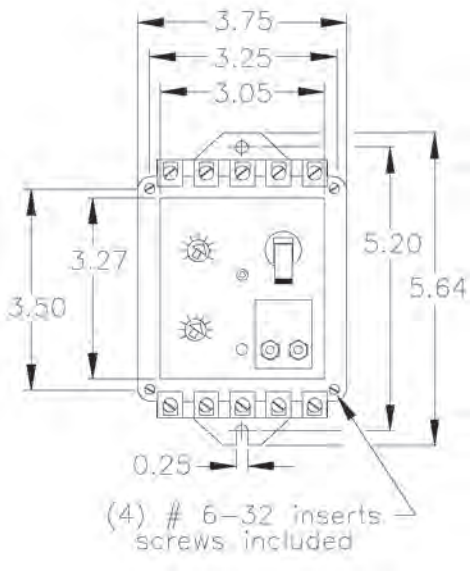
Description
These Class 1 Model BGFL ground fault relays and sensors form a system for detecting a ground fault current on a ground ac power system. When a ground fault exceeds a pre-selected current level and time delay setting, the relay initiates a trip signal for a shunt trip disconnect device to open and clear the fault. This BGFL system provides protection for electrical equipment, not for personnel.

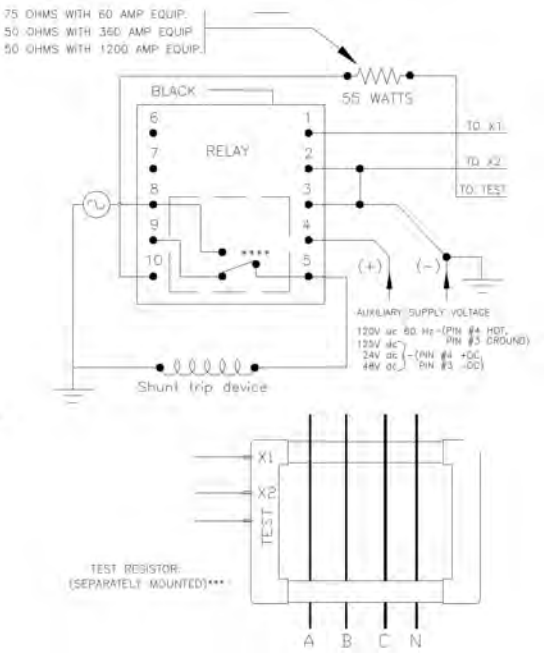
Operating range: Trip currents of 5-60, 30-360, or 100-1200A. Time delay from 0.10 to 1 second (adjustable).
Input power: 2 VA plus shunt coil requirements. Rated @ 120 Vac.
Input withstand: 200,000 Amperes RMS for 3 cycles, 50/60 Hz.
Nominal input voltage: 120 Volts ac, 125 Volts dc, 24 Volts dc, 48 Volts dc.
Frequency: 50/60 Hz.
Ambient temperature range: -30°C to +60°C
Only for use with GFL sensors.
Approximate weight 1.5 lbs.

- Meets NEC service entrance equipment standards.
- Available in three basic styles: Standard, Form C or Zone Interlocking for coordination of single or multiple ground fault devices in system.
- Integral test panel with Push To Test and Shunt Trip Bypass pushing for ease in proper operational testing of the system, with or without tripping the protective device.
- Power On LED indicator in cover.
- Positive visual trip indicator, manual reset.
- Infinitely adjustable Time Delay.
- Discrete current threshold adjustment.
- Panel or door mounting.
- Rear terminal kit and clear plastic cover standard with door mounting.
- Electromechanical relay output, positive ON and OFF.
- Operates with molded case and power circuit breakers, bolted pressure switches, fusible disconnect switches.

Contact rating

Device input power	Inrush	Cont.
120 Volts ac	10A	3A
125 Volts dc	1A	1A
48 Volts dc	4A	4A
24 Volts dc	8A	8A





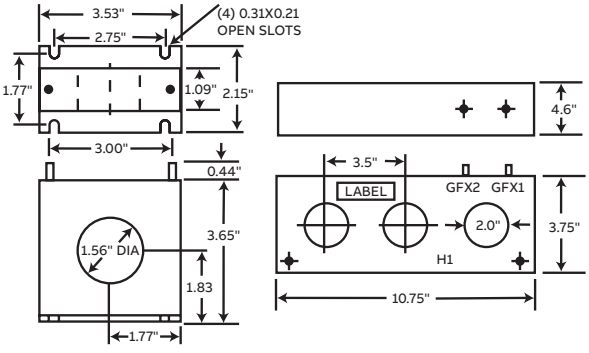
Note: Mounting provision on reteangular GFL sensors with 11.1" and 13.2" widths.

Ground fault current detection systems
Model GFM Relay
2.0 to 65 Amp Trip Currents

Description
These Class 1 Model GFM Ground Fault protection systems are designed to minimize damage or loss to equipment caused by destructive arcing ground faults. This GFM system is designed for all polyphase applications and is ideally suited for motor control, motor control centers, and medium voltage starters. Systems can be wye or delta, grounded or resistance grounded. When the ground fault current exceeds a preselected condition (current and time settings) the relay trips. The relay contacts can be connected in the control circuit of a motor starter, to the shunt trip of a circuit breaker or similar disconnecting or alarm devices. The system has an inverse time characteristic to prevent nuisance tripping. The relay tripping current value is field adjustable over the trip current range of the sensor. The adjustable trip time delay relay is field settable up to 36 cycles.

Operating range: Trip currents from 2.0-65A. Time delay from instantaneous to 36 cycles.
Input power: Self-powered
Frequency: 50/60 Hz.
Ambient temperature range: -30°C to +60°C
Only for use with GFL sensors.

Operation
- Positive condition indication
- Normal (Reset) - Green (“ON”)
- Tripped - Red (“OFF”)
- Manual Reset

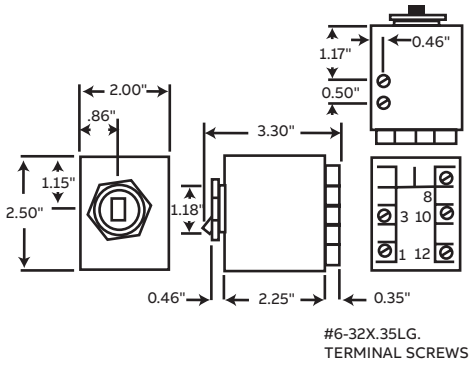


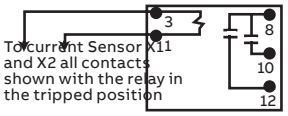
Model number	Trip(1) Current
GFM 156	3.8 to 18

Model number	Trip(1) Current
GFM 3P208	5 to 20

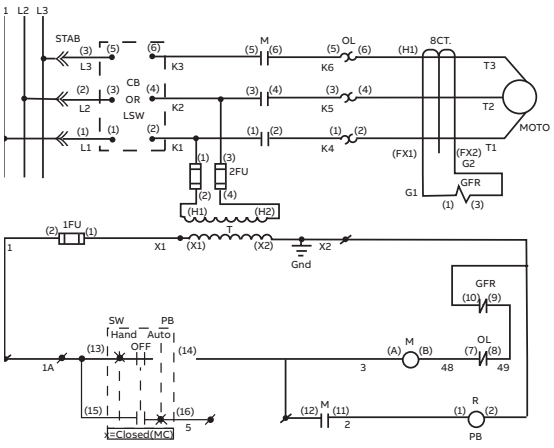
1. Trip current tolerance is ± 15 percent.

Model GFM-252 and 262
Contacts rated 10 Amps continuous, 23 Amps inrush, 120 Volts AC





Typical circuit



C2000 Line Motor Starters
C2000 Line motor starters offer greater design versatility. C2000 Line components are loaded with features that make them easier to install, allow more flexible configurations, and allow for a smaller unit footprint. These components conform to international standards (UL, cUL and IEC-947) and have dual (U.S./European) markings to ensure global acceptance. A single nomenclature system allows simple sourcing worldwide. AC coils (both 50 Hertz and 60 Hertz versions) are available for a wide range of voltages for flexibility.

Design versatility
- 3-pole AC contactors (non-reversing and reversing, ranging from 5-500 hp @ 460 volts)
- RT overload relays (Class 10 versions for contactors 5-125 hp range, and Class 10 and Class 30 versions for contactors in the 150-500 hp range)
- Contactor accessories — front– and side-mount auxiliary contact blocks, mechanical interlocks, pneumatic times, and surge suppressors
- Wye-delta starters
- Control relays available in various contact arrangements
- Up to six front-mount auxiliary contact blocks and one side-mount auxiliary contact block can be added to contactors in the 30-75 hp range.

Easier installation
- 5-75 hp contactors can be either DIN-rail or screw mounted
- Mechanical interlocks allow quick, easy configuration of reversing contactors
- Coil information is printed on top of each contactor for easy reference
- On 5-25 hp contactors, pozi-drive screws accept any screwdriver
- Easy attachment of accessories

Flexible, compact configurations
- In the 5-75 hp range, each contactor accepts both front– and side-mount auxiliary contact blocks
- Pneumatic timers can be used in conjunction with side-mount auxiliary contact blocks
- Double-clamp terminal accepts two differently sized wires; both control and power wires can be inserted
- Surge suppression is built into the electronic control module inside 100-500 hp contactors
- RT overload relays mount directly on 5-125 hp contactors to reduce space requirements

Safety protection
- Contactors in the 5-75 hp range have built-in finger and back-of-hand protection

Dimensions (in/mm)

Contactor	Width[1]	Height	Depth[1]
CL00	1.77/45	3.19/81	3.35/85
CL01	1.77/45	3.19/81	3.35/85
CL02	1.77/45	3.19/81	3.35/85
CL25	1.77/45	3.19/81	3.43/87
CL04	2.17/55	3.43/87	3.86/98
CL45	2.17/55	3.43/87	3.86/98
CL06	2.60/66	4.63/117.5	4.57/116
CL07	2.60/66	4.63/117.5	4.57/116
CL08	2.60/66	4.63/117.5	4.57/116
CL09	2.95/75	4.63/117.5	4.96/126
CL10	2.95/75	4.63/117.5	4.96/126
CK75	4.86/123	7.01/178	6.50/165
CK08	4.86/123	7.01/178	6.50/165
CK09	5.90/150	8.34/212	8.18/208
CK95	5.90/150	8.34/212	8.18/208
CK10	6.29/160	9.00/229	9.05/230
CK11	6.29/160	9.00/229	9.05/230
CK12	9.06/230	9.84/250	10.31/262

1. Does not include front- or side-mount auxiliary contacts required on CL25, CL45 and CL06-CL10.

Contactor with Overload	Width	Height	Depth
CL00+RT1	1.77/45	5.03/128	4.20/106.7
CL01+RT1	1.77/45	5.03/128	4.20/106.7
CL02+RT1	1.77/45	5.03/128	4.20/106.7
CL25+RT1	1.77/45	5.03/128	4.20/106.7
CL04+RT1	2.17/55	5.27/133.7	4.06/103
CL45+RT1	2.17/55	5.27/133.7	4.06/103
CL06+RT2	2.60/66	7.25/184	4.57/116
CL07+RT2	2.60/66	7.25/184	4.57/116
CL08+RT2	2.60/66	7.25/184	4.57/116
CL09+RT2	2.95/75	7.43/189	4.96/126
CL10+RT2	2.95/75	7.43/189	4.96/126
CK75+RT3	4.86/123	10.39/264	6.50/165
CK08+RT3	4.86/123	10.39/264	6.50/165
CK09+RT4	5.90/150	16.53/420	9.12/231.6
CK95+RT4	5.90/150	16.53/420	9.12/231.6
CK10+RT5	6.29/160	14.45/367	11.36/289
CK11+RT5	6.29/160	14.45/367	11.36/289
CK12+RT5	9.06/230	16.18/410.9	11.81/300

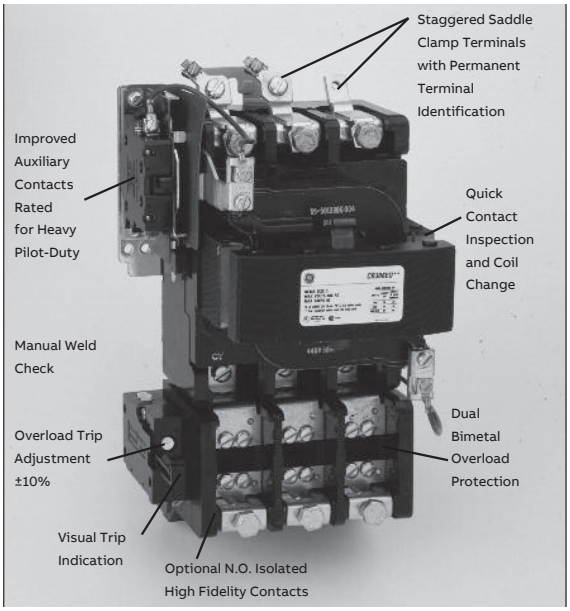
300-line motor starters

The 300-line starter is a full-voltage, magnetic motor starter with encapsulated coil and three-leg block overload relay with visual trip indicator, manual reset and manual weld check. It incorporates all the features and benefits most asked for by users and has received standard specification approval by many major manufacturers. In addition to the basic non-reversing form, the 300-Line is available in reversing, two-speed and combination forms in NEMA sizes 00-5.

The 300-Line's toolless contactor disassembly allows quick access for inspection and maintenance. Simply release two coil retainers and pull the spring clip from the "I" magnet to gain access to the magnet, coil and contacts. No need to remove any wiring.

Optional terminals can be provided to permit the easy connection of power factor correction capacitors for energy conservation.

The molded coil is impervious to moisture, dirt and oil. It is highly resistant to mechanical damage and high-humidity failure. Retaining clips engage detents encapsulated in the coil to hold it securely in place.



300-line motor starters

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Cover removed

Where it's essential to monitor performance or diagnose faults, a 300-Line starter may be ordered with an additional isolated, highfidelity, normally-open contact on the overload relay. This contact may be used for direct input to a programmable controller or direct interface with a computer.

All line and load terminals on NEMA size 00, 0 and 1 starters have saddle clamps to accommodate all types of terminations– ring, spade and stripped-wire. Terminal numbering is permanently stamped, and terminals are staggered to help prevent shorting. NEMA size 2, 3 and 4 starters are also available with provision for ring terminations with staggered terminals. Size 5 starters are available with provision for ring terminations. In-line terminals for spade and stripped-wire connections are standard.

On NEMA size 1 starters and larger, contact tips are weld-resistant with cool operation and extended life. The contacts have a wedgeshaped configuration for positive make with minimum bounce. They can be easily changed from normally open to normally closed without additional parts on Sizes 0 and 1. Magnet provides long life and is specially treated to resist rust.

The overload relay can be manually tripped deliberately as a convenient way to check against contact welding. Depressing the manual weld check arm trips the relay. Then a welded contact can be detected with a simple continuity check.

Overriding is eliminated because overload reset occurs only when the reset arm is released on the standard manual-reset form.

A bright yellow visual trip indicator tells operators at a glance if the overload has tripped. An optional automatic-reset overload relay is available for special applications upon request.

Overload relay heaters are completely interchangeable with heaters for 200- and 100-Line starters, eliminating the need to stock different heaters.

Relay trip points are factory calibrated at given currents for high accuracy. For added flexibility, the trip current of the relay is adjustable +10 percent to allow tuning the protection to any given motor and to eliminate nuisance tripping. A single calibration adjusts all three legs. The overload relay is available in standard or ambient-compensated forms.

Each auxiliary contact is rated 10 amperes AC, continuous current (NEMA A600), and is suitable for either right or left side mounting. All necessary parts are supplied in the modification kit for easy installation. An insulating shield is also provided for use between each auxiliary contact unit and the starter.

Auxiliary contact kits offered include one with a basic contact block and one with an adder block. The basic block is supplied with either a single circuit (one normally open contact or one normally closed contact) or a double circuit (one normally open and one normally closed contact). The adder block must be used in conjunction with a basic block. It may be ordered with either one normally open or one normally closed contact.

Overload Relays

	Series RT thermal Overload relay	CR324 thermal bimetallic Overload relay	CR324X electronic Overload relay	Basic communication Overload relay	MM200 motor controller	MM300 motor controller
Description	RT overload relays provide motor overload protection through fixed bimetal heaters. These relays are ambient compensated and utilize a differential mechanism for single-phase sensitivity. Overload relays may be set for 4 different operational modes — manual reset only, automatic reset only, manual reset/stop, or automatic reset/stop. Stop is initiated by pushing the reset button which interrupts the holding circuit in the latter two listed modes. Overload relays feature visible trip indication, reset on the upstroke, weld check, and trip test.	The CR324 thermal bimetallic overload relays use interchangeable match overload relays to motor amps. A ±10 trip adjustment dial is used to fine tune the motor overload relays. Overload relay features include trip test, manual reset on upstroke, weld check visible trip indicator and an optional normally open signal contact.	The CR324X is an electronic alternative to the CR324 bimetallic overload relay. The CR324X eliminates the need for heater elements, providing a broader amperage adjustment range. Provisions for increased diagnostic capabilities permit automation control via auxiliary contacts and remote reset open collector. Mounting dimensions are identical to the CR324 thermal overload relay and permit fast, simple field upgrades.	The Basic Communication overload relay is a solid-state overload relay with selectable trip class and wide current adjustment range settings. This robust relay allows for either ground fault or communication modules to be side mounted to the relay.	The MM200 integrates protection, control and multiple communication protocols in a rugged compact device for low voltage motor applications. Easily integrated into new and existing control system architectures, the MM200 provides comprehensive low voltage motor protection and communications for all types of motor protection applications.	The MM300 integrates protection, control, automation, metering, diagnostics and multiple communication protocols in a rugged compact device for low voltage motor applications. Designed for motor control centers, the MM300 delivers superior protection and control to extend equipment life and maximize process uptime.

	Series RT thermal Overload relay	CR324 thermal bimetallic overload relay	CR324X electronic overload relay	Basic communication overload relay	MM200 motor controller	MM300 motor controller
Type	Thermal	Thermal bimetallic	Electronic	Electronic	Electronic	Electronic
Protection class	10, 10A, 20, 30	20	10, 20, 30 (selectable)	10, 15, 20, 30 (selectable)	10, 15, 20, 30 (selectable)	10, 15, 20, 30 (selectable)
Ambient compensation	Ambient temperature compensating	Optional	Ambient insensitive	Ambient compensated	Yes*	Yes*
Phase loss protection	Yes	No	Yes	Yes	Yes	Yes
Phase unbalance	Yes	No	No	Yes	Yes	Yes
Ground fault	No	No	No	Yes*	Yes	Yes
Self powered	Yes	Yes	Yes	Yes	No (power from starter CPT)	No (power from starter CPT)
Accuracy	±5%	±5%	±2%	2.5-5%	2%	2%
Repeatability	±3%	±3%	±2%	1%		
FLA Adj. range	0.16-850A	Up to 135A	0.4-540 A (Depending on relay chosen)	0.4-540 A (Depending on relay chosen)	5 to 1000 FLA in steps of 1A**	5 to 1000 FLA in steps of 1A**
Reset mode	Manual and Automatic	Manual (auto optional)	Manual	Manual and Automatic	Manual and Automatic	Manual and Automatic
Trip test	Yes	Yes	Yes	Yes	Manual and Automatic	Manual and Automatic
Trip indication	Yes	Yes	Yes	Yes	LED/User Interface/ SCADA	LED/User Interface/ SCADA
Operating temp. range	–25° to 60°C (compensated)	0° to 55°C	–20° to 70°C	–20° to 60°C	–20° to 60°C	–20° to 60°C **
Communications	No	No	No	Profibus* DeviceNet* Ethernet IP*	Modbus RTU Modbus RTU + Profibus DP Modbus RTU + Profibus + DeviceNet	Modbus RTU Modbus RTU + Modbus TCP + Profibus DP Modbus RTU + Modbus TCP + DeviceNet
Addressable	No	No	No	Yes	Yes	Yes
Heater required	Yes	Yes	No	No	No	No
PFC terminals	No	Yes (optional through NEMA Size 2)	Yes (optional through NEMA Size 2)	No	No	No
PLC compatible contacts	No	No	Yes	Yes	Yes	Yes
Aux. contacts	NO and NC	NC (NO optional)	NO and NC	NO and NC	2 NO, 1 C form	2 NO standard, add on available
Mount	Designed to mount directly to C2000 contactor or panel mount	Designed to mount directly to CR305 contactor or panel mount	Designed to mount directly to CR305 contactor or panel mount	Din-Rail Panel Mount	Din-Rail Panel Mount	Din-Rail Panel Mount
Reference publication		Control catalog section 1	DEP-015		090824 - V17, GEK-113400E, 1601-9034-A6	131111 - V21, GEK-113022J, 1601-9023-AA
Notes				* Ground fault and communication modules cannot be used at the same time	*When ordered with RTD Module **1-10 turns are available to accommodate CT turns lower than 5A	*When ordered with RTD Module ** based on 1" around base unit ***1-10 turns are available to accommodate CT turns lower than 5A

This table reflects standard offering of overload relays; however, other overload relays can be included if needed. If you have other overload relays you wish to add to your MCC, please contact the factory for assistance.

ASTATs and VFDs utilize integral overload protection algorithms. External overload relays are only used with ASTATs and VFDs to support the motor control in a bypass configuration.

Industrial relays

C2000 Control relays

The C2000 Control Relay is a compact, industrial style relay designed for heavy-duty applications where reliability and versatility are required.

Basic forms: 4 NO; 3NO-1NC; 2NO-2NC; 4 NC Max front mounted aux. contacts: 4 (NO or NC)
Contact Rating: A600; P600
Aux. Contact Rating: A600; Q600; P300
Timer Contact Rating: A600; P600

Coil data

	AC Voltage	DC Voltage
Burden		
Inrush	45 VA	5.5 W
Holding	6 VA	5.5 W
Pickup Voltage (% of Coil Volts)	85-110	80-110
Drop-Out Voltage (% of Coil Volts)	40-55	20-40
Switching Delay (ms) **Switching Delay on**		
Coil Voltage at +10% to -20%	6-25	35-65
Coil Voltage at Rated Value	8-20	40-45
Switching Delay off		
Coil Voltage at +10% to -20%	6-13	30-60
Coil Voltage at Rated Value	6-13	30-60
Maximum Operations per Hour		
No Load	9000	3600
Rated load	1200	1200

Coil rating

AC Coil Rating		DC Coil Rating
24V/60 Hz	24V/50 Hz	24VDC
48V/60 Hz	42V/50 Hz	48VDC
120V/60 Hz	110V/50 Hz	125VDC
208V/60 Hz	190V/50 Hz	250VDC
240V/60 Hz	220V/50 Hz	
240V/60 Hz	220V/50 Hz	
277V/60 Hz	240V/50 Hz	
—	380V/50 Hz	
—	415V/50 Hz	
480V/60 Hz	440V/50 Hz	
600V/60 Hz	550V/50 Hz	

Contact ratings

	A600	P600	Q600	P300
Continuous thermal current	10A	5A	2.5A	5A
Max. VA/Amps making	7200VA/ 60A	138VA	69VA	138VA
Max. VA/Amps breaking	720VA/ 6A	138VA	69VA	138VA
Max. operating voltage	600VAC	600VDC	600VDC	300VDC

Accessories for C2000 contactor and control relay

Front-mount auxiliary contact blocks

1NO or 1NC
Front-mount auxiliary contact blocks clip into front face of control relay.

Pneumatic timers

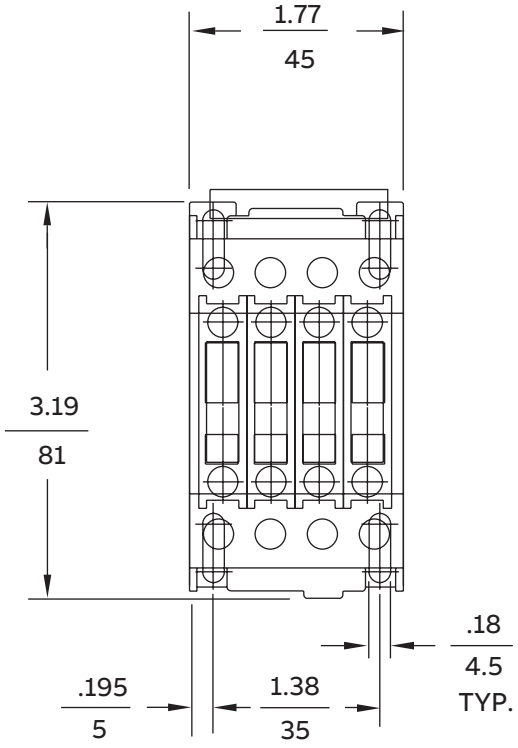
Pneumatic timers are adjustable time-delayed auxiliary contacts. They come equipped with two time-delayed contacts: 1NO or 1 NC, electrically separated. Setting is scaled over a 350° rotation by means of a knurled knob with timing guide marks. To mount a pneumatic timer, simply clip it on front face of control relay.

Type	Range	Contacts
Time	.1-30 sec	1NO-1NC
Delay On	1-60 sec.	1NO-1NC
Time	.1-30 sec.	1NO-1NC
Delay Off	1-60 sec	1NO-1NC

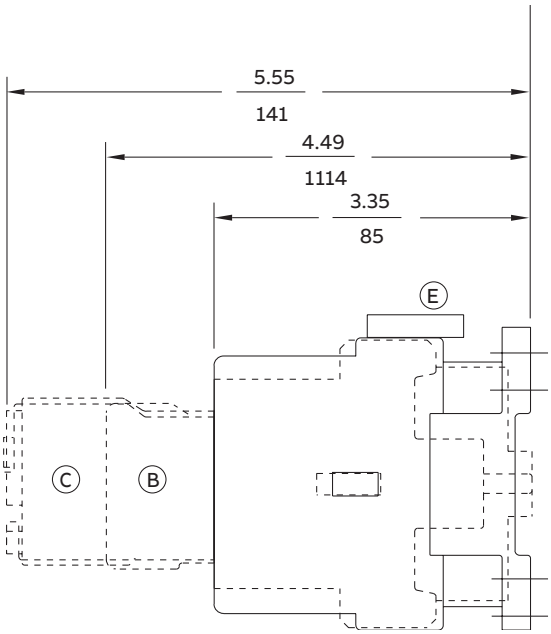
Surge suppressor

For suppression of disturbances on electronic circuits due to the coil transient voltage occurring on opening of the contactor. Limits high voltage transients that may be produced when coil is de-energized. Mounts directly on top of the coil.

Control relay - front view



AC control relay - side view



CR104P pilot devices

Description

Newly-designed nameplates with chrome-plated octagonal rings project an attractive, quality appearance. Positive feel selector switches give a quality touch in all illuminated, solid color, spring return, and maintained units.

Standard and illuminated push buttons and selector switches are available. Both push button and selector switches are available with key or for conventional operation. The CR104P push-button line also includes press-to-test and standard indicating lights, mushroom-head, joy stick, push-pull and push-push operators.

Application

Especially adapted to machine-tool service or any application where oil or coolant is present. The convenient one-hole mounting makes this line suitable for general purpose use in equipment of all kinds where panel mounting is possible. This line is ideal for applications where oil tightness, watertightness and long life are essential.

All units are suitable for use in Type 1, 3, 3R, 4, 12 and 13 environments when mounted in enclosures rated for those same applications.

Features

- Ease of assembly–One screw contact block mounting. Octagonal ring provides ease in front panel mounting and enclosure applications.
- Greater torque–Due to the eight-sided ring design, greater torque can be developed during assembly and installation to provide oil tightness.
- Stocking inventories reduced–Forms may be furnished as complete units or as components, allowing building block construction from a minimum of stock.
- Color Coded–Colored knobs and caps are available in kit forms for easy field conversion.

CR104P pilot lights

Pilot lights match appearance of switches above. Standard applications use full voltage or transformer type lights. Optional nameplates match those used with switches, neon lights are available (with limited lens colors).

Type	STD	Push-to-test	Bulb	Color
Full Voltage (120 VAC)	•	•	#120PSB	Red
				Green
Transformer (6 VAC Secondary)	•	•	#755	Amber
				Blue
				White
				Clear
Neon	•	N/A	Neon	Red
				White
				Amber
				Clear
LED (transformer type only)	•	•	LED (6 Volt)	Red
				Green
				Blue
				Amber

Contact ratings

AC ratings, NEMA A600 heavy pilot duty

Max. Ac	Continuous current Amps	AC Voltamperes @ 60/50 Hz[2]	
		Make	Break
600	10	7200	720

DC ratings, NEMA P600

Max. Make or Break Amps		
125V	250V	600V
1.1	0.55	0.2

1. CR104PTP units are suitable for Type 1,12, and 13 applications only.
2. Maximum make and break currents are 60 and 6 amperes respectively for voltages of 120 and below.

C2000 pilot devices

Description

C2000 Push Buttons are heavy-duty, 22.5mm water-tight and oil-tight pilot devices. Four operator styles – round polished and satin chrome, round and square engineered plastic – are available. They just snap onto the mounting flange and all reflect a sleek, distinctive European style that give you precisely the look and function you want in your push buttons. Choose from full-voltage, resistor and transformer power supplies with incandescent, LED or neon lamps.

Features

- Installation is quick, labor cost are reduced.
- Ergonomic design adds ease of assembly and operation.
- Back-tightened locking rings discourage tampering, accommodate a range of panel thickness, and tighten down with either a custom wrench or any flatbladed screwdriver.
- A removable orientation tab allows universal mounting in either notched or round 22.5 mm holes.
- Permanently bonded front gasket provides superior sealing against contaminants and makes installation nearly foolproof.
- Markings are easy to read and laser-etched so they remain permanently legible.
- 4-point contact, flanges snap securely onto the operator.
- Ultrasonically welded contact block housings hold up longer and resist contamination better, even in the dustiest environments.
- Double bridge sliding contacts provide excellent performance, even in low-voltage applications.
- Terminals (both screw and quick-connect) can be wired off the operator, then snapped on.
- Contacts are rated A600, Q300.

C2000 pilot devices

Standard for 1/2X compact starter. See Control Catalog.

C2000 double bridge feature

Solid-state motor winding heater

Description

The motor winding heater is designed for use with 3-phase ac motors to guard against damage caused by condensation build-up on motor windings, which can occur in high-humidity environments during motor idle periods. With the heater connected as indicated in the connection diagram, and the motor not running, an SCR controlled current flows in the motor windings, producing enough heat to maintain the temperature inside the motor above the ambient temperature. The motor winding heater is automatically energized after the starter contacts (M) open, and de-energized when the starter contacts close. Fuses are included for SCR overcurrent protection and protection for wiring.

If desired, a pilot light can be connected as shown (“Fuse Condition Indicator”) to visually monitor the condition of the fuses. With the starter contacts open, the light will be On if current paths through FU1 and FU2 are complete. The pilot light should have a line voltage rating.

Specifications

Output Voltage Regulation: Voltage applied to motor winding will vary +2% maximum for line voltage variations of +10%, -15%.

Operating Temperature Range: -20°C to +50°C.

Fusing: FU1–Fast-acting semiconductor fuse for SCR overcurrent protection. FU2–Class RK-5 rejection type fuse with time delay for wiring protection.

Additional SCR Protection: Metal oxide varistor protects against voltage surges. RC snubber circuit limits rate of change of circuit voltage.

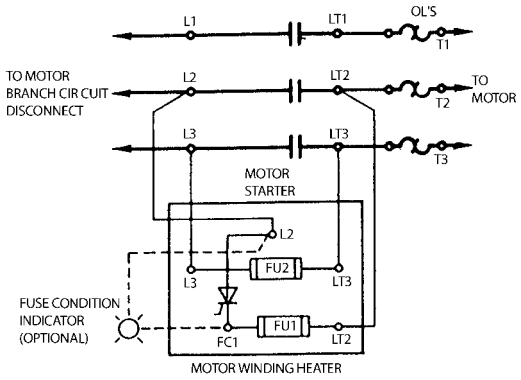
Motor Voltage +10%, –15%, 3-Phase 60 Hz	Motor Horsepower Range
230/460V	15-400 Hp
575V	25-400 Hp

Heater is UL Listed in MCC Construction

Applications

50 Hertz Applications: The 230/460 volt device can be used at 220/440 volts, 50 Hertz. The 575 volt device can be used at 550 volts, 50 Hertz.

Typical wiring diagram



Note: Since voltage is present at motor terminals at all times, cautionary information sent with the device must be observed.

EPM 6000 power meter
High Accuracy Power and Energy Measurement

Overview
EPM 6000 is one of the industry's highest performance revenue grade panel meters. Based on the latest technology and an all-new platform, EPM 6000 has a superior cost to performance ratio and significantly outperforms othe metering products many times its price.

Applications
- Continuous metering of electrical loads such as generator panels, feeders, switchgear etc.
- Provides remote status when used with EnerVista suite of software
- Low and medium voltage applications
- Replaces multiple analog meters saving space and installation costs

Key benefits
- High accuracy multifunction power meter
- Superior performance at competitive pricing
- Ultra compact, easy to install, program and use
- 0.2% class revenue certifiable energy and demand metering
- Total harmonic distortion (%THD)
- Fits both ANSI and DIN cutout
- Large 3 line .56" bright LED display for better visibility and longer life
- User programmable for different system voltages and current measurements
- Standard Modbus and DNP communications
- Optional Ethernet port for simplified integration into onto new or existing LAN infrastructures and multi-point connectivity

Features
Monitoring and Metering
- True RMS multifunction measurements including voltage, current, power, freq., energy, etc.
- Meets ANSI C12.20 (0.2%) and IEC 687 (0.2%) accuracy classes
- Future field upgradeable for added functionality without removing installed meter
- Load percentage graphical bar for instant load visualization

Communications
- RS485 Modbus and DNP 3.0 Protocol up to 57.6K Baud (Serial Option)
- Modbus TCP Protocol through 10/100BaseTX via RJ45 (Ethernet Option)
- 3 Line .56" Bright Red LED Display
- Front IrDA Port laptop communication
- Pulse output for accuracy testing and energy

For more information on EPM 6000, please see https://www.gedigitalenergy.com/multilin/catalog/ epm6000.htm

EPM 6010 automation power meter
BACnet/IP communications and energy measurement

Overview
The Multilin EPM 6010 is an industry leading revenue grade power meter with native BACnet/IP communications. This meter is designed to integrate seamlessly into existing and new building management systems using the popular BACnet protocol. The meter allows users to gather data on voltage, current, power and energy usage throughout a facility.

Designed to be the perfect device for environmental initiatives, LEED certified projects and smart energy projects, the EPM 6010 provides superior metrology, and revenue testable 0.2% energy accuracy. The meter is in compliance with ANSI and IEC accuracy standards, has advanced DSP technology, samples at high rates, and has 24 bit A/D conversion to measure and analyze power accurately and reliably.

Applications
- LEED projects
- Smart buildings
- Commercial energy management
- HVAC efficiency monitoring
- Building management systems

Key benefits
- Rapid integration into BACnet management systems
- High accuracy multifunction power meter, 0.2% class revenue certifiable energy and demand metering
- Ultra compact and easy to install, fits both ANSI and DIN cutouts
- EnerVista software makes metered data and power quality status easily accessible
- User programmable for different system voltages and current measurements
- Standard Modbus and TCP communications
- Easy to read, large 3 line .56” bright LED display for better visibility and longer life

Features
Measuring and Metering
• High accuracy multifunction power meter, 0.2% class revenue certifiable energy and demand metering.
• Samples at 400+ times per cycle and has 24 bit A/D conversion to measure accurately and reliably
• Meets ANSI C12.20 (0.2%) and IEC 687 (0.2%) accuracy classes.
• Total harmonic distortion (%THD)
• Load percentage graphical bar for instant load visualization.
• True RMS multifunction measurements including voltage, current, power, frequency and energy.

Communications
- BACnet/IP 100BaseT Ethernet protocol
- 40 pre-defined BACnet objects facilitate rapid integration
- Embedded web-server, allows BACnet/IP interface to be remotely configured and BACnet objects can be remotely viewed over the internet with a web browser
- Standard Modbus TCP communications can be used to poll the EPM 6010 while BACnet/IP interface is being used

For more information on EPM 6010, please see https://www.gedigitalenergy.com/multilin/catalog/ epm6010.htm

EPM 7000 power meter
Power quality and energy cost measurement

Overview
The EPM 7000 meter provides revenue class (0.2%) three phase power metering with optional Ethernet, relay, status, and analog output communication modules. This flexible meter can be used for a wide range of high accuracy applications including disturbance recording and power quality studies.

EPM 7000 can easily be mounted in a panel for generator monitoring, substation automation, power quality studies, data recording and more. The meter can also provide data to RTUs, PLCs and other control devices.

The EPM 7000 is a highly accurate meter providing 0.1% accuracy for Voltage and Current. The unit's real-time clock provides time stamping of all logs as they are created. Up to 4 MB of data can be logged for analysis of historical trends, limit alarms, I/O changes power quality recording and sequence of events.

Applications
- Four quadrant energy and power monitoring of distribution feeders, transformers, reactors and generators.
- Power monitoring of LV and MV industrial power control centers and motor control centers.
- Energy monitoring of commercial and distribution utilities.

Key benefits
- Four Quadrant Energy and Power Measurement, complying with ANSI C12.20 (0.2% Accuracy)
- Analyze power quality over long periods of time to improve network reliability through high resolution event and disturbance recording
- Ideal for monitoring industrial power centers, data centers and hospitals due to high accuracy disturbance recording (up to 512 samples/cycle)
- Retrieve archived data, capture past events and analyze disturbances through high resolution data recording (up to 4MB of data logging)
- Flexible communication options provide easy to access meter values, simplified configuration and seamless integration into new or existing automation systems

Features
Metering
- Meets ANSI C 12.20 and IEC 687 (0.2%) accuracy
- Ia Ib Ic In
- Va Vb Vc Vab Vbc Vca
- Hz W VAR VA
- Wh VARh VAh
- Demand: W VAR VA
- Power Factor
- Voltage and Current Angles
- Load Bar

Power Quality
- Harmonics to the 40th order
- Total Harmonic Distortion
- Disturbance Recording and Waveform Capture
- Sag and Swell

Data Logging
- Up to 4 MB Memory
- Disturbance Recording
- Power Quality Studies
- Load Studies

Communications
- Standard RS485 Modbus (DNP 3.0 and Modbus RTU or ASCII)
- Optional Ethernet 100BaseT
- IrDA Port
- Intuitive faceplate programming

Software
- Embedded Web Server
- Communicator
- EnerVista Integrator
- EnerVista Launchpad

For more information on EPM 7000, please see https://www.gedigitalenergy.com/multilin/catalog/epm7000.htm

PQM II power quality meter
Power quality and energy cost management

Overview
Multilin has set a new standard in metering technology with the introduction of the PQM II. This meter, designed on the latest industry specifications, provides accurate and reliable three-phase power metering with an optional Ethernet and fiber communications module in a small and modern package. The PQM II can be used for a variety of applications including metering of distribution feeders, transformers, generators and motors.

Applications
- Metering of distribution feeders, transformers, generators, capacitor banks and motors
- Medium and low voltage systems
- Commercial, industrial, utility
- Flexible control for demand load shedding, power factor, etc.

Key benefits
- Power quality metering with waveform capture and historical data logging
- Easy to program and use with keypad and large illuminated 40 character display
- Multiple communication ports for integration with DCS and SCADA systems
- Supports DNP 3.0 and Modbus protocols
- Digital and analog I/Os for control and alarms
- Voltage disturbance recording capability for electrical sag and swell events

Features
Monitoring and Metering
- Ia Ib Ic In
- Va Vb Vc Vab Vbc Vca
- V I unbalance
- True PF crest and K factor
- Hz W var VA
- Wh varh VAh W cost
- Demand: A W var VA
- Harmonic analysis through 63rd with THD and TIF
- Event recorder - 150 events
- Waveform capture
- Data logger -98,000 events
- Voltage Disturbance Recorder (VDR) -500 events

Communications
- Front RS232 serial port (1,200 to 19,200 bps)
- Two rear RS485 serial ports with ModBus and DNP 3.0 protocol
- Ethernet connectivity provided by MultiNet
- EnerVista software is provided for setup and monitoring functions
- External dial-in modem capabilities

Protection and Control
- Load shedding
- Power factor control
- Pulse input totalizing

For more information on PQM II, please see https://www.gedigitalenergy.com/multilin/catalog/pqmil.htm

Three-phase voltage monitors
Model SPVRB

General
UL Listed file No. E103039 The model SPVRB Voltage Sensing Relay is designed to protect against single phase, phase loss, phase unbalance, and phase reversal in a power system. The output contacts change their normal state only when a single phase, phase loss, phase unbalance, or phase reversal occurs for longer than the preset trip delay. A total power loss or de-energization of the SPVRB relay will not change the output contacts position. Recommended for manual reset switches and breaker applications. The SPVRB is suitable for loss of phase with motor loads.

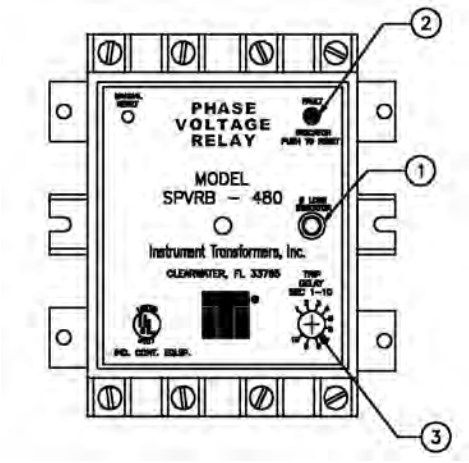
Features
- Phase unbalance: 8%
- Adjustable Trip Delay: 1 to 10 seconds after failure occurs, prevents nuisance operations
- Output Relay: normally de-energized, form C contacts for easy circuit configuration
- Electro-mechanical indicator: retains memory of fault until manually reset
- Door or panel mounting
- Status Indicator: bi-colored LED
  - Green: Output relay de-energized (normal condition)
  - Red: Output relay energized (fault condition)
  - Dark: Output relay de-energized (input power off)
- Single Phase, Phase Reversal, Phase Unbalance and Phase Loss Protection: operates the output relay after a preselected time
- Automatic or Manual mode
  - Automatic mode: Upon removal of fault conditions, relay automatically resets to normal
  - Manual mode: Upon removal of fault conditions, relay resets to normal after local or remote reset button has been pressed

SPVRB — XXX

Input Voltage:
120/208/240/480 or
575 Vac, (60 Hz)
380 or 415 Vac, (50 Hz)

Available models

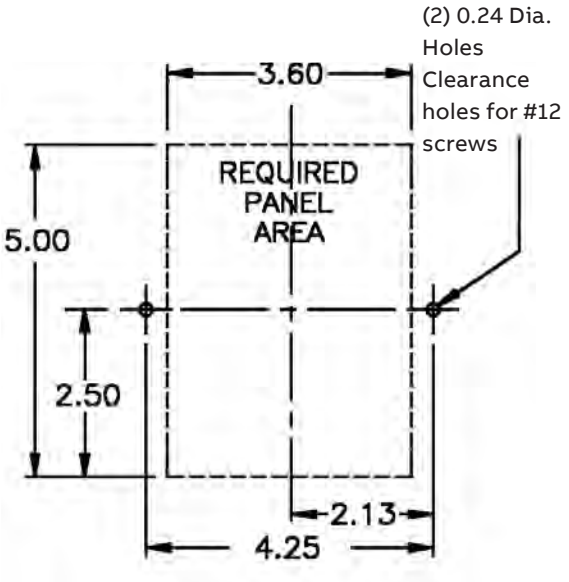
Model No.	Nominal Vac	Hz
SPVRB–120	120	60
SPVRB–208	208	60
SPVRB–480	480	60
SPVRB–575	575	60
SPVRB–380	380	50
SPVRB–415	415	50



[1] Bi-Colored LED Indicator
- Power system condition Normal (Green), Trip (Red)

[2] Electromechanical Diagnostic Indicator
- Phase loss

[3] Adjustable System Delay
- Phase loss
- Phase unbalance
- Single phase
- Phase reversal
- Under and over voltage



Panel mounting layout

Output contact ratings

Voltage	Continuous	HP
120 Vac	10 A	1/3
240 Vac	10 A	1/2
600 Vac	3 A	1/2

10 A, 28 Vdc/120 Vac/240 Vac, 80% pf
3 A, 480 Vac/600 Vac, 80% pf

High-resistance ground

Equipment overview

High Resistance Grounding Equipment coordinates the use of resistors and control devices, creating a high-resistance ground for a power system. The grounding equipment has the following features:

- **Over-voltage reduction:** Reduces the transient over voltages that can occur during arcing faults.
- **Fault detection:** Gives immediate warning when the first ground fault occurs.
- **Fault tracking:** Helps locate the fault by producing a tracer signal of current pulses easily distinguishable from background noise.
- **Operation protection:** Enables the system to continue operation with a single line-to ground fault present.

Operational description – low-voltage systems (600v max)

Typical circuit used in low-voltage is shown on page L22.

When a ground fault occurs, the resistor acts to limit the ground current to a pre-determined low value. Taps are provided on the resistor to adjust the fault current. The voltage appearing across the resistor or the amperage through the resistor is sensed by the PulserPlus Pro Controller. A variable time delay is entered via the operator's panel. When the time delay expires, the red Ground Fault indicator light will illuminate. Auxiliary contacts are provided in case a remote indication of the fault is needed or desired. The red light will stay illuminated until the ground fault is removed and the system is reset. Optionally, the PulserPlus Pro can be set for auto-reset. In addition, an audible alarm will sound when the ground fault occurs. This alarm can be silenced from the operator's panel.

Features

- Undervoltage and undercurrent detection and alarm
- Adjustable pulser from 10 to 50 per minute for custom setup
- Adjustable trip delay to avoid nuisance downtime
- Alarm contacts for remote monitoring of ground fault, high harmonics and loss of ground
- High harmonic filtering and detection
- Third harmonics generator winding protection
- Remote operation and monitoring via RS232, Modbus or Ethernet communication

Line and control connections

The line connections are made to the main bus. The control power and auxiliary device connections are made to the terminal blocks rated 30 amperes, 600 volts. Refer to the specific diagrams furnished with the equipment for location detail. Setup information is through the operator's panel.

Where to use

The function of high-resistance grounding equipment is:

1. To provide a ground for neutral of an ungrounded threephase power system, utilizing the high-resistance method. Using this equipment allows the system to operate basically as an ungrounded system. The equipment is designed to eliminate the danger of high-transient overvoltages during certain types of ground faults.

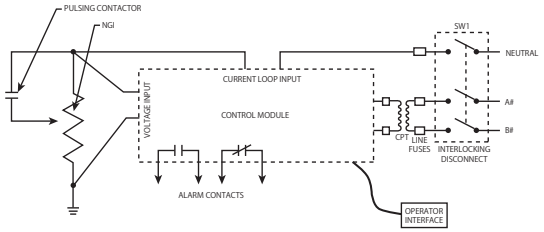
Note: The use of high-resistance grounding on 600 volt maximum systems precludes line-to-neutral loading.

2. To provide an immediate warning when the first ground fault occurs through an alarm system.
3. To provide a method for quickly locating and removing the fault before another fault develops on another phase, thereby preventing circuit outages due to double line-toground faults. This is done by using the pulsing ground current feature and portable detector.

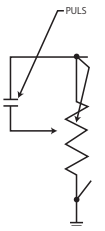
Approximate dimensions and weights

Equipment enclosure type	W x D x H (inches)	With pulsor in pounds		Without pulsor in pounds	
		Wye	Delta	Wye	Delta
NEMA 1	20 x 20 x 90	600	700	575	675

600 Volt maximum Wye system



600 Volt maximum Delta system



PulserPlus Pro is a trademark of Post Glover.

MM200 motor management system
Low voltage motor protection and control

Overview
The MM200 meter integrates protection, control and multiple communication protocols in a rugged compact device for low volage motor applications. Easily integrated into new and existing control system architectures, the MM200 provides comprehensive low voltage motor protection and communications for all types of motor protection applications.

Applications
- Low Voltage Three-Phase AC Motors
- MCC and standalone Panel Mount Applications
- IEC NEMA Motor Control Center (MCCs)
- Process control applications
- System architecture requiring multiple simultaneous communications
- FVNR, FVR, two speed

Key benefits
- Flexible Protection, Control, and Communication options to suit Low Voltage Motor applications
- Small footprint designed specifically for IEC and NEMA MCC applications
- Integrated pushbuttons and LED indicators reduce external components and wiring
- Flexible DIN rail mounting
- Multiple communication protocols allows simple integration into monitoring and control systems
- Optional control panel provides local control

Features
Protection and control
- Motor thermal model
- Undercurrent
- Current unbalance
- Acceleration time
- Sensitive ground fault
- Built-in starter logic
- FVNR, FVR, two-speed
- Auto / manual control
- Configurable inputs
- Power fail restart

Metering and monitoring
- Current, motor loads, thermal capacity
- Motor running time, cause of trip, total number of trips
- 1A / 5A combined CT inputs

Communications
- Networking through RS485
- Multiple Protocols - Modbus RTU ODVA Compliant DeviceNet Internally powered Profibus
- Simultaneous Communications

User Interface
- Optional Control Panel with control push buttons and LED status indicators
- Includes EnerVista MM200 Setup software for simple programming and retrieval of system or trip information

EnerVista Software
- State of the art software for configuration and commissioning Multilin products
- Graphical Logic Designer and Logic Monitor to simplify designing and testing procedures
- Document and software archiving toolset to ensure reference material and device utilities are up-to-date

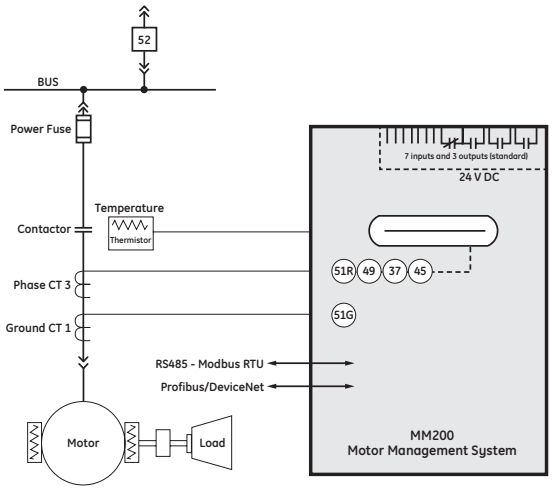
For more information on MM200, please see
https://www.gegridsolutions.com/multilin/catalog/mm200.htm

MM200 motor management system

Functional block diagram

ANSI device numbers and functions

Device No.	Function
37	Undercurrent
46	Current unbalance
49	Thermal overload
50G	Ground instantaneous overcurrent
51R	Locked/Stalled rotot, mechanical jam



MM200 motor management system

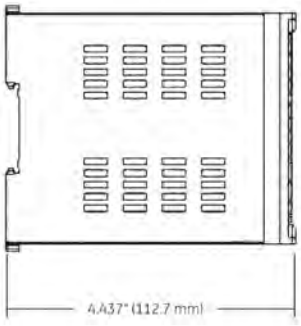
User interface

Front panel controls
- Integrated device controls

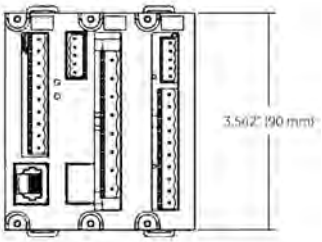
12 LED indicators
- Motor status
- Alarm indication and trip
- Communication status
- Additional user LEDs
- Auto/manual
- % motor load

Dimensions

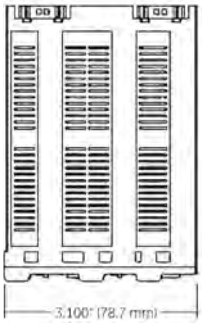
Side view



Front view



Top view



Optional FieldbusProtocols
(ProfiBus or DeviceNet)

Power supply and digital inputs
- 24 VDC Power supply
- 7 x 24 VDC inputs (wet)
- 60-300VAC power supply
- 6x AC inputs

3 Phase CT inputs

RS485 Communications and thermistor input

Optional control panel interface

- Sensitive ground fault
- 2 Form A outputs (5 Amps)
- 1 Form C outputs (5 Amps)

MM300 motor management system
Integrated automation and protection for low voltage motors

Overview
The MM300 meter integrates protection, control, automation, metering, diagnostics and multiple communication protocols in a rugged compact device for low volage motor applications. Designed for Motor Control Centers, the MM300 delivers superior protection and control to extend equipment life and maximize process uptime.

Applications
- Low Voltage three-phase AC motors
- MCC or stand alone panel mount applications
- Reversing and reduced voltage applications
- Motor applications requiring advanced automation or control such as conveyor systems or well recovery pumps
- IEC or NEMA class motors

Key benefits
- Full-featured protection for low voltage AC motors
- Advanced automation capabilities for providing customized protection and integrated process control
- Advanced FlexLogic reduces requirement for local PLC's
- Reduced installation space requirements through integration of multiple devices including protection, control functions, pushbuttons, status LEDs and communication interfaces
- Application flexibility with multiple I/O options and programmable logic options (FlexLogic)
- Enhanced troubleshooting tools including sequence of event records and waveform capture
- Powerful communications including Serial, Ethernet, Profibus, and DeviceNet protocols
- Small form factor and remote display options designed to fit in MCC buckets

Features
Protection and Control
- Enhanced Thermal Modeling
- Mechanical Jam / Stalled Rotor
- Undercurrent
- Underpower
- Acceleration Time
- Current Unbalance
- Ground Fault
- Sensitive Ground Fault
- Phase Overvoltage / Undervoltage
- Auxiliary undervoltage
- Phase reversal
- VT fuse failure
- Thermistor
- RTD overtemperature

Automation
- Programmable flexlogic option
- Starter control
- Process interlocks
- Programmable inputs and outputs
- Undervoltage auto-restart

Metering and Monitoring
- Metering — Current, Voltage, Power, Energy, Frequency, RTD, Thermistor
- Oscillography — Analog Values at 32 Samples/ cycle and Digital States
- Event Recorder — Up to 256 Time Tagged Events with 1ms re
- Advanced Device Health Diagnostics

Communications
- Networking Interfaces — Two Wire RS485, RJ45 Ethernet
- Multiple Protocols (Modbus RTU , Modbus TCP/IP, Internally Powered Profibus, ODVA Compliant DeviceNet)
- Programming Ports - USB, RS485
- Network Time Protocol (When Ordered with Ethernet)

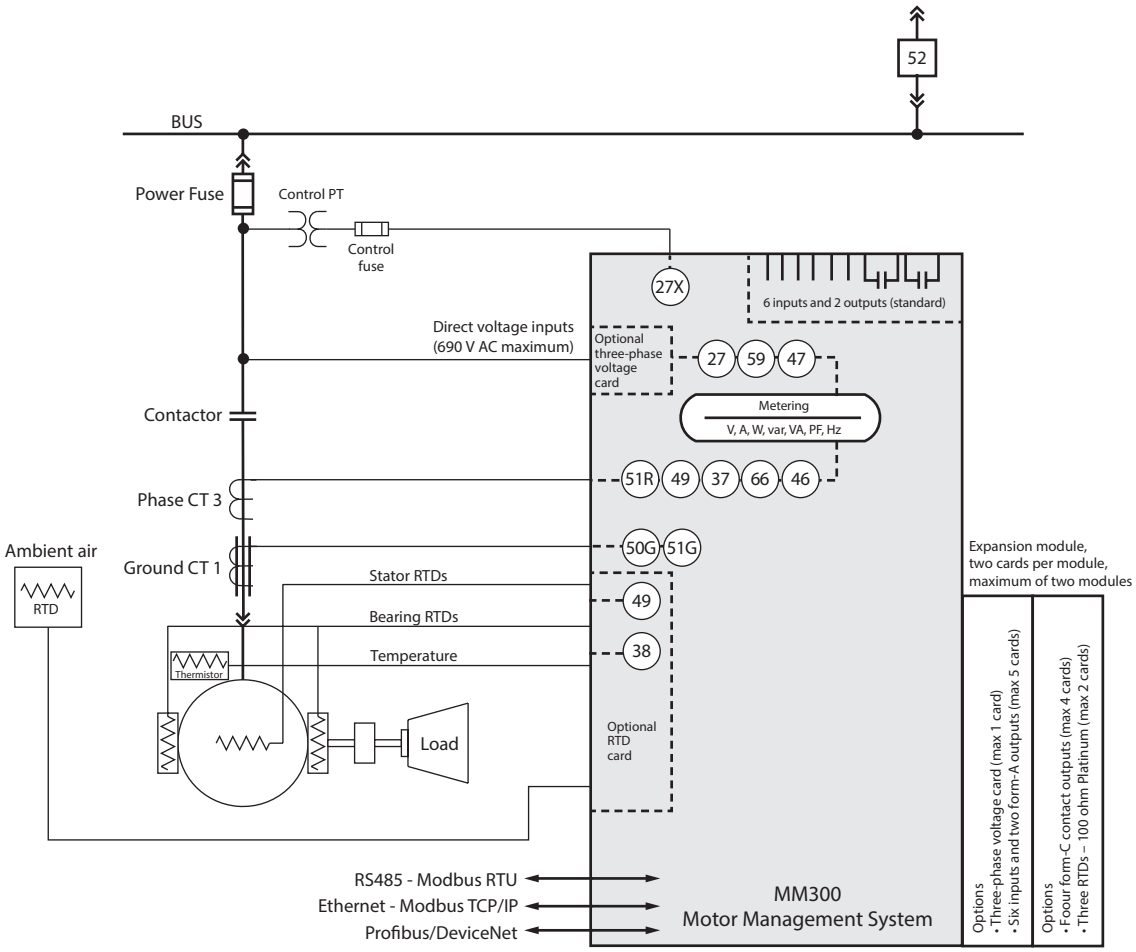
User Interface
- Control Panel with 12 Status LED's, Motor Control and Function Keys
- Color HMI Display featuring a full color graphical display, Motor and system status LED's, USB programming port and motor control keys

EnerVista Software
- State of the art software for configuration and commissioning Multilin products
- Graphical Logic Designer and Logic Monitor to simplify designing and testing procedures
- Document and software archiving toolset to ensure reference material and device utilities are up-to-date

For more information on MM300, please see
https://www.gegridsolutions.com/multilin/catalog/mm300.htm

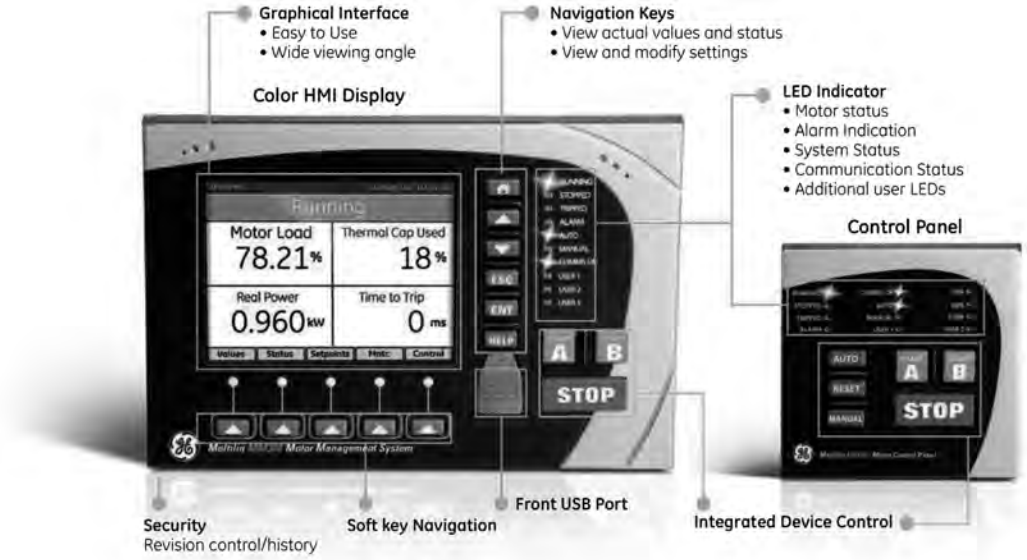
MM300 motor management system
Functional block diagram - ANSI device numbers and functions

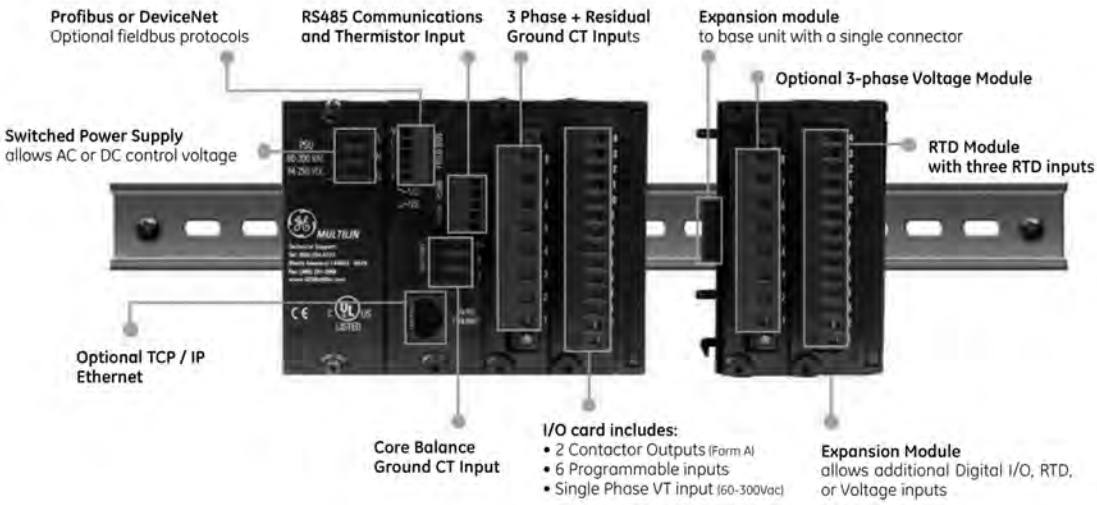
Device No.	Function
27AUX	Undervoltage - Auxiliary Input
27	Undervoltage - Three Phase
37	Undercurrent/Underpower
38	Bearing Temperature RTD
46	Current Unbalance
47	Voltage Phase Reversal
49	Thermal Overload
50G	Ground Instantaneous Overcurrent
51G	Ground Time Overcurrent
51R	Locked/Stalled Rotor/Mechanical Jam
59	Overvoltage - Three Phase
66	Starts/Hour and Time Between Starts



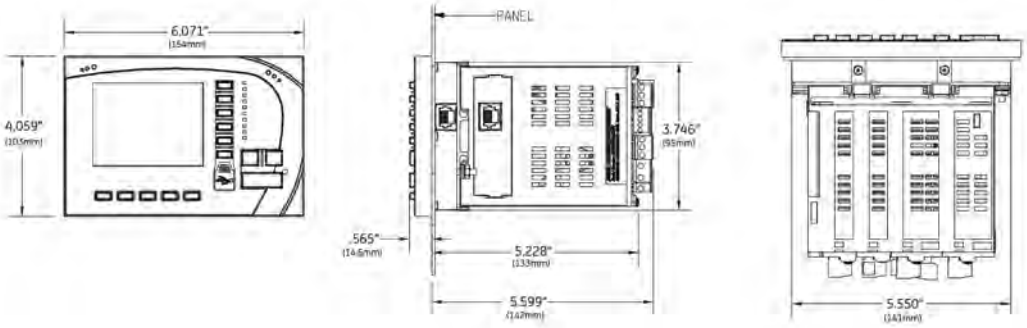
MM300 motor management system

User interface





Dimensions



Integrated tranquell HE and ME
Surge protective device (SPD) with enhanced thermal protection

Overview
Surge protective devices (SPD) are engineered for reliability, flexibility and long life in the most extreme surge environment. The true maximum surge current rating has been proven successful in third-party tests.

These SPD models connect to the panelboard or switchboard bus bars without adding width or depth to the panel enclosure, and only occupying 7X of vertical bus space. Third-party tested per IEEE C62.62 and NEMA LS-1 for the rated 8x20µs surge current, per mode with fusing included. Standard features include a surge counter, audible alarm, indicating lights, dry contacts and an integral surge rated disconnect. Rating options range from 65kA per mode to 300kA per mode.

All mode protection is provided with surge components (MOVs) connected on the phase to neutral, phase to ground and neutral to ground paths as appropriate for the voltage configuration.

Technical specifications

Nominal discharge current (in): 20ka
Short circuit current rating (SCCR): 200kA
Operating frequency: 50/60 Hz
Connection: 6 to 2/0 Conductors, Parallel Connected
Operating temperature: -40° F to 149° F (-40° C to +65° C)
Operating humidity: 0% to 95% Non-Condensing
Weight: 24 lbs. (10.89 kg)

Features and benefits
- UL 1449 3rd Edition, Type 1 or Type 2
- UL 1283, EMI/RFI noise filter
- UL 96A, Lightning Protection System
- cUL, CSA C22.2
- Integral surge rated disconnect
- Compact design requires only 7X height of space
- Tranquell ME device is tested to a minimum of 5,000 category C3 impulses (10kA, 20kV) per mode
- Tranquell HE device is tested to a minimum of 20,000 category C3 impulses (10kA, 20kV) per mode
- Industrial-sized MOV technology
- Thermally protected MOVs eliminate the need for additional upstream overcurrent protection
- Form C dry contacts for remote monitoring
- Green status indicating lights, red alarm light
- Audible alarm with test/disable feature
- LCD surge counter
- 5 year limited warranty (standard), 10 year limited warranty (optional)

Integrated Tranquell HE and ME

Surge protective device (SPD)

Catalog number

		Nominal Voltage (Volts RMS)	System Voltage Configuration	MCOV Max. Continuous Operating Voltage L-N/G (Vrms)
TPHE	**120S**	120/240	1 Ph, 3 W + G	150
TPME	**120Y**	120Y/208	3 Ph, 4 W + G	150
	220Y	220Y/380	3 Ph, 4 W + G	320
	240D	240 Delta	3 Ph, 3 W	270
	240H	120/240 Delta HL	3 Ph, 4 W + G	150/270 HL
	240Y	240Y/415	3 Ph, 4 W + G	320
	277Y	277Y/480	3 Ph, 4 W + G	320
	347Y	347Y/600	3 Ph, 4 W + G	420
	480D	480 Delta	3 Ph, 3 W	550

Maximum Surge Current Capacity			
Exposure Level		Per Mode	Per Phase
06	TPME	65kA	130kA
08	TPME	80kA	160kA
10	TPME	100kA	200kA
12	TPME	125kA	250kA
15	TPME	150kA	300kA
20	TPME	200kA	400kA
25	TPME	250kA	500kA
30	TPME	300kA	600kA

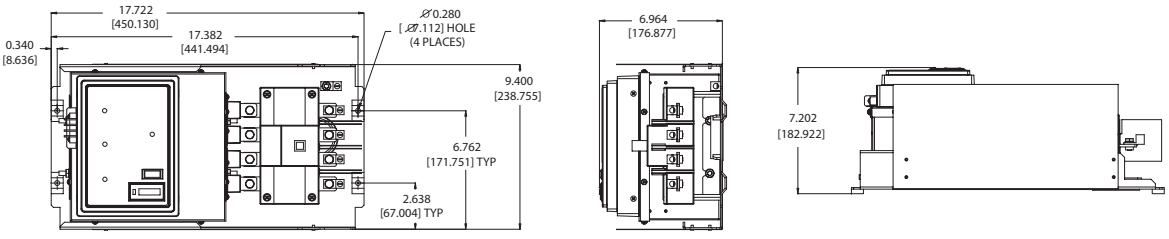
PP	For all kA ratings **(integral to Spectra panel or switchboard)** for UL Type 2 Locations
SG	For all TPHE devices (125kA - 300kA) **integral to switchgear** for UL Type 2 Locations
ME	For all kA ratings **(integral to MCC)** for UL Type 2 Locations
PPT1	For all kA ratings **(integral to Spectra panel or switchboard)** for UL Type 1 Locations
SGT1	For all TPHE devices (125kA - 300kA) **integral to switchgear** for UL Type 1 Locations
MET1	For all kA ratings **(integral to MCC)** for UL Type 1 Locations

Protection ratings

Voltage Code	**120S / 120Y**				**240D**								**240H**	**220Y / 240Y / 277Y**							**347Y**		**480D**
Protection Mode	**L-N**	**L-G**	**N-G**	**L-L**	**L-G**	**L-L**	**L-N**	**HL-N**	**L-G**	**HL-G**	**N-G**	**L-L**	**HL-L**	**L-N**	**L-G**	**N-G**	**L-L**	**L-N**	**L-G**	**N-G**	**L-L**	**L-G**	**L-L**
UL 1449, 3rd edition Voltage Protection Ratings (VPR) (assigned UL rating)	900	800	700	1200	1200	1800	1000	1200	800	1200	700	2000	2200	1500	1200	1200	2000	1500	1500	1500	2500	1800	3000
UL 1449, 2nd edition Suppression Voltage Ratings (SVR) (assigned UL rating)*	400	400	400	700	800	1500	500	700	400	700	400	900	—	800	800	800	1500	1200	1000	1000	2000	1500	3000
B3 Ring Wave Clamping Voltage @ 6kV, 500A	470	463	452	752	750	1240	465	—	466	—	476	1025	—	763	836	828	1393	883	1000	1000	1723	1223	1800
C3 Combo Wave Clamping Voltage @ 20kV, 10kA	793	670	680	1007	890	1640	775	—	670	—	680	1163	—	1170	1073	1180	1827	1467	1240	1240	2220	1607	2933

***Note:** SVR Ratings are no longer assigned by UL and are included in the table above for reference purposes only.

Dimensions



Note: All dimensions are for reference only and are shown in inches [millimeters]
See instruction manual for details

Application data

Approximate motor full-load current ratings
Full-Load Current for EPAC Compliant Motors

Average expected values
For three-phase, 60 Hertz, Type KE (NEMA Design B) dripproof, normal starting torque, continuous 40°C ambient (1.15 service factor) horizontal induction motors.

Motor HP	Synchronous speed, RPM	Average expected values of full-load currents			
		200V	230V	460V	575V
1/4[1]	1800	1.6	1.4	0.70	0.56
	1200	1.7	1.5	0.75	0.60
1/2[1]	3600	2.0	1.7	0.85	0.68
	1800	1.7	1.5	0.75	0.60
	1200	2.0	1.7	0.85	0.68
1/2	3600	2.0	1.8	0.88	0.70
	1800	2.3	2.0	1.0	0.80
	1200	2.3	2.0	1.0	0.80
	900	3.2	2.8	1.4	1.4
3/4	3600	2.8	2.4	1.2	0.96
	1800	3.2	2.8	1.4	1.1
	1200	3.7	3.2	1.6	1.3
	900	4.4	3.8	1.9	1.5
1	3600	3.7	3.2	1.6	1.3
	1800	4.1	2.2	1.6	1.4
	1200	4.4	4.6	2.3	1.5
	900	5.5	4.8	2.4	1.9
1 1/2	3600	5.3	4.8	2.4	1.8
	1800	6.0	4.4	2.2	2.1
	1200	6.0	4.6	2.3	2.1
	900	7.1	6.2	3.1	2.5
2	3600	6.9	6.0	3.0	2.4
	1800	7.1	5.8	2.9	2.5
	1200	7.6	6.2	3.1	2.6
	900	10.6	9.2	4.6	3.7
3	3600	9.4	8.0	4.0	3.3
	1800	9.9	7.9	3.9	3.4
	1200	12.0	8.6	4.3	4.2
	900	15.4	13.4	6.7	5.4
5	3600	15.4	12.2	6.1	5.4
	1800	14.4	12.6	6.3	5.7
	1200	19.3	14.0	7.0	6.7
	900	19.8	17.2	8.6	6.9
7 1/2	3600	21.4	18.0	9.0	7.5
	1800	23.7	18.0	9.3	8.2
	1200	26.0	19.8	9.9	9.0
	900	28.5	24.0	12.4	9.9
10	3600	27.4	24.0	12.0	9.5
	1800	27.0	23.8	11.9	10.9
	1200	32.7	25.8	12.9	11.4
	900	33.1	28.8	14.4	11.5
15	3600	42.6	36.0	18.0	14.8
	1800	40.3	35.0	17.6	16.2
	1200	45.1	33.0	19.1	15.7
	900	47.6	41.4	20.7	16.6
20	3600	62.3	45.4	22.7	21.7
	1800	53.2	46.2	23.1	20.6
	1200	56.6	50.0	25.0	19.7
	900	63.9	55.6	27.8	22.2

Motor HP	Synchronous speed, RPM	Average expected values of full-load currents			
		200V	230V	460V	575V
25	3600	72.0	56.0	28.0	25.0
	1800	71.3	60.0	30.0	24.8
	1200	73.8	63.2	31.6	25.7
	900	82.6	71.8	35.9	28.7
30	3600	85.6	67.8	33.9	29.8
	1800	81.7	71.2	35.6	29.9
	1200	88.6	73.8	36.9	30.8
	900	92.2	80.2	40.1	32.1
40	3600	101	89.0	44.6	39.2
	1800	112	97.8	48.9	40.3
	1200	114	99.6	48.5	39.8
	900	122	105.8	52.9	42.3
50	3600	140	129	64.5	48.9
	1800	142	122	61.1	49.4
	1200	144	125.2	61.0	50.1
	900	159	138.2	69.1	55.3
60	3600	163	145.6	72.8	56.6
	1800	172	147.4	73.7	59.9
	1200	172	149.2	69.8	59.7
	900	176	153.4	76.7	61.4
75	3600	206	181	90.5	71.5
	1800	207	180.0	91.6	72.0
	1200	206	719.2	86.7	71.7
	900	221	191.8	95.9	76.7
100	3600	262	238	119	91.2
	1800	281	232	116	97.7
	1200	283	246	118	98.4
	900	296	258	129	103
125	3600	338	290	139	116
	1800	340	296	143	118
	1200	352	306	149	122
	900	370	322	161	129
150	3600	398	346	164	138
	1800	412	348	169	143
	1200	419	364	177	146
	900	435	378	189	151
200	3600		446	217	178
	1800		468	226	187
	1200		482	239	193
250	3600		574	287	230
	1800		590	295	236
	1200		594	297	238
300	3600		676	338	270
	1800		686	340	274
350	3600		774	387	310
	1800		792	396	317
400	3600		890	445	356

1. Open, Type K, general purpose, NEMA SF, solid base, rolled-steel-shell, induction motors.

Note: The listed data is based on approximate full-load current ratings of standard, open, 1.15 service factor, continuous rated General Electric motors. Full-load current ratings of similar motors of other manufacturers may vary considerably. Therefore, whenever possible use actual full-load current rating given on motor nameplate. Contact motor manufacturer for full-load currents of single-phase and DC motors.

Mag-break magnetic circuit breaker trip set positions

The greatest degree of protection is provided when the magnetic trip setting is just above the motor starting inrush current. It is therefore recommended that the magnetic trip position be adjusted to a setting one position higher than the setting that carries the motor starting current. For recommended continuous-current ratings, see overload heater tables on pages J-5 through J-12.

Cat No. 3 Pole	Cont. Amperes	Trip setting positions						
		Lo	2	4	6	8	10	Hi
TEC36003	3	8	13	18	23	28	33	38
TEC36007	7	18	30	42	54	66	78	90
TEC36015	15	42	68	94	120	146	172	198
TEC36030	30	90	140	190	240	290	340	390
TEC36050	50	180	260	340	420	500	580	660
TEC36100	100	300	468	636	804	972	1140	1300
TEC36150	150	600	950	1300	1650	2000	2350	2700
TFC36225	225	600	780	1020	1200			1400
TFC36225A	225	1000	1200	1630	1920			2250
TJC36400B	400	1200	1400	1850	3250			4000
TJC36400E	400	330	435	600	860			1100
TJC36400F	400	550	720	945	1280			1670
TJC36400G	400	1000	1280	1780	2360			3300
TJC36600G	600	1000	1280	1780	2360			3300
TJC36600H	600	1800	2100	2600	3600			6000

Spectra RMS circuit breaker current ratings

Frame	Max. frame Amps	Rating plug Amps	Instantaneous trip setting, nominal RMS sym. Amperes Trip setting adjustment position						
			Min.	2	3	4	5	6	Max.
SE	7	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	1138
		100	297	376	475	593	775	998	1280
	150	110	328	415	524	654	857	1105	1426
		125	374	474	598	745	979	1265	1640
		150	450	570	720	897	1181	1528	1991
			Min.	2	3	4	5		Max.
SF	250	70	205	260	330	410	535		700
		90	265	335	425	530	690		900
		100	295	375	470	590	765		1000
		110	325	410	520	650	845		1100
		125	370	465	570	740	960		1250
		150	440	560	705	885	1150		1500
		175	515	655	825	1035	1345		1750
		200	590	750	940	1180	1535		2000
		225	665	840	1050	1330	1730		2250
		250	740	935	1180	1480	1920		2500
SG	400	125	380	480	620	765	990		1275
		150	455	575	740	920	1185		1530
		175	530	670	865	1070	1385		1785
		200	605	765	990	1225	1580		2040
		225	680	860	1115	1375	1780		2295
		250	755	955	1235	1530	1975		2550
		300	905	1145	1480	1835	2370		3060
		350	1060	1340	1730	2140	2765		3570
		400	1210	1530	1980	2445	3160		4080
	600	250	765	965	1215	1500	1960		2530
		300	915	1155	1455	1800	2355		3035
		350	1070	1350	1700	2100	2745		3545
		400	1200	1540	1940	2400	3135		4050
		450	1375	1735	2185	2695	3530		4555
		500	1525	1925	2425	2995	3920		5060
		600	1830	2310	2910	3595	4705		6075
SK	800	300	940	1150	1445	1795	2375		3015
		400	1255	1535	1930	2395	3165		4015
		500	1570	1915	2410	2990	3955		5020
		600	1875	2290	2895	3610	4740		6195
		700	2155	2665	3375	4240	5525		7420
		800	2440	3035	3860	4875	6305		8705
	1200	600	1825	2310	2905	3685	4730		6110
		700	2125	2695	3390	4300	5515		7125
		800	2430	3080	3870	4910	6305		8145
		1000	3040	3850	4840	6140	8880		10180
		1200	3650	4620	5805	7370	9455		12215

Thermal magnetic trip ratings for motor circuits
These selections are based on 2005 National Electric Code requirements for squirrel-cage motors without code letters or with code letter through G. Lower trip ratings may be required for motor with code letter A and higher trips for motors with code letters H to V. Local code or specific application requirements may necessitate special selection. Thermal-magnetic circuit breaker combination motor control units are not recommended for motors with full-load currents of 3.8 amperes or less.

NEMA size	Motor HP	CB type	200/208V trip	230V trip	380V trip	460V trip	575V trip
	2		15	15	15	15	15
	3		20	15	15	15	15
1	5	SE	30	30	20	15	15
	7.5		50	30	30	20	20
	10				30	20	20
	10		50	50			
	15			70	50	40	30
2	20	SE			70	50	40
	25				70	60	50
	15		70				
	20		100	100			
	25		100	100			
3	30	SE		125	100	70	50
	40				100	100	70
	50				125	125	100
	30		125				
	40		200	150			
	50	SF		200			
4	60	SGL			150	150	100
	75				200	200	125
	100					225	150

NEMA size	Motor HP	CB type	200/208V trip	230V trip	380V trip	460V trip	575V trip
	50		200 / 250				
	60		300	225 / 250			
	75		350	300 / 350			
5	100	SGL		400	225 / 250		
	125				300	225 / 250	225 / 250
	150				300 / 350	300	250
	200					350 / 400	300
	100		500				
	125		800	800			
	150	SGL/	800	800			
	200	SKL		1000	500		
6	250				800	500	400
	300				800	600	500
	350	SKL				800	800
	400					1000	800

Motor selection table for spectra motor circuit protectors

Max HP per system voltage					Starter Size	Rating plug		CB sensor	CB frame
208V	230V	380V	460V	575V		Amps	CAT#		
0.5	0.5	1.0	1.0	1.5		3	SRPE7A3	7	
1.0	1.5	3.0	3.0	3.0		7	SRPE7A7		
2.0	3.0	5.0	5.0	7.5		15	SRPE30A15	30	
3.0	5.0	10.0	10.0	10.0	1	20	SRPE30A20		
5.0						25	SRPE30A25		
—	7.5					30	SRPE30A30		
7.5						40	SRPE60A40	60	
				15		25	SRPE30A25	30	SE 150
			15	20		30	SRPE30A30		
		15		25	2	40	SRPE60A40	60	
10	10	25	25			50	SRPE60A50		
	15					60	SRPE60A60		
			25	30		50	SRPE60A50	100	
		30	30	40	3-4	70	SRPE100A70		
25	25	50	60	60		100	SRPE100A100		
	30					150	SRPE150A150	150	
				60	4RVAT[1]	100	SRPE150A100	150	
40	50	75	100	100		150	SRPE150A150		
		60	60	75	4STD	150	SRPF250A150	200	SF 250
40	50	75	100	100		200	SRPF250A200		
50	50	100	125	150		250	SRPG400A250	400	SG 600
60	60	125	150		5	300	SRPG400A300		
75	75	150		200		350	SRPG400A350		
	100		200			400	SRPG400A400		
				250		400	SRPG800A400	600	SG 600
100		200	250	300	6	500	SRPG800A500		
150	150	300	350	400		800	SRPK1200A800	1200	SK 1200
	200		400			1000	SRPK1200A1000		

1. Size 4 RVAT with SF CB requires an additional 6" height extension.

Overload heater tables

Heaters for thermal-mag controllers

For continuous rated motors with a service factor of 1.15 to 1.25, select heaters from the heater table. For continuous rated motors with a service factor of 1.0, multiply the motor full-load current by 0.9 and use this value to select heaters.

Overload relay tripping current in 40°C ambient is the minimum value of full load current multiplie by 1.25.

Provide short circuit protection in accordance with the National Electrical Code.

Warning: Opening of the circuit breaker may be an indication that a fault current has been interrupted. To provide continued protection against fire or shock hazard, all current-carrying parts and other components of the motor controller should be examined and replaced if damaged. If heater burnout occurs, the complete overload relay must be replaced.

Size 0 and 1 (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 Heater	Heater number CR 123	Motor full-load Amps 3-Ph, 3 Heater	Heater number CR 123
.41-.45	C054A	4.96-549	C592A
.46-.49	C060A	5.50-5.91	C630A
.50-.53	C066A	5.92-6.47	C695A
.54-.59	C071A	6.48-7.20	C778A
.60-.65	C078A	7.21-8.22	C867A
.66-.76	C087A	8.23-8.72	C955A
.77-.84	C097A	8.73-9.67	C104B
.85-.93	C109A	9.68-10.4	C113B
.94-1.04	C118A	10.5-11.0	C125B
1.05-1.15	C131A	11.1-12.4	C137B
1.16-1.27	C148A	12.5-13.2	C151B
1.28-1.39	C163A	13.3-15.4	C163B
1.40-1.55	C184A	15.5-17.1	C180B
1.56-1.73	C196A	17.2-18.0	C198B
1.74-1.89	C220A		Size 1
1.90-2.05	C239A		
2.06-2.28	C268A	17.2-18.1	C198B
2.29-2.47	C301A	18.2-20.0	C214B
2.48-2.79	C326A	20.1-21.5	C228B
2.80-3.31	C356A	21.6-22.5	C250B
3.32-3.70	C379A	22.6-23.9	C273B
3.71-4.06	C419A	24.0-26.3	C303B
4.07-4.47	C466A	26.4-27.0	C330B
4.48-4.95	C526A		

Size 2 (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123
5.48-5.85	C630A	16.8-17.9	C180B
5.85-6.47	C695A	18.0-18.7	C198B
6.48-7.35	C778A	18.8-20.4	C214B
7.36-8.06	C867A	20.5-22.7	C228B
8.07-9.03	C955A	22.8-24.7	C250B
9.04-9.61	C104B	24.8-26.3	C273B
9.62-10.5	C113B	26.4-29.5	C303B
10.6-11.6	C125B	29.6-32.5	C330B
11.7-12.5	C137B	32.6-36.7	C366B
12.6-13.6	C151B	36.8-41.9	C400B
13.7-16.7	C163B	42.0-43.2	C440B
		43.3-45.0	C460B

Size 3 (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123
19.0-19.3	F233B	17.8-18.4	F233B
19.4-22.1	F243B	18.5-21.1	F243B
22.2-23.4	F270B	21.2-22.1	F270B
23.5-27.0	F300B	22.2-26.1	F300B
27.1-29.1	F327B	26.2-28.0	F327B
29.2-31.8	F357B	28.1-31.3	F357B
31.9-33.9	F395B	31.4-33.3	F395B
34.0-37.6	F430B	33.4-34.3	F430B
37.7-41.9	F487B	34.4-40.9	F487B
42.0-47.7	F567B	41.0-44.7	F567B
47.8-52.1	F614B	44.8-51.0	F614B
52.2-55.8	F658B	51.1-52.0	F658B
55.9-59.7	F719B	52.1-55.4	F719B
59.8-68.1	F772B	55.5-63.3	F772B
68.2-71.5	F848B	63.4-66.1	F848B
71.6-78.2	F914B	66.2-73.5	F914B
78.3-87.5	F104C	73.6-82.2	F104C
87.6-90.0	F114C	82.3-90.0	F114C

Size 4 (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123
27.1-32.2	F357B	28.8-32.0	F357B
32.3-34.0	F395B	32.1-34.2	F395B
34.1-36.8	F430B	34.3-36.7	F430B
36.9-44.6	F487B	36.8-43.9	F487B
44.7-48.4	F567B	44.0-46.6	F567B
48.5-53.9	F614B	46.7-52.6	F614B
54.0-57.4	F658B	52.7-55.6	F658B
57.5-60.0	F719B	55.7-58.7	F719B
60.1-69.5	F772B	58.8-67.1	F772B
69.6-71.7	F848B	67.2-70.6	F848B
71.8-79.9	F914B	70.7-76.3	F914B
80.0-92.3	F104C	76.4-88.7	F104C
92.4-97.0	F114C	88.8-93.4	F114C
97.1-108	F118C	93.5-105	F118C
109-118	F133C	106-114	F133C
119-131	F149C	115-128	F149C
132-135	F161C	129-131	F161C
		132-135	F174C

Size 5 (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123
109-118	C592A	185-200	C104B
119-128	C630A	201-221	C113B
129-138	C695A	222-237	C125B
139-155	C778A	238-262	C137B
156-168	C867A	263-270	C151B
169-184	C955A		

Overload heater tables

Heaters for mag controllers

The Mag-Break protector is factory adjusted to the minimum trip setting.

Warning: To maintain overload, short circuit, and ground fault protection, use the following instructions to select heaters and to adjust the Mag-Break trip setting.

For continuous rated motors with a service factor of 1.15 to 1.25, select heaters from the heater table. For continuous rated motors with a service factor of 1.0, multiply motor fullload current by 0.9 and use this value to select heaters.

Use the heater table to verify that the Mag-Break and current limiter rating is correct for the motor full-load current. Then set the Mag-Break trip setting to the recommended value.

If the Mag-Break trips when starting the motor, increase trip setting one step at a time until the motor can be consistently started.

Do not exceed the maximum trip setting shown in the heater table.

Overload relay tripping current in 40°C ambient is the minimum value of heater full-load current multiplied by 1.25.

Warning: Overload relays with automatic reset may automatically start a motor connected to a 2-wire control circuit. When automatic restarting is not desired, use a 3-wire control circuit.

Warning: Tripping of the Mag-Break may be an indication that a fault current has been interrupted. To provide continued protection against fire or shock hazard, all current-carrying parts and other components of the motor controller should be examined and be replaced if damaged. If heater burnout occurs, the complete overload relay must be replaced.

Size 0 and 1 (standard)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-break trip setting	
			Rec.	Max.
.65-.74	C087A	3	LO	LO
.75-.84	C097A	3	LO	LO
.85-.92	C109A	3	LO	LO
.93-1.02	C118A	3	LO	2
1.03-1.10	C131A	3	LO	2
1.11-1.23	C148A	3	LO	2
1.24-1.38	C163A	3	LO	3
1.39-1.49	C184A	3	LO	4
1.50-1.67	C196A	3	LO	4
1.68-1.79	C220A	3	LO	5
1.80-1.98	C239A	3	2	5
1.99-2.24	C268A	3	3	5
2.25-2.43	C301A	3	3	6
2.44-2.75	C326A	7	LO	3
2.76-3.25	C356A	7	LO	4
3.26-3.43	C379A	7	LO	4
3.44-4.03	C419A	7	2	4
4.04-4.43	C466A	7	2	5
4.44-4.94	C526A	7	3	5
4.95-5.36	C592A	7	3	6
5.37-5.77	C630A	7	4	6
5.37-5.77	C630A	15	LO	3
5.78-6.35	C695A	15	LO	3
6.36-6.92	C778A	15	LO	4
6.93-7.99	C867A	15	2	4
8.00-8.47	C955A	15	2	5
8.48-9.19	C104B	15	3	5
9.20-10.0	C113B	20	2	4
10.1-10.7	C125B	20	2	5
10.8-12.0	C137B	20	2	5
12.1-12.9	C151B	20	3	5
13.0-15.1	C163B	20	4	6
15.2-16.3	C180B	25	3	5
16.4-17.9	C198B	25	3	6

Size 1 (standard)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-break trip setting	
			Rec.	Max.
18.0-19.7	C214B	30	3	5
19.8-21.2	C228B	30	3	5
21.3-22.3	C250B	30	3	6
22.4-23.5	C273B	40	2	5
23.6-25.5	C303B	40	3	5
25.6-27.0	C330B	40	3	5

Size 0 and 1 (Ambient Comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-break trip setting	
			Rec.	Max.
.66-.76	C087A	3	LO	LO
.77-.84	C097A	3	LO	LO
.85-.93	C109A	3	LO	LO
.94-1.04	C118A	3	LO	2
1.05-1.15	C131A	3	LO	2
1.16-1.27	C148A	3	LO	3
1.28-1.39	C163A	3	LO	3
1.40-1.55	C184A	3	LO	4
1.56-1.73	C196A	3	2	4
1.74-1.89	C220A	3	2	5
1.90-2.05	C239A	3	2	5
2.06-2.28	C268A	3	3	5
2.29-2.47	C301A	3	3	6
2.48-2.79	C326A	7	LO	3
2.80-3.31	C356A	7	LO	4
3.32-3.70	C379A	7	2	4
3.71-4.06	C419A	7	2	4
4.07-4.47	C466A	7	2	5
4.48-4.95	C526A	7	3	5
4.96-5.49	C592A	7	3	6
5.50-5.91	C630A	7	4	6
5.50-5.91	C630A	15	LO	3
5.92-6.47	C695A	15	LO	3
6.48-7.20	C778A	15	2	4
7.21-8.22	C867A	15	2	4
8.23-8.72	C955A	15	2	5
8.73-9.67	C104B	15	3	5
9.68-10.4	C113B	20	2	4
10.5-11.0	C125B	20	2	4
11.1-12.4	C137B	20	2	5
12.5-13.2	C151B	20	3	5
13.3-15.4	C163B	20	4	6
15.5-17.1	C180B	25	3	5

Size 1 (Ambient Comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-break trip setting	
			Rec.	Max.
17.2-18.1	C198B	25	3	6
18.2-20.0	C214B	30	3	5
20.1-21.5	C228B	30	3	5
21.6-22.5	C250B	30	3	6
22.6-23.9	C273B	40	2	5
24.0-26.0	C303B	40	3	5
26.1-27.0	C330B	40	3	5

Size 2 (Standard)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-break trip setting	
			Rec.	Max.
8.81-9.27	C104B	15	3	5
9.28-9.99	C113B	20	2	4
10.0-11.1	C125B	20	2	5
11.2-12.1	C137B	20	3	5
12.2-13.0	C151B	20	3	5
13.1-15.5	C163B	20	4	6
15.6-16.8	C180B	25	3	5
16.9-18.0	C198B	25	3	6
18.1-19.7	C214B	30	3	5
19.8-21.6	C228B	30	3	5
21.7-23.9	C250B	40	2	5
24.0-25.5	C273B	40	2	5
25.6-28.2	C303B	50	2	5
28.3-31.6	C330B	50	3	5
31.7-34.7	C366B	50	3	6
34.8-37.8	C400B	50	3	6
37.9-40.6	C440B	60	3	5
40.7-43.4	C460B	60	3	6

Size 2 (Ambient Comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-break trip setting	
			Rec.	Max.
9.04-9.61	C104B	15	3	5
9.62-10.5	C113B	20	3	4
10.6-11.6	C125B	20	2	5
11.7-12.5	C137B	20	3	5
12.6-13.6	C151B	20	3	5
13.7-16.7	C163B	20	4	6
16.8-17.9	C180B	25	3	5
18.0-18.7	C198B	25	3	6
18.8-20.4	C214B	30	3	5
20.5-22.7	C228B	30	3	6
22.8-24.7	C250B	40	2	5
24.8-26.3	C273B	40	2	5
26.4-29.5	C303B	50	2	5
29.6-32.5	C330B	50	3	5
32.6-36.7	C366B	50	3	6
36.8-41.9	C400B	50	3	6
42.0-43.2	C440B	60	3	5
43.3-43.4	C460B	60	3	6

Size 3 (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-Break Trip Setting	
			Rec.	Max.
17.8-18.4	F233B	30	2	5
18.5-21.1	F243B	30	3	5
21.2-22.1	F207B	30	3	5
22.2-26.0	F300B	40	3	5
26.1-28.0	F327B	40	3	5
28.1-31.3	F357B	50	3	5
31.4-33.3	F395B	50	3	5
33.4-34.3	F430B	50	3	5
34.4-40.9	F487B	70	2	5
41.0-44.7	F567B	70	3	5
44.8-51.0	F614B	100	LO	4
51.1-52.0	F658B	100	LO	4
52.1-55.4	F719B	100	2	5
55.5-63.3	F772B	100	3	5
63.4-66.1	F848B	100	3	5
66.2-73.5	F914B	100	3	6
73.6-82.2	F104C	150	2	4
82.3-86.9	F114C	150	2	5

Size 4 (ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-break trip setting	
			Rec.	Max.
28.8-32.0	F357B	50	3	5
32.1-34.2	F395B	50	3	5
34.3-36.7	F430B	70	2	5
36.8-43.8	F487B	70	3	5
43.9-46.6	F567B	70	3	5
46.7-52.6	F614B	100	2	4
52.7-55.6	F658B	100	2	5
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	100	3	5
67.2-70.6	F848B	100	3	6
70.7-76.3	F914B	150	2	4
76.4-88.7	F104C	150	2	5
88.8-93.4	F114C	150	3	5
93.5-105.0	F118C	150	3	5
106.0-114.0	F133C	150	3	5
115.0-128.0	F149C	150	4	6
129.0-130.0	F161C	150	4	6

Size 4 (standard)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SE rating plug	Mag-Break Trip Setting	
			Rec.	Max.
28.8-32.0	F357B	50	3	5
32.1-34.2	F395B	50	3	5
34.3-36.7	F430B	70	2	5
36.8-43.9	F487B	70	3	5
44.0-46.6	F567B	70	3	5
46.7-52.6	F614B	100	2	4
52.7-55.6	F658B	100	2	5
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	100	3	5
67.2-70.6	F848B	100	3	6
70.7-76.3	F914B	150	2	4
76.4-88.7	F104C	150	2	5
88.8-93.4	F114C	150	3	5
93.5-102.0	F118C	150	3	5
103.0-110.0	F133C	150	3	5
111.0-122.0	F149C	150	4	6
123.0-131.0	F161C	150	4	6

Size 4 (standard)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SF rating plug	Mag-break trip setting	
			Rec.	Max.
28.8-32.0	F357B	70	2	4
32.1-34.2	F395B	70	2	4
34.3-36.7	F430B	70	2	5
36.8-43.9	F487B	70	2	5
44.0-46.6	F567B	70	3	5
46.7-52.6	F614B	100	2	4
52.7-55.6	F658B	100	2	4
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	150	LO	4
67.2-70.6	F848B	150	LO	4
70.7-76.3	F914B	150	2	4
76.4-88.7	F104C	200	LO	4
88.8-93.4	F114C	200	LO	4
93.5-102.0	F118C	200	LO	5
103.0-110.0	F133C	200	2	6
111.0-122.0	F149C	200	2	6
123.0-131.0	F161C	200	2	6

Size 4 (ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SF rating plug	Mag-break trip setting	
			Rec.	Max.
28.8-32.0	F357B	70	2	4
32.1-34.2	F395B	70	3	4
34.3-36.7	F430B	70	3	5
36.8-43.8	F487B	70	3	5
43.9-46.6	F567B	70	3	5
46.7-52.6	F614B	100	2	4
52.7-55.6	F658B	100	2	4
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	150	LO	4
67.2-70.6	F848B	150	LO	4
70.7-76.3	F914B	150	2	4
76.4-88.7	F104C	200	LO	4
88.8-93.4	F114C	200	LO	4
93.5-105.0	F118C	200	LO	5
106.0-114.0	F133C	200	2	6
115.0-128.0	F149C	200	2	6
129.0-130.0	F161C	200	2	6

Size 5 – 300:15 CT (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SG rating plug	Instantaneous trip setting	
			Rec.	Max.
106-115	C592A	250	LO	3
116-125	C630A	250	LO	4
126-135	C695A	250	2	4
136-151	C778A	250	2	5
152-164	C867A	300	2	4
165-179	C955A	300	2	5
180-195	C104B	350	2	4
196-215	C113B	350	2	5
216-231	C125B	400	2	4
232-255	C137B	400	2	5
256-270	C151B	400	3	5

Size 6 – 600:5 CT (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SG rating plug	Instantaneous trip setting	
			Rec.	Max.
181-197	C220A	400	MIN	4
198-214	C239A	400	2	5
215-238	C268A	500	MIN	4
239-258	C301A	500	MIN	4
259-290	C326A	500	2	5
291-346	C356A	600	MIN	5
347-387	C379A	600	2	5
388-424	C419A	600	3	MAX

Size 6 – 600:5 CT (standard and ambient comp.)

Motor full-load Amps 3-Ph, 3 heater	Heater number CR 123	SK rating plug	Instantaneous trip setting	
			Rec.	Max.
181-197	C220A	400	LO	4
198-214	C239A	400	2	4
215-238	C268A	400	3	5
239-258	C301A	500	LO	4
259-290	C326A	500	2	5
291-346	C356A	800	LO	4
347-387	C379A	800	LO	5
388-423	C419A	800	2	5
424-467	C466A	1000	LO	4
468-516	C526A	1000	2	4
517-540	C592A	1000	2	5

Overload heater tables

Overload relays

Electronic overloads for circuit breaker controllers

Tripping current is 120% of Dial setting. Motors with 1.15-1.25 service factor, set dial to motor FLA Motors with 1.0 service factor, set dial to 0.9 motor FLA.

NEMA size	FLA range in Amps	Catalog number	Breaker frame and type
1	0.8 to 1.7	CR324CXD	E Mag. and Thermal Mag.
1	1.8 to 3.4	CR324CXE	E Mag. and Thermal Mag.
1	3.2 to 6.8	CR324CXF	E Mag. and Thermal Mag.
1	6.5 to 13.5	CR324CXG	E Mag. and Thermal Mag.
1	13 to 27	CR324CXH	E Mag. and Thermal Mag.
2	6.5 to 13.5	CR324DXG	E Mag. and Thermal Mag.
2	13 to 27	CR324DXH	E Mag. and Thermal Mag.
2	25 to 50	CR324DXJ	E Mag. and Thermal Mag.
3	17 to 35	CR324FXK	E Mag. and Thermal Mag.
3	35 to 70	CR324FXL	E Mag. and Thermal Mag.
3	65 to 135	CR324FXM	E Mag. and Thermal Mag.
4	17 to 35	CR324FXK	E,FandG Mag. and Thermal Mag.
4	35 to 70	CR324FXL	E,FandG Mag. and Thermal Mag.
4	65 to 135	CR324FXM	E,FandG Mag. and Thermal Mag.
5[1]	35 to 70	CR324GXN	E Mag. and Thermal Mag.
5[1]	65 to 135	CR324GXP	E Mag. and Thermal Mag.
5[1]	130 to 270	CR324GXQ	E Mag. and Thermal Mag.
6[2]	130 to 270	CR324HXS	G,K Mag. and Thermal Mag.
6[2]	260 to 540	CR324HXT	E Mag. and Thermal Mag.

1. 300:15 CT's
2. 800:5 CT's

Overload relays for compact 6" starter CL45A310MJ, NEMA size 1

FLA range in Amps	Class 10 catalog number	Class 20 catalog number	Breaker frame and type
0.4-.65	RTN1D		E Mag. and thermal mag.
0.65-1.1	RTN1F		E Mag. and thermal mag.
1-1.5	RTN1G		E Mag. and thermal mag.
1.3-1.9	RTN1H		E Mag. and thermal mag.
1.8-2.7	RTN1J		E Mag. and thermal mag.
2.5-4.1	RTNIK	RT12K	E Mag. and thermal mag.
4.0-6.3	RTNIL	RT12L	E Mag. and thermal mag.
5.5-8.5	RTNIM	RT12M	E Mag. and thermal mag.
8.0-12	RTNIN	RT12N	E Mag. and thermal mag.
10.0-16	RTNIP	RT12P	E Mag. and thermal mag.
14.5-18	RTNIS	RT12S	E Mag. and thermal mag.
17.5-22	RTNIT	RT12T	E Mag. and thermal mag.
21-26	RTNIU	RT12U	E Mag. and thermal mag.

Overload heater tables

Heaters for fused controllers

The Mag-Break protector is factory adjusted to the minimum trip setting.

For continuous rated motors with a service factor of 1.15 to 1.25, select heaters from the heater table. For continuous rated motors with a service factor of 1.0, multiply the motor full-load current by 0.9 and use this value to select heaters.

Table 1 – Maximum fuse and short-circuit rating

NEMA size	Class RK fuse		Class J fuse		Class K-1, K-5 fuse	
	Max. Clip	Max. RMS Sym. Amps	Max. Clip	Max. RMS sym. Amps	Max. clip	Max. RMS sym. Amps
1	30A	100.000	60A	100.000	Fuse per overload heater table	5.000
2	60	100.000	100	100.000		5.000
3	100	100.000	200	100.000		5.000
4	200	100.000	400	100.000		10.000
5	400	100.000	600	100.000		10.000

Warning: Opening of the fuse(s) may be an indication that a fault current has been interrupted. To provide continued protection against fire or shock hazard, all current-carrying parts and other components of the motor controller should be examined and replaced if damaged. If heater burnout occurs, the complete overload relay must be replaced.

Size 0 and 1 (standard and ambient comp.)

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
.41-.45	C054A	3
.46-.49	C060A	3
.50-.53	C066A	3
.54-.59	C071A	3
.60-.65	C078A	3
.66-.76	C087A	3
.77-.84	C097A	3
.85-.93	C109A	3
.94-1.04	C118A	3
1.05-1.15	C131A	3
1.16-1.27	C148A	3
1.28-1.39	C163A	3
1.40-1.55	C184A	6
1.56-1.73	C196A	6
1.74-1.89	C220A	6
1.90-2.05	C239A	6
2.06-2.28	C268A	6
2.29-2.47	C301A	6
2.48-2.79	C326A	10
2.80-3.31	C356A	10
3.32-3.70	C379A	12
3.71-4.06	C419A	15
4.07-4.47	C466A	15
4.48-4.95	C526A	15
4.96-5.49	C592A	20
5.50-5.91	C630A	20
5.92-6.47	C695A	25
6.48-7.20	C778A	25
7.21-8.22	C867A	30
8.23-8.72	C955A	30
8.73-9.67	C104B	35[1]
9.68-10.4	C113B	35[1]
10.5-11.0	C125B	40[1]
11.1-12.4	C137B	45[1]
12.5-13.2	C151B	50[1]
13.3-15.4	C163B	60[1]
15.5-17.1	C180B	60[1]

Overload relay tripping current in 40°C ambient is the minimum value of full-load current multiplied by 1.25.

Provide short-circuit protection in accordance with the National Electrical Code, except Fuses are not to exceed the value shown in the table.

Suitable for use in a circuit capable of delivering not more than the maximum RMS symmetrical amperes indicated in the table below, 600-volts maximum, when protected by an appropriate fuse having an interrupting rating not less than the available short-circuit current.

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
Size 1		
17.2-18.1	C198B	60(1)
18.2-20.0	C214B	60(1)
20.1-21.5	C228B	60(1)
21.6-22.5	C250B	60(1)
22.6-23.9	C273B	60(1)
24.0-26.3	C303B	60[1]
26.4-27.0	C330B	60(1)

Size 2 (standard and ambient comp.)

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
5.48-5.85	C630A	20
5.86-6.47	C695A	20
6.48-7.35	C778A	25
7.36-8.06	C867A	30
8.07-9.03	C955A	30
9.04-9.61	C104B	35
9.62-10.5	C113B	35
10.6-11.6	C125B	40
11.7-12.5	C137B	45
12.6-13.6	C151B	50
13.7-16.7	C163B	60
16.8-17.9	C180B	60
18.0-18.7	C198B	70(1)
18.8-20.4	C214B	80(1)
20.5-22.7	C228B	80(1)
22.8-24.7	C250B	90(1)
24.8-26.3	C273B	90(1)
26.4-29.5	C303B	100(1)
29.6-32.5	C330B	100(1)
32.6-36.7	C366B	100(1)
36.8-41.9	C400B	100(1)
42.0-43.2	C440B	100(1)
43.3-45.0	C460B	100(1)

1. See Table 1 for maximum fuse and short-circuit rating.

Size 3 (standard)

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
19.0-19.3	F233B	70
19.4-22.1	F243B	80
22.2-23.4	F270B	80
23.5-27.0	F300B	90
27.1-29.1	F327B	100
29.2-31.8	F357B	110(1)
31.9-33.9	F395B	125(1)
34.0-37.6	F430B	125(1)
37.7-41.9	F487B	150(1)
42.0-47.7	F567B	175(1)
47.8-52.1	F614B	175(1)
52.2-55.8	F658B	200(1)
55.9-59.7	F719B	200(1)
59.8-68.1	F772B	200(1)
68.2-71.5	F848B	200(1)
71.6-78.2	F914B	200(1)
78.3-87.5	F104C	200(1)
87.6-90.0	F114C	200(1)

Size 3 (ambient comp.)

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
17.8-18.4	F233B	70
18.5-21.1	F243B	80
21.2-22.1	F270B	80
22.2-26.1	F300B	90
26.2-28.0	F327B	100
28.1-31.3	F357B	110(1)
31.4-33.3	F395B	125(1)
33.4-34.3	F430B	125(1)
34.4-40.9	F487B	150(1)
41.0-44.7	F567B	150(1)
44.8-51.0	F614B	175(1)
51.1-52.0	F658B	200(1)
52.1-55.4	F719B	200(1)
55.5-63.3	F772B	200(1)
63.4-66.1	F848B	200(1)
66.2-73.5	F914B	200(1)
73.6-82.2	F104C	200(1)
82.3-90.0	F114C	200(1)

Size 4 (standard)

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
27.1-32.2	F357B	110
32.3-34.0	F395B	125
34.1-36.8	F430B	125
36.9-44.6	F487B	150
44.7-48.4	F567B	175
48.5-53.9	F614B	175
54.0-57.4	F658B	200
57.5-60.0	F719B	225[1]
60.1-69.5	F772B	225[1]
69.6-71.7	F848B	250[1]
71.8-79.9	F914B	275[1]
80.0-92.3	F104C	300[1]
92.4-97.0	F114C	350[1]
97.1-108	F118C	400[1]
109-118	F133C	400[1]
119-131	F149C	400[1]
132-135	F161C	400[1]

1. See Table 1 (page J-17) for maximum fuse and short-circuit rating.

Size 4 (ambient comp.)

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
28.8-32.0	F357B	110
32.1-34.2	F395B	125
34.3-36.7	F430B	125
36.8-43.9	F487B	150
44.0-46.6	F567B	175
46.7-52.6	F614B	175
52.7-55.6	F658B	200
55.7-58.7	F719B	225[1]
58.8-67.1	F772B	225[1]
67.2-70.6	F848B	250[1]
70.7-76.3	F914B	275[1]
76.4-88.7	F104C	300[1]
88.8-93.4	F114C	350[1]
93.5-105	F118C	350[1]
106-114	F133C	400[1]
115-128	F149C	400[1]
129-131	F161C	400[1]
132-135	F174C	400[1]

Size 5 – 300:15CT (standard and ambient comp.)

Motor full-load Amps 3-Ph., 3-heater	Heater number CR123	Maximum fuse rating
109-118	C592A	600
119-128	C630A	600
129-138	C695A	600
139-155	C778A	600
156-168	C867A	600
169-184	C955A	600
185-200	C104B	600
201-221	C113B	600
222-237	C125B	600
238-262	C137B	600
263-270	C151B	600

Electronic overload table for fusible controllers

Tripping current is 120% of Dial setting. Motors with 1.15-1.25 service factor, set dial to motor FLA Motors with 1.0 service factor, set dial to 0.9 motor FLA.

NEMA size	FLA range in Amps	Catalog number	Max. fuse in Amps	
1	0.8 to 1.7	CR324CXD	Class R 30	Class J 60
1	1.8 to 3.4	CR324CXE		
1	3.2 to 6.8	CR324CXF		
1	6.5 to 13.5	CR324CXG		
1	13 to 27	CR324CXH		
2	6.5 to 13.5	CR324DXG	60	100
2	13 to 27	CR324DXH		
2	25 to 50	CR324DXJ		
3	17 to 35	CR324FXK	100	200
3	35 to 70	CR324FXL		
3	65 to 135	CR324FXM		
4	17 to 35	CR324FXK	200	400
4	35 to 70	CR324FXL		
4	65 to 135	CR324FXM		
5[(1)]	35 to 70	CR324GXN	400	600
5[(1)]	65 to 135	CR324GXP		
5[(1)]	130 to 270	CR324GXQ		
6[(2)]	130 to 270	CR324HXS	600	Class L 1200
6[(2)]	260 to 540	CR324HXT		

1. 300:15 CT's
2. 800:5 CT's

Starter fuse selection

The following tables are furnished as a guide. Check vendor fuse characteristics before making final selection.

200 and 208 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J						Time-Delay RK-5	
				Time delay		No time delay BMC		CSC FRN	Clip	TR	Clip
				CSC# AJT	Clip	CSC# A4J	Clip				
1	1/2	2.3	30	3	30	10	30	2.8	30	3.5	30
	3/4	3.2	30	5	30	10	30	4	30	4.5	30
	1	3.9	30	6	30	15	30	5	30	6.25	30
	1 1/2	5.3	30	8	30	20	30	7	30	8	30
	2	7.1	30	10	30	25	30	9	30	12	30
	3	10.6	30	15	30	30	30	12	30	15	30
	5	16.3	30	25	30	45	60	20	30	25	30
	7 1/2	25.3	30	30	30	60	60	30	30	30	30
2	10	31.3	60	50	60	90	100	40	60	40	60
3	15	45.1	100	60	60	110	200	60	60	60	60
	20	591	100	90	100	150	200	70	100	90	100
	25	731	100	100	100	175	200	90	100	100	100
4	30	881	200	125	200	200	200	100	100	125	200
	40	120	200	175	200	225	400	150	200	175	200
5	50	150	400	225	400	300	400	175	200	225	400
	60	174	400	250	400	350	400	200	200	225	400
	75	210	400	300	400	450	600	250	400	300	400

BMC–Bussman Fuse
CSC–Chase Shawmut Fuse

230 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J						Time-Delay RK-5	
				Time delay		No time delay		BMC FRN	Clip	TR	CSC Clip
				CSC# AJT	Clip	CSC# A4J	Clip				
1	1/2	2.0	30	3	30	10	30	2.5	30	3	30
	3/4	2.8	30	4	30	15	30	3.5	30	4	30
	1	3.4	30	6	30	15	30	4	30	5.6	30
	1 1/2	4.6	30	8	30	30	30	6.25	30	8	30
	2	6.2	30	10	30	25	30	8	30	10	30
	3	9.2	30	15	30	30	30	12	30	15	30
	5	14.2	30	25	30	45	60	17.5	30	25	30
	7 1/2	22.0	30	30	30	60	60	25	30	30	30
2	10	27.2	60	40	60	90	100	35	60	40	60
	15	39.2	60	60	60	—	—	50	60	60	60
	15	39.2	100	60	60	110	200	—	—	—	—
3	20	51.4	100	80	100	150	200	60	60	80	100
	25	63.6	100	100	100	175	200	80	100	100	100
	30	76.6	100	100	100	200	200	100	100	100	100
4	40	104	200	150	200	225	400	125	200	150	200
	50	130	200	200	200	300	400	150	200	200	200
5	60	151	400	225	400	350	400	175	200	225	400
	75	183	400	300	400	400	400	225	400	300	400
	100	240	400	350	400	600	600	300	400	350	400
6	125	296	600	450	600	600	600	350	400	450	600
	150	348	600	500	600			450	600	500	600
	200	468	600					500	600	600	600

460 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J						Time-Delay K-5	
				Time delay		No time delay		BMC FRS	Clip	CSC TRS	Clip
				CSC# AJT	Clip	CSC# A4J	Clip				
	1/2	1.0	30	1.5	30	3	30	1.25	30	1.4	30
	3/4	1.4	30	2	30	3	30	1.6	30	2	30
	1	1.7	30	3	30	6	30	2	30	2.5	30
	1 1/2	2.3	30	4	30	6	30	2.8	30	4	30
1	2	3.1	30	5	30	10	30	3.5	30	5	30
	3	4.6	30	8	30	15	30	5	30	7	30
	5	7.1	30	10	30	25	30	9	30	10	30
	7 1/2	11.0	30	15	30	35	60	15	30	15	30
	10	13.6	30	20	30	40	60	17.5	30	20	30
	15	19.6	60	30	30	50	60	25	30	30	30
2	20	25.7	60	40	60	90	100	35	60	40	60
	25	31.8	60	50	60	100	100	40	60	50	60
	30	38.3	100	60	60	110	200	45	60	60	60
3	40	52.0	100	80	100	125	200	60	60	75	100
	50	65.0	100	100	100	150	200	80	100	100	100
	60	75.5	200	110	200	175	200	90	100	110	200
4	75	91.5	200	150	200	225	400	110	200	150	200
	100	120	200	175	200	225	400	150	200	175	200
	125	148	400	225	400	300	400	200	200	225	400
5	150	172	400	250	400	350	400	225	400	250	400
	200	224	400	300	400	500	600	300	400	350	400
	250	295	600	450	600	600	600	350	400	400	400
6	300	343	600	500	600			400	400	500	600
	350	396	600	600	600			450	600	600	600
	400	453	600					500	600	600	600

575 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J						Time-Delay K-5	
				Time delay		No time delay		BMC FRS	Clip	CSC TRS	Clip
				CSC# AJT	Clip	CSC# A4J	Clip				
	3/4	1.1	30	2	30	3	30	1.25	30	1.6	30
	1	1.4	30	2	30	6	30	1.6	30	2	30
	1 1/2	1.8	30	3	30	6	30	2.25	30	3	30
1	2	2.5	30	4	30	10	30	2.8	30	4	30
	3	3.7	30	6	30	15	30	4.5	30	6	30
	5	5.7	30	10	30	20	30	7	30	9	30
	7 1/2	8.8	30	15	30	30	30	10	30	15	30
	10	10.9	30	15	30	35	60	15	30	15	30
	15	15.7	60	25	30	45	60	20	30	25	30
2	20	20.6	60	35	60	60	60	25	30	35	60
	25	25.4	60	40	60	80	100	35	60	40	60
	30	30.6	100	45	60	100	100	40	60	45	60
3	40	41.6	100	60	60	110	200	45	60	60	60
	50	52.0	100	80	100	125	200	60	60	80	100
	60	60.4	200	90	100	150	200	70	100	90	100
4	75	73.2	200	125	200	175	200	90	100	125	200
	100	96.0	200	150	200	225	400	110	200	150	200
	125	118	400	175	200	225	400	150	200	175	200
5	150	138	400	225	400	300	400	175	200	225	400
	200	179	400	300	400	400	400	225	400	300	400
	250	236	600	350	400	500	600	300	400	350	400
6	300	274	600	450	600	600	600	350	400	450	600
	350	317	600	500	600			400	400	500	600
	400	363	600	600	600			450	600	600	600

Control transformer fusing

	600V Type ATMR or Equivalent							Secondary Volts 250V Type TRM or Equivalent
XFMR VA	**200-230V 60HZ**	**240V 60HZ**	**380-400V 50HZ**	**416V 50HZ**	**440-480V 60HZ**	**575-600V 60HZ**	**110-120V 50HZ**	**220-240V 50HZ**
60	1	1	3/4	6/10	1/2	1/2	6/10	3/10
75	1-1/2	1-1/2	8/10	8/10	3/4	6/10	8/10	1/2
100	2	2	1-1/4	1	1	3/4	1	6/10
150	3-1/2	3	1-1/2	1-1/2	1-1/2	1-1/4	1-6/10	8/10
200	4	4	2	2	2	1-1/2	2	1
250	5	5	2	2	2	2	2-8/10	1-1/2
300	6	6	3-1/2	3-1/2	2	2	3-2/10	1-6/10
500	6	6	6	6	5	4	5	2-8/10

Control fusing for non-CPT applications

Type control	Fuse Amps (class CC)
Line to line	10
Line to neutral	10
Common control	6
Separate source	6

Typical CPT ratings (480V/120V Shown)			
VA	**%R**	**%X**	**Open circuit secondary Volts**
60	9.05	1.03	131.9
100	6.39	1.18	129.4
150	5.02	1.01	127.3
200	5.09	1.06	126.2
250	6.81	.88	127.8
300	5.15	.73	126.4
500	5.84	1.45	128.7

Heat loss considerations

In determining the heat loss of a motor control center for air conditioning requirements, 250 watts per foot of lineup is a reasonable assumption.

Actual heat loss will vary due to section loading and diversity factors. A typical motor control center may operate normally at 60 percent of maximum possible loading.

Fully rated circuit breaker starters with CPT's, approximate losses are:
Size 1– 27 Watts
Size 2– 57 Watts
Size 3–130 Watts
Size 4–200 Watts
Size 5–300 Watts
Size 6–650 Watts

Heat losses for feeders and mains vary depending on frame size, loading and type of trip with electronic trips having lower losses. The following table provides a general guide for estimating losses assuming 80 percent loading. For critical applications refer to the Company.

Type	Frame	Loss (Watts)
Molded case circuit breaker frame	SE150	15
	SF250	20
	SG600	25
	SK800	40
	SK1200	50
Insulated case power break	800A	80
	1600A	210
	2000A	305
	2500A	375
Air circuit breaker (EntelliGuard G)	2500A - fixed	195
	2500A - drawout	438
	3200A - fixed	318
	3200A - drawout	558

Typical losses for transformers:

1kVA, 1-Ph	75 Watts
5 kVA, 1-Ph	190 Watts
9 kVA, 3-Ph	295 Watts
15 kVA, 3-Ph	460 Watts
30 kVA, 3-Ph	1000 Watts

Horizontal and vertical bus losses, when loaded to capacity are approximately 100 watts per section.

Solid State Starters or VFDs will typically generate 3 watts per ampere of load during operation.

Motor Loads

NEMA contactor ratings

Description		Normal starting duty HP/ KW rating by NEMA size					
		1	2	3	4	5	6
Single phase	115V	2	3	7.5			
	230V	3	7.5	15			
Three phase	200V	7.5/ 5.5	10/ 7.5	25/ 18.5	40/ 30	75/ 55	150/ 110
	230V	7.5/ 5.5	15/ 11	30/ 22	50/ 37	100/ 75	200/ 150
	380/ 415V	10/ 7.5	25/ 18.5	50/ 37	75/ 55	150/ 110	300/ 260
	460V	10/ 7.5	25/ 18.5	50/ 37	100/ 75	200/ 150	400/ 260
	575V	10/ 7.5	25/ 18.5	50/ 37	100/ 75	200/ 150	400/ 260

Non-Motor Loads

When selecting contactors for non-motor loads, the following load characteristics should be considered:

1. Voltage and maximum continuous current.
2. Maximum peak inrush current and duration.
3. RMS current and duration of maximum current on cyclic loads.
4. Frequency of operation.
5. Maximum interrupting current, voltage, power factor and wave form.
6. Available short-circuit current.

Non-motor load ratings are based on the use of two poles to control single-phase loads and three poles to control three-phase loads.

Capacitor switching, requires special considerations. A discharged capacitor acts essentially like a short circuit, and the inrush current is limited by the impedance connected in series with the capacitor which includes connecting cables. Therefore, the maximum capacitance which can be switched by a contactor will increase with higher series impedance. Switching more than one capacitor or capacitor bank in close electrical proximity to each other should be avoided as the energized capacitor bank can increase the inrush current to the second bank when it is energized. Reactors or resistors may be required between the two capacitor banks to limit inrush currents.

NEMA Standards require shunt capacitors to operate satisfactorily at 135 percent of rated KVAR due to manufacturing tolerances and other variations. The higher inrush and steady state currents associated with these capacitors should be taken into consideration.

NEMA Publication ICS2-210 covers non-motor loads.

NEMA contactor ratings

Size of Contactor	Cont. Amps	Max. inrush current (Amps Peak)	Tungsten[1] Lamps	Resistive Loads[2]	Transformer primary switching (kVA)															
					Transformers having inrush currents of not more than 20 times FLA								Transformers having inrush currents of over 20 through 40 times FLA							
					Single-phase Volts				Three-phase Volts				Single-phase Volts				Three-phase Volts			
					120	240	480	600	208	240	480	600	120	240	480	600	208	240	480	600
0	18	140	10	18	0.6	1.2	2.4	3	1.8	2.1	4.2	5.2	0.3	0.6	1.2	1.5	0.9	1.0	2.1	2.6
1	27	288	15	27	1.2	2.4	4.9	6.2	3.6	4.3	8.5	11	0.6	1.2	2.5	3.1	1.8	2.1	4.3	5.3
2	45	483	30	45	2.1	4.1	8.3	10	6.3	7.2	14	18	1.0	2.1	4.2	5.2	3.1	3.6	7.2	8.9
3	90	947	60	90	4.1	8.1	16	20	12	14	28	35	2.0	4.1	8.1	10	6.1	7.0	14	18
4	135	1581	120	135	6.8	14	27	34	20	23	47	59	3.4	6.8	14	17	10	12	23	29
5	270	3163	240	270	14	27	54	68	41	47	94	117	6.8	14	27	34	20	24	47	59
6	540	6326	480	540	27	54	108	135	81	94	188	234	14	27	54	68	41	47	94	117

1. 300-volts maximum, Tungsten lamp loads include infrared lamps having Tungsten filaments.
2. Resistive loads include electric discharge lamps such as fluorescent, mercury, vapor, etc.

Non-motor loads

NEMA contactor ratings for single capacitor or capacitor bank switching

Size of controller	Continuous ratings rms amperes	Three-phase rating of capacitor					
		Maximum size of three-phase capacitor in kVAR or available current in Amperes RMS sym.					
		3000	5000	10.000	14.000	18.000	22.000
At 230 Volts, 60 Hertz							
2	45	12	8	4	3	2	2
3	90	27	27	15	11	9	7
4	135	40	40	40	30	24	20
5	270	80	80	80	80	80	75
6	540	160	160	160	160	160	160
At 460 Volts, 60 Hertz							
2	45	25	16	8	6	4	4
3	90	53	53	31	23	18	15
4	135	80	80	80	61	49	41
5	270	160	160	160	160	160	149
6	540	320	320	320	320	320	320
At 575 Volts, 60 Hertz							
2	45	31	20	10	7	6	5
3	90	67	67	39	29	23	19
4	135	100	100	100	77	61	51
5	270	200	200	200	200	200	189
6	540	400	400	400	400	400	400

Disconnect minimums: thermal magnetic breakers rated 135%, fused switch rated 165%.

NEMA contactor for heating loads

NEMA size	Continuous current rating amps	Maximum kW ratings[2]							
		575 Volts		460 Volts		230 Volts		115 Volts	
		2-Pole 1-Ph	3-Pole 3-Ph	2-Pole 1-Ph	3-Pole 3-Ph	2-Pole 1-Ph	3-Pole 3-Ph	2-Pole 1-Ph	3-Pole 3-Ph
00	**9**	**5**	**9**	**4**	**7**	**2**	3.5	1	1.75
0	18	10	18	8	14	4	7	2	3.5
1	27	15	25	12	20	6	10	3	5
2	45	24	43	20	34	10	17	5	8.5
3	90	50	86	40	68	20	34	10	17
4	135	75	130	60	105	30	52	15	26
5	270	150	260	120	210	60	105	30	52
6	540	300	515	240	415	120	210	60	105
7	810	450	775	360	625	180	315	90	155
8	1215	700	1200	540	960	270	480	135	240
9	2250	1290	2200	1020	1740	510	880	255	440

1. Available at capacitor terminals.
2. Applicable only to resistive loads having inrush currents not exceeding 1.5 times the continuous current rating.
3. Spectra CB will permit deletion of overload heaters for these loads.

Application of starters for heating and lighting loads

1. No Tungsten lamp loads, No transformer loads.
2. Contactor loading must meet table above.
3. Overload heaters may be sized for maximum[3].
4. Disconnect must be thermal magnetic or fused switch rated per NEC @ 125% of load amps.

Non-motor loads

Application rated

Maximum kVA of transformer for primary switching (50/60Hz)

Catalog number	Max. Peak closing current	Phase	Inrush = 20 x Normal					Inrush = 40 x Normal				
			120V	208V	240V	480V	600V	120V	208V	240V	480V	600V
CL00	450 Amps	1	0.6	1	1.2	1.7	2.1	0.3	0.5	0.6	0.8	1
		3	1.1	1.9	2.2	3.1	3.8	0.5	0.9	1.1	1.5	1.9
CL01	450 Amps	1	0.8	1.4	1.7	2.4	3.0	0.4	0.7	0.8	1.2	1.5
		3	1.5	2.6	3.0	4.2	5.2	0.7	1.3	1.5	2.1	2.6
CL02	450 Amps	1	1.2	2.0	2.5	3.5	4.4	0.6	1.0	1.2	1.7	2.2
		3	2.2	3.8	4.5	6.3	7.7	1.1	1.9	2.2	3.1	3.8
CL25	550 Amps	1	1.8	3.1	3.7	5.2	6.4	0.9	1.5	1.8	2.6	3.2
		3	3.2	5.5	6.5	9.1	11.2	1.6	2.7	3.2	4.5	5.6
CL04	550 Amps	1	2.2	3.8	4.5	6.3	7.8	1.1	1.9	2.2	3.1	3.9
		3	4.0	7.0	8.0	11.2	13.7	2.0	3.5	4.0	5.6	6.8
CL45	550 Amps	1	2.8	4.8	5.7	8.0	9.7	1.4	2.4	2.8	4.0	4.8
		3	5	8.6	10	14.0	17	2.5	4.3	5	7.0	8.5
CL06	1000 Amps	1	3.4	5.9	6.8	9.5	12	1.7	2.9	3.4	4.7	6
		3	6	10.4	12	16.8	21	3	5.2	6	8.4	10.5
CL07	1000 Amps	1	4.2	7.2	8.5	12	14.2	2.1	3.6	4.2	6.0	7.1
		3	7.5	13	15	21	25	3.7	6.5	7.5	10.5	12.5
CL08	1000 Amps	1	5.7	10	11.4	16	20	2.8	5.0	5.7	8.0	10
		3	10	17.3	20	28	35	5	8.6	10	14	16
CL09	1280 Amps	1	7.1	12.3	14.2	20	22.8	3.5	6.1	7.1	10	11.4
		3	12.5	21.6	25	35	40	6.2	10.8	12.5	17.5	20
CL10	1280 Amps	1	8.5	14.7	17.1	24	28.5	4.2	7.3	8.5	12	14.2
		3	15	26	30	42	50	7.5	13	15	21	25
CK75	1850 Amps	1	10	17.2	20	28	31.3	5	8.6	10	14	15.6
		3	17.5	30.3	35	49	55	8.75	15.1	17.5	24.5	27.5
CK08	1850 Amps	1	11.4	19.7	22.8	32	34.2	5.7	9.8	11.4	16	17.1
		3	20	34.6	40	56	60	10	17.3	20	28	30
CK09	2500 Amps	1	14.2	24.6	28.5	40	48.5	7.1	12.3	14.2	20	24.2
		3	25	43.3	50	70	85	12.5	21.6	25	35	42.5
CK95	3700 Amps	1	18.5	32.0	37.1	52	62.8	9.2	16.0	18.5	26	31.4
		3	32	55.4	65	91	110	16	27.7	32	45	55
CK10	7000 Amps	1	22.8	39.5	45.7	64	85.7	11.4	19.7	22.8	32	42.8
		3	40	69.3	80	112	150	20	34.6	40	56	75
CK11	7000 Amps	1	28.5	49.4	57.1	80	97.1	14.2	24.7	28.5	40	48.5
		3	50	86.6	100	140	170	25	43.3	50	70	85
CK12	8400 Amps	1	45.7	79.2	91.4	128	160	22.8	39.6	45.7	65	80
		3	80	138.6	160	224	280	40	69.3	80	112	140

Maximum three-phase kVAR rating for switching capacitors

Catalog number	10,000 Amps RMS				22,000 Amp RMS			
	Maximum available fault current				Maximum Available Fault Current			
	200V	230V	460V	575V	200V	230V	460V	575V
CL00	3	3	5	5.7	1.5	1.5	2.5	2.8
CL01	435	4.5	9.5	11	2.2	2.2	4.5	5.5
CL02	6.5	6.5	11	12.5	3.2	3.2	5.5	6.2
CL25	9	9	15	17.5	4.5	4.5	7.5	8.2
CL04	12.5	12.5	21	24	6.2	6.2	10.5	12
CL45	17	17	30	35	8.5	8.5	15	17.5
CL06	22	22	40	50	11	11	20	25
CL07	25	25	45	65	12.5	12.5	22.5	32.5
CL08	30	30	50	70	15	15	25	35
CL09	40	40	65	95	20	20	32.5	47.5
CL10	50	50	80	120	25	25	40	60
CK75	60	60	100	150	60	60	100	150
CK08	70	70	130	175	70	70	130	175
CK09	95	95	165	230	95	95	165	230
CK95	105	105	190	288	105	105	190	288
CL10	135	135	260	370	135	135	260	370
CL11	190	190	325	450	190	190	325	450
CK12	250	250	400	600	250	250	400	600

Utilization in category AC-1, general use

3-pole contactors			CL Contactors															CK Contactors	
			00	01	02	25	04	45	06	07	08	09	10	75	08	09	95	10	11	12
Max. operational current at ambient temperature of: (for all voltages)	40°C	A	25	25	32	32	54	55	80	100	102	120	120	150	175	200	310	500	600	650
	55°C	A	25	25	32	32	54	55	80	100	102	120	120	150	175	200	310	425	510	546
	70°C	A	20	20	25	25	41	44	62	78	81	80	80	130	155	175	270	335	432	468

4-pole contactors			CL Contactors												CK Contactors	
			01	02	03	04	06	07	08	09	08	09	95	10	11	12
Max. operational current at ambient temperature of: (for all voltages)	40°C	A	25	32	40	54	70	100	110	120	175	200	310	500	550	650
	55°C	A	25	32	40	54	70	100	110	120	175	200	310	425	462	543
	70°C	A	20	25	28	41	52	78	88	80	155	175	270	335	462	468

Horsepower/kilowatt ratings are shown below

Catalog number	General purpose ratings	Max. FLA	1 Phase-HP A					3 Phase-HP A	Power In
			115V	230V	200V	230V	460V	575V	380/400V kW A
CL00	25	10	.5 (9.8)	1.5 (10)	3 (11)	3 (9.6)	5 (7.6)	7.5 (9)	4 (9)
CL01	25	13.8	.75 (13.8)	2 (12)	3 (11)	3 (9.6)	7.5 (11)	10 (11)	5.5 (12)
CL02	32	17.5	1 (16)	3 (17)	5 (17.5)	5 (15.2)	10 (14)	!5 (17)	7.5 (18)
CL25	32	22,22,17[1]	1.5 (20)	3 (17)	5 (17.5)	7.5 (22)	15. (21)	15 (17)	11 (25)
CL04	54	32A	2 (24)	5 (28)	10 (32)	10 (28)	20 (27)	25 (27)	16 (32)
CL45	55	34,34,27[1]	3 (34)	5 (28)	10 (32)	10 (28)	25 (34)	25 (27)	18.5 (40)
CL06	80	48	3 (34)	7.5 (40)	15 (48)	15 (42)	30 (40)	40 (41)	22 (50)
CL07	100	62	5 (56)	10 (50)	20 (62)	20 (54)	40 (52)	50 (52)	30 (65)
CL08	110(O) 102 (E)	68	5 (56)	15 (68)	20 (62)	25 (68)	50 (65)	60 (62)	37 (80)
CL09	140 (O) 120 (E)	80	7.5 (80)	15 (68)	25 (78)	30 (80)	60 (77)	75 (77)	45 (95)
CL10	140 (O) 120 (E)	104,96,80[1]	10 (100)	20 (88)	30 (92)	40 (104)	75 (96)	75 (77)	55 (105)
CK75	150	140	10 (100)	25 (110)	40 (120)	50 (130)	100 (124)	125 (125)	75 (154)
CK08	175	156	15 (135)	30 (136)	50 (149.5)	60 (145)	125 (156)	125 (125)	90 (185)
CK09	200	192			60 (169.4)	75 (192)	150 (180)	150 (144)	132 (250)
CK95	310	302			100 (285)	100 (248)	250 (302)	300 (289)	160 (310)
CK10	500	398			125 (358)	150 (360)	300 (361)	400 (382)	220 (420)
CK11	600	480			150 (414)	200 (480)	400 (477)	500 (472)	280 (550)
CK12	650(E) 750 (O)	602			200 (552)	250 (602)	500 (590)	600 (574)	375 (700)

Publication references

Construction equipment and components

Publication	Description	Stockinglocation
GEP-1100	Buylog Catalog–Covers Full Line of Products	Bloomington
Molded case circuit breakers		
GET-2779	Application and Selection Guide for Molded Case Circuit Breakers	Bloomington
GEZ-7000	MCCB Time-Current Curves	Bloomington
GET-7002	Spectra RMS Molded Case Circuit Breakers	Bloomington
Power break insulated case circuit breakers		
GET-6211	Selection and Application	Bloomington
GEZ-7001	Time-Current Curves	Bloomington
Low Voltage Power Circuit Breakers		
GEI-86150	Installation and Operation Instructions	Bloomington
GEK-7310	Maintenance Manual	Bloomington
GEZ-7002	Type AKR Time-Current Curves	Bloomington
GES-6227	Type AKR MicroVersaTrip RMS-9 Time Current Curves	Bloomington
GES-6228	MicroVersaTrip Ground Fault Time-Current Curves	Bloomington
Disconnect switches		
GET-6205	Type HPC High-Pressure Contact Switches, Technical	Bloomington
GEZ-7003	Type HPC Time-Current Curves	Bloomington
Ground fault protective products		
GET-2964	Ground Break Systems	Bloomington
GEZ-7003	Ground Break Time-Current Curves	Bloomington
Panelboards		
GET-6592	“A” series Tech. Specifications	Bloomington
GEA-11316	A Series	Bloomington

Factory automation products

Publication[1]	Description	Stocking location
Fanuc programmable logic control		
GFW-0067	Automation Solutions Catalog	Charlottesville
Fanuc I/O		
GEK-90486	Genius I/O System User’s Manual	Charlottesville
GFA-089	Genius I/O System	Charlottesville
GEI-86150	Installation and Operation Instructions	Bloomington
GFA-150	Field Control™	Charlottesville
GFT-298	VersaMax I/O	Charlottesville
GFA-180	VersaMax	Charlottesville

Motor control center equipment

Publication	Description	Stocking Location
Spectra series and 8000-line MCC		
DEA-036	Spectra Series Product Brochure	Bloomington
GEF-4628	8000-Line Renewal Parts Bulletin	Bloomington
GEH-4961	Installation and Maintenance (Instructions)	Bloomington

1. For more information visit our website at www.gefanuc.com/default2.htm

General purpose controls

Publication	Description	Stocking location
GEP-1260	Control catalog–covers full line of products	Bloomington
Magnetic motor starters		
GEA-10928	300-Line magnetic motor starters, descriptive	Bloomington
GEH-5190	300-Line Instructions, NEMA size 1, FVNR	Bloomington
GEH-4774	300-Line Instructions, NEMA size 2, FVNR	Bloomington
GEH-4806	300-Line Instructions, NEMA size 3, FVNR	Bloomington
GEH-4807	300-Line Instructions, NEMA size 4, FVNR	Bloomington
GEH-4869	300-Line Instructions, NEMA size 5, FVNR	Bloomington
GEH-5198	300-Line Instructions, NEMA size 6, FVNR	Bloomington
GEH-5190	300-Line Instructions, NEMA size 1, FVR and 2-Speed	Bloomington
GEH-4775	300-Line Instructions, NEMA size 2, FVR and 2-Speed	Bloomington
GEH-4806	300-Line Instructions, NEMA size 3, FVR and 2-Speed	Bloomington
GEH-4807	300-Line Instructions, NEMA size 4, FVR and 2-Speed	Bloomington
GEH-4839	300-Line Instructions, NEMA size 5, FVR and 2-Speed	Bloomington
Pilot devices		
GEA-10877		Bloomington
Relays and timers		
GEA-10639		Bloomington
GEH-4115		Bloomington
GEH-4120		Bloomington
GEH-4147		Bloomington
GEH-4139		Bloomington
GEH-6435		Bloomington
DET-069		Bloomington
Variable speed drives[1]		
GEI-100364		Fort Wayne
GEI-100363		Fort Wayne
Solid state starters		
DEH-40397		Bloomington
GEH-6533		Bloomington
DEH-40396		Bloomington
DEH-40417		Bloomington

MCC's shipped after October 2019 will likely include a VFD from Danfoss FC102 and/or FC302.

Electrical data

Motor horsepower output may also be calculated as follows:

$$HP = \frac{V \times A \times Pf \times EFF}{746}$$

Rules of thumb (approximation)

At 1800 RPM, a motor develops a 3 lb. – ft. per HP. At 1200 RPM, a motor develops 4.5 lb – ft. per HP. At 460 volts, a 3-phase motor draws 1.25 amp per HP. At 230 volts, a 3-phase motor draws 2.5 amp per HP.

Conversion formulas

To find	Alternating current three-phase
Amperes when Horsepower is known	$\frac{HP \times 746}{1.73 \times V \times Eff \times fp}$
Amperes when Kilowatts is known	$\frac{Kw \times 1000}{1.73 \times V \times pf}$
Amperes when Kva is known	$\frac{Kva \times 1000}{1.73 \times V}$
Kilowatts	$\frac{1.73 \times A \times V \times pf}{1000}$
Kva	$\frac{1.73 \times A \times V}{1000}$
Horsepower - (Output)	$\frac{1.73 \times A \times V \times Eff \times pf}{746}$
KW (alternating current) = KVA x Power Factor	
KW (direct current) = V x A x .001	
KWH = KW x Hours	
HP = $\frac{KW}{\text{Motor Efficiency}}$	

Values
V=Volts
A or I = Amperes (amps)
Work/P = Watts/Power
KW=Kilowatts
KwH=Kilowatt Hours
KVA=Kilovolt Amperes
Pf=Power Factor, Table
Ph= Phase Factor, Table

Ohms Law
I=E/R
R=E/I
E=IXR
P=IXE
P=IXIXR

kVAR calculation when motor operating characteristics are known

If motor HP, full-load power factor (PF) and efficiency (eff) are known, its easy to calculate the correct kVAR necessary to improve PF to any value.

Example: 75HP, 3600 RPN, NEMA B motor with full-load PF of 87% and eff. of 92% corrected to 95%PF
Original PF = .87 Cos: Tan: = .567
Desired PF = .95 = Cos: Tan: = .329
Difference = .238

$$KW = \frac{HPx.746}{Eff.} \quad \text{or} \quad \frac{75x.746}{.902} = 62$$

.238 X 62 = 14.8 kVAR (use 15 kVAR)

Defining the load

Rotating motion horsepower

$$HP = \frac{T \times N}{5250}$$

Where: T = Torque (lb-ft)
N = Speed (RPM)

$$HP = \frac{T \times N}{63.000}$$

Where: T = Torque (lb-in)
N = Speed (RPM)

Linear motion

$$HP = \frac{F \times V}{33.000}$$

Where: F = Force or Tension (lb)
V = Velocity (FPM)

$$HP = \frac{F \times V}{396.000}$$

Where: F = Force or Tension (lb)
V = Velocity (in/min)

Accelerating torque/force

$$T_A = \frac{WK^2 \times N}{308t}$$

Where: T_A = Accelerating torque (lb ft)
WK^2 = Total system inertia that must be accelerated. This includes motor rotor, speed reducer (if used), and load. (lb-ft²)

$$F_A = \frac{W \times V}{1933t}$$

Where: F_A = Accelerating Force (lb-ft)
W = Weight (lb)
V = Change in velocity (FPM)
t = Time (sec.)

Torque

T = F x R

Where: T = Torque (lb-ft)
F = Force (lb)
R = Radius (ft)

WK^2 – reflected

$$\text{Reflected } WK^2 = \frac{WK^2 \text{ of Load}}{(\text{Reduction Ratio})^2}$$

This is for either belt or gear reductions.

FPM to RPM

$$RPM = \frac{FPM}{.262 \times (\text{diameter in inches})}$$

Electrical data

Centrifugal loads

Flow rate:

$$\text{Flow}_1 = \left(\frac{\text{RPM}_1}{\text{RPM}_2}\right)$$
$$\text{Flow}_2 = \left(\frac{\text{RPM}_1}{\text{RPM}_2}\right)$$

Torque:

$$\text{Torque}_1 = \left(\frac{\text{RPM}_1}{\text{RPM}_2}\right)$$
$$\text{Torque}_2 = \left(\frac{\text{RPM}_1}{\text{RPM}_2}\right)$$

Pressure:

$$\frac{\text{Pres}_1}{\text{Pres}_2} = \left(\frac{\text{RPM}_1}{\text{RPM}_2}\right)^2$$

Horsepower:

$$\frac{\text{BHP}_1}{\text{BHP}_2} = \frac{\text{RPM}_1^{\ 3}}{\text{RPM}_2{}^3}$$

Fans and blowers:

$$\text{BHP} = \frac{\text{CFM x PSF}}{3300 \text{ x (fan efficiency)}}$$

$$\text{BH} = \frac{\text{CFM x PIW}}{6350 \text{ x (fan efficiency)}}$$

$$\text{BHP} = \frac{\text{CFM x PSI}}{229 \text{ x (fan efficiency)}}$$

Pumps:

$$\text{BHP} = \frac{\text{GPM x TH x (specific gravity)}}{3960 \text{ x (pump efficiency)}}$$

$$\text{BHP} = \frac{\text{GPM x PSI x (specific gravity)}}{1713 \text{ x (pump efficiency)}}$$

Where:

BHP = Brake horsepower
PSF = Pounds per square foot
PIW = Pressure in inches of water guage
PSI = Pounds per square inch
GPM = Gallons per minute
TH = Total head (including friction)

Other useful formulas

Gear ratio - most favorable

$$\text{GR} = \frac{WK^2 + Tf^2 + Tf}{WKM^2\ TM^2\ T_M}$$

Where: WK^2 = WK^2 of the load
WK^2_M = WK^2 of the motor
Tf = Friction torque of the laod
T_M = Average motor torque during acceleration

If friction torque is low compared to accelerating torque this can be reduced to:

$$\text{GR} = \sqrt{\frac{WK^2}{WK^2}}$$

Duty cycle calculations

$$\text{HP}_{\text{RMS}} = \sqrt{\frac{HP^2_1 t + HP^2_2 t + HP_3 t^2 + \text{etc}}{t_1 + t_2 + t_3 + \text{etc}}}$$

Drawings/tests

E9000 MCC unit numbering system
The General Electric Engineering Documentation System will accept a 3-character unit address designation consisting of a combination of letters and/or numbers (such as: 12J, ABC, A1D, 2AD, etc.). The recommended unit addressing system is illustrated and described in the following paragraphs.

Note: Should customer's (3-character maximum) unit numbering system differ from the following unit addressing system, then both can appear when requested on the CAD-generated motor control center unit summary drawings issued from the factory.

Benefits
When ordering NEMA Class I or II motor control centers where factory interconnections are required, this system produces a uniform numbering format for engineering documentation. The unit numbering system produces a unique unit address designation. When wiremarkers are specified, it ensures consistency and ease of wire tracing/troubleshooting between factory-wired units and other devices within the motor control center lineup such as programmable control I/O racks.

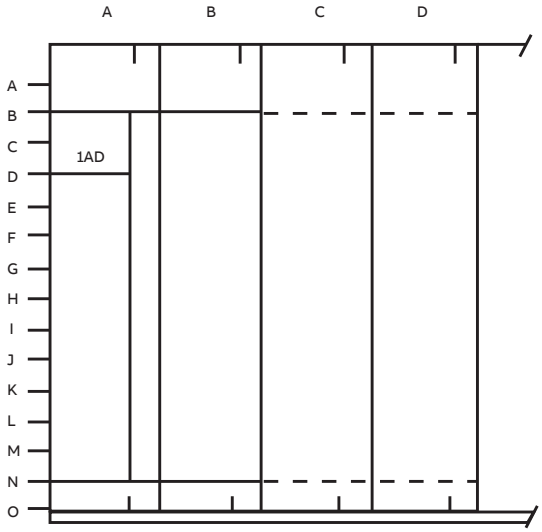
General

Typical 3-Character designation
Motor control center number/character
Vertical section number/character
Unit location (line number/character)

Note: The motor control center number/character assignment may be a number (1, 2, 3, 4, etc.) provided the number of MCC lineups on an order does not exceed 9. If 10 or greater, then the motor control center character should be a letter of the alphabet (A, B, C, D, etc.). Likewise, the vertical section character should be an alphabetic entry for lineups exceeding 9 sections.

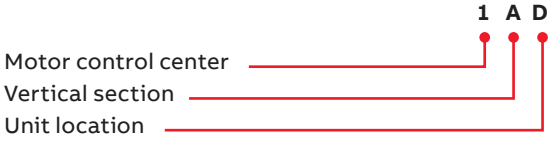
The outline summary drawing furnished with the equipment cross-references the unit location and the service designation specified for each unit.

Motor control center no. 1



Number the front view arrangement from left-to-right 1, 2, 3 … or A, B, C … Line off the space required for the top and bottom horizontal wireways. Then line off the interconnecting vertical wireway in each vertical section. Note that some units (including large starters, transformers, panelboards, etc.) may require full width of section and that no separate vertical wireway door will be adjacent to these units.

Example:
Assume that the top horizontal wireway is to be 12 inches high. In the first section a full-voltage non-reversing NEMA size 1 combination starter is to be installed in the first available position below the top horizontal wireway. Assuming conventional unit sizing (FVNR-1 equals 1X or 12-inch unit height), the unit location assignment becomes: 1 A D



Motor control center
Vertical section
Unit location

Continue lining off the unit space requirements for various units and future spaces as required until the lineup is complete and all spaces have been addressed. Notice that every unit location has a unique unit location designation. This unit designation will not be repeated again within the order. Since every motor control center lineup also has a unique panel catalog number, then the unit nameplate and catalog number will never be duplicated.

15XXXXXXX - 1AD

Example:
MCC Cat Number
Unit Location

A reminder about future spaces: If a 2X future space is to be arranged into two 1X compartments, then the outline sketch must be lined off into 1X compartments with individual unit addresses. This will ensure that the necessary unit doors A B C D and shelves will be provided by the factory.

E9000 MCC unit numbering system

CAD documentation system permits the engineer to perform virtually all design functions without the need of traditional drafting tools and associated equipment.

This computer-based system is used to translate equipment functional requirements into detailed equipment designs and material lists. These computerized drawings are used in the manufacturing process to increase product assembly accuracy, repeatability and consistency. Standardization of production procedures and methods has been improved such that given devices are consistently located in the same position on or within the equipment. Unit wiring is handled in the same manner, resulting in improved wiring accuracy and productivity. The following drawing elements are included in the standard documentation package.

1) Lead Sheet	Figure 1
2) Outline	Figure 2
3) Summary Tables	Figure 3
4) Unit Elementaries	Drawings/tests section

1. Lead Sheet – Contains special Customer notes and manufacturing or test instructions.
2. Outline – Presents front view plan drawings showing the physical arrangement of units and associated equipment within the motor control center lineup.
3. Summary Tables – Provides all necessary functional detail of each unit including nameplate inscriptions.

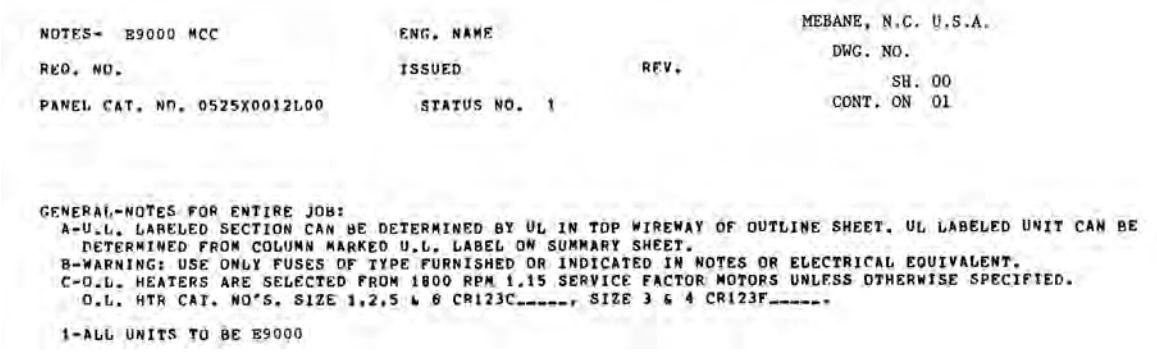


Figure 1

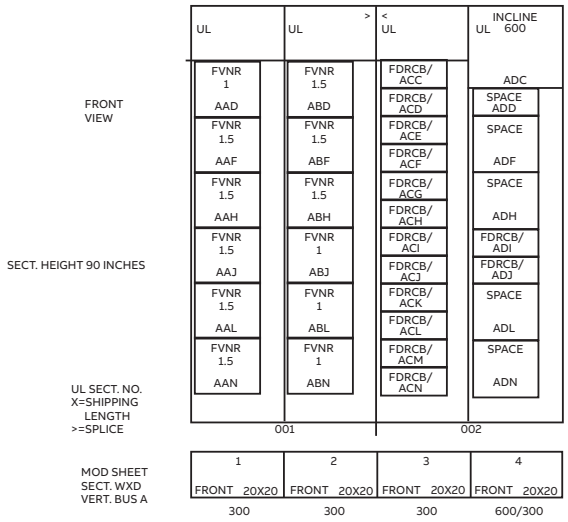


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Figure 2

UNIT SUMMARY EVOLUTION SERIES MCC
REQ. NO.
PANEL CAT. NO.
FRONT

ENG. NAME JBC
ISSUED 01/16/1996 REV.
REV NO. 0

ABB
MEBANE, NC USA

DWG. FOR INSTALLATAION
DWG. NO. SH F01A
CONT. ON SH F01B

UNIT LOC	UNIT MOD SH	CUST UNIT NO	CAT# 273A7916P3FC NAMEPLATE	ELEM	CONN.	DRW SIZE	FUNCTION	SIZE	HP KW K-KW	FLA	RPM	SF	OL HEATER CR123	OL RELAY TYPE	CB SW	TRIP FUSE/ CLIP	FUSES BY	TOTAL AUX INILK 0	TOTAL AUX INILK 0	NOT LABELED UL LABEL	NOT LABELED CSA LABEL	SC MARKER	CPT VA	CATALOG NUMBER
AAD			6-MILL FEED END JACKING PUMP	100	200A		FVNR	1	1	1.8	1000	1.150	C220A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102437
	RED RUN PTT LT																							
AAF			6-MILL FEED END JACKING PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102438
	RED RUN PTT LT																							
AAH			6-MILL FEED END FILTRATION PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102438
	RED RUN PTT LT																							
AAJ			6-MILL DISCHARGE END JACKING PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102438
	RED RUN PTT LT																							
AAL			6-MILL DISCHARGE END EXT. LUBE PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102439
	RED RUN PTT LT																							
AAN			6-MILL DISCHARGE END FILTRATION PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102439
	RED RUN PTT LT																							
ABD			7-MILL FEED END JACKING PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102438
	RED RUN PTT LT																							
ABF			7-MILL FEED END EXT. LUBE PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102438
	RED RUN PTT LT																							
ABH			7-MILL FEED END FILTRATION PUMP	100	200A		FVNR	1	1.5	2.4	1000	1.150	C301A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102438
	RED RUN PTT LT																							
ABJ			7-MILL DISCHARGE END JACKING PUMP	100	200A		FVNR	1	1	1.8	1000	1.150	C220A	AMBIENT	SELI	3		3	0	UL		157	150	IA52-102437
	RED RUN PTT LT																							

—
Figure 3

Paint finish

Indoor equipment

The standard Mebane paint system consists of the following two processes.

Phase I – Cleaning

In a 7-stage spray washer, steel parts are cleaned and sprayed in the controlled cleaning solutions.

Stage	Temperature	Chemical solution(s)
1–Cleaning	115-120°	Ferro clean
2–Rinse	105-118°	None
3–Iron phosphate	90-105°	Secure low foam
4–Rinse	Ambient	None
5–Non chrome sealer	Ambient	Non chrome final seal
6–Rinse	Ambient	None
7–Deionized rinse	Ambient	None

Cleaned steel parts enter a drying oven at 300-350°F. The preceding operating parameters have been determined to produce an Iron Phosphate coating of a minimum of 150 milligrams per square foot to meet MIL Spec. TT-C-490.

Phase II – Painting by electro-static powder process

Primed metal parts are electrostatically coated with a powder paint consisting of the following: 670-011 ANSI-61 Polyester Paint (Light Gray)

Metal parts will enter drying oven at 375-400°F and remain for 20 minutes. The standard color is ANSI-61 light gray with a gloss of 60±5, and a thickness of 1.5 mils. This system will withstand a minimum of 1000 hour humidity test, plus 600 hours salt spray test.

Packaging and storage

Domestic packaging

Normally a motor control center Lineup is shipped in groups of three vertical sections for ease of handling. Each shipping split is mounted on a hardwood skid to facilitate moving by rollers or fork-lift truck. Lifting eyes are also provided for moving by crane. Shipping blocks are placed on the face of the sections to protect handles and devices. The shipping splits are wrapped in clear stretch polyfilm to protect the equipment from the usual dust and dirt encountered during shipment. Necessary bus splice bars are included for connecting the shipping splits together.

Export crating

The sections are bolted to a skid with a solid floor. The equipment is then enclosed in a 3/8" plywood crate with 2 x 4 reinforcing at the top and corners. Three 1 1/4" steel bands are placed horizontally around the crate for additional reinforcing.

All equipment should be protected against moisture and temperature extremes during shipment and storage. See Environmental Considerations in "Overview" section. For prolonged shipping periods where export crating is involved, it is recommended the equipment space heaters (when specified) be wired for connecting to an external power source while in transit, to minimize condensation.

Storage

If it is necessary to store the equipment for any length of time, the following precautions should be taken:

1. Uncrate equipment.
2. Store in a clean, dry area at moderate temperature. Cover with a suitable canvas or heavy-duty plastic cover to prevent entrance of foreign material.
3. If equipment must be stored in cool or damp areas, not only should the equipment be completely covered, but heat should be provided to prevent condensation of moisture in the equipment. Energize space heaters (if furnished in the equipment) or place a standard 120-volt lamp rated 75 watts inside the bottom of each vertical section.

Standard commercial tests and inspection

General
The following summary description defines the standard factory tests and inspections performed during manufacture. All motor control center equipment is tested and inspected for conformance with NEMA ICS 18-2001. Production tests and inspections encompass the verification of physical configuration of assembly and workmanship, the mechanical adjustments of parts and components, and the sequencing and functional operations of the control systems. These tests and inspections are performed on manufactured products to verify conformance of the equipment to a previously qualified design. The tests do not include type testing or other destructive tests on equipment to be shipped to a customer. Any additional factory tests beyond those listed in the following paragraphs must be referred to Mebane to verify availability of test facilities and qualified manpower. Additional testing beyond the scope of the following standard commercial tests will affect normal shipment schedules.

Production tests
The following list of inspection activities shall be performed to assure proper and correct materials, workmanship and for any damage conditions in accordance with the manufacturing documentation and drawings:
- Components, parts and material.
- Physical condition of components, parts, wire insulation.
- Location and orientation of components and parts.
- Finish–plating–painting.
- Wire/cable type, size, insulating and clamping support.
- Wire terminations, insulation removal and crimping of terminals.
- Tightness of electrical connections and torque of bus bar bolts.
- Wire markers and terminal markers (where specified).
- Labeling of components, parts, etc.
- Tightness torque of assembly bolts and hardware.
- Welds (spot only).
- Mechanical clearance.
- Electrical clearance (potential hazards).

Mechanical operations test
Mechanical operating tests shall be performed to insure proper
functioning of operating mechanisms and interchangeability.

a. The operation of shutters, mechanical interlocks, circuitbreaker-door interlocks, operating handles, trip mechanisms, solenoid armature travels, contact wipes, electromechanical interlocks, physical clearances for mechanical and electrical isolation including any additional mechanically related operating functions shall be verified.
b. The interchangeability of removable units designed to be interchangeable shall be verified as well as the rejection functions of non-interchangeable units.

Continuity tests – control wiring and power cables
The correctness of the individual circuit wiring contained in each assembly and the assembly wiring interfaces shall be verified as in accordance with the connection diagram, wiring table, or elementary drawing. The continuity of each circuit shall be checked.

Functional operations test
All equipments shall be subjected to an operational test. The test shall verify the functional operation of the control and power circuits and related components, devices and subassemblies- modules under simulated operating conditions (excluding loading of the power circuits).

Devices
All devices, including subassemblies-modules, shall be operated, set and checked for their functional characteristics in accordance with the instructions for each and any additional characteristics peculiar to a device:
- Pick-up
- Drop-out
- Contact wipe
- Amperes
- In-rush current
- Time-delay

Contactors must pick-up and hold-in at or below the following percentage or rated coil voltage:

Device type	Voltage source	Pick-up (percentage)
DC	DC	63
AC	AC	85[1]
DC	AC with rectifier	70 with holding resistor
DC	AC with rectifier	75 with holding and pick-up resistor

1. If a control power transformer is used, apply 90 percent voltage to primary of transformer.

Sequence and timing circuits
Assemblies and systems involving sequential operation of devices and time delays shall be tested to assure that the devices in the sequence function properly and in the order intended.

Polarity – phase-sensitive circuits
The polarity of direct-current circuits and phase connections of alternating-current circuits shall be verified by application of power and measurement of the relative polarities and phase sequence.

Grounding
The grounding circuits and buses shall be verified.

Standard commercial tests and inspection
High Potential – Insulation Tests

Control wiring insulation tests
A dielectric test (hi-pot) shall be performed on circuit wiring to confirm the insulation resistance to withstand breakdown to a selected test voltage. The test voltage – amplitude and waveshape, method of application and duration of time applied – shall be specified in
NEMA ICS 18-2001.

Power cable insulation and isolation test
Power cables and buses shall be tested, phase-to-phase and phase-to-ground for insulation breakdown resistance and circuit isolation as specified in NEMA ICS 18-2001.

Note: These test conditions are as specified for newly constructed equipment and performed in a clean, temperature- and humidity-controlled factory environment.

The test voltages include the standard test voltage (two times rated plus 1000), times 120 percent (for one-second application).

Rated circuit Voltage AC or DC	High potential test voltage	Duration of test
120	1500	1 second
240	1800	1 second
480/600	2700	1 second

The frequency of the test voltage shall not be less than the rated frequency of the equipment tested and shall be essentially sinusoidal in wave shape.

Note: Consideration shall be made for low-voltage devices, semiconductors, meters, instruments, transformers, grounding circuits, etc., in preparation for the dielectric tests.

Option – insulation resistance (megger) tests
Insulation resistance tests measure the amount of circuit resistance to current leakage. This test is performed when this resistance measurement is desired and so specified. A nominal charge will be assessed.

The test voltage and minimum insulation resistance shall be selected as specified by the contract. Standard test values are:
a. 500 volts DC with 10 megohms minimum
b. 1000 volts DC with 1 megohm minimum

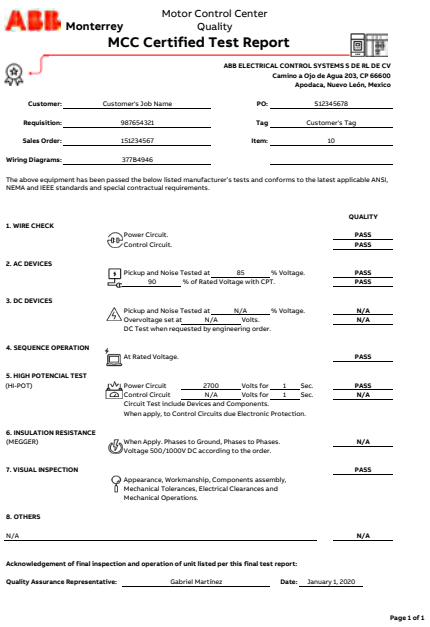


ABB Monterrey
Motor Control Center
Quality
MCC Certified Test Report

ABB ELECTRICAL CONTROL SYSTEMS S DE RL DE CV
Camino a Ojo de Agua 203, CP 66600
Apodaca, Nuevo León, Mexico

Customer: Customer's Job Name
PO: S12345678
Requisition: 987654321
Tag Customer's Tag
Sales Order: 1S1234567
Item: 10
Wiring Diagrams: 37784946

The above equipment has been passed the below listed manufacturer's tests and conforms to the latest applicable ANSI, NEMA and IEEE standards and special contractual requirements.

		QUALITY
1. WIRE CHECK		
	Power Circuit.	PASS
	Control Circuit.	PASS
2. AC DEVICES		
	Pickup and Noise Tested at 85 % Voltage.	PASS
	90 % of Rated Voltage with CPT.	PASS
3. DC DEVICES		
	Pickup and Noise Tested at N/A % Voltage.	N/A
	Overvoltage set at N/A Volts.	N/A
	DC Test when requested by engineering order.	
4. SEQUENCE OPERATION		
	At Rated Voltage.	PASS
5. HIGH POTENCIAL TEST (HI-POT)		
	Power Circuit 2700 Volts for 1 Sec.	PASS
	Control Circuit N/A Volts for 1 Sec.	N/A
	Circuit Test Include Devices and Components. When apply, to Control Circuits due Electronic Protection.	
6. INSULATION RESISTANCE (MEGGER)		
	When Apply. Phases to Ground, Phases to Phases. Voltage 500/1000V DC according to the order.	N/A
7. VISUAL INSPECTION		PASS
	Appearance, Workmanship, Components assembly, Mechanical Tolerances, Electrical Clearances and Mechanical Operations.	
8. OTHERS		
N/A		N/A

Acknowledgement of final inspection and operation of unit listed per this final test report:

Quality Assurance Representative: Gabriel Martínez **Date:** January 1, 2020

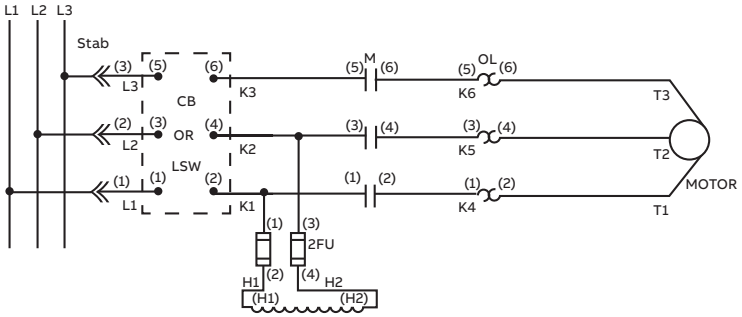
Page 1 of 1

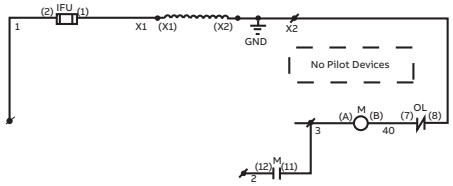
Example of standard test report available on request for a nominal charge.

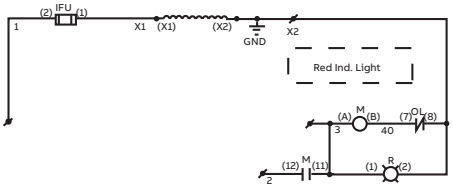
Typical circuits

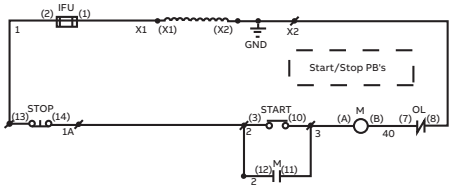
FVNR size 1-4

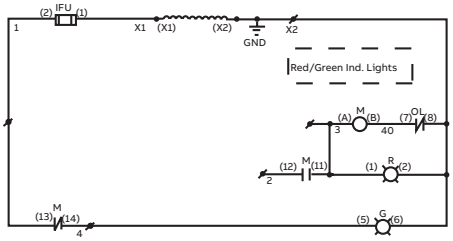
Typical circuit diagrams

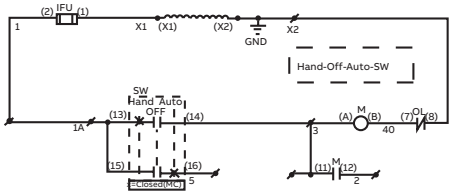


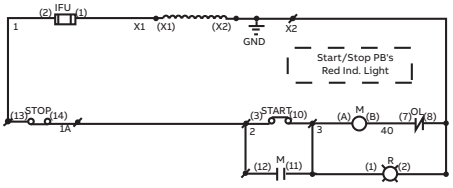


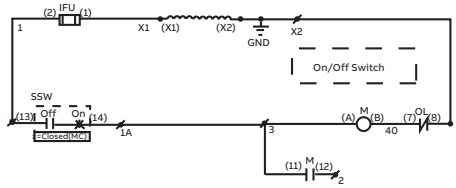


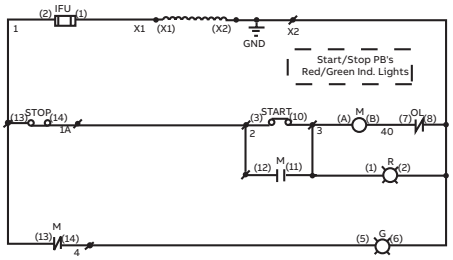






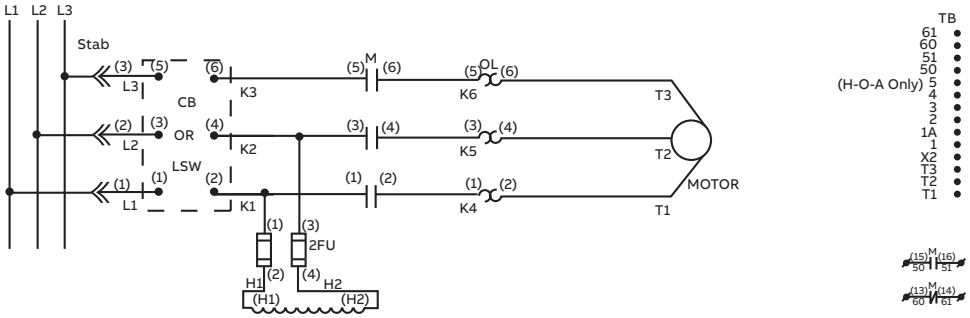


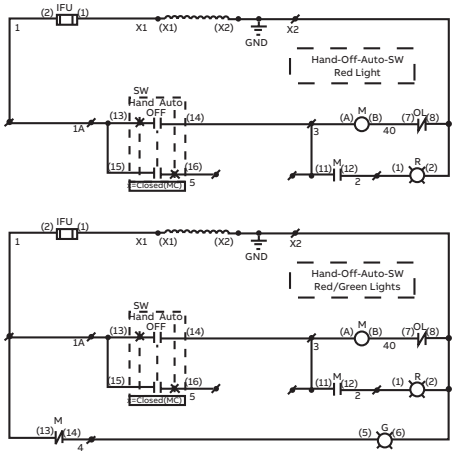


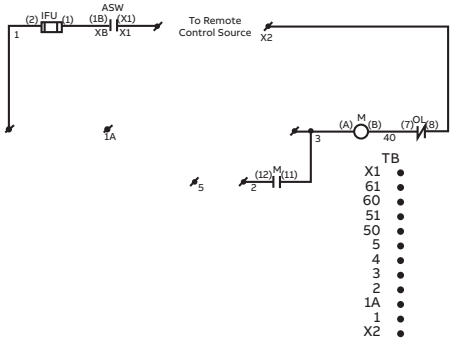


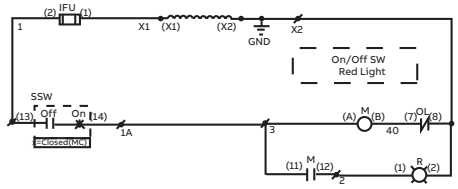
FVNR size 1-4

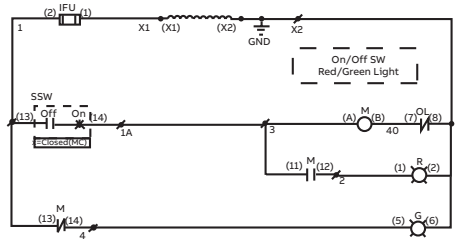
Typical circuit diagrams





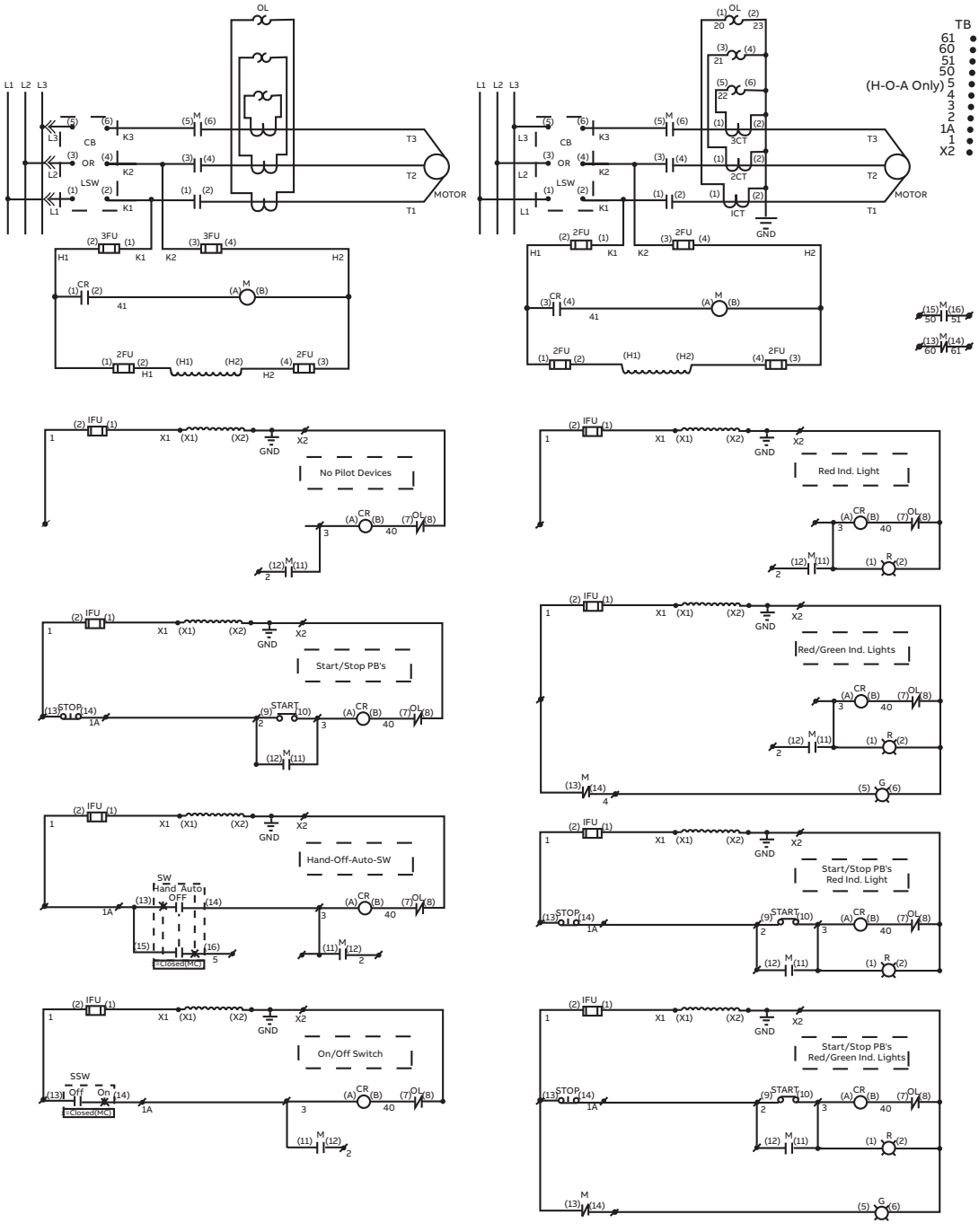






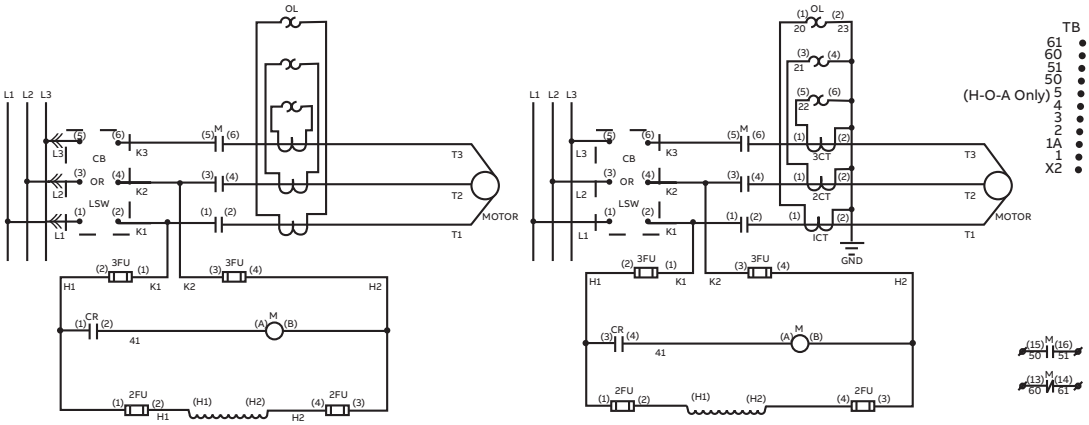
FVNR size 5-6

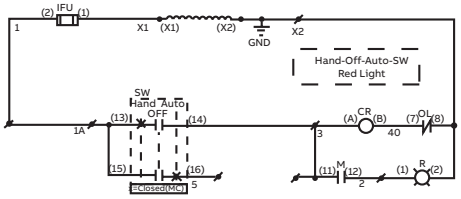
Typical circuit diagrams
S-5

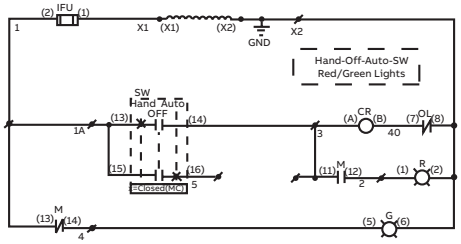


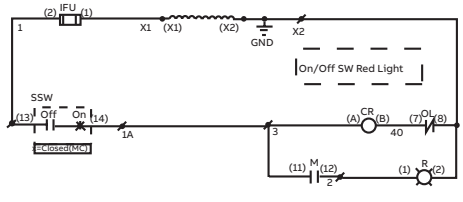
FVNR size 5-6

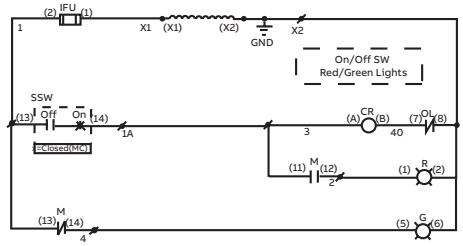
Typical circuit diagrams
S-5





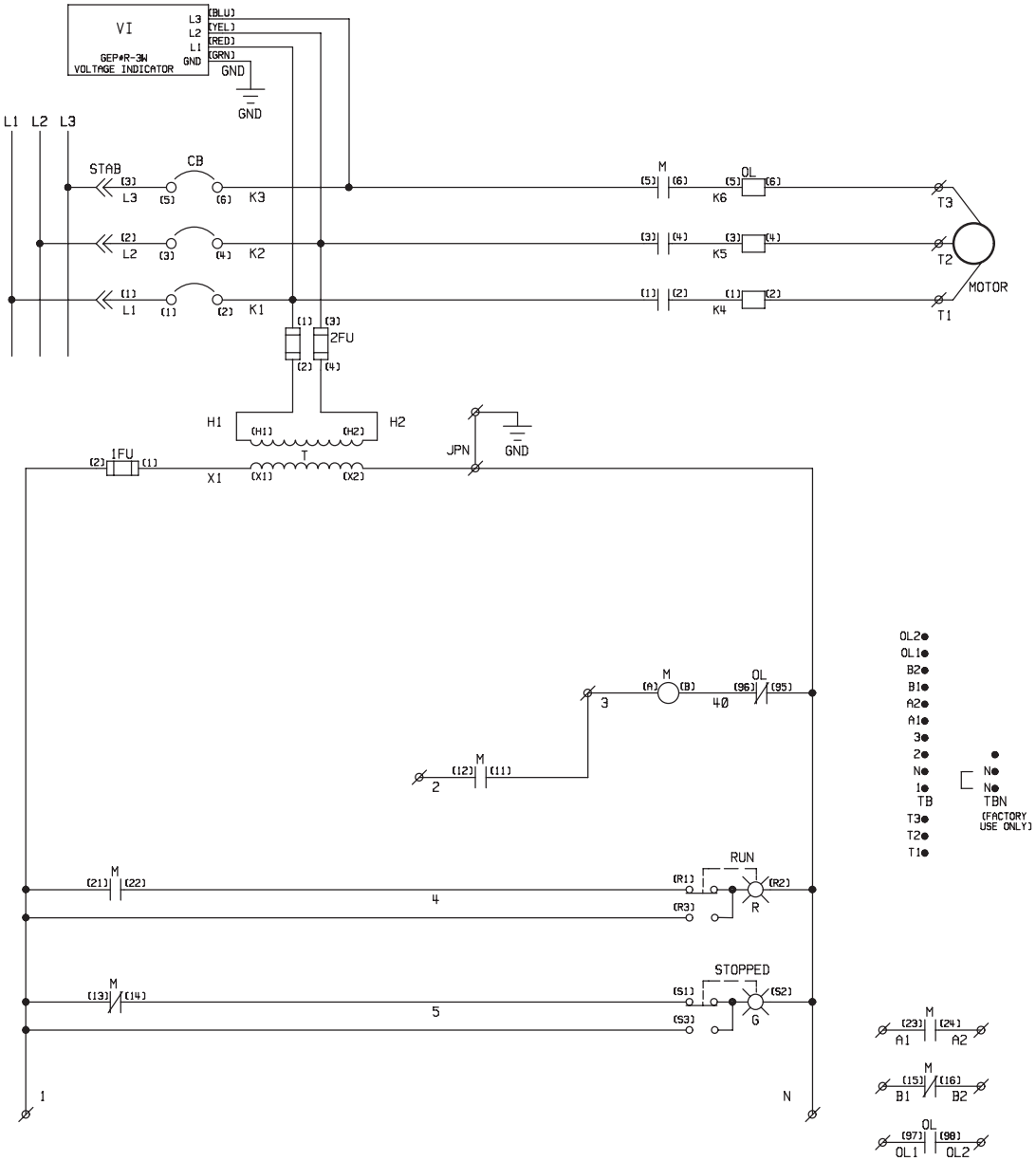






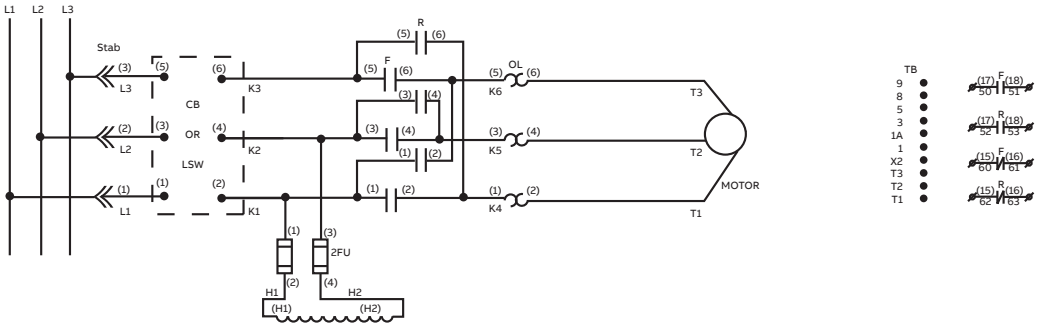
FVNR with voltage indicator module

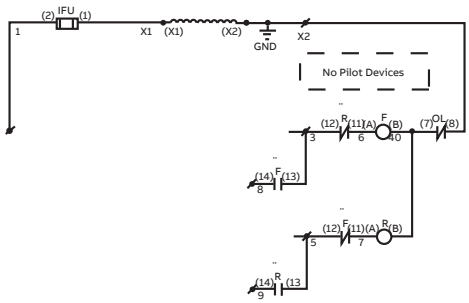
Typical circuit diagrams

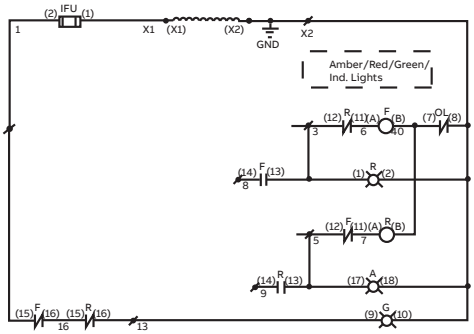


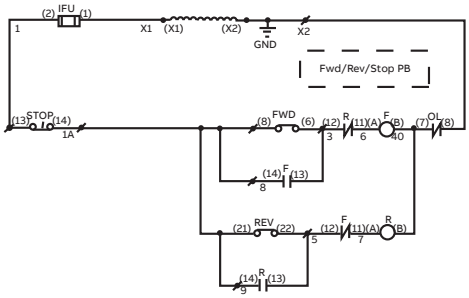
FVR size 1-4

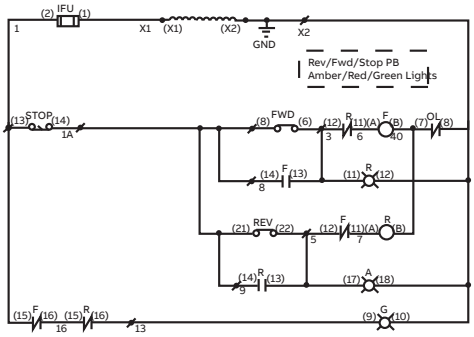
Typical circuit diagrams

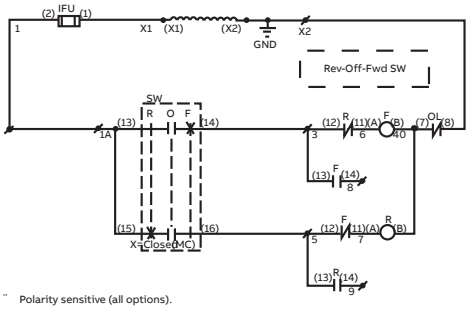


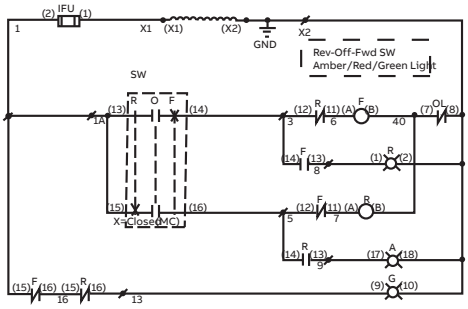








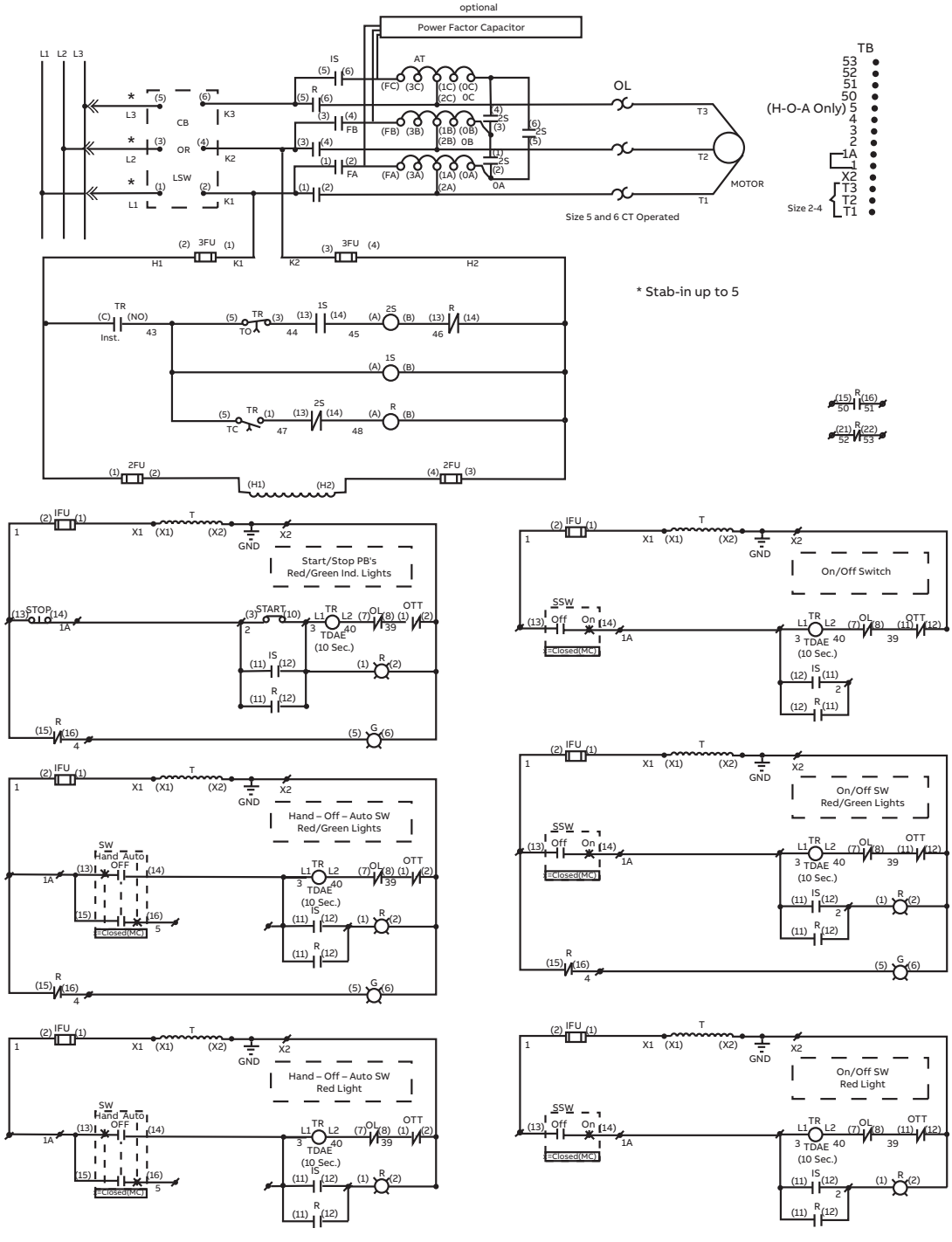




¨ Polarity sensitive (all options).

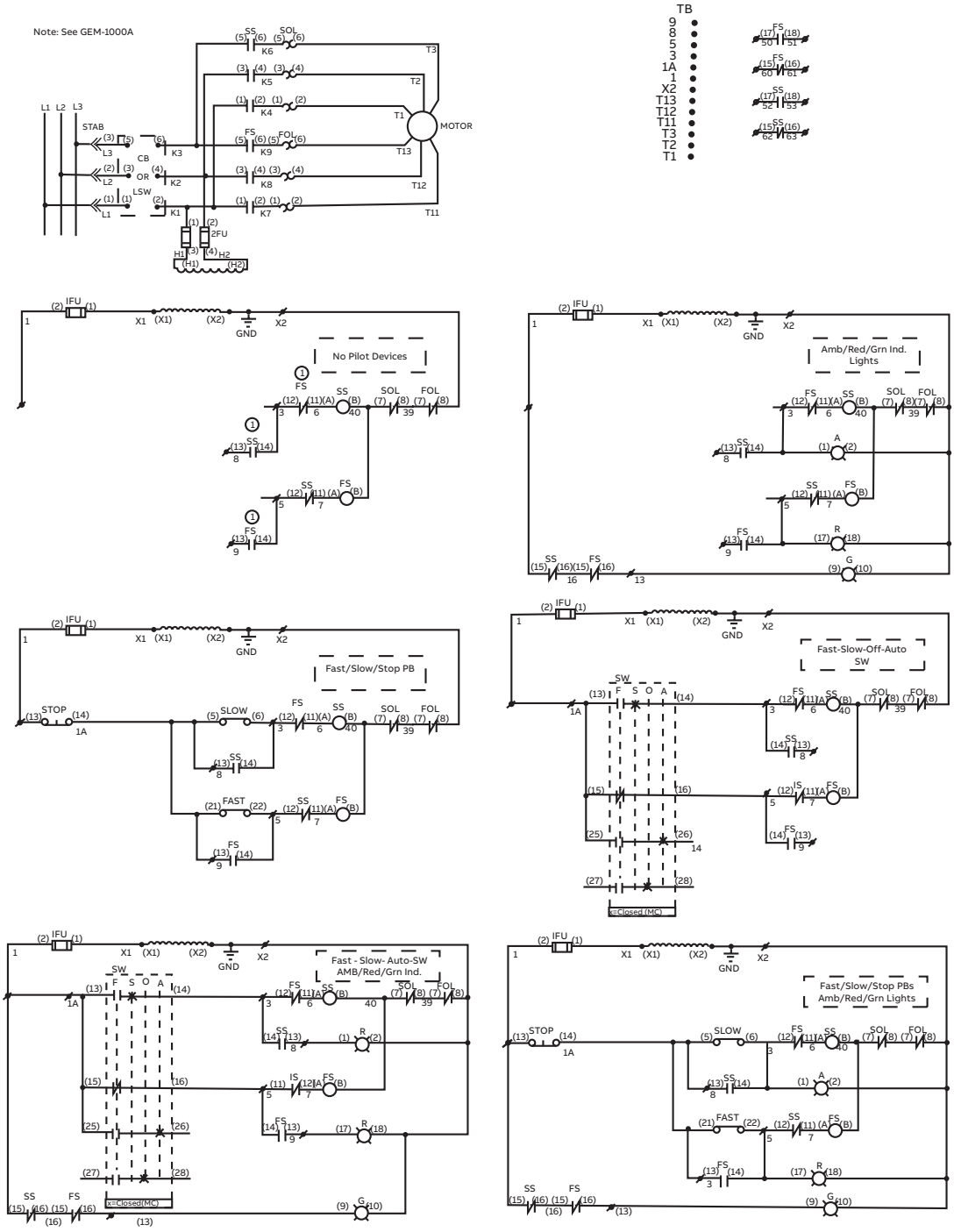
RVAT size 2-6

Typical circuit diagrams
Size 2, 3-65, 80% Taps
Size 4, 5, 6-50, 65, 80% Taps



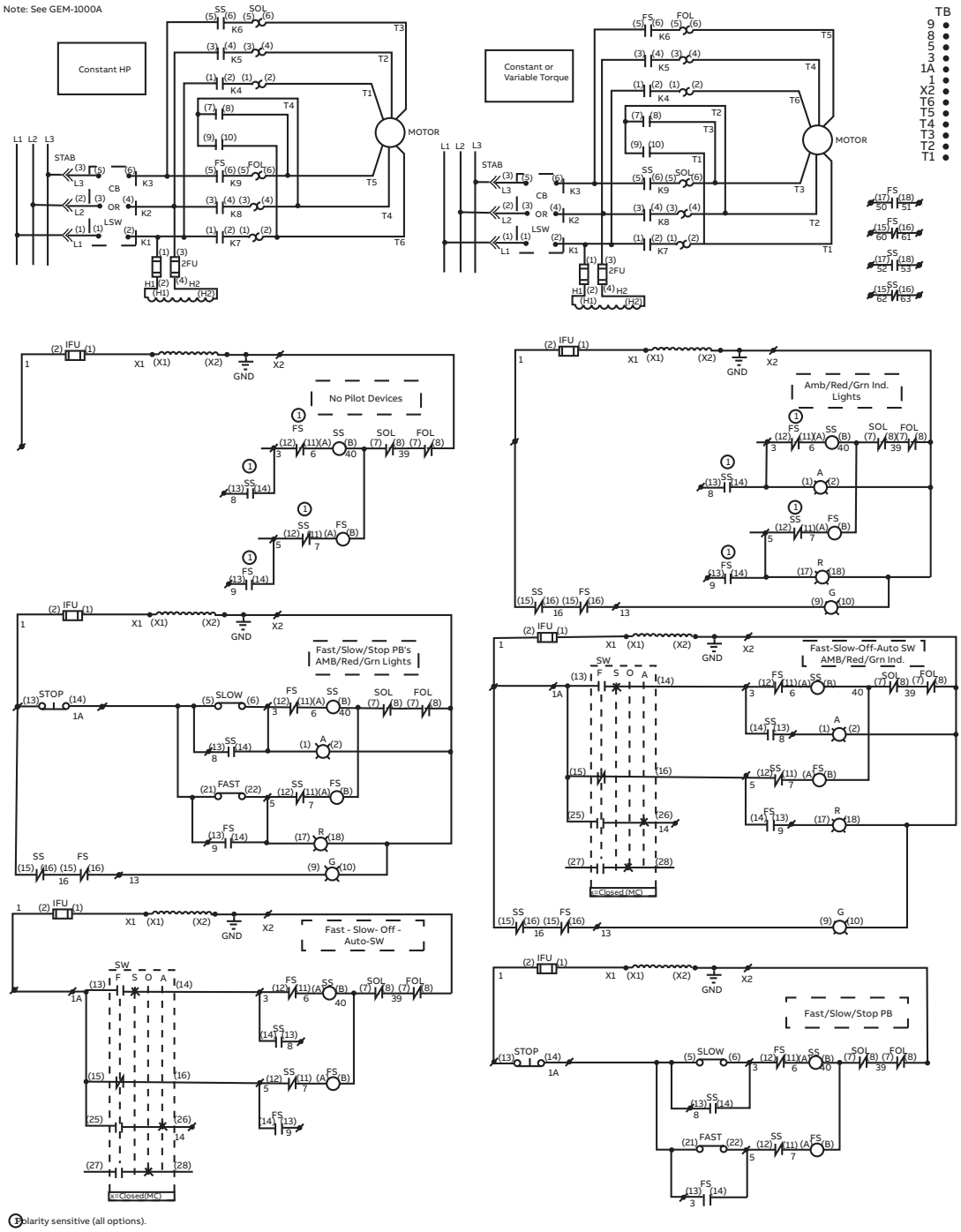
2S2W-C.T., V.T., C.H. Size 1-4

Typical circuit diagrams



2S1W-C.T., V.T., C.H. Size 1-4

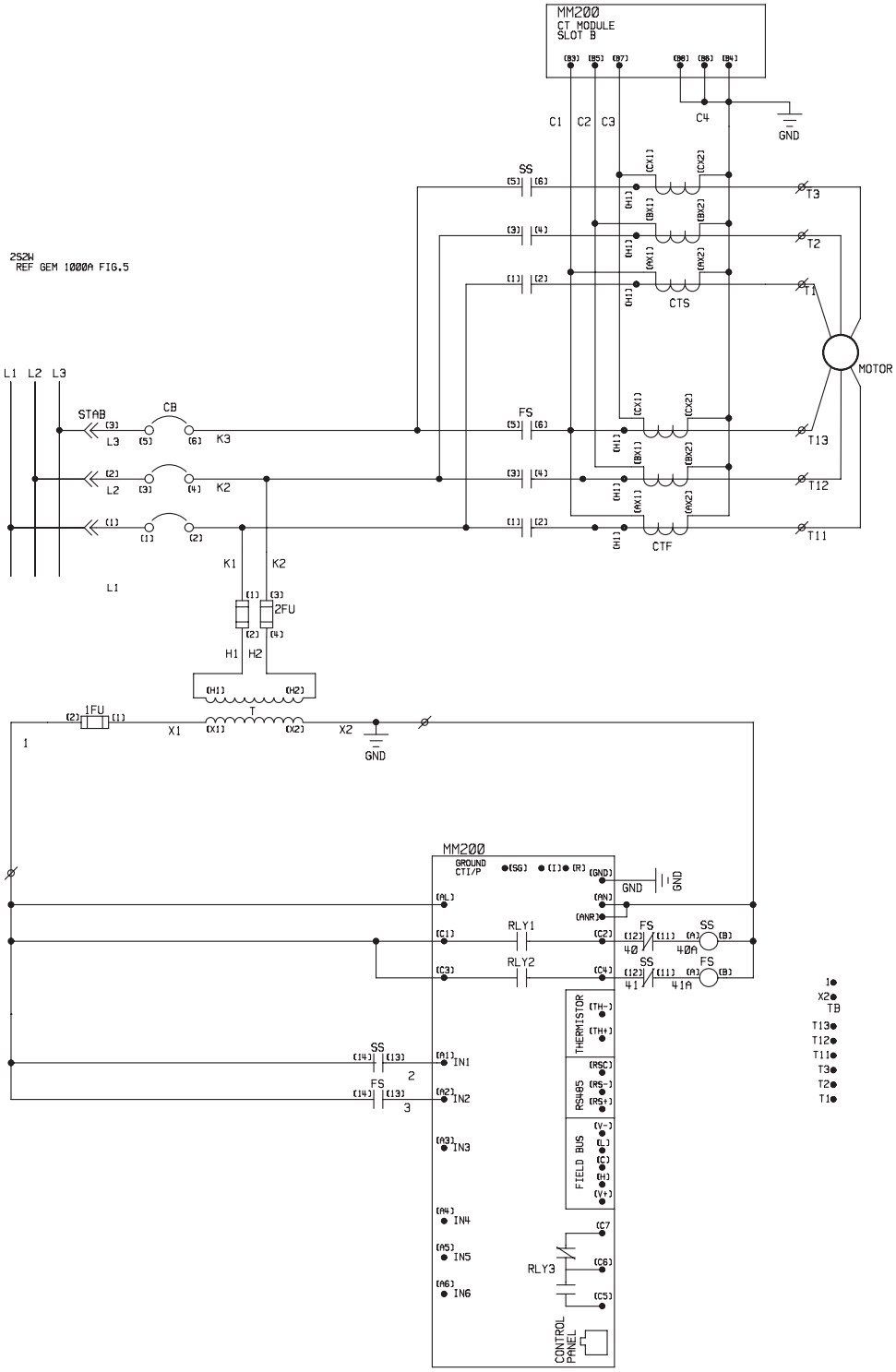
Typical circuit diagrams



Ⓟ Polarity sensitive (all options).

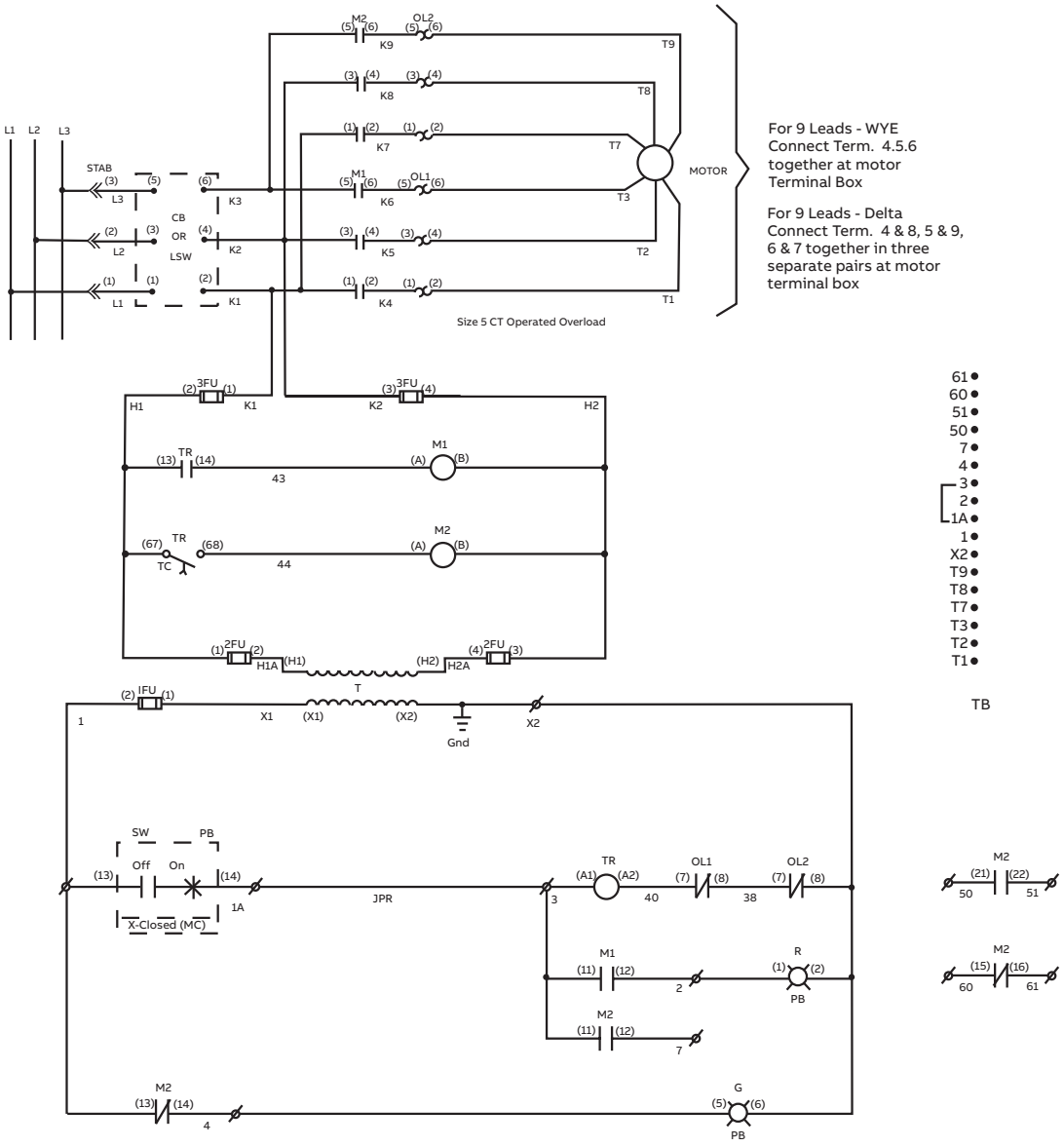
2S2W with MM200

Typical circuit diagrams

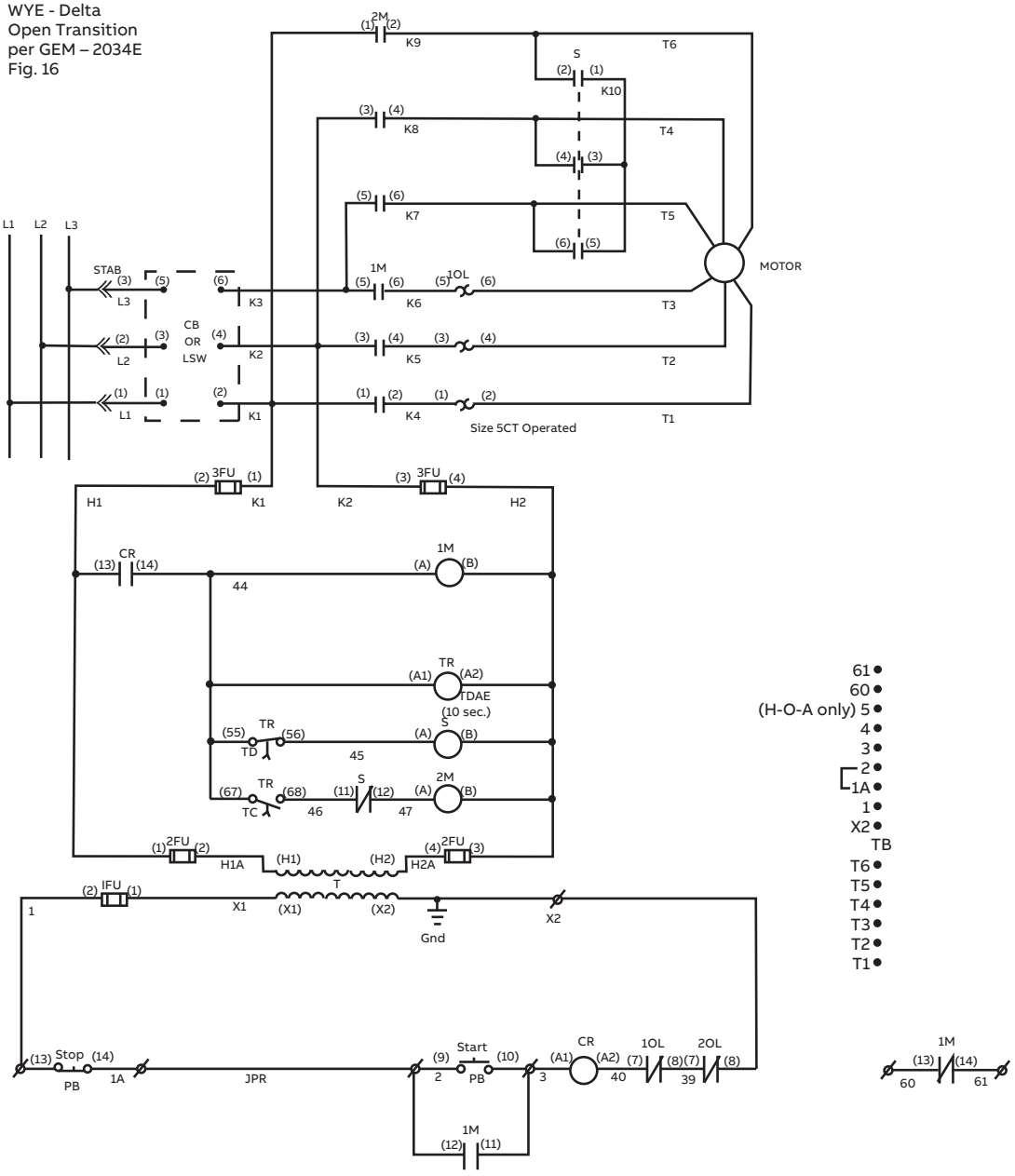


2S-PW size 1-5

Typical circuit diagrams

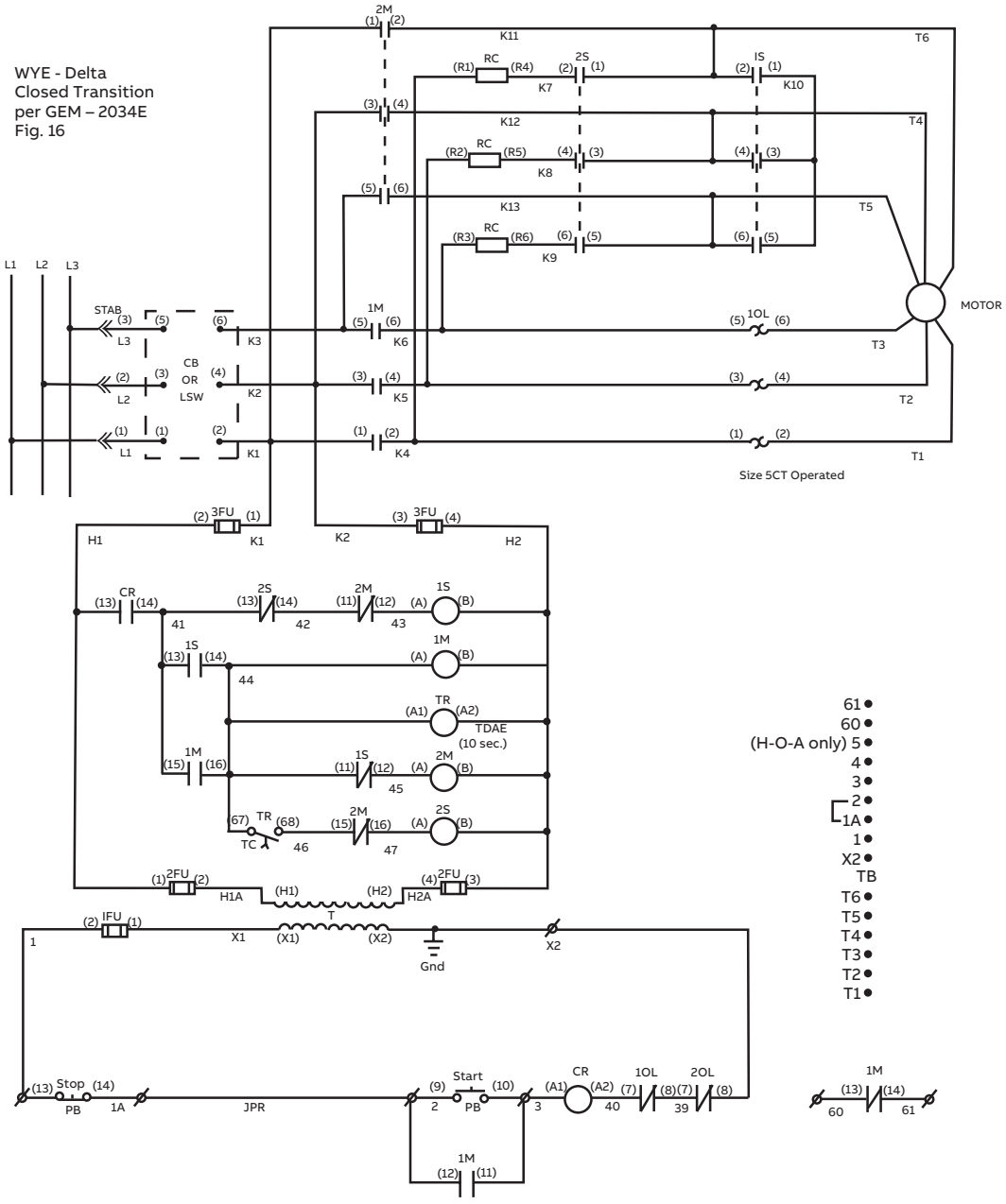


Wye-Delta open transition



Note: Control circuit options similar to the FVNR size 5

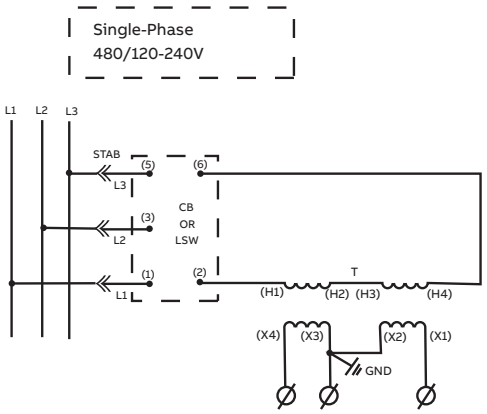
Wye-Delta closed transition

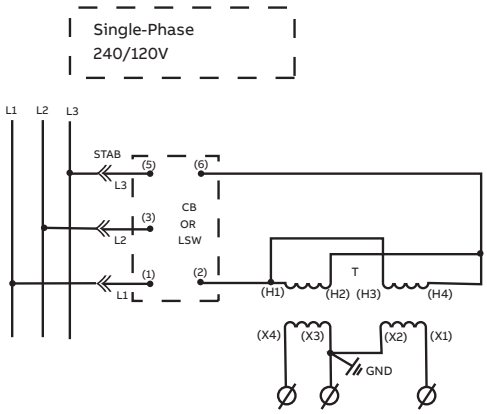


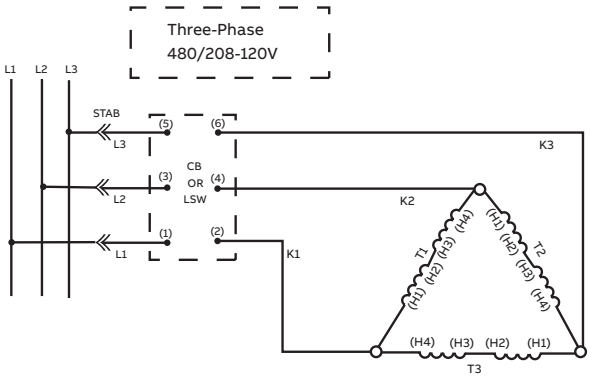
Note: Control circuit options similar to the FVNR size 5

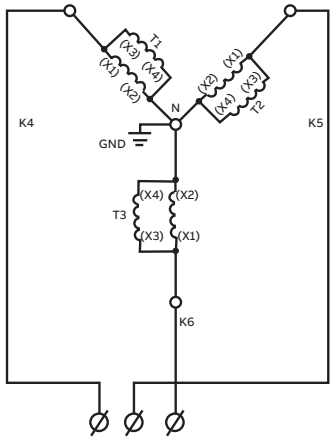
Distribution transformers

Typical circuit diagrams



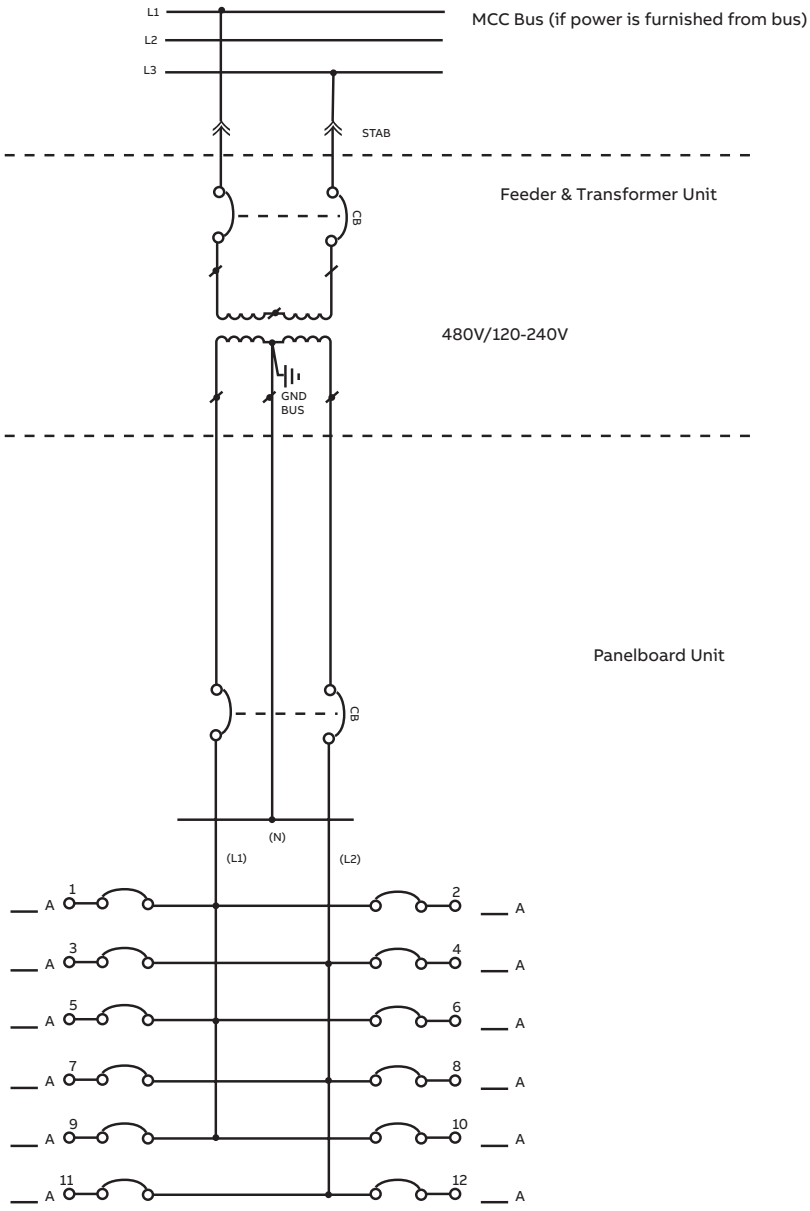






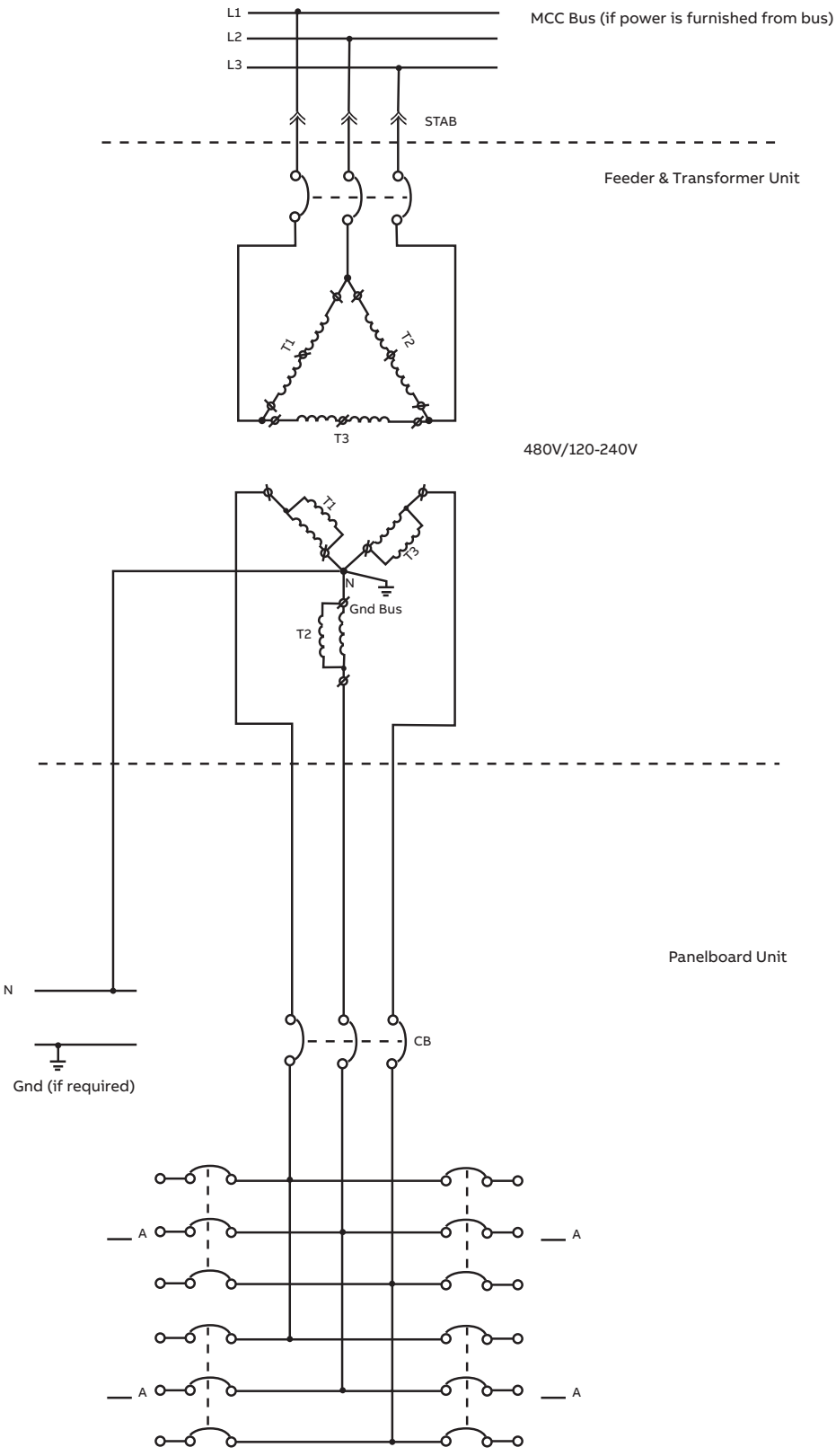
Single-phase panelboard

Typical circuit diagrams



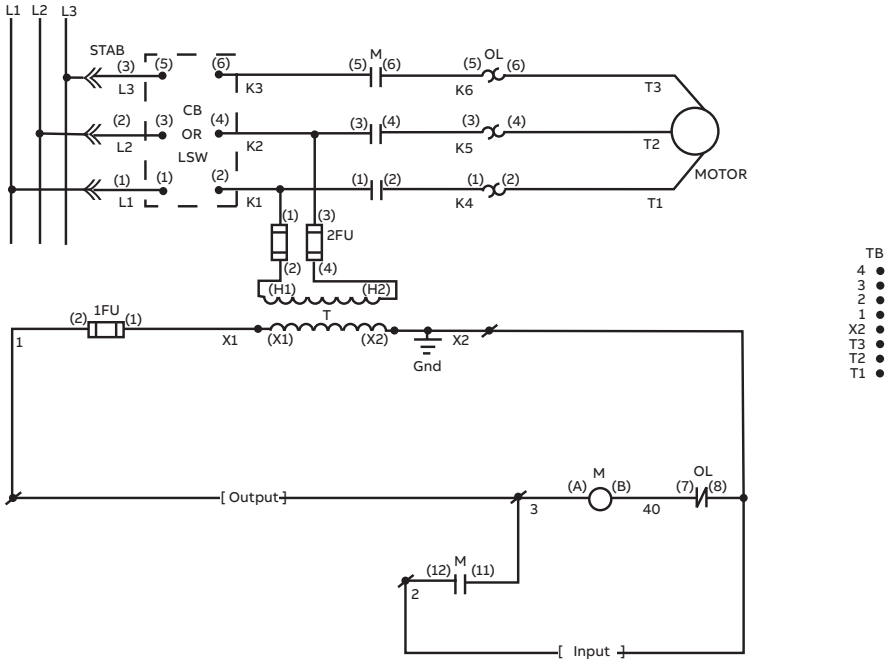
Three-phase panelboard

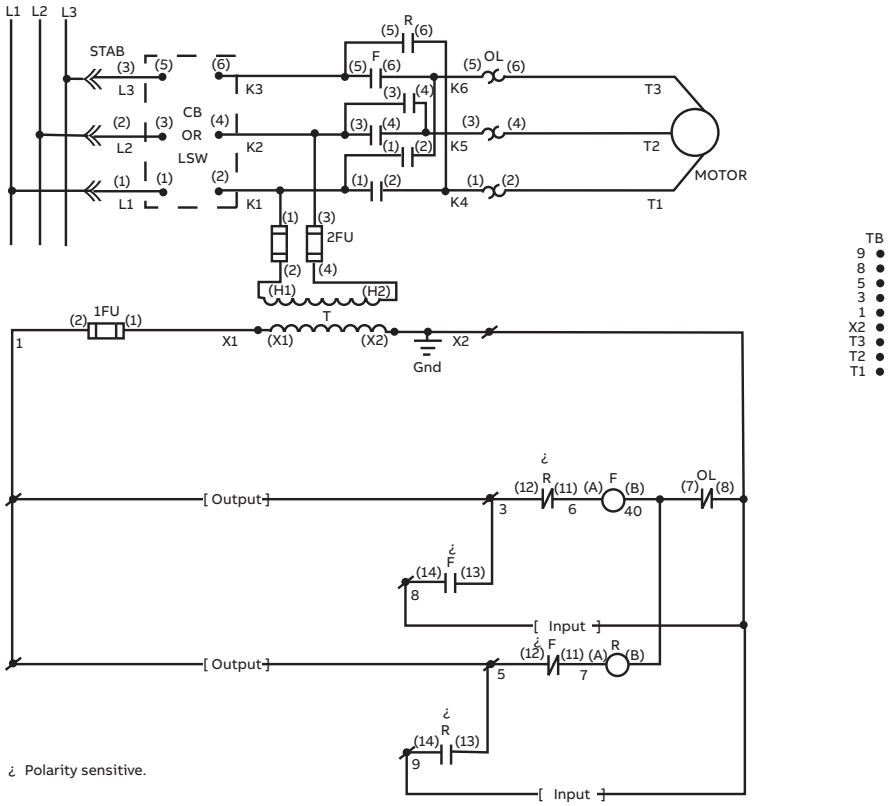
Typical circuit diagrams



FVNR with PLC

Typical circuit diagrams

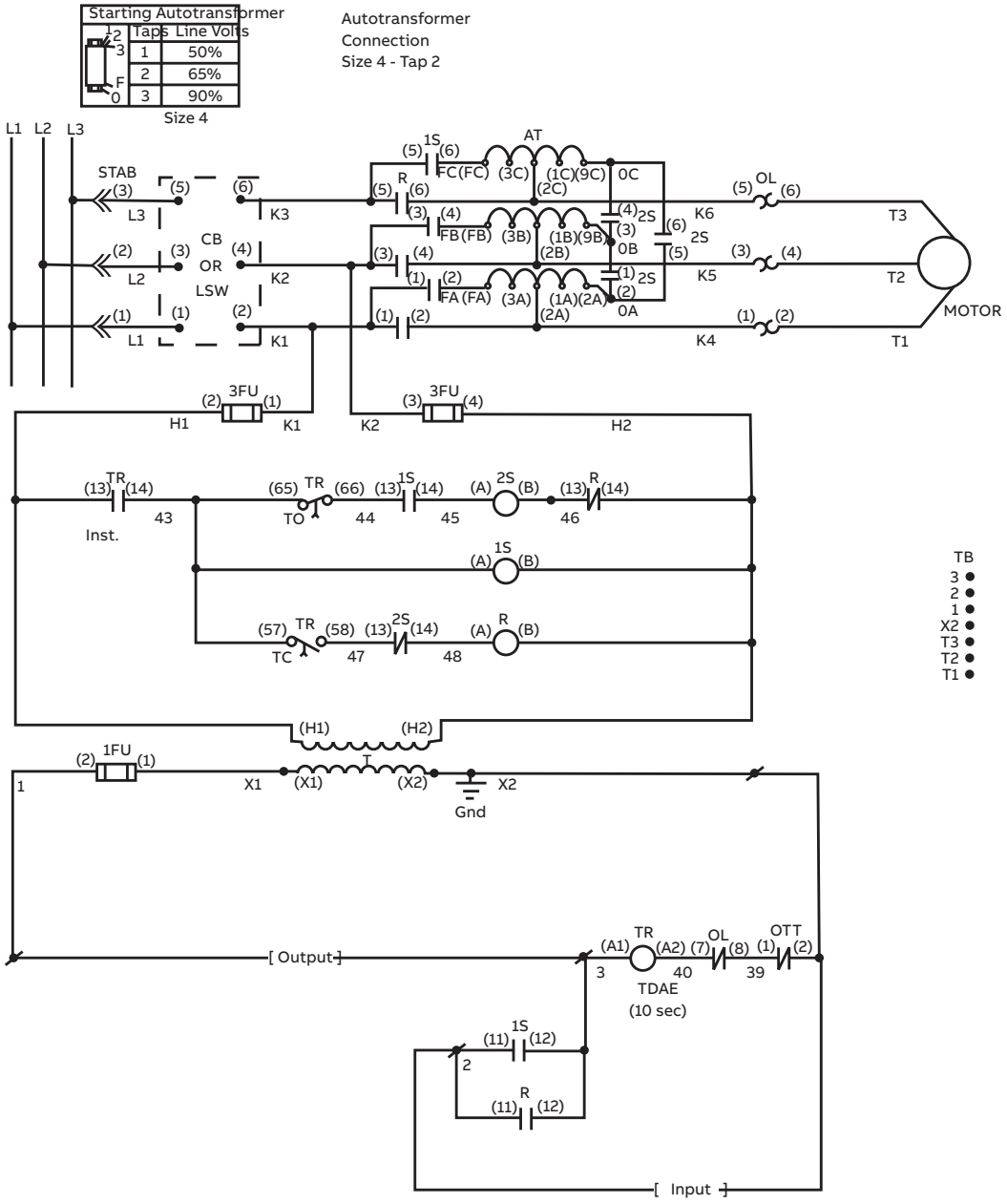




¿ Polarity sensitive.

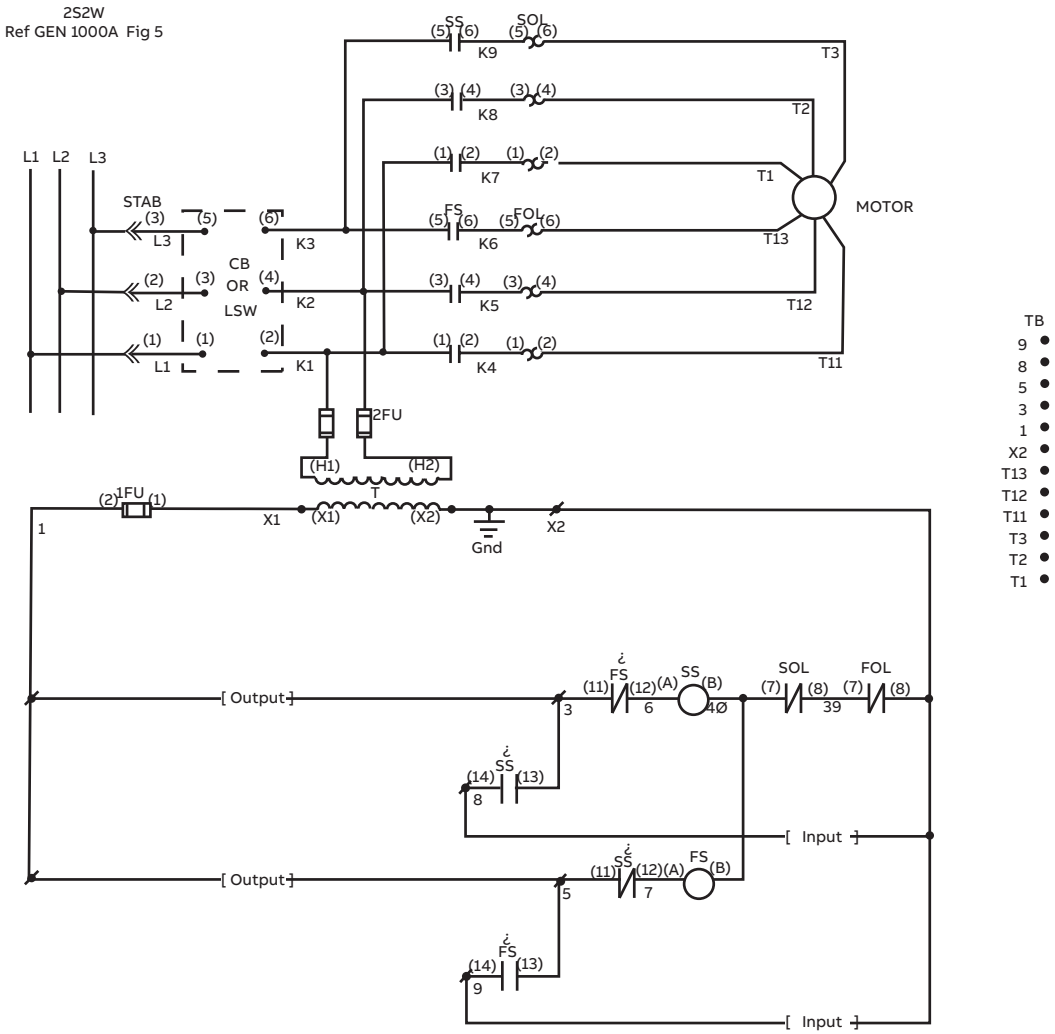
RVNR-AT with PLC

Typical circuit diagrams



2S2W with PLC

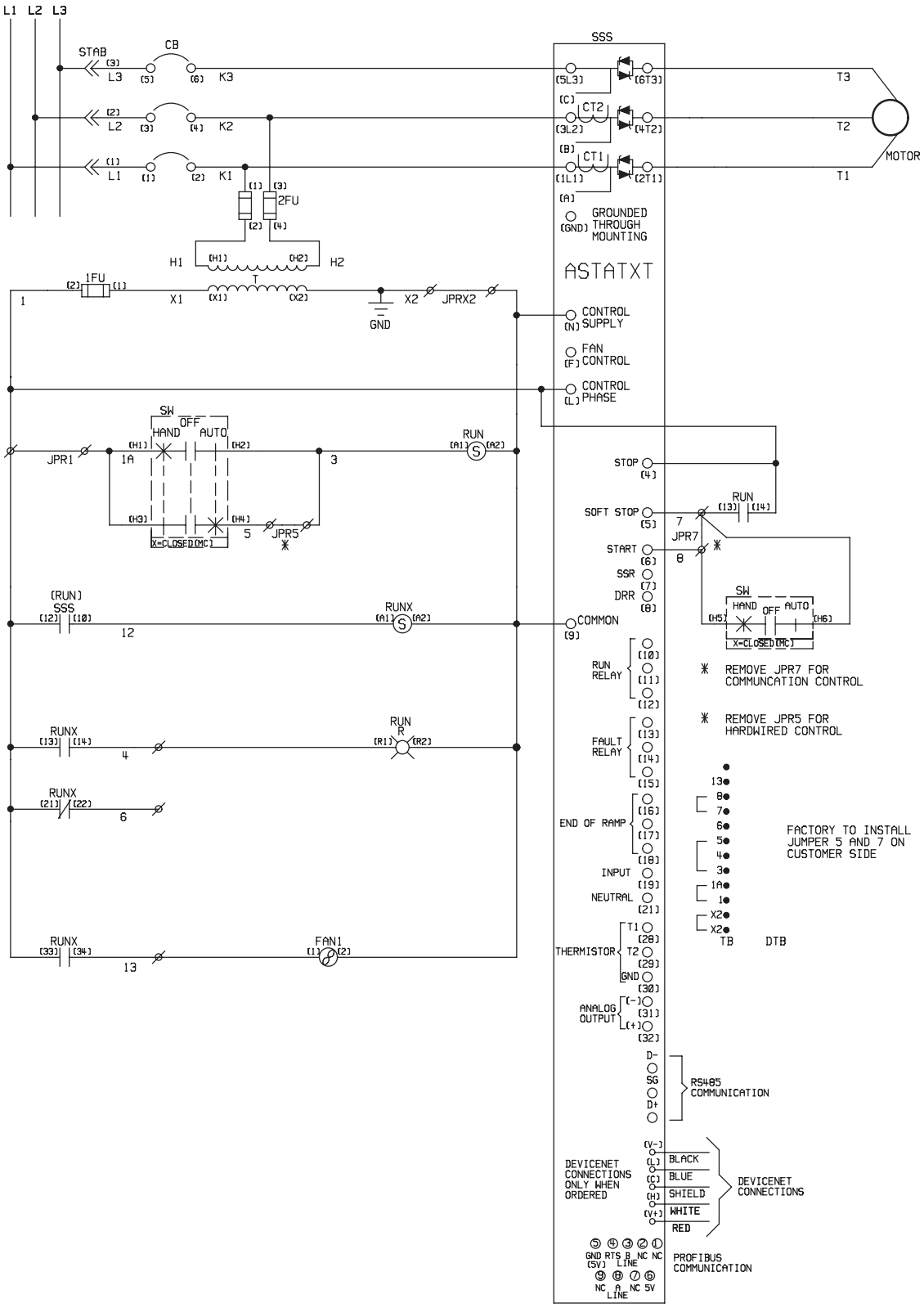
Typical circuit diagrams



Polarity sensitive.

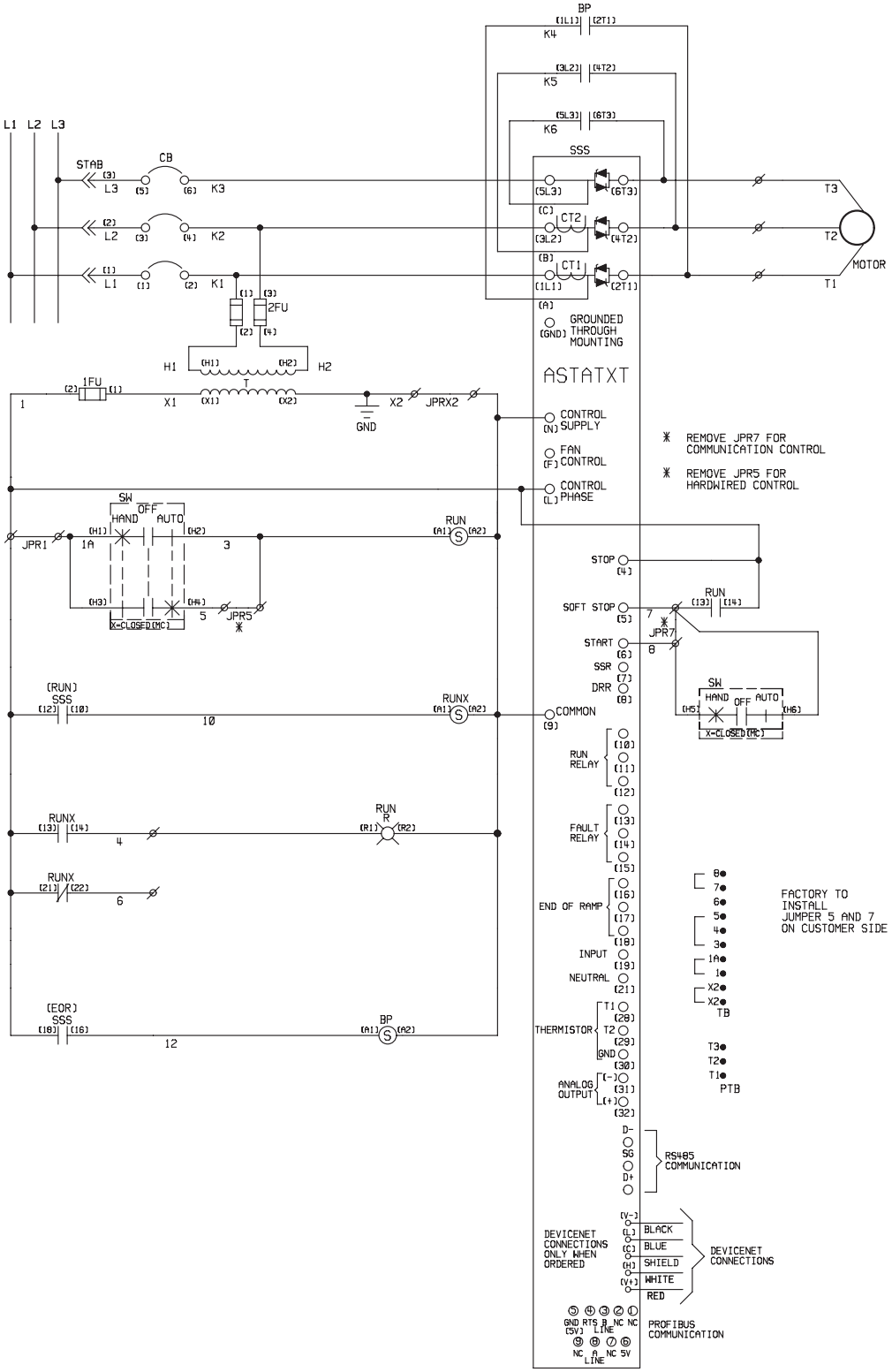
ASTAT XT

Typical circuit diagrams



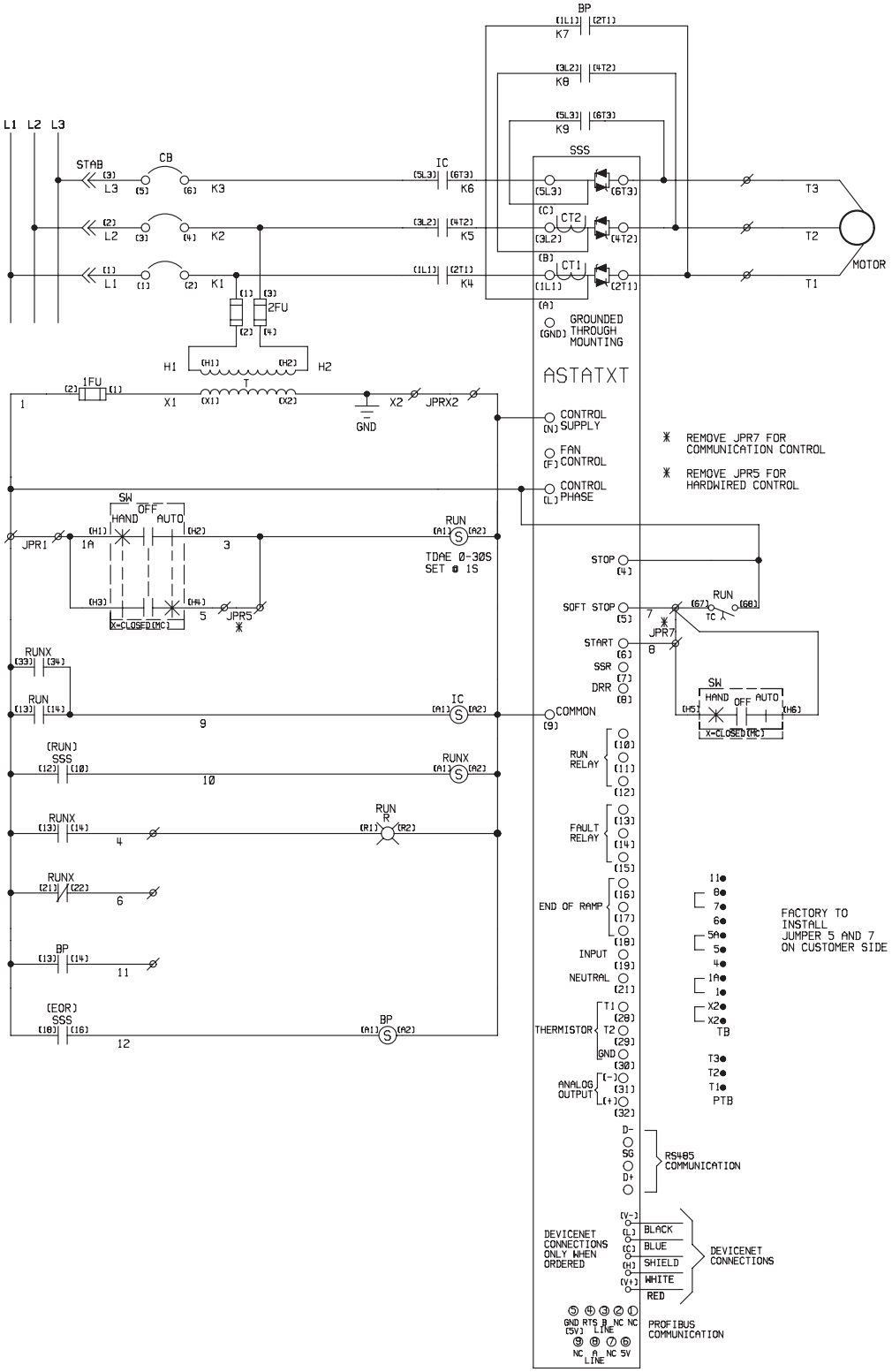
ASTAT XT Bypass

Typical Circuit Diagrams



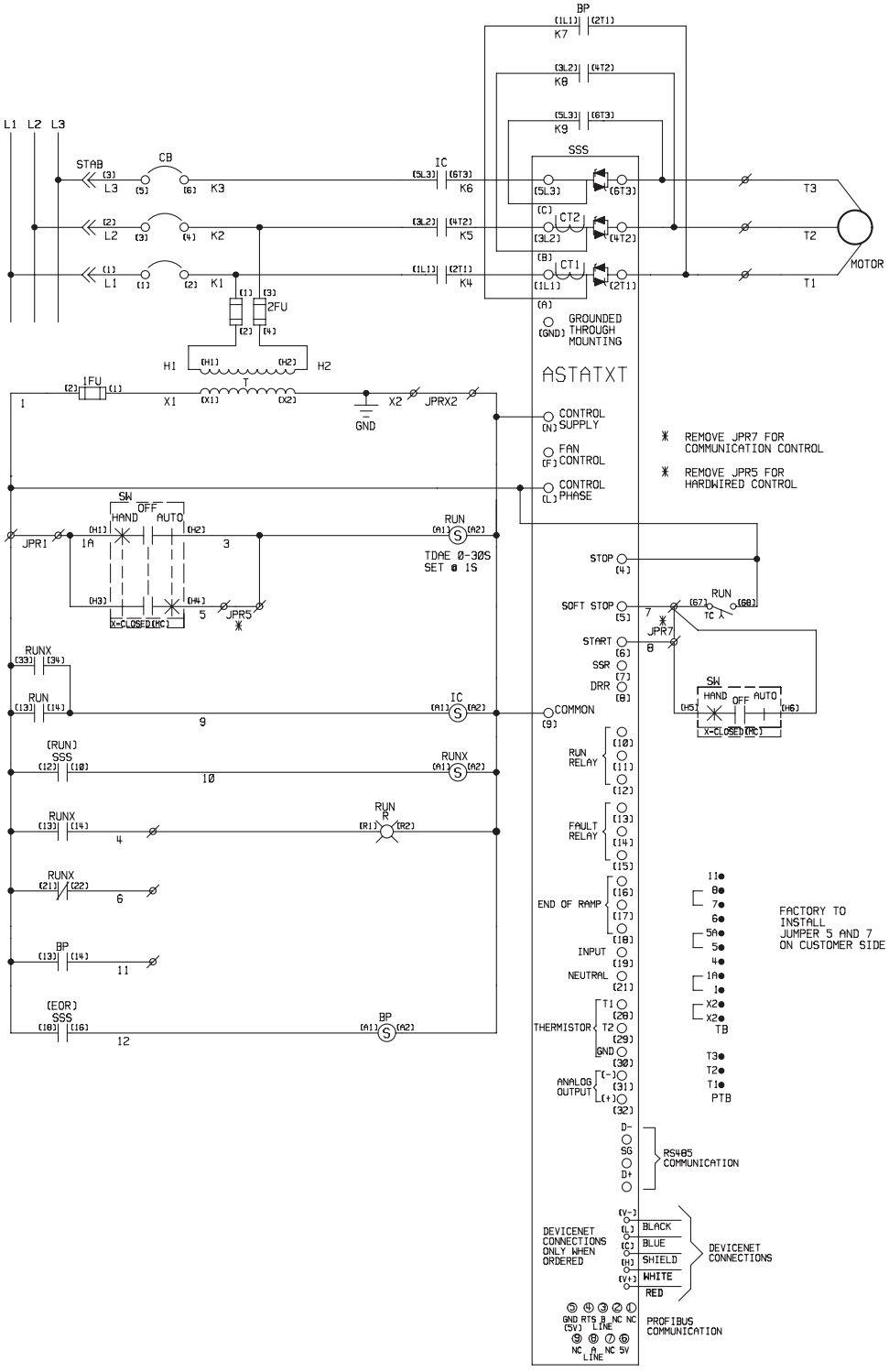
ASTAT XT isolation bypass

Typical circuit diagrams



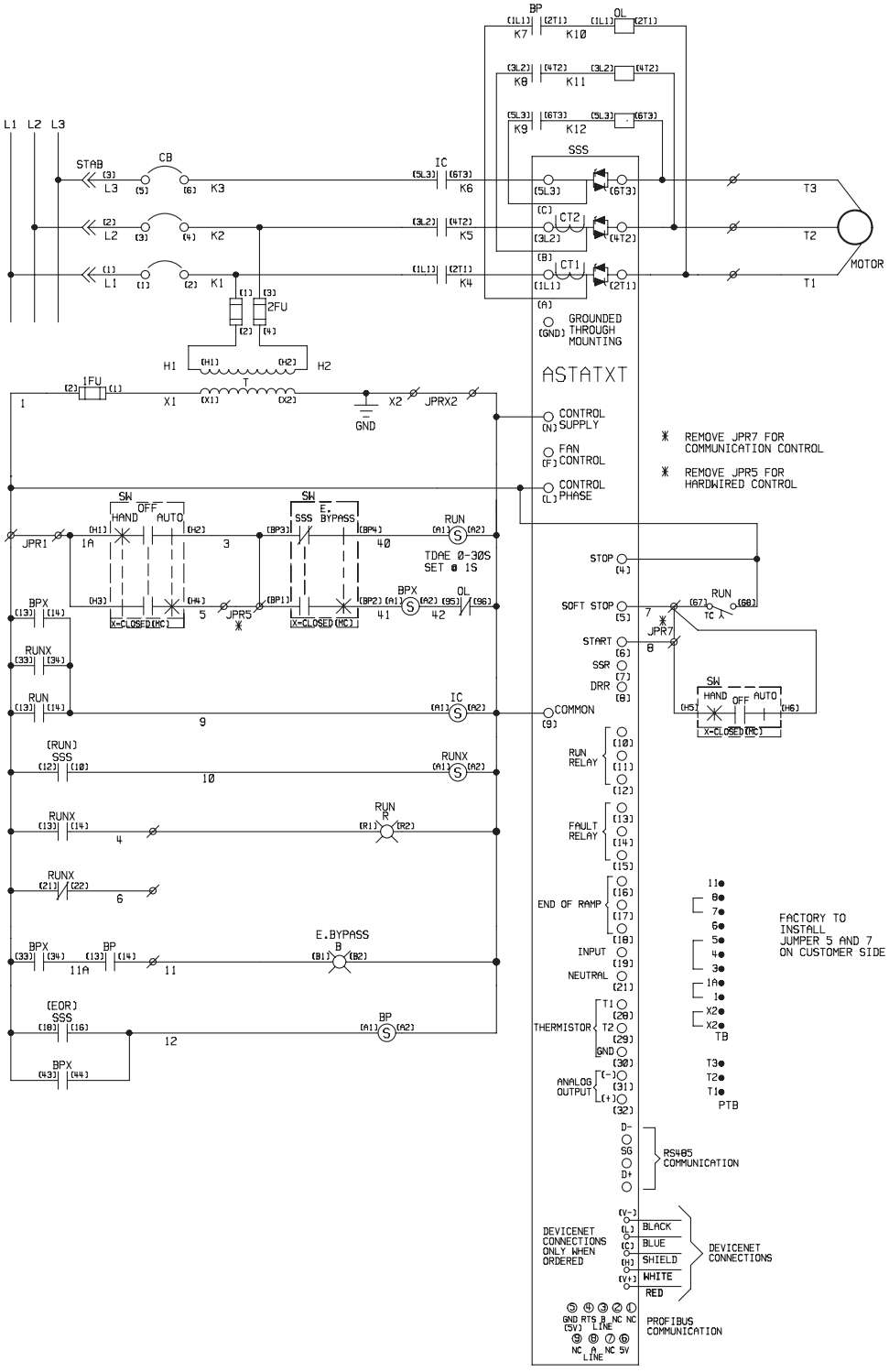
ASTAT XT bypass emergency bypass

Typical circuit diagrams



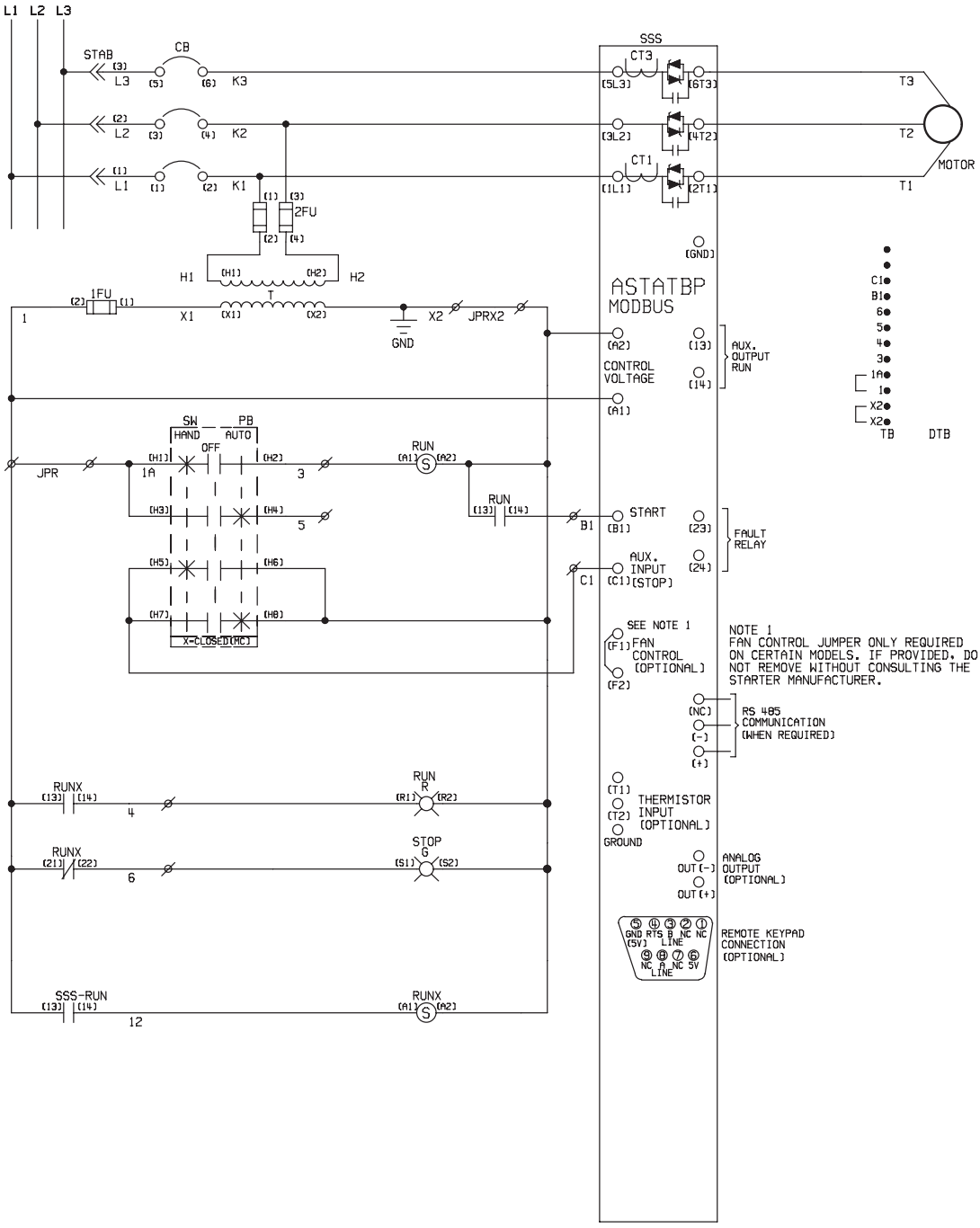
ASTAT XT isolation bypass emergency bypass

Typical circuit diagrams



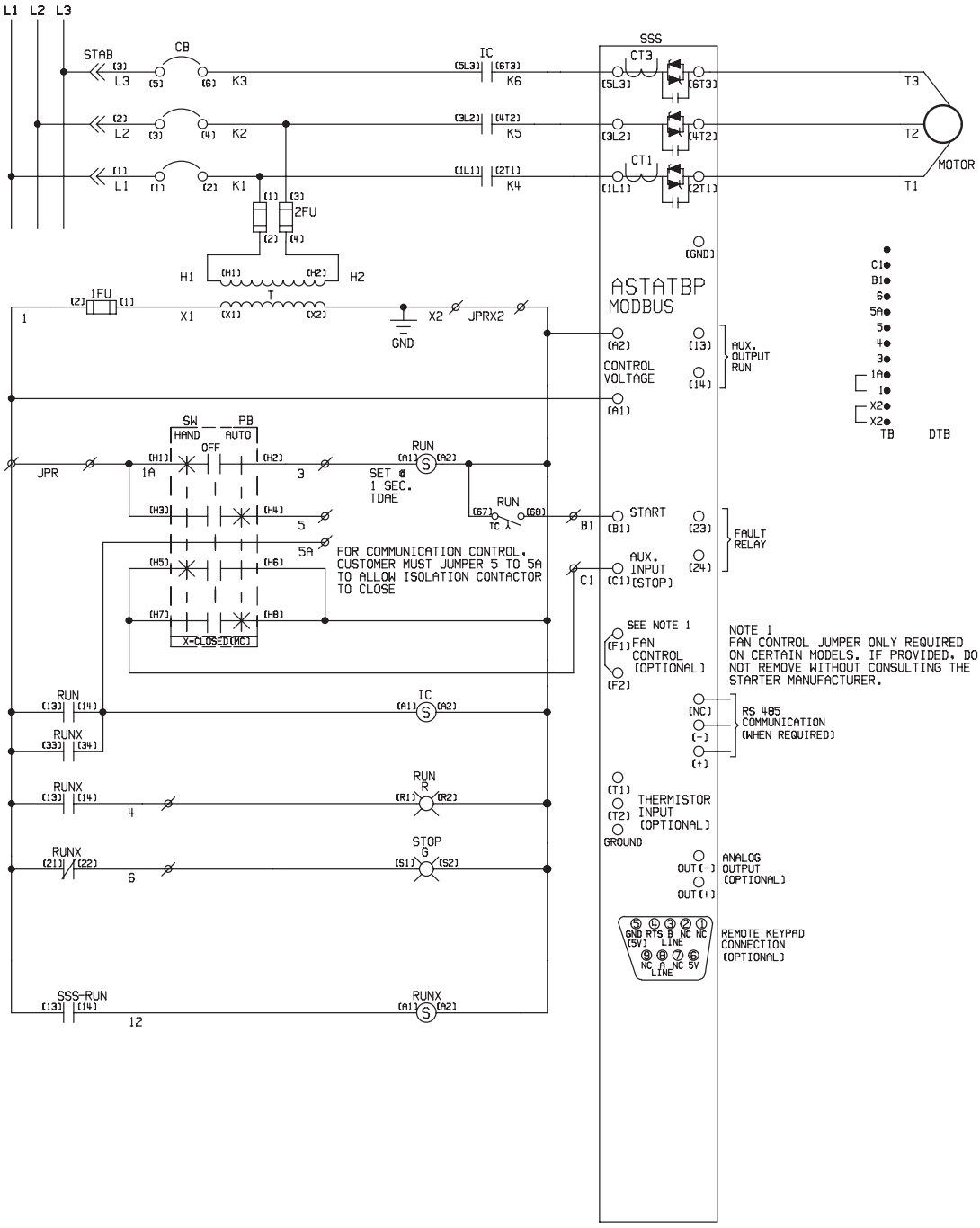
ASTAT BP

Typical circuit diagrams



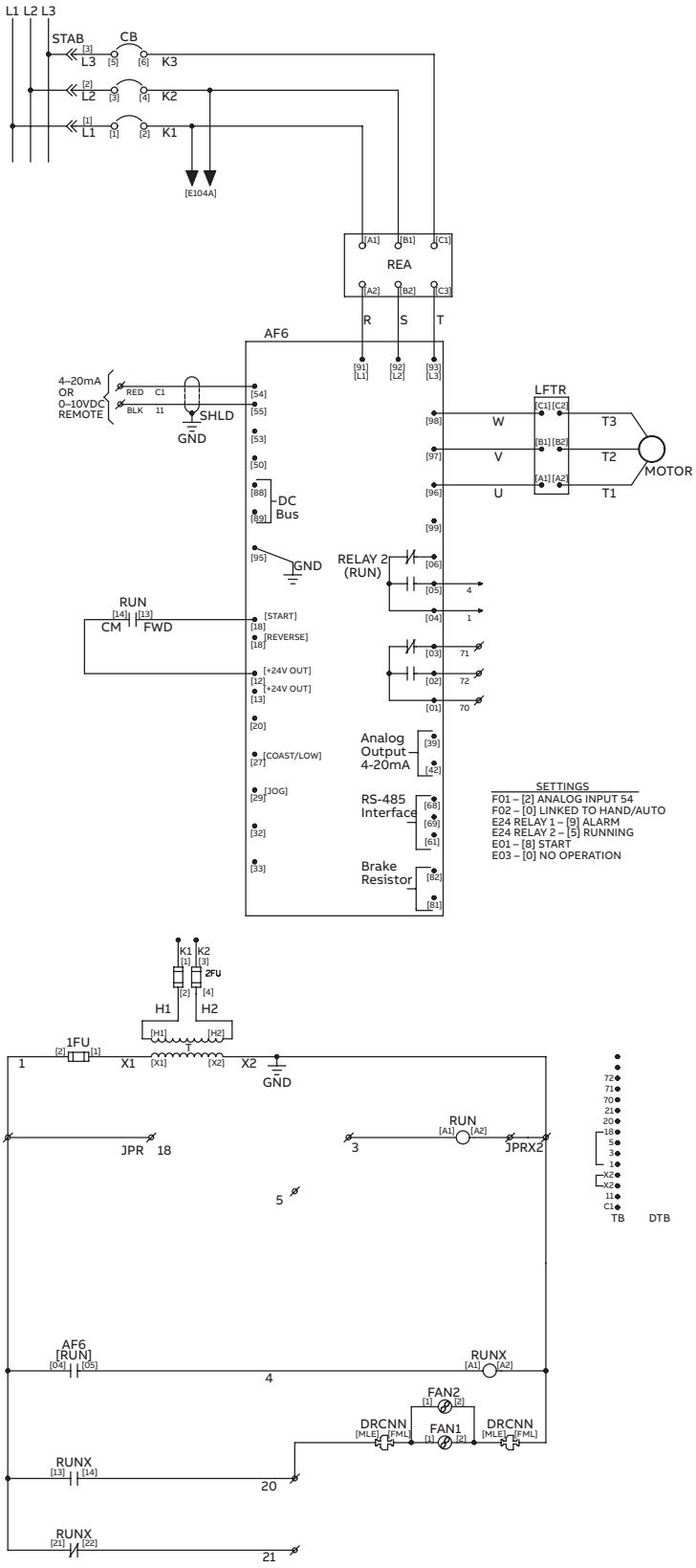
ASTAT BP isolation

Typical circuit diagrams



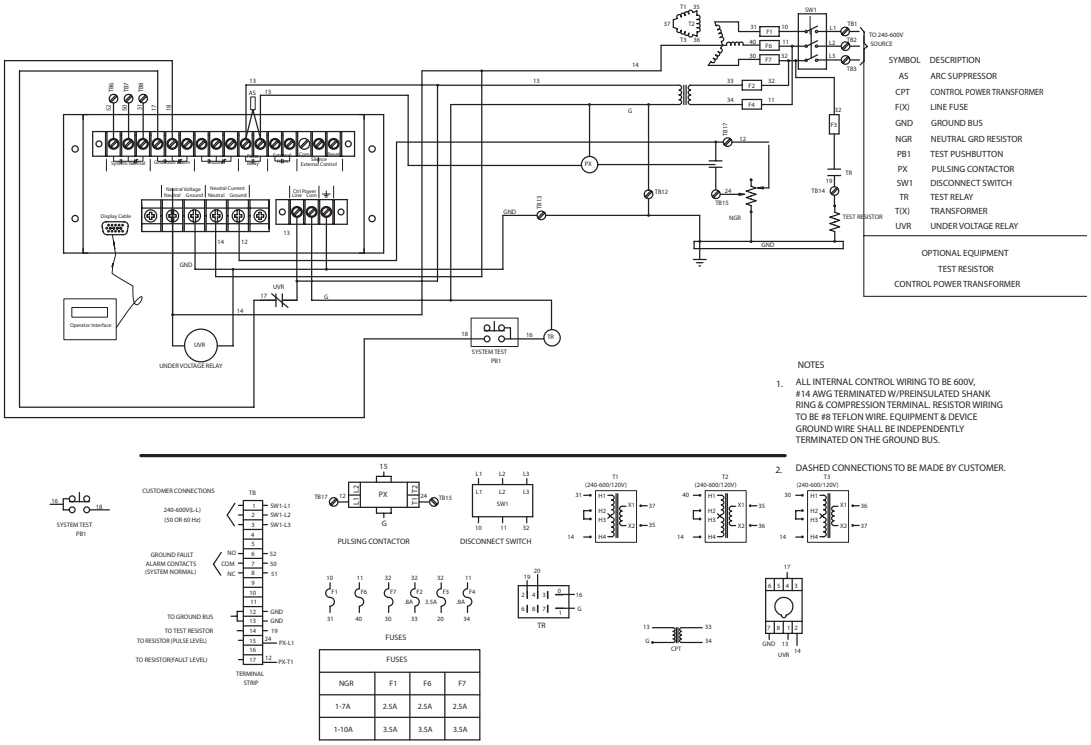
Adjustable speed drives

FC 102 and FC 302 drives



High-resistance ground

Typical circuit diagrams

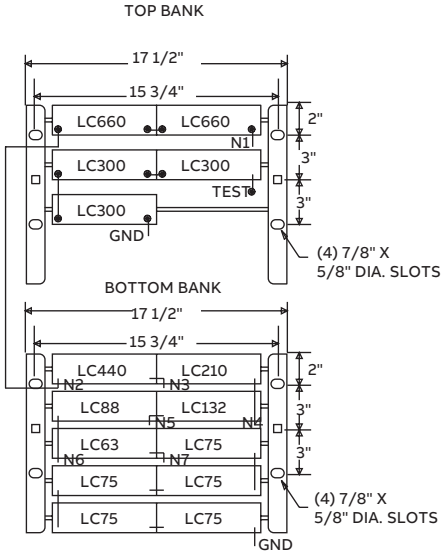


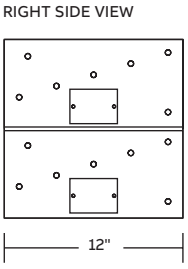
NOTES

1. ALL INTERNAL CONTROL WIRING TO BE 600V, #14 AWG TERMINATED W/PREINSULATED SHANK RING & COMPRESSION TERMINAL. RESISTOR WIRING TO BE #8 TEFLON WIRE. EQUIPMENT & DEVICE GROUND WIRE SHALL BE INDEPENDENTLY TERMINATED ON THE GROUND BUS.
2. DASHED CONNECTIONS TO BE MADE BY CUSTOMER.

FUSES			
NGR	F1	F6	F7
1-7A	2.5A	2.5A	2.5A
1-10A	3.5A	3.5A	3.5A

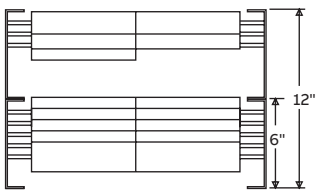
Top view





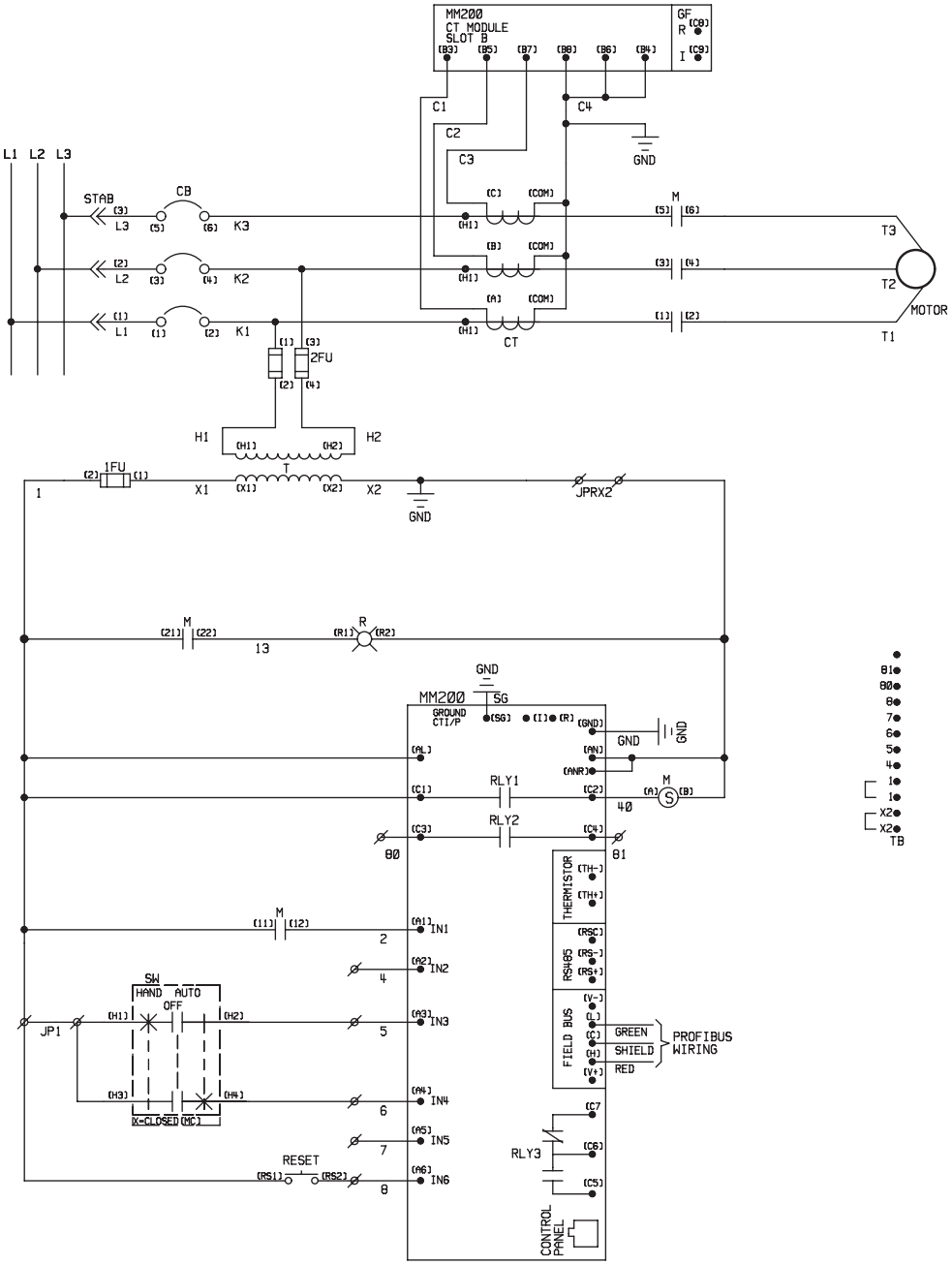
2 banks, each 17 1/2
(1) 10 coils/bank. (1) 5 coils/bank. 2727-5p Endframes. Turn flanges in. Terminals up. Furnish jumpers.

FRONT VIEW



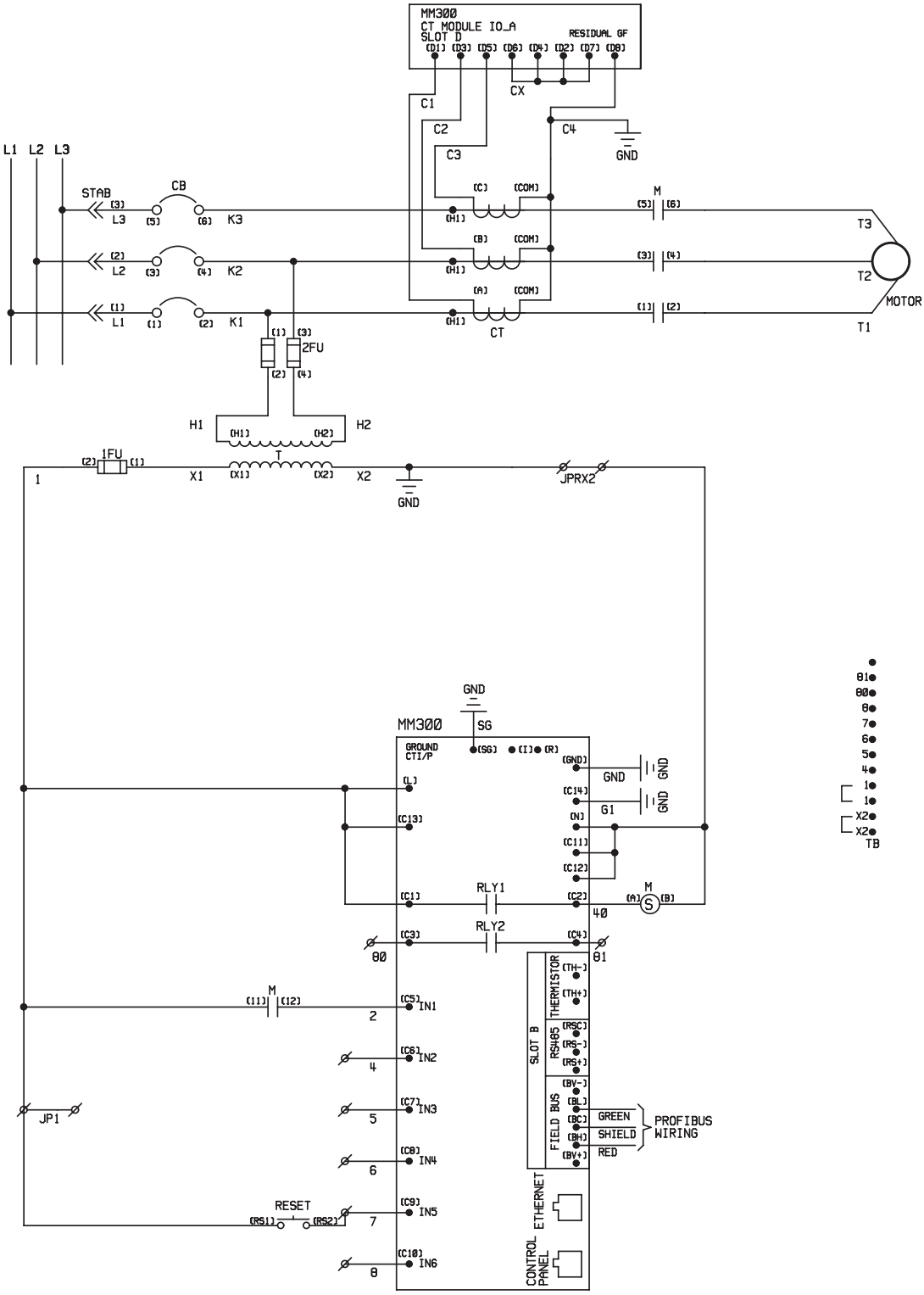
MM200

Typical circuit diagrams



MM300

Typical circuit diagrams



Specifications

Specification for motor control centers 600 Volts and below

1.0 General
This specification covers low voltage motor control centers with combination starter units.

1.1 Standards
The motor control centers shall be manufactured and tested in accordance with NEMA ICS 2-3 and UL Standard 845. Vertical sections and individual units shall be UL Labeled where possible.

1.2 Service
Each motor control center shall be suitable for use on a _____ volt, three phase, _____ wire, _____ Hertz power system having a short circuit availability of _____ amperes RMS symmetrical.

1.3 Wiring
Wiring shall be NEMA Class [I] [II], Type [A] [BD] [BT] [C]. Where Type C wiring is required, the master terminal blocks shall be located at the [top] [bottom] of the vertical section. Combination starter units shall be wired out to split type terminal blocks for easy removal of the starter unit without disturbing either factory or field installed wiring. All control terminal boards shall be accessible from the front.

2.0 Construction
Indoor enclosures shall be NEMA Type [1-Gasketed] [2] [12]. Indoor enclosures shall be suitable for front mounting. Outdoor enclosures when specified, shall be NEMA [3R Non-Walk-In] or [3R Walk-in]. The motor control center shall be seismic rated for UBC/CBC Zone 4.

Each motor control center shall consist of the required number of vertical sections of heavy gauge sheet steel bolted together to form a rigid self-supporting assembly.A removable lifting angle shall be mounted to the motor control center at the top.

Removable bottom channel sills shall be mounted front and rear of the vertical sections and shall extend the width of the lineup. Motor control center vertical sections shall be nominally 90-inch high and 20-inch deep. Alternate section heights shall be 78" or 66". Alternate section widths shall be 24-inches or 30-inches wide when required.

2.1 Horizontal wireway
Each vertical section shall contain a minimum 12-inch high top horizontal wireway and a 6” bottom wireway. When loads exit the bottom a 12” bottom wireway shall be provided. The horizontal wireway shall be covered by a removable hinged door.

2.2 vertical wiring trough
A separate vertical wiring trough shall be furnished in each vertical section adjacent to plug-in unit. The wire trough shall permit the installation of field wiring and shall isolate this wiring from the adjacent unit. No terminal blocks shall be located in the vertical wireway. Cable tie supports shall be furnished in the vertical wireway to hold cable and wiring in place. The vertical wiring trough shall be covered by a removable hinged door. [A low-level signal raceway shall be provided.]

3.0 Incoming power/Main protective device
Incoming power to the motor control center shall be [cable] [bus duct]. [Incoming power cables shall enter the [top] [bottom] of the motor control center.] [Incoming cables shall be of the size and number shown on the plans.] [Incoming bus duct shall enter the top of the motor control center and shall have a current rating as shown on the plans.] The motor control center main protective device shall be a [molded case circuit breaker] [insulated case circuit breaker] [fused switch]. The main device shall be of the ampere rating shown on the plans and shall have an interrupting rating equal to or greater than the available short circuit current.

4.0 Bus System

4.1 Main horizontal bus
Power shall be distributed by means of a continuous horizontal bus with a current rating of [600] [800] [1200] [1600] [2000] [2500] amperes. The main bus shall be [tin-plated .0003 inch thick] [standard silver-plated .0002 inch thick] [heavy silverplated .0005 inch thick] copper. The main bus shall be braced for [65,000][100,000] amperes RMS symmetrical. The main bus shall be isolated by barriers from wire troughs, starters, and other areas. There shall be double bolt connections on main bus joints and splice connections. Main bus splicing between shipping splits shall be accomplished from the front with no structural disassembly. The main bus shall be fully rated and arranged for future extension.

4.2 Vertical bus
The vertical bus in each section shall be rated [300] [600] [850]*amperes and shall be [tin-plated] [silver-plated]. *(1200A Main bus or greater)

The vertical bus shall be braced for [65KAIC] [100KAIC]. The vertical bus shall have a flame-retardant polyester-glass insulation / isolation system. This system shall insulate the vertical bus front and rear. In addition, the barrier shall isolate each phase bus. Openings in the vertical bus insulation/isolation system shall permit the entry of unit stabs. Unused openings shall have plugs or covers to prevent the entry of foreign objects. [The openings in the vertical bus used for starter connections shall be covered by an automatic shutter mechanism. The shutters shall automatically cover the openings when the starter is removed].The vertical bus bracing AIC rating shall be the same as the main horizontal bus.

4.3 Ground Bus
A copper ground bus shall extend the full width of the motor control center. The ground bus shall be rated [300] [600] amperes.

The ground bus shall be drilled and lugs furnished as specified. [There shall be a vertical copper ground bus in each section. This ground bus shall be accessible to a bus stab mounted in the unit compartment area and arranged so that the unit ground stab engages before the power stabs engage the vertical bus]. [A motor load ground lug shall be mounted in the unit and used for terminating the ground of multi-conductor cables.]

4.4 Neutral bus
A neutral bus shall be furnished when shown on the plans. The neutral bus shall be [300] [600] [800] [1000] [1200] [1250]. The neutral bus shall [be in the incoming section only] [extend the full-width] of the motor control center. When a neutral bus is specified, bottom plates shall be furnished. Lugs of the proper ampacity shall be furnished.

5.0 Units
Combination motor controller and feeder units shall employ [molded case circuit breakers] [fusible switches with clips for J or R type fuses] for branch circuit protection. Circuit breaker disconnects for combination motor starters shall be [thermalmagnetic] [magnetic only].

All combination starter and feeder units of plug-in construction shall utilize a positive guidance system to insure positive connection of the unit stabs to the section vertical bus. Insertion and removal of each unit shall not require the use of special tools. Unit shelves shall be of a lift out design. Connection from the power stabs to the unit disconnect shall be a direct connection. Each circuit breaker starter unit size 1 through size 5 shall be of plug-in construction. Each circuit breaker feeder 600A or less shall be plug-in.

Each unit compartment shall be equipped with a flange-formed pan type door. The door shall be mounted on the vertical section with removable hinges.

Each unit shall be equipped with an operating handle. The handle shall be connected to the disconnect operator using a direct drive and requiring no adjustment of linkage. The handle shall be mechanically interlocked with the door, preventing door opening with disconnect closed. The interlock shall also prevent disconnect being closed with the door open and prevent the unit from being removed or installed with disconnect ON. The interlock shall be capable of being defeated, allowing the door to be opened with disconnect closed or disconnect closed with the door open. The unit handle shall have provision for padlocking in the off position. On circuit breaker units the handle shall have a “tripped” position in addition to OFF/ON.

Each unit shall be capable of being padlocked in a partially withdrawn position. In this position, the unit power stabs are disengaged from the vertical bus and no power can enter the unit.

Combination starter units specified with Type B or C wiring shall be supplied with split-type terminal blocks. These terminal blocks shall be mounted in front of the unit and shall allow the removal of the unit without disconnecting any of the control wiring. Combination starter units up to size 5 shall be plug-in construction and shall be capable of being removed without disconnecting any control leads from their terminal blocks.

Overload relays shall be:
- {select one}
- [Bimetallic, ambient compensated]
- [Bimetallic, non-ambient compensated]
- [Solid-state, ambient insensitive, self powered, adjustable FLA, adjustable phase unbalance, phase loss protection, and selectable overload class (10, 20, 30) with 2% accuracy and repeatability, built-in thermal memory to prevent hot motor starts, isolated 1NO and 1 NC auxiliary contacts]
- [Advanced microprocessor based motor protection, Dip switch selectable Phase loss protection/Phase Unbalance, adjustable FLA, Selectable overload class (10, 20, 30)]
- [Ground fault protection]

Provisions to Communicate over the following Protocol:
[DeviceNet] [Modbus RTU]

The following minimum information shall be available over the Network.
- Metering (Average Phase Current in Amps, Control Voltage, Motor Run Time)
- Starter Status and Configuration Notification (Run, Overload, Ground Fault, Phase Unbalance, Commanded Trip, Class setting)
- Information (Voltage, Internal failure, 100% Motor Load Warning)
- Remote Control (On, Off, Trip, Reset)

[Provide a Display Module for accessing at the unit all Network data] [Door mounted] [Hand held using phone jack on the door].

Control power for starter units shall be from:
{select one}
[Individual control power transformers furnished in each starter unit. One secondary lead shall be furnished with a fuse and the other lead shall be grounded. Control power primary fuses are required].
[Line voltage. Control circuits on all starter units with line voltage control power shall be provided with current limiting fuses mounted in both legs of the control circuit].
[Separate source (common control)] Two wired terminal points shall be provided. One leg shall be wired through a normally open auxiliary contact in each disconnect and a control power fuse rated 1 amp shall be provided.]

Starter units shall be provided with the following auxiliary devices:
- [auxiliary starter interlocks, _____ N/O, _____N/C].
- [control / timing relays (as shown on the drawings)]
- [door mounted pilot devices: Start-stop pushbutton, H-O-A selector switch, Indicating lights (quantity and color)].

Miscellaneous units
The following units shall be included in the motor control center(s) as indicated on the drawings:
- [Lighting and Power transformers]
- [Lighting panelboards]
- [Power metering and associated instrument transformers, where required]
- [Power factor correction capacitors]
- [Reduced Voltage Solid State]
- [Variable Frequency Drives]
- [PLC's]

ABB Inc.
305 Gregson Drive
Cary, NC 27511 USA

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