Evolution Series E9000™
Motor Control Centers
Application Guide

imagination at work

Evolution Series E9000 Motor Control Centers

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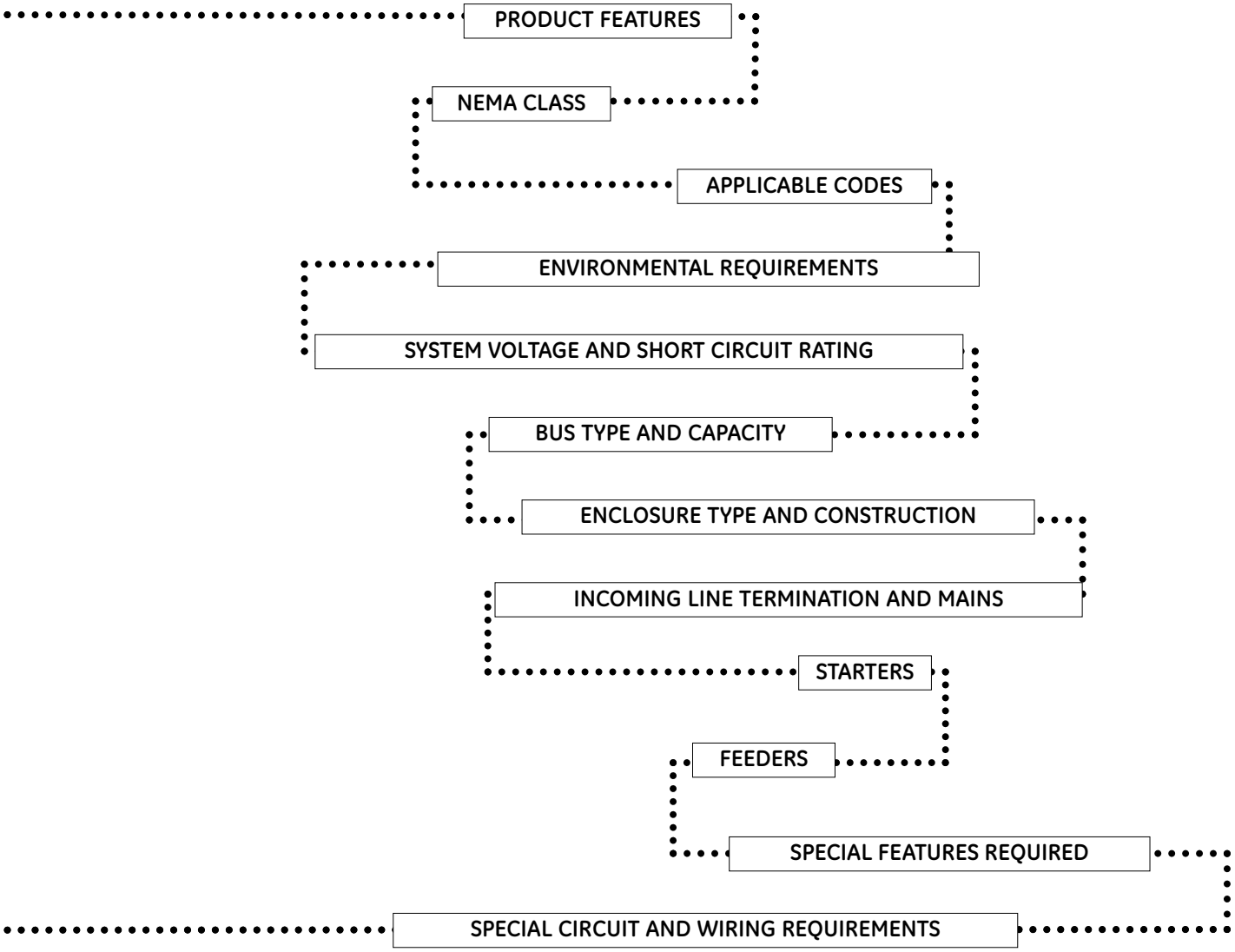
The General Electric Evolution Series™ motor control centers provide safe and flexible centralizing motor starters and related control equipment. It permits combination motor control units, feeder tap units, distribution transformers, lighting panels, interlocking relays, programmable control, metering and other miscellaneous devices to be contained in a single floor-mounted structural assembly fed from a common enclosed main bus.

GE 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 entire center may be powered by incoming line connection at a single point. Where possible, motor control centers bear UL section and unit labels.

The purpose of this publication is to simplify the selection of GE motor control centers. The following logic flow chart lists basic items which must be considered for each application.



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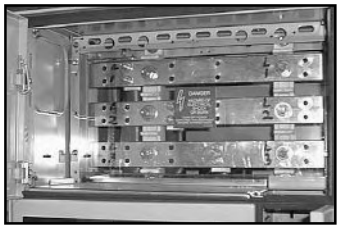
Product Features
Design Features

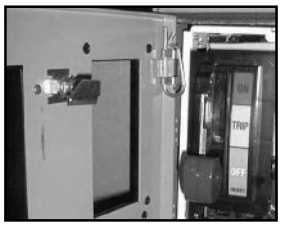
Design flexibility, performance, personnel and equipment protection, ease of maintenance and installation are all contained in the Evolution Series. Evolution Series features, such as separate wiring troughs, split-type terminal boards, isolated bus, drawout starter units, operating mechanisms, and provisions for starter interchangeability, are designed for a high level of reliability, safety and convenience.

These steel-enclosed control centers can be joined together to centralize and protect the most complex systems of industrial auxiliary drives, or the simplest of fan- or pump-motor controls. As the need arises, additional sections can be added to an existing lineup.



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.

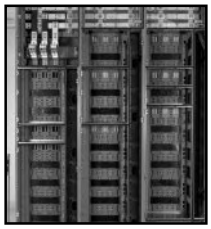
An incoming-line terminal compartment can be located at the top or bottom of a vertical section to allow cable termination with minimum bending. The standard 600-ampere incoming line terminal compartment shown is furnished with mechanical type lugs. Other incoming line terminal compartments are available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

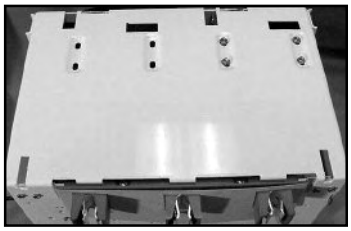


New doors mounted on the case feature a removable hinge pin providing easy door removal and accurate alignment.

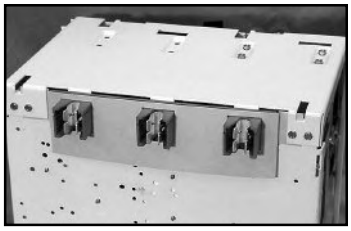
Device bracket mounts 30mm pilot devices in Evolution Series. Bracket swings open to allow easy access to unit components, wiring and terminal blocks. Fully insulated – does not require grounding.

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 effective isolation. 65kA short circuit bracing is standard for Evolution Series MCC.



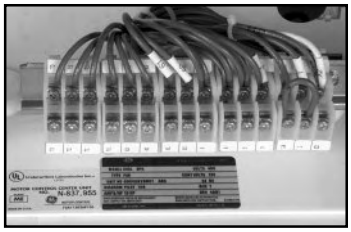


Plug-in stabs are rated 250A and 600A. The 250A stab connections shown are made with copper unit power stabs which are under double spring pressure and engage the vertical bus to provide positive contact.



All combination starters and feeder units of plug-in construction utilize a positive guidance system.

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.



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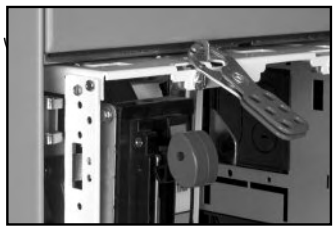
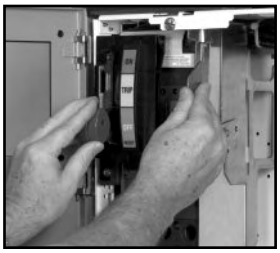
Product Features
Design Features

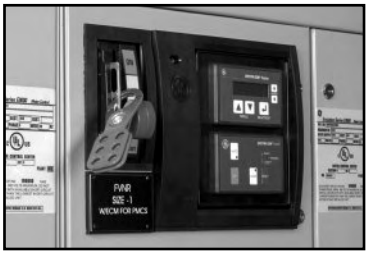
Large isolated wire trough provides a 4" x 11" area to "lay in" wire and make control and load connections. A separate removable door, adjacent to drawout units, makes wiring installation and inspection easy. The door can be opened without disturbing adjacent unit doors. 8" x 11" wire troughs are available



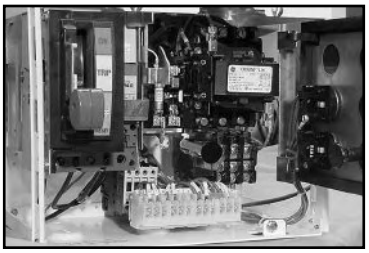
Units can be withdrawn to a disconnected position and padlocked for maintenance.



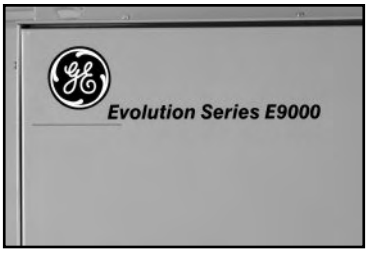
An interlock release system is provided so that – if it becomes necessary for maintenance purposes – the disconnect may be closed with the door open. A by-pass is provided to allow opening the door with the disconnect closed. *Only qualified personnel familiar with the equipment should use the interlock release and by-pass features.*



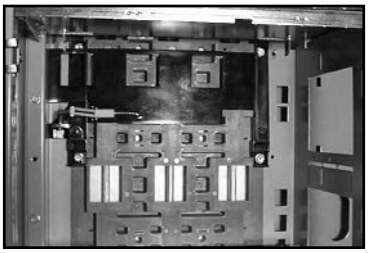
The vertically mounted integral handle can be locked in the OFF position with up to three padlocks. A drilling pattern is furnished, allowing the handle to be modified for locking in the ON position with a single padlock. This modification should only be made after the user determines it is desirable to lock the disconnect in the ON position. Padlock to have maximum ⅜" shackle.



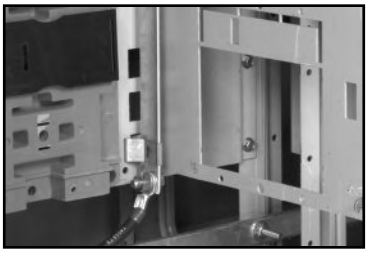
For flexibility, standard Size 1 and Size 2 FVNR starters are interchangeable in the same 12" high space unit. This design allows quick, easy field changes when modifications are desired after installation. Front accessible quarter-turn latches provide for ease of securing and withdrawal of all plug-in units.



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



(Option) 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.



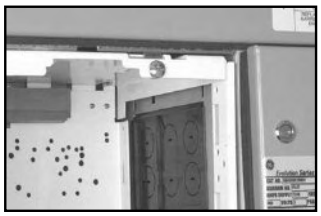
(Option) Vertical Ground Bus and Unit Stab. Vertical copper ground bus allows direct grounding of unit saddles to the equipment ground bus. A unit ground bus stab engages the vertical ground bus before the unit power stabs engage the vertical bus. A load ground lug is available for customer cable grounding.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

A

Product Features
Design Features

E9000 MCC can be spliced onto existing 7700 Line, 8000 Line and Spectra MCC for 1200A (supplied with 2" bars) and below. Horizontal bus location in E9000 matches the existing bus location.

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

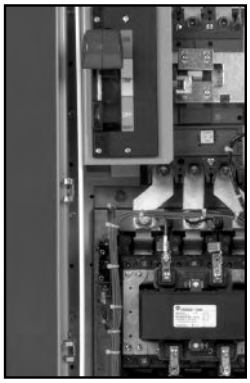


Easily removable plastic knock-outs are provided in the vertical wireway ladder assembly to allow routing of field wiring into units.

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

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

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.

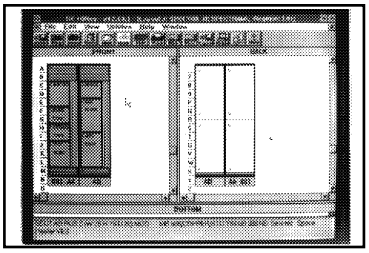


S-5 FVNR circuit breaker combination can be provided in 36”, allowing two size 5 units in one section.

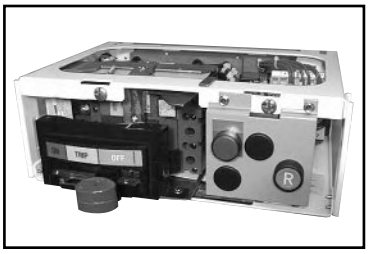
All case side wireways are roll-formed to provide a 1/2” lip for cross wiring to rest on, thus preventing skinned insulation.

A

Product Features
Design Features

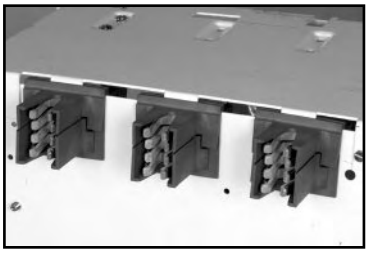


Drawing Software
Windows™-based Engineering Drawing System creates high-quality detailed front, top, bottom and side views as well as specific device information.



Size 1 FVNR Starter
50% smaller (1/2X)

NEMA rated compact C-2000 starter with 100VA CPT with up to a quantity of three 22mm C-2000 pilot devices.



Plug-in Stabs
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.

Horizontal Handles
Horizontal handles are standard on 6” 150A and 12” 250A feeder breakers to optimize space. Optional vertical handles are available, but they affect unit height.

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 are:
- Red – AC Control
- Blue – DC Control
- Black – AC/DC Power
- 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).

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", fastened with non-corrosive nylon clips. Plated steel screws are available as an option.

Nameplates are engraved with white letters on a black background using the Arial typeface found in Microsoft Office applications. Standard nameplates carry up to nine lines of .18" high characters (20 characters per line maximum) OR up to four lines of .30" characters (10 characters per line maximum).

Six-inch units and the F-frame circuit breaker come with a 1"x 3" nameplate that accommodates up to three lines of .18" characters with a maximum of 19 characters on lines 1 and 3 and 15 characters on line 2.

A

NEMA Class of Diagrams and Wiring

Motor control centers are classified by NEMA as follows:

NEMA Class I Definition①

Class I motor control centers consist essentially of a mechanical grouping of combination motor control, feeder tap and/or other units arranged in a convenient assembly. They include connections from the common horizontal power bus to the units.

They do not include interwiring or interlocking between units or to remotely mounted devices, nor do they include control system engineering.

Diagrams of the individual units only are supplied.

NEMA Class II Definition①

Class II motor control centers consist of a grouping of combination motor control, feeder tap 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 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 Definition①

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.

① From NEMA Standard 18-2001.

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

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, GE offers a NEMA 1A Modified MCC. This type of MCC will be supplied without wiring and without control diagrams. GE can mount low voltage control devices on the pilot device bracket and supply terminal boards. This would be considered on OEM product.

Wiring Features by NEMA Classification

	Class I			Class IS			Class II		Class IIS	
Type of Power or Control Termination Furnished	**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
Stationary 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 boards on unit starter –Sizes 1 and 2. (On Type A wiring: Same type of numbered terminals on starter itself for Sizes 1, 2, 3 and 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
Stationary master terminal boards (Top, bottom or rear of section) For control – Sizes 1 thru 5 / For power – Sizes 1 thru 3	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	No	Yes	No	No	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.

A

Codes and Standards

Motor control centers are manufactured to NEMA standard ICS 18-2001 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 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 is dependent 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. Where 100 percent UL listed equipment is mandatory or there are other special code requirements refer to the factory for verification.

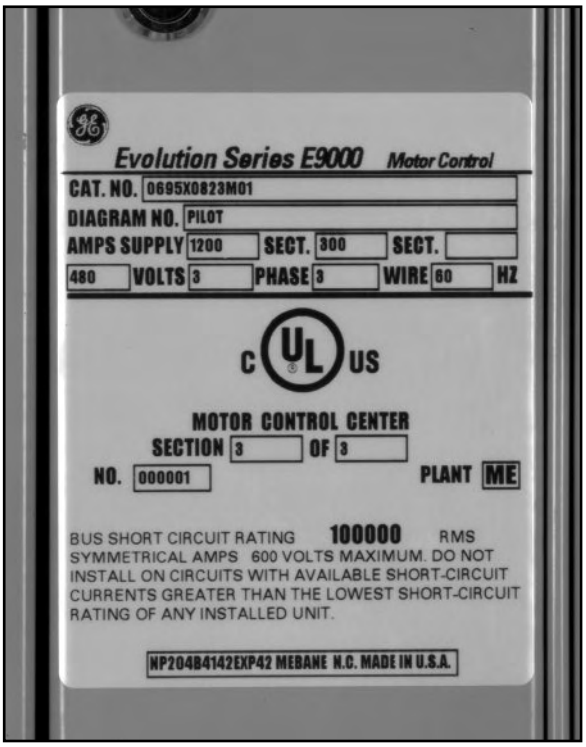
The NEC defines several types of control circuits and the over-current protection required for each type. The following paragraphs provide a general reference to the NEC Article applicable for the more common control circuits.

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, for the type power source and field wiring conductor sizes.

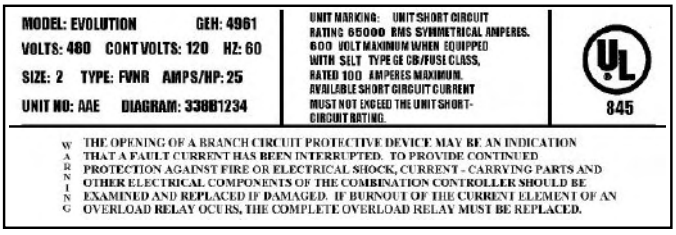
Where a motor control circuit transformer is provided, the transformer should be protected in accordance with NEC Article 430.72(c). Transformers other than motor control circuit transformers should be protected in accordance with NEC Article 450.3(b).

Section Label



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

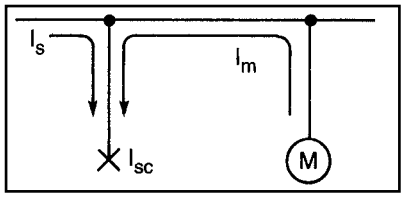


Fig. 1

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. I_m 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 (Fig. 1).

A motor control center should be protected for all types of faults from low-level arcing ground faults to bolted three-phase faults which can develop the full available short-circuit current. Line-to-line and line-to-ground arcing faults (often 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 self-extinguishing. 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-to-phase current. It is used to protect motor control centers from extensive damage, which can be caused by phase-to-ground 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 fast-acting 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 optionally is 100,000 rms symmetrical amperes. The bus rating must equal or exceed the available short-circuit current. Refer to Structure (Section B) for ratings.

A

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 D) 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 C) 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.

UL listed combination motor starter units used with Class H, K-1 or K-5 fuses are short-circuit rated 5kA for NEMA size 1, 2 and 3 starters, and 10kA for larger starters. Higher short-circuit ratings require rejection type fuses. See Fuse Classifications table below for short-circuit ratings.

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

Fuse Classifications

Characteristic①	UL Standard		
	Class J-TD	Class R	Class L
Ampere Range	0-600	0-600	601-6000
Voltage Ratings	600	250	600
		600	
Interrupting Rating RMS Symmetrical Amperes	200K	200K	200K
Current-Limiting	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 SEPS. 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 can satisfactorily withstand a force of 5 g's, 1 to 100 Hz, input at its floor sills simultaneously in all three orthogonal axes, and is rated for UBC/C Seismic Zone 4 installation. It is IBC-2003 rated.

For dusty atmospheres, semi-dust-tight NEMA 1 gasketed or NEMA 12 construction are recommended.

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, terminals for connection of an external source of space heater power can be provided on the outside of the crate.

NEMA Enclosure Types

Type 1 – General Purpose, Indoor
Intended for use indoors, primarily to prevent accidental contact of personnel with the enclosed equipment, in areas where unusual service conditions do not exist. In addition, they provide protection against falling dirt.

Type 1 – Gasketed – Semi Dust-tight, Indoor
Intended to cushion doors and mitigate vibration.

Type 2 – Drip-proof, Indoor
Intended for use indoors to protect the enclosed equipment against falling noncorrosive liquids and falling dirt. These enclosures have provision for drainage. 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.

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).

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, and light splashing, seepage, dripping and external condensation of noncorrosive liquids.

E9000 Indoor Enclosure

GE 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.

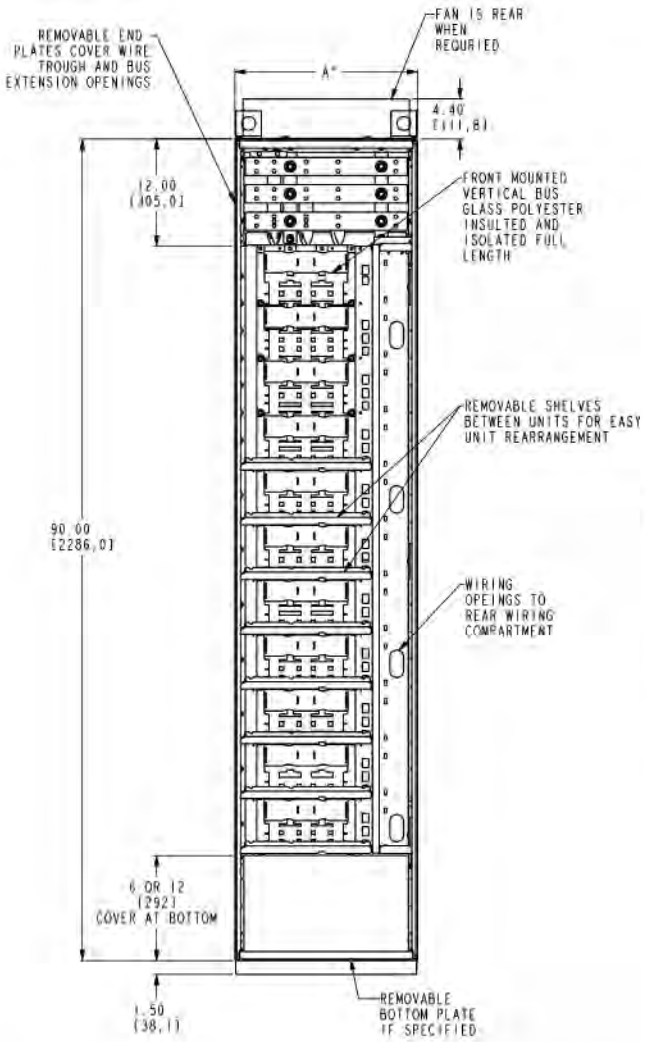
Standard NEMA 1 or NEMA 1 (Gasketed) Enclosures
Standard finish is light-gray ANSI 61 over a phosphate rust inhibitor. All unpainted parts are zinc-chromate electroplated or galvanized. Enclosures are furnished with bolt-on rear covers. Hinged rear doors are available as an option. Pan-type doors utilize 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.

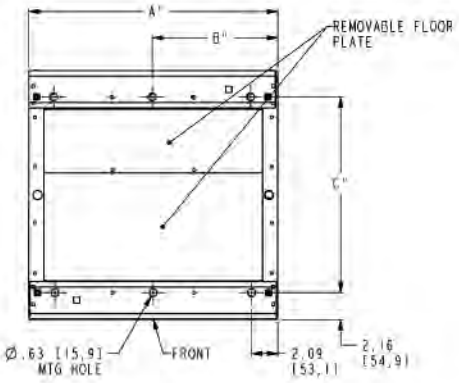
NEMA 2 Drip-proof Construction
Similar to NEMA 12 gasketed construction except with catch pan-type dripshield on top and with open bottom. Dripshield extends four inches beyond front of motor control center. Standard finish: light gray ANSI 61. Furnished with removable conduit cover plates unless otherwise specified.

NEMA 12
Similar to NEMA 1 gasketed construction except that bottom plates are furnished and all removable plates are gasketed.

Evolution Series E9000 Motor Control Centers
Structure

Indoor Enclosures
Front Elevation & Mounting Locations (13", 20", 22" & 25" Deep Sections)





BOTTOM VIEW
LOCATION OF MOUNTING HOLES

Note:
1) If anchor bolts are to be inbedded in the foundation, they must be Located according to the drawing furnished by GE 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 vertical sections are used, anchor bolts or some form of external bracing is required.

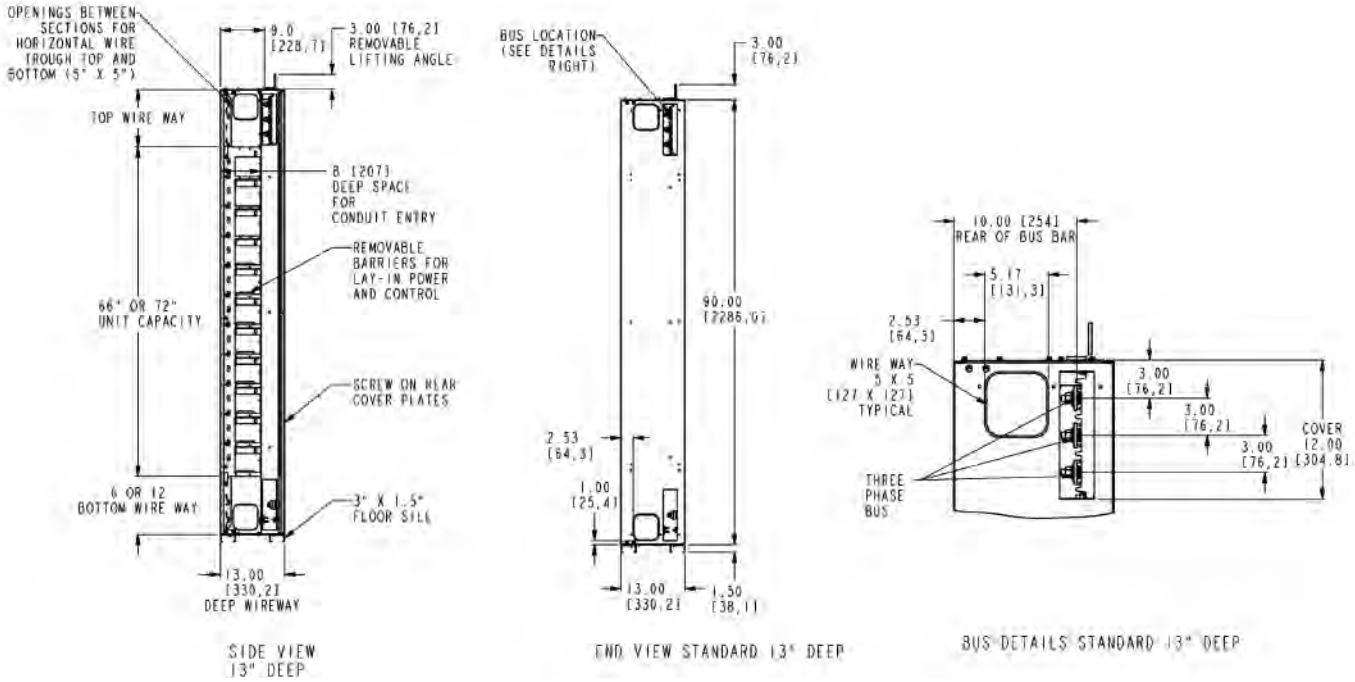
2) Seismic Zone-4 IBC testing was performed use 1/2"-13 Grade 5 bolts, torqued to 70 foot-pounds, located in each of the four corners in each section.

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

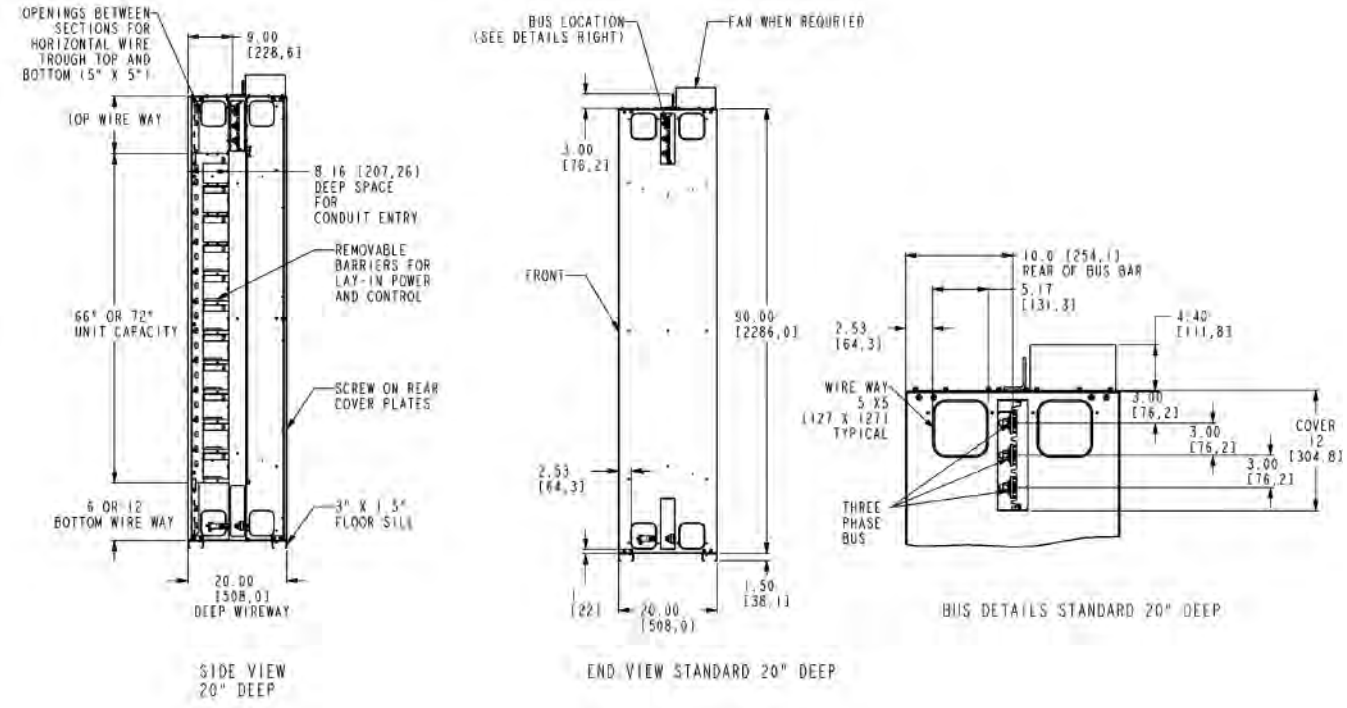
B

Indoor Enclosures

Side Elevations 13" Deep Section 600A to 1200A Main Bus



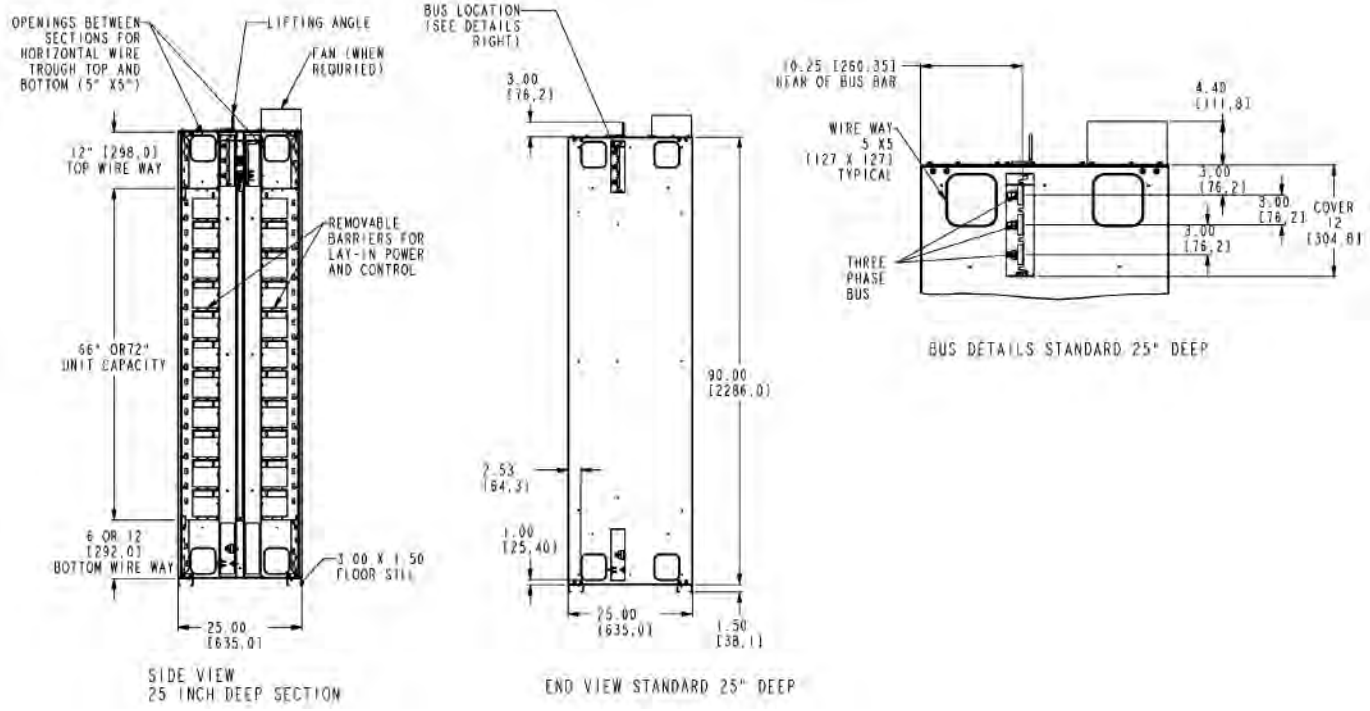
Side Elevations 20" Deep Section 600A to 1200A Main Bus



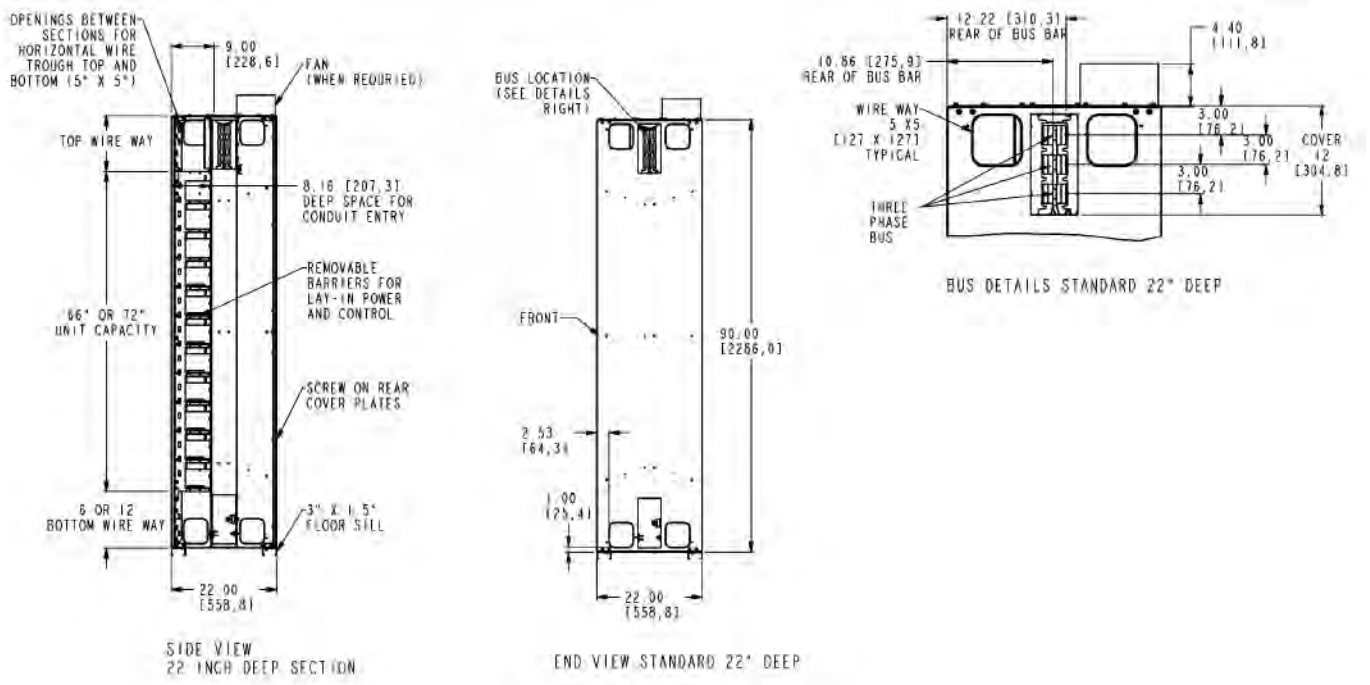
B

Indoor Enclosures

Side Elevations 25" Deep Back-to-Back Section 1200A Main Bus



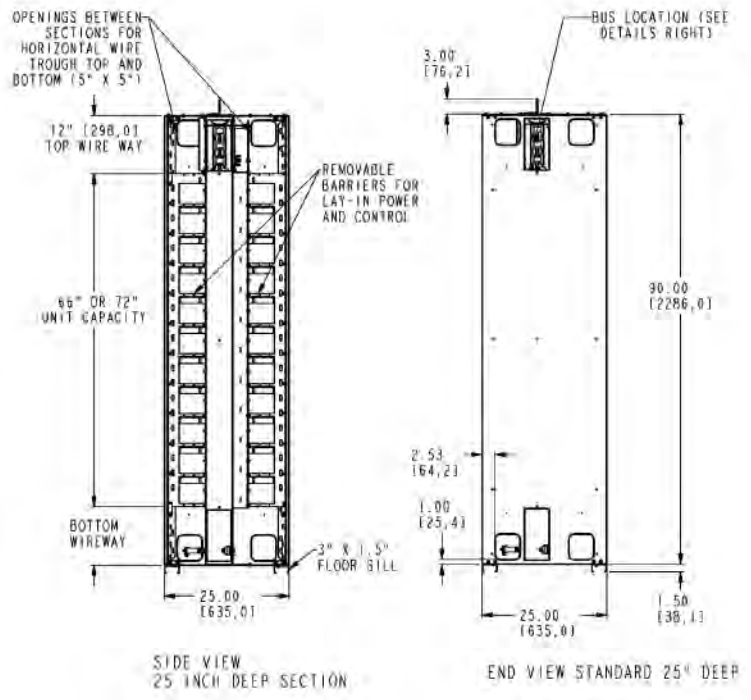
Side Elevations 22" Deep Section 1600A to 2500A Main Bus

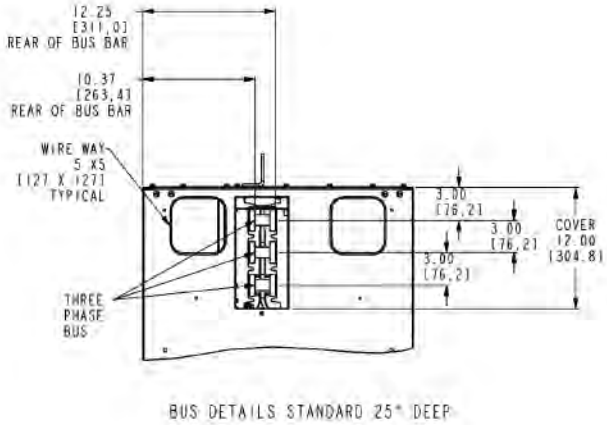


B

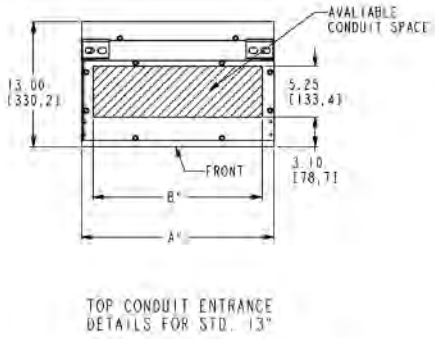
Indoor Enclosures

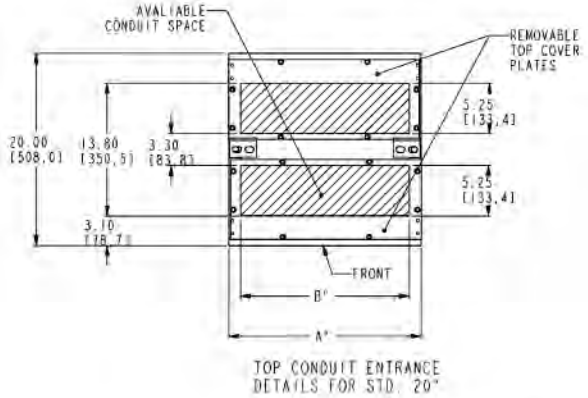
Side Elevations 25" Deep Back-to-Back Section 1600A to 2500A Main Bus

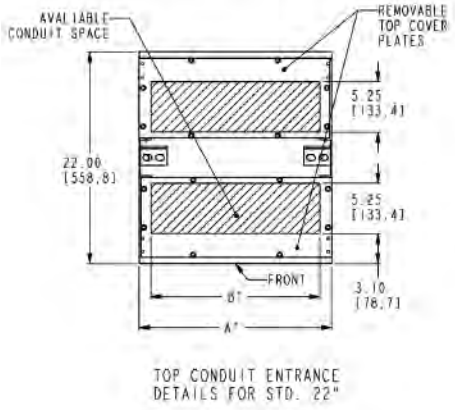


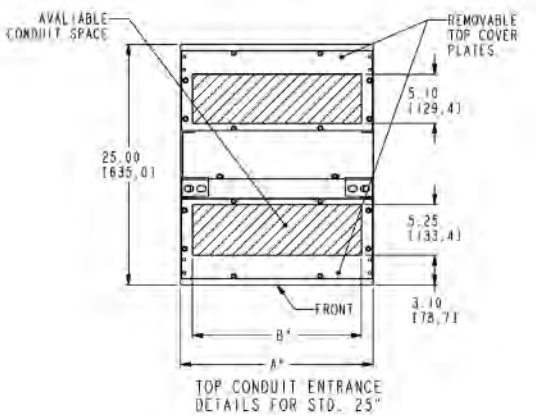


Top Conduit Entry (13", 20", 22" & 25" Deep Sections)



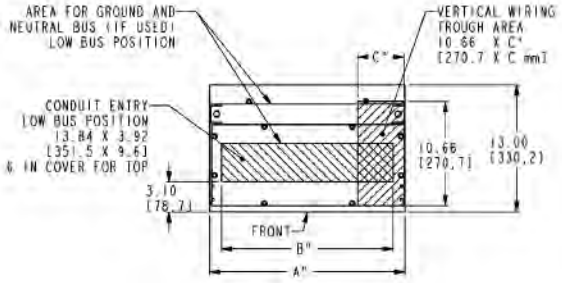




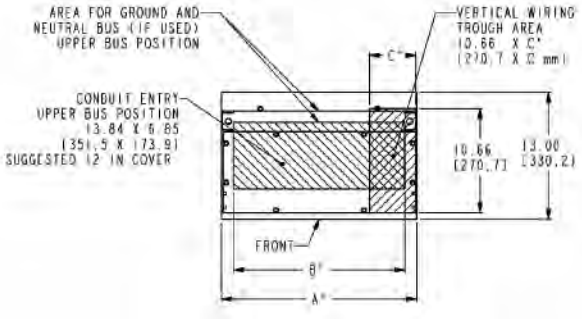


Evolution Series E9000 Motor Control Centers
Structure

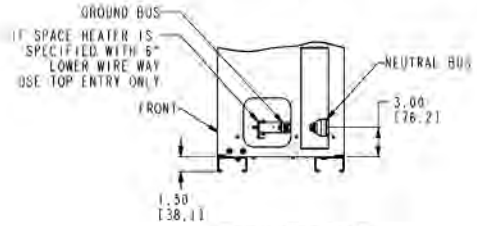
Indoor Enclosures
Bottom Conduit Entry 13" Deep Section



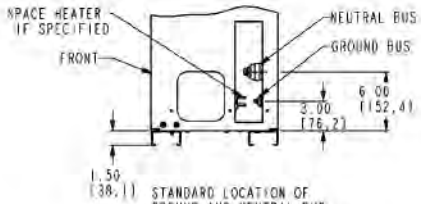
BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 13" LOW BUS POSITION



BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 13" BUS UPPER POSITION

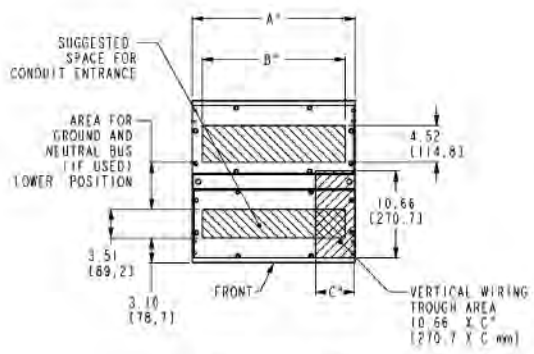


LOW BUS POSITION OF GROUND AND NEUTRAL BUS (MINIMUM AVAILIABLE SPACE FOR CONDUIT ENTRY) 6 IN [152.4] COVER

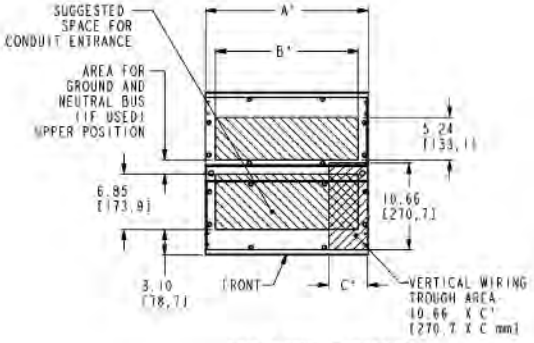


STANDARD LOCATION OF GROUND AND NEUTRAL BUS WITH 12IN [304.8] COVER COMPARTMENT AT THE BOTTOM OF MCC

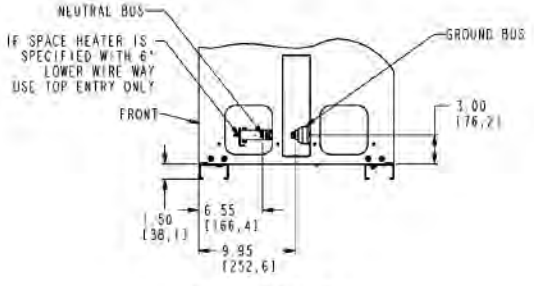
Bottom Conduit Entry 20" Deep Section



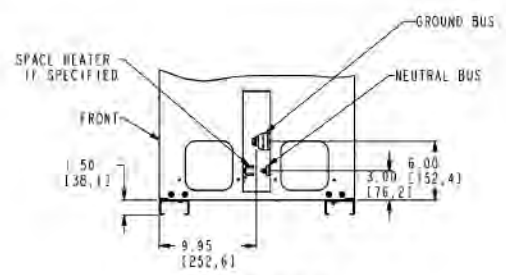
BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 20" X 20" LOW BUS POSITION, 6" BOTTOM COVER



BOTTOM CONDUIT ENTRANCE DETAILS FOR STD 20" BUS UPPER POSITION



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

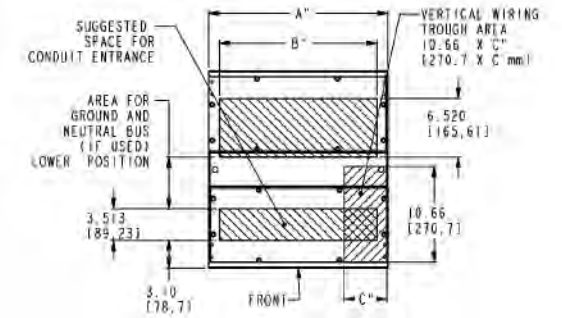


UPPER POSITION OF GROUND AND NEUTRAL BUS (MAXIMUM AVAILIABLE SPACE FOR CONDUIT ENTRY) 12 IN [304.8 MM] COVER

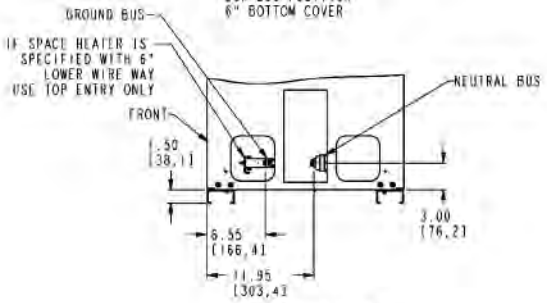
B

Indoor Enclosures

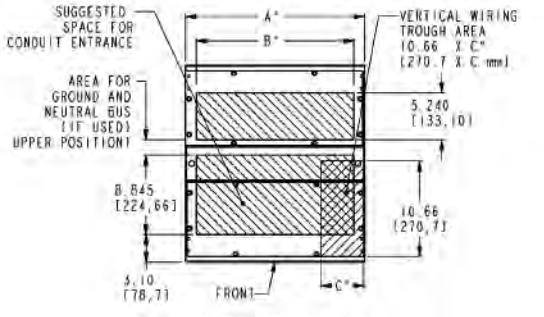
Bottom Conduit Entry 22" Deep Section



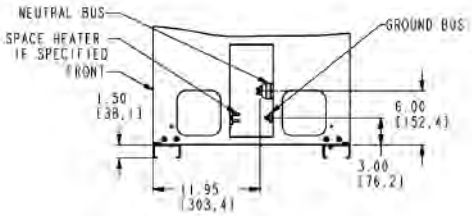
BOTTOM CONDUIT ENTRANCE
DETAILS FOR STD 22"
LOW BUS POSITION
6" BOTTOM COVER



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

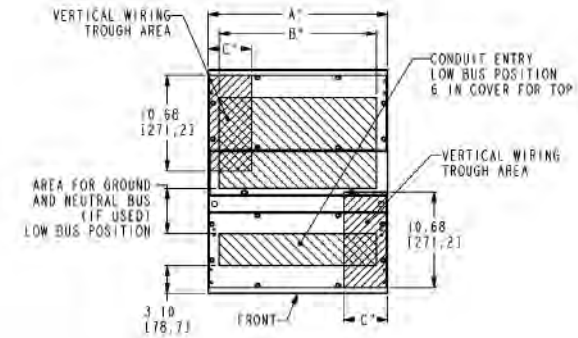


BOTTOM CONDUIT ENTRANCE
DETAILS FOR STD 22"
BUS UPPER POSITION
12" BOTTOM COVER

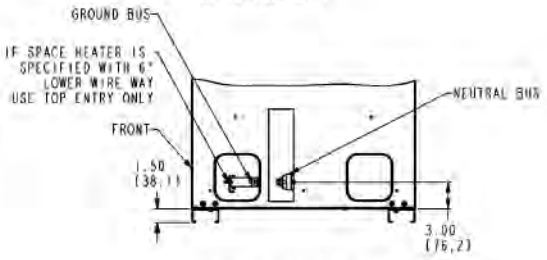


UPPER POSITION OF
GROUND AND NEUTRAL BUS
(MAXIMUM AVAILIABLE
SPACE FOR CONDUIT ENTRY)
12 IN [304.8 MM] COVER

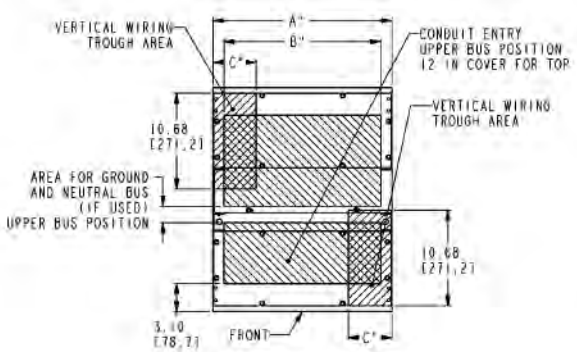
Bottom Conduit Entry 25" Deep Section



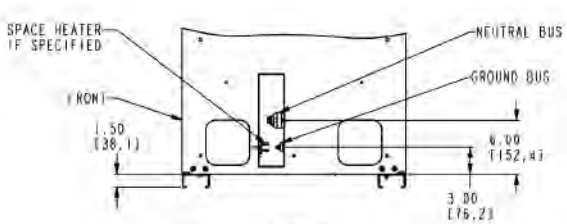
BOTTOM CONDUIT ENTRANCE
DETAILS FOR STD 25"
LOW BUS POSITION
6" BOTTOM COVER



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



BOTTOM CONDUIT ENTRANCE
DETAILS FOR STD 25"
BUS UPPER POSITION
12" BOTTOM COVER

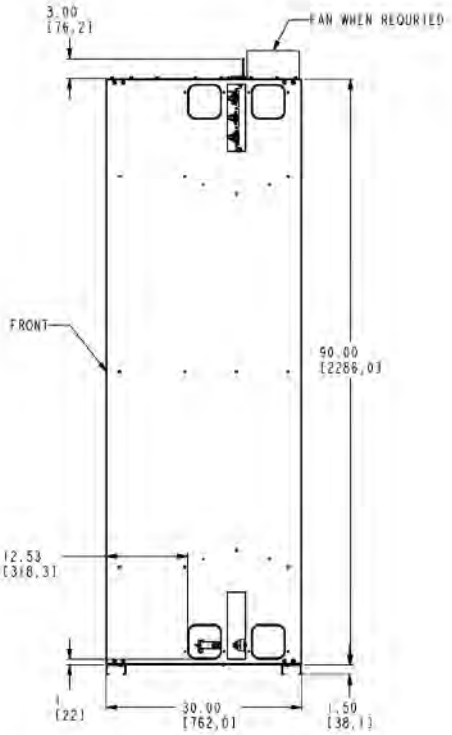


UPPER POSITION OF
GROUND AND NEUTRAL BUS
(MAXIUM AVALIABLE
SPACE FOR CONDUIT ENTRY)
12 IN [304.8 MM] COVER

Indoor Enclosures

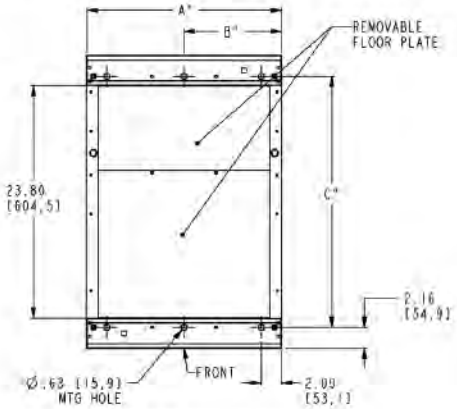
Elevation and Mounting 30" Deep Section 600A to 1200A Main Bus

B



END VIEW STANDARD 30" DEEP

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



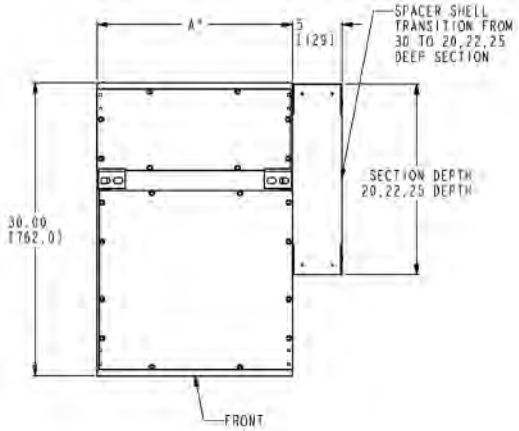
BOTTOM VIEW
LOCATION OF MOUNTING HOLES

Note:

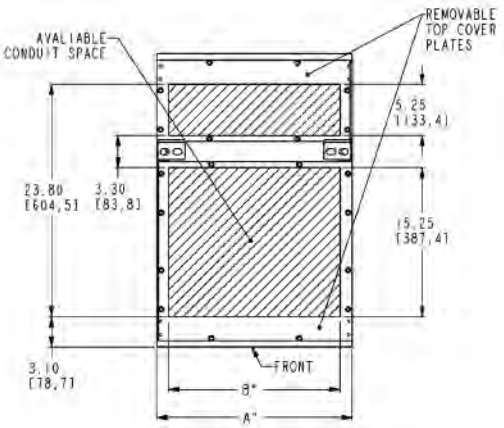
1) If anchor bolts are to be inbedded in the foundation, they must be Located according to the drawing furnished by GE for the specific Equipment. Locate one in the center front and one in the center back. Anchor bolts should be 1/2 inch diameter, of Grade 2 steel (minimum) In non-Seismic Zone 4 Locations. 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 vertical sections are used, anchor bolts or some form of external bracing is required.

2) Seismic Zone-4 IBC testing was performed use 1/2"-13 Grade 5 bolts, torqued to 70 foot-pounds, located in each of the four corners in each section.

Top Conduit Entry 30" Deep Section



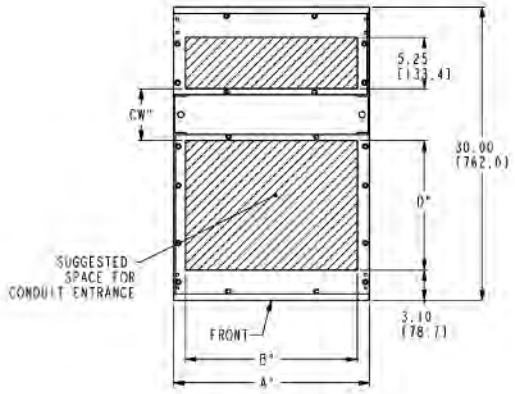
Note: Spacer shell allows unit doors, in spliced section on the right, to open fully.



TOP CONDUIT ENTRANCE
DETAILS FOR STD. 20" X 30"
3" CHANNEL

Indoor Enclosures

Bottom Conduit Entry 30" Deep Section

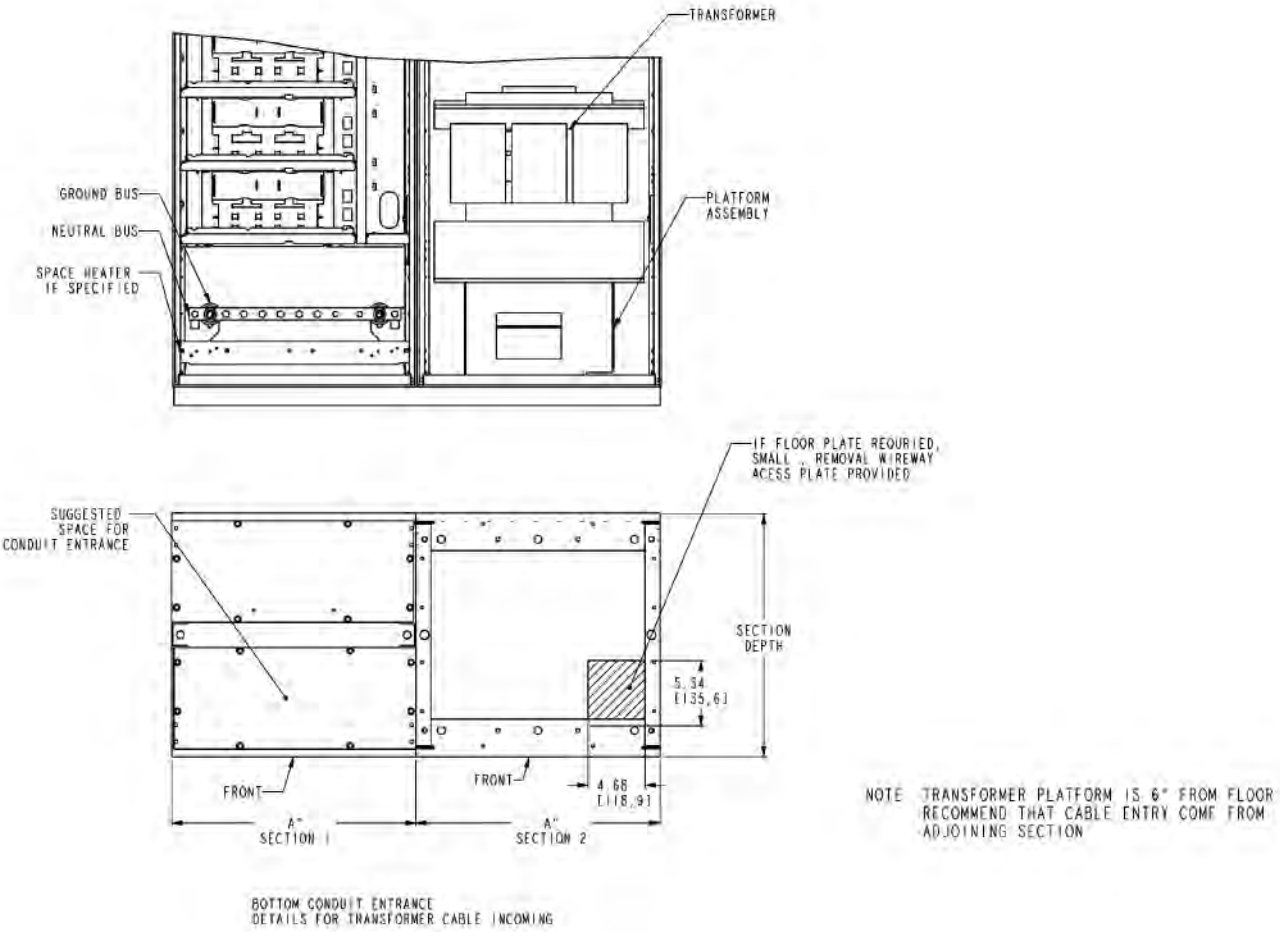


BOTTOM CONDUIT ENTRANCE
DETAILS FOR STD 30"

	REF. DIM.	30" DEEP SECTION		
	A"	20.00"	24.00"	30.00"
	B"	17.56"	21.56"	27.56"
D	CW" - 3" 600-1200A	13.25"	13.25"	13.25"
	CW" - 5" 1600-2500A	15.25"	15.25"	15.25"

CW - CHANNEL WIDTH

Details for Auto Transformer



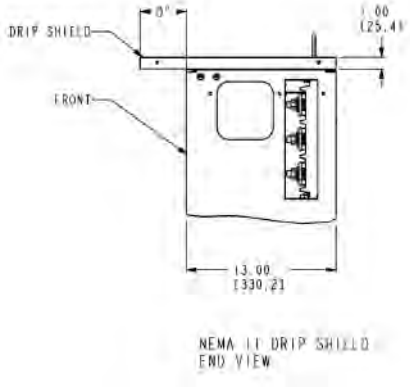
NOTE TRANSFORMER PLATFORM IS 6" FROM FLOOR
RECOMMEND THAT CABLE ENTRY COME FROM
ADJOINING SECTION

BOTTOM CONDUIT ENTRANCE
DETAILS FOR TRANSFORMER CABLE INCOMING

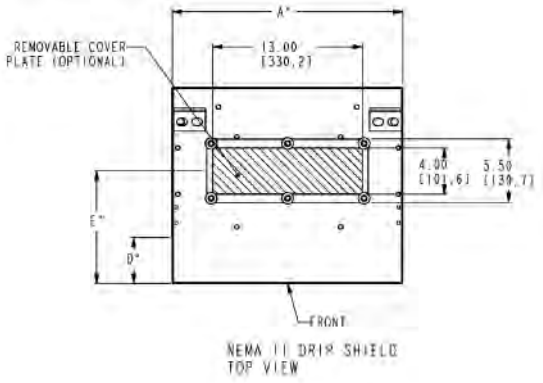
B

Indoor Enclosures

Drip Pan — Nema II 13" Deep Section

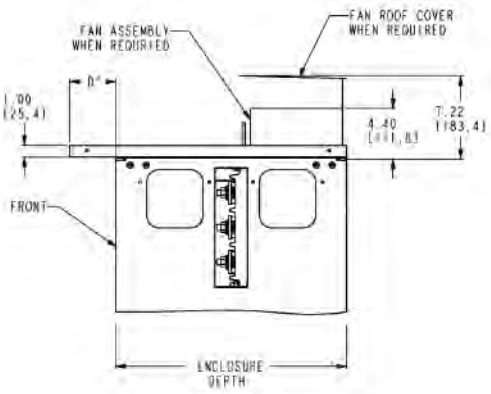


NEMA II DRIP SHIELD
END VIEW

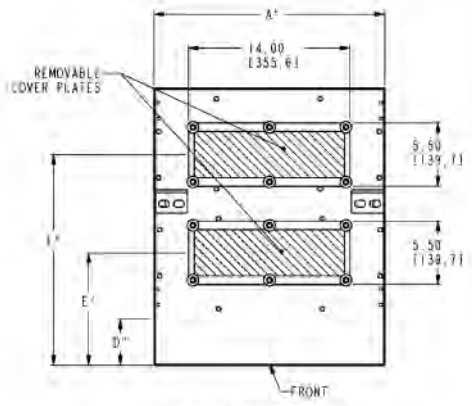


NEMA II DRIP SHIELD
TOP VIEW

Drip Pan — Nema II 20", 22", 30" Deep Sections

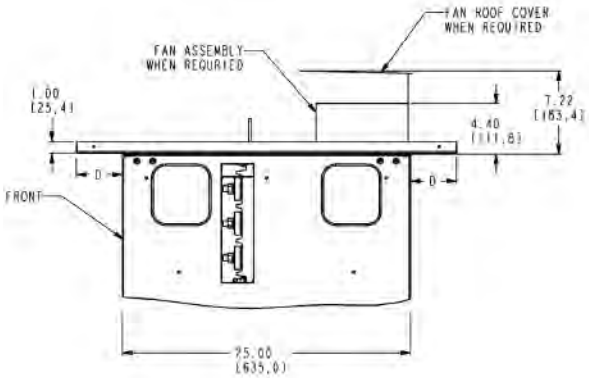


NEMA II DRIP SHIELD
END VIEW



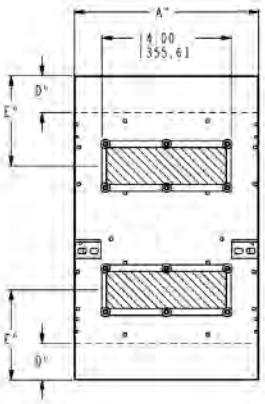
NEMA II DRIP SHIELD
TOP VIEW

Drip Pan — Nema II 25" Deep Section Back-to-Back



NEMA II DRIP SHIELD
END VIEW

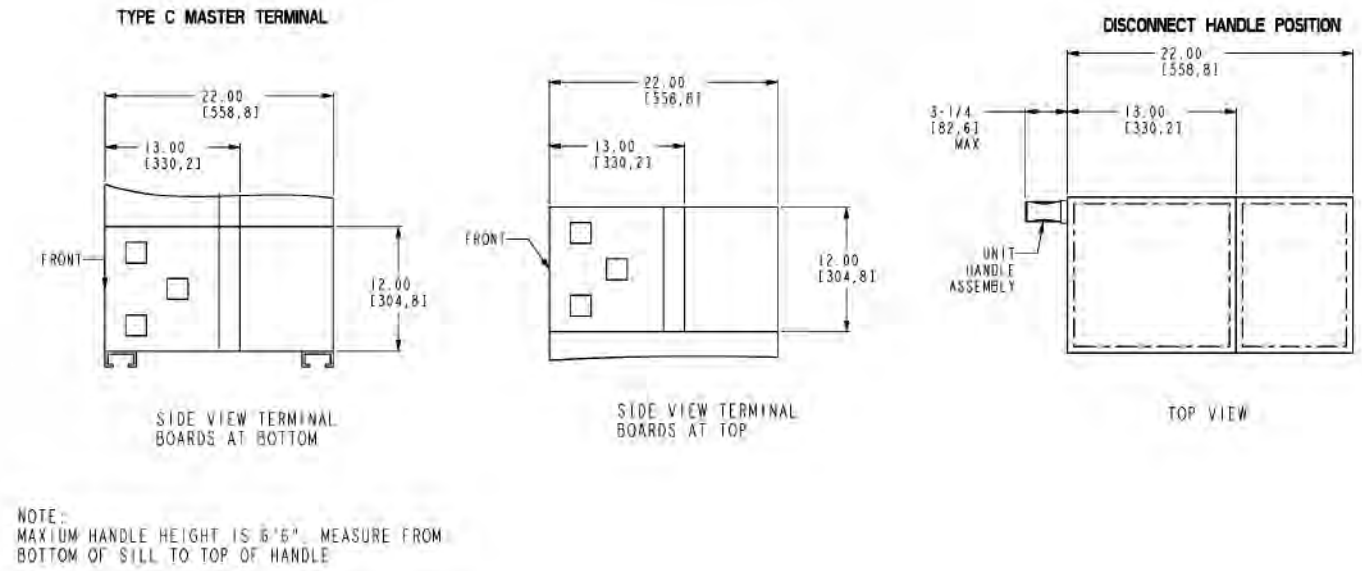
REF DIM	13" DEEP	20" DEEP	22" DEEP	25" DEEP	30" DEEP
A"	20.00"	20.00"	20.00"	20.00"	20.00"
D"	4.00"	4.00"	4.00"	4.00"	4.00"
E"	9.75"	9.75"	9.75"	9.75"	9.75"
F"	NA	18.25"	20.25"	NA	28.25"



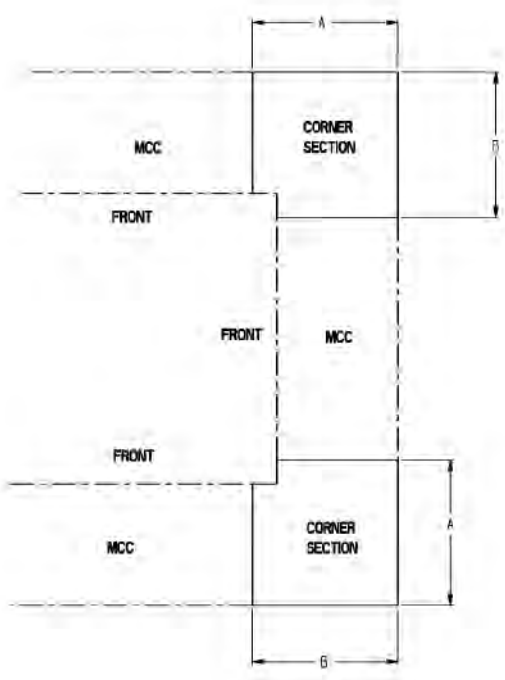
NEMA II DRIP SHIELD
TOP VIEW

Indoor Enclosures

Type C Master Terminal

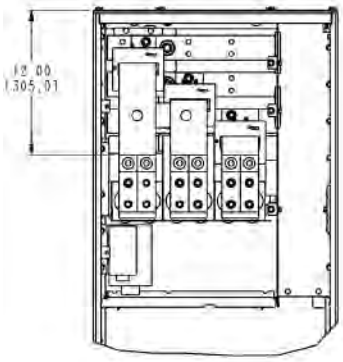


Used for L and U Shaped Motor Control Center Arrangements

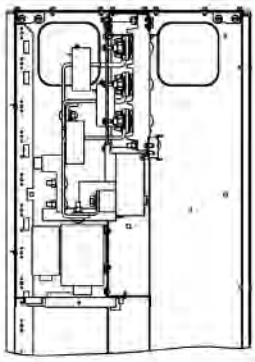


Dimensions (in inches)		
MCC Depth	A	B
13	20	17
20	24	24
22	24	26

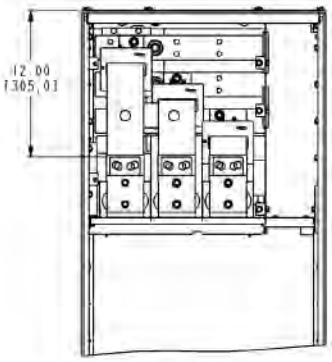
Indoor Enclosures
Incoming Line Terminations



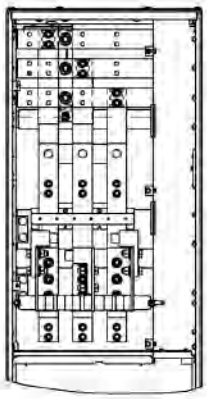
Front Elevation
600 Ampere (Top)
20" W, NEMA Lug
Shown with Lightening Arrestor and
Surge Suppressor for 24" H



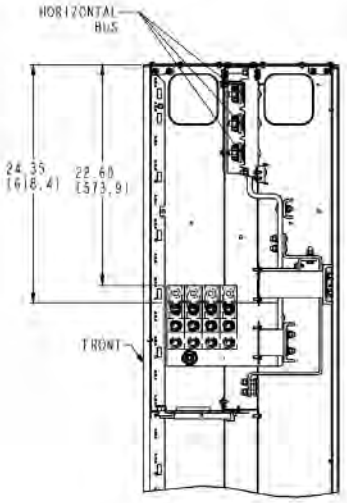
Side View
600 Ampere (Top)
20" W



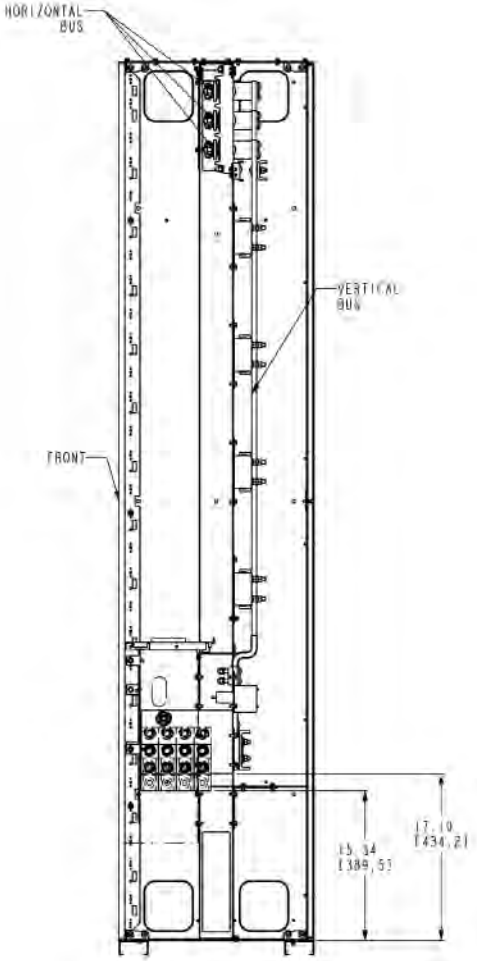
Front Elevation
600 Ampere (Top)
20" W, STD. Lug



Front Elevation
600/1200 Ampere (Top)
20" W, NEMA Lug

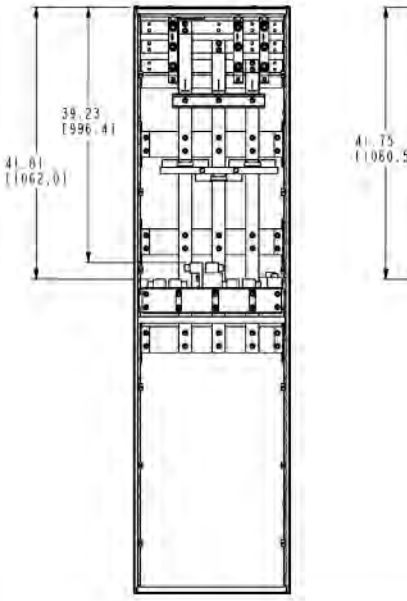


Side View
800 /1200 Ampere (Top)
20" W, NEMA Lug

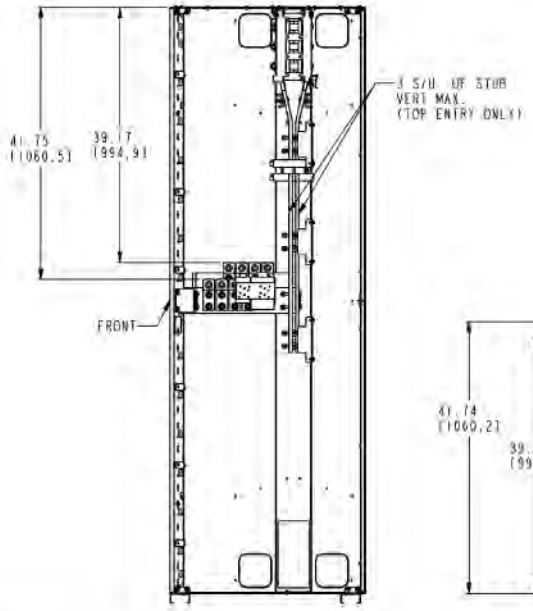


End View
800 /1200 Ampere (Bottom)
20" W, NEMA Lug

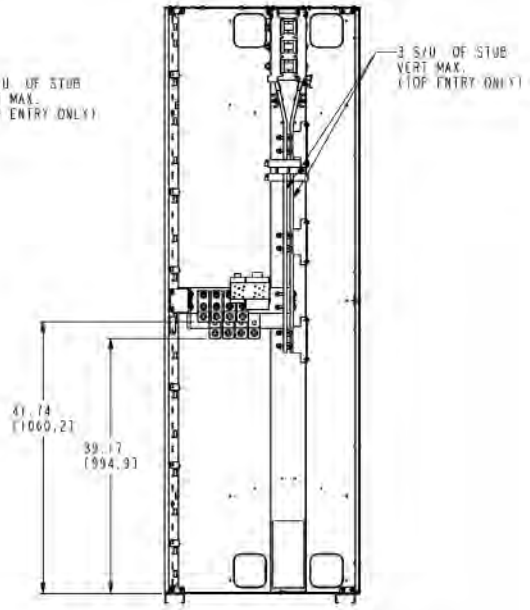
Indoor Enclosures



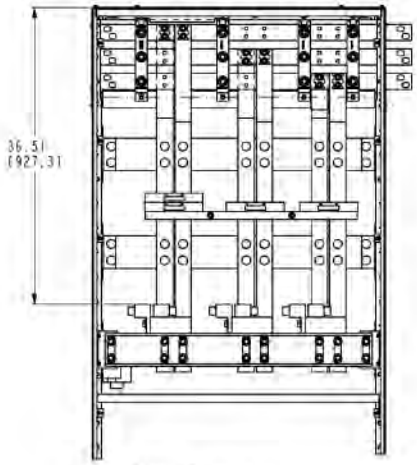
Front Elevation
1600/2000 Ampere (Top/Bottom)
24" W X 30" D



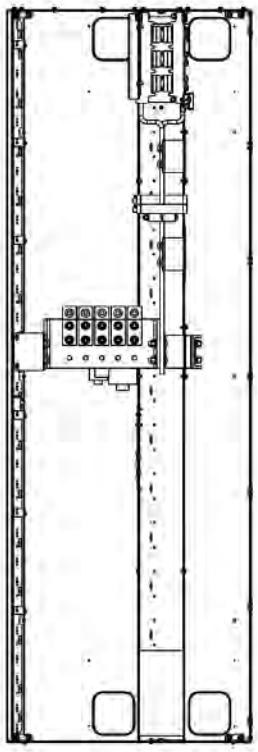
Side View
1600/2000 Ampere (Top)
24" W X 30" D



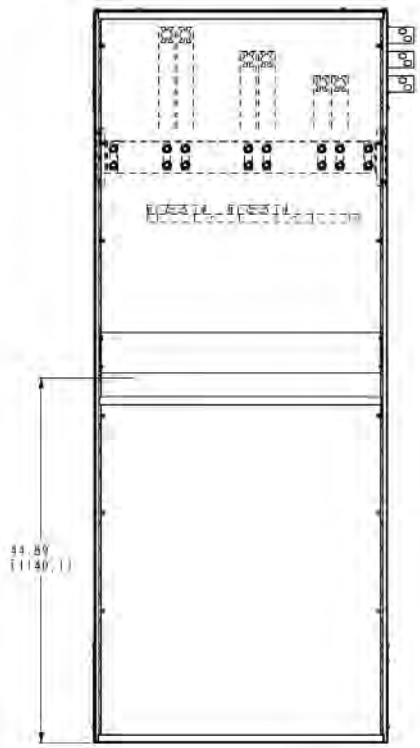
Side View
1600/2000 Ampere (Bottom)
24" W X 30" D



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

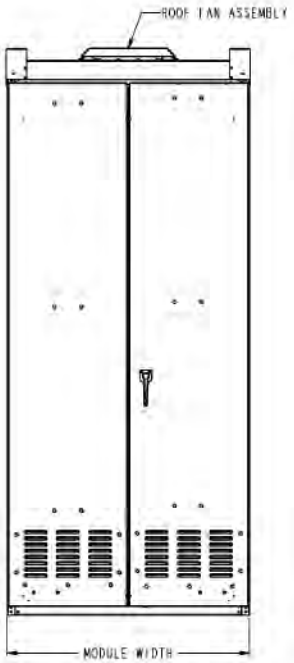
B

Outdoor Enclosures

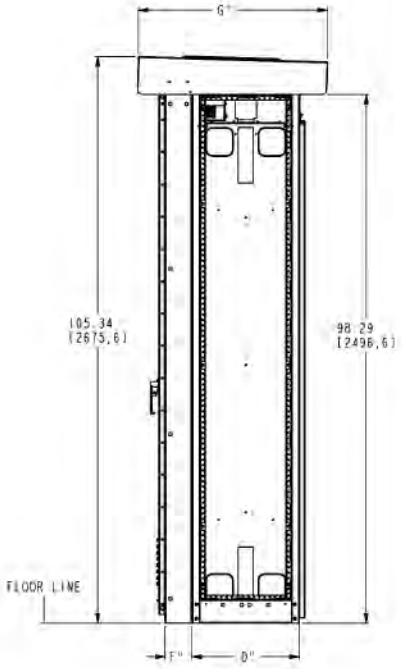
UL Listed Type 3R Non-Walk-In Enclosure (Standard)
The standard NEMA 3R enclosure consists of a specially constructed MCC section with a mating framework which supports the roof and extended front. The basic design is similar to switchboard construction. The smaller footprint will permit a broader usage than the optional NEMA 3R construction. Meets Seismic Zone 4.

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

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.



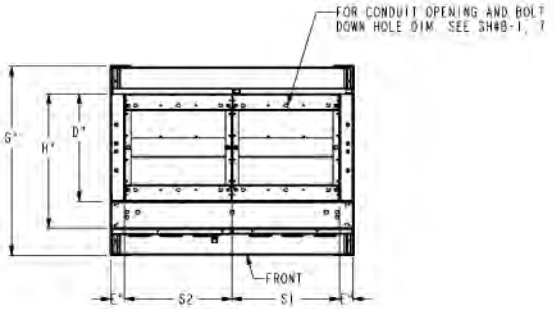
ELEVATION
NEMA 3R TYPE A



SIDE VIEW
NEMA 3R TYPE A

Module Width (Total)	E	MCC Split Length (S1 & S2)
25	2.5	20"
30	3.0	24"
35	2.5	30"
40	2.5	40"
45	3.0	44"
50	2.5	50"
55	3.5	48"
60	3.0	54"
65	2.5	60"

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



BOTTOM VIEW
MCC Floor Plan
NEMA 3R Type A

Note:
1) Doors shown are double door or single door Moudle 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 section 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 in inches.

Indoor Enclosures
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 14 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.

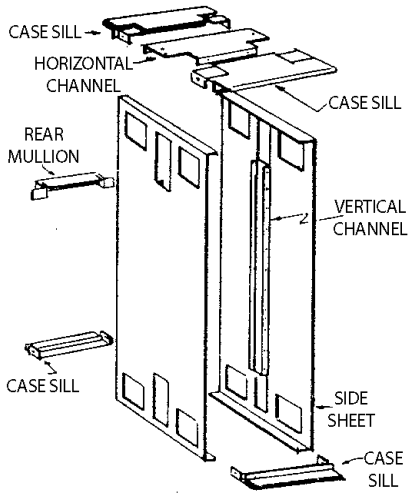
An enclosed foreign voltage disconnect switch is available as an option.

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.

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.



Indoor enclosure, exploded view

Motor Control Center Construction

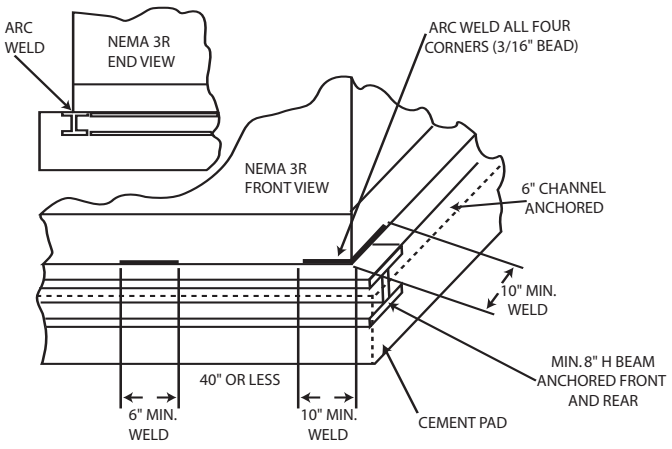
Major Structural Components Side Sheets, L-H & R-H	0.075"
Vertical Bus Mounting Channels	0.090"
Case Sills, Front/Rear, Top/Bottom	(13 Gauge)
Top Horizontal Channel	
Lifting Channel (Top)	0.187"
Channel Sills, Front/Rear	0.105" (12 Gauge)
Enclosing Covers/Panels	
Rear Covers, 13" & 30" Deep	0.075" (14 Gauge)
Rear Covers, 20" & 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"

B

Indoor Enclosures

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



ARC WELD DOWN LENGTH OF NEMA 3R EVERY 40" OR LESS

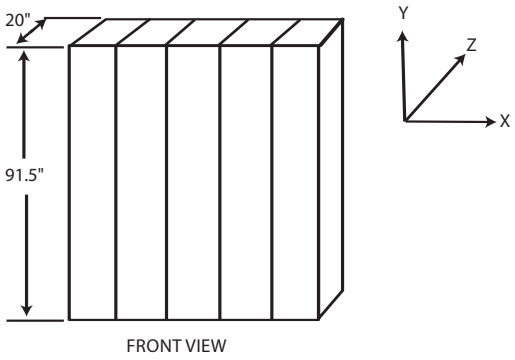
FOR 130MPH WINDS AND 2.25G SHOCK (LENGTH & DEPTH PER OUTLINE)

Note:
Seismic Zone 4 testing was performed using 1/2"-13 Grade 5 bolts, torqued to 70 foot-pounds, located in each of the four corners in each section.

Estimated shipping weights per section

Sections	Lbs	Kg
90"H x 20"W Indoor Nema 1 & 12	600	272
90"H x 20"W Indoor Back-to-Back Nema 1 & 13	700	318
90"H x 20"W Outdoor Nema 3R	725	329

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"

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 General (Section A) 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

MCC Bus	Continuous Current⑤ Rating Amperes	Material Cu	Short-Circuit Rating in RMS Symmetrical Amperes–(kA) 65	100	UL	Notes
Main Horizontal	600	X	X		X	1/4" x 2" Bus
	800	X	X		X	3/8" x 2" Bus
	1200	X		X	X	1/2" x 2" Bus
	1600①	X		X	X	(2) 1/2" x 2" Bus
	2000①	X		X	X	(2) 1/2" x 2" Bus
	2500①③	X		X	X	(2) 1/2" x 2" Bus
Vertical	300②	X	X		X	3/8" x 3/4"
	600/850④	X		X	X	3/8" x 1 1/2"
Neutral	300	X			X	
	600	X			X	
	800	X			X	
	1200	X			X	
	1250	X			X	
Horizontal Ground	300	X			X	1/4" x 1"
	600	X			X	1/4" X 2"
Vertical Grounds	150	X			X	1/8" x 1"

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

① Requires a 22" deep section.
② Will not except 600A stabs.
③ Provided with fans.
④ 1200A horizontal or higher.
⑤ Bus ratings based on UL Temperature Rise testing.

Evolution Series E9000 Motor Control Centers
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 J).

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
Line side CTs can be provided in the main compartment for use with a metering unit. This option in some cases will add space.

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.

Fused Switch Mains

Amperes	Interrupting Rating RMS Amps (In thousands)① Volts			Construction		Space Units	UL Listed	Notes
	240	480	600	Stab-In	Bolt-In			
Fusible Switches								
200	100	100	100	X		2	X	
400 MCS	100	100	100		X	4	X	④
600 MCS	100	100	100		X	4	X	④
High Pressure Contact Switch								
800	100	100	100		X	6	X	②
1200	100	100	100		X	6	X	②
1600	100	100	100		X	6	X	③
2500	100	100	100		X	6	X	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.

C

Evolution Series E9000 Motor Control Centers
Mains, Feeders, Incoming Lines

Mains

Circuit Breaker Mains – Standard Selection

Amperes	CB Type	IC (kA) 240V	IC (kA) 480V	IC (kA) 600V	Stab-In	Bolt-In	Space Units	UL (X) Listed	Notes	Entry Top/Bot
Spectra Thermal Magnetic										
150	SEL/SEP	65/100	65/100	25/25	X		1	X		T/B
250	SFL/SFP	65/100	65/100	25/25	X		1½	X		T/B
600	SGL/SGP	65/100	65/100	65/65	X		2	X		T/B
1200	SKL	65	65	42		X	3.5	X	①⑤	T/B
Power Break® Insulated-Case MicroVersaTrip										
800	SSF/SHF	65	65	42		X	6 (24W)	X	②	T/B
1200	SSF/SHF	65	65	42		X	6 (24W)	X	②	T/B
1600	SSF/SHF	65/100	65/100	42/65		X	6 (30W)	X	③	T/B
2000	SSF/SHF	65/100	65/100	42/65		X	6 (30W)	X	③⑥	T/B
2500	SSF/SHF	65/100	65/100	42/65		X	6 (36W)	X	③⑥	T/B
800	SSD	65	65	42	X		6 (30W)	–	⑥⑦⑧	T/B
1600	SSD	65	65	42	X		6 (30W)	–	③⑥⑦⑧	T/B
2000	SSD	65	65	42	X		6 (30W)	–	③⑥⑦⑧	T/B
Conventional, Thermal Magnetic										
150	THED	30	25	18	X		1½	X		T/B
Limiter Assisted, Thermal Magnetic										
100	THEDL	–	–	100	X		1	X		T/B

① When a size 6 or 7 starter is in the motor control center lineup, use a 1200 ampere MicroVersaTrip 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 Requires full 20" depth of enclosure; rear is not available for back-to-back construction.
⑤ Main breaker must be mounted at top of the section and requires full 20" depth of enclosure.
⑥ 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.
⑦ For UL or service entrance labels provide main breaker in switchboard construction.
⑧ Consult factory for availability.

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, shall 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.

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)①			Construction		Space Units ①	UL Listed (X)	Notes
	Volts			Stab-In	Bolt-In			
	240	480	600					
Fusible Switches								
30	100	100	100	X		1	X	
30/30	100	100	100	X		1	X	②
60	100	100	100	X		1	X	
60/60	100	100	100	X		1	X	②
100	100	100	100	X		1.5	X	
100/30	100	100	100	X		1.5	X	
100/60	100	100	100	X		1.5	X	
100/100	100	100	100	X		1.5	X	
200	100	100	100	X		2	X	
400 MCS	100	100	100	X		3	X	
600 MCS	100	100	100	X		3	X	
THPR High Pressure Contact Switch								
800	100	100	100		X	6	X	③
1200	100	100	100		X	6	X	③
1600④	100	100	100		X	6	–	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.

Feeders

Circuit Breaker Feeders – Standard Selection

Amperes	CB Type	IC (kA) 240V	IC (kA) 480V	IC (kA) 600V	Stab-In	Bolt-In	Space Units	UL (X) Listed	Notes	Entry Top/Bot
Spectra Thermal Magnetic										
100	SEL/SEP	65/100	65/100	25/25	X		1/2	X		T/B
100/100	SEL/SEP	65/100	65/100	25/25	X		1	X		T/B
150	SEL/SEP	65/100	65/100	25/25	X		1/2	X		T/B
150/150	SEL/SEP	65/100	65/100	25/25	X		1 1/2	X		T/B
250	SFL/SFP	65/100	65/100	25/25	X		1	X	②	T/B
250/250	SFL/SFP	65/100	65/100	25/25	X		2	X	②	T/B
600	SGL/SGP	65/100	65/100	65/65	X		2	X		T/B
1200	SKL	65	65	42		X	3.5	X	③④	T
Conventional, Thermal Magnetic										
100	THED	30	25	18	X		1/2	X	①	T/B
150	THED	30	25	18	X		1	X		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.

Options for Mains and Feeders

Accessories for Spectra Molded Case Circuit Breakers

Breaker Type	Bell Alarm	Shunt Trip① or Undervoltage Release	Aux. Switch②	Total # of Accessories
All Spectra	Left Pole	Left Pole	Right Pole	Aux. Switch & Bell Alarm Plus 1 other

Accessories for Power Break

Breaker Type	Bell Alarm Switch	Auxiliary Switch	Shunt Trip	Undervoltage Release	Blown Fuse Trip	Electrical Operator	Total No. of Accessories
SSF, SHF	UL	UL③④	UL	UL	UL	UL	All⑤

① Shunt trip requires aux. switch (G&K) or bell alarm (E&F) for continuous operation.
② Aux. switch available @ 240V max only.
③ 600V AC aux. switches are not UL Listed.
④ Maximum number of SPDT aux. switch elements is 10 when shunt trip is used, 12 without shunt.
⑤ UVR and blown fuse trip cannot be installed simultaneously.

Options for Mains and Feeders

Terminals for Field Wiring Mains and Feeders

Terminal Size	Will Accept Wire② AWG/kcmil①	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) 2-350③	Cu-Al
	(1) 8-600	Cu-Al
600A MCS (Molded Case Switch)	(1) 8-600	Cu-Al
	(1) 4-500③	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
300-1200A 3 lugs	300-750	Cu-Al
4 lugs	250-400	Cu-Al
THED 15-30A	14-8	Cu-Al
THEDL (100A Max) 35-60A	13-3	Cu-Al
70-110A	6-2/0	Cu
70-110A	4-2/0	Al
125-150A	2-3/0	Cu-Al
Ground Lug	1/0-300	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

Switch Rating	Auxiliary Contacts 1 NO	1 NC	2 NO	1 N0, 1 NC
30	UL	UL	UL	UL
60	UL	UL	UL	UL
100	UL	UL	UL	UL
200	UL	UL	UL	UL
400	UL	UL	UL	UL
600	UL	UL	UL	UL

Note: Aux. contacts listed above are shown with fused switch in the open position.

Accessories for High Pressure Contact Switches

- Integral ground fault with three-phase sensor adjustable pick-up, adjustable time-delay, test function, mechanical ground fault indicator.
- Integral ground fault with three-phase sensor and relay only (without test function, without indicator).
- Integrally mounted three-phase current sensor and 120 volt AC electric trip only, for use with ITI BGFL relay and monitor panel.
- Blown fuse protection (480 volts max.)
- 1,2,3 or 4 SPDT auxiliary switches rate 6 amperes, 240 volts AC.

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 H) 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 J19 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.

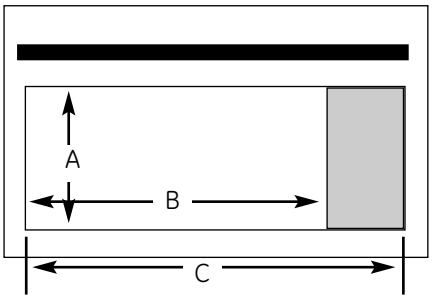
For other custom cable termination arrangements refer to Company. The number of cables indicated must not be exceeded to maintain the short-circuit rating.

C

Incoming Line Cable Assemblies	MLO Space in inches / Vertical Space Available		Cables/lug③	Cables/phase	Cable Range Per NEMA Bending⑦	Minimum Width & Depth	Top Feed Conduit Space (Fig.1)
	Top	Bottom					
600A Std. Lug④⑤	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 Lug②	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 GE Std. Lug①④	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	-	30/48⑥	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 Lug②④	72/0	72/0	1	8	500-1000kcmil	30"x30"	13"x27.6" A-C
2500A NEMA Lug②④	72/0	72/0	1	10	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.

Fig. 1



Busway Entrances

GE motor control centers include provisions for connecting GE busways. Busways 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

GE motor control centers may be furnished with GE 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 equipments.

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 GE Zenith.

GE 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 1&2 position, Source 1&2 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 Switches①

Minimum MCC Space Units②	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 General Electric 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.

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 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.

Specify basic starter units from the tables in this section. Starters are listed by starter function, line voltage, HP, NEMA size, and combination short-circuit rating. Indicate type control power desired. Include any options from "Optional Modifications," noting additional space requirements for some options.

Typical starter circuits are shown in (Section K). Starters can also be used for lighting or resistive heat loads (Section J).

Selection Tables
Circuit Breaker Type

208 Volts, 60 Hertz – Combination Motor Starters

FVNR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	7.5	25	TEC	1	X	②
2	10	25	TEC	1	X	
3	25	25	TEC	1.5	X	
4	40	25	SFL	2	X	
5	75	100	SGL	3	X	
6	150	65	SKL	3.5	X	
1	7.5	65/100	SEL/SEP	1	X	
2	10	65/100	SEL/SEP	1	X	
3	25	65/100	SEL/SEP	1.5	X	
4	40	65/100	SFL/SFP	2	X	
5	75	100	SGL	3.0	X	
6	150	65	SKL	4	X	

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	7.5	25	TEC	2	X	
2	10	25	TEC	2	X	
3	25	25	TEC	1.5	X	
4	40	25	SFL	2	X	
5	75	100	SGL	3	X	
6	150	65	SKL	3.5	–	
1	7.5	65/100	SEL/SEP	2	X	
2	10	65/100	SEL/SEP	2	X	
3	25	65/100	SEL/SEP	3.5	X	
4	40	65/100	SFL/SFP	4	X	
5	75	100	SGL	5.5	X	
6	150	65	SKL	8.5	–	①

RVAT

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units③		UL Listed (X)	Notes
				13" Deep	20" Deep		
2	10	25	TEC	4	4	X	
3	25	25	TEC	5	4	X	
4	40	25	SFL	5	4	X	
5	75	100	SGL	–	5	X	②
6	150	65	SKL	N/A	12	X	①
2	10	65/100	SEL/SEP	4	4	X	
3	25	65/100	SEL/SEP	5	4	X	
4	40	65/100	SEL/SEP	5.5	4.5	X	
5	75	100	SGL	–	5	X	②
6	150	65	SKL	N/A	12	X	①

Part Winding

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	TEC	2		
2	20	25	TEC	2		
3	40	25	TEC	4		
4	–	–	–	–		
5	–	–	–	–		
1	10	65/100	SEL/SEP	2		
2	20	65/100	SEL/SEP	2		
3	40	65/100	SFL/SFP	4.5		
4	75	100	SGL	5		
5	–	–	–	–		

Y-Delta

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
2	20	25	TEC	4		
3	40	25	TEC	4.5		
4	60	100	TGL	5.5		
5	–	–	–	–		④
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		④
6	300	100	TGL	5.5		

2S1W, 2S2W

NEMA Size	Max. Hp		IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes	Rev Space Units
	Constant Variable Torque	Constant HP						
1	7.5	5	25	TEC	1.5	X		2.5
2	10	7.5	25	TEC	2	X		3
3	25	20	25	TEC	4	X		4.5
4	40	30	25	SFL	4.5	X		7.5
5	75	60	30	SGL	5	–	②	10
6	150	100	65	SGL/SKL	8.5	–	①	–
1	7.5	5	65/100	SEL/SEP	2	X		2.5
2	10	7.5	65/100	SEL/SEP	2	X		3
3	25	20	65/100	SEL/SEP	4	X		4.5
4	40	30	65/100	SFL/SFP	4.5	X		5.5
5	75	60	100	SGL	5.5	–	②	10
6	150	100	65	SKL	8.5	–	①	–

① Size 6 FVR, RVAT, 2S2W require (2) adjacent 24" wide sections, 20" deep (2S1W).
② A 1/2X compact starter is available.
③ The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to Company. One space unit or X unit equals 12 inches of vertical height.
④ 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	UL Listed (X)	Notes
1	7.5	25	TEC	1	X	⑤
2	15	25	TEC	1	X	
3	30	25	TEC	1.5	X	
4	50	25	TEC	2	X	
5	100	100	SGL	3	X	
6	200	65	SKL	5.5	X	
1	7.5	65/100	SEL/SEP	1	X	
2	15	65/100	SEL/SEP	1	X	
3	30	65/100	SEL/SEP	2	X	
4	50	65/100	SFL/SFP	2.5	X	
5	100	100	SGL	3	X	
6	200	65	SKL	6	X	①

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	7.5	25	TEC	2	X	
2	15	25	TEC	2	X	
3	30	25	TEC	3	X	
4	50	25	TEC	3	X	
5	100	100	SGL	5.5	X	①
6	200	65	SKL	8.5	–	②
1	7.5	65/100	SEL/SEP	2	X	
2	15	65/100	SEL/SEP	2	X	
3	30	65/100	SEL/SEP	3	X	
4	50	65/100	SFL/SFP	3	X	
5	100	100	SGL	5.5	X	①
6	200	65	SKL	8.5	–	②

RVAT

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units③ 13" Deep	Space Units③ 20" Deep	UL Listed (X)	Notes
2	15	25	TEC	4	4	X	
3	30	25	TEC	5	4	X	
5	100	100	SGL	N/A	5	X	
6	200	65	SKL	N/A	12	X	②
2	15	65/100	SEL/SEP	4	4	X	
3	30	65/100	SEL/SEP	5	4	X	
4	50	65/100	SFL/SFP	6	4.5	X	
5	100	100	SGL	N/A	5	X	
6	200	65	SKL	N/A	12	X	②

Part Winding

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	TEC	2		
2	25	25	TEC	2		
3	50	25	TEC	4		
4	–	–	–	–		
5	–	–	–	–		④
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	–	–	–	–		④

Y-Delta

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
2	25	25	TEC	4		
3	50	25	TEC	4.5		①
4	75	100	SGL	5.5		①
5	–	–	–	–		④
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		④
6	350	100	SGL	5.5		④

2S1W, 2S2W

NEMA Size	Max. Hp Constant Variable Torque	Max. Hp Constant HP	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes	Rev Space Units
1	7.5	5	25	TEC	2	X		2.5
2	15	10	25	TEC	2	X		3
3	30	25	25	TEC	4	X		4.5
4	50	40	25	SFL	4.5	X		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	X		2.5
2	15	20	65/100	SEL/SEP	2	X		3
3	30	40	65/100	SEL/SEP	4	X		4.5
4	50	75	65/100	SFL/SFP	4.5	X		7.5
5	100	150	100	SGL	5.5	–	②	10
6	200	150	65	SKL	8.5	–	②	–

① Requires 24" wide section.
② Size 6 FVR, RVNR, 2S2W require (2) adjacent 24" wide sections, 20" deep (2S1W).
③ The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to Company. One space unit or X unit equals 12 inches of vertical height.
④ Refer to factory.
⑤ A 1/2X compact starter is available.

Selection Tables
Circuit Breaker Type

460 Volts, 60 Hertz – Combination Motor Starters

FVNR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	TEC	1	X	⑥
2	25	25	TEC	1	X	
3	50	25	TEC	1.5	X	
4	100	25	SFL	2	X	
5	200	100	SGL	3	X	
6	400	65	SKL	5.5	X	
1	10	65/100	SEL/SEP	1	X	
2	25	65/100	SEL/SEP	1	X	
3	50	65/100	SEL/SEP	1.5	X	
4	100	65/100	SFL/SFP	2	X	
5	200	100	SGL	3.0	X	
6	400	65	SKL	5.5	X	

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	TEC	1.5	X	
2	25	25	TEC	2	X	
3	50	25	TEC	3	X	
4	100	25	SFL	3	X	
5	200	100	SGL	6	X	①
6	400	65	SKL	12	–	②
1	10	65/100	SEL/SEP	2	X	
2	25	65/100	SEL/SEP	2	X	
3	50	65/100	SEL/SEP	3	X	
4	100	65/100	SFL/SFP	4	X	
5	200	100	SGL	5.5	X	①
6	400	65	SKL	8.5	–	②

RVAT

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units③ 13" Deep	Space Units③ 20" Deep	UL Listed (X)	Notes
2	25	25	TEC	4	4	X	
3	50	25	TEC	5	4	X	
4	100	25	TEC	5	4	X	
5	200	100	SGL	–	5	X	③
6	400	65	SKL	N/A	12	X	②
2	25	65/100	SEL/SEP	4	4	X	
3	50	65/100	SEL/SEP	5	4	X	
4	100	65/100	SEL/SEP	6	4.5	X	
5	200	100	SGL	N/A	5	X	③
6	400	65	SKL	N/A	12	X	②

Part Winding

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	15	25	TEC	2		
2	40	25	TEC	2		
3	75	25	TEC	4		
4	150	10	SGL	4.5		
5	–	–	–	–		⑤
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	–	–	–	–		⑤

Y-Delta, OT

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
2	40	25/65	TEC/SE	3		
3	75	25/65	TEC/SGL	3.5		①
4	150	65	SGL	4.5		①
5	300	65	SGL	5		

2S1W, 2S2W

NEMA Size	Max. Hp Constant Variable Torque	Max. Hp Constant HP	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes	Rev Space Units
1	10	7.5	25	TEC	1.5	X		2.5
2	25	20	25	TEC	2	X		3
3	50	40	25	TEC	3.5	X		4.5
4	100	75	25	SFL	4.5	X		5.5
5	200	150	30	TJC	6	–	①②	10
6	400	300	65	SKL	12	–	②	–
1	10	7.5	65/100	SEL/SEP	1.5	X		2.5
2	25	20	65/100	SEL/SEP	2	X		3
3	50	40	65/100	SEL/SEP	4	X		4.5
4	100	75	65/100	SFL/SFP	4.5	X		7.5
5	200	150	100	SGL	6	–	①②	10
6	400	300	65	SKL	12	–	②	–

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 13Æ deep enclosure.
④ The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to Company. One space unit or X unit equals 12 inches of vertical height.
⑤ Refer to factory.
⑥ A 1/2X compact starter is available.

Selection Tables
Fused Switch Type

575 Volts, 60 Hertz – Combination Motor Starters

FVNR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	SEL	1	X	
2	25	25	SEL	1	X	
3	50	25	SEL	1.5	X	
4	100	25	SFL	2	X	
5	200	65	SGL	3	X	
6	400	42	SKL	6	X	①
1	10	100	TECL	1	X	
2	25	100	TECL	1	X	
3	50	100	TECL	1.5	X	
4	100	42	SGL	2	X	
5	200	65	SGL	3.5	X	
6	400	42	SKL	6	X	

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	SEL	2	X	
2	25	25	SEL	2	X	
3	50	25	SEL	3	X	
4	100	25	SFL	3	X	
5	200	65	SGL	5.5	X	①
6	400	42	SKL	8.5	–	②
1	10	100	TECL	2	X	
2	25	100	TECL	2	X	
3	50	100	TECL	3	X	
4	100	42	SGL	3	X	
5	200	100	SGL	5.5	X	①
6	400	42	SKL	8.5	X	①

RVAT

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units③ 13" Deep	Space Units③ 20" Deep	UL Listed (X)	Notes
2	25	25	SEL	4	4	X	
3	50	25	SEL	5	4	X	
4	100	25	SFL	6	4.5	X	
5	200	65	SGL	5	4.5	X	
6	400	42	SKL	N/A	12	X	②
2	25	100	TECL	4	4	X	
3	50	100	TECL	5	4	X	
4	100	100	TECL	5	4	–	
5	200	100	SGL	N/A	5	X	
6	400	42	SKL	N/A	11	X	②

Part Winding

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	15	25	SEL	2		
2	40	25	SEL	2		
3	75	25	SEL	4.5		
4	150	10	SGL	5		
5	–	–	–	–		④
1	15	100	TECL	2		
2	40	100	TECL	2		
3	75	100	TECL	4		
4	150	42	SGL	5		
5	–	–	–	–		④

Y-Delta, OT

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	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	–	–	–	–		④
2	40	100	TECL	3		
3	75	100	TECL	3.5		①
4	150	42	SGL	5		①
5	–	–	–	–		④

2S1W, 2S2W

NEMA Size	Max. Hp Constant Variable Torque	Max. Hp Constant HP	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes	Rev Space Units
1	10	7.5	25	SEL	2	X		2.5
2	25	20	25	SEL	2	X		3
3	50	40	25	SEL	4	X		4.5
4	100	75	25	SFL	5	X		7.5
5	200	150	22	SGL	5.5	–	①②	10
6	400	300	42	SKL	8.5	–	②	–
1	10	7.5	100	TECL	2	X		2.5
2	25	20	100	TECL	2	X		3
3	50	40	100	TECL	3.5	X		4.5
4	100	75	100	TECL	3.5	–		5.5
5	200	150	100	SGL	5.5	–	①②	10

① Requires 24" wide section.
② Size 6 FVR, RVAT, 2S2W require (2) adjacent 20 and 24" wide sections, 20" deep (2S1W).
③ The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to Company. One space unit or X unit equals 12 inches of vertical height.
④ Refer to factory.

Selection Tables
Fused Switch Type

208 Volts, 60 Hertz – Combination Motor Starters⑤⑦

FVNR

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

FVR

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
1	7.5	100	30	30	1.5	X	
2	10	100	60	60	2	X	
3	15	65	100	60	3	X	⑤
3	25	65	100	100	3.5	X	⑤
4	40	100	200	200	5	X	
5	75	100	400	400	9.5	X	③⑥
6	–	–	–	–	–	–	

RVAT

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units 13" Deep	Space Units 20" Deep	Listed (X)	UL Notes
2	10	100	60	60	4	4	X	
3	15	65	100	60	5	4	X	⑤
3	25	65	100	100	5	4	X	⑤
4	40	100	200	200	6	5	X	
5	75	100	400	400	–	6	X	③
6	–	–	–	–	–	–	–	

Part Winding

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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 Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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 CT VT	Max. Hp Constant HP	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	Listed (X)	UL Notes
1	7.5	5	100	30	30	2	X	
2	–	7.5	100	60	30	2	X	
2	10	–	100	60	60	2	X	
3	15	15	65	100	60	3.5	X	⑤
3	25	20	65	100	100	3.5	X	⑤
4	40	–	100	200	200	5.5	X	
5	75	–	100	400	400	8.5	–	③
1	7.5	5	100	30	30	2	X	
2	–	7.5	100	60	30	2	X	
2	10	–	100	60	60	2	X	
3	15	15	65	100	60	3.5	X	⑤
3	25	20	65	100	100	3.5	X	⑤
4	40	–	100	200	200	5.5	X	
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).

Selection Tables
Fused Switch Type

230 Volts, 60 Hertz – Combination Motor Starters⑤⑦

FVNR

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
1	7.5	100	30	30	1	X	
2	15	100	60	60	1	X	
3	30	65	100	100	2	X	⑥
3	30	100	200	200	2.5	X	
4	50	100	200	200	3.5	X	
5	100	100	400	400	5	X	
6	200	100	600	600	5.5	–	①

FVR

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
1	7.5	100	30	30	1.5	X	
2	15	100	60	60	2	X	
3	30	65	100	100	3	X	⑥
4	50	100	200	200	5	X	
5	100	100	400	400	8.5	X	③⑥
6	200	100	600	600	8.5	–	②

RVAT

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

Part Winding

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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 Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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		①⑥
4	60	100	400	400	6		④

2S1W, 2S2W

NEMA Size	Max. Hp CT VT	Max. Hp Constant HP	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	Listed (X)	UL Notes
1	7.5	5	100	30	30	2	X	
2	–	7.5	100	60	30	2	X	
2	15	10	100	60	60	2	X	
3	30	25	65	100	100	4	X	⑥
4	–	30	100	200	100	5.5	X	
4	50	40	100	200	200	5.5	X	
5	100	75	100	400	400	8.5	–	③
1	7.5	5	100	30	30	2	X	
2	–	7.5	100	60	30	2	X	
2	15	10	100	60	60	2	X	
3	30	25	65	100	100	4	X	⑥
4	–	30	100	200	100	5.5	X	
4	50	40	100	200	200	5.5	X	
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).

Selection Tables
Fused Switch Type

460 Volts, 60 Hertz – Combination Motor Starters⑥⑦

FVNR

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

FVR

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

RVAT

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units 13" Deep	Space Units 20" Deep	Listed (X)	UL Notes
2	15	100	60	30	4	4	X	
2	25	100	60	60	4	4	X	
3	30	65	100	60	5	4	X	
3	50	65	100	100	5	4	X	
4	100	100	200	200	6	5	X	
5	125	100	400	200	–	6	X	
5	200	100	400	400	–	6	X	
6	250	100	600	400	N/A	12	X	②
6	400	100	600	600	N/A	12	X	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 The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to Company. One space unit or X unit equals 12 inches of vertical height.
⑦ All 400/600A units are MCS (molded case switches).

Part Winding

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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 Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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

2S1W

NEMA Size	Max. Hp CT VT	Max. Hp Constant HP	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	Listed (X)	UL Notes
1	10	7.5	100	30	30	2	X	
2	15	15	100	60	30	2	X	
2	25	20	100	60	60	2	X	
3	30	30	65	100	60	4	X	
3	50	40	65	100	100	4	X	
4	100	75	100	200	200	5.5	X	
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 CT VT	Max. Hp Constant HP	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	Listed (X)	UL Notes
1	10	7.5	100	30	30	2	X	
2	15	15	100	60	30	2	X	
2	25	20	100	60	60	2	X	
3	30	30	65	100	60	4	X	
3	50	40	65	100	100	4	X	
4	100	75	100	200	200	5.5	X	
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

208 Volts, 60 Hertz – Combination Motor Starters⑤⑦

FVNR

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

FVR

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
1	10	100	30	30	1.5	X	
2	25	100	60	60	2	X	
3	40	100	100	60	3	X	
3	50	100	200	100	5	X	
4	100	100	200	200	5	X	
5	200	100	400	400	8.5	X	④
6	400	100	600	600	8.5	–	②

RVAT

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

Part Winding

NEMA Size	Max. Hp	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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 Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	UL Listed (X)	Notes
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	–	–	–	–	–		⑦

2S1W, 2S2W

NEMA Size	Max. Hp CT VT	Max. Hp Constant HP	IC (kA)	Class RK-1, RK-5, J-TD Switch Amps	Class RK-1, RK-5, J-TD Clip Amps	Space Units	Listed (X)	UL Notes
1	10	7.5	100	30	30	2	X	
2	25	–	100	60	60	2	X	
3	40	40	100	200	60	5.5	X	
3	50	–	100	200	100	5.5	X	
4	100	–	100	200	200	5.5	X	
5	200	–	100	400	400	8.5	–	④
6	400	–	100	600	600	8.5	–	②
1	10	7.5	100	30	30	2	X	
2	25	–	100	60	60	2	X	
3	40	40	100	200	60	5.5	X	
3	50	–	100	200	100	5.5	X	
4	100	–	100	200	200	5.5	X	
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 The space requirements shown in these tables are minimum. Where layout dimensions are critical, refer to Company. One space unit or X unit equals 12 inches of vertical height.
⑦ Refer to factory.
⑧ All 400/600A units are MCS (molded case switches).

Starter Options

Option	Function	Additional Space Required	UL Listed (X)
Control Transformer	Provides control power. See "Control Transformer" for details	–	X
CPT Primary Fuses	Class CC fuse wired in each ungrounded transformer primary conductor.	–	X
CPT Secondary Fuse	One midget fuse (typical Gould Ferraz type TRM) wired in ungrounded Control Power Conductor	–	X
Control Power Fuse	One Class CC fuse wired in each ungrounded control power conductor. Use when control power source is remote from unit.		
Standard OL Relay	1 NC contact (standard)– 1 NC and 1 NO (pilot duty) contact (Optional)	– –	X X
Ambient Comp. OL Electronic OL	Ultimate trip current remains essentially unchanged over a range of OL ambient temperatures. 1 NC contact (standard) 1 NC and 1 NO (pilot duty) contact (Optional)	 – –	 X X
Pilot Lights Full Voltage Transformer LED① Push-to-test	CR104P type. Red–ON FAST, FWD, UP Amber–DOWN, REV, SLOW Green–STOPPED, READY CR104P with 6V lamp (See full voltage lights for lens colors) CR104P Type transformer type with 6V LED Lamp CR104P, Full-voltage transformer type, or LED (See full-voltage lights for lens colors)	 – – – –	 X X X X
Push buttons Start-Stop① Stop① Stop① Fwd, Rev, Stop① Fast, Slow, Stop	CR104P momentary type-use with FVNR starters with 3-wire control. CR104P momentary type-provides stop function at MCC with 3-wire control. CR104P maintained type–provides stop function at MCC with 2/3 wire control. Can be furnished with mushroom head and provision for locking open. CR104P momentary type-use with FVR starters. CR104P momentary type-use with 2-speed starters.	 – – – – –	 X X X X X
Selector Switches On-Off	CR104P maintained type–use as permissive start with 2 or 3 wire control.	–	X

Option	Function	Additional Space Required	UL Listed (X)
Hand-Off-Auto①	CR104P maintained type–use to select auto or manual start with 2-wire control.	–	X
Fast-Slow-Off-Auto	CR104P maintained type–use with 2-speed starters.	–	X
Fixed Control TB	Stationary control terminal boards in place of split type terminal boards.	–	X
Power TB	Stationary motor lead terminal boards Size 3 and 4	Yes	X
Power TB	Split Type terminal blocks on Nema Size 1 and 2	–	X
Control Disconnect	High density pull-apart TB will provide foreign voltage isolation without disengaging the unit vertical bus stabs.	–	X
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. CR120B type (optional), rated 600V, with 10A convertible contacts. Three 4/8 pole relays will mount in a half-space unit extension, plus nine additional terminal board points. Size 1 and 2 FVNR starters require an additional half-space unit for one to three relays. One relay can be added on other starters with no increase in space unit.	Yes Yes	X X
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	X
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.		X

① Functions also available with LM10 PDU.

Starter Options

Option	Function	Additional Space Required	UL Listed (X)
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.		X
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.		X
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.		X
Latch Relay	CR120BL, 4 pole. Once relay closes, mechanical latch holds relay closed until electrically reset. Requires same space as CR120B (4 pole) control relay.		X
Ambient Comp. CB's	Thermal trip is ambient compensated.	–	X
Fused Switch Auxiliary Interlock	2-10A auxiliary interlocks operated by disconnect operator Max. (2NO, or 1NO and 1NC)	–	X
CB Options (Spectra only) Aux. Interlock Bell Alarm Shunt Trip	SPDT auxiliary interlocks mounted in CB. Refer to factory if more than 2 required. Internal CB alarm switch. Electric remote trip.	– – –	X X X
Key Interlock Above 250A	Added to disconnect operating handle to require a predetermined system operating sequence. Specify operating sequence.	–	X
Ground Fault①	Zero sequence sensing Ground Fault Relay for equipment protection for NEMA size 2-6 starters.	Yes	X
Current Transformer	Donut type CT located in one motor phase conductor for purchasers use. (Also used for door mounted Ammeter.)	Yes	X
Amp Transducer	Integrated CT/Current transducer with 4-20 MA output. (Requires 120V Power).	Yes	X

Option	Function	Additional Space Required	UL Listed (X)
Ammeter①	AC panel-type, single current-transformer operated five-ampere movement. Scale selected based on 125% motor full-load amperes.	①	X
Elapsed Time Meter①	Mounts on pushbutton bracket. Meter① Visible from front of MCC.	②	X
Phase Loss/ Current Sensing Alternate ECM	CR324X Electronic overload module senses running motor currents (no reversal).	–	X
Phase Loss/ Unbalance Voltage Sensing	APVR used primarily to sense phase loss, unbalance, or reversal, has time delay under-voltage.	–	X
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 H). (1X-size 5)	1/2X	X
Coil Suppressor, 120V	Surge suppressors reduce undesirable transients in control circuits by absorbing voltage transients generated by operating coils.	③	X
Over Size Unit	Standard unit height may be increased ½X or 1X	1/2X, 1X	X X
Door Diagram	Circuit diagram mounted on back of unit door.	–	X
Wire markers	Permanent wire number identification on each control wire. Tube type standard, heat shrink optional.	–	X
Provision For PLC	See Programmable Logic Control (Section F).		
Provision for VersaMax	See Programmable Logic Control (Section F).		
Provision for PFC Capacitor	Terminals located between contactor and OL relay.		X

① Functions also available with LM10.
② Functions also available with LM10 display.
③ Standard with LM10.

D

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
Both analog and digital relays are also available with or without communications (see page H-11).

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. ATM-R 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 unless otherwise 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
1-6①	5000	6000

① Distance based on using an interposing relay, type C2000 [CR120B is 1600/2500 feet]

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

	Amperes		
AC Volts	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

Product Information

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	5	6②	6	6	6	6
Full voltage, Reversing						
Forward Contactor	4	4	4	4	4	4
Reverse Contactor	4	4	4	4	4	4
Two-speed, One winding①						
Low-speed Contactor	4	4	4	4	4	5
High-speed Contactor	3	4	4	4	4	5
Two-speed, Two winding						
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 K) 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 Type③	CPT Std. VA		CPT Max.UL VA⑤		Listed (X)	Notes
	60 Hz	50 Hz	60 Hz	50 Hz		
All Size 1	60	150	300	250	X	⑥
All Size 2	150	150	300	250	X	
All Size 3	300	250	300	250	X	
All Size 4	300	250	300	250	X	
All Size 5 and 6	100	100	300	250	X	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 P/U	% Volts D/O	Millisec P/U	Millisec 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.

Product Information

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 J) for recommended thermal-magnetic circuit breaker trip ratings.

NEMA Size Starter	Standard Circuit Breaker	Substitute	Short-Circuit Rating			UL Listed (X)
			230V	460V	575V	
1,2,3	TEC	THED	25	25	22	X
	SELI	SELT	100	100	25	X
	TECL	TEDL	100	100	100	X
4	TEC/SEL	SFLT	65	65	25	X
	SFLI	SFLT	100	100	25	X
	SFLI	—	100	100	100	X
5	SGLI	SGLT	100	100	65	X

Terminals for Field Wiring

Description	Will Accept Wire①	
	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 & 2 Type C Wiring	14-6②	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.

Evolution Series E9000 Motor Control Centers
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, 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 (panel or switchboard type)
- Instrument and transfer switches
- Electronic power meter
- Control relays
- Timing relays (pneumatic, motor-operated or electronic)

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

E

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.

Single Vertical Row of T.B.s				Double Vertical Row of T.B.s		
Space Units	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	20"W		20"W	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.

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

Evolution Series E9000 Motor Control Centers
Miscellaneous Units

Mounting Plates

Blank plates for customer use for field mounting of 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
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

Evolution Series E9000 Motor Control Centers
Miscellaneous Units

Mounting Plates

Description	Min. Enclosure Depth (inches)	Mounting Plate Dimensions (inches)		Part Number
		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 CB, which then feeds the M.L.O. panel.

Panel Type	System Voltage (Maximum)	Branch			Interrupting Rating② RMS Symmetrical Amps (in thousands)
		Type	Poles①	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.
- 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 Units③ AL, AQ	Space Units③ AE	UL Listed
12	100	2	2	X
12	225	2 1/2	2	X
18	100	2 1/2	2 1/2	X
18	225	2 1/2	2 1/2	X
24	225	2 1/2	2 1/2	X
24	400	4 1/2	3 1/2	X
30	225	3	3	X
30	400	4 1/2	3 1/2	X
36	225	3 1/2	3	X
36	400	5	4	X
42	225	3 1/2	3 1/2	X
42	400	5	4	X

AD

Number of Circuits	Panel Main Bus Rating (Amps) (X)	Space Units③	UL Listed (X)
12	100	2 1/2	
12	225	3	
18	100	3	
18	225	3 1/2	
24	100	3	
24	225	3 1/2	
30	100	3 1/2	
30	225	4	
36	100	4	
36	225	4 1/2	
42	100	4	
42	225	4 1/2	

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. 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.

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 Prot. Rating	Secondary Protection Rating
9 amps or more	250% maximum	125% or next higher standard rating
Less than 9 amps	250% maximum	167% maximum

Three-Phase Transformers (Delta-Y, no Taps⑥)

Fused Switch-100kAIC						Circuit Breaker						
KVA	Switch Size	Fuse Amps ④	Space Unit	UL Listed (X)	Notes	IC Rating (kA) 25	IC Rating (kA) 65	IC Rating (kA) 100	CB Trip	Space Unit ⑤	UL Listed	Notes (X)
380-120/208 Volts, 50 Hertz												
3	30	7	2.5	X				QMW		2.5		
9	30	17.5	3	X		THED	SEL	TEDL	30	3	X	
30	60	60	6	X	①②	THED	SEL	TEDL	70	4	X	①②
45	200	90	6	X	③	THED	SEL	SEP	150	4.5	X	③
480-120/208 Volts, 60 Hertz												
3	30	5.6	2.5	X				QMW		2.5		
9	30	15	3	X		THED	SEL	TEDL	20	3	X	
15	30	25	4	X		THED	SEL	TEDL	30	3.5	X	
30	60	45	4	X	①⑦	THED	SEL	TEDL	70	3.5	X	①⑦
45	100	70	4	X	③	THED	SEL	SEP	125	3.5	X	①⑦
600-120/208 Volts, 60 Hertz												
3	30	4.5	2.5	X				QMW		2.5		
9	30	12	3	X		–	–	TEDL	20	3.5	X	
30	60	40	4	X	①⑦	–	–	TEDL	70	3.5	X	①⑦
45	60	60	6	X	①⑦	–	–	TEDL	100	3.5	X	①⑦

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

Fused Switch-100kAIC						Circuit Breaker						
kVA	Switch Size	Fuse Amps ④	Space Unit	UL Listed (X)	Notes	IC Rating (kA) 25	65	100	CB Trip ⑤	Space Unit	UL Listed (X)	Notes
240-120/240 Volts, 60 Hertz												
0.50	30	3.2	1	X				QMW		1		
1	30	7	1	X				QMW		1		
3	30	15	1.5	X		THED	SEL	THEDL	30	1.5	X	
5	30	30	2	X		THED	SEL	THEDL	40	2	X	
10	60	60	2	X	①	THED	SEL	THEDL	70	2	X	①
15	200	80	4	X	①⑥	THED	SEL	SEP	150	3.5	X	①⑥
25	200	150	4	X	①⑥	THFK	SEL	SEP	225	3	X	①⑥
37.5	200	200	6	X	①⑦	THFK	SEL	SEP	225	4	X	①⑦
380-120/240 Volts, 50 Hertz												
0.50	30	3.5	1	X				QMW		1		
1	30	4	1	X				QMW		1		
3	30	12	1.5	X		THED	SEL	THEDL	15	1.5	X	
10	60	35	2	X	①	THED	SEL	THEDL	50	2	X	①
15	60	50	3	X	①⑥	THED	SEL	THEDL	90	2.5	X	①⑥
25	100	90	3	X	③	THED	SEL	SEP	150	2.5	X	③
37.5	200	125	4	X	⑥⑦	THED	SEL	SEP	125	4	X	⑥⑦
480-120/240 Volts, 60 Hertz												
0.50	30	2.8	1	X		THED	SEL	THEDL		1		
1	30	3.5	1	X		THED	SEL	THEDL		1		
3	30	10	1.5	X		THED	SEL	THEDL	15	1.5	X	
5	30	12	2	X		THED	SEL	THEDL	20	2	X	
10	30	25	2	X	①	THED	SEL	THEDL	40	2	X	①
15	60	40	3	X	①⑥	THED	SEL	THEDL	50	2.5	X	①⑥
25	100	70	3	X	③	THED	SEL	SEP	125	2.5	X	③
37.5	100	100	4	X	⑥⑦	THED	SEL	SEP	125	3.5	X	⑥⑦
600-120/240 Volts, 60 Hertz												
0.50	30	2.5	1	X				QMW		1		
1	30	4	1	X				QMW		1		
3	30	8	1.5	X				QMW		1.5		
10	30	20	2	X	①	THEDL	–	THEDL	40	2	X	①
15	60	35	3	X	①⑥	THEDL	–	THEDL	50	2.5	X	①⑥
25	60	60	3	X	③	THEDL	–	THEDL	100	2.5	X	③
37.5	100	80	4	X	⑥⑦	THEDL	–	THEDL	90	3.5	X	⑥⑦

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 I^2R losses. Capacitors installed near inductive loads can be used to reduce the reactive currents which flow through much of the system, thereby reducing I^2R 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.

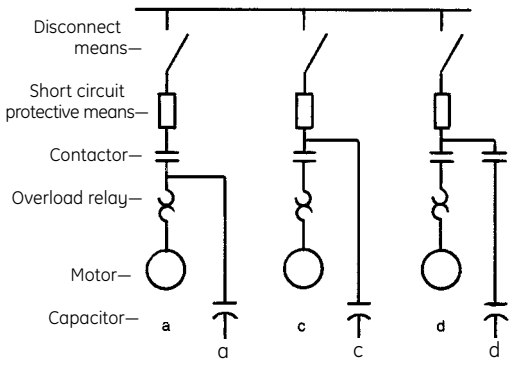
Capacitors Switched with the Motor
Capacitors used for power factor correction should be selected using the motor manufacturer's application data.

When the capacitor is connected ahead of the overload relay (sketch a, c or d), the overload current elements should be selected using the full-load motor current and service factor values specified on the nameplate of the motor. When the capacitor is connected on the load side of the overload heaters (sketch b), lower rated heaters are required, since the overload relay in this case will respond to the vector sum of the motor and capacitor currents. 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 d) 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 (2SIW, 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 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.

E

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 Ratings①

HP	Nameplate Volts	Full L RPM	Max 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. Visible through unit door.

All capacitor units are Dry Type.

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

Switching Capacitors Spearately
When a group of motors are so operated that some run while others are idle, a single capacitor bank (containing a number of individual units) can be connected to the motor control center bus to supply kilovars to the group. In these instances, a separate switching device is needed for the capacitors. The interrupting rating of the switching device should be at least as great as the short-circuit current available. Cable must be capable of at least 135 percent rated capacitor current. Switching device selections in the following tabulation are based on the continuous current of the capacitors.

- Low-Voltage Power Circuit Breakers 135%
- Fuses and Fusible Switches 165%
- Molded-Case Circuit Breakers 150%

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.

Evolution Series E9000 Motor Control Centers
Programmable Logic Control PLC

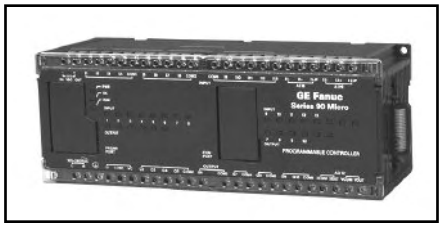
General

GE Fanuc Automation – Charlottesville, VA, has continually updated/improved its PLC products, which are mounted and wired in the Motor Control Center.

The Series Six PLC was the first in a succession of developments that established GE Fanuc in the marketplace. The Series Six was the first PLC to employ the family concept. Other industry firsts include the Workmaster, the first IBM-based programmer; the Series One, the first modular small PLC; Genius, the first distributed, intelligent I/O system; and the first embedded MAP 3.0 interface in a PLC. GE Fanuc's newest line of PLCs family.

GE Fanuc was one of the first companies in the United States to attain ESO 9001 registration from UL, CSA and BSI. This means that GE Fanuc has met the most comprehensive quality standard in the design, manufacturing and service of its products. Many of the PLC packages have UL, CSA and FM recognition.

Micro Series
8 Input 6 Outputs
16 Input 12 Outputs
85–265 VAC



Series 90-30
A versatile unit, the 90-30 is a small PLC with extended capabilities. It is used for MCC lineup sequencing, similar to the Series One PLC. However, with the capability of 512 I/O points, analog I/O, coprocessor modules, and genius communication, it approaches the definition of a larger PLC.

- Inputs — AC or DC (common), analog, high speed counter.
- Outputs — AC, DC, (Relay, Common, Isolated), analog display (special module). The isolated AC outputs have been tested with Size 1-4 starters for MCC use.
- Special — Motion control, high speed counter, third party modules

Field Control
Modular design gives you more choices. Each field control station consists of a bus interface unit or BIU, an optional field control processor for local logic, up to four field terminal bases and as many as eight field I/O modules. With field control, you can design a system that meets the precise needs of your application – and upgrade it easily as your application needs change.

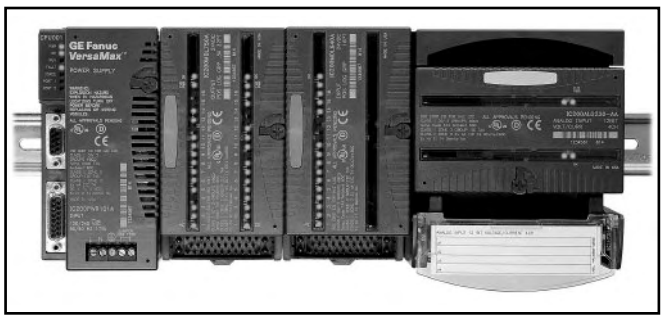
Series 90-70
The 90-70 system has the most capability in the Series 90 family and is used for system PLCs as well as process lineups of MCC's. It has a wide range of input and output modules as well as extensive communication capabilities. With the GE Fanuc authorized third party VME modules, the Series 90-70 is exceptionally versatile (including imbedded PCs, hard drives, motion control, etc.). The 90-70 is positioned to eventually supercede the Series Six Plus.

Genius I/O System
A system of inherently distributed inputs and outputs, which consists of:

- **Genius I/O Blocks** (mounted at the point of control). Input and outputs: AC, DC, isolated, analog, counter. Special Power Management Module
- **Bus Controller** (which serves as the interface between the genius system and the Series Six or Series 90 PLC or other industrial controllers)
- **Hand Held Monitor** (the portable diagnostic and configuration tool) used for trouble-shooting, monitoring, scaling and configuring the I/O Blocks.
- **Genius Bus** which provides communications between the bus controller, hand held monitor, and up to 30 I/O Blocks over a single shielded twisted wire pair.
- **Genius Local Area Network** can communicate between computers, PLCs, and genius blocks up to 7500 ft. using a single twisted pair.

Genius I/O Blocks are mounted, wired, and configured by the factory, and provide superior, built-in diagnostics which detect open circuits, short circuits, overloads, and a variety of other malfunctions which are beyond the power of conventional PLCs to detect.

VersaMax
The new VersaMax PLC combines all the advantages of the VersaMax I/O with a powerful CPU to provide a programmable controller that is easy to use, affordably priced and feature rich. With a modular and scalable architecture, the VersaMax PLC is ideal for standalone or distributed control applications up to 256 I/O. It can be networked as a slave to Profitbus-DP or you can choose a DeviceNet master module for easy third-party integration. The CPU features floating point math and easy configuration and programming.



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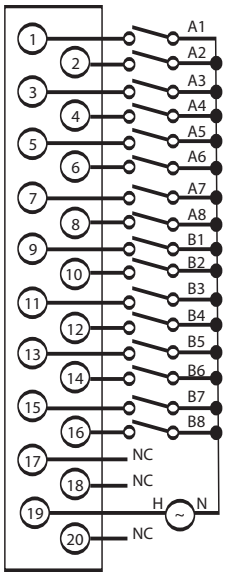
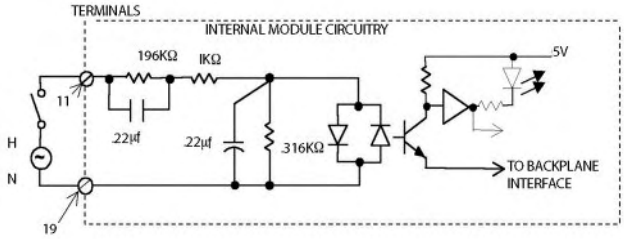
General
I/O Circuits

Standard Input Circuit – 120 Volt AC Input Module (VersaMax IC200MDL240)

Terminals **Field Wiring**

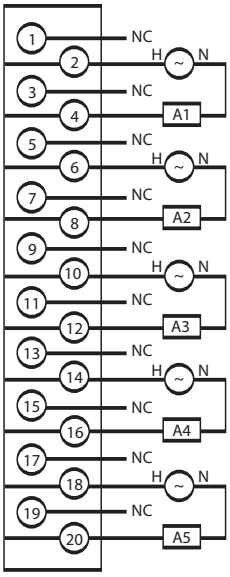


Rated Voltage	120 Volts AC
Indicators	One Lcd per point
Inputs per Module	16 (1 group with a single common)
Isolation	1500 volts RMS between field side an logic side
Current Draw	50 mA (typical) at rated voltage from backplane
Input Characteristics:	
Max. On-state	70 volts to 132 volts
Min. Off-state	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

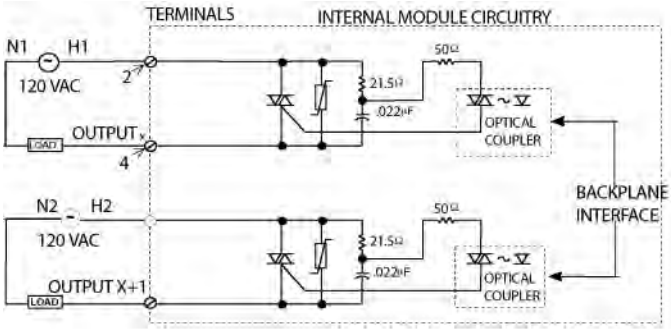


Standard Input Circuit – 120/240 Volt Isolated AC Output Module (VersaMax IC200MDL331)

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).

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Selection Application

MCC-PLC Selection and Application
EVOLUTION offers GE VersaMax I/O as a standard Distributed I/O. VersaMax will interface with most PLC's using an open network. The standard package offers isolated triac outputs and grouped inputs, one input and one output per FVNR starter. Distributed I/O contains the hard wiring within the MCC shipping split and provides a network interface to where the logic resides. This approach reduces field connections and reduces start up time. If custom configurations are needed use the following guide lines.

Determining I/O (Input, Output)
The voltage and current level requirements of I/O are needed to properly select. Input power for remote I/O is also required. A typical starter would be 120Vac Input, and 120Vac Output. A combination of DC In and AC Out may also be required. The recommended PLC Output for a GE starter coil is a two amp isolated Triac. The data needed to determine I/O should be represented in the elementary or functionally described in the specification. An example would be "a hard wired contact shall be provided for Positive feed back" or " provide a 4 to 20Ma signal to the drive".

- Discrete Input example: Push Button, Selector Switch, Starter Overload contact, Starter/Contactor Aux. Contact, Et.
- Discrete Output example: Coil on Starter/Contactor, Pilot Light, Alarm, and ET.

Note: Confirm output is sufficiently rated to handle inrush of coils.

- Analog Input example: Transducer or Drives Process signals, 4-20Ma. 0-10Vdc, 0-5Vdc, et.
- Analog Output example: Drives or other process controller.
- Communication: Typically Field I/O has a predetermined Protocol (communication Language)
  Example: A GE Genius block I/O or Field Control I/O uses Genius communications VersaMax I/O has the option for GENIUS, (ODVA) Device-Net or Profi-DP communication protocol.
  Most PLC Central Processing Units have communication ports. Communication Cards or Modules are also available.

The PLC manufacturer can determine correct CPU (CENTRAL PROCESSING UNIT) required. Functional specification should determine if ladder only logic is required or if floating point math is need or what kind of communication is needed if any. The requirement for Analog inputs or outputs will add the need for register memory to be considered. This kind of data will determine the CPU required. The input for PLC's Power Supply is also required.

Space only for field mounting of PLC is available. GE Industrial Systems can also provide logic programming if it is clearly defined but it is recommended that a local Control Systems Integrator provide this service. A computer is needed to program most PLC's. GEIS can exercise (test) the starter coils and its return wiring to the PLC if requested.

Please contact your GE FANUC office or distributor for more details and additional related PLC & OIT products.

GEIS will mount and wire Major Brands of PLC's. The customer can supply or we will source. Customers are responsible for Bill of Material of competitive brands.

Predefined Distributed I/O using GE VersaMax

Package A for 1 to 8 FVNR Starters

Qty	VersaMax	Description
1	IC200MDL240	Input 120Vac, 16 pt
1	IC200MDL331	Output 120Vac, 8 pt Isolated
3	IC200CHS002	I/O Carrier, Box style
1	IC200GBI001	Network Interface, (NIU) Genius, Slave
1	IC200PWR101	120/240Vc Power Supply

Package B for 1 to 16 FVNR Starters

Qty	VersaMax	Description
1	IC200MDL240	Input 120Vac, 16 pt
2	IC200MDL331	Output 120Vac, 8 pt Isolated
3	IC200CHS002	I/O Carrier, Box style
1	IC200GBI001	Network Interface, (NIU) Genius, Slave
1	IC200PWR101	120/240Vc Power Supply

Package C for 4 Drives & 4 FVNR Starters

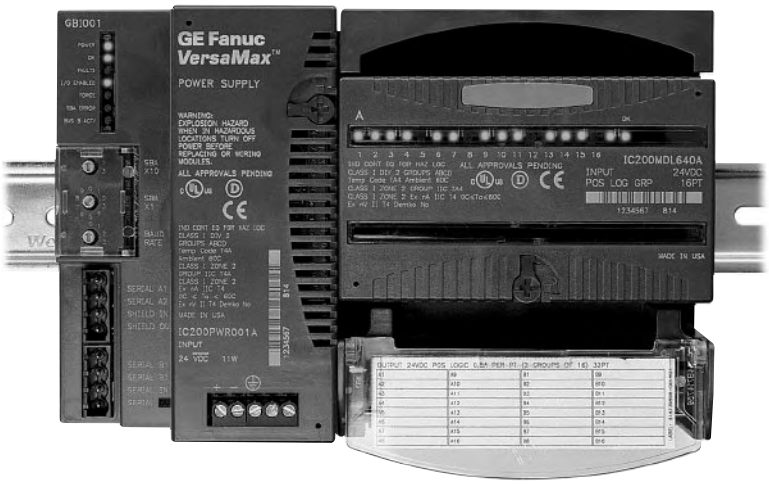
Qty	VersaMax	Description
1	IC200MDL240	Input 120Vac, 16 pt
1	IC200MDL331	Output 120Vac, 8 pt Isolated
4	IC200CHS002	I/O Carrier, Box style
1	IC200GBI001	Network Interface, (NIU) Genius, Slave
1	IC200PWR101	120/240Vc Power Supply
1	IC200ALG230	Analog Input 12 Bit Current/Voltage, 4 Channels 4-20ma, 010 Vdc, -10Vdc to + 10 Vdc
1	IC200ALG320	Analog Output 12 Bit Current, 4 Channels 4-20ma

Package D for 1 to 64 DeviceNet Nodes

Qty	VersaMax	Description
1	IC200PWR101	120/240Vc Power Supply
1	IC200CPU001	12k Memory, Two Ports RS-232 & RS-485
1	IC200BEM103	DeviceNet Master
1	IC200CHS006	Communication Carrier

Evolution Series E9000 Motor Control Centers
Programmable Logic Control PLC

Distributed I/O
VersaMax – Universal I/O



Diagnostics
- Network Status
- Fault
- Force
- Power

Easy to Use
- Set Bus Addresses with Rotary Switch – No Programming Required
- Automatic Addressing of I/O

Variety of Network Interfaces
- DeviceNet™
- Profitbus–DP
- Genius® Bus

Modular & Scalable
- Each Network Interface Supports Up to 8 I/O Modules & 256 Points

Wide Range of Discrete I/O
- 25 Modules
- 8, 16 & 32 Point Densities
- Mixed Discrete I/O
- High Speed Counter Inputs

Analog I/O Options
- 9 Modules
- RTD and Thermocouple
- 4 & 8 Channel Analog
- Mixed Analog I/O

LED Status Indicators
- Field Power
- Module OK
- Point Status

Snap-Together Carriers
- No Cable Interconnects
- DIN Rail Mounting
- Hot Insertion/ Removal of I/O

GE Fanuc Field Control

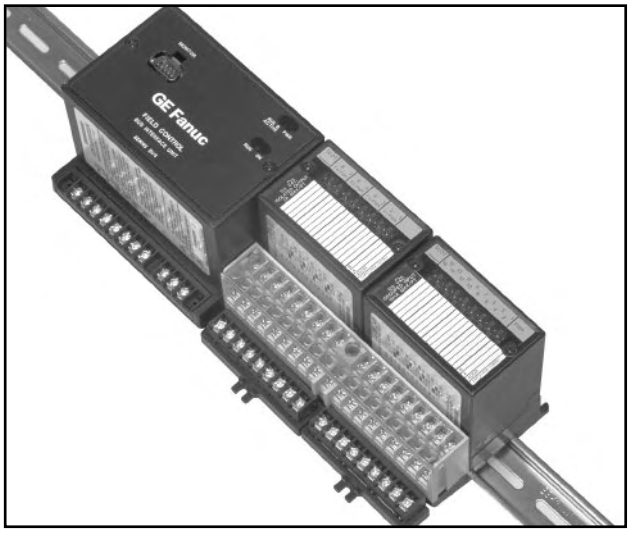
General
With Field Control, GE Fanuc engineers have refined proven technology to create a truly modular system for decentralized I/O and control. Each station of a Field Control network can act as a stand-alone controller, allowing for physical separation of logical control functions and faster processing times. As a result, Field Control is an ideal complement for the Series 90 PLC and Genius I/O a single low-cost solution for a variety of application needs.

A Local Solution to Field Logic
By providing simple logic solving at the local station, Field Control produces sharp increases in a system's raw speed and efficiency. Future versions of Field Control will accommodate additional programming options to build on these advances.

Initially, users will be able to program a Field Control station using standard GE Fanuc Logicmaster™ programming software used on Series 90-30 and Series 90-20 PLCs. In the future, they will be able to choose a programming language of their choice.

With Field Control, GE Fanuc engineers have created a single device that can accept field wiring and condition the signal for input to or output from the control system. There is no need for accessory terminal blocks installed solely to connect field devices with I/O. Designed to be installed and wired like a field terminal block, Field Control can reduce connections by up to one-half.

The One Choice for Both Local Panel Control and Decentralized I/O
Currently, control specifiers must purchase one I/O platform for local panels and a different platform for decentralized I/O. Field Control is an open platform, equally at home in both applications. Using the Genius bus and other available fieldbuses or communication options, Field Control provides an extremely cost-effective, space-saving option in both local panels and decentralized panel applications.



Open Architecture Provides the Solution for Diverse Applications
GE Fanuc embraces open architecture for two reasons. It helps our customers make the most of their existing investment in industrial automation. And it enables them to take advantage of new products as they are developed.

To address the diverse needs of all our customers, GE Fanuc will be opening the field processor component to third-party partners to develop additional fieldbus interfaces. In addition, I/O protocol has been published, and we will be encouraging the development of third-party I/Os and accessories.

Description

Bus Interface Units:	Genius BIU, 24 Vdc Power
	FIP BIU 24 Vdc Power
Field Terminal Bases:	I/O Base, Barrier Style, accommodates 2 modules
	I/O Base, Box style, accommodates 2 modules
	High Density Connector Base, accommodates 2 modules
	Aux. Terminal Block, Qty. 2 Barrier Style
	Aux. Terminal Block, Qty. 2 Box Style
	21" I/O Base Expansion Cable (only 1 per person)
Field Processors:	Micro Field Processor
Field I/O Modules:	24 Vdc Pos./Neg. Input 16 Pt. Grouped
	12/24 Vdc 0.5A Pos. Output 16 Pt. Grouped
	Analog Input Current 8 Pt. Grouped
	Analog Output Current/Voltage 4 Pt. Grouped
	48 Vdc Pos./Neg. Input 16 Pt. Grouped
	120 Vac Input 16 Pt. Grouped
	240 Vac Input 16 Pt. Grouped
	120 Vac 2A Output 8 Pt. Grouped
	12-120Vac Output 16 Pt. Grouped
	Relay 2A 8 Pt. 6 Form A/2 Form C Isolated
	125 Vdc Input 16 Pt. Grouped
	Analog Input Current 16 Pt. Grouped
	Analog Output Current 8 Pt. Grouped
	Thermocouple 8 Pt. Isolated
	RTD 4 Channel Isolated - 3 wire

Genius I/O System

General
The Genius I/O, a system of inherently distributed inputs and outputs, is designed to interface to any number of industrial controllers, including GE Fanuc PLCs, and third party CPUs. It can be used as the only I/O on a System or it can be mixed with the present rack-type I/O. Genius represents a complete rethinking of the role of I/O in industrial control. Genius Blocks are UL, CSA, FM and CSA hazardous environment approved. The Genius I/O system was made possible through two key General Electric technological innovations:

Smart Switch: A device with the built-in current and voltage sensors required for the extensive diagnostics available with Genius I/O. The smart switch allows detection of faults not only within the programmable controller I/O system, but also faults in the coils and other actuator devices under the control of the programmable controller, as well as the signal path from pushbuttons and other input devices. No other technology provides this level of fault detection.

Communications Controller: A token bus local area network controller which allows Genius I/O devices to communicate over a single-shielded twisted wire pair, rather than via bundles of point-to-point wires required in conventional systems.

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Genius I/O System Architecture
A simplified block diagram of the Genius I/O System is shown in Figure 2. The PLC, CPU and I/O rack shown are standard Series 90-70 units. The Genius serial bus connects I/O Blocks with a single shielded twisted pair up to 7500 feet from the Bus Controller.

Genius I/O Block
A microprocessor-based, configurable, ruggedized solid-state device to which field I/O devices are attached. Measuring approximately 9" x 4" x 3", I/O Blocks can be mounted virtually anywhere, such as in a draw-out unit of a motor control center or pushbutton station where it is common to have one input and one output per motor circuit. No separate rack or power supply is required. Field wiring is attached to a terminal assembly which separates from the removable electronics assembly. Thus, field wiring need not be disturbed to service the electronics. Due to the microprocessor and intelligent switching, inputs and outputs may be mixed arbitrarily on blocks. There are no dip switches nor replaceable fuses.

An EEPROM (Electrically Erasable Programmable Read-Only Memory) is located within the terminal assembly. The EEPROM stores all user-selectable options and retains these selections even during POWER OFF conditions. It can be read by the electronics assembly at any time and altered by commands from either the CPU or the Hand Held Monitor. The EEPROM is the only electronic device in the terminal assembly and has a long Mean-Time-Between-Failure (MTBF).

The electronics assembly contains the power supply, communications chip, microprocessor, smart switches and other electronic components required to perform Genius I/O functions.

Each I/O Block is keyed to prevent the insertion of a non-matching electronics assembly into a terminal assembly wired for a different power. Once inserted, the electronics assembly automatically reads the content of the EEPROM and initializes itself to match the configuration originally established for the I/O Block in that position. Table 1 lists the types of I/O Blocks currently available, as well as other basic system components.

Typical Genius I/O Unit

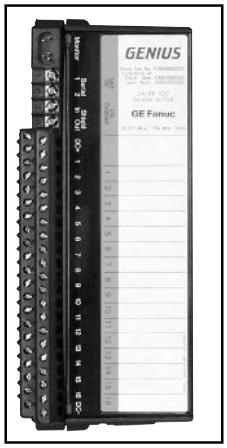
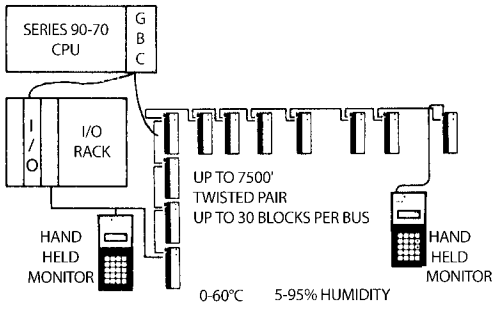


Fig. 2. Genius I/O System Block Diagram



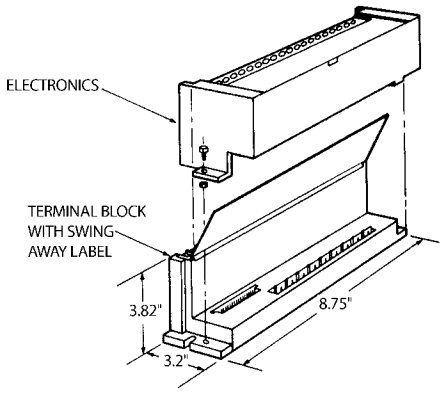


Fig. 3. Genius I/O Block Assembly

Genius I/O System

Table 1 – Genius I/O Components

Block Function	Nominal Voltage	Working Voltage	No. of Circuits
AC I/O	115 Vac, Grouped combination input and output	93-132 Vac 47-63 Hz	8 (1 x 8) 16 (1 x 16)
AC/DC I/O	115 Vac/125 Vdc Isolated combination input and output 4 groups of 2	93-132 Vac 47-63 Hz 105-140 Vdc	8 (4 x 2)
DC I/O	24-48 Vdc Source combination input and output	18-50 Vdc	16 (1 x 16)
DC I/O	24/48 Vdc Sink combination input and output	18-50 Vdc	16 (1 x 16)
AC Analog	Analog 115 Vdc Powered	93-132 Vac 47-63 Hz	4 In/2 Out
DC Analog	Analog 24/48 Vdc Powered	18-50 Vdc	4 In/2 Out
Other Components			
	Hand Held Monitor	93-132 Vac 47-63 Hz or 185-265 Vac 47-63 Hz	
	Bus Controller	With Diagnostics	
	Bus Controller	Without Diagnostics	
Metering	Power Trac Block	93-132 Vac 105-140 Vdc	120V-PT 5A-CT

MCC Space Requirements
Allow 18" height for the first two blocks, plus 12 inches for each additional set of two. This allows room for 120 volt power supply disconnect (or CPT). Maximum of 8 blocks per section, without ventilation.

Hand Held Monitor (HHM)
A portable diagnostic and configuration tool used for addressing, trouble-shooting, monitoring, scaling and configuring the I/O Blocks. The HHM plugs directly into any block or into the programmable controller, or it can be attached to any location on the twisted pair communications link. It is supplied in a case suitable for you to attach to your belt, or it can be panel mounted using the mounting bezel included with each HHM. It has an alphanumeric LCD display (4 lines x 16 characters) with microprocessor-driven prompts available in English, German, French or Italian. A key feature of the HHM is its ability to manually perform functions and force discrete and analog I/O, whether or not there is a programmable controller connected to the system. This greatly facilitates system check-out prior to full-scale operation.
The HHM includes:

- An LCD display capable of displaying 16 characters per line on four separate lines.
- Four display-labeled soft keys.
- A decimal keypad, including sign and decimal point keys.
- Four fixed-function keys.

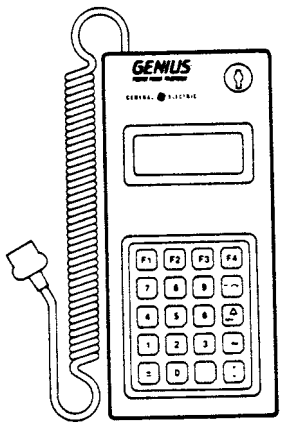


Fig. 4. Hand Held Monitor

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Genius I/O System

The Bus Controller serves as the interface between the Genius I/O systems and the industrial controller.

Bus Controllers are available for Series 90-70, Series 90-30 (for communications), Series Six PLCs, personal computers, DCSs, Industrial Robots, GE Drive Systems and others.

Genius I/O Bus
To connect Genius I/O elements together is a 150 kbit/sec serial token passing bus communications link formed by daisy-chain connection of twisted pair wire. It has high noise immunity (1500 volt common mode) and its operation is not affected by any block attachment, removal or failure. Each data bit is triply encoded for data integrity; error detection is further improved via cyclical redundancy check (CRC). Bus errors are reported automatically.

This link requires only one pair and can be Belden type 9302 (or factory approved equivalent) up to 100 feet (30 meters) in total length, or must be Belden type 9182 or Alpha type 9823 (or factory approved equivalent) up to 7500 feet (2258 meters). Belden type 9182 or equivalent is used in motor control center equipment.

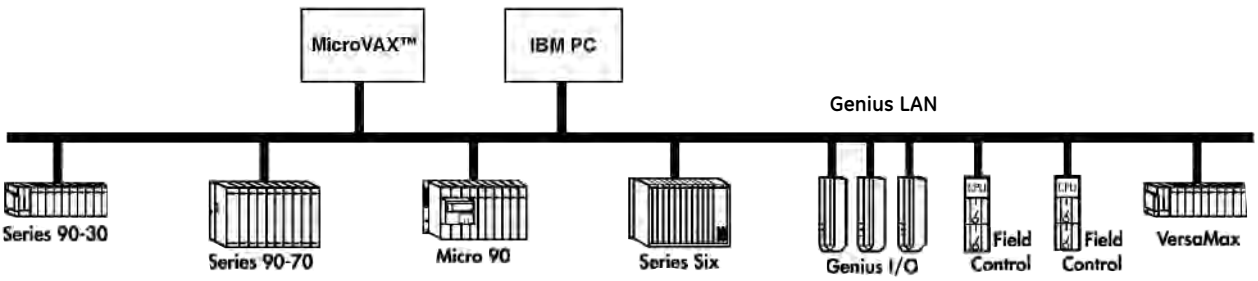
Diagnostics
The Genius I/O system provides advanced diagnostic capability. Error detection for discrete and analog circuits is summarized in Table 2. Such detection includes a variety of block failure modes, bus failures and failures within the Bus Controller. Of greater significance, however, is the diagnostic power for the attached I/O devices. On discrete blocks, the system detects open wires, short circuits, overloads, and a variety of other malfunctions which are beyond the power of conventional programmable controllers to detect. Many faults may be detected before they cause a malfunction in equipment. The Genius I/O can detect the integrity of a control circuit before the circuit must actually be energized by periodic "pulse-testing" under microprocessor control within a Genius I/O Block. Over temperature sensors are also built into each circuit.

On the analog blocks, the Genius I/O can detect an input open wire, mix high-level analog signals on one I/O Block (±10 volts dc, ±5 volts dc, 0-10 volts dc, 0-5 volts dc, 1-5 volts dc, or 4-20 mA), establish linear conversions from analog values to engineering units, process high-level and low-level alarms, and detect overrange and underrange analog signals. Analog blocks also allow you to establish different filter delays on inputs: short filter delays (5-10 msec) for fast system response in controlled low-noise environment or longer filter delays (20-1000 msec) to reject electrical noise in harsh environments. All of these faults are automatically reported to the HHM or CPU.

Table 2 – Genius I/O Diagnostic Features

Block	Discrete Point	
	Input	Output
Addition of Block	Open Wire	Failed Switch
	Power Loss①	Load not present
Loss of Block	Over Temp.	Overload
(incl. Communications		Short Circuit
Power, Memory Losses)		Over Temp.
		Power Loss①
Address Conflict	Analog I/O	
	Open Wire②	Underrange
Bus Error	Underrange	Overrange
	Overrange	
Bus Controller OK	Hi Alarm	
	Low Alarm	

① Isolated only.
② 1-5 volt DC (4-20mA DC) range only.



DEC and MicroVAX are trademarks of Digital Equipment Corporation.

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.

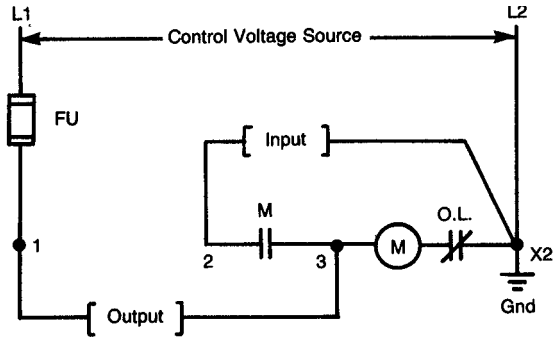


Fig. 5. Input and Output Connection

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.

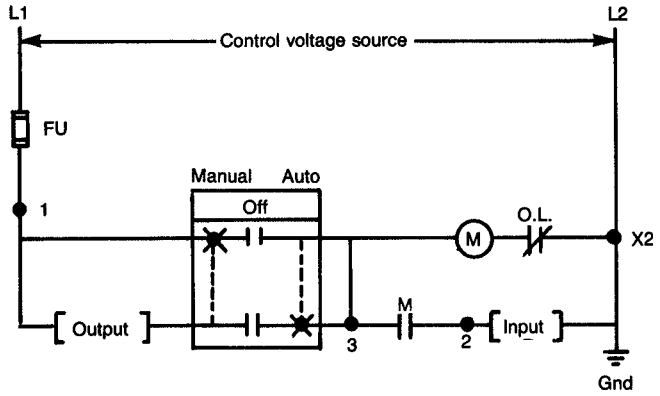


Fig. 6. H-O-A Connection

Starter Units with Individual Control Transformers

For starters having individual control power transformers all OUT-PUTs 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 X^2 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 electrically-isolated, normally-open auxiliary contact can be ordered with the GE 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 X^2 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 X^2 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 GE's standard split-type control terminal boards on all draw-out units, or with GE's pull-apart terminal boards.

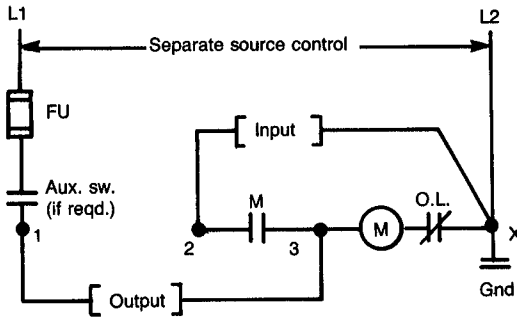


Fig. 7. INPUT and OUTPUT Connections for Separate-Source Control

Isolated Versus Non-Isolated Outputs

Isolated Outputs

GE's 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 GE's 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 GE'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.

F

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 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 GE's high efficiency Type KE 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.

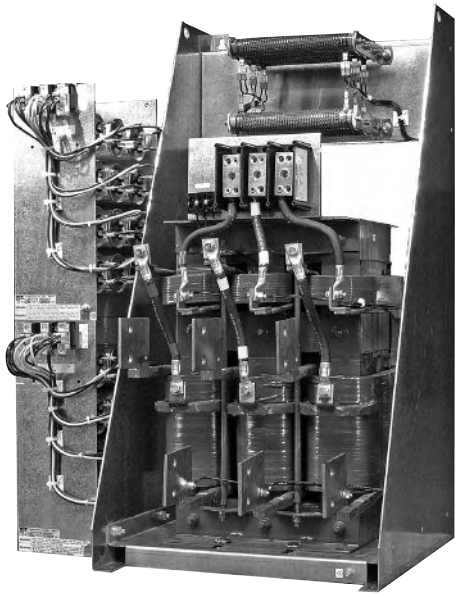
Load Filters
IGBT drives create voltage spikes at the motor. Motor insulation rating must be higher than these peaks. Motor should meet NEMA MGI part 31. If not, load filters may be required. Refer to page G4.

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

GE 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 diode or SCR rectifiers. For applications other than variable torque, contact the factory for filter selection.

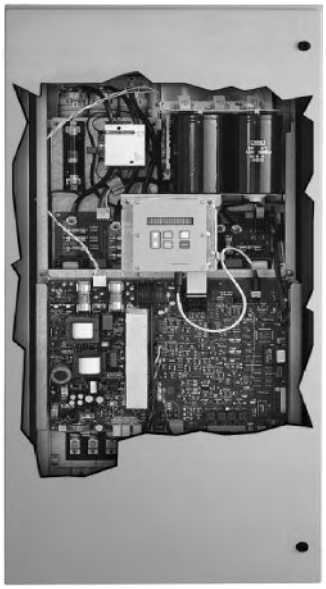
GE Matrix Harmonic Filters enable most AC drive systems to comply with the voltage and current distortion limits outlined in IEEE 519. A complete harmonic analysis and product selection tool is available at www.geelectrical.com. *Select Products > Capacitors > Matrix Harmonic Filter > Energy Savings Calculator and Harmonic Estimator*.

GE 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.



GE 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 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

GE 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. GE 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. General Electric 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 Fig. 1. For other applications refer to the Company.

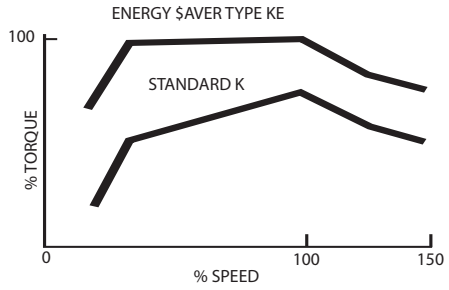
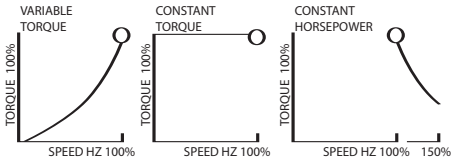


Fig. 1

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:

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

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.

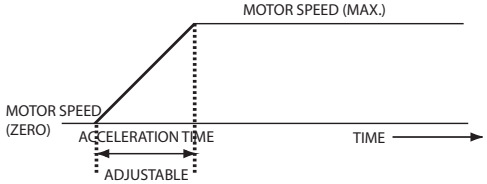
3. Multi Motor Drives
Multiple motors can be driven simultaneously by one drive unit. In order to select the proper inverter, total the individual motor full load currents and multiply the sum by a factor of 1.1. Select the inverter than can deliver the total current calculated. Each motor will require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

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

Where:
TA = Time to accelerate the driven load (in seconds).
ΔN = Change in speed (in RPM)
WK^2 = 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 G11 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.



G

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)

Wk^2 = 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 & Motor Considerations for AF 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 at 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 AF-650GP and AF-600FP drives:

Max. cable lengths between drive and motor without filters

Motor Insulation Level	1000V	1300V	1600V
AF-650GP & AF 600FP 460V Input	49 ft. (15M)	984 ft. (300M)	984 ft. (300M)
AF-650GP & AF 600FP 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 GE Consumer & Industrial representative.

Peak Voltage Insulation Rating (Horizontal, 60 Hz Only)

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

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.

Adjustable Speed Drives
AF-600 FP & AF-650 GP Series

Adjustable Frequency Drive
The AF-600 FP 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 ready-to-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 AF-650 GP 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 AF-650 GP 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 AF-650 GP provides flexibility across a wide range of constant torque applications.

The AF-600 FP and AF-650 GP 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.

AF-600 FP

AF-650 GP

G

Adjustable Speed Drives

Standard Specifications AF-600 FP & AF-650 GP

Environmental Conditions	
Enclosures	IP20 Chassis, IP00 Chassis
Installation Location	Do not install in locations where product could be exposed to dust, corrosive gas, inflammable gas, oil mist, vapor, water drops or direct sunlight. There must be no salt in the atmosphere. Condensation must not be caused by sudden changes in temperature. For use ataltitudes of 3280 ft. (1000M) or less without derating.
Storage Temperature	-25° to 65°C
Ambient Temperature	-10° to +50°C (24 hour average max of 45°C)
Ambient Humidity	5 to 95% RH (non-condensing)
Vibration	1 g.
Cooling Method	Fan Cooled all ratings. Fan Control Auto, 50% level, 75% level, 100% level adjustable
Standards / Approvals	CE, UL, cUL, and C-Tick Suitable for use on a circuit capable of delivering not more than 100,000 rms symmetrical amperes for 230V and 460V
Input Power Supply	
Rated Input AC Voltage	200-240 Vac, 3-phase, 50-60 Hz, +/- 10% V, 380-500 Vac, 3-phase, 50-60 Hz, +/- 10% V, 525-600 Vac, 3-phase, 50-60Hz, +/- 10% V, 525-690 Vac, 3-phase, 50-60 Hz, +/- 10% V
Maximum Voltage Imbalance	3% of rated supply voltage
True Power Factor	> 0.9 nominal at rated load
Displacement Power Factor	> 0.98
Switching On Input Power Supply	Maximum twice/minute up to 10HP, Maximum once/minute above 10HP
Environment According to EN60664-1	Overvoltage category III/pollution degree 2
DC Link Reactors	Built-In DC Link Reactors on all ratings
RFI Filters	Built-In RFI Filters to reduce noise generated by the drive. Meets industrial standards.
Output	
Rated Output Voltage	0-100% of supply voltage
Output Frequency	0-1000 Hz; 0-800Hz for 460V above 100HP and 525/600/690 V above 50HP
Switching on output	Unlimited
Accel/Decel Times	0.01-3600 seconds
Control Method	Sinusoidal PWM Control (V/Hz, Avd. Vector Control, Sensorless Vector, and Flux Vector with motor feedback)
Control	
Starting Torque	160% starting torque for 1 minute (constant torque), 110% starting torque for 1 minute (variable torque)
Carrier Frequency (Motor Noise	Selectable - 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 6, 7, 8, 10, 12, 14, 16 kHz
Torque Boost	**AF650 GP**-Selectable by up to 5 individual V/Hz settings in V/Hz Mode or by 0 - 300% setting of Torque Boost parameter in Adv. Vector Mode. **AF600 FP-** 0 - 300% setting to compensate voltage in relation to the load at low speed.
Acceleration / Deceleration Time	0.01-3600 seconds (4 acceleration and deceleration times are selectable via digital inputs. Acceleration and deceleration patterns can be selected from linear or S-curve).
Data Protection	Password Protection for Quick Menu or Main Menu, 0-9999.
Pattern Operation	Settings via Built-In Logic Controller Sequencer
Jump Frequency Control	4 jump (or skip) frequencies via parameter set to avoid mechanical vibration
Slip Compensation	Maintains motor at constant speed with load fluctuations
Torque Limit Control	Output torque can be controlled within a range of 0.0 to 160% (0.1 and steps)
8 Preset Speeds	8 programmable preset speeds selectable by 3 digital inputs
Built-In Communications	Drive RS-485, Modbus RTU, Metasys N2, or Apogee FLN P1
Trim Reference Setting	Available for speed reference offset via potentiometer, voltage input, or current input
DC Injection Braking	Starting frequency: 0.0-1000 Hz, 0-800Hz for 460V above 100HP and 525-690 V above 50HP Braking time: 0.0-60.0 seconds Braking level: 0-100% of rated current
Jogging Operation	Operation via On key or digital input (Fwd or Rev).
Auto-Restart After Power Failure	Restarts the drive without stopping after instantaneous power failure
Energy Savings	Controls output voltage to minimize motor loss during constant speed operation
Start Mode Function	This functionality smoothly catches a spinning motor
Real Time Clock	Built-In with programmable timed actions
Logic Controller (LC) Sequencer	
Logic Controller Events	Up to 37 types of Programmable Events
Comparators	Array of 6 Comparators
Timers	Array of 8 Timers, adjustable from 0.0 to 3600 sec
Logic Rules	Array of 6 Boolean Logic Rules
Logic Controller States	Array of 20 Logic Controller Action States
Process Controller (PID)	
Process CL Feedback Select	Up to 2 references. Selectable - No function, Motor Feedback, Separate Encoder, Encoder Option Module, or Resolver Option Module
Process PID Control	Normal or Inverse
Process PID Anti Windup	Disabled or enabled
Process PID Start Speed	0.0-200 Hz
Process PID Proportional Gain	0.00-10.00
Process PID Integral Time	0.1 - 10000.0 ms

Standard Specifications AF-600 FP & AF-650 GP *(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. Ddigital 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 arfter 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

AF-600 FP & AF-650 GP Standard Options

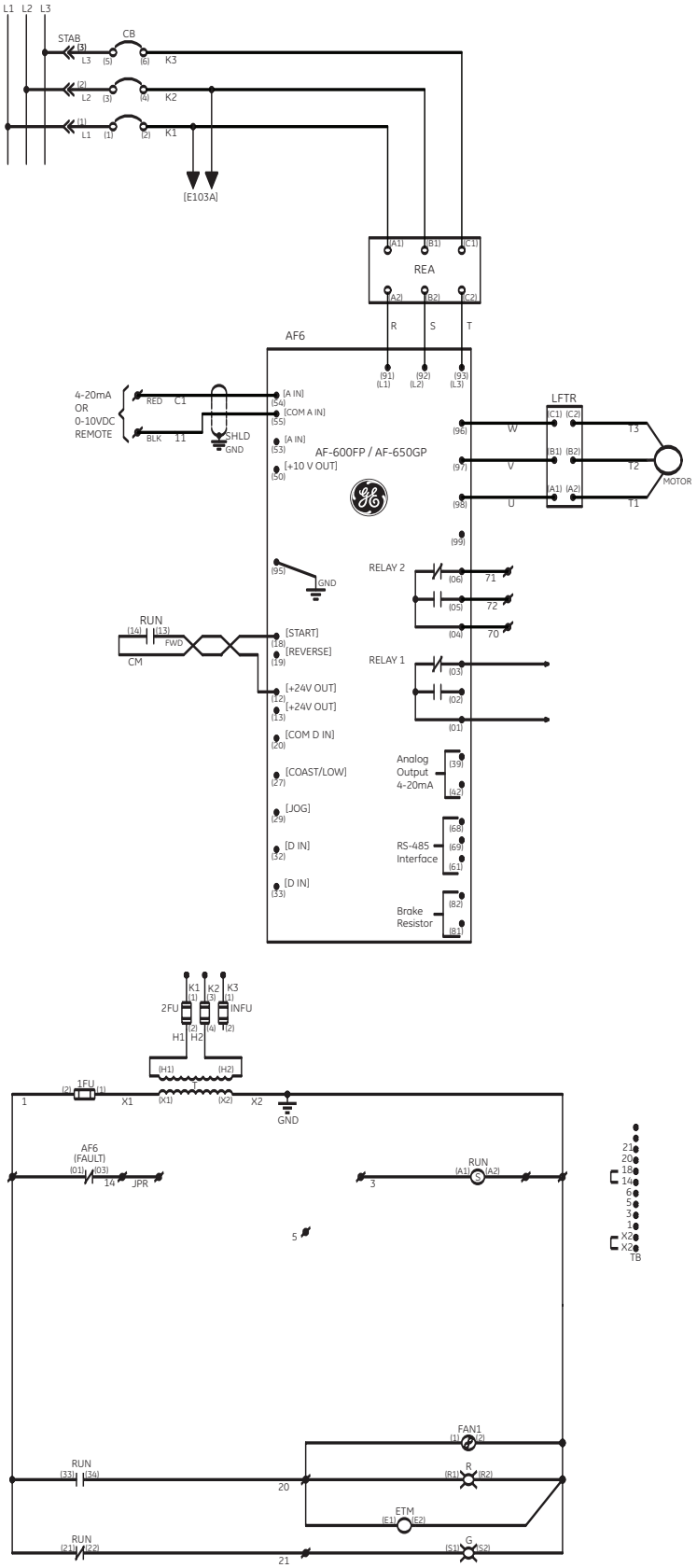
Line Reactor	3% Reactor is standard with the drive
DC Link Reactors	Standard with drive
Class AFII RFI	Standard with drive
Speed Control	The unit comes with a Keypad that can be used for Speed adjustmemt.
Outputs Relays	Drive come standard with two relays form C rated to 2A at 240 VAC.
Outputs Analog	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

AF-600 FP & AF-650 GP 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 AF-650 GP & AF-600FP. Supports Profibus DP V1 communications networks.
DeviceNet	DeviceNet internal mounted module for use on AF-650 GP & AF-600FP. ODVA certified device.
Ethernet IP	Ethernet IP internal mounted module for use on AF-650 GP/FP. 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 AF-650 GP & AF-600FP. (Available 2009)
ProfiNet RT	ProfiNet RT internal mounted module for use on AF-650 GP & AF-600 FP. (Available 2009)
LonWorks	LonWorks internal mounted module for use on AF-600 FP drives only. Supports LonWorks building automation communications networks
BacNet	BacNet internal mounted module for use on AF-60 FP drives only. Supports BacNet MSTP building automation communications networks.
Relay Output	Relay Output internal mounted module for use on the AF-650 GP and AF-600 FP. 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 us on the AF-600 FP drive only. Module Includes: 3 - Analog Inputs 0-10V, 0/4-20mA & 3 - Analog Outputs 0-10V, Battery Back-Up power for AF-600 FP's internal Real Time Clock
24V DC External Supply	24V DC External Supply internal mounted module for use on the AF-650 GP & AF-600 FP 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 AF-650 GP and AF-600 FP drives. Module includes: 3 - 24V Digital Inputs, 2 - PNP/NPN Digital Outputs, 2 - 0-10V Analog Inputs & 1 - 0/4-20mA Analog Output
Encoder	Encoder internal mounted module for use on the AF-650 GP. Module supports all 5V incremental encoders. Also supports Hyperface SinCos encoders.
Resolver	Resolver internal mounted module for use on the AF-650 GP 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 AF-650 GP drive. This module provides a safety input based on a single pole 24V DC input.

Adjustable Speed Drives

AF-600 FP & AF-650 GP Drives

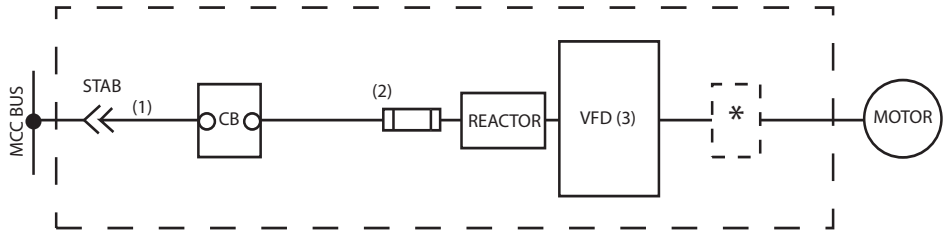


Note: See Section K for more circuits.

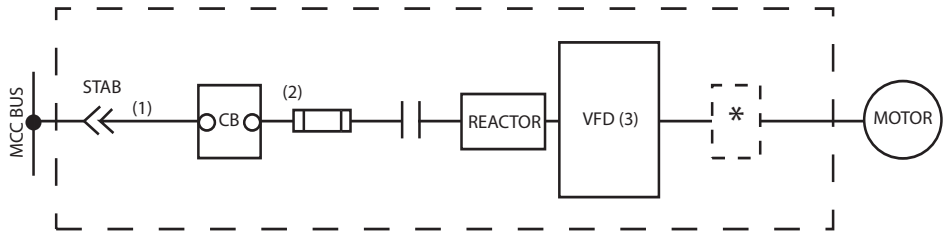
Adjustable Speed Drives

Drive Configuration in Motor Control Center Construction
Circuit Breaker or Fusible Switch Required for Disconnect

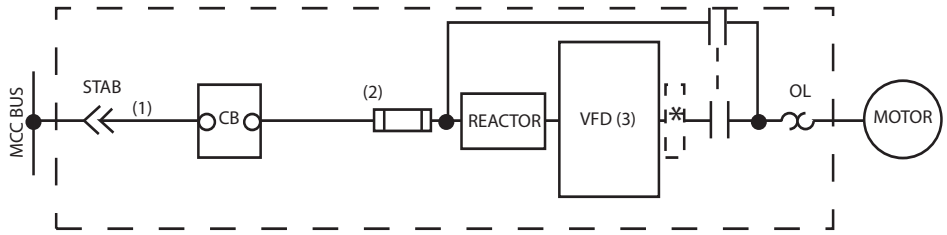
STANDARD VFD



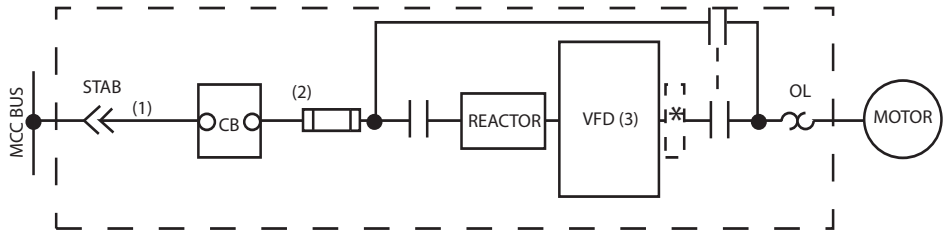
VFD WITH
LINE ISOLATION



VFD WITH
BYPASS FEATURE



VFD WITH
LINE ISOLATION
PLUS BYPASS FEATURE



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

* Load Filter option

Evolution Series E9000 Motor Control Centers
Solid-State Drives & Starters

Adjustable Speed Drives
Space Height & Assembly

AF-600 FP & AF-650 GP Space Height, 42 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	Width	X Height
Basic , LR, Bypass, & Isolation	X	5/5	5/5	3/3	5/5		SELI, SELT	15	2.5		
	X			5/7.5	10/10		SELI, SELT	15	3		
	X	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.

AF-600 FP & AF-650 GP 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 & LR	X	3/3	3/3	3/3	5/5		SELI, SELT	15	2		
	X					10/10	SELI, SELT, TECL	15	2		
	X	10/15	10/15	15/15	20/25		SELI, SELT	15	3		
	X					20/25	SELI, SELT, TECL	15	3		
	X	15/20	15/20	30/30	40/50		SELI, SELT	15	4		
	X					40/50	SELI, SELT, TECL	15	4		
		25/40	25/40	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 & Assembly

AF-600 FP & AF-650 GP 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	575/600V		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

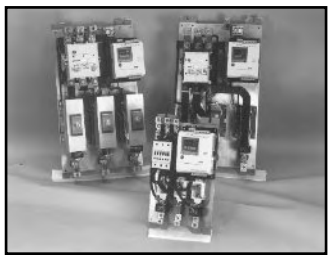
Solid-State Starters

Overview of ASTAT®-CD Plus & ASTAT®-IBP Plus

Applications

There are numerous applications where soft starting and limited current peaks are needed for the starting of squirrel cage induction motors. Traditionally, reduced voltage starting was accomplished using such electromechanical starters as star delta starters, autotransformer starters, stator resistance starters or by using part winding motors. These methods would provide a two, three or four step torque change by switching the motor voltage from reduced value to full voltage (in steps) after a preset time interval.

ASTAT Plus Solid State Reduced-Voltage Starters (also known as soft starters) use solid state devices to gradually increase the voltage from an initial preset level (initial torque) to full voltage over a selected time period. The same solid state devices may also be used to reduce the voltage for the deceleration of the motor should this be required in the application. This starting and stopping method provides smooth, stepless acceleration and deceleration of ac squirrel-cage induction motors. The solid state control circuitry also offers many additional functions to be accomplished using the ASTAT Plus.



Versatile Use

ASTAT Plus Solid State Reduced-Voltage Starters offer customer-configurable functions, including pedestal voltage, kick start (selectable), acceleration ramp, current limit, and soft stop (selectable). Typical applications include the following:

- Belted equipment
- Centrifugal fans
- Centrifuges
- Compressors
- Conveyors
- Crushers
- Extruders
- Fans and blowers
- Mixers
- Packaging equipment
- Pumps
- Textile machinery

Advanced Features

ASTAT Plus incorporates many additional advanced features to insure suitability for most applications.

Monitoring

- Motor Current
- Line Voltage①
- Line Power Factor
- Elapsed Time
- Fault History

Protection

- Password
- Lockout
- Undervoltage
- Overvoltage①
- Undercurrent①
- Overcurrent
- Long Start Time
- Stalled Rotor

Secondary Functions

- Secondary Ramp Up
- Secondary Ramp Down
- Tachometer Feedback
- Dual Motor Switch

Advanced features on ASTAT-CD Plus only

- Slow Speed (7% & 14%)
- Reverse Slow Speed (20%)
- Retry
- DC Injection Braking
- Energy Saving

The ASTAT-CD Plus also features two programmable inputs, three programmable (two programmable on IBP) output relays and RS232 serial communications control through ASCII protocol for local PC control and monitoring of up to 32 different stations.

① Monitors L1

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Solid-State Starters
Features and Benefits

Increase in productivity and reliability with the use of static soft starters.
The ability to start and stop the motor without steps or transitions lengthens the life of power-driven machines' mechanical parts, and it reduces stress on transmission belts and coupling parts. Consequently, maintenance time is reduced and machine/ facility lifespans are lengthened.

Improvement in acceleration/deceleration characteristics
By starting with the voltage ramp or, alternatively, by limiting current, the acceleration and deceleration ramp more closely fits the load characteristics. A kick start also may be selected in instances of high static friction load.

Protected motor
The soft starter protects the motor from overloads and from such incorrect operating conditions as loss of an input or output phase, blocked rotor, thyristor short circuit, etc.

Digital technology
The control system is based on the use of a highly specialized micro-controller that treats the signals digitally, thereby avoiding deratings and adjustments common to analog circuits. This type of control insures excellent precision and speed of execution. The control board uses surface-mounted devices (SMD) to increase equipment reliability.

High level of immunity
The control signals are optically isolated, and various levels of protection have been set up in the circuits to immunize the equipment against external disturbances and their harmful effects.

Easy to run and adjust
This unit can be used for a wide range of applications. A keypad and digital display make it easy to select a range of options that allow the equipment capabilities to be matched to application need.

Easy maintenance due to full monitoring
Advanced microprocessor technology allows starters to identify 21 (20 for IBP) different types of fault. The last four faults are retained in memory to facilitate troubleshooting and minimize downtime.

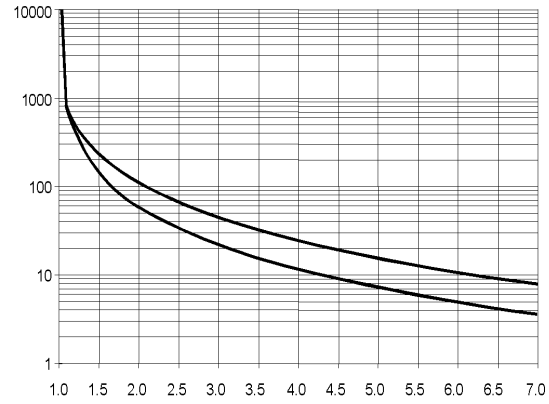
Pump control
The ASTAT Plus includes a pump control function that is more effective in fluid systems than standard soft starting and stopping. The control reduces fluid surges and hammering in a pipeline system. This method controls the motor speed by monitoring the motor parameters voltage control in a closed-loop system.

Advanced functions
The ASTAT-CD Plus includes advanced functions – e.g., linear acceleration ramp, programmable I/O, and connection to a computer by serial communication (RS 232) – as standard features.

Solid-State Starters
Types and Ratings

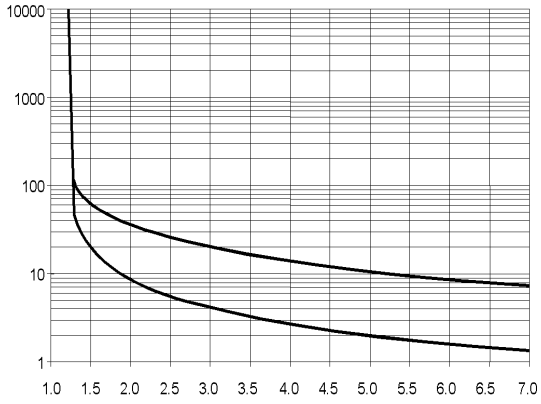
Thermal characteristics
ASTAT Plus allows motor protection according to IEC Class 10 or Class 20 and NEMA 10, 20 or 30, free selectable by the "O" parameter.

IEC Class 10



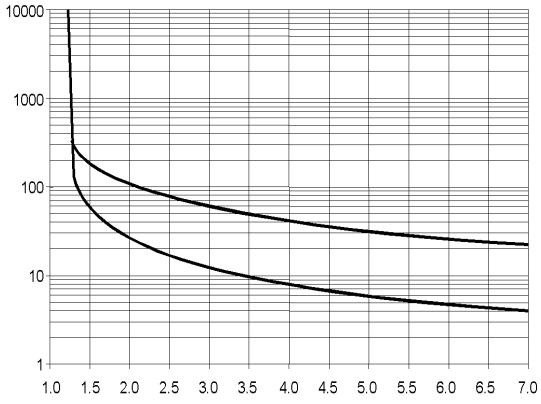
Multiples of Motor FLA Rating In

NEMA 10



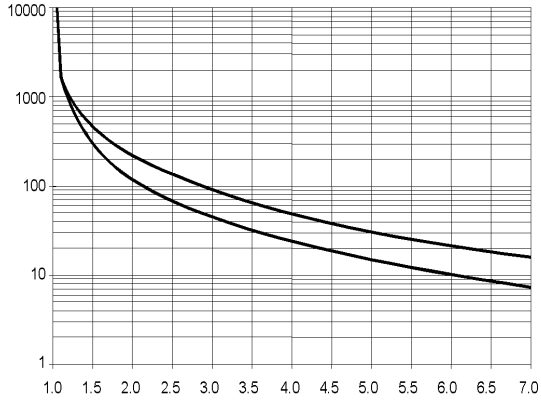
Multiples of Motor FLA Rating In

NEMA 30



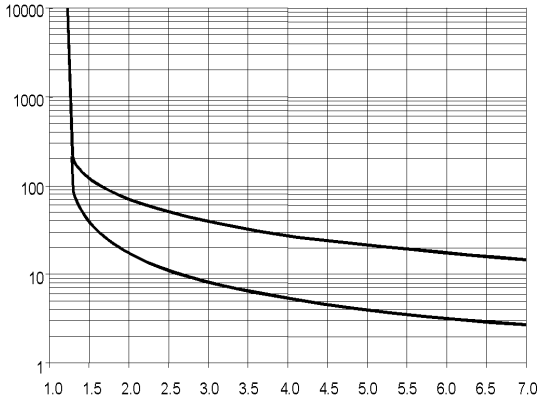
Multiples of Motor FLA Rating In

IEC Class 20



Multiples of Motor FLA Rating In

NEMA 20



Multiples of Motor FLA Rating In

Thermal memory
If the control voltage is not removed, the unit has a cool down characteristic, the time for cool down is 300 sec. after the overload trip. If the control voltage is removed after tripping, you must wait, at least, 2 minutes before the unit can be restarted.

Operations per hour (CD Only)①
Using a cycle T, with starting time of t1, running time of T-2t1 at rated current and OFF time of t1 sec. (minimum), the ASTAT-CD Plus allows the following operations per hour.

Starting Current	Operations / Hour. Starting time t1= 10sec.	Operations / Hour Starting time t1=20 sec.
2 Ir	180	90
3 Ir	160	60
4 Ir	30	10

① IBP is preset at 5 starts per hour.

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Solid-State Starters

General Specifications

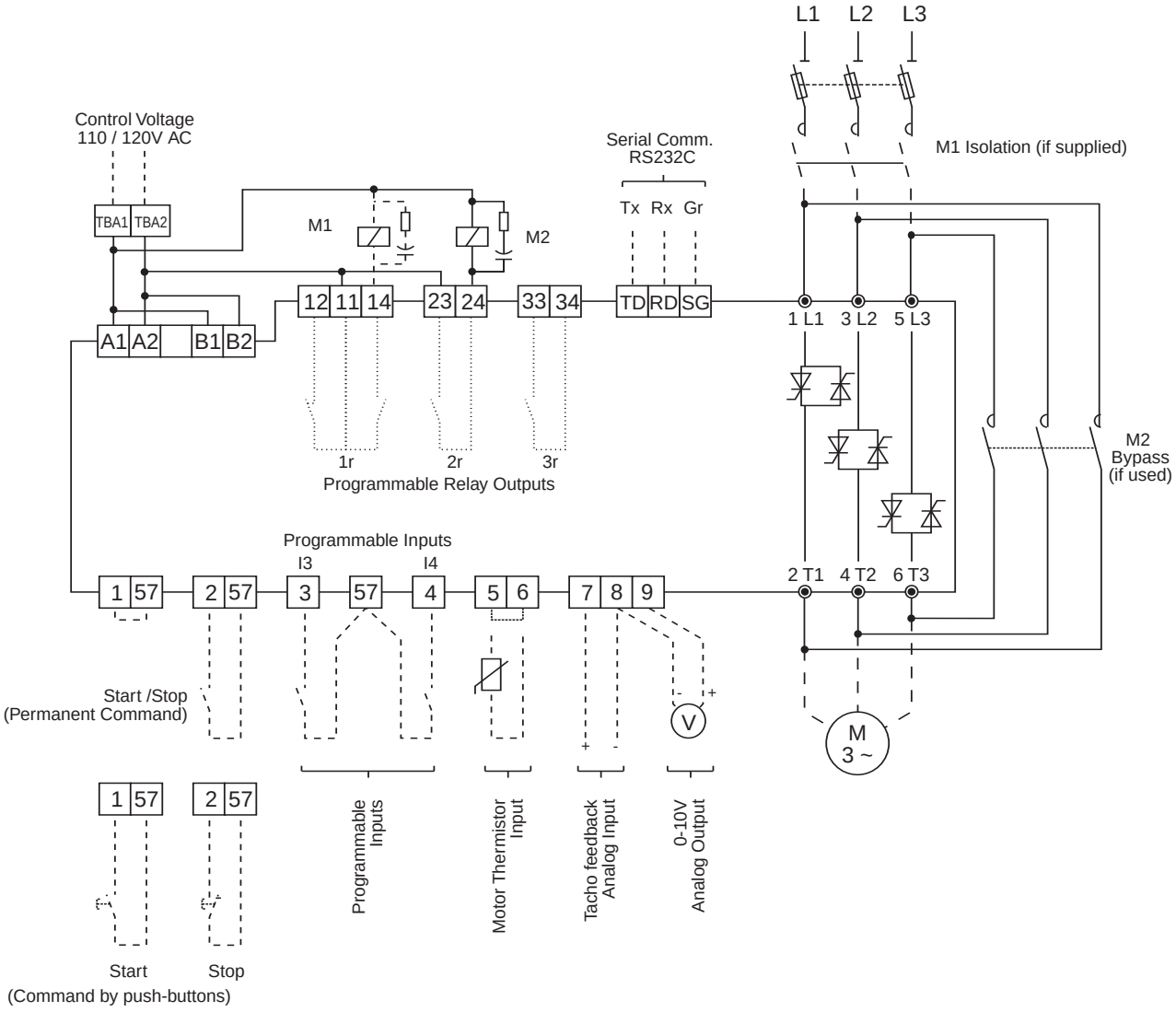
Voltage Ratings	3ph AC Systems CD up to 500V, IBP up to 600V		Up to 600V, +10%, -15% ASTAT- Plus series
Freq. Range	50/60	Hz	Control range of 45-65 Hz
Control Specifications	Control system		Digital system with microcontroller Starting ramp with progressive increase in voltage and current limitation
	Initial voltage (pedestal)	%	30 - 95 Un
	Starting torque	%	10 - 90 $M_{direct\ start}$
	Kick start	%	95 Un (90% $M_{direct\ start}$), adjustable 0 to 999 ms
	Motor unit ratio (N)		0.4 to 1.2
	Current limitation (starting)		1 to 4.5 (Ir/In) Max. 4.5 In (IBP) Max. 7.0 In (CD)
	Bypass (IBP)		Direct control of a bypass contactor
	Acceleration ramp time	s	1 to 45 on IBP 1 to 99 on CD (types: standard or linear ramp up)
	Energy savings (CD)	s	Output voltage reduction according to power factor
	Override (CD)		Fixed output voltage permanently equal to supply voltage
	Brake time by ramp	s	1 to 120 (1 to 99 in secondary ramp) adjustable independently of starting ramp time (types: standard, pump control or linear ramp down) IBP is limited to 1 to 60 sec. ramp
	DC braking (CD)		0 to 99 s.; 0.5 to 2.5 In
	Slow speed (CD)		Direct torque: 7% or 14% of nominal speed; reverse torque: 20% of nominal speed
	Retry (CD)		0 to 4 attemps, and 1 to 99 sec. retry time
	Monitoring		Motor current, line voltage, power, power factor and elapsed time
Running	External control		Start - Stop
	Acceleration phase		Adjustable time
	Permanent phase		Energy savings / Override choice
	Stop phase		Power cut-off / Ramp / DC braking (CD)/Pump control
Inputs / Outputs	Inputs		4 digital optocoupled. Two fixed (Start , Stop) , and 2 programmable (I3, I4)
			1 Analog 0-5VDC for Tachogenerator input feedback
	Outputs		3 programmable relays, (1r, 2r, 3r) [2 programmable relays, (1r, 3r) for IBP]
			1 Analog 0-10VDC output for current metering
Protections	Current limit		Adjustable from 1 to 4.5 (Ir/In) Max. 4.5 In (IBP) Max. 7.0 In (CD)
	Overload		IEC class 10 and 20 ; NEMA class 10,20 and 30 all selectable
	Cool-down time after overload trip	s	300 for reset (for IBP, see restart times)
	Loss on input phase	s	Trip at 3
	Thyristor short circuit	ms	Trip at 200
	Heatsink overheating	ms	Trip at 200
	Motor thermistor	ms	Trip at 200 if thermistor impedance > response value
	Loss on output phase	s	Trip at 3
	Stalled rotor	ms	Trip at 200
	Supply frequency error	Hz	If f < 45 or f > 65, will not start
	Over-current		100 to 150% In; trip time adjustable from 0 to 99 sec.
	Undercurrent		0 to 99% In; trip time adjustable from 0 to 99 sec.
	Over-voltage①		100 to 130% Un; trip time adjustable from 0 to 99 sec.
	Under-voltage①		0 to 50% Un; trip time adjustable from 0 to 99 sec.
	Error (CPU)	ms	60
	Memory		4 former errors
	Long start time	s	2 x ta (ta = acceleration ramp time)
	Long slow speed time (CD)	s	120
Environmental conditions	Temperature	°C	0 to +55 (derate output current by 1.5% / °C above 40°C)
	Relative humidity	%	95% without condensation
	Maximum altitude	m	3000 (derate output current by 1% / 100m above 1000m)
	Mounting position		Vertical
	Protection Degree		IP00, UL Open
Standards	CE, cUL, UL		CE Conforming IEC 947-4-2; UL, cUL conforming to UL508 (CE is not on IBP)
	Conducted & Radiated emissions		Conforming IEC 947 -4-2, Class A
	Electrostatic discharges		Conforming to IEC 1000-4-2, level 3
	Radio-electric interference		Conforming to IEC 1000-4-6, level 3 and to IEC 1000-4-3, level 3
	Immunity to fast transients		Conforming to IEC 1000-4-4, level 3
	Immunity to surge voltage		Conforming to IEC 1000-4-5, level 3

① Monitors L1

Solid-State Starters

I/O Wiring

ASTAT Plus' terminal layout and wiring configuration is shown in the diagram below.



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Solid-State Starters
Operating Modes

Starting and stopping

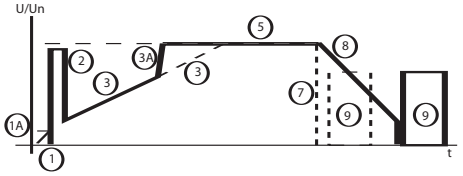
Initial ramp	(1)	5 main frequency cycles
Initial voltage (pedestal)	(1a)	30 to 95% Un (adjustable)
Kick start	(2)	95% Un. Enabled by parameter "Pxxx" to ON
Acceleration ramp (t_{ramp})	(3)	Voltage ramp up from1 to 99s (adjustable). Dual ramp possibility
		Linear speed ramp by tacho feedback also possible
	(3a)	Fast increase of output voltage when motor gets rated speed
Current limit	(4)	1 to 4.5 (Ir/In) Max. 4.5 In (IBP) Max. 7.0 In (CD)
Permanent state	(5)	Rated voltage (Override)
	(5a)	Rated current
	(6)	Energy savings. Enabled by "Fxxx" to OFF
Stopping modes	(7)	Motor power cut-off. "Sxxx" to OFF, "Cxxx" to OFF
(All selectable)	(8)	Deceleration ramp 1 to 120s (1 to 60s IBP) (adjustable). Secondary ramp 1 to 99 s (1 to 60s IBP)
		Ramp down modes available are: - Soft Stop -Voltage ramp down-. Enabled by "Sxxx" to ON - Pump control. Selectable by "Sxxx" to ON and "Cxxx" to ON - Linear ramp down (Tacho feedback needed)
	(8a)	Evolution of current in deceleration ramp mode
	(9)	DC brake (0 to 99s adjustable). Enabled by "Bxxx" to ON (CD)

Jog and linear ramp

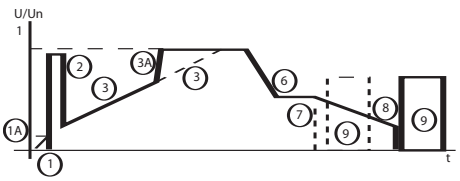
Linear acceleration and deceleration ramp		(1) (1a) Ramp time adjustable (Selectable by parameter "Dxxx" to ON)
Low slow (7%) and High slow (14%) speeds	(CD)	(2) (3) Enabled by parameter "Jxxx" to ON and "jxxx" to LO or HI
Reverse slow speed (20%)	(CD)	(3a) Enabled by parameter "Jxxx" to ON and "rxxx" to ON
Slow speed (7% or 14%)		(4) Enabled by parameter "Jxxx" to ON
Acceleration ramp		(5) Ramp time adjustable
Soft stop (deceleration ramp)		(6) Ramp time adjustable
Slow speed (7% or 14%)	(CD)	(7) Enabled by parameter "Jxxx" to ON
DC Brake	(CD)	(8) Current and time adjustables, Enabled by parameter Bxxx to ON, and bxx, Ixxx adjustments

Starting by voltage ramp

Override

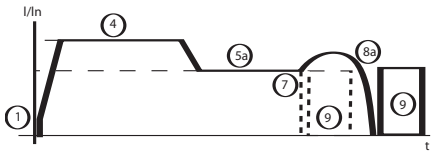


Energy Savings

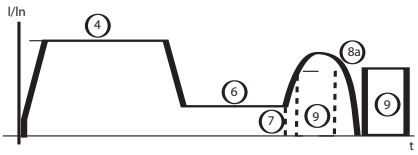


Starting by current limitation

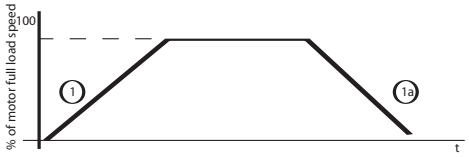
Override



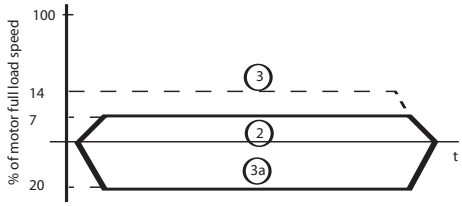
Energy Savings



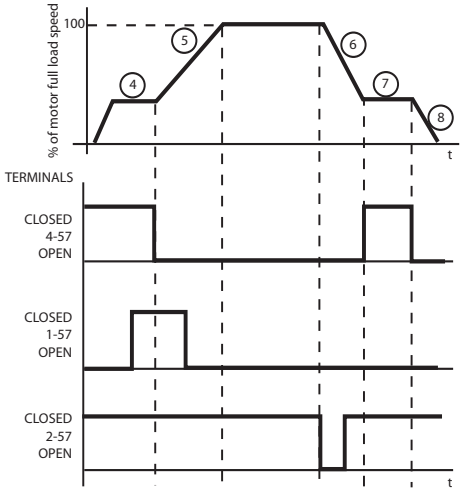
Linear ramp with T.G. feedback



Slow speed
Basic diagram



Slow speed
Full diagram



Solid-State Starters

ASTAT-IBP Plus Lockout

The number of starts per hour that the ASTAT-IBP Plus can initiate is limited and depends on the starting current and the ramp time. It has a lockout feature that is designed to protect the SCRs between starts. This parameter should be set before operating the ASTAT-IBP Plus. The lockout setting range is 0-45 minutes between starts. After starting a motor, the ASTAT-IBP Plus goes into lockout mode for the period set for the LKXX parameter. If a consecutive soft start is attempted within the time set for the LKXX parameter, error code E027 will appear on the display. See the ASTAT-IBP Plus User Manual for the appropriate value to program this parameter.

Note: If Soft Stop is enabled, the lockout times listed should be increased by 50%.

Note: If control power is lost, lockout time resets to two minutes.

Power Unit Size	Duty Cycle	Starting % of Frame Rating	Amps	30 sec. start		20 sec. start		10 sec. start		5 sec. start	
				Starts per hour	LK time between starts, min.	Starts per hour	LK time between starts, min.	Starts per hour	LK time between starts, min.	Starts per hour	LK time between starts, min.
K	Std	300%	165	6	10	15	4	30	2	30	2
	Hvy	450%	248	1	45	8	8	20	3	30	2
L	Std	300%	204	1	45	8	5	20	3	30	2
	Hvy	450%	306	—	—	—	—	8	7	12	5
Y	Std	300%	240	1	45	8	7	20	3	30	2
	Hvy	450%	360	1	—	—	—	—	—	—	—
M	Std	300%	315	6	10	12	5	28	3	30	2
	Hvy	450%	473	2	30	8	8	15	4	30	2
Z	Std	300%	390	4	15	10	6	20	3	30	2
	Hvy	450%	585	1	45	6	10	10	6	30	2
N	Std	300%	468	2	30	8	8	15	4	30	2
	Hvy	450%	702	—	—	4	15	10	6	20	3
P	Std	300%	576	6	10	14	4	30	2	30	2
	Hvy	450%	864	2	30	4	15	10	6	20	3
Q	Std	300%	744	4	15	9	6	24	3	30	2
	Hvy	450%	1116	—	—	—	—	6	10	12	5
R	Std	300%	906	2	30	4	15	10	6	25	3
	Hvy	450%	1359	—	—	—	—	—	—	6	10
S	Std	300%	1083	1	45	3	20	6	7	12	5
	Max		1161	1	45	3	20	8	7	12	5

Evolution Series E9000 Motor Control Centers
Solid-State Drives & Starters

Solid-State Starters
Standard Reduced-Voltage, Nonreversing with Primary Disconnect

ASTAT-IBP Plus Integrated By-Pass Space Requirement

Starter Type and Feature		Power Unit Size	Circuit Breaker Frame	Horsepower 200V	230V	460V	575V	IC (kA) @ 480V	Section Width	X-Height
ASTAT-IBP	STAB	K	SELT	15	20	40	50	42	20"	3
		L	SELT	20	25	50①	60	42	20"	3
		Y	SELT	25	25	60①	75	42	20"	3
		M	SELT	30	30	75	75	65	20"	3
		Z	SFLT	40	50	100	125	65	20"	4
		N	SGLT	50	60	125	150	65	20"	5
		P	SGLT	60	75	150	200	65	24"	5
		Q	SGLT	75	100	200②	300	65	24"+ 20"	4 + 2.5
		R	SGLT	100	100	250③	300	65	24"+ 20"	4 + 2.5
		S	SGLT	125	150	300③	350	65	24"+ 20"	4 + 2.5
ASTAT-IBP with J Fuses	STAB	K	SELT	15	20	40	50	100	20"	3.5
		L	SELT	20	25	50①	60	100	20"	3.5
		Y	SELT	25	25	60①	75	100	20"	3.5
		M	SELT	30	30	75	75	100	20"	3.5
		Z	SFLT	40	50	100	125	100	20"	4
		N	SGLT	50	60	125	150	100	20"	5
		P	SGLT	60	75	150	200	100	24"	5.5
		Q	SGLT	75	100	200②	300	100	24"+ 20"	5 + 2.5
		R	SGLT	100	100	250③	300	100	24"+ 20"	5 + 2.5
		S	SGLT	125	150	300③	350	100	24"+ 20"	5 + 2.5
ASTAT-IBP with Isolation & J Fuse	STAB	K	SELT	15	20	40	50	100	20"	3.5
		L	SELT	20	25	50①	60	100	20"	3.5
		Y	SELT	25	25	60①	75	100	20"	3.5
		M	SELT	30	30	75	75	100	20"	3.5
		Z	SFLT	40	50	100	125	100	20"	4.5
		N	SGLT	50	60	125	150	100	20"	5
		P	SGLT	60	75	150	200	100	24"	5 + 2.5
		Q	SGLT	75	100	200②	300	100	24"+ 20"	5 + 2.5
		R	SGLT	100	100	250③	300	100	24"+ 20"	5 + 2.5
		S	SGLT	125	150	300③	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

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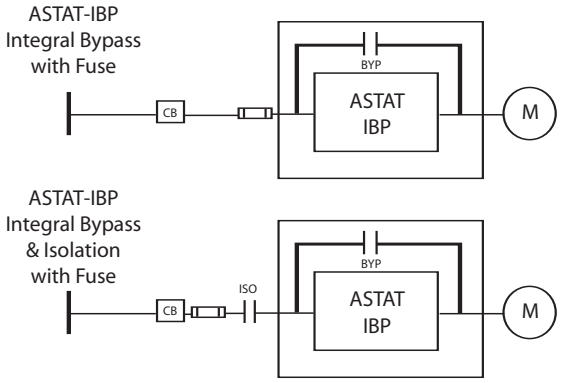
Standard Features

Fully Rated C-2000 Contactor
The ASTAT-IBP is supplied with a fully rated bypass contactor across the entire product line. Refer to factory if NEMA contactors are required.

Reduced Heat Dissipation
The SCRs are used only during starting and stopping of the motor. After the motor ramps up, the bypass contactor is engaged, allowing the ASTAT-IBP to run cool, thus eliminating the need for ventilation, large heat sinks, and fans, which are required for conventional solid state starters.

Solid-State Starters in MCC's Configuration in MCC



Evolution Series E9000 Motor Control Centers
Solid-State Drives & Starters

Solid-State Starters
Reduced-Voltage, 300/450%

ASTAT SS Starters Standard Duty (300/450% selectable)

Function	NEMA Size①	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	STAB-IN	25	20"		2X
		5-7.5	5-7.5	10		QC2IDP					
	2			15	15-20	27.8 A	SELT				
		10	10-15	20-25	25	QC2KDP		100	20"		2.5X
	3	15	20	30	30-40	54.8 A					
		20-25	25-30	40-50	50	QC2MDP					
	4	30		60	75	91.3 A					
		40	40-50	75	100	QC2QDP	SFLT		20"		4X
	5	50-60	60-75	100-125	150	187.0 A			24"		5X
		75	100	150	200	QC2SDP	SGT	65	30"	20"	3X 5.5X
	6	100	125	200-250	300	321.7A			30"	20"	3X 5.5X
		125-150	150	300	350	QC2TDP			30"		5.5X
					400	413.0A			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	STAB-IN	42	20"		2.5X
		5-7.5	5-7.5	10		QC2IDP					
	2			15	15-20	27.8 A	SELT				
		10	10-15	20-25	25	QC2KDP			20"		3X
	3	15	20	30	30-40	54.8 A					
		20-25	25-30	40-50	50	QC2MDP					
	4	30		60	75	91.3 A					
		40	40-50	75	100	QC2QDP			24"		5X
	5	50-60	60-75	100-125	150	187.0 A	SFLT		30"		5X
		75	100	150	200	QC2SDP					
	6	100	125	200-250	300	321.7A	SGT		30"	20"	5X 3.5X
		125-150	150	300	350	QC2TDP			36"	20"	5X 3.5X
			200		400	413.0A		65			
		200-250①	250-300①	400-500①	500	QC2UDP 547.8A	SKT				
SSS With By-Pass Isolation	1	.1-3	.1-3	.1-7.5	.1-10	QC2GDP 13.9 A	STAB-IN	42	20"		2.5X
		5-7.5	5-7.5	10		QC2IDP					
	2			15	15-20	27.8 A	SELT				
		10	10-15	20-25	25	QC2KDP			20"		3.5X
	3	15	20	30	30-40	54.8 A					
		20-25	25-30	40-50	50	QC2MDP					
	4	30		60	75	91.3 A					
		40	40-50	75	100	QC2QDP	SFLT		24"		5X
	5	50-60	60-75	100-125	150	187.0 A			30"		5X
		75	100	150	200	QC2SDP	SGT		30"	20"	5X 3.5X
	6	100	125	200-250	300	321.7A					
		125-150	150	300	350	QC2TDP			36"	20"	5X 3.5X
			200		400	413.0A		65			
		200-250①	250-300①	400-500①	500	QC2UDP 547.8A	SKT				

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

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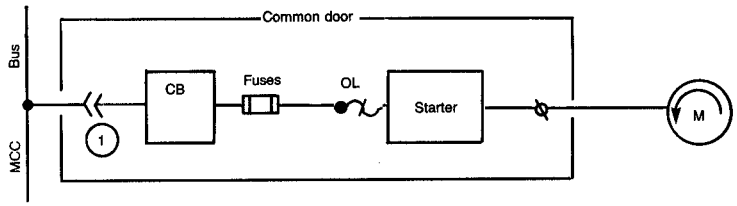
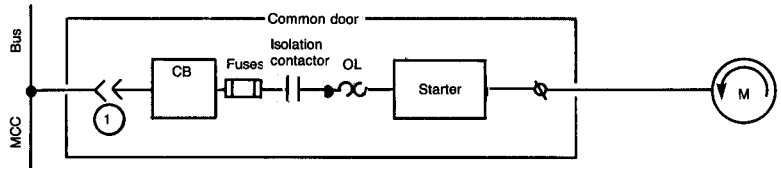
Solid-State Starters
Standard Reduced-Voltage, Nonreversing with Primary Disconnect

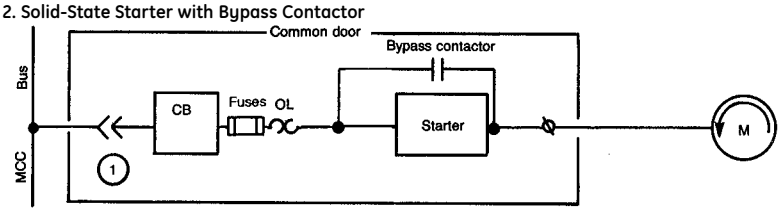


Options

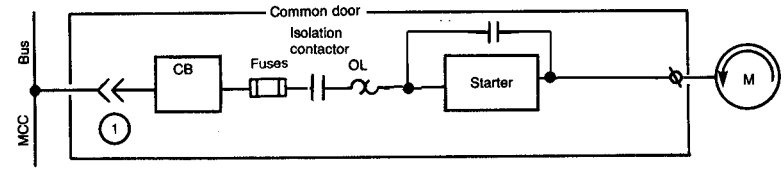
1. Solid-State Starter with Isolation Contactor



2. Solid-State Starter with Bypass Contactor



3. Solid-State Starter, Isolation & Bypass



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Mag-Break Motor Circuit Protectors②

Mag-Break motor circuit protectors were specifically developed to provide accurate and fast clearing of low-level faults, the type most prevalent in motor circuits. Because they are designed expressly for motor circuits in combination with overload relays, they minimize damage to motors and motor-control apparatus in addition to protecting motor branch-circuit conductors. Continuous-current ratings and adjustable instantaneous trip ranges have been designed to meet NEC code requirements concerning motor full-load and locked-rotor current. The instantaneous-trip point can be set low and precisely (just above motor inrush) assuring fault protection and eliminating nuisance tripping.

To minimize circuit damage, select precise, optimum trip points. Each pole of the Mag-Break breaker contains a current sensing element to trip the breaker instantaneously when the pre-selected current setting is exceeded. Mag-Break's unique magnetic system permits independent factory calibration of both HI and LO ends of the trip range. This feature provides field adjustability with superior accuracy and repeatability at all Mag-Break trip scale positions.

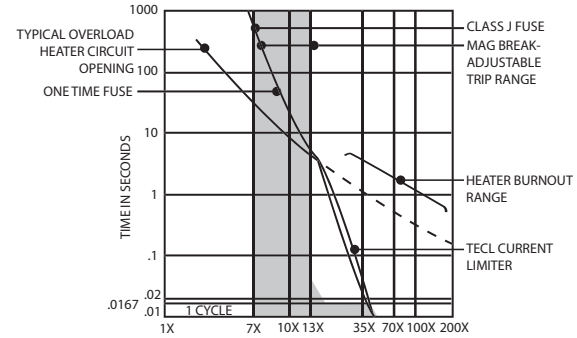
Mag-Break is field adjustable by means of simple screwdriver adjustments on the front of each breaker. The field-adjustable setting is continuous over the entire range from HI to LO and each breaker rating label contains a table converting setting position to amperes. An overcurrent on any pole will cause all three poles to trip simultaneously, thus preventing costly single phasing problems.

Features of Mag-Break motor circuit protectors include:

- No costly equipment modifications are required. Mag-Break motor circuit protectors are mechanically interchangeable in all respects with conventional circuit breakers of the same frame size.
- Conventional circuit breaker accessories such as under-voltage release, shunt trip and auxiliary switches can be used.
- Mag-Breaks include the Verifier™-Twist-to-trip – permitting the mechanical simulation of overcurrent tripping through actuation of linkages and latch surfaces not operated by the ON-OFF handle. Experience has shown that protective devices in industrial applications better maintain their original protective characteristics when regularly exercised.

- Widest trip setting ranges in the industry-specifically designed to meet control flexibility demands of modern motor installations.
- Highly accurate calibration over the entire range of trip settings.
- "Designed in" withstandability for use with slow trip overload relays – meets "6 times rated current for 30 seconds" criteria.
- Mag-Break covers an area of motor circuit protection not provided by any other class of device. In the range of 7-35X rated current, the region where most motor circuits failures begin. Mag-Break acts instantly to remove the fault from the system. At 13X (the maximum setting allowed by the NEC) other devices take 50 to 400 times as long.①

Times Rated Current



- Current Limiter (optional feature) – The Type TECL is a fusible current-limiter attachment that bolts to the load end of the Type Mag-Break motor circuit protector. The limiter provides for up to 100,000 amperes IC at 600 volts AC and is coordinated with the TEC so that normal short circuits will be cleared in the usual fashion. Only the unusual circumstances of a high fault will cause the limiter to function. Type TBC Mag-Break motor circuit protectors provide 100,000 amperes IC on 225 ampere and larger frame sizes. Type TBC protectors are similar in size and operation to Tri-Break circuit breakers and employ current limiters integral to the frame as opposed to an add-on limiter such as the Type TECL. TECL is used for 600V applications.

① All data based on NEC requirements and manufacturer's recommendation.
② See Section J for application information.

Spectra RMS – Mag-Break Motor Circuit Protectors

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

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

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

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

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

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

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

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

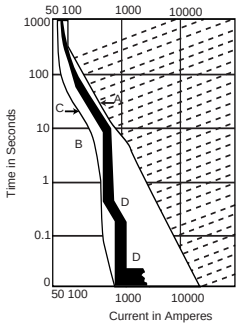
Use of this two-tiered time-current curve prevents nuisance tripping due to magnetizing inrush current, without compromising superior short-circuit protection during motor acceleration as indicated on page H3.

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

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

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

Motor Circuit Protection using Mag-Break Motor Circuit Protectors



Spectra RMS Mag-Break Motor Circuit Protector and Rating Plug Current Ratings

Circuit Breaker Frame	Maximum Frame Amperes	Available Rating Plugs, Amperes
SE-Frame	7	3 & 7
	30	15, 20, 25 & 30
	60	40, 50 & 60
	100	70, 80, 90 & 100
	150	110, 125 & 150
SF-Frame	250	70, 90, 100, 110, 125, 150, 175, 200, 225 & 250
SG-Frame	400	125, 150, 175, 200, 225, 250, 300, 350 & 400
	600	250, 300, 350, 400, 450, 500 & 600
SK-Frame	800	300, 400, 500, 600, 700 & 800
	1200	600, 700, 800, 1000 & 1200

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 SE- and SF-Frame Spectra RMS circuit breakers are used interchangeably in Spectra RMS molded case switches. SG- and SK-Frame molded case switches use the same bolt-on termination lugs used with Spectra RMS circuit breakers.

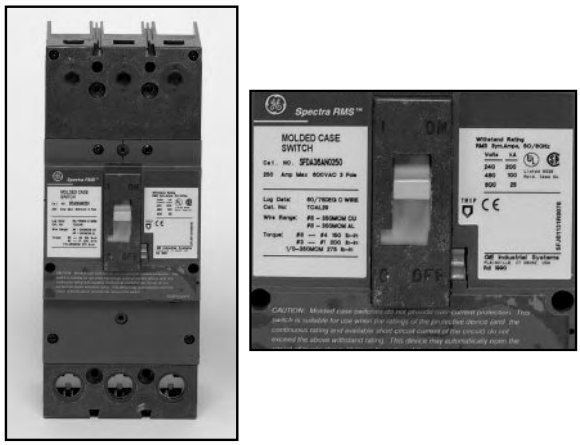
External Accessories. The full range of external circuit breaker accessories offered for use with Spectra RMS circuit breakers and Mag-Break motor circuit protectors, are available for molded case switches. In addition, plug-in bases, motor-operated mechanisms, mechanical interlocks, and the full complement 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	12,750
	1200	12,600

Spectra RMS Molded Case Switch



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

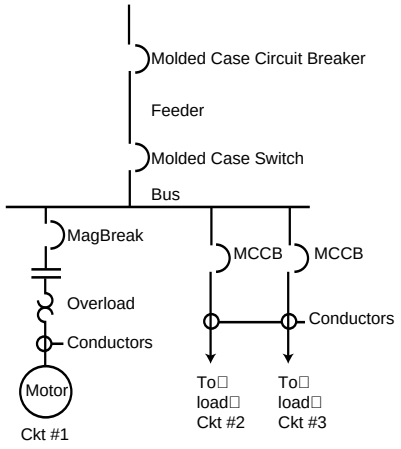
A common application of Spectra RMS molded case switches is illustrated below. The figure shows a system containing three branch circuits.

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

Spectra RMS molded case switches are excellent circuit disconnect devices for those applications where both the advantages of molded case switch construction are desired, and where the available short-circuit current is less than the switch withstand rating.

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

Spectra RMS Molded Case Switch Application



Spectra RMS Molded-Case Switch Current Ratings

Molded Case Switch Frame	Maximum Ampere Rating
SE-Frame	100 & 150
SF-Frame	250
SG-Frame	400 & 600
SK-Frame	800 & 1200

Heavy Duty Fusible Disconnects

E9000 Switch (30-200 Amps)
The E9000 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 withstandability and interrupting ratings, and it is UL listed for use in Evolution MCC.

MCS 400 & 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. Evolution 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.

Withstandability – 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 withstandability 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 full-load 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."

HPC High-Pressure Contact Switches

Construction Features

GE Type HPC switches are UL Listed in accordance with Standard 977, Fused Power Circuit Devices. The over-center toggle mechanism provides stored energy, quick-make/quick-break operation. Multiple spring-loaded high-pressure current-carrying contact arms and an arcing contact arm provide excellent current carrying capability without sacrificing high interrupting fault performance. These switches can interrupt, on a make and break basis, a minimum of 12 times their nameplate rating without fuse assistance at 600 volts AC. Complete HPC switch and Class L fuse coordination is therefore achieved for all levels of fault current up to 200,000 RMS amperes symmetrical at 600 volts AC maximum. Type HPC switches used as service disconnects comply with the National Electrical Code Article 230-98 and Article 230-95 for adequate short-circuit current and ground-fault protection. HPC switches with integral ground fault, when provided with 120 volts AC external control power, permit compliance with NEC Article 230-95, which requires ground-fault protection system testing when first installed.

- 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 withstandability– 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–Extra-heavy-duty, low-torque rotary-operated closing mechanism. L-handle 800-1600 amperes; T-handle 2000 amperes.
- Emergency open–Quick Break–Finger-tip "OFF" button instantly opens the breaker contacts.
- Positive Door and switch interlocking–Separate fuse access door is not required.
- Fuse mounting bolts with captive washers–For ease of mounting fuses.

Product Forms

- Top feed–Line terminals at top of switch.
- Bottom Feed–Line terminals at bottom of switch; fuses are de-energized when switch is in OFF position. Same size as top feed.

Options Available

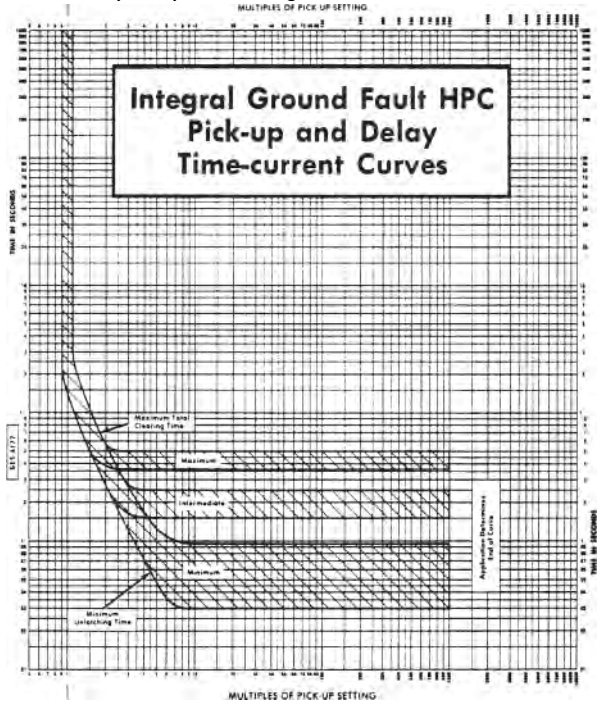
- Manual Operation–For manual, high-interrupting capacity disconnects not requiring remote tripping and/or ground-fault protection.
- Integral ground fault–Incorporates a solid-state, inverse-time and fixed-time response. Ground-fault function is self-powered and has field-adjustable ground-fault current and delay time settings for maximum coordination and selectivity. Through 3000 amperes, switches with integral ground fault are the same size as manual switches.
- Electric Trip–For remote tripping or for use with Ground-Break® components. All 800-2000 ampere electric trip switches are the same size as manual devices.
- Blown-Fuse Protector–Provides single-phase protection by tripping switch when a fuse blows or when switch is closed with a blown fuse or no fuse installed. Suitable for system voltage of 208 to 480 volts AC. Mounted internally. Does not provide protection of single-phasing of the power source.
- Auxiliary switch–Provides remote indication of main contact position.

HPC switch with integral ground fault

Manual HPC switch

Switch elements are Type "AB," single-pole, double-throw. Switch element ratings are 0.25 amperes at 250 volts DC; 0.5 amperes at 125 volts DC; 6.0 amperes at 240 volts AC.

Ground-fault pickup and Delay Time-current curves



H

Power Break II Insulated Case Circuit Breakers

General Description
The GE line of Power Break II insulated case circuit breakers offers the rugged, reliable type of system protection critical for heavy-duty applications. Power Break circuit breakers are rated up to 200,000 amperes RMS symmetrical interrupting capacity without fuses or current limiters. The Power Break II design consists of two physical envelope sizes: 800, 1600, 2000, 2500; and 3000, 4000 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.

MicroVersaTrip Plus Trip Unit
The enhanced MicroVersaTrip Plus trip units utilize a digital, LCD display with a five-button keypad to provide local set-up and readout of trip settings. A built-in battery allows cold set-up (no phase or control power required). A three-phase ammeter and trip indicators are standard, as is a hinged plastic cover with provisions for sealing to allow tamper-resistant installation. The trip unit digitally measures the current waveform in each phase to determine the true RMS value of the current, regardless of the waveshape. MicroVersaTrip Plus trip units provide accurate, predictable overload and short circuit protection for distribution systems that include variable speed drives, rectifiers, induction heating, and other loads that cause high harmonic distortion as well as standard circuits. They provide maximum breaker-to-breaker selectivity and custom load protection. Short-time and ground fault functions include the flexibility of coordination with or without an I^2t ramp and are also available with high range instantaneous.

Standard
- 3-phase Ammeter with ±2% accuracy.
- Adjustable Long-Time (L) pickup, 0.5-1.0X, with four delay bands.
- Adjustable instantaneous (I) pickup, 1.5-10X without short time, 15X with short time–thru 2500A and 13X for 2500A.
- Local Overload, Short Circuit, and Short-Time Trip Indicators with overload pickup warning.
- Test set initiated trip indication.

Options
- Adjustable Short-Time (S) pickup, 1.0-9.0C, and delay (3 bands) with I^2t ON/OFF selection and trip indicator
- Adjustable Ground Fault (G) pickup, 02.-0.6S, and delay (3 bands) with I^2t ON/OFF selection and trip indicator.
- Adjustable High range instantaneous (H) multiples of short-time rating.
- Zone Selective Interlocking for ground fault (Z1) or ground fault and short time (Z2).

MicroVersaTrip PM Trip Unit
The MicroVersaTrip PM trip unit adds power management system capability, including advanced metering, and protective relays to the basic functions of the MicroVersaTrip Plus. MicroVersaTrip PM trip units communicate directly on the GE Power Leader communications bus (commnet).

Options
- Power Leader Communication System Link with user-selectable address assignment for Commnet communications.
- Metering.
- 3-phase Voltmeter, ±1.5@ 1X, configurable for Wye and Delta systems.
- Frequency Meter, ±1 Hz.
- kW Meter, ±3.5%
- kVa Meter, ±3.5%
- kWh Meter, ±3.5%
- Protective Relaying—User selectable in any combination from 1 to 5 relays
  - — Current Unbalance Relay
    - — Adjustable pickup, 10-50%
    - — Adjustable delay, 1-15 seconds, OFF
  - — Undervoltage Relay
    - — Adjustable pickup, 10-50%
    - — Adjustable pickup, 1-15 seconds, OFF
  - — Overvoltage Relay
    - — Adjustable pickup, 10-50%
    - — Adjustable pickup, 1-15 seconds, OFF
  - — Voltage Unbalance Relay
    - — Adjustable pickup, 10-50%
    - — Adjustable delay, 1-15 seconds, OFF
  - — Power Reversal Relay
    - — Adjustable pickup, .01-3.00 per unit
    - — Adjustable delay, 1-15 seconds, OFF

Spectra RMS Circuit Breakers and THED/TEDL 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 including SE150.

MicroVersaTrip Plus Trip System
SG600 and SK1200 are optionally available with the MicroVersaTrip Plus trip system which offers expanded functionality in the same space-saving size of standard Spectra RMS breakers.

Standard
- 3-phase Ammeter with ±4% accuracy.
- Adjustable Long Time (L) pickup, 0.5-1.0X, and delay (3-4 bands).
- Adjustable Instantaneous (I) pickup, 1.5-10X.
- Local Overload and Short Circuit Trip Indicators (T) with overload pickup warning.
- Interchangeable trip rating plugs with test set jack for TVRMS test set.
- Digital LCD display with four-button keypad for function selection and set point adjustment and sealable, clear Lexan® cover for tamper-resistant settings.
- True RMS sensing for accurate response to high harmonic content waveforms.
- EMI immunity per ANSI C37.90.

Optional
- Adjustable Short Time (S) pickup, 1.0-9.0C, and delay (4 bands) with I^2t ON/OFF selection.
- Adjustable Ground fault (G) pickup, 0.2-1.0S, and delay (4 bands) with I^2t ON/OFF selection and trip indicator. The 4 short time and ground fault delay bands provide broader system selectivity.

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 200 kA @ 240 volts AC and 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 equivalent 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.

THED/TEDL Circuit Breakers
Made similar to the Mag-Break TEC with TECL limiter, the THED with appropriate TEDL limiter provides a thermal magnetic breaker, UL listed with 100 kAIC short circuit ratings through 600 Volts.

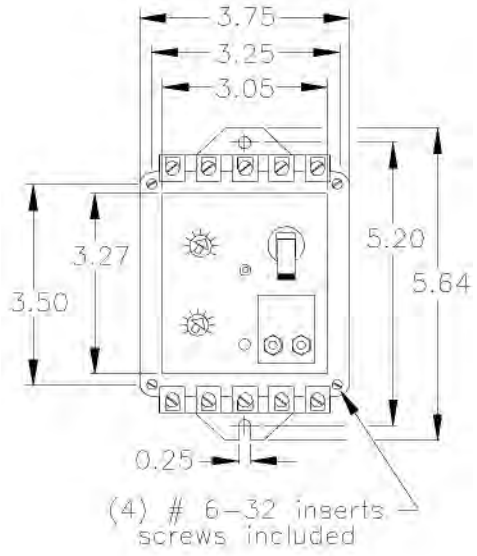
The add-on limiter coordinates with the THED's thermal magnetic trip to allow normal tripping functions at standard ratings with backup limiting at high short-circuit levels.

THED Trip	TEDL
15	TEDL36015
20	TEDL36020
30-60	TEDL36060
70-100	TEDL36100

Ground Break Systems

Model BGFL (Relay)

Trip Currents 5-60, 30-360, or 100-1200A

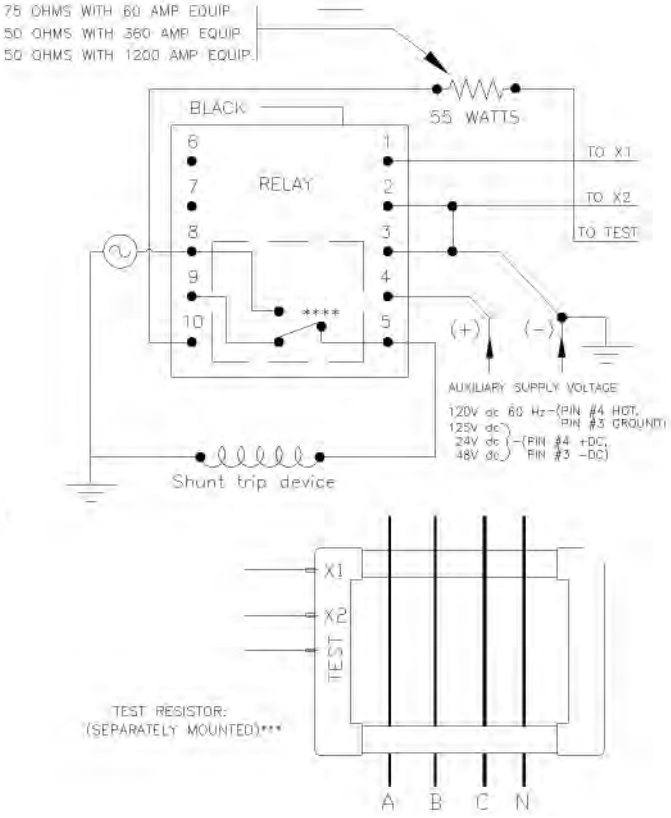


Description

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

Ground Break Systems
Type GFM Ground Fault System

U.L. Listed File no. E110395

Self powered.

Temperature Range: -30°C. to +75°C.

Positive "ON" (Green) and "OFF" (Red) condition indication, manual reset.

Instantaneous only (GFM-252)-standard

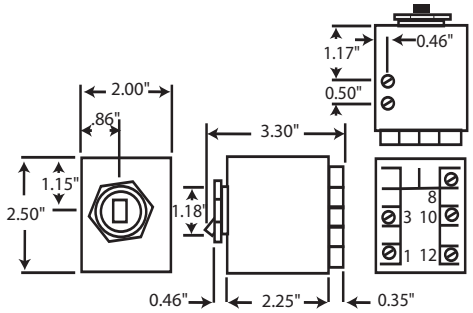
Time delay from instantaneous to 36 cycles (GFM-262).

Trip currents from 3.8 to 18 amperes (size 1 to 3 starters)
5 to 18 amperes (size 4, 5, 6, 7 starters)

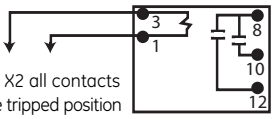
General

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 high voltage starters. Systems can be wye or delta, grounded or resistance grounded. When the ground fault current exceeds a preselected condition (current only, or 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, when specified, is field settable up to 36 cycles.

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

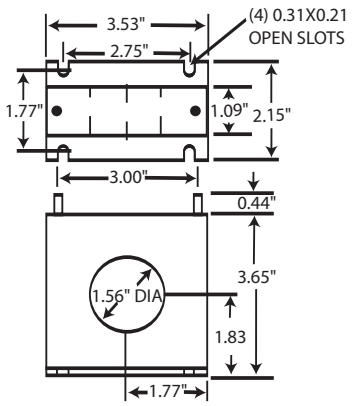


#6-32X.35LG.
TERMINAL SCREWS

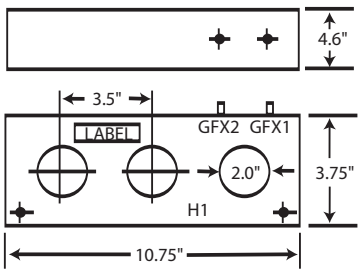


To current Sensor X1 and X2 all contacts shown with the relay in the tripped position

Model Number	Trip① Current
GFM 156	3.8 to 18

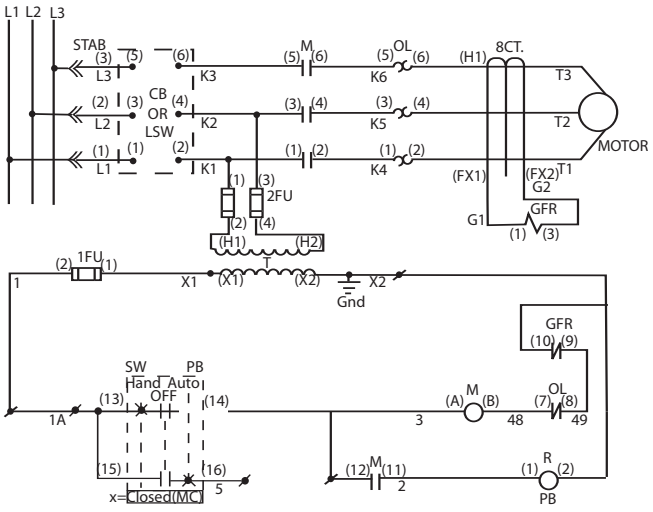


Model Number	Trip① Current
GFM 3P208	5 to 20



① Trip current tolerance is ± 15 percent.

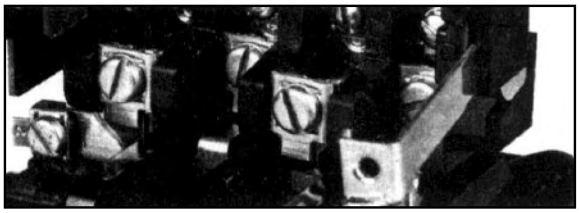
Typical Circuit



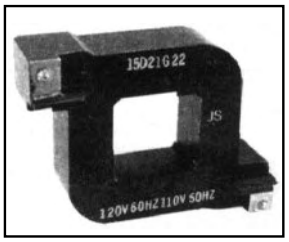
300-Line Motor Starters

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.

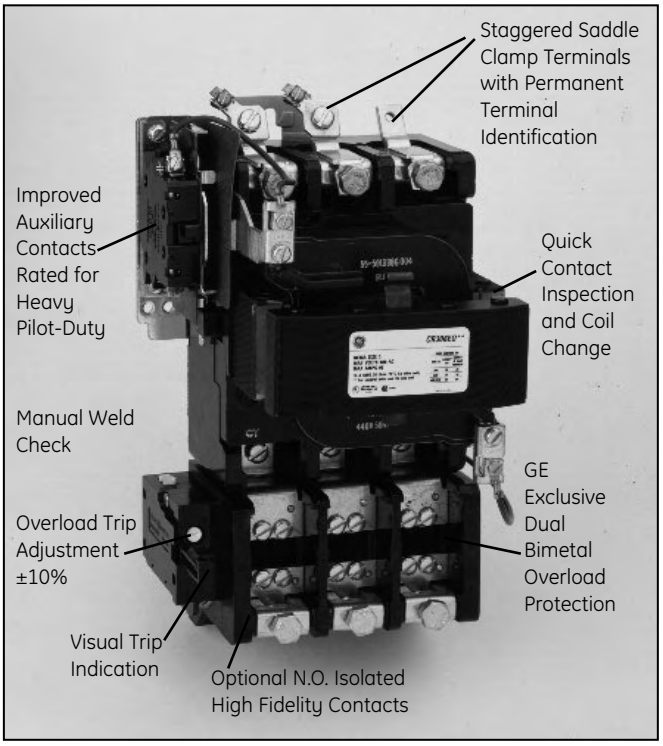
The 300-Line's toolless contactor disassembly allows quick access for inspection and maintenance. Simply release two coil retainers and pull the spring clip from the "I" magnet to gain access to the magnet, coil and contacts. No need to remove any wiring.



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.



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300-Line Motor Starters

(Cover removed)

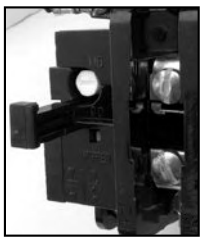
Where it's essential to monitor performance or diagnose faults, a 300-Line starter may be ordered with an additional isolated, high-fidelity, normally-open contact on the overload relay. This contact may be used for direct input to a programmable controller or direct interface with a computer.

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 wedge-shaped 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.

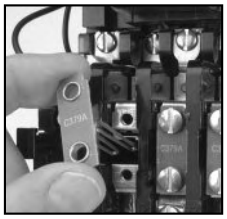
Magnet provides long life and is specially treated to resist rust.

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.

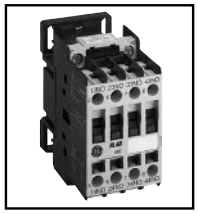
H

300-Line Motor Starters

	CR324 Thermal Overload Relay	CR324X Electronic Overload Relay	LM10 Motor Protection Relay
Description	Standard factory assembled 8000-Line MCCs use GE NEMA 300-Line Starters, which utilize CR324 Thermal bimetal overload relays and fused or circuit breaker protective devices. Bimetal overload relays use inter-changeable 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 CR324C advanced electronic overload relay replaces the traditional CR324 bimetal overload relays in motor control centers. The electronic overload relay eliminates the need for heater elements, providing a broader amperage adjustment range. Other phase loss protection, selectable class range, and higher accuracy and repeatability. 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 Relays and permit fast, simple upgrading in the field.	The compact design of the modular LM10 is ideally suited for low voltage MCC. It comes standard with the DeviceNet protocol that allows the user to control and monitor the relay over a network, and an interface port communicates to the optional programma-ble display unit (PDU). This display unit allows for local programming and monitoring. Matched sets of three phase current transformers (CT) and one ground CT are also available as part of the LM10 package.
NEMA Size	1–6	1–6	1–6
Type	Thermal bimetal	Electronic	Electronic
Protection Class	20	10, 20, 30 (selectable)	10, 15, 20, 30 (selectable)
Ambient Compensation	Optional	Ambient insensitive	Ambient insensitive
Phase loss protection	No	Standard (fixed)	Selectable (On–Off)
Phase unbalance	No	No	Selectable (On–Off) Adjustable 2-25%
Ground Fault	No	No	Yes (5A, Zero sequence), w/GFCT
Self Powered	Yes	Yes	No (120V source required)
Accuracy	±5%	±2%	±2%
Repeatability	±3%	±2%	±1%
Thermal Memory	Yes	Yes	Yes
FLA Adj. Range	1.25:1	2:1	1.2 – 3200A
Reset Mode	Manual (auto optional)	Manual	Manual/Remote
Trip Test	Yes	Yes	Yes, with commnet (digital self-diagnostics)
Trip Indication	Yes	Yes	Yes (last 10 fault diagnostics)
FVNR, FVR	Yes	Yes	Yes
2 Speed, 1 & 2 Winding	Yes	Yes	Yes
Operating Temp. Range	0° to 55°C	–20° to 70°C	0° to 65°C
Communications	No	No	Device Net
Addressable	No	No	Yes
Power Leader Compatible	No	No	No
Heater Required	Yes	No	No
PFC Terminals	Yes (optional through NEMA Size 2)	Yes (optional through NEMA Size 2)	No
PLC Compatible Contacts	No	Yes	Yes
Aux. Contacts	NC (NO optional)	NO, NC	NA
Reference Publication	—	DEP-015	GEK106642

Industrial Relays

C-2000™ Control Relays



The C-2000 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

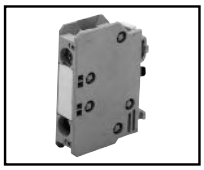
Coil Rating

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

Front-Mount Auxiliary Contact Blocks



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

Pneumatic Timers

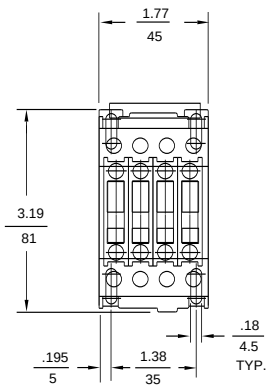
Pneumatic timers are adjustable time-delayed auxiliary contacts. They come equipped with two time-delayed contacts: 1NO or 1 NC, electrically separated. Setting is scaled over a 350° rotation by means of a knurled knob with timing guide marks. To mount a pneumatic timer, simply clip it on front face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

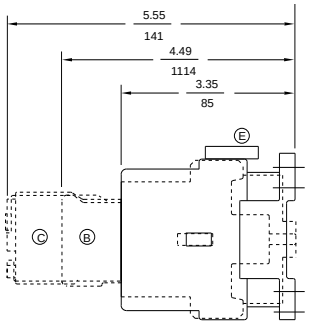
Surge Suppressor

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



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CR120B Machine Tool and Industrial Relays

The CR120B and CR120BL, Series A, multi-circuit industrial relays are designed to meet most panel application requirements. They are available as standard or latched relays. All forms of the relay mount on the same base and in the same small panel-mounting area. Relays may be arranged in any configuration or modified on a panel without altering the mounting area.

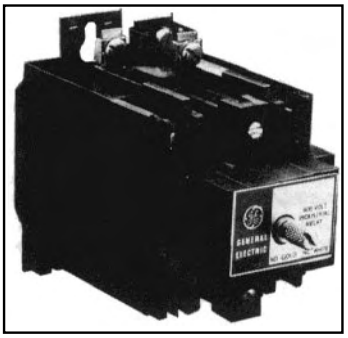
Features

- Bifurcated contacts assure positive make–unique bifurcated contacts assure positive make at all voltages and give excellent fidelity even in harsh environments.
- Transparent Lexan contact cartridges–allow inspection of contacts.
- Convertible contacts–allow conversion from normally open to normally closed, or vice versa. Just change the terminal screws and invert the contact module.
- Quick-change coil–can be changed without removing any screws.

Latch Attachment

The latch attachment mounts on any standard CR120B relay in the same manner as a deck adder.

	Inrush VA	Sealed VA	Sealed Watts
AC Relay coil	120	15	7
AC Unlatch coil	31	15	9.2
DC Relay coil	235	2.8	2.8



CR120B standard AC relay

Contact Ratings

Type of Contacts	Max. AC Voltage	Max.Continuous Rating Amps	Max. AC Voltampere Rating		Max. AC Rating Amps		Max. DC Rating Amps		Max. DC Voltampere Rating
			Make	Break	Make	Break	125V	250V	300V or less
Inst.①	600	10	7200	720	60	6	1.1	0.55	138
Delay	600	5	3600	360	30	3	0.5	–	–

① Use for CR120B and CR122BT contact rating.

Coil Data

60 Hz	24V	115V	120V	200V	208V	230V	460V	575V	600V
50 Hz	24V		110V		220V	380V	440V		550V
DC	12V		24V		48V		54V		125V

H

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, water-tightness 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.①

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)	X	X	#120PSB	Red Green Amber Blue White Clear
Transformer (6 VAC Secondary)	X	X	#755	
Neon	X	N/A	Neon	Red White Amber Clear
LED (Transformer Type only)	X	X	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 Hz②	
		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.

C-2000 Pilot Device

Standard for 1/2X Starter. See GEP-1260, Section 7.

H

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 over-current 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.

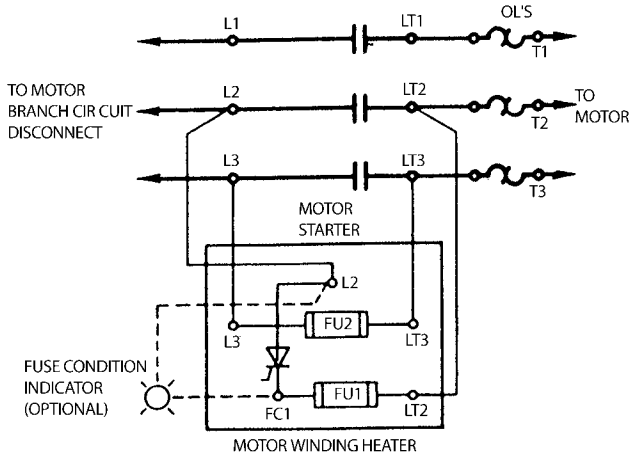
Motor Voltage +10%, –15% 3-Phase 60 Hz	Motor Horsepower Range
230/460V	15-400 Hp
575V	25-400 Hp

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.

Power Leader EPM

General

The Power Leader EPM is a microprocessor based device that displays a full range of over 50 metered values with revenue class accuracy of 0.5%. The PLEPM is available with a communication option that is factory- or field-installable so that all data can be transmitted to a remote host computer.

Features

The PLEPM comes in a panel mount version standard or an optional S1 case. Metered values cover a full range of parameters.

Revenue Class accuracy of 0.5%.

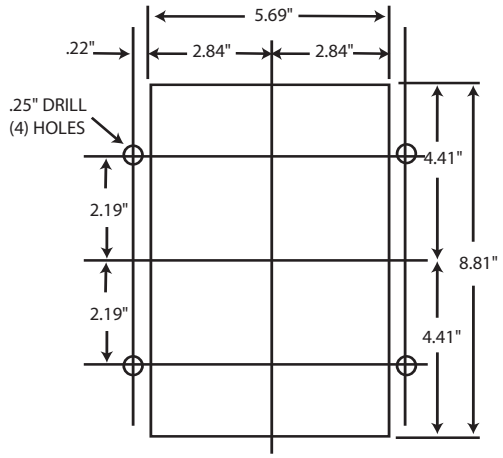
Optional communications provides connectivity to POWER LEADER network (commnet) and Modbus RTU.

Pulse initiation option with programmable outputs.

	(kwh, kvarh, kvah, kqh)
Amps	3 phase and neutral (0.25% accuracy)
Volts	L-L & L-N (0.25% accuracy)
Watts	(per phase, 3 phase total, peak watts, watt demand, & watts at maximum KVA)
Energy	(kwh, kvah, kvarh lag and lead, and KQH)
Volt-Amps	(per phase, 3 phase total, peak KVA, & KVA demand)
KVARs	(per phase, 3 phase total, peak KVAR, peak KVAR lead, KVAR demand, KVAR demand lead)
Power Factor	(per phase, 3 phase total, average, power factor at previous interval, power factor at maximum KVA)
Frequency	(60 Hz only)

Inputs

The PLEPM requires CT inputs with a 5A secondary current. The meter can accept direct input voltages up to 600V and is self-powered from the voltage inputs. Three CTs are required for four wire (Y) systems and two CTs are required for three wire (Δ) system.



Panel drilling for Semi-Flush Mounting (front view)

H

Power Leader PQM

Description
The PQM is an ideal choice when continuous monitoring of a three phase system is required. It provides metering for current, voltage, real and reactive power, energy use, cost of power, power factor and frequency. Programmable setpoints and 4 assignable output relays allow control functions to be added for specific applications. This includes basic alarm on over/under current or voltage, unbalance, demand based load shedding and capacitor power factor correction control. More complex control is possible using the 4 switch inputs which also can be used for status such as breaker open/closed,flow information etc.

The PQM may be used as a data gathering device for a plant automation system that integrates process, instrument and electrical requirements. All monitored values are available via two digital RS485 communication ports running the Modbus protocol. If analog values are required for direct interface to a PLC, any of the monitored values can be output to one of 4 isolated analog outputs. A process variable can be measured using an analog input. A front panel RS232 communication port can be connected to a PC for simultaneous access of information by other plant personnel.

The quality of the power system is important with increasing use of electronic loads such as computers, ballasts or variable frequency drives. With the PQM's power analysis, any phase current or voltage can be displayed and the harmonic content calculated. By knowing the harmonic distribution, action can be taken to prevent overheated transformers, motors, capacitors, neutral wires and nuisance breaker trips. Redistribution of system loading can also be determined. Waveform and chart recorder printouts available from the PQM assist in problem diagnosis.

GEPQMIIT20CA is standard.
See GE Multilin Products Catalog and www.ge.com/edc/pmsys

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.
- Power quality analysis

Metering/Control
- AVW var VA varh Wh PF Hz unbalance
- AW can VA demand
- Load shedding
- Power factor control
- Pulse input totalizing
- Pulse output based on kWh, kvarh or kVah

Monitoring
- Harmonic analysis through 63rd with THD and TIF
- Event recorder
- Waveform capture
- Data logger
- Triggered trace memory

Communication
- Ports: RS232 front, dual RS485 rear
- Modbus RTU protocol
- Mini RTU: digital 4 in / 4 out
- Analog 1 in / 4 out
- Local/remote display of all values

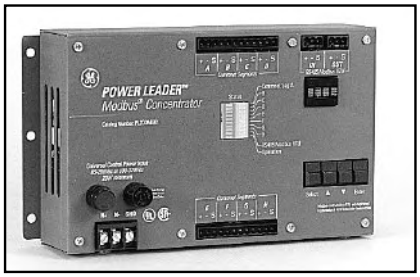
Power Leader Modbus Concentrator

Product Overview
GE's recent introduction of the POWER LEADER Modbus Concentrator brings performance and compatibility to users of GE's Power Leader communication network (commnet) family of power management devices. Used in conjunction with GE's Power Management Control System (PMCS) software, the Modbus Concentrator allows you to integrate your existing base of commnet devices into the faster Modbus Remote Terminal Unit (RTU) based PMCS network, improving overall system performance while retaining the full functionality of each commnet device.

Modbus RTU is an industry-standard communications protocol that operates on an RS485 network. The Modbus RTU protocol is widely supported for supervisory control and data acquisition (SCADA) systems, building management systems (BMS) and distributed control systems, (DCS). Industry leaders such as Multilin, Power Measurements Limited and GE Fanuc produce Modbus RTU-compatible devices and programmable logic controllers.

Modbus open architecture provides a high level of flexibility while reducing the risks associated with proprietary communications protocols. Key benefits of the modbus RTU protocol include:

- Devices and systems can be upgraded easily.
- A wide range of compatible devices from a variety of manufacturers is supported.
- Communications are extremely flexible, both upstream (to DCS, SCADA and BMS systems) and downstream (to meters and trip units).



Standard Features
- One-piece steel case construction
  - Simple installation (no cut-outs)
- Ease of operation
  - Four-character alphanumeric high-contrast LED display
  - Simple four-button keypad
  - All setup done via faceplate keypad and display; no confusing DIP switches
  - Quick automatic setup capability
  - Remote setup capability allows automated configuration from host PC
- Communications
  - Communicates on POWER LEADER commnet communications protocol
  - Communicates on Modbus RTU communications protocol
  - Each Modbus Concentrator supports up to 32 commnet devices (maximum 215 Commnet devices per RS485 network possible with multiple Concentrators)

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 manually reset switches and breaker applications. The SPVRB is suitable for loss of phase with motor loads.

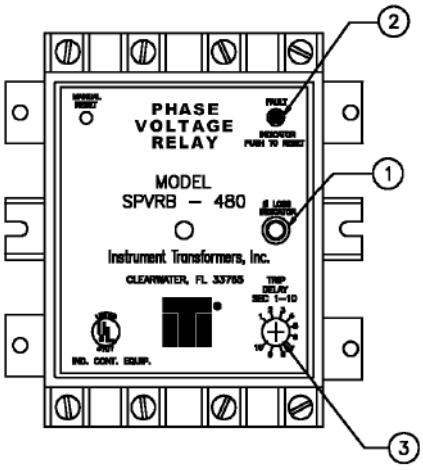
Features
- Phase unbalance: 8%
- Adjustable Trip Delay: 1 to 10 seconds after failure occurs, prevents nuisance operations
- Output Relay: normally de-energized, form C contacts for easy circuit configuration
- Electro-mechanical indicator: retains memory of fault until manually reset
- Door or panel 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
  Automatic Reset to Normal: Upon removal of fault conditions
  Manual Reset: Operates from a remote or local pushbutton in cover

SPVRB — XXX

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

Available Models

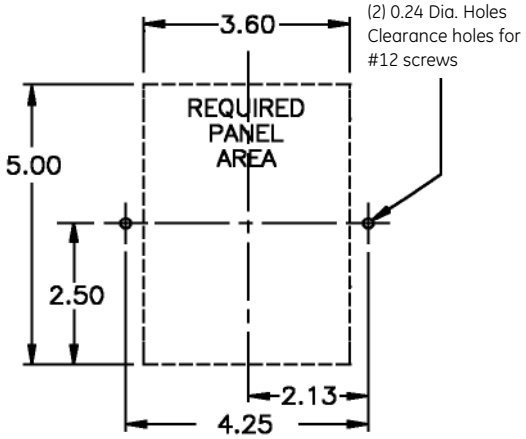
Model No.	Nominal Vac	Vac Range	Freq.
SPVRB–120	120	96–138	60
SPVRB–240	240	192–276	60
SPVRB–480	480	384–552	60
SPVRB–575	575	460–661	60
SPVRB–380	380	304–437	50
SPVRB–415	415	332–477	50



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

② Electromechanical Diagnostic Indicator
- Pops out upon fault

③ Adjustable System Delay
- Phase loss
- Phase unbalance
- Single phase
- Phase reversal



Panel Mounting Layout

Output Contact Ratings

Voltage	Continuous	Make	Break
120 Vac	10 A	3160 VA	316 VA
240 Vac	10 A	4800 VA	480 VA
380 Vac	3 A	4800 VA	480 VA
600 Vac	3 A	4800 VA	480 VA

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

Three-Phase Voltage Monitors
Model LPVRB

General
The Model LPVRB is designed to protect 3-phase loads from damaging power conditions. Its wide operating range combined with UL and CE compliance enables quick access to domestic and global markets.

A unique microcontroller-based voltage and phase sensing circuit constantly monitors the three phase voltages to detect harmful power line conditions. When a harmful condition is detected, the LPVRB's output relay is deactivated after a specified trip delay. The output relay reactivates after power line conditions return to an acceptable level for a a specified amount of time (Restart Delay) or after a manual reset. The trip and restart delays prevent nuisance tripping due to rapidly fluctuating power line conditions.

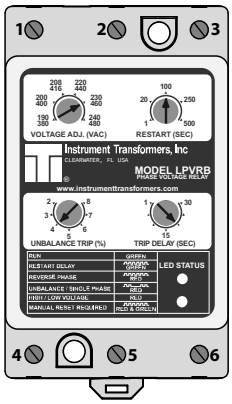
The Model LPVRB automatically senses whether it is connected to a 190 to 240V 60Hz system, a 440 to 480V 60Hz system, or a 380 to 416V 50Hz system. An adjustment is provided to set the nominal line voltage from 190-240 or 380-420Vac. Other adjustments include a 1-30 second trip delay, a 1-500 second restart delay, and a 2-8% voltage unbalance trip point adjustment.

Two LEDs indicate the status of the Model LPVRB; Run Light, Under Voltage, Over Voltage, Phasing/Fault Reverse Phase and Manual Reset.

The LPVRB ships with a jumper installed for automatic restart. A connector with two 12" wires is included for manual reset switch.

Features
- Compact design
- UL and cUL listed
- CE compliant
- Finger safe terminals
- 5 year warranty
- Made in USA
- Standard surface or DIN rail mount
- Standard 1-500 second variable restart delay
- Standard 2-8% variable voltage unbalance
- Standard 1-30 second variable trip delay
- One 10 amp general purpose form C relay
- Optional manual reset
- Four adjustment pots provide versatility for all kinds of applications
- Universal range from 190-480Vac 50/60Hz provides the versatility needed to handle global applications
- Diagnostic LEDs indicate trip status and provide simple troubleshooting
- Microcontroller based circuitry provides better accuracy and higher reliability than analog designs
- Transient protected to meet IEEE and IEC standards and operate under tough conditions
- Will detect single phase condition regardless of regenerated voltages

Protects 3-Phase motors from:
- Loss of any phase
- Low voltage
- High voltage
- Voltage unbalance
- Phase reversal
- Rapid cycling



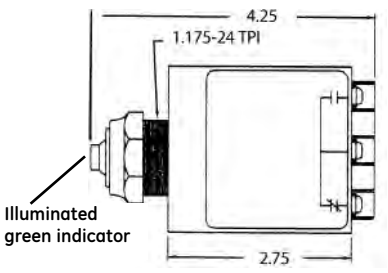
Model APVR

General
(UL)103039
The model APVR phase sensing relay performs the same functions as the model LPVR, except that the relay requires no adjustments. It will fit in the push-button bracket, and thus does not increase the required unit spacing.

Available with the following 3 Phase Voltages

P/N	Nominal	Voltage Range	Frequency
APVR 120	120	95-135	60Hz
APVR 240	240	190-270	60Hz
APVR 480	480	380-530	60Hz
APVR 575	575	455-600	60Hz
APVR 380	380	300-425	50Hz

Specifications
- Failsafe–will not operate if a fault is present.
- Manual or Automatic reset.
- Fixed undervoltage trip point: approx. 90% pickup, 80% dropout.
- Operates at 6% phase unbalance
- Operates with 6% phase voltage loss.
- 3 second drop-out delay to avoid nuisance tripping
- Operational green LED indicator.
- Isolated Form "C" output contacts.
- Output contact rating:
  250Vac, 5 amps (general use)
  30Vdc, 5 amps (resistive)



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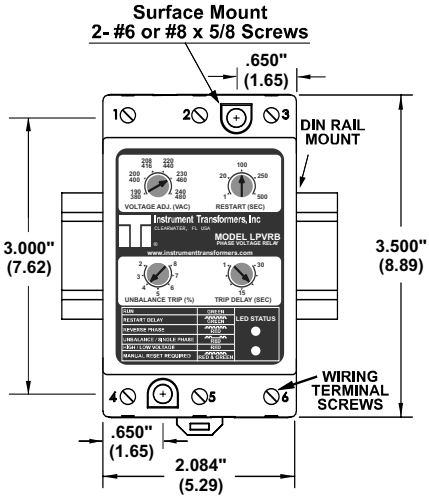
Three-Phase Voltage Monitors
Model LPVRB

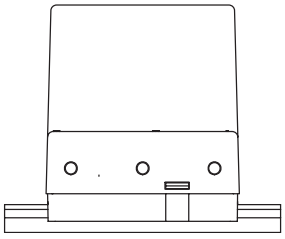
Specifications

3-Phase Line Voltage	190-480Vac (475-600Vac optional) (95 -120Vac optional)
Frequency	50* or 60Hz
Low Voltage (% of set point)	
• Trip	90% ±1%
• Reset	93% ±1%
High Voltage (% of set point)	
• Trip	110% ±1%
• Reset	107% ±1%
Voltage Unbalance (NEMA)	
• Trip	2-8% adjustable
• Reset	Trip setting minus 1% (5-8%) Trip setting minus .5% (2-4%)
Trip Delay Time	
• Low, High and Unbalanced Voltage	1-30 seconds adjustable
• Single Phasing Faults	1 second fixed
Restart Delay Time (when manual reset pins are shorted)	
• After a Fault	1-500 seconds adjustable
• After a Complete Power Loss	1-500 seconds adjustable
Output Contact Rating	
• 1-Form C	10A general purpose @ 240Vac pilot duty 480VA @ 240Vac, B300
Power Consumption	6 watts (max)
Weight	14 oz.
Enclosure	Polycarbonate
Terminal Torque	6 in-lbs.
Wire Type	Stranded or solid 12-20AWG, one per terminal
Safety Marks	
• UL	UL508
• CE	IEC 60947-6-2
Standards Passed	
• Electrostatic Discharge (ESD)	IEC 1000-4-2, Level 3, 6kV contact, 8kV air
• Radio Frequency Immunity, Radiated	150MHz, 10V/m
• Fast Transient Burst	IEC 1000-4-4, Level 3, 3.5kV input power and controls
Surge	
• IEC	IEC 1000-4-5, Level 3, 4kV line-to-line; Level 4, 4kV line-to-ground
• ANSI/IEEE	C62.41 surge and ring wave compliance to a level of 6kV line-to line
• Hi-potential Test	Meets UL 508 (2 x rated V + 1000V for 1 minute)
Environmental	
• Temperature Range	Ambient operating: -20° to 70°C (-4° to 158°F) Ambient storage: -40° to 80°C (-40° to 176°F)
• Class of Protection	IP20, NEMA 1 (finger safe)
• Relative Humidity	10-95%, non-condensing per IEC 68-2-3
Special options	
• Manual reset	External momentary push button required

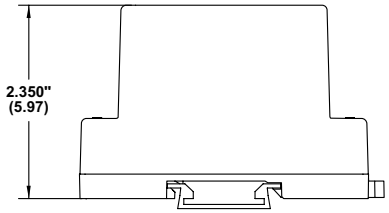
* 50Hz will increase all delay timers by 20%



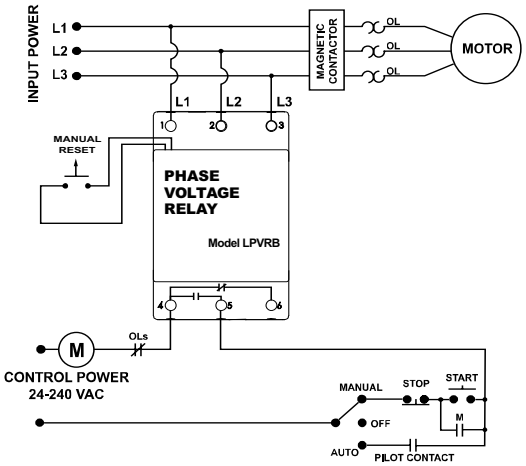
FRONT VIEW



BOTTOM VIEW



SIDE VIEW



TYPICAL WIRING DIAGRAM

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 three-phase 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.

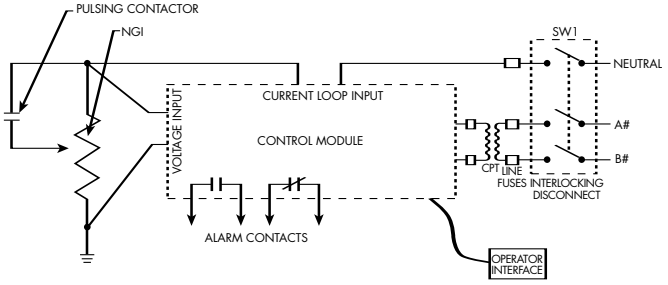
Note: The use of high-resistance grounding on 600 volt maximum systems precludes line-to-neutral loading.

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-to-ground faults. This is done by using the pulsing ground current feature and portable detector.

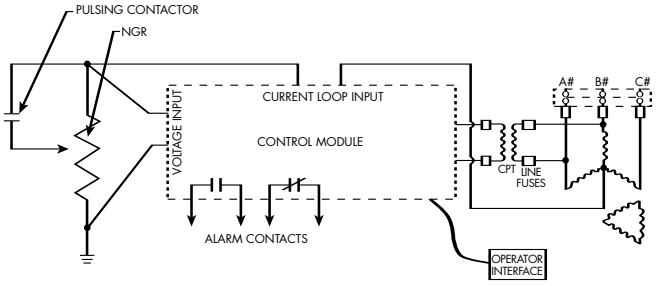
Approximate Dimensions and Weights

Equipment Enclosure Type	W x D x H (in 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.

H

Motor Protection Relay LM10

General
The General Electric LM10 Motor Protection Relay (MPR) is a modular device for Low & Medium Voltage Motor Control Centers designed to protect motors from various fault conditions. The LM10 comes with DeviceNet™ protocol. The relay's 5-pin connector allows the user to control and monitor the relay over the network. Additionally, the relay has an interface port to communicate to the LM10 Programming & Display Unit (PDU).

The PDU is a self-contained device consisting of a poly-carbonate plastic housing, a membrane switch keypad, a Liquid Crystal Display (LCD), and control electronics for communication with the Relay.

The LM10 (PDU) is used to configure the relay. An optional method of configuring the relay is a phone jack interface to a laptop PC. The LM10 is ideally suited for process markets and shortened construction & manufacturing time tables.

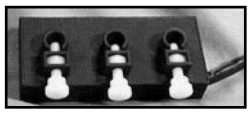
In addition the Programmable Display Unit (PDU) can be used to check status, phase current, voltage and Power.

- Time Delays
- Auto Restart
- Two Speed & RV
- Power - kW, PF
- MAC ID
- Start/Stop Test
- Fault Reset
- Phase current
- Voltage
- Current Unbalance
- ETM (Elapsed Time Meter)

The LM10 is compatible with most PLC's and is SCADA and DCS adaptable. Control wire in buckets is #18 MTW.

The LM10 system can replace:
- PLC I/O
- Load Sensing Relays
- Ammeter
- Timing Relays
- Power Meter
- Ground Fault Relays
- Elapsed Time Meter

The PDU can display the following faults: Over current, Adjustable ground fault, Jam, Stall, Current unbalance, Communication failure, Load loss, Power loss and User trip. The MS2000 Relay has inputs for two matched sets of three phase current transformers (CT) and one ground CT.



The LM10 provides the flexibility to select the type and size of starter in the field. No special overloads, just different CT's.

Environmental Information
- 0 to 60 degree C
- -30 to 80 degree C storage
- Run in 95% non-condensing humidity

Optional: Programmable Display Unit (PDU)
- NEMA 12
- Self powered form MPR
- RJ phone jack to MPR or PC
- Door mounted or hand held
- High impact screen

Programmable Fault Outputs
- Zero Sequence Ground Fault
- Load Loss
- Current Unbalance

Accuracy
- Power Factor + 5%
- Current + 3%
- Timers 5% + 1 second

Error Messages
- Over Current LED & Network
- Current Unbalance LED & Network
- Ground Fault LED & Network
- Load loss
- Command Trip

CT-Sensor Pack
- NEMA size 1, 1/2 Amp to 27 FLA
- NEMA size 2 & 3, 5 Amps to 90 FLA's

CT's with 5A secondary, matched for MPR
- 30-540 FLA

Voltage Rating
- Control power 100V to 135V, 60 Hz
- System set up range 200V to 7.2KV

Relay Outputs
- NEMA C150 rated
- 1/3HP @120V AC

Motor Protection Relay LM10

Display
Liquid crystal display -5x8 font pixelized character type in a 16 character X 4 line format. English and Spanish messages

Status
The Status sub-menu can display Current (FLA) Status, Run 1, Run 2, Faults, MAC ID, Baud rate & OL Class

Reset
The rely can be reset from the PDU, Push Button or the LAN.

Mounting flexibility
Relay can be attached to PDU with out hardware to facilitate door mounting.

LEDS
Green LED power indicator and a flashing Red LED fault indicator, over/under current, current unbalance, ground fault, under/over voltage, and trip command.

Configuration
The parameters can be programmed by the Config. button. The Config sub-menu is similar to Status but here the user may change parameters: Current, Voltage, Fault Settings & Time Delays.

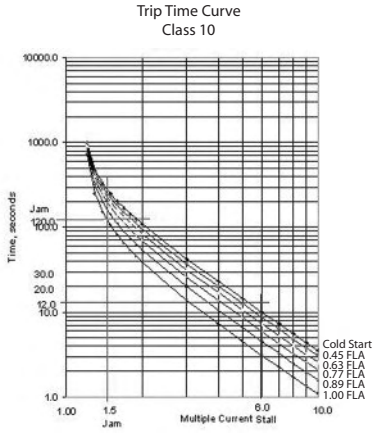
History
Display last 10 trip records. The conditions at the time of that fault are displayed and can be scrolled through using the Up/Down arrows.

Architecture
The LM10 uses a 6-channel simultaneous sample A/D converter that takes a "snapshot" image of the three phases of current, one phase of voltage, and ground. When the relay trips one or more of the onboard control relays, indicators will be illuminated to show the status of the device. Additionally, the trip event will be stored in non-volatile memory. The relay also has an auxiliary communications port for connection to the PDU. This port not only allows the PDU to obtain and display any of the real-world data that is contained in the relay it can also be used to configure the relay.

Analog Inputs
The LM10 Relay has inputs for two sets of three phase Current Transformers (CT) and one ground CT. One set will allow for 1.2A to 135A CTs to be connected; the other will allow for 135A to 1000A CTs.

Additionally, provisions were made both in the CPU application code and the Analog interface circuit to support various CTs for the 3 phase measurements. NEMA Class 10, 15, 20 & 30 are rotary Switch selectable. Additional Jam and Stall protection can be programmed. Using a Ground CT provides Zero-sequence ground fault protection as an option.

Voltage input from the Control Power Transformer (CPT) will be conditioned and measured by the AD Converter to determine supply voltage.



Relay overload curves

Features
The LM10 has DeviceNet communication utilizing a micro-style 5-pin connector that allow the use of pre-built cables for attachment to the unit. Baud Rate is Dip switch selectable.

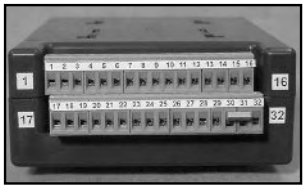
The configuration port is standard RJ connector and provides interface to the PDU. Both communication and power will be provided to the PDU through this connection.

The 256 Bytes EE Prom memory stores the operating parameters for the device, the DeviceNet required unique serial number for the unit and also stores trip status for the last ten events.

Inputs qty 6
Two for Run 1 & 2, Stop, Trip, Operation Mode and Reset.

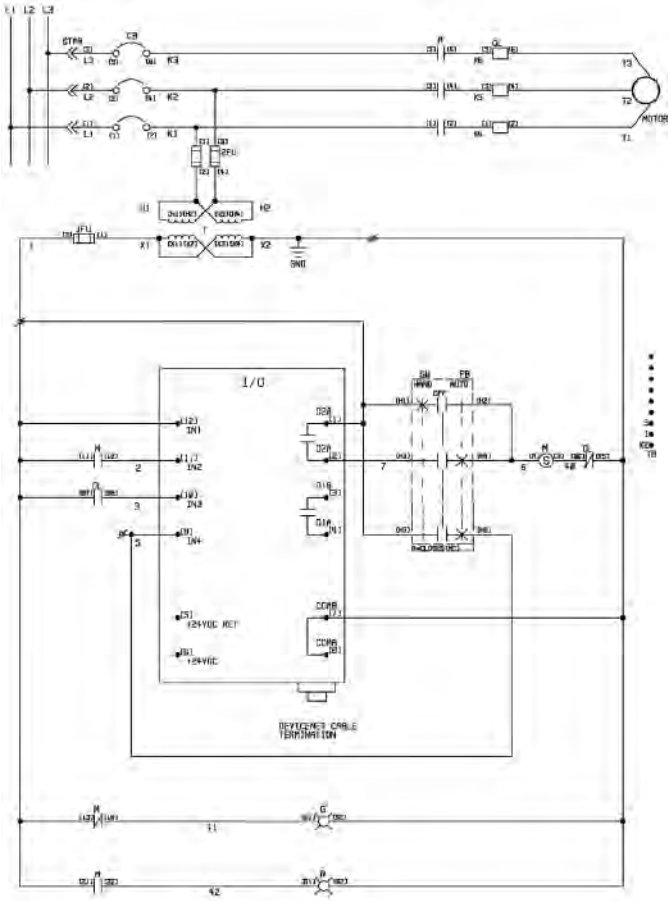
Relay Outputs
The Overload Relay contains 4 onboard NO relays with C150 pilot duty ratings that control the coils for the motor contactors and programmable fault outputs. There are two control relays enabled from the control logic Ground Fault and a programmable trip relay.

Terminals
Clearly marked for inputs and outputs.



PDU mounted in Evolution Series E9000 MCC

MS2000CNT Input-Output Module



General
A compact I/O module to access Input Data and Control relays over a DeviceNet communications network.

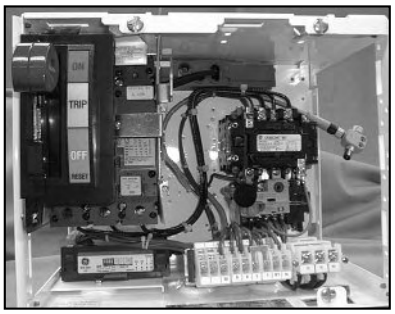
- 4 inputs/2 outputs
- Inputs rated 120V AC or 24V DC, Dip switch selectable
- Relay outputs rated NEMA C150, 1-NO
- 30mm DIN Rail mounting
- DeviceNet communication (ODVA certified) Polling & COS
- Dip switch selectable communication failure state, On or Off
- Dip switch baud rate (default 125Kbaud)
- Dip switch selectable communication failure state, On or Off
- Change of state messaging
- Individual LED's for I/O & communications

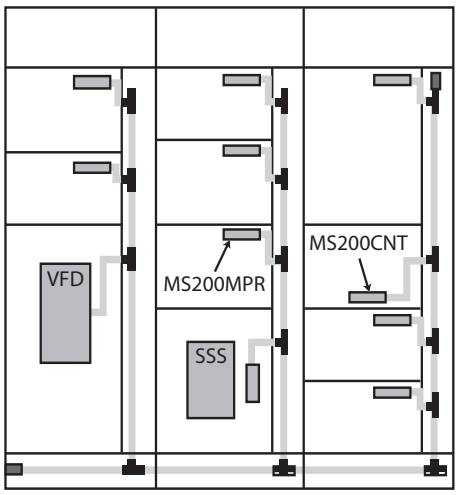
Application
Applications include monitoring status of:

- Switches
- Breakers
- Motor starters
- Contactors

Two relay outputs are suitable for On Off control of:
- Motor Starters
- Contactors
- Breaker trip
- Motor Operated Breakers

The small footprint makes it ideally suited for Motor Control Center buckets without a size penalty. 1.5"H X 4.8"W X 4.4"D
Catalog number: MS2000CNT





DeviceNet Wiring Example
Thick Mini Trunk with Thin Micro Drop Cables and Connectors with Vertical Wire-way Barriers

H

Transient Voltage Surge Suppressors

Integrated Tranquell™ HE & ME

This TVSS model connects to the panelboard or switchboard bus bars without adding width or depth to the panel enclosure, and only occupying 7X of vertical bus space. These units have been tested to surge current ratings per NEMA LS-1, up to 200kA per mode, including the fuses in the surge path. 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.

Operating Frequency
•50/60 HZ

Connection
•6 to 2/0 conductors, parallel connected

Operating Temperature
•-40 C to +65 C

Operating Humidity
•0% to 95% non-condensing

Weight
•24 lbs.

2X Height 24" Plug-in

Catalog # _ _ _ _ _ _ _ _ _ _ _ *

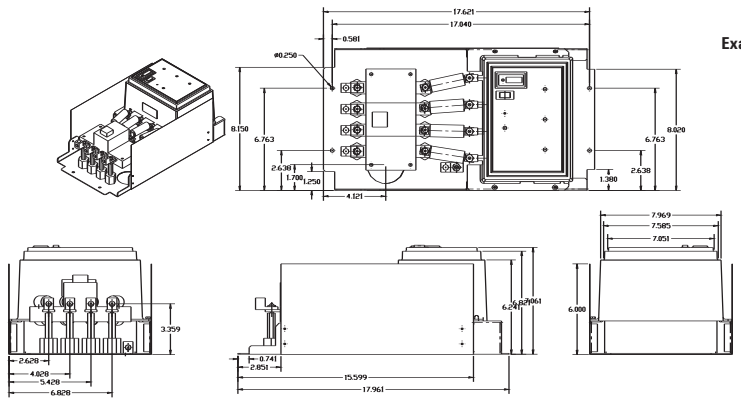
* **PP** suffix available for all kA ratings (integral to Spectra panel or switchboard)
SG suffix for all THE devices (100kA - 300kA) (integral to switchgear)
ME suffix available for all kA ratings (integral to MCC)

		Nominal Voltage (Volts RMS)	Configuration	Suppressed Voltage Rating UL 1449 2nd Edition L-N / L-G / N-G	MCOV% Max. Continuous Operating Voltage
THE / **TME**	**120S**	120/240	1 Phase, 3 Wire + Ground	400 / 400 / 400	125%
	120Y	208Y/120	3 Phase, 4 Wire + Ground	400 / 400 / 400	125%
	240D	240 Delta	3 Phase, 3 Wire + Ground	- / 800 / -	115%
	240H	120/240 Delta HL	3 Phase, 4 Wire + Ground	400/700 / 400 / 400/700	115%
	240Y	415Y/240	3 Phase, 4 Wire + Ground	800 / 800 / 800	130%
	277Y	480Y/277	3 Phase, 4 Wire + Ground	800 / 800 / 800	115%
	220Y	380Y/220	3 Phase, 4 Wire + Ground	800 / 800 / 800	145%
	480D	480 Delta	3 Phase, 3 Wire + Ground	- / 1500 / -	170%
	347Y	600Y/347	3 Phase, 4 Wire + Ground	1000 / 1000 / 900	115%
	600D	600 Delta	3 Phase, 3 Wire + Ground	- / 1500 / -	170%

065	65kA per mode (TME)
080	80kA per mode (TME)
100	100kA per mode (THE)
150	150kA per mode (THE)
200	200kA per mode (THE)
300	300kA per mode (THE)

Note: For TVSS field installation kit, add the prefix "A" and replace "PP" suffix with "K" suffix.

Example: **THE277Y150PP**
Factory Installed
ATHE277Y150K
Field Installation



Approximate Motor Full-Load Current Ratings

Full-Load Current for EPAC Compliant Motors

Average Expected Values

For three-phase, 60 Hertz, GE Type KE (NEMA Design B) drip-proof, 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
1/4①	1800	1.6	1.4	0.70	0.56
	1200	1.7	1.5	0.75	0.60
1/2①	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
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	179.2	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, GE 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	Continuous 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	1,138
		100	297	376	475	593	775	998	1,280
	150	110	328	415	524	654	857	1,105	1,426
		125	374	474	598	745	979	1,265	1,640
		150	450	570	720	897	1,181	1,528	1,991
			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	1,000	
		110	325	410	520	650	845	1,100	
		125	370	465	570	740	960	1,250	
		150	440	560	705	885	1,150	1,500	
		175	515	655	825	1,035	1,345	1,750	
		200	590	750	940	1,180	1,535	2,000	
		225	665	840	1,050	1,330	1,730	2,250	
		250	740	935	1,180	1,480	1,920	2,500	
SG	400	125	380	480	620	765	990	1,275	
		150	455	575	740	920	1,185	1,530	
		175	530	670	865	1,070	1,385	1,785	
		200	605	765	990	1,225	1,580	2,040	
		225	680	860	1,115	1,375	1,780	2,295	
		250	755	955	1,235	1,530	1,975	2,550	
		300	905	1,145	1,480	1,835	2,370	3,060	
		350	1,060	1,340	1,730	2,140	2,765	3,570	
		400	1,210	1,530	1,980	2,445	3,160	4,080	
	600	250	765	965	1,215	1,500	1,960	2,530	
		300	915	1,155	1,455	1,800	2,355	3,035	
		350	1,070	1,350	1,700	2,100	2,745	3,545	
		400	1,200	1,540	1,940	2,400	3,135	4,050	
		450	1,375	1,735	2,185	2,695	3,530	4,555	
		500	1,525	1,925	2,425	2,995	3,920	5,060	
		600	1,830	2,310	2,910	3,595	4,705	6,075	
SK	800	300	940	1,150	1,445	1,795	2,375	3,015	
		400	1,255	1,535	1,930	2,395	3,165	4,015	
		500	1,570	1,915	2,410	2,990	3,955	5,020	
		600	1,875	2,290	2,895	3,610	4,740	6,195	
		700	2,155	2,665	3,375	4,240	5,525	7,420	
		800	2,440	3,035	3,860	4,875	6,305	8,705	
	1,200	600	1,825	2,310	2,905	3,685	4,730	6,110	
		700	2,125	2,695	3,390	4,300	5,515	7,125	
		800	2,430	3,080	3,870	4,910	6,305	8,145	
		1,000	3,040	3,850	4,840	6,140	8,880	10,180	
		1,200	3,650	4,620	5,805	7,370	9,455	12,215	

J

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
1	2	SE	15	15	15	15	15
	3		20	15	15	15	15
	5		30	30	20	15	15
	7.5		50	30	30	20	20
	10				30	20	20
2	10	SE	50	50			
	15			70	50	40	30
	20				70	50	40
	25				70	60	50
3	15	SE	70				
	20		100	100			
	25		100	100			
	30			125	100	70	50
	40				100	100	70
	50				125	125	100
4	30	SF SGL	125				
	40		200	150			
	50			200			
	60				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
5	50	SGL	200/250				
	60		300	225/250			
	75		350	300/350			
	100			400	225/250		
	125				300	225/250	225/250
	150				300/350	300	250
	200					350/400	300
6	100	SGL/SKL	500				
	125		800	800			
	150		800	800			
	200			1000	500		
	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	1	3	SRPE7A3	7	SE 150
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		20	SRPE30A20		
5.0						25	SRPE30A25		
–	7.5					30	SRPE30A30		
7.5						40	SRPE60A40	60	
				15	2	25	SRPE30A25	30	
			15	20		30	SRPE30A30		
		15		25		40	SRPE60A40	60	
10	10	25	25			50	SRPE60A50		
	15					60	SRPE60A60		
			25	30	3-4	50	SRPE60A50	100	
		30	30	40		70	SRPE100A70		
25	25	50	60	60		100	SRPE100A100		
	30					150	SRPE150A150	150	
				60	4RVAT①	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	5	250	SRPG400A250	400	SG 600
60	60	125	150			300	SRPG400A300		
75	75	150		200		350	SRPG400A350		
	100		200			400	SRPG400A400		
				250	6	400	SRPG800A400	600	SG 600
100		200	250	300		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 Ther-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 multiplied 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 full-load 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	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
.65-.74	C087A	3	LO	LO
.75-.84	C097A	3	LO	LO
.85-.92	C109A	3	LO	1
.93-1.02	C118A	3	LO	1
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	1	4
1.68-1.79	C220A	3	1	5
1.80-1.98	C239A	3	1	6
1.99-2.24	C268A	3	2	7
2.25-2.43	C301A	3	3	8
2.25-2.43	C301A	7	LO	1
2.44-2.75	C326A	7	LO	2
2.76-3.25	C356A	7	LO	3
3.26-3.43	C379A	7	LO	4
3.44-4.03	C419A	7	1	4
4.04-4.43	C466A	7	1	5
4.44-4.94	C526A	7	2	6
4.95-5.36	C592A	7	2	7
5.37-5.77	C630A	7	3	6
5.37-5.77	C630A	15	LO	2
5.78-6.35	C695A	15	LO	2
6.36-6.92	C778A	15	LO	3
6.93-7.99	C867A	15	LO	3
8.00-8.47	C955A	15	1	4
8.48-9.19	C104B	15	1	5
9.20-10.0	C113B	15	1	6
10.1-10.7	C125B	15	2	6
10.8-12.0	C137B	15	2	7
10.8-12.0	C137B	30	LO	2
12.1-12.9	C151B	15	3	8
12.1-12.9	C151B	30	LO	2
13.0-15.1	C163B	30	LO	3
15.2-16.3	C180B	30	LO	4
16.4-17.9	C198B	30	1	4
Size 1				
18.0-19.7	C214B	30	1	5
19.8-21.2	C228B	30	1	6
21.3-22.3	C250B	30	2	7
22.4-23.5	C273B	30	2	8
23.6-25.5	C303B	30	3	8
23.6-25.5	C303B	50	LO	3
25.6-27.0	C330B	50	LO	3

Size 0 and 1 (Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
.66-.76	C087A	3	LO	LO
.77-.84	C097A	3	LO	LO
.85-.93	C109A	3	LO	1
.94-1.04	C118A	3	LO	1
1.05-1.15	C131A	3	LO	2
1.16-1.27	C148A	3	LO	2
1.28-1.39	C163A	3	LO	3
1.40-1.55	C184A	3	LO	4
1.56-1.73	C196A	3	1	4
1.74-1.89	C220A	3	1	5
1.90-2.05	C239A	3	2	6
2.06-2.28	C268A	3	2	7
2.29-2.47	C301A	3	3	8
2.29-2.47	C301A	7	LO	1
2.48-2.79	C326A	7	LO	2
2.80-3.31	C356A	7	LO	3
3.32-3.70	C379A	7	LO	4
3.71-4.06	C419A	7	1	5
4.07-4.47	C466A	7	1	5
4.48-4.95	C526A	7	2	6
4.96-5.49	C592A	7	2	7
4.96-5.49	C592A	15	LO	1
5.50-5.91	C630A	7	3	8
5.50-5.91	C630A	15	LO	2
5.92-6.47	C695A	15	LO	2
6.48-7.20	C778A	15	LO	3
7.21-8.22	C867A	15	LO	3
8.23-8.72	C955A	15	1	4
8.73-9.67	C104B	15	1	5
9.68-10.4	C113B	15	1	6
10.5-11.0	C125B	15	2	7
11.1-12.4	C137B	15	2	7
11.1-12.4	C137B	30	LO	2
12.5-13.2	C151B	30	LO	2
13.3-15.4	C163B	30	LO	3
15.5-17.1	C180B	30	LO	4
Size 1				
17.2-18.1	C198B	30	1	5
18.2-20.0	C214B	30	1	5
20.1-21.5	C228B	30	2	6
21.6-22.5	C250B	30	2	7
22.6-23.9	C273B	30	2	8
22.6-23.9	C273B	50	LO	2
24.0-26.0	C303B	30	3	8
24.0-26.0	C303B	50	LO	3
26.1-27.0	C330B	50	LO	4

Overload Heater Tables

Heaters for Mag-Break Controllers

Size 2 (Standard)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
8.81-9.27	C104B	15	2	5
9.28-9.99	C113B	15	2	6
10.0-11.1	C125B	15	3	6
11.2-12.1	C137B	15	3	7
11.2-12.1	C137B	30	LO	2
12.2-13.0	C151B	15	4	8
12.2-13.0	C151B	30	LO	2
13.1-15.5	C163B	30	1	3
15.6-16.8	C180B	30	1	4
16.9-18.0	C198B	30	2	5
18.1-19.7	C214B	30	2	5
19.8-21.6	C228B	30	2	6
21.7-23.9	C250B	30	3	7
21.7-23.9	C250B	50	LO	2
24.0-25.5	C273B	30	3	8
24.0-25.5	C273B	50	LO	3
25.6-26.0	C303B	30	3	9
25.6-28.2	C303B	50	LO	3
28.3-31.6	C330B	50	1	4
31.7-34.7	C366B	50	2	5
34.8-37.8	C400B	50	2	6
37.9-40.6	C440B	50	3	7
40.7-43.4	C460B	50	3	8

Size 2 (Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
9.04-9.61	C104B	15	2	5
9.62-10.5	C113B	15	2	6
10.6-11.6	C125B	15	3	7
11.7-12.5	C137B	15	3	8
11.7-12.5	C137B	30	LO	2
12.6-13.0	C151B	15	4	9
12.6-13.6	C151B	30	LO	3
13.7-16.7	C163B	30	1	3
16.8-17.9	C180B	30	1	5
18.0-18.7	C198B	30	2	5
18.8-20.4	C214B	30	2	6
20.5-22.7	C228B	30	2	7
22.8-24.7	C250B	30	3	8
22.8-24.7	C250B	50	LO	2
24.8-26.0	C273B	30	4	9
24.8-26.3	C273B	50	LO	4
26.4-29.5	C303B	50	LO	4
29.6-32.5	C330B	50	1	4
32.6-36.7	C366B	50	2	6
36.8-41.9	C400B	50	2	7
42.0-43.2	C440B	50	3	9
43.3-43.4	C460B	50	3	9

Size 3 (Standard and Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
17.8-18.4	F233B	30	1	5
18.5-21.1	F243B	30	1	6
21.2-22.1	F270B	30	2	7
22.2-26.0	F300B	30	3	7
26.1-28.0	F327B	50	LO	4
28.1-31.3	F357B	50	LO	4
31.4-33.3	F395B	50	1	5
33.4-34.3	F430B	50	1	6
34.4-40.9	F487B	50	1	6
41.0-43.4	F567B	50	2	8
43.5-44.7	F567B	100	LO	3
44.8-51.0	F614B	100	LO	3
51.1-52.0	F658B	100	1	4
52.1-55.4	F719B	100	1	4

Size 3 (Standard and Ambient Comp.) cont.

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
55.5-63.3	F772B	100	1	5
63.4-66.1	F848B	100	2	6
66.2-73.5	F914B	100	2	6
73.6-82.2	F104C	100	2	7
82.3-86.9	F114C	100	3	9

Size 4 (Standard)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
28.8-32.0	F357B	50	1	4
32.1-34.2	F395B	50	2	5
34.3-36.7	F430B	50	2	6
36.8-43.4	F487B	50	3	7
43.5-43.9	F487B	100	1	3
44.0-46.6	F567B	100	1	3
46.7-52.6	F614B	100	1	3
52.7-55.6	F658B	100	1	4
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	100	2	5
67.2-70.6	F848B	100	3	6
70.7-76.3	F914B	100	3	7
70.7-76.3	F914B	150	LO	1
76.4-86.9	F104C	100	4	8
76.4-88.7	F104C	150	LO	2
88.8-93.4	F114C	150	1	3
93.5-102	F118C	150	1	3
103-110	F133C	150	1	4
111-122	F149C	150	1	4
123-131	F161C	150	2	5

Size 4 (Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
28.8-32.0	F357B	50	2	4
32.1-34.2	F395B	50	2	5
34.3-36.7	F430B	50	2	6
36.8-43.4	F487B	50	3	7
36.8-43.8	F487B	100	LO	2
43.9-46.6	F567B	100	2	3
46.7-52.6	F614B	100	1	3
52.7-55.6	F658B	100	1	4
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	100	2	5
67.2-70.6	F848B	100	3	6
70.7-76.3	F914B	100	3	7
76.4-86.9	F104C	100	4	8
76.4-88.7	F104C	150	LO	2
88.8-93.4	F114C	150	1	3
93.5-105	F118C	150	1	3
106-114	F133C	150	1	4
115-128	F149C	150	2	5
129-130	F161C	150	2	6

Size 5 (Standard and Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
106-115	C592A	550-1670	2	6
116-125	C630A	550-1670	3	7
126-135	C695A	550-1670	3	7
126-135	C695A	1000-3300	LO	3
136-151	C778A	1000-3300	LO	3
152-164	C867A	1000-3300	LO	4
165-179	C955A	1000-3300	1	5
180-195	C104B	1000-3300	2	5
196-215	C113B	1000-3300	2	6
216-231	C125B	1000-3300	3	6
232-255	C137B	1000-3300	4	7
256-270	C151B	1000-3300	4	HI

Overload Heater Tables

Heaters for Mag-Break Controllers

Size 0 and 1 (Standard)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR123	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 CR123	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 CR123	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 CR123	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

Overload Heater Tables

Heaters for Mag-Break Controllers

Size 2 (Standard)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR123	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 CR123	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 CR123	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 (Standard)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR123	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 (Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR123	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

Overload Heater Tables

Heaters for Mag-Break Controllers

Size 4 (Standard)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR123	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 CR123	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 CR123	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 CR123	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 CR123	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 & Type
1	0.8 to 1.7	CR324CXD	E Mag. & Thermal Mag.
1	1.8 to 3.4	CR324CXE	E Mag. & Thermal Mag.
1	3.2 to 6.8	CR324CXF	E Mag. & Thermal Mag.
1	6.5 to 13.5	CR324CXG	E Mag. & Thermal Mag.
1	13 to 27	CR324CXH	E Mag. & Thermal Mag.
2	6.5 to 13.5	CR324DXG	E Mag. & Thermal Mag.
2	13 to 27	CR324DXH	E Mag. & Thermal Mag.
2	25 to 50	CR324DXJ	E Mag. & Thermal Mag.
3	17 to 35	CR324FXK	E Mag. & Thermal Mag.
3	35 to 70	CR324FXL	E Mag. & Thermal Mag.
3	65 to 135	CR324FXM	E Mag. & Thermal Mag.
4	17 to 35	CR324FXK	E,F&G Mag. & Thermal Mag.
4	35 to 70	CR324FXL	E,F&G Mag. & Thermal Mag.
4	65 to 135	CR324FXM	E,F&G Mag. & Thermal Mag.
5 ①	35 to 70	CR324GXN	G Mag. & Thermal Mag.
5 ①	65 to 135	CR324GXP	G Mag. & Thermal Mag.
5 ①	130 to 270	CR324GXQ	G Mag. & Thermal Mag.
6 ②	130 to 270	CR324HXS	G,K Mag. & Thermal Mag.
6 ②	260 to 540	CR324HXT	K Mag. & 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 & Type
0.4-.65	RTN1D		E Mag. & Thermal Mag.
0.65-1.1	RTN1F		E Mag. & Thermal Mag.
1-1.5	RTN1G		E Mag. & Thermal Mag.
1.3-1.9	RTN1H		E Mag. & Thermal Mag.
1.8-2.7	RTN1J		E Mag. & Thermal Mag.
2.5-4.1	RTNIK	RT12K	E Mag. & Thermal Mag.
4.0-6.3	RTNIL	RT12L	E Mag. & Thermal Mag.
5.5-8.5	RTNIM	RT12M	E Mag. & Thermal Mag.
8.0-12	RTNIN	RT12N	E Mag. & Thermal Mag.
10.0-16	RTNIP	RT12P	E Mag. & Thermal Mag.
14.5-18	RTNIS	RT12S	E Mag. & Thermal Mag.
17.5-22	RTNIT	RT12T	E Mag. & Thermal Mag.
21-26	RTNIU	RT12U	E Mag. & 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	5,000
2	60	100,000	100	100,000	per	5,000
3	100	100,000	200	100,000	Overload	5,000
4	200	100,000	400	100,000	Heater	10,000
5	400	100,000	600	100,000	Table	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	35①
9.68-10.4	C113B	35①
10.5-11.0	C125B	40①
11.1-12.4	C137B	45①
12.5-13.2	C151B	50①
13.3-15.4	C163B	60①
15.5-17.1	C180B	60①
17.2-18.0	C198B	60①

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	60①
18.2-20.0	C214B	60①
20.1-21.5	C228B	60①
21.6-22.5	C250B	60①
22.6-23.9	C273B	60①
24.0-26.3	C303B	60①
26.4-27.0	C330B	60①

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	70①
18.8-20.4	C214B	80①
20.5-22.7	C228B	80①
22.8-24.7	C250B	90①
24.8-26.3	C273B	90①
26.4-29.5	C303B	100①
29.6-32.5	C330B	100①
32.6-36.7	C366B	100①
36.8-41.9	C400B	100①
42.0-43.2	C440B	100①
43.3-45.0	C460B	100①

① See Table 1 for maximum fuse and short-circuit rating.

J

Overload Heater Tables

Heaters for Fused Controllers

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	110①
31.9-33.9	F395B	125①
34.0-37.6	F430B	125①
37.7-41.9	F487B	150①
42.0-47.7	F567B	175①
47.8-52.1	F614B	175①
52.2-55.8	F658B	200①
55.9-59.7	F719B	200①
59.8-68.1	F772B	200①
68.2-71.5	F848B	200①
71.6-78.2	F914B	200①
78.3-87.5	F104C	200①
87.6-90.0	F114C	200①

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	110①
31.4-33.3	F395B	125①
33.4-34.3	F430B	125①
34.4-40.9	F487B	150①
41.0-44.7	F567B	150①
44.8-51.0	F614B	175①
51.1-52.0	F658B	200①
52.1-55.4	F719B	200①
55.5-63.3	F772B	200①
63.4-66.1	F848B	200①
66.2-73.5	F914B	200①
73.6-82.2	F104C	200①
82.3-90.0	F114C	200①

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	225①
60.1-69.5	F772B	225①
69.6-71.7	F848B	250①
71.8-79.9	F914B	275①
80.0-92.3	F104C	300①
92.4-97.0	F114C	350①
97.1-108	F118C	400①
109-118	F133C	400①
119-131	F149C	400①
132-135	F161C	400①

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	225①
58.8-67.1	F772B	225①
67.2-70.6	F848B	250①
70.7-76.3	F914B	275①
76.4-88.7	F104C	300①
88.8-93.4	F114C	350①
93.5-105	F118C	350①
106-114	F133C	400①
115-128	F149C	400①
129-131	F161C	400①
132-135	F174C	400①

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

				UL Class J				Time-Delay RK-5			
				Time Delay		No Time Delay		BMC	CSC		
Size	Hp	Typical FLA	Switch Amp	CSC# AJT	Clip	CSC# A4J	Clip	FRN	Clip	TR	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

				UL Class J				Time-Delay RK-5			
				Time Delay		No Time Delay		BMC			CSC
Size	Hp	Typical FLA	Switch Amp	CSC# AJT	Clip	CSC# A4J	Clip	FRN	Clip	TR	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

Starter Fuse Selection

460 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J				Time-Delay K-5			
				Time Delay		No Time Delay		BMC		CSC	
				CSC# AJT	CLIP	CSC# A4J	CLIP	FRS	Clip	TRS	Clip
1	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
	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
2	15	19.6	60	30	30	50	60	25	30	30	30
	20	25.7	60	40	60	90	100	35	60	40	60
	25	31.8	60	50	60	100	100	40	60	50	60
3	30	38.3	100	60	60	110	200	45	60	60	60
	40	52.0	100	80	100	125	200	60	60	75	100
	50	65.0	100	100	100	150	200	80	100	100	100
4	60	75.5	200	110	200	175	200	90	100	110	200
	75	91.5	200	150	200	225	400	110	200	150	200
	100	120	200	175	200	225	400	150	200	175	200
5	125	148	400	225	400	300	400	200	200	225	400
	150	172	400	250	400	350	400	225	400	250	400
	200	224	400	300	400	500	600	300	400	350	400
6	250	295	600	450	600	600	600	350	400	400	400
	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		CSC	
				CSC# AJT	CLIP	CSC# A4J	CLIP	FRS	Clip	TRS	Clip
1	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
	1½	1.8	30	3	30	6	30	2.25	30	3	30
	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
2	15	15.7	60	25	30	45	60	20	30	25	30
	20	20.6	60	35	60	60	60	25	30	35	60
	25	25.4	60	40	60	80	100	35	60	40	60
3	30	30.6	100	45	60	100	100	40	60	45	60
	40	41.6	100	60	60	110	200	45	60	60	60
	50	52.0	100	80	100	125	200	60	60	80	100
4	60	60.4	200	90	100	150	200	70	100	90	100
	75	73.2	200	125	200	175	200	90	100	125	200
	100	96.0	200	150	200	225	400	110	200	150	200
5	125	118	400	175	200	225	400	150	200	175	200
	150	138	400	225	400	300	400	175	200	225	400
	200	179	400	300	400	400	400	225	400	300	400
6	250	236	600	350	400	500	600	300	400	350	400
	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 Breaker Frame	SE150	15
	SF250	20
	SG600	25
	SK800	40
	SK1200	50
Insulated Case Power Break	800A	80
	1600A	210
	2000A	305
	2500A	375

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	Maximum Inrush Current (Amps Peak)	Tungsten① Lamps	Resistive Loads①	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.

J

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 Current① 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 Ratings②							
		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	25	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

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 maximum③.
4. Disconnect must be thermal magnetic or fused switch rated per NEC @ 125% of load amps.

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.

Non-Motor Loads

Application Rated

Maximum kVA of Transformer for Primary Switching (50/60Hz)a

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	64	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 Maximum Available Fault Current				22,000 Amp RMS 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

Non-Motor Loads

Application Rated

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	40°C	A	25	25	32	32	54	55	80	100	102	120	120	150	175	200	310	500	600	650
at ambient temperature	55°C	A	25	25	32	32	54	55	80	100	102	120	120	150	175	200	310	425	510	546
of: (for all voltages)	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	40°C	A	25	32	40	54	70	100	110	120	175	200	310	500	550	650
at ambient temperature	55°C	A	25	32	40	54	70	100	110	120	175	200	310	425	462	543
of: (for all voltages)	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	22,22,17①	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	34,34,27①	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)	104,96,80①	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	Stocking Location
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

Publication①	Description	Stocking Location
GE Fanuc Programmable Logic Control		
GFW-0067	Automation Solutions Catalog	Charlottesville
GE 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

J

Publication References

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	CR104P Push-buttons and Pilot Lights	Bloomington
Relays and Timers		
GEA-10639	CR122B, CR122BT, Series A Relays	Bloomington
GEH-4115	CR120B AC Relays	Bloomington
GEH-4120	CR120B Latched Relays	Bloomington
GEH-4147	CR122B Time-Delay Relays	Bloomington
GEH-4139	CR122BP Time-Delay Relays	Bloomington
GEH-6435	Spectra ECM Instructions	Bloomington
DET-069	Spectra ECM Product Brochure	Bloomington
*Variable Speed Drives*①		
GEI-100364	AF 300P User Guide	Fort Wayne
GEI-100363	AF 300G User Guide	Fort Wayne
Solid State Starters		
DEH-40397	ASTAT–CD Plus User Manual	Bloomington
GEH-6533	ASTAT–CD Plus Instructions	Bloomington
DEH-40396	ASTAT–IBP Plus User Manual	Bloomington
DEH-40417	ASTAT–IBP Plus Instructions	Bloomington

Web Access

① G11/P11 Drives — www.ge.com/industrialsystem/drives/catalog/af300g11/index.htm

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

$KW = \frac{HPx.746}{Eff.}$ or $\frac{75x.746}{.902} = 62$
.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)

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-ft^2)

Torque

$T = F \times R$

Where: T = Torque (lb-ft)
F = Force (lb)
R = Radius (ft)

WK^2 – reflected

Reflected $WK^2 = \frac{WK^2 \text{ of Load}}{(\text{Reduction Ratio})^2}$

This is for either belt or gear reductions.

FPM to RPM

$RPM = \frac{FPM}{.262 \times (\text{diameter in inches})}$

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)

$F_A = \frac{W \times V}{1933t}$

Where: F_A = Accelerating Force (lb-ft)
W = Weight (lb)
V = Change in velocity (FPM)
t = Time (sec.)

Electrical Data

Centrifugal Loads

Flow Rate:

$$Flow_1 = \left(RPM_1\right)$$
$$Flow_2 = \left(RPM_2\right)$$

Torque:

$$Torque_1 = \left(RPM_1\right)\ 2$$
$$Torque_2 = \left(RPM_2\right)$$

Pressure:

$$Pres_1 = \left(RPM_1\right)\ 2$$
$$Pres_2 = \left(RPM_2\right)$$

Horsepower:

$$BHP_1 = RPM_1\ 3$$
$$BHP_2 = RPM_{22}$$

Fans & Blowers:

$$BHP = \frac{CFM \times PSF}{3300 \times (\text{fan efficiency})}$$

$$BH = \frac{CFM \times PIW}{6350 \times (\text{fan efficiency})}$$

$$BHP = \frac{CFM \times PSI}{229 \times (\text{fan efficiency})}$$

Pumps:

$$BHP = \frac{GPM \times TH \times (\text{specific gravity})}{3960 \times (\text{pump efficiency})}$$

$$BHP = \frac{GPM \times PSI \times (\text{specific gravity})}{1713 \times (\text{pump efficiency})}$$

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

$$GR = \sqrt{\frac{WK^2}{WKM^2} + \frac{Tf^2}{TM^2} + \frac{Tf}{T_M}}$$

Where: $WK^2 = WK^2$ of the load
$WK^2_M = WK^2$ of the motor
T_f = 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:

$$GR = \sqrt{\frac{WK^2}{WK^2}}$$

Duty Cycle Calculations

$$HP_{RMS} = \sqrt{\frac{HP^2_1 t + HP^2_2 t + HP_3 t^2 + etc}{t_1 + t_2 + t_3 + etc}}$$

J

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 GE 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 GE 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 1 A D

Motor Control Center number/character

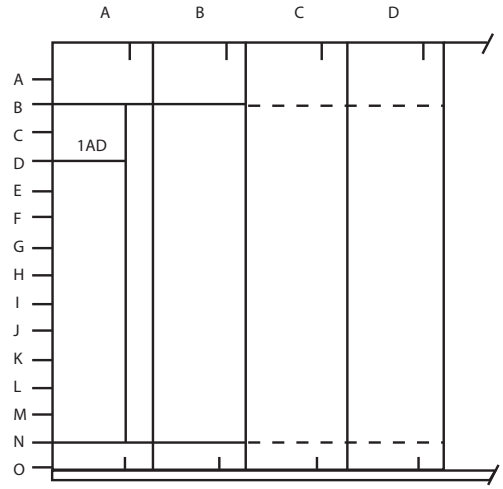
Vertical Section number/character

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



Front View

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.

Example: ML # 0447X0542L01 – 1AD

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 and shelves will be provided by the factory.

E9000 MCC Unit Numbering System

Mebane 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. Customer will receive A-size (81/2 x 11 inches) prints.

1) Lead Sheet	Fig. 1
2) Outline	Fig. 2
3) Summary Tables	Fig. 3
4) Unit Elementaries	Section K

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.

Fig. 1

GENERAL ELECTRIC CO.

NOTES- E9000 MCC ENG. NAME MEBANE, N.C. U.S.A.

REQ. NO. ISSUED REV. DWG. NO.

SH. 00

PANEL CAT. NO. 0525X0012L00 STATUS NO. 1 CONT. ON 01

GENERAL-NOTES FOR ENTIRE JOB:
A-U.L. LABELED SECTION CAN BE DETERMINED BY UL IN TOP WIREWAY OF OUTLINE SHEET. UL LABELED UNIT CAN BE DETERMINED FROM COLUMN MARKED U.L. LABEL ON SUMMARY SHEET.
B-WARNING: USE ONLY FUSES OF TYPE FURNISHED OR INDICATED IN NOTES OR ELECTRICAL EQUIVALENT.
C-O.L. HEATERS ARE SELECTED FROM 1800 RPM 1.15 SERVICE FACTOR MOTORS UNLESS OTHERWISE SPECIFIED.
O.L. HTR CAT. NO'S. SIZE 1,2,5 & 6 CR123C_____, SIZE 3 & 4 CR123F_____.

1-ALL UNITS TO BE E9000

E9000 MCC Unit Numbering System

Fig. 2

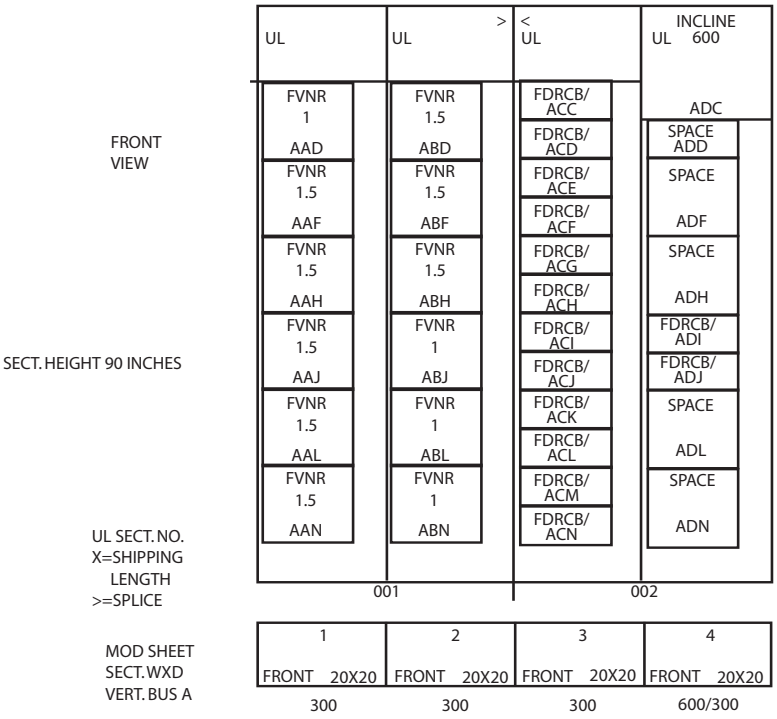


Fig. 3

UNIT SUMMARY EVOLUTION SERIES MCC
REQ. NO.
PANEL CAT. NO.
FRONT

ENG. NAME JBC
ISSUED 01/16/1996 REV.
REV NO. 0

GE INDUSTRIAL SYSTEMS
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																							

K

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 GE
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 1000 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 Section A (General). 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 GE 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, circuit-breaker-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 sub-assemblies-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	85①
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

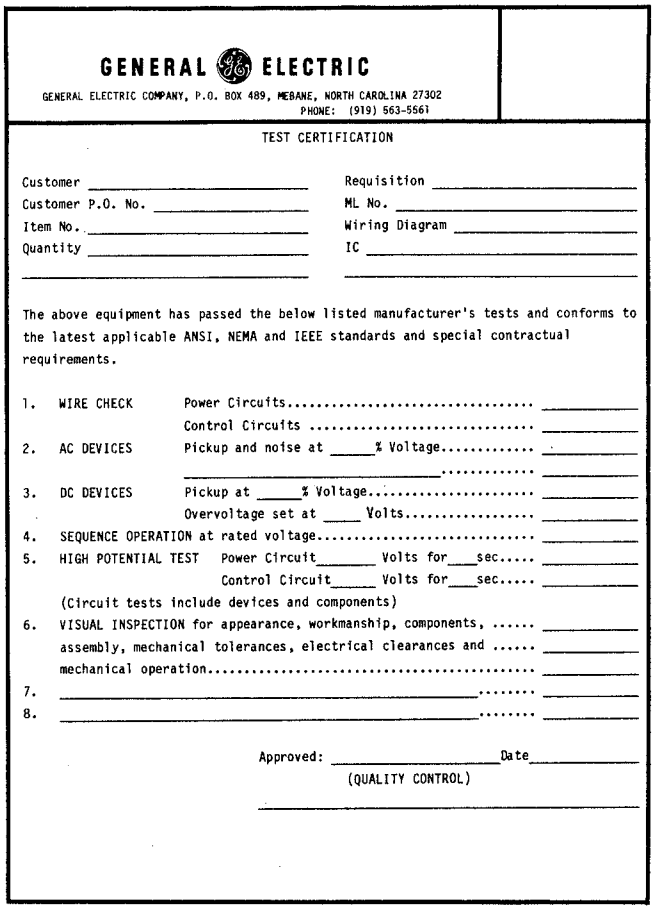
The frequency of the test voltage shall not be less than the rated frequency of the equipment tested and shall be essentially sinusoidal in wave shape.

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



GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, P.O. BOX 489, MEBANE, NORTH CAROLINA 27302
PHONE: (919) 563-5561

TEST CERTIFICATION

Customer _____ Requisition _____
Customer P.O. No. _____ ML No. _____
Item No. _____ Wiring Diagram _____
Quantity _____ IC _____

The above equipment has passed the below listed manufacturer's tests and conforms to the latest applicable ANSI, NEMA and IEEE standards and special contractual requirements.

1. WIRE CHECK — Power Circuits..... _____
   Control Circuits ..... _____
2. AC DEVICES — Pickup and noise at _____% Voltage..... _____
   _____..... _____
3. DC DEVICES — Pickup at _____% Voltage..... _____
   Overvoltage set at _____ Volts..... _____
4. SEQUENCE OPERATION at rated voltage..... _____
5. HIGH POTENTIAL TEST — Power Circuit_____ Volts for___sec..... _____
   Control Circuit_____ Volts for___sec..... _____
   (Circuit tests include devices and components)
6. VISUAL INSPECTION for appearance, workmanship, components, ... _____
   assembly, mechanical tolerances, electrical clearances and ..... _____
   mechanical operation..... _____
7. _____..... _____
8. _____..... _____

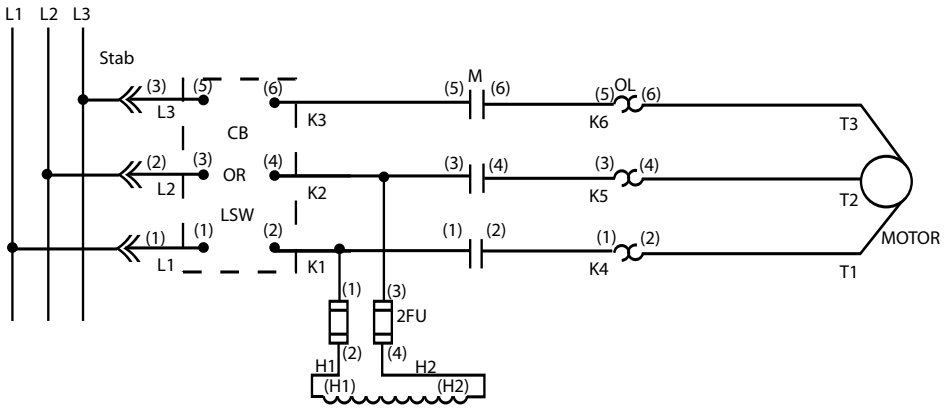
Approved: _____Date_____
(QUALITY CONTROL)

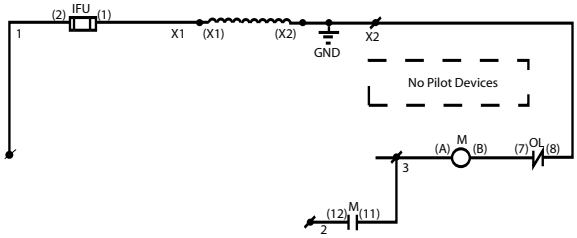
Example of standard test report available on request for a nominal charge.

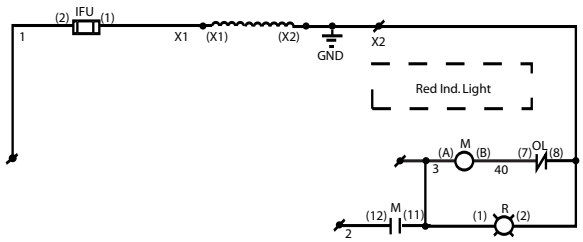
Evolution Series E9000 Motor Control Centers
Typical Circuits

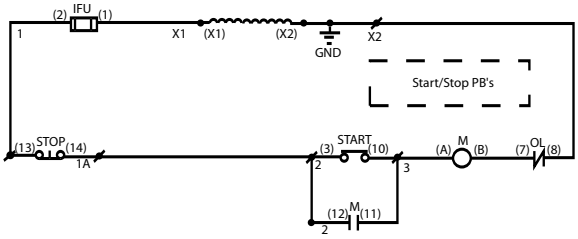
FVNR Size 1-4

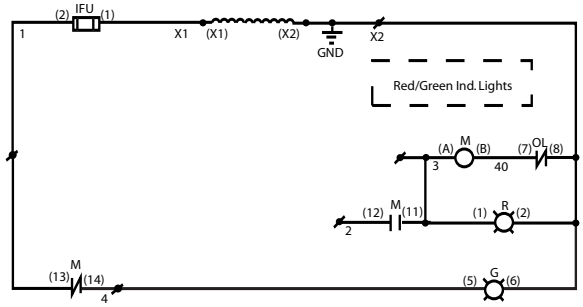
Typical Circuit Diagrams

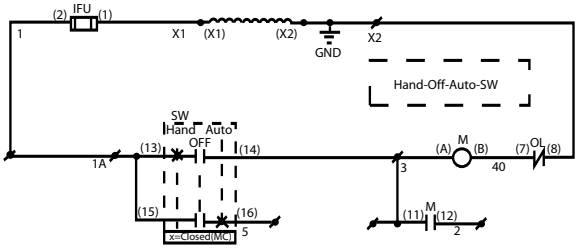


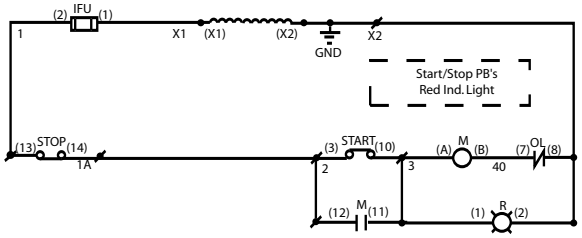


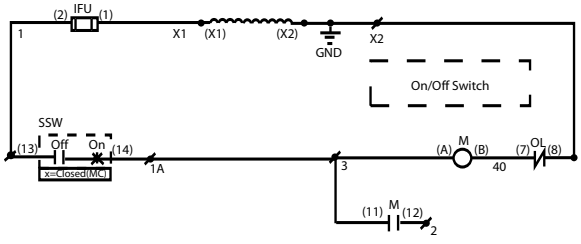


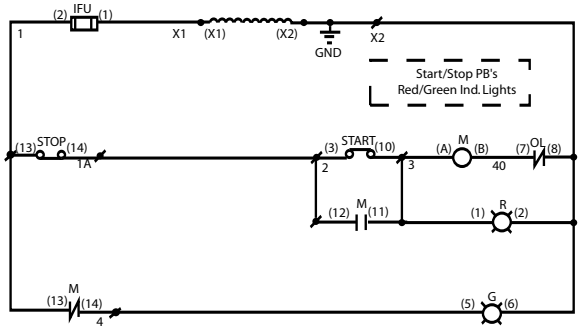








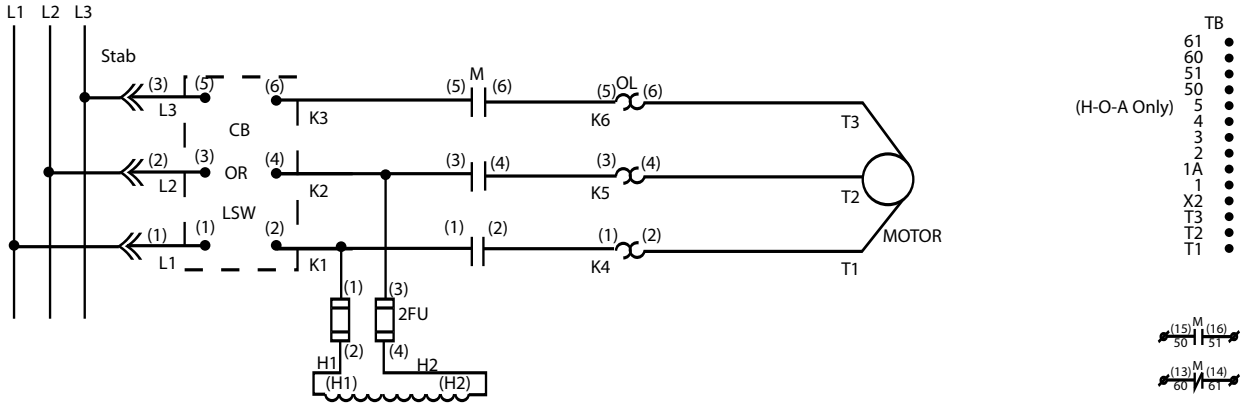


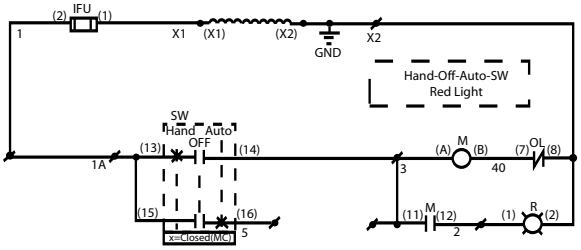


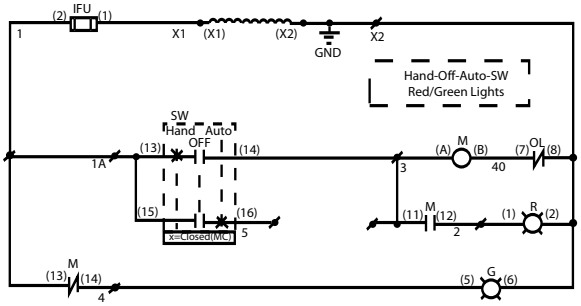
Evolution Series E9000 Motor Control Centers
Typical Circuits

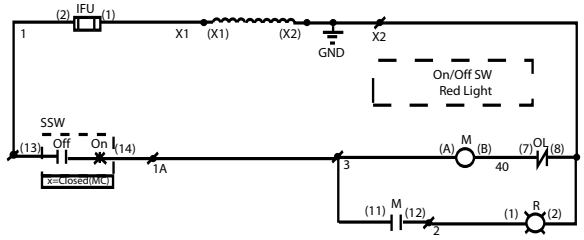
FVNR Size 1-4

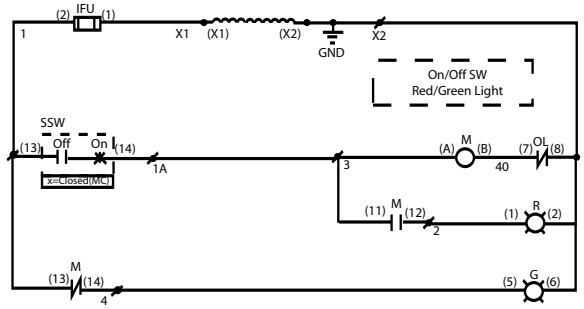
Typical Circuit Diagrams

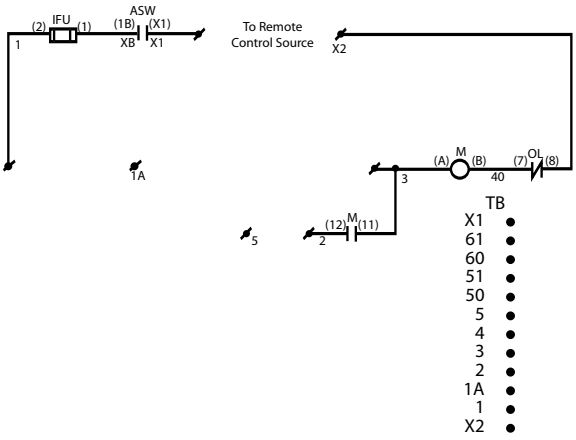










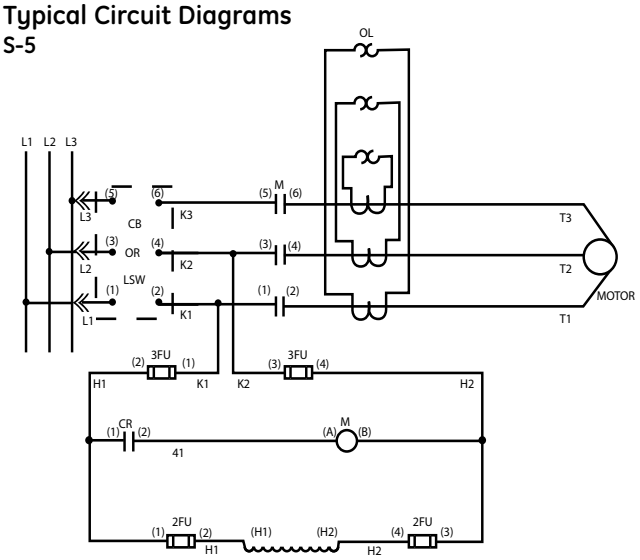


Evolution Series E9000 Motor Control Centers
Typical Circuits

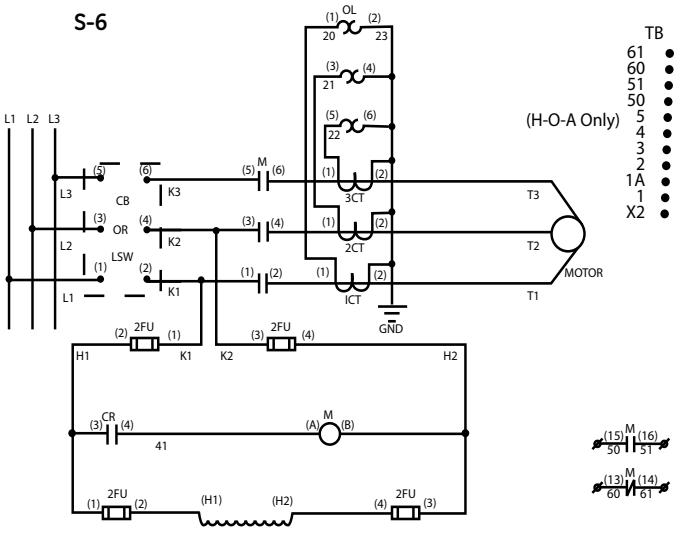
FVNR Size 5-6

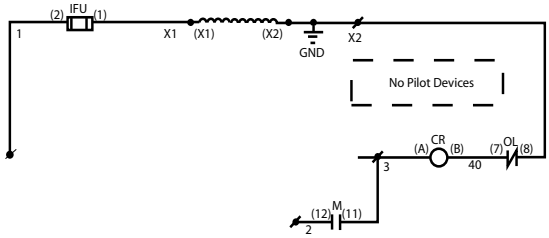
Typical Circuit Diagrams

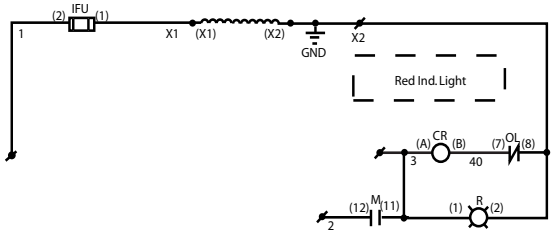
S-5

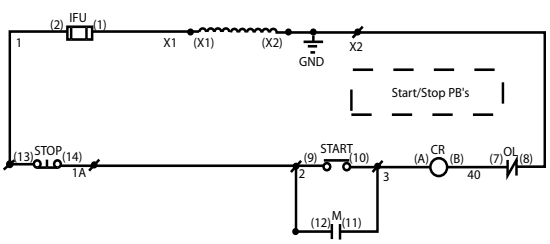


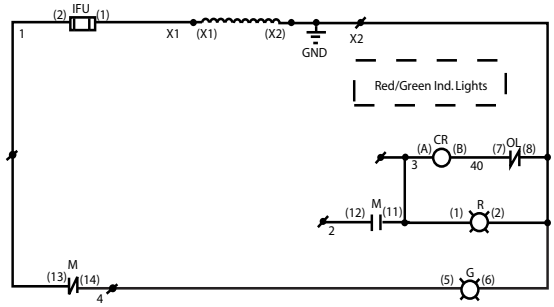
S-6

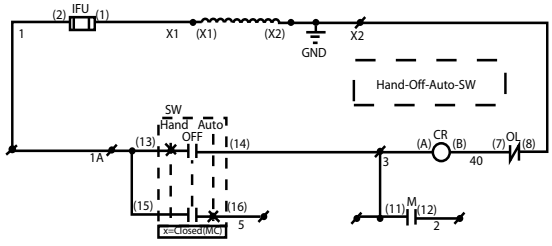


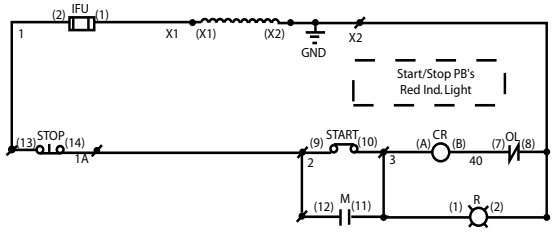


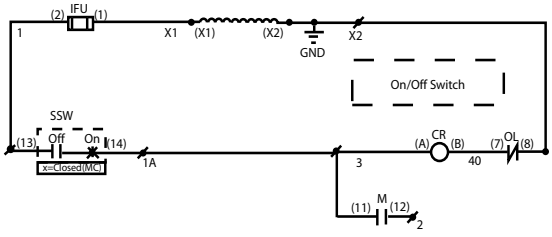


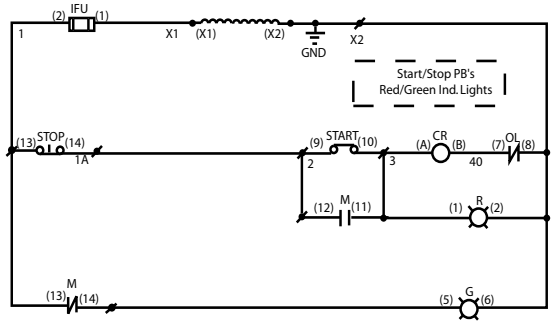










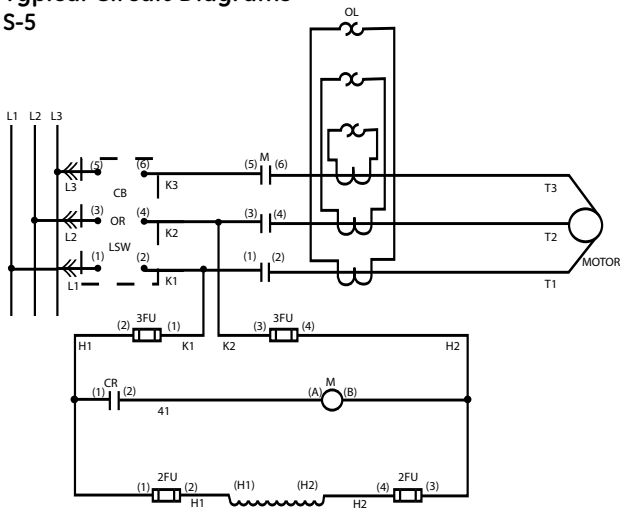


Evolution Series E9000 Motor Control Centers
Typical Circuits

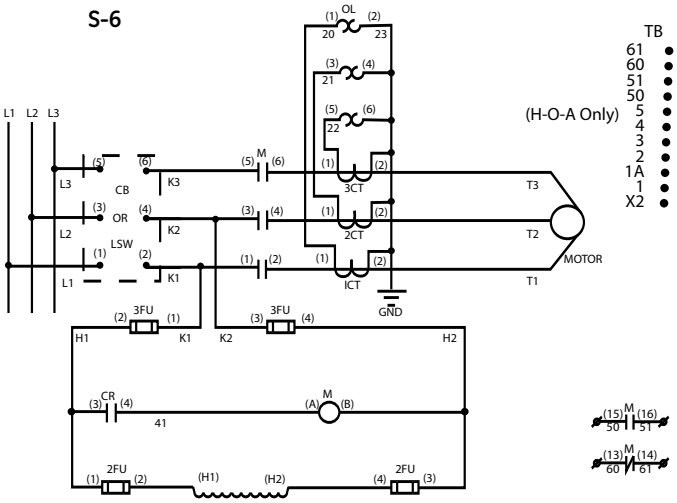
FVNR Size 5-6

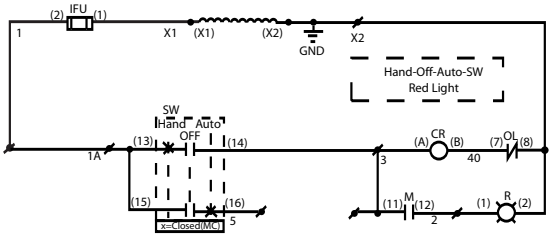
Typical Circuit Diagrams

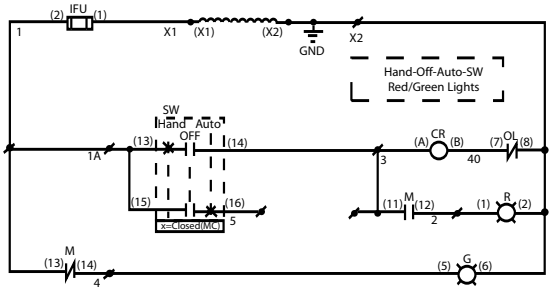
S-5

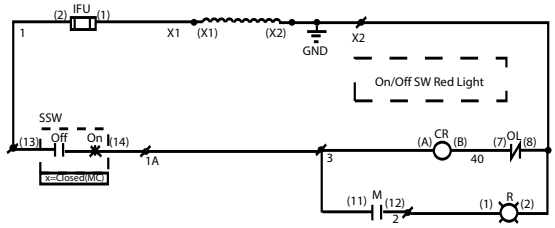


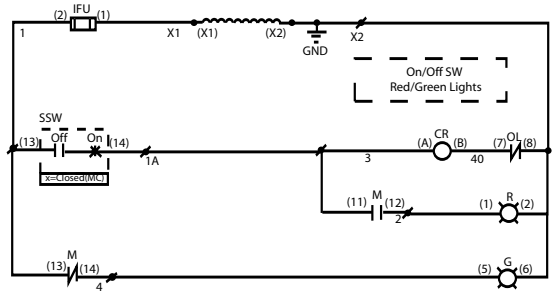
S-6







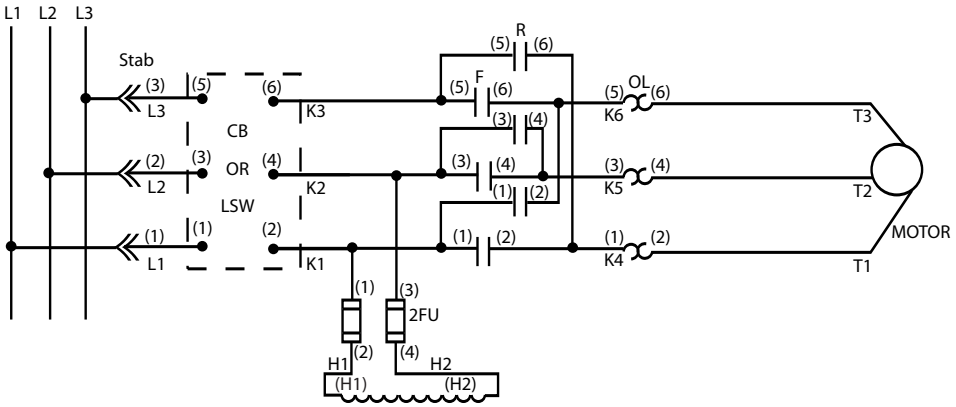


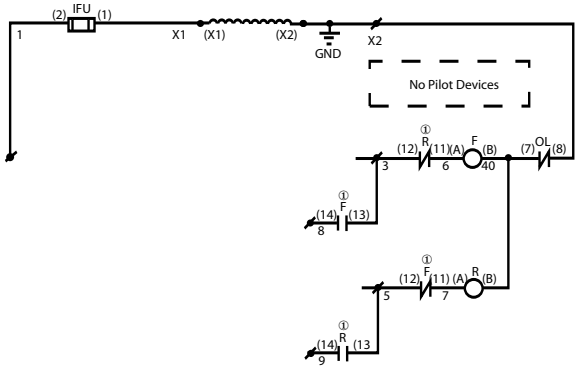


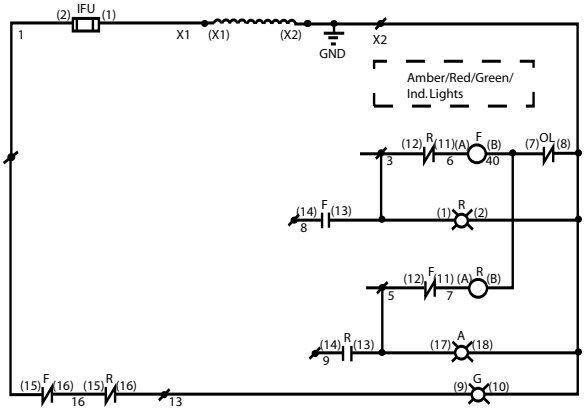
Evolution Series E9000 Motor Control Centers
Typical Circuits

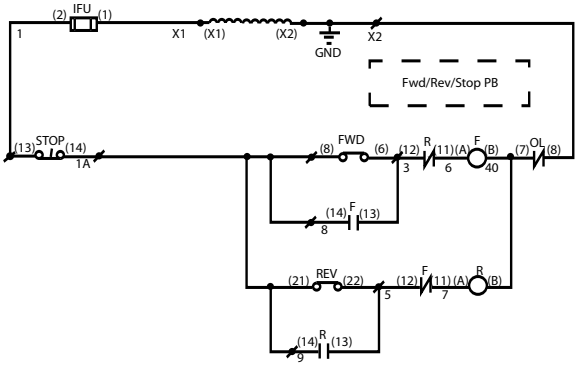
FVR Size 1-4

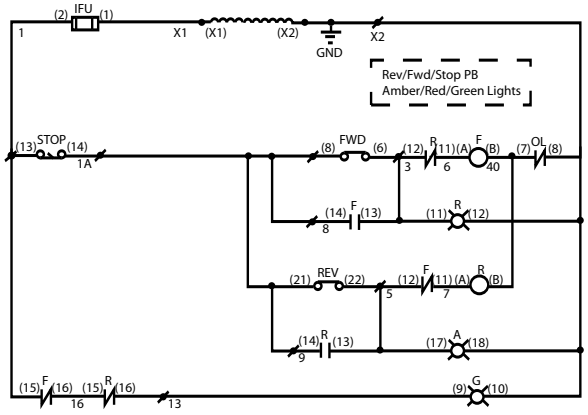
Typical Circuit Diagrams

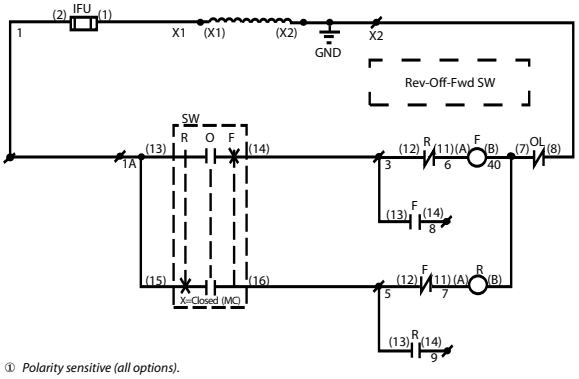


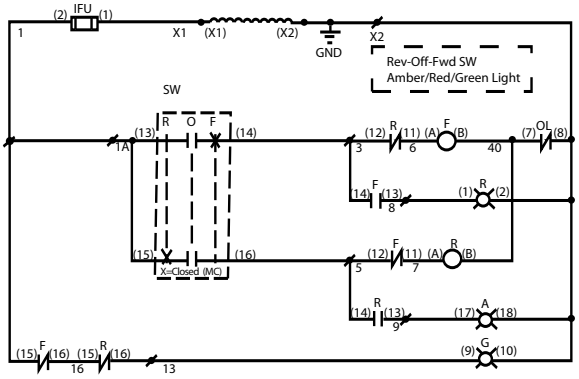










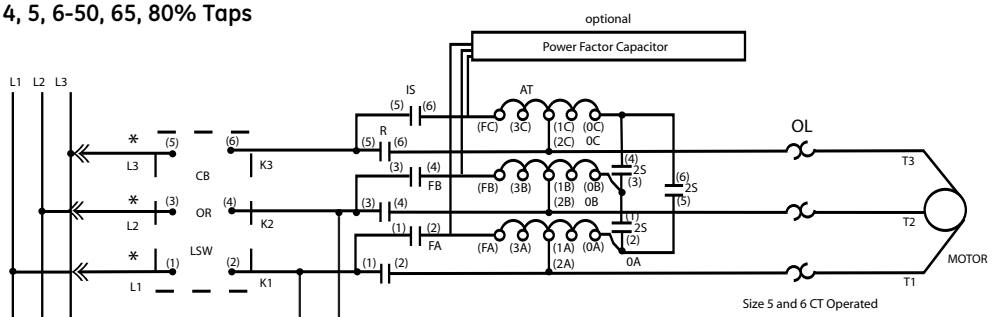


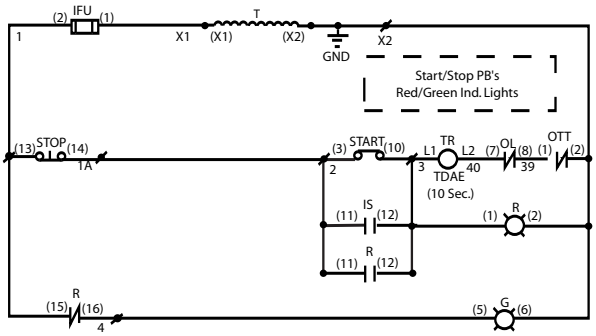
① *Polarity sensitive (all options).*

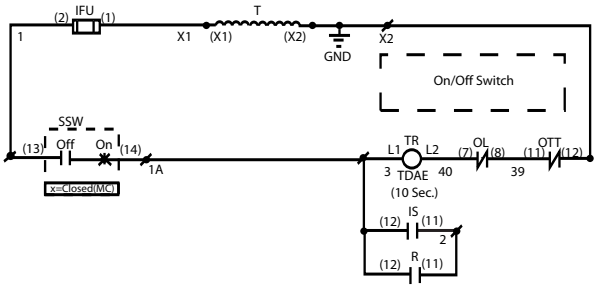
Evolution Series E9000 Motor Control Centers
Typical Circuits

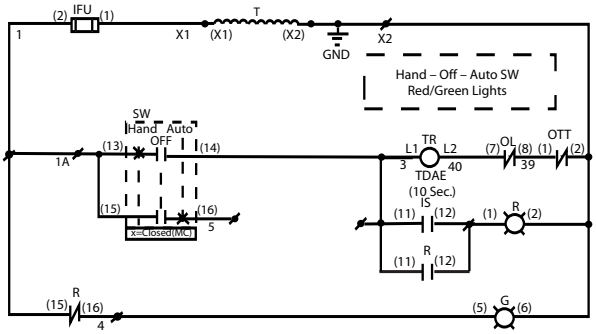
RVAT Size 2-6

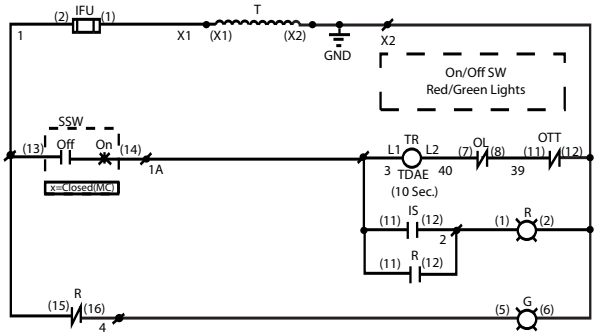
Typical Circuit Diagrams
Size 2, 3-65, 80% Taps
Size 4, 5, 6-50, 65, 80% Taps

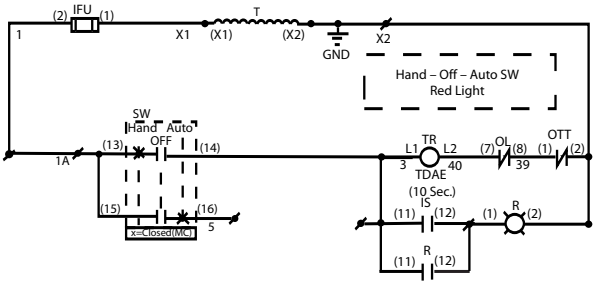


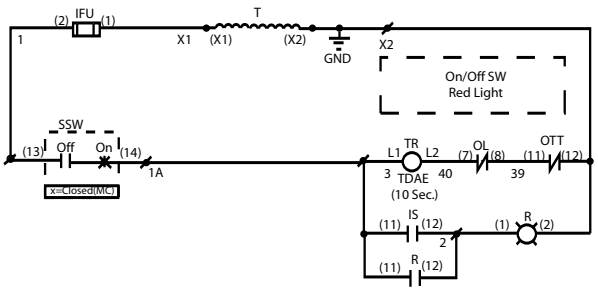








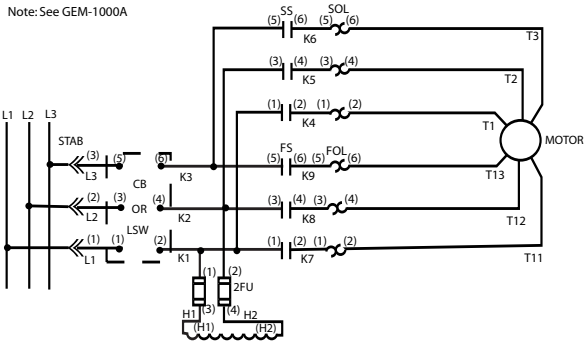


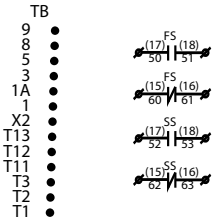


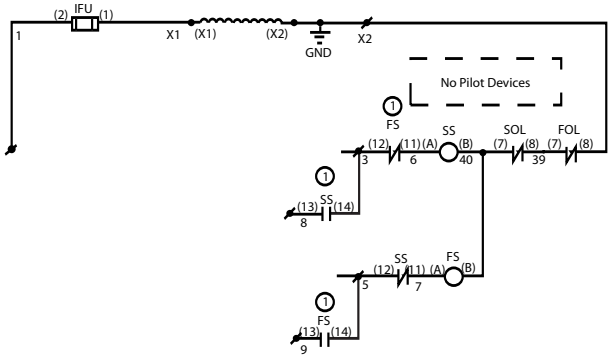
Evolution Series E9000 Motor Control Centers
Typical Circuits

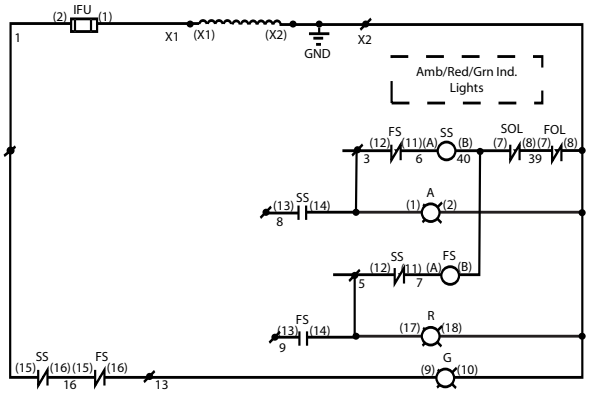
2S2W-C.T., V.T., C.H. Size 1-4

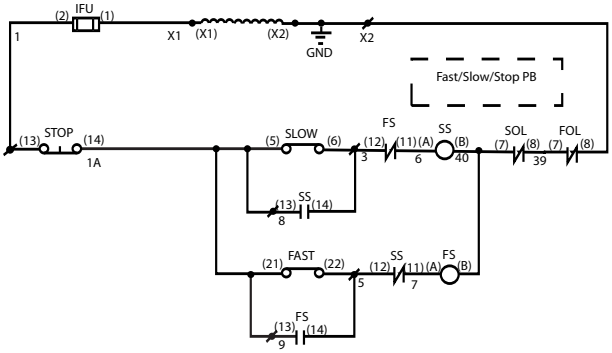
Typical Circuit Diagrams

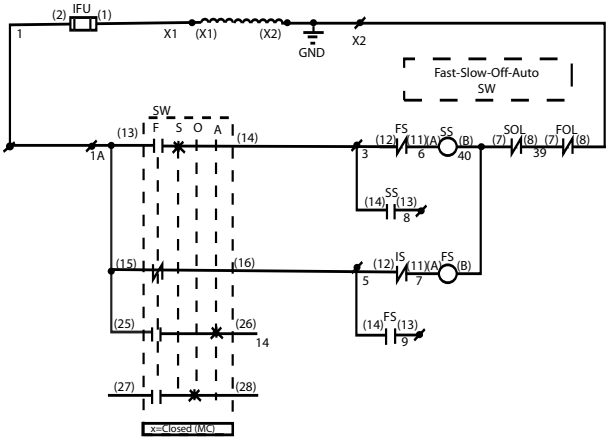


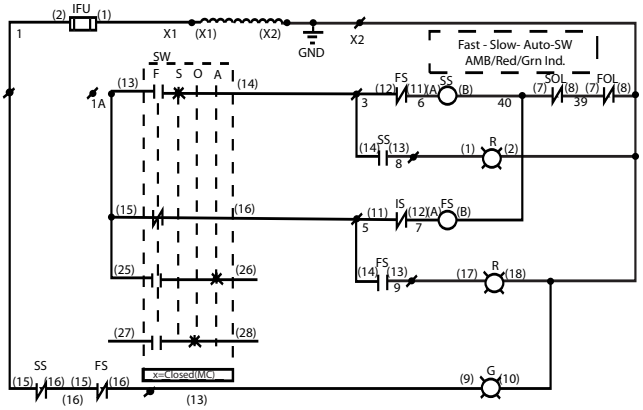


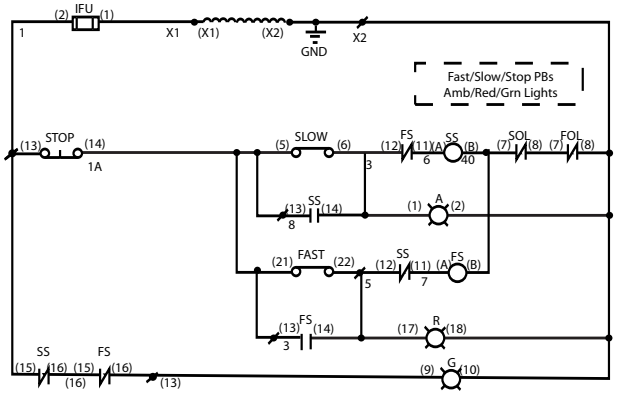










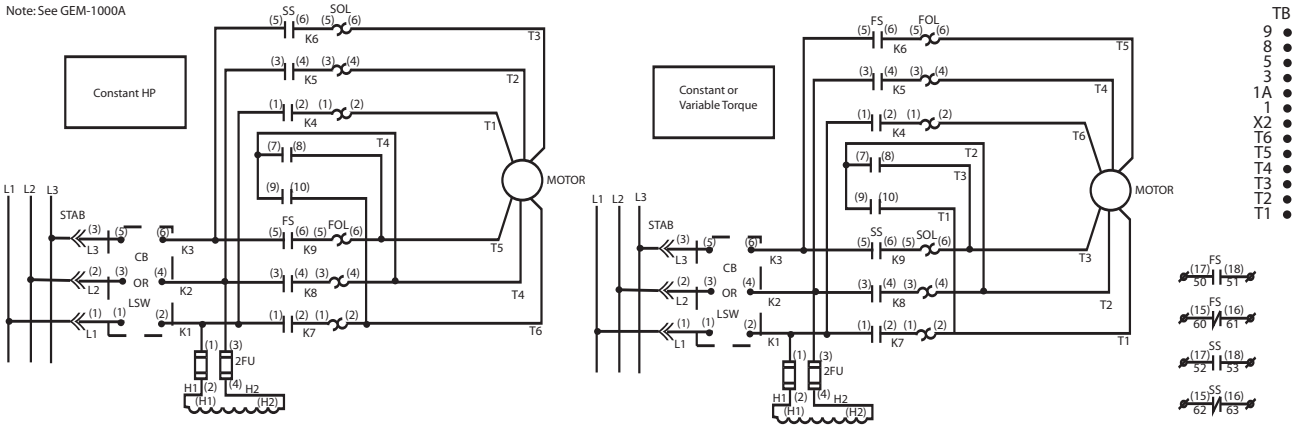


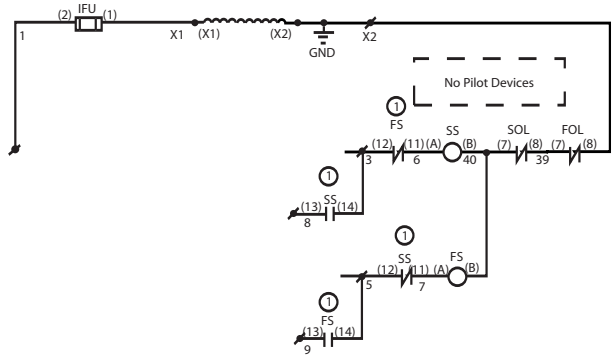
Evolution Series E9000 Motor Control Centers

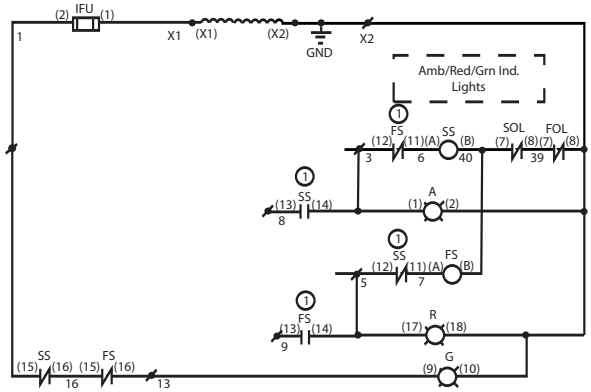
Typical Circuits

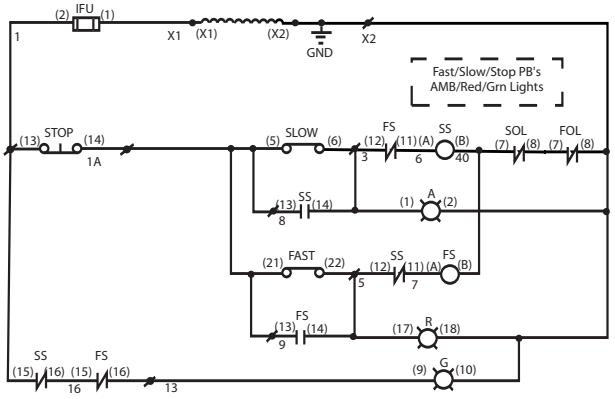
2S1W-C.T., V.T., C.H. Size 1-4

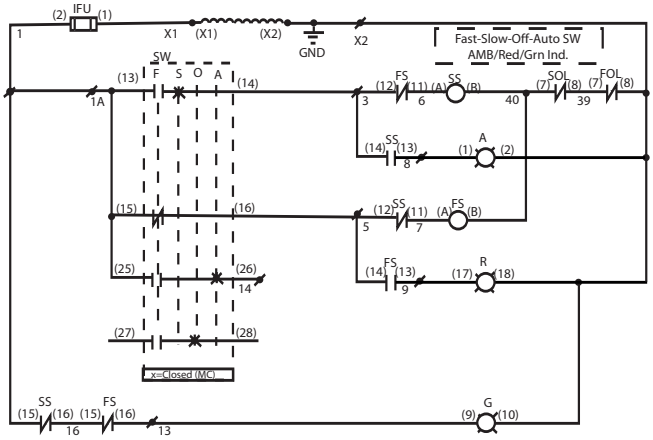
Typical Circuit Diagrams

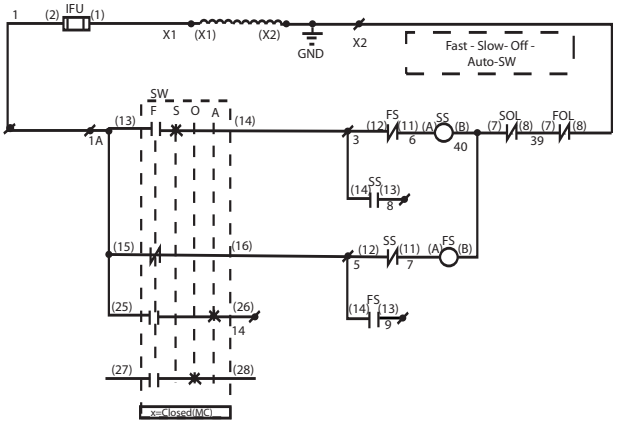


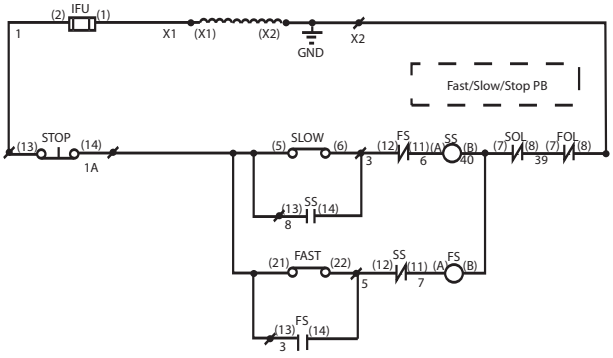










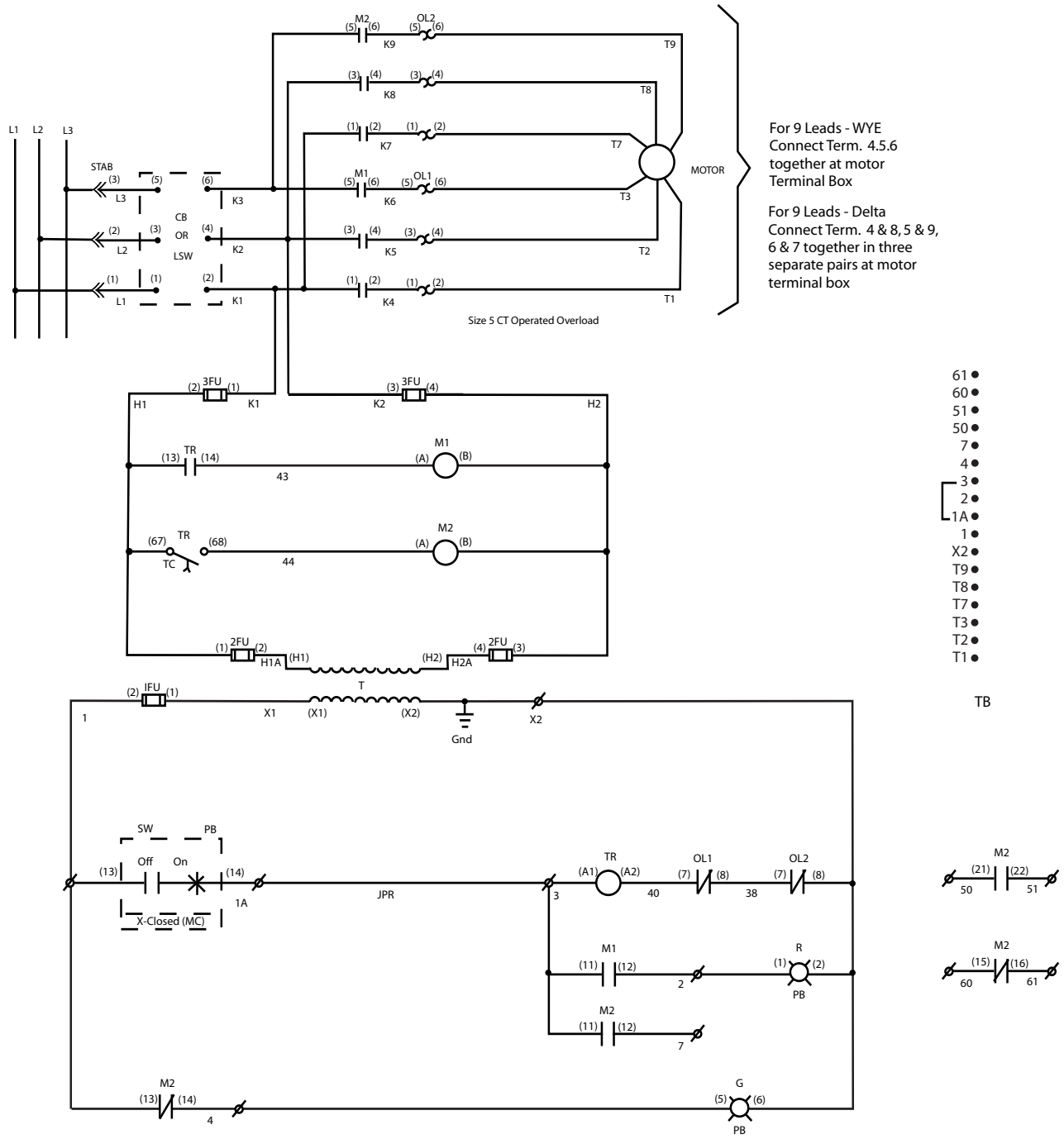


① Polarity sensitive (all options).

Evolution Series E9000 Motor Control Centers
Typical Circuits

2S-PW Size 1-5

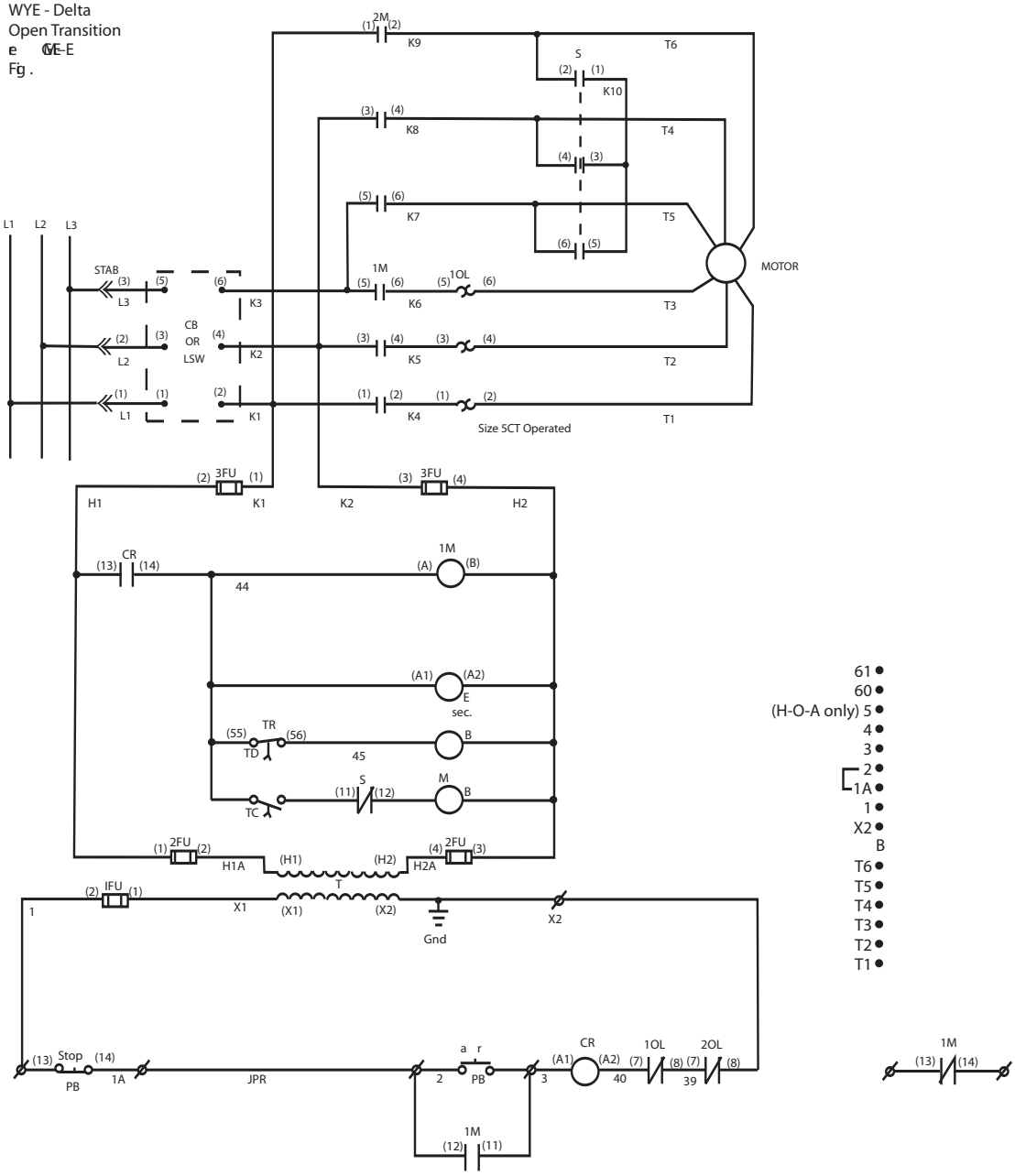
Typical Circuit Diagrams



Evolution Series E9000 Motor Control Centers
Typical Circuits

Wye-Delta Open Transition

WYE - Delta
Open Transition
e W E
Fig .



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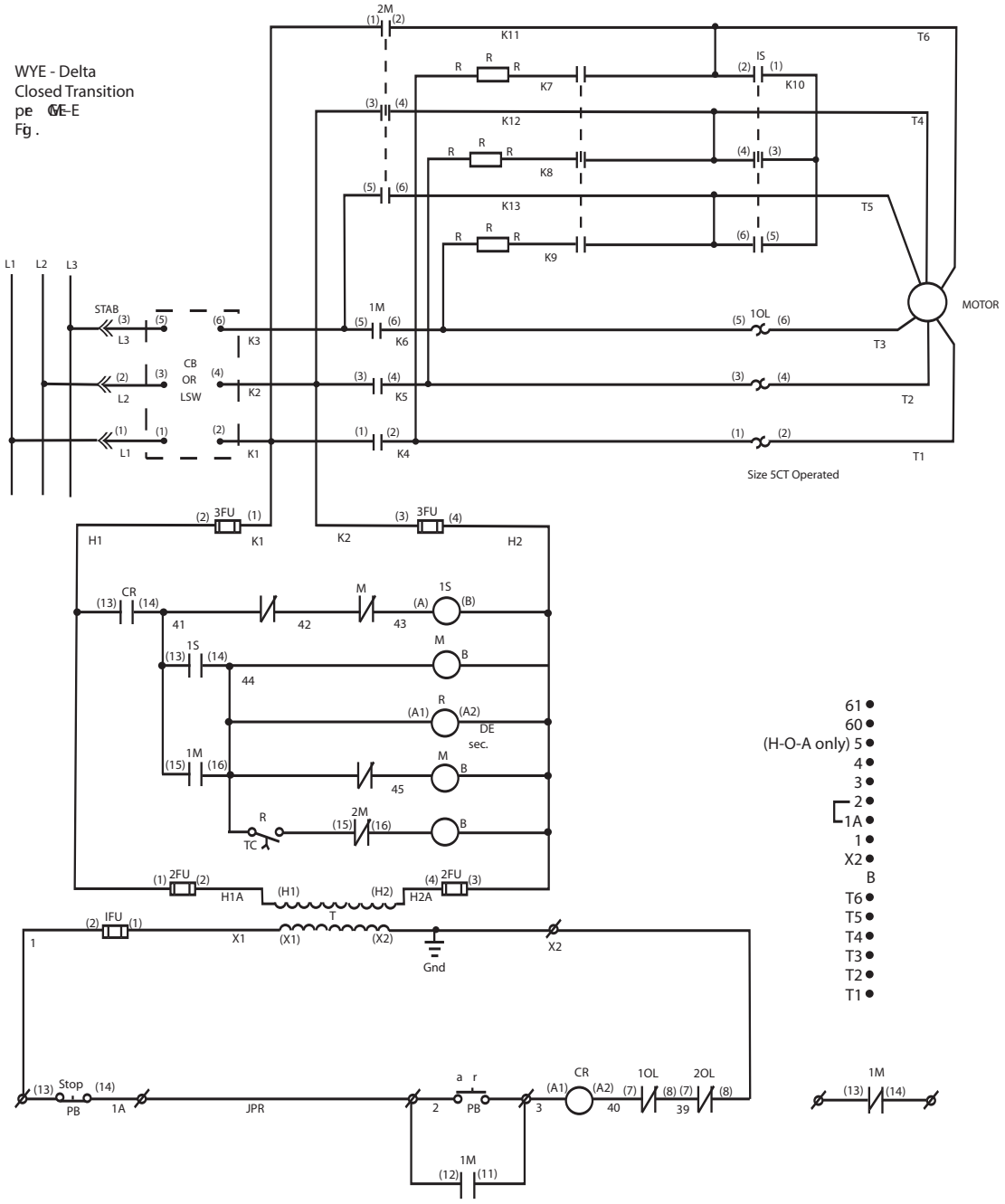
Evolution Series E9000 Motor Control Centers
Typical Circuits

Wye-Delta Open Transition

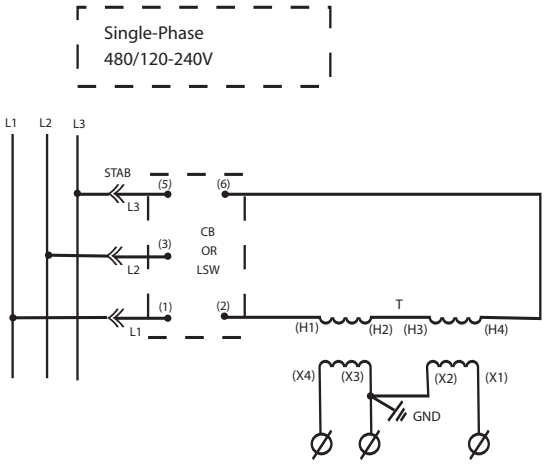


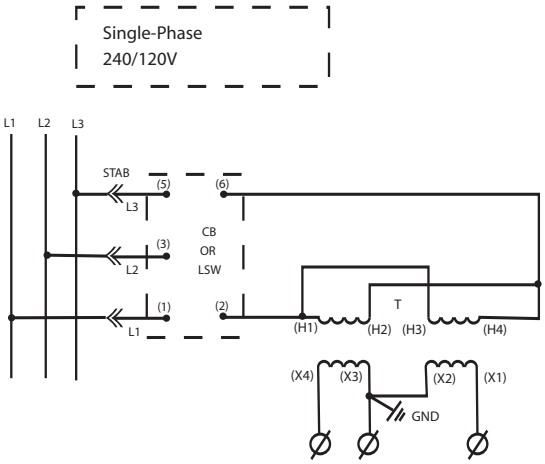
NE: rl circui pis similar he FVNRz e

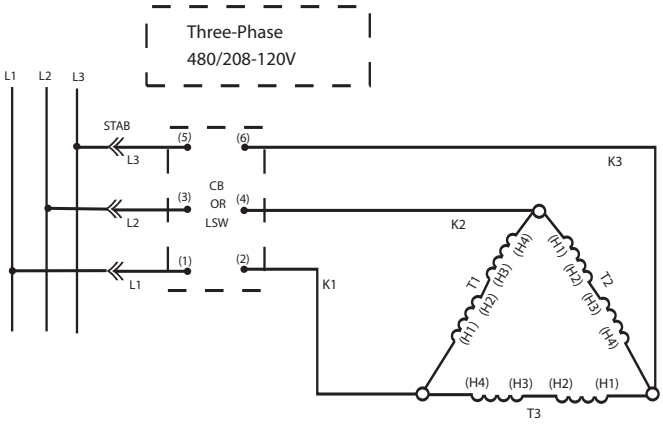
Evolution Series E9000 Motor Control Centers
Typical Circuits

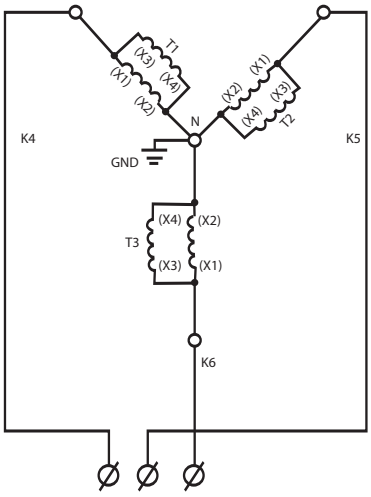
Distribution Transformers

Typical Circuit Diagrams







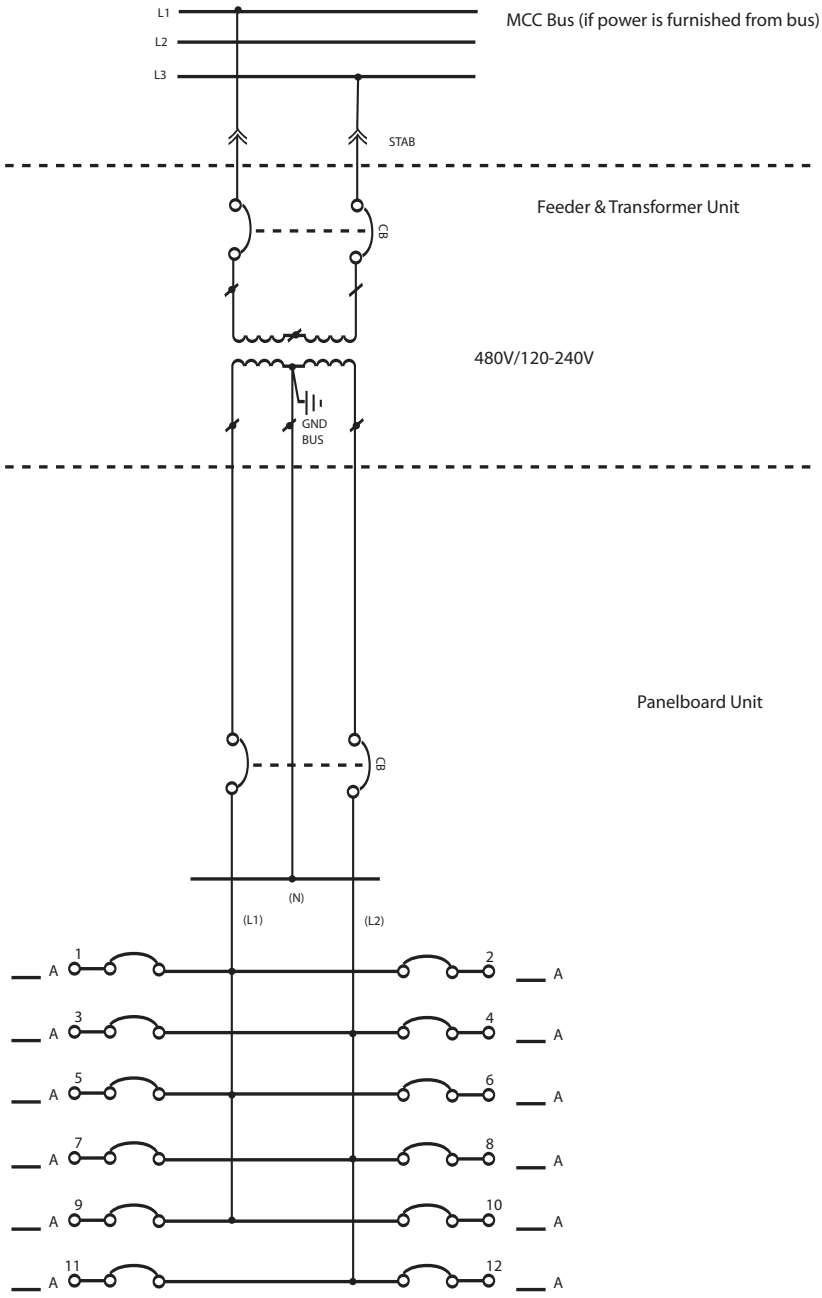


L

Evolution Series E9000 Motor Control Centers
Typical Circuits

Single-Phase Panelboard

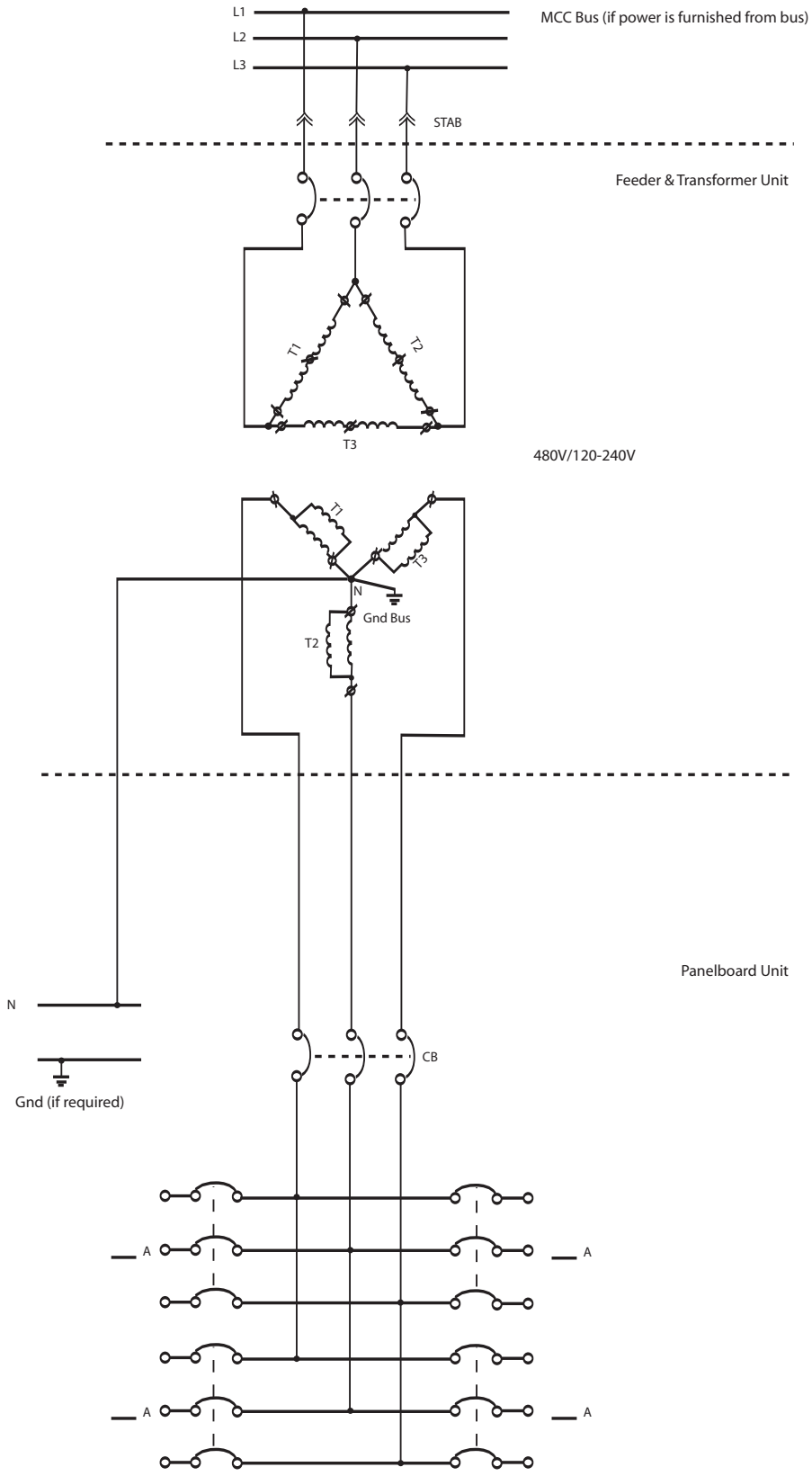
Typical Circuit Diagrams



Evolution Series E9000 Motor Control Centers
Typical Circuits

Three-Phase Panelboard

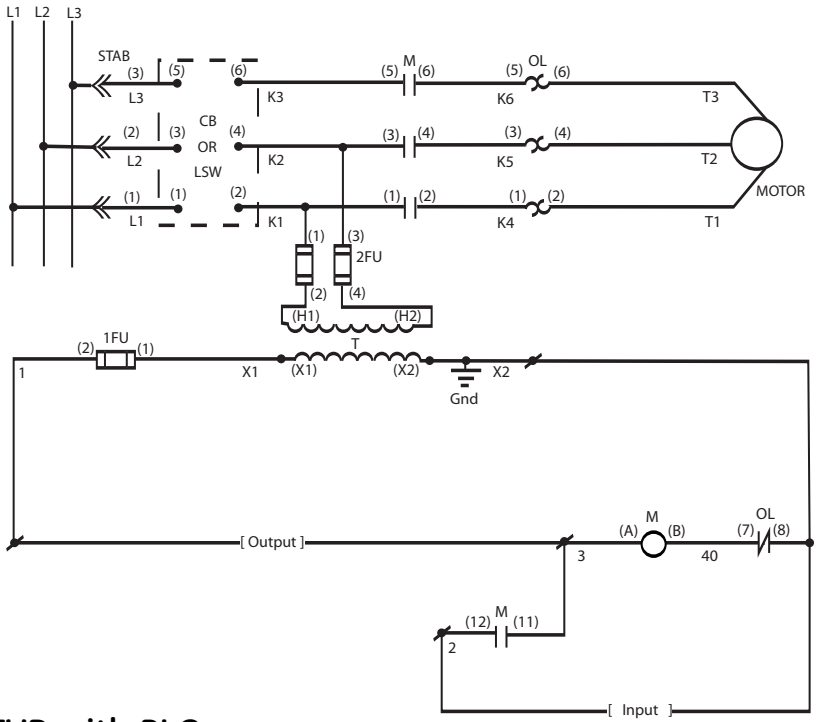
Typical Circuit Diagrams



Evolution Series E9000 Motor Control Centers
Typical Circuits

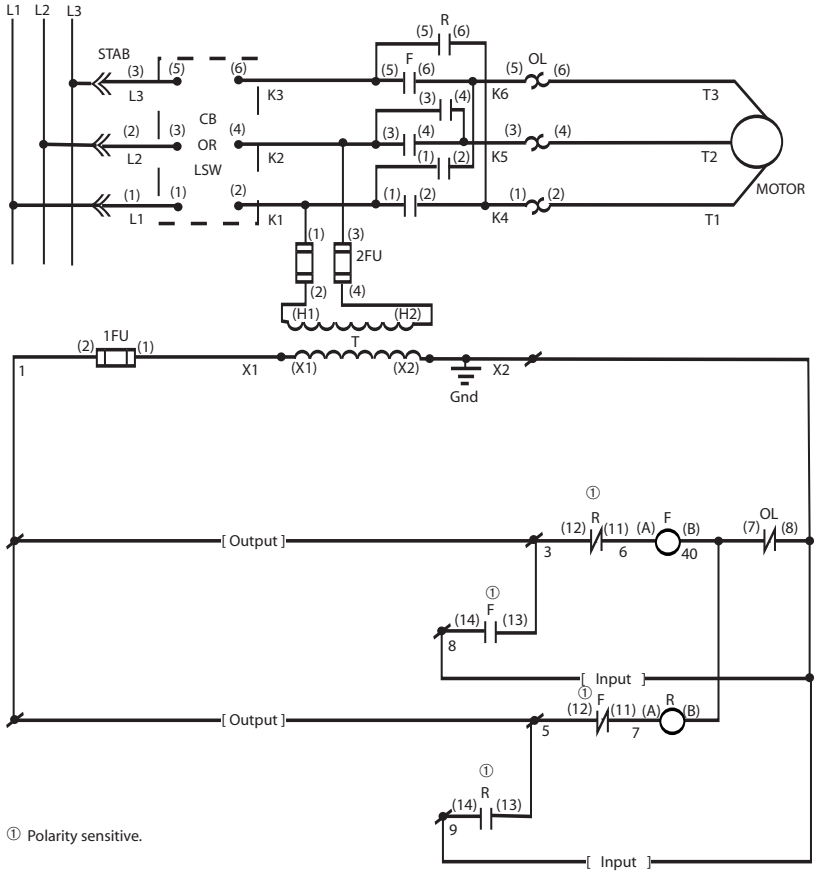
FVNR with PLC

Typical Circuit Diagrams



FVR with PLC

Typical Circuit Diagrams

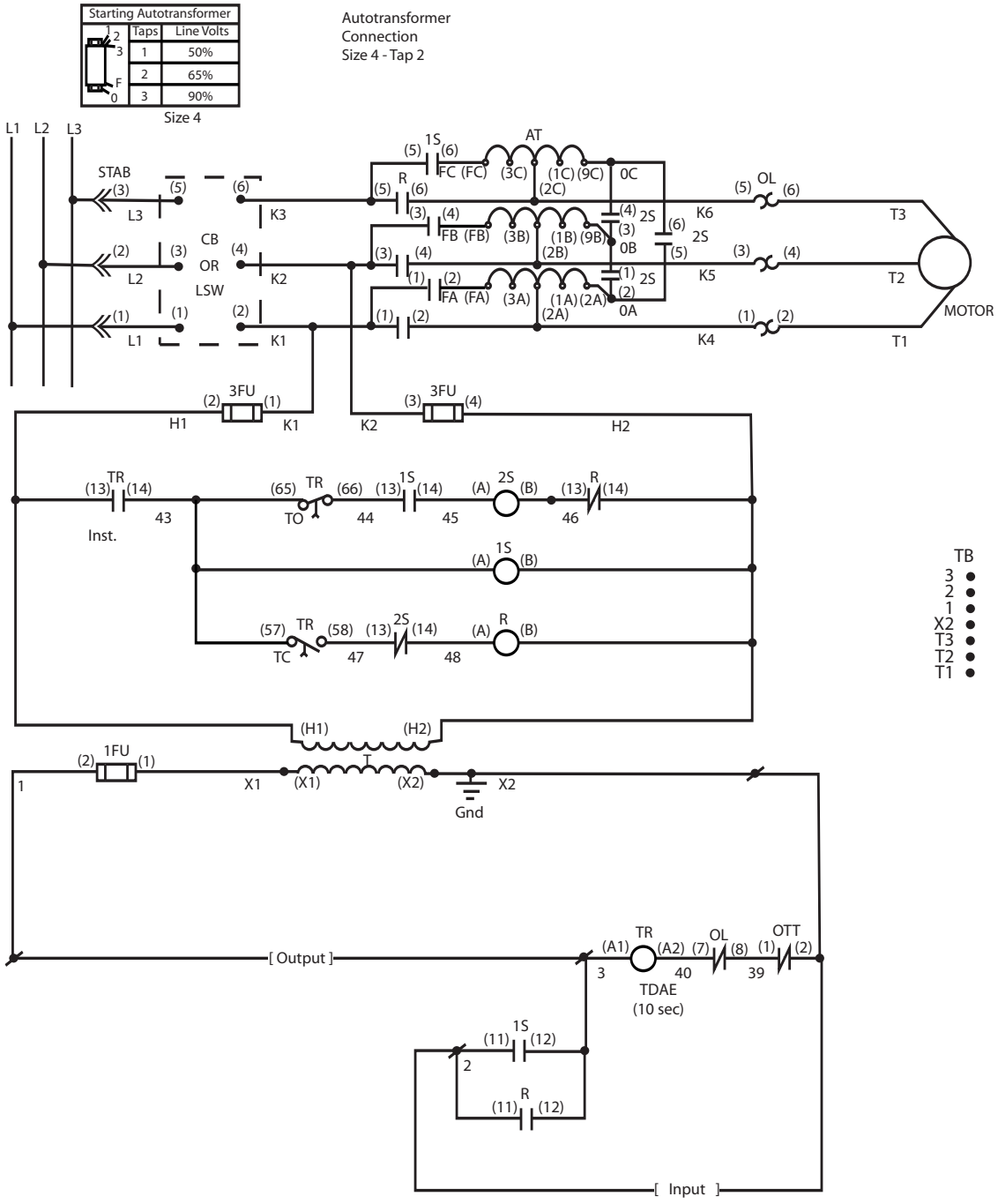


① Polarity sensitive.

Evolution Series E9000 Motor Control Centers
Typical Circuits

RVNR-AT with PLC

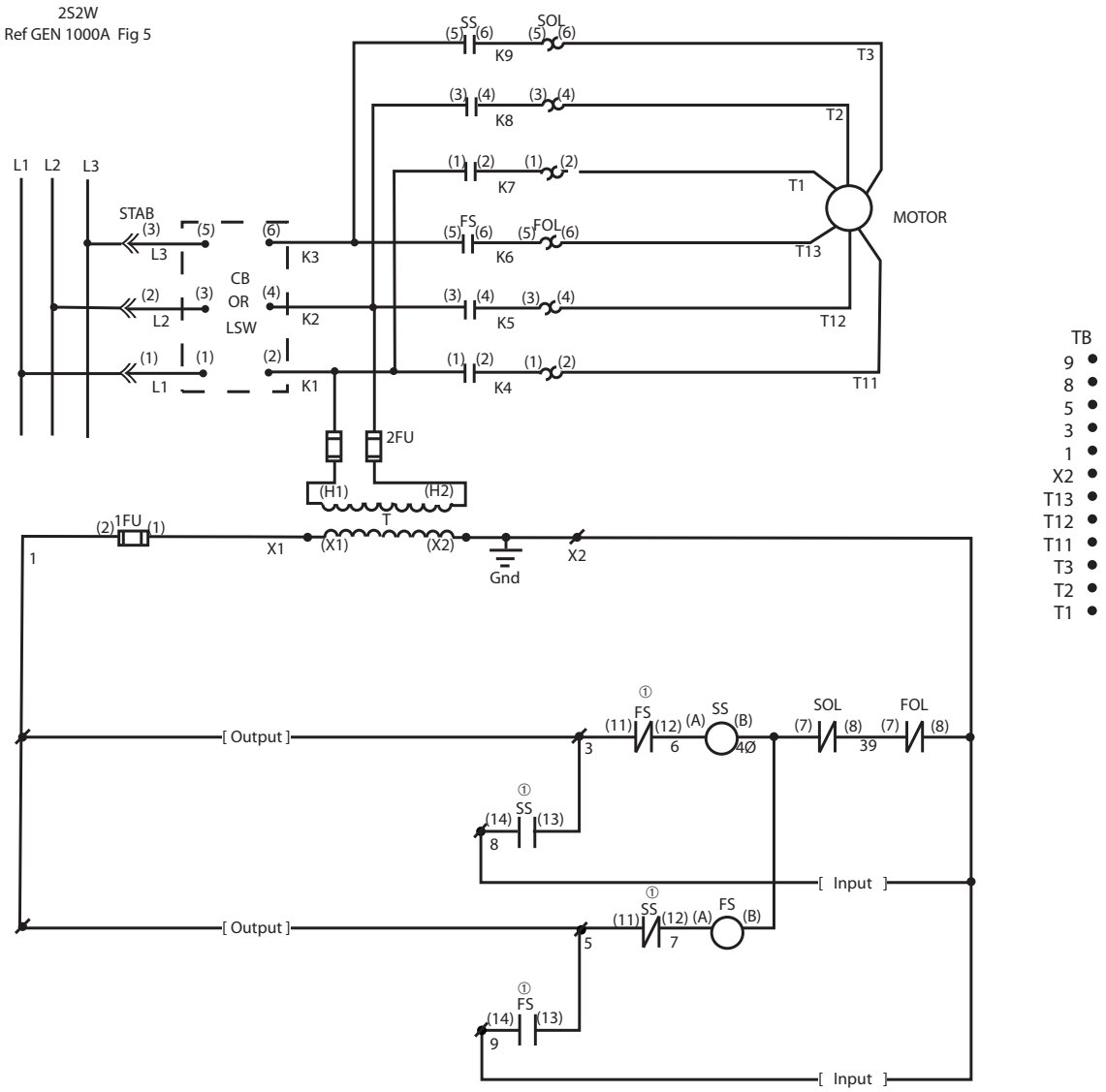
Typical Circuit Diagrams



Evolution Series E9000 Motor Control Centers
Typical Circuits

2S2W with PLC

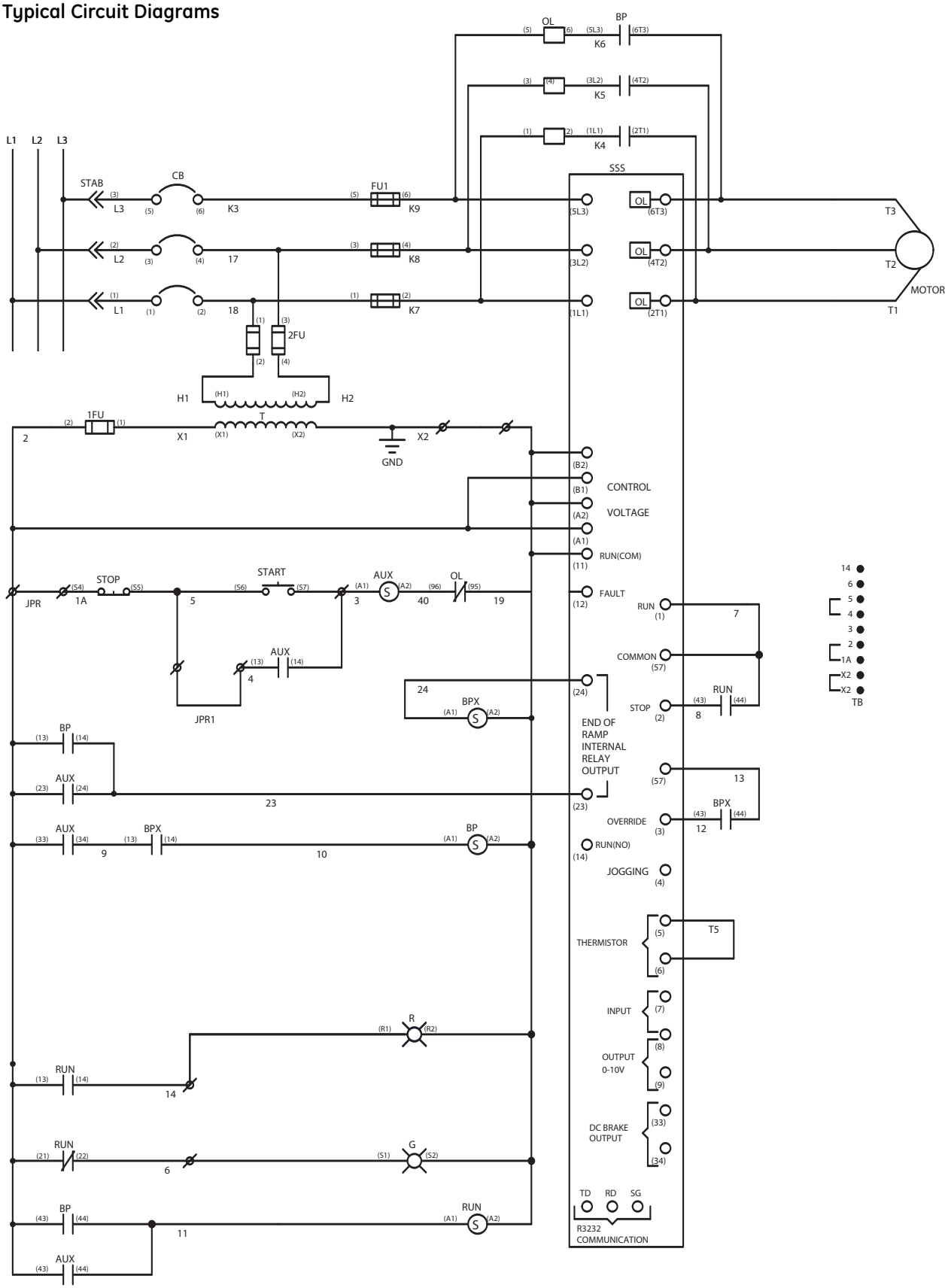
Typical Circuit Diagrams



① Polarity sensitive.

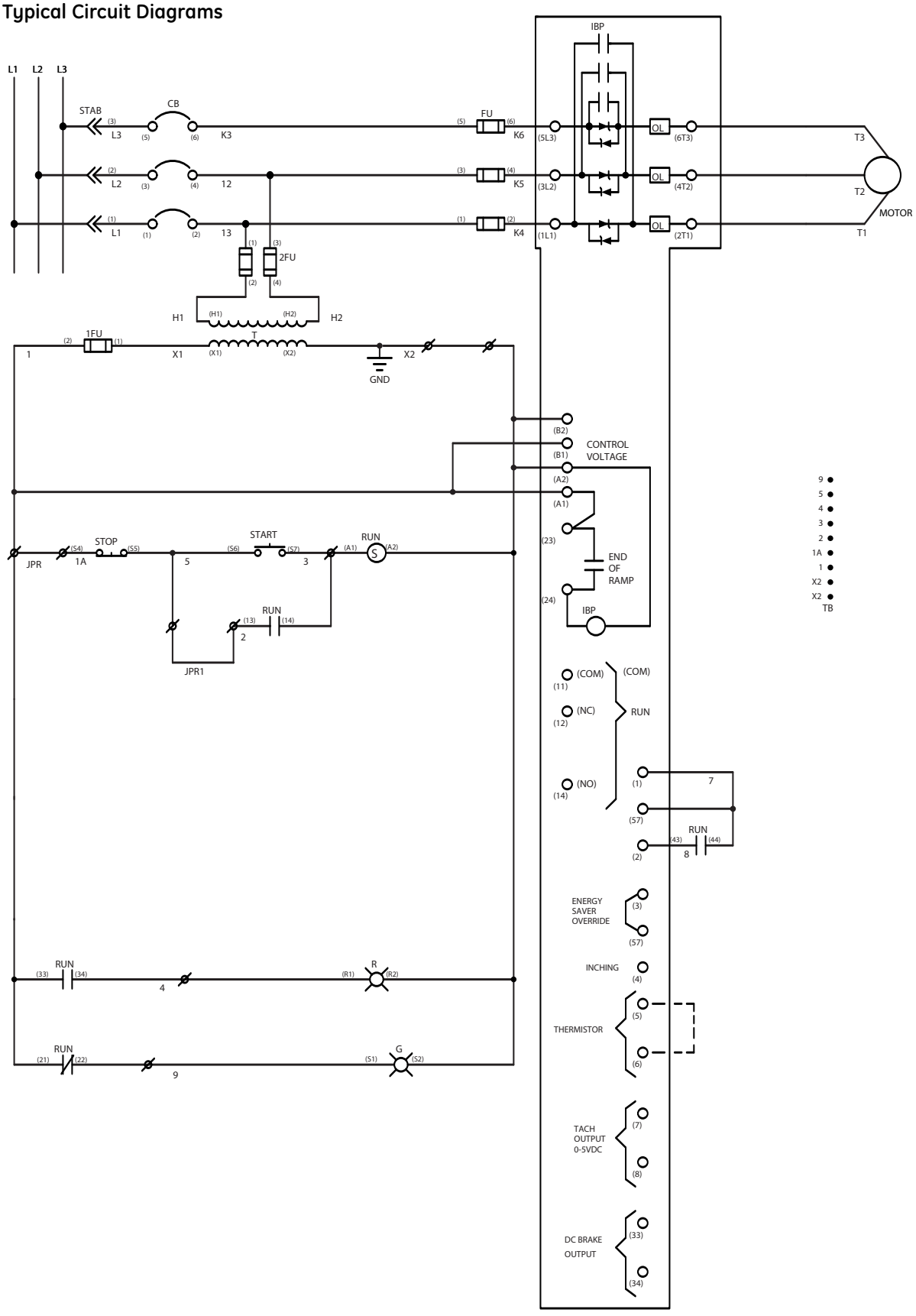
Solid-State Starter – ASTAT CD

Typical Circuit Diagrams



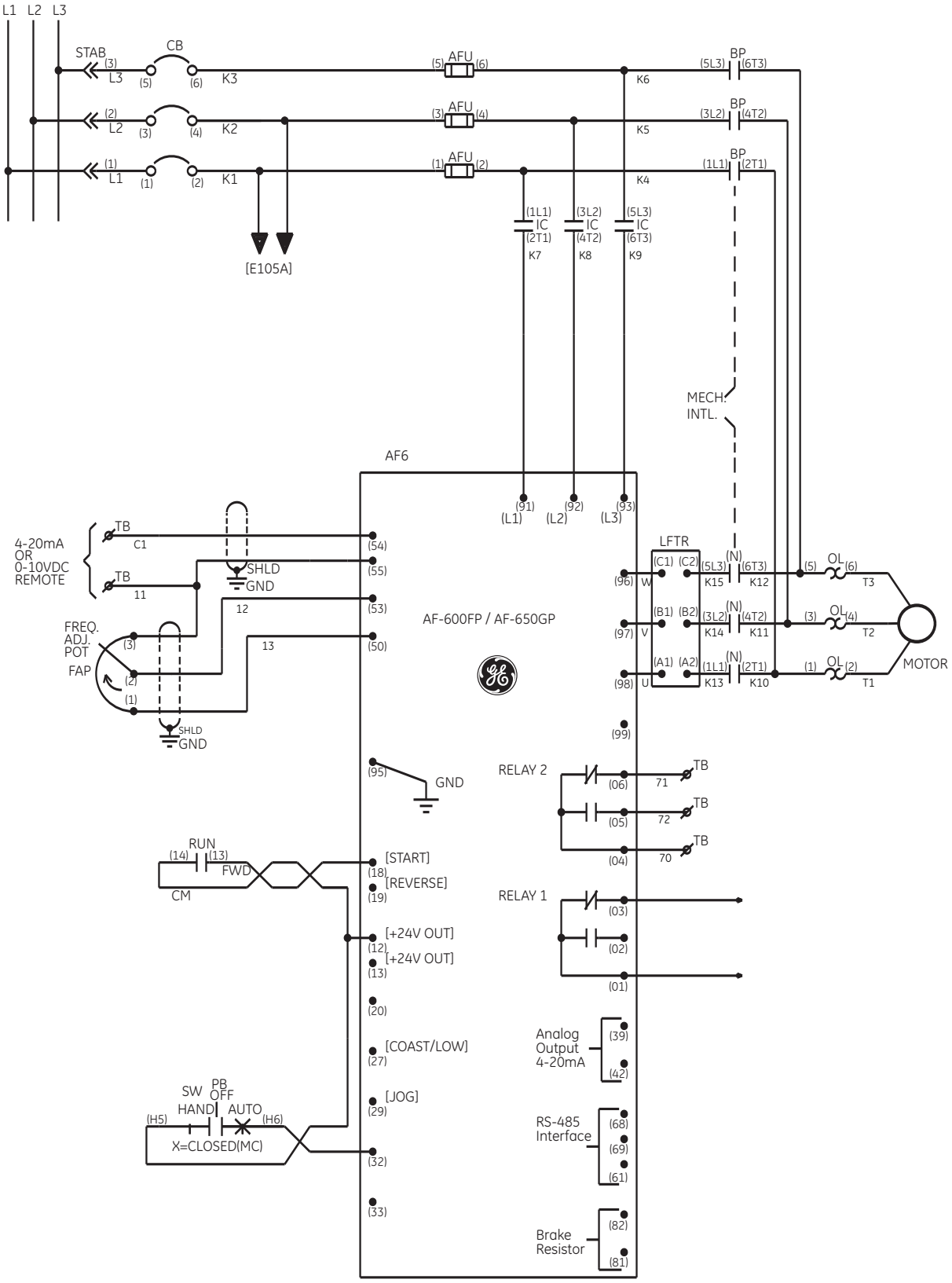
Solid-State Starter – IBP

Typical Circuit Diagrams



AF-600 FP & AF-650 GP Variable Speed Drives

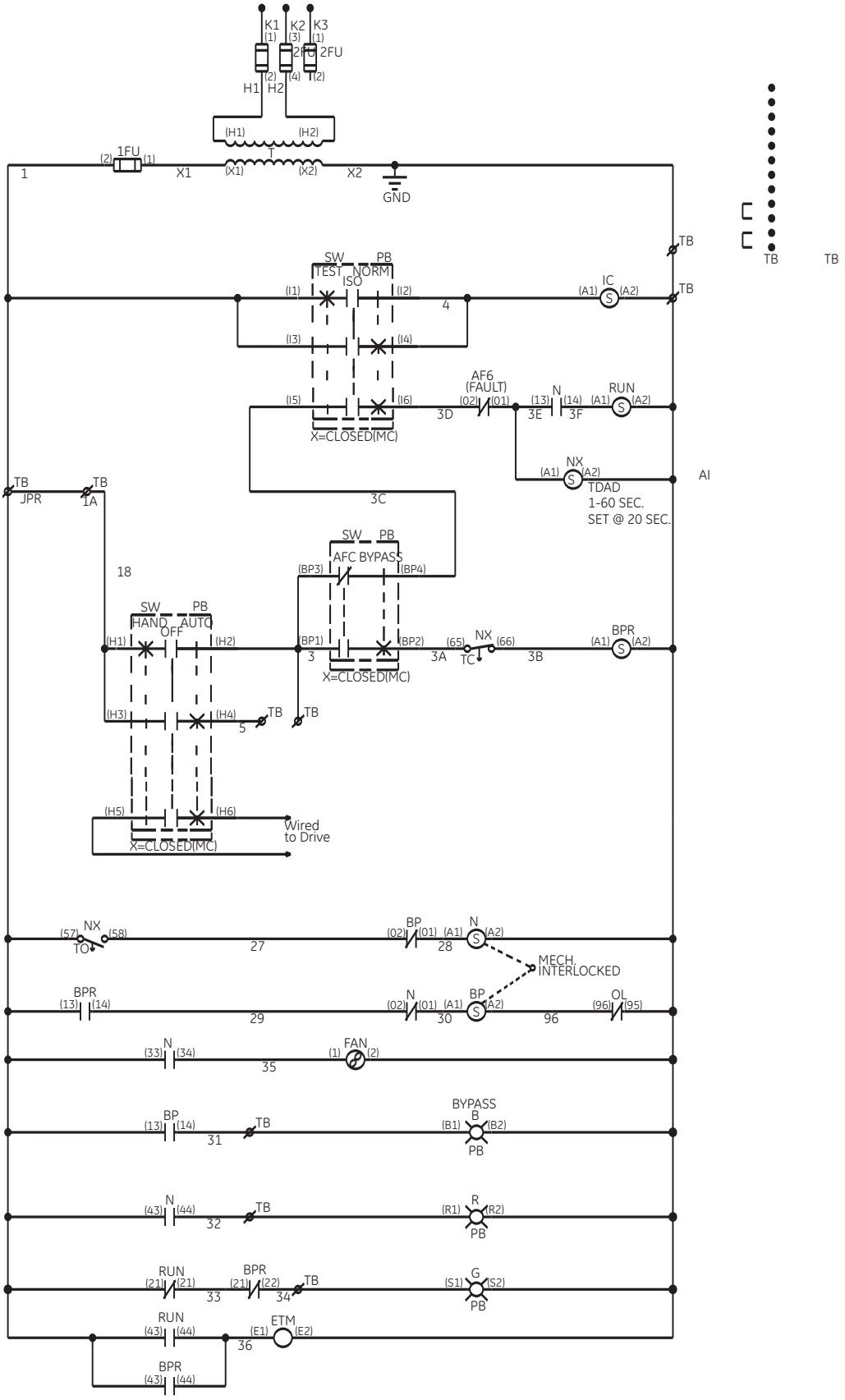
Typical Circuit Diagrams



Evolution Series E9000 Motor Control Centers
Typical Circuits

AF-600 FP & AF-650 GP Variable Speed Drives

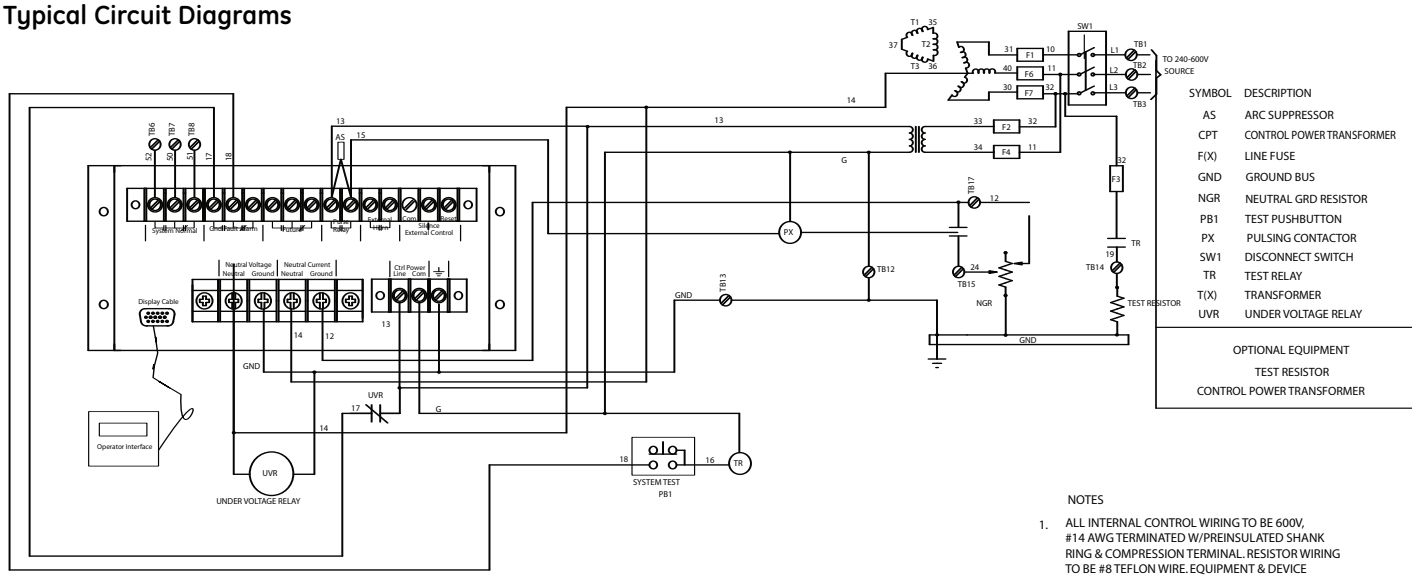
Typical Circuit Diagrams



Evolution Series E9000 Motor Control Centers
Typical Circuits

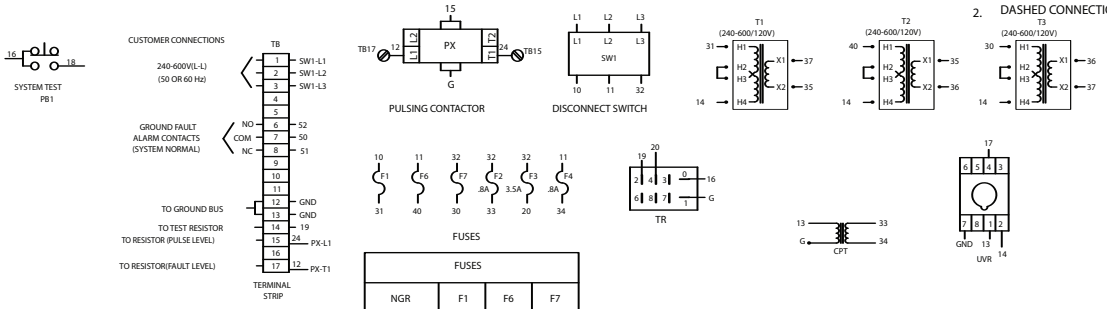
High-Resistance Ground

Typical Circuit Diagrams

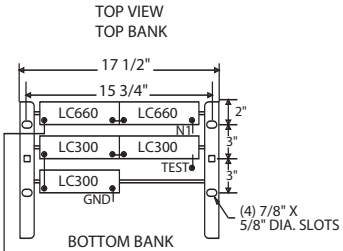


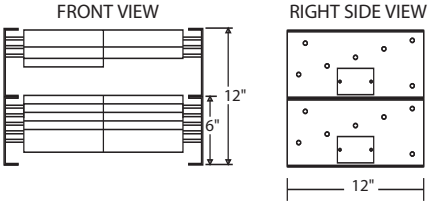
NOTES

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

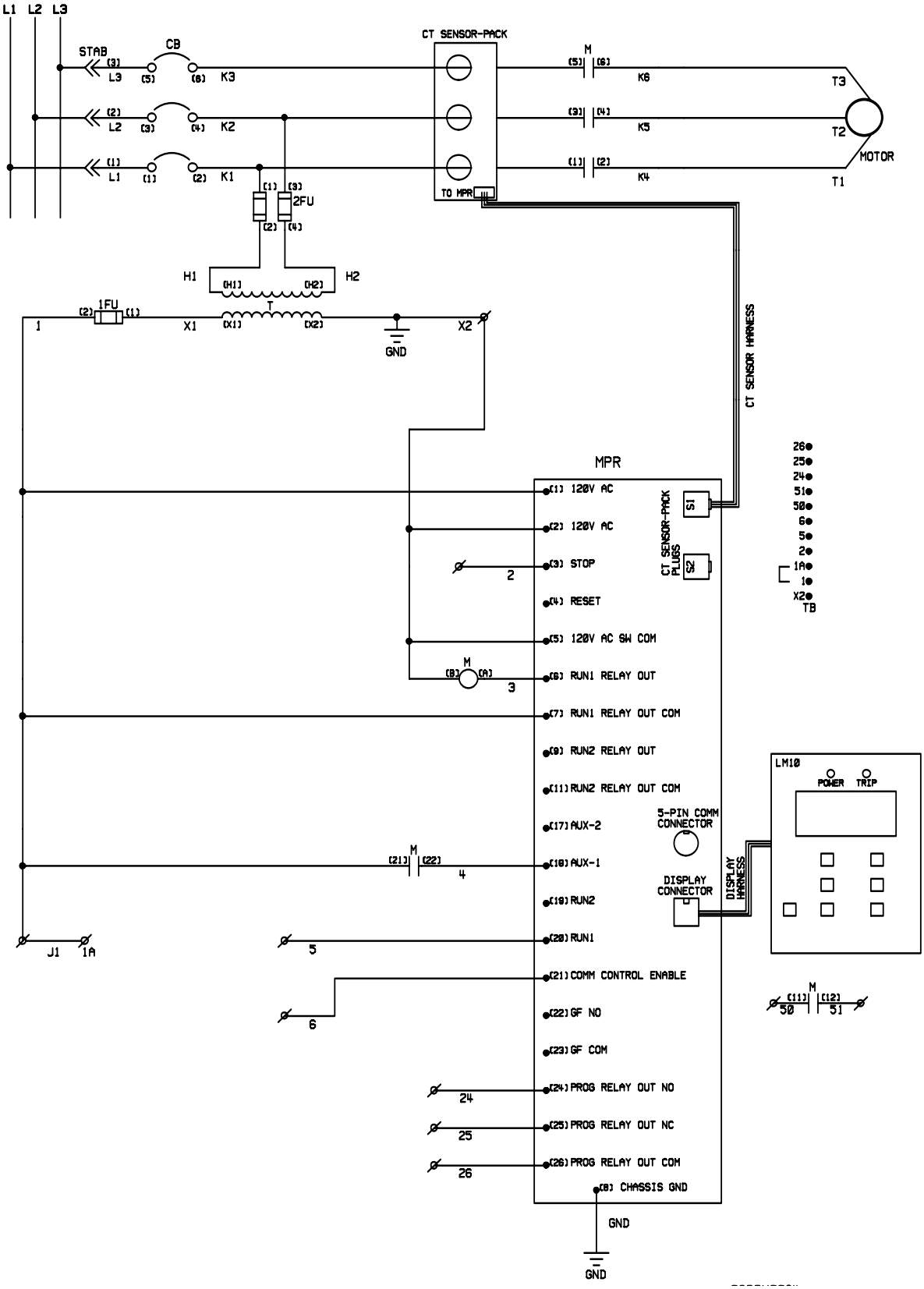




2 BANKS, EACH 17 1/2
(1) 10 COILS/BANK. (1) 5 COILS/BANK. 2727-5P ENDFRAMES. TURN FLANGES IN. TERMINALS UP. FURNISH JUMPERS.

LM10

Typical Circuit Diagrams



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 silver-plated .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 [thermal-magnetic] [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 up to three padlocks 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]

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