GE Electrical Distribution & Control

Spectra Series™ and 8000-Line Motor Control Centers

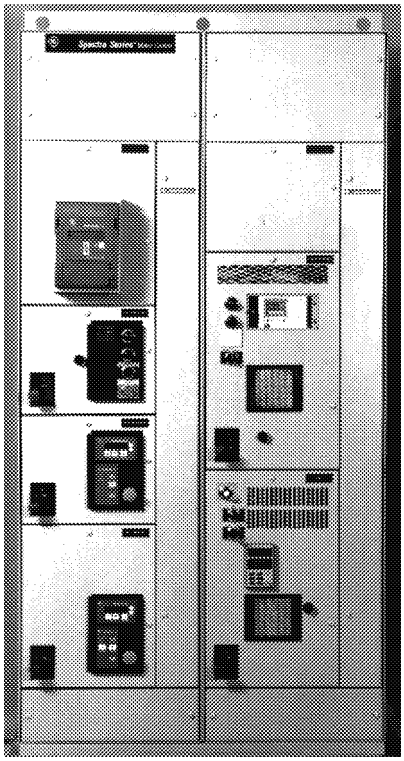
Application and Selection Guide

The General Electric Spectra Series™ and 8000-Line motor control centers provide an economical means of 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 level of factory wiring purchased. 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.

- PRODUCT FEATURES
- NEMA CLASS
- APPLICABLE CODES
- ENVIRONMENTAL REQUIREMENTS
- SYSTEM VOLTAGE AND SHORT CIRCUIT RATING
- BUS TYPE AND CAPACITY
- ENCLOSURE TYPE AND CONSTRUCTION
- INCOMING LINE TERMINATION AND MAINS
- STARTERS
- FEEDERS
- SPECIAL FEATURES REQUIRED
- SPECIAL CIRCUIT AND WIRING REQUIREMENTS

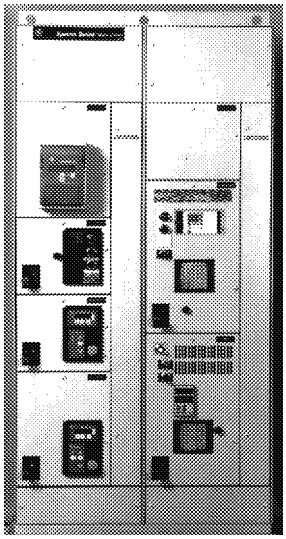


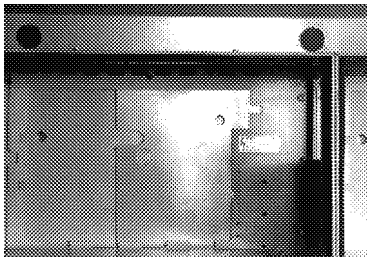
PRODUCT FEATURES

STANDARD DESIGN FEATURES

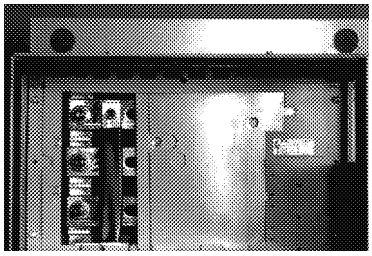
Design flexibility, performance, personnel and equipment protection, ease of maintenance and installation are all contained in the Spectra Series™. Spectra Series™ features, such as separate wiring troughs, split-type terminal boards, isolated bus, drawout starter units, operating mechanisms, and provisions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



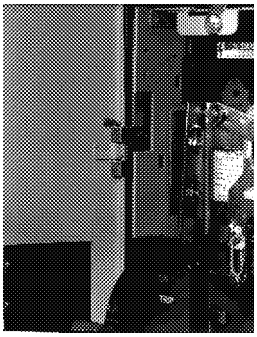


Barriers located in front of the main horizontal bus isolate the bus from the top horizontal wireway. Maintenance personnel can easily gain entrance to the top horizontal wireway of the control center without danger of contact with a live bus.

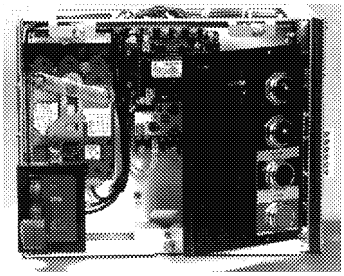


Barriers furnished with 2-inch main bus systems use a sliding panel. After de-energizing the bus, maintenance personnel may slide back the panels to give ready access to the main bus for inspection of bolted connections. Main bus splicing is accomplished in this area with the hardware already in place. 4-inch main bus systems have stationary removable barriers

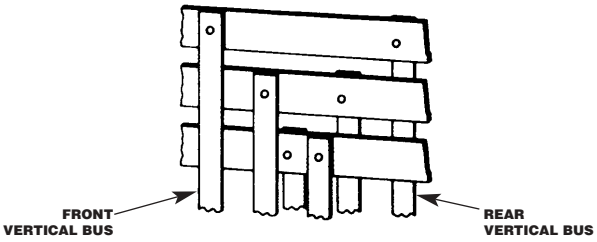
An incoming-line terminal compartment can be located at the top or bottom of a vertical section to allow cable termination with minimum bending. The standard 600-ampere incoming line terminal compartment shown is furnished with 2 mechanical type lugs per phase. Other incoming line terminal compartments are available for main bus ampacities up to 2500 amperes.



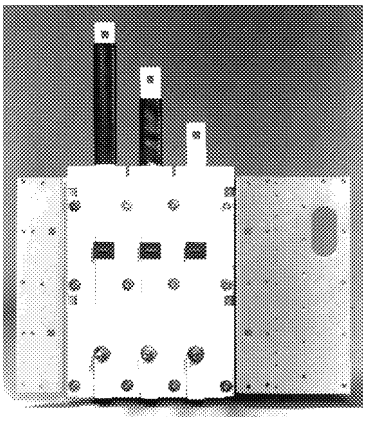
New doors mounted on the case feature a removable hinge pin providing easy door removal and accurate alignment, in Spectra Series™.



High density door bracket mounts up to 8 NEMA pilot devices in Spectra Series™. Bracket swings open to allow easy access to unit components, wiring and terminal blocks.



In back-to-back single section construction, two independent vertical bus assemblies eliminate the need for reversing the phase sequence of front and rear mounted units.



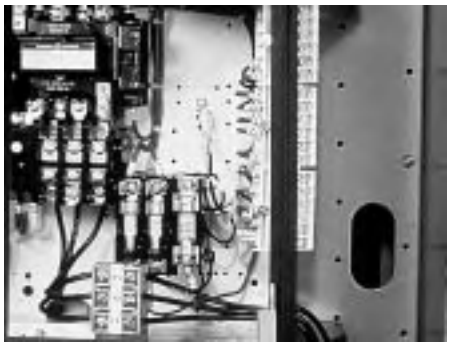
A polyester-reinforced “sandwich” insulates and isolates the vertical bus and helps prevent the spread of faults from starter and feeder units to vertical or horizontal bus. Small stab openings provide effective isolation. 65 kA short circuit bracing is standard for Spectra Series™ MCC.

PRODUCT FEATURES

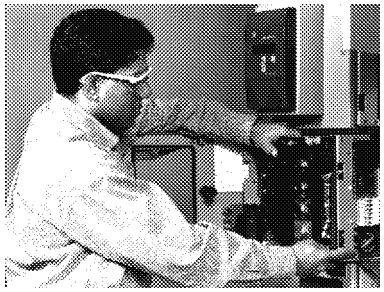
Stab connections are made with wedge-shaped silver-plated copper unit power stabs which are under double spring pressure and engage the vertical bus to provide positive contact and expand under short-circuit stress to increase contact pressure. Design maintains common unit interface between 7700 Line, 8000 Line, and Spectra Series™ MCCS.

All combination starters and feeder units of plug-in construction utilize a positive guidance system combined with a mechanical insertion means. This unique GE design grounds the unit to the structure and provides positive electrical connection between the unit stabs and the vertical bus.

High density two-piece cam-operated 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 25 Amps, 600 Vac. Meets NEC Article 430-74.

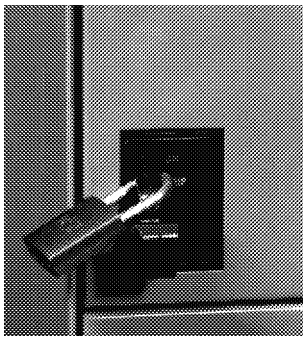


Large isolated wire trough provides a 4 5/8-inch x 8 1/8-inch area to “lay in” wire and make control and load connections. A separate removable door, adjacent to drawout units, makes wiring installation and inspection easy. The door can be opened without disturbing adjacent unit doors. 8 5/8-inch x 8 1/8- inch wire troughs are available with 24-inch wide enclosures.

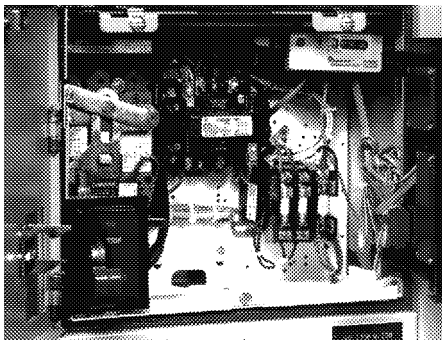


Units can be withdrawn to a disconnected position and padlocked for maintenance. Old style “B Block” terminal boards are still available as an option. All Spectra Series™ units and sections are fully compatible with 7700 and 8000 Line units.

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.**

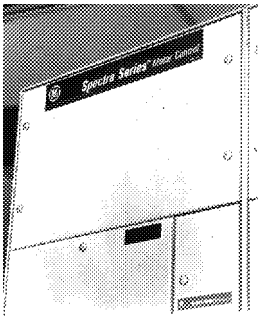


The vertically mounted integral handle can be locked in the OFF position with up to three padlocks. A drilling pattern is furnished, allowing the handle to be modified for locking in the ON position with a single padlock. This modification should only be made after the user determines it is desirable to lock the disconnect in the ON position. Padlock to have maximum 3/8-inch shackle.



For flexibility, standard Size 1 and Size 2 FVNR starters are interchangeable in the same 12-inch high space unit. This design allows quick, easy field changes when modifications are desired after installation.

New front 1/4-turn latches for secure installation and visual engagement



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

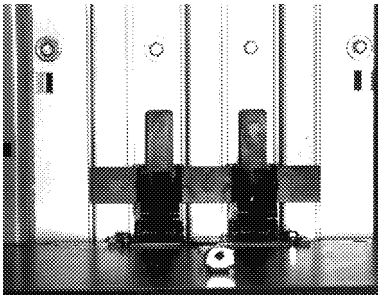
PRODUCT FEATURES

OPTIONAL CUSTOMIZING FEATURES

Vertical Ground Bus and Unit Stab

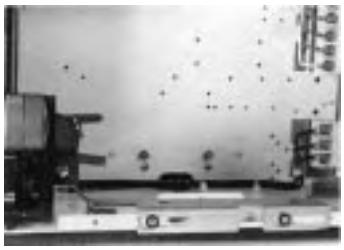
Vertical copper ground bus allows direct grounding of unit saddles to the equipment ground bus. A unit ground bus stab engages the vertical ground bus before the unit power stabs engage the vertical bus.

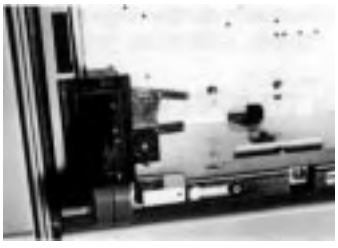
A load vertical ground bus is available for customer cable grounding. Termination points are located at the rear of the vertical wireway, next to starter/feeder lugs.



Vertical Bus Shutter Mechanism

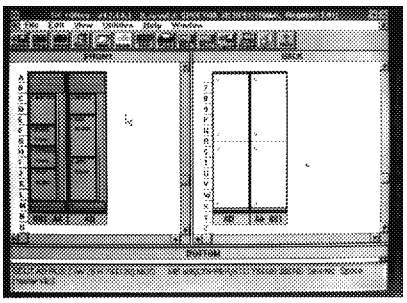
A vertical bus shutter mechanism can be supplied which covers the vertical bus stab area when a plug-in starter or feeder is withdrawn. This feature may also be added to existing 7700-Line, 8000-Line and Spectra Series™ motor control centers. Cap plugs are available to close unused stab openings.





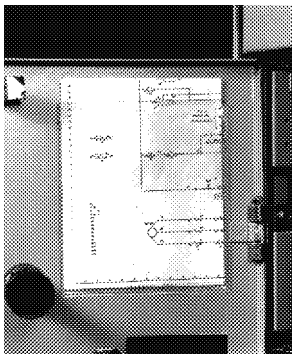
Power-Off Insertion or Withdrawal Feature

Provides power-OFF insertion or withdrawal for plug-in combination starter or feeder units. A slide, mounted to the starter frame, coupled with the operating handle, inhibits access to the driving screw until the primary disconnect is open or OFF.



New Drawing Software

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



Drawing Holder

An optional drawing holder allows you to mount complete wiring diagrams inside doors.

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, 1-inch x 3-inch, fastened with non-corrosive nylon clips. Plated steel screws are available as an option. One to three lines of white letters on a black background can be engraved with 0.18-inch high characters. Lines 1 and 3 can have a maximum of 19 characters and line 2, 15 characters.

A 2-inch x 6-inch master nameplate mounted on the top left wireway cover of each motor control center lineup can be supplied if requested. One line of 6 characters is possible with 1-inch high letters; with 1/2-inch high letters, two lines of 12 characters each are possible. The standard is white letters on a black background.

Refer to the factory for special nameplates.

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.

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 ICS-2-322.08.

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 drawing provided with Class I and II motor control centers, additionally modified as specified by the user.

WHEN TO SPECIFIY 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.

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, 2 or 3 starters). NOTE: For feeders and large starters, customer must wire direct to unit device terminals.

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. Stationary terminal boards on Size 3 (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 CR8000-Line motor control center standard unit numbering system be followed to identify the section and location of each unit. This is explained in detail in application data (Section J). It greatly simplifies wire tracing of interconnection wires, and is beneficial to the application of programmable control. The Outline and Summary drawing furnished with the equipment cross references the unit numbers and customer unit designations when specified.

CODES AND STANDARDS

Motor control centers are manufactured to NEMA standard ICS 2-322 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 listing mark. 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.

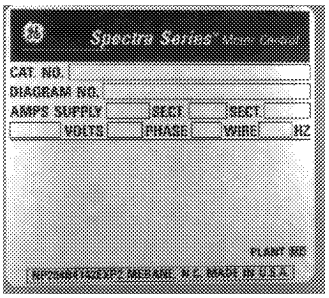
The National Electrical code covers installation of electric conductors and equipment for installations identified in the NEC Article 90. The NEC is not intended as a design specification and acceptance of an installed motor control center by a local code authority is dependent on factors independent 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 overcurrent protection required for each type. The following paragraphs provide a general reference to the NEC Article applicable for the more common control circuits.

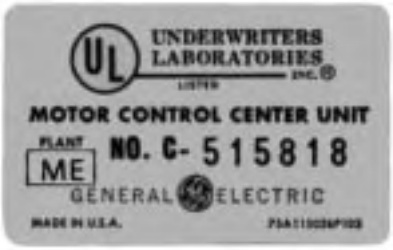
NEC Articles 430-72(a) and (b) cover motor control circuits tapped from the load side of a motor branch-circuit short-circuit protective device (unit disconnect). Control circuit conductors from such a tapped control circuit shall be protected in accordance with NEC Table 430-72(b), which lists the maximum 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



Unit Label

In addition, CSA labeling per CSA 22.2-14 Industrial Equipment is also available when all devices are CSA approved - refer to factory.

SHORT CIRCUIT CONSIDERATIONS

ALL RATINGS IN THIS PUBLICATION ARE RMS SYMMETRICAL AMPERES

SHORT-CIRCUIT CURRENT RATINGS

The NEMA Motor Control Center Standard ICS-2-322 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."

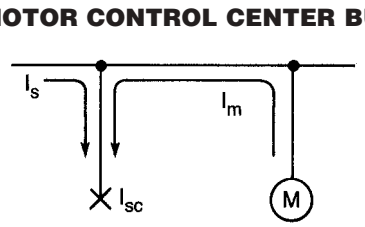


Fig. 1

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 of 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. Wherever located, it must have an interrupting rating equal to 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 NON-AUTOMATIC CIRCUIT BREAKER (MOLDED CASE SWITCH) OR A NON-FUSED SWITCH 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, a GSR 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 42,000 rms symmetrical amperes. Also available optionally are ratings of 50,000, 65,000 and 100,000 rms symmetrical amperes. The bus rating must equal or exceed the available short-circuit current. Refer to Structure (Section B) for ratings.

COMBINATION MOTOR CONTROL UNITS

The short-circuit rating of a combination controller is based on tests with rated short-circuit current available at the line terminal of the control center and at rated voltage.

The short-circuit rating must equal or exceed the available short-circuit current. Refer to Starters (Section 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 charactertistics, 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 H—defines dimensions for 600 amperes maximum, 250 volts or 600 volts, with non-reject type mounting. Fuse characteristics may vary.

B. Class K—have Class H mounting dimensions and limit peak let-through currents, though not classified as "Current Limiting." Class K fuses are sub-divided into Classes K-1, K-5 and K-9, depending on peak let-through current, with K-1 having the lowest peak let-through currents. K-9 fuses are not recommended because their peak let-through currents are too great to be considered safe for controllers. Class K fuses are rated 600 amperes maximum, 250 volts or 600 volts.

C. 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.

D. Class J — are more current limiting than RKs and due to their unique dimensions have an inherent rejection feature. Ratings are 600 amperes maximum, 600 volts.

E. 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 "D," "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 furnished with non-rejection 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	Class R	Class L	Class H	Class K-1, K-5
Ampere Range	0-600	0-600	601-6000	0-600	0-600
Voltage Ratings	600	250 600	600	250 600	250 600
Interrupting Rating RMS Symmetrical Amperes	200K	200K	200K	10K	50K 100K 200K
Current-Limiting	Yes	Yes	Yes	No	No
Rejection Type	Yes	Yes	Yes	No	No

① Check fuse manufacturers for specific fuse characteristics

ENVIRONMENTAL CONSIDERATIONS

The standard 8000-Line 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 weatherproof enclosures are required. These can be non-walk-in, walk-in, non-walk-in back-to-back, and walk-through with common aisle. 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. This special design is also necessary if the NEMA 3R enclosure has to withstand seismic conditions, including seismic Zone 4 applications.

A modification of the 20- and 22-inch deep 8000-Line 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 suitable for Seismic Zone 4 installation.

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 in a motor control center can be provided. It should be noted that the best available treatment has a very limited effective life of only a few months. Keeping equipment dry and above the dew-point is a much better 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.

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 restrict the entrance of dust and dirt into Type 1 enclosures, but are **not** dust-tight. Standard is closed-cell gasketing material.

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.

INDOOR ENCLOSURES

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. 20- and 22-inch deep enclosures are furnished with hinged doors on the rear, while the 13-inch deep enclosures are supplied with bolt-on rear covers. Pan-type doors utilize quarter-turn fasteners. Gasketed doors, cover plates, and operating handles are available as an option. Two heavy-duty 3-inch-by-1$^{1}/_{2}$-inch,12-gauge floor sills and 3-inch full-length lifting beam are included. Open bottom is standard.

NEMA 2 DRIP-PROOF CONSTRUCTION

Similar to NEMA 12 gasketed construction except with 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

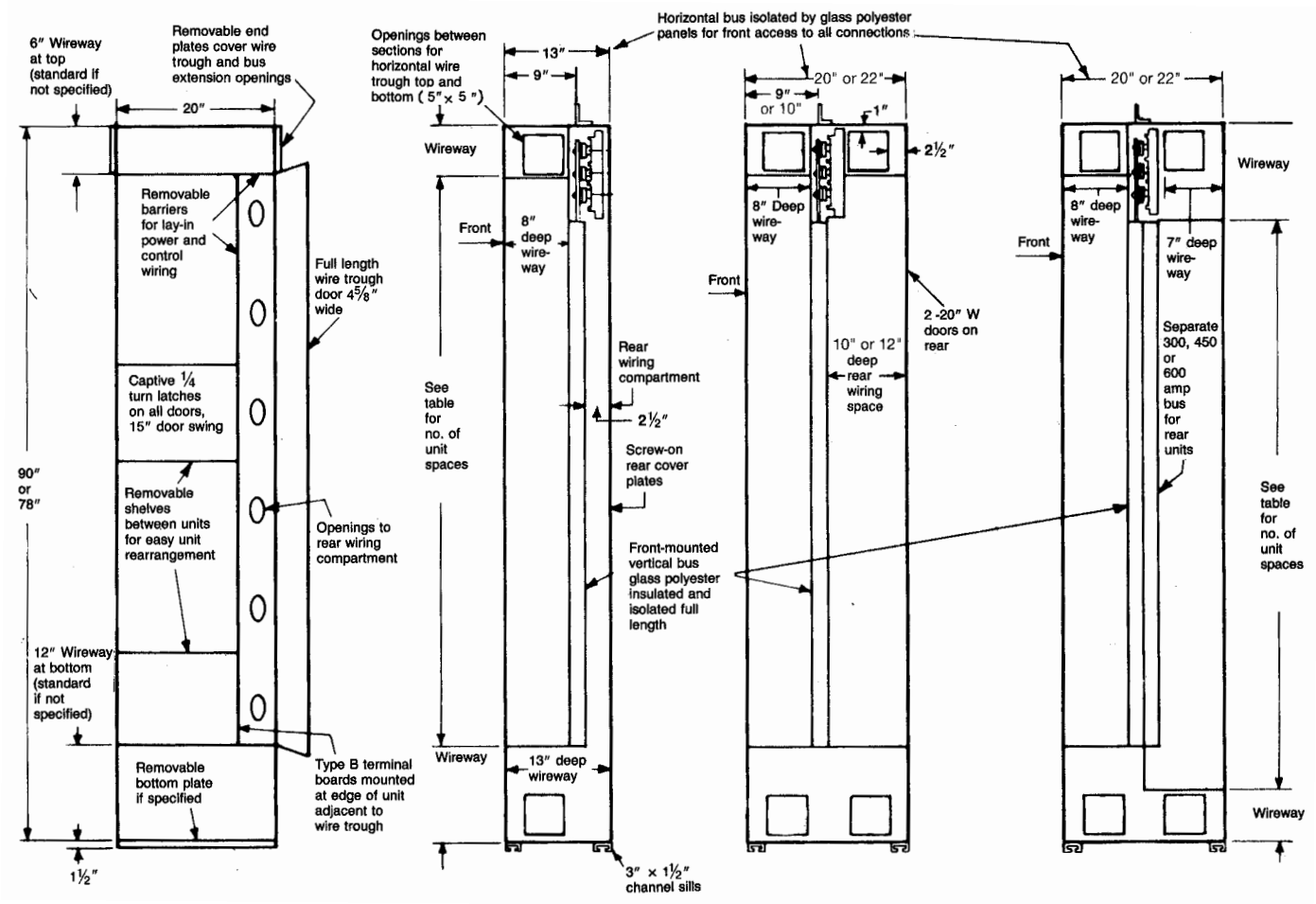
Similar to NEMA 1 gasketed construction except that bottom plates are furnished and all removable plates are gasketed.

HOW TO DEFINE UNUSED SPACES

Future Unit Space–	Unit space specified and equipped to accept a future unit.
Blank Unit Space–	Unit space not equipped to accept a future unit.
Unuseable Unit Space–	Unit space not suitable to accept accept a future unit.

B

INDOOR ENCLOSURES



Front view

Side view
13-inch-deep section
(1200 amp max.)

Side view
20- or 22-inch-deep section
(Front mounted only)
(20" - 1600 amp max.)
(22" - 2000/2500 amp only)

Side view
20- or 22-inch-deep section
(Back-to-Back)
(20" - 1200 amp max.)
(22" - 2000/2500 amp only)

Enclosure Height	90"						78"					
Horizontal Bus	2" Bus			4" Bus			2" Bus			4" Bus		
Top Wireway	6"①	12"	12"	12"①	12"①	18"	6"①	12"	12"	12"①	12"①	18"
Bottom wireway	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"
No S.U.'s②	6	6	5½	6	5½	5½	5	5	4½	5	4½	4½

Notes:
- One S.U. = 12-inch vertical height.
- Average weight per vertical section including units–500 lbs.

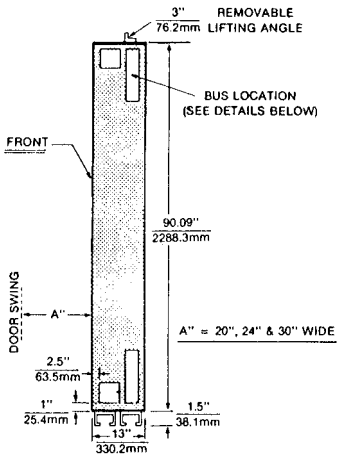
① A ½ S.U. unit cannot be mounted immediately below a 6-inch top wireway with 2-inch bus, or immediately below a 12-inch wireway with 4-inch bus.

② On back-to-back sections, the rear side must always have a 12-inch top wireway with 2-inch bus and an 18-inch top wireway with 4-inch bus.

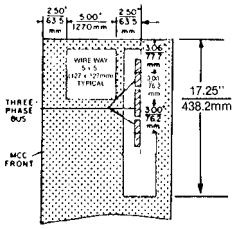
INDOOR ENCLOSURES

13" DEEP SECTION

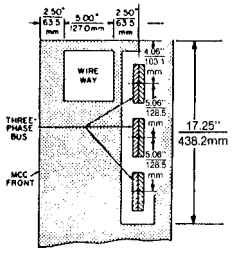
END VIEW STANDARD 13" DEEP



BUS DETAILS STANDARD 13" DEEP

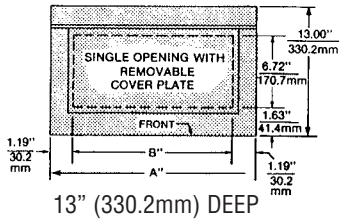


END VIEW WITH 2" (50.8mm) BUS BAR



END VIEW WITH 4" (101.6mm) BUS BAR

TOP CONDUIT ENTRANCE DETAILS FOR STD. 13"

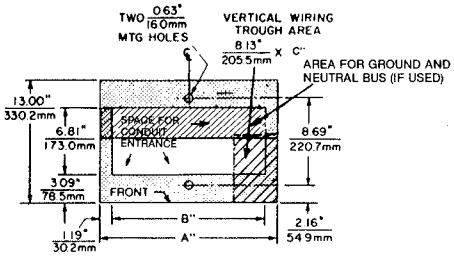


13" (330.2mm) DEEP

GENERAL DIMENSIONS

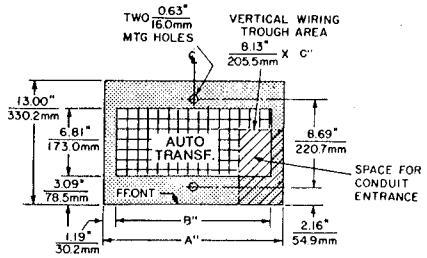
REF. DIM.	20" WIDE ENCLOSURE	24" WIDE ENCLOSURE	30" WIDE ENCLOSURE
A" =	20" 508.0mm	24" 609.6mm	30" 762.0mm
B" =	17.63" 447.8mm	21.63" 549.4mm	27.63" 701.8mm
C" =	4.63" 117.6mm	8.63" 219.4mm	NOT APPLICABLE

BOTTOM CONDUIT ENTRANCE DETAILS FOR STD. 13"

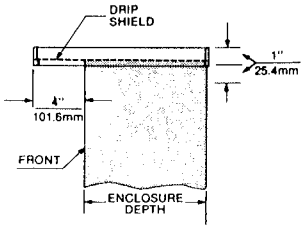


13" (330.2mm) DEEP

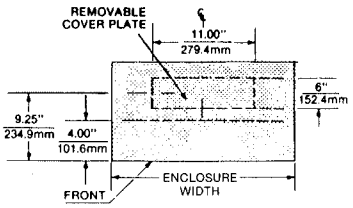
BOTTOM CONDUIT ENTRANCE DETAILS WHEN AUTO—TRANSFORMER IS FURNISHED



13" (330.2mm) DEEP

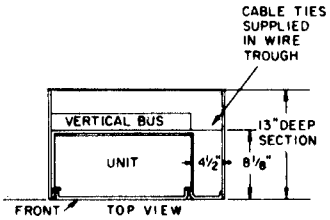


END VIEW



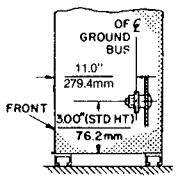
TOP VIEW

NEMA II DRIP SHIELD

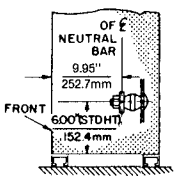


VERTICAL WIRING TROUGHS

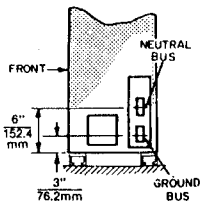
STANDARD GROUND AND NEUTRAL BUS DETAILS



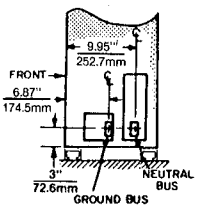
Ground bus bolted directly to section frame



Insulated neutral bus

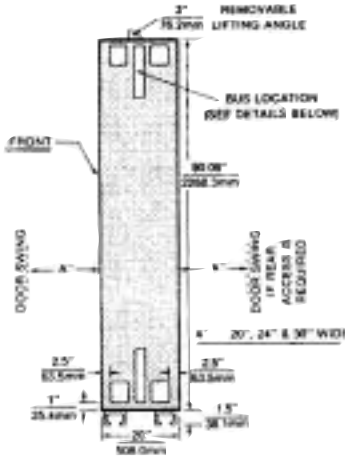


Standard location of ground and neutral bus with a 12-in. (304.8 mm) compartment at the bottom of MCC

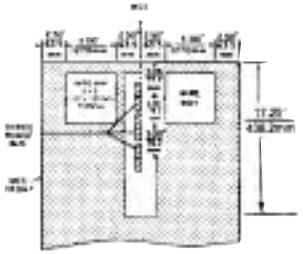


Standard location of ground and neutral bus with a 6-in. (152.4 mm) compartment at the bottom of MCC

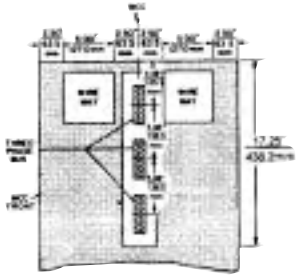
END VIEW STANDARD 20" DEEP



BUS DETAILS STANDARD 20" DEEP

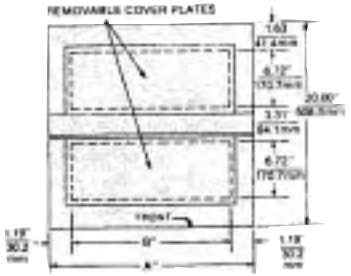


END VIEW WITH 2" (50.8mm) BUS BAR



END VIEW WITH 4" (101.6mm) BUS BAR

TOP CONDUIT ENTRANCE

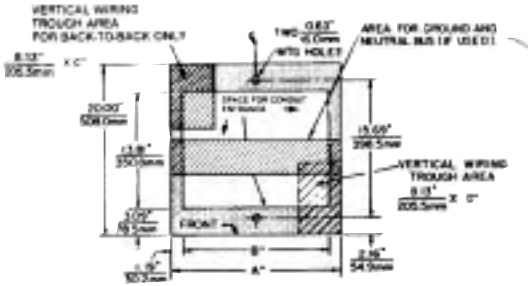


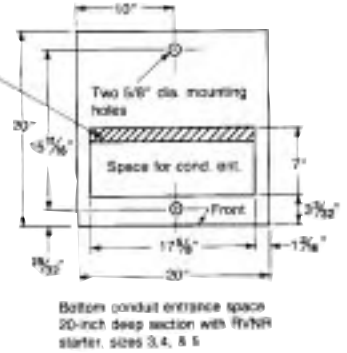
20" (508.0mm) DEEP

GENERAL DIMENSIONS

REF. DIM.	20" WIDE ENCLOSURE	24" WIDE ENCLOSURE	30" WIDE ENCLOSURE
A" =	20" / 508.0mm	24" / 609.6mm	30" / 762.0mm
B" =	17.63" / 447.8mm	21.63" / 549.4mm	27.63" / 701.8mm
C" =	4.63" / 117.6mm	8.63" / 219.4mm	NOT APPLICABLE

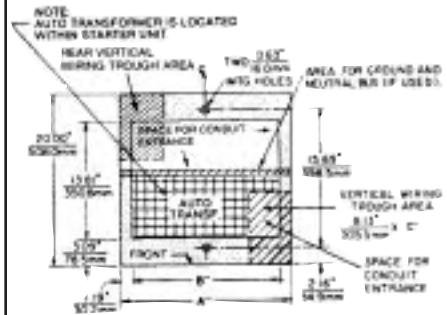
BOTTOM CONDUIT ENTRANCE



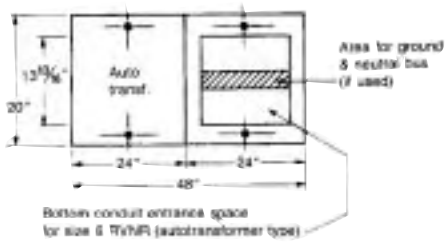


Bottom conduit entrance space 20-inch deep section with RVNR starter, sizes 3,4, & 5

BOTTOM CONDUIT ENTRANCE DETAILS WHEN AUTO-TRANSFORMER IS FURNISHED

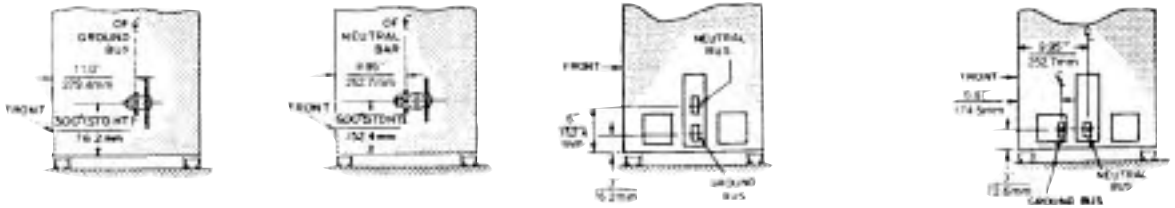


20" (508.0MM) DEEP BACK-TO-BACK (SIZE 3,4)

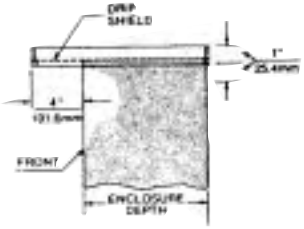


Bottom conduit entrance space for size 6 RVNR (autotransformer type)

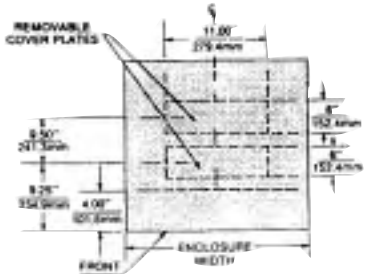
STANDARD GROUND AND NEUTRAL BUS DETAILS



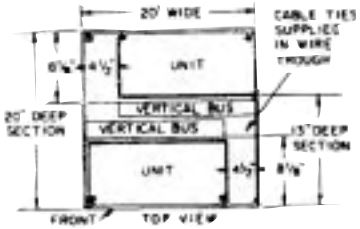
NEMA II DRIP SHIELD



END VIEW



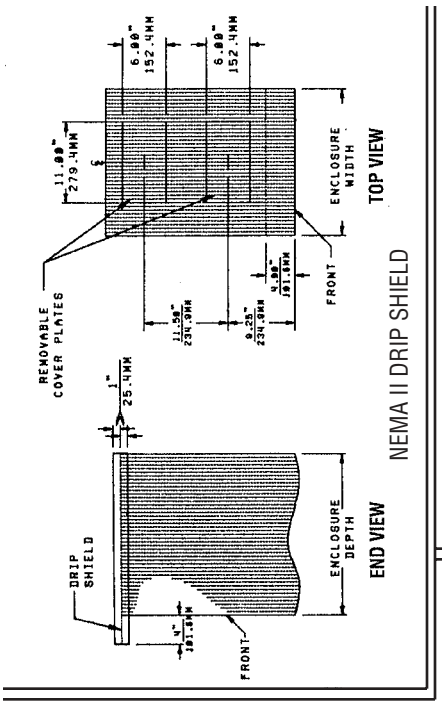
TOP VIEW

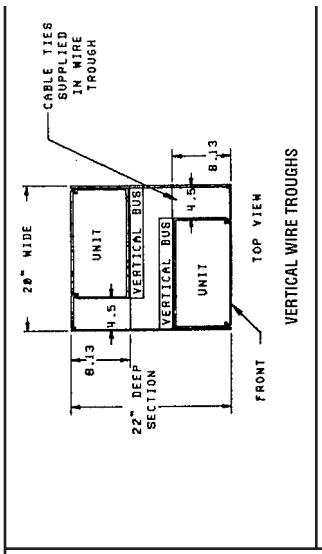


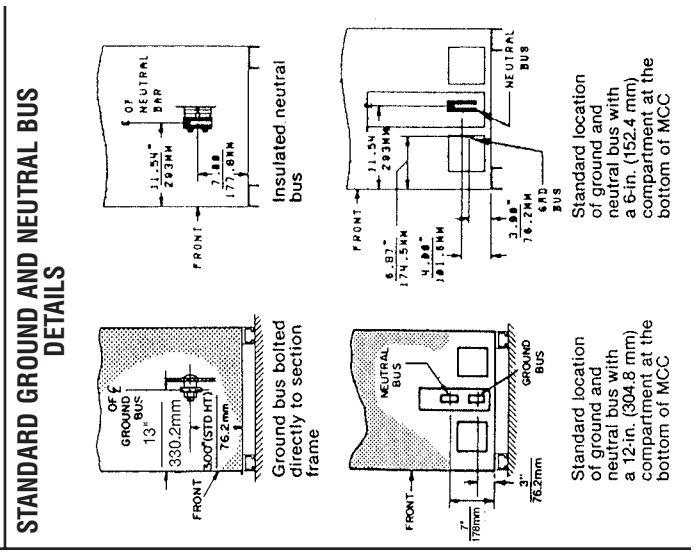
VERTICAL WIRING TROUGHS

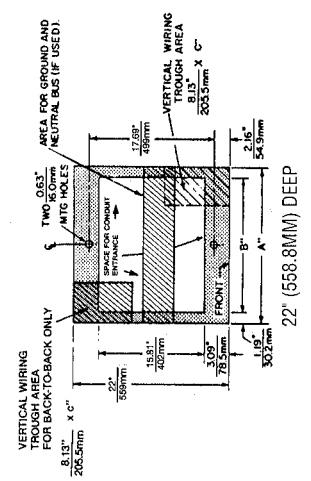
INDOOR ENCLOSURES

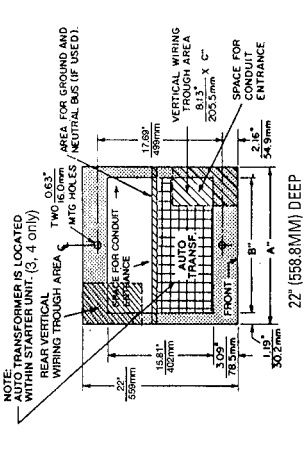
22" DEEP SECTION

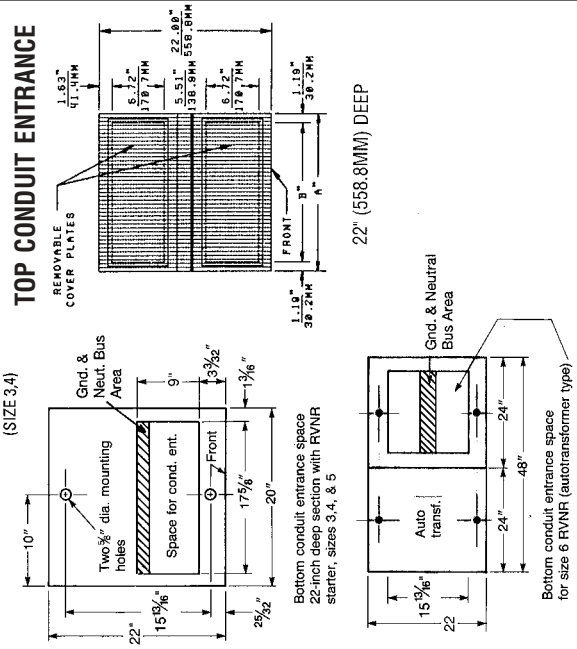


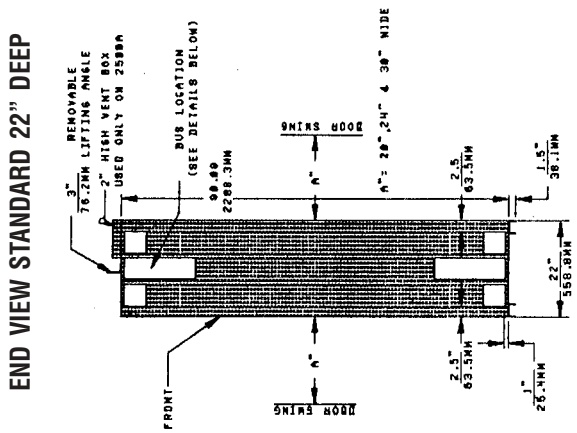










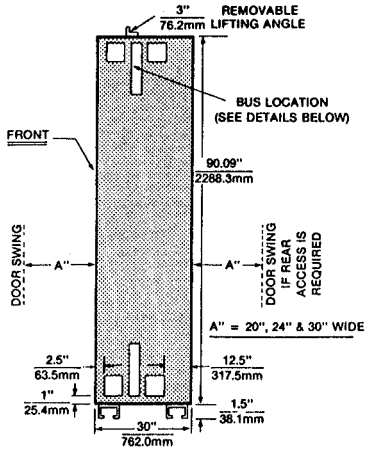


GENERAL DIMENSIONS

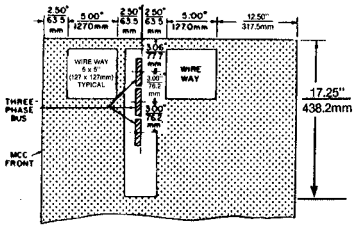
REF. DIM.	20" WIDE ENCLOSURE	24" WIDE ENCLOSURE	30" WIDE ENCLOSURE
A" =	20" / 508.0mm	24" / 609.6mm	30" / 762.0mm
B" =	17.63" / 447.8mm	21.63" / 549.4mm	27.63" / 701.8mm
C" =	4.63" / 117.6mm	8.63" / 219.4mm	NOT APPLICABLE

30" DEEP SECTION

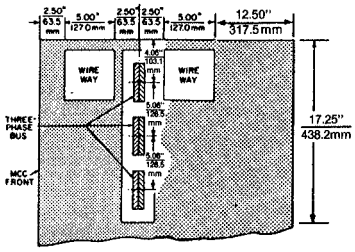
END VIEW STANDARD 30" DEEP



BUS DETAILS STANDARD 30" DEEP

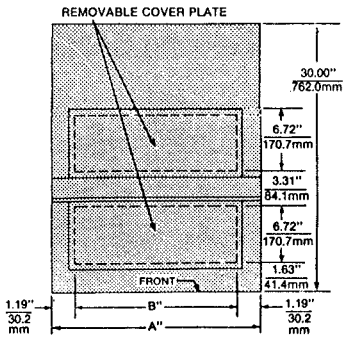


END VIEW WITH 2" (50.8mm) BUS BAR



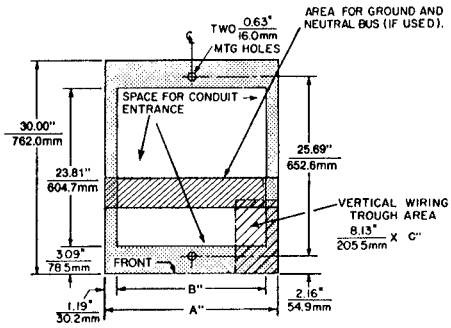
END VIEW WITH 4" (101.6mm) BUS BAR

TOP CONDUIT ENTRANCE DETAILS



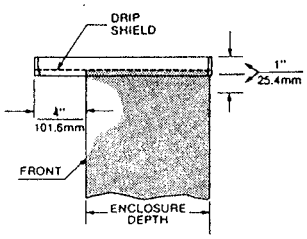
30" (762.0mm) DEEP

BOTTOM CONDUIT ENTRANCE

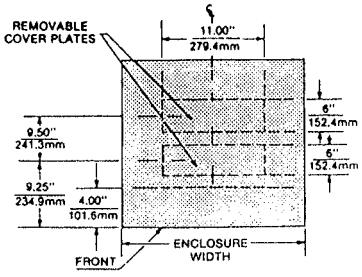


GENERAL DIMENSIONS

REF. DIM.	20" WIDE ENCLOSURE	24" WIDE ENCLOSURE	30" WIDE ENCLOSURE
A" =	20" 508.0mm	24" 609.6mm	30" 762.0mm
B" =	17.63" 447.8mm	21.63" 549.4mm	27.63" 701.8mm
C" =	4.63" 117.6mm	8.63" 219.4mm	NOT APPLICABLE



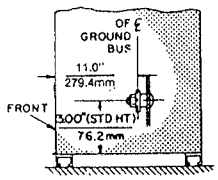
END VIEW



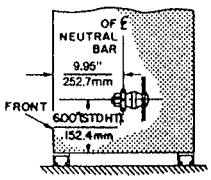
TOP VIEW

NEMA II DRIP SHIELD

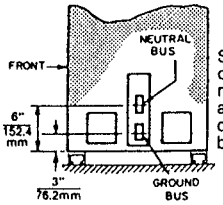
STANDARD GROUND AND NEUTRAL BUS DETAILS



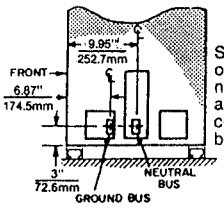
Ground bus bolted directly to section frame



Insulated neutral bus



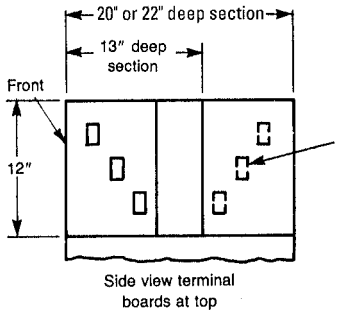
Standard location of ground and neutral bus with a 12-in. (304.8 mm) compartment at the bottom of MCC

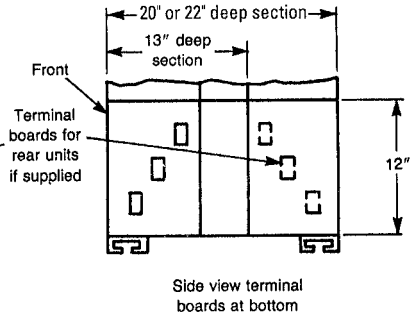


Standard location of ground and neutral bus with a 6-in. (152.4 mm) compartment at the bottom of MCC

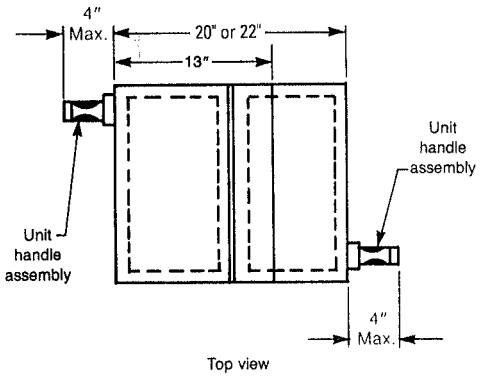
INDOOR ENCLOSURES

Type C Master Terminal Boards



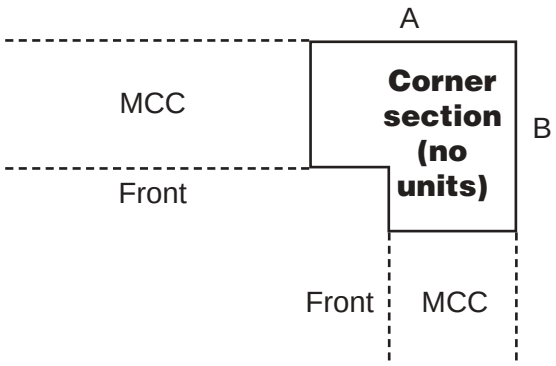


Disconnect Handle Projection



Used For L- and U- Shaped Motor Control Center Arrangements

Dimensions (In Inches)		
MCC Depth	A	B
13	17	20
20	24	24
22	26	24



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 and effective 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.

Starters Mounted Back-to-Back (Single Section)

This construction requires a minimum 20-inch deep enclosure. A common main horizontal bus is furnished with individual front and rear vertical buses to maintain same phase sequence, front and rear. This allows for mounting draw-out units in the rear of the section without changing phasing.

The back-to-back section is UL labelled per table below and can be mounted in a NEMA 3R non-walk-in outdoor enclosure.

Care must be exercised when arranging units as some of the larger starters, power transformers, etc., require the full enclosure depth.

Back-to-Back Availability

Main Bus Amps	42/50K AIC	65K AIC	100K AIC
600	UL	UL	N/A
800	UL	UL	N/A
1000	UL	UL	N/A
1200	UL	UL	N/A
1600	N/A	N/A	N/A
2000	UL	UL	N/A
2500	UL	UL	N/A

Back-To-Back Line Ups

13-inch through 22-inch motor control center equipments may be mounted back-to-back provided back access is not required. Refer to the factory, noting specific requirements. This arrangement may require a main bus transition assembly.

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-inch 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.

Structural Floor Sills

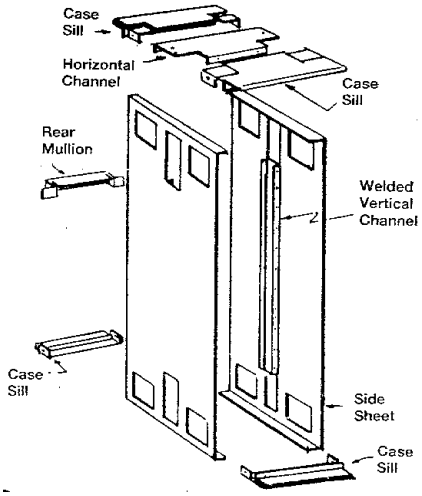
1½-inch X 3-inch structural channels are furnished in place of standard formed channels.

Extra Width Vertical Wireway

24-inch wide sections can be furnished with 8-inch wide vertical wireway and door.

Motor Control Center Construction

Indoor enclosure, exploded view



Major Structural Components
- Side Sheets, L-H & R-H
- Vertical Bus Mounting Channels — 0.090”
- Case Sills, Front/Rear, Top/Bottom — (13 Gauge)
- Top Horizontal Channel

Lifting Channel (Top) — 0.250”

Floor Sills, Front/Rear — 0.105”

Enclosing Covers/Panels
- Rear Doors, 45” (2 per section)
- Endplates, Top/Bottom Wireways
- Top Conduit Covers — 0.060”
- Bottomplates
- Vertical Wiretrough Door

Other Steel
- Unit Barrier Shelves .....0.060”
- Unit Cover Doors 6”, 12”, 18” .....0.060”
- Unit Cover Doors 24” & Larger .....0.090”
- Unit Saddles 6” & 12” .....0.060”
- Unit Saddles 24” & Larger .....0.075”

ENCLOSURES

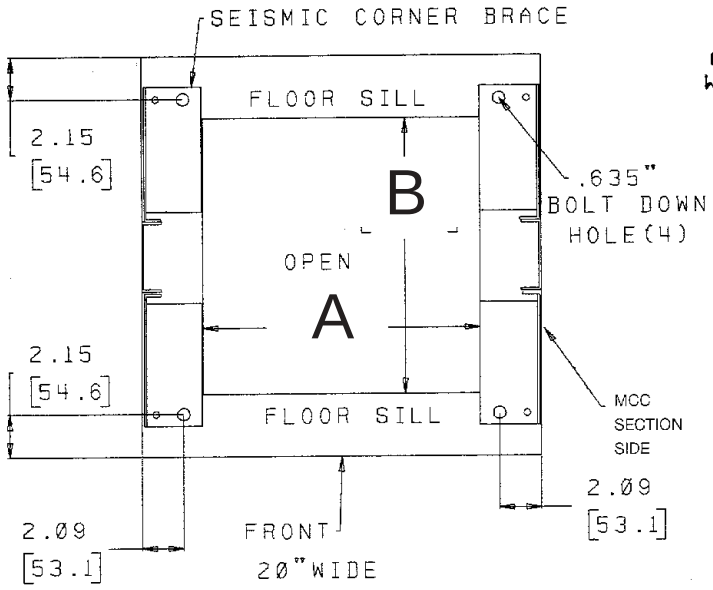
Seismic Bracing

Floor plan of each vertical section showing conduit entrance limitations for motor control center vertical sections with seismic bracing.

See standard indoor enclosures for other construction details.

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 ½-inch bolts.

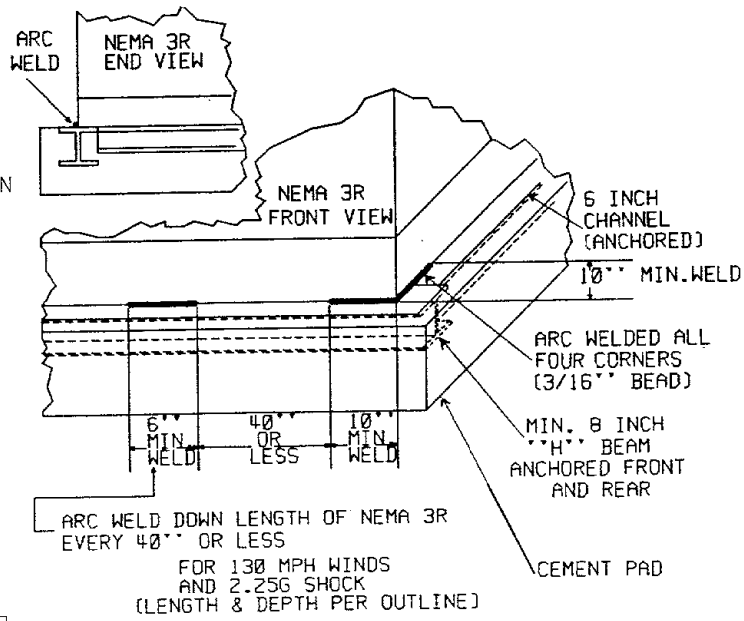
Section Floor Plan for Seismic Bracing for NEMA 1 or NEMA 3R Construction



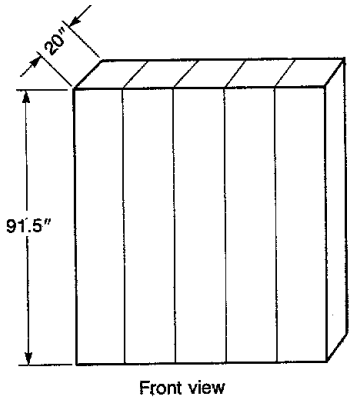
Case Width	"A"
20" (508mm) W	13.88" (352.5 mm)
24" (609.6 mm) W	17.88" (454.2 mm)
30" (762 mm) W	23.88" (606.6 mm)

"B" (Depth)	
20" DP	22" DP
13.75"	15.75"
(349.2)	(398.5)

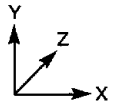
Mounting Requirements for Seismic NEMA 3R with Optional Heavy Base



Center of Gravity



Front view



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

X = center of lineup
Y = 46½" above bottom of floor sill
Z = 8" in from front (front-mounted devices 20" deep)
OR: 10" in from front (back-to-back construction)
5" in from front (13" deep)
8½" in from front (22" deep)
11" in from front (25" NEMA 3R)

Typical variations due to uneven loads:

X = ± 5"
Y = ± 1"
Z = ± .5"

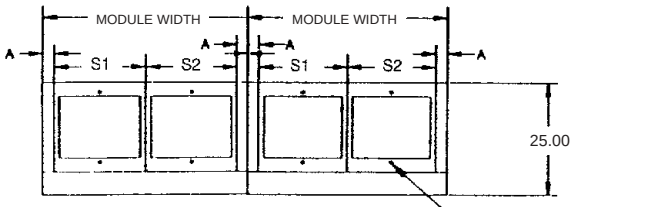
OUTDOOR ENCLOSURES

NEMA 3R NON-WALK-IN ENCLOSURE (STANDARD)

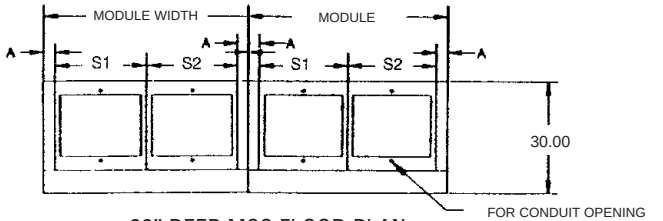
The standard NEMA 3R enclosure consists of a specially constructed MCC section with a mating framework which supports the roof and extended front. The basic design is similar to switchboard construction. The smaller footprint will permit a broader usage than the optional NEMA 3R construction. Meets Seismic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

Module Width (Total)	A	MCC Split Length (S1 & S2) ②
25	2.5	20”
30	3.0	24”
35	2.5	30”
45	2.5	40”
50	3.0	44”
55	2.5	50”
55	3.5	48”
60	3.0	54”
65	2.5	60”

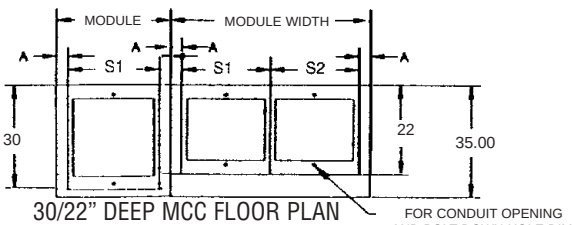
NOTES:
① Doors shown are double doors, or MW less than 45” door will be single door.
② NEMA 3R module may contain 1, 2 or 3 MCC sections, 3 section shipping split limited to (3) 20” wide MCC sections only.
③ All dimensions in inches.
④ For Seismic mounting see Sh # B-10



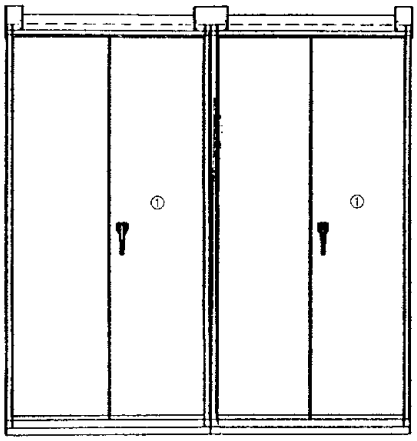
20” DEEP MCC FLOOR PLAN
FOR CONDUIT OPENING AND BOLT DOWN HOLE DIM. SEE SH #B-5

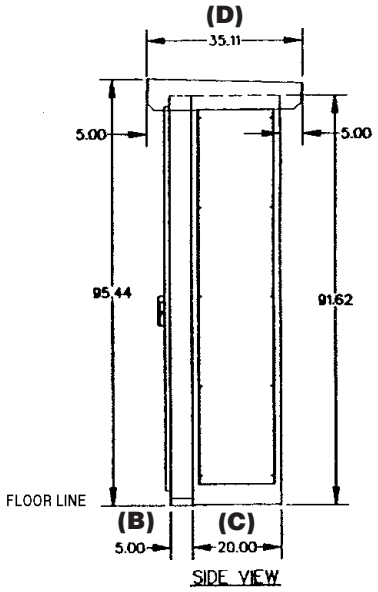


22” DEEP MCC FLOOR PLAN
FOR CONDUIT OPENING AND BOLT DOWN HOLE DIM. SEE SH #B-6



30/22” DEEP MCC FLOOR PLAN
FOR CONDUIT OPENING AND BOLT DOWN HOLE DIM. SEE SH #B-6, 7





MCC Depth (C)	Front Extension (B)	Top Cover (D)
20”	5	35
22”	8	40
30” Plus	5	45
22”	13	

OUTDOOR ENCLOSURES

NEMA 3R WEATHERPROOF ENCLOSURE (OPTIONAL)

General Electric's outdoor construction consists of an indoor (20-inch deep only) motor control center line-up in an outdoor enclosure. Standard NEMA 3R enclosures generally house two or more vertical sections and are bolt-together type construction with provision for future expansion. Standard construction will withstand wind velocities up to 75 mph. Roof loading should be limited to 30 lbs./ft^2. Exterior finish is an air-dry alkyd enamel ANSI 61 (light gray) over a phosphate corrosion-resistant primer. Outdoor enclosures are approximately 104 inches overall height. Floor plates beneath the interior motor control center line-up are not provided. If required, order motor control center bottom plates with the motor control center sections. Space heaters with thermostatic control are recommended in the motor control center line-up. Refer to specific job drawings for mounting and anchoring details.

NEMA 3R outdoor enclosures are available in four enclosure types:

- NEMA 3R non-walk-in
- NEMA 3R non-walk-in (back-to-back)
- NEMA 3R walk-in
- NEMA 3R common-aisle, walk-through

Each NEMA 3R module may vary in width from 20 inches to 48 inches, and modules of varying width may be bolted together to form a single shipping section. With the standard base a maximum of two modules can be shipped bolted together. Specify a heavy base under the following conditions:

- If more than two NEMA 3R modules form a single shipping section.
- Rear access to the motor control center is specified.
- Wall insulation is specified.
- Extended height is specified.
- Wind withstandability above 75 mph (130 mph max.)
- Seismic withstandability is specified (Zone 4, 2.25g max.).
- NEMA 3R walk-through construction is required.

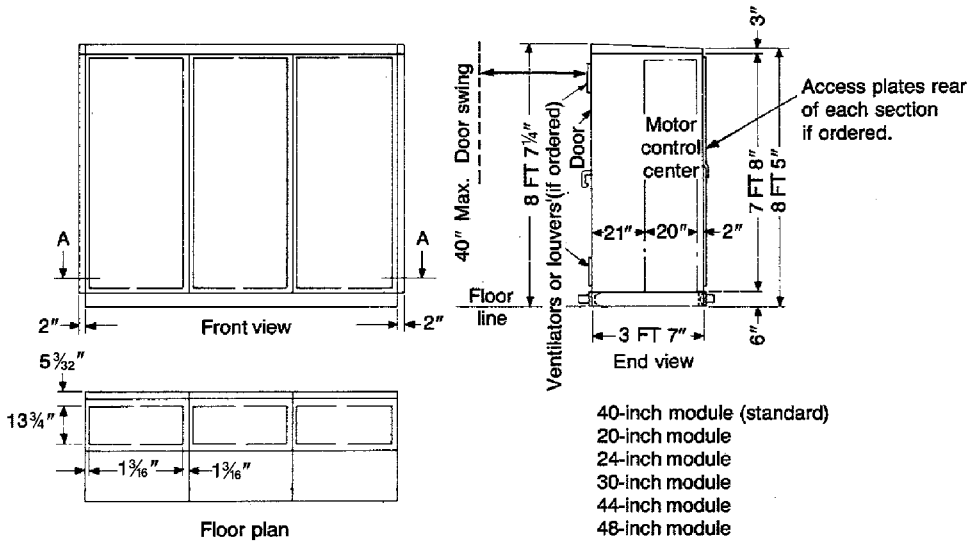
OUTDOOR ENCLOSURE FEATURES

	STANDARD	OPTIONAL			
Feature	3R Non-Walk-In	3R Non-Walk-In	3R Non-Walk-In Back-To-Back	3R Walk-In	3R Walk Through
Rear Access	Standard	Optional	–	Optional	Optional
Louvered Door Ventilation	–	Standard	Standard	Standard	–
Filters For Door Ventilation	–	Optional	Optional	Optional	–
Top or End Ventilation	Standard	–	–	Optional	Optional
Filters for Top or End Ventilation	–	–	–	Optional	Optional
Insulation–Top & Sides	–	Optional	Optional	Optional	Optional
Insulation–Top Only	–	Optional	Optional	Optional	Optional
Fluorescent Lighting, Switches and Convenience Outlets	Optional	Optional	–	Optional	Optional
130 mph Wind Withstandability	Optional	Optional	Optional	Optional	Optional
Seismic Withstandability (2.25G Max)	Optional	Optional	Optional	Optional	Optional
Extended Height (10")	–	Optional	Optional	Optional	Optional
Door Stops	Standard	Standard	Standard	Standard	–
Panic Door Hardware	–	–	–	–	Standard
Removable Floor Plates in Front of MCC	–	Standard	Standard	Standard	Standard
Key Lockable Doors (cylinder lock)	Padlock Prov.	Standard	Standard	Standard	Standard
Heating and Cooling	–	Optional	Optional	Optional	Optional
Heavy Base		Optional	Optional	Optional	Standard

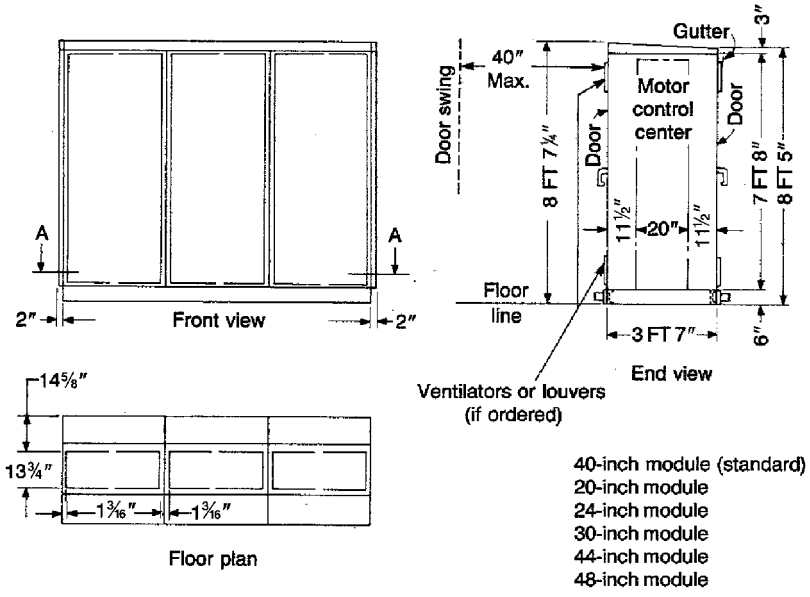
B

OUTDOOR ENCLOSURE DIMENSIONS

Optional NEMA 3R Outdoor Non-Walk-In



Optional NEMA 3R Outdoor Non-Walk-In (Back-to-Back)

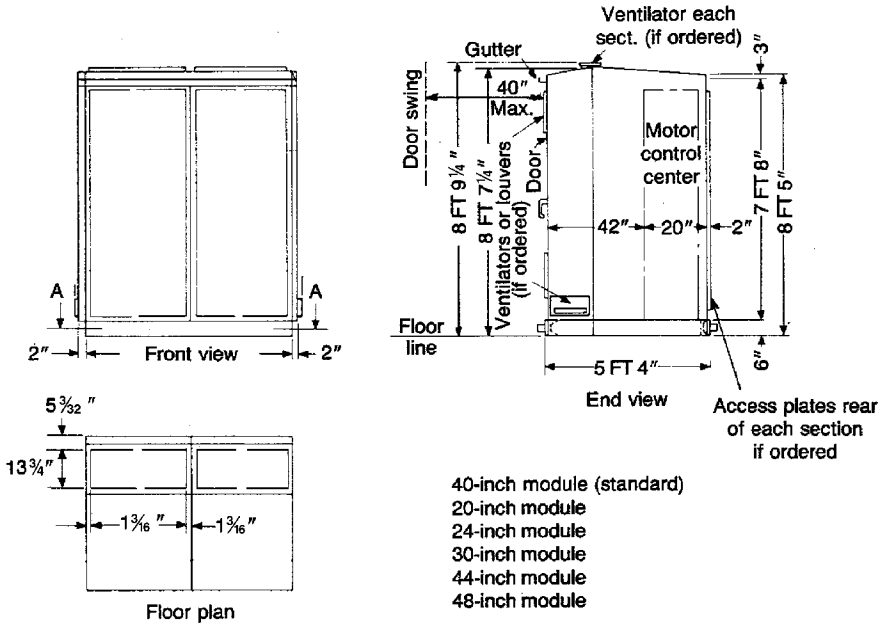


GENERAL NOTES:

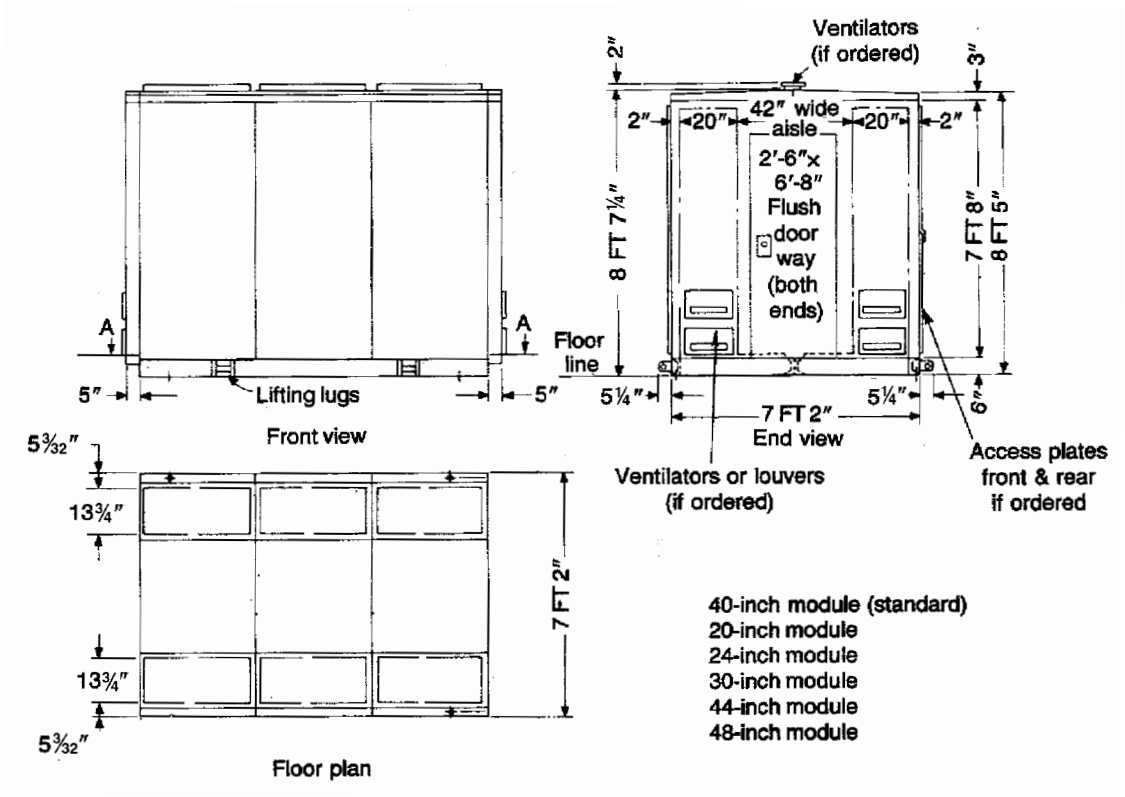
- NEMA 3R bolt-down hole size and location is subject to change depending on equipment requirements. See specific job drawings.
- Average shipping weight of all outdoor enclosures is based on 50 lbs. per square foot of floor space plus the weight of the interior motor control center line-ups.
- Some local codes require 30-inch minimum door width.

OUTDOOR ENCLOSURE DIMENSIONS

Optional NEMA 3R Outdoor Walk-In



Optional NEMA 3R Outdoor Common-Aisle Walk Through



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

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 verticval bus is standard, with silver plating as an option.

NEUTRAL BUS

Neutral bus is normally rated 50 percent or 100 percent of the main bus ampacity depending on system requirements.

GROUND BUS

UL requires a ground bus in multisection motor control centers. 300 ampere Cu or 375 ampere Al ground bus will meet minimum size requirements for main busses rated through 2000 amperes. A clearance hole for 3/8-inch hardware is provided in each section.

OPTIONS

The following UL listed options are available:

- Cap plugs for unused vertical bus stab openings.
- Shutter mechanism for vertical bus stab openings.
- Fully-insulated main horizontal bus.
- Silver plated horizontal and vertical bus.
- Plated ground bus (tin/silver).

BUS SYSTEMS/SELECTION

MCC Bus	Continuous Current Rating Amperes	Material		Short-Circuit Rating in RMS Symmetrical Amperes–(kA)			UL	Notes
		Cu	Alum⑧	42	65⑨	100②		
Main Horizontal	600	X	X		X	X	X	2” Bus
	800	X	X		X		X	2” Bus
	1000		X		X	X	X	④2” Bus
	1200	X	X	X	X	X	X	①4” Bus
	1600⑤⑦	X		X	X	X	X	①4” Bus
	2000⑥	X		X	X	X	X	①4” Bus
	2500⑥	X		X	X	X	X	①4” Bus
Vertical	300	X		X	X		X	
	450	X		X	X		X	
	600	X		X	X	X	X	③
Neutral	300	X					X	
	375		X				X	
	600	X	X				X	
	800	X	X				X	
	1000	X					X	
	1200	X	X				X	
	1250	X					X	
Horizontal Ground	300	X					X	1/4” x 1”
	375		X				X	1/4” x 2”
	600	X					X	1/4” X 2”
	600		X				X	3/8” X 2”
Vertical Grounds	150	X					X	1/8” x 1”

① 4-inch bus requires top 18-inch motor control center bus compartment.
② Not available in back-to-back construction (requires 4" main bus with 600 A vertical bus)
③ Required for all bolt-in assemblies.
④ Can be UL rated at 1200 amperes in a 20” deep section.
⑤ Back to back 20” deep not available.
⑥ 2000 and 2500 amp main bus require 22” deep section.
⑦ 1600 amp main bus requires a 20” deep section.
⑧ Copper bus is standard in Spectra MCC construction.
⑨ Standard bracing in Spectra MCC construction, 42K for back-to-back construction.

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).

Refer to the factory when ground fault protection or metering is required.

MAIN METERING/LUGS

Line side CTs can be provided in the main compartment for use with a metering unit. This option 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.

FUSED SWITCH MAINS

Amperes	Interrupting Rating RMS Amps (In thousands)③			Construction		Space Units ④	UL Listed (X)	Notes
	Volts			Stab-	Bolt-			
	240	480	600	In	In			
FUSIBLE SWITCHES								
100⑤	65	65	N/A	X		1½	X	
200	100	100	100	X		2½	X	
400	100	100	100		X	3	X	②⑩
600	100	100	100		X	3	X	②⑩
HIGH PRESSURE CONTACT SWITCH								
800	100	100	100		X	6	X	①
1200	100	100	100		X	6	X	①
1600	100	100	100		X	6	X	⑦
2000	100	100	100		X	6	X	⑧
2500	100	100	100		X	6	X	⑨

① Requires a 24-inch wide by 20-inch deep section. Full depth of enclosure is required; rear is not available for back-to-back construction.
② Requires additional ½X of mounting space when located at top of section adjacent to 6-inch wireway cover with 2-inch horizontal bus.
③ With Class J, R and L fuses.
④ Top/bottom entry.
⑤ For 600 volt applications or 100k ratings, provide a 200 amp switch with 100A clips. 100A switch can be rated at 100kA with Class J fuses only.
⑦ Requires 30-inch wide by 20-inch deep section full depth.
⑧ Requires 30-inch wide by 30-inch deep section. Rating based on NEMA 1 enclosure only.
⑨ Requires 30-inch wide by 30-inch deep section. Must be NEMA 1 Construction, 80% rated only.
⑩ Requires 24-inch wide section if bottom fed incoming line.

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		1½	X		T/B
225	SFL/SFP	65/100	65/100	25/25	X		2	X	⑫	T/B
600	SGL/SGP	65/100	65/100	65/65		X	2	X	①	T/B
1200	SKL	65	65	42		X	2	X	①②⑦	T
1200	SKL	65	65	42		X	6	X	②⑥	B
POWERBREAK® INSULATED-CASE MICROVERSATRIP										
800	TP/THP/SSF	65	65	42		X	6 (24W)	X	③	T/B
1600	TP/THP/SSF	65/100	65/100	42/65		X	6 (30W)	X	④⑩	T/B
2000	TP/THP/SSF	65/100	65/100	42/65		X	6 (30W)	X	⑧⑩	T/B
2500	TP/THP/SSF	65/100	65/100	42/65		X	6 (30W)	X	⑧⑬	T/B
800	TC/THC/SSD	65	65	42	X		6 (30W)	–	⑨⑧	T/B
1600	TC/THC/SSD	65	65	42	X		6 (30W)	–	⑨⑧	T/B
2000	TC/THC/SSD	65	65	42	X		6 (30W)	–	⑨⑧	T/B
CONVENTIONAL, THERMAL MAGNETIC										
150	THED	30	25	18	X		1½	X		T/B
225	THFK	30	25	18	X		1½	X	⑭	T/B

OTHER CIRCUIT BREAKER MAINS

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
TRI-BREAK® INTEGRALLY FUSED, THERMAL MAGNETIC										
400	TB4	–	–	100		X	2½	X		T/B
600	TB6	–	–	100		X	2½	X	①⑦	T
800	TB8	–	–	100		X	2½	X	①⑦	T
LOW-VOLTAGE POWER CIRCUIT BREAKER–AKR MICROVERSATRIP										
800	AKR-30S	22	22	22	X		6	–	⑨⑤	T/B
800	AKR-30H	42	42	42	X		6	–	⑨⑤	T/B
1600	AKR-50	50	50	42	X		6	–	⑨⑤	T/B
1600	AKR-50H	65	65	42	X		6	–	⑨⑤	T/B
2000	AKRT-50H	65	65	42	X		6	–	⑨⑤	T/B
800	AKR70-30S	22	22	22		X	6	–	⑨⑤	T/B
800	AKR70-30H	42	42	42		X	6	–	⑨⑤	T/B
1600	AKR70-50	50	50	42		X	6	–	⑨⑤	T/B
1600	AKR70-50H	65	65	42		X	6	–	⑨⑤	T/B
2000	AKR70-50H	65	65	42		X	6	–	⑨⑤	T/B

① Main breaker requires additional ½ X of mounting space when located at top of section adjacent to 6-inch wireway cover with 2-inch horizontal bus or 12-inch wireway cover with 4-inch horizontal bus.
② When a size 6 or 7 starter is in the motor control center line-up, use a 1200 ampere MicroVersa Trip circuit breaker as a main.
③ Requires special section 90-inch high, 24-inch wide, 20-inch deep
④ Requires special section 90-inch high, 30-inch wide, 20 inch deep.
⑤ Requires special section 90-inch high, 30-inch wide, 40-inch deep.
⑥ Requires full 20” depth of enclosure; rear is not available for back-to-back construction.
⑦ Main breaker must be mounted at top of the section and requires full 20” depth of enclosure; rear is not available for back-to-back construction.
⑧ Requires special section 90-inch high, 30-inch wide, 30-inch deep.
⑨ For UL or service entrance labels provide main breaker in switchboard construction.
⑩ NEMA 12; 80% Rating
⑪ NEMA 1, 80% Rated Only
⑫ 1½ X units are available at 180 Amps Max. Load.
⑬ In 8000-Line MCC only.

Data subject to change without notice

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.

Note that magnetic only circuit breakers are not approved for use as feeder units.

FUSED SWITCH FEEDERS

Amperes	Interrupting Rating RMS Amps (In thousands)③			Construction		Space Units ⑥	UL Listed (X)	Notes
	Volts			Stab-	Bolt-			
	240	480	600	In	In			
FUSIBLE SWITCHES								
30	100	100	100	X		1/2	–	①②④
60	100	100	100	X		1/2	–	①②④
30	100	100	100	X		1	X	
60	100	100	100	X		1	X	
100⑨	65	65	–	X		1	X	
100⑦	100	100	100	X		1	X	
200	100	100	100	X		2	X	②
400	100	100	100		X	4	X	②
600	100	100	100		X	4	X	②
THPR HIGH PRESSURE CONTACT SWITCH								
800	100	100	100		X	6	X	③
1200	100	100	100		X	6	X	③⑧
1600	100	100	100		X	6	–	③⑧

Note:
- Dual or twin feeder units are not available.

① 1/2 space unit feeders with "J" type fuses can be UL labeled. All other type fuses cannot be labeled.
② Feeder unit requires additional 1/2X of mounting space when located at top of section adjacent to 6-inch wireway cover with 2-inch horizontal bus or 12-inch wireway cover with 4-inch horizontal bus.
③ Requires a 24-inch wide by 20-inch deep section. Full depth of enclosure is required; fear is not available for back-to-back construction.
④ When feeder unit requires accessories, the unit height must be minimum of 1 space.
⑤ With Class J, R, L fuses.
⑥ Top/bottom entry.
⑦ Class J fuses only.
⑧ See note #6, sheet C-5.
⑨ For 600 Volt applications or 100K ratings, provide a 200 amp switch with 100A clips.

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		½	X	①③	T/B
150	SEL/SEP	65/100	65/100	25/25	X		1½	X		T/B
225	SFL/SFP	65/100	65/100	25/25	X		2	X	⑦	T/B
600	SGL/SGP	65/100	65/100	65/65		X	2	X	①	T/B
1200	SKL	65	65	42		X	2	X	② ⑥	T
1200	SKL	65	65	42		X	6	X	④ ⑥	B
CONVENTIONAL, THERMAL MAGNETIC										
100	THED	30	25	18	X		½	X	①③	T/B
150	THED	30	25	18	X		1	X		T/B
225	THFK	30	25	18	X		1	X	⑧	T/B

OTHER CIRCUIT BREAKER FEEDERS

Amperes	CB Type	ICV (kA) 240V	ICV (kA) 480V	ICV (kA) 600V	Stab-In	Bolt-In	Space Units	UL (X) Listed	Notes	Entry Top/Bot
LIMITER ASSISTED, THERMAL MAGNETIC										
100	THEDL	–	–	100	X		½	X	①③	T/B
TRI-BREAK® INTEGRALLY FUSED, THERMAL MAGNETIC										
400	TB4	–	–	100		X	2½	X	①	T/B
600	TB6	–	–	100		X	4	X	⑤	T/B
800	TB8	–	–	100		X	6	X	②④	T/B

① Feeder breaker requires additional ½X of mounting space when located at the top of section adjacent to 6-inch wireway cover with 2-inch horizontal bus or 12-inch wireway cover with 4-inch horizontal bus.

② Must be located at the top of section adjacent to 12-inch wireway cover (minimum) with 2-inch horizontal bus or 18-inch wireway cover with 4-inch horizontal bus.

③ When feeder unit accessories are required such as shunt trip, AUX switch, UV release, etc., unit height must be a minimum of 1 space.

④ Requires full depth of enclosure; rear is not available for back-to-back construction (20" deep minimum).

⑤ Feeder breaker must be mounted at the bottom of the section and requires full depth of enclosure; rear is not available for back-to-back construction.

⑥ 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

⑦ 1½ X units are available at 180 Amp. Max. load.

⑧ 8000-Line only.

C

OPTIONS FOR MAINS AND FEEDERS

ACCESSORIES FOR MOLDED CASE CIRCUIT BREAKERS

Breaker Type	Bell Alarm Switch			Auxiliary Switch or Shunt Strip		Undervoltage Release		Three Coil Shunt Trip		Total Number of Accessories Within Any One Circuit-Breaker
	Mounting Pole⑥			Mounting Pole⑥		Mounting Pole⑥		Mounting Pole⑥		
	L	C	R	L	R	L	R	L	R	
THED	UL		UL	UL②	UL②③		UL		UL	Any two Except UVR and 3-Coil, Shunt Trip
THFK①			UL	UL②	UL②④	UL	UL	UL	UL	Any Two
TJK, THJK, TB4		UL		UL②	UL②④	UL	UL	UL		Any Two Plus Bell Alarm
TB6, TB8		UL		UL②	UL②④	UL	UL	UL		Any Two Plus Bell Alarm

ACCESSORIES FOR SPECTRA MOLDED CASE CIRCUIT BREAKERS

Breaker Type	Bell Alarm	Shunt Trip⑨ or Undervoltage Release	Aux. Switch⑧	Total # of Accessories
All Spectra	Left Pole	Left Pole	Right Pole	Aux. Switch & Bell Alarm Plus 1 other

ACCESSORIES FOR POWER BREAK® AND LOW VOLTAGE POWER CIRCUIT BREAKERS

Breaker Type	Bell Alarm Switch	Auxiliary Switch	Shunt Trip	Undervoltage Release	Blown Fuse Trip	Electrical Operator	Total No. of Accessories
TP, THP TC, THC	UL	UL②⑤	UL	UL	UL	UL	All⑦
All AKR-800, 1600 and 2000 A.	UL	UL②	UL	UL	UL	UL	All

① UL Listed interrupting capacity with accessories as follows: 10K AIC at 600-volts AC, 22K AIC at 240-and 480-volts AC.
② 600 volts AC auxiliary switches are not UL listed.
③ Maximum number of SPDT aux. switch elements is 2.
④ Maximum number of SPDT aux. switch elements is 4.
⑤ Maximum number of SPDT aux. switch elements is 10 when shunt trip is used, 12 without shunt trip.
⑥ Pole positions: L=left; C=center; R=right
⑦ UVR and blown fuse trip cannot be installed simultaneously.
⑧ Aux. Switch available @ 240 V max only.
⑨ Shunt trip requires aux. switch (G&K) or bell alarm (E&F) for continuous operation.

TERMINALS FOR FIELD WIRING MAINS AND FEEDERS

Terminal Size		Will Accept Wire②	
		AWG/MCM①	Material
SWITCHES			
30A QMW 60A QMW		14-8 14-2 12-2	Cu-Al Cu Al
100A QMW		14-1/0 12-1/0	Cu Al
200A QMW 400A QMR		6-250 2-600/ 1/0-250 (2/Ph)	Cu-Al Cu-Al Cu-Al
600A QMR		2-600 (2/Ph)	Cu-Al
HPC Switch 800-1600A		 300-750 300-800	 Cu Al
CIRCUIT BREAKERS			
SE150 15-150A	1 lug	12-3/0	Cu-Al
SF250 70-225A	1 lug	8-350	Cu-Al
SG600 125-600A	1 lug 2 lugs	6-600 2/0-400	Cu-Al Cu-Al
SK1200 300-1200A	3 lugs (800A) 3 lugs 4 lugs	3/0-500 300-750 250-500	Cu-Al Cu-Al Cu-Al
THED THEDL (100A Max)	15-30A 35-60A 70-110A 70-110A 125-150A	14-8 13-3 6-2/0 4-2/0 2-3/0	Cu-Al Cu-Al Cu Al Cu-Al
TFK/THFK	225A Feeder 225A Main	4-300 2-600/ 1/0-250 (2/Ph)	Cu-Al Cu-Al Cu-Al
TJK/THJK	125-400A 250-600A	6-600/ 2/0-250 (2/Ph) 250-300 (2/Ph) 250-500 (2/Ph)	Cu-Al Cu-Al 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.

TERMINALS FOR FIELD WIRING MAINS AND FEEDERS

Terminal Size	Will Accept Wire②	
	AWG/MCM①	Material
CIRCUIT BREAKERS		
TB4 125–400A	6-600 2/0-250 (2/Ph)	Cu-Al Cu-Al
TB6 3-–600A	2/0-500 (2/Ph)	Cu-Al
TB8 600–800A	250–500 (3/Ph)	Cu-Al
GROUND LUG	1/0-300	Cu-Al

C

OPTIONS FOR MAINS AND 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 Ground Break® 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 breaks and fusible switches. 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 12-inch 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. Type TGSR 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-inch 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.

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 be installed to maintain the short-circuit rating.

Incoming Line Cable Assemblies	Terminal Board Space Adjacent Wireway		Cables Per Ph②	Wire Size	Fig. No.	UL Listed	Short-Circuit Rating Max.
	6”	12”					
1. 600A Top Entry	12” 18”	6” 12”	2 2 or 3	2-400MCM① 2-600 MCM	1 1	Yes Yes	65K 65K
2. 600A Bottom Entry	12” 18”	6” 12”	2 2 or 3	2-400 MCM 2-600 MCM	2 2	Yes Yes	65K 65K
3. 800 or 1000A Top Entry ⑥	–	12”	3	2-600 MCM	3	Yes	65K
4. 800 or 1000A Bottom Entry ⑥	18”	12”	3	2-600 MCM	4③	Yes	65K
5 1200A Top or Bottom Entry Consists of (2) 600-ampere terminal compartments in adjacent vertical sections. An equal number of cables per phase Must be terminated in each section.	12” 18”	6” 12”	2 2	2-400 MCM① 2-600 MCM	1,2 1,2	Yes Yes	65K 65K
6. 1200A Top Entry (4” Bus)	–	18”	3	2-600 MCM	5	Yes	65K
7. 1200A Bottom Entry	18”	12”	3	2-600 MCM	4③	Yes	65K
8. 1200/1600A Top Entry	N/A	36”④	5	500-1000 MCM	6	Yes	100K
9. 1200/1600A Bottom Entry	N/A	90”④	5	500-1000 MCM	6	Yes	100K
10. 2000/2500 Top	N/A	90”⑤	8	500-1000 MCM	7	Yes	100K
11. 2000/2500A Bottom	N/A	90”⑤	8	500-1000 MCM	7	Yes	100K

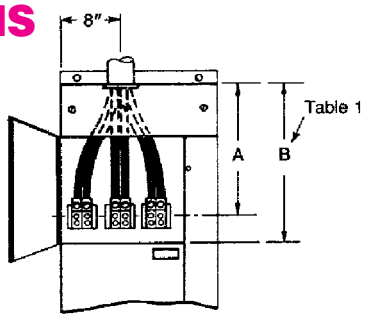
① Can be increased to 600 MCM when used with a 6-inch high pull box.
② Mechanical type Cu/Al lugs furnished for 75°C cable.
③ Requires 20-inch deep section (no rear vertical bus).
④ Requires 20” deep, 24” wide section.
⑤ Requires 22” deep, 40” wide section.
⑥ 1200A 2” bus uses a similar TB, except with 4 lugs per phase capability.

INCOMING LINE TERMINATIONS

CABLE ASSEMBLIES (Cont'd)

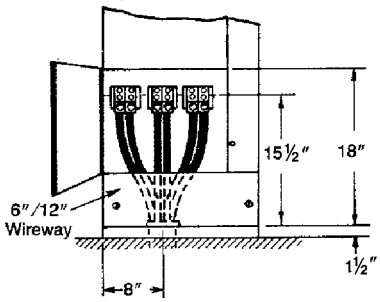
Table 1

Adjacent Wireway	A	B
6"	15½"	18"
12"	15½"	18"
18"	21½"	24"



Front View

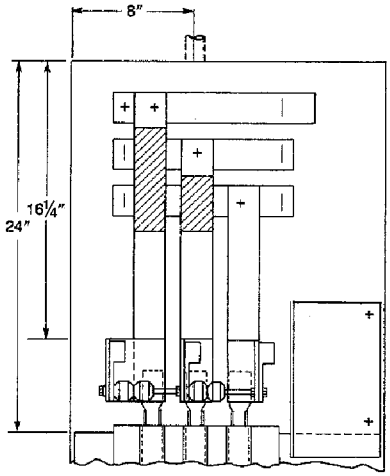
Fig. 1. 600-ampere (top) 20"/24" W



Front View

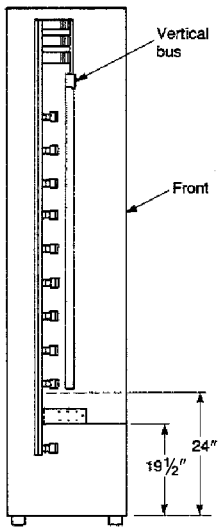
Fig. 2. 600-ampere (bottom) 20"/24" W

C



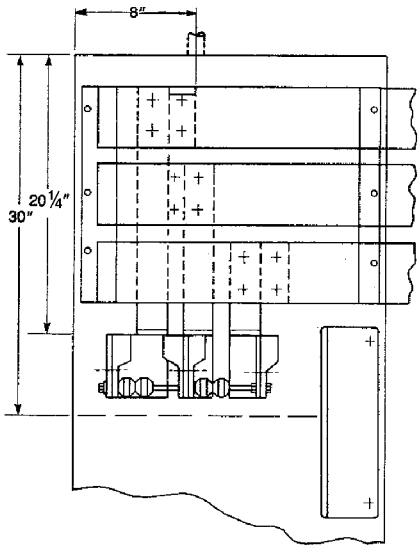
Front View

Fig. 3. 800/1000/1200(2")-ampere (top) 20" W



Side View

Fig. 4. 800/1000/1200-ampere (bottom) 20" W



Front View

Fig. 5. 1200-ampere (top) 20" W

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"	20"W x 20"D	1600	1500	1350	1000
Bottom	–	20"W x 20"D	1600	1500	1350	1000
Top	12"	24"W x 22"D	2000	2000	2000	2000
Bottom	–	24"W x 22"D	2000	2000	2000	2000
Top	12"	24"W x 22"D	2500	2500	2500	2500
Bottom	–	24"W x 22"D	2500	2500	2500	2500

Note:

- Bus bars must be phased front-to-rear in 24-inch width enclosure. Bottom entry requires full section.

INCOMING LINE TERMINATIONS

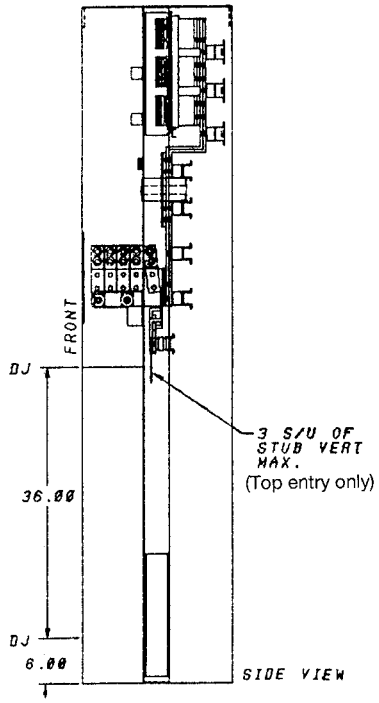


Fig. 6. 1600 ampere (top/bottom) 24" W

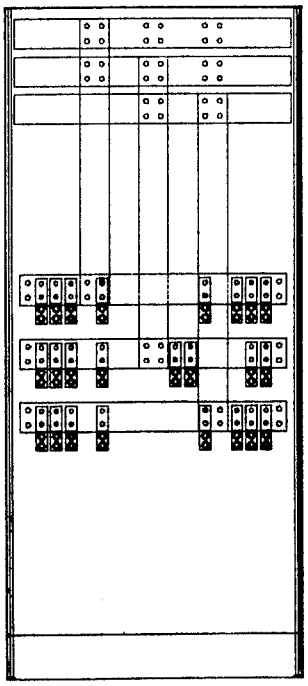


Fig. 7. 2000/2500-ampere (top/bottom) 40" W, 22" deep

AUTOMATIC TRANSFER SWITCHES

GE motor control centers may be furnished with transfer switches manufactured by ASCO. 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 ASCO Bulletin 940 open-type switches which are UL Listed through 480 volts AC. For specific ratings and additional optional features refer to ASCO.

- Voltage sensing of normal source
- Voltage sensing of emergency source
- Frequency sensing of emergency source
- Time delay to override momentary outage
- Retransfer to normal time delay
- Emergency generator cool-down time delay
- Transfer to emergency time delay
- Engine control contacts (1 N.O., 1 N.C.) for engine start
- Manual control for testing
- Auxiliary contacts (1 N.O., 1 N.C.)
- Indicating lights–green and red

WITHSTAND CURRENT RATINGS (WCR) FOR ASCO 940 AUTOMATIC TRANSFER SWITCHES

MCC Space Units①	MCC Enclosure Widths (In Inches)	Switch Rating (Amps)②	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)	WCR③	Max. Breaker Size (Amps)
3	20	30	100,000	60	10,000	50
3	20	70	200,000	200	10,000	150
3	20	100	200,000	200	10,000	150
3	20	150	200,000	450	10,000	225
3	20	260	200,000	600	35,000	600
3	20	400	200,000	600	35,000	600
3	24	600	200,000	1200	50,000	1600
3	24	800	200,000	1200	50,000	1600

① Does not include space for protection; switches must be mounted at bottom of section in order to install vertical bus above switch.

② Larger sizes require special over-size enclosures. Refer to factory.

③ With coordinated GE CB, 70, 100 & 150 amp switches have WCR of 22,000 amps. Likewise, the 400 amp switch has 42,000 amps and 600 & 800 amp switches have 65,000 amp ratings.

INCOMING LINE REACTORS

A section containing three reactors connected ahead of the motor control center bus can be utilized to reduce the available short circuit current at the motor control center. Short-circuit protection for the reactors is normally provided in the up-stream feeder circuit.

Continuous Amps	Enclosure	Comments
600	24"W x 20"D	With main bus. Cable connected from reactor load terminals to main bus.
800	24"W x 20" D	With main bus. Also requires top 24" of adjacent section for cable connections from reactor load terminals to main bus.
1000 & 1200	30"W x 24"D	No main bus. Also requires top 30" of adjacen section for cable connections from reactor load terminals to main bus. Flush rear.

Notes:

- Sections are not UL Listed.
- Incoming power lugs are mounted on the reactor pads. Pads are NEMA drilled.
- Specify the ohms impedance per phase required, continuous current rating, and the available short circuit current (RMS symmetrical) at the reactor load terminals.

C

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.

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. Drawout or pull-apart control terminal boards through NEMA Size 4.
6. Drawout power terminal boards through NEMA Size 3 (when specified).
7. Extra CPT capacity for operating auxiliary relays and pilot devices (when specified).
8. Plug-in construction through NEMA Size 4 (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 Typical Circuits (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	10	25	TEC	1	X	
3	25	25	TEC	2	X	
4	40	25	TEC	2.5	X	
5	75	100	SGL	3	X	⑧
6	150	65	SKL	6	X	①④
1	7.5	65,100	SEL	1	X	
2	10	65,100	SEL	1	X	
3	25	65,100	SEL	2	X	
4	40	65,100	SFL	2.5	X	
5	75	100	SGL	3.0	X	⑧
6	150	65	SKL	6	X	①⑧

FVR

1	7.5	25	TEC	1.5	X	
2	10	25	TEC	2	X	
3	25	25	TEC	3	X	
4	40	25	TEC	3	X	
5	75	100	SGL	6	X	①⑧
6	150	65	SKL	12	–	②④
1	7.5	65,100	SEL	1.5	X	
2	10	65,100	SEL	2	X	
3	25	65,100	SEL	3.5	X	
4	40	65,100	SFL	4	X	
5	75	100	SGL	6	X	①⑧
6	150	65	SKL	12	–	②④

RVNR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units④		UL Listed (X)	Notes
				13" Deep or Back-to-Back	20" Deep		
2	10	25	TEC	4	4	X	
3	25	25	TEC	5	4	X	
4	40	25	TEC	5	4	X	
5	75	100	SGL	–	4.5	X	③⑧
6	150	65	SKL	N/A	12	X	②
2	10	65,100	SEL	4	4	X	
3	25	65,100	SEL	5	4	X	
4	40	65,100	SEL	5.5	4.5	X	⑦
5	75	100	SGL	–	6	X	③
6	150	65	SKL	N/A	12	X	②

2S1W, 2S2W

NEMA Size	Max. Hp		IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
	Constant Variable Torque	Constant Hp					
1	7.5	5	25	TEC	1½	X	⑨
2	10	7.5	25	TEC	2	X	
3	25	20	25	TEC	3.5	X	
4	40	30	25	TEC	3.5	X	
5	75	60	30	TJC	6	–	①④
6	150	100	65	SKL	12	–	②④
1	7.5	5	65,100	SEL	1½	X	⑨
2	10	7.5	65,100	SEL	2	X	
3	25	20	65,100	SEL	4	X	
4	40	30	65,100	SFL	4	X	
5	75	60	100	TBC4	6	–	①④
6	150	100	65	SKL	12	–	②④

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	2.5		
3	40	25	TEC	4		
4	75	10	SGL	4.5		
5	–	–	–	–		④⑥
1	10	65,100	SEL	2		
2	20	65,100	SEL	2.5		
3	40	65,100	SFL	4.5		
4	75	100	TBC4	5		
5	–	–	–	–		④⑥

Y-DELTA

2	20	25	TEC	4		
3	40	25	TEC	4.5		①
4	60	100	TBC4	5.5		①
5	–	–	–	–		⑥
2	20	65,100	SEL	4		
3	40	65,100	SEL	5		
4	60	100	TBC4	5.5		
5	–	–	–	–		④⑥

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 6 FVR, RVNR, 2S2W require (2) adjacent 24-inch wide sections, 20-inch deep (2S1W-RTF).
③ Size 5 RVNR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑤ 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.
⑥ Refer to factory.
⑦ For 40 HP applications requiring a thermal-magnetic CB, the disconnect will be SFT type and will require an additional .5 space height.
⑧ Requires 12" bottom wireway cover to UL Label.
⑨ Requires additional 6 inches if Type "A" wiring specified.

D

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	
2	15	25	TEC	1	X	
3	30	25	TEC	2	X	
4	50	25	TEC	2.5	X	
5	100	100	SGL	3	X	⑧
6	200	65	SKL	6	X	①⑧
1	7.5	65,100	SEL	1	X	
2	15	65,100	SEL	1	X	
3	30	65,100	SEL	2	X	
4	50	65,100	SFL	2.5	X	
5	100	100	SGL	3.5	X	⑧
6	200	65	SKL	6	X	①⑧

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	7.5	25	TEC	1.5	X	
2	15	25	TEC	2	X	
3	30	25	TEC	3	X	
4	50	25	TEC	3	X	
5	100	100	SGL	6	X	①⑧
6	200	65	SKL	12	–	②④
1	7.5	65,100	SEL	1.5	X	
2	15	65,100	SEL	2	X	
3	30	65,100	SEL	3.5	X	
4	50	65,100	SFL	4	X	
5	100	100	SGL	6	X	①⑧
6	200	65	SKL	12	–	②④

RVNR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units④		UL Listed (X)	Notes
				13" Deep or Back-to-Back	20" Deep		
2	15	25	TEC	4	4	X	
3	30	25	TEC	5	4	X	
4	50	25	TEC	5.5	4.5	X	
5	100	100	SGL	N/A	4.5	X	③⑧
6	200	65	SKL	N/A	12	X	②⑧
2	15	65,100	SEL	4	4	X	
3	30	65,100	SEL	5	4	X	
4	50	65,100	SEL	6	4.5	X	⑦
5	100	100	SGL	N/A	6	X	③⑧
6	200	65	SKL	N/A	12	X	②⑧

2S1W, 2S2W

NEMA Size	Max. Hp		IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
	Constant Variable Torque	Constant Hp					
1	7.5	5	25	TEC	1½	X	⑨
2	15	10	25	TEC	2	X	
3	30	25	25	TEC	3.5	X	
4	50	40	25	TEC	3.5	X	
5	100	75	30	TJC	6	–	①
6	200	150	65	SKL	12	–	②
1	7.5	7.5	65,100	SEL	1½	X	⑨
2	15	20	65,100	SEL	2	X	
3	30	40	65,100	SEL	4	X	
4	50	75	65,100	SFL	4	X	
5	100	150	100	TBC4	6	–	①
6	200	150	65	SKL	12	–	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	2.5		
3	50	25	TEC	4		
4	75	10	SGL	4.5		
5	–	–	–	–		④⑥
1	10	65,100	SEL	2		
2	25	65,100	SEL	2.5		
3	50	65,100	SEL	4.5		
4	75	100	TBC4	5		
5	–	–	–	–		④⑥

Y-DELTA

2	25	25	TEC	4		
3	50	25	TEC	4.5		①
4	75	100	TBC4	5.5		①
5	–	–	–	–		④⑥
2	25	65,100	SEL	4		
3	50	65,100	SEL	5		①
4	75	100	TBC4	5.5		①
5	–	–	–	–		④⑥

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 6 FVR, RVNR, 2S2W require (2) adjacent 24-inch wide sections, 20-inch deep (2S1W-RTF).
③ Size 5 RVNR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑤ 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.
⑥ Refer to factory.
⑦ For 50 HP applications requiring a thermal-magnetic CB, the disconnect will be SFT type and will require an additional .5 space height.
⑧ Requires 12" bottom wireway cover to UL Label.
⑨ Requires additional 6 inches if Type "A" wiring.

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	
2	25	25	TEC	1	X	
3	50	25	TEC	2	X	
4	100	25	TEC	2.5	X	
5	200	100	SGL	3	X	⑧
6	400	65	SKL	6	X	①⑧
1	10	65,100	SEL	1	X	
2	25	65,100	SEL	1	X	
3	50	65,100	SEL	2	X	
4	100	65,100	SFL	2.5	X	
5	200	100	SGL	3.0	X	⑧
6	400	65	SKL	6	X	①⑧

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	TEC	3	X	
5	200	100	SGL	6	X	①⑧
6	400	65	SKL	12	–	②④
1	10	65,100	SEL	1.5	X	
2	25	65,100	SEL	2	X	
3	50	65,100	SEL	3.5	X	
4	100	65,100	SFL	4	X	
5	200	100	SGL	6	X	①⑧
6	400	65	SKL	12	–	②④

RVNR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units④		UL Listed (X)	Notes
				13" Deep or Back-to-Back	20" Deep		
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	–	4.5	X	③⑧
6	400	65	SKL	N/A	12	X	②
2	25	65,100	SEL	4	4	X	
3	50	65,100	SEL	5	4	X	
4	100	65,100	SEL	6	4.5	X	⑦
5	200	100	SGL	N/A	6	X	③
6	400	65	SKL	N/A	12	X	②

2S1W, 2S2W

NEMA Size	Max. Hp		IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
	Constant Variable Torque	Constant Hp					
1	10	7.5	25	TEC	1½	X	⑨
2	25	20	25	TEC	2	X	
3	50	40	25	TEC	3.5	X	
4	100	75	25	TEC	3.5	X	
5	200	150	30	TJC	6	–	①④
6	400	300	65	SKL	12	–	②④
1	10	7.5	65,100	SEL	1½	X	⑨
2	25	20	65,100	SEL	2	X	
3	50	40	65,100	SEL	4	X	
4	100	75	65,100	SFL	4	X	
5	200	150	100	TBC4	6	–	①④
6	400	300	65	SKL	12	–	②④

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	2.5		
3	75	25	TEC	4		
4	150	10	SGL	4.5		
5	–	–	–	–		④⑥
1	15	65,100	SEL	2		
2	40	65,100	SEL	2.5		
3	75	65,100	SEL	4.5		
4	150	100	TBC4	5		
5	–	–	–	–		④⑥

Y-DELTA

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
2	40	25	TEC	4		
3	75	25	TEC	4.5		①
4	150	10	SGL	5.5		①
5	–	–	–	–		④⑥
2	40	65,100	SEL	4		
3	75	65,100	SEL	5		
4	150	100	TBC4	5.5		
5	–	–	–	–		④⑥

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 6 FVR, RVNR, 2S2W require (2) adjacent 24-inch wide sections, 20-inch deep (2S1W-RTF).
③ Size 5 RVNR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑤ 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.
⑥ Refer to factory.
⑦ For 100 HP applications requiring a thermal-magnetic CB, the disconnect will be SFT type and will require an additional .5 space height.
⑧ Requires 12" bottom wireway cover to UL Label.
⑨ Requires additional 6 inches if Type "A" wiring.

D

SELECTION TABLES

CIRCUIT BREAKER 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	2	X	
4	100	25	SFL	2.5	X	
5	200	65	SGL	3	X	⑧
6	400	42	SKL	6	X	①⑧
1	10	100	TECL	1	X	
2	25	100	TECL	1	X	
3	50	100	TECL	2	X	
4	100	100	TECL	2.5	–	
5	200	100	TBC4	3.5	X	⑧
6	400	42	SKL	6	X	①⑧

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	SEL	1.5	X	
2	25	25	SEL	2	X	
3	50	25	SEL	3.5	X	
4	100	25	SFL	4	X	
5	200	65	SGL	6	X	①⑧
6	400	42	SKL	12	–	②④
1	10	100	TECL	1.5	X	
2	25	100	TECL	2	X	
3	50	100	TECL	3	X	
4	100	100	TECL	3	X	
5	200	100	TBC4	6	X	①⑧
6	400	42	SKL	12	X	①④

RVNR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units④		UL Listed (X)	Notes
				13" Deep or Back-to-Back	20" Deep		
2	25	25	SEL	4	4	X	
3	50	25	SEL	5	4	X	
4	100	25	SEL	6	4.5	X	⑦
5	200	65	SGL	4.5	4.5	X	③⑧
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	TBC4	N/A	6	X	③
6	400	42	SKL	N/A	12	X	②

2S1W, 2S2W

NEMA Size	Max. Hp		IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
	Constant Variable Torque	Constant Hp					
1	10	7.5	25	SEL	1½	X	⑨
2	25	20	25	SEL	2	X	
3	50	40	25	SEL	4	X	
4	100	75	25	SFL	4	X	
5	200	150	22	TJC	6	–	①④
6	400	300	42	SKL	12	–	②④
1	10	7.5	100	TECL	1½	X	⑨
2	25	20	100	TECL	2	X	
3	50	40	100	TECL	3.5	X	
4	100	75	100	TECL	3.5	–	
5	200	150	100	TBC4	6	–	①④
6	400	300	42	SKL	–	–	②④⑥

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	2.5		
3	75	25	SEL	4.5		
4	150	100	TBC4	5		
5	–	–	–	–		④⑥
1	15	100	TECL	2		
2	40	100	TECL	2.5		
3	75	100	TECL	4		
4	150	100	TBC4	5		
5	–	–	–	–		④⑥

Y-DELTA

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
2	40	25	SEL	4		
3	75	25	SEL	5		①
4	100	25	SEL	5		①
4	150	100	TBC4	5.5		①
5	–	–	–	–		④⑥
2	40	100	TECL	4		
3	75	100	TECL	4.5		①
4	150	100	TBC4	5.5		①
5	–	–	–	–		④⑥

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 6 FVR, RVNR, 2S2W require (2) adjacent 24-inch wide sections, 20-inch deep (2S1W-RTF).
③ Size 5 RVNR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑤ 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.
⑥ Refer to factory.
⑦ For 100 HP applications requiring a thermal-magnetic CB, the disconnect will be SFT type and will require an additional .5 space height.
⑧ Requires 12" bottom wireway cover to UL Label.
⑨ Requires additional 6 inches if Type "A" wiring.

FUSED SWITCH TYPE, 208 VOLTS, 60 HERTZ

Combination Motor Starters⑧ (For Notes, See Page D-8)

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	100	30	30	1	X	
1	7½	100	30	60	1	X	
2	10	100	60	100	1½	X	
3	25	100	100	200	2½	X	
4	30	100	200	200	3½	X	
4	40	100	200	400	3½	X	
5	60	100	400	400	4½	X	
5	75	100	400	600	4½	X	
6	–	–	–	–	–	–	④⑨
			Class H, K-1, K-5				
1	3	5	30	30	1	X	
1	7½	5	30	60	1	X	
2	10	5	60	60	1	X	
3	20	5	100	100	2½	X	
3	25	5	100	200	2½	X	
4	40	10	200	200	3½	X	
5	75	10	400	400	4½	X	
6	–	–	–	–	–	–	④⑨
			Class RK-1, RK-5				
1	7½	100	30	30	1	X	
2	10	100	60	60	1	X	
3	15	65	100	60	2½	X	⑩
3	25	65	100	100	2½	X	⑩
4	40	100	200	200	3½	X	
5	75	100	400	400	4½	X	
6	–	–	–	–	–	–	④⑨

FVR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	100	30	30	1½	X	
1	7½	100	30	60	1½	X	
2	10	100	60	100	2	X	
3	25	100	100	200	3½	X	
4	30	100	200	200	5	X	
4	40	100	200	400	5	X	
5	60	100	400	400	9½	X	⑥
5	75	100	400	600	9½	X	⑥
6	–	–	–	–	–	–	④⑨
			Class H, K-1, K-5				
1	3	5	30	30	1½	X	
1	7½	5	30	60	1½	X	
2	10	5	60	60	2	X	
3	20	5	100	100	3½	X	
3	25	5	100	200	3½	X	
4	40	10	200	200	5	X	
5	75	10	400	400	9½	X	⑥
6	–	–	–	–	–	–	④⑨
			Class RK-1, RK-5				
1	7½	100	30	30	1½	X	
2	10	100	60	60	2	X	
3	15	65	100	60	3½	X	⑩
3	25	65	100	100	3½	X	⑩
4	40	100	200	200	5	X	
5	75	100	400	400	9½	X	⑥
6	–	–	–	–	–	–	④⑨

RVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units④ 13" Deep or Back-To-Back	Space Units④ 20" Deep	UL Listed (X)
2	10	100	60	100	4	4	X
3	25	100	100	200	5½	4½	X
4	30	100	200	200	6	5	X
4	40	100	200	400	6	5	X
5	60	100	400	400	③	6	X
5	75	100	400	600	③	6	X
6	–	–	⑨	⑨	–	–	–
			Class H, K-1, K-5				
2	10	5	60	60	4	4	X
3	20	5	100	100	5	4	X
3	25	5	100	200	5½	4½	X
4	40	10	200	200	6	5	X
5	75	10	400	400	③	6	X
6	–	–	⑨	⑨	–	–	–
			Class RK-1, RK-5				
2	10	100	60	60	4	4	X
3	15	65	100	60	5	4	X⑩
3	25	65	100	100	5	4	X⑩
4	40	100	200	200	6	5	X
5	75	100	400	400	–③	6	X
6	–	–	⑨	⑨	–	–	–

2S1W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	3	100	30	30	1½	X	⑮
1	7½	5	100	30	60	1½	X	⑮
2	–	7½	100	60	60	2	X	
2	10	–	100	60	100	2	X	
3	25	20	100	100	200	4	X	
4	30	30	100	200	200	5	X	
4	40	–	100	200	400	5	X	
5	60	60	100	400	400	9½	–	④⑥
5	75	–	100	400	600	9½	–	④⑥
6	–	–	–	–	–	–	–	④⑨
				Class H, K-1, K-5				
1	3	3	5	30	30	1½	X	⑮
1	7½	5	5	30	60	1½	X	⑮
2	10	7½	5	60	60	2	X	
3	20	20	5	100	100	4	X	
3	25	–	5	100	200	4	X	
4	40	30	10	200	200	5	X	
5	–	40	10	400	200	9½	–	④⑥
5	75	60	10	400	400	9½	–	④⑥
6	–	–	–	–	–	–	–	④⑨
				Class RK-1, RK-5				
1	7½	5	100	30	30	1½	X	⑮
2	–	7½	100	60	30	2	X	
2	10	–	100	60	60	2	X	
3	15	15	65	100	60	4	X	⑩
3	25	20	65	100	100	4	X	⑩
4	40	–	100	200	200	5	X	
5	75	–	100	400	400	9½	–	④⑥
6	–	–	100	–	–	–	–	④⑥

D

SELECTION TABLES

FUSED SWITCH TYPE, 208 VOLTS, 60 HERTZ

Combination Motor Starters⑧

2S2W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	3	100	30	30	1½	X	⑫
1	7½	5	100	30	60	1½	X	⑫
2	–	7½	100	60	60	2	X	
2	10	–	100	60	100	2	X	
3	25	20	100	100	200	4	X	
4	30	30	100	200	200	5	X	
4	40	–	100	200	400	5	X	
5	60	60	100	400	400	9½	–	④⑥
5	75	–	100	400	600	9½	–	④⑥
6	–	–	–	–	–	–	–	④⑥
				Class H, K-1, K-5				
1	3	3	5	30	30	1½	X	⑫
1	7½	5	5	30	60	1½	X	⑫
2	10	7½	5	60	60	2	X	
3	20	20	5	100	100	4	X	
3	25	–	5	100	200	4	X	
4	40	30	10	200	200	5	X	
5	_	40	10	400	200	9½	–	⑥
5	75	60	10	400	400	9½	–	⑥
6	–	–	–	–	–	–	–	⑨
				Class RK-1, RK-5				
1	7½	5	100	30	30	1½	X	⑫
2	–	7½	100	60	30	2	X	
2	10	–	100	60	60	2	X	
3	15	15	65	100	60	4	X	⑩
3	25	20	65	100	100	4	X	⑩
4	40	–	100	200	200	5	X	
5	75	–	100	400	400	9½	–	④⑥
6	–	–	–	–	–	–	–	④⑥

PART WINDING

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	100	30	30	2		
1	7½	100	30	60	2		
2	10	100	60	100	2½		
3	20	100	100	200	4½		
3	30	100	200	200	5		
4	40	100	200	400	5		
4	60	100	400	400	6		
5	–	–	–	–	–		④⑨
			Class H, K-1, K-5				
1	3	5	30	30	2		
1	7½	5	30	60	2		
1	10	5	60	60	2		⑤
2	20	5	100	100	3		
3	40	10	200	200	5		
4	75	10	400	400	6		
5	—	–	–	–	–		④⑨
			Class RK-1, RK-5				
1	7½	100	30	30	2		
2	15	100	100	60	3		
3	20	65	100	100	4		⑩
3	30	100	200	200	5		
4	60	100	400	400	6		
5	–	–	–	–	–		④⑨

Y-DELTA

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
2	3	100	60	30	4		②
2	7½	100	60	60	4		
2	10	100	60	100	4		
3	20	100	100	200	5		①
3	30	100	200	200	5½		①
4	40	100	200	400	5½		①
4	60	100	400	400	6		⑦
5	–	–	–	–	–		④⑨
			Class H, K-1, K-5				
2	3	5	60	30	4		②
2	7½	5	60	60	4		
2	20	5	100	100	4		
3	40	10	200	200	5½		①
4	60	10	400	400	6		⑦
5	–	–	–	–	–		④⑨
			Class RK-1, RK-5				
2	7½	100	60	30	4		②
2	10	100	60	60	4		
2	15	100	100	60	4		
3	20	65	100	100	4½		①
3	30	100	200	200	5½		①
4	40	100	200	200	5½		①
4	60	100	400	400	6		⑦
5	–	–	–	–	–		④⑨

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 1 not available. Use Size 2.
③ Size 5 RNVR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑤ Use time-delay fuse, maximum rating same as switch amps.
⑥ Size 5 FVR, 2S1W, 2S2W with fused switch requires (2) adjacent sections; left hand section is 24-inch wide 6X, right hand section is 20-inch wide with top 3½ X used for disconnect.
⑦ Size 4 Wye-Delta with fused switch requires a 24-inch wide section when main horizontal bus is rated 1000 ampere UL or less. A 30-inch wide section is required with 1200 ampere UL or higher rated main horizontal bus.
⑧ 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.
⑨ Refer to factory.
⑩ Use size 4 spacing for 100K ratings.
⑫ Requires 12" bottom wireway cover to UL Label.
⑬ Class J Table is based on fast-acting Class J fuses. For time delay Class J fuses (Std.) use RK-1, RK-5 Table.
⑰ Requires additional 6 inches if Type"A" wiring.

FUSED SWITCH TYPE, 230 VOLTS, 60 HERTZ

Combination Motor Starters⑧ (For Notes, See Page D-10)

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	100	30	30	1	X	
1	7½	100	30	60	1	X	
2	15	100	60	100	1½	X	
3	30	100	100	200	2½	X	
4	50	100	200	400	3½	X	
5	75	100	400	400	4½	X	
5	100	100	400	600	4½	X	
6	150	100	600	800	6	X	①
6	200	100	600	1200	6	X	①
			Class H, K-1, K-5				
1	2	5	30	30	1	X	
1	7½	5	30	60	1	X	
2	15	5	60	100	1½	X	
3	30	5	100	200	2½	X	
4	60	10	200	400	3½	X	
5	100	10	400	600	4½	X	
6	–	–	–	–	–	–	①⑨
			Class RK-1, RK-5				
1	7½	100	30	30	1	X	
2	15	100	60	60	1	X	
3	30	65	100	100	2½	X	
4	50	100	200	200	3½	X	
5	100	100	400	400	4½	X	
6	200	100	600	600	6	X	①

FVR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	100	30	30	1½	X	
1	7½	100	30	60	1½	X	
2	15	100	60	100	2	X	
3	30	100	100	200	3½	X	
4	50	100	200	400	5	X	
5	75	100	400	400	9½	X	⑥
5	100	100	400	600	9½	X	⑥
6	150	100	600	800	12	–	②
6	200	100	600	1200	12	–	②
			Class H, K-1, K-5				
1	2	5	30	30	1½	X	
1	7½	5	30	60	1½	X	
2	15	5	60	100	2	X	
3	30	5	100	200	3½	X	
4	60	10	200	400	5	X	
5	100	10-	400	600	9½	X	⑥
6	–	–	–	–	–	–	②⑨
			Class RK-1, RK-5				
1	7½	100	30	30	1½	X	
2	15	100	60	60	2	X	
3	30	65	100	100	3½	X	
4	50	100	200	200	5	X	
5	100	100	400	400	9½	X	⑥
6	200	100	600	600	12	–	②

RVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units④ 13" Deep or Back-To-Back	Space Units④ 20" Deep	UL Listed (X)
2	10	100	60	100	4	4	X
2	15	100	60	100	4	4	X
3	30	100	100	200	5½	4½	X
4	50	100	200	400	6	5	X
5	75	100	400	400	③	6	X
5	100	100	400	600	③	6	X
6	150	100	600	800	N/A	12②	X
6	200	100	600	1200	N/A	12②	X
			Class H, K-1, K-5				
2	15	5	60	100	4	4	X
3	30	5	100	200	5½	4½	X
4	60	10	200	400	6	5	X
5	100	10	400	600	③	6	X
6	–	–	⑨	⑨	–	–	–
			Class RK-1, RK-5				
2	15	100	60	60	4	4	X
3	30	65	100	100	5	4	X
4	50	100	200	200	6	5	X
5	100	100	400	400	③	6	X
6	200	100	600	600	N/A	12②	X

2S1W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	3	100	30	30	1½	X	
1	7½	5	100	30	60	1½	X	
2	–	7½	100	60	60	2	X	
2	10	10	100	60	100	2	X	
2	15	–	100	60	100	2	X	
3	30	25	100	100	200	4	X	
4	50	40	100	200	400	5	X	
5	75	75	100	400	400	9½	–	⑥
5	100	–	100	400	600	9½	–	⑥
6	–	100	100	600	600	12	–	②
6	150	125	100	600	–	12	–	②
6	200	150	100	600	1200	12	–	②
				Class H, K-1, K-5				
1	2	2	5	30	30	1½	X	
1	7½	5	5	30	60	1½	X	
2	–	7½	5	60	60	2	X	
2	15	10	5	60	100	2	X	
3	–	15	5	100	100	4	X	
3	30	25	5	100	200	4	X	
4	–	30	10	200	200	5	X	
4	50	40	10	200	400	5	X	
5	60	50	10	400	400	9½	–	⑥
5	100	75	10	400	600	9½	–	⑥
6	125	100	10	600	400	12	–	②
6	200	150	10	600	600	12	–	②
				Class RK-1, RK-5				
1	7½	5	100	30	30	1½	X	
2	–	7½	100	60	30	2	X	
2	15	10	100	60	60	2	X	
3	30	25	65	100	100	4	X	
4	–	30	100	200	100	5	X	
4	50	40	100	200	200	5	X	
5	100	75	100	400	400	9½	–	⑥
6	200	150	100	600	600	12	–	②

D

SELECTION TABLES

FUSED SWITCH TYPE, 230 VOLTS, 60 HERTZ

Combination Motor Starters®

2S2W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	3	100	30	30	1½	X	
1	7½	5	100	30	60	1½	X	
2	–	7½	100	60	60	2	X	
2	10	10	100	60	100	2	X	
2	15	–	100	60	100	2	X	
3	30	25	100	100	200	4	X	
4	50	40	100	200	400	5	X	
5	75	75	100	400	400	9½	–	⑥
5	100	–	100	400	600	9½	–	⑥
6	–	100	100	600	600	12	–	②
6	150	125	100	600	800	12	–	②
6	200	150	100	600	1200	12	–	②
				Class H, K-1, K-5				
1	2	2	5	30	30	1½	X	
1	7½	5	5	30	60	1½	X	
2	–	7½	5	60	60	2	X	
2	15	10	5	60	100	2	X	
3	–	15	5	100	100	4	X	
3	30	25	5	100	200	4	X	
4	–	30	10	200	200	5	X	
4	50	40	10	200	400	5	X	
5	60	50	10	400	400	9½	–	⑥
5	100	75	10	400	600	9½	–	⑥
6	125	100	10	600	400	12	–	②
6	200	150	10	600	600	12	–	②
				Class RK-1, RK-5				
1	7½	5	100	30	30	1½	X	
2	–	7½	100	60	30	2	X	
2	15	10	100	60	60	2	X	
3	30	25	65	100	100	4	X	
4	–	30	100	200	100	5	X	
4	50	40	100	200	200	5	X	
5	100	75	100	400	400	9½	–	⑥
6	200	150	100	600	600	12	–	②

PART WINDING

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	3	100	30	30	2		
1	7½	100	30	60	2		
2	10	100	60	100	2½		
3	30	100	100	200	4½		
4	50	100	200	400	5		
4	75	100	400	400	6		
5	–	–	–	–	–		⑨
			Class H, K-1, K-5				
1	2	5	30	30	2		
1	7½	5	30	60	2		
1	10	5	60	60	2		⑩
2	25	5	100	100	3		⑩
3	30	5	100	100	4		⑩
3	50	5	200	200	5		⑩
4	60	10	400	400	6		
4	75	10	400	400	6		⑩
5	–	–	–	–	–		⑨
			Class RK-1, RK-5				
1	7½	100	30	30	2		
2	15	100	60	60	2½		
2	20	100	100	100	3		
3	30	65	100	100	4		
4	60	100	400	400	6		
5	–	–	–	–	–		⑨

Y-DELTA

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
2	3	100	60	30	4		⑤
2	7½	100	60	60	4		
2	10	100	60	100	4		
3	30	100	100	200	5		①
							①
4	75	100	400	400	6		⑦
5	–	–	–	–	–		⑨
			Class H, K-1, K-5				
2	2	5	60	30	4		⑤
2	7½	5	60	60	4		
2	10	5	60	60	4		⑩
2	25	5	100	100	4		⑩
3	30	5	100	100	4½		①⑩
3	50	5	200	200	5½		①⑩
4	60	10	400	400	6		⑦
4	75	10	400	400	6		⑦⑩
5	–	–	–	–	–		⑨
			Class RK-1, RK-5				
2	7½	100	60	30	4		⑤
2	10	100	60	60	4		
2	15	100	60	60	4		
2	20	100	100	100	4		
3	30	65	100	100	4½		①
4	60	100	400	400	6		⑦
5	–	–	–	–	–		⑨

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 6 FVR, RVNR, 2S1W, 2S2W require (2) adjacent 24-inch wide sections, 20-inch deep, with 12-inch bottom wireway cover.
③ Size 5 RNVR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑥ Size 5 FVR, 2S1W, 2S2W with fused switch requires (2) adjacent sections; left hand section is 24-inch wide 6X, right hand section is 20-inch wide with top 3½ X used for disconnect.
⑦ Size 4 Wye-Delta with fused switch requires a 24-inch wide section when main horizontal bus is rated 1000 ampere UL or less. A 30-inch wide section is required with 1200 ampere UL or higher rated main horizontal bus.
⑧ 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.
⑨ Refer to factory.
⑩ Use time-delay fuse, maximum rating same as switch amps.
Use size 4 spacing for 100K ratings.
Requires 12" bottom wireway cover to UL Label.
Class J Table is based on fast acting Class J fuses. For time delay Class J fuses (Std.) use RK1, RK5 Table.
Requires Additional 6 inches if Type "A" wiring.

FUSED SWITCH TYPE, 460 VOLTS, 60 HERTZ

Combination Motor Starters⑧ (For Notes, See Page D-12)

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	5	100	30	30	1	X	
1	10	100	30	60	1	X	
2	15	100	60	60	1	X	
2	25	100	60	100	1½	X	
3	50	100	100	200	2½	X	
4	60	100	200	200	3½	X	
4	100	100	200	400	3½	X	
5	150	100	400	400	4½	X	
5	200	100	400	600	4½	X	
6	250	100	600	600	6	X	①
			Class H, K-1, K-5				
1	7½	–	30	30	1	X	
1	10	5	30	60	1	X	
2	15	5	60	60	1	X	
2	25	5	60	100	1½	X	
3	30	5	100	100	2½	X	
3	50	5	100	200	2½	X	
4	75	10	200	200	3½	X	
4	100	10	200	400	4½	X	
5	150	10	400	400	4½	X	
5	200	10	400	600	4½	X	
6	400	10	600	600	6	–	①④⑩
			Class RK-1, RK-5				
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	2½	X	
3	50	65	100	100	2½	X	
4	100	100	200	200	3½	X	
5	125	100	400	200	4½	X	
5	200	100	400	400	4½	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 J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	5	100	30	30	1½	X	
1	10	100	30	60	1½	X	
2	15	100	60	60	2	X	
2	25	100	60	100	2	X	
3	50	100	100	200	3½	X	
4	60	100	200	200	5	X	
4	100	100	200	400	5	X	
5	150	100	400	400	9½	X	⑥
5	200	100	400	600	9½	X	⑥
6	250	100	600	600	12	–	②
			Class H, K-1, K-5				
1	7½		30	30	1½	X	
1	10	5	30	60	1½	X	
2	15	5	60	60	2	X	
2	25	5	60	100	2	X	
3	30	5	100	100	3½	X	
3	50	5	100	200	3½	X	
4	75	10	200	200	5	X	
4	100	10	200	400	5	X	
5	150	10	400	400	9½	X	⑥
5	200	10	400	600	9½	X	⑥
6	400	10	600	600	12	–	②⑩
			Class RK-1, RK-5				
1	10	100	30	30	1½	X	
2	15	100	60	30	2	X	
2	25	100	60	60	2	X	
3	30	65	100	60	3½	X	
3	50	65	100	100	3½	X	
4	100	100	200	200	5	X	
5	125	100	400	200	9½	X	⑥
5	200	100	400	400	9½	X	⑥
6	250	100	600	400	12	–	②

RVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units④ 13" Deep or Back-To-Back	Space Units④ 20" Deep	UL Listed (X)
2	15	100	60	60	4	4	X
2	25	100	60	100	4	4	X
3	50	100	100	200	5½	4½	X
4	60	100	200	200	6	5	X
4	100	100	200	400	6	5	X
5	100	100	400	400	③	6	X
5	200	100	400	600	③	6	X
6	250	100	600	600	N/A	12②	X
			Class H, K-1, K-5				
2	15	5	60	60	4	4	X
2	25	5	60	100	4	4	X
3	30	5	100	100	5	4	X
3	50	5	100	200	5½	4½	X
4	75	10	200	200	6	5	X
4	100	10	200	400	6	5	X
5	150	10	400	400	③	6	X
5	200	10	400	600	③	6	X
6	400	10	600	600⑩	N/A	12②	–
			Class RK-1, RK-5				
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	③	6	X
5	200	100	400	400	③	6	X
6	250	100	600	400	N/A	12②	X
6	400	100	600	600	N/A	12②	X

2S1W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	5	5	100	30	30	1½	X	
1	10	7½	100	30	60	1½	X	
2	15	15	100	60	60	2	X	
2	25	20	100	60	100	2	X	
3	–	25	100	100	100	4	X	
3	50	40	100	100	200	4	X	
4	60	50	100	200	200	5	X	
4	100	75	100	200	400	5	X	
5	150	150	100	400	400	9½	–	④⑥
5	200	–	100	400	600	9½	–	④⑥
6	250	200	100	600	600	12	–	②
				Class H, K-1, K-5				
1	7½	7½	5	30	30	1½	X	
1	10	–	5	30	60	1½	X	
2	15	10	5	60	60	2	X	
2	25	20	5	60	100	2	X	
3	30	25	5	100	100	4	X	
3	50	40	5	100	200	4	X	
4	75	75	10	200	200	5	X	
4	100	–	10	200	400	5	X	
5	150	150	10	400	400	9½	–	④⑥
5	200	–	10	400	600	9½	–	④⑥
6	250	250	10	600	400	12	–	②
6	400	300	10	600	600	12	–	②⑩
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	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	X	
5	125	100	100	400	200	9½	–	⑥
5	200	150	100	400	400	9½	–	⑥
6	250	250	100	600	400	12	–	②
6	400	300	100	600	600	12	–	②

D

SELECTION TABLES

FUSED SWITCH TYPE, 460 VOLTS, 60 HERTZ

Combination Motor Starters⑧

2S2W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	5	5	100	30	30	1½	X	
1	10	7½	100	30	60	1½	X	
2	15	15	100	60	60	2	X	
2	25	20	100	60	100	2	X	
3	–	25	100	100	100	4	X	
3	50	40	100	100	200	4	X	
4	60	50	100	200	200	5	X	
4	100	75	100	200	400	5	X	
5	150	150	100	400	400	9½	–	④⑥
5	200	–	100	400	600	9½	–	④⑥
6	250	200	100	600	600	12	–	②
				Class H, K-1, K-5				
1	7½	7½	5	30	30	1½	X	
1	10	–	5	30	60	1½	X	
2	15	10	5	60	60	2	X	
2	25	20	5	60	100	2	X	
3	30	25	5	100	100	4	X	
3	50	40	5	100	200	4	X	
4	75	75	10	200	200	5	X	
4	100	–	10	200	400	5	X	
5	150	150	10	400	400	9½	–	④⑥
5	200	–	10	400	600	9½	–	④⑥
6	250	250	10	600	400	12	–	②
6	400	300	10	600	600	12	–	②⑩
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	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	X	
5	125	100	100	400	200	9½	–	⑥
5	200	150	100	400	400	9½	–	⑥
6	250	250	100	600	400	12	–	②
6	400	300	100	600	600	12	–	②

PART WINDING

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	5	100	30	30	2		
1	10	100	30	60	2		
1	15	100	60	60	2		
2	25	100	60	100	2½		
3	50	100	100	200	4½		
3	60	100	200	200	5		
4	100	100	200	400	5		
4	150	100	400	400	6		
5	–	–	–	–	–		④⑨
			Class H, K-1, K-5				
1	7½	5	30	30	2		
1	10	5	30	60	2		
1	15	5	60	60	2		
2	25	5	60	60	2½		⑩
2	30	5	100	100	3		
2	40	5	100	100	3		
3	50	5	100	100	4		⑩
3	75	10	200	200	5		
4	100	10	200	200	5		⑩
4	150	10	400	400	6		
5	–	–	–	–	–		④⑨
			Class RK-1, RK-5				
1	10	100	30	30	2		
1	15	100	60	30	2		
2	25	100	60	60	2½		
2	30	100	100	60	3		
3	50	65	100	100	4		
3	60	100	200	200	5		
4	100	100	200	200	5		
4	125	100	400	200	6		
5	–	–	–	–	–		④⑨

Y-DELTA

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
2	5	100	60	30	4		⑤
2	10	100	60	60	4		
2	15	100	60	60	4		
2	25	100	60	100	4		
3	50	100	100	200	5		①
3	60	100	200	200	5½		①
4	100	100	200	400	6		①
4	150	100	400	400	6		⑦
5	–	–	–	–	–		④⑨
			Class H, K-1, K-5				
2	7½	5	60	30	4		⑤
2	10	5	60	60	4		
2	15	5	60	60	4		
2	25	5	60	60	4		⑩
2	30	5	100	100	4		
2	40	5	100	100	4		
3	50	5	100	100	4½		①⑩
3	75	5	200	200	5½		①
4	100	10	200	200	6		①⑩
4	150	10	400	400	6		⑦
5	–	–	–	–	–		④⑨
			Class RK-1, RK-5				
2	10	100	60	30	4		⑤
2	15	100	60	30	4		
2	25	100	60	60	4		
2	30	100	100	60	4		
3	50	65	100	100	4½		①
3	60	100	200	200	5½		①
4	100	100	200	200	6		①
4	125	100	400	200	6		⑦
5	–	–	–	–	–		④⑨

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 6 FVR, RVNR, 2S1W, 2S2W require (2) adjacent 24-inch wide sections, 20-inch deep, with 12-inch bottom wireway cover.
③ Size 5 RNVR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑤ Size 1 not available. Use Size 2.
⑥ Size 5 FVR, 2S1W, 2S2W with fused switch requires (2) adjacent sections; left hand section is 24-inch wide 6X, right hand section is 20-inch wide with top 3½ X used for disconnect.
⑦ Size 4 Wye-Delta with fused switch requires a 24-inch wide section when main horizontal bus is rated 1000 ampere UL or less. A 30-inch wide section is required with 1200 ampere UL or higher rated main horizontal bus.
⑧ 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.
⑨ Refer to factory.
⑩ Use time-delay fuse, maximum rating same as switch amps.
Use size 4 spacing for 100K ratings.
Requires 12" bottom wireway cover to UL Label.
Class J Table is based on fast acting Class J fuses. For time delay Class J fuses (Std.) use RK-1, RK-5 Table.
Requires additional 6 inches if Type "A" wiring.

FUSED SWITCH TYPE, 575 VOLTS, 60 HERTZ

Combination Motor Starters⑧ (For Notes, See Page D-14)

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	7½	100	30	30	1	X	
1	10	100	30	60	1	X	
2	20	100	60	60	1	X	
2	25	100	60	100	1½	X	
3	30	100	100	100	2½	X	
3	50	100	100	200	2½	X	
4	75	100	200	200	3½	X	
4	100	100	200	400	3½	X	
5	200	100	400	400	4½	X	
6	250	100	600	600	6	X	①
			Class H, K-1, K-5				
1	10	5	30	30	1	X	
2	20	5	60	60	1	X	
2	25	5	60	100	1½	X	
3	40	5	100	100	2½	X	
3	50	5	100	200	2½	X	
4	100	10	200	200	3½	X	
5	200	10	400	400	4½	X	
6	400	10	600	600	6	–	①②⑩
			Class RK-1, RK-5				
1	10	100	30	30	1	X	
2	25	100	60	60	1	X	
3	40	100	200	60	3½	X	
3	50	100	200	100	3½	X	
4	100	100	200	200	3½	X	
5	200	100	400	400	4½	X	
6	400	100	600	600	6	X	①

FVR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	7½	100	30	30	1½	X	
1	10	100	30	60	1½	X	
2	20	100	60	60	2	X	
2	25	100	60	100	2	X	
3	30	100	100	100	3½	X	
3	50	100	100	200	3½	X	
4	75	100	200	200	5	X	
4	100	100	200	400	5	X	
5	200	100	400	400	9½	X	⑥
6	250	100	600	600	12	–	②
			Class H, K-1, K-5				
1	10	5	30	30	1½	X	
2	20	5	60	60	2	X	
2	25	5	60	100	2	X	
3	40	5	100	100	3½	X	
3	50	5	100	200	3½	X	
4	100	10	200	200	5	X	
5	200	10	400	400	9½	X	⑥
6	400	10	600	600	12	–	②⑩
			Class RK-1, RK-5				
1	10	100	30	30	1½	X	
2	25	100	60	60	2	X	
3	40	100	200	60	5	X	
3	50	100	200	100	5	X	
4	100	100	200	200	5	X	
5	200	100	400	400	9½	X	⑥
6	400	100	600	600	12	–	②

RVNR

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units④ 13" Deep or Back-To-Back	Space Units④ 20" Deep	UL Listed (X)
2	20	100	60	60	4	4	X
2	25	100	60	100	4	4	X
3	30	100	100	100	5	4	X
3	50	100	100	200	5½	4½	X
4	75	100	200	200	6	5	X
4	100	100	200	400	6	5	X
5	200	100	400	400	③	6	X
6	250	100	600	600	N/A	12②	X
			Class H, K-1, K-5				
2	20	5	60	60	4	4	X
2	25	5	60	100	4	4	X
3	40	5	100	100	5	4	X
3	50	5	100	200	5½	4½	X
4	100	10	200	200	6	5	X
5	200	10	400	400	③	6	X
6	400	10	600	600⑩	N/A	12②	X
			Class RK-1, RK-5				
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	③	6	X
6	400	100	600	600	N/A	12②	X

2S1W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	7½	7½	100	30	30	1½	X	⑮
1	10	–	100	30	60	1½	X	⑮
2	20	20	100	60	60	2	X	
2	25	–	100	60	100	2	X	
3	30	25	100	100	100	4	X	
3	50	40	100	100	200	4	X	
4	75	75	100	200	200	5	X	
4	100	–	100	200	400	5	X	
5	200	150	100	400	400	9½	–	⑥
6	–	200	100	600	400	12	–	②
6	250	250	100	600	600	12	–	②
				Class H, K-1, K-5				
1	10	7½	5	30	30	1½	X	⑮
2	–	10	5	60	30	2	X	
2	20	20	5	60	60	2	X	
2	25	–	5	60	100	2	X	
3	40	40	5	100	100	4	X	
3	50	–	5	100	200	4	X	
4	100	75	10	200	200	5	X	
5	–	100	10	400	200	9½	–	⑥
5	200	150	10	400	400	9½	–	⑥
6	350	300	10	600	400	12	–	②⑩
6	400	–	10	600	600	12	–	②⑩
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	X	⑮
2	25	–	100	60	60	2	X	
3	40	40	100	200	60	5	X	
3	50	–	100	200	100	5	X	
4	100	–	100	200	200	5	X	
5	200	–	100	400	400	9½	–	⑥
6	400	–	100	600	600	12	–	②

D

SELECTION TABLES

FUSED SWITCH TYPE, 575 VOLTS, 60 HERTZ

Combination Motor Starters⑧

2S2W

NEMA Size	Max. Hp CT/VT	Max. Hp Const. Hp.	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	7½	7½	100	30	30	1½	X	⑫
1	10	–	100	30	60	1½	X	⑫
2	20	20	100	60	60	2	X	
2	25	–	100	60	100	2	X	
3	30	25	100	100	100	4	X	
3	50	40	100	100	200	4	X	
4	75	75	100	200	200	5	X	
4	100	–	100	200	400	5	X	
5	200	150	100	400	400	9½	–	④⑥
6	–	200	100	600	400	12	–	②
6	250	250	100	600	600	12	–	②
				Class H, K-1, K-5				
1	10	7½	5	30	30	1½	X	⑫
2	–	10	5	60	30	2	X	
2	20	20	5	60	60	2	X	
2	25	–	5	60	100	2	X	
3	40	40	5	100	100	4	X	
3	50	–	5	100	200	4	X	
4	100	75	10	200	200	5	X	
5	–	100	10	400	200	9½	–	④⑥
5	200	150	10	400	400	9½	–	④⑥
6	350	300	10	600	400	12	–	②⑩
6	400	–	10	600	600	12	–	②⑩
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	X	⑫
2	25	–	100	60	60	2	X	
3	40	40	100	200	60	5	X	
3	50	–	100	200	100	5	X	
4	100	–	100	200	200	5	X	
5	200	–	100	400	400	9½	–	⑥
6	400	–	100	600	600	12	–	②

Y-DELTA

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
2	7½	100	60	30	4		⑤
2	20	100	60	60	4		
2	25	100	60	100	4		
2	30	100	100	100	4		
3	50	100	100	200	5		①
3	75	100	200	200	5½		①
4	100	100	200	400	6		①
4	150	100	400	400	6		⑦
5	–	–	–	–	–		⑨
			Class H, K-1, K-5				
2	10	5	60	30	4		⑤
2	25	5	60	60	4		⑩
2	40	5	100	100	4		
3	75	5	200	200	5½		①
4	100	10	200	200	6		①
4	150	10	400	400	6		⑦
5	–	–	–	–	–		⑨
			Class RK-1, RK-5				
2	10	100	60	30	4		⑤
2	15	100	60	30	4		
2	20	100	60	60	4		
2	25	100	60	60	4		
3	50	100	200	100	5½		①
3	75	100	200	200	5½		①
4	100	100	200	200	6		①
4	150	100	400	400	6		⑦
5	–	–	–	–	–		⑨

PART WINDING

NEMA Size	Max. Hp	IC (kA)	Class J Switch Amps	Class J Clip Amps	Space Units	UL Listed (X)	Notes
1	7½	100	30	30	2		
1	10	100	30	60	2		
1	15	100	60	60	2		
2	20	100	60	60	2½		
2	25	100	60	100	2½		
2	30	100	100	100	3		
3	50	100	100	200	4½		
3	75	100	200	200	5		
4	100	100	200	400	5		
4	150	100	400	400	6		
5	–	–	–	–	–		⑨
			Class H, K1, K5				
1	10	5	30	30	2		
1	15	5	60	60	2		
2	20	5	60	60	2½		
2	25	5	60	100	2½		
2	40	5	100	100	3		
3	75	5	200	200	5		
4	100	10	200	200	5		
4	150	10	400	400	6		
5	–	–	–	–	–		⑨
			Class RK1, RK5				
1	10	100	30	30	2		
1	15	100	60	30	2		
2	20	100	60	60	2½		
2	25	100	60	60	2½		
3	50	100	200	100	5		
3	75	100	200	200	5		
4	100	100	200	200	5		
4	150	100	400	400	6		
5	–	–	–	–	–		⑨

① Requires 24-inch wide section (Size 6 requires minimum 20-inch deep).
② Size 6 FVR, RVNR, 2S1W, 2S2W require (2) adjacent 24-inch wide sections, 20-inch deep, with 12-inch bottom wireway cover.
③ Size 5 RNVR cannot be mounted in 13-inch deep enclosure. Two Size 5 RVNR starters cannot be mounted back-to-back in the same 20-inch deep section.
④ 12-inch wireway at bottom required.
⑤ Size 1 not available. Use Size 2.
⑥ Size 5 FVR, 2S1W, 2S2W with fused switch requires (2) adjacent sections; left hand section is 24-inch wide 6X, right hand section is 20-inch wide with top 3½ X used for disconnect.
⑦ Size 4 Wye-Delta with fused switch requires a 24-inch wide section when main horizontal bus is rated 1000 ampere UL or less. A 30-inch wide section is required with 1200 ampere UL or higher rated main horizontal bus.
⑧ 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.
⑨ Refer to factory.
⑩ Use time-delay fuse, maximum rating same as switch amps.
⑪ Requires 12" bottom wireway cover to UL Label.
⑫ Class J Table is based on fast acting Class J fuses. For time delay Class J fuses (Std.) use RK-1, RK-5 Table.
⑬ Requies additional 6 inches if Type "A" wiring.

STARTER OPTIONS

Option	Function	Additional Space Required	UL Listed (X)
Control Transformer	Provides 120V 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 Class H or Equivalent Fuse 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)–	–	X
	1 NC and 1 NO (pilot duty) contact (Optional)	–	X
Ambient Comp. OL Electronic OL	Ultimate trip current remains essentially unchanged over a range of OL ambient temperatures.		
	1 NC contact (standard)	–	X
	1 NC and 1 NO (pilot duty) contact (Optional)	–	X
Pilot Lights Full Voltage	CR104P type with 120V lamp. Red–ON FAST, FWD, UP Amber–DOWN, REV, SLOW Green–STOPPED, READY	–	X
Transformer	CR104P with 6V lamp (See full voltage lights for lens colors)	–	X
LED①	CR104P Type transformer type with 6V LED Lamp	–	X
Push-to-test	CR104P, Full-voltage transformer type, or LED (See full-voltage lights for lens colors)	–	X
Push buttons Start-Stop①	CR104P momentary type-use with FVNR starters with 3-wire control.	–	X
Stop①	CR104P momentary type-provides stop function at MCC with 3-wire control.	–	X
Stop①	CR104P maintained type–provides stop function at MCC with 2/3 wire control. Can be furnished with mushroom head and provision for locking open.	–	X
Fwd, Rev, Stop①	CR104P momentary type-use with FVR starters.	–	X
Fast, Slow, Stop①	CR104P momentary type-use with 2-speed starters.	–	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 split type terminal boards. (NEMA size 1, 2)	–	X
Shielded Unit Racking Screw	Disconnect must be in open position to rack unit in or out.	–	X
Control Disconnect	High density pull-apart TB will provide foreign voltage isolation without disengaging the unit vertical bus stabs.	–	X
Control Relay	MCR4 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 two to four relays. One relay can be added with no increase in space units. CR7RA Alternate Relay	Yes	X
	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	X
Timing Relays Pneumatic	CR7R (standard) .3 to 3 seconds or 10 to 180 seconds timing range. 10A contacts. 4 INST and 2 TD interlocks (NO and NC).	1/2 X	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 ECM keypad.

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STARTER OPTIONS

Option	Function	Additional Space Required	UL Listed (X)
Motor Driven	Used for long timing periods. Specify timing range.	1/2 X	–
Accelerating Relay	CR7R (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	CR7R (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 CR7R 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 (2NO, or 1NO and 1NC)	–	X
CB Options Aux. Interlock	SPDT auxiliary interlocks mounted in CB. Refer to factory if more than 2 required.	–	X
Bell Alarm	Internal CB alarm switch.	–	X
Key Interlock	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 1-6 starters.	1/2 X	X
Current Transformer	Donut type CT located in one motor phase conductor for purchasers use. Purchaser connects directly to CT secondary terminals. (Also used for door mounted Ammeter.)	1/2 X	X
Amp Transducer	Integrated CT/Current transducer with 4-20 MA output. (Requires 120V Power).	1/2 X	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.	1/2 X①	X
Voltmeter	AC panel-type, direct-reading 600 volts maximum. Includes a fuse in each ungrounded conductor.	–	X
Elapsed Time Meter①	Mounts on pushbutton bracket. Visible from front of MCC.	–	X
Phase Loss/Unbalance Current Sensing Alternate ECM	CR324X Electronic overload module senses unbalanced 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)	1/2 X	X
Coil Suppressor, 120V	Surge suppressors reduce undesirable transients in control circuits by absorbing voltage transients generated by operating coils.	–	X
Over Size Unit	Standard unit height may be increased 1/2 X or 1X	1/2 X, 1X	X X
Door Diagram	Circuit diagram mounted on back of unit door.	–	X
Wire markers	Permanent wire number identification on each control wire.	–	X
V-Gnd Bus Stab	Grounds unit to V-ground bus when specified (order ground bus under “Structure”).	–	X
Provision For PLC	See Programmable Logic Control (Section F).		
Provision for GENIUS	See Programmable Logic Control (Section F).		
Provision for PFC Capacitor	Terminals located between contactor and OL relay.		X

① Functions also available with ECM, Display.

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 fuses in each ungrounded conductor. UL requires rejection type fuses for equipment rated above 10KA short-circuit rating. 10 ampere, 600-volt Class CC fuses are furnished as standard. If loading dictates a larger fuse, the fuse rating may be increased up to 20 amperes maximum. Time delay Class J fuses are available as an option.

Motor control circuit transformers are protected with a fuse in each ungrounded secondary conductor. Secondary fuses are (Class RK-5) sized on the basis of 125 percent rated secondary (20 amperes maximum). UL requires primary transformer protection in accordance with NEC Article 430-72(c). 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 MCR4, CR7A [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

D

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

① For constant- or variable-torque motors.
② Limit 4 with APVR relay.

CONTROL TERMINALS

The table below lists the total number of control terminals available on standard heights units. Nine additional control terminal points (12 for HD) can be provided for each 6-inch increase in unit height. 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	
	OPT	HD	OPT	HD	OPT	HD	OPT		HD	
FVNR	12	18	12	18	15	18	24	18	21	48
FVR	21	30	30	42	33	48	33	48	24	48
2S1W	27	24	15	36	24	48	24	48	24	48
2S2W	27	24	27	36	33	48	33	48	24	48

CB = Circuit Breaker; FS = Fused Switch; HD = High Density; OPT= 3-point split type.

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. VA⑤		UL Listed (X)	Notes
	60 Hz	50 Hz	60 Hz	50 Hz		
All Size 1 60	60	150	150	150	X	
All Size 2 150	150	150	150	150	X	
All Size 3 300	300	250	300	250	X	
All Size 4 300	300	250	300	250	X	
All Size 5 and 6	300	250	500	500	X	④

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.

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 RVNR Size 3 and 4	55	9
Relay for FVNR Size 5 and 6	55	9

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				

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	THEDL	100	100	100	X
4	TEC	THFK②	25	5	18	X
	SFLI	SFLT	100	100	25	X
	SFLI	TB4①	100	100	100	X
	TBC4	TB4	100	100	100	X
5	SGLI	SGLT	100	100	65	X
	TBC4	TB4	100	100	100	X

① TB4 requires same unit space as TBC4.
② Available in 8000-Line MCC only.

TERMINALS FOR FIELD WIRING

Description	Will Accept Wire②	
	AWG/MCM	Material
STARTER LOAD TERMINALS		
Size 1 and 2 Power Block (Draw out)	14-4 12-2	CU AL
Size 1 Starter	14-8	CU
Size 2 Starter	14-4	CU
Size 3 Power Block (Stationary)	6-2/0	CU-AL
Size 3 Starter	8-1/0	CU
Size 4 Power Block (Stationary)	6-250	CU-AL
Size 4 Starter	4-3/0	CU
Size 5 Starter	1/0-500	CU
Size 6 Contactor	(2) 2/0-500	CU-AL
Control Terminal Boards		
Drawout/Stationary	10 Max.	CU
Hi Density Pull-Apart	(2) 12 Max.	CU
POWER TERMINAL BOARDS		
50 AMP Size 1 & 2 Type C Wiring and Distribution Transformers	14-4 12-2	CU AL
100 AMP Size 3 Type C Wiring and Distribution Transformers	6-2/0	CU-AL
100 AMP Size 2 Wye-Delta Starters	14-1/0 12-1/0	CU AL
150 AMP Size 4 Type C Wiring and Distribution Transformers	4-3/0	CU

② Conductors #1 and smaller may be rated 60/75°C.
Conductors #0 and larger must be rated 75°C.
Conductors wired directly to OL device terminals must be rated 75°C CU.

D

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.

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**	**24"W**	**20"W**	**24"W**		**20"W**	**24"W**	**20"W**	**24"W**
1	12	11½"	14½"	6	8	24	6"	7½"	3	4
1½	24	11½"	14½"	12	16	48	6"	7½"	6	8
2	30	11½"	14½"	18	24	60	6"	7½"	9	12
2½	42	11½"	14½"	24	32	84	6"	7½"	12	16
3	48	11½"	14½"	36	48	96	6"	7½"	18	24
3½	60	11½"	14½"	42	56	120	6"	7½"	21	28
4	72	11½"	14½"	48	64	144	6"	7½"	24	32
4½	78	11½"	14½"	54	72	156	6"	7½"	27	36
5	90	11½"	14½"	60	80	180	6"	7½"	30	40
5½	96	11½"	14½"	66	88	192	6"	7½"	33	44
6	108	11½"	14½"	72	96	216	6"	7½"	36	48

ALTERNATOR RELAY PANELS

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

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 Rating ② RMS SymmetricalAmps (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.

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.

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	2½	2	X
18	100	2½	2½	X
18	225	2½	2½	X
24	225	3	2½	X
24	400	4½	3½	X
30	225	3	3	X
30	400	4½	3½	X
36	225	3½	3	X
36	400	5	4	X
42	225	3½	3½	X
42	400	5	4	X

AD

Number of Circuits	Panel Main Bus Rating (Amps) (X)	Space Units③	UL Listed (X)
12	100	2½	
12	225	3	
18	100	3	
18	225	3½	
24	100	3	
24	225	3½	
30	100	3½	
30	225	4	
36	100	4	
36	225	4½	
42	100	4	
42	225	4½	

③ One space unit (X) equals 12-inch vertical height.
M.L.O. panel does not include feeder space requirements. (see pg. C-5)

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 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 includes 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 rated 225-amperes and less stab into the vertical bus. Higher ratings use bolted connections. 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:

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

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

THREE-PHASE TRANSFORMERS (DELTA-Y)

FUSED SWITCH–100kA IC						CIRCUIT BREAKER					
KVA	Switch Size	Fuse Amps ④	Space Unit	UL Listed (X)	Notes	IC Rating (kA) 25	IC Rating (kA) 100	CB Trip ⑤	Space Unit	UL Listed (X)	Notes
380-120/208 VOLTS, 50 HERTZ											
3	30	7	2.5	X							
9	30	17.5	3	X		THED	THEDL	30	3	X	
30	60	60	6	X	①②	THED	THEDL	70	6	X	①②
45	200	90	6	X	③	THED	SEP	150	6	X	③
480-120/208 VOLTS, 60 HERTZ											
3	30	5.6	2.5	X							
9	30	15	3	X		THED	THEDL	20	3	X	
15	30	25	3	X		THED	THEDL	30	3	X	
30	60	45	6	X	①②	THED	THEDL	70	6	X	①②
45	200	70	6	X	③	THED	SEP	125	6	X	③
600-120/208 VOLTS, 60 HERTZ											
3	30	4.5	2.5	X							
9	30	12	3	X		THEDL	THEDL	20	3	X	
30	60	40	6	X	①②	THEDL	THEDL	70	6	X	①②
45	60	60	6	X	③	THEDL	THEDL	100	6	X	③

① Requires full depth of motor control center. Units cannot be mounted below or behind transformer.
② Requires 24-inch wide enclosure.
③ Requires 20-inch deep enclosure 24-inch wide. Units cannot be mounted below or behind transformer.
④ Sized for primary protection only. (Dual element fuses)
⑤ Sized for primary and secondary protection.

SINGLE-PHASE TRANSFORMERS

FUSED SWITCH–100KA IC						CIRCUIT BREAKER					
KVA	Switch Size	Fuse Amps ④	Space Unit	UL Listed (X)	Notes	IC Rating (kA) 25	IC Rating (kA) 100	CB Trip ⑤	Space Unit	UL Listed (X)	Notes
240-120/240 VOLTS, 60 HERTZ											
0.50	30	3.2	1	X							
1	30	7	1	X							
3	30	15	1.5	X		THED	THEDL	30	1.5	X	
5	30	30	2	X		THED	THEDL	40	2	X	
10	60	60	2	X	①	THED	THEDL	70	2	X	①
15	200	80	4	X	①⑥⑦	THED	SEP⑧	150	3.5	X	①⑥
25	200	150	4	X	①⑥	THFK	SFP⑨	225	3	X	①⑥
37.5	200	200	6	X	③	THFK	SFP⑨	225	6	X	③
380-120/240 VOLTS, 50 HERTZ											
0.50	30	3.5	1	X							
1	30	4	1	X							
3	30	12	1.5	X		THED	THEDL	15	1.5	X	
10	60	35	2	X	①	THED	THEDL	50	2	X	①
15	60	50	2.5	X	①⑥	THED	THEDL	90	2.5	X	①⑥
25	200	90	4	X	①⑥⑦	THED	SEP⑧	150	3	X	①⑥
37.5	200	125	6	X	③	THED	SEP⑧	125	6	X	③
480-120/240 VOLTS, 60 HERTZ											
0.50	30	2.8	1	X							
1	30	3.5	1	X							
3	30	10	1.5	X		THED	THEDL	15	1.5	X	
5	30	12	2	X		THED	THEDL	20	2	X	
10	30	25	2	X	①	THED	THEDL	40	2	X	①
15	60	40	2.5	X	①⑥	THED	THEDL	50	2.5	X	①⑥
25	200	70	4	X	①⑥⑦	THED	SEP⑧	125	3	X	①⑥
37.5	200	100	6	X	③	THED	SEP⑧	125	6	X	③
600-120/240 VOLTS, 60 HERTZ											
0.50	30	2.5	1	X							
1	30	4	1	X							
3	30	8	1.5	X							
10	30	20	2	X	①	THEDL	THEDL	40	2	X	①
15	60	35	2.5	X	①⑥	THEDL	THEDL	50	2.5	X	①⑥
25	60	60	3	X	①⑥	THEDL	THEDL	100	3	X	①⑥
37.5	200	80	6	X	③	THEDL	THEDL	90	6	X	③

⑥ Requires 20" deep enclosure.
⑦ Delete 1SU for 65KAIC and below. (100A SW.)
⑧ Add ½ space unit.
⑨ Add 1 space unit.

E

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

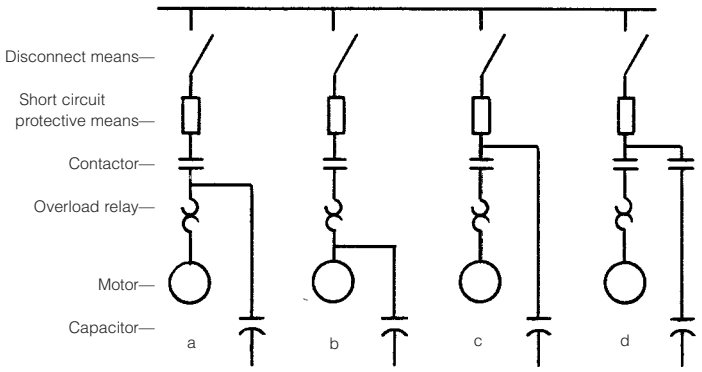
Capacitors used for power factor correction should be selected using the motor manufacturer's application data.

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. The Capacitor Department, Hudson Falls, NY, has published tables showing maximum capacitance and percent ampere reduction for specific GE motors.

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.



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

Horsepower Rating	High Efficiency and Older Design (Pre "T-Frame")		"T Frame" NEMA Design "B" Motors	
	Capacitor KVAR	Current Reduction %	Capacitor KVAR	Current Reduction %
3	1½	15	1½	23
5	2	13	2½	22
7½	2½	12	3	20
10	3	11	4	18
15	4	10	5	18
20	5	10	6	17
25	6	10	7½	17
30	7½	10	8	16
40	9	9	15	17
50	11	9	17½	15
60	15	9	20	15
75	15	8	25	14
100	20	8	30	14
125	27½	8	35	12
150	30	8	40	12
200	37½	8	50	11

① For use with 1800 rpm, 3-phase, 60 Hz classification B motors, to raise full-load power factor to approximately 95 percent.

MCC Space Units Required	Maximum KVAR			UL Listed (X)
	240V	480V	600V	
1X	1½ thru 4 6, 8, 11, 12	20	20	X
1½ X	5, 7½, 9, 10 15 thru 22½	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-inch 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.

SWITCHING CAPACITORS SEPARATELY

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		
2½	10	15
5	20	20
7½	30	30
10	40	40
15	60	60
20	80	80
27½	125	100
30	125	110
37½	175	150
480 VOLTS, 60 HERTZ		
5	10	15
7½	15	15
10	20	20
15	30	30
20	40	40
25	50	50
27½	60	50
30	60	60
37½	80	70

E

F

GENERAL

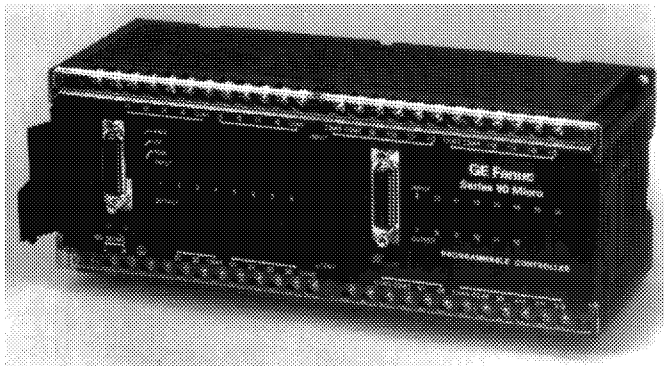
GE Fanuc Automation - Charlottesville, VA, has continually updated/improved its PLC products, which are mounted and wired in the Motor Control Center.

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, the Series 90-70 family, is the first PLC with truly open architecture. Thanks to the VME bus back plane, many third party specialty modules are available to enhance the functionality of the Series 90-70.

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

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, harddrives, motion control, etc.). The 90-70 is positioned to eventually supercede the Series Six Plus.

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.

GENIUS I/O SYSTEM

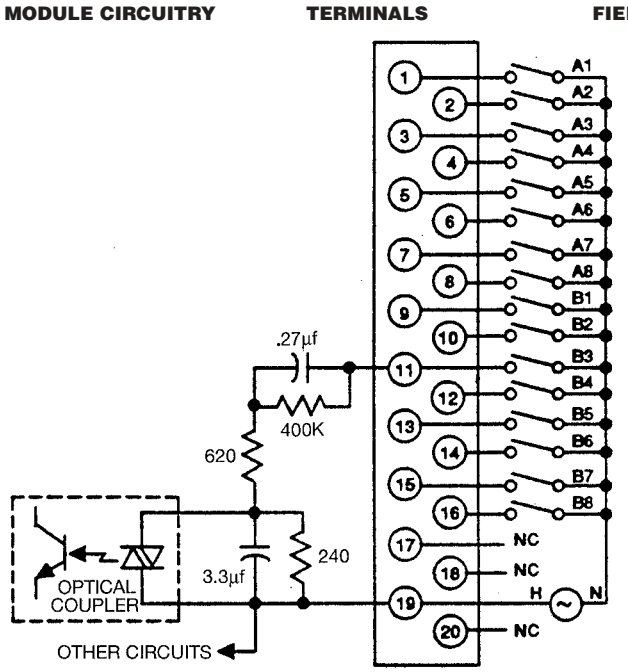
A system of inherently distributed inputs and outputs, which consists of:

- **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.

I/O CIRCUITS

SAMPLE INPUT CIRCUIT - 120 VOLT AC INPUT MODULE (90-30)



Rated Voltage	120 Volts AC
Inputs per Module	16 (1 group with a single common)
Isolation	1500 volts RMS between field side and logic side
Input Current	14.5 mA (typical) at rated voltage
Input Characteristics:	
Max. On-state	74 volts to 132 volts
Min. Off-state	0 to 20 volts
Min. On-state	6 mA maximum
Max. Off-state	2.2 mA maximum
On response time	30 ms maximum
Off response time	45 ms maximum

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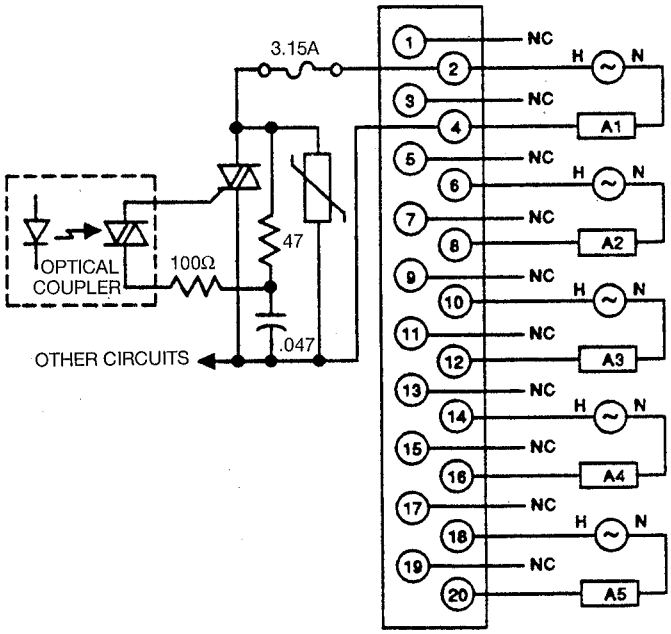
SAMPLE OUTPUT CIRCUIT - 120/240 VOLT ISOLATED AC OUTPUT MODULE (90-30)



Rated Voltage	120/240 VAC
Output Voltage Range	85 to 264 VAC
Outputs per Module	5 (each output isolated)
Isolation	1500 volts RMS between field side 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 (½ 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 all standard motor control center starters).

SERIES 90™-30 PLC

MCC SPACE REQUIREMENTS

12-inch per rack plus a 6-inch minimum space for a local CPT and fuses. A 10 slot rack requires a 24-inch wide section for wireway space.

MODEL 311

The entry level Series 90-30 PLC, Model 311, is available in either a five or ten I/O slot version. With the CPU built into the backplane, the Model 311 provides an "extra" slot for additional I/O or intelligent modules. Model 311 offers 512 words of register memory and 3K of logic memory. This unit provides all the features you want with a small programmable controller.

MODEL 331

For applications requiring additional I/O the Model 331 can handle your needs. It is expandable to five racks to provide the user with 49 available slots for discrete, analog or intelligent I/O. It offers up to 512 I/O points, 2K words of register memory and 8K words of logic memory.

SERIES 90-30 GENERAL SPECIFICATIONS

	MODEL 311	MODEL 331
I/O Points (Maximum)	160	512
Logic Memory (Words) CMOS RAM	3K	8K
PROM	3K	8K
EEPROM	3K	8K
Execution Speed (1K)	18msec	0.4msec
Internal Functions		
Password Protection	Yes	Yes
Output Coils	512	512
Internal Coils	1024	1024
Timers/Counters	170	>500
Shift Registers	Yes	Yes
Data Registers	512	2048
High Speed Counter		
80KHz	Yes	Yes
Analog I/O (12 Bit)	Yes	Yes
Programmable Coprocessor Module	No	Yes
Genius Communications	Yes	Yes
Programming		
Languages		
Relay Ladder	Yes	Yes
Statement List	Yes	Yes
Advanced Data Operations	Yes	Yes
Devices		
Hand Held Programmer	Yes	Yes
Workmaster or IBM compatible	Yes	Yes
CPU	Built-in	Module
Racks		
5 slot	Yes	Yes
10 slot	Yes	Yes
Operating Environment: 0 to 60° C	5-95% non-condensing humidity	

The Series 90-30 PLC has dimensions similar to the older Series One PLC. It is available in two forms: the model 311 has a basic five slot rack, or a ten slot rack when the I/O requirements exceed the five slot rack capabilities. The model 331 is available with a five or ten slot base rack (CPU plus I/O modules), which then can be expanded to a total of five racks for additional I/O capabilities. With the built-in coprocessor and calendar clock, the Model 331 has faster execution times and can be used with time-of-day programs. The programs are stored in battery-backed CMOS RAM (EPROM chips are available).

The PLC can be programmed form the hand-held programmer, or PC's with LM90 software

Types of I/O Modules

IC693MDL390: 120 VAC, 5PT. ISO. OUT.*
IC693MDL930: Relay Out. 6PT. ISO.4A
IC693MDL940: Relay Output, 2A MOD. (16)
IC693ALG220: Analog Input, E/I, MOD (4)
IC693ALG390: Analog Output, E MOD. (2)
IC693PCM300: Prog. Copress. Comm. Mod.
IC693CMM301: Genius Comm. Mod
IC693PRG300: Hand Held Programmer

* Isolated output points have been tested with GE contactors and will energize size 1 through 4 without interposing relays.

SERIES 90™-70 PLC

GENERAL

The Series 90-70 CPU contains an INTEL-base microprocessor and a GE Fanuc-designed Boolean coprocessor for high speed response. It is designed for system level control, and will communicate with other PLCs thru the CCM Protocol, GE net or the Genius LAN. Since it uses the VME standard, many intelligent modules can be added to the rack, thus increasing its versatility. The 90-30 instruction set is a subset or the 90-70s to allow commonality in programming. Built into the CPU is an alarm processor which records and time stamps any faults. This could allow the master program to perform corrective action routines when required.

SPECIFICATIONS

Operating Temperature	0° to 60° C 5% to 95% humidity (non-condensing)
AC Power Required	120/240 VAC (-25%, +10%)
Frequency	47 to 63 Hz
Maximum Load	100 Watts
Battery Type (to retain CMOS memory) load	Lithium 6 month retention under 8-10 year shelf life (no load)
Programmer	Workmaster or IBM PC
Terminal Board	Removable 40 point (1 #14AWG or 2 #16AWG)

MCC SPACE REQUIREMENTS

9 slot rack – 2 S.U., 24 in. W
5 slot rack – 2 S.U., 20 in. W

No vertical bus behind these PLCs. Interposing TB and smaller wire should be considered due to module density.

F

APPLICATION

Series 90-70 PLCs can be coordinated with motor control centers to form a complete, integrated system for material handling, transportation, water treatment, power generation, and many other continuous or batch process applications. From performing simple functions such as start/stop or sequencing operations to comprehensive system monitoring and feed back loops, Series 90-70 control is a powerful addition to MCCs for medium to large applications.

CPU AND I/O OPTIONS

CPU	731/732	771/772	781/782
User Memory (K words)	16	32,64,128,256	64,128
Discrete I/O Addressing	512	2K	12K
Analog I/O addressing	8K	8K	8K
Boolean Execution	0.4 msec/K	0.4 msec/K	0.4 msec/K
Processor	80186	80186	80386
Floating Point Coprocessor	No/Yes	No/Yes	No/Yes

Input Modules

16 Ckt, 120V AC Isolated Input
16 Ckt, 240V AC Isolated Input
32 Ckt, 120V AC Input
32 Ckt, 24V DC Pos Logic Input
32 Ckt, TTL Neg Logic Input
32 Ckt, 12V DC +/- Logic Input
32 Ckt, 24V DC +/- Logic Input
32 Ckt, 48V DC +/- Logic Input
8 Ckt, Analog Volt/Curr Input
16 Ckt, Analog Current Input Expander
16 Ckt, Analog Voltage Input Expander

Output Modules

16 Ckt, 120V AC 2A Output
16 Ckt, 120/240V AC Isolated Output*
32 Ckt, 120V AC 0.5A Output
16 Ckt, 24/48V DC 2A Pos Logic Output
32 Ckt, 24/48V DC 0.5A Pos Logic Output
32 Ckt, 12V DC 0.5A Pos Logic Output
32 Ckt, 5-48V DC 0.5A Neg Logic Output
16 Ckt, Signal Relay 2A Output
4 Ckt, Analog Volt/Current Output

Specialty Modules

Genius Bus Controller
Programmable Coprocessor
Graphics Display Coprocessor
GEnet MAP Carrierband
GEnet MAP Broadband
MODBUS Interface
MMS Ethernet

* Capable of energizing GE size 1 through size 4 starters without interposing relays.

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 a Field Logic

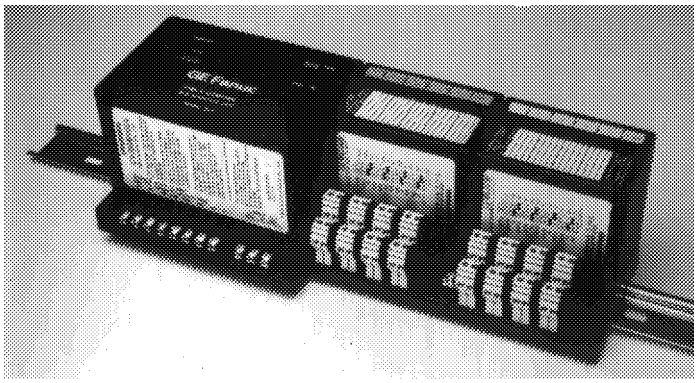
By providing simple logic solving at the local station, Field Control produces shaarp increases in a system's raw speed and effieiency. Future versions of Field Control will accommodate additional programming options to build on these advances.

Iinitially, users will be able to program a Field Control station using standard GE Fanuc Logicmaster™ programming soltware 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-holf.

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

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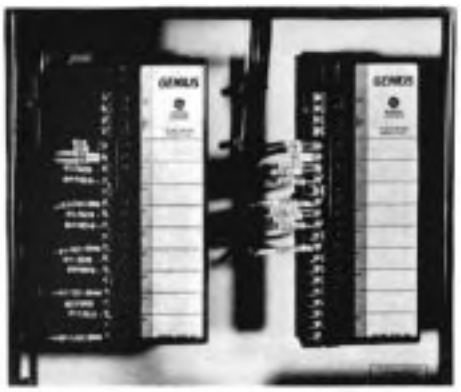
GENIUS® I/O SYSTEM

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.



Typical Genius I/O Unit

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.

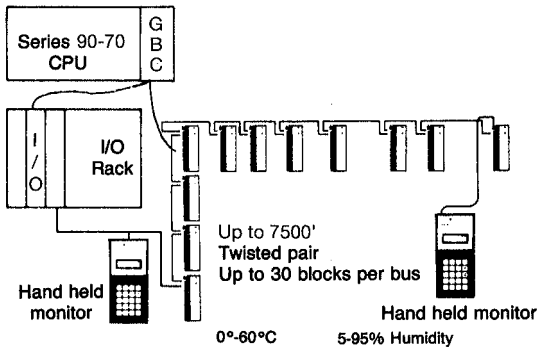


Fig. 2. Genius I/O System Block Diagram

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).

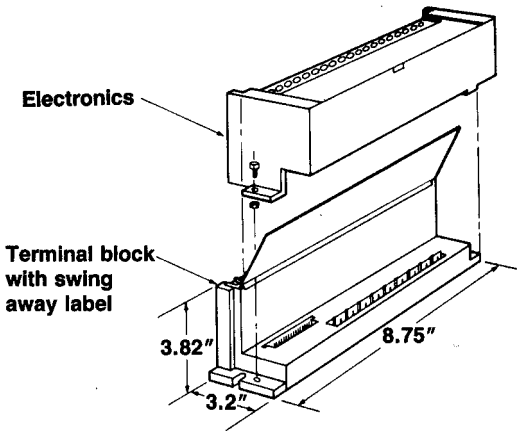


Fig. 3. Genius I/O Block Assembly

Genius I/O Block (Cont'd)

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.

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-inch 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.

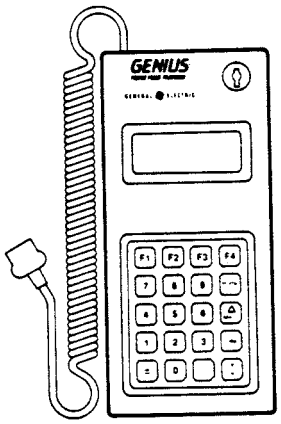


Fig. 4. Hand Held Monitor

F

GENIUS® I/O SYSTEM

SERIES SIX BUS CONTROLLER

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.

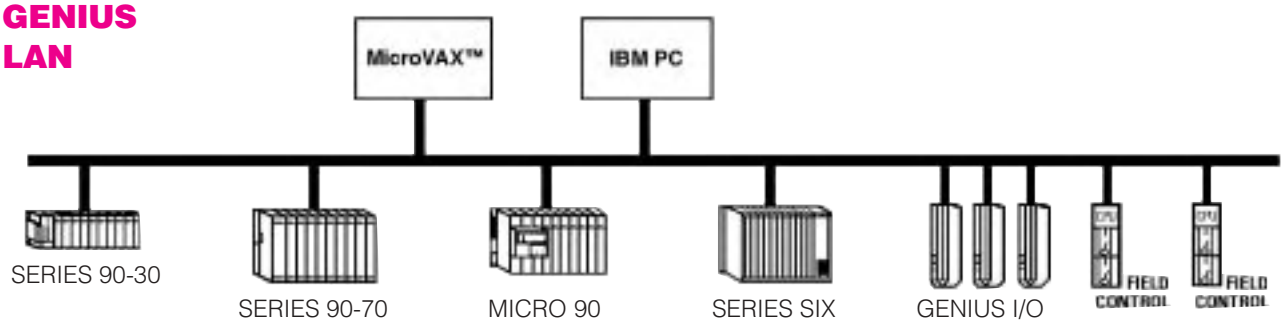
On the analog blocks, the Genius I/O can detect an input open wire, mix high-level analog signals on one I/O Block (±10 volts DC, ±5 volts DC, 0-10 volts DC, 0-5 volts DC, 1-5 volts DC, or 4-20 mA), establish linear conversions from analog values to engineering units, process high-level and low-level 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 –Loss of Block (incl. Communications Power, Memory Losses)	–Open Wire –Power Loss① –Over Temp.	–Failed Switch –Load not present –Overload –Short Circuit –Over Temp. –Power Loss①
–Address Conflict	Analog I/O	
–Bus Error –Bus Controller OK	–Open Wire② –Underrange –Overrange –Hi Alarm –Low Alarm	–Underrange –Overrange

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

GENIUS LAN



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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, X_2). The INPUT monitors the status of the seal circuit to independently verify that the starter has closed.

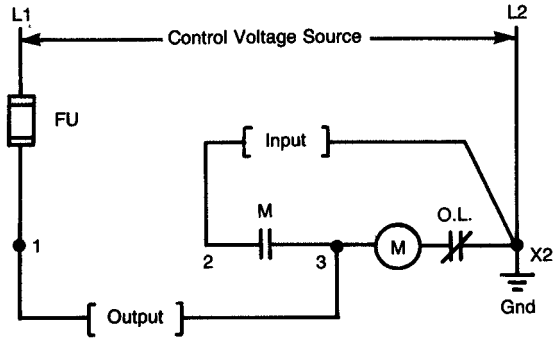


Fig. 5. INPUT and OUTPUT Connection

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.

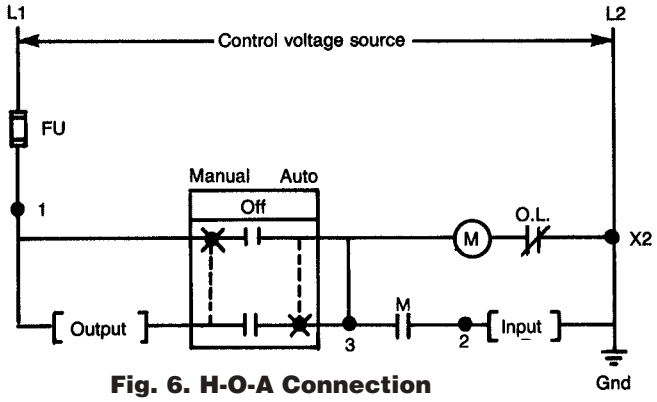


Fig. 6. H-O-A Connection

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 OUT-PUT), 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.

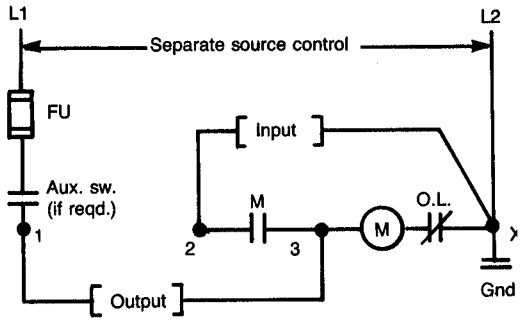


Fig. 7. INPUT and OUTPUT Connections for Separate-Source Control

ISOLATED VERSUS NON-ISOLATED OUPUTS

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 SPEED DRIVES

GENERAL

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% 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).

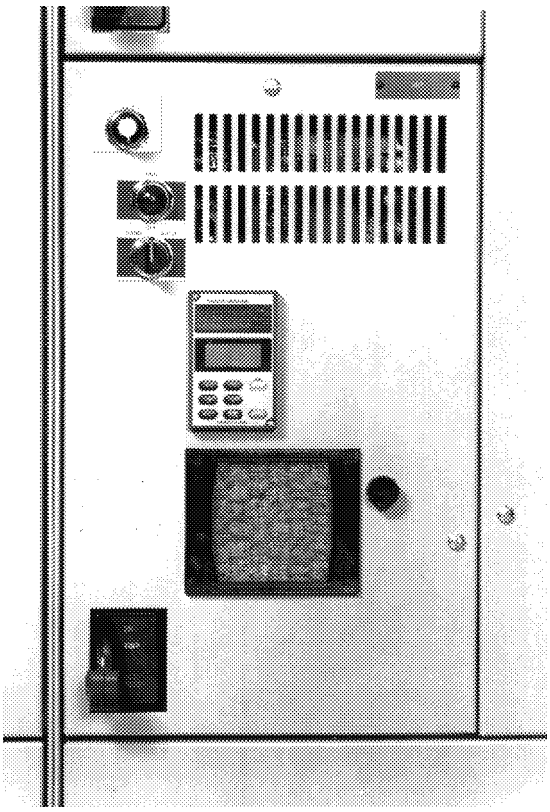
A drive creates noise on the power system. Although we use reactors to minimize system disturbances, a drive will create harmonics on the power/system (both at the motor and at the transformer). If sensitive computer systems are to be utilized, they should be isolated from the drive's source. Likewise, 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 ENERGY SAVER® motors for drive applications. See motor application data, SH. G-3

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.)

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.



AF300E$™ Drives

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 factory for analysis.

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.

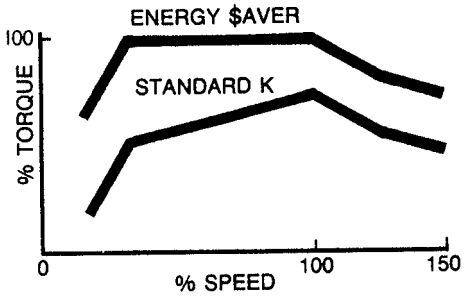
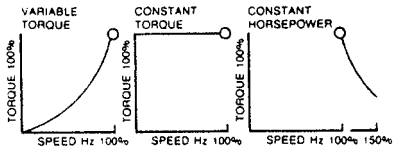


Fig. 1

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).



$$(1) \quad HP = \frac{T \times N}{5250}$$

HP = Required HP

T = Torque in lb./ft.

N = Speed in RPM

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

2. Motor Speed Range

Motor synchronous speed is determined by the following equation:

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

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

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

3. Multi Motor Drives

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

4. Acceleration Time

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

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

Where:

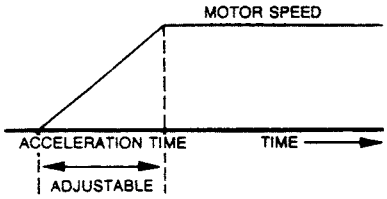
TA = Time to accelerate the driven load (in seconds).

#N = 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 drive can deliver is 150 percent of rated, 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'D.)

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.

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

Where:

TD = Time to decelerate the driven load (in seconds).

#N = 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.

ORDERING INFORMATION

Please provide the following information to assure proper application of the drive

Machine	• Name_____ For _____ Drive
Motor	• Name of Manufacturer • Type l TEFC l DP l Others (_____) • Horsepower _____ • Number of Poles _____ • Full Load Current _____A • Voltage _____V • Frequency _____ Hz
Power Supply	• 3. _____ V _____%_____Hz
Operating Frequency Range	•_____ Hz Minimum to _____ Hz Maximum①
Duty	l Continuous _____H/Day l Repetitive Operating Time _____Minutes Downtime_____Minutes
Load	l Constant Torque l Variable Torque l Constant Horsepower •* Maximum Load Torque _____ lb./ft. @ _____ RPM •* Load Inertia Wk^2_____ ft./lb.^{2}
Start/Stop	• Acceleration Time_____ Seconds • Deceleration Time _____ Seconds
Environment	• Ambient temperature_____°C l Dust l Other (_____)
Inverter	l Rating _____ KVA
Other Options	

① Variable torque loads operated above line frequency require larger drives (& motors) due to increased loading. Verify motor is capable of overspeed.

* Calculated at motor shaft

ADJUSTABLE SPEED DRIVES

AF-300E$™

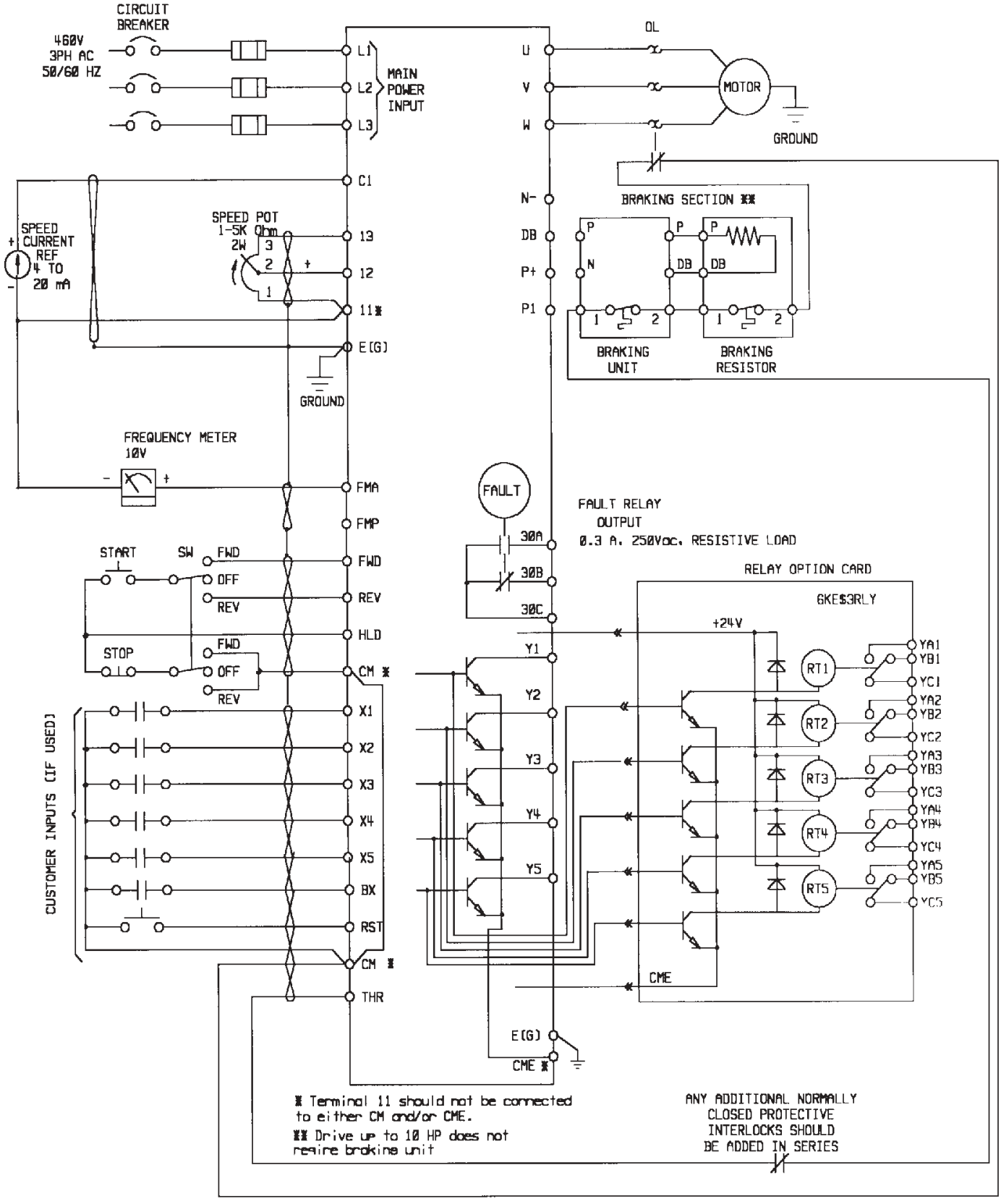
- **Available Ratings**
  - 1-125 HP, 380-460 VAC. 3 Phase. 50/60 Hz
  - 0.5-30 HP, 200-230 VAC, 50/60 Hz
- **Control**
  - Twin 16-bit microprocessors operating with a speed allowing the drive to maximize frequency regulation with acceleration rate and impact loading, making adjustments quickly to avoid nuisance trips.
- **Key Features and Functions**
  - Torque Vector Control with auto tune feature.
  - Dual nameplate rating for constant and variable torque.
  - Multiple, independently adjustable, accel/decel rates.
  - Slip compensation.
  - Torque boost.
  - 10 selectable carrier frequencies.
  - 5 programmable Inputs and Outputs
  - Resonant frequency rejection.
  - Static DC braking.
  - Adjustable torque limit.
  - Electronic reversing.
  - Run and Fault output contact (Run available only on 40 HP and above rating).
  - Programmable open collector outputs.
  - Automatic (programmable) Restart and Reset.
  - 15 ms control power ride through.
  - Output ground fault protection.
  - Signal follower (0-10V, 4-20mA).
  - Pulse frequency output.
  - 0-10V output, proportional to frequency, current, torque, or power.
  - User programmable via keypad.
  - Digital Display – 4 digit LED.
  - Graphic Display – LCD, with brightness control.
  - Designed to NEMA standards and compatible with NEC installation requirements.
  - UL 508 listed and CSA certified.
- **Protective functions**
  - Stall prevention.
  - Momentary power failure
  - Drive overheating
  - External Faults
  - CPU malfunction
  - Motor overload (electronic thermal)
  - Undervoltage
  - Overvoltage
  - Overcurrent
  - Link error
  - Communication error
  - Ground fault
- **Available Diagnostic information**
  - Acceleration Overcurrent
  - Deceleration Overcurrent
  - Constant speed Overcurrent
  - Ground fault
  - Undervoltage
  - Overvoltage at accel
  - Overvoltage at decel
  - Overvoltage at constant speed
  - DC bus fuse failed
  - Drive overheat (Heatsink)
  - External alarm
  - Drive internal temperature
  - EE Prom malfunction
  - Communication error
  - CPU malfunction
  - Link error
  - Option malfunction
  - Drive error at start-up
  - Missing motor connection
- **Optional Features**
  - Relay card
  - GENIUS™ communication card
  - RS 485 communication card
  - Dynamic Breaking
- **Typical Default Settings**

Frequency Command	0-10VDC & 4-20mA
Operation Method	Terminal strip
Maximum Frequency	60 Hz
Base Frequency	60 Hz
Rated Output Voltage	460 Vac
Acceleration Time	6s (20s for 40 HP & up)
Deceleration Time	6s (20s for 40 HP & up)
Torque Boost	Automatic
Number of Motor Ploles	4
FM Terminal Output Volts	100% (0-10V)
Energy Savings	Inactive
Motor Sound	10kHz
Language	English

AF300E$ Specification

Input	Power System	200-230 & 380-480V AC, 50/60 Hz +10 –15%
Output	Converter Control System	Sinusoidal PWM (with torque vector control)
	Frequency Control Range	0.2 to 400 Hz (Consult the company for drive operation >120 Hz_
	Rated Voltage	Voltage: 200 to 230 & 380 to 480V AC
	Carrier Frequency	2 to 15K Hz (up to 30 Hp) 2 to 10K Hz (40–75 Hp) 2–6K Hz (100–350 Hp)
Control	Frequency Fluctuation	Digital setting: +/0.01% of max. frequency (@ –10°C tp 50°C) Analog setting: +/–0.2% of max. frequency (@ 25°C +/–10°C)
	Frequency Resolution	Digital setting: 0.01 Hz @ max. frequency <100 Hz; .1 Hz @ max. frequency, >100 Hz Analog setting: 1/3000 of max. frequency (ex. 0.02 Hz/60 Hz)
	Torque Boost	Adjustable from 0.1 to 20 (variable, proportional & constant torque load characteristics) or automatic
	Accel/Decel Settings	0.01 to 3600 sec. independently adjustable, linear, non-linear & S-curve characteristic
	DC Braking	Frequency activation Hz =>0.1 to 60 Hz, operating time: 0.1 to 30 sec. Voltage 0 to 100%
	Torque Vector Control	Optimizes drive operation at low frequency
	Standard Functions	Slip compensation, torque limit control, switch from line to inverter, restart alfter instantaneous power failure, multi-speed and acceleration/deceleration settings, 3 jump frequencies, bias frequency, pattern operation & energy saving selection.
	Momentary Voltage Dip	When input voltage dips below 165V AC (230V AC system) or 310V AC (460V AC system) inverter can operate for 15 millisec with 85% of full load applied.
Operation	Frequency Setting Input	Potentiometer or voltage input: 0 to 10V DC, adjusts to 5V DC Process follower input: 4 to 20mA DC (external), adjusts to 10mA 7 preset frequency levels selectable by contact closure (internal)
	Input Signal (contacts)	Forward-Reverse, self-hold selection, 7 preset frequency levels/multi-step speed selection, acceleration/deceleration time selection, coast to stop, external alarm input & alarm reset input.
	Output Signal	Relay output: Fault alarm (SPST, 250V AC, 0.3A inductive) Open collector output: 14 selectable running conditions Analog output FMA =>0–10V DC selectable: frequency, current, torque & load factor Digital output FMP => voltage & pulse rate yielding frequency output.
	Protection	Inverter: current limit, instantaeous overcurrent torque limit, overload, overvoltage, incoming transients, undervoltage & overheating, short circuit & ground fault for output, motor & dynamic braking overheating, stall protection :& setup error.
Indication	Keypad Panel	Output frequency, current, voltage, torque, synchronous speed & line (machine speed)
	Setting	Function, operational and data codes
	Faults	Overcurrent during acceleration & deceleration and running at constant speed; overvoltage, undervoltage, overheating, motor overload (electronic OL relay): external fault; setting, communication, memory, cpu, option, operating procedure and tuning error. Previous 3 faults retained in memory.
	Charge Lamp	DC link voltage level detection.
Conditions	Location	Indoor, altitude up to 3300 ft. (1000M), drive derate required above 300 ft. Do not install in locations exposed to dust, corrosive gas, oil splashes, or direct sunlight.
	Ambient Temperature	–10 to 50°C (ratings up to 30 Hp requires ventilating covers be removed)
	Storage Temperature	–20 to 65°C
	Ambient Humidity	20 to 90% (non-condensing)
	Vibration	0.6G or less
	Type enclosure	NEMA 1 standard; NEMA 4/12 optional
Options & Accessories		Relay output unit, function code copy unit, keypad extension cable for remote operation, dynamic braking units, AC line reactors, serial communications link.

1/2 to 30 HP AF-300E$ DRIVE RATING



BASIC CONNECTION DIAGRAM

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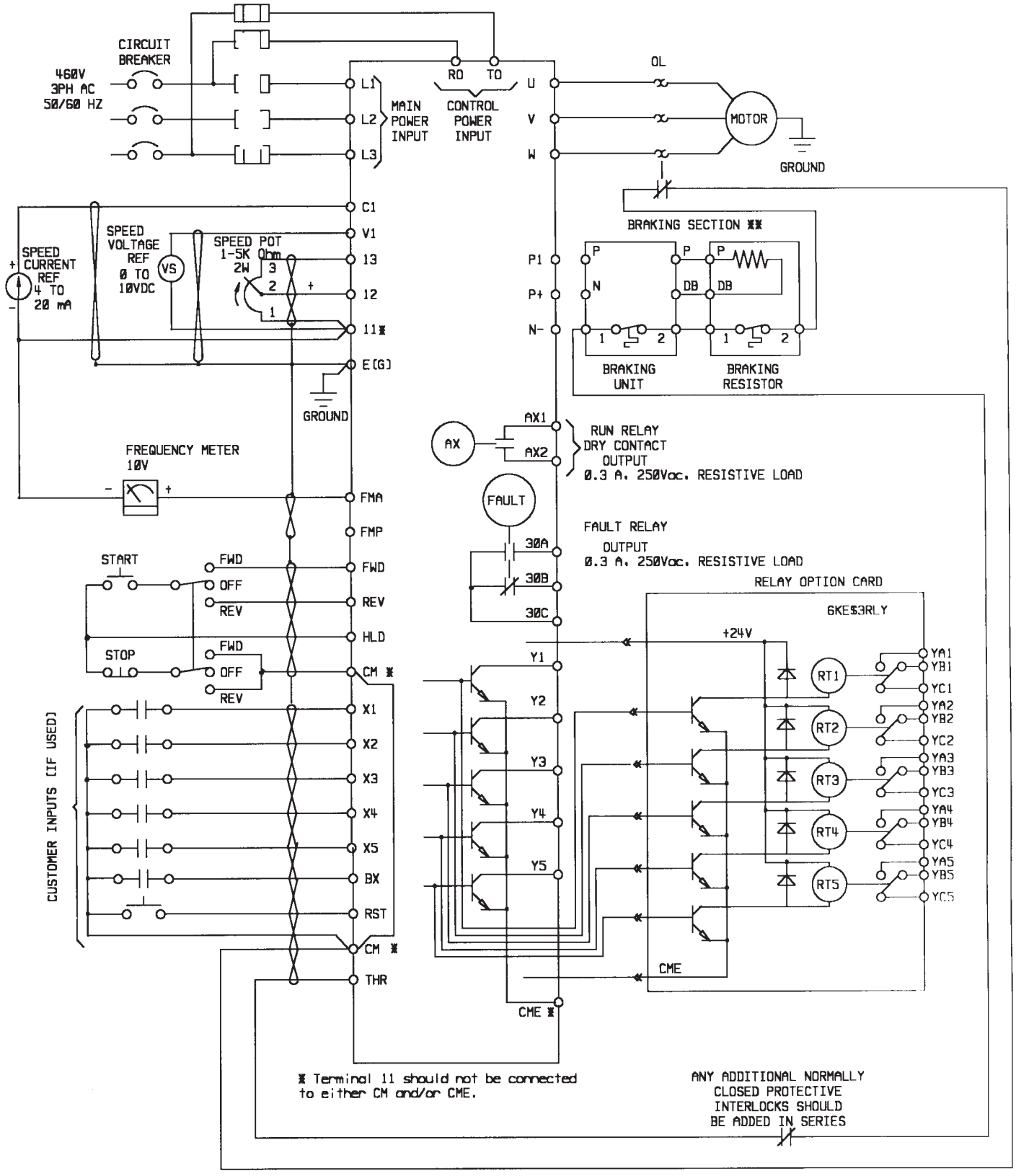
40 to 125 HP AF-300E$ DRIVE RATING

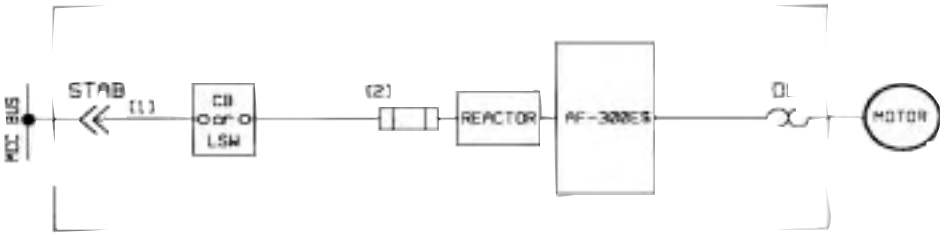


BASIC CONNECTION DIAGRAM

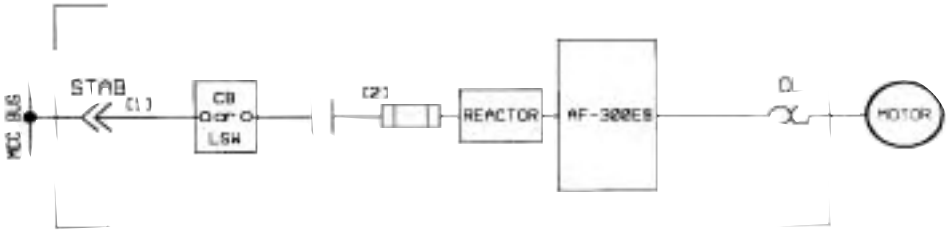
DRIVE CONFIGURATION IN MOTOR CONTROL CENTER CONSTRUCTION

Circuit Breaker or Fusible Switch Required for Disconnect

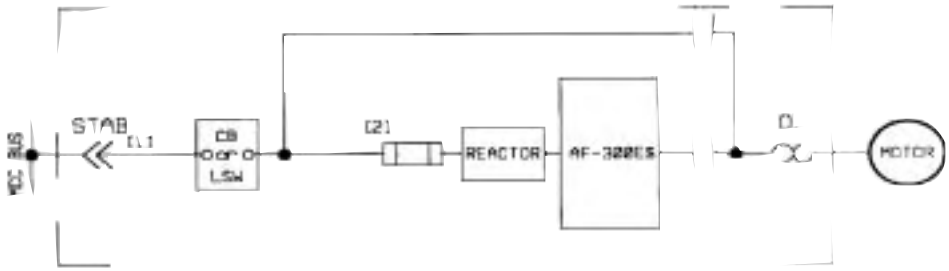
Standard VFD



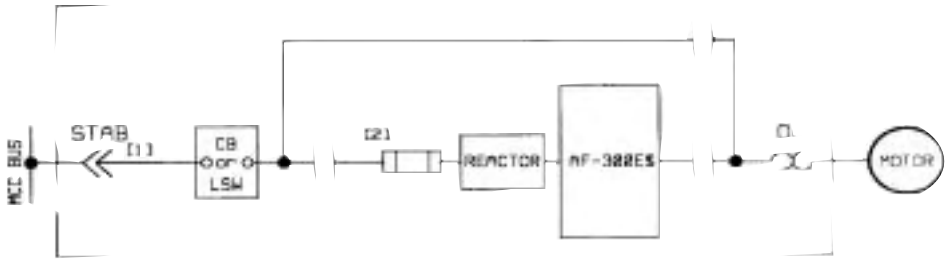
VFD with
Line Isolation



VFD with
ByPass Feature



VFD with
Line Isolation
Plus ByPass Feature



(1 Drawout breaker through 225A
Drawout QMW switch through 200A

(2) J Fuse through 30 Hp
Semiconductor Fuse 40–125 Hp

NOTE: Drive may use DC link reactor in addition to the line reactor (std for 100 HP & 125 HP)

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AF300E$ SPACE HEIGHT AND ASSEMBLY REFERENCE

Function		NEMA Size	HP's @ 200/208	HP's @ 230/240	HP's @ 380/50 Hz	HP's @ 460/480	Disconnect	Section 1 Width	Section 1 X Height	Section 2 Width	Section 2 X Height
Basic Drive	PLUG IN	1	.1–5.0	.1–5.0	.1–5.0	.1–5.0	SELI, SELT`	20"	2.0		
							QMW	20"	2.0		
			7.5	7.5	7.5–10	7,5–10	SELI, SELT	20"	2.5		
							QMW	20"	2.5		
		2	10	10			SELI, SELT	20"	2.5		
							QMW	20"	2.5		
				15	15–25	15–25	SELI, SELT	20"	3.0		
							QMW	20"	3.0		
		3	15–25	20–30	30	30	SELI, SELT	20"	3.5		
							QMW	20"	3.5		
					40–50	40–50	SELI, SELT	24"	4.5		
							QMW	24"	4.5		
		4	30				SELI, SELT	20"	3.5		
							QMW	20"	3.5		
					60–75	60–100	SFLI, SFLT	24"	5.0	20"	2.0
							QMW	24"	5.0	20"	2.0
Drive with Bypass or Line Isolation	PLUG IN	1	.1–5.0	.1–5.0	.1–5.0	.1–5.0	SELI, SELT	20"	3.0		
							QMW	20"	3.0		
			7.5	7.5	7.5–10	7.5–10	SELI, SELT	20"	4.0		
							QMW	20"	4.0		
		2	10	10			SELI, SELT	20"	4.0		
							QMW	20"	4.0		
				15	15–25	15–25	SELI, SELT	20"	4.0		
							QMW	20"	4.0		
		3	15–25	20–30	30	30	SELI. SELT	20"	4.5		
							QMW	20"	4.5		
					40–50	40–50	SELI, SELT	24"	5.0	20"	1.0
							QMW	24"	5.0	20"	1.0
		4	30				SELI, SELT	20"	4.5		
							QMW	20"	4.5		
					60–75	60–100	SFLI, SFLT	24"	5,0	20"	4.0
							QMW	24"	5.0	20"	4.0
Drive with Bypass and Isolation	PLUG IN	1	.1–5.0	.1–5.0	.1–5.0	.1–5.0	SELI, SELT	20"	3.5		
							QMW	20"	3.5		
			7.5	7.5	7.5–10	7.5–10	SELI, SELT	20"	4.0		
							QMW	20"	4.0		
		2	10	10			SELI, SELT	20"	4.0		
							QMW	20"	4.0		
				15	15–25	15–25	SELI, SELT	20"	5.5		
							QMW	20"	5.5		
		3	15–25	20–30	30	30	SELI, SELT	20"	5.5		
							QMW	20"	5.5		
					40–50	40–50	SELI, SELT	24"	5.0	20"	2.0
							QMW	24"	5.0	20"	2.0
		4	30				SELI, SELT	20"	5.5		
							QMW	20"	5.5		
					60–75	60–100	SFLI, SFLT	24"	5.0	20"	5.0
							QMW	24"	5.0	20"	5.0

Function	NEMA Size	HP's @ 380/50 Hz	HP's @ 460/480	Disconnect	SECT 1 Width	SECT 1 X Ht	SECT 2 Width	2" BUS X Ht	4" BUS X Ht	SECT 3 Width	SECT 3 X Ht
Basic Drive	5	100		GL4I, GL4T	24"	5.0	20"	2.0	2.0		
				QMR	24"	5.0	20"	4.0	4.0		
		125	125	GL4I, GL4T	30"	5.0	20"	2.0	2.0		
				QMR	30"	5.0	20"	4.0	4.0		
Drive with Bypass	6	100		GL4I, GL4T	24"	5.0	24"	6.0	5.5		
				QMR	24"	5.0	24"	6.0	5.5	20"	3.5
		125	125	GL4I, GL4T	30"	5.0	24"	6.0	5.5		
				QMR	30"	5.0	24"	6.0	5.5	20"	3.5
Drive with Line Isolation	5	100		GL4I, GL4T	24"	5.0	24"	3.0	3.0		
				QMR	24"	5.0	24"	4.5	4.5		
		125	125	GL4I, GL4T	30"	5.0	24"	3.0	3.0		
				QMR	30"	5.0	24"	4.5	4.5		
Drive with Bypass and Line Isolation	5	100		GL4I. GL4T	24"	5.0	24"	6.0	5.5	20"	1.5
				QMR	24"	5.0	24"	6.0	5.5	20"	5.0
		125	125	GL4I, GL4T	30"	5.0	24"	6.0	5.5	20"	1.5
				QMR	30"	5.0	24"	6.0	5.5	20"	5.0

NOTE: Stationary mounted drives require 2" vent installed on the top of MCC section. Dimensions shown above do not reflect additional space required for load filters. Refer to factory if required.

For layout purposes, any X height 5.0 or larger will not permit additional units in that section.

SOLID STATE STARTERS

GENERAL

The GE solid-state starter is a reduced-voltage starter that provides smooth, stepless controlled acceleration of AC squirrel cage induction motors from standstill to full speed. It provides controlled extended starting times by supplying continuously varying voltage to the AC motor from zero to full voltage. The solid-state starter can be supplied in 8000-Line motor control center construction to combine the advantages of solid-state starters together with conventional electromechanical motor control.

ADVANTAGES OF SOLID-STATE STARTERS

- Inexpensive conventional NEMA design B, C, or D induction motors.
- Lower maintenance cost through elimination of power line transients, excessive line voltage dips as well as high impact torques transmitted to mechanical linkages.
- Lower operating costs versus equivalent electromechanical starters together with a concurrent reduction in starter size and power requirements.
- Starting characteristics can be matched to the specific application for smooth startup and protection.
- Automatic regulation and control of starting currents. Continuous monitoring of motor line current provides automatic shutdown in the event of locked-rotor or mechanical jamming of couplings, etc.

Description

GE's advanced ASTAT-CD™ solid state reduced voltage starter — sometimes called a soft starter — is the industry's first solid state starter featuring microprocessor controlled digital technology, digital adjustment, digital alphanumeric display and error code traceability. These features, coupled with the optional communications module, allow the ASTAT-CD to be effectively incorporated into distributed control systems and automated plant processes. Up to 16 ASTAT-CD solid state reduced voltage starters can be coupled on a single bi-directional serial RS422/485 computer interface.

The ASTAT-CD starter's advanced control technology individually fires each phase in a special selected sequence to offer reliable performance for the smooth acceleration of all types of loads. reducing shock to mechanical components, thereby extending component and motor life.

Each starter consists of an electronic control module and a power base consisting of six SCRs arranged in anti-phase parallel pairs for optimum performance. The ASTAT-CD starter's deceleration ramp is programmed with non-linear characteristics to more closely match variable torque loads to help eliminate water hammer and stress on couplings, plastic pipe and check valves in pumping applications.

The ASTAT-CD starter offers many standard features including energy savings mode with override, adjustable current limit, motor overload protection, kick start, loss of load detection, and loss of phase protection. These, plus many additional features, make the ASTAT-CD starter the obvious choice for reduced voltage starting applications.

Application

ASTAT-CD solid state reduced voltage starters are used to reduce or eliminate mechanical shock and stress on mechanical components such as vee belts, gear boxes, chain drives, couplings, transmissions and shafts. ASTAT-CD reduced voltage starters are used to reduce brownout conditions and may limit energy and demand charges. ASTAT-CD solid state reduced voltage starters are used to control process lines, to smoothly accelerate and decelerate loads, to position and move loads and restrict process surges.

Typical applications include: compressors, pumps, belted equipment, centrifuges, conveyors, cranes, crushers, winches, fans/blowers, extruders, flywheels, hoists, laundry extractors, mixers, packaging equipment, machine tools, shears, saws, spinning frames, textile machinery, winders and wire drawing machines.

Note: When installed in the Motor Control Center, the "standard" ASTAT-CD starter is rated for motors with a 1.15 service factor. It provides 300% motor full load current for 30 seconds acceleration, or, when the overload curve is selected for heavy duty, will also provide 450% motor fla for 30 seconds. The 500% rated starter has been derated to provide extra capacity for those loads requiring heavy starting currents due to high inertia, or conveyor type applications.

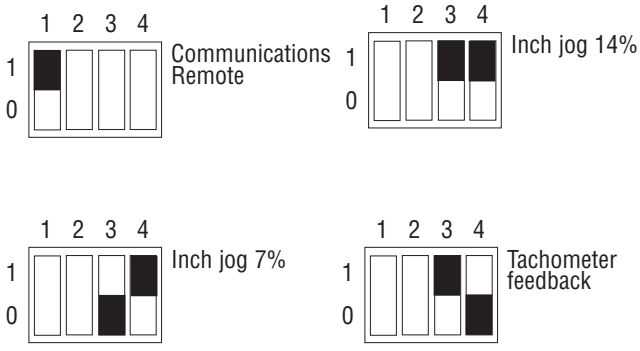
The electronic OL on the standard duty ASTAT is suitable for motor protection when programmed at 300%. When using 450% (or 500%) acceleration limits, always verify motor capacity for extended acceleration time with motor manufacturer. Separate OL relay required with 500% ratings, since ASTAT is derated for extra capacity beyond standard OL curves.

ASTAT-CD Default Settings

ASTAT-CD starters are supplied with the following factory settings:

Nominal motor current	100%
Current limit	300%
Starting torque	15%
Acceleration ramp	20 sec.
Deceleration ramp	20 sec.
Kick start time	100 msec.
Kick start	Off
DC braking time	5 sec.
DC braking current	150%
DC brake	Off
Soft stop	Off
Energy saving	
Terminal (3-57 open)	On
Terminal (3-57 jumper)	Disabled
Overload trip	Standard duty
User configurable relay	
Run	Engaged
Fault	Not engaged
Local Control (DIP switch 1 down)	Enabled
No load detection (DIP switch 2 down)	Disabled

The following options are hardware enabled when the option is supplied in starter control module:



Semiconductor Fuse Selection

Starter	Gould Shawmut Type A50QS
QC2G*A	60A
QC2I*A	100A
QC2K*A	200A
QC2M*A	350A
QC2Q*A	600A
QC2S*A	2 x 600A in parallel

8000-LINE MCC CONFIGURATION

The basic combination nonreversing starter in 8000-Line motor control center construction consists of:

- Primary line disconnect (circuit breaker/fusible switch)
- ASTAT solid state starter
- Semiconductor type (I^2t) fuses for SCR protection
- Control power transformer
- 3-Phase thermal overload relay (required with bypass)
- NEMA 1 indoor-ventilated enclosure

Options

POWER

- Bypass contactor for starting-duty application
  Note: This option required when NEMA 12 enclosure is specified
- Starter isolation contactor
- Isolation contactor and bypass contactor for full-voltage operation after controlled startup.
- Reversing duty contactors
- DC braking contactor
- Motor thermal overload (thermistor input)
- Running phase failure protection
- Ground fault protection

CONTROL

- Local Start/Stop pushbuttons (provision for remote Start/Stop)
- H-O-A selector switch
- Local/Remote selector switch
- Manual bypass selector switch
- Status indicating lights
- Standard and oversized control power transformers
- Time-delay relay
- Auxiliary control relay, 4-pole
- Circuit breaker UVR or shunt trip, bell alarm switch
- Line disconnect auxiliary contact

INSTRUMENTATION

- Current transformers
- Ammeter, panel type
- Ammeter, switchboard type
- Meter transfer switch
- Potential transformers
- Voltmeter, panel type
- Voltmeter, switchboard type

ENCLOSURE

- NEMA 12 indoor enclosure with bottom plates (requires bypass option)
- Thermostat with space heaters (external power required)
- Space heater only

Note: When ASTAT-CD™ Reduced Voltage Starters are used in conjunction with semi-conductor fuses, Type 2 Coordination to IEC 947-4 is attained. These fuses are recommended for best overall short circuit protection. (Rating of 100KA @ 208V thru 480VAC)

Standard Features

DIGITAL TECHNOLOGY
Provides precise phase control of the back to back SCRs over each $^1/_2$ cycle. Special ASTAT-CD™ design allows initial motor torque to be adjusted from 10% to 90%.

DIGITAL CONTROL PANEL
Displays setup and operating parameters with alphanumeric display. Provides accurate setting of parameters and visible indication of starter status and fault codes.

SOFT STARTING
The most frequent application for the ASTAT-CD starter. Provides a linear increase in voltage at the motor terminals, eliminates starting shock to the load and reduces stress on mechanical components, such as gears, belt drives, piping and valves.

THREE SEGMENT RAMP
The three segment ramp consists of (1) the initial voltage ramp - which lasts for 5 cycles and brings voltage from 0 to the preset initial pedestal voltage (30%-95%). (2) Acceleration ramp - increases motor voltage from preselected initial voltage to 100% voltage over selected acceleration time period. (3) Fast ramp - brings motor voltage to 100% if motor reaches full speed prior to end of acceleration ramp.

ELECTRONIC OVERLOAD RELAY
Overload relay selectable trip characteristic - for standard (300%, 30 sec.) or heavy duty (450%, 30 sec.) applications. Provides accurate, repeatable, reliable motor protection.

KICK START
Used to start loads with a high breakaway torque (belted conveyors, extruders, mixers). Feature may be engaged (95% voltage for a time of 1-999msec, or feature may be disengaged for applications not requiring kick start.

CURRENT LIMIT
The motor current may be limited with an adjustable current range from 100-450% starting current. Used to reduce starting current to limit brownout/low voltage conditions during motor starting.

SOFT STOPPING
Allows motor driven load to be brought to rest over an adjustable time period. The enhanced soft stop pump control allows pump shut down while limiting pump system water hammer and fluid surges.

ENERGY SAVING MODE
Reduces motor voltage under no load or low load conditions, thereby reducing reactive power required by the motor. Motor voltage is automatically increased as the load is increased. Feature may be disengaged when not desired.

DC BRAKING
Braking current is adjustable from keypad for a range from 50-250% of the operational current for a predetermined time (0-99 seconds). Also keyboard selectable, feature may be disengaged when not desired. Requires external contactor.

LOSS OF LOAD DETECTION
Prevents motor burnout for application in which driven load is also cooling motor (for example a submersible pump motor). Time delay is 10 seconds after load loss, feature is DIP switch selectable.

MOTOR THERMISTOR PROTECTION INPUT
Used with motors protected with PTC thermistor. Trips within 200msec when resistance is higher than 2800-3200 ohms. Resets when resistance falls below 1000 ohms.

STALLED ROTOR PROTECTOR
Power is removed from motor when stalled condition exceeds 200msec. Provides motor protection and process feedback.

SNUBBERS
RC network connected in parallel with SCR to protect against commutation spikes, thereby limiting harmonics being fed into power lines.

MOVs
Metal oxide varistors used to protect electronic components against external voltage spikes.

ERROR TRACEABILITY
Displays last 4 error codes on alphanumeric display. Affords feedback for corrective action.

PHASE LOSS PROTECTION
Removes power from motor terminals in 3 seconds upon detection of phase loss. Provides additional protection against motor burnout.

THERMAL OVERLOAD MEMORY
Overload relay retains memory of overload conditions to closely profile motor winding thermal condition to insure adequate protection under repetitive overload conditions. Memory is maintained as long as the control power remains applied to the soft starter.

SCR OVER TEMPERATURE PROTECTION
Heat sinks are fitted with thermostats to protect SCR against fan failure. (Trip @ 80°C ± 5°; reset @ 50°C ± 10°C)

FREQUENCY ERROR DETECTION
Electronic frequency sensing will not allow start to begin load ramp-up if frequency is < 48Hz or > 62Hz, providing protection to the motor and starter should frequency be excessively out of tolerance.

LONG START TIME PROTECTION
If current limit is set too low and/or starting time is longer than 240 sec. or two times the preselected acceleration ramp time, it is assumed that the motor heating could be excessive. The ASTAT-CD starter provides long start time protection and disconnects the load under these conditions.

3 OUTPUT RELAYS
- Run/fault relay – user configurable from keypad. When configured as run, relay contacts close upon initialization of start command and open when stop order is given or the starter shuts down due to a fault condition. When configured as a fault, the relay closes when control power is applied and opens only if a fault condition is detected.

- At speed relay (end of ramp), contact closes when starting ramp voltage reaches the end of ramp, indicating the motor is running at full speed.

- DC brake relay – contact closes to supply voltage to external injection braking contactor when brake command is given.

SOLID STATE STARTERS

Optional Features

SLOW SPEED
Factory option which, when supplied, is engaged by DIP switch selection. DIP switch selection allows user to engage either 7% or 14% speed to align or position loads.

TACHOMETER FEEDBACK
Factory option which, when supplied, provides linear speed ramp independent of load torque. Speed feedback is provided by user supplied tachometer attached to driven shaft. A voltage transducer is required to match tachometer voltage to required input voltage range (0 to 5VDC). Option is DIP switch selectable when supplied.

COMMUNICATIONS RS422/485
Factory option which, when supplied, allows setup and readout of starter parameters and operating conditions via serial computer connection. Up to 16 ASTAT-CD starters may be monitored and controlled on a single serial interface. Starters are DIP switch identified on communications board and maintain identity via communications link. Each starter may be given its own name/location identity on the computer screen. Each starter may be configured either locally through enabling local control or remotely at the computer interface terminal. If local setup is required, the setup parameters may be polled by the computer terminal and the configuration saved for remote control.

Product

Microprocessor technology. The solid-state reduced voltage starter uses digital microprocessor technology for high reliability and versatility.

Keyboard/digital display. The starter is keypad programmable and has an alphanumeric display capable of displaying setpoints and running functions. The starter provides traceable fault diagnostics when fault conditions occur. The display has the ability to look back at the last four events and actively indicate the present mode of operation:

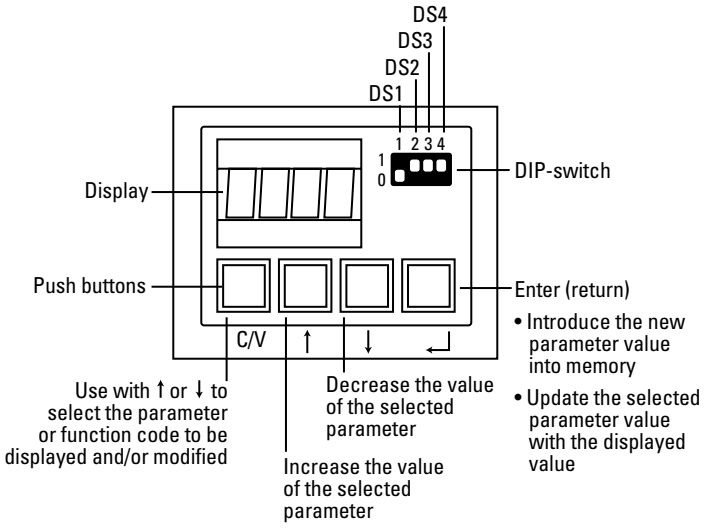
	Display Indicators
ON	Equipment connected to main supply
SAVE	Energy saving
STOP	Stop
SOFT	Soft stop
LOCK	Remote stop/lockout
DCBK	DC braking
PULS	Kick start
FULL	Override (full voltage)
RAMP	Acceleration ramp
INCH	Inching/jog speed
FULL	Full conduction
TACH	Linear ramp (tacho generator)

Fault conditions. The following 17 fault conditions are detected by the solid-state reduced voltage starter and digitally displayed:

Fault conditions	Fault conditions
Frequency out of range	Phase A lost
Overload trip	Phase B lost
Phase sequence lost	Phase C lost
Synchronism lost	Stalled rotor
Phase A SCR shorted	Internal error
Phase B SCR shorted	No motor load
Phase C SCR shorted	Long start time (current limit)
Heatsink overtemperature	Long jog speed time
Motor thermistor	

The last four faults to occur are recorded.

ASTAT-CD Digital Control Panel



Electronic overload. The solid-state reduced voltage starter provides overload functions for both starting and running protection. An overload condition automatically de-energizes the starter and registers a fault. The overload function is selectable for either standard or heavy-duty motor operation. When the relay trips, thermal memory is maintained as long as the control voltage remains applied to the starter. The overload relay is suitable for either heavy-duty starting (450% current, 30 seconds) or standard-duty starting (300% current, 30 seconds). The overload has the following trip time characteristics:

Current Limit (% of MFLC)	Standard-Duty	Heavy-Duty
150%	420 seconds	420 seconds
300%	30	55
425%	6.5	33

Starting and Stopping

Figures 6 and 7 illustrate a combination of several of the most popular drive functions for both starting and stopping: voltage ramp, acceleration ramp, kick start, pedestal voltage, soft stop, current limit. Figure 8 illustrates pumping control (Water "Hammer" Prevention).

Starting by Voltage Ramp

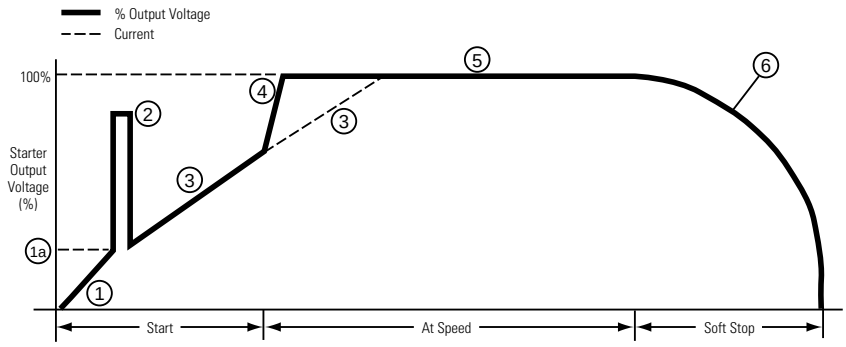


Figure 6

Starting by Voltage Ramp and Current Limit

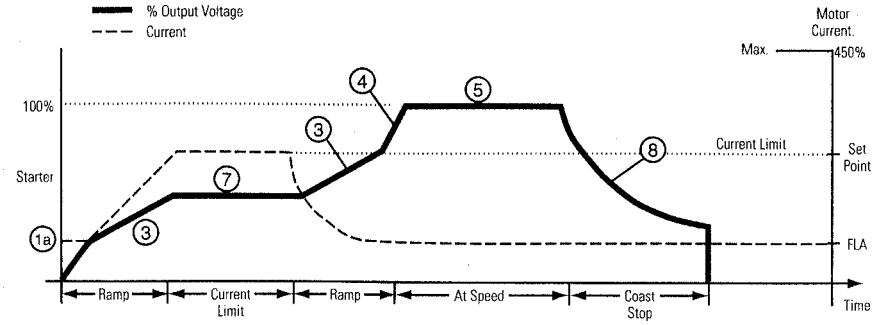


Figure 7

Pumping Control Using Voltage Ramp, Pedestal Voltage, Soft Stop and Load Loss "Protection

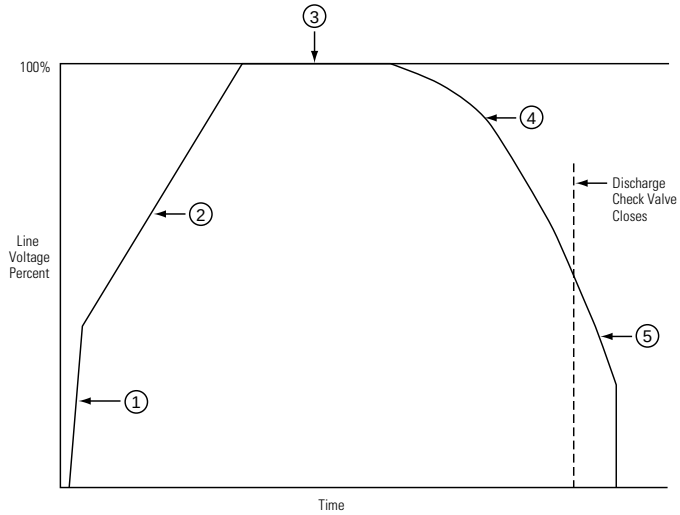


Figure 8

① Initial ramp (5 main frequency cycles).

①a Initial voltage ramp or pedestal (adjustable from 30 - 90% volts) provides quick ramping to initial motor rotation point. Starting torque required by load is also a programming setpoint (adjustable from 10% - 90% of full voltage value).

In this example, motor starting current is below the starter's current limit setting and the current limit override has no effect on the starting ramp. During set-up programming, all starters have an adjustable current limit setpoint.

② Kick-start function - user selectable "On" or "Off" - provides 95% voltage pulse immediately following end of pedestal ramp. Pulse time adjustable from 0 to 999 msec. Objective - to overcome static or seal friction.

③ Voltage acceleration ramp (time adjustable from 1 to 999 seconds)

④ Quick ramp up - automatic fast ramp when motor is up to speed prior to end of normal ramp time.

⑤ Rated speed - starter at full voltage.

⑥ Soft stop - non-linear voltage ramp (deceleration time adjustable from 1 to 999 seconds).

⑦ Current limit (ramp hold). The current limiting set point between 100% to 450% FLA

⑧ Stop mode - standard stopping (coast to reset). When stop push button is pressed, starter cuts off voltage to motor and it coasts to a stop. During set-up program, user choose either soft stop or coast to stop.

① Initial value - set both voltage and torque values below values that produce a speed that will open discharge check valve. Objective is for check valve to open during voltage ramp - not at or before completion of pedestal.

② Voltage ramp acceleration.

③ Rated speed.

④ Soft stop, adjustable ramp down.

⑤ Discharge check valve opens. Either starter load-loss function (10 seconds delay) or quick shutdown function shuts off starter.

NOTE: Soft Stop Pump Control disables Kick Start and DC Brake functions.

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1-4 Technical Characteristics

Environmental

Temperature	0 to +45°C ①
Relative humidity	95% without condensation
Maximum altitude	3300 feet (1000m) ②
Mounting positions	Vertical

Electrical characteristics

Three phase supply voltage	500VAC + 10% maximum
Frequency	48 - 62Hz
Rated Current	11 ratings, 14 - 370A
Motor horsepower (KW)	7.5 - 300HP at 480V, (7.5 - 250 KW at 500V)
Motor voltages	200V, 230V, 460V (220V, 380/415V, 440V, 500V for IEC)
Control voltages	110/120VAC or 220/240VAC, 50/60Hz

Control characteristics

Control system	Digital system with microcontroller Starting ramp with progressive increase in voltage and current limitation
Starting	
Initial voltage (pedestal)	30 to 95% line voltage
Initial (starting) torque	10 to 90% Full voltage starting torque
Kick start	95% line voltage (90% Full voltage starting torque), adjustable 0 to 999ms
(Full Load) Motor current (in)	0.4 to 1.0 x 6 rated starter current (Ir)
Current limit	100 to 450% in (FLA)
Acceleration ramp time	1 to 999 sec
Running	
Energy savings	Output voltage reduction according to power factor of running motor to optimize system energy consumption
Override - energy savings	Fixed output voltage permanently equal to supply voltage, energy saving mode turned OFF
Stopping	
Coasting	With no soft stop or DC brake, power removed from motor
Brake time by ramp	Soft stop, 1 to 999 sec adjustable independently of starting ramp time (longer than coast down time)
Brake time DC injection	DC brake, 0 to 99 sec (set no longer than time to actual stop)
Braking current by DC injection	DC brake, 50 to 250% in

Reduced voltage starter operating modes

Acceleration phase	Adjustable time, initial torque, kick start, current limit
Running phase	Energy savings or Full voltage (Override mode) choice
Stop phase	Power cut-off (coasting) / Ramp down (soft stop) / DC Braking

Options

Linear ramp with tachogenerator feedback (selected with dip-switch 3)	1 to 999 sec
Slow speed (selected with dip switch 4 Selectable [7% or 14% speed] with dip-switch 3)	Current: In Time limit: 120 sec.

ASTAT Block Diagram

Ir = ASTAT Current Rating
In = Motor FLA

① Reduce rated controller current (Ir) by 1.5% /°C above 45°C, maximum 55°C.
② Reduce rated controller current (Ir) by 1% / 330 feet above 3300 feet, maximum 10000 feet
(1% / 100 meters above 1000 meters, maximum 3000 meters).

Inputs / Outputs

Starter control	Start/Stop/Bypass inputs
Inputs	4 isolated inputs for Start/Stop/Override energy saving/motor thermal protection input (PTC)
Input ratings	12VDC solid state optoisolators
Output auxiliary relays	1. Start/Fault (selectable, 1NO, 1NC) 2. Up to speed (1NO) 3. For DC brake contactor (1NO)
Relay output ratings	5A Maximum 120VAC 360VA, Pilot duty B300 & 1/3HP 45LRA 7.2FLA 240VAC 470VA Pilot duty B300 & 1/2HP 30LRA 5.0FLA General purpose DC ratings: 24VDC 8A, 48VDC 0.8A, 240VDC 0.1A

Protections

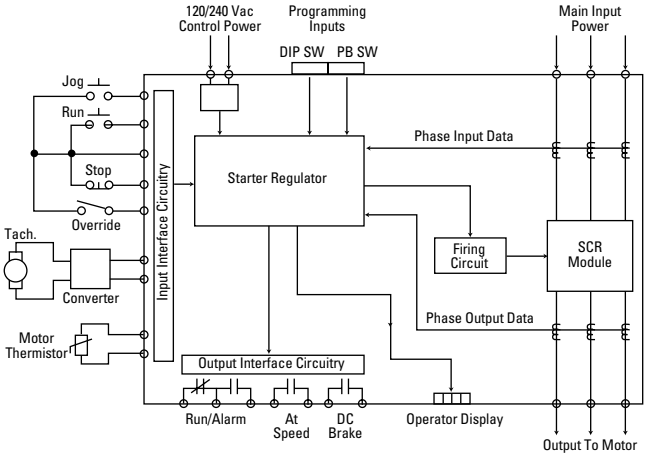
Current limit	Adjustable from 100 to 450% In
Overload (I^2 x t)	See figure on page 21 for cold starting overload conditions & time delay between starts
Loss of input phase	Trip at 3 sec
Thyristor short circuit	Trip at 200msec
Heatsink overheating	Trip at 200msec (trips at 80°C +/- 5°C, reset at 50°C +/- 10°C)
Motor thermistor	Trip at 200msec if thermistor impedance >response value
Loss of output phase	Trip at 3 sec
Stalled rotor	Trip at 200 msec
Supply frequency error	If frequency < 48Hz or frequency > 62 Hz will not start
No motor load	10 sec
Error (CPU)	60msec
Memory	Last four error codes
Long start time	2 times accelerating time(ta), 240msec. max. (Current limit ramp hold only)
Long slow speed time	120 sec

Features

SCR repetitive peak inverse voltage rating - 1600V standard
Transient Protection - Metal Oxide Varisters - QC2F through QC2M use 120 joules
- QC2N through QC2QS use 220 joules

Communications (Option)

Transmission mode	RS-422 or RS-485; 2 or 4 wires; semiduplex; 1:N
Transmission method	Asynchronous (1 bit START, 1 bit STOP, 8 bits ASCII DATA, selectable parity bit O/E/N)
Baud rate	9600, 4800, 3400 or 1200 selectable
Error detection	Parity and CHECKSUM
Maximum distance	3300 feet (1000 meters)
Maximum number of ASTAT stations within the net	16



GE ASTAT SOLID STATE STARTERS STANDARD DUTY

(300% / 450% Selectable) For Larger HP Ratings, Consult Factory (600 HP Max.)

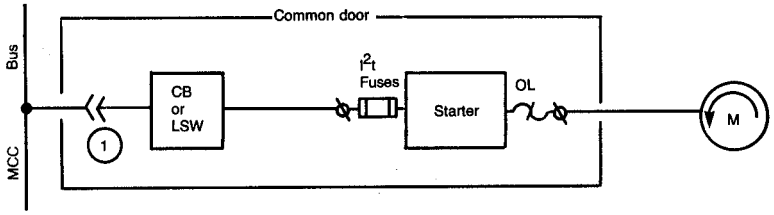
Function		NEMA Size	HP's @ 200/208	HP's @ 230/240	HP's @ 380/50 Hz	HP's @ 460/480	SSS Cat. No. FLA @ 1.15 SF	Disconnect	IC (KA)	Section 1 Width	Section 1 X Height	Section 2 Width	Section 2 X Height
.25	STAB IN	1	.1–.3	.1–.3	.1–7.5	.1–7.5	QC2GDA 13.9A	SELT, SELI	100	20" or 24"	2.0		
								QMW 30/30	100	20" or 24"	2.0		
			5–7.5	5–7.5	10		QC2IDA 27.8A	SELT, SELI	100	20 or 24""	2.0		
								QMW 30/30	100	20" or 24"	2.0		
		2			15	15–20		SELT, SELI	100	20" or 24"	2.0		
								QMW 60/30	100	20" or 24"	2.0		
			10	10–15	20–25	25	QC2KDA 54.8A	SELT, SELI	100	20"	4.0		
								QMW 60/30/60	100	20"	4.0		
SSS Basic		3	15	20	30	30–40		SELT, SELI	100	20"	4.0		
								QMW 100/60/100	100	20"	4.0		
			20–25	25–30	40–50	50	QC2MDA 91.3A	SELT, SELI	100	20"	4.5		
								QMW 100/60/100	100	20"	4.0		
		4	30		60	60		SELT, SELI	100	20"	4.5		
								QMW 200/100	100	20"	5.0		
			40	40–50	75	75–100	QC2QDA 187.0A	SELT, SELI	100	24"	5.5		
								SFLT, SFLI	100	24"	6.0		
								QMW 200/100/200	100	24"	6.0		
		5	50–60	60–75	100–125	125–150		SG	100	24"	5.5		
								QMR 400/200/400	100	24"	5.5	20"	4.0
			75	100	150	200	QC2SDA 321.7A	SG	100	30"	5.5	20"	2.0
								QMR 400/200/400	100	30"	5.5	20"	4.0
		6	100	125	200–250	250		SG	100	30"	5.5	20"	2.0
								QMR 600/400	100	30"	5.5	20"	5.5
	STAB IN	1	.1–3	.1–3	.1–7.5	.1–7/.5	QC2GDA 13.9A	SELT, SELI	100	20" or 24"	3.0		
								QMW 30/30	100	20" or 24"	3.0		
			5–7.5	5–7.5	10		QC21DA ;27.8A	SELT, SELI	100	20" or 24"	3.0		
								QMW 30/30	100	20" or 24"	3.0		
		2			15	15–20		SELT, SELI	100	20" or 24"	3.0		
								QMW 60/30	100	20" or 24"	3.0		
			10	10–15	20–25	25	QC2KDA 54.8A	SELT, SELI	100	20"	5.0		
								QMW 60/30/60	100	20"	5.0		
SSS with Bypass or Isolation		3	15	20	30	30–40		SELT, SELI	100	20"	5.0		
								QMW 100/60/100	100	20"	5.0		
			20–25	25–30	40–50	50	QC2MDA 91.3A	SELT, SELI	100	20"	5.5		
								QMW 100/60/100	100	20"	5.0		
		4	30		60	60		SELT, SELI	100	20"	5.5		
								QMW 200/100	100	20"	6.0		
			40	40–50	75	75–100	QC2QDA 187.0A	SELT, SELI	100	24"	5.5	20"	1.5
								SFLT, SFLI	100	24"	5.5	20"	2.0
								QMW 200/100/200	100	24"	5.5	20"	2.0
		5	50–60	60–75	100–125	125–150		SG	100	24"	5.5	20"	2.0
								QMR 400/200/400	100	24"	5.5	20"	4.0
			75	100	150	200	QC2SDA 321.7A	SG	100	30"	5.5	20"	3.0
								QMR 400/200/400	100	30"	5.5	20"	4.5
		6	100	125	200–250	250		SG	100	30"	5.5	24"	6.0
								QMR 600/400	100	30"	5.5	24"	6.0

GE ASTAT SS STARTERS HEAVY DUTY (500%)

Function		NEMA Size	HP's @ 200/208	HP's @ 230/240	HP's @ 380/50 Hz	HP's @ 460/480	SSS Cat. No. FLA @ 1.15 SF	Disconnect	IC (KA)	Section 1 Width	Section 1 X Height	Section 2 Width	Section 2 X Height
	STAB IN	1	.1–3	.1–3	.1–5	.1–7.5	QC2GDA 11.3A	SELT, SELI	100	20" or 24"	2.0		
								QMW 30/30	100	20" or 24"	2.0		
			3–5	5–7.5	7.5–10	10	QC21DA 22.5A	SELT, SELI	100	20" or 24"	2.0		
								QMW 30/30	100	20" or 24"	2.0		
		2			15	15		SELT, SELI	100	20" or 24"	2.0		
								QMW 60/30	100	20" or 24"	2.0		
			10	10–15	20–25	20–25	QC2KDA 44.4A	SELT, SELI	100	20"	4.0		
								QMW 60/30/60	100	20"	4.0		
SSS Basic		3	15		30	30		SELT, SELI	100	20"	4.0		
								QMW 100/60/100	100	20"	4.0		
			20–25	20–30	40–50	40–50	QC2MDA 74.0A	SELT, SELI	100	20"	4.5		
								QMW 100/60/100	100	20"	4.0		
		4	30–40	40–50	60–75	60–100	QC2QDA 151.5A	SELT, SELI	100	24"	4.5		
								SFLT, SFLI	100	24"	5.0		
								QMW 200/100/200	100	24"	5.5		
		5	50	60	100	125		SG	100	24"	5.5		
								QMW 400/200/400	100	24"	5.5	20"	4.0
			60–75	75–100	125–150	150–200	QC2SDA 260.6A	SG	100	30"	5.5	20"	2.0
								QMR 400/200/400	100	30"	5.5	20"	4.0
	STAB IN	1	.1–3	.1–3	.1–5	.1–7.5	QC2GDA 11.3A	SELT, SELI	100	20" or 24"	3.0		
								QMW 30/30	100	20" or 24"	3.0		
			3–5	5–7.5	7.5–10	10	QC21DA 22.5A	SELT, SELI	100	20" or 24"	3.0		
								QMW 30/30	100	20" or 24"	3.0		
		2			15	15		SELT, SELI	100	20" or 24"	3.0		
								QMW 60/30	100	20" or 24"	3.0		
			10	10–15	20–25	20–25	QC2KDA 44.4A	SELT, SELI	100	20"	5.0		
								QMW 60/30/60	100	20"	5.0		
SSS with Bypass or Isolation		3	15		30	30		SELT, SELI	100	20"	5.0		
								QMW 100/60/100	100	20"	5.0		
			20–25	20–30	40–50	40–50	QC2MDA 74.0A	SELT, SELI	100	20"	5.5		
								QMW 100/60/100	100	20"	5.0		
		4	30–40	40–50	60–75	60–100	QC2QDA 151.5A	SELT, SELI	100	24"	5.5	20"	1.5
								SFLT, SFLI	100	24"	6.0	20"	2.0
								QMW 200/100/200	100	24"	5.5	20"	2.0
		5	50	60	100	125		SG	100	24"	5.5	20"	2.0
								QMR 400/200/400	100	24"	5.5	20"	4.0
			60–75	75–100	125–150	150–200	QC2SDA 260.6A	SG	100	30"	5.5	20"	3.0
								QMR 400/200/400	100	30"	5.5	20"	4.5

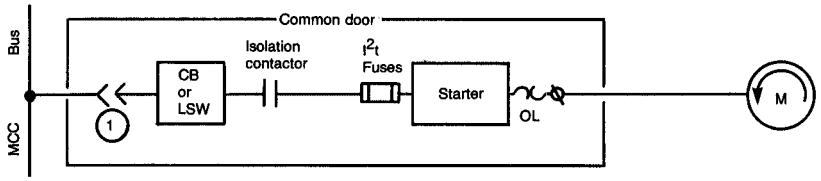
G

STANDARD REDUCED-VOLTAGE, NONREVERSING WITH PRIMARY DISCONNECT

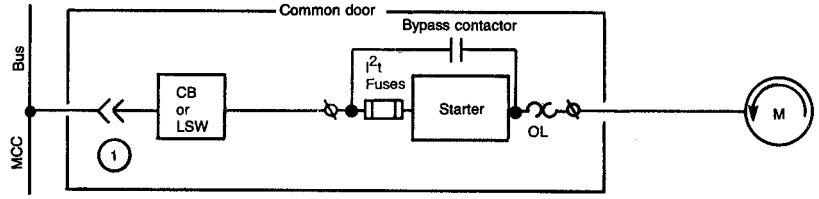


OPTIONS

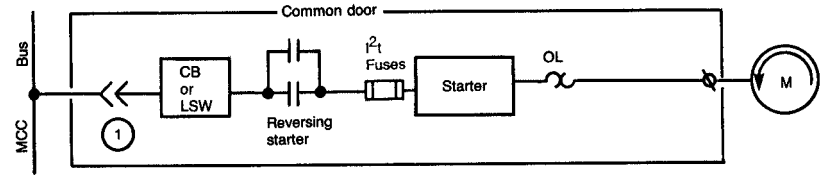
I. Solid-State Starter with Isolation Contactor



II. Solid-State Starter with Bypass Contactor



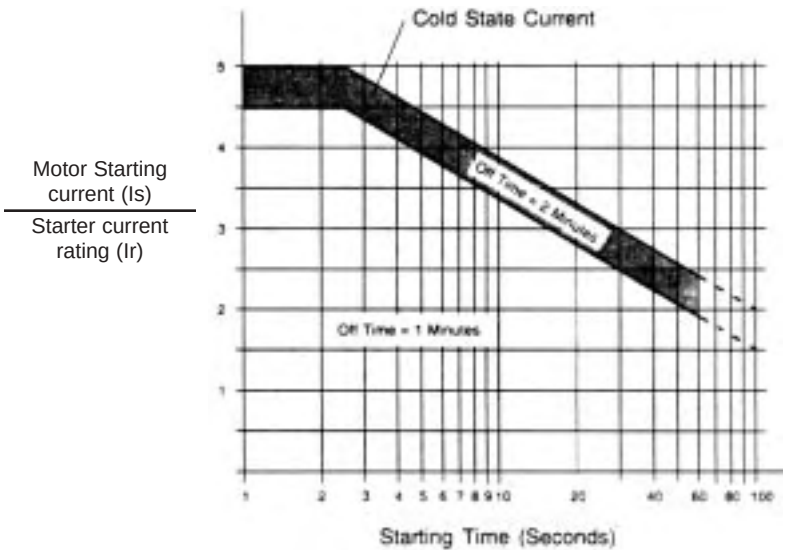
III. Solid-State Starter, Reversing



Motor Starting and Duty Cycle Conditions

The following illustration shows allowable motor starting currents according to the starting time.

The **OFF TIME** is the minimum amount of time between the motor stop and motor start. The duty cycle is the start time + stop time + off time. This graph will enable the user to develop a duty cycle within the capabilities of the motor starter ratings.



① Drawout through 225-ampere frame breaker/200-ampere fusible switch.

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.

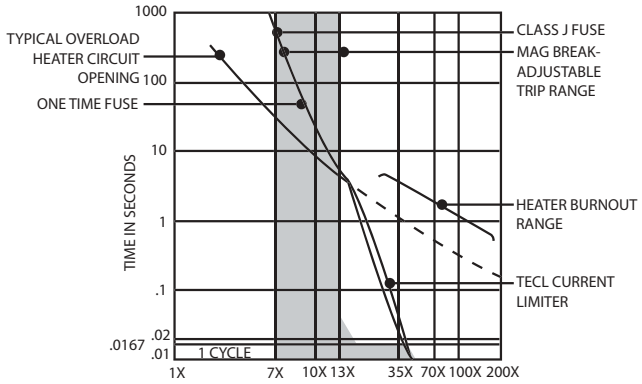
To minimize circuit damage, select precise, optimum trip points. Each pole of the Mag-Break breaker contains a current sensing element to trip the breaker instantaneously when the pre-selected current setting is exceeded. Mag-Break's unique magnetic system permits independent factory calibration of both 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 undervoltage 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.

H

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.

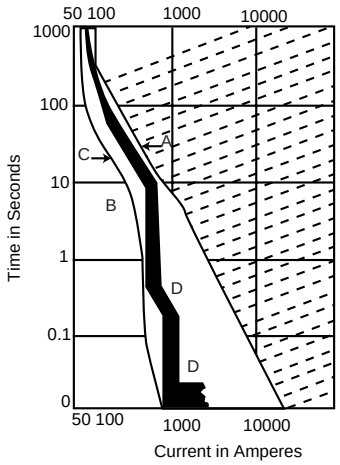
Use of this two-tiered time-current curve prevents nuisance tripping due to magnetizing inrush current, without compromising superior short-circuit protection during motor acceleration as indicated on page H3.

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.

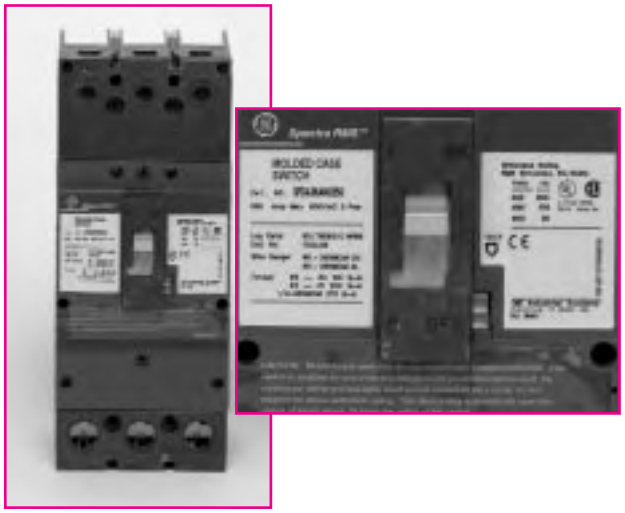
External Accessories. The full range of external circuit breaker accessories offered for use with Spectra RMS circuit breakers and Mag-Break motor circuit protectors, are available for molded case switches. In addition, plug-in bases, motor-operated mechanisms, mechanical interlocks, and the full complement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

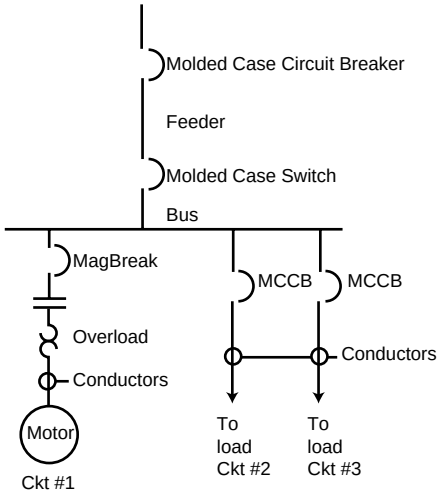
A common application of Spectra RMS molded case switches is illustrated below. The figure shows a system containing three branch circuits.

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

H

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.

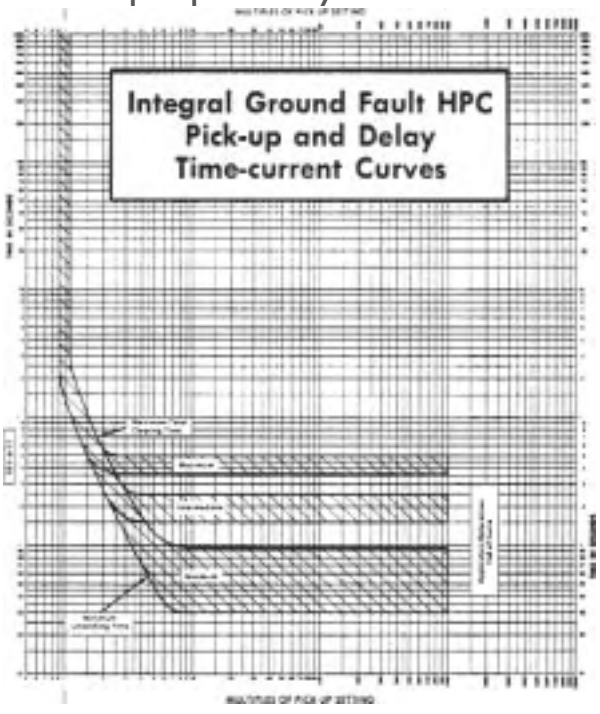
HPC switch with integral ground fault

Manual HPC switch

- 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.

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 read-out 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

H

Ground Break Systems

Type TGSR Protective Equipment

Description

The Ground Break system of solid-state ground fault signaling relays, sensors and monitor panels provides a new dimension in power-system protection. These components can be combined to operate at lower magnitudes of ground-fault current and shorter time delays than conventional over-current protective devices. The built-in memory function integrates intermittent faults with time providing protection against low-level arcing faults. The components which comprise a complete system are:

Solid-State Relay

Used in conjunction with devices having an electric trip, or shunt trip, this relay will sense ground currents and cause the interrupter to open when these currents reach a preselected value for a preselected length of time. Optional zone selecting interlocking is available for a fully coordinated system. This type of relay initiates an instantaneous trip when a fault occurs in its own zone. In addition, it will block upstream zone selective relays for a pre-set delay time to allow the downstream breaker to clear the fault.

Monitor Panel

Provides a ground fault indicator, control power indicator and TEST and RESET buttons. The control circuitry offers the ability to test the complete Ground Break system with or without tripping the interrupter.

Current Sensor

Solid- or split-core construction for easy installation, includes an integral test winding for checkout of the complete system. A large variety of window sizes are available.

System Selection Guide

Sensors may be used 1 per phase or any other combination. For this type of use all outputs except "T" should be connected in parallel. When sensors are used more than 1 per circuit the thermal rating (current) must not be less than the maximum phase current.

- Maximum ground and phase fault current withstanding ratings
  200,000 amperes for 0.1 second
  60,000 amperes for 1.0 second
- Thermal ratings (maximum continuous current which can exist without overheating the sensor)
  TGM Sensors–600 amperes
  TGS0002–1600 amperes
  TGS0005–2500 amperes
- Dielectric withstand:
  Windings to mounting bushings–1.5 kV
  Windings to CT window surface–2.2 kV
  Mounting bushings to CT window surface–2.2 kV
- Current Transformer Ratio–800:1 except type TGM
- Integral Test Winding Ratio–1:700 except type TGM

Features

- Current Transformer Insulation–cast Epoxy all sizes
- UL recognized, File E51048
- Instantaneous zone-selective trip for optimum system coordination and protection.
- Heavy-duty design permits direct operation of electric trip and alarm devices without external relays.
- Dependable operation–solid-state relay, cast insulated sensor.

Solid state relay | Current sensor | Motor panel

- Two NO contacts, one of which is electrically isolated from the electronic device.
- Output contact rating 5 amperes continuous, 30 amperes inrush, up to 240 volts AC or 125 volts DC.
- Adjustable pickup and delay time.
- Memory function for system protection against intermittent arcing faults.

Relays

Control Voltage	Adjustable Trip Range Amperes LO	Adjustable Trip Range Amperes HI	Standard Catalog Number	Zone Selective Catalog Number
120 VAC	5	60	TGSR06	TGR06Z
125 VDC	5	60	TGSR06	TGSR06Z
48 VDC	5	60	TGSR06B	TGSR06BZ
36 VDC	5	60	TGSR06C	TGSR06CZ
24 VDC	5	60	TGSR06D	TGSR06DZ
120 VAC	100	1200	TGSR12	TGSR12Z
125 VDC	100	1200	TGSR12	TGSR12Z
48 VDC	100	1200	TGSR12B	TGSR12BZ
36 VDC	100	1200	TGSR12C	TGSR12CZ
24 VDC	100	1200	TGSR12D	TGSR12DZ

Monitor Panels①

Control Voltage	With GP Indicator Light Catalog Number	With Mechanical Target GF Indicator Catalog Number
120 VAC	TGSMP	TGSMA
125 VDC	TGSMPA	.....
48 VDC	TGSMPB	.....
36 VDC	TGSMPC	.....
24 VDC	TGSMPD	.....

① Monitor panel requires 120 volts AC for system test function.

Current Sensors

Window Diameter (Inches)	Catalog Number	Construction	Test Winding
21/2	TGS0002	Round-Solid Core	Yes
5	TGS0005		
8	TGS0008		
4 X 8	TGS0408	Rectangular-Split Core	Yes
4 X 18	TGS0418		
4 X 24	TGS0424		
4 X 32	TGS0432		
8 X 8	TGS0808		
8 X 10	TGS0810		
8 X 18	TGS0818		
8 X 24	TGS0824		
8 X 32	TGS0832		
8 X 38	TGS0838		
11 X 13	TGS1113		

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

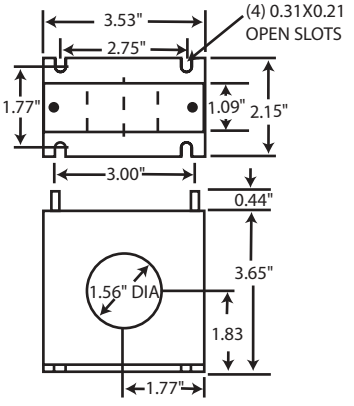
Time delay from instantaneous to 36 cycles (GFM-262).

Trip currents from 3.8 to 18 amperes (size 1 to 4 starters)
5 to 20 amperes (size 5, 6, 7 starters)

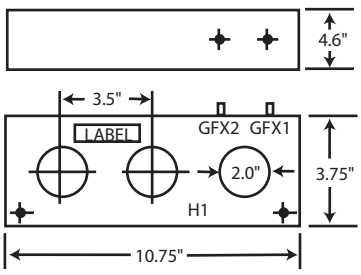
General

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 Number	Trip① Current
GFM 156	3.8 to 18



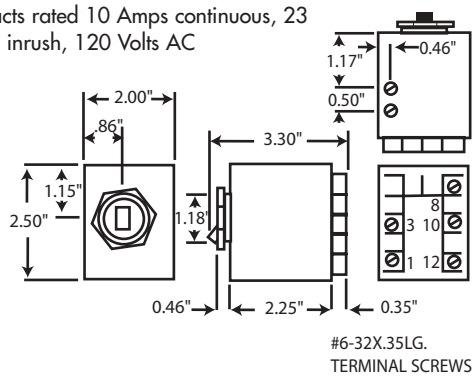
Model Number	Trip① Current
GFM 3P208	5 to 20

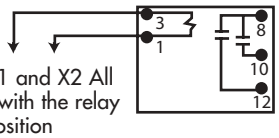


① Trip current tolerance is ± 15 percent.

Model GFM-252, 262

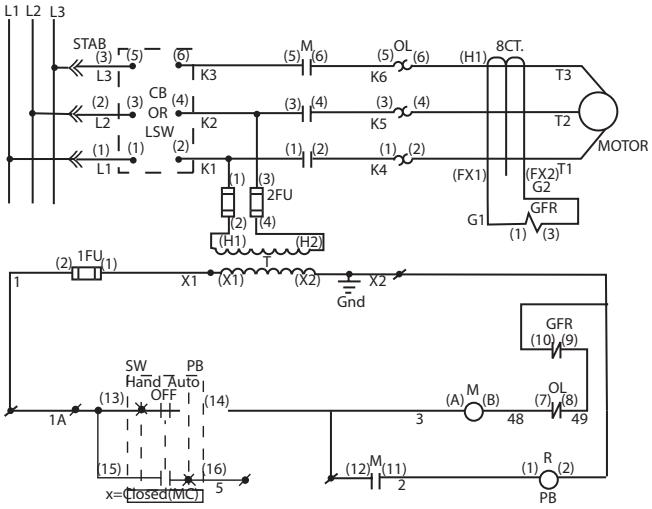
Contacts rated 10 Amps continuous, 23 Amps inrush, 120 Volts AC





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

Typical Circuit

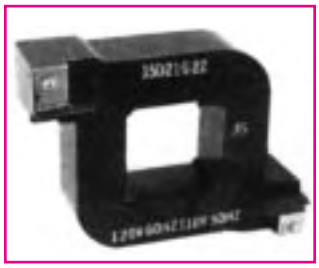


300-Line Motor Starters

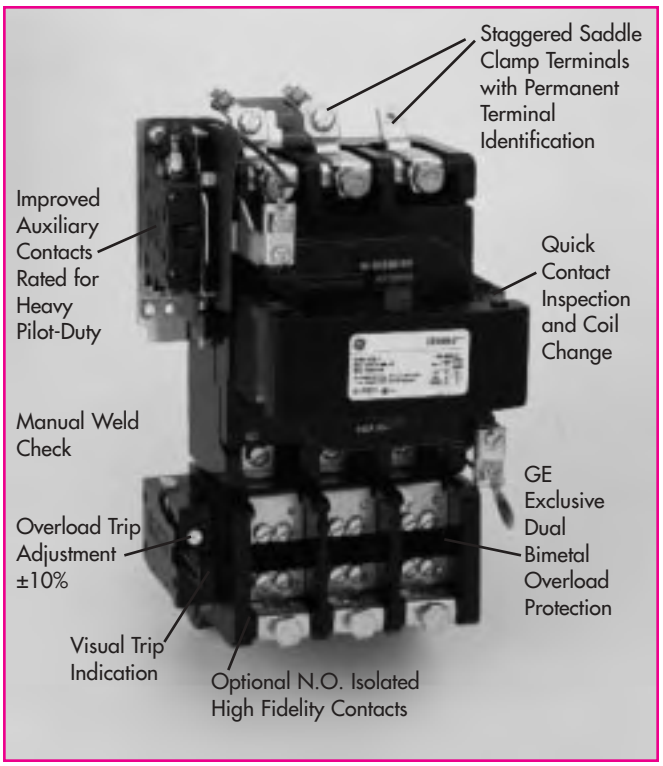
The 300-Line starter is a full-voltage, magnetic motor starter with encapsulated coil and three-leg block overload relay with visual trip indicator, manual reset and manual weld check. It incorporates all the features and benefits most asked for by users and has received standard specification approval 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.

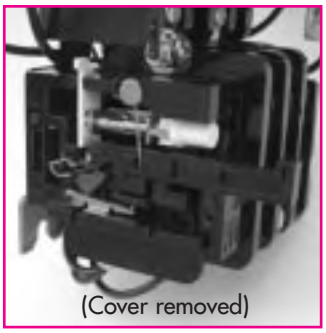
Optional terminals can be provided to permit the easy connection of power factor correction capacitors for energy conservation.



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.



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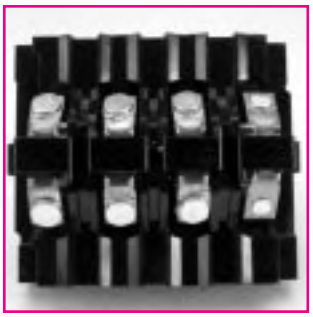
Where it's essential to monitor performance or diagnose faults, a 300-Line starter may be ordered with an additional isolated, high-fidelity, normally-open contact on the overload relay. This contact may be used for direct input to a programmable controller or direct interface with a computer.

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.

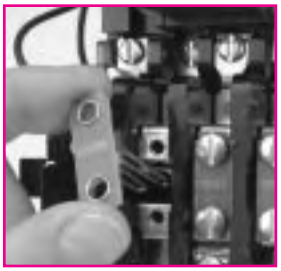


On NEMA Size 1 starters and larger, contact tips are weld-resistant with cool operation and extended life. The contacts have a wedge-shaped configuration for positive make with minimum bounce. They can be easily changed from normally open to normally closed without additional parts on Sizes 0 and 1. 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.

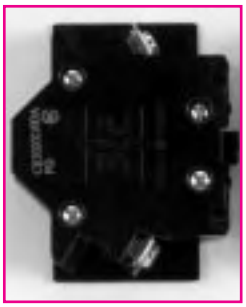
Overriding is eliminated because overload reset occurs only when the reset arm is released on the standard manual-reset form.

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	Spectra RMS Electronic Control Module
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 interchangeable match overload relays to motor amps. A ±10 trip adjustment dial is used to fine tune the motor overload relays. Overload relay features include trip test, manual reset on upstroke, weld check visible trip indicator and an optional normally - open signal contact.	The 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, adjustable phase unbalance, 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 Electronic Control Module uses Spectra RMS E, F, G, & K circuit motor protectors with a module to provide advanced motor protection. The module features phase loss unbalance, selectable ground fault, selectable phase unbalance, communications, unit accuracy and compatibility with GE Power Leader System Modules. Adjustment range is accomplished merely by changing the table without removing the power wiring. The Electronic Control Module is compatible with all existing MCC Spectra RMS installations. For Display and Keypad, see H-12
NEMA Size	1–6	1–6	1–6
Type	Thermal bimetal	Electronic	Electronic
Protection Class	20	10, 20, 30 (selectable)	10, 20, 30 (selectable)
Ambient Compensation	Optional	Ambient insensitive	Ambient insensitive
Phase loss protection	No	Standard (fixed)	Selectable (On–Off)
Phase unbalance	No	Adjustable 20–50%	Selectable (On–Off) Fixed at 25%
Ground Fault	No	No	Yes (5A, Zero sequence)
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	2:1
Reset Mode	Manual (auto optional)	Manual	Manual
Trip Test	Yes	Yes	Yes, with commnet (digital self-diagnostics)
Trip Indication	Yes	Yes	Yes, with commnet (last fault diagnostics)
FVNR, FVR	Yes	Yes	Yes
2 Speed, 1 & 2 Winding	Yes	Yes	No
Operating Temp. Range	0° to 55°C	–20° to 70°C	–20° to 80°C
Communications	No	No	Yes, with commnet
Addressable	No	No	Yes
Power Leader Compatible	No	No	Yes
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, with commnet
Aux. Contacts	NC (NO optional)	NO, NC	NO, NC
Reference Publication	—	DEA-015	DET-069

Spectra ECM™ Electronic Control Module

Module & Accessories for Motor Protection and Control

Spectra ECM Control Module with rating plug harness connection for Spectra RMS molded-case circuit breaker

Overview

The Spectra ECM is a microprocessor-based digital device which provides advanced motor protection, control and communications capability for full-voltage non-reversing (FVNR) and reversing (FVR) combination starter applications.

The ECM is available exclusively with Spectra RMS E-, F-, G-, and K-Frame molded-case circuit breakers. Integral to the system is a special rating plug harness connecting the rating plug of the Spectra RMS circuit breaker to the ECM, providing the module with three-phase RMS current sensing capability.

Enhanced Product Functionality

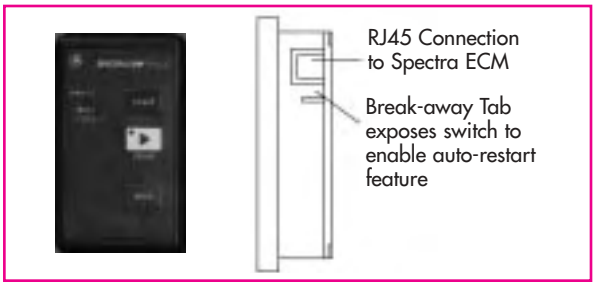
Capable of one or two contactor control, elapsed run time monitoring, enhanced trip notification, and undervoltage protection. Compatible with both POWER LEADER™ and SDS™ communications systems.

Product Features

- Available for NEMA Starter Sizes 1 through 6 in three-phase FVNR and FVR applications.
- Electronic overload protection with 3:1 current adjustability.
- User selectable motor protection classes 10, 20, 30.
- Phase current unbalance/loss protection.
- Undervoltage protection.
- Equipment ground fault protection with external zero sequence current transformer.
- Thermal model tracks motor heating characteristics.
- Built-in self-test digital electronics.
- Supports both local/remote control interfaces.
- DeviceNet①, POWER LEADER and SDS compatible

Spectra ECM Display Accessory

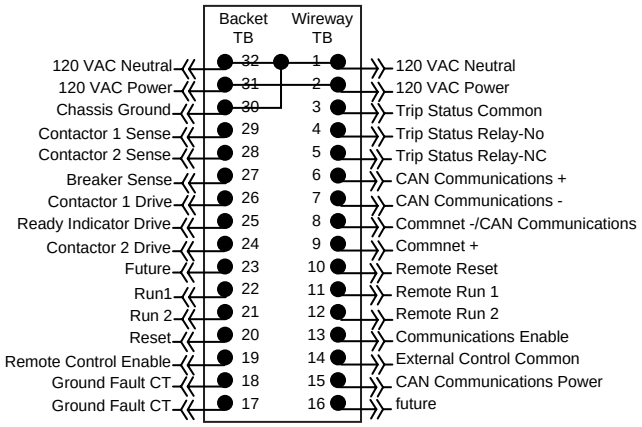
- 2 line 16 character alphanumeric LCD local display showing:
  - ECM settings–overload, ground fault, and phase loss/unbalance protection settings, communications address.
  - Motor and ECM status information (START/STOP/RUN etc.)
  - Trip indication and pre-trip current information.
  - Metering–individual and average phase currents, elapsed motor run time, motor load, phase unbalance, ground current, control voltage.



Spectra ECM Control

- Five controllers for FVNR and FVR applications:
  - HAND/OFF/AUTO
  - START/STOP
  - HAND/OFF/AUTO/START/STOP
  - FWD/REV/STOP
  - FWD/REV/AUTO/OFF
- Motor status and trip indication LEDs.
- Maintained or Instantaneous selection.

Spectra ECM Pin Assignments



External wiring notes:

- Pin 19 Auto must have 120V to enable the remote control (Key Pad in Auto)
- Pin 14 is common neutral for 10, 11, 12 & 13, jumper pin 14 to 1 if common source.
- Pins 2 & 13 need to be connected to enable communication control (120V input)
- SECMOD02 has Commnet communication use Pins -8 & +9, selfpowered
- SECMOD03 has SDS/CAN Communication use Pins +6 & - 7, (requires 24V DC, Pins 8 Neg. & 15 Plus)
- SECMOD04 has DeviceNet/CAN Communication use Pins+6 & -7, (requires 24V DC, Pin 8 is Neg. & 15 Plus)

Factory defaults: FLA = Minimum, Class = 20, Phase Unbalance = ON, GF=OFF unless ordered with GF sensor, Communication address = 000.

Reference: GEH-6435A, DEH-40125, DEH-035

① ODVA approved.

Mini-Contactors

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

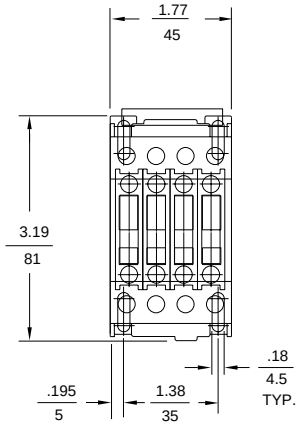
Pneumatic timers are adjustable time-delayed auxiliary contacts. They come equipped with two time-delayed contacts: 1NO or 1 NC, electrically separated. Setting is scaled over a 350° rotation by means of a knurled knob with timing guide marks. To mount a pneumatic timer, simply clip it on front face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

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

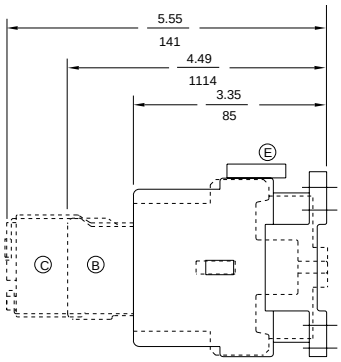
Surge Suppressor

For suppression of disturbances on electronic circuits due to the coil transient voltage occurring on opening of the contactor.

Control Relay - Front View



AC Control Relay - Side View



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.

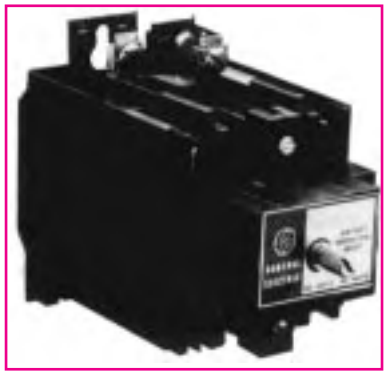
Features

- 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		

CR7R Industrial Timing Control Relay

The CR7R industrial control timing relay is a compact relay designed for heavy-duty industrial control applications where reliability and versatility are required.

- Compact mounting dimensions
- Mounted on vertical plane
- Straight-through wiring
- Easy coil replacement
- Long contact life
- High operating speed
- Silver alloy contacts
- Tropicalized throughout
- Captive terminals
- Rated 600 volts
- UL Listed
- Pull-in volts — Min. 85% Rated Voltage
- Drop-out volts — 50% or less Rated Voltage
- Mechanical Life — In excess of 10 Mill. OPS
- Contact Life — In excess of 1 Mill. OPS

Relay Contacts

Contact Arrangement
4 NO
3 NO, 1 NC
2 NO, 2 NC

Timer Contacts

NO, 1 NC Time-Delay Contacts	
Delay (Convertible)	Range (Seconds)
TDE/TDD	0.3–30
TDE/TDD	10.0–180

Contact Ratings – For Relay Contacts and Timer Contacts

Max. AC Voltage	Max. Continuous Amperes	Max. AC Voltamperes		Max. AC Amperes		Max. DC Amperes – Break or Make					
						Relay			Timer		
		Make	Break	Make	Break	24V	125V	250V	24V	125V	250V
600	10	7200	720	60	6	5.0	1.1	0.55	2.5	.55	.27

Coil Ratings

AC Coil Rating		DC Coil Rating
24V/60 Hz	24V/50 Hz	24 VDC
48V/60 Hz	48V/50 Hz	48 VDC
120V/60 Hz	110V/50 Hz	125 VDC
208V/60 Hz	190V/50 Hz	250 VDC
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	

AC Inrush	Holding
VA	VA
55	9
DC Inrush	Holding
W	W
8.5	8.5

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, watertightness and long life are essential.

All units are suitable for use in Type 1, 3, 3R, 4, 12 and 13 environments when mounted in enclosures rated for those same applications.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 ½X Starter. See GEP-1260, Section 9.

Solid-State Motor Winding Heater

Description

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

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

Specifications

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

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

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

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

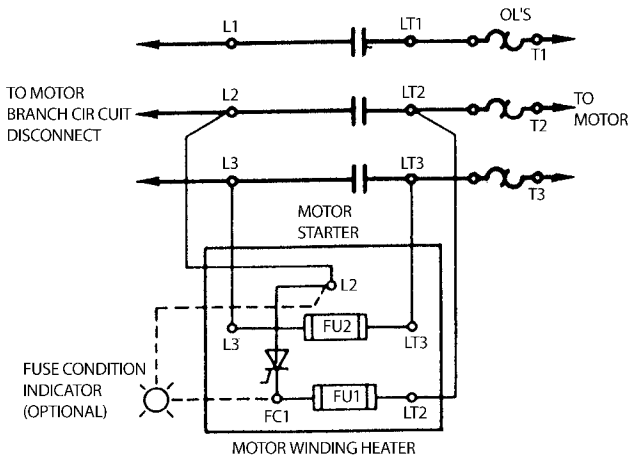
Motor Voltage +10%, –15% 3-Phase 60 Hz	Motor Horsepower Range
230/460V	15-400 Hp
575V	25-400 Hp

Heater is UL Listed in MCC Construction

Applications

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

Typical Wiring Diagram



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

H

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%.

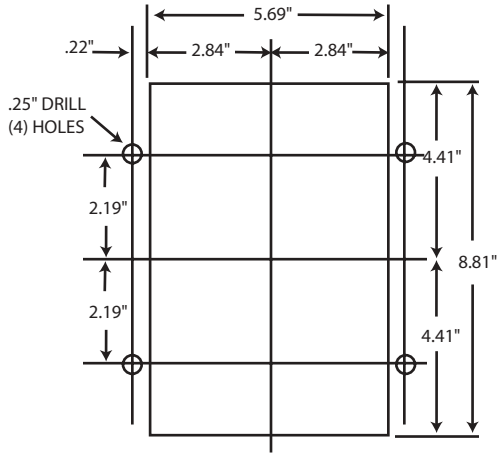
Optional communications provides connectivity to POWER LEADER network (commnet) and Modbus RTU.

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)

Power Leader Modbus Monitor

- Convenient, in-equipment viewing of data from local and remote power management devices — breakers, relays, meters, controllers
- Critical alarms and events can be quickly and easily viewed at one location
- Easy-to-use, menu-driven interface
- Customizable data display adapts to specific needs
- Compatible with GE's Power Management Control System software (Version 5.1 or greater)
- Upgradeable firmware
- Free configuration and download tool included

Standard Features

- Remote viewing of device data
- Supports up to 31 Modbus devices and 215 commnet power management devices
- View up to 50 events
- High-speed communications via RS-485 network
- Customizable data display
- Flash-ROM upgradeable to support future enhancements and new devices
- Compatible with GE's Power Management Control System for remote viewing of PMCS event log
- Universal power supply accepts 100-240Vac, 125-250Vdc
- Password protection prevents unauthorized configuration changes

Optional Features

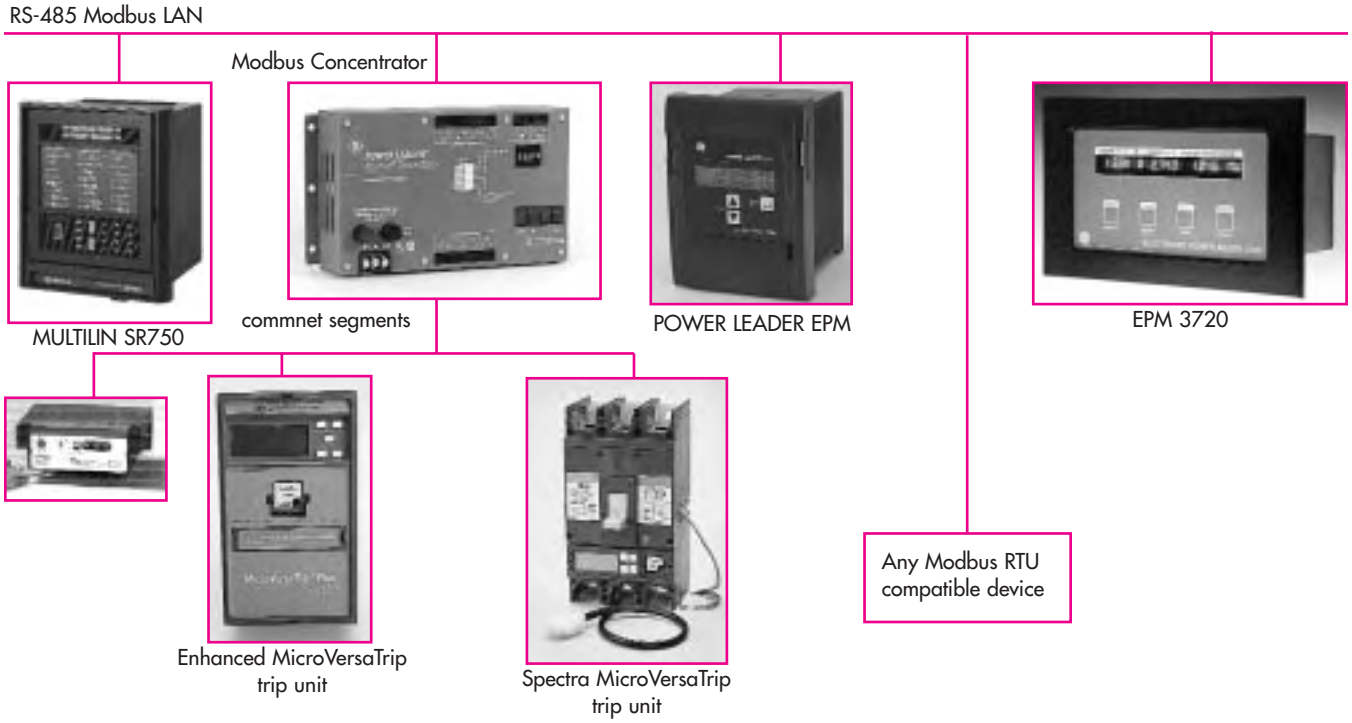
- Single- and dual-port RS-485 Modbus versions available

Standards

- UL Listed
- CSA Certified

In addition, the Modbus Monitor supports any third-party device with register-based Modbus RTU communications over RS-485 networks.

The Modbus Monitor is not certified to be compatible with any Modbus master other than GE's PMCS version 5.1 or greater.



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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)

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.

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

GEPQMT20CA See GE Multilin Products Catalog and www.ge.com/edc/pmsys

H

Three-Phase Voltage Monitors

Model SPVR

General

UL Listed file No. E103039

The model SPVR is a three-phase voltage monitor which uses negative phase sequence monitoring to protect against phase loss and phase unbalance in a three phase system. It is recommended for main breaker applications since the output relay only changes state when the unbalance is detected. Note that when the optional over/under voltage functions are included, the output relay is energized when conditions are correct and de-energizes on fault, similar to the model LPVR.

Standard Features

- Phase unbalance: 12% (6% recommended for motor load protection)
- Phase loss protection
- Adjustable Trip Delay: 1 to 10 seconds after failure occurs
- Automatic Reset to Normal: upon removal of fault conditions
- Output Relay: nomally de-energized, form C contacts
- Electro-mechanical fault indicator: manually reset
- Status Indicator: bi-colored LED

  Green: Output relay de-energized (normal state)
  Red: Output relay energized (fault condition)
  Dark: Loss of power

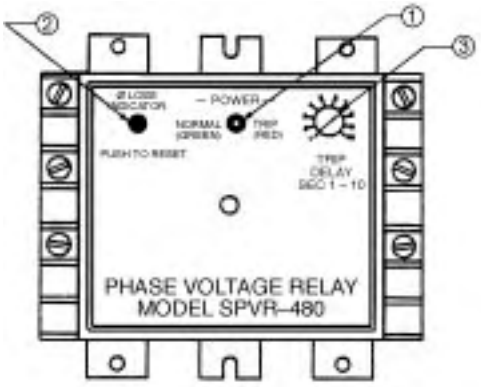
Optional Features

- Phase Reversal Protection: operates output relay instantaneously, has LED indicator
- Phase Sequence Protection: (same as phase reversal)
- Overvoltage and Undervoltage Protection: output relay de-energizes after preset time delay, if system voltage is over 115% or under 80%. (reset values are 107% and 90% respectively)
- Phase Unbalance: 6% (recommended for motor loads)

SPVR — XXX — XXXXX

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

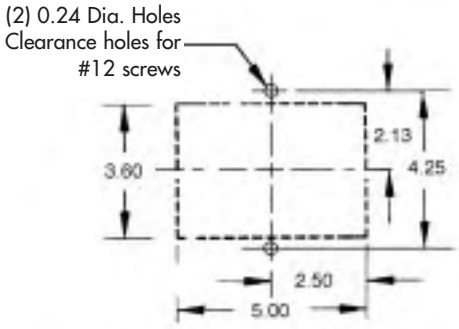
Optional Features:
M – Manual Reset with local Push Button
O – Over and Under Voltage protection
R – Phase Reversal/Sequence protection
U – Phase Unbalance 6%



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

② Electromechanical Diagnostic Indicator
- Phase loss

③ Adjustable System Delay
- Phase loss
- Phase unbalance



Panel Mounting Layout

Available Models

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

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 LPVR

General

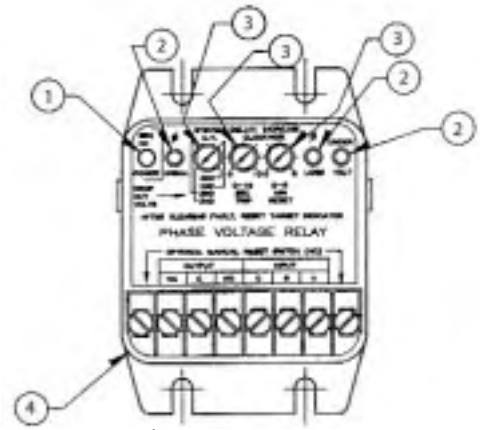
U.L. Listed file No. E103039

The model LPVR is a three-phase voltage monitor which uses negative phase sequence monitoring to protect against phase loss, phase reversal, and undervoltage on the power system. Electromechanical diagnostic indicators (manually reset) show trip condition due to phase unbalance, phase loss, and undervoltage. A green led indicates that the power system has no faults present and that the phases are in sequence.

- Provides pre-start and running protection.
- Fully rated 600 volt contacts.
- Diagnostic indicators continue to show cause of operation after voltage removed.
- Adjustable under voltage trip point settable to 75% of nominal.
- Adjustable trip delay from 50 milliseconds to 10 seconds.
- Adjustable reset delay from 1 second to 5 minutes.
- Operates at 6% phase unbalance.
- Operates with a 12.5% phase voltage loss.
- Automatic or manual reset, local or remote.
- Operational green LED indicator.
- Failsafe–will not operate if fault is present.
- Isolated Form "C" output contacts.
- Terminal screws are #6-32 nickel-plated brass.

Available with the following 3 Phase Voltages

P/N	Nominal Rating	Voltage Range
LPVR 120	120	90-125
LPVR 240	240	180-250
LPVR 480	480	360-500
LPVR 575	575	430-600

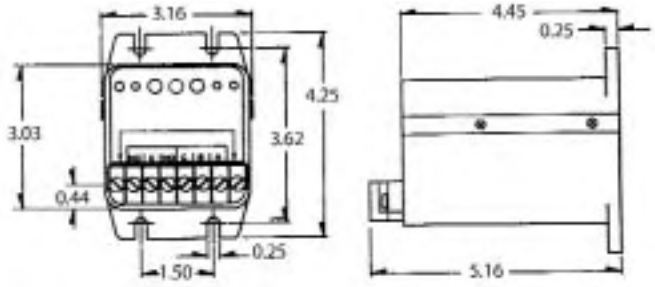


① Green LED Indicator
- Power system condition.

② Electromechanical Diagnostic Indicator
- Phase unbalance.
- Phase loss.
- Undervoltage.

③ Adjustable System Delay
- Undervoltage trip point.
- .05 - 10 second trip delay.
- 0 - 5 minute reset delay.

④ Terminal Block
- Automatic or manual reset.
- Input Voltage – 120 to 575 volts.
- Output Contacts – Form C, 1 NO & 1 NC.



Model APVR

General

UL 103039

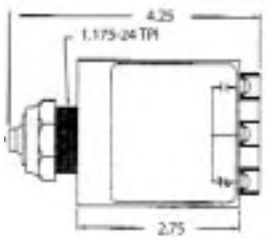
The model APVR phase sensing relay performs the same functions as the model LPVR, except that the relay requires no adjustments. It will fit in the push-button bracket, and thus does not increase the required unit spacing.

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)



Illuminated green indicator

High-Resistance Grounding Unit

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.

240, 480, or 600 Volt Systems

Equipment Range

Taps are provided on the standard DS9181 grounding resistor to adjust for a system charging current maximum of 3.56 amps or less. Since the normal charging current for most 600 volt or less systems is usually below one ampere, our standard equipment is adequate; however, for systems with greater charging currents refer to the Company for a quotation. Data for estimating the system charging current is shown in GEK-83750.

Description of modifications applicable to all panels.

Mod.	Item	Function
UV	Undervoltage Relay	Drops out on low voltage and provides auxiliary contacts for motor relay failure remote alarm.
TR	Timing Relay	Prevents nuisance tripping on temporary transient faults.
CT	Current Transformer	Detects ground current
AM	Ammeter	Indicates ground current

Specifications

Equipment Included in Standard 240, 480 or 600 volt Wye and Delta Systems

1–Line disconnect switch, three phase, interlocked with the door
3–Line fuses, 600 volts, 10 amp, interrupt 200,000 amps RMS symmetrical
3–Neutral deriving transformers, dry-type (delta system only)
1–Control power transformer (CPT)
1–Meter relay (double set point)
1–Pulsing contactor, set to produce approximately 40 current pulsations per minute
1–Neutral-grounding resistor
1–Relay for pulsing contactor
1–Control relay, with interlocks for remote alarm
1–"Ground Fault" red indicating light
1–"Normal" green indicating light
1–"Normal-Pulse" selector switch
1–TEST resistor
1–TEST push button (momentary type)
1–Instruction plate on door
1–Enclosure
1–Portable ground-current detector with carrying case (Optional–must be ordered as a separate item)
X–Control circuit operates from 120 volts supplied by secondary of CPT.
X–All connections to control and annunciator circuits wired to terminal boards
X–Cable entry from top or bottom
X–Optional Modifications (See table below)

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

High-Resistance Grounding Unit

Standard Equipment Operation

The circuits used for low-voltage systems are shown in Fig. 1 and Fig. 2.

During normal conditions, with no ground fault on the system, only a small magnetizing current (capacitance-charging current) flows in the grounding transformers and no voltage appears across the resistor.

When a ground fault occurs, the resistor limits the ground current to a low value.

Taps are provided on the resistor to adjust the magnitude of the ground current in the range of 0.9 to 3.6 amperes, depending on the size of the system, so that the current supplied by the resistor to a ground fault will be slightly greater than the system's natural capacitance-charging current.

The voltage appearing across the resistor will be sensed by the meter relay. Auxiliary contacts in the control, operated by the meter relay, are available for remote indication and annunciation of a ground.

A green indicating light on the equipment indicates that control voltage is available and that the system is normal. When a fault develops, a red indicating light on the equipment will light and remain lighted until the ground fault is removed. If no remote annunciator is available to notify the operator, an audible alarm may be added to the equipment as an option. A rotating red signal beacon can be used in noisy or remote installations.

To trace the ground fault, the operator turns the selector switch to the "pulse" position. This initiates cycle timing, alternately energizing and de-energizing a shorting contactor at the secondary resistor, resulting in a rhythmic fluctuation in the magnitude of the ground current.

The portable hook-on detector is then used to trace the fluctuations in ground current through the system to the point of fault. After the ground point has been located and removed from the system, the operator then resets the selector switch to de-energize the pulse-cycle timing circuits.

The ground transformer for delta systems will consist of three single-phase transformers connected wye-delta. For wye systems, where system neutral is available, these grounding transformers are not needed.

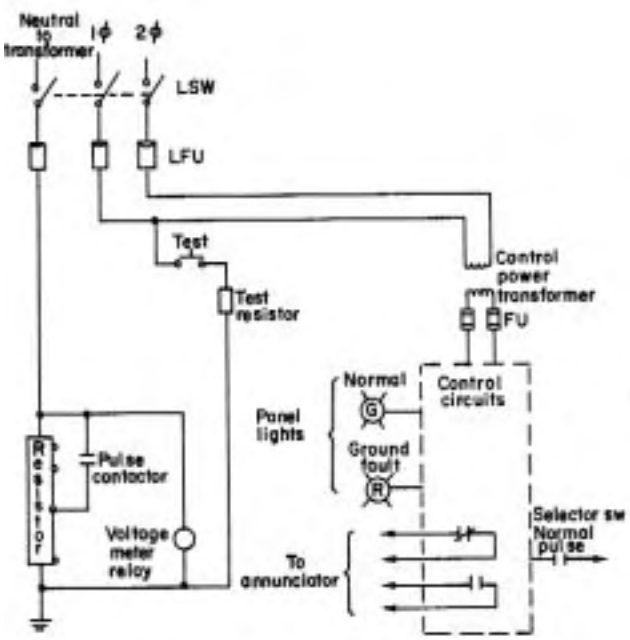


Fig. 1 600 volts maximum wye systems

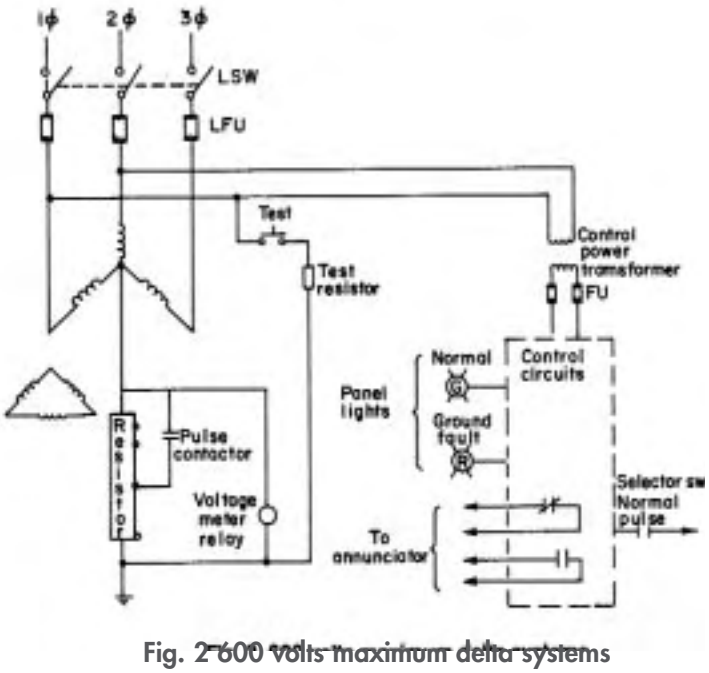


Fig. 2 600 volts maximum delta systems

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
¼①	1800	1.6	1.4	0.70	0.56
	1200	1.7	1.5	0.75	0.60
½①	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
½	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
¾	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
1½	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
7½	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

① Open, Type K, general purpose, NEMA SF, solid base, rolled-steel-shell, GE induction motors.

Motor HP	Synchronous Speed, RPM	Average Expected Values of Full-load Currents			
		200V	230V	460V	575V
25	3600	72.0	56.0	28.0	25.0
	1800	71.3	60.0	30.0	24.8
	1200	73.8	63.2	31.6	25.7
	900	82.6	71.8	35.9	28.7
30	3600	85.6	67.8	33.9	29.8
	1800	81.7	71.2	35.6	29.9
	1200	88.6	73.8	36.9	30.8
	900	92.2	80.2	40.1	32.1
40	3600	101	89.0	44.6	39.2
	1800	112	97.8	48.9	40.3
	1200	114	99.6	48.5	39.8
	900	122	105.8	52.9	42.3
50	3600	140	129	64.5	48.9
	1800	142	122	61.1	49.4
	1200	144	125.2	61.0	50.1
	900	159	138.2	69.1	55.3
60	3600	163	145.6	72.8	56.6
	1800	172	147.4	73.7	59.9
	1200	172	149.2	69.8	59.7
	900	176	153.4	76.7	61.4
75	3600	206	181	90.5	71.5
	1800	207	180.0	91.6	72.0
	1200	206	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

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-7 through J-15.

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	

Thermal Magnetic Trip Ratings for Motor Circuits

These selections are based on 1999 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	100	100
4	30	SF SGL	125				
	40		200	150			
	50			200			
	60				150	125	100
	75				200	200	125
	100					200	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	50	SRPE60A50	100	
		30	30	40		70	SRPE100A70		
25	25	50	50	50		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.

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.

Provide short circuit protection in accordance with the National Electrical Code.

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

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 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		

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Overload Heater Tables

Heaters for Mag-Break 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

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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

Size 3 (Standard and Ambient Comp.) cont.

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR123	SE Rating Plug	Mag-Break Trip Setting	
			Rec.	Max.
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 1.59	CR324CXD	E Mag. & Thermal Mag.
1	1.6 to 3.19	CR324CXE	E Mag. & Thermal Mag.
1	3.2 to 6.49	CR324CXF	E Mag. & Thermal Mag.
1	6.5 to 12.8	CR324CXG	E Mag. & Thermal Mag.
1	13 to 27	CR324CXH	E Mag. & Thermal Mag.
2	13 to 25.6	CR324DXG	E Mag. & Thermal Mag.
2	26 to 49.9	CR324DXH	E Mag. & Thermal Mag.
2	50 to 100	CR324DXJ	E Mag. & Thermal Mag.
3	17 to 34.9	CR324FXK	E Mag. & Thermal Mag.
3	35 to 64.9	CR324FXL	E Mag. & Thermal Mag.
3	65 to 90	CR324FXM	E Mag. & Thermal Mag.
4	17 to 34.9	CR324FXK	E,F&G Mag. & Thermal Mag.
4	35 to 64.9	CR324FXL	E,F&G Mag. & Thermal Mag.
4	65 to 135	CR324FXM	E,F&G Mag. & Thermal Mag.
5 ①	32 to 64.0	CR324GXN	G Mag. & Thermal Mag.
5 ①	65 to 129.9	CR324GXP	G Mag. & Thermal Mag.
5 ①	130 to 270	CR324GXQ	G Mag. & Thermal Mag.
6 ②	130 to 259.9	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.

Overload relay tripping current in 40°C ambient is the minimum value of 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.

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.

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

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.

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 1.59	CR324CXD	Class R 30	Class J 60
1	1.6 to 3.19	CR324CXE		
1	3.2 to 6.49	CR324CXF		
1	6.5 to 12.8	CR324CXG		
1	13 to 27	CR324CXH		
2	13 to 25.6	CR324DXG	60	100
2	26 to 49.9	CR324DXH		
2	50 to 100	CR324DXJ		
3	17 to 34.9	CR324FXK	100	200
3	35 to 64.9	CR324FXL		
3	65 to 90	CR324FXM		
4	17 to 34.9	CR324FXK	200	400
4	35 to 64.9	CR324FXL		
4	65 to 135	CR324FXM		
5 ①	32 to 64.0	CR324GXN	400	600
5 ①	65 to 129.9	CR324GXP		
5 ①	130 to 270	CR324GXQ		
6 ②	130 to 259.9	CR324HXS	600	Class L 1200
6 ②	260 to 540	CR324HXT		

① 300:15 CT's
② 800:5 CT's

J

Starter Fuse Selection

The following tables are furnished as a guide. Check vendor fuse characteristics before making final selection.

200 and 208 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J				Time-Delay RK-5			
				Time Delay		No Time DelayBMC			CSC		
				CSC# AJT	Clip	CSC# A4J	Clip	FRN	Clip	TR	Clip
1	½	2.3	30	3	30	10	30	2.8	30	3.5	30
	¾	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
	1½	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
	7½	25.3	30	30	30	60	60	30	30	30	30
2	10	31.3	60	50	60	90	100	40	60	40	60
3	15	45.1	100	60	60	110	200	60	60	60	60
	20	591	100	90	100	150	200	70	100	90	100
	25	731	100	100	100	175	200	90	100	100	100
4	30	881	200	125	200	200	200	100	100	125	200
	40	120	200	175	200	225	400	150	200	175	200
5	50	150	400	225	400	300	400	175	200	225	400
	60	174	400	250	400	350	400	200	200	225	400
	75	210	400	300	400	450	600	250	400	300	400

BMC–Bussman Fuse
CSC–Chase Shawmut Fuse

230 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J				Time-Delay RK-5			
				Time Delay		No Time Delay		BMC			CSC
				CSC# AJT	Clip	CSC# A4J	Clip	FRN	Clip	TR	Clip
1	½	2.0	30	3	30	10	30	2.5	30	3	30
	¾	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
	1½	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
	7½	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	½	1.0	30	1.5	30	3	30	1.25	30	1.4	30
	¾	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
	1½	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
	7½	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	½	.8	30	1.5	30	3	30	1.25	30	1.4	30
	¾	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
	7½	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

CPT VA	Primary Fuse Amps					Sec. Fuse Amps	
	208V	240V	380V	480V	600V	120V	240V
60	1	1	1	0.5	0.5	0.6	0.3
100	2	2	1.25	1	1	1	0.5
150	3	3	2	1.5	1.25	1.6	0.8
200	4	4	2	2	1.5	2	1
250	5	5	2	2	2	2.5	1.25
300	6	6	3.5	2	2	3.2	1.6
500	6	①	6	5	4	5	2.5
750	①	①	8	7	6	7	3.5
1000	①	①	①	①	8	10	5

Primary Fuses–Class CC Or Equivalent (GOULD #ATM-R STD)
Secondary Fuses– Class H Or Equivalent (GOULD #TR STD)

① Requires class RK-5 time delay or equivalent.

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.

Rating (Amps)	Loss (Watts)
50	15
100	20
150	25
225	40
400	50
600	80
1200	150

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.

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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

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
CL025	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

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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 380/400V kW A
			115V	230V	200V	230V	460V	575V	
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-1100F	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
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

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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-4756	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-4789	300-Line Instructions, Nema Size 4, FVNR	Bloomington
GEH-4869	300-Line Instructions, Nema Size 5, FVNR	Bloomington
GEH-5108	300-Line Instructions, Nema Size 6-9, FVNR	Bloomington
GEH-4757	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 Drives①		
GEI-100364	AF 300P User Guide	Fort Wayne
GEI-100363	AF 300G User Guide	Fort Wayne
Solid State Starters		
DET-024	ASTAT–CD	Bloomington
GEH-5951	ASTAT–CD Installation Instructions	Bloomington
GEH-6533	ASTAT–CD Service Instructions	Bloomington
DEH-195	ASTAT-IBP	Bloomington
DEH-208	ASTAT-IBP Service 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	Linear Motion
Horsepower	
$HP = \frac{T \times N}{5250}$	$HP = \frac{F \times V}{33{,}000}$
Where: T = Torque (lb-ft) N = Speed (RPM)	Where: F = Force or Tension (lb) V = Velocity (FPM)
$HP = \frac{T \times N}{63{,}000}$	$HP = \frac{F \times V}{396{,}000}$
Where: T = Torque (lb-in) N = Speed (RPM)	Where: F = Force or Tension (lb) V = Velocity (in/min)
Accelerating Torque/Force	
$T_A = \frac{WK^2 \times N}{308t}$	$F_A = \frac{W \times V}{1933t}$
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. ($lb\text{-}ft^2$)	Where: F_A = Accelerating Force (lb-ft) W = Weight (lb) V = Change in velocity (FPM) t = Time (sec.)

Torque

$$T = F \times R$$

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

WK^2 – reflected

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

This is for either belt or gear reductions.

FPM to RPM

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

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Electrical Data

Centrifugal Loads

Flow Rate:
$\frac{Flow_1}{Flow_2} = \frac{RPM_1}{RPM_2}$

Torque:
$\frac{Torque_1}{Torque_2} = \left(\frac{RPM_1}{RPM_2}\right) 2$

Pressure:
$\frac{Pres_1}{Pres_2} = \left(\frac{RPM_1}{RPM_2}\right) 2$

Horsepower:
$\frac{BHP_1}{BHP_2} = \left(\frac{RPM_1}{RPM_2}\right) 3$

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

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

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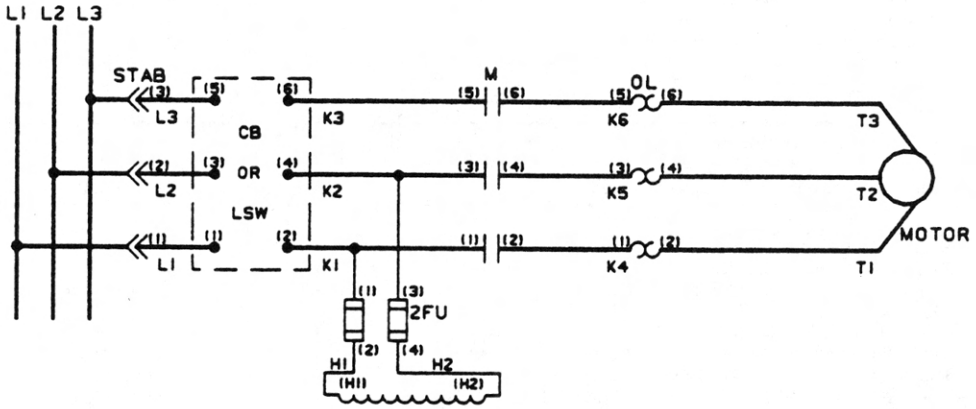
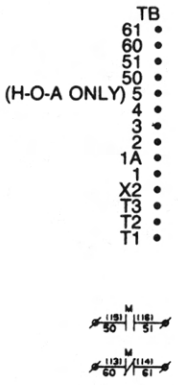
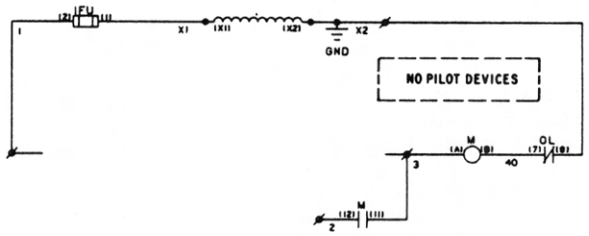
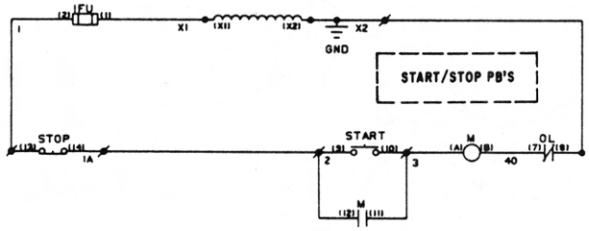
FVNR SIZE 1-4

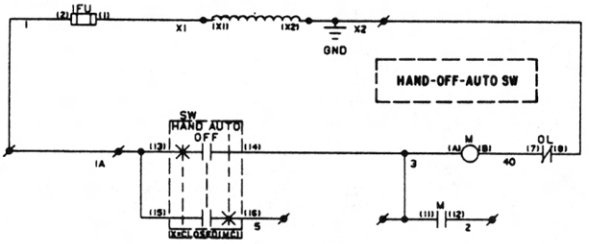
TYPICAL CIRCUIT DIAGRAMS

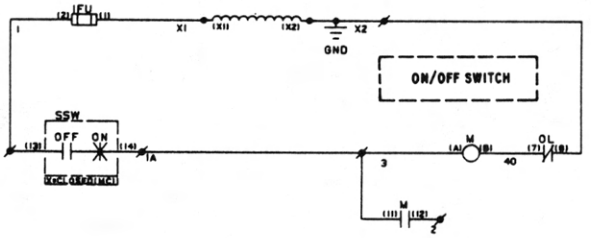


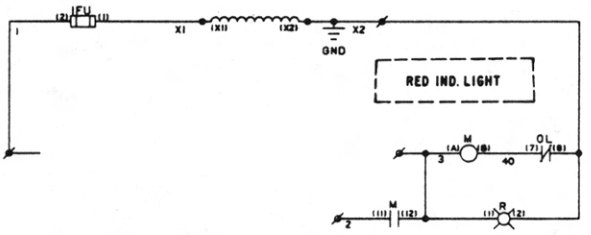


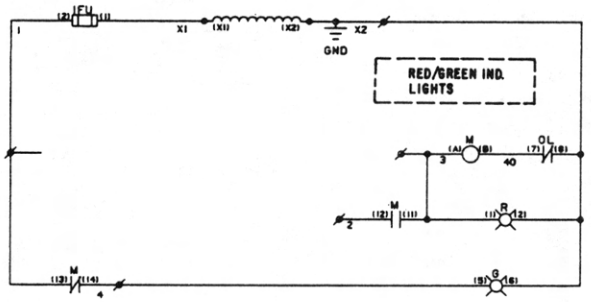


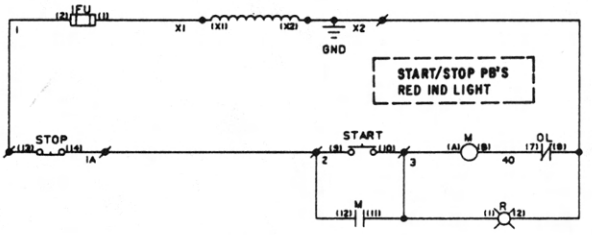


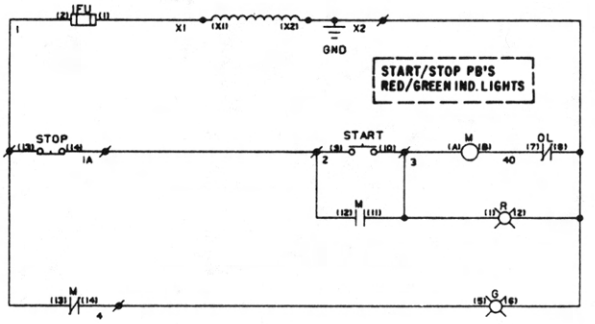






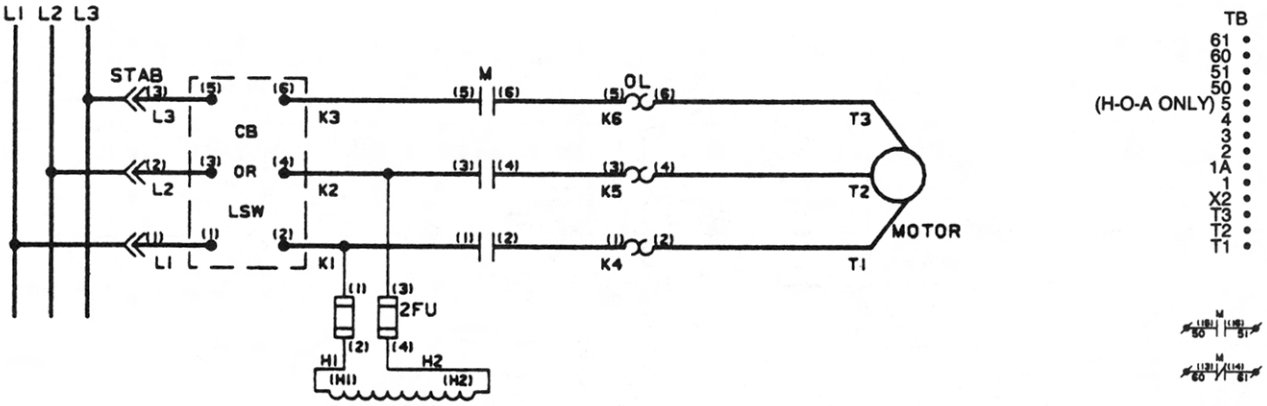


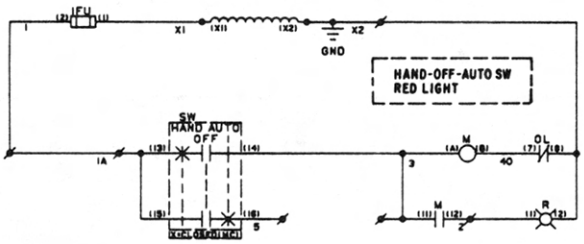


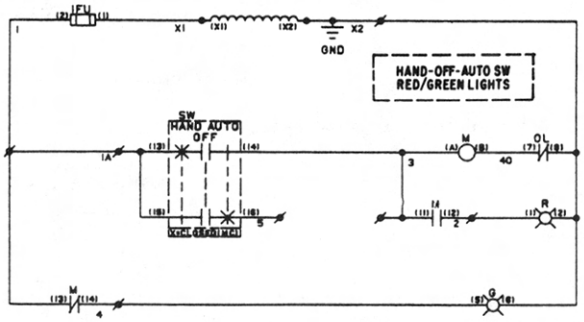


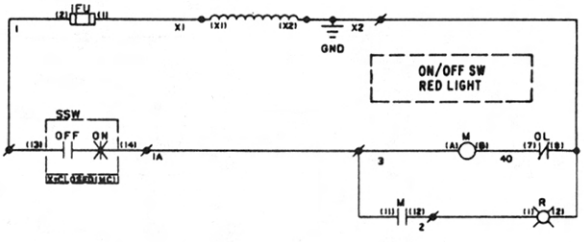
FVNR SIZE 1-4

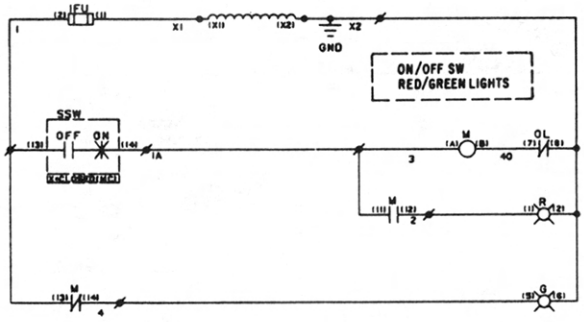
TYPICAL CIRCUIT DIAGRAMS











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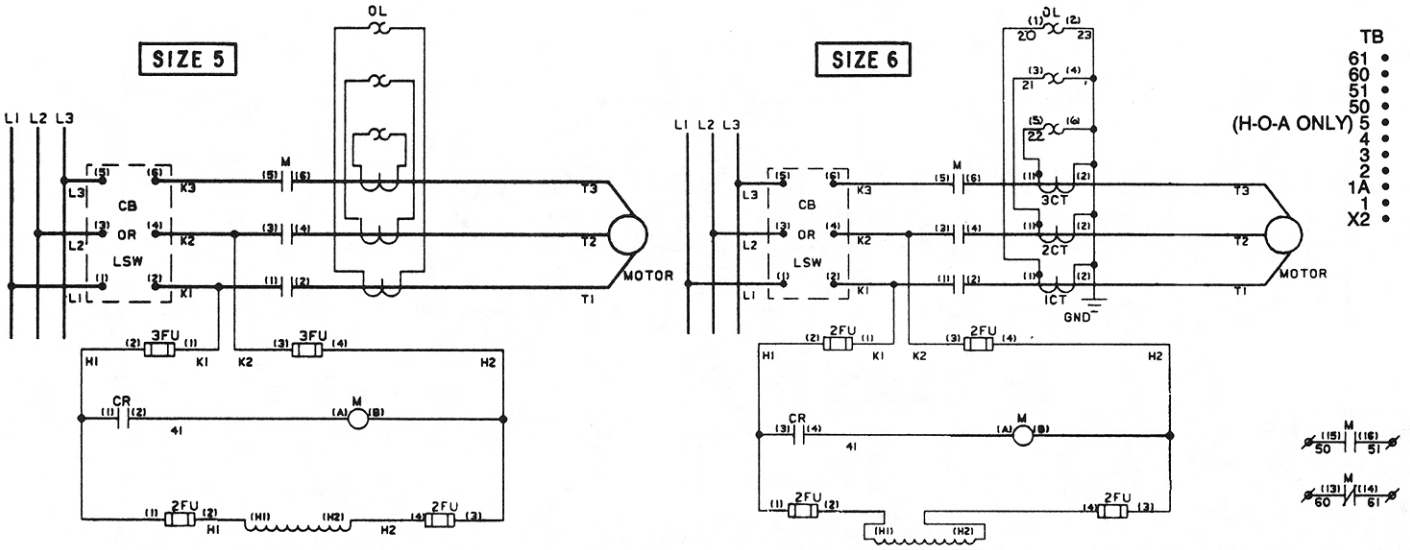
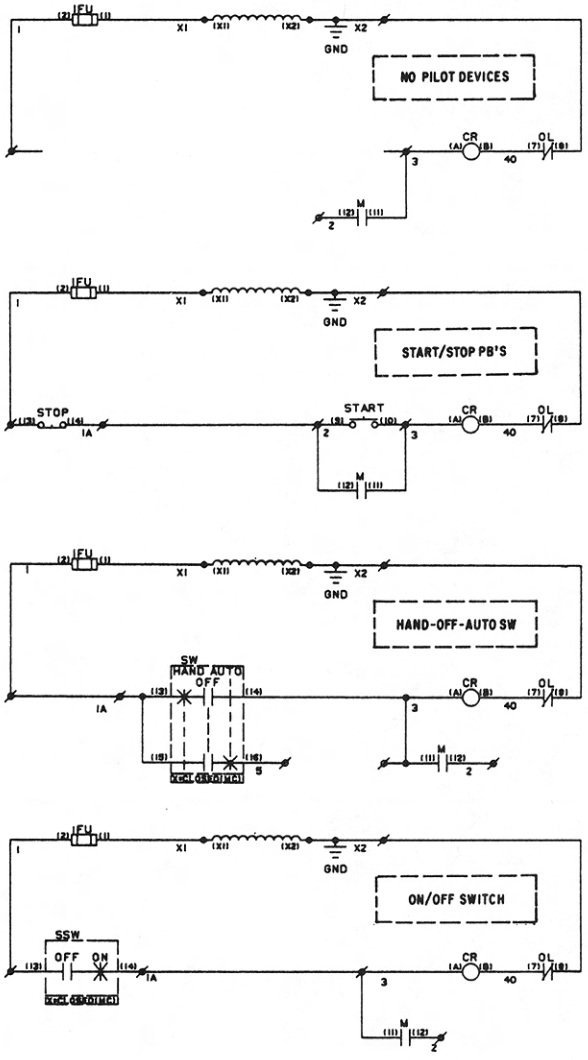
FVNR SIZE 5-6

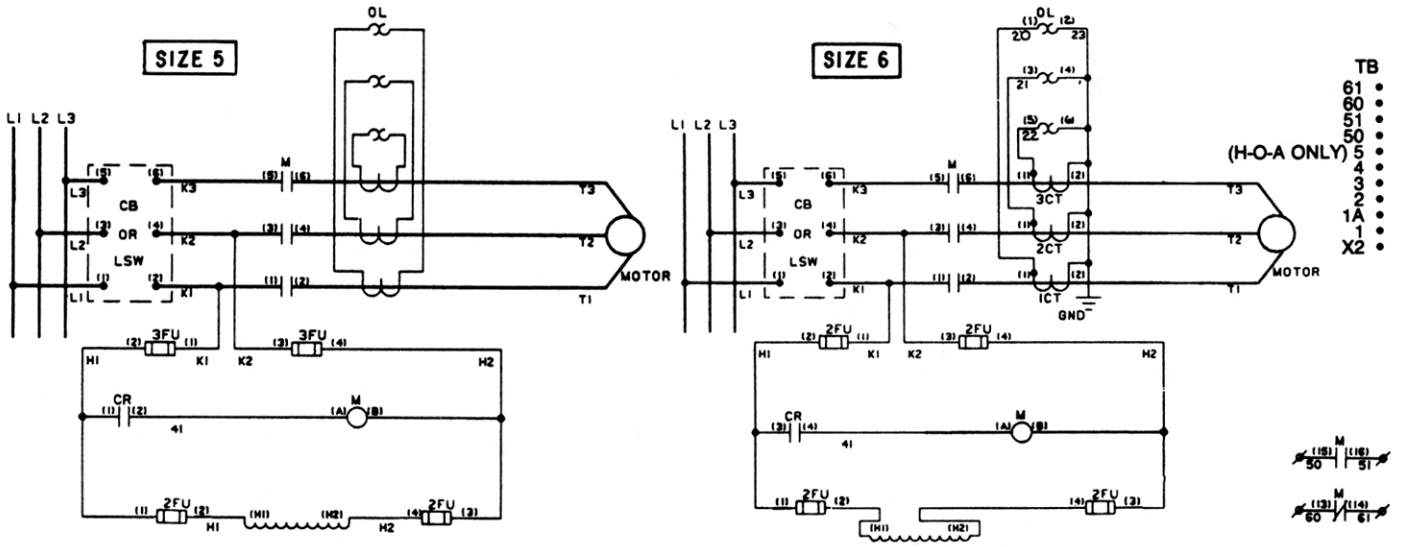
TYPICAL CIRCUIT DIAGRAMS

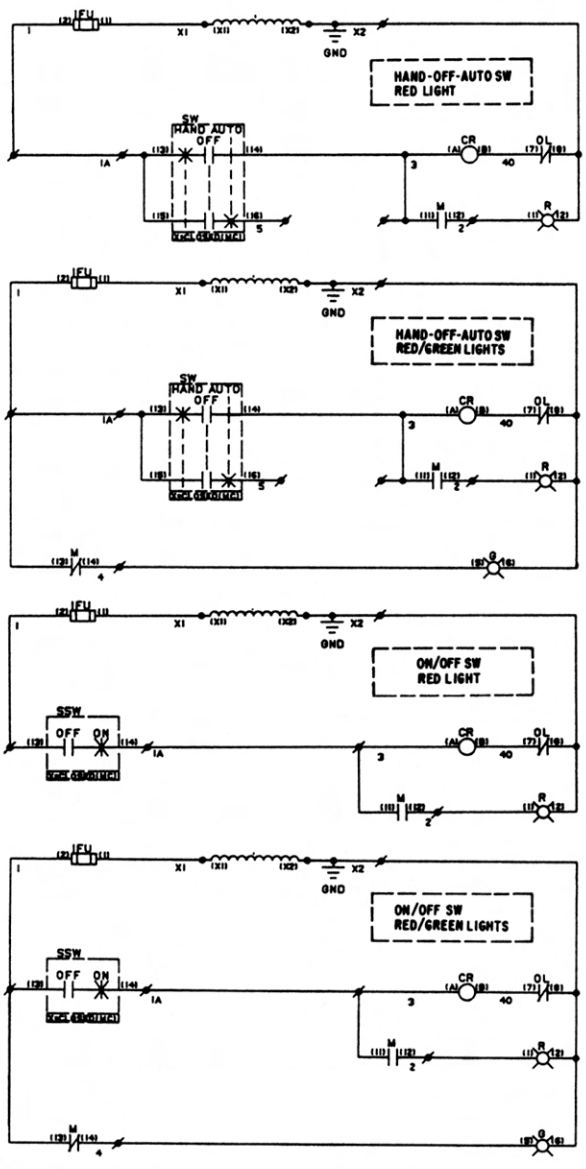




FVNR SIZE 1-4

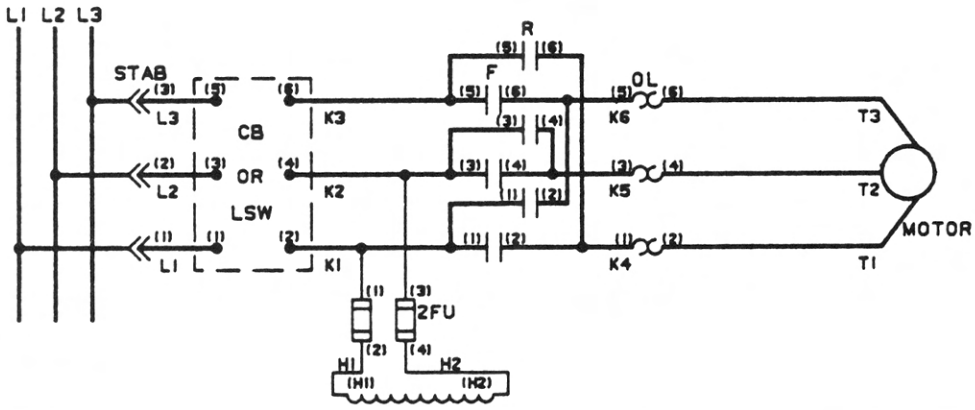
TYPICAL CIRCUIT DIAGRAMS

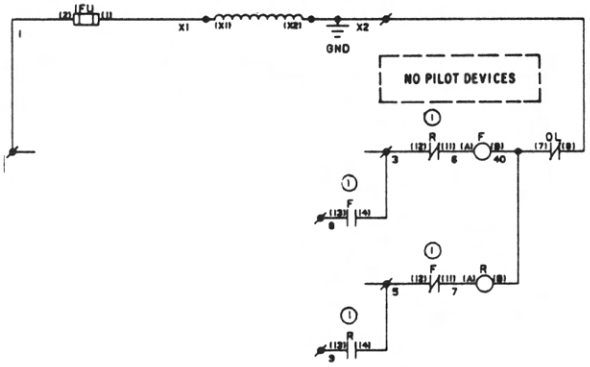


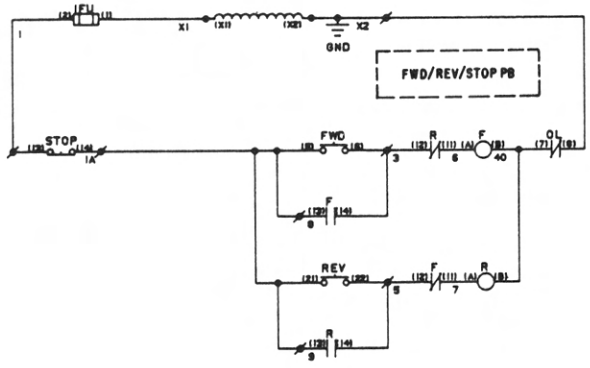


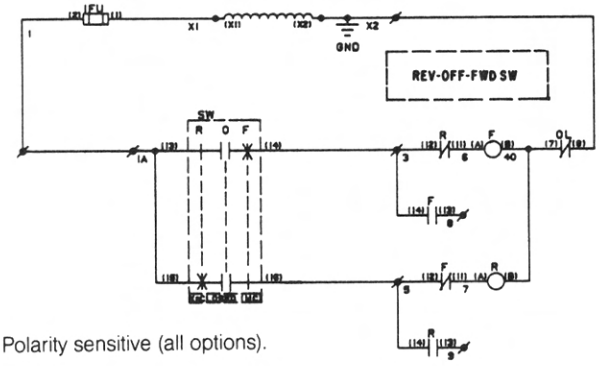
FVR SIZE 1-4

TYPICAL CIRCUIT DIAGRAMS

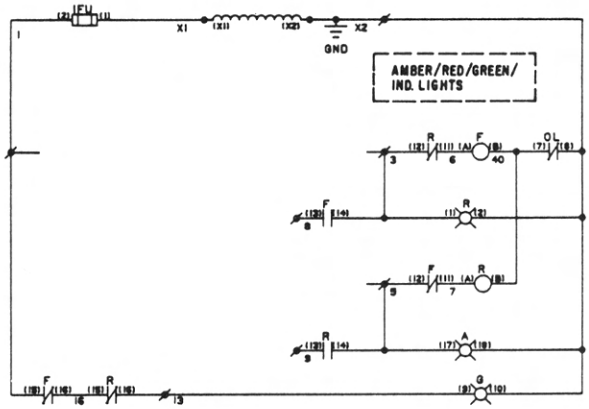


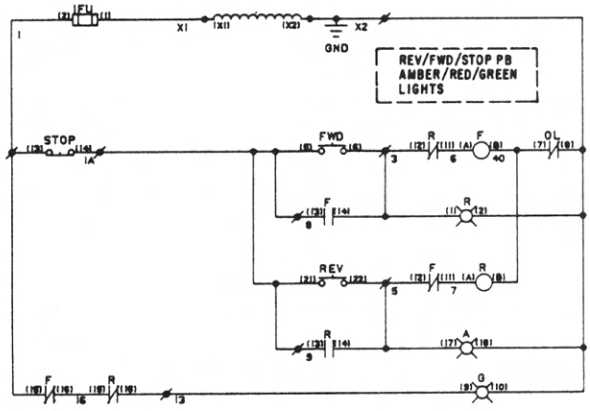


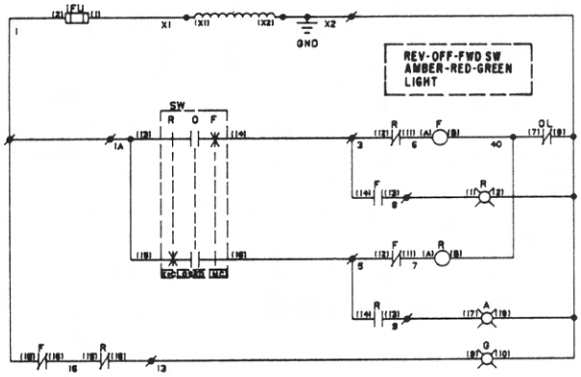




① Polarity sensitive (all options).



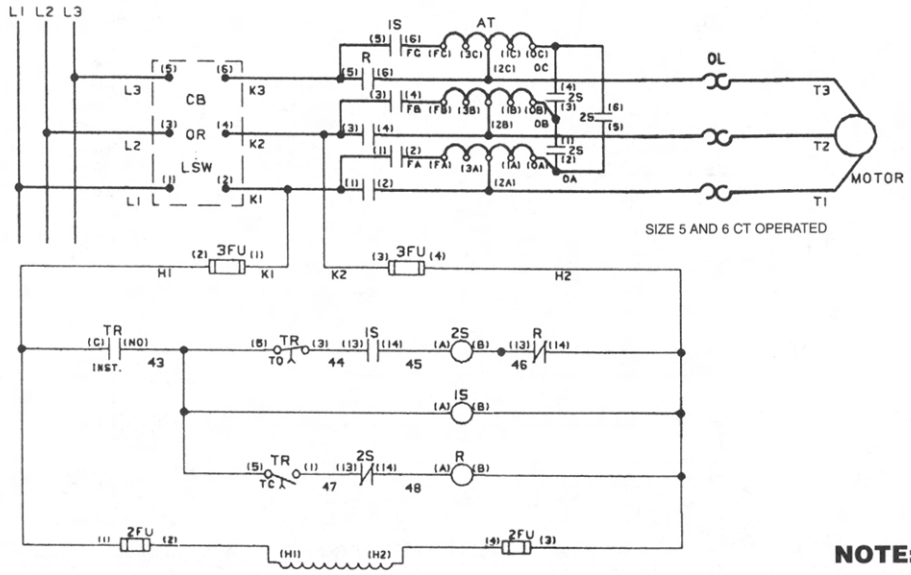


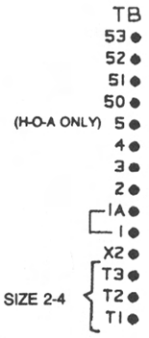


RVNR-AT SIZE 2–6

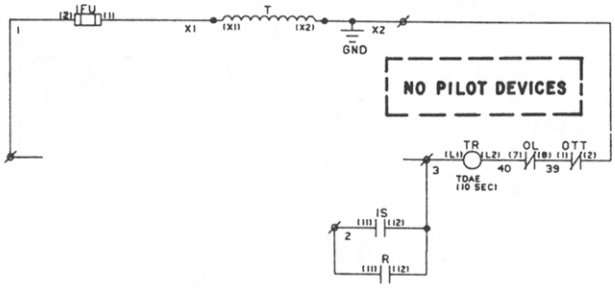
Size 2, 3–65, 80% Taps
Size 4, 5, 6–50, 65, 80% Taps

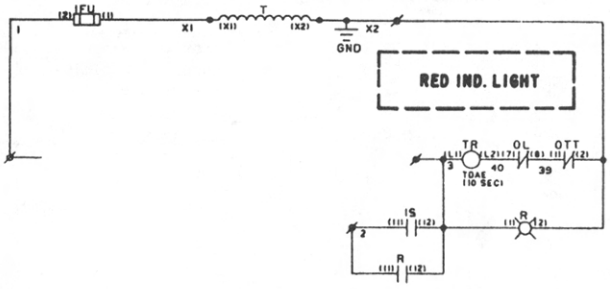
TYPICAL CIRCUIT DIAGRAMS

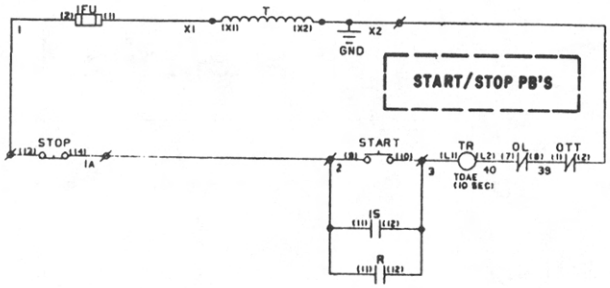


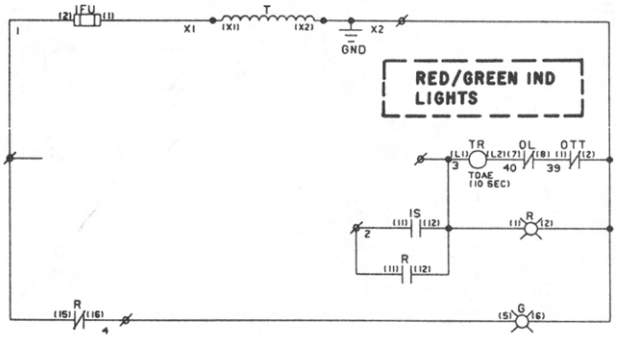


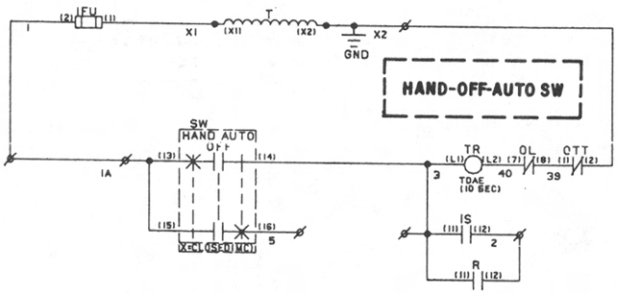
NOTE: See page K-8 for RVNR with P.F. capacitor.

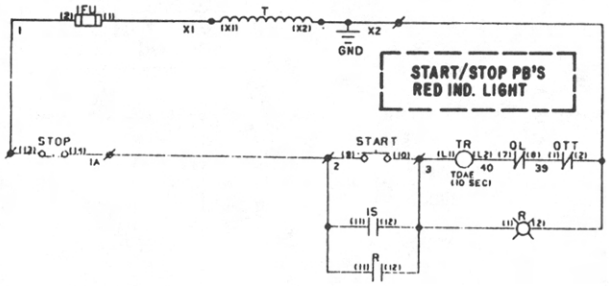










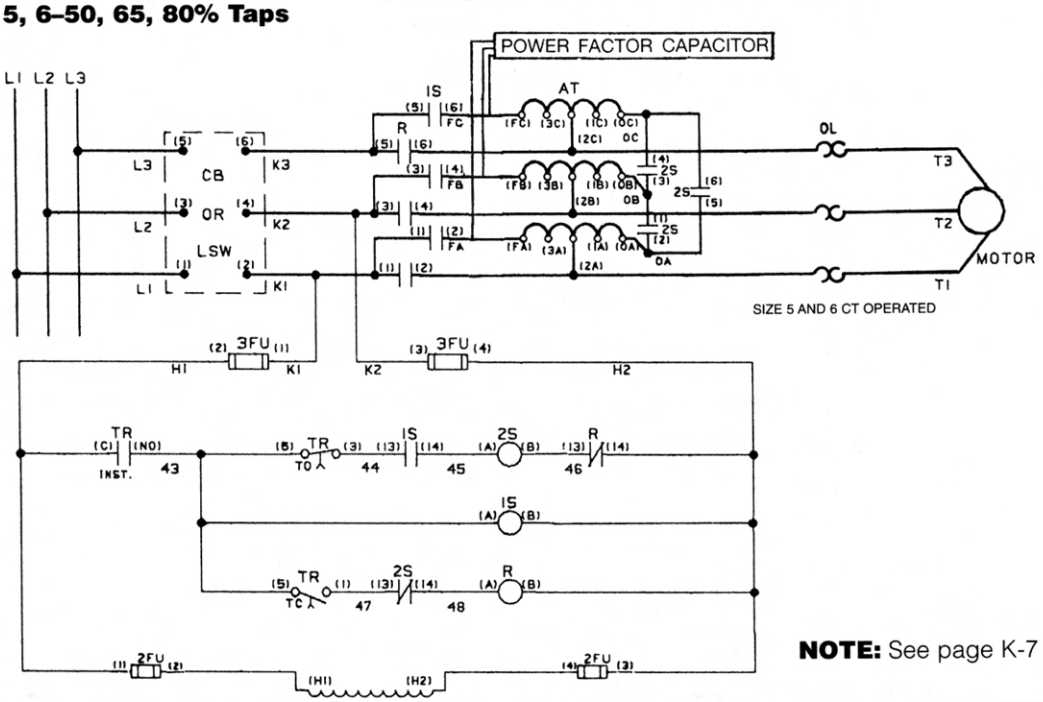


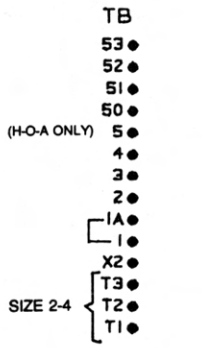
K

RVNR-AT SIZE 2–6 (CONT'D.)

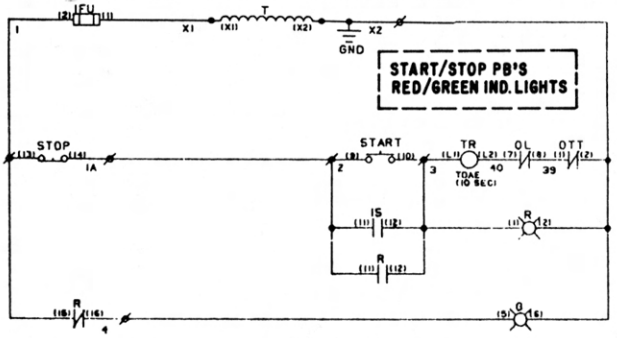
Size 2, 3–65, 80% Taps
Size 4, 5, 6–50, 65, 80% Taps

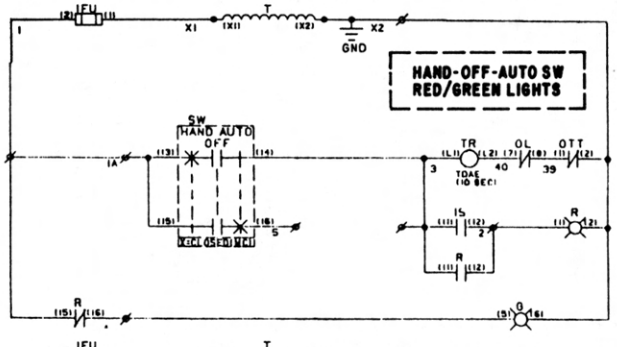
TYPICAL CIRCUIT DIAGRAMS

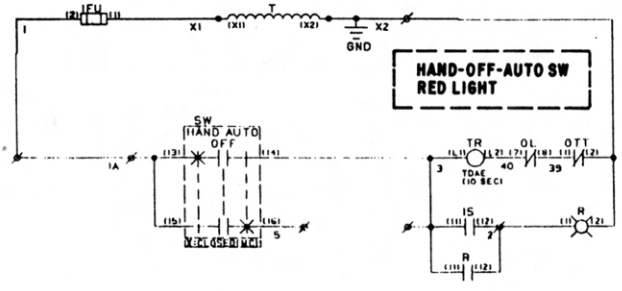


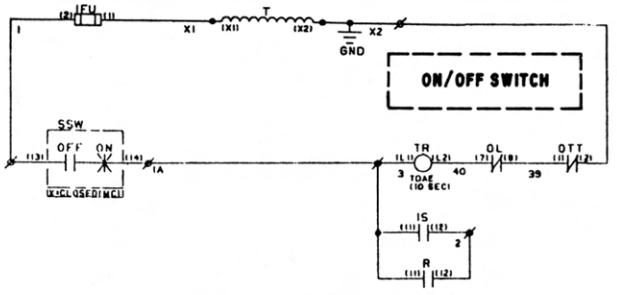


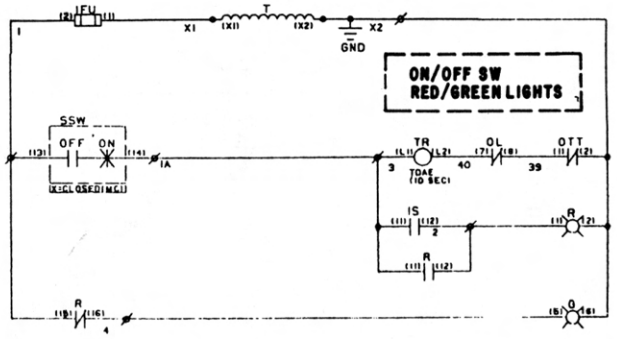
NOTE: See page K-7 for RVNR w/o P.F. capacitor.

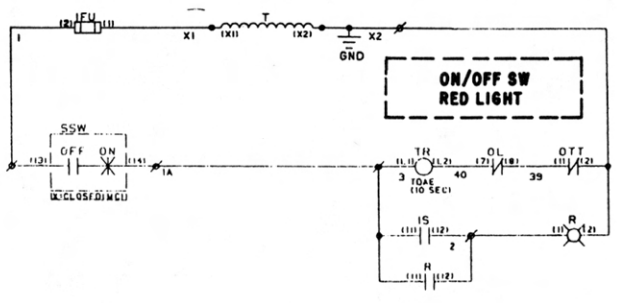






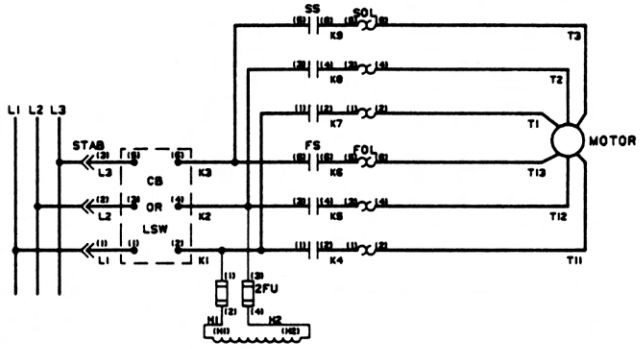


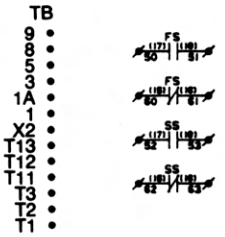


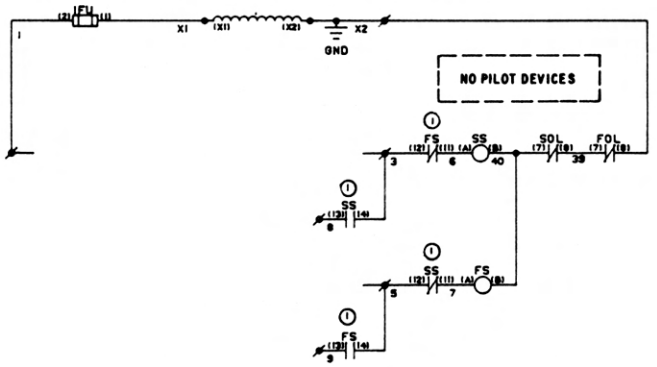


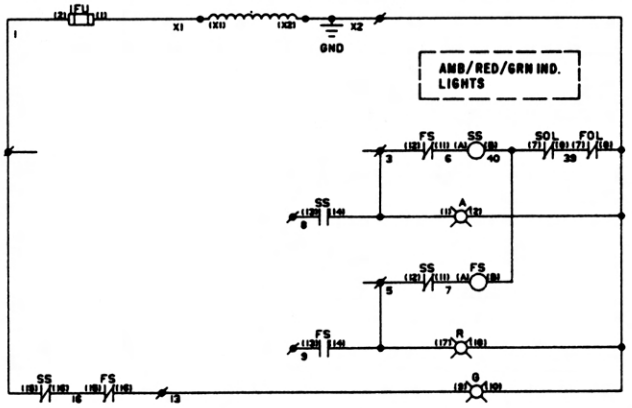
2S2W-C.T., V.T., C.H. SIZE 1-4

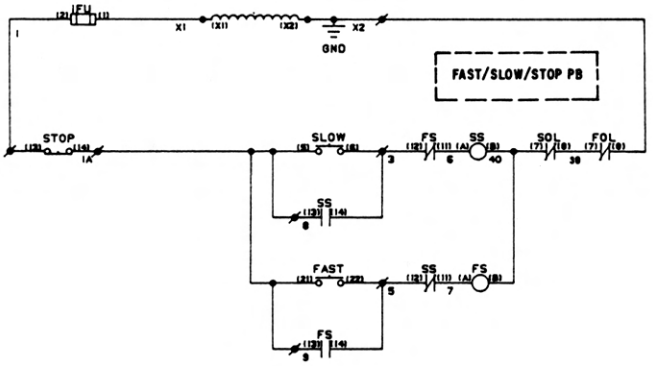
TYPICAL CIRCUIT DIAGRAMS

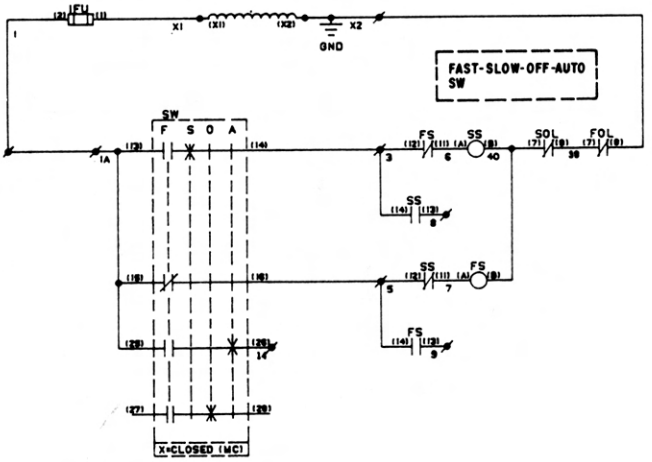


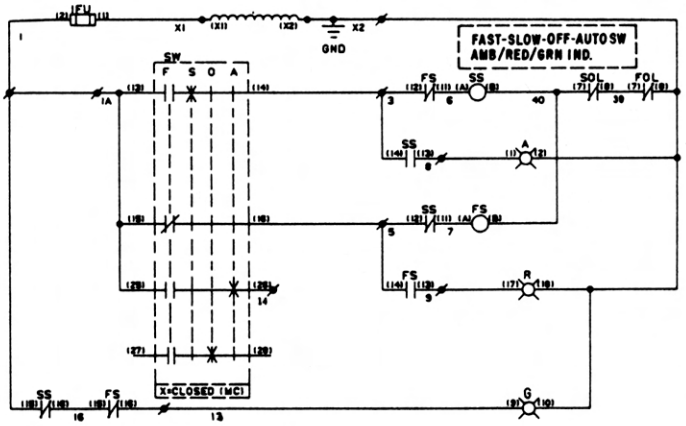


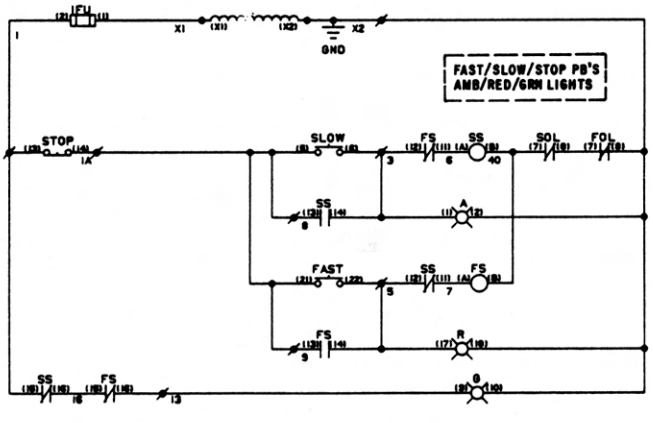










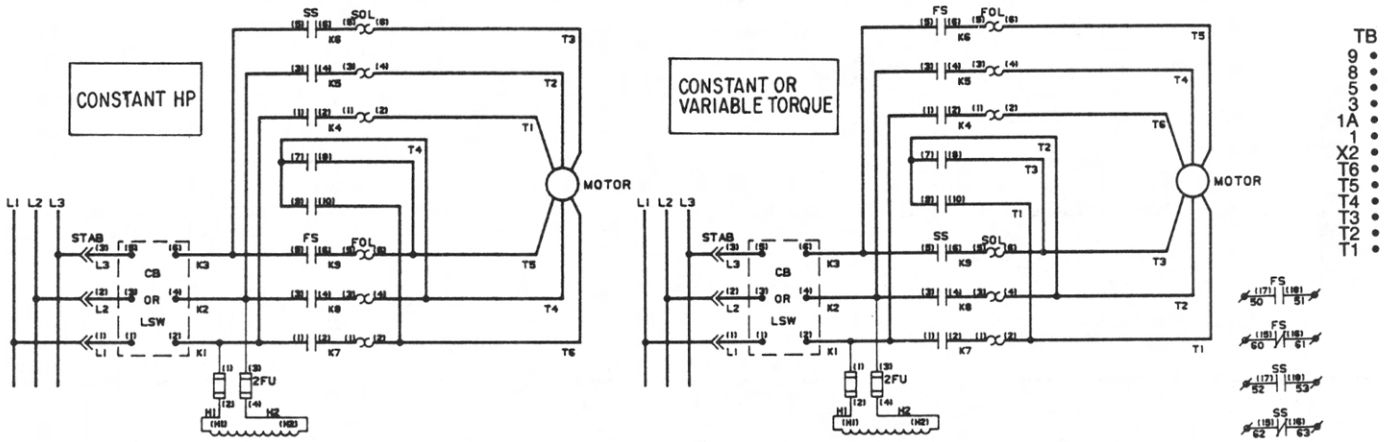


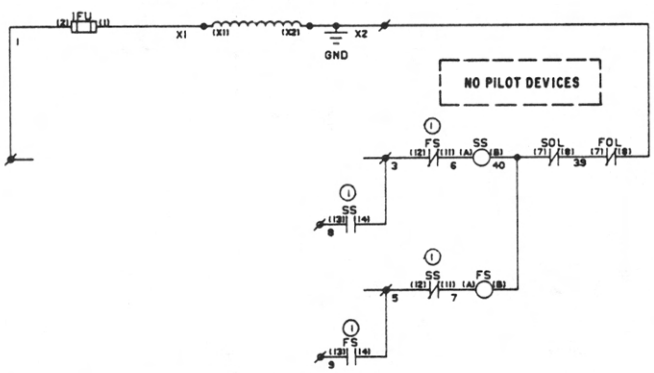
① Polarity sensitive (all options).

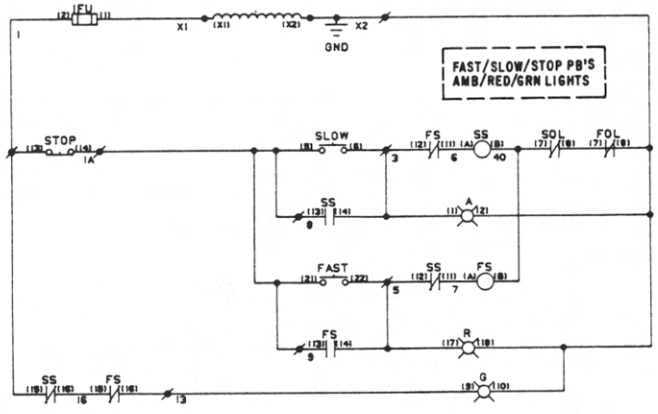
K

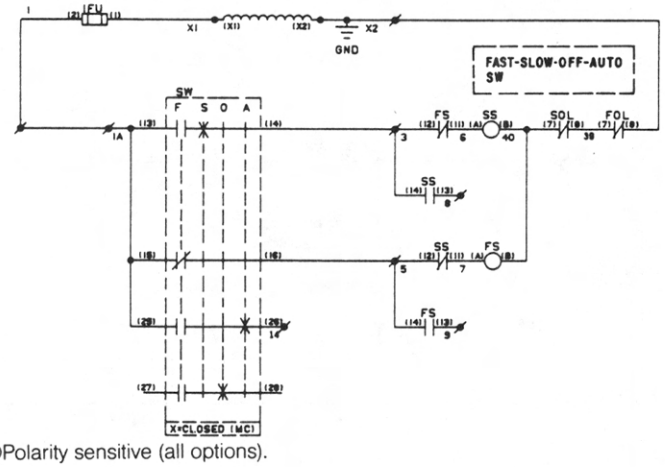
2S1W-C.T., V.T., C.H. SIZE 1-4

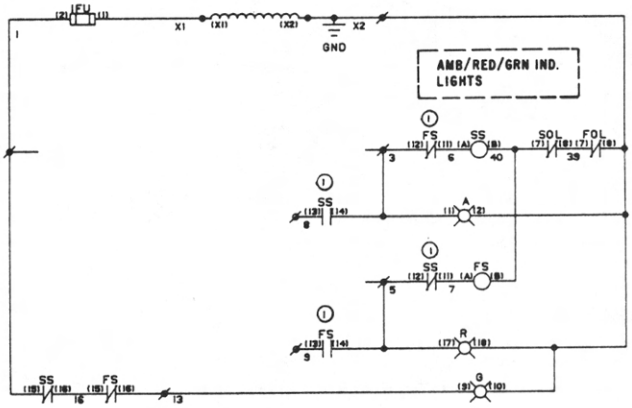
TYPICAL CIRCUIT DIAGRAMS

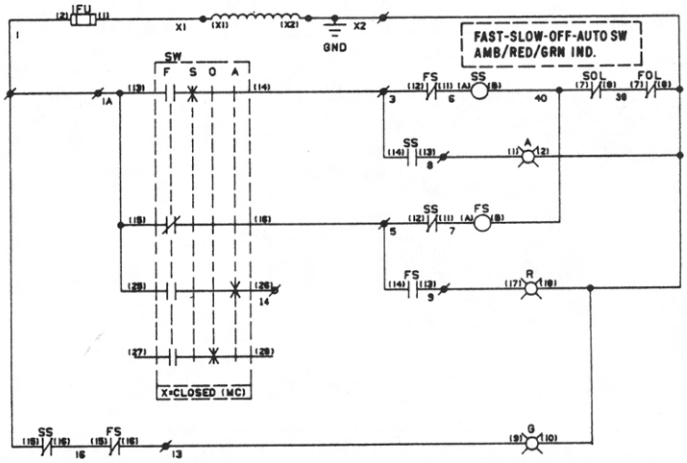


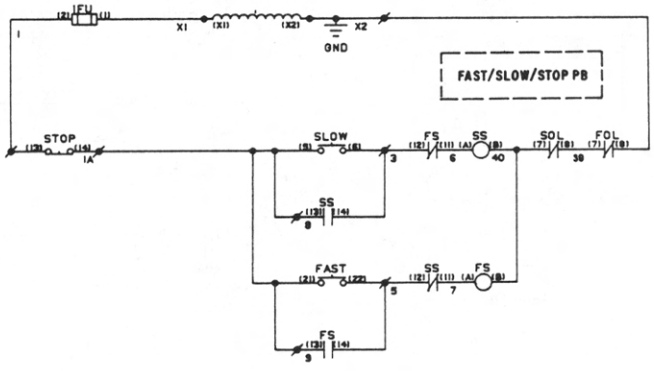








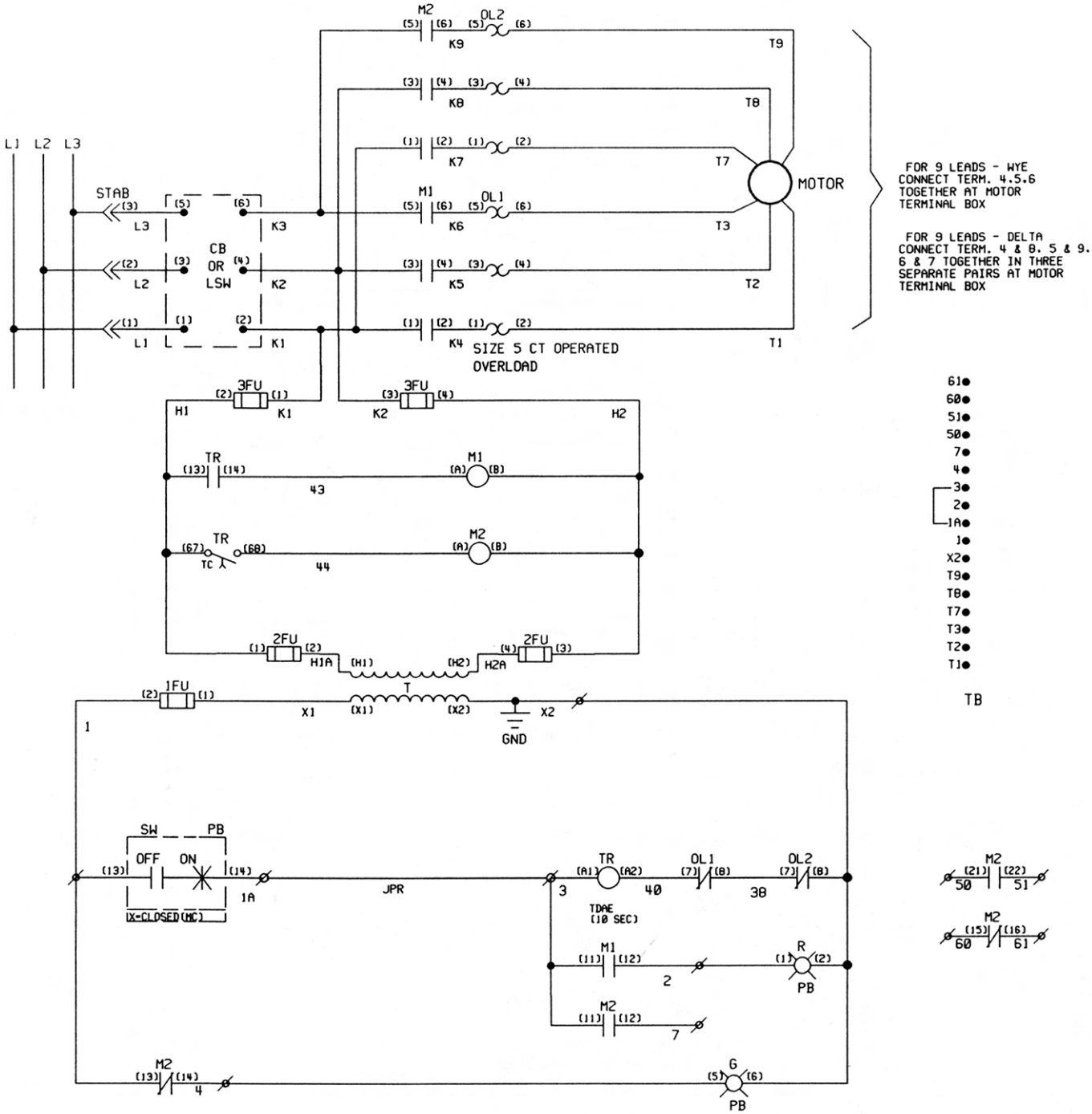




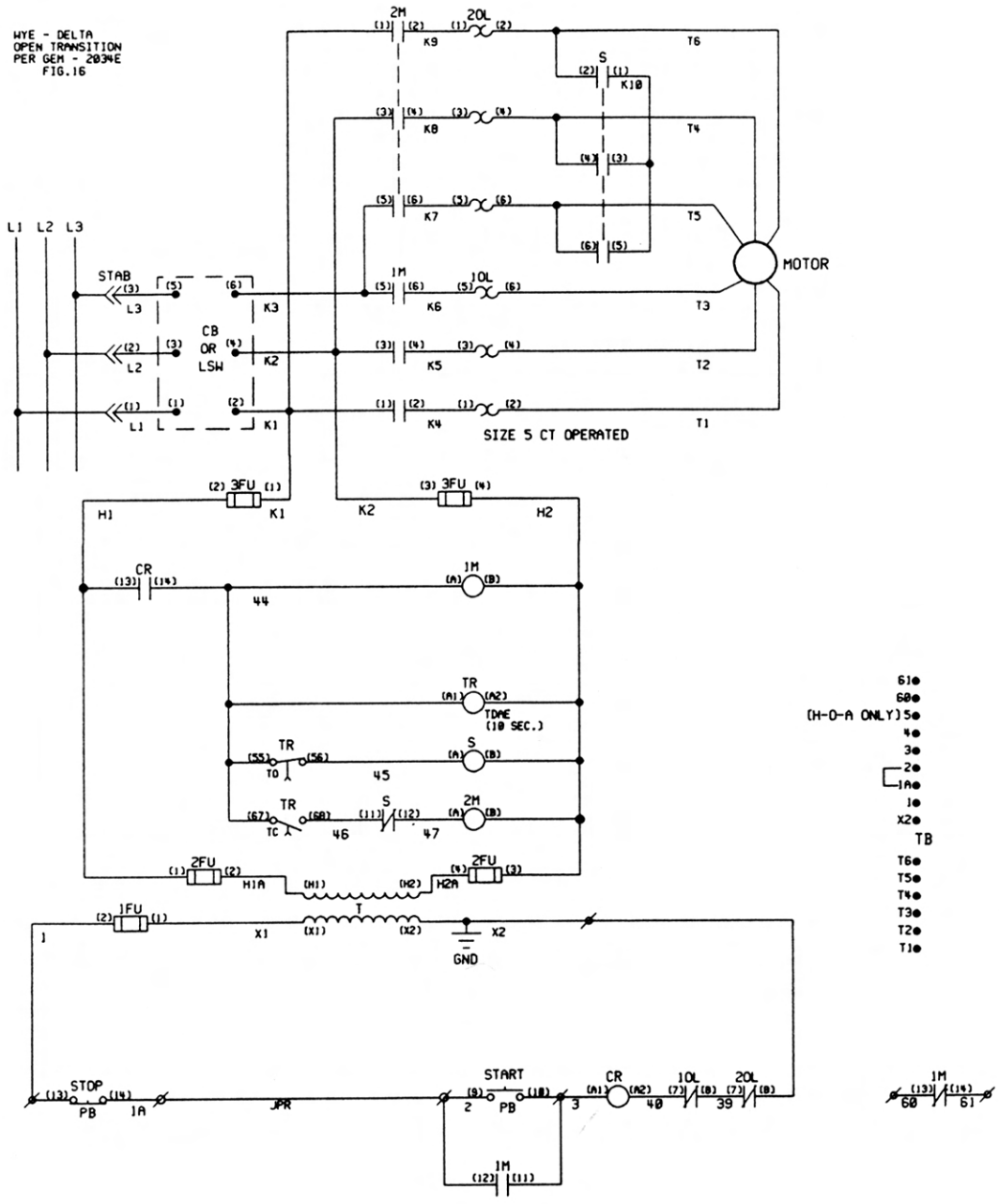
①Polarity sensitive (all options).

2S-PW SIZE 1-5

TYPICAL CIRCUIT DIAGRAMS

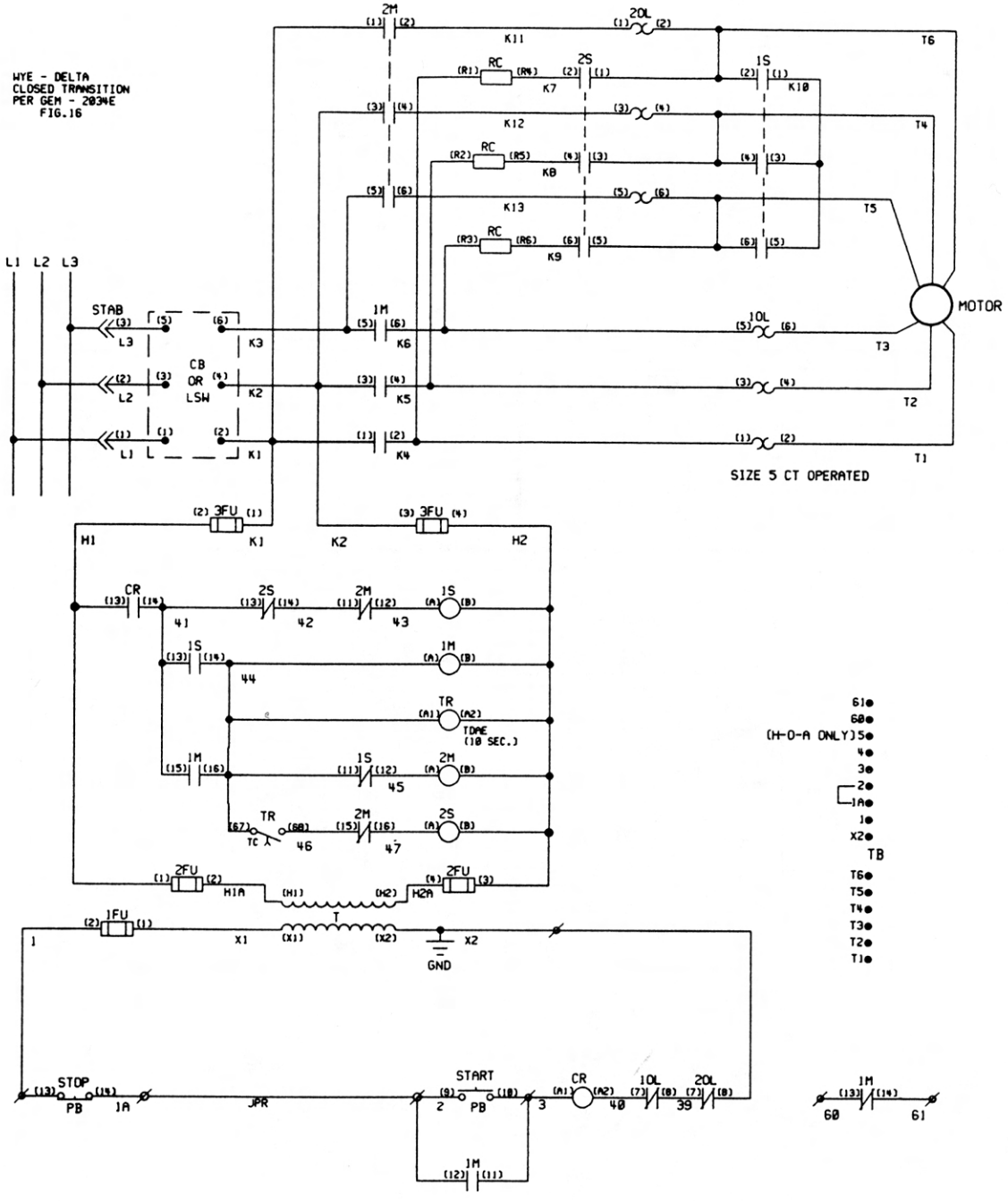


WYE-DELTA OPEN TRANSITION



NOTE: Control circuit options similar to the FVNR Size 5

WYE-DELTA CLOSED TRANSITION

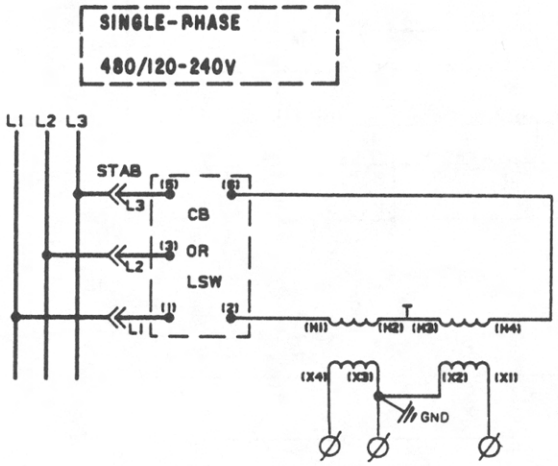


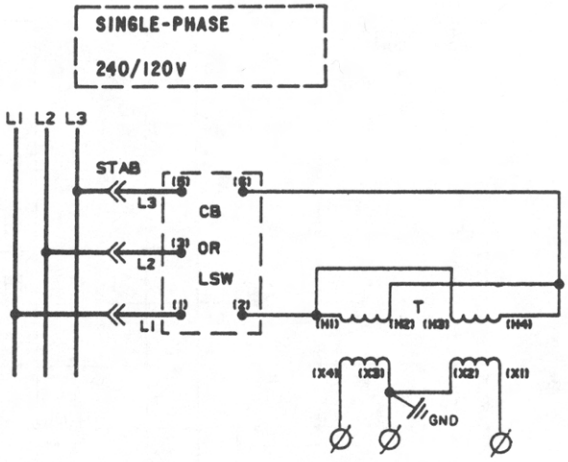
NOTE: Control circuit options similar to the FVNR Size 5

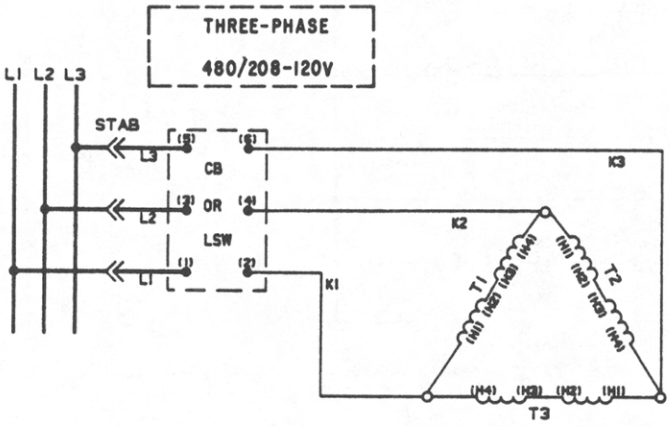
K

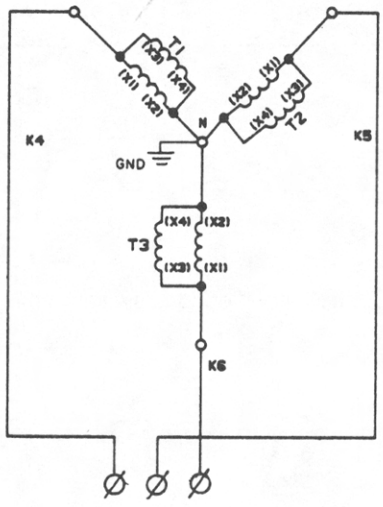
DISTRIBUTION TRANSFORMERS

TYPICAL CIRCUIT DIAGRAMS



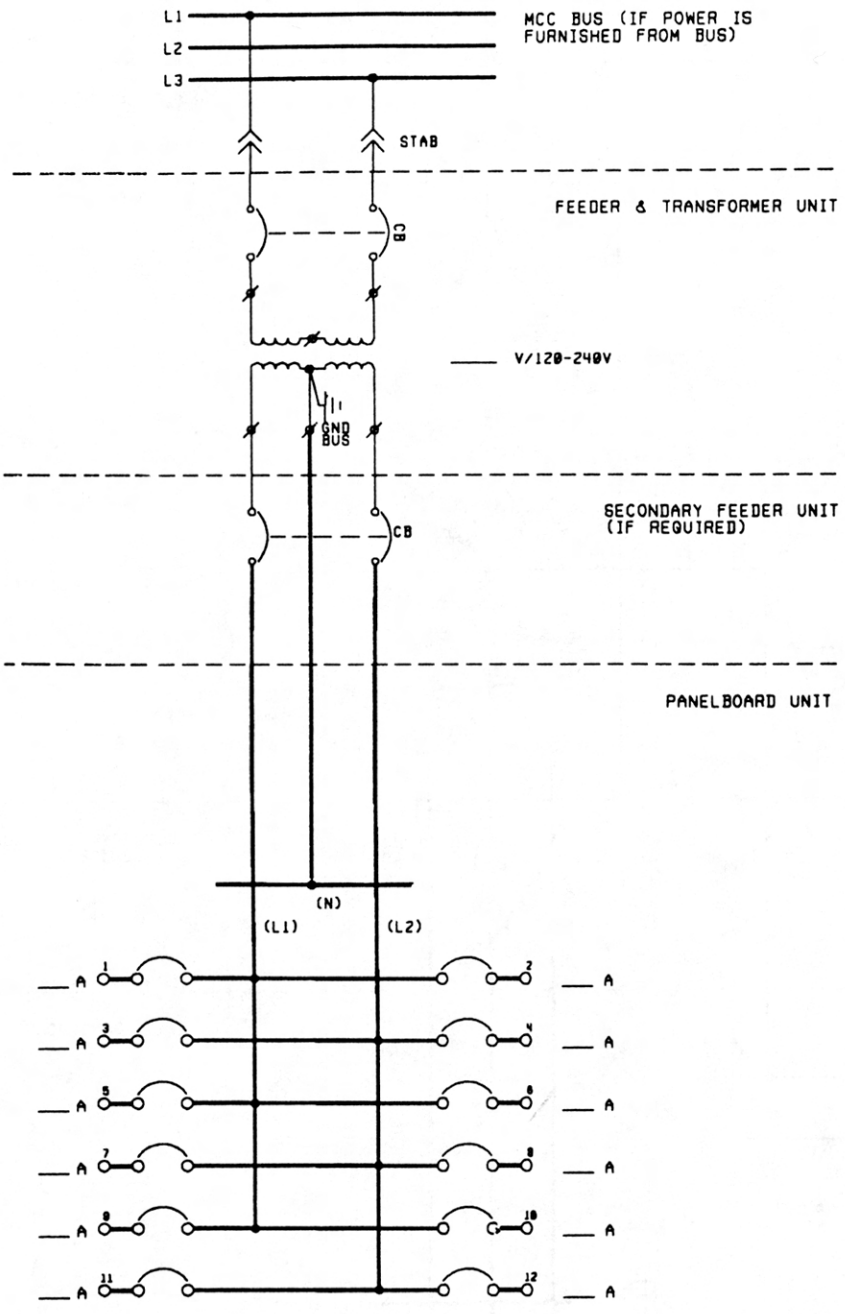






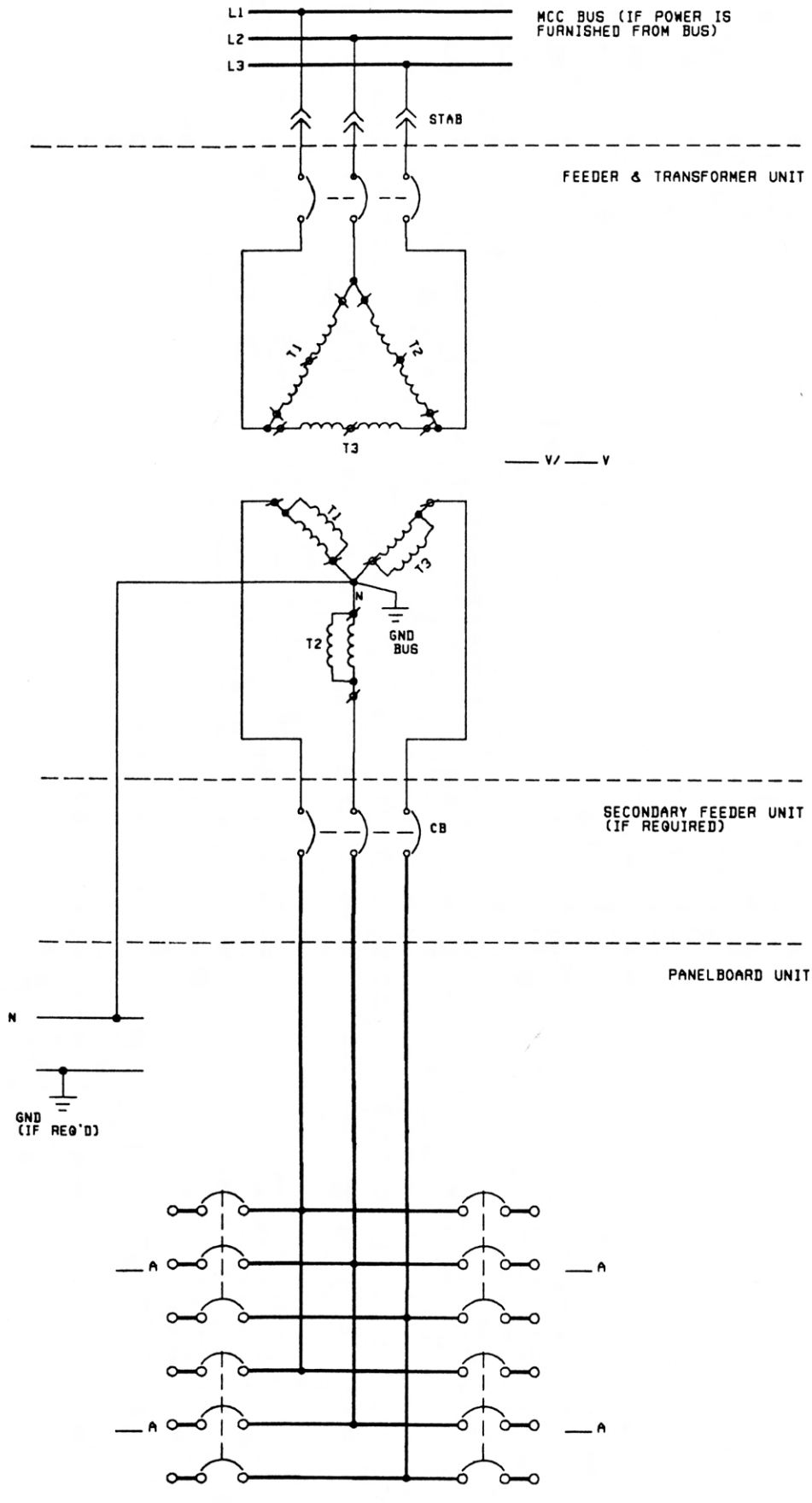
SINGLE-PHASE PANELBOARD

TYPICAL CIRCUIT DIAGRAMS



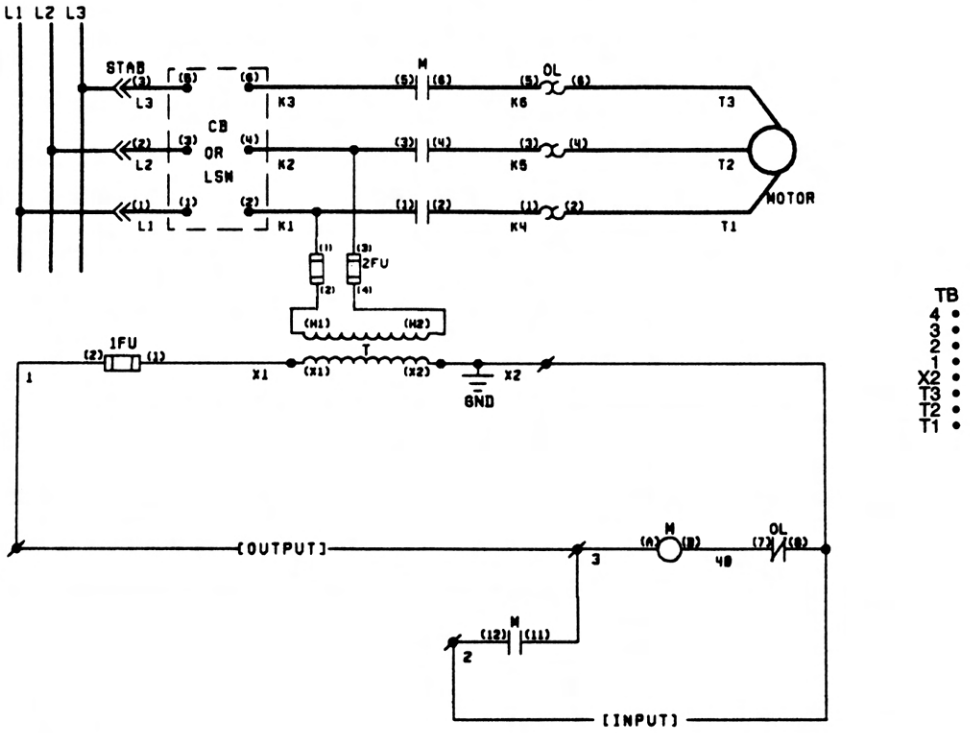
THREE-PHASE PANELBOARD

TYPICAL CIRCUIT DIAGRAMS

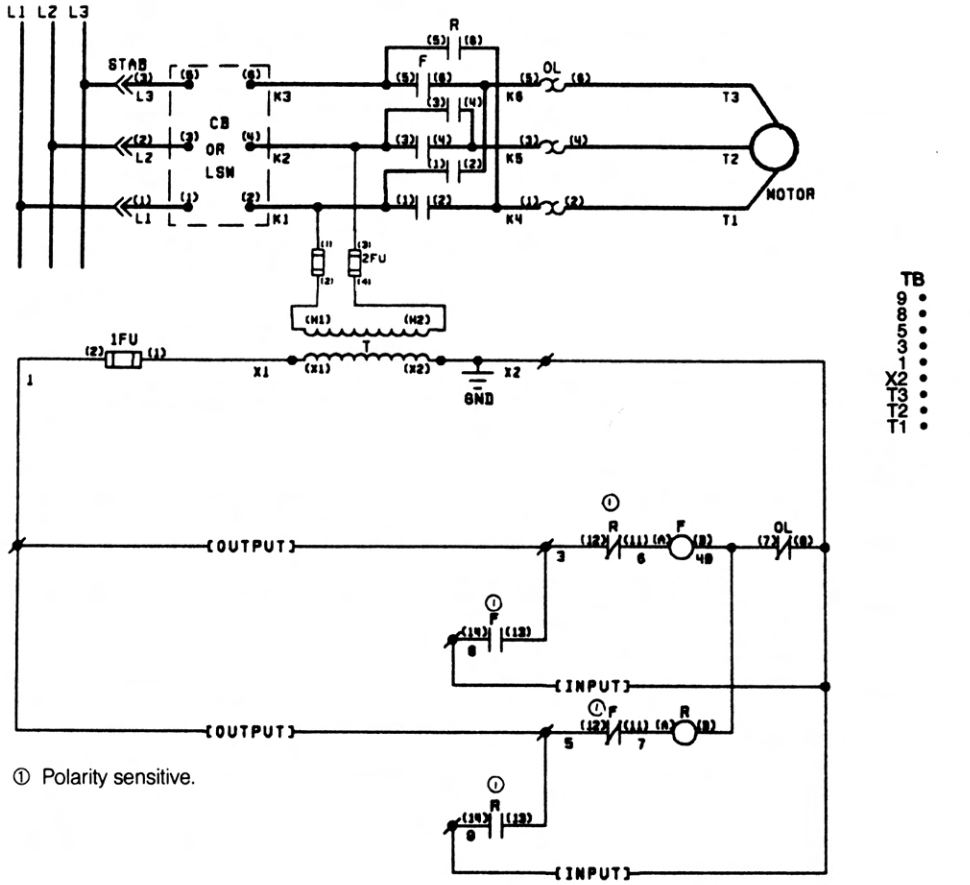


FVNR WITH PLC

TYPICAL CIRCUIT DIAGRAMS



FVR WITH PLC



① Polarity sensitive.

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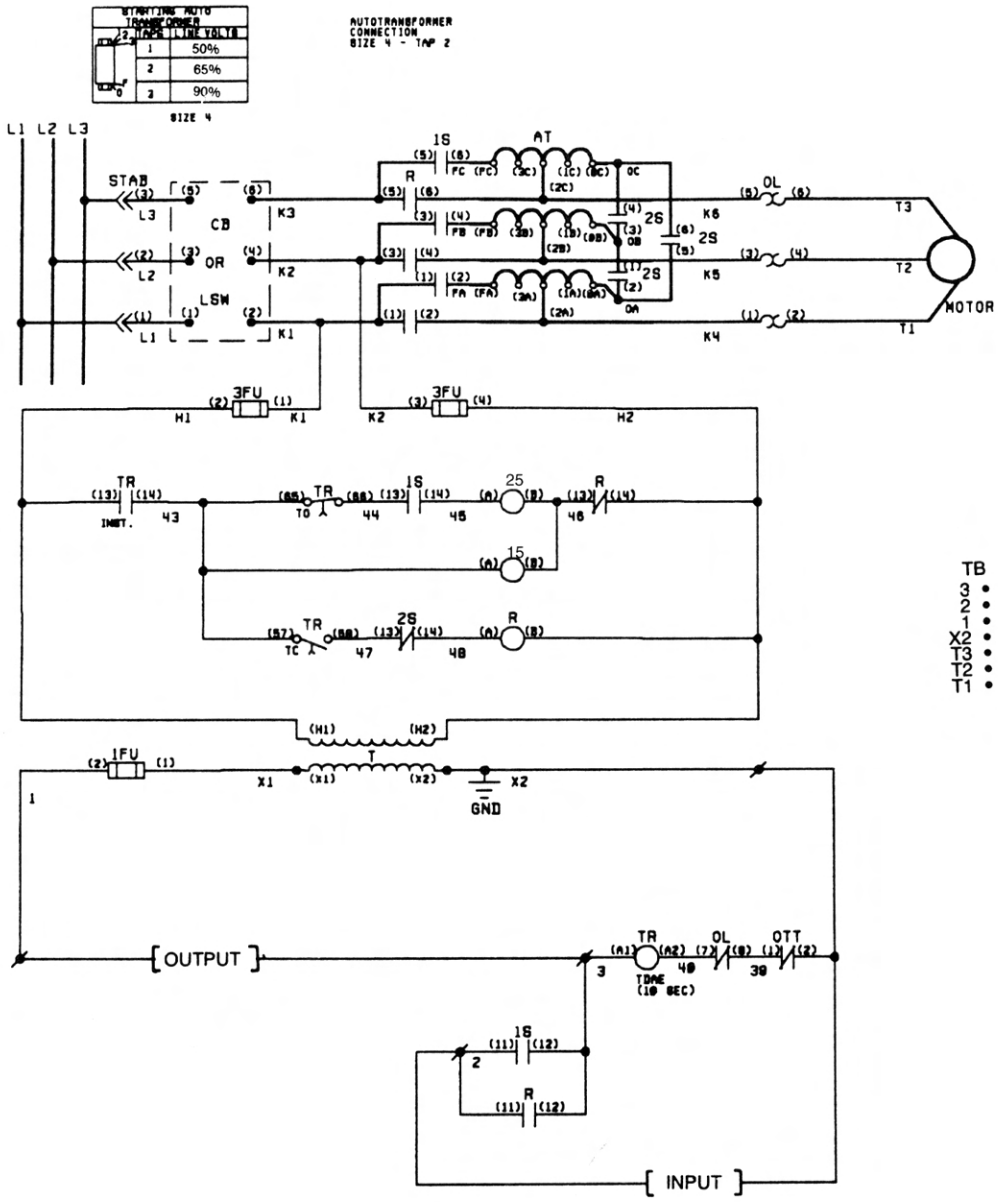
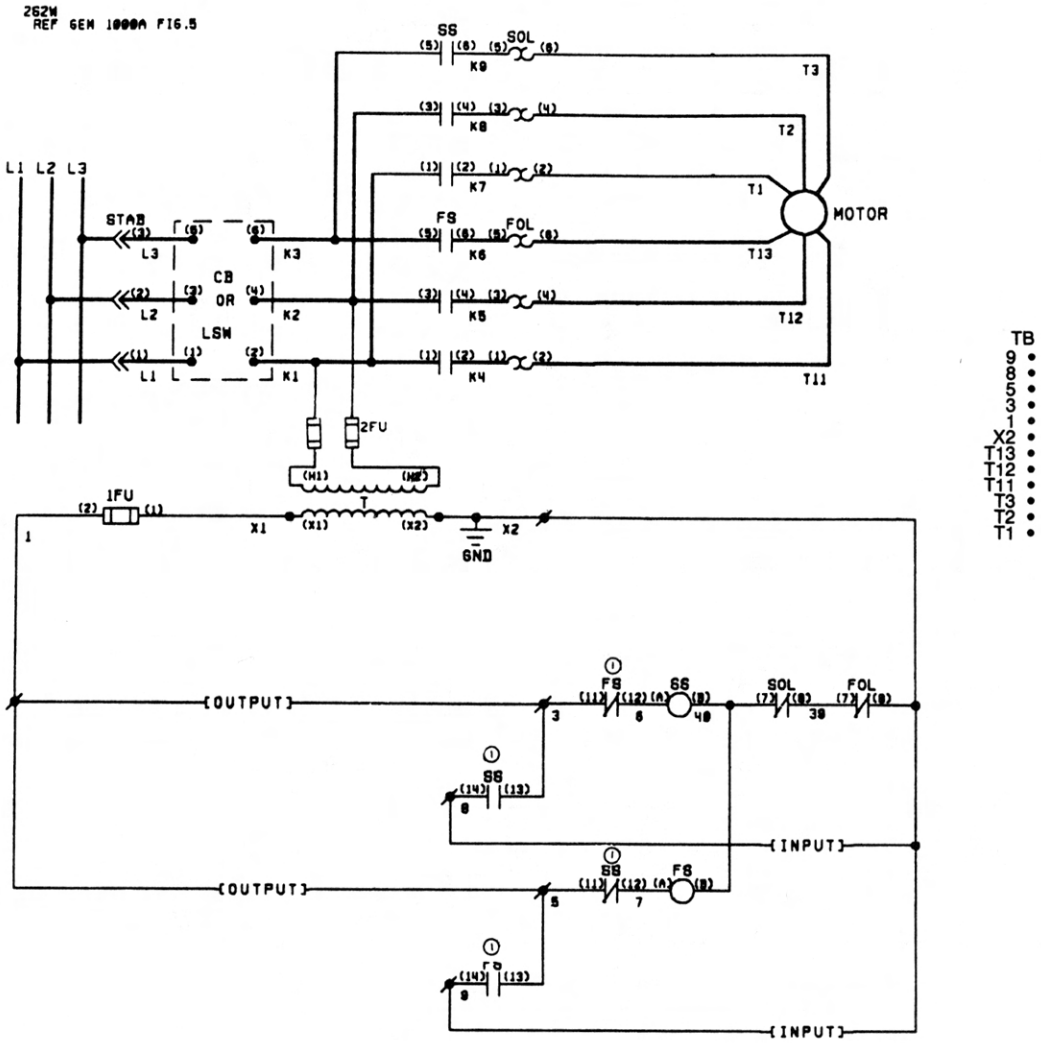
RVNR-AT WITH PLC

TYPICAL CIRCUIT DIAGRAMS



2S2W WITH PLC

TYPICAL CIRCUIT DIAGRAMS

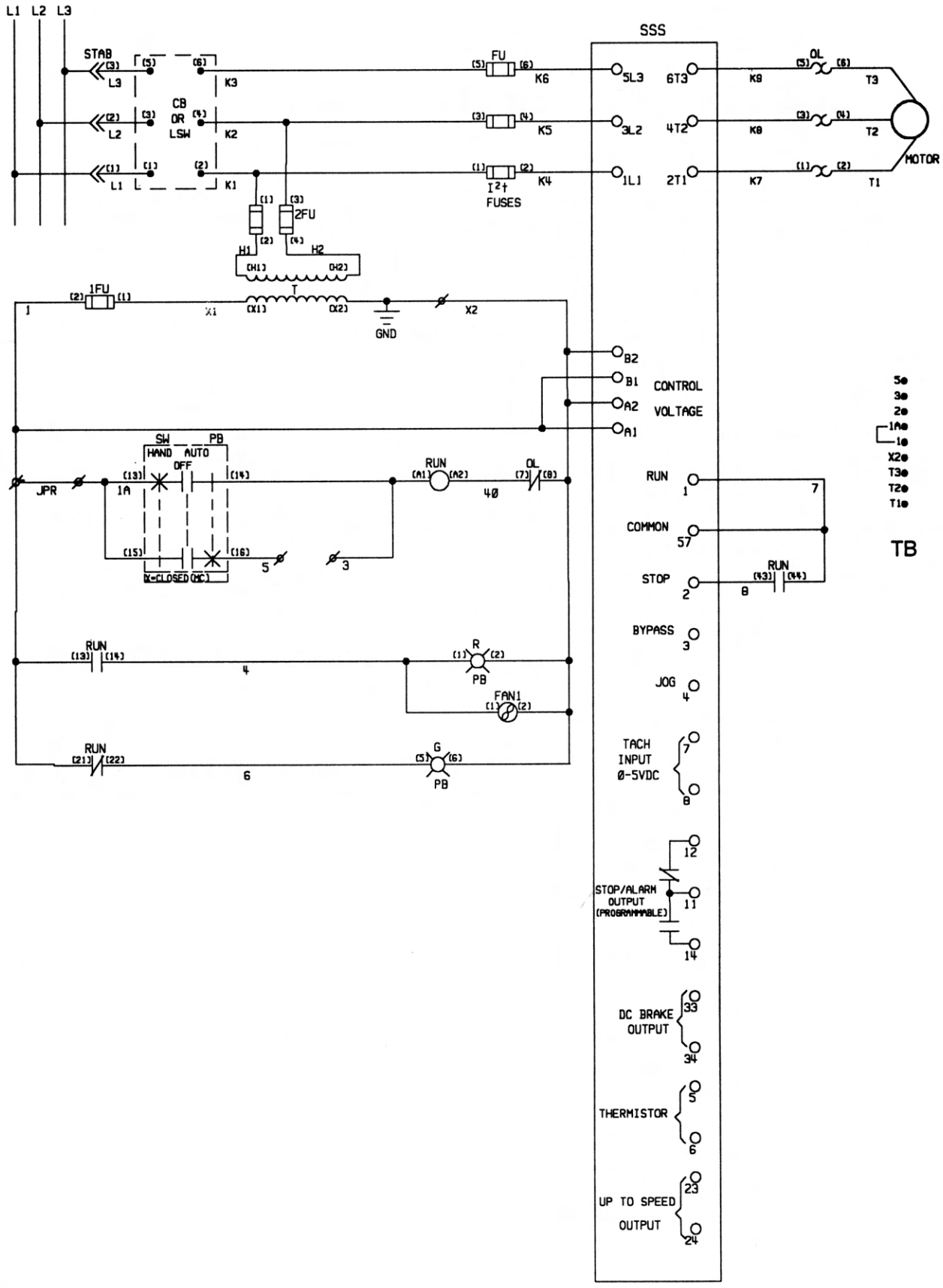


① Polarity sensitive.

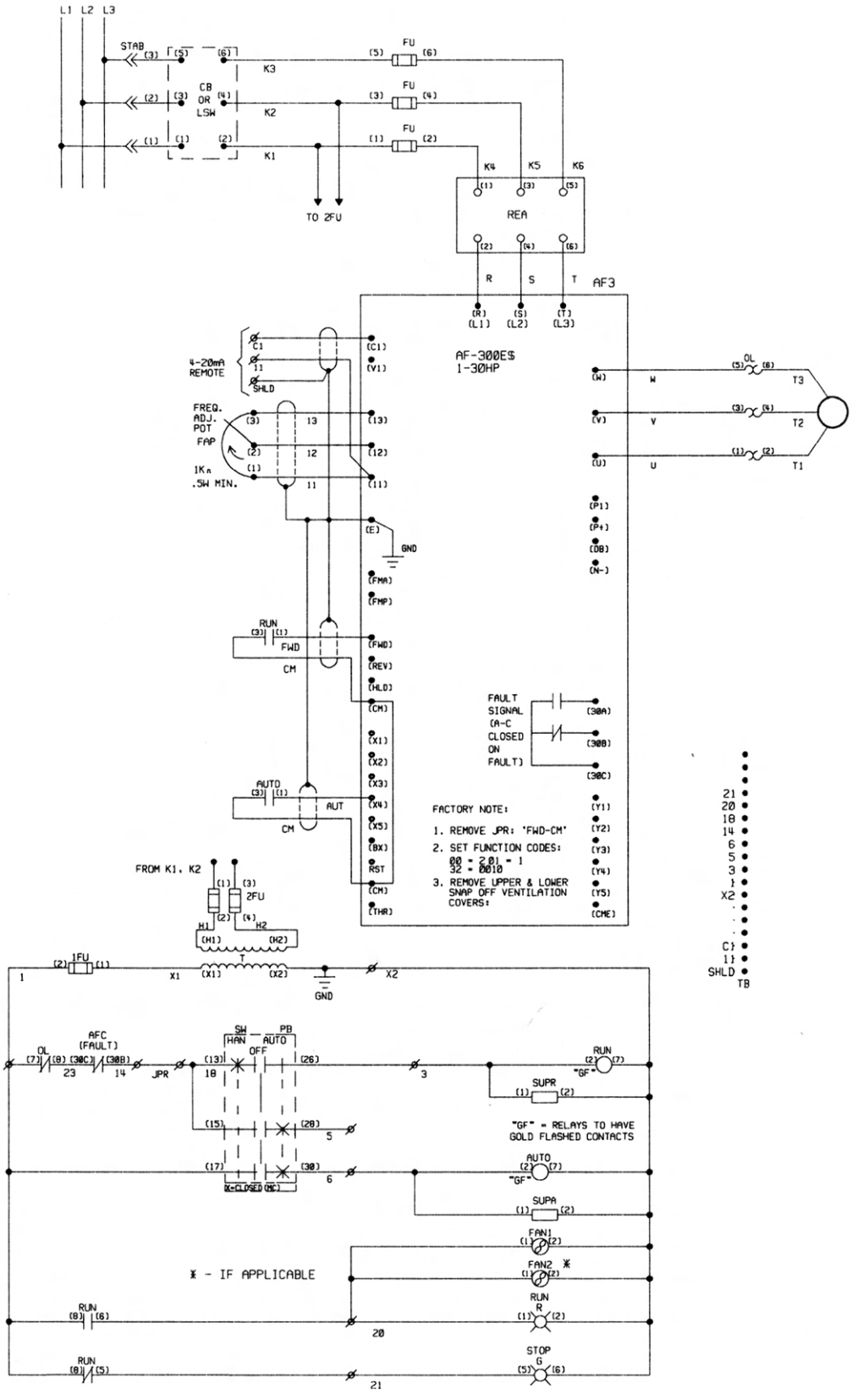
K

SOLID STATE STARTER

TYPICAL CIRCUIT DIAGRAMS



AF-300E$ VARIABLE SPEED DRIVE



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