APPLICATION AND SELECTION GUIDE

Spectra Series™ and 8000-Line Motor Control Centers

GE legacy product
documentation

In 2018 ABB acquired General Electric Industrial Solutions (GEIS). 8000-Line motor control centers are now serviced and maintained by ABB. If you need spare parts or your installed equipment has aged and requires modernization or replacement – ABB is your first point of contact (look for contact details on the last page).

Spectra Series™ and 8000-Line Motor Control Centers

Please note that the 7700-Line, 8000-Line and Spectra Series™ motor control centers (MCCs) are no longer manufactured as new line-ups. Additionally, many of the original components from these MCCs are obsolete, including Spectra Molded Case Circuit Breakers (MCCBs) and earlier MCCBs. However, a very large installed based of these MCC's is still operating at customer sites globally. Therefore, ABB still supports these MCCs with new buckets and spare parts.

Major areas of support for these MCC product lines include:

- Spare sheet metal parts for all enclosures
- Spare bus parts for main (horizontal) and vertical bus
- New units (buckets)
  - Main
  - Feeder
  - FVNR
  - FVR
  - 2S1W
  - 2S2W
- All unit (bucket spare parts)

Please note that all buckets, cabinets, and vertical buses for these various product lines are compatible. The 2700-Line, 7700-Line and Spectra Series MCCs are now supported with 8000-Line style buckets, which are fully compatible with the other MCC product lines.

Purchasing spare parts and buckets (units) from ABB will usually maintain the UL 845 listing of the original MCC. In special cases, this may not be the case, and the customer will be notified of any change in status.

Note: 2700-Line, 7700-Line, 8000-Line and Spectra Series MCCs were original manufactured by the General Electric Company (GE). During 2018, ABB acquired the GE Industrial Solutions division (GEIS), including all MCC lines from GE. These MCCs are still supported from the Mebane, NC USA factory which was acquired in the GEIS acquisition by ABB.

Note: When ordering parts or new units (buckets), please provide a photo of the MCC nameplate, which is located on the vertical wireway door of each section. This data allows drawings to be located, which also helps locate the proper replacement parts for the original MCC design.

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The 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.

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.

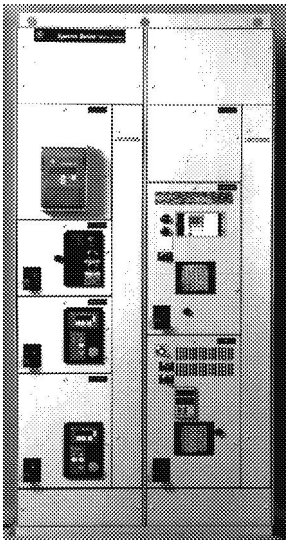
The purpose of this publication is to simplify the selection of motor control centers. The following logic flow chart lists basic items which must be considered for each application.

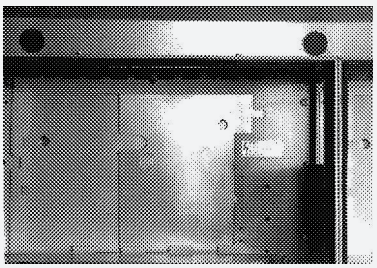
PRODUCT FEATURES
NEMA CLASS
APPLICABLE CODES
ENVIRONMENTAL REQUIREMENTS
SYSTEM VOLTAGE AND SHORT CIRCUIT RATING
BUS TYPE AND CAPACITY
ENCLOSURE TYPE AND CONSTRUCTION
INCOMING LINE TERMINATION AND MAINS
STARTERS
FEEDERS
SPECIAL FEATURES REQUIRED
SPECIAL CIRCUIT AND WIRING REQUIREMENTS

Product Features
Standard Design Features

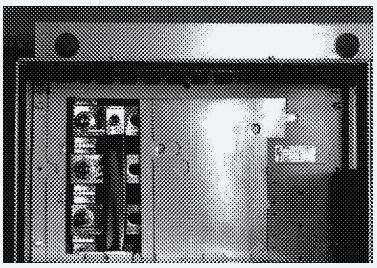
Design flexibility, performance, personnel and equipment protection, ease of maintenance and installation are all contained in the Spectra Series™. Spectra Series™ features, such as separate wiring troughs, split-type terminal boards, isolated bus, drawout starter units, operating mechanisms, and provisions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



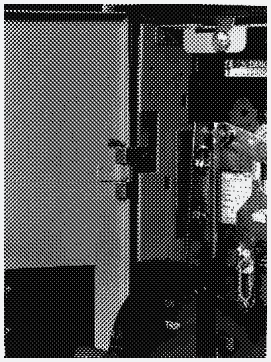


Barriers located in front of the main horizontal bus isolate the bus from the top horizontal wireway. Maintenance personnel can easily gain entrance to the top horizontal wireway of the control center without danger of contact with a live bus.

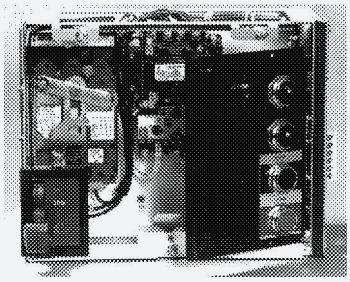


Barriers furnished with 2-inch main bus systems use a sliding panel. After de-energizing the bus, maintenance personnel may slide back the panels to give ready access to the main bus for inspection of bolted connections. Main bus splicing is accomplished in this area with the hardware already in place.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

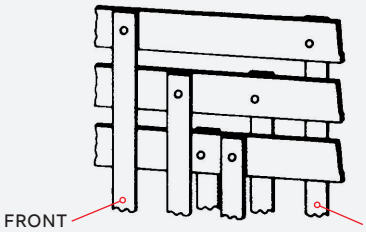
An incoming-line terminal compartment can be located at the top or bottom of a vertical section to allow cable termination with minimum bending. The standard 600-ampere incoming line terminal compartment shown is furnished with 2 mechanical type lugs per phase. Other incoming line terminal compartments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



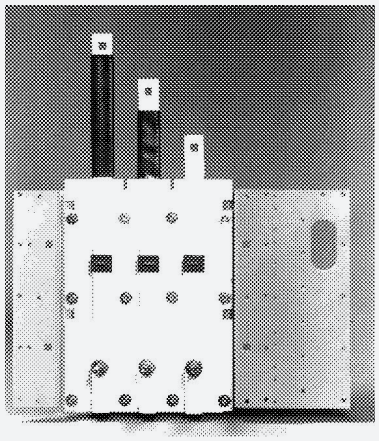
New doors mounted on the case feature a removable hinge pin providing easy door removal and accurate alignment, in Spectra Series™.



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.



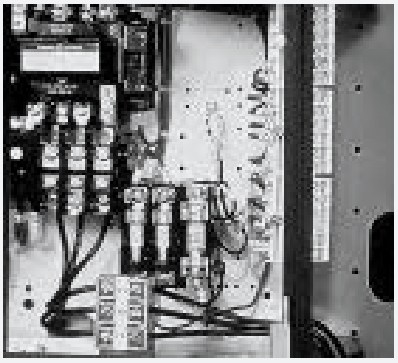
A polyester-reinforced “sandwich” insulates and isolates the vertical bus and helps prevent the spread of faults from starter and feeder units to vertical or horizontal bus. Small stab openings provide effective isolation. 65 kA short circuit bracing is standard for Spectra Series™ MCC.

Product Features

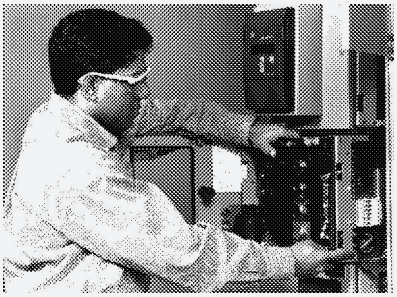
Stab connections are made with wedge-shaped silver-plated copper unit power stabs which are under double spring pressure and engage the vertical bus to provide positive contact and expand under short-circuit stress to increase contact pressure. Design maintains common unit interface between 7700 Line,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

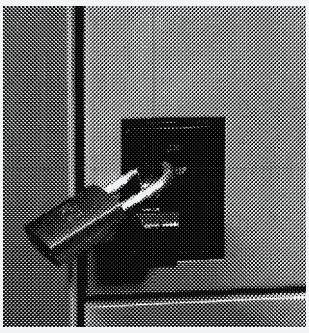


Large isolated wire trough provides a 45/8-inch x 81/8-inch area to “lay in” wire and make control and load connections. A separate removable door, adjacent to drawout units, makes wiring installation and inspection easy. The door can be opened without disturbing adjacent unit doors. $8^{5}/_{8}$-inch x $8^{1}/_{8}$-inch wire troughs are available with 24-inch wide enclosures.



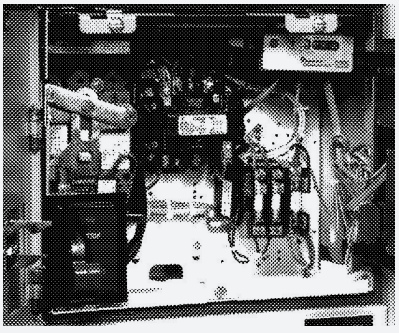
Units can be withdrawn to a disconnected position and padlocked for maintenance. All 8000-Line units and sections are fully compatible with 7700-Line and Spectra Series™ units.

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.

Note: New units up to 250A are supplied with Tmax XT circuit breakers with a rotary operating mechanism. This mechanism allows similar locking capabilities.



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.

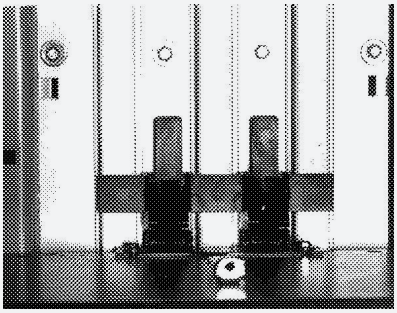
A new ABB paint finish is applied to all un-plated steel part. The powder coat finishing is heavier than the prior coating and is extremely durable.

Product Features
Optional Customizing Features

Vertical Ground Bus and Unit Stab

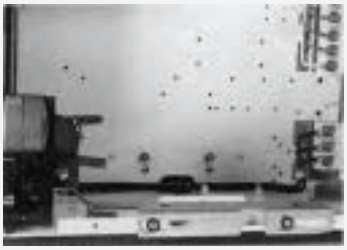
Vertical copper ground bus allows direct grounding of unit saddles to the equipment ground bus. A unit ground bus stab engages the vertical ground bus before the unit power stabs engage the vertical bus.

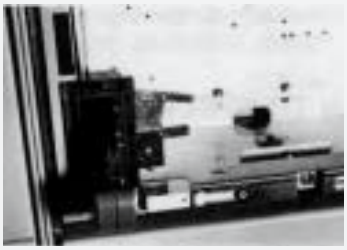
A load vertical ground bus is available for customer cable grounding. Termination points are located at the rear of the vertical wireway, next to starter/feeder lugs.



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.

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 strand- ed 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 Definition *)
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 Definition *)
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 Definition *)
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.

*) 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 Specify Class I
Specify NEMA Class I control centers for independently operated motors requiring no interlocking or other interconnection between units.

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

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

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	
	A	B	C	A	B	C	B	C	B	C
Type of Power or Control Termination Furnished										
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 thesame control center. Sections and units which will be shipped with the UL listing mark are identified in the appropriate sections of this publication.

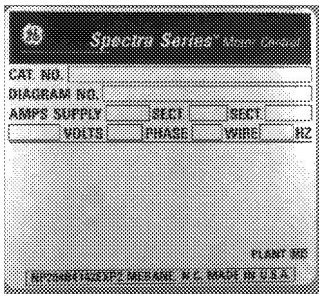
The National Electrical code covers installation of electric conductors and equipment for installations identified in the NEC Article 90. The NEC is not intended as a design specification and acceptance of an installed motor control center by a local code authority is dependent on factors independent 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."

Motor Control Center Bus

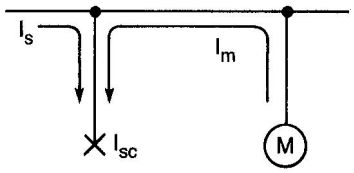


Figure 1

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

Short Circuit Considerations

ALL RATINGS IN THIS PUBLICATION ARE RMS SYMMETRICAL AMPERES

Main Protective Devices
A motor control center requires adequate over-current 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 (Figure 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 **Characteristic** [1)]	**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 drip-proof 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

8000 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-11/2-inch,12-gauge floor sills and 3-inch full-length lifting beam are included. Open bottom is standard.

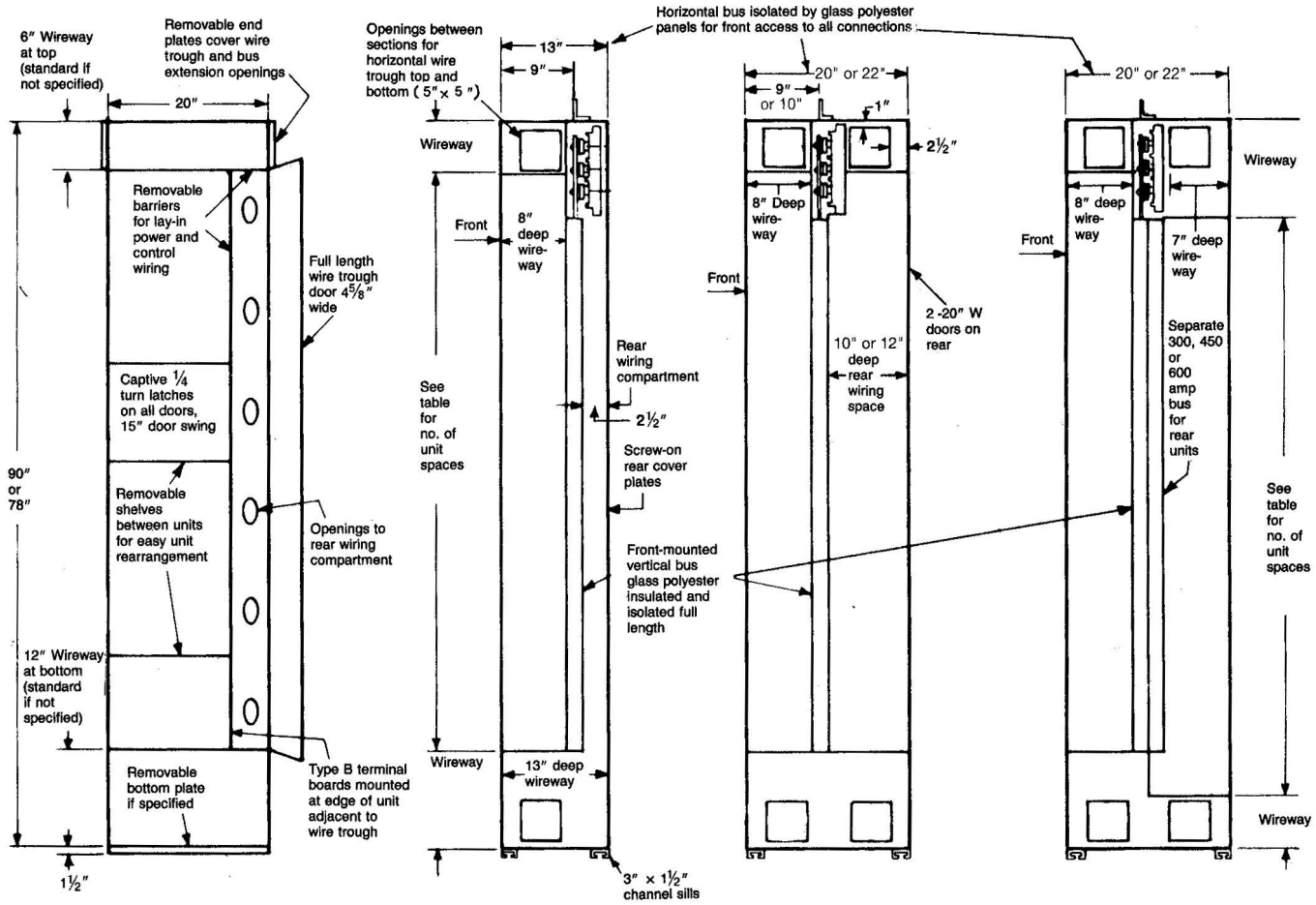
NEMA 2 DRIP-PROOF CONSTRUCTION
Similar to NEMA 12 gasketed construction except with pan-type dripshield on top and with open bottom. Dripshield extends four inches beyond front of motor control center. Standard finish: light gray ANSI 61. Furnished with removable conduit cover plates unless otherwise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

Please note that new enclosures for these MCCs are no longer manufactured. However, spare parts for the enclosures and new buckets (units) are available.

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.’s[2)]	6	6	5½	6	5½	5½	5	5	4½	5	4½	4½

Notes:

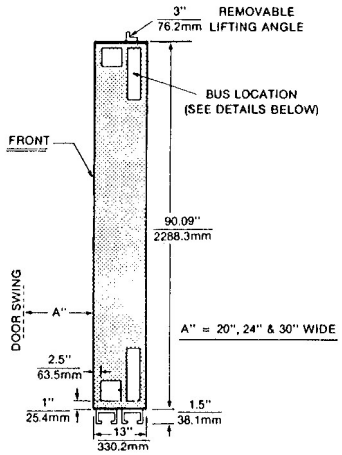
- One S.U. = 12-inch vertical height.
- Average weight per vertical section including units–500 lbs.

[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.

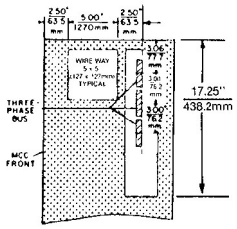
[2)] On back-to-back sections, the rear side must always have a 12-inch top wireway with 2-inch bus and an 18-inch top wireway with 4-inch bus.

Indoor Enclosures
13” Deep Section

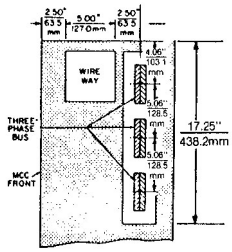
END VIEW STANDARD 13” DEEP



BUS DETAILS STANDARD 13” DEEP

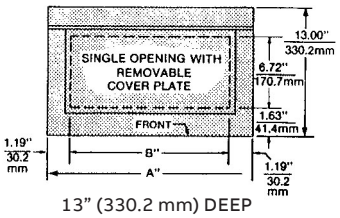


END VIEW WITH 2” (50.8 mm) BUS BAR



END VIEW WITH 4” (101.6 mm) BUS BAR

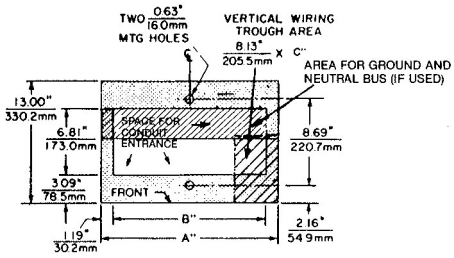
TOP CONDUIT ENTRANCE DETAILS FOR STD. 13”



13” (330.2 mm) DEEP

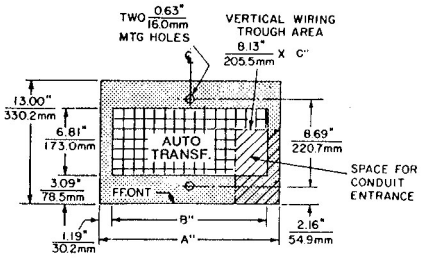
GENERAL DIMENSIONS			
REF. DIM.	20” WIDE ENCLOSURE	24” WIDE ENCLOSURE	30” WIDE ENCLOSURE
A” =	20” / 508.0 mm	24” / 609.6 mm	30” / 762.0 mm
B” =	17.63” / 447.8 mm	21.63” / 549.4 mm	27.63” / 701.8 mm
C” =	4.63” / 117.6 mm	8.63” / 219.4 mm	NOT APPLICABLE

BOTTOM CONDUIT ENTRANCE DETAILS FOR STD. 13”

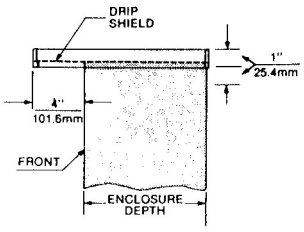


13” (330.2 mm) DEEP

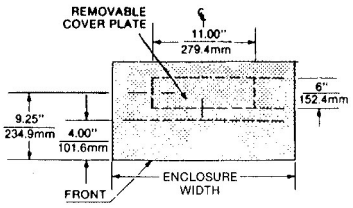
BOTTOM CONDUIT ENTRANCE DETAILS WHEN AUTO—TRANSFORMER IS FURNISHED



13” (330.2 mm) DEEP

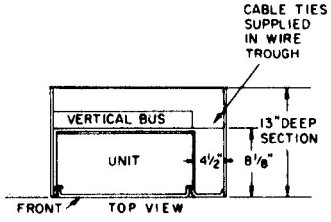


END VIEW



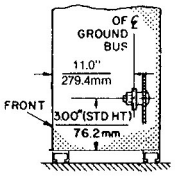
TOP VIEW

NEMA II DRIP SHIELD

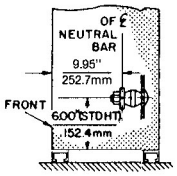


VERTICAL WIRING TROUGHS

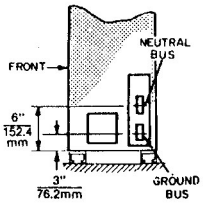
STANDARD GROUND AND NEUTRAL BUS DETAILS



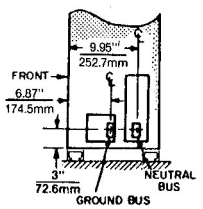
Ground bus bolted directly to section frame



Insulated neutral bus



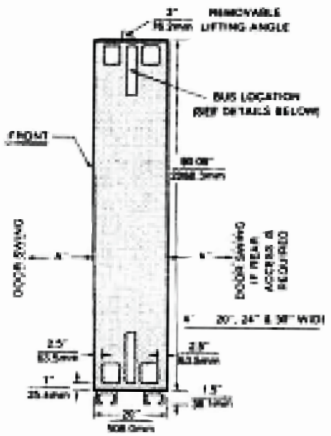
Standard location of ground and neutral bus with a 12-in. (304.8 mm) compartment at the bottom of MCC



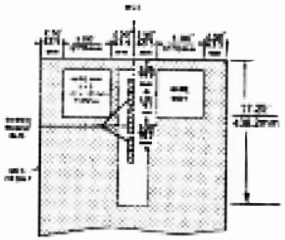
Standard location of ground and neutral bus with a 6-in. (152.4 mm) compartment at the bottom of MCC

Indoor Enclosures
20" Deep Section

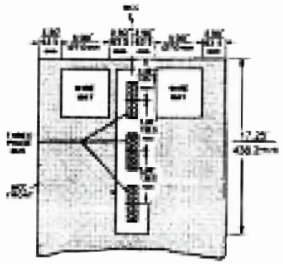
END VIEW STANDARD 20" DEEP



BUS DETAILS STANDARD 20" DEEP

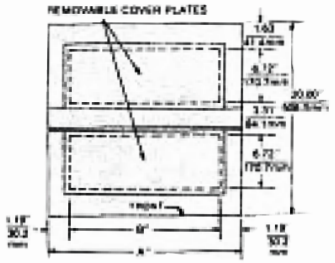


END VIEW WITH 2" (50.8 mm) BUS BAR



END VIEW WITH 4" (101.6 mm) BUS BAR

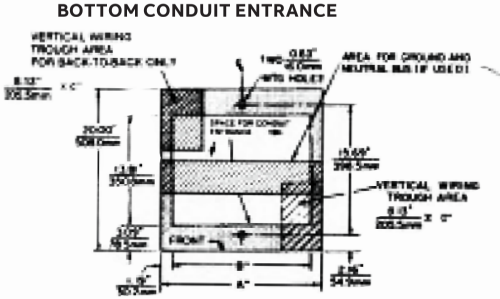
TOP CONDUIT ENTRANCE

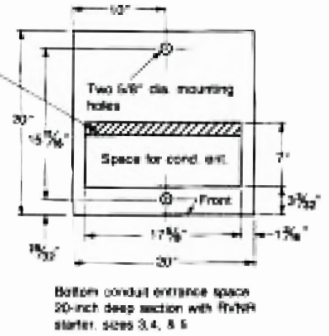


20" (508.0 mm) DEEP

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

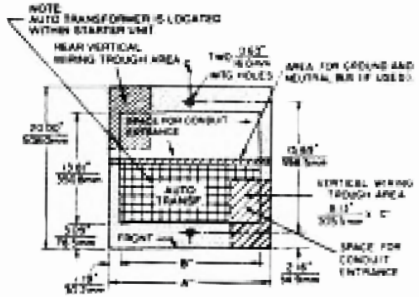
BOTTOM CONDUIT ENTRANCE



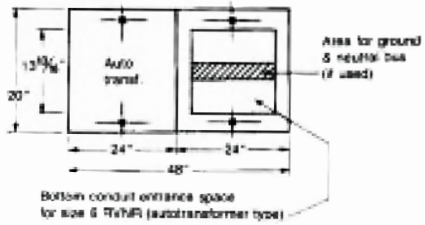


Bottom conduit entrance space 20-inch deep section with RVNR starter, sizes 3,4, & 5

BOTTOM CONDUIT ENTRANCE DETAILS WHEN AUTO-TRANSFORMER IS FURNISHED

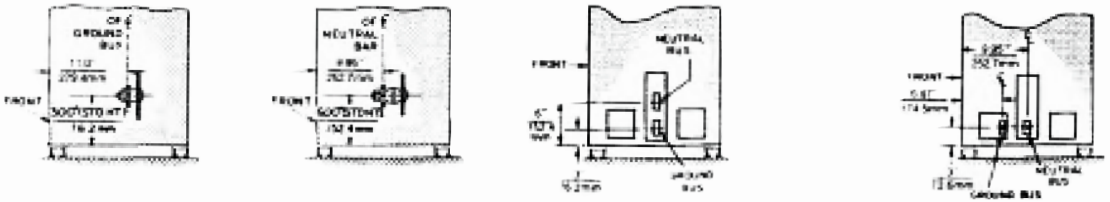


20" (508.0 mm) DEEP
BACK-TO-BACK
(SIZE 3,4)

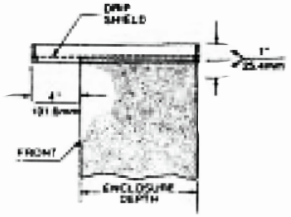


Bottom conduit entrance space for size 6 RVNR (autotransformer type)

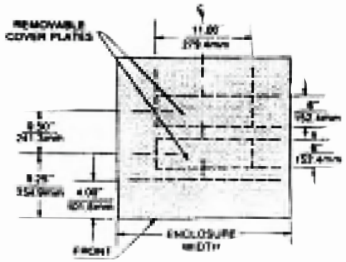
STANDARD GROUND AND NEUTRAL BUS DETAILS



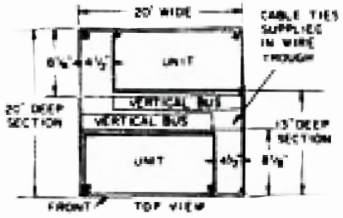
NEMA II DRIP SHIELD



END VIEW



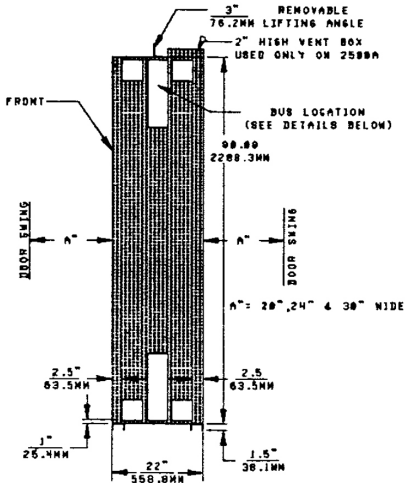
TOP VIEW



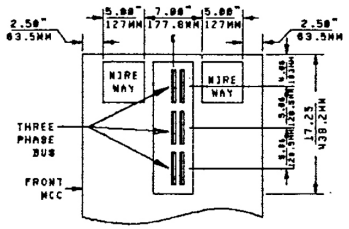
VERTICAL WIRING TROUGHS

Indoor Enclosures
22" Deep Section

END VIEW STANDARD 22" DEEP

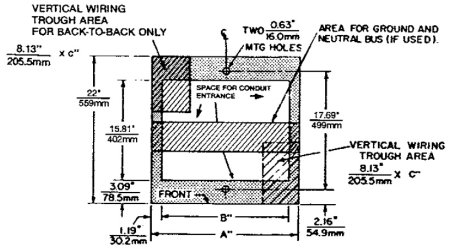


BUS DETAILS STANDARD 22" DEEP

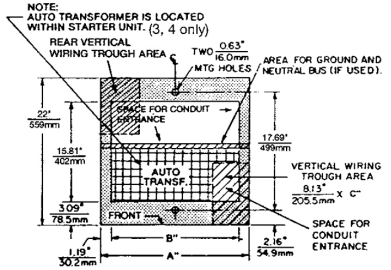


GENERAL DIMENSIONS			
REF. DIM.	20" WIDE ENCLOSURE	24" WIDE ENCLOSURE	30" WIDE ENCLOSURE
A" =	20" / 508.0 mm	24" / 609.6 mm	30" / 762.0 mm
B" =	17.63" / 447.8 mm	21.63" / 549.4 mm	27.63" / 701.8 mm
C" =	4.63" / 117.6 mm	8.63" / 219.4 mm	NOT APPLICABLE

BOTTOM CONDUIT ENTRANCE

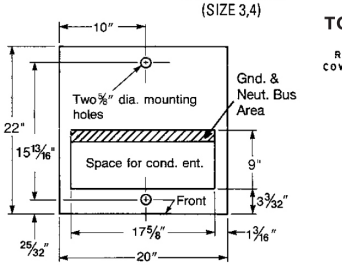


22" (558.8MM) DEEP

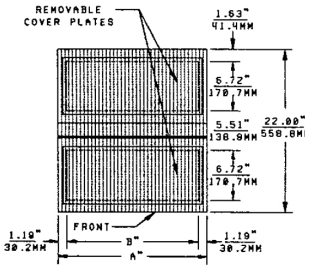


22" (558.8MM) DEEP
BACK-TO-BACK
(SIZE 3,4)

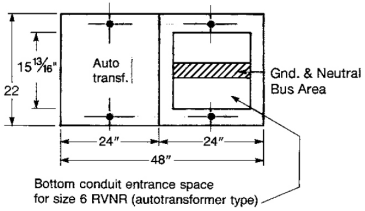
TOP CONDUIT ENTRANCE



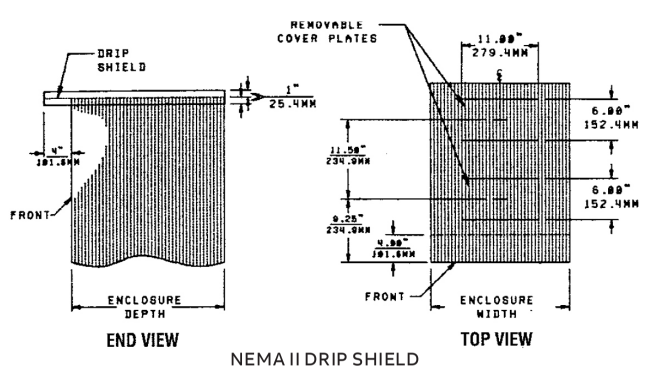
Bottom conduit entrance space
22-inch deep section with RVNR
starter, sizes 3,4, & 5



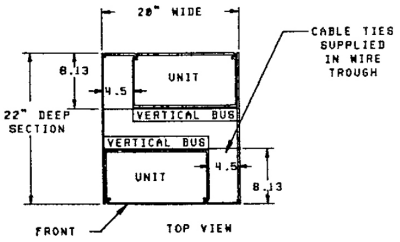
22" (558.8MM) DEEP



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

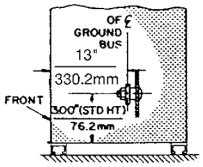


NEMA II DRIP SHIELD

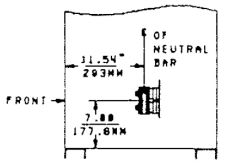


VERTICAL WIRE TROUGHS

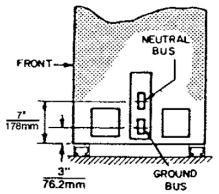
STANDARD GROUND AND NEUTRAL BUS DETAILS



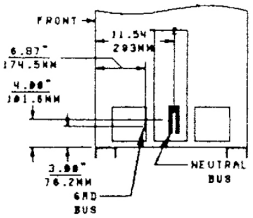
Ground bus bolted directly to section frame



Insulated neutral bus



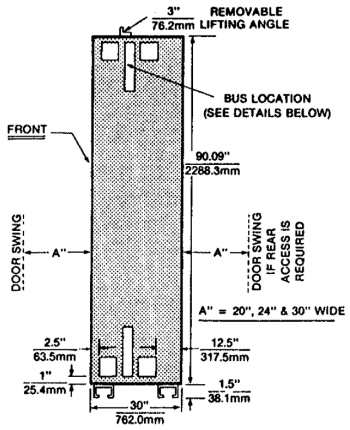
Standard location of ground and neutral bus with a 12-in. (304.8 mm) compartment at the bottom of MCC



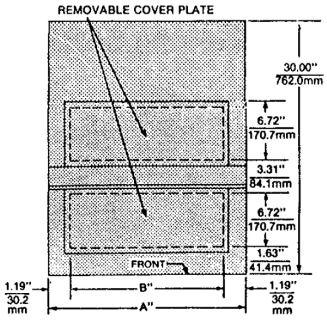
Standard location of ground and neutral bus with a 6-in. (152.4 mm) compartment at the bottom of MCC

Indoor Enclosures
30” Deep Section

END VIEW STANDARD 30” DEEP

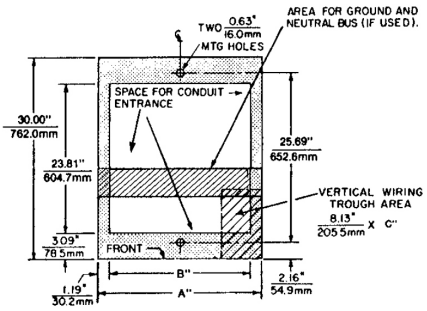


TOP CONDUIT ENTRANCE DETAILS

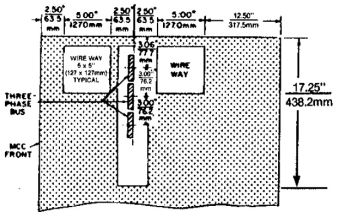


30” (762.0 mm) DEEP

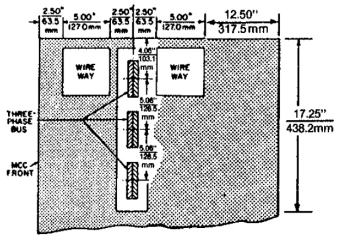
BOTTOM CONDUIT ENTRANCE



BUS DETAILS STANDARD 30” DEEP



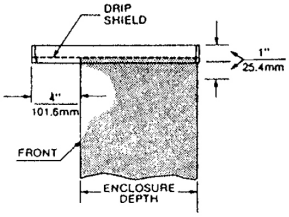
END VIEW WITH 2” (50.8 mm) BUS BAR



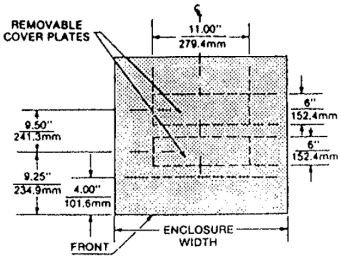
END VIEW WITH 4” (101.6 mm) BUS BAR

GENERAL DIMENSIONS

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



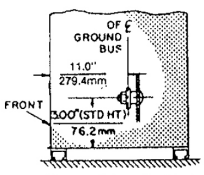
END VIEW



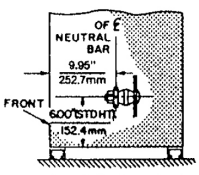
TOP VIEW

NEMA II DRIP SHIELD

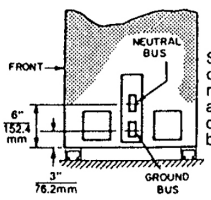
STANDARD GROUND AND NEUTRAL BUS DETAILS



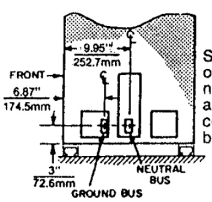
Ground bus bolted directly to section frame



Insulated neutral bus



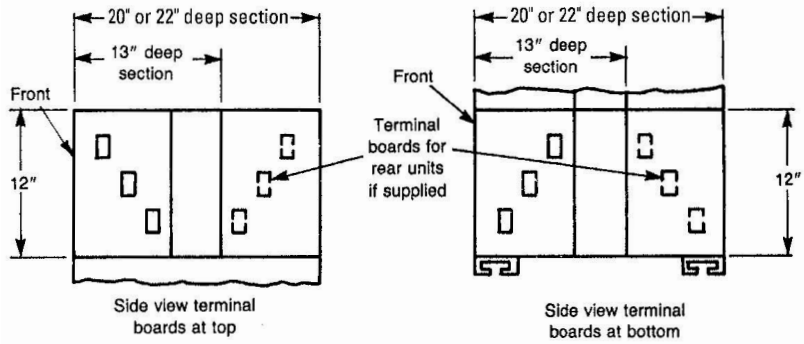
Standard location of ground and neutral bus with a 12-in. (304.8 mm) compartment at the bottom of MCC



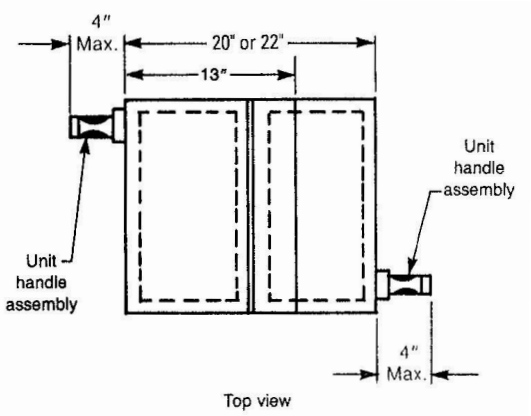
Standard location of ground and neutral bus with a 6-in. (152.4 mm) compartment at the bottom of MCC

Indoor Enclosures

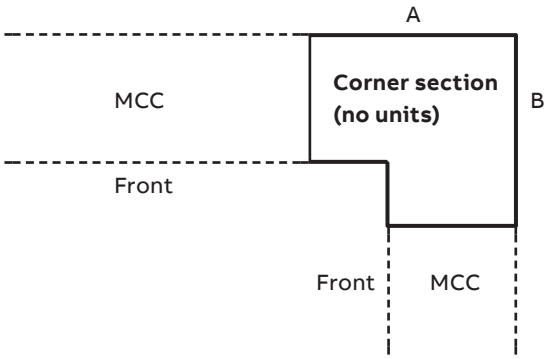
Type C Master Terminal Boards



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

Indoor Enclosures
Options

Space Heaters
Space heaters are used to prevent moisture condensation on the inside of the motor control center. One heater (62.5 watts at 120 volts AC) is installed in the bottom of each vertical section. UL requires space heaters be controlled by a thermostat. One thermostat can control up to 14 heaters and is located in the top horizontal wireway.

A terminal board for connecting an external 120-volt power source is standard. The terminal board is located in the top horizontal wireway adjacent to the thermostat(s). This is recommended since it permits the space heaters to be energized 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.

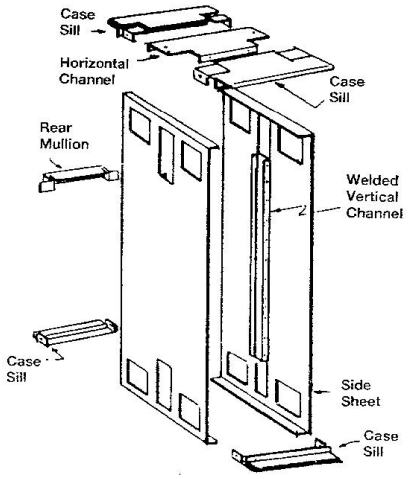
Rodent Barriers
Metal plates bolted to the bottom of each end section to close the opening between the front and rear floor sills. Not required if the floor sills will be removed or imbedded in concrete.

Structural Floor Sills
11/2-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”

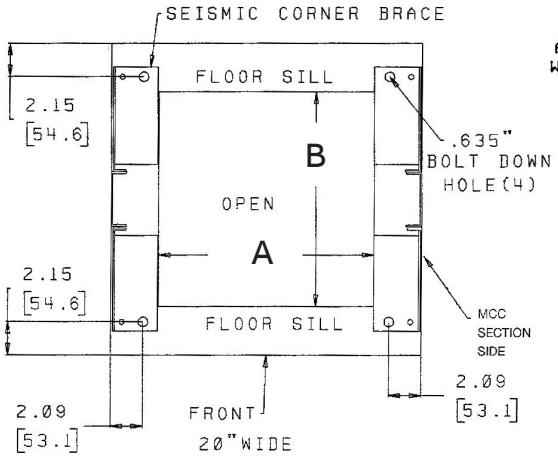
Enclosures

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

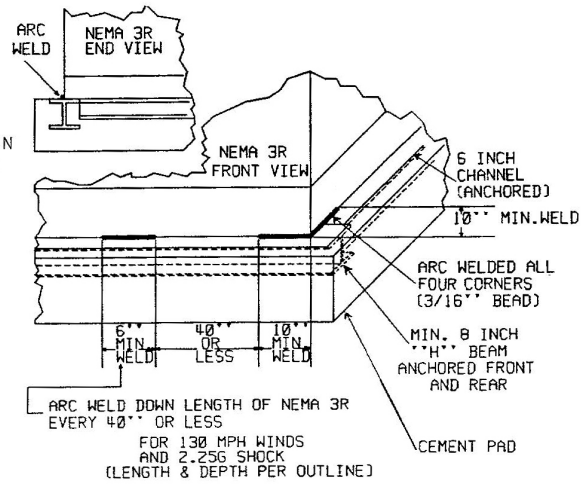
See standard indoor enclosures for other construction details.

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 1/2-inch bolts.

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

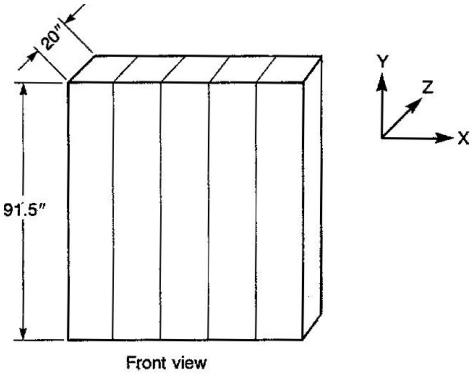


Mounting Requirements for Seismic NEMA 3R with Optional Heavy Base



Case Width	"A"	"B" (Depth)	
20" (508 mm) W	13.88" (352.5 mm)	20" DP	22" DP
24" (609.6 mm) W	17.88" (454.2 mm)	13.75"	15.75"
30" (762 mm) W	23.88" (606.6 mm)	(349.2)	(398.5)

Center of Gravity



For a uniformly loaded 90" high x 20" deep lineup, center of gravity is:
X = center of lineup
Y = 461/2" above bottom of floor sill
Z = 8" in from front (front-mounted devices 20" deep)
OR: 10" in from front (back-to-back construction)
Z = 5" in from front (13" deep)
Z = 81/2" in from front (22" deep)
Z = 11" in from front (25" NEMA 3R)

Typical variations due to uneven loads:
X = ± 5"
Y = ± 1"
Z = ± .5"

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”

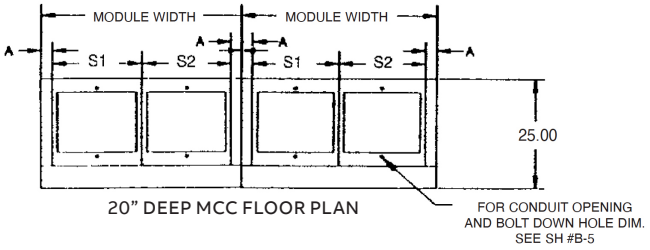
Notes:

[1)] Doors shown are double doors, or MW less than 45” door will be single door.

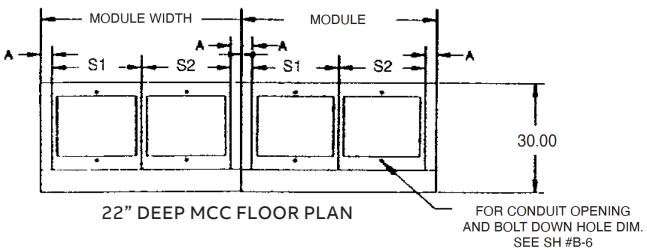
[2)] NEMA 3R module may contain 1, 2 or 3 MCC sections, 3 section shipping split limited to (3) 20” wide MCC sections only.

[3)] All dimensions in inches.

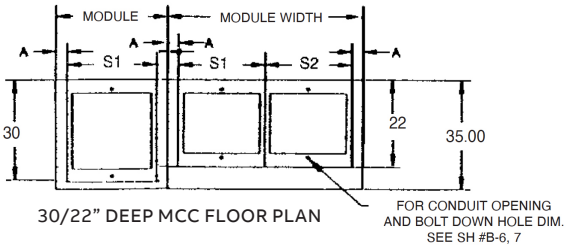
[4)] For Seismic mounting see Sh # B-10



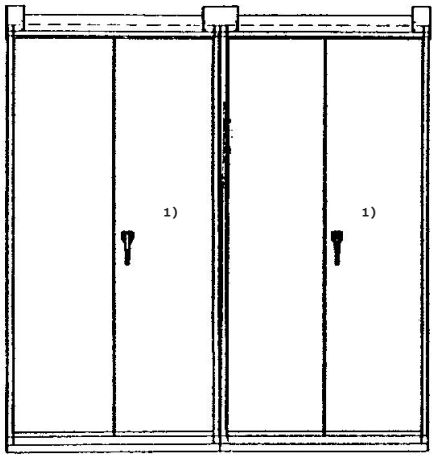
20” DEEP MCC FLOOR PLAN

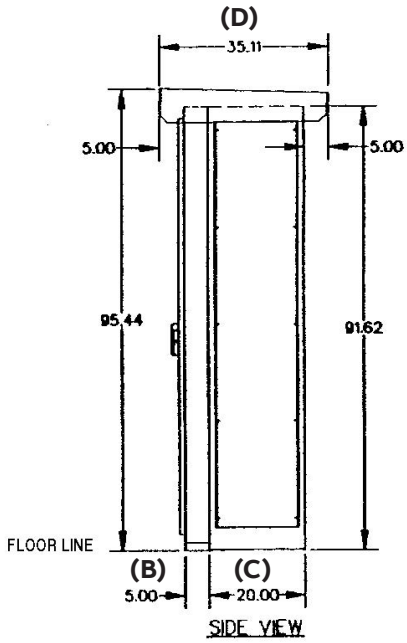


22” DEEP MCC FLOOR PLAN



30/22” DEEP MCC FLOOR PLAN





MCC Depth (C)	Front Extension (B)	Top Cover (D)
20”	5	35
22”	8	40
30” Plus 22”	5	45
	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./ft2. 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

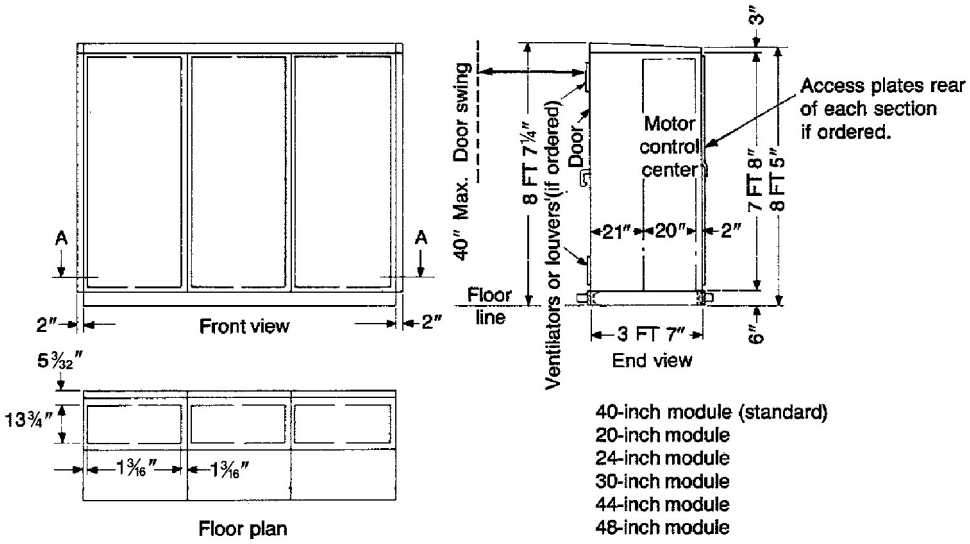
Each NEMA 3R module may vary in width from 20 inches to 48 inches, and modules of varying width may be bolted together to form a single shipping section. With the standard base a maximum of two modules can be shipped bolted together. Specify a heavy base under the following conditions:

- 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.

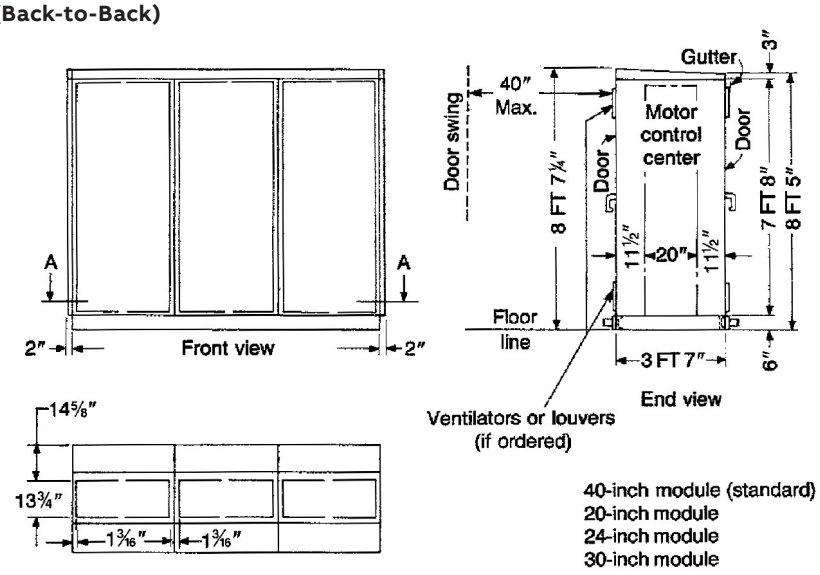
OUTDOOR ENCLOSURE FEATURES	STANDARD	OPTIONAL			
Feature	3R Non-Walk-In	3R Non-Walk-In	3R Non-Walk-In Back-To-Back	3R Walk-In	3R Walk Through
Rear Access	Standard	Optional	–	Optional	Optional
Louvered Door Ventilation	–	Standard	Standard	Standard	–
Filters For Door Ventilation	–	Optional	Optional	Optional	–
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

Outdoor Enclosures
Outdoor Enclosure Dimensions

Optional NEMA 3R Outdoor Non-Walk-In



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

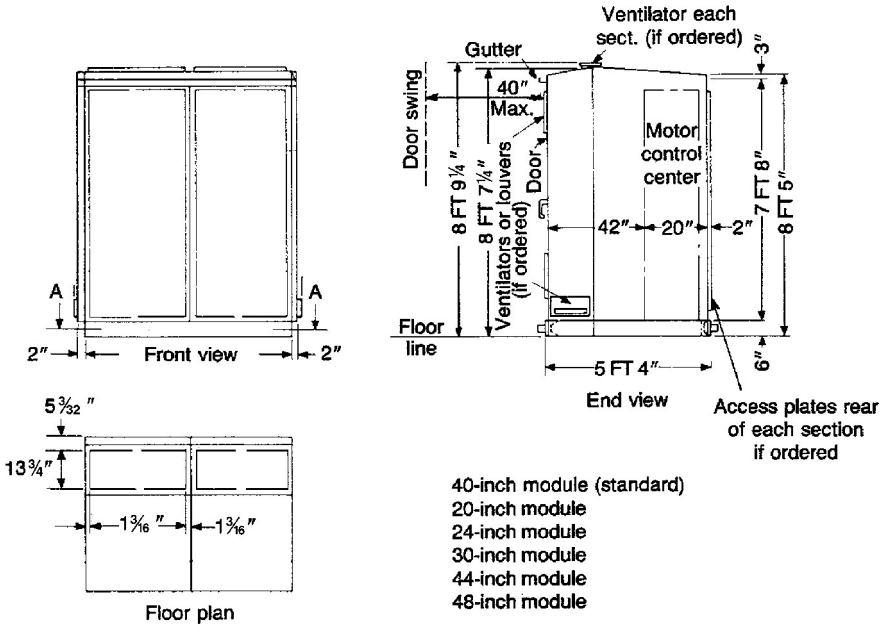


GENERAL NOTES:

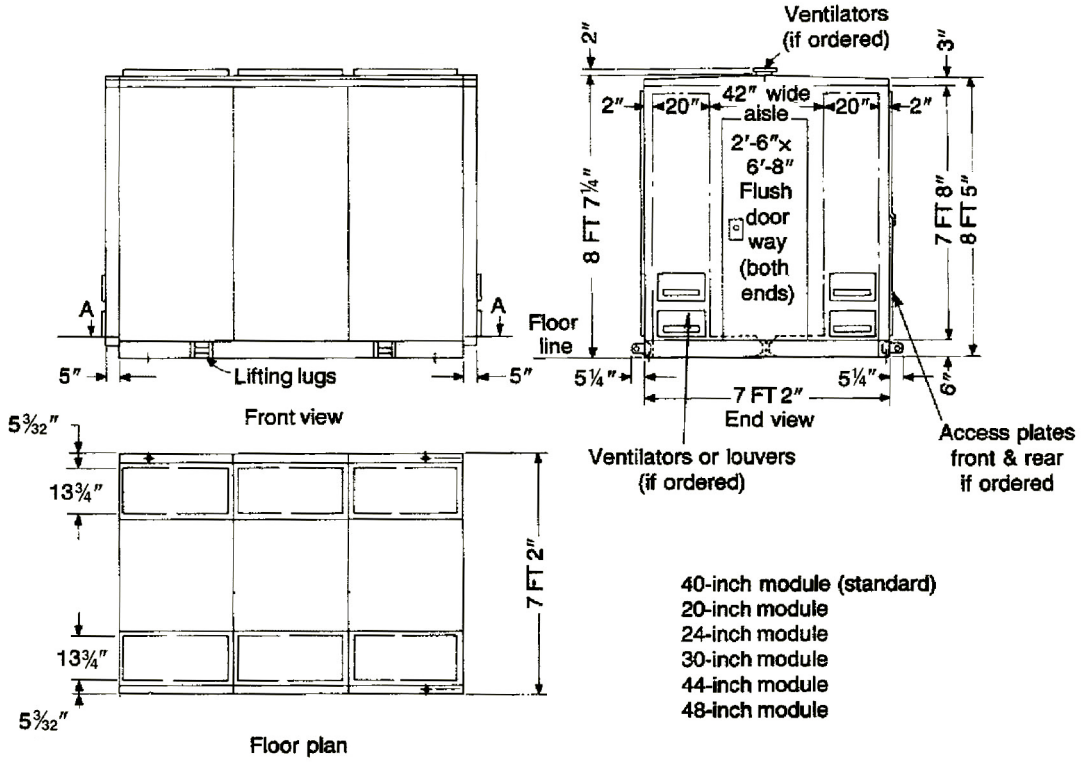
- NEMA 3R bolt-down hole size and location is subject to change depending on equipment requirements. See specific job drawings.
- Average shipping weight of all outdoor enclosures is based on 50 lbs. per square foot of floor space plus the weight of the interior motor control center line-ups.
- Some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

Outdoor Enclosures
Outdoor Enclosure Dimensions

Optional NEMA 3R Outdoor Walk-In



Optional NEMA 3R Outdoor Common-Aisle Walk Through



Bus Selection

Note: Both vertical and horizontal bus components are still supported as spare parts. However, aluminum bus parts are not available. Copper bus parts can be plated to make them compatible with existing aluminum bus to avoid galvanic corrosion issues.

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 vertical 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 Cu	Short-Circuit Rating in RMS Symmetrical Amperes–(kA)			UL	Notes
			42	65 [9]	100 [2]		
Main Horizontal	600	X		X	X	X	2” Bus
	800	X		X		X	2” Bus
	1200	X	X	X	X	X	[1] 4” Bus
	1600 [5] [7]	X	X	X	X	X	[1] 4” Bus
	2000 [6]	X	X	X	X	X	[1] 4” Bus
	2500 [6]	X	X	X	X	X	[1] 4” Bus
Vertical	300	X	X	X		X	[3]
	450	X	X	X		X	
	600	X	X	X	X	X	
Neutral	300	X				X	
	600	X				X	
	800	X				X	
	1000	X				X	
	1200	X				X	
	1250	X				X	
Horizontal Ground	300	X				X	$^{1}/_{4}$” x 1”
	600	X				X	$^{1}/_{4}$” x 2”
Vertical Grounds	150	X				X	$^{1}/_{8}$” x 1”

[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

Note
Mains are still supported. However, please note some important limitations:
- Fusible switches are only available to 200A. 400A and 600A are obsolete.
- Power Break I has been replaced by Power Break II.
- THED and THFK are obsolete and replaced by Spectra.
- Tri-Break is obsolete.
- AKR is obsolete.

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-In	Bolt-In			
	240	480	600					
Fusible switches								
100 [5]	65	65	N/A	X		1 1/2	X	
200*f*	100	100	100	X		2 1/2	X	
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 1/2 X 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)			Stab-In	Bolt-In	Space Units	UL (X) Listed	Notes	Entry Top/Bot
		240V	480V	600V						
SPECTRA THERMAL MAGNETIC										
150	SEL/SEP	65/100	65/100	25/25	X		$1^1/_2$	X		T/B
225	SFL/SFP	65/100	65/100	25/25	X		2	X	▫	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	1) 2) 7)	T
1200	SKL	65	65	42		X	6	X	2) 6)	B
POWERBREAK® INSULATED-CASE MICROVERSATRIP is obsolete and replaced by PowerBreak II										
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	4) 10)	T/B
2000	TP/THP/SSF	65/100	65/100	42/65		X	6 (30W)	X	8) 10)	T/B
2500	TP/THP/SSF	65/100	65/100	42/65		X	6 (30W)	X	8) 10)	T/B
800	TC/THC/SSD	65	65	42	X		6 (30W)	–	9) 8)	T/B
1600	TC/THC/SSD	65	65	42	X		6 (30W)	–	9) 8)	T/B
2000	TC/THC/SSD	65	65	42	X		6 (30W)	–	9) 8)	T/B

1) Main breaker requires additional $^1/_2$ 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) $1^1/_2$ X units are available at 180 Amps Max. Load.
13) In 8000-Line MCC only.

Data subject to change without notice

Feeders

Note that feeders are still supported with these important changes:

- Fusible switches are only available to 200A. The 400A and 600A fusible switches are obsolete.
- Tmax XT has replaced Spectra for lower amperages up to 250A.
- THED and THFK circuit breakers are obsolete.
- Tri-Break is obsolete.

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-In	Bolt-In			
	240	480	600					
FUSIBLE SWITCHES								
30	100	100	100	X		1/2	–	[1] [2] [4]
60	100	100	100	X		1/2	–	[1] [2] [4]
30	100	100	100	X		1	X	
60	100	100	100	X		1	X	
100 [9]	65	65	–	X		1	X	
100 [7]	100	100	100	X		1	X	
200	100	100	100	X		2	X	[2]
THPR HIGH PRESSURE CONTACT SWITCH								
800	100	100	100		X	6	X	[3]
1200	100	100	100		X	6	X	[3] [8]
1600	100	100	100		X	6	–	[3] [8]

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 ½X 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)			Stab-In	Bolt-In	Space Units	UL (X) Listed	Notes	Entry Top/Bot
		240V	480V	600V						
Tmax XT and SPECTRA THERMAL MAGNETIC										
100	Tmax XT2	65/100	65/100	-	X		1/2	X	[1] [3]	T/B
150	Tmax XT2	65/100	65/100	-	X		1/2	X		T/B
250	Tmax XT4	65/100	65/100	-	X		1/2	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

[1] Feeder breaker requires additional 1/2X 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] 1 1/2 X units are available at 180 Amp. Max. load.
[8] 8000-Line only.

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 Pole [6]			Mounting Pole [6]		Mounting Pole [6]		Mounting Pole [6]		
	L	C	R	L	R	L	R	L	R	
THED	UL		UL	UL [2]	UL [2] [3]		UL		UL	Any two Except UVR and 3-Coil, Shunt Trip

ACCESSORIES FOR SPECTRA MOLDED CASE CIRCUIT BREAKERS

Breaker Type	Bell Alarm	Shunt Trip [9] or Undervoltage Release	Aux. Switch [8]	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	UL [2] [5]	UL	UL	UL	UL	All [7]

[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.

C

Options for Mains and Feeders

TERMINALS FOR FIELD WIRING MAINS AND FEEDERS

Terminal Size		Will Accept Wire [2]	
		AWG/MCM [1]	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		6-250 2-600/ 1/0-250 (2/Ph)	Cu-Al Cu-Al 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
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
TJK/THJK	125-400A	6-600/ 2/0-250 (2/Ph) 250-300 (2/Ph) 250-500 (2/Ph)	Cu-Al Cu-Al Cu Al
GROUND LUG		1/0-300	Cu-Al

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

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

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.

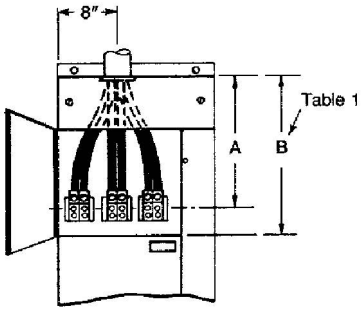
Incoming Line Cable Assemblies	Terminal Board Space		Cables Per Ph [2]	Wire Size	Fig. No.	UL Listed	Short-Circuit Rating Max.
	Adjacent Wireway						
	6”	12”					
1. 600A Top Entry	12” 18”	6” 12”	2 2 or 3	2-400MCM [1] 2-600 MCM	1 1	Yes Yes	65K 65K
2. 600A Bottom Entry	12” 18”	6” 12”	2 2 or 3	2-400 MCM 2-600 MCM	2 2	Yes Yes	65K 65K
3. 800 or 1000A Top Entry [6]	–	12”	3	2-400 MCM	3	Yes	65K
4. 800 or 1000A Bottom Entry [6]	18”	12”	3	2-600 MCM	4 [3]	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 MCM [1] 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	4 [3]	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” [6]	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

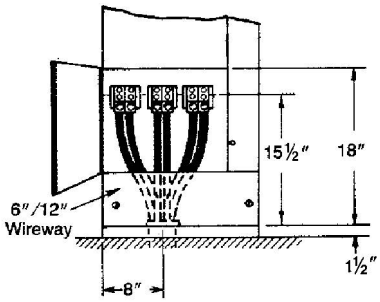
Table 1. CABLE ASSEMBLIES (Cont'd)

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



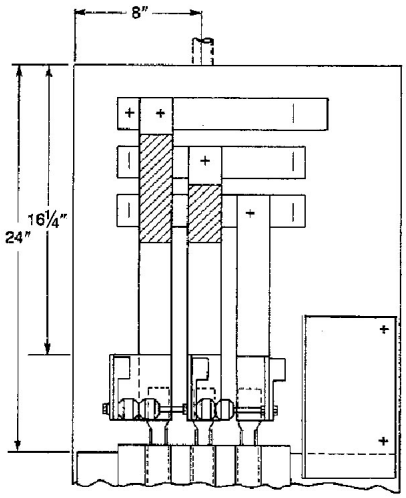
Front View

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



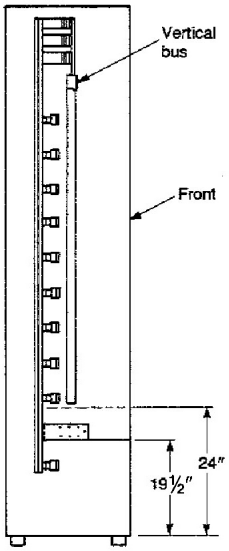
Front View

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



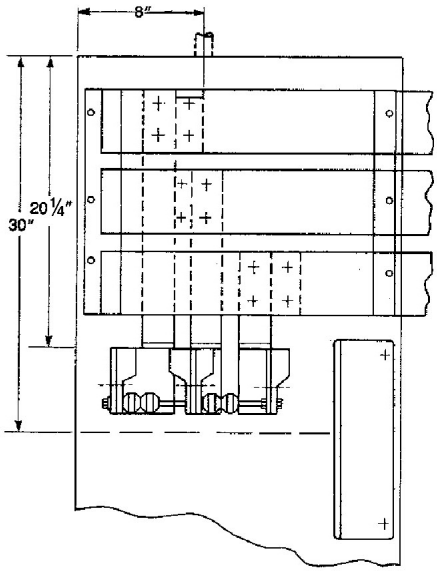
Front View

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

Motor control centers include provisions for connecting 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

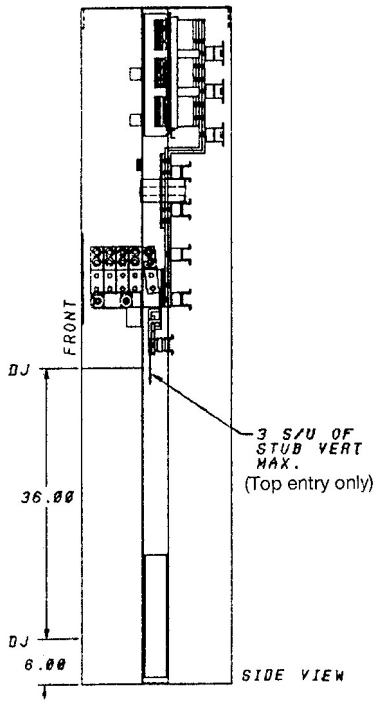


Fig. 6. 1600 ampere (top/bottom) 24” W

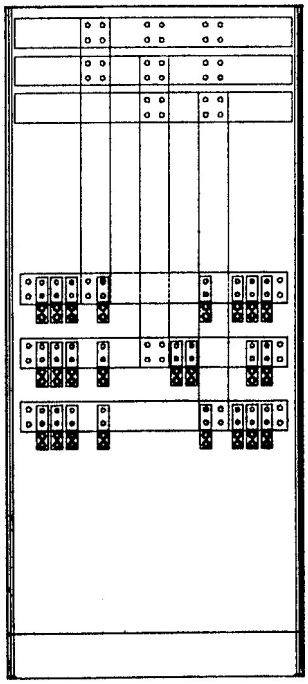


Fig. 7. 2000/2500-ampere (top/bottom) 40” W, 22” deep

Automatic Transfer Switches

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 Units [1]	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)	WCR [3]	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 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.

C

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.

Transitions

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

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 over-load 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 I). Starters can also be used for lighting or resistive heat loads (Section D).

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	XT2	1	X	
2	10	25	XT2	1	X	
3	25	25	XT2	2	X	
4	40	25	XT4	2.5	X	
5	75	100	SGL	3	X	8)
6	150	65	SKL	6	X	1) 4)
1	7.5	65,100	XT2	1	X	
2	10	65,100	XT2	1	X	
3	25	65,100	XT2	2	X	
4	40	65,100	XT4	2.5	X	
5	75	100	SGL	3.0	X	8)
6	150	65	SKL	6	X	1) 8)

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	7.5	25	XT2	1.5	X	
2	10	25	XT2	2	X	
3	25	25	XT2	3	X	
4	40	25	XT4	3	X	
5	75	100	SGL	6	X	1) 8)
6	150	65	SKL	12	–	2) 4)
1	7.5	65,100	XT2	1.5	X	
2	10	65,100	XT2	2	X	
3	25	65,100	XT2	3.5	X	
4	40	65,100	XT4	4	X	
5	75	100	SGL	6	X	1) 8)
6	150	65	SKL	12	–	2) 4)

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	XT2	1½	X	9)
2	10	7.5	25	XT2	2	X	
3	25	20	25	XT2	3.5	X	
4	40	30	25	XT4	3.5	X	
5	75	60	30	SGL	6	–	1) 4)
6	150	100	65	SKL	12	–	2) 4)
1	7.5	5	65,100	XT2	1½	X	9)
2	10	7.5	65,100	XT2	2	X	
3	25	20	65,100	XT2	4	X	
4	40	30	65,100	XT4	4	X	
5	75	60	100	SGL	6	–	1) 4)
6	150	100	65	SKL	12	–	2) 4)

[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.

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	XT2	1	X	
2	15	25	XT2	1	X	
3	30	25	XT2	2	X	
4	50	25	XT4	2.5	X	
5	100	100	SGL	3	X	8)
6	200	65	SKL	6	X	1) 8)
1	7.5	65,100	XT2	1	X	
2	15	65,100	XT2	1	X	
3	30	65,100	XT2	2	X	
4	50	65,100	XT4	2.5	X	
5	100	100	SGL	3.5	X	8)
6	200	65	SKL	6	X	1) 8)

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	7.5	25	XT2	1.5	X	
2	15	25	XT2	2	X	
3	30	25	XT2	3	X	
4	50	25	XT4	3	X	
5	100	100	SGL	6	X	1) 8)
6	200	65	SKL	12	–	2) 4)
1	7.5	65,100	XT2	1.5	X	
2	15	65,100	XT2	2	X	
3	30	65,100	XT2	3.5	X	
4	50	65,100	XT4	4	X	
5	100	100	SGL	6	X	1) 8)
6	200	65	SKL	12	–	2) 4)

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	XT2	1½	X	9)
2	15	10	25	XT2	2	X	
3	30	25	25	XT2	3.5	X	
4	50	40	25	XT4	3.5	X	
5	100	75	30	SGL	6	–	1)
6	200	150	65	SKL	12	–	2)
1	7.5	7.5	65,100	XT2	1½	X	9)
2	15	20	65,100	XT2	2	X	
3	30	40	65,100	XT2	4	X	
4	50	75	65,100	XT4	4	X	
5	100	150	100	SGL	6	–	1)
6	200	150	65	SKL	12	–	2)

[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.

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	XT2	1	X	
2	25	25	XT2	1	X	
3	50	25	XT2	2	X	
4	100	25	XT4	2.5	X	
5	200	100	SGL	3	X	8)
6	400	65	SKL	6	X	1) 8)
1	10	65,100	XT2	1	X	
2	25	65,100	XT2	1	X	
3	50	65,100	XT2	2	X	
4	100	65,100	XT4	2.5	X	
5	200	100	SGL	3.0	X	8)
6	400	65	SKL	6	X	1) 8)

FVR

NEMA Size	Max. Hp	IC (kA)	Circuit Breaker Type	Space Units	UL Listed (X)	Notes
1	10	25	XT2	1.5	X	
2	25	25	XT2	2	X	
3	50	25	XT2	3	X	
4	100	25	XT4	3	X	
5	200	100	SGL	6	X	1) 8)
6	400	65	SKL	12	–	2) 4)
1	10	65,100	XT2	1.5	X	
2	25	65,100	XT2	2	X	
3	50	65,100	XT2	3.5	X	
4	100	65,100	XT4	4	X	
5	200	100	SGL	6	X	1) 8)
6	400	65	SKL	12	–	2) 4)

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	XT2	$1^1/_2$	X	9)
2	25	20	25	XT2	2	X	
3	50	40	25	XT2	3.5	X	
4	100	75	25	XT4	3.5	X	
5	200	150	30	SGL	6	–	1) 4)
6	400	300	65	SKL	12	–	2) 4)
1	10	7.5	65,100	XT2	$1^1/_2$	X	9)
2	25	20	65,100	XT2	2	X	
3	50	40	65,100	XT2	4	X	
4	100	75	65,100	XT4	4	X	
5	200	150	100	SGL	6	–	1) 4)
6	400	300	65	SKL	12	–	2) 4)

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.

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	1) 8)
1	10	100	SEL	1	X	
2	25	100	SEL	1	X	
3	50	100	SEL	2	X	
4	100	100	SFL	2.5	–	
5	200	100	SGL	3.5	X	8)
6	400	42	SKL	6	X	1) 8)

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	1) 8)
6	400	42	SKL	12	–	2) 4)
1	10	100	SEL	1.5	X	
2	25	100	SEL	2	X	
3	50	100	SEL	3	X	
4	100	100	SFL	3	X	
5	200	100	SGL	6	X	1) 8)
6	400	42	SKL	12	X	1) 4)

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	$1^1/_2$	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	SGL	6	–	1) 4)
6	400	300	42	SKL	12	–	2) 4)
1	10	7.5	100	SEL	$1^1/_2$	X	9)
2	25	20	100	SEL	2	X	
3	50	40	100	SEL	3.5	X	
4	100	75	100	SFL	3.5	–	
5	200	150	100	SGL	6	–	1) 4)
6	400	300	42	SKL	–	–	2) 4) 6)

[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.

Selection Tables

FUSED SWITCH TYPE, 208 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J [12)]		Space Units	UL Listed (X)	Notes
			Switch Amps	Clip Amps			
1	3	100	30	30	1	X	
1	7 1/2	100	30	60	1	X	
2	10	100	60	100	1 1/2	X	
3	25	100	100	200	2 1/2	X	
4	30	100	200	200	3 1/2	X	
4	40	100	200	400	3 1/2	X	
			Class H, K-1, K-5				
1	3	5	30	30	1	X	
1	7 1/2	5	30	30	1	X	
2	10	5	60	60	1	X	
3	20	5	100	100	2 1/2	X	
3	25	5	100	100	2 1/2	X	
4	40	10	200	200	3 1/2	X	
			Class RK-1, RK-5				
1	7 1/2	100	30	30	1	X	
2	10	100	60	60	1	X	
3	15	65	100	60	2 1/2	X	10)
3	25	65	100	100	2 1/2	X	10)
4	40	100	200	200	3 1/2	X	

FVR

NEMA Size	Max. Hp	IC (kA)	Class J [12)]		Space Units	UL Listed (X)	Notes
			Switch Amps	Clip Amps			
1	3	100	30	30	1 1/2	X	
1	7 1/2	100	30	60	1 1/2	X	
2	10	100	60	100	2	X	
3	25	100	100	200	3 1/2	X	
4	30	100	200	200	5	X	
4	40	100	200	400	5	X	
			Class H, K-1, K-5				
1	3	5	30	30	1 1/2	X	
1	7 1/2	5	30	60	1 1/2	X	
2	10	5	60	60	2	X	
3	20	5	100	100	3 1/2	X	
3	25	5	100	200	3 1/2	X	
4	40	10	200	200	5	X	
			Class RK-1, RK-5				
1	7 1/2	100	30	30	1 1/2	X	
2	10	100	60	60	2	X	
3	15	65	100	60	3 1/2	X	10)
3	25	65	100	100	3 1/2	X	10)
4	40	100	200	200	5	X	

[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 3 1/2 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.
[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)] Requires additional 6 inches if Type"A" wiring.

Selection Tables

FUSED SWITCH TYPE, 208 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

2S1W

NEMA Size	Max. Hp		IC (kA)	Class J [12)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
1	3	3	100	30	30	1½	X	13)
1	7½	5	100	30	60	1½	X	13)
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	
				Class H, K-1, K-5				
1	3	3	5	30	30	1½	X	13)
1	7½	5	5	30	60	1½	X	13)
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	
				Class RK-1, RK-5				
1	7½	5	100	30	30	1½	X	13)
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	

2S2W

NEMA Size	Max. Hp		IC (kA)	Class J [12)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
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	–	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	
				Class H, K-1, K-5				
1	3	3	5	30	30	1½	X	13)
1	7½	5	5	30	60	1½	X	13)
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	
				Class RK-1, RK-5				
1	7½	5	100	30	30	1½	X	
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	

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.
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) Requires additional 6 inches if Type"A" wiring.

Selection Tables

FUSED SWITCH TYPE, 230 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J [12)] Switch Amps	Class J [12)] 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	
			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	
			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	

FVR

NEMA Size	Max. Hp	IC (kA)	Class J [12)] Switch Amps	Class J [12)] 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	
			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	
			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	

[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.
[11)] 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 RK1, RK5 Table.
[14)] Requires Additional 6 inches if Type "A" wiring.

Selection Tables

FUSED SWITCH TYPE, 230 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

2S1W

NEMA Size	Max. Hp		IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
1	3	3	100	30	30	1½	X	14)
1	7½	5	100	30	60	1½	X	14)
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	
				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	
				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	

2S2W

NEMA Size	Max. Hp		IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
1	3	3	100	30	30	1½	X	14)
1	7½	5	100	30	60	1½	X	14)
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	
				Class H, K-1, K-5				
1	2	2	5	30	30	1½	X	14)
1	7½	5	5	30	60	1½	X	14)
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	
				Class RK-1, RK-5				
1	7½	5	100	30	30	1½	X	14)
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	

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.
11) 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 RK1, RK5 Table.
14) Requires Additional 6 inches if Type "A" wiring.

Selection Tables

FUSED SWITCH TYPE, 460 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
			Switch Amps	Clip Amps			
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	1 1/2	X	
3	50	100	100	200	2 1/2	X	
4	60	100	200	200	3 1/2	X	
4	100	100	200	400	3 1/2	X	
			Class H, K-1, K-5				
1	7 1/2	–	30	30	1	X	
1	10	5	30	60	1	X	
2	15	5	60	60	1	X	
2	25	5	60	100	1 1/2	X	
3	30	5	100	100	2 1/2	X	
3	50	5	100	200	2 1/2	X	
4	75	10	200	200	3 1/2	X	
4	100	10	200	400	4 1/2	X	12)
			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	2 1/2	X	11)
3	50	65	100	100	2 1/2	X	11) 12)
4	100	100	200	200	3 1/2	X	12)

FVR

NEMA Size	Max. Hp	IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
			Switch Amps	Clip Amps			
1	5	100	30	30	1 1/2	X	
1	10	100	30	60	1 1/2	X	
2	15	100	60	60	2	X	
2	25	100	60	100	2	X	
3	50	100	100	200	3 1/2	X	
4	60	100	200	200	5	X	
4	100	100	200	400	5	X	
			Class H, K-1, K-5				
1	71/2		30	30	1 1/2	X	
1	10	5	30	60	1 1/2	X	
2	15	5	60	60	2	X	
2	25	5	60	100	2	X	
3	30	5	100	100	3 1/2	X	
3	50	5	100	200	3 1/2	X	
4	75	10	200	200	5	X	
4	100	10	200	400	5	X	
			Class RK-1, RK-5				
1	10	100	30	30	1 1/2	X	
2	15	100	60	30	2	X	
2	25	100	60	60	2	X	11)
3	30	65	100	60	3 1/2	X	11)
3	50	65	100	100	3 1/2	X	
4	100	100	200	200	5	X	

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 3 1/2 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) 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.
14) Requires additional 6 inches if Type "A" wiring.

Selection Tables

FUSED SWITCH TYPE, 460 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

2S1W

NEMA Size	Max. Hp		IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
1	5	5	100	30	30	1½	X	14)
1	10	7½	100	30	60	1½	X	14)
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	
				Class H, K-1, K-5				
1	7½	7½	5	30	30	1½	X	14)
1	10	–	5	30	60	1½	X	14)
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	
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	X	14)
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	11)
4	100	75	100	200	200	5	X	11)

2S2W

NEMA Size	Max. Hp		IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
1	5	5	100	30	30	1½	X	14)
1	10	7½	100	30	60	1½	X	14)
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	
				Class H, K-1, K-5				
1	7½	7½	5	30	30	1½	X	14)
1	10	–	5	30	60	1½	X	14)
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	
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	X	14)
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	11)
4	100	75	100	200	200	5	X	11)

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.
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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.
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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) 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.
14) Requires additional 6 inches if Type "A" wiring.

Selection Tables

FUSED SWITCH TYPE, 575 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

FVNR

NEMA Size	Max. Hp	IC (kA)	Class J [12)] Switch Amps	Class J [12)] 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	
			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	[11)]
			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	

FVR

NEMA Size	Max. Hp	IC (kA)	Class J [12)] Switch Amps	Class J [12)] 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	
			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	
			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	

[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.
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[5)] Size 1 not available. Use Size 2.
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[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.

Selection Tables

FUSED SWITCH TYPE, 575 VOLTS, 60 HERTZ
Combination Motor Starters [8)]

2S1W

NEMA Size	Max. Hp		IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
1	7½	71/2	100	30	30	1½	X	13)
1	10	–	100	30	60	1½	X	13)
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	
				Class H, K-1, K-5				
1	10	7½	5	30	30	1½	X	13)
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	
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	X	13)
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	

2S2W

NEMA Size	Max. Hp		IC (kA)	Class J [13)]		Space Units	UL Listed (X)	Notes
	CT/VT	Const. Hp		Switch Amps	Clip Amps			
1	7½	7½	100	30	30	1½	X	13)
1	10	–	100	30	60	1½	X	13)
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	
				Class H, K-1, K-5				
1	10	7½	5	30	30	1½	X	13)
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	
				Class RK-1, RK-5				
1	10	7½	100	30	30	1½	X	13)
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	

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.
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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)– 1 NC and 1 NO (pilot duty) contact (Optional)	– –	X X
Ambient Comp. OL Electronic OL	Ultimate trip current remains essentially unchanged over a range of OL ambient temperatures. 1 NC contact (standard) 1 NC and 1 NO (pilot duty) contact (Optional)	 – –	 X X
Pilot Lights Full Voltage	A3 type with 120V LED. Red–ON FAST, FWD, UP Amber–DOWN, REV, SLOW Green–STOPPED, READY	–	X
Push-to-test	A3, LED (See full-voltage lights for lens colors)	–	X
Push buttons			
Start-Stop [1)]	A3 momentary type-use with FVNR starters with 3-wire control.	–	X
Stop [1)]	A3 momentary type-provides stop function at MCC with 3-wire control.	–	X
Stop [1)]	A3 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, Stop [1)]	A3 momentary type-use with FVR starters.	–	X
Fast, Slow, Stop [1)]	A3 momentary type-use with 2-speed starters.	–	X
Selector Switches On-Off	A3 maintained type–use as permissive start with 2 or 3 wire control.	–	X
Hand-Off-Auto [1)]	A3 maintained type–use to select auto or manual start with 2-wire control.	–	X
Fast-Slow-Off-Auto	A3 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 ter minal 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 verti cal bus stabs.	–	X
Control Relay	ABB 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
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.

Starter Options

Option	Function	Additional Space Required	UL Listed (X)
Ambient Comp. CB's	Thermal trip is ambient compensated.	–	X
Fused Switch Auxiliary Interlock	2-10A auxiliary interlocks oper-ated 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 Fault [1)]	Zero sequence sensing Ground Fault Relay for equipment protection for NEMA size 1-6 starters.	½ X	X
Current Transformer	Donut type CT located in one motor phase conductor for pur-chasers use. Purchaser connects directly to CT secondary terminals. (Also used for door mounted Ammeter.)	½ X	X
Amp Transducer	Integrated CT/Current transducer with 4-20 MA output. (Requires 120V Power).	½ X	X
Ammeter [1)]	AC panel-type, single current-transformer operated five-ampere movement. Scale selected based on 125% motor full-load amperes.	½ X [1)]	X
Voltmeter	AC panel-type, direct-reading 600 volts maximum. Includes a fuse in each ungrounded conductor.	–	X
Elapsed Time Meter [1)]	Mounts on pushbutton bracket. Visible from front of MCC.	–	X

Option	Function	Additional Space Required	UL Listed (X)
Phase Loss/ Unbalance Current Sensing Alternate ECM	CR324X Electronic overload mod- ule 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)	½ X	X
Coil Suppressor, 120V	Surge suppressors reduce unde- sirable transients in control circuits by absorbing voltage transients generated by operating coils.	–	X
Over Size Unit	Standard unit height may be increased ½ X or 1X	½ 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

[1)] Functions also available with ECM keypad.

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
1-6 [1)]	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.

Product Information

AUXILIARY CONTACT RATINGS, NEMA Size 1-6			
AC Volts	Amperes		
	Continuous	Make	Break
115	10	60	6.0
230	10	30	3.0
460	10	15	1.5
575	10	12	1.2
DC Volts			
125	10	–	1.1
250	10	–	0.5

Starter Auxiliary Contacts (Option)

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

Starter Type	Total Control Contacts Available (includes contacts required in basic control circuit for seal-in, cross interlocking, etc.)					
	NEMA Size Starter					
	1	2	3	4	5	6
Full-voltage, Nonreversing	5	6[2]	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 winding[1]						
Low-speed Contactor High-speed	4	4	4	4	4	5
Contactor Two-speed, Two winding	3	4	4	4	4	5
Low-speed Contactor	4	4	4	4	4	5
High-speed Contactor	4	4	4	4	4	5

[1] For constant- or variable-torque motors.
[2] Limit 4.

Control Terminals

The table below lists the total number of control terminals avail- able 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 Type[3]	CPT Std. VA		CPT Max. VA[5]		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

Product Information

300 LINE STANDARD COIL DATA

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

TERMINALS FOR FIELD WIRING

Description	Will Accept Wire [2)]	
	AWG/MCM	Material
STARTER LOAD TERMINALS		
Size 1 and 2 Power Block (Draw out)	14-4	CU
	12-2	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

Space Units	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
1	12	11½"	14½"	6	8
1½	24	11½"	14½"	12	16
2	30	11½"	14½"	18	24
2½	42	11½"	14½"	24	32
3	48	11½"	14½"	36	48
3½	60	11½"	14½"	42	56
4	72	11½"	14½"	48	64
4½	78	11½"	14½"	54	72
5	90	11½"	14½"	60	80
5½	96	11½"	14½"	66	88
6	108	11½"	14½"	72	96

DOUBLE VERTICAL ROW OF T.B.'s

Maximum No. of T.B. Points	Horizontal Width for Component Mounting		Maximum No. of Std. 4-Pole Relays	
	20"W	24"W	20"W	24"W
24	6"	7½"	3	4
48	6"	7½"	6	8
60	6"	7½"	9	12
84	6"	7½"	12	16
96	6"	7½"	18	24
120	6"	7½"	21	28
144	6"	7½"	24	32
156	6"	7½"	27	36
180	6"	7½"	30	40
192	6"	7½"	33	44
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 Symmetrical Amps (in thousands)
		Type	Poles [1]	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	1,2	10
		THHQB	2,3	2,3	22
		TXQB	3	3	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.

Number of Circuits	Panel Main Bus Rating (Amps)	Space Units [3] AL, AQ	Space Units [3] 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 Units [3]	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-34)

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	1) 2)	THED	THEDL	70	6	X	1) 2)
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	1) 2)	THED	THEDL	70	6	X	1) 2)
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		THED	THEDL	20	3	X	
30	60	40	6	X	1) 2)	THED	THEDL	70	6	X	1) 2)
45	60	60	6	X	3)	THED	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											
0.5	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	1) 6) 7)	THED	SEP [8]	150	3.5	X	1) 6)
25	200	150	4	X	1) 6)	THFK	SFP [9]	225	3	X	1) 6)
37.5	200	200	6	X	3)	THFK	SFP [9]	225	6	X	3)
380-120/240 VOLTS, 50 HERTZ											
0.5	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	1) 6)	THED	THEDL	90	2.5	X	1) 6)
25	200	90	4	X	1) 6)	THED	SEP [8]	150	3	X	1) 6)
37.5	200	125	6	X	7) 3)	THED	SEP [8]	125	6	X	3)
480-120/240 VOLTS, 60 HERTZ											
0.5	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	1) 6)	THED	THEDL	50	2.5	X	1) 6)
25	200	70	4	X	1) 6)	THED	SEP [8]	125	3	X	1) 6)
37.5	200	100	6	X	7) 3)	THED	SEP [8]	125	6	X	3)
600-120/240 VOLTS, 60 HERTZ											
0.5	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	1) 6)	THEDL	THEDL	50	2.5	X	1) 6)
25	60	60	3	X	1) 6)	THEDL	THEDL	100	3	X	1) 6)
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.

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.

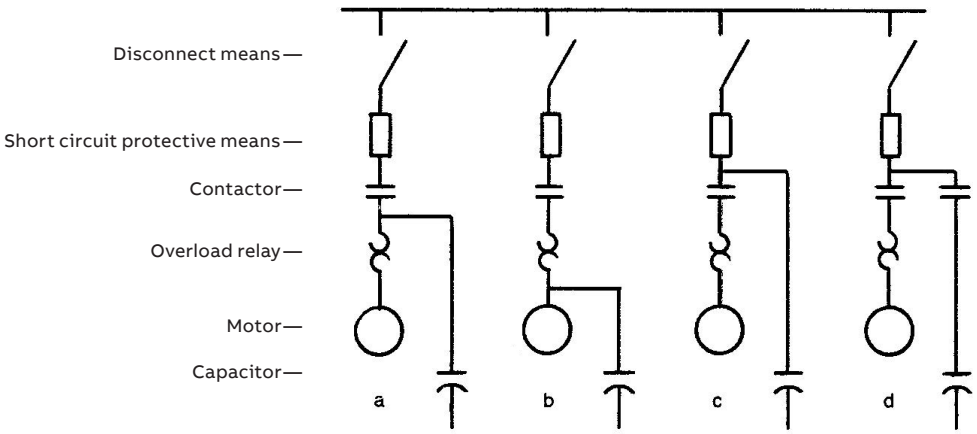
Low-voltage capacitors are generally three-phase units, delta-connected, and are protected by current limiting fuses. The fuses disconnect the capacitor in the event of an electrical short, providing service continuity for the system and reducing the possibility of rupturing the capacitor case.

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 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 Ratings [1)]

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

Variable Frequency Drives

ACS580 general purpose drives simplify your processes and motor control with effortless process automation. The ACS580 is a good choice for a wide range of applications, making it easy to comprehensively manage your plant. The ACS580 is part of ABB's all-compatible drives portfolio, sharing the same architecture and user interfaces for easy usability. The ACS580 is plug-in ready to control your compressors, conveyors, mixers, pumps, centrifuges, fans and many other variable and constant torque applications in different industries.

- Easy to select, install and use
- All essential features built into the drive for minimized number of external components
- Many built-in control functions for simplified automation and process control
- Straightforward settings menu and assistants for fast commissioning
- Energy efficiency features for optimal energy use
- Connect to any automation system or use stand-alone
- Wide availability and support
- Designed for reliability and consistent high quality

Link:
new.abb.com/drives/low-voltage-ac/general-purpose/acs580

ABB ACS580 VFD

Line Reactors
VFD units are available with three options for line reactors:
- No Line Reactor
- 3% Line Reactor
- 5% Line Reactor

This selection must be made at the time a quotation is requested.

Note from the ACS 580 product documentation:
The available power source for the drive should not exceed 500kVA. If the power source is > 500kVA and the drive rating is < 10% of the power source kVA, AC line reactors must be installed on the power leads of the drive.

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.

VFD Unit Selection
Many ranges are voltage and horsepower are available for the 8000 MCC, which are also compatible with the 7700 and Spectra MCCs. Use the table below to select from available units.

					208V		230/240V		380/415V		440/480V		
VFD Frame	**NEMA Size**	**Bus Design**	**Width (in)**	**Height (in)**	**Light-Duty (HP)**	**Light-Duty (HP)**	**Light-Duty (HP)**	**Light-Duty (HP)**	**Light-Duty (HP)**	**Light-Duty (HP)**	**Light-Duty (HP)**	**Light-Duty (HP)**	**Line Reactor**
R1	1	Stab	15	30	0.5-5	0.33-3	0.5-5	0.33-3	0.5-5	0.5-3	0.5-7.5	0.5-5	None
R1	1	Stab	15	30	0.5-5	0.33-3	0.5-5	0.33-3	0.5-5	0.5-3	0.5-7.5	0.5-5	+3% or +5%
R2	1	Stab	15	36	7.5	5	7.5	5	7.5-10	5-7.5	10	7.5	None
R2	2	Stab	15	36	10	7.5	10	7.5			15	10	
R2	1	Stab	15	36	7.5	5	7.5	5	7.5-10	5-7.5	10	7.5	+3% or +5%
R2	2	Stab	15	36	10	7.5	10	7.5			15	10	
R3	2	Stab	15	42					15-25	10-20	20-25	15-20	None
R3	3	Stab	15	42	15-20	10-15	15-20	10-15			30	25	
R3	2	Stab	15	42					15-25	10-20	20-25	15-20	+3% or +5%
R3	3	Stab	15	42	15-20	10-15	15-20	10-15			30	25	
R4	3	Stab	15	48	25	20	25	20	30-40	25-30	40-50	30-40	None
R4	3	Stab-Bolt	20	48	25	20	25	20	30-40	25-30	40-50	30-40	+3% or +5%
R4	3	Stab-Bolt	24	48	25	20	25	20	30-40	25-30	40-50	30-40	+3% or +5%
R5	3	Stab	15	48					50	40			None
R5	4	Stab	15	48	30	25	30	25					
R5	3	Stab-Bolt	20	54					50	40			+3% or +5%
R5	4	Stab-Bolt	20	54	30	25	30	25					
R5	3	Stab-Bolt	24	54					50	40			+3% or +5%
R5	4	Stab-Bolt	24	54	30	25	30	25					

Solid State Starters

PSTX Soft Starter

The PSTX combines many years of research and product development with extensive knowledge of application specific requirements and needs. The PSTX is our latest advancement in motor control and protection and adds new functionality with increased reliability to any motor starting application.

Complete Motor Protection
The PSTX offers complete motor protection and is able to handle both load and network irregularities. PT-100, earth fault protection and over/under voltage protection along with many other functions keep your motor safer than ever.

Reliable Operations
Time to use your processes to their full potential.
The PSTX features many application enhancing features, including torque control, standstill brake, dynamic brake, motor heating, pump cleaning, underload, and lock rotor protections to securing uptime of your system.

Flexible Communication
Bulit-in Modbus and as an option Anybus for all major communication protocols such as Modbus RTU, Profibus, Profinet, Ethercat, BACnet, Ethernet and DeviceNet

PSTX Soft Starter

F

Intelligent Motor Management

UMC100.3 Universal Motor Controller

ABB motor controllers combine intelligent motor protection and control functions, fieldbus and Ethernet communication, and fault diagnosis in a single device. The Universal Motor Controller provides detailed operational, diagnostic and service data in real time, giving your plant an effective data source for predictive maintenance.

Main Benefits

- Reduced wiring time, space requirements and costs
- Fast replacement times mean less downtime
- Commissioning time savings
- Seamless integration into ABB Ability™ System 800xA platform
- Choice of communication interfaces
- Safe motor shutdown

Main Features

- Max 1000 V AC motor voltage
- Suitable for single- and three-phase motors
- Rated motor current from 0.24 to 63 A, without accessories
- Tripping classes 5, 10, 20, 30, 40 in accordance with EN/IEC 60947-4-1
- Flexible mounting of communication interfaces
- Standard fieldbus connection and wiring

UMC100.3 Universal Motor Controller

SACE Tmax XT2 and SACE Tmax XT4 – Circuit Breakers

The following units are now supplied with SACE Tmax XT molded case circuit breakers (MCCBs):

- Feeders: 15A – 250A
- FVNR: Sz 1-4
- FVR: Sz 1-4
- 2S1W: Sz 1-4
- 2S2W: Sz 1-4

Tmax XT moulded case circuit breakers guarantee an extremely high performance level while being progressively smaller in size, simple to install and able to provide increasingly better safety.

- High breaking capacity in compact dimensions.
- Limiting characteristics allow savings in copper and footprint in switchboard, high selectivity values and very compact motor protection solutions.
- Ease of use and installation flexibility.
- A dedicated range of accessories and a renewed solution for electronic trip units to adapt Tmax XT to different applications scenarios.
- Customized protection and information availability.
- Specific electronic trip units for energy metering, motor protection and generator protection in addition to a Modbus communication module for integration in a supervision system.
- Increased safety for operators.
- Wide range of keylocks and padlocking options, plug in and withdrawable versions to speed up maintenance operations and improved diagnostic to have ready to use information about breakers' status.

SACE Tmax XT Circuit Breakers

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.

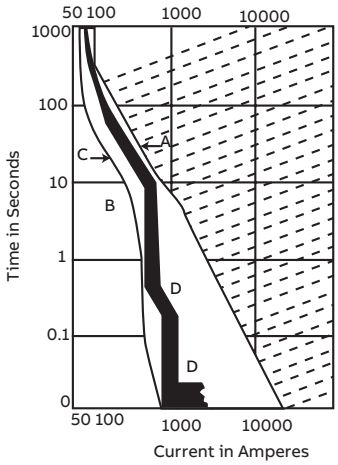
The figure below illustrates the most popular application of Mag-Break motor circuit protectors. This time-current curve shows a plot of motor current versus time (Curve C) for a three-phase squirrel cage induction motor. The shaded portion of the time-current curve (above Curve A) indicates

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 over- load 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

Tmax XT Molded Case Switches

Switch-disconnectors are devices created from the corresponding circuit-breakers and feature the same overall dimensions, versions, and can be fitted with the same accessories

Applications
These devices are mainly used as:
- General disconnection devices in sub-switchboards;
- Switching and insulation devices for lines, bus bars or groups of apparatus; bus ties.

In the open position, the disconnector guarantees a sufficient insulation distance (between the contacts) to ensure safety and to prevent an electrical arc from striking.

Utilization category
Tmax XT disconnectors comply with utilization categories defined by IEC 60947-3 Standard.

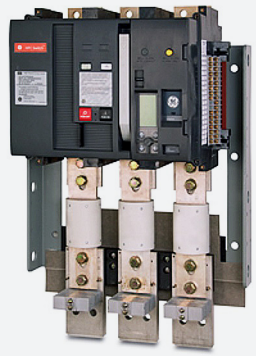
Protection
Each switch-disconnector must be protected on the supply side by a coordinated device which safeguards it against short-circuits.
The section "Coordination" in the table below shows the correspondence between each switch-disconnector and the relevant circuit-breaker.

Making capacity
The making capacity Icm is highly important since a switch-disconnector must be able to withstand the dynamic, thermal and current stresses which can occur during closing operations without being destroyed, right up to short-circuit closing conditions.

The web link for this device is:
https://new.abb.com/low-voltage/products/circuit-breakers/tmax-xt

Tmax XT Molded Case Switch

HPC II High-Pressure Contact Switches



HPC II Switch

Construction Features

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

- High Durability–Safety of Operation–High dielectric strength, glass reinforced insulating case.
- High Interrupting capability–Arc chute of unique construction suppresses arcs and cools gases rapidly, providing quick arc interruption and extended switch life.
- High Transient Voltage withstandability– Interphase partitions mesh with switch cover to completely isolate each pole.
- Extended switch life–Preloaded constant pressure pivot eliminates braid whip and fraying on high short-circuit currents and repeated operations.
- Positive “ON-OFF” indication–Green (OFF), Red (ON), eliminates any question about the position of the switch contacts.
- Easy operation–Quick Make–Extra-heavy-duty, low-torque rotary-operated closing mechanism. L-handle 800-1600 amperes; T-handle 2000 amperes.
- Emergency open–Quick Break–Finger-tip “OFF” button instantly opens the breaker contacts.
- Positive Door and switch interlocking–Separate fuse access door is not required.
- Fuse mounting bolts with captive washers – For ease of mounting fuses.

Product Forms

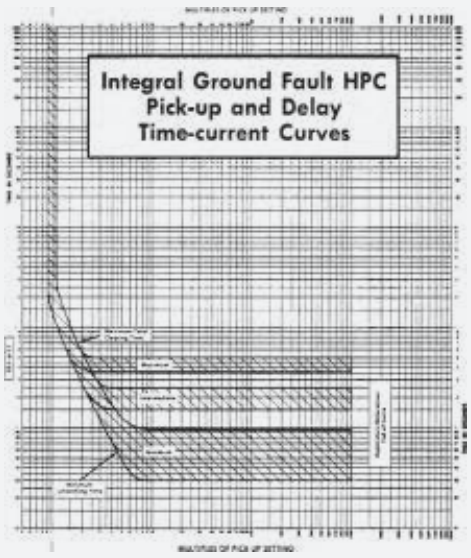
- Top feed–Line terminals at top of switch.
- Bottom Feed–Line terminals at bottom of switch; fuses are de-energized when switch is in OFF position. Same size as top feed.

Options Available

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

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



Power Break II Insulated Case Circuit Breakers

General Description
The 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 over-load 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 I2t 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 Power Leader communications bus (commnet).

Options
- Power Leader Communication System Link with user-selec-table 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

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 I2t ON/OFF selection.
- Adjustable Ground fault (G) pickup, 0.2-1.0S, and delay (4 bands) with I2t 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.

Ground Break Systems
Type GFM Ground Fault System

U.L. Listed File no. E110395

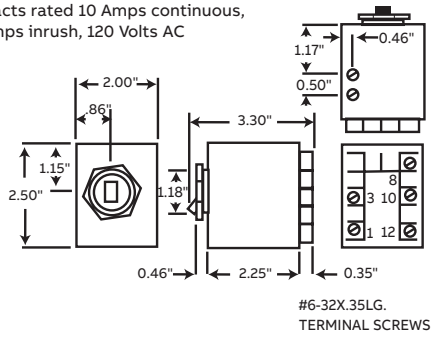
- Self powered.
- Temperature Range: -30°C. to +75°C.
- Positive “ON” (Green) and “OFF” (Red) condition indication, manual reset.
- Instantaneous only (GFM-252)-standard
- Time delay from instantaneous to 36 cycles (GFM-262).
- Trip currents from
  - 3.8 to 18 amperes (size 1 to 4 starters)
  - 5 to 20 amperes (size 5, 6, 7 starters)

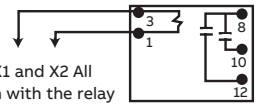
General

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 GFM-252, 262

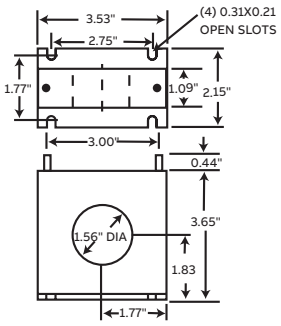
Contacts rated 10 Amps continuous, 23 Amps inrush, 120 Volts AC



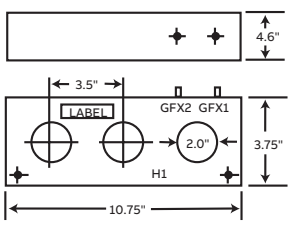


To current Sensor X1 and X2 All contacts shown with the relay in the tripped position

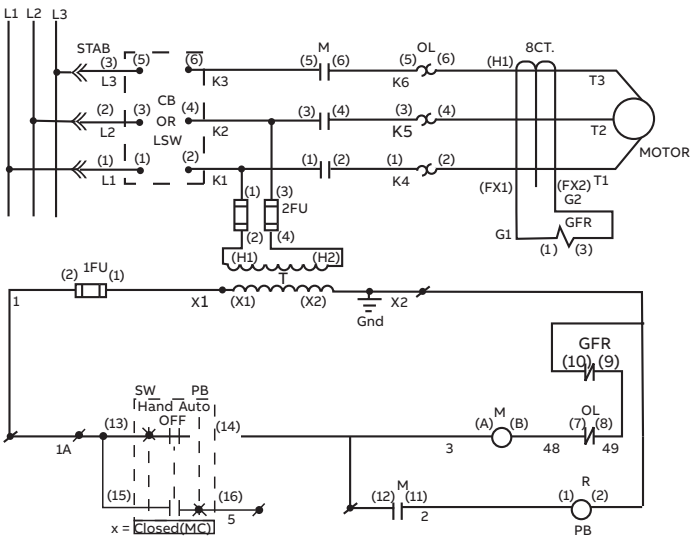
Model Number	Trip [1] Current
GFM 156	3.8 to 18



Model Number	Trip [1] Current
GFM 3P208	5 to 20



Typical Circuit

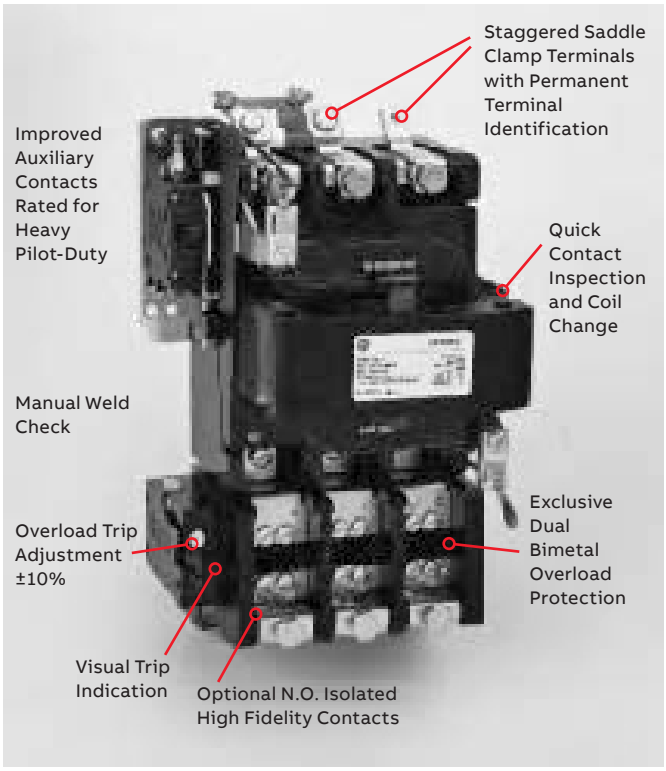


[1] Trip current tolerance is ± 15 percent.

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.

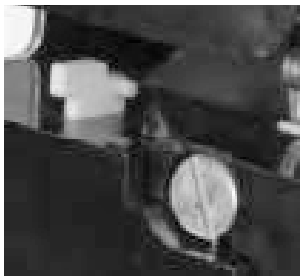
300-Line Motor Starters


(Cover removed)

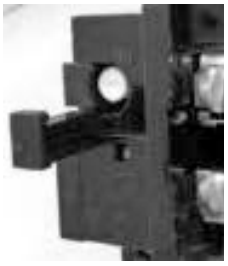
Where it's essential to monitor performance or diagnose faults, a 300-Line starter may be ordered with an additional isolated, high-fidelity, normally-open contact on the overload relay. This contact may be used for direct input to a programmable controller or direct interface with a computer.

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

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



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

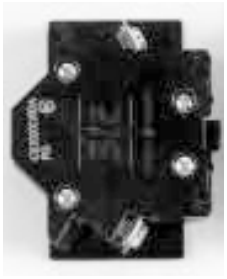


Overriding is eliminated because overload reset occurs only when the reset arm is released on the standard manual-reset form.

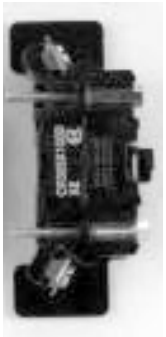
A bright yellow visual trip indicator tells operators at a glance if the overload has tripped. An optional automatic-reset overload relay is available for special applications upon request.

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

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



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



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

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 NEMA 300-Line Starters, which utilize CR324 Thermal bimetal over-load 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 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 °C to 55 °C	–20 °C to 70 °C	–20 °C 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

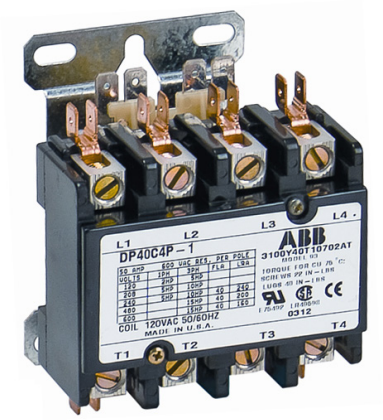
Mini-Contactors

Flexibility Meets High Performance
Definite purpose contactors provide high performance with flexibility and reliability and are designed to match numerous applications. They are ideal for resistive heating, for motors and compressors in air conditioning and refrigeration, as well as for food service equipment.

Product Benefits
- Wide current range (from 20 A up to 75 A up to 600 V AC)
- Flexible sizes: compact 1 and 2 pole contactors and full size 2, 3, and 4-pole devices
- Various contact configuration from one pole up to four poles
- Industry standard mounting plate provides easily accessible mounting holes

Product Features
- UL Listed, CSA certified
- Coil is class B (130 °C) insulation system with a wide range of voltages and 50/60 Hz ratings
- Double E magnet assembly provides optimal performance with reduced power consumption
- Snap-in auxiliary switch with one SPDT or two SPDT contacts available as an option

Link:
new.abb.com/low-voltage/products/motor-protection/definite-purpose-contactors



Definite Purpose Contactor

A3 30mm Pilot Devices

Heavy Duty Oil-Tight Range
The A3 (30 mm) heavy duty oil-tight range includes pilot lights, pushbuttons and selector switches with a variety of accessories and enclosures. It is suitable for many applications such as machine control panel, material handling (conveyors, food and beverage, packaging) and automotive.

A3 Pilot Devices

Features
- Configurable products: wide choice of contact blocks, cap color, LED color
- Available ratings:
  - NEMA 1, 3, 3R, 4, 4X, 12, 13
  - IEC IP10, IP11, IP14, IP52, IP54, IP56, IP66
- NEMA 4X rated out of the box solution
- Add up to 8 contact blocks

Benefits
- Ease of assembly with one-screw contact block mounting
- Rubber gasket helps seal pushbutton against oil, water, and dust.
- 45-degree angled wire terminals allows for easy wiring
- Positive make and break with strong contact spring to prevent contact freezing or accidental closure from machine vibration.

Link:
https://new.abb.com/low-voltage/products/pilot-devices/a3-30mm-pilot-devices

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.

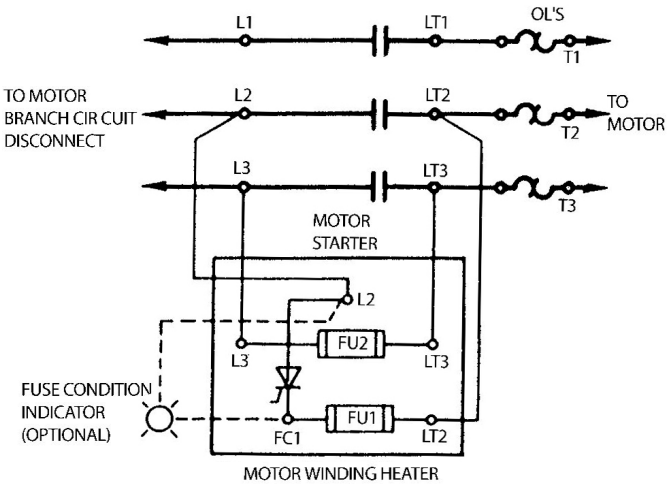
Additional SCR Protection: Metal oxide varistor protects against voltage surges. RC snubber circuit limits rate of change of circuit voltage.

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.

G

PQM II

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 https://www.gegridsolutions.com/multilin/catalog/pqmii.htm

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

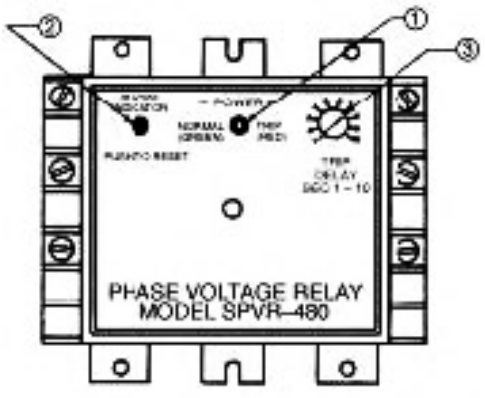
Optional Features

- 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)

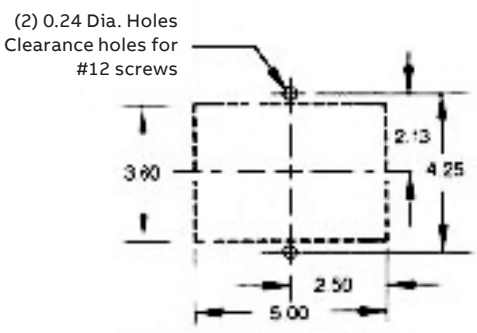
Optional Features:
M – Manual Reset with local Push Button
O – Over and Under Voltage protection
R – Phase Reversal/Sequence protection
U – Phase Unbalance 6%



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

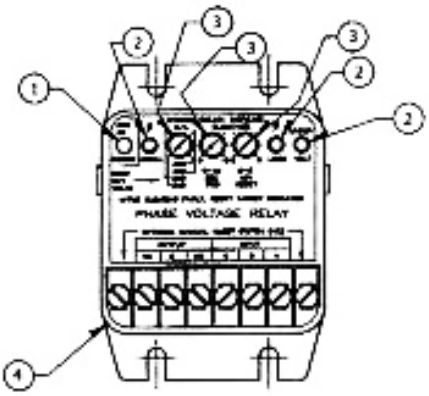
Model LPVR

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 under-voltage on the power system. Electro-mechanical 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.

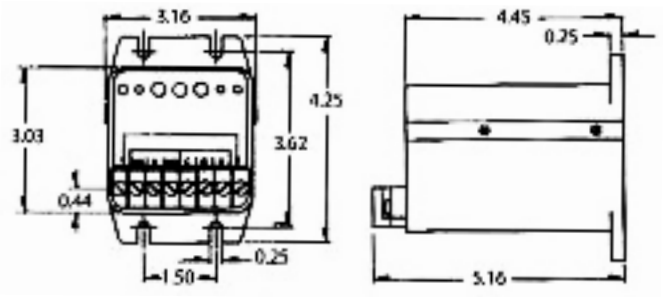


① Green LED Indicator
- Power system condition.

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.



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

Model APVR

General

UL 103039

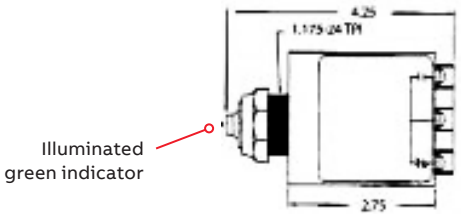
The model APVR phase sensing relay performs the same functions as the model LPVR, except that the relay requires no adjustments. It will fit in the push-button bracket, and thus does not increase the required unit spacing.

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)

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



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) dripproof, normal starting torque, continuous 40 °C ambient (1.15 service factor) horizontal induction motors.

Motor HP	Synchronous Speed, RPM	Average Expected Values of Full-load Currents			
		200V	230V	460V	575V
¼ [1]	1800	1.6	1.4	0.70	0.56
	1200	1.7	1.5	0.75	0.60
½ [1]	3600	2.0	1.7	0.85	0.68
	1800	1.7	1.5	0.75	0.60
	1200	2.0	1.7	0.85	0.68
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
25	3600	72.0	56.0	28.0	25.0
	1800	71.3	60.0	30.0	24.8
	1200	73.8	63.2	31.6	25.7
	900	82.6	71.8	35.9	28.7
30	3600	85.6	67.8	33.9	29.8
	1800	81.7	71.2	35.6	29.9
	1200	88.6	73.8	36.9	30.8
	900	92.2	80.2	40.1	32.1
40	3600	101	89.0	44.6	39.2
	1800	112	97.8	48.9	40.3
	1200	114	99.6	48.5	39.8
	900	122	105.8	52.9	42.3
50	3600	140	129	64.5	48.9
	1800	142	122	61.1	49.4
	1200	144	125.2	61.0	50.1
	900	159	138.2	69.1	55.3
60	3600	163	145.6	72.8	56.6
	1800	172	147.4	73.7	59.9
	1200	172	149.2	69.8	59.7
	900	176	153.4	76.7	61.4
75	3600	206	181	90.5	71.5
	1800	207	180.0	91.6	72.0
	1200	206	179.2	86.7	71.7
	900	221	191.8	95.9	76.7
100	3600	262	238	119	91.2
	1800	281	232	116	97.7
	1200	283	246	118	98.4
	900	296	258	129	103
125	3600	338	290	139	116
	1800	340	296	143	118
	1200	352	306	149	122
	900	370	322	161	129
150	3600	398	346	164	138
	1800	412	348	169	143
	1200	419	364	177	146
	900	435	378	189	151
200	3600	–	446	217	178
	1800	–	468	226	187
	1200	–	482	239	193
250	3600	–	574	287	230
	1800	–	590	295	236
	1200	–	594	297	238
300	3600	–	676	338	270
	1800	–	686	340	274
350	3600	–	774	387	310
	1800	–	792	396	317
400	3600	–	890	445	356

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

Note: The listed data is based on approximate full-load current ratings of standard, open, 1.15 service factor, continuous rated 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 H-96 through H-107.

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	4RVAT [1]	100	SRPE150A100	150	
40	50	75	100	100		150	SRPE150A150		
		60	60	75	4STD	150	SRPF250A150	200	SF 250
40	50	75	100	100		200	SRPF250A200		
50	50	100	125	150	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.

H

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		
1.90-2.05	C239A	**Size 1**	
2.06-2.28	C268A		
2.29-2.47	C301A	17.2-18.1	C198B
2.48-2.79	C326A	18.2-20.0	C214B
2.80-3.31	C356A	20.1-21.5	C228B
3.32-3.70	C379A	21.6-22.5	C250B
3.71-4.06	C419A	22.6-23.9	C273B
4.07-4.47	C466A	24.0-26.3	C303B
4.48-4.95	C526A	26.4-27.0	C330B

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		

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

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	TEC & TECL Rating	Mag-Break Trip Setting	
			Rec.	Max.
Size 2 (Standard)				
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.)				
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.)				
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

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

Overload Heater Tables

Heaters for Mag-Break Controllers

Size 0 and 1 (Standard)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	SE Rating Plug	Mag-Break Trip Setting	
			Rec.	Max.
.65-.74	C087A	3	LO	LO
.75-.84	C097A	3	LO	LO
.85-.92	C109A	3	LO	LO
.93-1.02	C118A	3	LO	2
1.03-1.10	C131A	3	LO	2
1.11-1.23	C148A	3	LO	2
1.24-1.38	C163A	3	LO	3
1.39-1.49	C184A	3	LO	4
1.50-1.67	C196A	3	LO	4
1.68-1.79	C220A	3	LO	5
1.80-1.98	C239A	3	2	5
1.99-2.24	C268A	3	3	5
2.25-2.43	C301A	3	3	6
2.44-2.75	C326A	7	LO	3
2.76-3.25	C356A	7	LO	4
3.26-3.43	C379A	7	LO	4
3.44-4.03	C419A	7	2	4
4.04-4.43	C466A	7	2	5
4.44-4.94	C526A	7	3	5
4.95-5.36	C592A	7	3	6
5.37-5.77	C630A	7	4	6
5.37-5.77	C630A	15	LO	3
5.78-6.35	C695A	15	LO	3
6.36-6.92	C778A	15	LO	4
6.93-7.99	C867A	15	2	4
8.00-8.47	C955A	15	2	5
8.48-9.19	C104B	15	3	5
9.20-10.0	C113B	20	2	4
10.1-10.7	C125B	20	2	5
10.8-12.0	C137B	20	2	5
12.1-12.9	C151B	20	3	5
13.0-15.1	C163B	20	4	6
15.2-16.3	C180B	25	3	5
16.4-17.9	C198B	25	3	6
Size 1 (Standard)				
18.0-19.7	C214B	30	3	5
19.8-21.2	C228B	30	3	5
21.3-22.3	C250B	30	3	6
22.4-23.5	C273B	40	2	5
23.6-25.5	C303B	40	3	5
25.6-27.0	C330B	40	3	5

Size 0 and 1 (Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	SE Rating Plug	Mag-Break Trip Setting	
			Rec.	Max.
.66-.76	C087A	3	LO	LO
.77-.84	C097A	3	LO	LO
.85-.93	C109A	3	LO	LO
.94-1.04	C118A	3	LO	2
1.05-1.15	C131A	3	LO	2
1.16-1.27	C148A	3	LO	3
1.28-1.39	C163A	3	LO	3
1.40-1.55	C184A	3	LO	4
1.56-1.73	C196A	3	2	4
1.74-1.89	C220A	3	2	5
1.90-2.05	C239A	3	2	5
2.06-2.28	C268A	3	3	5
2.29-2.47	C301A	3	3	6
2.48-2.79	C326A	7	LO	3
2.80-3.31	C356A	7	LO	4
3.32-3.70	C379A	7	2	4
3.71-4.06	C419A	7	2	4
4.07-4.47	C466A	7	2	5
4.48-4.95	C526A	7	3	5
4.96-5.49	C592A	7	3	6
5.50-5.91	C630A	7	4	6
5.50-5.91	C630A	15	LO	3
5.92-6.47	C695A	15	LO	3
6.48-7.20	C778A	15	2	4
7.21-8.22	C867A	15	2	4
8.23-8.72	C955A	15	2	5
8.73-9.67	C104B	15	3	5
9.68-10.4	C113B	20	2	4
10.5-11.0	C125B	20	2	4
11.1-12.4	C137B	20	2	5
12.5-13.2	C151B	20	3	5
13.3-15.4	C163B	20	4	6
15.5-17.1	C180B	25	3	5
Size 1 (Ambient Comp.)				
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

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	SE Rating Plug	Mag-Break Trip Setting	
			Rec.	Max.
Size 2 (Standard)				
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.)				
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.)				
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

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	SE Rating Plug	Mag-Break Trip Setting	
			Rec.	Max.
Size 3 (Standard and Ambient Comp.) cont.				
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)				
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.)				
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 CR 123	SF Rating Plug	Mag-Break Trip Setting	
			Rec.	Max.
28.8-32.0	F357B	70	2	4
32.1-34.2	F395B	70	2	4
34.3-36.7	F430B	70	2	5
36.8-43.9	F487B	70	2	5
44.0-46.6	F567B	70	3	5
46.7-52.6	F614B	100	2	4
52.7-55.6	F658B	100	2	4
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	150	LO	4
67.2-70.6	F848B	150	LO	4
70.7-76.3	F914B	150	2	4
76.4-88.7	F104C	200	LO	4
88.8-93.4	F114C	200	LO	4
93.5-102.0	F118C	200	LO	5
103.0-110.0	F133C	200	2	6
111.0-122.0	F149C	200	2	6
123.0-131.0	F161C	200	2	6

Size 4 (Ambient Comp.)

28.8-32.0	F357B	70	2	4
32.1-34.2	F395B	70	3	4
34.3-36.7	F430B	70	3	5
36.8-43.8	F487B	70	3	5
43.9-46.6	F567B	70	3	5
46.7-52.6	F614B	100	2	4
52.7-55.6	F658B	100	2	4
55.7-58.7	F719B	100	2	5
58.8-67.1	F772B	150	LO	4
67.2-70.6	F848B	150	LO	4
70.7-76.3	F914B	150	2	4
76.4-88.7	F104C	200	LO	4
88.8-93.4	F114C	200	LO	4
93.5-105.0	F118C	200	LO	5
106.0-114.0	F133C	200	2	6
115.0-128.0	F149C	200	2	6
129.0-130.0	F161C	200	2	6

Size 5 – 300:15 CT (Standard and Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	SG Rating Plug	Mag-Break 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.)

181-197	C220A	400	MIN.	4
198-214	C239A	400	2	5
215-238	C268A	500	MIN	4
239-258	C301A	500	MIN	4
259-290	C326A	500	2	5
291-346	C356A	600	MIN	5
347-387	C379A	600	2	5
388-424	C419A	600	3	MAX

Size 6 – 600:5 CT (Standard and Ambient Comp.)

Motor Full-Load Amps 3-Ph, 3 Heater	Heater Number CR 123	SK Rating Plug	Mag-Break 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		
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 per Overload Heater Table	5,000
2	60	100,000	100	100,000		5,000
3	100	100,000	200	100,000		5,000
4	200	100,000	400	100,000		10,000
5	400	100,000	600	100,000		10,000

Overload Heater Tables

Heaters for Fused Controllers

WARNING: Opening of the fuse(s) may be an indication that a fault current has been interrupted. To provide continued protection against fire or shock hazard, all current-carrying parts and other components of the motor controller should be examined and replaced if damaged. If heater burnout occurs, the complete overload relay must be replaced.

Size 0 and 1 (Standard and Ambient Comp.)

Motor Full-Load Amps 3-Ph., 3-Heater	Heater Number CR123	Maximum Fuse Rating
.41-.45	C054A	3
.46-.49	C060A	3
.50-.53	C066A	3
.54-.59	C071A	3
.60-.65	C078A	3
.66-.76	C087A	3
.77-.84	C097A	3
.85-.93	C109A	3
.94-1.04	C118A	3
1.05-1.15	C131A	3
1.16-1.27	C148A	3
1.28-1.39	C163A	3
1.40-1.55	C184A	6
1.56-1.73	C196A	6
1.74-1.89	C220A	6
1.90-2.05	C239A	6
2.06-2.28	C268A	6
2.29-2.47	C301A	6
2.48-2.79	C326A	10
2.80-3.31	C356A	10
3.32-3.70	C379A	12
3.71-4.06	C419A	15
4.07-4.47	C466A	15
4.48-4.95	C526A	15
4.96-5.49	C592A	20
5.50-5.91	C630A	20
5.92-6.47	C695A	25
6.48-7.20	C778A	25
7.21-8.22	C867A	30
8.23-8.72	C955A	30
8.73-9.67	C104B	35 [1)]
9.68-10.4	C113B	35 [1)]
10.5-11.0	C125B	40 [1)]
11.1-12.4	C137B	45 [1)]
12.5-13.2	C151B	50 [1)]
13.3-15.4	C163B	60 [1)]
15.5-17.1	C180B	60 [1)]
17.2-18.0	C198B	60 [1)]

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

Size 1

Motor Full-Load Amps 3-Ph., 3-Heater	Heater Number CR123	Maximum Fuse Rating
17.2-18.1	C198B	60 [1)]
18.2-20.0	C214B	60 [1)]
20.1-21.5	C228B	60 [1)]
21.6-22.5	C250B	60 [1)]
22.6-23.9	C273B	60 [1)]
24.0-26.3	C303B	60 [1)]
26.4-27.0	C330B	60 [1)]

Size 2 (Standard and Ambient Comp.)

5.48-5.85	C630A	20
5.86-6.47	C695A	20
6.48-7.35	C778A	25
7.36-8.06	C867A	30
8.07-9.03	C955A	30
9.04-9.61	C104B	35
9.62-10.5	C113B	35
10.6-11.6	C125B	40
11.7-12.5	C137B	45
12.6-13.6	C151B	50
13.7-16.7	C163B	60
16.8-17.9	C180B	60
18.0-18.7	C198B	70 [1)]
18.8-20.4	C214B	80 [1)]
20.5-22.7	C228B	80 [1)]
22.8-24.7	C250B	90 [1)]
24.8-26.3	C273B	90 [1)]
26.4-29.5	C303B	100 [1)]
29.6-32.5	C330B	100 [1)]
32.6-36.7	C366B	100 [1)]
36.8-41.9	C400B	100 [1)]
42.0-43.2	C440B	100 [1)]
43.3-45.0	C460B	100 [1)]

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

Overload Heater Tables

Heaters for Fused Controllers

Motor Full-Load Amps 3-Ph., 3-Heater	Heater Number CR123	Maximum Fuse Rating
Size 3 (Standard)		
19.0-19.3	F233B	70
19.4-22.1	F243B	80
22.2-23.4	F270B	80
23.5-27.0	F300B	90
27.1-29.1	F327B	100
29.2-31.8	F357B	110 [1]
31.9-33.9	F395B	125 [1]
34.0-37.6	F430B	125 [1]
37.7-41.9	F487B	150 [1]
42.0-47.7	F567B	175 [1]
47.8-52.1	F614B	175 [1]
52.2-55.8	F658B	200 [1]
55.9-59.7	F719B	200 [1]
59.8-68.1	F772B	200 [1]
68.2-71.5	F848B	200 [1]
71.6-78.2	F914B	200 [1]
78.3-87.5	F104C	200 [1]
87.6-90.0	F114C	200 [1]
Size 3 (Ambient Comp.)		
17.8-18.4	F233B	70
18.5-21.1	F243B	80
21.2-22.1	F270B	80
22.2-26.1	F300B	90
26.2-28.0	F327B	100
28.1-31.3	F357B	110 [1]
31.4-33.3	F395B	125 [1]
33.4-34.3	F430B	125 [1]
34.4-40.9	F487B	150 [1]
41.0-44.7	F567B	150 [1]
44.8-51.0	F614B	175 [1]
51.1-52.0	F658B	200 [1]
52.1-55.4	F719B	200 [1]
55.5-63.3	F772B	200 [1]
63.4-66.1	F848B	200 [1]
66.2-73.5	F914B	200 [1]
73.6-82.2	F104C	200 [1]
82.3-90.0	F114C	200 [1]
Size 4 (Standard)		
27.1-32.2	F357B	110
32.3-34.0	F395B	125
34.1-36.8	F430B	125
36.9-44.6	F487B	150
44.7-48.4	F567B	175
48.5-53.9	F614B	175
54.0-57.4	F658B	200
57.5-60.0	F719B	225 [1]
60.1-69.5	F772B	225 [1]
69.6-71.7	F848B	250 [1]
71.8-79.9	F914B	275 [1]
80.0-92.3	F104C	300 [1]
92.4-97.0	F114C	350 [1]
97.1-108	F118C	400 [1]
109-118	F133C	400 [1]
119-131	F149C	400 [1]
132-135	F161C	400 [1]

[1] See Table 1 (page J-17) for maximum fuse and short-circuit rating.

Motor Full-Load Amps 3-Ph., 3-Heater	Heater Number CR123	Maximum Fuse Rating
Size 4 (Ambient Comp.)		
28.8-32.0	F357B	110
32.1-34.2	F395B	125
34.3-36.7	F430B	125
36.8-43.9	F487B	150
44.0-46.6	F567B	175
46.7-52.6	F614B	175
52.7-55.6	F658B	200
55.7-58.7	F719B	225 [1]
58.8-67.1	F772B	225 [1]
67.2-70.6	F848B	250 [1]
70.7-76.3	F914B	275 [1]
76.4-88.7	F104C	300 [1]
88.8-93.4	F114C	350 [1]
93.5-105	F118C	350 [1]
106-114	F133C	400 [1]
115-128	F149C	400 [1]
129-131	F161C	400 [1]
132-135	F174C	400 [1]
Size 5 – 300:15CT (Standard and Ambient Comp.)		
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

[1] See Table 1 (page J-17) for maximum fuse and short-circuit rating.

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

H

Starter Fuse Selection

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

200 and 208 Volts

Size	Hp	Typical FLA	Switch Amp	UL Class J				Time-Delay RK-5			
				Time Delay		No Time Delay BMC		FRN	CSC Clip	TR	Clip
				CSC# AJT	Clip	CSC# A4J	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		BMC FRN	Clip	TR	CSC Clip
				CSC# AJT	Clip	CSC# A4J	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 RK-5			
				Time Delay		No Time Delay BMC		BMC FRS	Clip	CSC TRS	Clip
				CSC# AJT	Clip	CSC# A4J	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 RK-5			
				Time Delay		No Time Delay BMC		BMC FRS	Clip	CSC TRS	Clip
				CSC# AJT	Clip	CSC# A4J	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)	Tungsten [1] Lamps	Resistive Loads [2]	Transformer Primary Switching (kVA)															
					Transformers having inrush currents of not more than 20 times FLA								Transformers having inrush currents of over 20 through 40 times FLA							
					Single-Phase Volts				Three-Phase Volts				Single-Phase Volts				Three-Phase Volts			
					120	240	480	600	208	240	480	600	120	240	480	600	208	240	480	600
0	18	140	10	18	0.6	1.2	2.4	3	1.8	2.1	4.2	5.2	0.3	0.6	1.2	1.5	0.9	1.0	2.1	2.6
1	27	288	15	27	1.2	2.4	4.9	6.2	3.6	4.3	8.5	11	0.6	1.2	2.5	3.1	1.8	2.1	4.3	5.3
2	45	483	30	45	2.1	4.1	8.3	10	6.3	7.2	14	18	1.0	2.1	4.2	5.2	3.1	3.6	7.2	8.9
3	90	947	60	90	4.1	8.1	16	20	12	14	28	35	2.0	4.1	8.1	10	6.1	7.0	14	18
4	135	1581	120	135	6.8	14	27	34	20	23	47	59	3.4	6.8	14	17	10	12	23	29
5	270	3163	240	270	14	27	54	68	41	47	94	117	6.8	14	27	34	20	24	47	59
6	540	6326	480	540	27	54	108	135	81	94	188	234	14	27	54	68	41	47	94	117

[1] 300-volts maximum, Tungsten lamp loads include infrared lamps having Tungsten filaments.
[2] Resistive loads include electric discharge lamps such as fluorescent, mercury, vapor, etc.

Non-Motor Loads

NEMA Contactor Ratings for Single Capacitor or Capacitor Bank Switching

Size of Controller	Continuous Ratings RMS Amperes	Three-Phase Rating of Capacitor					
		Maximum Size of Three-Phase Capacitor in kVAR or Available Current [1] 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 Ratings [2]							
		575 Volts		460 Volts		230 Volts		115 Volts	
		2-Pole 1-Ph	3-Pole 3-Ph	2-Pole 1-Ph	3-Pole 3-Ph	2-Pole 1-Ph	3-Pole 3-Ph	2-Pole 1-Ph	3-Pole 3-Ph
00	9	5	9	4	7	2	3.5	1	1.75
0	18	10	18	8	14	4	7	2	3.5
1	27	15	25	12	20	6	10	3	5
2	45	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 maximum [3].
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				22,000 Amp RMS			
	Maximum Available Fault Current				Maximum Available Fault Current			
	200V	230V	460V	575V	200V	230V	460V	575V
CL00	3	3	5	5.7	1.5	1.5	2.5	2.8
CL01	435	4.5	9.5	11	2.2	2.2	4.5	5.5
CL02	6.5	6.5	11	12.5	3.2	3.2	5.5	6.2
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

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 at ambient temperature of: (for all voltages)	40°C	A	25	25	32	32	54	55	80	100	102	120	120	150	175	200	310	500	600	650
	55°C	A	25	25	32	32	54	55	80	100	102	120	120	150	175	200	310	425	510	546
	70°C	A	20	20	25	25	41	44	62	78	81	80	80	130	155	175	270	335	432	468

4-pole Contactors			CL Contactors								CK Contactors					
			01	02	03	04	06	07	08	09	08	09	95	10	11	12
Max. operational current at ambient temperature of: (for all voltages)	40°C	A	25	32	40	54	70	100	110	120	175	200	310	500	550	650
	55°C	A	25	32	40	54	70	100	110	120	175	200	310	425	462	543
	70°C	A	20	25	28	41	52	78	88	80	155	175	270	335	462	468

Horsepower/kilowatt ratings are shown below

Catalog Number	General Purpose Ratings	Max. FLA	1 Phase-HP A		3 Phase-HP A				Power In 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	22,22,17 [1)]	1.5 (20)	3 (17)	5 (17.5)	7.5 (22)	15. (21)	15 (17)	11 (25)
CL04	54	32A	2 (24)	5 (28)	10 (32)	10 (28)	20 (27)	25 (27)	16 (32)
CL45	55	34,34,27 [1)]	3 (34)	5 (28)	10 (32)	10 (28)	25 (34)	25 (27)	18.5 (40)
CL06	80	48	3 (34)	7.5 (40)	15 (48)	15 (42)	30 (40)	40 (41)	22 (50)
CL07	100	62	5 (56)	10 (50)	20 (62)	20 (54)	40 (52)	50 (52)	30 (65)
CL08	110(O) 102 (E)	68	5 (56)	15 (68)	20 (62)	25 (68)	50 (65)	60 (62)	37 (80)
CL09	140 (O) 120 (E)	80	7.5 (80)	15 (68)	25 (78)	30 (80)	60 (77)	75 (77)	45 (95)
CL10	140 (O) 120 (E)	104,96,80 [1)]	10 (100)	20 (88)	30 (92)	40 (104)	75 (96)	75 (77)	55 (105)
CK75	150	140	10 (100)	25 (110)	40 (120)	50 (130)	100 (124)	125 (125)	75 (154)
CK08	175	156	15 (135)	30 (136)	50 (149.5)	60 (145)	125 (156)	125 (125)	90 (185)
CK09	200	192	–	–	60 (169.4)	75 (192)	150 (180)	150 (144)	132 (250)
CK95	310	302	–	–	100 (285)	100 (248)	250 (302)	300 (289)	160 (310)
CK10	500	398	–	–	125 (358)	150 (360)	300 (361)	400 (382)	220 (420)
CK11	600	480	–	–	150 (414)	200 (480)	400 (477)	500 (472)	280 (550)
CK12	650(E) 750 (O)	602	–	–	200 (552)	250 (602)	500 (590)	600 (574)	375 (700)

Publication References

Construction Equipment and Components	
Publication	**Description**
GEP-1100F	Buylog Catalog–Covers Full Line of Products
Molded Case Circuit Breakers	
GET-2779	Application and Selection Guide for Molded Case Circuit Breakers
GEZ-7000	MCCB Time-Current Curves
GET-7002	Spectra RMS Molded Case Circuit Breakers
Power Break Insulated Case Circuit Breakers	
GET-6211	Selection and Application
GEZ-7001	Time-Current Curves
Low Voltage Power Circuit Breakers	
GEI-86150	Installation and Operation Instructions
GEK-7310	Maintenance Manual
GEZ-7002	Type AKR Time-Current Curves
GES-6227	Type AKR MicroVersaTrip RMS-9 Time Current Curves
GES-6228	MicroVersaTrip Ground Fault Time-Current Curves
Disconnect Switches	
GET-6205	Type HPC High-Pressure Contact Switches, Technical
GEZ-7003	Type HPC Time-Current Curves
Ground Fault Protective Products	
GET-2964	Ground Break Systems
GEZ-7003	Ground Break Time-Current Curves
Panelboards	
GET-6592	“A” series Tech. Specifications
GEA-11316	A Series

Factory Automation Products	
Publication [1)]	**Description**
Fanuc Programmable Logic Control	
GFW-0067	Automation Solutions Catalog
Fanuc I/O	
GEK-90486	Genius I/O System User’s Manual
GFA-089	Genius I/O System
GFA-150	Field Control™
GFT-298	VersaMax I/O
GFA-180	VersaMax

Motor Control Center Equipment	
Publication	**Description**
Spectra Series and 8000-Line MCC	
DEA-036	Spectra Series Product Brochure
GEF-4628	8000-Line Renewal Parts Bulletin
GEH-4961	Installation and Maintenance (Instructions)

Publication References

General Purpose Controls	
Publication	**Description**
GEP-1260	Control Catalog–Covers Full Line of Products
Magnetic Motor Starters	
GEA-10928	300-Line Magnetic Motor Starters, Descriptive
GEH-4756	300-Line Instructions, Nema Size 1, FVNR
GEH-4774	300-Line Instructions, Nema Size 2, FVNR
GEH-4806	300-Line Instructions, Nema Size 3, FVNR
GEH-4789	300-Line Instructions, Nema Size 4, FVNR
GEH-4869	300-Line Instructions, Nema Size 5, FVNR
GEH-5108	300-Line Instructions, Nema Size 6-9, FVNR
GEH-4757	300-Line Instructions, Nema Size 1, FVR and 2-Speed
GEH-4775	300-Line Instructions, Nema Size 2, FVR and 2-Speed
GEH-4806	300-Line Instructions, Nema Size 3, FVR and 2-Speed
GEH-4807	300-Line Instructions, Nema Size 4, FVR and 2-Speed
GEH-4839	300-Line Instructions, Nema Size 5, FVR and 2-Speed
Pilot Devices	
GEA-10877	CR104P Push-buttons and Pilot Lights
Relays and Timers	
GEA-10639	CR122B, CR122BT, Series A Relays
GEH-4115	CR120B AC Relays
GEH-4120	CR120B Latched Relays
GEH-4147	CR122B Time-Delay Relays
GEH-4139	CR122BP Time-Delay Relays
GEH-6435	Spectra ECM Instructions
DET-069	Spectra ECM Product Brochure
Variable Speed Drives	ABB General Purpose Drives ACS 580, 0.75 to 500 kW
3AUA0000145061	
Solid State Starters	
1SFC132012C0201	Softstarters PSR, PSRC, PSE and PSTX

Link to ABB library:
https://electrification.us.abb.com/publibrary

Electrical Data

Motor horsepower output may also be calculated as follows:

$$HP = \frac{V \times A \times Pf \times EFF}{746}$$

Motor Control Center Equipment

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 × 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-ft2)	Where: T_A = Accelerating torqu (lb ft) V = Total system inertia that must be accelerated. This includes motor rotor, speed reducer (if used), and load. (lb-ft2
Torque	
$T = F \times R$	
Where: T = Torque (lb-ft) F = Force (lb) R = Radius (ft)	
WK^2 – reflected	
Reflected $WK^2 = \frac{WK^2 \text{ of Load}}{(\text{Reduction Ratio})^2}$	
This is for either belt or gear reductions.	
FPM to RPM	
$RPM = \frac{FPM}{.262 \text{ x (diameter in inches)}}$	

H

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:

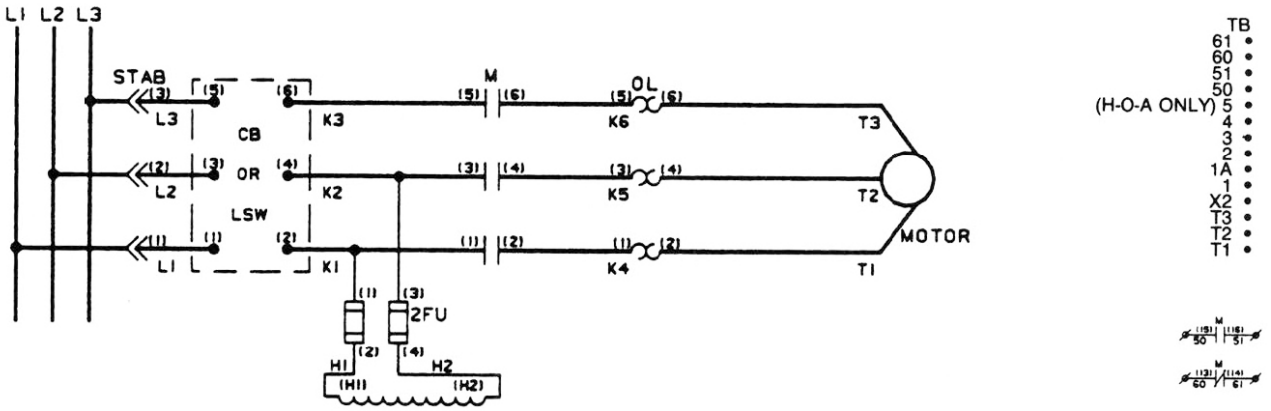
$$GR = \sqrt{\frac{WK^2}{WK^2}}$$

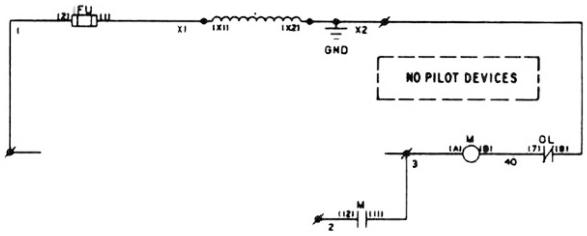
Duty Cycle Calculations

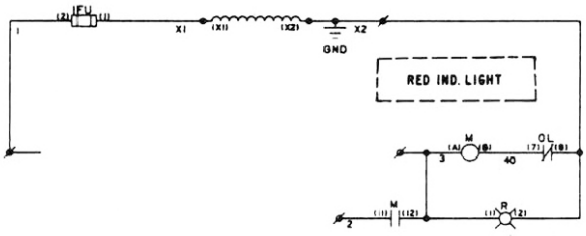
$$HP_{RMS} = \sqrt{\frac{HP^2{}_1t + HP^2{}_2t + HP_3t^2 + etc}{t_1 + t_2 + t_3 + etc}}$$

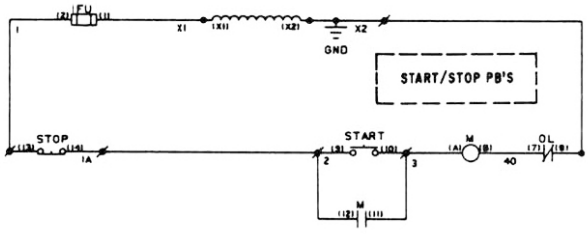
H

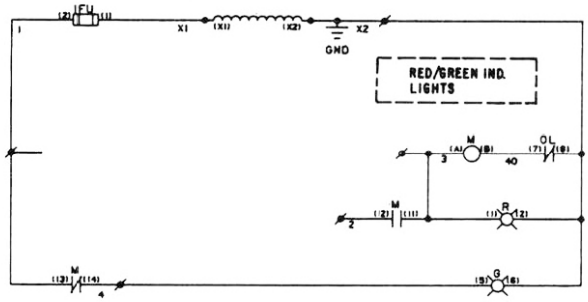
FVNR Size 1-4
Typical Circuit Diagrams

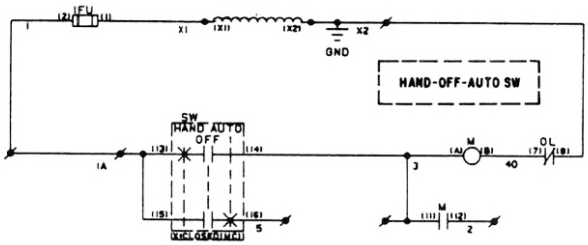


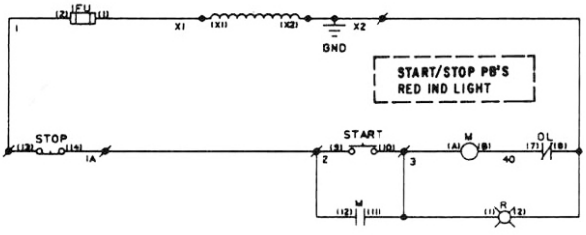


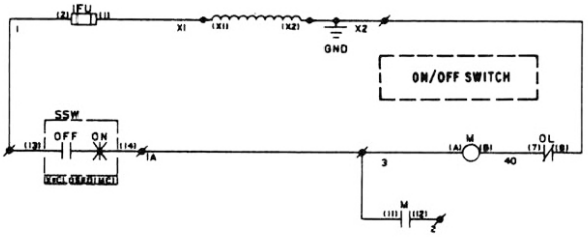


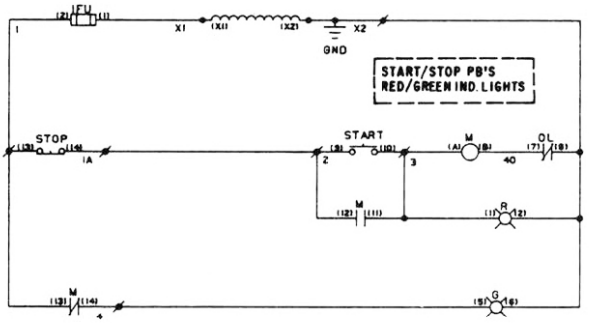




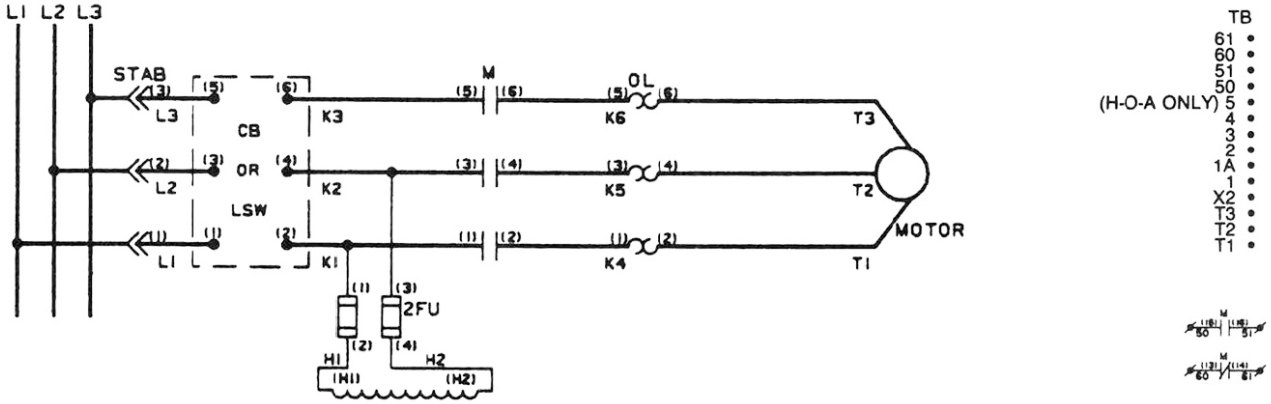


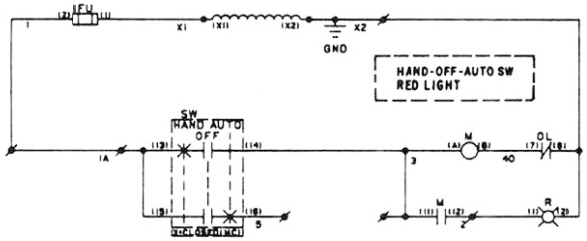


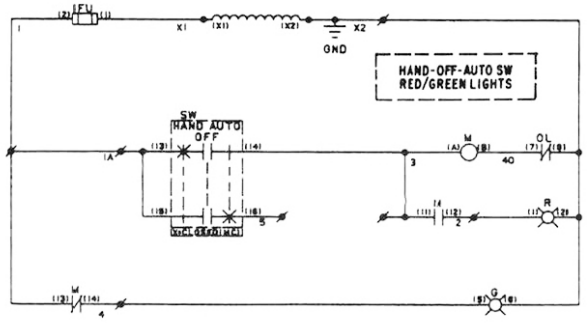


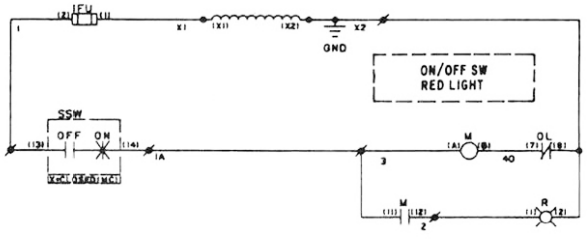


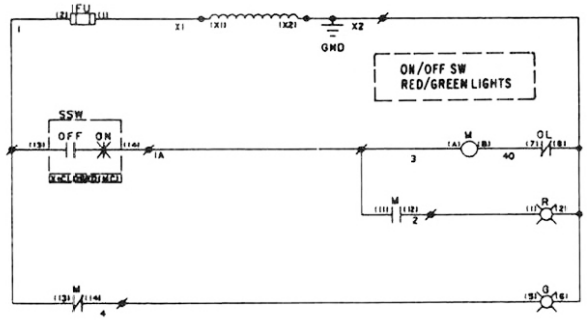
FVNR Size 1-4
Typical Circuit Diagrams



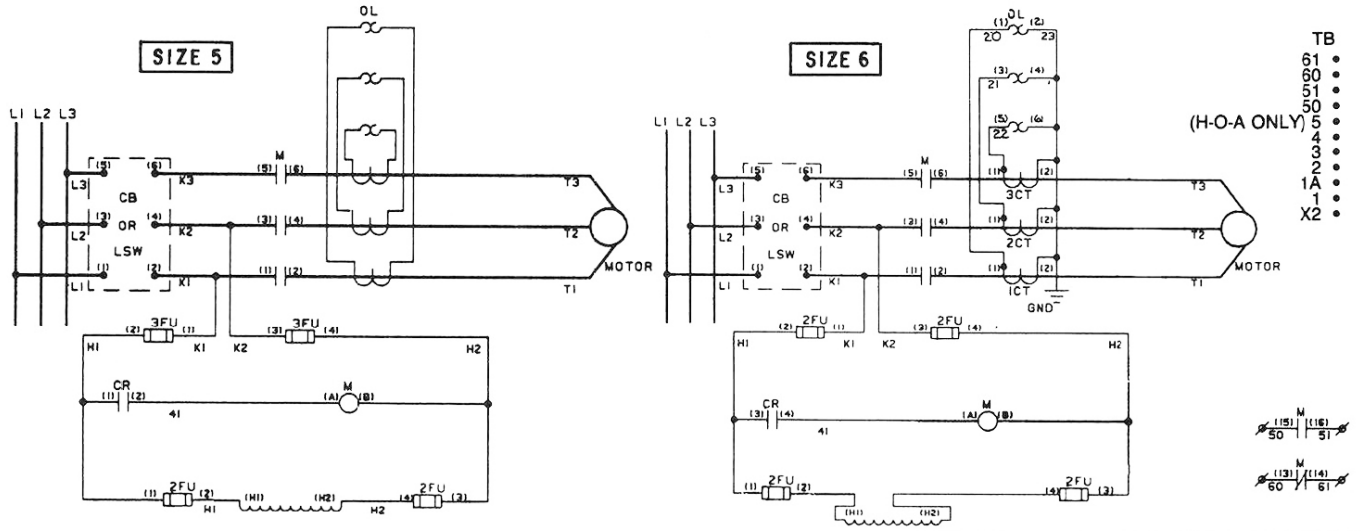


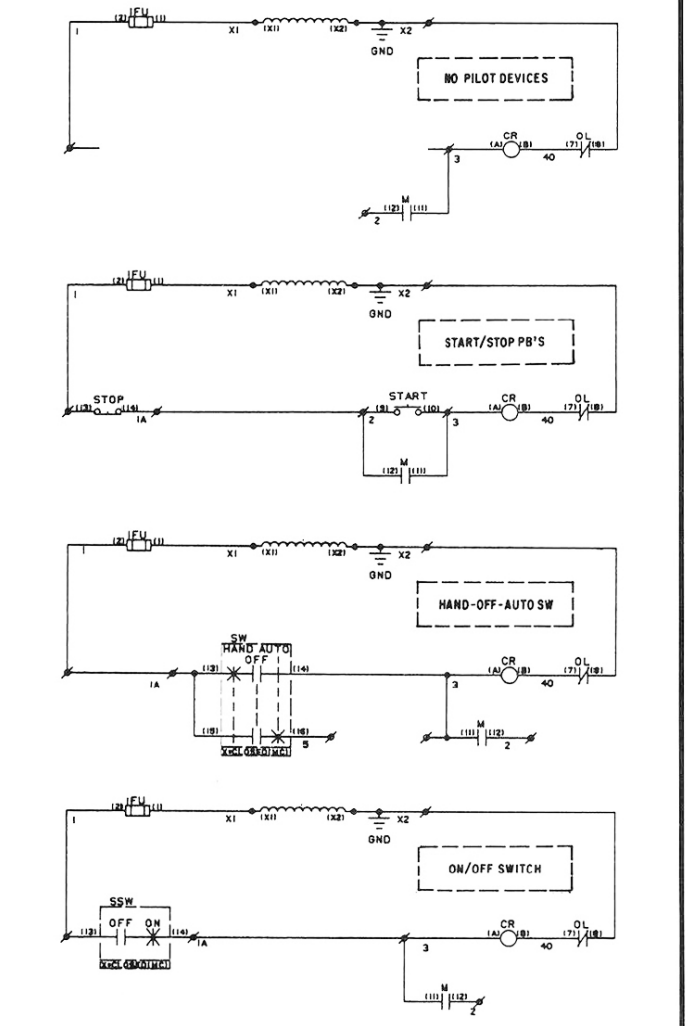


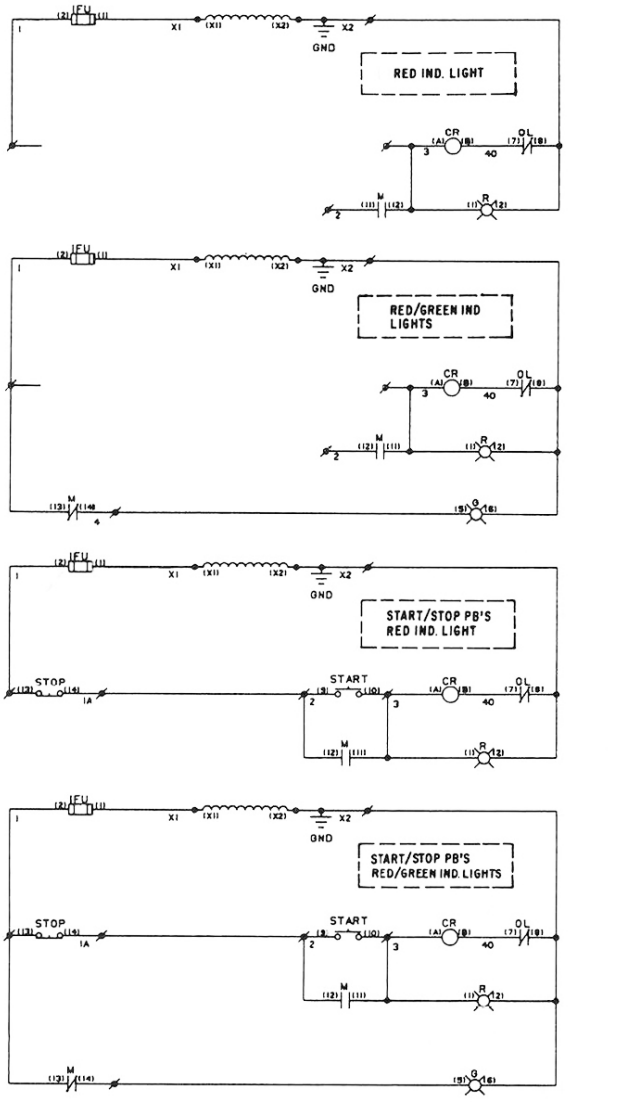




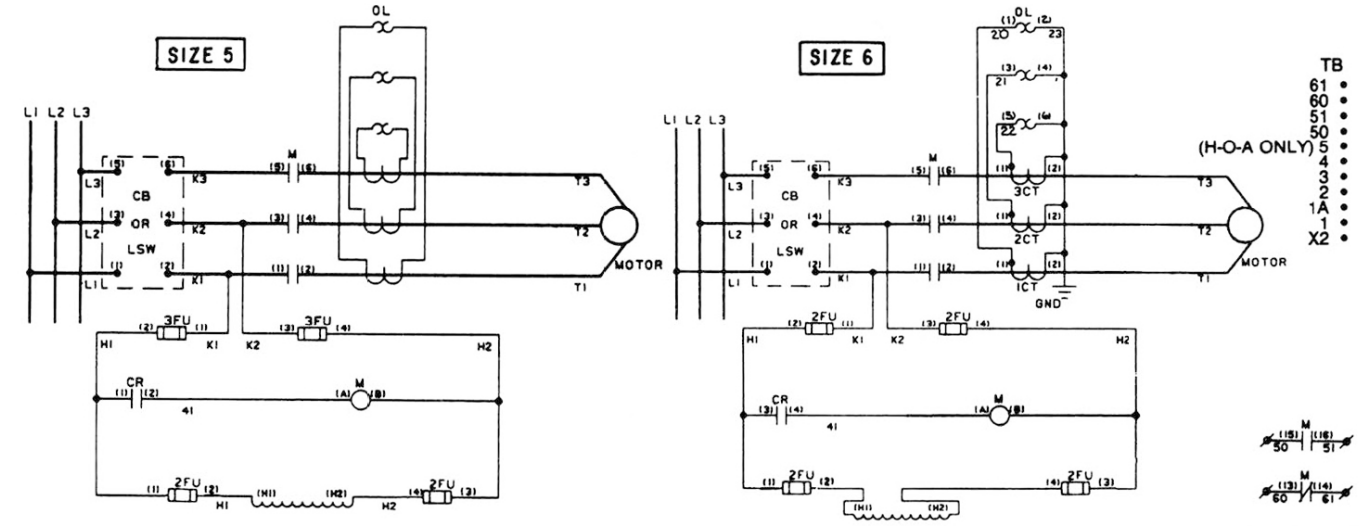
FVNR Size 5-6
Typical Circuit Diagrams

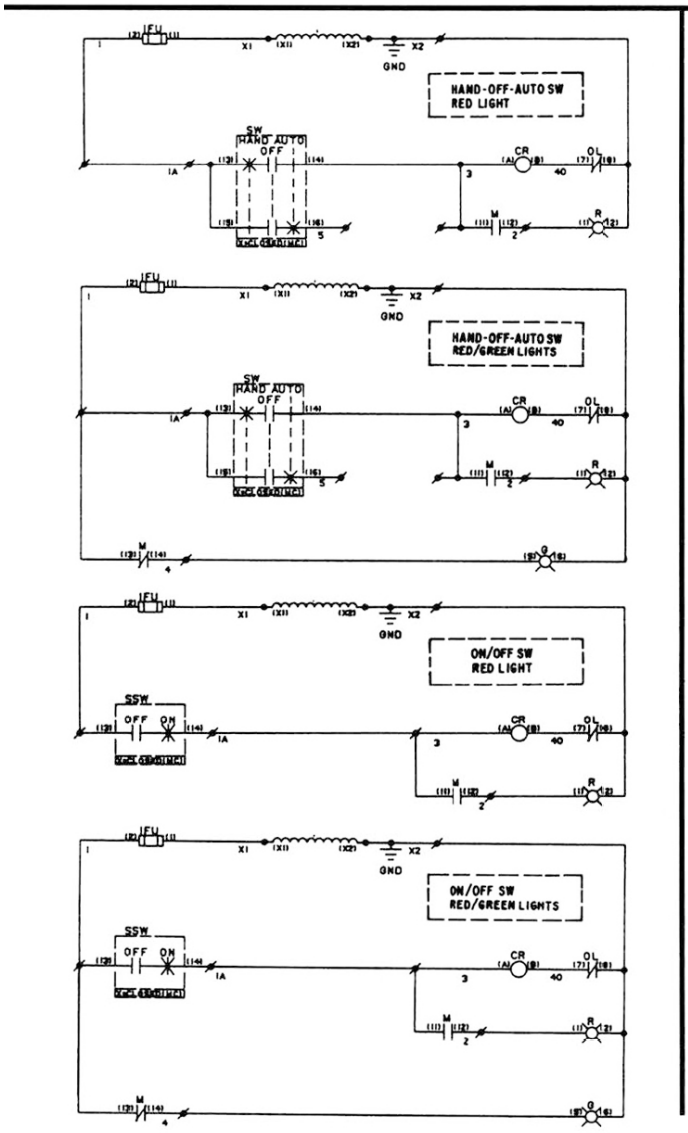




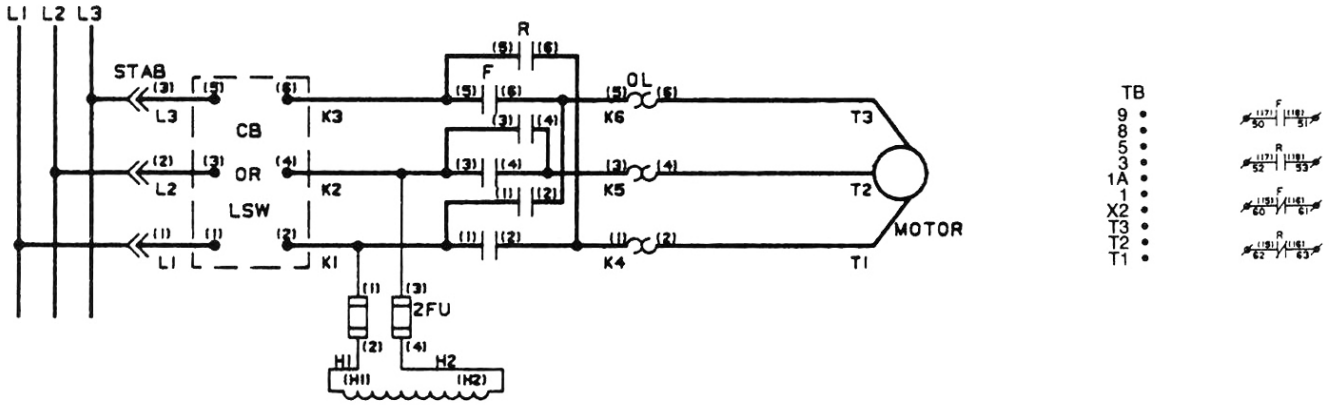


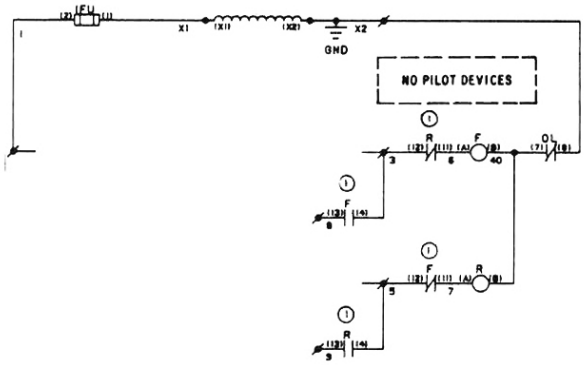
FVNR Size 5-6
Typical Circuit Diagrams

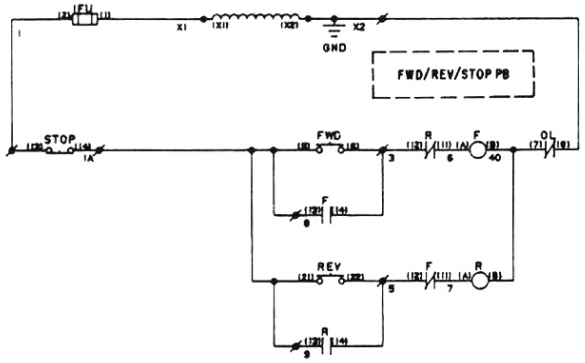


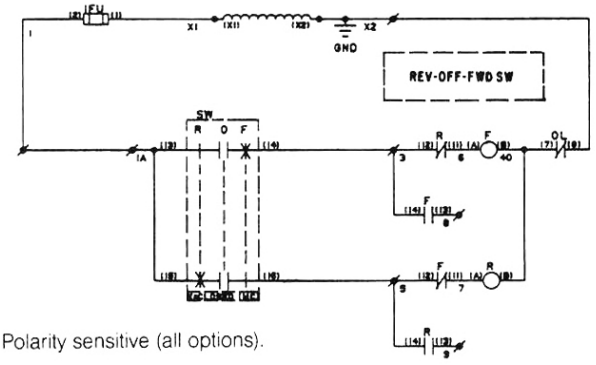


FVR Size 1-4
Typical Circuit Diagrams

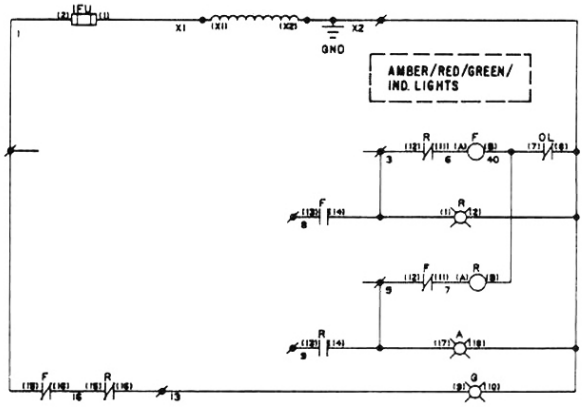


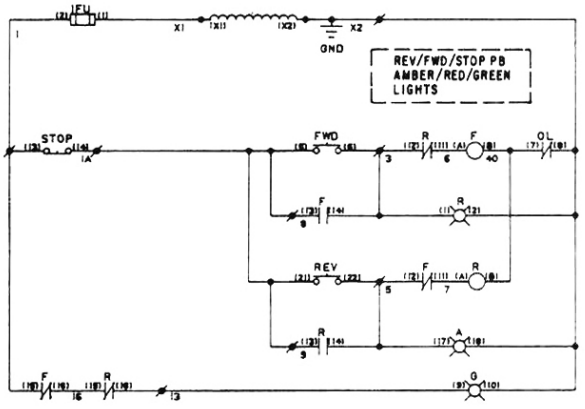


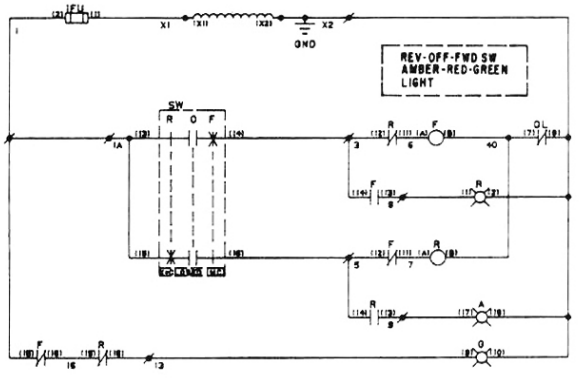




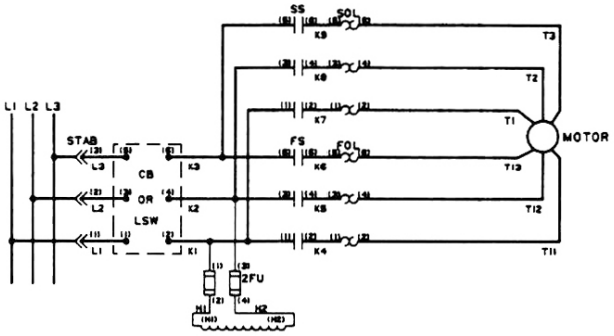
① Polarity sensitive (all options).

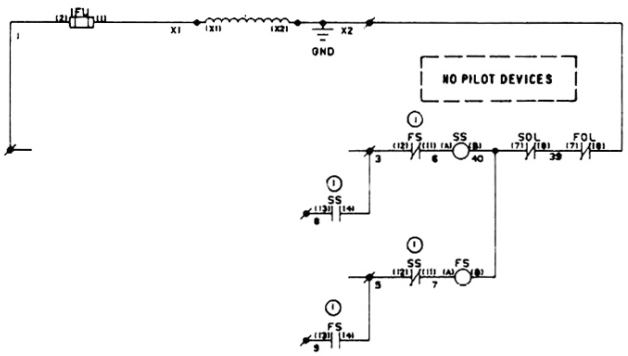


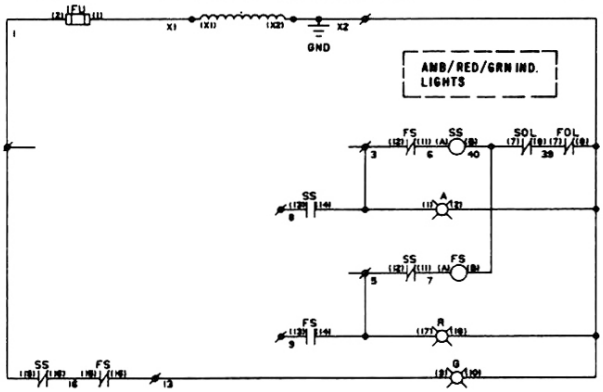


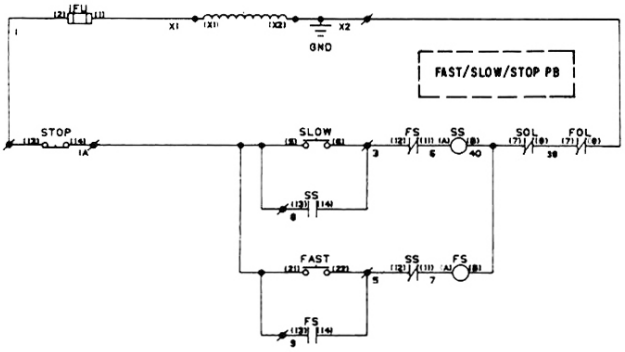


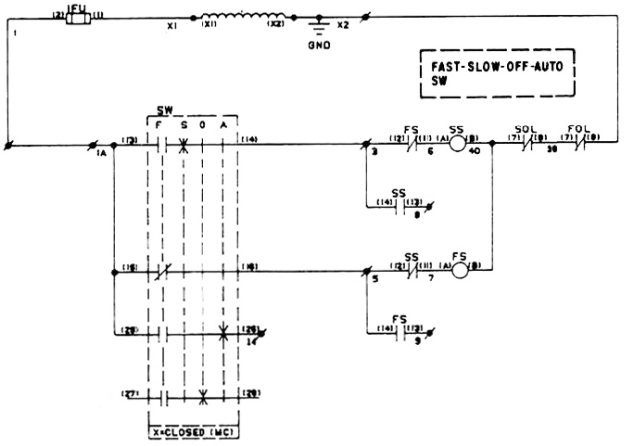
2S2W-C.T., V.T., C.H. Size 1-4
Typical Circuit Diagrams

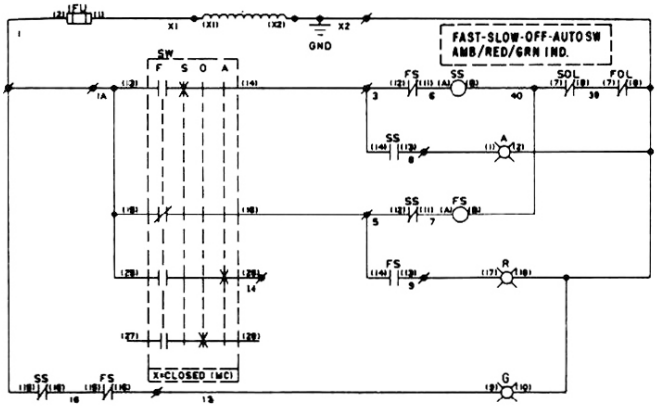


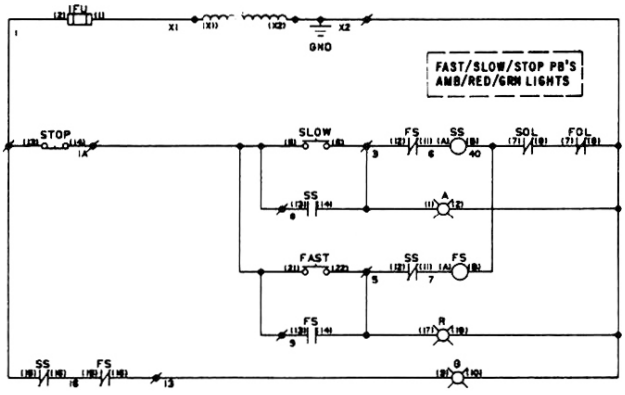






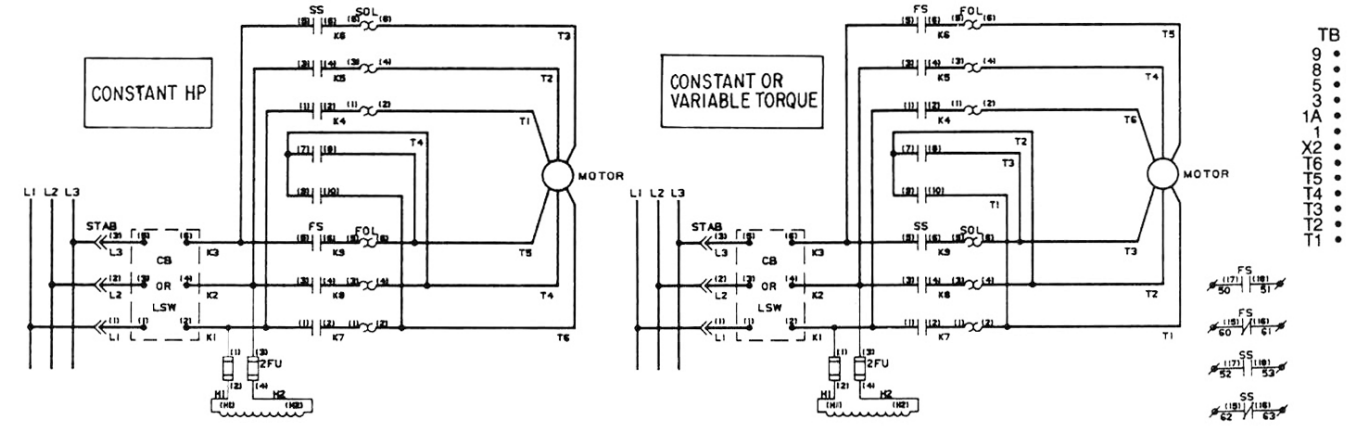


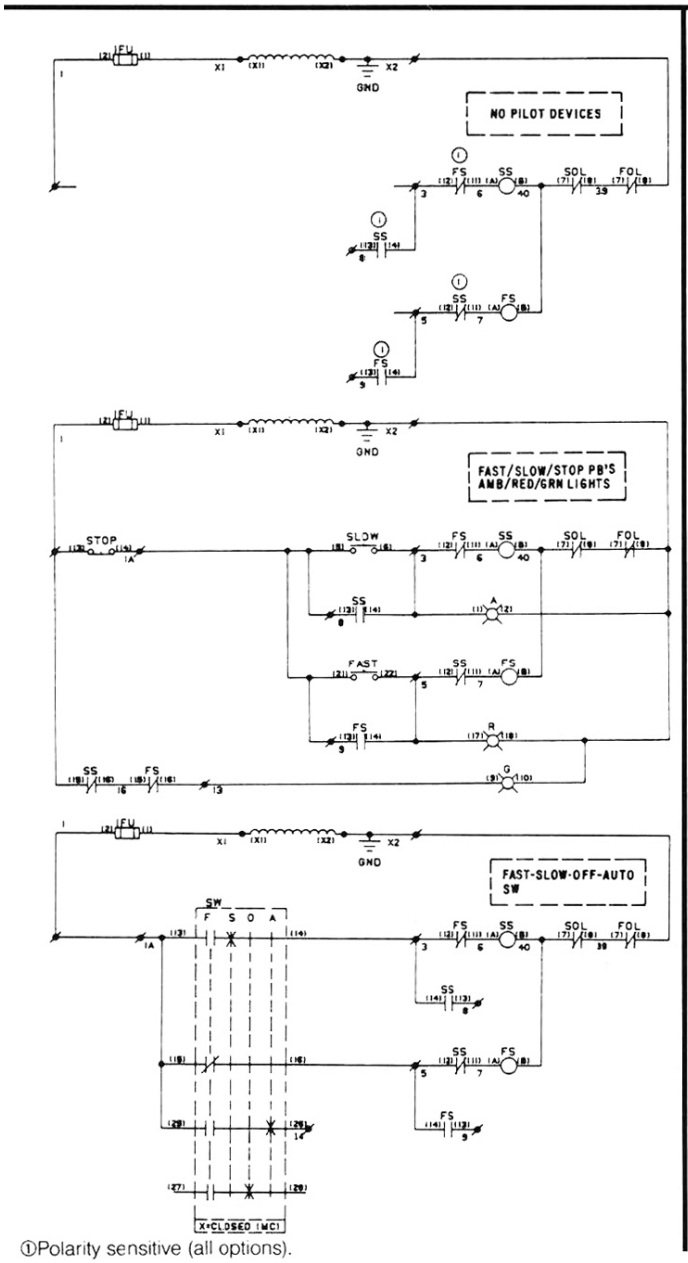


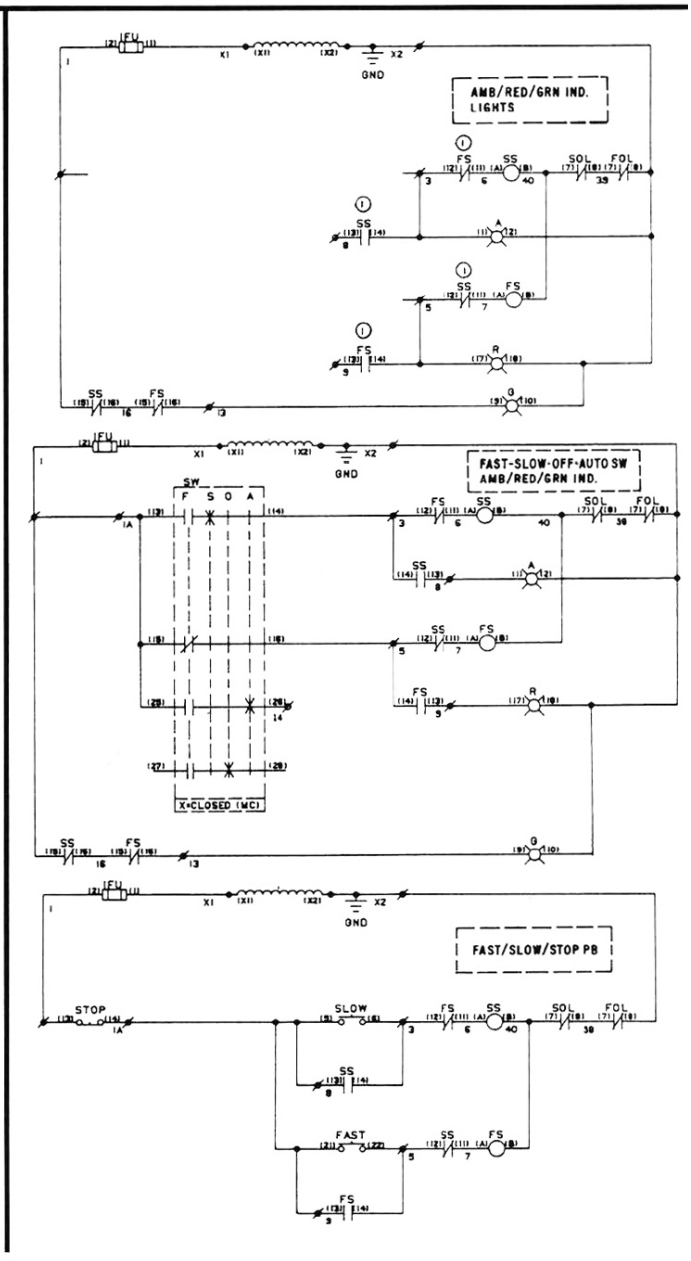


① Polarity sensitive (all options).

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

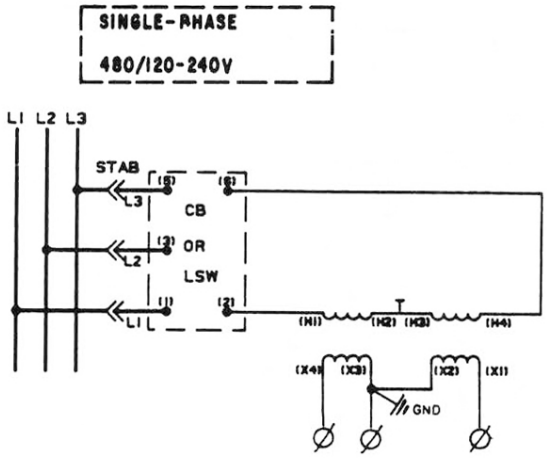


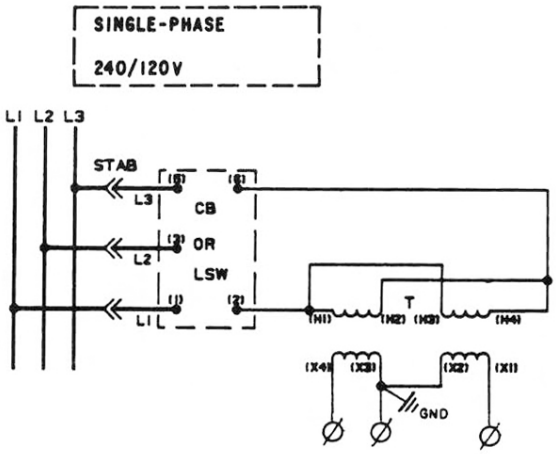


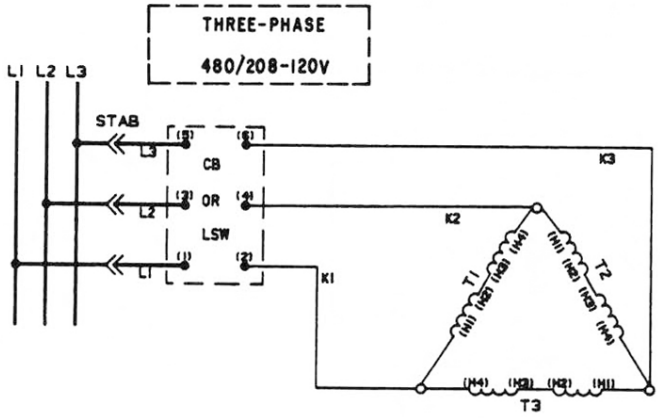


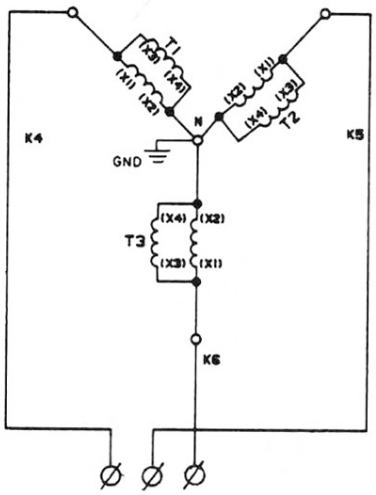
①Polarity sensitive (all options).

Distribution Transformers
Typical Circuit Diagrams

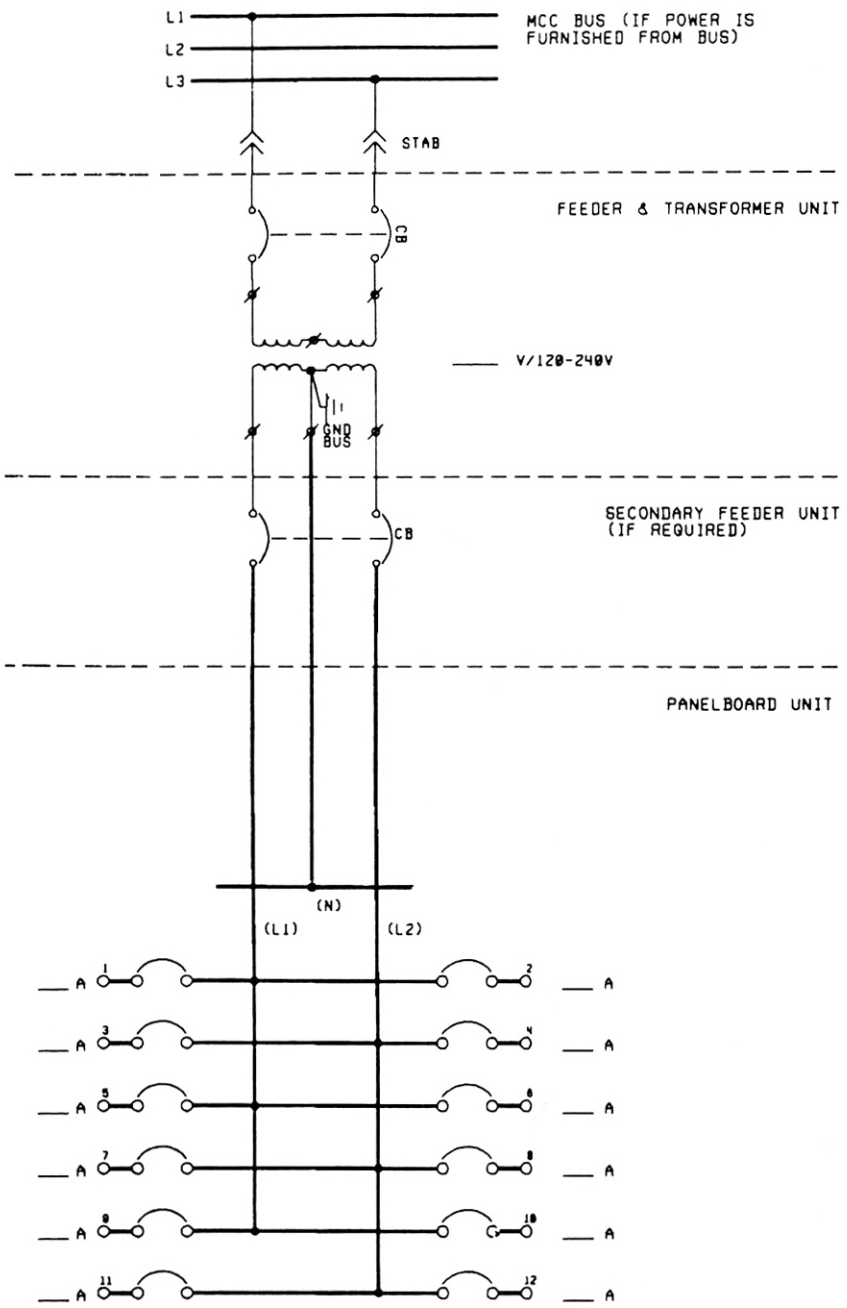




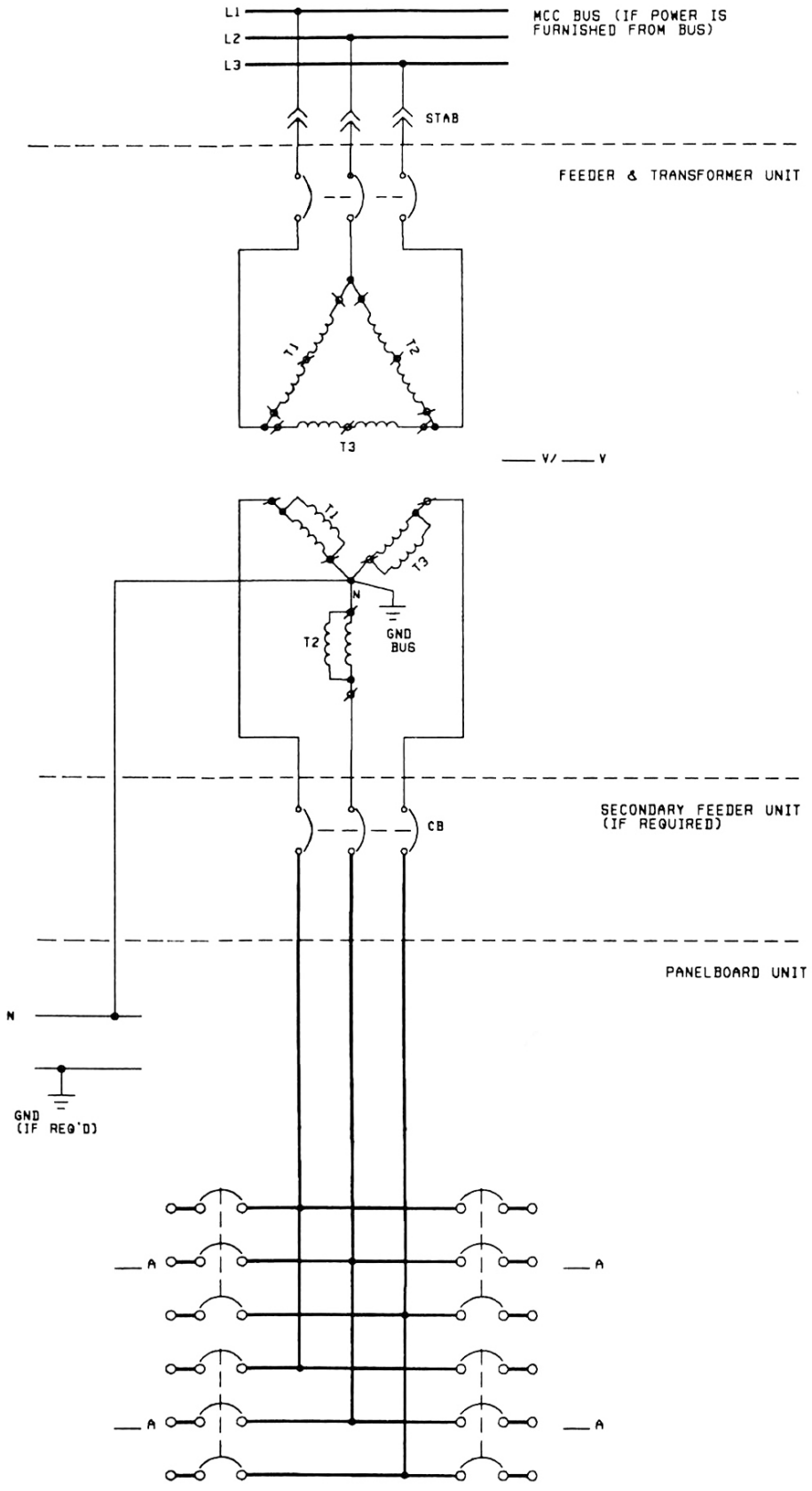




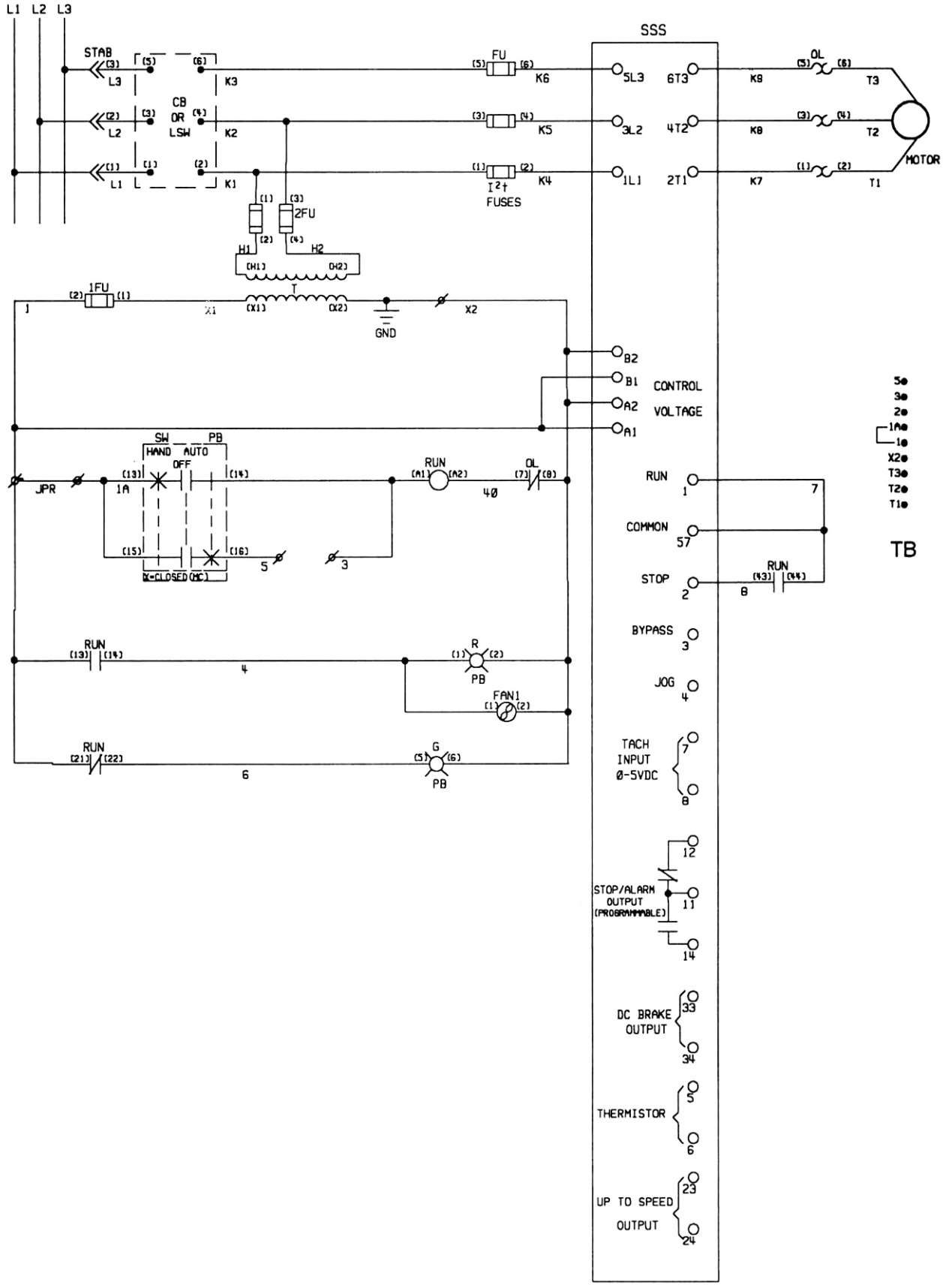
Single-Phase Panelboard
Typical Circuit Diagrams



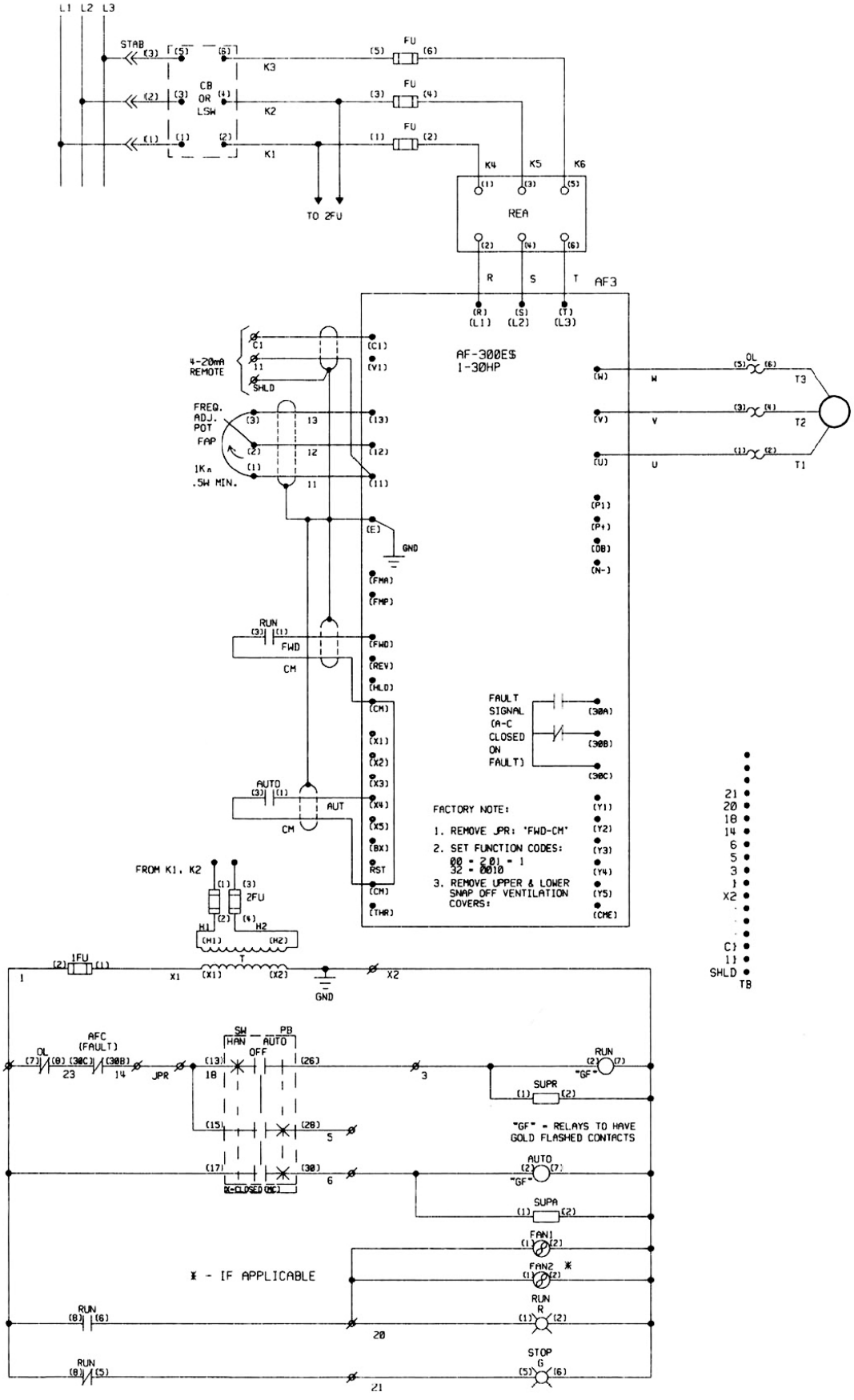
Three-Phase Panelboard
Typical Circuit Diagrams



Solid State Starter
Typical Circuit Diagrams



Variable Speed Drive



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