ADJUSTABLE SPEED DRIVES

GENERAL

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

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

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

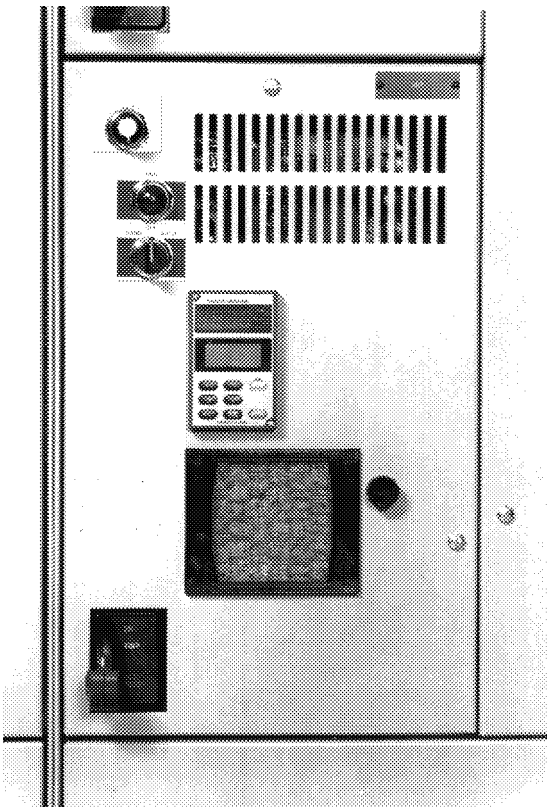
A drive creates noise on the power system. Although we use reactors to minimize system disturbances, a drive will create harmonics on the power/system (both at the motor and at the transformer). If sensitive computer systems are to be utilized, they should be isolated from the drive's source. Likewise, the harmonics created at the motor may cause the motor to run hotter than expected. Standard motors should be derated 10% when used with a drive. We recommend GE's high efficiency ENERGY SAVER® motors for drive applications. See motor application data, SH. G-3

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

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

LINE REACTORS

The available power source connected to the Drive is not to exceed 500KVA. If the ac power source is greater than 500KVA and the Drives rating (HP) is less than 10% of the power source's KVA; ac line reactors will have to be installed in L1, L2, and L3 power leads of the Drive.



AF300E$™ Drives

LOAD FILTERS

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

MOTOR APPLICATION DATA

Harmonic Derating

AC motors have traditionally been applied as constant speed motors, so there is little published information on reduced speed efficiencies, especially when operated with a non-sinusoidal supply such as an inverter. The harmonics present in the PWM inverter output increase motor losses and thus motor heating. General Electric Energy Saver® motors, designed for high efficiency and improved thermal characteristics, may be applied at nameplate rating for variable torque duty, such as centrifugal fans and pumps, for 4 and 6 pole ratings. Standard AC motors designed for 60 Hertz operation should be derated 10% for variable torque duty. For constant torque applications, Energy Saver and standard design motors should be applied per Fig. 1. For other applications refer to the Company.

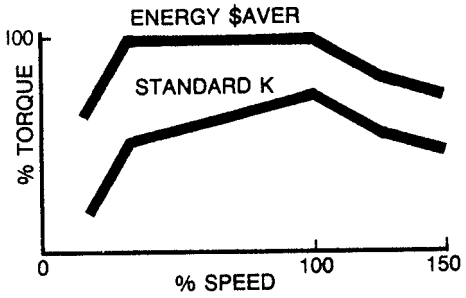
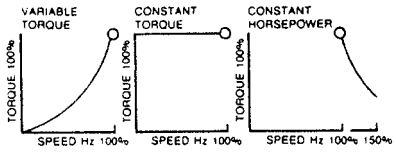


Fig. 1

HOW TO SELECT DRIVES

1. Types of Load

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



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

HP = Required HP

T = Torque in lb./ft.

N = Speed in RPM

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

2. Motor Speed Range

Motor synchronous speed is determined by the following equation:

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

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

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

3. Multi Motor Drives

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

4. Acceleration Time

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

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

Where:

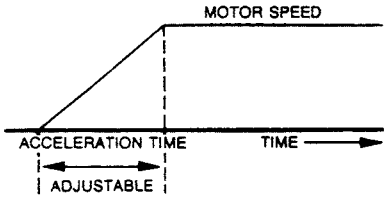
TA = Time to accelerate the driven load (in seconds).

#N = Change in speed (in RPM)

WK^2 = The total system inertia reflected to the motor shaft. Includes motor, machine gears (in ft./lbs.^{2})

T = Motor full load torque (lb./ft.)

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



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ADJUSTABLE SPEED DRIVES

HOW TO SELECT DRIVES (CONT'D.)

5. Deceleration Time

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

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

Where:

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

#N = Change in speed (in RPM)

Wk^2 = The total system inertia reflected to the motor shaft. Includes motor, machine gears (in ft./lbs.^{2})

T = Motor full load torque (lb./ft.)

If faster deceleration is required, refer to the Company.

ORDERING INFORMATION

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

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

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

* Calculated at motor shaft

ADJUSTABLE SPEED DRIVES

AF-300E$™

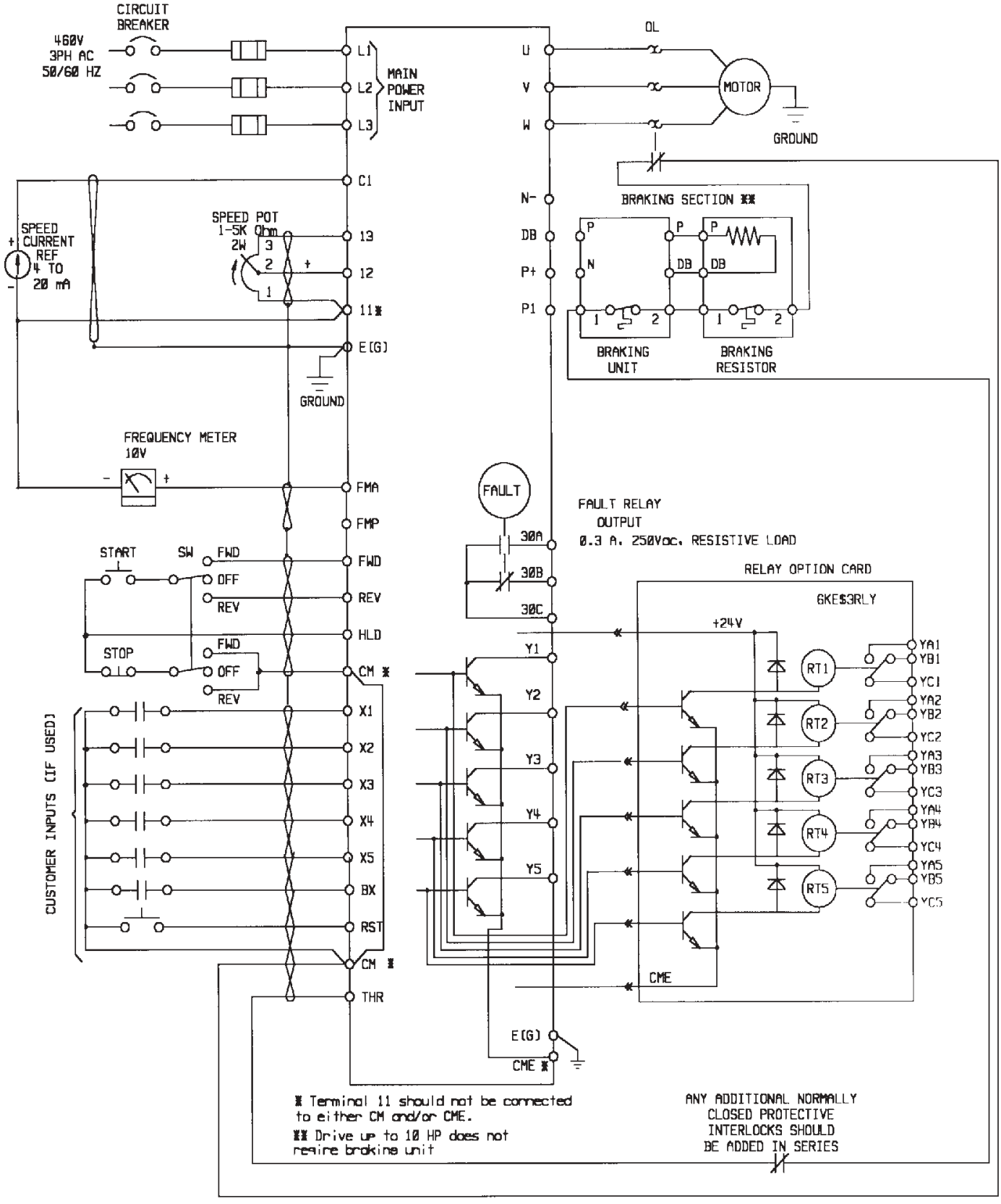
- **Available Ratings**
  - 1-125 HP, 380-460 VAC. 3 Phase. 50/60 Hz
  - 0.5-30 HP, 200-230 VAC, 50/60 Hz
- **Control**
  - Twin 16-bit microprocessors operating with a speed allowing the drive to maximize frequency regulation with acceleration rate and impact loading, making adjustments quickly to avoid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

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

AF300E$ Specification

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

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



BASIC CONNECTION DIAGRAM

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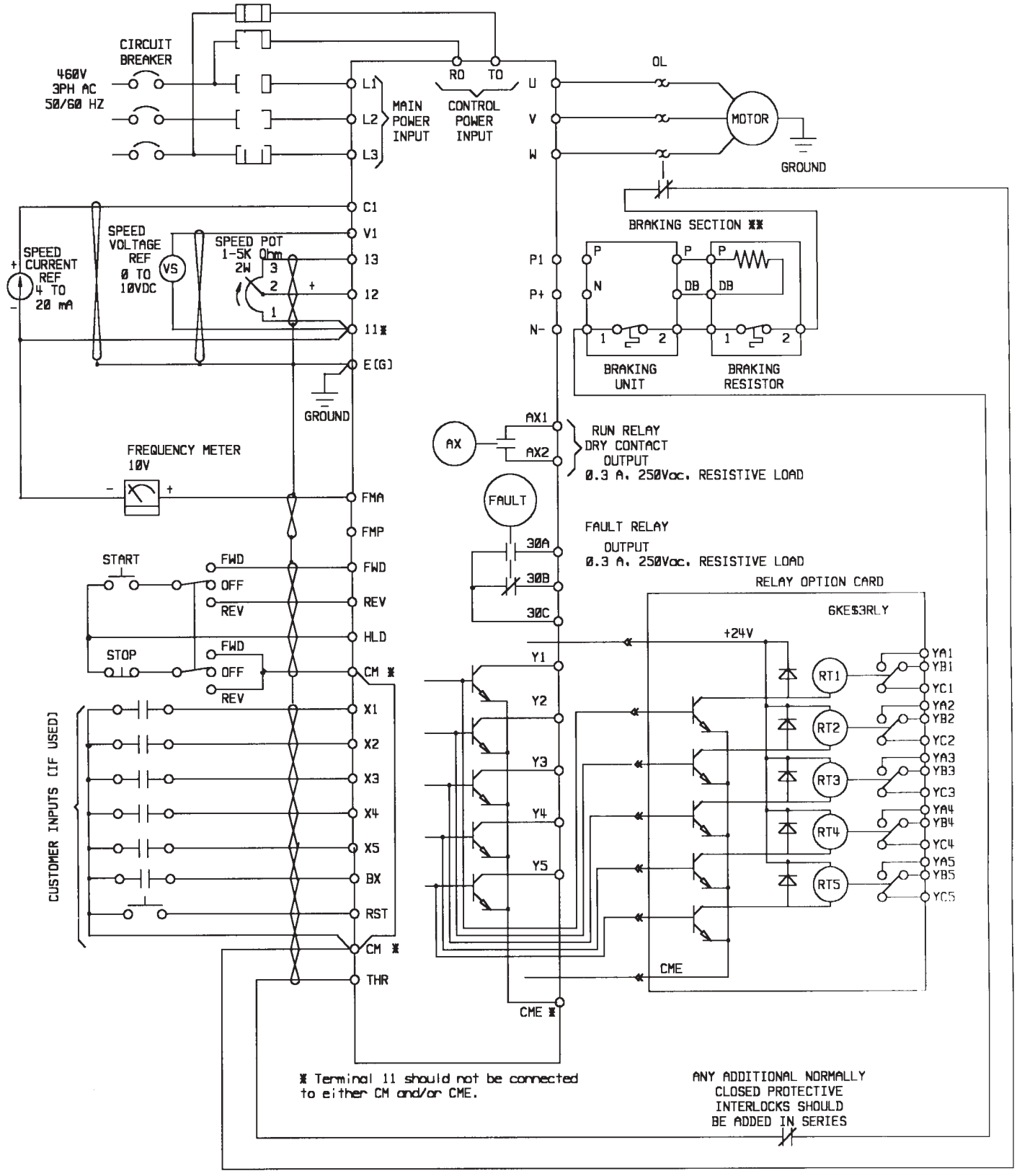
40 to 125 HP AF-300E$ DRIVE RATING

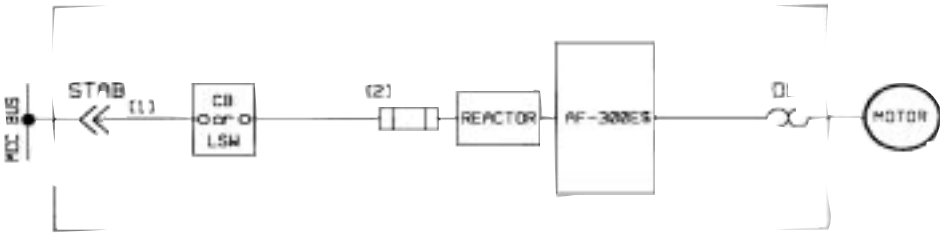


BASIC CONNECTION DIAGRAM

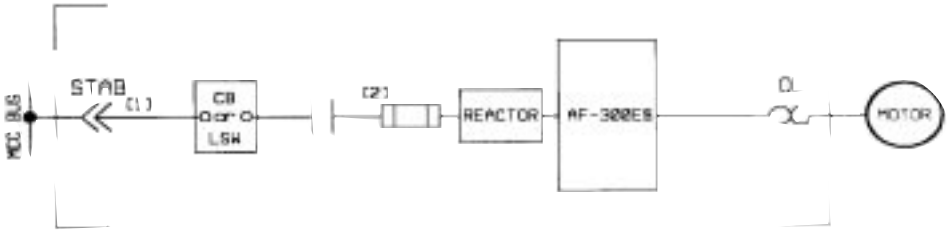
DRIVE CONFIGURATION IN MOTOR CONTROL CENTER CONSTRUCTION

Circuit Breaker or Fusible Switch Required for Disconnect

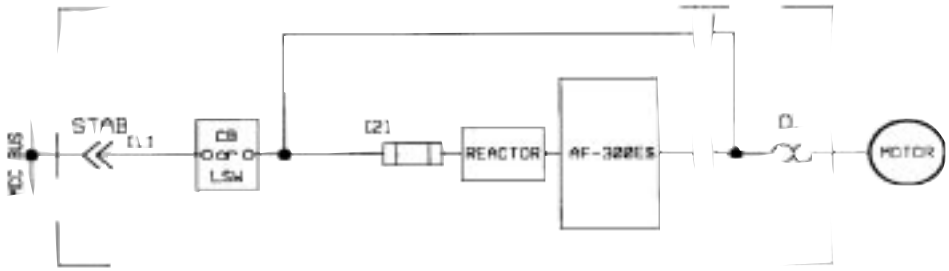
Standard VFD



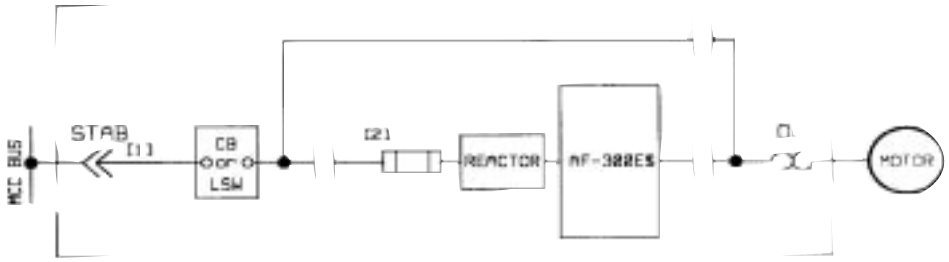
VFD with
Line Isolation



VFD with
ByPass Feature



VFD with
Line Isolation
Plus ByPass Feature



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

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

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

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AF300E$ SPACE HEIGHT AND ASSEMBLY REFERENCE

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

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

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

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

SOLID STATE STARTERS

GENERAL

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

ADVANTAGES OF SOLID-STATE STARTERS

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

Description

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

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

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

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

Application

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

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

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

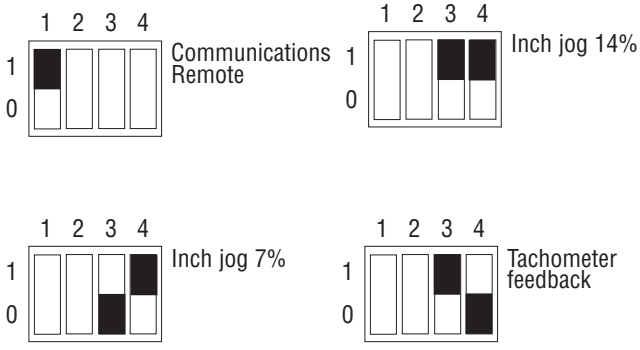
The electronic OL on the standard duty ASTAT is suitable for motor protection when programmed at 300%. When using 450% (or 500%) acceleration limits, always verify motor capacity for extended acceleration time with motor manufacturer. Separate OL relay required with 500% ratings, since ASTAT is derated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

ASTAT-CD Default Settings

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

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

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



Semiconductor Fuse Selection

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

8000-LINE MCC CONFIGURATION

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

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

Options

POWER

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

CONTROL

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

INSTRUMENTATION

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

ENCLOSURE

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

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

Standard Features

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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SOLID STATE STARTERS

Optional Features

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

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

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

Product

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

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

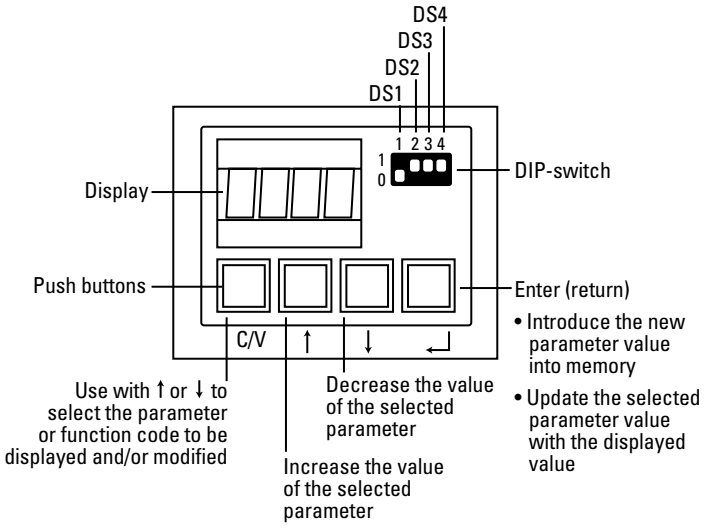
	Display Indicators
ON	Equipment connected to main supply
SAVE	Energy saving
STOP	Stop
SOFT	Soft stop
LOCK	Remote stop/lockout
DCBK	DC braking
PULS	Kick start
FULL	Override (full voltage)
RAMP	Acceleration ramp
INCH	Inching/jog speed
FULL	Full conduction
TACH	Linear ramp (tacho generator)

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

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

The last four faults to occur are recorded.

ASTAT-CD Digital Control Panel



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

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

Starting and Stopping

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

Starting by Voltage Ramp

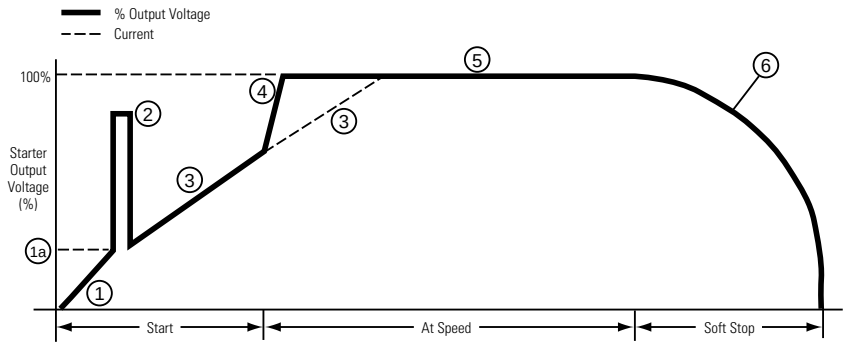


Figure 6

Starting by Voltage Ramp and Current Limit

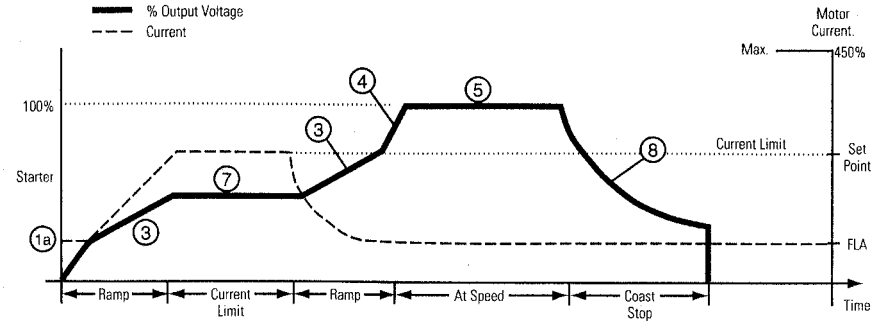


Figure 7

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

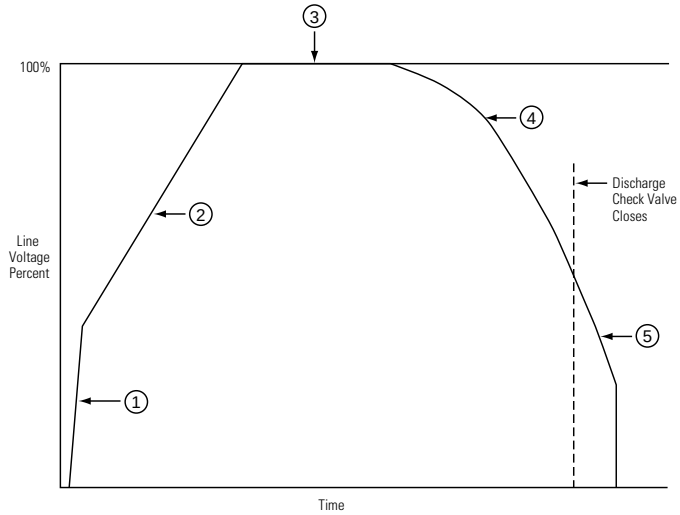


Figure 8

① Initial ramp (5 main frequency cycles).

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

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

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

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

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

⑤ Rated speed - starter at full voltage.

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

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

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

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

② Voltage ramp acceleration.

③ Rated speed.

④ Soft stop, adjustable ramp down.

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

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

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1-4 Technical Characteristics

Environmental

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

Electrical characteristics

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

Control characteristics

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

Reduced voltage starter operating modes

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

Options

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

ASTAT Block Diagram

Ir = ASTAT Current Rating
In = Motor FLA

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

Inputs / Outputs

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

Protections

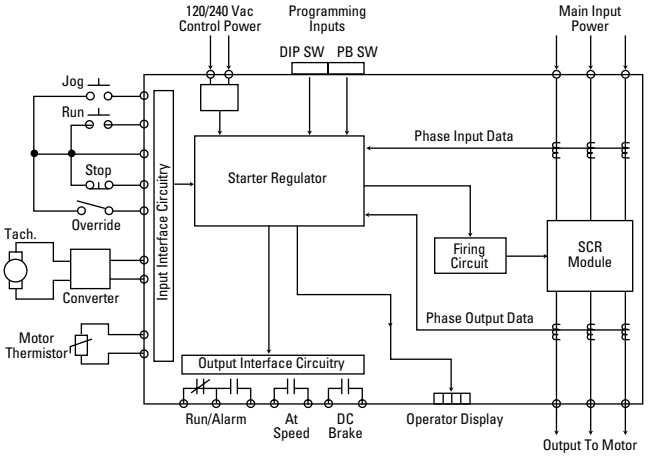
Current limit	Adjustable from 100 to 450% In
Overload (I^2 x t)	See figure on page 21 for cold starting overload conditions & time delay between starts
Loss of input phase	Trip at 3 sec
Thyristor short circuit	Trip at 200msec
Heatsink overheating	Trip at 200msec (trips at 80°C +/- 5°C, reset at 50°C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

Features

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

Communications (Option)

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



GE ASTAT SOLID STATE STARTERS STANDARD DUTY

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

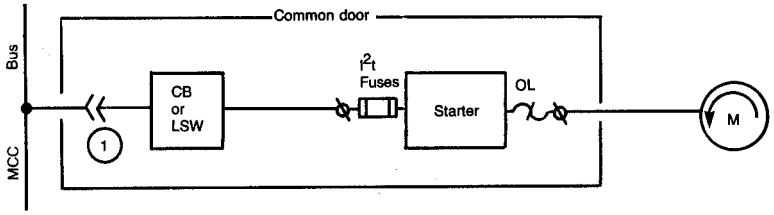
Function		NEMA Size	HP's @ 200/208	HP's @ 230/240	HP's @ 380/50 Hz	HP's @ 460/480	SSS Cat. No. FLA @ 1.15 SF	Disconnect	IC (KA)	Section 1 Width	Section 1 X Height	Section 2 Width	Section 2 X Height
.25	STAB IN	1	.1–.3	.1–.3	.1–7.5	.1–7.5	QC2GDA 13.9A	SELT, SELI	100	20" or 24"	2.0		
								QMW 30/30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

GE ASTAT SS STARTERS HEAVY DUTY (500%)

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

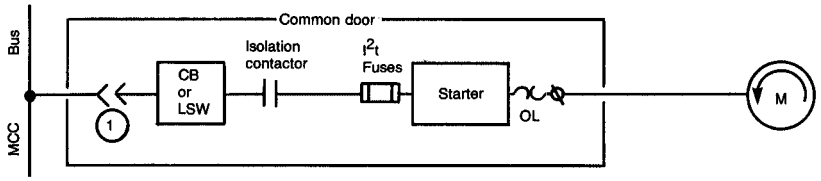
G

STANDARD REDUCED-VOLTAGE, NONREVERSING WITH PRIMARY DISCONNECT

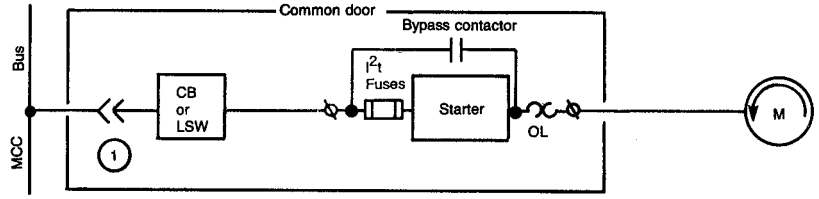


OPTIONS

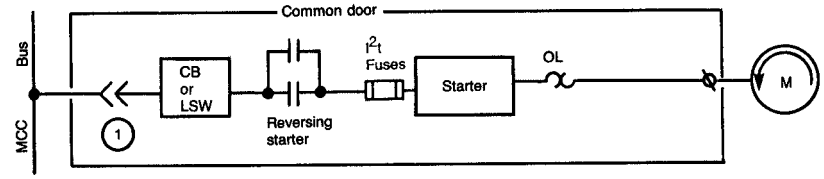
I. Solid-State Starter with Isolation Contactor



II. Solid-State Starter with Bypass Contactor



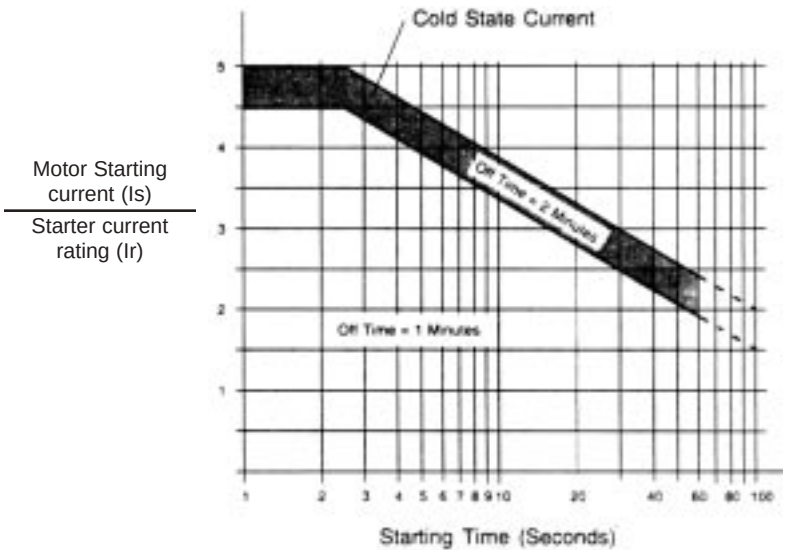
III. Solid-State Starter, Reversing



Motor Starting and Duty Cycle Conditions

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

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



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