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.

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).

\[
(1) \quad HP = \frac{TN}{5250}
\]

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

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

2. Motor Speed Range

Motor synchronous speed is determined by the following equation:

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

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

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

3. Multi Motor Drives

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

4. Acceleration Time

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

\[
TA = \frac{(WK^2 \times \#N)}{308 (T \times 1.2)}
\]

Where:

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

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

<table>
<thead>
<tr>
<th>Machine</th>
<th>• Name________________________________ For ______________________ Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Name of Manufacturer</td>
</tr>
<tr>
<td></td>
<td>• Type 1TEFC 1DP Others (__________________________________________)</td>
</tr>
<tr>
<td>Motor</td>
<td>• Horsepower ___________ • Number of Poles ____________________________</td>
</tr>
<tr>
<td></td>
<td>• Full Load Current _____A • Voltage _________________V</td>
</tr>
<tr>
<td></td>
<td>• Frequency ______________ Hz</td>
</tr>
<tr>
<td>Power Supply</td>
<td>• 3. _______________ V _______________% ________________Hz</td>
</tr>
<tr>
<td>Operating Frequency Range</td>
<td>• __________________________ Hz Minimum to __________________________ Hz Maximum①</td>
</tr>
<tr>
<td>Duty</td>
<td>1 Continuous __________________________H/Day</td>
</tr>
<tr>
<td></td>
<td>1 Repetitive Operating Time ____________________________Minutes</td>
</tr>
<tr>
<td></td>
<td>Downtime __________________________Minutes</td>
</tr>
<tr>
<td>Load</td>
<td>1 Constant Torque 1 Variable Torque 1 Constant Horsepower</td>
</tr>
<tr>
<td></td>
<td>•* Maximum Load Torque ___________ lb./ft. @ ______________ RPM</td>
</tr>
<tr>
<td></td>
<td>•* Load Inertia Wk^2___________ ft./lb.^2</td>
</tr>
<tr>
<td>Start/Stop</td>
<td>• Acceleration Time_________ Seconds  • Deceleration Time_________ Seconds</td>
</tr>
<tr>
<td>Environment</td>
<td>• Ambient temperature_____________°C</td>
</tr>
<tr>
<td></td>
<td>1 Dust 1 Other (____________________________________________________)</td>
</tr>
<tr>
<td>Inverter</td>
<td>• Rating ______________________ KVA</td>
</tr>
<tr>
<td>Other Options</td>
<td>• Calculated at motor shaft</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Command</td>
<td>0-10VDC &amp; 4-20mA</td>
</tr>
<tr>
<td>Operation Method</td>
<td>Terminal strip</td>
</tr>
<tr>
<td>Maximum Frequency</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Base Frequency</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Rated Output Voltage</td>
<td>460 Vac</td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>6s (20s for 40 HP &amp; up)</td>
</tr>
<tr>
<td>Deceleration Time</td>
<td>6s (20s for 40 HP &amp; up)</td>
</tr>
<tr>
<td>Torque Boost</td>
<td>Automatic</td>
</tr>
<tr>
<td>Number of Motor Ploles</td>
<td>4</td>
</tr>
<tr>
<td>FM Terminal Output Volts</td>
<td>100% (0-10V)</td>
</tr>
<tr>
<td>Energy Savings</td>
<td>Inactive</td>
</tr>
<tr>
<td>Motor Sound</td>
<td>10kHz</td>
</tr>
<tr>
<td>Language</td>
<td>English</td>
</tr>
</tbody>
</table>
**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)
- Frequency Resolution: Digital setting: 0.01 Hz @ max. frequency <100 Hz; 1 Hz @ max. frequency, >100 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 after 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 & load factor
- Digital output FMP => voltage & pulse rate yielding frequency output.

**Protection**
- Inverter: current limit, instantaneoues overcurrent torque limit, overload, overvoltage, incoming transients, undervoltage & overheating, short circuit & ground fault for output, motor & dynamic braking overheating, stall protection & setup error.
- 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.

**Indication**
- Charge Lamp: DC link voltage level detection.
- Conditions: 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.
- Ambien 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

**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**

Terminal 11 should not be connected to either CM and/or CME.

Drive up to 10 HP does not require braking unit.
40 to 125 HP AF-300E$ DRIVE RATING
DRIVE CONFIGURATION IN MOTOR CONTROL CENTER CONSTRUCTION

Circuit Breaker or Fusible Switch Required for Disconnect

---

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

*(2) *Fuse through 3G 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)*
<table>
<thead>
<tr>
<th>Function</th>
<th>NEMA Size</th>
<th>HP's @ 200/230V</th>
<th>HP's @ 250/460V</th>
<th>HP's @ 380-50 Hz</th>
<th>Disconnect</th>
<th>Section 1 Width</th>
<th>Section 2 Width</th>
<th>Section 1 X Height</th>
<th>Section 2 X Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Drive</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>2.0</td>
<td>20”</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>15</td>
<td>15–25</td>
<td>15–25</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>2.5</td>
<td>20”</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>15–25</td>
<td>20–30</td>
<td>30</td>
<td>30</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>3.5</td>
<td>24”</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>60–75</td>
<td>60–100</td>
<td>SFLI, SFLT</td>
<td>QMW</td>
<td>20”</td>
<td>3.5</td>
<td>24”</td>
<td>5.0</td>
</tr>
<tr>
<td>Drive with Bypass or Line Isolation</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>3.0</td>
<td>20”</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>15</td>
<td>15–25</td>
<td>15–25</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>4.0</td>
<td>24”</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>15–25</td>
<td>20–30</td>
<td>30</td>
<td>30</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>4.5</td>
<td>24”</td>
<td>5.0</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>60–75</td>
<td>60–100</td>
<td>SFLI, SFLT</td>
<td>QMW</td>
<td>20”</td>
<td>4.5</td>
<td>24”</td>
<td>5.0</td>
</tr>
<tr>
<td>Drive with Bypass and Line Isolation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>1.1–5.0</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>3.5</td>
<td>20”</td>
<td>3.5</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>15</td>
<td>15–25</td>
<td>15–25</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>5.5</td>
<td>24”</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>15–25</td>
<td>20–30</td>
<td>30</td>
<td>30</td>
<td>SELI, SELT</td>
<td>20”</td>
<td>5.5</td>
<td>24”</td>
<td>6.0</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>60–75</td>
<td>60–100</td>
<td>SFLI, SFLT</td>
<td>QMW</td>
<td>20”</td>
<td>5.5</td>
<td>24”</td>
<td>6.0</td>
</tr>
</tbody>
</table>

**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.

G-10
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 full load 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 set-

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

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

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

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

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

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

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

**DIGITAL TECHNOLOGY**
Provides precise phase control of the back to back SCRs over each 1/2 cycle. Special ASTAT-CD™ design allows initial motor torque to be adjusted from 10% to 90%.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**3 OUTPUT RELAYS**
- Run/fault relay – user configurable from keypad. When configured as run, relay contacts close upon initialization of start command and open when stop order is given or the starter shuts down due to a fault condition. When configured as a fault, the relay closes when control power is applied and opens only if a fault condition is detected.
- At speed relay (end of ramp), contact closes when starting ramp voltage reaches the end of ramp, indicating the motor is running at full speed.
- DC brake relay – contact closes to supply voltage to external injection braking contactor when brake command is given.
SOLID STATE STARTERS

Optional Features

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

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

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

<table>
<thead>
<tr>
<th>Display Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
</tr>
<tr>
<td>SAVE</td>
</tr>
<tr>
<td>STOP</td>
</tr>
<tr>
<td>SOFT</td>
</tr>
<tr>
<td>LOCK</td>
</tr>
<tr>
<td>DCBK</td>
</tr>
<tr>
<td>PULS</td>
</tr>
<tr>
<td>FULL</td>
</tr>
<tr>
<td>RAMP</td>
</tr>
<tr>
<td>INCH</td>
</tr>
<tr>
<td>FULL</td>
</tr>
<tr>
<td>TACH</td>
</tr>
</tbody>
</table>

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

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

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:

<table>
<thead>
<tr>
<th>Current Limit (% of MFLC)</th>
<th>Standard-Duty</th>
<th>Heavy-Duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>150%</td>
<td>420 seconds</td>
<td>420 seconds</td>
</tr>
<tr>
<td>300%</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>425%</td>
<td>6.5</td>
<td>33</td>
</tr>
</tbody>
</table>
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](image)

Starting by Voltage Ramp and Current Limit

![Figure 7](image)

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

![Figure 8](image)
1-4 Technical Characteristics

Environmental
Temperature 0 to +45°C
Relative humidity 95% without condensation
Maximum altitude 3300 feet (1000m)
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)
Control voltages 110/120VAC or 220/240VAC, 50/60Hz

Control characteristics
Control system Digital system with microcontroller
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 1 to 999 sec
(selected with dip-switch 3)
Slow speed Current: In
(selected with dip switch 4)
Selectable [7% or 14% speed] with dip-switch 3

A_ ASTAT Block Diagram
If = ASTAT Current Rating
In = Motor FLA

- Reduce rated controller current (ir) by 1.5% /°C above 45°C, maximum 55°C.
- 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 1. Start/Fault (selectable, 1NO, 1NC)
2. Up to speed (1NO)
3. For DC brake contactor (1NO)
Output auxiliary relays
Relay output ratings 5A Maximum
120VAC 360VA, Pilot duty B300 & 1/2HP 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 (I² 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
Supply frequency error If frequency < 48Hz or frequency > 62 Hz will not start
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.)

<table>
<thead>
<tr>
<th>Function</th>
<th>NEMA Size</th>
<th>HP's @ 200/208</th>
<th>HP's @ 230/240</th>
<th>HP's @ 360/50 Hz</th>
<th>HP's @ 400/480</th>
<th>SSS Cat. No.</th>
<th>PLA @ 1.15 SF</th>
<th>Disconnect</th>
<th>IC (KA)</th>
<th>Section 1 Width</th>
<th>X Height</th>
<th>Section 2 Width</th>
<th>X Height</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Duty</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SSS Basic</strong></td>
<td>1</td>
<td>1-3</td>
<td>1-3</td>
<td>1-7.5</td>
<td>1-7.5</td>
<td>QC52A</td>
<td>13.9A</td>
<td>SELT, SELI</td>
<td>GMW 600</td>
<td>100</td>
<td>20&quot;</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-7.5</td>
<td>5-7.5</td>
<td>10</td>
<td>QC52A</td>
<td>27.8A</td>
<td>SELT, SELI</td>
<td>GMW 600</td>
<td>100</td>
<td>20&quot;</td>
<td>2.0</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>10-15</td>
<td>15-19-20</td>
<td>QC52A</td>
<td>54.8A</td>
<td>SELT, SELI</td>
<td>GMW 600</td>
<td>100</td>
<td>20&quot;</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>20-25</td>
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<td>91.3A</td>
<td>SELT, SELI</td>
<td>GMW 100</td>
<td>200/200/100</td>
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<tr>
<td></td>
<td>40</td>
<td>60</td>
<td>60</td>
<td>QC52A</td>
<td>187.0A</td>
<td>SELT, SELI</td>
<td>SPLIT, SPLIT</td>
<td>GMW 200/100/200</td>
<td>100</td>
<td>24&quot;</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50-60</td>
<td>60-75</td>
<td>100-125</td>
<td>125-150</td>
<td>QC52DA</td>
<td>321-7A</td>
<td>SELT, SELI</td>
<td>QQ2MDA</td>
<td>100</td>
<td>24&quot;</td>
<td>5.5</td>
<td>20&quot;</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>QQ2MDA</td>
<td>321-7A</td>
<td>SELT, SELI</td>
<td>QQ2MDA</td>
<td>100</td>
<td>24&quot;</td>
<td>5.5</td>
<td>20&quot;</td>
<td>2.0</td>
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<tr>
<td></td>
<td>125</td>
<td>200-250</td>
<td>250</td>
<td>QQ2MDA</td>
<td>321-7A</td>
<td>SELT, SELI</td>
<td>QQ2MDA</td>
<td>100</td>
<td>24&quot;</td>
<td>5.5</td>
<td>20&quot;</td>
<td>2.0</td>
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</tr>
<tr>
<td><strong>SSS with Bypass or Isolation</strong></td>
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<td>1-3</td>
<td>1-75</td>
<td>1-75</td>
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<td>SELT, SELI</td>
<td>GMW 600</td>
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<td>20&quot;</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-7.5</td>
<td>5-7.5</td>
<td>10</td>
<td>QC52A</td>
<td>27.8A</td>
<td>SELT, SELI</td>
<td>GMW 600</td>
<td>100</td>
<td>20&quot;</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10-15</td>
<td>15-19-20</td>
<td>QC52A</td>
<td>54.8A</td>
<td>SELT, SELI</td>
<td>GMW 600</td>
<td>100</td>
<td>20&quot;</td>
<td>3.0</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>20-25</td>
<td>20-25-25</td>
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<td>91.3A</td>
<td>SELT, SELI</td>
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<td>3.0</td>
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<td>40</td>
<td>60</td>
<td>60</td>
<td>QC52A</td>
<td>187.0A</td>
<td>SELT, SELI</td>
<td>SPLIT, SPLIT</td>
<td>GMW 200/100/200</td>
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<td>3.0</td>
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<td></td>
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<td>QC52DA</td>
<td>321-7A</td>
<td>SELT, SELI</td>
<td>QQ2MDA</td>
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<td>24&quot;</td>
<td>3.0</td>
<td>20&quot;</td>
<td>2.0</td>
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<td></td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>QQ2MDA</td>
<td>321-7A</td>
<td>SELT, SELI</td>
<td>QQ2MDA</td>
<td>100</td>
<td>24&quot;</td>
<td>3.0</td>
<td>20&quot;</td>
<td>2.0</td>
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<tr>
<td></td>
<td>125</td>
<td>200-250</td>
<td>250</td>
<td>QQ2MDA</td>
<td>321-7A</td>
<td>SELT, SELI</td>
<td>QQ2MDA</td>
<td>100</td>
<td>24&quot;</td>
<td>3.0</td>
<td>20&quot;</td>
<td>2.0</td>
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</tbody>
</table>

## GE ASTAT SS STARTERS HEAVY DUTY (500%)

<table>
<thead>
<tr>
<th>Function</th>
<th>NEMA Size</th>
<th>HP's @ 200/208</th>
<th>HP's @ 230/240</th>
<th>HP's @ 360/50 Hz</th>
<th>HP's @ 400/480</th>
<th>SSS Cat. No.</th>
<th>PLA @ 1.15 SF</th>
<th>Disconnect</th>
<th>IC (KA)</th>
<th>Section 1 Width</th>
<th>X Height</th>
<th>Section 2 Width</th>
<th>X Height</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy Duty</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
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.

Motor Starting current (Is)  
Starter current rating (Ir)