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Cover photo: SC9000 EP medium voltage drives
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Safety

Definitions and symbols

**WARNING**

This symbol indicates high voltage. It calls your attention to items or operations that could be dangerous to you and other persons operating this equipment. Read the message and follow the instructions carefully.

This symbol is the “Safety Alert Symbol.” It occurs with either of two signal words: CAUTION or WARNING, as described below.

**CAUTION**

Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the CAUTION may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING).

**Hazardous High Voltage**

**WARNING**

Motor control equipment and electronic controllers are connected to hazardous line voltages. When servicing drives and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.

Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

**Warnings and cautions**

This manual contains clearly marked cautions and warnings which are intended for your personal safety and to avoid any unintentional damage to the product or connected appliances.

Please read the information included in cautions and warnings carefully.

**Warnings**

**WARNING**

Be sure to ground the unit following the instructions in this manual. Ungrounded units may cause electric shock and/or fire.

**WARNING**

This equipment should be installed, adjusted, and serviced by qualified electrical maintenance personnel familiar with the construction and operation of this type of equipment and the hazards involved. Failure to observe this precaution could result in death or severe injury.

**WARNING**

Components within the SC9000 EP power unit are live when the drive is connected to power. Contact with this voltage is extremely dangerous and may cause death or severe injury.

**WARNING**

Line terminals (L1, L2, L3), motor terminals (U, V, W) and the DC-link terminals (-/+/N) are live when the drive is connected to power, even if the motor is not running. Contact with this voltage is extremely dangerous and may cause death or severe injury.

**WARNING**

Even though the control I/O-terminals are isolated from line voltage, the relay outputs and other I/O-terminals may have dangerous voltage present even when the drive is disconnected from power. Contact with this voltage is extremely dangerous and may cause death or severe injury.

**WARNING**

The SC9000 EP drive has a large capacitive leakage current during operation, which can cause enclosure parts to be above ground potential. Proper grounding, as described in this manual, is required. Failure to observe this precaution could result in death or severe injury.
**WARNING**

An upstream disconnect/protective device must be provided as required by the National Electrical Code® (NEC®). Failure to follow this precaution may result in death or severe injury.

---

**WARNING**

Before opening the SC9000 EP drive doors:

Open main disconnect switch on the SC9000 EP drive.

Wait a minimum of 5 (five) minutes after all the lights on the keypad are off. This allows time for the DC bus capacitors to discharge.

A hazard voltage may still remain in the DC bus capacitors even if the power has been turned off. While wearing proper PPE, open the doors to the drive. Locate the yellow shorting stick and ensure metal end of stick is grounded. Discharge both halves of DC bus utilizing grounding studs on the rectifier.

Failure to follow the above precautions may cause death or severe injury.

---

**Cautions**

**CAUTION**

Do not perform any meggar or voltage withstand tests on any part of the SC9000 EP drive or its components. Improper testing may result in damage.

---

**CAUTION**

Prior to any tests or measurements of the motor or the motor cable, disconnect the motor cable at the SC9000 EP output terminals (U, V, W) to avoid damaging the SC9000 EP during motor or cable testing.

---

**CAUTION**

Do not touch any components on the circuit boards. Static voltage discharge may damage the components.

---

**CAUTION**

Any electrical or mechanical modification to this equipment without prior written consent of Eaton will void all warranties and may result in a safety hazard in addition and voiding of the UL listing.

---

**CAUTION**

Prevent foreign material such as wire clippings or metal shavings from entering the drive enclosure, as this may cause arcing damage and fire.

---

**CAUTION**

Install the SC9000 EP drive in a well-ventilated room that is not subject to temperature extremes, high humidity, or condensation, and avoid locations that are directly exposed to sunlight, or have high concentrations of dust, corrosive gas, explosive gas, inflammable gas, grinding fluid mist, etc. Improper installation may result in a fire hazard.

---

**Motor and Equipment Safety**

**CAUTION**

Before starting the motor, check that the motor is mounted properly and aligned with the driven equipment. Ensure that starting the motor will not cause personal injury or damage equipment connected to the motor.

---

**CAUTION**

Set the maximum motor speed (frequency) in the SC9000 EP drive according to the requirements of the motor and the equipment connected to it. Incorrect maximum frequency settings can cause motor or equipment damage and personal injury.

---

**CAUTION**

Before reversing the motor rotation direction, ensure that this will not cause personal injury or equipment damage.

---

**CAUTION**

Make sure that no power correction capacitors are connected to the SC9000 EP output or the motor terminals to prevent SC9000 EP malfunction and potential damage.

---

**CAUTION**

Make sure that the SC9000 EP output terminals (U, V, W) are not connected to the utility line power as severe damage to the SC9000 EP may occur.
Glossary

Many of the following terms and acronyms are used throughout the manual and on schematics. They are included to clarify verbiage.

Terms and abbreviations

24PR—24 pulse diode rectifier bridge
27/47—Undervoltage and phase reversal detection relay
Active Front End (AFE)—Refers to controllable rectification of AC to DC; makes a drive regenerative
Adjustable frequency drive—a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor
Bypass—Systems provide backup for the SC9000 EP adjustable frequency drive
Cn—DC bus capacitors (C1, C2, C3…)
COE—Custom order engineering
Constant torque (ct)—A drive whose torque rating is constant over its operational range
CPT—Control power transformer
CRn—DC bus rectifier from pre-charge transformer
CTB—Customer terminal block
CT—Current transformer
DMCR—Drive motor control rack
EP—Encapsulated powerpole
EPC—Electric pre-charge
Fieldbus—An industrial network system for real-time distributed control
ICG—Ampgard integrated control gear
Fn—24 pulse rectifier fuse (F1, F2, F3…)
IGBT—Insulated gate bipolar transistor
Inverter (INV)—An electronic device or circuitry that change direct current (DC) to alternating current (AC)
ISW—Isolation switch
ISWX—Isolation switch auxiliary relay
ITG—Integrated interface card
M—Main contactor
MBn—Main blower (MB1, MB2, MB3…)
MCO—Main cooling on
MCR—Main contactor relay
MCX—Main cooling contact
MFn—Main fan (MF1, MF2, MF3…)

MFX—Main cooling interposing relay
Motor ID Run—the better way to identify a motor, requires motor shaft be disconnected from the load
MOV—Metal oxide varistor
MSn—Main blower starter (1, 2, 3…)
OCS—Output contactor status
OCX—Output contactor contact
OPTXX—SPX controller option card
PCR—Pre-charge ready relay
PFN—Primary fuse (PF1, PF2, PF3…)
PMR—Phase monitor relay
PS—ITG power supply
PT—Potential transformer
PX—Pre-charge relay
RCO—Redundant cooling on
RCX—Redundant cooling contact
Rectifier—an electrical device that converts an alternating current into a direct one by allowing current to flow through it in one direction only.
Rn—Resistor (RS1, RS2, RS3…)
RSn—Redundant blower starter (RS1, RS2, RS3…)
RTD—Resistive thermal device
RVSS—Reduced-voltage soft starter
SPX—Drive controller module
T2—Blower transformer
UPB—UPS replace battery
UPR—UPS ready
UPS—Uninterrupted power source
Variable torque (vt)—A drive whose torque rating varies over its operational range
SC9000 EP medium voltage drives
Chapter 1: Introduction

Purpose
This user manual covers the handling and installation of the SC9000 Encapsulated Powerpole (EP) Medium Voltage Adjustable Frequency Drive (AFD). It does not cover all possible contingencies, variations, and details that may arise during the handling and installation of this equipment due to the customizations which happen on a per customer basis.

Application and description
The Eaton SC9000 EP provides adjustable frequency control and protection of medium voltage AC motors and equipment rated at 2400 V, 3300 V, and 4160 V. The SC9000 EP is typically supplied as an integrated drive that includes an integrated drive isolation transformer. It can be supplied as a stand-alone drive or it can be directly connected to other Ampgard products in a configuration known as Ampgard Integrated Control-Gear.

The SC9000 EP is available in five frame sizes, dependent on horsepower and voltage. Frame sizes, number of shipping sections, and shipping weights can be found in Chapters 3 and 4.

The drive consists of several main components mounted together in the drive enclosure(s). Incoming cable or bus is fed through an incoming section that includes a non-load break isolation switch, current limiting power fuses, and a main vacuum contactor. The isolation switch can be opened to allow access inside the drive for servicing or troubleshooting. The 24-pulse drive isolation transformer and the DC bus capacitor charging is accomplished by use of the softmag (pre-charger circuit). The DC bus capacitors are charged and the 24-pulse transformer is magnetized before application of main power, assuring proper phasing and limiting the very high damaging inrush currents to the main rectifier bridge devices. When the proper DC bus voltage is attained, the pre-charge circuit is turned off and the main contactor is closed. The transformer's output feeds into the rectifier. The rectifier powers the DC bus that in turn feeds the drive inverter. The inverter creates the adjustable frequency AC output that controls the speed of the connected motor. The inverter is a drawout truck-mounted device that can be withdrawn from the structure for repair or replacement. The inverter may feed an optional output filter that is supplied when the motor cable length is excessive.

Contact Eaton if the motor cable length is greater than what is recommended in Section 2 of Appendix D and the optional output filter has not been supplied.

Control power transformers are supplied to provide 120 V single-phase control power for the drive and 480 V three-phase power to the blowers. The CPTs are connected after the isolation switch and main fuses and are thus energized any time the isolation switch is closed.

Cooling blowers are provided to exhaust hot air from the drive enclosure. Replaceable filters are provided in the lower portion of the drive doors to minimize dust accumulation inside the enclosure.

Other standard and optional devices are supplied with the drive. Refer to the specific order drawings supplied with the drive to determine which devices have been provided with your equipment.

SC9000 EP standard features
- Delivers maximum benefits while being the smallest fully integrated medium voltage drive in the industry
- Precise control of medium voltage motors up to 6000 hp
- Fully integrated package with isolation switch, main contactor, 24-pulse phase shifting isolation transformer, rectifier and inverter. Current limiting fuses, contactor assembly, inverter assembly, and isolating switch assembly are easily removed from the enclosure; line and load terminals are completely accessible from the front
- Positive mechanical isolating switch with visible disconnect completely grounds and isolates the AFD from the line power with a mechanically driven isolation shutter, leaving no exposed high voltage
- Utilizes highly reliable Ampgard components such as a non-load break switch rated for 10,000 mechanical operations, an SL contactor with the highest interrupting rating in the industry at 8500 A, Eaton power fuses, and a low profile handle mechanism
- Utilizes the same keypad and programming software as the SPX9000 line of low voltage drives. This standardization translates into a reliable, easy-to-use system that does not require hours of learning new software
- The SC9000 EP’s keypad offers a full view of the drive’s inner workings. Customers can view and change parameters and monitor actual running values right from the keypad. In addition, the keypad’s built-in upload and download capability reduces startup time
- Extensively tested, manufactured, and assembled to ISO® 9001:2000 certification standards
- Designed and constructed to exacting UL® certification standards for use in the most rigorous applications
- The SC9000 EP’s integrated phase shifting isolation transformer / 24-pulse converter coupled to a three-level inverter topology assures minimum component usage and reduces output harmonics, delivering sine wave power to the motor. Heat pipe technology improves cooling efficiency and allows the SC9000 EP to run at reduced noise levels. Output filters may be required in some applications
- Individual power poles are encapsulated, producing a harsh environment inverter
Chapter 1: Introduction

- The SC9000 EP’s specialized design and patented thermal management system yields the smallest footprint per hp in the industry as a fully integrated drive. This size benefit ensures installations in space limited electrical rooms, eliminating the need for additional cable and conduit installations, and in some cases, eliminating the need for additional feeders required by our competitors.

- The SC9000 EP’s modular roll-in roll-out inverter design significantly reduces Mean Time to Repair (MTTR), which means that the SC9000 EP is built for maximum uptime.

- The test/burn-in procedure runs the drive for a minimum of seven hours before shipping. This allows problems to be detected and corrected before shipment. This process exceeds the new IEEE 1566 requirements of 4 hour minimum test/burn-in before shipment.

- Gateway for multiple communication protocols allow easy communication with all commonly used control systems, such as Modbus®, CANbus, PROFIBUS® DP, LonWorks®, CANopen, DeviceNet™.

- System bus, CAN, for the networking of drives and peripherals.

- Simple programming via a PC. The NCDrive software allows customers to upload and download drive parameters, which can be changed, saved, and transferred back to the drive and then printed or saved to a file for future reference. These parameters can also be compared to default values to determine drive configuration. Other operator functions include the ability to set references, start and stop the drive, and monitor and display signals and values. The NCLoad tool gives customers the ability to upload system, application, and option card software intended for engineering, commissioning, and service personnel.

- Programmable for custom applications for control and I/O functions.

- Low air volume displacement.

- Low electrical noise.

- Volts/hertz control for single or multiple motor applications.

- Open-loop vector control.

- Isolation with fiber optics.

- Digital synchronization.

- Integrated automation interface.

Revision

September 2015 Revision.

Documentation reference

For further information on installation and application, refer to the applicable technical data, publications, and/or industry standards. Download Eaton electronic information from www.eaton.com.

Eaton contact information

For the location of your nearest Eaton sales office or distributor, call toll-free 1-800-525-2000 or log on to www.eaton.com. Eaton’s Electrical Services & Systems (EESS) can be reached at 1-800-498-2678.
Chapter 2: Safety

Precautions

There is a hazard of electric shock whenever working on or near electrical equipment. Turn off all power supplying the equipment before starting work. Lock out the disconnecting means in accordance with NFPA 70E®, “Electrical Safety Requirements for Employee Safety In the Workplace.”

Where it is not feasible to de-energize the system, take the following precautions:

1. Instruct persons working near exposed parts that are or may be energized to use practices (including appropriate apparel, equipment and tools) in accordance with NFPA 70E.

2. Require persons working on exposed parts that are or may be energized to be qualified persons who have been trained to work on energized circuits.

Only qualified electrical personnel with training and experience with medium voltage equipment (>1000 V) shall be permitted to work on this apparatus. They shall be familiar with the work to be performed, as well as industry and local safety procedures and standards.

In addition, this person should have the following qualifications:

1. Be trained and authorized to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.

2. Be trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established practices.

3. Be trained in rendering first aid.

4. Be knowledgeable with respect to electrical installation codes and standards, for example, the National Electrical Code (NEC).

Read and understand all instructions before attempting installation, operation, or maintenance of the medium voltage drive.

Disconnect all low and medium voltage power sources to the drive or the medium voltage control-gear before working on the equipment. Lockout procedures must be followed. Verify that the voltage has been removed. Observe all local and national codes and standards.

Safety features

The medium voltage drive has many safety features to help ensure the safety of operators and maintenance personnel. Incoming voltage is disconnected from the downstream portion of the circuit by the isolation switch in the incoming section of the drive. The isolation switch is interlocked with the medium voltage door in the incoming section to prevent access to the compartment before the switch is opened. The switch is interlocked with the main contactor to prevent opening the switch under load. The switch operating mechanism is also interlocked to prevent closing the switch with the door open. A viewing window is provided to verify the switch position before entering the medium voltage compartment. Other medium voltage doors are also interlocked to prevent access until the switch is open as well. Distinctive marking on back of switch assembly appears when shutter barrier is in position and starter is completely isolated from the line. Grounding clips provide a positive grounding of the SC9000 EP AFD and main fuses when the isolating switch is opened. High and low voltage circuits are compartmentalized and isolated from each other. The drawout isolation switch is easily removed by loosening two bolts in the back of the switch. The shutter remains in place when the switch is withdrawn (shutter shown in users manual in Chapter 5, but not in this installation manual). Grounding device is provided for shorting the DC bus to ground before entering the medium voltage compartments.

The operating mechanism has provision for lockout/tagout. All local and other procedures should be followed to ensure safe operation.

DC link capacitors

WARNING

High storage device, do not enter drive until capacitors have discharged.

The DC Link consists of a large, medium voltage capacitor bank charged to a maximum of 7500 Vdc for 4160 V drives, 5940 Vdc for 3300 drives, and 4320 Vdc for 2400 V drives. The capacitors require 5 minutes to discharge to 50 Vdc after the main contactor is opened. Verify on the keypad that the DC voltage has discharged before entering the compartment. Follow verification and grounding procedures before installing or servicing the equipment.

Grounding practices

WARNING

The SC9000 EP must be solidly grounded.

The inverter must be grounded in accordance with Article 250 of the National Electrical Code or Section 10 of the Canadian Electrical Code, Part I. The grounding conductor should be sized in accordance with NEC Table 250.122 or CEC, Part I Table 16. The SC9000 EP is supplied with a ground bus that runs the length of the drive. If the drive is shipped in sections, be sure that the ground bus connection splices are installed across all shipping splits. This ground bus must be solidly connected to the building ground grid. The ground connection is required for proper drive operation. The ground connection is required for personal safety. THE METAL OF CONDUIT IS NOT AN ACCEPTABLE GROUND.
Identification

**WARNING**

Exceeding the nameplate ratings of an SC9000 EP medium voltage drive may cause equipment damage, severe injury, or death. Do not apply an SC9000 EP beyond its nameplate ratings.

A rating nameplate is located on the door nearest isolation switch of each SC9000 EP AFD. The drive type and ratings as required by industry standards are contained on this nameplate. Also contained on this nameplate is the factory’s general order number. This number should be given to the Eaton sales office if a question should arise concerning the equipment or if renewal parts are required.

The SC9000 EP is rated for use at a specific motor voltage and current as well as for a particular duty cycle. Care must be taken to ensure that these ratings are not exceeded. Verify that motor full load amperes do not exceed the rating indicated on the drive nameplate. The variable torque duty cycle allows for 110% overload for 1 minute in each 10-minute period. The constant torque duty cycle allows for 150% overload for 1 minute in each 10-minute period. Consult the factory if other duty cycle drives are required. The higher rating will be specified on the drive’s rating nameplate. Verify that the duty cycle indicated on the nameplate matches the application.

The SC9000 EP may be rated for use with Constant Torque or Variable Torque loads. Ensure that the load type as noted on the drive-rating nameplate correctly matches the application.

The standard SC9000 EP is designed for use with non-regenerative loads. Consult the factory if the SC9000 EP is to be used with regenerative loads.

If the motor will be operated at speeds below 50% of base speed, a motor overload relay may not protect the motor. An internal motor RTD may be required. Failure to observe this precaution could result in damage to the motor.
### Table 1. Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power rating</td>
<td>300–6000 hp (150–4313 kW)</td>
</tr>
<tr>
<td>Motor type</td>
<td>Induction and synchronous</td>
</tr>
<tr>
<td>Input voltage rating</td>
<td>2400–13,800 V</td>
</tr>
<tr>
<td>Input voltage tolerance</td>
<td>±10% of nominal</td>
</tr>
<tr>
<td>Power loss ride-through</td>
<td>5 cycles (std.)</td>
</tr>
<tr>
<td>Input protection</td>
<td>Metal oxide varistor</td>
</tr>
<tr>
<td>Input frequency</td>
<td>50/60 Hz, ±5%</td>
</tr>
<tr>
<td>Input short-circuit current withstand</td>
<td>50 kA RMS SYM</td>
</tr>
<tr>
<td>Basic impulse level</td>
<td>60 kV</td>
</tr>
<tr>
<td>Input power circuit protection</td>
<td>Contactor/fuses</td>
</tr>
<tr>
<td>Input impedance device</td>
<td>Isolation transformer</td>
</tr>
<tr>
<td>Output voltage</td>
<td>0–2400 V</td>
</tr>
<tr>
<td>Inverter design</td>
<td>0–3300 V</td>
</tr>
<tr>
<td>Inverter switch</td>
<td>0–4160 V</td>
</tr>
<tr>
<td>Inverter switch failure mode</td>
<td>PWM</td>
</tr>
<tr>
<td>Inverter switch failure rate (FIT)</td>
<td>400 per one billion hours of operating time</td>
</tr>
<tr>
<td>Inverter switch cooling</td>
<td>Air-cooled</td>
</tr>
<tr>
<td>Inverter switching frequency</td>
<td>600 Hz</td>
</tr>
<tr>
<td>Number of inverter IGBTs</td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>Number of IGBTs</td>
</tr>
<tr>
<td>2400 V</td>
<td>12</td>
</tr>
<tr>
<td>3300 V</td>
<td>12</td>
</tr>
<tr>
<td>4160 V</td>
<td>12</td>
</tr>
<tr>
<td>IGBT PIV rating (peak inverse rating)</td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>PIV Rating</td>
</tr>
<tr>
<td>2400 V</td>
<td>3300 V</td>
</tr>
<tr>
<td>3300 V</td>
<td>6500 V</td>
</tr>
<tr>
<td>4160 V</td>
<td>6500 V</td>
</tr>
<tr>
<td>Rectifier designs</td>
<td>24-pulse</td>
</tr>
<tr>
<td>Rectifier switch</td>
<td>Diode</td>
</tr>
<tr>
<td>Rectifier switch failure mode</td>
<td>Non-rupture, non-arc</td>
</tr>
<tr>
<td>Rectifier switch failure rate (FIT)</td>
<td>100 per one billion hours of operating time</td>
</tr>
<tr>
<td>Rectifier switch cooling</td>
<td>Air-cooled</td>
</tr>
</tbody>
</table>

**Notes**

1. Refer to Chapter 6, Table 8 for GP specifications.
2. 24 IGBTs are required for motors above 3500 hp.
### Table 1. Specifications, continued

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of rectifier devices</td>
<td>1</td>
</tr>
<tr>
<td>Voltage</td>
<td>Value</td>
</tr>
<tr>
<td>2400 V</td>
<td>24</td>
</tr>
<tr>
<td>3300 V</td>
<td>24</td>
</tr>
<tr>
<td>4160 V</td>
<td>24</td>
</tr>
<tr>
<td>Diode PIV rating (peak inverse rating)</td>
<td>1</td>
</tr>
<tr>
<td>Voltage</td>
<td>PIV Rating</td>
</tr>
<tr>
<td>2400 V</td>
<td>4000 V</td>
</tr>
<tr>
<td>3300 V</td>
<td>4000 V</td>
</tr>
<tr>
<td>4160 V</td>
<td>4000 V</td>
</tr>
<tr>
<td>Output waveform to motor</td>
<td>Sinusoidal current</td>
</tr>
<tr>
<td>Medium voltage isolation</td>
<td>Fiber-optic</td>
</tr>
<tr>
<td>Control method</td>
<td>V/Hz; sensorless vector; closed-loop</td>
</tr>
<tr>
<td></td>
<td>Fully digital signal processor</td>
</tr>
<tr>
<td>Speed regulation</td>
<td>0.1% without tachometer feedback</td>
</tr>
<tr>
<td>Output frequency range</td>
<td>0–120 Hz</td>
</tr>
<tr>
<td>Service duty rating</td>
<td>Standard (variable torque load) / Optional (constant torque load)</td>
</tr>
<tr>
<td></td>
<td>110% overload for 1 minute every 10 minutes / 150% overload for 1 minute every 10 minutes</td>
</tr>
<tr>
<td>Typical efficiency</td>
<td>96%–97% efficiency</td>
</tr>
<tr>
<td>Input power factor</td>
<td>&gt; 0.97 PF</td>
</tr>
<tr>
<td>Meet IEEE 519 harmonic guidelines</td>
<td>Yes</td>
</tr>
<tr>
<td>Noise level</td>
<td>&lt; 80 dB (A)</td>
</tr>
<tr>
<td>Flying start capability</td>
<td>Yes—able to start into and control a spinning load in forward or reverse direction</td>
</tr>
<tr>
<td>Local interface</td>
<td>Removable graphical backlit LCD and keypad</td>
</tr>
<tr>
<td>Keys</td>
<td>Local/Remote, Start/Stop, Reset, Enter, Up/Down, Forward/Back</td>
</tr>
<tr>
<td>Indicators</td>
<td>LCD: Local/Remote, Fault, Door: Contactor open/closed, Fault, Run status / DC bus</td>
</tr>
<tr>
<td>Inputs/outputs</td>
<td>6 DI / 6 DO, 2AI / 1AO, 1 + 10 Vdc reference</td>
</tr>
<tr>
<td></td>
<td>2 Ext + 24 Vdc standard</td>
</tr>
<tr>
<td>Enclosure</td>
<td>NEMA 1, Gasketed and Filtered; IP20</td>
</tr>
<tr>
<td>Ambient temperature (without derating)</td>
<td>0 °C to 40 °C (32 °F to 104 °F)</td>
</tr>
<tr>
<td>Storage and transportation temperature range</td>
<td>−40 °C to +70 °C (−40 °F to +185 °F)</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>95% noncondensing</td>
</tr>
<tr>
<td>Altitude (without derating)</td>
<td>0 to 3300 ft (0 to 1000 m)</td>
</tr>
<tr>
<td>Seismic</td>
<td>2006 IBC</td>
</tr>
<tr>
<td>Vibration</td>
<td>10–50 Hz, 0.5 G or less</td>
</tr>
<tr>
<td>Standards</td>
<td>NEMA, cUL, UL, ANSI, IEEE</td>
</tr>
<tr>
<td>Cooling</td>
<td>Air-cooling advanced heat pipe technology</td>
</tr>
<tr>
<td>Average watts loss</td>
<td>25 watts/hp</td>
</tr>
</tbody>
</table>

**Notes**

1. Refer to Chapter 6, Table 8 for GP specifications.
2. See Chapter 4 for long-term storage temperature ranges.
3. Reflects conservative estimate. Actual amounts may vary.
### Table 2. Power specifications

**Voltage class**

<table>
<thead>
<tr>
<th>Voltage class</th>
<th>Drive rating (A)</th>
<th>2400</th>
<th>2400</th>
<th>2400</th>
<th>2400</th>
<th>2400</th>
<th>2400</th>
<th>2400</th>
<th>2400</th>
<th>2400</th>
</tr>
</thead>
<tbody>
<tr>
<td>2400</td>
<td>Drive rating (A)</td>
<td>69</td>
<td>80</td>
<td>91</td>
<td>103</td>
<td>114</td>
<td>134</td>
<td>156</td>
<td>178</td>
<td>201</td>
</tr>
<tr>
<td>2400 drive output (kVA)</td>
<td>2400</td>
<td>333</td>
<td>378</td>
<td>428</td>
<td>474</td>
<td>557</td>
<td>648</td>
<td>740</td>
<td>836</td>
<td>927</td>
</tr>
<tr>
<td>Nominal hp 2400 V</td>
<td>2400</td>
<td>300</td>
<td>350</td>
<td>400</td>
<td>450</td>
<td>500</td>
<td>600</td>
<td>700</td>
<td>800</td>
<td>900</td>
</tr>
<tr>
<td>Frame size</td>
<td>Frame A</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Frame B</td>
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</table>

<table>
<thead>
<tr>
<th>Voltage class</th>
<th>Drive rating (A)</th>
<th>3300</th>
<th>3300</th>
<th>3300</th>
<th>3300</th>
<th>3300</th>
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</thead>
<tbody>
<tr>
<td>3300</td>
<td>Drive rating (A)</td>
<td>48</td>
<td>56</td>
<td>64</td>
<td>72</td>
<td>80</td>
<td>96</td>
<td>112</td>
<td>128</td>
<td>144</td>
</tr>
<tr>
<td>3300 drive output (kVA)</td>
<td>3300</td>
<td>320</td>
<td>366</td>
<td>412</td>
<td>457</td>
<td>549</td>
<td>640</td>
<td>732</td>
<td>823</td>
<td>915</td>
</tr>
<tr>
<td>Nominal hp 3300 V (1)</td>
<td>3300</td>
<td>300</td>
<td>350</td>
<td>400</td>
<td>450</td>
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<td>600</td>
<td>700</td>
<td>800</td>
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<td>Frame size</td>
<td>Frame A</td>
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<td></td>
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<tr>
<td>Frame C</td>
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</table>

<table>
<thead>
<tr>
<th>Voltage class</th>
<th>Drive rating (A)</th>
<th>4160</th>
<th>4160</th>
<th>4160</th>
<th>4160</th>
<th>4160</th>
<th>4160</th>
<th>4160</th>
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</thead>
<tbody>
<tr>
<td>4160</td>
<td>Drive rating (A)</td>
<td>38</td>
<td>44</td>
<td>51</td>
<td>57</td>
<td>63</td>
<td>76</td>
<td>89</td>
<td>101</td>
<td>114</td>
</tr>
<tr>
<td>4160 drive output (kVA)</td>
<td>4160</td>
<td>317</td>
<td>367</td>
<td>411</td>
<td>454</td>
<td>548</td>
<td>641</td>
<td>728</td>
<td>821</td>
<td>915</td>
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<tr>
<td>Nominal hp 4160 V</td>
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<td>600</td>
<td>700</td>
<td>800</td>
<td>900</td>
</tr>
<tr>
<td>Frame size</td>
<td>Frame A</td>
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<td></td>
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<tr>
<td>Frame D</td>
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<tr>
<td>Frame E</td>
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**Note**

(1) Contact factory.
### Table 3. Dimensions

<table>
<thead>
<tr>
<th>Output voltages</th>
<th>Motor FLA</th>
<th>hp</th>
<th>Cabinet size (inches)</th>
<th>Redundant blower additional height</th>
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<tbody>
<tr>
<td></td>
<td>Width</td>
<td>Height</td>
<td>Depth</td>
<td></td>
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<tr>
<td><strong>Frame A</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2400</td>
<td>69–114</td>
<td>300–500</td>
<td>65</td>
<td>92</td>
</tr>
<tr>
<td>3300 (1)</td>
<td>48–112</td>
<td>300–700</td>
<td>65</td>
<td>92</td>
</tr>
<tr>
<td>4160</td>
<td>38–140</td>
<td>300–1150</td>
<td>65</td>
<td>92</td>
</tr>
<tr>
<td><strong>Frame B</strong></td>
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<td></td>
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<tr>
<td>2400</td>
<td>134–223</td>
<td>600–1000</td>
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<td>3300 (1)</td>
<td>128–240</td>
<td>800–1500</td>
<td>95</td>
<td>92</td>
</tr>
<tr>
<td>4160</td>
<td>155–248</td>
<td>1250–2000</td>
<td>95</td>
<td>92</td>
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<tr>
<td><strong>Frame C</strong></td>
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</tr>
<tr>
<td>2400</td>
<td>279–390</td>
<td>1250–1750</td>
<td>131</td>
<td>92</td>
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<td>3300 (1)</td>
<td>280–320</td>
<td>1750–2000</td>
<td>131</td>
<td>92</td>
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<td>4160</td>
<td>279–372</td>
<td>2250–3000</td>
<td>137</td>
<td>92</td>
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<tr>
<td><strong>Frame D</strong></td>
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<td></td>
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<tr>
<td>2400</td>
<td>448–561</td>
<td>2000–2500</td>
<td>172</td>
<td>92</td>
</tr>
<tr>
<td>3300 (1)</td>
<td>360–480</td>
<td>2250–3000</td>
<td>172</td>
<td>92</td>
</tr>
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<td>4160</td>
<td>403–558</td>
<td>3250–4500</td>
<td>222</td>
<td>92</td>
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<tr>
<td><strong>Frame E</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3300 (1)</td>
<td>520–640</td>
<td>3250–4000</td>
<td>222</td>
<td>92</td>
</tr>
<tr>
<td>4160</td>
<td>589–744</td>
<td>4750–6000</td>
<td>246</td>
<td>92</td>
</tr>
</tbody>
</table>

**Notes**

1. Contact factory.
2. Contact factory for 1150 hp.
Chapter 4: Handling, storage, and installation

General information

WARNING

Tall structure—may tip over if mishandled. May cause bodily injury or equipment damage. Do not remove from skid until ready to secure in place. Read handling instructions below before moving.

Medium voltage drives are extremely heavy and the moving equipment used in handling must be capable of supporting the weight of the drive. Confirm this capability prior to starting any handling operations with the drive. Refer to the charts below for standard SC9000 EP shipping section weights. These weights are approximate. Refer to the job specific drawings for the weights of each shipping section.

Table 4. 2400 V AFD typical shipping section weights (lb)

<table>
<thead>
<tr>
<th>Frame</th>
<th>hp</th>
<th>Transformer</th>
<th>Inverter</th>
<th>Main disconnect</th>
<th>Incoming</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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The drive should be kept in an upright position. If the equipment is received in the horizontal position, notify the carrier of possible damage, and restore the drive to the vertical position as soon as practicable.

Upon receipt, immediately inspect the drive for any signs of visible or concealed damage that might have occurred during shipment. If damage is found, it should be noted with the carrier prior to accepting the shipment, if possible. Carefully unpack the equipment sufficiently to check for concealed damage. Verify that there are no bent, broken or loose components. Review the drive nameplate to ensure that the marked ratings match the order specifications.
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Chapter 4: Handling, storage, and installation

Lifting equipment list

- Overhead lifting of transformer shipping section:
  - Crane of adequate load rating (refer to Tables 4, 5 and 6)
  - Spreader bar of adequate load rating
  - Optional overhead lifting cradle kit
  - Lifting chains, cables or slings of adequate load rating
  - Safety hooks or shackles of adequate load rating

- Overhead lifting of input and inverter shipping sections:
  - Crane of adequate load rating (refer to Tables 4, 5 and 6)
  - Lifting chains, cables or slings of adequate load rating
  - Safety hooks or shackles of adequate load rating

- Fork truck lifting transformer shipping section (required for FRAME E transformer shipping section and optional for other sections)
  - Fork truck of adequate load rating (refer to Tables 4, 5 and 6)
  - Safety strap

Receiving check list

1. _____ Inspect the unit for any signs of shipping damage.
2. _____ Check the job specific drawings for the actual weights of each shipping section. Verify that all handling equipment is of adequate load rating to lift the shipping sections.
3. _____ Review the drive nameplate and verify that the information on the nameplate matches the rating specified on the order.
4. _____ Open all doors and inspect equipment for any bent, broken or loose components.

Handling

Exercise extreme care during any movement and placement operations to prevent dropping or unintentional rolling or tipping. The preferred method of handling is by crane or forklift. See Figure 4 and for instructions on lifting the drive shipping sections by crane. The drive shipping sections contain heavy equipment, such as transformers, that can make the center of gravity vary considerably from the center of the cabinet. Verify that the capacity of the crane is not exceeded by the weight of the section being lifted.

- Select or adjust the rigging lengths to compensate for any unequal distribution of load, and to maintain the shipping section in an upright position. Some shipping section interiors may contain heavy equipment that can make the center of gravity be considerably off
- Do not allow the angle between the lifting cables and vertical to exceed 45 degrees
- Do not pass ropes or cables through the lift holes
- Use slings with safety hooks or shackles of adequate load rating
- Avoid pinch points

Refer to the job specific drawings for the diagrams showing the proper lifting points of each shipping section.

The shipping section that contains the transformer can alternatively be lifted by forklift. The channels for lifting by the forklift can be exposed by removing the panel at the front bottom of the shipping section. Verify that the fork truck rating is not exceeded by the weight of this section. A safety strap should be used when handling with a forklift. Do not allow an end of a fork to enter the bottom of an open bottom enclosure. Refer to Tables 4, 5 and 6 for the weights of each shipping section.

Long-term storage

If it is necessary to store an SC9000 EP AFD before installation, restore the protective packaging for the storage period and keep it in a clean, dry location with ample air circulation and heat to prevent condensation. Like all electrical apparatus, an SC9000 EP contains insulation and electrical components that must be protected against dirt and moisture. It is absolutely crucial that the drive will not accumulate moisture. Special consideration must be taken for the UPS battery in the control panel. Please refer to the supplier’s specifications on long-term battery storage.

Storage temperature: –20 °C to +65 °C.
Figure 1. Frame B inverter section, Frame C main disconnect and inverter sections, Frame D main disconnect, and inverter sections, Frame E main disconnect section, and filters

**“A” width dimensions**

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<th>Description</th>
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<tr>
<td>dV/dt filters up to 500 hp</td>
<td>24 inches</td>
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<tr>
<td>Frame B/C/D inverter</td>
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<tr>
<td>dV/dt filters 600 to 2500 hp</td>
<td>36 inches</td>
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<tr>
<td>Output reactors and sine filters</td>
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Figure 2. Frame A drive and Frame B transformer section overhead lifting

- Spreader and rigging
- I-bolts for lifting, (4) places
- Channels for top lifting
- Remove cover plates front and rear to insert lifting channels or forks for lifting
- 39.50 Eye bolts C/C
- 44.25 Tubing width for fork truck lifting
- 65.00
Figure 3. Frame C, Frame D, and Frame E transformer section overhead lifting

A and B Dimensions

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<tr>
<th>Unit</th>
<th>A Dimension</th>
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<td>Frame E converter</td>
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</table>
Chapter 4: Handling, storage, and installation

Installation

General information

The SC9000 EP is designed to be installed, operated, and maintained by adequately trained and qualified personnel. These instructions do not cover all details, variations, or combinations of the equipment, its storage, delivery, installation, check-out, safe operation, or maintenance. The required electrical connections are shown on the order-specific wiring diagram shipped with each controller. Comply with local, state, and national regulations, as well as safety practices for this class of equipment. The drive is designed for front access, meaning that it can be installed directly against a wall to the rear and/or either side. Sufficient space must be allowed in front of the drive for installation, troubleshooting, and maintenance access. In general, 60 inches of clearance must be allowed. See Appendix A for diagrams showing standard space requirements and door swing for each frame size. Job specific drawings should be checked for any variation from the standard.

Site preparation

Complete the site preparation before the drive is unpacked, so that possible problems, such as headroom, conduit location, cable tray locations, ventilation, etc., can be solved, ensuring a safe installation, in compliance with the building plans and codes. Verify that conduit locations are compatible with the available area shown on the order drawings.

Make the intended mounting surface level so that the drive is not distorted when bolted into place. Check the overhead for plumbing condensation, sprinklers or similar possible sources of trouble and take corrective steps where necessary.

Provide for adequate grounding connections to be made in accordance with applicable code requirements.

If plans call for bottom conduit entry, conduits must be placed in locations where there is adequate clearance for conduit bushings. See the outline drawings for the order. Available space for top and bottom conduit entry is order specific.
Mounting

After the drive/lineup has been placed in position, anchor bolts should be installed and tightened in the floor of the enclosure. See Appendix A for diagrams showing standard bolt locations for each frame size and provisions for seismic-resistant mounting. For job specific mounting holes, sizes, and weights, refer to job specific drawings supplied with the drive. Refer to regional building codes and laws for mounting requirements for seismic applications. It is recommended that anchorage and support design be completed by a structural engineer. The foundation must be solid and level with a maximum of 1/16 inches separation at the anchor bolt locations. The use of 1/2 inch diameter grade 5 bolts or greater is recommended. Use flat and lock washer under nut or bolt head and torque appropriately (75 ft lb for grade 5). When a drive/lineup includes two or more shipping sections, the order outline drawing will show the sequence in which the sections are to be lined up and which shipping splits are to be joined. A busbar splice kit (where applicable) and a connecting hardware kit are supplied for each open joint between sections.

Redundant blowers/pull box

If the SC9000 EP drive has redundant blowers or a pull box for mating to an integrated control-gear lineup, they will be shipped loose due to carrier height restrictions. The Frame A would have one redundant blower assembly, Frame B/C would have two redundant blower assemblies, Frame D would have three to five redundant blower assemblies and the Frame E would have four to five redundant blower assemblies. These assemblies must be installed per the instructions shipped with the job specific drawings before commissioning the AFD.

SC9000 EP unit connection

Main bus connection

For units requiring main bus, connections to be made using 3/8-16 HHCS, flat washers, lock washers, and nut. Apply 18-25 ft-lb torque. Bus splice plates may or may not be shipped connected to one end of the unit split (Figure 5).

Ground bus connection

Ground bus is typically linked between units/splits using a braided flexible shunt (P/N 151B587G02). Ground bus links will be shipped connected to one end of the split (Figures 6 and 7). Connections to be made using 3/8-16 HHCS with flat and lock washer. Apply 18-25 ft-lb torque. In specific configurations hard bus links may be used, however hardware and torque values will be consistent.
In drive-to-drive applications, the ground bus connection will generally be made through the forward most opening in the side sheet. In rear aligned drive to Ampgard applications, the ground bus connection will be made through the central opening of the drive, while the forward opening is blanked by a cover plate (Figure 8).

**Figure 8. Ground bus openings**

Structure connection

Drive-to-drive and shipping splits within a drive unit are directly coupled. One coupling method utilizes a side sheet with weld nut where the mating side sheet has a clearance hole. Other couplings use clearance holes in both mating sheets. In either case, 3/8-16 HHCS, flat washer, and lock washer are to be used and torqued to 18–25 ft-lb torque (Figure 9).

**Figure 9. Structure connection detail**

Drive units are secured to Ampgard units through the use of a transition section. In these applications, Tinnerman nuts are placed in the side sheet of the drive and the transition section is bolted to it using 3/8-16 HHCS with flat and lock washer. Tinnerman nuts (5/16-18) are also placed in the opposite flange (Ampgard side) of the transition section (Figure 10).

**Figure 10. Transition section**
The Ampgard-Drive connection is made by passing hardware through the Ampgard side sheet (Figure 11) into the Tinnerman nuts of the transition and requires the use of 5/16-18 x 2 HHCS, (2) flat washers, lock washer, and spacer—Eaton PN 25A4184H01, 0.625OD x 0.328ID x 0.85 LGH and torqued to 10–14 ft-lb (Figure 12).

**Figure 11. Transition connection to Ampgard**

![Transition connection to Ampgard](image)

**Figure 12. Hardware for transition to Ampgard**

![Hardware for transition to Ampgard](image)

**Low voltage connection**

Low voltage pathways for drive-to-drive and shipping splits within a drive are located in the upper front area of the side sheet (Figure 15). Within the drive, low voltage cables are routed along the top front of the cabinet (Figure 13) and in some cases are nested in wireways (Figure 14).

**Figure 13. Low voltage pathway**

![Low voltage pathway](image)

**Figure 14. Low voltage wireway**

![Low voltage wireway](image)
Low voltage pathways between drives and Ampgard are most often located in the center of the drive side sheet (Figure 15). In each case, pull apart terminal blocks are the general method of providing breaks between units (Figure 16).

Figure 15. Low voltage pathway between splits

![Drive/drive low voltage pathway](image)

Drive/Drive low voltage pathway

Drive/Ampgard low voltage pathway

The order outline drawing will show the sequence in which the sections are to be joined. A bus bar splice kit and a connecting hardware kit is supplied for each open joint between sections.

Remove the bus compartment top cover plates from the two adjacent sections to be joined. Store lifting angles for possible future use. Also remove any knockouts in the side plates that will be used, e.g., for control cables.

Place the transformer shipping section into position. Move the inverter shipping split(s) into position alongside the first and use the 3/8 x 1.50 inch bolts and companion hardware to connect the two side plates. Place one flat washer under the bolt head and one flat washer and one lock washer under the nut. Tighten each bolt to 12 ft-lb (16 Nm). On Frame C, D, and E only, move the input shipping split into position alongside the first and use the 3/8 x 1.50 inch bolts and companion hardware to connect the two side plates. Place one flat washer under the bolt head and one flat washer and one lock washer under the nut. Tighten each bolt to 12 ft-lb (16 Nm).

Connect the main bus bars using the splice kit provided (where applicable). Tighten bolts to 25 ft-lb (33 Nm).

Figure 17. Main bus shipping split connection

![Internal control wires and power cables](image)

Internal control wires and power cables will have to be connected across any shipping splits.

Standard connections across shipping splits for a Frame B drive are as described below (see Appendix B for section details):

- Ground bus from Inverter section to transformer section (Section 2 to 1)
- Power cables from DC bus to line side bus of Inverter (Section 1 to 2)
- Power cables from drive output terminals to the load-side bus of inverter (Section 1 to 2)
- Fiber optic cables from inverter to control card rack (Section 2 to 1)
- Control wiring from Inverter to control compartment (Section 2 to 1)
Typical connections across shipping splits for a Frame C drive are as described below (see Appendix C for section details):

- Ground bus from Inverter section to transformer section and from incoming section to transformer section (Section 3 to 2 and 1 to 2)
- Power cables from load side of main contactor to isolation transformer and precharge contactor (Section 1 to 2)
- Power cables from DC bus to line side of Inverter (Section 2 to 3)
- Power cables from load side of inverter to the drive output terminals; Both ends of cables must be connected (Sections 3 to 2 and 2 to 1)
- Fiber optic cables from inverter to control card rack (Section 3 to 2)
- Control wiring from Inverter to control compartment (Section 3 to 2)
- Control wiring from main contactor to control compartment (Section 1 to 2)

Typical connections across shipping splits for a Frame D and E drive are as described below (see Appendix B for section details):

- Ground bus from inverter section to transformer section and from incoming section to transformer section (Section 3 to 2 and 1 to 2)
- Power cables from load side of main contactor to isolation transformer and precharge contactor (Section 1 to 2)
- Power cables from DC bus to line side of inverter (Section 2 to 3)
- Fiber optic cables from inverter to control card rack (Section 3 to 2)
- Control wiring from inverter to control compartment (Section 3 to 2)
- Control wiring from main contactor to control compartment (Section 1 to 2)

Refer to the order specific drawings for any additional wiring that must be connected across shipping splits.

Incoming connections

**WARNING**

De-energize and lock out all incoming power connections at their source before servicing any part of the equipment directly connected to the incoming power, including main horizontal bus, vertical bus, bus potential transformers, or control power transformers.

Incoming power connects to the drive/lineup in a variety of ways. For A, B, and C frames, the use of a pullbox option (Figure 18) is very common due to its reduced footprint. A pullbox is an adapter that allows a cable to bus connection from the top. Mounting holes on the busbar are staggered to allow more room between connections. If a large phase to phase separation is desired, or more than two cables per phase are required, an incoming line section would be the better option. Cables, bus from other close-coupled equipment, and bus duct are also common methods. These connections should be made using 3/8-16 HHCS, flat washers, lock washers, and nut. Apply 18–25 ft-lb torque. Note that these connections may be energized even when the drive isolation switch or other switching devices are in the open position.
See correct Appendix for diagrams showing standard locations for incoming connections. Review the order drawings supplied with the equipment for information on the incoming terminal connections for your specific equipment.

Isolation panels must be removed to connect to the load and line terminals. These isolation panels must be installed in the original locations after making the load and line terminations.

Ensure that all connections are tight and of the proper ampacity to carry the rated load. Cables should be properly supported and braced, with special attention to ensure that the insulation is protected from damage.

Load cable terminations are typically located in the left front of the drive for an A Frame if there is no output filter or bypass. For other frames, the load cables come out of the inverter cabinet unless there is an output filter or bypass. Load cables may exit either the top or bottom of the structure. Ensure that the factory supplied phase barriers are installed before energizing the drive. Failure to do so can result in a flashover at the load connections.

Individual motor cable length should not be greater than what is recommended in Section 2, Appendix D without consulting the manufacturer. Motor cables must be kept separate from line cables and control wiring to minimize the amount of radiated noise from the motor cables. Cables must include the proper insulation for the applied voltage. Special specification cables are not required.

Control wires may enter the enclosure from either the top or the bottom. A low voltage wireway is located in the drive running from the conduit plates to the control section to facilitate top and bottom entry of control wiring. Refer to the order specific drawings for specific locations for control wireways.

All cable/wire entry openings must be sealed to reduce the risk of entry by rodents and to allow for proper airflow and cooling of components.

The SC9000 EP is provided with a ground bus that runs the full length of the drive. If the drive consists of multiple shipping sections, the ground bus must be connected across all shipping splits using the flexible shunts and hardware supplied with the drive. These will be installed on the ground bus and secured inside the drive shipping section.

Always ground the drive to prevent electrical shock and reduce electrical noise. The user is responsible for meeting all regulatory requirements with respect to grounding of the drive. Failure to observe this precaution could result in bodily injury or death.

**Power factor correction capacitors or surge capacitors must not be connected to the drive output.**
Chapter 5: ARC

Purpose
This chapter explains the differences between the SC9000 EP and the SC9000 EP AR. It does not cover all possible contingencies, variations, and details that may arise during installation, operation, and maintenance of this equipment. Due to similarities in ducting and construction, refer to IB48077E and IB48076 for ducting installation instruction.

Introduction
The Eaton SC9000 EP AR provides adjustable frequency control and protection of medium voltage AC motors and equipment rated at 2400 V and 4160 V while incorporating Eaton arc resistant technology. The SC9000 EP AR meets or exceeds UL 347A and UL 50E as they apply to metal-enclosed medium voltage industrial equipment and ANSI/IEEE C37.20.7 for arc resistant type 2B and CSA C22.2 NO. 0.22-11. The SC9000 EP AR is available in three frame sizes: C, D, and E dependent on horsepower and voltage. The SC9000 AR is a stand-alone unit and is comprised of a 60-inch input section, followed by the transformer section and the inverter section. The contactor, softmag pre-charge, and blower CPTs are located in the input section to ensure consistency between frame sizes.

All frame sizes in the ARC lineup have undergone changes in order to meet arc standards.
- Reinforced cabinet construction providing robust resistance to arc flash events
- LV compartment design allowing for 2B rating
- Air flow channels employing debris and flame blocking means
- Internal cabinet design features to control arc propagation

Table 7. SC9000 EP AR dimensions

<table>
<thead>
<tr>
<th>Output voltages</th>
<th>FLA</th>
<th>hp</th>
<th>Width</th>
<th>Height (incl. plenum)</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frame C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2400</td>
<td>38–390</td>
<td>300–1750</td>
<td>165</td>
<td>128</td>
<td>50</td>
</tr>
<tr>
<td>4160</td>
<td>38–390</td>
<td>300–2500</td>
<td>165</td>
<td>128</td>
<td>50</td>
</tr>
</tbody>
</table>

| **Frame D**     |       |          |       |                       |       |
| 2400            | 448–561| 2000–2500| 176   | 128                   | 50    |
| 4160            | 390–434| 2750–3500| 176   | 128                   | 50    |
| 4160            | 403–558| 3750–4500| 226   | 128                   | 50    |

| **Frame E**     |       |          |       |                       |       |
| 4160            | 589–754| 4750–6000| 226 ②| 128                   | N/A   |

Notes
① Allow 16 inches of clearance above unit.
② 226-inch width is dual inverter.
Shipping weights

The Eaton SC9000 EP AR comes in 3 sections: one for the input section, one for the transformer section, and one for the inverter cabinet. These weights are approximate. Refer to the job-specific drawings for the weights of each shipping section.

Input sections each weigh approximately 5800 lb.

<table>
<thead>
<tr>
<th>Frame</th>
<th>hp</th>
<th>Transformer</th>
<th>Inverter</th>
<th>Total (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'C'</td>
<td>300</td>
<td>6700</td>
<td>2500</td>
<td>15000</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>6815</td>
<td>2500</td>
<td>15115</td>
</tr>
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<td></td>
<td>400</td>
<td>6930</td>
<td>2500</td>
<td>15230</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>7160</td>
<td>2500</td>
<td>15460</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>7160</td>
<td>2500</td>
<td>15460</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>7505</td>
<td>2500</td>
<td>15805</td>
</tr>
<tr>
<td></td>
<td>700</td>
<td>7850</td>
<td>2500</td>
<td>16150</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>8260</td>
<td>2500</td>
<td>16560</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>8700</td>
<td>2500</td>
<td>17000</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>8035</td>
<td>3200</td>
<td>17035</td>
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<tr>
<td></td>
<td>1250</td>
<td>8550</td>
<td>3200</td>
<td>17550</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>9300</td>
<td>3200</td>
<td>18300</td>
</tr>
<tr>
<td></td>
<td>1750</td>
<td>9875</td>
<td>3200</td>
<td>18875</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>11025</td>
<td>3200</td>
<td>20025</td>
</tr>
<tr>
<td></td>
<td>2250</td>
<td>11715</td>
<td>3200</td>
<td>20715</td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td>12865</td>
<td>3200</td>
<td>21865</td>
</tr>
<tr>
<td>'D'</td>
<td>3000</td>
<td>14590</td>
<td>3200</td>
<td>23590</td>
</tr>
<tr>
<td></td>
<td>3500</td>
<td>15000</td>
<td>3200</td>
<td>24000</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>15740</td>
<td>6500</td>
<td>28040</td>
</tr>
<tr>
<td></td>
<td>4500</td>
<td>16315</td>
<td>6500</td>
<td>28615</td>
</tr>
<tr>
<td></td>
<td>5000</td>
<td>16890</td>
<td>6500</td>
<td>29190</td>
</tr>
<tr>
<td>'E'</td>
<td>4750–6000</td>
<td>21045</td>
<td>6500</td>
<td>33345</td>
</tr>
</tbody>
</table>

Connections

Due to Eaton’s unique integrated design, shipping section connections remain the same. Refer to job-specific drawings for exact connections.
Chapter 6: GP

Purpose
This chapter explains the differences between the SC9000 EP and the SC9000 GP. It does not cover all possible contingencies, variations, and details that may arise during installation, operation, and maintenance of this equipment.

Introduction
The Eaton SC9000 GP provides adjustable frequency control and protection of medium voltage AC motors and equipment rated at 4160 V. The design and performance of the GP meet or exceed UL 347A, NEMA ICS6, and IEEE 519 standards. The GP is offered in a front accessible, single structure with modular enclosures, and provides simple, easy installation with its back or either side against the wall. The GP allows customers to use their existing main contactor or breaker to keep cost at a minimum.

Customer supplied power

Input contactor and fuses
- The VFD shall be supplied with 4160 V (±10%), three-phase, 60 Hz (±5%) power with 50 kA maximum fault current
- Customer shall provide dedicated fused contactor with isolation switch or power circuit breaker as feeder
- Customer shall provide dedicated fused contactor with isolation switch rated to protect the VFD from specified short-circuit levels
- Incoming line overload protection required to meet UL standard to include voltage phase balance protection
- Fuses shall be current limiting type 50 kA, maximum 200E
- If power circuit breaker is provided instead of fused input contactor, fuses must be installed in the system between the breaker and the drive or added to the drive

Control power
- Three customer supplied control power circuits shall be provided to supply 120 Vac. One is for drive control, one for cooling the inverter enclosure, and one for cooling the transformer enclosure
- Each circuit shall be 15 A 120 Vac source. See schematic for connection location and terminals

Feeder I/O requirements
- Contactor/breaker closed input (MCR)
- Contactor/breaker closed feedback (normally open)—aux contact
- Breaker open command if breaker supplied (for latched contactors, breaker trip coil)

Control I/O requirements
- Customer supplied ‘Pre-Charge’ contacts

CAUTION
When troubleshooting with 120 Vac applied, this pre-charge circuit generates medium voltage when the ‘Pre-Charge’ contacts are closed.

Specifications

Table 9. GP Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power rating</td>
<td>100–1000 hp (75–750 kW)</td>
</tr>
<tr>
<td>Input voltage rating</td>
<td>4160 V</td>
</tr>
<tr>
<td>Input frequency</td>
<td>60 Hz, ±5%</td>
</tr>
<tr>
<td>Input short-circuit current withstand</td>
<td>50 kA rms sym (1)</td>
</tr>
<tr>
<td>Basic impulse level</td>
<td>30 kV (option 60 kV)</td>
</tr>
<tr>
<td>Input power circuit protection</td>
<td>Customer supplied</td>
</tr>
<tr>
<td>Output voltage</td>
<td>0–4160 V</td>
</tr>
<tr>
<td>Number of inverter IGBTs</td>
<td>12</td>
</tr>
<tr>
<td>IGBT PIV rating</td>
<td>6500 V</td>
</tr>
<tr>
<td>Number of rectifier devices (diodes)</td>
<td>24</td>
</tr>
<tr>
<td>Diode PIV rating</td>
<td>4000 V</td>
</tr>
<tr>
<td>Cooling</td>
<td>Air cooling</td>
</tr>
</tbody>
</table>

Table 10. GP power specifications

Voltage class 4160

<table>
<thead>
<tr>
<th>Drive rating (A)</th>
<th>13</th>
<th>19</th>
<th>26</th>
<th>32</th>
<th>38</th>
<th>44</th>
<th>51</th>
<th>57</th>
<th>63</th>
<th>76</th>
<th>89</th>
<th>101</th>
<th>114</th>
<th>124</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive output (kVA)</td>
<td>91</td>
<td>137</td>
<td>183</td>
<td>228</td>
<td>274</td>
<td>317</td>
<td>367</td>
<td>411</td>
<td>454</td>
<td>548</td>
<td>641</td>
<td>728</td>
<td>821</td>
<td>893</td>
</tr>
<tr>
<td>Nominal hp 4160 V</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>300</td>
<td>350</td>
<td>400</td>
<td>450</td>
<td>500</td>
<td>600</td>
<td>700</td>
<td>800</td>
<td>900</td>
<td>1000</td>
</tr>
</tbody>
</table>
Table 11. GP dimensions

<table>
<thead>
<tr>
<th>Output Voltages</th>
<th>FLA</th>
<th>hp</th>
<th>Width</th>
<th>Height</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>4160</td>
<td>13–124</td>
<td>100–1000</td>
<td>72</td>
<td>92</td>
<td>50</td>
</tr>
</tbody>
</table>

The Eaton SC9000 GP comes in one shipping section but with different weights depending on horsepower and other customer options. These weights are approximate. Refer to the job-specific drawings for the accurate weight.

Table 12. GP Shipping weights

<table>
<thead>
<tr>
<th>hp</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>5775</td>
</tr>
<tr>
<td>150</td>
<td>5875</td>
</tr>
<tr>
<td>200</td>
<td>5975</td>
</tr>
<tr>
<td>250</td>
<td>6075</td>
</tr>
<tr>
<td>300</td>
<td>6175</td>
</tr>
<tr>
<td>350</td>
<td>6275</td>
</tr>
<tr>
<td>400</td>
<td>6375</td>
</tr>
<tr>
<td>450</td>
<td>6575</td>
</tr>
<tr>
<td>500</td>
<td>6575</td>
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<tr>
<td>600</td>
<td>6575</td>
</tr>
<tr>
<td>700</td>
<td>7175</td>
</tr>
<tr>
<td>800</td>
<td>7525</td>
</tr>
<tr>
<td>900</td>
<td>7975</td>
</tr>
<tr>
<td>1000</td>
<td>8325</td>
</tr>
</tbody>
</table>

Connections

With the Eaton SC9000 GP, installation and connections remain consistent with the entire SC9000 lineup. The GP has options for top and bottom incoming and load entry.

Drive discharge and grounding

Compared to the original SC9000, the GP rectifier and inverter neutral point is at floating potential and extra caution is required when grounding out the DC bus. Before entering the SC9000 GP compartments, remove the 4160 V source. Turn off the “PreCharge” input to the drive. Once 4160 is removed, wait at least 5 minutes and verify with the SPX controller keypad that the DC voltage is below 50 Vdc. Remove all 120 V sources from the drive. Lock out all power sources connected to the drive.

In units with the optional Kirk key interlocks, the proper key sequence must be executed to open the inverter and landing cabinets. After disengaging Kirk key interlocks, remove fastening bolts from the top medium voltage inverter cabinet door. First ground the floating neutral terminal (center), and then ground the negative and positive terminals. Attach a ground cable to all three inverter terminals to maintain the grounded state during maintenance or storage.

Inverter grounding and replacement

The SC9000 GP utilizes a removable air cooled inverter. The inverter is a drawout truck-mounted device that can be withdrawn from the structure for repair or replacement. The GP inverter uses simple cable connections instead of stab engagements. After discharging and grounding the DC bus, remove the fastening bolts from the lower MV inverter cabinet door. Compared to the SC9000 EP that uses rear stabs, the GP inverter uses cable connections.

Precautions

The GP includes static sensitive components. Use a grounded wrist or heel strap when handling or touching the DMCR or inverter and their components. This reduces the chance of ESD damage.

Use caution to prevent pinched fingers; inverters can weigh up to 2000 lb (910 kg).

There is a hazard of electric shock whenever working on or near electrical equipment. Turn off all power supplying the equipment before starting work. Lock out the disconnecting means in accordance with NFPA 70E, “Electrical Safety Requirements for Employee Safety in the Workplace.” Discharge rectifier, inverter, and DC bus with grounding stick. Where it is not feasible to de-energize the system, take the following precautions:

1. Instruct persons working near exposed parts that are or may be energized to use practices (including appropriate apparel, equipment, and tools) in accordance with NFPA 70E.

2. Require persons working on exposed parts that are or may be energized to be qualified persons who have been trained to work on energized circuits.

For the purpose of these instructions, a qualified person is one who is familiar with the installation, construction, or operation of the equipment and the hazards involved. In addition, this person should have the following qualifications:

1. Be trained and authorized to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.

2. Be trained in the proper care and use of protective equipment such as rubber gloves, hard hats, safety glasses or face shields, flash clothing, etc., in accordance with established practices.

3. Be trained in rendering first aid.

4. Be knowledgeable with respect to electrical installation codes and standards, for example, the National Electrical Code (NEC).
GP inverter removal or installation

PUBLIC WARNING

All incoming power must be disconnected and locked out before performing maintenance on the SC9000 EP. The DC bus voltage must be fully discharged. Failure to disconnect incoming power and verify DC bus is discharged can result in equipment damage, personal injury, or death.

1. Complete the inverter grounding process and verify the drive is in a zero energy state.
2. Disconnect the gate card fiber optic cables and URTD fiber optic cable from the ITG (Figure 19). Coil and secure fibers so they will not be damaged during inverter removal. Refer to job-specific diagrams for correct wire locations.
3. Disconnect the power supply harness from the base of the inverter carriage (Figure 20).
4. Disconnect inverter DC cables from landings (Figure 21). (These connections should be made using 3/8-16 HHCS bolts, flat washers, lock washers, and nuts. They should be torqued to 18–25 ft-lb).
5. Disconnect inverter AC cables from landings (Figure 22A) or DVDT filter tabs (Figure 22B). (These connections should be made using 3/8-16 HHCS bolts, flat washers, lock washers, and nuts. They should be torqued to 18–25 ft-lb).
6. Remove the support bracket holding the inverter in place. Perform this step with a coworker spotting you in case the inverter begins to move.
7. Align inverter wheels with cart or ramp and adjust cart or ramp to proper height for a smooth transition.
8. Ensure that all wiring is held or secured free from interference with the inverter. Take special care of the position of the fiber optic cables, which can catch on other objects. Check to make sure all wires and groundings are unattached from the inverter.

9. Pull the inverter slowly toward the cart or ramp with the help of multiple coworkers.

10. For storage or shipment, short circuit the positive, neutral, and negative DC connections on the inverter using a shorting strap.

11. Reverse steps for installation.

Figure 22A. Inverter AC Cable Landings

Figure 22B. DVDT Tabs
Appendix A: Typical Frames A, B, C

Figure 23. Typical schematic for SC9000 EP—sheet 1
Figure 25. Typical schematic for SC9000 EP—sheet 3

The information on this document is intended to convey and document that the contract specification has been accurately interpreted and may not be accurate for construction purposes.
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Figure 27. Typical schematic for SC9000 EP—sheet 5

The information on this document is intended to convey and document that the contract specification has been accurately interpreted and may not be accurate for construction purposes.
Figure 28. Frame A parts layout—SC9000 EP
Appendix A: Typical Frames A, B, C

Figure 29. Frame A configuration—SC9000 EP

SC9000 EP
3rd Generation of Eaton Medium Voltage Drives

Legend Notes:
A - Use 3/8 in. top 4 holes, mounting studs to extend a minimum of 2.000 in. above Grade.
B - Rear door frame requires 1/2" for 3/4" wide structure, 1/2" for 1/2" wide structure, 2/3" for 1/2" wide structure, 3/4" for 3/4" wide structure, 1/2" for 1/2" wide structure, 5/8" for 1/2" wide structure.
C - Inverters:
D - LV Inverters:
E - LV Inverters:
F - LV Inverters:
G - 408" LV Inverters:
H - LV Inverters:
I - LV Inverters:
J - LV Inverters:
K - LV Inverters:
L - LV Inverters:
M - LV Inverters:
N - LV Inverters:

FRAME-A, 2400V, 4160V

STRUCTURE # 1

SC9000 EP Drive
Stand-Alone Frame-A

60 inches clear in front of drive unit for removal of inverter.
Figure 30. Frame B parts layout—SC9000 EP

- Main Blowers
- ISO Switch
- Power Fuses
- Contactor
- CPT Line Fuses
- 120 V CPT
- Discharge Resistors
- Softmag Precharge
- Voltage Sensors
- 480 V CPT
- Fans
- Fiber Optic Board
- 24 pulse Transformer
- Current Sensors
- Inverter
- Capacitors
- Converter
Figure 31. Frame B configuration—SC9000 EP
Figure 33. Frame C configuration—SC9000 EP
Figure 35. Typical schematic for SC9000 EP—sheet 2
Figure 36. Typical schematic for SC9000 EP—sheet 3

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Figure 39. Typical schematic for SC9000 EP—sheet 6

The information on this document is intended to convey and document that the contract specification has been accurately interpreted and may not be accurate for construction purposes.
Appendix B: Typical Frames D, E

Figure 40. Typical schematic for SC9000 EP—sheet 7
Figure 41. Frame D parts layout—SC9000 EP

- Iso Switch
- Main Blowers
- Redundant Blowers
- CPT line fuses
- Voltage Sensors
- Softmag Precharge
- Fiber optic interface boards
- Inverter Fans
- 24 pulse transformer
- Current Sensors
- Output Reactors
- Capacitors
- Inverters
- 120v CPT
- Contactors
- Discharge Resistors
- Converters

Appendix B: Typical Frames D, E
Figure 42. Frame D configuration—SC9000 EP—2400 V
Figure 43. Frame D configuration—SC9000 EP—4160 V
Figure 44. Frame E parts layout—SC9000 EP

- Iso Switch
- CPT line fuses
- Power fuses
- Main Blowers
- Redundant Blowers
- Softmag Precharge
- Fiber Optic interface boards
- Inverter Fans
- Load Sharing Current Sensors
- Inverters
- 480V CPT
- 120V CPT
- Contactor
- 24 pulse transformer
- Discharge Resistors
- Voltage Sensors
- Converter
- Load Sharing Output Reactors
- Capacitors
Figure 45. Frame E configuration—SC9000 EP
Figure 46. ARC parts layout—SC9000 EP
Figure 47. ARC, EP Frame D configuration — SC9000 EP
Appendix C: Typical Frame GP

Figure 48. Typical schematic for SC9000 GP—sheet 1
Figure 49. Typical schematic for SC9000 GP—sheet 2

The information on this document is intended to convey and document that the contract specification has been accurately interpreted and may not be accurate for construction purposes.
Figure 50. Typical schematic for SC9000 GP—sheet 3
Figure 51. Typical schematic for SC9000 GP—sheet 4
The information on this document is intended to convey and document that the contract specification has been accurately interpreted and may not be accurate for construction purposes.
Figure 53. SC9000 GP parts layout

- Exhaust Duets
- Discharge Stick and Stabs
- Transformer Section Low Voltage
- Converter
- Motor Landings
- DVDT Reactor
- Current Sensors
- Pre-Charge Assembly
- Roll Out Inverter
- Optional Surge Arrestors
- Secondary Landings
- 24 Pulse Transformer
Figure 54. SC9000 GP configuration
Appendix D: Optional equipment

Section 1: Introduction

Purpose
This user manual addendum covers the installation, operation, and maintenance of selected SC9000 EP medium voltage adjustable frequency drive optional equipment. It does not cover all possible contingencies, variations, and details that may arise during installation, operation, and maintenance of this equipment.

The SC9000 EP can be equipped with several optional features. This addendum addresses these features:

- dV/dt filter
- Sine filter
- Synchronous transfer
- Synchronous motor control
- High voltage input
- Bypass control

Optional features summary

dV/dt filter
Standard induction motors driven by adjustable frequency drives can experience excessive induced voltages at the motor under certain cable length conditions. An SC9000 EP dV/dt filter, selected for the motor’s ratings and cable length, reduces these voltages, and makes longer cable runs possible with satisfactory operation.

Inverter-duty motors driven by adjustable frequency drives also can experience excessive induced voltages at the motor if cable length is excessive. For inverter-duty motors, the circumstances when these voltages occur are different, but an SC9000 EP dV/dt filter also addresses these conditions.

Sine filter
Total Harmonic Distortion, or THD, is a measurement of the amount the addition of other frequency waves corrupts a wave shape.

The SC9000 EP sine filter design reduces the drive output THD to less than 5% on both output voltage and current. Although its purpose is harmonic distortion reduction, the sine filter will also reduce the drive output dV/dt to less than 10 volts per microsecond.

Synchronous transfer system
With additional equipment, the SC9000 EP can provide synchronous transfer control to a multiple-motor system. For any number of motors, this system individually starts and accelerates each motor, matches its voltage, frequency and phase angle to a utility power bus, and transfers the motor from the SC9000 EP to the utility bus. In addition, the synchronous transfer system can transfer any connected motor’s power source from the utility bus back to the SC9000 EP and run or stop it.

Synchronous motor control
The SC9000 EP adjustable frequency drive can power synchronous motors. Additional power and control components power the motor’s rotor field.

While the Ampgard motor control product line offers four different versions of synchronous motor field excitation for motor starters, the SC9000 EP offers synchronous motor field control for AC brushless and DC brush fields.

High voltage input
The SC9000 EP can deliver 2400 V, 3300 V or 4160 V output voltages, and can accommodate input voltages between 2.4 kV and 13.8 kV. When input voltages above 6.9 kV are required, the SC9000 EP is equipped with an additional 72-inch wide cabinet to incorporate a 95 kV BIL incoming line and a 15 kV input contactor.

Bypass system
The Ampgard system offers two systems for bypass control: full voltage bypass and Reduced Voltage Solid State bypass.

Full voltage bypass serves as a backup to the SC9000 EP AFD and can run a connected using a full voltage starter while the AFD is down.

RVSS bypass starts the connected motor using a reduced-voltage solid-state starter technology while the AFD is down.

Refer to the specific order drawings supplied with your drive system for details on which devices are part of your equipment.

Documentation reference
For further information on installation and application, refer to the applicable technical data, publications, and/or industry standards. Download Eaton electronic information from www.eaton.com.

Eaton contact information
For the location of your nearest Eaton sales office or distributor, call toll-free 1-800-525-2000 or log on to www.eaton.com. Eaton’s Engineering Services & Systems (EESS) can be reached at 1-800-498-2678.
Section 2: dV/dt filter

The SC9000 EP dV/dt filter is a combination of reactors, capacitors and resistors that reduces the sharp change in voltages due to IGBT switching. Smoothing the voltage spikes reduces the high frequency ringing, lowers the voltage added to the drive output and reduces the effects on motor insulation and bearings when cable lengths are excessive.


When to use a dV/dt filter

For motors used with SC9000 EP drives, the decision to apply a dV/dt filter depends upon the motor used and the connecting cable lengths between the SC9000 EP and the motor.

Longer cable runs are possible with a dV/dt filter present. Permissible lengths depend upon the type of motor used.

dV/dt use on a standard motor

If a standard (non-inverter rated) motor is used,

- Apply a dV/dt filter to a 2400 V motor whenever the connecting cable lengths are greater than 60 feet
- Apply a dV/dt filter to a 4160 V motor whenever the connecting cable lengths are greater than 120 feet
- Apply only a sine filter (see Chapter 3) whenever the cable length is greater than 1250 feet

Figure 55 shows a representative dV/dt elementary diagram.

dV/dt use on an inverter duty motor

- Apply a dV/dt filter to a 2400 V motor whenever the connecting cable lengths are greater than 150 feet
- Apply a dV/dt filter to a 4160 V motor whenever the connecting cable lengths are greater than 300 feet
- Apply only a sine filter (see Chapter 3) whenever the cable length is greater than 1250 feet

Contact Eaton if the motor cable length is greater than what is recommended above and the optional output filter has not been supplied.

Figure 55. Typical dV/dt filter
Example showing the effects of a dV/dt filter

Figure 56 shows a representative SC9000 EP voltage step output (in green) with a corresponding dV/dt filter voltage output (in purple). In this example, the rate of change of drive output voltage (dV/dt) has decreased by about 23 times.

Figure 56. dV/dt filter effect on drive output

Figure 57 shows an example dV/dt filter in its cabinet.

Figure 57. dV/dt filter in cabinet
Appendix D: Optional equipment

SC9000 EP dV/dt filters and ratings

SC9000 EP dV/dt Filter designs are based upon drive rated voltage and current. Eaton application engineers select a filter during the project design process. Tables 13 and 14 show SC9000 EP dV/dt filter models.

Table 13. 2300 V dV/dt filters

<table>
<thead>
<tr>
<th>Catalog number</th>
<th>Drive power (hp)</th>
<th>Filter rating (A)</th>
<th>Cabinet size (H x W x D)</th>
<th>Watts loss (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>39C2078 G43</td>
<td>300</td>
<td>71</td>
<td>92 x 24 x 50</td>
<td>1024</td>
</tr>
<tr>
<td>39C2078 G44</td>
<td>400</td>
<td>93</td>
<td>92 x 24 x 50</td>
<td>1084</td>
</tr>
<tr>
<td>39C2078 G45</td>
<td>500</td>
<td>116</td>
<td>92 x 24 x 50</td>
<td>1102</td>
</tr>
<tr>
<td>39C2078 G46</td>
<td>600</td>
<td>136</td>
<td>92 x 24 x 50</td>
<td>1383</td>
</tr>
<tr>
<td>39C2078 G48</td>
<td>800</td>
<td>180</td>
<td>92 x 36 x 50</td>
<td>1440</td>
</tr>
<tr>
<td>39C2078 G410</td>
<td>1000</td>
<td>225</td>
<td>92 x 36 x 50</td>
<td>1514</td>
</tr>
<tr>
<td>39C2078 G412</td>
<td>1250</td>
<td>279</td>
<td>92 x 36 x 50</td>
<td>1658</td>
</tr>
<tr>
<td>39C2078 G415</td>
<td>1500</td>
<td>335</td>
<td>92 x 36 x 50</td>
<td>1802</td>
</tr>
<tr>
<td>39C2078 G420</td>
<td>2000</td>
<td>446</td>
<td>92 x 36 x 50</td>
<td>2129</td>
</tr>
<tr>
<td>39C2078 G425</td>
<td>2500</td>
<td>558</td>
<td>92 x 36 x 50</td>
<td>2226</td>
</tr>
</tbody>
</table>

Table 14. 4160 V dV/dt filters

<table>
<thead>
<tr>
<th>Catalog number</th>
<th>Drive power (hp)</th>
<th>Filter rating (A)</th>
<th>Cabinet size (H x W x D)</th>
<th>Watts loss (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>39C2028 G43</td>
<td>300</td>
<td>44.7</td>
<td>92 x 24 x 50</td>
<td>1282</td>
</tr>
<tr>
<td>39C2028 G44</td>
<td>400</td>
<td>57.0</td>
<td>92 x 24 x 50</td>
<td>1360</td>
</tr>
<tr>
<td>39C2028 G45</td>
<td>500</td>
<td>65.1</td>
<td>92 x 24 x 50</td>
<td>1357</td>
</tr>
<tr>
<td>39C2028 G46</td>
<td>600</td>
<td>81.5</td>
<td>92 x 36 x 50</td>
<td>1674</td>
</tr>
<tr>
<td>39C2028 G48</td>
<td>800</td>
<td>101</td>
<td>92 x 36 x 50</td>
<td>2029</td>
</tr>
<tr>
<td>39C2028 G410</td>
<td>1000</td>
<td>125</td>
<td>92 x 36 x 50</td>
<td>2011</td>
</tr>
<tr>
<td>39C2028 G412</td>
<td>1250</td>
<td>159</td>
<td>92 x 36 x 50</td>
<td>2163</td>
</tr>
<tr>
<td>39C2028 G415</td>
<td>1500</td>
<td>186</td>
<td>92 x 36 x 50</td>
<td>3348</td>
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<tr>
<td>39C2028 G420</td>
<td>2000</td>
<td>248</td>
<td>92 x 36 x 50</td>
<td>3444</td>
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<tr>
<td>39C2028 G425</td>
<td>2500</td>
<td>310</td>
<td>92 x 36 x 50</td>
<td>3592</td>
</tr>
<tr>
<td>39C2028 G430</td>
<td>3000</td>
<td>373</td>
<td>92 x 40 x 50</td>
<td>4843</td>
</tr>
<tr>
<td>39C2028 G435</td>
<td>3500</td>
<td>434</td>
<td>92 x 40 x 50</td>
<td>4832</td>
</tr>
<tr>
<td>39C2028 G442</td>
<td>4250</td>
<td>527</td>
<td>92 x 40 x 50</td>
<td>6731</td>
</tr>
<tr>
<td>39C2028 G450</td>
<td>5000</td>
<td>633</td>
<td>92 x 40 x 50</td>
<td>7892</td>
</tr>
<tr>
<td>39C2028 G460</td>
<td>6000</td>
<td>780</td>
<td>92 x 40 x 50</td>
<td>8033</td>
</tr>
</tbody>
</table>

dV/dt filter as part of the SC9000 EP lineup

During the project application and design process, the intended cable lengths and motor type selected will determine whether to apply a dV/dt filter. If your project needs a dV/dt filter, Eaton application engineers will select a filter for the intended drive, motor and installation.

Physical location in SC9000 EP drive

The SC9000 EP dV/dt filter, when present, is typically located in the SC9000 EP panel lineup, adjacent to and downstream of the inverter cabinet. However, it can be located remotely depending on the application and installation constraints.

Filter cabinet outline

Figure 58 shows a typical cabinet outline for a dV/dt filter.

Figure 58. dV/dt representative cabinet outlines
Figures 59 and 60 show the dV/dt filter cabinet location and power flow position in the SC9000 EP.

Figure 59. dV/dt filter cabinet in SC9000 EP lineup

Figure 60. dV/dt filter power flow

**dV/dt cooling requirements**

The installed filter’s cabinet cooling system provides its required cooling. This system consists of an inlet air filter and outlet air fan, located in the cabinet door, and an air outlet vent on top of the control cabinet. The filter and fan require periodic maintenance for maximum efficiency.

**Maintenance**

Inspect the dV/dt filter cabinet cooling system periodically to assure maximum uptime and effectiveness. Inspect the cooling fan and inlet air filter at least once every three months. Clean the filters with an air jet and dust the fan to prevent dust buildup in the fan motor and bearings. Replace the fan every three to five years.
Appendix D: Optional equipment

Troubleshooting
The dV/dt filter includes reactor thermal switches. When a dV/dt filter is included in the SC9000 EP, these sensors connect to the SC9000 EP I/O and the drive application is programmed to monitor them. Detection of a thermal switch opening causes a drive shutdown and a fault message to be displayed and recorded.

Replacement parts
Table 15 shows replacement part numbers.

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W2E250-HJ32-0</td>
<td>Fan, WE250, 1P, 115V, 60HZ, 50C</td>
</tr>
<tr>
<td>478C779H01</td>
<td>Intake filter</td>
</tr>
<tr>
<td></td>
<td>Reactor (includes thermal switch and thermal sensor)</td>
</tr>
</tbody>
</table>

O&M technical references
For additional information about the SC9000 EP, refer to this SC9000 EP User Manual, IB02004001E.

Section 3: Sine filter

Sine filter definition
A sine filter is an SC9000 EP system element designed to reduce Total Harmonic Distortion of the output. Total Harmonic Distortion, or THD, is a measurement of the amount the addition of other frequency waves corrupts a wave shape. THD measures the power quality of electric power systems.

Unlike the dV/dt filter, which works to reduce high-frequency drive output components, the sine filter reduces specific lower-frequency harmonics to produce a more sinusoidal drive output voltage and current.

Reducing Total Harmonic Distortion of the voltage and current delivered to a motor can decrease heating and increase efficiency. Harmonics, if present, will increase the electrical losses, and increase motor heating.

Sine filter purpose
The SC9000 EP sine filter design reduces the drive output THD to less than 5% on both output voltage and current, for loads above 30% of rated. Although its purpose is harmonic distortion reduction, the sine filter will also reduce the drive output dV/dt.

With the sine filter applied, the only limitation on connecting cable lengths is the voltage drop between the drive and the motor.
Sine filter location in the SC9000 EP drive

Sine filters mount in their own cabinets, and come with cabinet cooling fans and inlet air filters. Due to their weight, sine filter inductors mount in the cabinet bottom, with the resistors and capacitors on a shelf above them.

Figure 63. Sine filter panel layout

Figures 64 and 65 show a typical SC9000 EP lineup with a sine filter included. The sine filter mounts adjacent to the inverter cabinet in an SC9000 EP lineup.

Figure 64. Sine filter added to SC9000 EP lineup
Appendix D: Optional equipment

Figure 65. Sine filter power flow one-line diagram

Figures 66 and 67 show installed Sine Filters in two frame sizes.

Figure 66. Sine filter with filter fans shown

Figure 67. Frame D sine filter
When to apply a sine filter

Deciding to apply a sine filter depends upon several design factors. The length of the cable between the drive and motor; whether there is concern for motor heating due to additional harmonics; the motor design (inverter duty versus non-inverter duty), all play a role in the application decision. If the cable length from drive to a standard motor or to an inverter duty motor is greater than 1250 feet, apply a Sine Filter.

Sine filter ratings

The connected motor horsepower and current determine which SC9000 EP sine filter to apply. Tables 16 and 17 show the filter catalogue numbers along with corresponding induction motor ratings. Contact the factory for synchronous motor applications.

### Table 16. 2400 V sine filters for induction motors

<table>
<thead>
<tr>
<th>Catalog number 39C2022</th>
<th>Motor power (hp)</th>
<th>Filter output (A)</th>
<th>Cabinet size (H x W x D)</th>
<th>Watts loss (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G02</td>
<td>350</td>
<td>82</td>
<td>92 x 40 x 50</td>
<td>1492</td>
</tr>
<tr>
<td>G04</td>
<td>450</td>
<td>104</td>
<td>92 x 40 x 50</td>
<td>1759</td>
</tr>
<tr>
<td>G06</td>
<td>600</td>
<td>135</td>
<td>92 x 40 x 50</td>
<td>2151</td>
</tr>
<tr>
<td>G08</td>
<td>800</td>
<td>178</td>
<td>92 x 40 x 50</td>
<td>2628</td>
</tr>
<tr>
<td>G10</td>
<td>1000</td>
<td>223</td>
<td>92 x 40 x 50</td>
<td>3142</td>
</tr>
<tr>
<td>G11</td>
<td>1250</td>
<td>279</td>
<td>92 x 40 x 50</td>
<td>3720</td>
</tr>
<tr>
<td>G12</td>
<td>1500</td>
<td>335</td>
<td>92 x 40 x 50</td>
<td>4013</td>
</tr>
<tr>
<td>G14</td>
<td>2000</td>
<td>446</td>
<td>92 x 40 x 50</td>
<td>5043</td>
</tr>
<tr>
<td>G16</td>
<td>2500</td>
<td>558</td>
<td>92 x 40 x 50</td>
<td>6327</td>
</tr>
</tbody>
</table>

### Table 17. 4160 V Sine filters for induction motors

<table>
<thead>
<tr>
<th>Catalog number 39C2022</th>
<th>Motor power (hp)</th>
<th>Filter output (A)</th>
<th>Cabinet size (H x W x D)</th>
<th>Watts loss (W)</th>
</tr>
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<tbody>
<tr>
<td>G22</td>
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<td>G24</td>
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<td>92 x 40 x 50</td>
<td>1792</td>
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<tr>
<td>G26</td>
<td>600</td>
<td>77</td>
<td>92 x 40 x 50</td>
<td>2199</td>
</tr>
<tr>
<td>G28</td>
<td>800</td>
<td>103</td>
<td>92 x 40 x 50</td>
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<td>1000</td>
<td>128</td>
<td>92 x 40 x 50</td>
<td>3245</td>
</tr>
<tr>
<td>G31</td>
<td>1250</td>
<td>162</td>
<td>92 x 40 x 50</td>
<td>3860</td>
</tr>
<tr>
<td>G32</td>
<td>1500</td>
<td>186</td>
<td>92 x 40 x 50</td>
<td>4123</td>
</tr>
<tr>
<td>G34</td>
<td>2000</td>
<td>250</td>
<td>92 x 40 x 50</td>
<td>5204</td>
</tr>
<tr>
<td>G36</td>
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<td>4250</td>
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<tr>
<td>G42</td>
<td>6000</td>
<td>747</td>
<td>90 x 56 x 50</td>
<td>15212</td>
</tr>
</tbody>
</table>

Cooling requirements and filter monitoring

Sine filters are power components and require cooling to operate properly. Each sine filter cabinet is equipped with cooling fans and inlet air filters to provide satisfactory cooling. The sine filter reactors are also equipped with over-temperature switches and the capacitors have over-pressure switches to detect adverse conditions.

Maintenance

Sine Filter maintenance consists of periodic inspections of the cooling air fans and inlet air filters, and periodic checks of the oil-filled capacitors.

Inspect the cooling fans and inlet air filters at least once every three months. Clean the filters with an air jet and dust the fans to prevent dust buildup in the fan motor and bearings. Replace fans every three to five years.

Check the capacitors annually.
Appendix D: Optional equipment

SC9000 EP application programming

⚠️ CAUTION
Do not attempt to perform an SC9000 EP motor characteristics identification procedure with the sine filter connected between the SC9000 EP and the motor. This could damage to the SC9000 EP and require repair.

⚠️ CAUTION
Do not use the Open Loop Vector Control mode with a sine filter installed. The Sine Filter will interfere with the SC9000 EP motor model calculations, resulting in improper operation.

Applying a sine filter to the SC9000 EP requires programming the medium voltage drives application. The sine filter introduces a voltage drop in the output to the motor. The SC9000 EP application programming raises the drive output voltage to restore full voltage performance at the motor.

Refer to Chapter 5, Parameter Group G1.14 for detailed information about the Sine Filter parameters.

The sine filter affects the choice of SC9000 EP operating modes. Refer to the Caution messages above for important restrictions.

Troubleshooting

The sine filter includes reactor thermal and capacitor pressure switches. When a sine filter is included in the SC9000 EP, these sensors connect to the SC9000 EP I/O and the drive application is programmed to monitor them. Detection of a thermal switch or capacitor pressure switch opening causes a drive shutdown and a fault message to be displayed and recorded.

Replacement parts

Table 18 shows replacement part.

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W2E250-HJ32-0</td>
<td>Fan, WE250, 1P, 115V, 60HZ, 50C C</td>
</tr>
<tr>
<td>478C779H01</td>
<td>Intake filter</td>
</tr>
<tr>
<td>Contact Eaton for project-specific part</td>
<td>Capacitor assembly (overtemperature, overpressure switches included)</td>
</tr>
</tbody>
</table>

O&M technical references

For additional information about the SC9000 EP, refer to this SC9000 EP User Manual, IB02004001E.

Section 4: Synchronous transfer

Purpose

With additional equipment, the SC9000 EP can provide synchronous transfer control to a multi-motor system. (This excludes SC9000 GP, which is not capable of synchronous transfer). For any number of motors, this system individually starts and accelerates each motor and runs it at any desired speed. Or, it can start a motor, match the motor’s voltage, frequency and phase angle to a utility power bus, and transfer the motor from the SC9000 EP to the utility bus. The Synchronous Transfer system can also transfer any connected motor’s power from the utility bus back to the SC9000 EP and individually control its speed or stop it.

Components

To perform this function, the Synchronous Transfer System must have an SC9000 EP output damping reactor, a PLC control system to receive customer commands, and bypass and motor select contactors for each motor. Customer commands include Start or Stop, Sync Up or Sync Down, for each system motor. The SC9000 EP can also include an optional AFD feeder bus contactor.

SC9000 EP output reactor

Sized for the SC9000 EP drive and motors’ rating, the output reactor dampens current transients during the bypass contactor and motor select contactor switching.

Bypass contactor

This Ampgard medium voltage starter assembly connects a selected motor to the utility feed line upon command. There is one bypass contactor module for each connected motor.

Motor select contactor

This Ampgard medium voltage starter assembly connects a selected motor to the AFD feeder bus upon command. There is one motor select contactor module for each connected motor. Unlike the bypass contactor module, this module does not include motor starter fuses, since the SC9000 EP provides overload protection.

PLC system

The SC9000 EP Synchronous Transfer system includes programmable controllers to receive command inputs from the customer’s supervisory control and sequence the SC9000 EP, the motor select and bypass contactors. A Drive master PLC mounts behind a low voltage door in an SC9000 EP cabinet. Smaller PLCs for each motor in the system provide system scalability plus status monitoring for each system motor.
The Drive master PLC receives requests from individual motor PLCs for transfer operations. The master PLC checks system permissives and system status before initiating a transfer sequence.

The master PLC sequences and monitors each motor’s bypass contactor, motor select contactor and motor status to assure that proper execution of drive operation and contactor switching take place. Since a successful transfer includes voltage, frequency and phase synchronization between the SC9000 EP and the utility bus, the drive times each transfer step to the millisecond.

Figure 68. Synchronous transfer
Synch transfer panel layout and power flow

Figure 69 shows a typical synchronous transfer system panel layout and power flow.

Figure 69. Synchronous transfer panel layout
Transfer control operation

Following is a description of the synchronous transfer system operation. Figure 70 shows the elements that make up an SC9000 EP Synchronous Transfer system.

Control elements colors and symbols

- ■ = de-energized
- ■ = energized feeder bus
- ■ = energized AFD bus
- ■ = contactor energized and closed

Figure 70. Synchronous transfer elements

Sequence of operation

1. The AFD and feeder bus are energized (Figure 71).

2. The PLC receives a Start Command from the supervisory control system.
   - The PLC closes the appropriate motor select contactor
   - When the motor select contactor is closed, the PLC starts the AFD. The AFD accelerates and operates the selected motor at either a preset speed or a reference speed (Figure 72)

3. Sync UP
   - When the motor is required to transfer to the utility line, the supervisory control instructs the PLC to send a “Sync Up” command to the AFD
   - The AFD adjusts its output to match the utility line voltage, frequency and phase angle
   - Once the AFD is synchronized with the utility line, the selected motor’s bypass contactor closes, connecting the motor to the utility line, and the selected motor’s select contactor opens, disconnecting the motor from the AFD bus (Figure 73)

Figure 72. AFD runs selected motor at speed

Figure 73. Selected motor contactors switching

- The AFD output reactor dampens any transient currents that may occur during the transition
- Once the transition is complete, the AFD shuts down and waits for another Start command from the PLC
- Now only the utility bus feeds the selected motor (Figure 74)
4. **Sync Down**

- When instructed by the supervisory control, the PLC sends a command to the AFD to “Sync Down”
- The PLC commands the AFD to start
- With the AFD output contactor open and the selected motor’s bypass contactor closed, the PLC closes the selected motor’s motor select contactor (Figure 75)

**Figure 75. Motor select contactor closes**

- The AFD is commanded to match the utility’s voltage, frequency and phase angle; once this is completed, the AFD output contactor closes and the selected motor’s utility’s bypass contactor opens. The AFD output reactor dampens any transient currents that may occur during the transition (Figure 76)

**Figure 76. AFD contactor closes, bypass opens**

- The AFD, now connected to the selected motor, operates at a set speed or follows a reference speed (Figure 77)

**Figure 77. Selected motor runs on AFD bus**

**Control interface**

Customer commands for each motor include Start, Stop, Sync Up, Sync Down, and Run Speed. Motor and Contactor status are available for supervisory control.

**Control options**

The SC9000 EP Synchronous Transfer system comes standard with Eaton Programmable Controllers. Other controllers can be furnished as an option.

**Control application configuration**

The SC9000 EP medium voltage drives application has programming parameters for use with Synchronous Transfer systems. Refer to Chapter 5, Parameter Group G1.17 for detailed information on these parameters.

**Fault conditions / alarm states**

The SC9000 EP monitors fault conditions and alarm states for all Synchronous Transfer system elements. Individual motor PLCs monitor motor and contactors’ status and coordinate with the Drive master PLC at all times. Drive status and alarm conditions are available through the SC9000 EP operator interface and remote supervisory control interface provisions.

**O&M technical references**

For additional information about the Synchronous Transfer system elements, refer to this SC9000 EP User Manual, IB02004001E and your project O&M Manual references:

AD02004001E  Synchronous Transfer Control with SC9000 EP
Section 5: Synchronous motor system

Synchronous motors

Synchronous motors are like other induction motors in that they have stator windings that induce currents and magnetic fields in rotor squirrel cage bars. In the synchronous motor, these squirrel cage bars, or amortisseur windings, are short-time rated, for starting duty. The synchronous motor also has externally-powered wound rotor magnets. How the wound rotor magnets receive their power defines the two synchronous motor types.

Synchronous motors come in two varieties: brush-type and brushless. The brush-type motor uses slip rings and brushes to conduct DC excitation current to the rotor wound electromagnets. The brushless type uses a separate set of stator windings and rotor bars to transmit AC to rotor-mounted hardware for conversion to DC.

Synchronous motor components

Figure 78, Figure 79 and Figure 80 show the essential rotor DC excitation components of brush-type and brushless synchronous motors.

A synchronous motor starts like a conventional induction motor, using a motor starter or VFD and relying on the torque produced by the stator magnets and squirrel cage bar magnets for acceleration. As the motor speed approaches its synchronous speed, an external control system detects this and energizes the rotor’s separate-excitation windings, the wound electromagnets, pulling the rotor up to synchronous, or rated speed. Once at synchronous speed, the amortisseur windings act as damping windings to discourage motor speed variation, or hunting.
The brushless type synchronous motor has distinct advantages over the brush-type. Maintenance of the brushless type is considerably simpler. The brushless type does not require cleaning the slip ring collector, repairing damaged or corroded slip rings, inspecting and replacing worn brushes, etc. In addition, brush particles abraded from the brushes and loose in the motor frame can deposit on the motor windings, affecting insulation life.

In addition, the brushless type is more suitable for use in adverse environmental conditions. Maintaining slip rings and brushes under conditions like those found in chemical plants, where steam, oil or corrosive gases are present, is very difficult. Brushless motors designs for pressurized or explosion-proof requirements are much simpler than with slip rings and brushes.

The SC9000 EP drive system can include control and excitation for brushless synchronous motors.

**SC9000 EP synchronous motor control**

The SC9000 EP Synchronous Motor control system provides both stator and rotor control and power. The SC9000 EP Adjustable Frequency Drive powers and protects the synchronous motor’s stator windings, while the separate power and protection system provides the rotor windings excitation. Figure 81 shows the SC9000 EP functional block diagram for brushless synchronous motors.

The SC9000 EP directs the field exciter, based upon configuration and settings parameters established in the drive application software. For more information about the application parameters, see Chapter 5, Parameter Group G1.15, which includes parameters for enabling or disabling the control, choosing control modes, setting control loop constants, and so on.

**Brush-type synchronous motor control**

Although the SC9000 EP Synchronous Motor Control system is designed for brushless synchronous motors, Eaton also offers control systems for brush-type motors, powered by Ampgard Medium Voltage Starters. For more information about these systems, refer to Eaton IB 48045, Instructions for Mark VI Solid-State, Brush-Type, Synchronous Motor Controllers.

**O&M technical references**

For detailed information on your Synchronous Motor control system, refer to the O&M manual, publications:

IB48045  Instructions For Ampgard® Mark 5.5 Solid-State, Brush-Type, Synchronous Motor Controllers
Section 6: High voltage input

Purpose

The SC9000 EP can deliver 2400 V, 3300 V or 4160 V output voltages, and can accept input voltages between 2.4 kV and 13.8 kV. When the source voltage is above 6.9 kV, the SC9000 EP must include an additional 72-inch wide cabinet grouping. This grouping houses a 95 kV BIL incoming line termination array and a 15 kV input vacuum contactor starter. The SC9000 EP 24 pulse isolation transformer primary and secondary windings are also chosen according to the project input and output voltage requirements.

Representative mechanical diagrams

Contactor

The Ampgard Type SL, 300A, 15 kV vacuum contactor can be applied at voltages up to 13,800V and is rated to drive up to a 7500 hp induction motor (300 AFL).
Representative photos

**Figure 83** shows a high voltage input incoming compartment. **Figure 84** shows a detail of the incoming cable termination points.

**Figure 83. High voltage incoming compartment**

**Figure 84. Incoming cable terminations**

O&M technical references

For additional information about the high voltage Input system elements, refer to your project O&M manual references:

- IB 48050  Instructions for Installation, Operation, and Maintenance of the AMPGARD 15 kV, 300 A Vacuum Starter
- IB 48051  Instructions for Installation, Operation, and Maintenance of the SL 15 kV, 300 A Vacuum Contactor
Section 7: Bypass system

Purpose
Bypass control provides for those times when an SC9000 EP AFD is taken offline and the connected motor must run. This chapter addresses the Eaton SC9000 EP bypass control products.

Types of SC9000 EP bypass
There are two types of bypass control generally applied with SC9000 EP products:

- Full voltage bypass
- RVSS Bypass

Full voltage bypass
This system switches an induction motor’s power source between two sources: a utility source and an SC9000 EP AFD. Use Full voltage bypass when the AFD requires maintenance or troubleshooting. It allows the motor to connect to the incoming line, bypassing the AFD and performing a full-voltage start.

The motor and connected equipment must be able to tolerate an across-the-line start without mechanical or electrical damage. Fan or pump applications are examples of systems where a full-voltage start can work without connected equipment damage.

Representative panel layout diagram

Figure 85. Representative full voltage bypass panel layout

Sequence of operation

Control Elements colors and symbols

= de-energized

= energized feeder bus

= contactor closed

Under normal conditions, the SC9000 EP powers the motor, and the bypass contactor is open, isolating the motor from the AC power feed bus.

Figure 86. Normal operation using SC9000 EP AFD

When the AFD is not available, the AFD input contactor is open, the bypass contactor AC line feeder contactor closes, the AFD output contactor opens, and the AC line feeds the motor.

Figure 87. Full voltage bypass operation
Appendix D: Optional equipment

**RVSS bypass**

When the connected mechanical equipment cannot tolerate a full-voltage bypass start, reduced voltage solid state bypass can provide bypass functionality while delivering a smoother, softer motor start. This can eliminate high motor inrush currents and connected load mechanical stresses. In addition, RVSS is easier on the electrical supply system, softening the burden during the motor start.

This bypass method works well on conveyors, PD pumps or systems where supplied voltage is limited. *Figure 88* shows a typical RVSS cabinet.

*Figure 88. Typical RVSS cabinet*

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**Sequence of operation**

*Control elements colors and symbols*

- **= de-energized**
- **= energized bus**
- **= energized contactor closed**

Under normal operation, the SC9000 EP is operating and providing power to the connected motor. The bypass contactor is in the non-bypass position, with power from the reduced voltage soft start system not connected to the motor through the bypass contactor.

*Figure 90. RVSS bypass normal operation*
Figure 91. RVSS bypass system bypassed

O&M technical references
For detailed information on your bypass control system, refer to the O&M manual, publications:
DEH41021 Medium Voltage Solid State OEM Soft Starter Installation and Operation Manual
IB 48041 Instructions for AMPGARD 400 A Medium Voltage Starter
At Eaton, we’re energized by the challenge of powering a world that demands more. With over 100 years experience in electrical power management, we have the expertise to see beyond today. From groundbreaking products to turnkey design and engineering services, critical industries around the globe count on Eaton.

We power businesses with reliable, efficient and safe electrical power management solutions. Combined with our personal service, support and bold thinking, we are answering tomorrow’s needs today. Follow the charge with Eaton. Visit eaton.com/electrical.

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